Mullard
Book 1 Part 1
Transistors AC127 to BF451
September 1974

Mullard technical handbook

Book one
Semiconductor devices

Part one
Transistors AC127 to BF451

September 1974

TRANSISTORS

CONTENTS

TRANSISTORS

CONTENTS

Book 1 comprises the following parts—

Part 1	Transistors and accessories
Part 2	Transistors and accessories
Part 3	Diodes, photodiodes and phototransistors
Part 4	Rectifier diodes, rectifier diode stacks, medium and high-power voltage regulator diodes, transient suppressor diodes
Part 5	Thyristors, thyristor stacks and accessories
Part 6	Digital integrated circuits
Part 7	Linear integrated circuits

Made and printed in England by Wightman & Co., Ltd.

BOOK 1 (Part 1)

SEMICONDUCTOR DEVICES

Transistors
AC127 to BF451

MULLARD LTD., MULLARD HOUSE, TORRINGTON PLACE,
LONDON, WC1E 7HD

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DATA HANDBOOK SYSTEM

The Mullard data handbook system is made up of three sets of books, each comprising several parts.

The three sets of books, easily identifiable by the colours on their covers, are as follows:

Book 1	(blue)	Semiconductor devices and integrated circuits
Book 2	(orange)	Valves and tubes
Book 3	(green)	Passive components, materials, and assemblies.

Each part is completely reviewed annually; revised and reprinted where necessary. Revisions to previous data are indicated by an arrow in the margin.

The data contained in these books are as accurate and up to date as it is reasonably possible to make them at the time of going to press. It must however be understood that no guarantee can be given here regarding the availability of the various devices or that their specifications may not be changed before the next edition is published.

The devices on which full data are given in these books are those around which we would recommend equipment to be designed. Where appropriate, other types no longer recommended for new equipment designs, but generally available for equipment production are listed separately with abridged data. Data sheets for these types may be obtained on request. Older devices on which data may still be obtained on request are also included in the index of the appropriate part of each book.

Requests for information on the data handbook system and for individual data sheets should be made to

Central Technical Services
Mullard Limited
New Road
Mitcham
Surrey CR4 4XY

Telephone: 01-648 3471   Telex: 22194

Information regarding price and availability of devices must be obtained from our authorised agents or from our representatives.

SELECTION GUIDE

1. SMALL/MEDIUM SIGNAL TRANSISTORS

Germanium types

Type No.	N-P-N	P-N-P	General Purpose	Switching	Low Noise	V_{CE} max (V)			h_{FE} min			P_{tot}max (mW)	Case
						⩾15	⩾30	⩾60	⩽30	<60	⩾60		
AC127	★		★				★			★		340	TO–1
AC128		★	★				★				★	1000	TO–1
AC176	★		★				★			★		700	TO–1
AC187	★		★			★					★	1000	TO–1
AC188		★	★			★					★	1000	TO–1

P-N-P Silicon alloy types

Type No.	General Purpose	Switching	V_{CE} max (V)			h_{FE} min			P_{tot} max (mW)	Case
			⩾15	⩾30	⩾60	⩽30	<60	⩾60		
BCY30	★	★			★	★			250	TO–5
BCY31	★	★			★		★		250	TO–5
BCY32	★	★			★			★	250	TO–5
BCY33	★	★		★		★			250	TO–5
BCY34	★	★		★			★		250	TO–5
BCY38	★	★		★		★			410	TO–5
BCY39	★	★			★	★			410	TO–5
BCY40	★	★		★			★		410	TO–5
BCY54	★	★		★			★		410	TO–5

SMALL/MEDIUM SIGNAL TRANSISTORS (cont.)
N-P-N Silicon planar types

Type No.	General Purpose	Switching	Low Noise	V_{CE} max (V)			f_T (GHz)			P_{tot}max (mW)	Case
				⩾15	⩾30	⩾60	<0·4	<1·0	>1·0		
BC107†	★	★			★		★			300	TO–18
BC108†	★	★		★			★			300	TO–18
BC109†	★		★	★			★			300	TO–18
BC147	★				★		★			300	lock-fit
BC148	★			★			★			300	lock-fit
BC149	★		★	★			★			300	lock-fit
BC547	★				★		★			300	TO–92
BC548	★			★			★			300	TO–92
BC549	★		★	★			★			300	TO–92
BCW31R	★			★			★			200	μ min
BCW32R	★			★			★			200	μ min
BCW33R	★			★			★			200	μ min
BCW71R	★				★		★			200	μ min
BCW72R	★				★		★			200	μ min
BCX19	★	★			★		★			310	μ min
BCX20	★	★		★			★			310	μ min
BCX31	★					★	★			1000	lock-fit
BCX32	★					★	★			1000	lock-fit
BCX33	★				★		★			1000	lock-fit
BCX34	★				★		★			1000	lock-fit
BF180	★		★					★		150	TO–72
BF181	★		★	★				★		150	TO–72
BF194	★		★	★			★			220	lock-fit
BF195	★		★	★			★			220	lock-fit
BF196	★		★	★			★			250	lock-fit
BF197	★			★				★		250	lock-fit
BF200	★		★	★			★			150	TO–72
BF336	★					★	★			3000	TO–39
BF337	★					★	★			3000	TO–39
BF338	★					★	★			3000	TO–39
BF355		★				★	★			3000	TO–39
BF362	★			★				★		120	T pack
BF363	★			★				★		120	T pack
BFR63	★		★	★					★	3500	Capstan
BFR64	★		★	★					★	3500	Capstan
BFR90	★		★	★					★	180	T pack
BFR91	★		★	★					★	180	T pack

†Also available to BS 9365–F112

SMALL/MEDIUM SIGNAL TRANSISTORS (cont.)

N-P-N Silicon planar types (cont.)

Type No.	General Purpose	Switching	Low Noise	V_{CE} max (V)			f_T (GHz)			P_{tot} max (mW)	Case
				⩾15	⩾30	⩾60	<0·4	<1·0	>1·0		
BFR92	★		★	★					★	180	μ min
BFR93	★		★						★	180	μ min
BFS17R	★		★	★					★	200	μ min
BFS20R	★			★				★		200	μ min
BFT24	★		★	‡					★	30	T pack
BFT25	★		★	‡					★	30	μ min
BFW16A	★		★	★					★	1500	TO–39
BFW17A	★			★					★	1500	TO–39
BFW30	★		★	★					★	250	TO–72
BFX84	★	★				★	★			800	TO–5
BFX85	★	★				★	★			800	TO–5
BFX86	★	★			★		★			800	TO–5
BFX89	★		★	★					★	200	TO–72
BFY50†	★	★				★	★			800	TO–5
BFY51†	★	★				★	★			800	TO–5
BFY52†	★	★			★		★			800	TO–5
BFY53	★			★			★			800	TO–5
BFY90	★		★	★					★	200	TO–72
BSS40		★			★		★			360	TO–18
BSS41		★			★		★			360	TO–18
BSV52R		★			★			★		200	μ min
BSW66		★				★	★			800	TO–5
BSW67		★				★	★			800	TO–5
BSW68		★				★	★			800	TO–5
BSX19	★	★			★			★		360	TO–18
BSX20	★	★			★			★		360	TO–18
BSX21	★					★	★			300	TO–18
BSX59		★			★		★			800	TO–5
BSX60		★		★			★			800	TO–5
BSX61		★			★		★			800	TO–5
BSY95A		★		★			★			300	TO–18
2N1613	★	★				★	★			800	TO–5
2N1711	★	★			★		★			800	TO–5
2N2297	★	★			★		★			800	TO–5
2N2369A		★		★				★		360	TO–18
2N3053		★			★		★			800	TO–5

†Also available to BS 9365–F012

‡V_{CEO} max = 5V

SMALL/MEDIUM SIGNAL TRANSISTORS (cont.)

P-N-P Silicon planar types

Type No.	General Purpose	Switching	Low Noise	V_{CE} max (V)			f_T (MHz)			P_{tot} max (mW)	Case
				⩾15	⩾30	⩾60	<200	<400	>400		
BC157	★				★		★			300	lock-fit
BC158	★			★			★			300	lock-fit
BC159	★		★	★			★			300	lock-fit
BC327	★				★		★			625	Plastic
BC328	★			★			★			625	Plastic
BC557	★				★		★			300	TO–92
BC558	★			★			★			300	TO–92
BC559	★		★	★			★			300	TO–92
BCW29R	★		★	★			★			200	μ min
BCW30R	★		★	★			★			200	μ min
BCW69R	★				★		★			200	μ min
BCW70R	★				★		★			200	μ min
BCX17	★	★			★		★			310	μ min
BCX18	★	★		★			★			310	μ min
BCX35	★					★	★			1000	lock-fit
BCX36	★					★	★			1000	lock-fit
BCX37	★				★		★			1000	lock-fit
BCY70†	★	★	★		★			★		350	TO–18
BCY71†	★		★		★			★		350	TO–18
BCY72†	★	★	★	★				★		350	TO–18
BF324	★		★		★				★	250	TO–92
BF450	★		★		★			★		250	TO–92
BF451	★		★		★			★		250	TO–92
BFX29‡	★	★				★	★			600	TO–5
BFX30‡		★				★				600	TO–5
BFX87	★	★			★		★			600	TO–5
BFX88	★	★			★		★			600	TO–5
BSV68		★				★	★			250	TO–18
2N2904	★	★			★			★		600	TO–5
2N2904A	★	★				★		★		600	TO–5
2N2905	★	★			★			★		600	TO–5
2N2905A	★	★				★		★		600	TO–5
2N2906	★	★			★			★		400	TO–18
2N2906A	★	★				★		★		400	TO–18
2N2907	★	★			★			★		400	TO–18
2N2907A	★	★				★		★		400	TO–18

† Also available to BS9365-F009

‡ Also available to BS9365-F010/F011

2. L.F./H.F. POWER TRANSISTORS
Silicon types

Type No.	N-P-N	P-N-P	General Purpose	Switching	H.F.	V_{CE} max (V)		h_{FE} min	P_{tot} max (W)	Case
						⩾35	⩾70	⩾30		
BD131	★		★		★	★		★	15	TO–126
BD132		★	★		★	★		★	15	TO–126
BD133	★		★		★	★		★	15	TO–126
BD135	★		★		★	★		★	6·5	TO–126
BD136		★	★		★	★		★	6·5	TO–126
BD137	★		★		★	★		★	6·6	TO–126
BD138		★	★		★	★		★	6·5	TO–126
BD139	★		★		★		★	★	6·5	TO–126
BD140		★	★		★		★	★	6·5	TO–126
BD181	★		★			★			117	TO–3
BD182	★		★			★			117	TO–3
BD183	★		★				★		117	TO–3
BD184	★		★				★		117	TO–3
BD201	★		★			★		★	55	Plastic
BD202		★	★			★		★	55	Plastic
BD203	★		★			★		★	55	Plastic
BD204		★	★			★		★	55	Plastic
BD232	★		★		★		300V		7	TO–126
BD233	★		★			★			25	TO–126
BD234		★	★			★			25	TO–126
BD235	★		★			★			25	TO–126
BD236		★	★			★			25	TO–126
BD237	★		★				★		25	TO–126
BD238		★	★				★		25	TO–126
BD433	★		★					★	36	TO–126
BD434		★	★					★	36	TO–126
BD435	★		★					★	36	TO–126
BD436		★	★					★	36	TO–126
BD437	★		★			★		★	36	TO–126
BD438		★	★			★		★	36	TO–126
BDX35	★			★	★	★		★	15	TO–126
BDX36	★			★	★	★		★	15	TO–126
BDX37	★			★	★		★	★	15	TO–126
BDY20	★		★	★		★			115	TO–3
BDY38	★		★			★		★	115	TO–3

L.F./H.F. POWER TRANSISTORS (cont.)

Silicon types (cont.)

Type No.	N-P-N	P-N-P	General Purpose	Switching	H.F.	V_{CE} max (V)		h_{FE} min	P_{tot} max (W)	Case
						≥35	≥70	≥30		
BDY90	★		★	★	★		★	★	40	TO–3
BDY91	★		★	★	★		★	★	40	TO–3
BDY92	★		★	★	★	★		★	40	TO–3
BDY93	★		★	★			★		30	TO–3
BDY94	★		★	★			★		30	TO–3
BDY95	★		★	★			★		30	TO–3
BDY96	★		★	★			350V		40	TO–3
BDY97	★		★	★			300V		40	TO–3
BDY98	★		★	★			250V		40	TO–3
BSV64	★			★	★	★		★	5	TO–39
BU126	★		★				750V		30	TO–3
BU133	★		★				750V		30	TO–3
BU204	★		★				1300V		10	TO–3
BU205	★		★				1500V		10	TO–3
BU206	★		★				1700V		10	TO–3
BU207	★		★				1300V		12·5	TO–3
BU208	★		★				1500V		12·5	TO–3
BU209	★		★				1700V		12·5	TO–3
2N3055	★		★			★			115	TO–3
2N3442	★		★				★		117	TO–3
2N4347	★		★				★		100	TO–3

Germanium types

Type No.	N-P-N	P-N-P	General Purpose	Switching	H.F.	V_{CE}max (V)			h_{FE} min	P_{tot}max (W)	Case
						≥15	≥30	≥60	≥40		
AD149		★	★				★			22·5	TO–3
AD161	★		★			★			★	4	SO–55
AD162		★	★			★			★	6	SO–55
OC28		★	★	★				★		30	TO–3
OC29		★	★	★			★		★	30	TO–3
OC35		★	★	★			★			30	TO–3
OC36		★	★	★				★		30	TO–3

3. R.F. POWER DEVICES
N-P-N Transistors

Type No.	V.H.F.	U.H.F.	V_{CE}max (V)		P_o(C.W.) (W at MHz)				Case
			⩾18	⩾33	175	400	470	1000	
BLX13	★			★	25†				Capstan
BLX14	★			★	50†				Stripline
BLX65	★	★	★		2		2		TO–39
BLX66	★	★	★		3		2·5		Capstan
BLX67	★	★	★		3		3		Capstan
BLX69		★	★				20		Capstan
BLX91		★		★			1·4	1·4	Capstan
BLX92		★		★			3	2.5	Capstan
BLX93		★		★			8	5	Capstan
BLX94		★		★			20		Capstan
BLY33	★			★	2‡				TO–39
BLY34	★		★		3				TO–39
BLY35	★			★	7				TO–60
BLY36	★		★		13				TO–60
BLY53A	★	★	★		7·2		7		Capstan
BLY55	★		★		4				TO–60
BLY83	★			★	7				Capstan
BLY84	★		★		13				Capstan
BLY85	★		★		0·2				Capstan
BLY89A	★		★		25				Capstan
BLY90	★		★		50				Stripline
BLY93A	★			★	25				Capstan
BLY94	★			★	50				Stripline
BLY97	★			★	0·14				Capstan
2N3375	★	★		★	7·5§	3			TO–60
2N3553	★			★	2·5				TO–60
2N3632	★			★	13·5				TO–60
2N3866	★	★		★		1			TO–39
2N4427	★	★	★		1		0·4		TO–39

† At 70MHz ‡ A.M. (Carrier) § At 100MHz

Broad Band U.H.F. Amplifier Modules

Type No.	Frequency range (MHz)	V. supply (V)	Po min at Pdr (W)	(W)
BGY22	380–512	13·5	2·5	0·05
BGY22A	420–480	12·5	2·5	0·05
BGY23	380–512	13·5	7	2·5
BGY23A	420–480	12·5	7	2·5

4. DARLINGTON TRANSISTORS

Type No.	N-P-N	P-N-P	V_{CE} max (V)				h_{FE} min at I_C		P_{tot} max	Case
			45	60	80	100		(A)	(W)	
BCX21	★		★				2000	0·15	3·5	TO–39
BDX42	★		★				1500	0·5	5	TO–126
BDX43	★			★			1500	0·5	5	TO–126
BDX44	★				★		1500	0·5	5	TO–126
BSS50	★		★				1500	0·5	5	TO–39
BSS51	★			★			1500	0·5	5	TO–39
BSS52	★				★		1500	0·5	5	TO–39
BD262		★		★			750	1·5	36	TO–126
BD262A		★			★		750	1·5	36	TO–126
BD262B		★				★	750	1·5	36	TO–126
BD263	★			★			750	1·5	36	TO–126
BD263A	★				★		750	1·5	36	TO–126
BD263B	★					★	750	1·5	36	TO–126
BDX62		★		★			1000	3	90	TO–3
BDX62A		★			★		1000	3	90	TO–3
BDX62B		★				★	1000	3	90	TO–3
BDX63	★			★			1000	3	90	TO–3
BDX63A	★				★		1000	3	90	TO–3
BDX63B	★					★	1000	3	90	TO–3
BDX64		★		★			1000	5	117	TO–3
BDX64A		★			★		1000	5	117	TO–3
BDX64B		★				★	1000	5	117	TO–3
BDX65	★			★			1000	5	117	TO–3
BDX65A	★				★		1000	5	117	TO–3
BDX65B	★					★	1000	5	117	TO–3

5. FIELD-EFFECT TRANSISTORS
(n-channel, depletion)

Type No.	Junction gate	Insulated gate	General purpose	Switching	Low noise	Low 'On' resistance	U.H.F.	V_{DS}max (V)	Case
BF245A	★		★		★			30	TO–92
BF245B	★		★		★			30	TO–92
BF245C	★		★		★			30	TO–92
BFQ10		★	★		★			30	TO–71
BFQ11		★	★		★			30	TO–71
BFQ12		★	★		★			30	TO–71
BFQ13		★	★		★			30	TO–71
BFQ14		★	★		★			30	TO–71
BFQ15		★	★		★			30	TO–71
BFQ16		★	★		★			30	TO–71
BFR29		★	★		★			30	TO–72
BFR30	★		★					25	µ min
BFR31	★		★					25	µ min
BFS28		★	★		★		★	20	TO–72
BFW10	★		★		★			30	TO–72
BFW11	★		★		★			30	TO–72
BFW61	★		★					25	TO–72
BSV78	★			★		★		40	TO–18
BSV79	★			★		★		40	TO–18
BSV80	★			★		★		40	TO–18
BSV81		★		★		★		30	TO–72
2N3823	★		★		★			30	TO–72
2N3966	★			★				30	TO–72
2N4091	★			★		★		40	TO–18
2N4092	★			★		★		40	TO–18
2N4093	★			★				40	TO–18
2N4391	★			★		★		40	TO–18
2N4392	★			★		★		40	TO–18
2N4393	★			★				40	TO–18
2N4856	★			★		★		40	TO–18
2N4857	★			★		★		40	TO–18
2N4858	★			★		★		40	TO–18
2N4859	★			★		★		30	TO–18
2N4860	★			★		★		30	TO–18
2N4861	★			★		★		30	TO–18

6. MICROMINIATURE TRANSISTORS

Type No.	N-P-N	P-N-P	General Purpose	Switching	Low Noise	V_{CE}max (V)			f_T (MHz)			P_{tot}max (mW)
						⩾15	⩾30	⩾60	<200	<500	>1000	
BCW29R		★	★		★	★			★			200
BCW30R		★	★		★	★			★			200
BCW31R	★		★			★				★		200
BCW32R	★		★			★				★		200
BCW33R	★		★			★				★		200
BCW69R		★	★				★		★			200
BCW70R		★	★				★		★			200
BCW71R	★		★				★			★		200
BCW72R	★		★				★			★		200
BCX17		★	★	★			★		★			310
BCX18		★	★	★		★			★			310
BCX19	★		★	★			★		★			310
BCX20	★		★	★		★			★			310
BFR30†			★			★						200
BFR31†			★			★						200
BFR92	★		★		★	★					★	180
BFR93	★		★		★						★	180
BFS17R	★		★		★	★					★	200
BFS20R	★		★			★				★		200
BFT25	★		★		★	‡					★	30
BSV52R	★			★		★				★		200

†Field effect transistors
‡V_{CEO} max = 5V

7. LOCK-FIT TRANSISTORS

Type No.	N-P-N	P-N-P	General Purpose	Switching	Low Noise	V_{CE}max (V)			f_T (MHz)			P_{tot} max (mW)
						⩾15	⩾30	⩾60	<200	<400	>400	
BC147	★		★				★			★		350
BC148	★		★			★				★		350
BC149	★		★		★	★				★		350
BC157		★	★				★		★			350
BC158		★	★			★			★			350
BC159		★	★		★	★			★			350
BCX31	★		★					★	★			1W
BCX32	★		★					★	★			1W
BCX33	★		★				★		★			1W
BCX34	★		★				★		★			1W
BCX35		★	★					★	★			1W
BCX36		★	★					★	★			1W
BCX37		★	★				★		★			1W
BF194	★		★		★	★				★		220
BF195	★		★		★	★			★			220
BF196	★		★		★	★				★		250
BF197	★		★			★					★	250

8. SPECIAL DEVICES

Type No.	Description	Case
BCY87 **BCY88** **BCY89**	Differential amplifiers — High performance in first and second stages of d.c. amplifiers	TO–71 TO–71 TO–71
BRY39	P-N-P-N Silicon controlled switch	TO–72

GENERAL SECTION A

INDEX

Section I. Type Nomenclature

This section explains the system of type nomenclature used for Mullard Semiconductor devices showing the significance of each type letter or number.

Section II. List of Symbols for Light Current Semiconductor Devices

This section gives the main symbols used in quoting ratings and characteristics of Semiconductor Devices.

Section III. Explanation of Handbook Data

1. Form of issue.

1.1 Types of data, Tentative Data, Final Data.

1.2 Presentation of data—division into description, Quick Reference, Outlines, Ratings, Characteristics, Application information, Environmental data, Curves.

2. Ratings.

2.1 Definition of the three Ratings System—Absolute Maximum, Design Centre, Design Maximum.

3. Transistor Ratings.

3.1 Transistor Voltage Ratings.
Definitions of the main voltage ratings, V_{CB}, V_{EB}, V_{CE} under various circuit and current conditions, showing their interdependence. Voltage ratings charts and permissible area of operation.

3.2 Transistor Current Ratings.
Definitions of the main current ratings, I_C, I_E, I_B, under various conditions.

3.3 Transistor Power Ratings.
Definition of P_{tot} maximum—distinction between steady state and pulse—dependence on temperature—de-rating chart—heatsinks and thermal resistance considerations.

3.4 Temperature Ratings.
Definition of T_j, T_{mb}, T_{case}.

Section IV. Mounting and Soldering Recommendations

1. Mounting of 'Lockfit' Transistors.

1.1 Mounting on printed wiring boards.

1.2 Soldering.

Section V. Field Effect Transistors

Section VI. Safe Operating ARea for power transistors

TYPE NOMENCLATURE

Section 1

Mullard semiconductor devices are registered by Pro Electron.
The type nomenclature of a discrete device or, in certain cases, of a range of devices, consists of two letters followed by a serial number. The serial number may consist of three figures or of one letter and two figures depending on the main application of the device.

The first letter indicates the semiconductor material used:

A — germanium
B — silicon
C — compound materials such as gallium arsenide
D — compound materials such as indium antimonide
R — compound materials such as cadmium sulphide

The second letter indicates the general function of the device:

A — detection diode, high speed diode, mixer diode.
B — variable capacitance diode
C — transistor for a.f. applications (not power types)
D — power transistor for a.f. applications
E — tunnel diode
F — transistor for r.f. applications (not power types)
G — multiple of dissimilar devices; miscellaneous devices
L — power transistor for r.f. applications
N — photo-coupler
P — radiation sensitive device such as photodiode, phototransistor, photoconductive cell, or radiation detector diode
Q — radiation generating device such as light-emitting diode
R — controlling and switching device (e.g. thyristor) having a specified breakdown characteristic (not power types)
S — transistor for switching applications (not power types)
T — controlling and switching power device (e.g. thyristor) having a specified breakdown characteristic
U — power transistor for switching applications
X — multiplier diode such as varactor or step recovery diode
Y — rectifier diode, booster diode, efficiency diode
Z — voltage reference or voltage regulator diode, transient suppressor diode

The remainder of the type number is a **serial number** indicating a particular design or development and is in one of the following two groups:

(a) Devices intended primarily for use in consumer applications (radio and television receivers, audio amplifiers, tape recorders, domestic appliances, etc.).
The serial number consists of three figures.

(b) Devices intended mainly for applications other than (a), e.g. industrial, professional and transmitting equipments.
The serial number consists of one letter (Z, Y, X, W, etc.) followed by two figures.

Range Numbers

Where there is a range of variants of a basic type of rectifier diode, thyristor or voltage regulator diode the type number as defined above is often used to identify the range; further letters and figures are added after a hyphen to identify individual types within the range. These additions are as follows:

Rectifier Diodes and Thyristors

The group of figures indicates the rated repetitive peak reverse voltage, V_{RRM}, or the rated repetitive peak off-state voltage, V_{DRM}, whichever value is lower, in volts for each type.

The final letter R is used to denote a reverse polarity version (stud anode) where applicable. The normal polarity version (stud cathode) has no special final letter.

Voltage Regulator Diodes, Transient Suppression Diodes

The first letter indicates the nominal percentage tolerance in the operating voltage V_Z.

A — ±1%
B — ±2%
C — ±5%
D — ±10%
E — ±15%

The letter is omitted on transient suppressor diodes.

The group of figures indicates the typical operating voltage V_Z for each type at the nominal operating current I_Z rating of the range. For transient suppressor diodes the figure indicates the maximum recommended standoff voltage V_R.

The letter V is used to denote a decimal sign.

The final letter R is used to denote a reverse polarity version (stud anode) where applicable. The normal polarity version (stud cathode) has no special final letter.

Examples:

BF362	Silicon r.f. transistor intended primarily for 'consumer' applications.
ACY17	Germanium a.f. transistor primarily for 'industrial' applications.
BTW24–800R	Silicon thyristor for 'industrial' applications. In BTW24 range with 800V maximum repetitive peak voltage, reverse polarity, stud connected to anode.
BZY88–C5V6	Silicon voltage regulator diode for 'industrial' applications. In BZY88 range with 5·6V operating voltage ±5% tolerance.
RPY71	Photoconductive cell for 'industrial' applications.

OLD SYSTEM

Some earlier semiconductor diodes and transistors have type numbers consisting of two or three letters followed by a group of one, two or three figures.

The first letter is always 'O', indicating a semiconductor device.

The second (and third) letter(s) indicate the general class of device:

A — diode or rectifier
AP — photodiode
AZ — voltage regulator diode
C — transistor
CP — phototransistor

The group of figures is a serial number indicating a particular design or development.

Section II

LIST OF SYMBOLS FOR SEMICONDUCTOR DEVICES

These symbols are based on British Standard Specification No. 3363: "Letter Symbols for Semiconductor Devices." A full description of the system is contained in this publication.

QUANTITY SYMBOLS

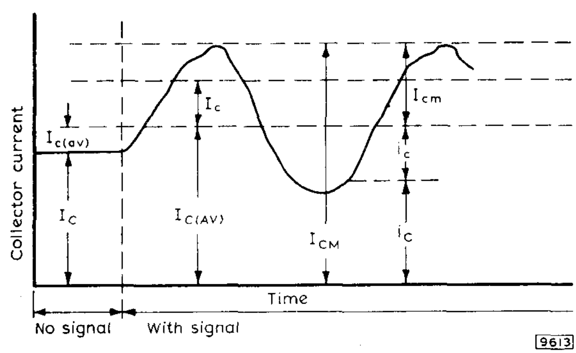
V	Voltage
I	Current
P	Power

i, v, p with subscripts e, b, c — instantaneous value of the varying component.

i, v, p with subscripts E, B, C — instantaneous total value.

I, V, P with subscripts e, b, c — the r.m.s. value of the varying component, or with appropriate additional subscript the peak (m) or average (d.c.) (av) value of the varying component.

I, V, P with subscripts E, B, C — the no-signal (d.c.) value or, with the appropriate additional subscripts the total average value (AV) with signal or the total peak value (M).



Examples:

I_E	d.c. emitter current no signal.
I_e	*r.m.s. value of varying component of emitter current.*
i_e	Instantaneous value of varying component of emitter current.
i_E	Instantaneous value of total emitter current.
$I_{E(AV)}$	Average (d.c.) value of total emitter current with signal applied.
$I_{e(av)}$	Average (d.c.) value of the varying component of the emitter current.
I_{em}	Peak value of the varying component of the emitter current.
I_{EM}	Peak value of the total emitter current.

Subscripts for quantity sumbols

A, a	Anode terminal
AV, av	Average
B, b	Base terminal
BO	Breakover
BR	Breakdown
C, c	Collector terminal, conversion, capacitive
D, d	Delay, Off-state (i.e. non trigger) drain terminal
E, e	Emitter terminal
F, f	Forward
G, g	Gate terminal
H, h	Holding
I, i	Input
J, j	Junction
K, k	Cathode terminal
M, m	Peak value
O, o	Open-circuit, output
OV	Average value of overload
R, r	Resistive, reverse, repetitive
S, s	Short-circuit, series, shield, source
T, t	On-state (i.e. triggered)
W, w	Working
X, x	Specified circuit, reactive
Z, z	Reference or regulator (i.e. Zener), impedance

The letter O is used with three terminal devices as a third subscript only to denote that the terminal not indicated in the subscript is open-circuited.

The letter S is also used with three terminal devices as a third subscript to denote that the terminal not indicated in the subscript is shorted to the reference terminal.

Sequence of subscripts

The first subscript denotes the terminal at which the current or terminal voltage is measured.

The second subscript denotes the reference terminal or circuit mode that the current or terminal voltage is measured.

Where the reference terminal or circuit is understood the second subscript may be omitted where its use is not required to preserve the meaning of the symbol.

The supply voltage shall be indicated by repeating the terminal subscript. The reference terminal may then be designated by the third subscript.

Examples V_{EE}, V_{CC}, V_{BB}, V_{EEB}

In devices having more than one terminal of the same type, the terminal subscripts shall be modified by adding a number following the subscript and on the same line.

Example B2

In multiple unit devices the terminal subscripts shall be modified by a number preceding the terminal subscript.

Example 2B

Where ambiguity might arise the complete terminal designations shall be separated by hyphens or commas.

Example $V_{1C1-2C1}$

the voltage at the first collector of the first unit referred to the voltage at the first collector of the second unit.

The first subscript in the matrix notation shall identify the element of the four pole matrix.

i	input
o	output
f	forward transfer
r	reverse transfer

A second subscript may be used to identify the circuit configuration.

e	common emitter
b	common base
c	common collector

Example $V_{ie} = h_{ie}.\, I_{ie} + h_{re}.\, V_{oe}$

When the common terminal is understood the second subscript may be omitted.

Static value of parameters shall be indicated by the upper case (capital) subscripts.

Example h_{IE}, h_{IB}

The four pole matrix parameters of the device are represented by lower case symbols with the appropriate subscripts

h_{ib}

The four pole matrix parameters of external circuits and of circuits in which the device forms only a small part are represented by upper case symbols with the appropriate subscripts.

H_i, Z_o

Symbols for the components of small-signal equivalent circuits used to represent devices are qualified by lower case symbols.

r_b, r_e, $r_{bb'}$

ELECTRICAL PARAMETERS

	Device	Associated circuit
Resistance	r	R
Reactance	x	X
Impedance	z	Z
Admittance	y	Y
Conductance	g	G
Susceptance	b	B
Mutual inductance	m	M
Inductance	l	L
Capacitance	c	C
Distortion	D	
Frequency limits	f max. f min.	
Bandwidth	Δf	
Bandwidth (for associated circuits)		B
Noise factor		N

List of Symbols for Semiconductor Devices

C_d	diode capacitance (reverse bias)
C_f	diode capacitance (forward bias)
C_{ib}	transistor input capacitance (grounded base)
C_{ie}	transistor input capacitance (grounded emitter)
C_j	junction capacitance (of the intrinsic diode)
C_{min}	diode capacitance (at breakdown voltage)
C_o	diode capacitance (zero bias)
C_{ob}	transistor output capacitance (grounded base)
C_{oe}	transistor output capacitance (grounded emitter)
C_p	parasitic (parallel) capacitance
C_s	stray capacitance
C_{Te}	capacitance of the emitter depletion layer
C_{Tc}	capacitance of the collector depletion layer
f_{co}	varactor diode cut-off frequency
f_{hfb}, f_{hfe}	transistor cut-off frequency (the frequency at which the parameter indicated by the subscript is 0.7 times its low frequency value)
f_1	frequency of unity current transfer ratio modulus
f_{max}	maximum frequency of oscillations
f_r	tunnel diode resistive cut-off frequency
f_T	transition frequency (common emitter gain-bandwidth product)
g_j	tunnel diode negative conductance (of the intrinsic diode)
g_p	small signal power gain
G_p	large signal power gain
h_{IB}, h_{IE}, h_{IC}	the static value of the input resistance with the output voltage held constant
h_{ib} (h_{11}), h_{ie} (h_{11}), h_{ic}	The small-signal value of the input impedance with the output short-circuited to alternating current
h_{RB}, h_{RE}, h_{RC}	The static value of the reverse voltage transfer ratio with the input current held constant
h_{rb} (h_{12}), h_{re} (h_{12}), h_{rc}	The small-signal value of the reverse voltage transfer ratio with the output voltage held constant
h_{FB}, h_{FE}, h_{FC}	The static value of the forward current transfer ratio with the output voltage held constant
h_{fb} (h_{21}), h_{fe} (h_{21}), h_{fc}	The small-signal forward current transfer ratio with the output short-circuited to alternating current
h_{OB}, h_{OE}, h_{OC}	The static value of the output conductance with the input current held constant
h_{ob} (h_{22}), h_{oe} (h_{22}), h_{oc}	The small-signal value of the output admittance with the input open-circuited to alternating current
$h_{FE(sat)}$	transient forward current transfer ratio in saturation
h_{FEL}	inherent forward current transfer ratio $= \dfrac{I_C - I_{CBO}}{I_B + I_{CBO}}$

I_B, I_C, I_E	total d.c. current
$I_{B(AV)}$ $I_{C(AV)}$ $I_{E(AV)}$	average (d.c.) value of total current
I_{BBX}	base current (with both junctions reverse biased)
I_{BEX}, I_{CEX}	base (respectively collector) cut off current in a specified circuit
I_{BM}, I_{CM}, I_{EM}	peak value of total current
I_b, I_c, I_e	r.m.s. value of varying component of current
I_{bm}, I_{cm}, I_{em}	peak value of varying component of current
i_B, i_C, i_E	instantaneous total value of current
i_b, i_c, i_e	instantaneous value of varying component of current
$I_{(BO)}$	thyristor breakover current (d.c.)
I_{CBO}	collector cut-off current (emitter open-circuited)
I_{CBS}, I_{CES}	collector cut-off current (emitter short-circuited to base)
I_{CBX}	collector current with both junctions reverse biased with respect to base
I_{CEO}	collector cut-off current (base open-circuit)
I_{CER}	collector cut-off current (with specified resistance between base and emitter)
I_D	thyristor continuous (d.c.) off-state current, field effect transistor drain current
I_{EBO}	emitter cut-off current (collector open-circuit)
I_{EBX}	emitter current with both junctions reverse biased with respect to base
I_F	D.C. forward current
i_F	instantaneous forward current
$I_{F(AV)}$	average forward current
I_{FG}	thyristor forward gate current
I_{FGM}	thyristor peak forward gate current
I_{FM}	peak forward current
$I_{F(OV)}$, I_{FOM}	overload mean forward current
I_{FRM}	repetitive peak forward current
I_{FSM}	surge (non-repetitive) forward current
I_{GD}	thyristor gate non-trigger current
I_{GT}	thyristor gate trigger current
I_{GQ}	thyristor gate turn-off current
I_H	thyristor holding current (d.c.)
I_L	thyristor latching current
I_O	average output current
I_{ORM}	repetitive peak output current
I_P	tunnel diode peak point current
I_p/I_V	tunnel diode peak to valley point current ratio
I_R	continuous (d.c.) reverse leakage current
i_R	instantaneous reverse leakage current
I_{RG}	thyristor reverse gate current
I_{RRM}	repetitive peak reverse current
I_{RSM}	non-repetitive peak reverse current
I_S	source current
I_T	thyristor continuous (d.c.) on-state current
$I_{T(OV)}$	thyristor overload mean on-state current
$I_{T(AV)}$	thyristor average on-state current
I_{TRM}	thyristor repetitive peak on-state current
I_{TSM}	thyristor non-repetitive peak on-state current

I_V	tunnel diode valley point current
I_Z	voltage regulator (zener) diode continuous (d.c.) operating current
$I_{Z(AV)}$	voltage regulator (zener) diode average operating current
I_{ZM}	voltage regulator (zener) diode peak current
L_c	conversion loss
L_s	series inductance
N_f	flicker noise
N_{if}	noise figure at intermediate frequency
N_o	overall noise figure
N_r	noise temperature ratio
P_G	thyristor average gate power
P_{GM}	thyristor peak gate power
P_{tot}	total power dissipated within the device
Q_s	recovered (stored) charge
$r_{bb'}$	extrinsic base resistance
R_S	source resistance
r_S	series resistance
R_{th}	thermal resistance
r_Z	voltage regulator (zener) diode differential resistance
S_{ts}	tangential signal sensitivity
S_Z	voltage regulator (zener) diode temperature coefficient of the operating voltage
T_{amb}	ambient temperature
T_{case}	case temperature
T_j	junction temperature
T_{mb}	mounting base temperature
T_{stg}	storage temperature
t_d	delay time
t_f	fall time
t_{fr}	forward recovery time
t_{gt}	thyristor gate controlled turn-on time
t_{gq}	thyristor gate controlled turn-off time
t_p	pulse duration
t_q	thyristor circuit-commutated turn-off time
t_{on}	turn-on time
t_{off}	turn-off time
t_r	rise time
t_{rr}	reverse recovery time
t_s	storage time
θ_h	thermal resistance of heat sink
θ_i	contact thermal resistance
θ_{j-amb}	thermal resistance junction to ambient
θ_{j-case}	thermal resistance junction to case
θ_{j-mb}	thermal resistance junction to mounting base
τ_C	collector time coefficient of a switching transistor
τ_S	carrier storage time coefficient of a switching transistor
τ_F	fall time factor
τ_R	rise time factor

$V_{BE(sat)}$	base-emitter saturation voltage
$V_{(BO)}$	thyristor breakover voltage
$V_{(BR)}$	breakdown voltage
$V_{(BR)CBO}$	breakdown voltage collector to base (emitter open-circuited)
$V_{(BR)CBS}$	breakdown voltage collector to base (emitter and base short-circuited)
$V_{(BR)CEO}$	breakdown voltage collector to emitter (base open circuited)
$V_{(BR)CER}$	breakdown voltage collector to emitter (with specified resistance between base and emitter)
$V_{(BR)CES}$	breakdown voltage collector to emitter (emitter and base-short-circuited)
$V_{(BR)CEX}$	breakdown voltage collector to emitter (with specified circuit between base and emitter)
$V_{(BR)EBO}$	breakdown voltage emitter to base (collector open-circuited)
$V_{(BR)R}$	reverse breakdown voltage
V_{CB}	collector-base voltage (d.c.)
V_{CBO}	collector-base voltage (with emitter open-circuited)
V_{CBfl}	collector-base floating potential
V_{CC}	collector supply voltage (d.c.)
V_{CE}	collector to emitter voltage (d.c.)
V_{CEO}	collector to emitter voltage (with base open-circuited)
V_{ce}	collector to emitter r.m.s. voltage
$V_{CE(knee)}$	collector knee voltage.
$V_{CE(sat)}$	collector to emitter saturation voltage
$V_{CE(sust)}$	collector to emitter sustaining voltage
V_D	thyristor continuous (d.c.) off-state voltage
V_{DG}	drain to gate voltage
V_{DM}	thyristor peak off-state voltage
V_{DRM}	thyristor repetitive peak off-state voltage
V_{DS}	drain to source voltage
V_{DSM}	thyristor non-repetitive off-state voltage
V_{DWM}	thyristor crest (peak) working off-state voltage
V_{EB}	emitter-base voltage (d.c.)
V_{EBO}	emitter-base voltage (with collector open circuited)
V_{eb}	emitter-base r.m.s. voltage
V_{EBfl}	emitter-base floating potential
V_{ECfl}	emitter-collector floating potential
V_F	D.C. forward voltage
v_F	instantaneous total value of the forward voltage
V_{FG}	thyristor forward gate voltage
V_{FGM}	thyristor peak forward gate voltage
V_{fr}	signal diode forward recovery voltage
V_{GB}	gate to substrate voltage
V_{GD}	thyristor gate non-trigger voltage
V_{GS}	gate to source voltage
V_{GT}	thyristor gate trigger voltage
V_I	input voltage
V_{IRM}	repetitive peak input voltage
V_{ISM}	non-repetitive peak input voltage
V_{IWM}	crest working input voltage
V_O	output voltage

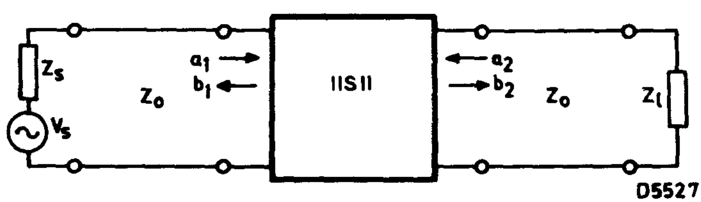
V_P	peak point voltage
V_{PP}	projected peak point voltage
V_R	D.C. reverse voltage
v_R	instantaneous total value of the reverse voltage
V_{RG}	thyristor reverse gate voltage
V_{RGM}	thyristor peak reverse gate voltage
V_{RM}	peak reverse voltage
V_{RRM}	repetitive peak reverse voltage
V_{RSM}	non-repetitive peak reverse voltage
V_{RWM}	crest (peak) working reverse voltage
V_T	thyristor continuous (d.c.) on-state voltage
$V_{T(TO)}$	thyristor threshold voltage
V_V	valley point voltage
V_Z	voltage regulator (zener) diode operating voltage
Z_{if}	intermediate frequency impedance
Z_v	video impedance

y-parameters

Common base	Common emitter		
y_{ib} (y_{11})	y_{ie} (y'_{11})	Input admittance	Output short-circuited
g_{ib} (g_{11})	g_{ie} (g'_{11})	Input conductance	
c_{ib} (c_{11})	c_{ie} (c'_{11})	Input capacitance	
ϕ_{ib}	ϕ_{ie}	Phase angle of input admittance	
y_{ob} (y_{22})	y_{oe} (y'_{22})	Output admittance	Input short-circuited
g_{ob} (g_{22})	g_{oe} (g'_{22})	Output conductance	
c_{obs} (c_{22})	c_{oes} (c'_{22})	Output capacitance	
ϕ_{ob}	ϕ_{oe}	Phase angle of output admittance	
$\|y_{fb}\|$($\|y_{21}\|$)	$\|y_{fe}\|$($\|y'_{21}\|$)	Transfer admittance	Output short-circuited
g_{fb}	g_{fe}	Transfer conductance	
c_{fb}	c_{fe}	Transfer capacitance	
ϕ_{fb} (ϕ_{21})	ϕ_{fe} (ϕ'_{21})	Phase angle of transfer admittance	
$\|y_{rb}\|$ (y_{12})	$\|y_{re}\|$ (y'_{12})	Feedback admittance	Input short-circuited
g_{rb}	g_{re}	Feedback conductance	
c_{rb}	c_{re}	Feedback capacitance	
ϕ_{rb} (ϕ_{12})	ϕ_{re} (ϕ'_{12})	Phase angle of feedback admittance	

Scattering parameters

In distinction to the conventional h, y and z parameters, s-parameters relate to travelling wave conditions. The figure below shows a two-port network with the incident and reflected travelling wave quantities a_1, b_1, a_2 and b_2, which are square roots of power.



a_1^2 = the power incident at the input $\left(= \frac{V_{i1}^2}{Z_o}\right)$

a_2^2 = the power incident at the output $\left(= \frac{V_{i2}^2}{Z_o}\right)$

b_1^2 = the power reflected from (or generated at) the input $\left(= \frac{V_{r1}^2}{Z_o}\right)$

b_2^2 = the power reflected from (or generated at) the output $\left(= \frac{V_{r2}^2}{Z_o}\right)$

Z_o = the characteristic impedance of the transmission line in which the two-port is connected

V_i = incident voltage

V_r = reflected (generated) voltage

The four-pole equations for s-parameters are:

$$b_1 = s_{11}a_1 + s_{12}a_2$$
$$b_2 = s_{21}a_1 + s_{22}a_2$$

Using the subscripts i for 11, o for 22, f for 21 and r for 12, it follows that

$$s_i = s_{11} = \left.\frac{b_1}{a_1}\right|_{a_2 = 0}$$

$$s_f = s_{21} = \left.\frac{b_2}{a_1}\right|_{a_2 = 0}$$

$$s_o = s_{22} = \left.\frac{b_2}{a_2}\right|_{a_1 = 0}$$

$$s_r = s_{12} = \left.\frac{b_1}{a_2}\right|_{a_1 = 0}$$

a_1 can be made zero by terminating the input side with $Z_s = Z_o$ (no input power and no reflection from the source).

a_2 can be made zero by terminating the output side with $Z_1 = Z_o$ (no reflection from the load).

Because $\frac{b_1}{a_1} = \frac{V_{r1}}{V_{i1}}$ it can be seen that s_i is the input reflection coefficient; in the same way s_o is the output reflection coefficient.

The s-parameters can be named and expressed as follows:

$s_i = s_{11}$ = *Input reflection coefficient* (for the given characteristic impedance) – Ratio between the square root of the power reflected from the input and the square root of the power incident at the input, output terminated with the characteristic impedance.

$s_f = s_{21}$ = *Forward transmission coefficient* (for the given characteristic impedance) – Ratio between the square root of the power generated at the output and the square root of the power incident at the input, output terminated with the characteristic impedance.

$s_o = s_{22}$ = *Output reflection coefficient* (for the given characteristic impedance) – Ratio between the square root of the power reflected from the output and the square root of the power incident at the output, input terminated with the characteristic impedance.

$s_r = s_{12}$ = *Reverse transmission coefficient* (for the given characteristic impedance) – Ratio between the square root of the power generated at the input and the square root of the power incident at the output, input terminated with the characteristic impedance.

Section III. Explanation of Handbook Data

1. FORM OF ISSUE

The semiconductor data published in the Handbook follows the same pattern, as much as possible, concerning, (a) the forms of issue, (b) the ratings system and (c) the ratings presentation.

1.1 Types of Data

The Handbook data is published either as tentative or final data.

Tentative Data

Tentative data aims at providing information on new devices as early as possible to allow the customer to proceed with circuit design. The tentative data may not include all the characteristics or ratings which will be incorporated later in the final data and some of the numerical values quoted may be slightly adjusted later on.

Final Data

The transfer from tentative data to final data involves the addition of those numerical values and curves which were not available at tentative data stage and small adjustments to those values already quoted in tentative data. Reissue of final data may be made from time to time to incorporate additional information resulting from prolonged production experience or to meet new applications.

1.2 Presentation of Data

The information on the published data sheets is presented in the following form:

- —description of basic application and physical characteristics of the device.
- —quick reference data giving the most important ratings and characteristics.
- —outline and dimensions. Reference to standard outline nomenclature if applicable and lead connections.
- —Ratings. Voltage, current, power and thermal ratings.
- —Characteristics.
- —Application information or operating conditions.
- —Mechanical and environmental data if applicable.
- —Charts showing ratings and characteristics.

2. RATINGS

A rating is a limiting condition of usage specified for a device by the manufacturer, beyond which the serviceability may be impaired.

A rating system is a set of principles upon which ratings are established and which determines their interpretation. There are three systems which have been internationally accepted and which allocate responsibility between the device manufacturer and the circuit designer differently.

2.1 Rating Systems

Unless otherwise stated the ratings given in semiconductor data sheets follow the absolute maximum rating system.
The definitions of the three systems accepted by the International Electrotechnical Commission are as follows:

ABSOLUTE MAXIMUM RATING SYSTEM

Absolute maximum ratings are limiting values of operating and environmental conditions applicable to any device of a specified type as defined by the published data, and should not be exceeded under the worst probable conditions.

These values are chosen by the device manufacturer to provide acceptable serviceability of the device, taking no responsibility for variations in equipment or environment, and the effects of changes in operating conditions due to variations in the characteristics of the device under consideration and of all other devices in the equipment.

The equipment manufacturer should design so that initially and throughout life no absolute maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to variations in supply voltage, environment, equipment components, equipment control adjustment, load, signal or characteristics of the device under consideration and of all other devices in the equipment.

DESIGN-CENTRE RATING SYSTEM

Design-centre ratings are limiting values of operating and environmental conditions applicable to a bogey device of a specified type as defined by its published data, and should not be exceeded under normal conditions.
These values are chosen by the device manufacturer to provide acceptable serviceability of the device in average applications, taking responsibility for normal changes in operating conditions due to variations in supply voltage, environment, equipment components, equipment control adjustment, load, signal or characteristics of all other devices in the equipment.
The equipment manufacturer should design so that initially no design-centre value for the intended service is exceeded with a bogey device in equipment operating at the stated normal supply voltage.

DESIGN-MAXIMUM RATING SYSTEM

Design-maximum ratings are limiting values of operating and environmental conditions applicable to a bogey device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

These values are chosen by the device manufacturer to provide acceptable serviceability of the device, taking responsibility for the effects of changes in operating conditions due to variations in the characteristics of the device under consideration.

The equipment manufacturer should design so that initially and throughout life no design-maximum value for the intended service is exceeded with a bogey device under the worst probable operating conditions with respect to variations in supply voltage, environment, equipment components, equipment control adjustment, load, signal or characteristics of the device under consideration and of all other devices in the equipment.

3 Transistor ratings

The ratings are presented as voltage, current, power and temperature ratings. The list of these ratings and their definitions is given as follows:

3.1 Transistor voltage ratings

Collector to base voltage ratings

V_{CB} max	The maximum permissible instantaneous voltage between collector and base terminals. The collector voltage is negative with respect to base in PNP transistors and positive w.r.t. base in NPN types.
V_{CB} max ($I_E = 0$)	The maximum permissible instantaneous voltage between collector and base terminals, when the emitter terminal is open circuited.

Emitter to base voltage ratings

V_{EB} max	The maximum permissible instantaneous reverse voltage between emitter and base terminal. The emitter voltage is negative w.r.t. base for PNP transistor and positive w.r.t. base for NPN types.
V_{EB} max ($I_C = 0$)	The maximum permissible instantaneous reverse voltage between emitter and base terminals when the collector terminal is open circuited.

Collector to emitter voltage ratings

V_{CE} max	The maximum permissible instantaneous voltage between collector and emitter terminals. The collector voltage is negative w.r.t. emitter in PNP transistors and positive w.r.t. emitter in NPN types. This rating is very dependent on circuit conditions and collector current and it is necessary to refer to the curve of V_{CE} versus I_C for the appropriate circuit condition in order to obtain the correct rating
V_{CE} max (Cut-off)	The maximum permissible instantaneous voltage between collector and emitter terminals when the emitter current is reduced to zero by means of a reverse emitter base voltage, i.e. the base voltage is normally positive w.r.t. emitter for PNP transistor and negative w.r.t. emitter for NPN types.

NOTE: The term "cut-off" is sometimes replaced by $V_{BE} > x$ volts, or $\frac{R_B}{R_E}$, $\leqslant y$ which are equivalent conditions under which the device may be cut-off.

V_{CE} max (I_C = x mA) The maximum permissible instantaneous voltage between collector and emitter terminals when the collector current is at a high value, often the max. rated value.

V_{CE} max (I_B = 0) The maximum permissible instantaneous voltage between collector and emitter terminals when the base terminal is open circuited or when a very high resistance is in series with the base terminal. Special care must be taken to ensure that thermal runaway due to excessive collector leakage current does not occur in this condition.

Due to the current dependency of V_{CE} it is usual to present this information as a voltage rating chart which is a curve of collector current versus collector to emitter voltage (see Fig. 1).
This curve is divided into two areas:

A permissible area of operation under all conditions of base drive provided the dissipation rating is not exceeded (area 1) and an area where operation is allowable under certain specified conditions (area 2).
To assist in determining the rating in this second area, further curves are provided relating the voltage rating to external circuit conditions, for example:

$$\frac{R_B}{R_E},\ R_B,\ Z_{Bg},\ V_{BE},\ I_B \text{ or } \frac{V_{BB}}{R_B}$$

An example of this type of curve is given in Fig. 2 as V_{CE} versus $\frac{R_B}{R_E}$ for two different values of collector current.

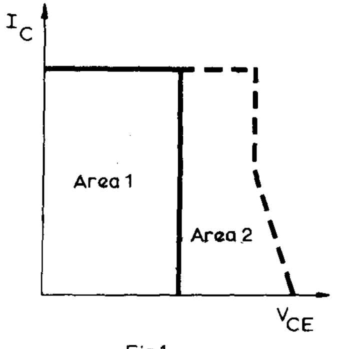


Fig.1

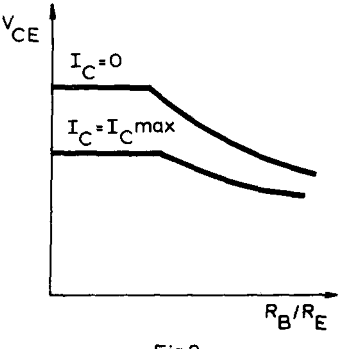


Fig.2

It should be noted that when R_E is shunted by a capacitor, the collector voltage V_{CE} during switching must be restricted to a value which does not rely on the effect of R_E.
In the case of an inductive load and when an energy rating is given, it may be permissible to operate outside the rated area provided the specified energy rating is not exceeded.

3.2 Transistor Current Ratings

Collector current ratings

I_C max	The maximum permissible collector current. Without further qualification, the dc value is implied.
$I_{C(AV)}$ max	The maximum permissible average value of the total collector current.
I_{CM}	The maximum permissible instantaneous value of the total collector current.

Emitter current ratings

I_E max	The maximum permissible emitter current. Without further qualification, the dc value is implied.
$I_{E(AV)}$ max	The maximum permissible average value of the total emitter current.
$I_{ER(AV)}$ max	The maximum permissible average value of the total emitter current when operating in the reverse emitter-base breakdown region.
I_{EM}	The maximum permissible instantaneous value of the total emitter current.
I_{ERM}	The maximum permissible instantaneous value of the total reverse emitter current allowable in the reverse breakdown region.

Base current ratings

I_B max	The maximum permissible base current (without further qualification, the dc value is implied).
$I_{B(AV)}$ max	The maximum permissible average value of the total base current.
$I_{BR(AV)}$ max	The maximum permissible average value of the total reverse base current allowable in the reverse breakdown region.
I_{BM}	The maximum permissible instantaneous value of the total base current. The rating also includes the switch off current.
I_{BRM}	The maximum permissible instantaneous value of the total reverse current allowable in the reverse breakdown region.

3.3 Transistor Power Ratings

P_{tot} max: The total maximum permissible continuous power dissipation in the transistor and includes both the collector-base dissipation and the emitter-base dissipation. Under steady state conditions the total power is given by the expression:

$$P_{tot} = V_{CE} \times I_C + V_{BE} \times I_b$$

In order to distinguish between "steady state" and "pulse" conditions the terms "steady state power (P_S)" and "pulse power (P_P)" are often used. The permissible total power dissipation is dependent upon temperature and its relationship is shown by means of a chart as shown in figure 3.

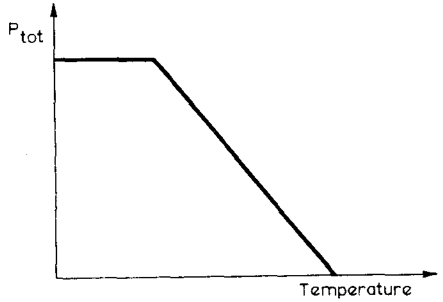


Fig.3

The temperature may be ambient, case or mounting base temperatures. Where a cooling clip or a heatsink is attached to the device, the allowable power dissipation is also dependent on the efficiency of the heatsink.

The efficiency of this clip or heatsink is measured in terms of its thermal resistance (θ_h) normally expressed in degrees centigrade per watt (deg. C/W). For mounting base rated device, the added effect of the contact resistance (θ_i) must be taken into account.

The effect of heatsinks of various thermal resistance and contact resistance is often included in the above chart.

Thus for any heatsink of known thermal resistance and any given ambient temperature, the maximum permissible power dissipation can be established. Alternatively, knowing the power dissipation which will occur and the ambient temperature, the necessary heatsink thermal resistance can be calculated.

A general expression from which the total permissible steady state power dissipation can be calculated is:

$$P_{tot} = \frac{T_j - T_{amb}}{\theta_{j-amb}}$$

where θ_{j-amb} is the thermal resistance from the transistor junction to the ambient. For case rated or mounting base rated devices, the thermal resistance θ_{j-amb} is made up of the thermal resistance junction to case or mounting base (θ_{-mb}), the contact thermal resistance (θ_i) and the heatsink thermal resistance (θ_h).

For the calculation of pulse power operation P_p, the maximum pulse power is obtained by the aid of a chart as shown in figure 4.

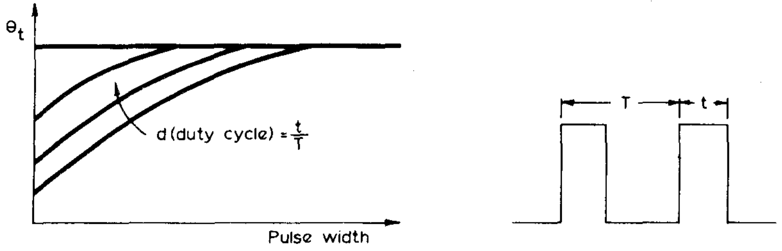


Fig 4

the general expression from which the maximum pulse power dissipation can be calculated is:

$$P_p = \frac{T_j - T_{amb} - P_s \times \theta_{j-amb}}{\theta_t + d(\theta_{case-amb})}$$

where θ_t and d are given in the above chart and $\theta_{case-amb}$ is the thermal resistance between case and ambient for case rated device. For mounting base rated device, it is equal to $\theta_h + \theta_i$ and is zero for free air rated device because the effect of the temperature rise of the case over the ambient for a pulse train is already included in θ_t.

3.4 Temperature Ratings

T_j max	The maximum permissible junction temperature which is used as the basis for the calculation of power ratings. Unless otherwise stated, the continuous value is implied.
T_j max (continuous operation)	The maximum permissible continuous value.
T_j max (intermittent operation)	The maximum permissible instantaneous junction temperature usually allowed for a total duration of 200 hours.
T_{mb}	The temperature of the surface making contact with a heatsink. This is confined to devices where a flange or stud for fixing onto a heatsink forms an integral part of the envelope.
T_{case}	The temperature of the envelope. This is confined to devices to which may be attached a clip-on cooling fin.

Section IV. Mounting and Soldering Recommendations

1. MOUNTING OF "LOCKFIT" TRANSISTORS

1.1 Mounting on printed-wiring boards

The "Lockfit" encapsulation is usable with printed-wiring boards having either the standard e-grid or the more closely spaced ε-grid. The relevant dimensions of these boards are given in Table 1.

TABLE 1

Dimensions of Printed-wiring Boards

Board	Grid	Hole diameter	Maximum board thickness
e-board	2·54mm (0·1in)	1·05±0·05mm (up to 1·30mm allowable)	1·7mm
ε-board	0·635mm (0·025in)	0·80±0·03mm	1·1mm

The pins of "Lockfit" transistors each have three enlargements along their length, as shown in Fig. 1. At the tip is a spade-shaped (lock 'B'); partway up is a tapered cross-piece (lock 'A') that projects further left and right than lock 'B'; and nearest to the body of the assembly is another cross-piece (lock 'C') that extends even further left and right than lock 'A'.

Hole spacing in either type of grid allows the insertion of the "Lockfit" pins; but as the holes of the closely spaced ε-grid are necessarily of smaller diameter than those of the other grid, the pins cannot be (or should not be) pushed in beyond the middle expansion – lock 'A'. Thus the functions of the three locks are as indicated in Fig. 1a for e-grid boards and Fig. 1b for ε-grid boards.

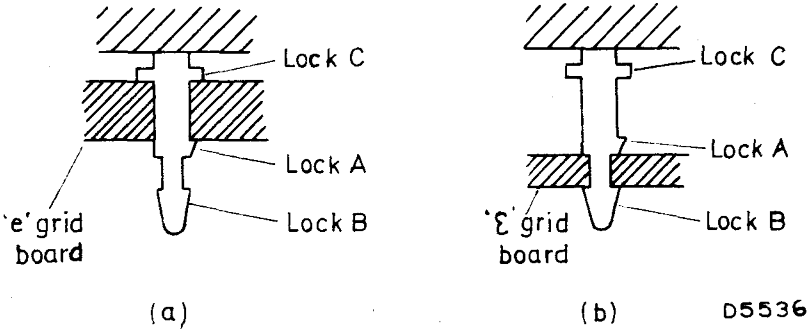


Fig. 1 – *Detail of "Lockfit" pins, and function of three "locks" when used with (a) e-grid and (b) ε-grid printed-wiring boards*

1.1.1 Mounting procedure with e-grid boards

The best insertion procedure with the e-(2·54mm) grid is as follows:
(1) Place the rear two pins into their corresponding printed-circuit board holes with the transistor at a slight angle to the vertical (Fig. 2a).

(2) Place the centre pin into the remaining hole by light pressure at a slight angle to the vertical on the device. Continue this light pressure until both the 'A' locks of the rear two leads are inside the holes (Fig. 2b).

(3) Tilt the device with light pressure from the rear until it is in a vertical position. Lock 'A' of the centre lead will now enter the hole (Fig. 2c).

(4) Move the device perpendicularly downwards with light pressure until all three 'A' locks snap into position beneath the printed-wiring board, and the 'C' locks rest on the upper side of the board (Fig. 2d.)

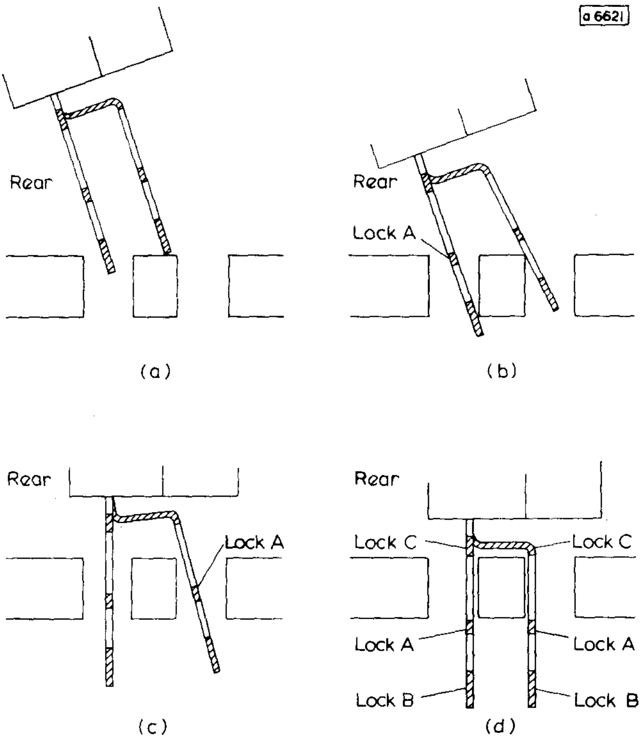


Fig. 2 – *Mounting procedure for "Lockfit" transistors using e-grid printed-wiring boards; procedure is similar for ε-grid boards*

1.1.2 Mounting prodedure with ε-grid boards

The best insertion procedure with the ε-(0·635mm) grid is as follows:
(1) Place the rear two pins into their corresponding printed-circuit board holes with the transistor at a slight angle to the vertical.
(2) Place the centre pin into the remaining hole by light pressure at a slight angle to the vertical on the device. Continue this light pressure until both the 'B' locks of the rear two leads are inside the holes.
(3) Tilt the device with light pressure from the rear until it is in a vertical position. Lock 'B' of the centre lead will now enter the hole.
(4) Move the device perpendicularly downwards with light pressure until all three 'B' locks snap into position beneath the printed-wiring board, and the 'A' locks rest on the upper side of the board.
No attempt should be made to force lock 'A' through this type of board.

1.2 Soldering

For both boards, the temperature should *not* exceed 300°C and the application time should *not* exceed 3 seconds.

INTRODUCTION TO TECHNICAL DATA

1. LEAD DESIGNATIONS

Source S, s. Drain D, d. Gate G, g. Substrate B, b.

2. SEQUENCE OF SUBSCRIPTS

The first subscript denotes the terminal at which the current or voltage is measured.

Where the reference terminal or circuit is understood, the second subscript may be omitted where its use is not required to preserve the meaning of the symbol.

The letter O is used with three terminal devices as a third subscript only to denote that the terminal not indicated in the subscript is open circuited. The letter S is used as a third subscript to denote that the terminal not indicated in the subscript is short circuited to the reference terminal. The letter X is used as a third subscript to denote measurements taken under specified circuit conditions.

2.1 Quantity Symbols

V — Voltage
I — Current
P — Power

i, v, p with subscripts	d, s, g	instantaneous value of varying component
i, v, p with subscripts	D, S, G	instantaneous total value
I, V, P with subscripts	d, s, g	the r.m.s. value of the varying component or with appropriate subscript the peak (m) average (d.c.) (av) value of the varying component
I, V, P with subscripts	D, S, G	the no-signal (d.c.) value of or with the appropriate additional subscripts the total average value (AV) with signal or the total peak value (M)

The letter symbol usually indicates by two subscripts the two reference terminals. The first subscript indicates the terminal which is positive with respect to the second subscript.
e.g.

$V_{DS} = 6V$: Drain is 6V positive w.r.t. Source

$V_{DS} = -6V$: Drain is 6V negative w.r.t. Source

Reversal of the subscripts also changes the polarity sign
For example the following statements are identical

$$V_{DS} = -6V; \ V_{SD} = 6V; \ -V_{DS} = 6V$$

The supply voltage shall be indicated by repeating the terminal subscript. The reference terminal may then be designated by the third subscript.

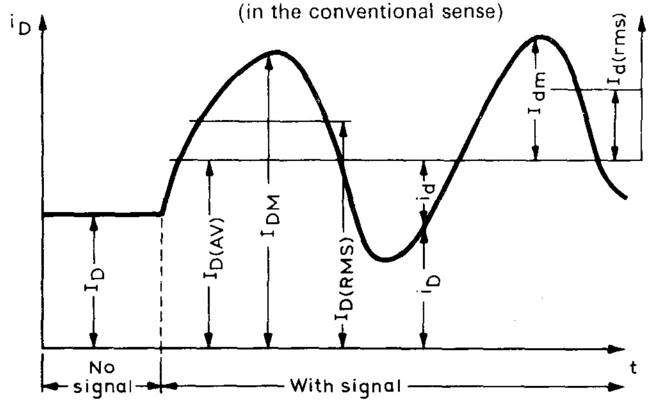
Examples V_{DD}, V_{SS}, V_{SSD}

2.3 Current

Conventionally, current which flows into the transistor terminals has a positive value.

e.g. $I_D = 1mA$ means 1 mA flowing into the drain terminal (in the conventional sense)

$I_S = -1mA$ means 1 mA flowing out of the source terminal (in the conventional sense)



Examples

I_D	d.c. drain current—no signal
$I_{D(AV)}$	Average (d.c.) value of total drain current with signal applied
I_{DM}	Peak value of total drain current
$I_{D(RMS)}$	Root-mean-square value of total drain current
i_D	Instantaneous value of total drain current
I_{dm}	Peak value of the varying component of the drain current
$I_{d(rms)}$	Root-mean-square value of varying component of drain current
i_d	Instantaneous value of varying component of the drain current

The following are examples of the implied relationship

$$I_{DM} = I_{D(AV)} + I_{dm}; \ i_D = I_{D(AV)} + i_d; \ I_{D(RMS)} = \sqrt{I_{D(AV)}^2 + I_{d(rms)}^2}$$

To avoid any misunderstanding with maximum or minimum values the negative sign is always put in front of the letter symbol and not in front of the value given.

For example in quoting a limit value

$$-I_S \text{ max} = 50\text{mA}$$

and in quoting a spread value

$$-V_{P(GS)} \leqslant 1{\cdot}5\text{V}$$

In devices having more than one terminal of the same type the terminal subscripts shall be modified by adding one number following the subscript and on the same line.

Examples:

V_{G1S}, V_{G2S}, refers to a dual gate MOS device

$|V_{G1S1} - V_{G2S2}|$ refers to a matched pair of junction FET's where the gate-source voltage of the first device is referred to the gate-source voltage of the second device, as a modulus of their difference over a given temperature range.

2.4 The first subscript in the matrix notation identifies the element of the four pole matrix.

i — input
o — output
f — forward transfer
r — reverse transfer.

A second subscript may be used to identify the circuit configuration.

d — common drain
s — common source
g — common gate

Examples

C_{is} C_{os} C_{rs}

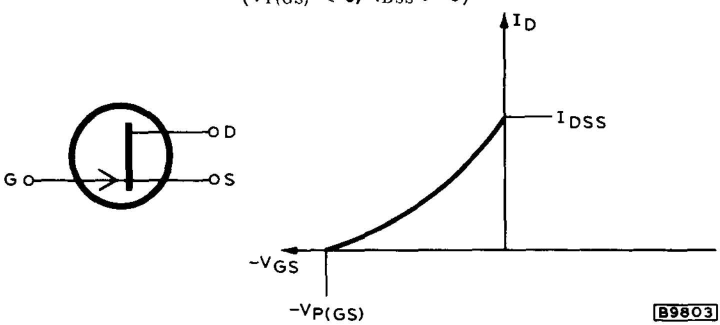
Input, output and reverse feedback capacitances in common source configuration.

3. TYPES OF FIELD EFFECT TRANSISTORS

3.1 Junction gate Field effect transistors

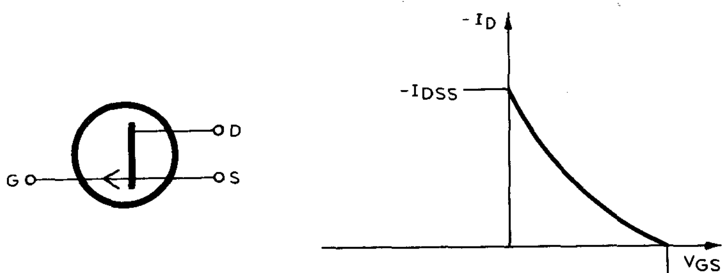
N-channel-junction FET

($V_{P(GS)} < 0$, $I_{DSS} > 0$)



P-channel-junction FET

($V_{P(GS)} > 0$, $I_{DSS} < 0$)

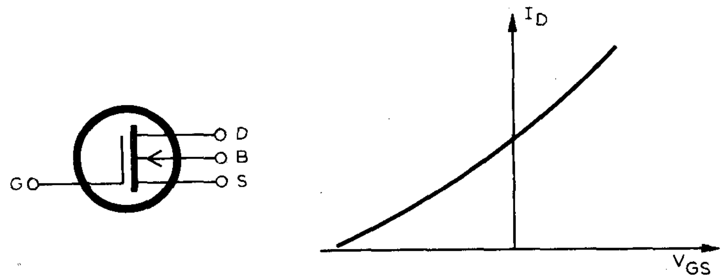


B9804

3.2 Insulated gate M.O.S. field effect transistors

N-channel-M.O.S.-FET (depletion mode)

($V_{P(GS)} < 0$, $I_{DSS} > 0$)



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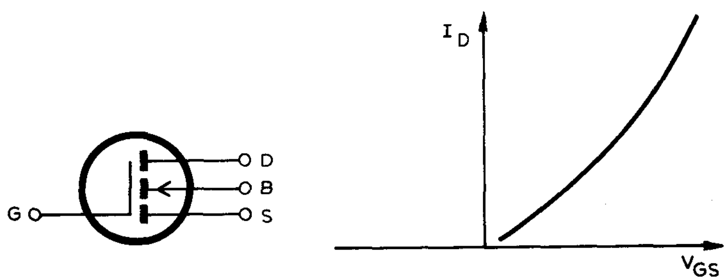
N-channel-M.O.S.-FET (enhancement mode)

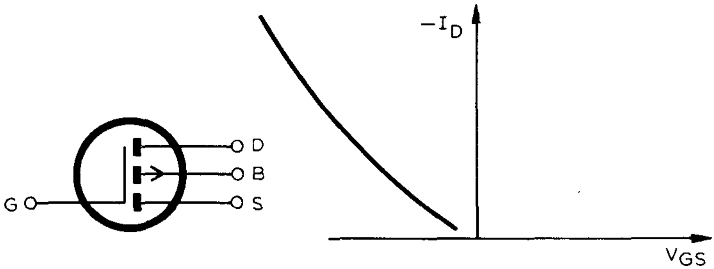
($V_{P(GS)} \geqslant 0$ $I_{DSS} \approx 0$)



B9806

P-channel-M.O.S.FET (enhancement mode)

$(V_{P(GS)} \leqslant 0,\ I_{DSS} \approx 0)$



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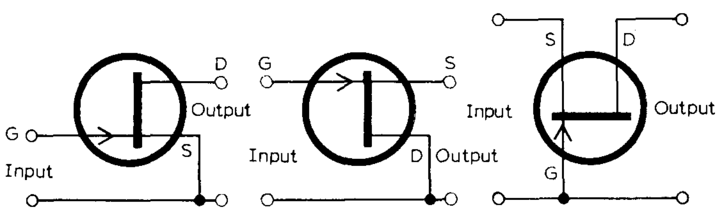
4. BASIC CIRCUITS CONFIGURATIONS



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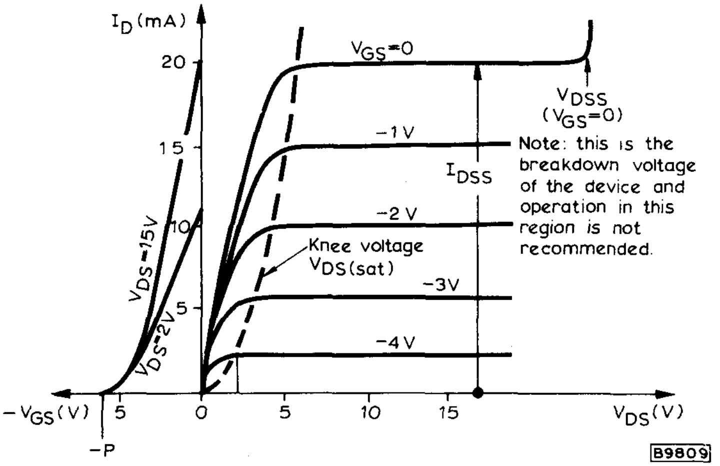
Grounded-source	Grounded-drain	Grounded-gate
The source is common to input and output	The drain is common to input and output	The gate is common to input and output

An additional subscript s, d or g may be used to identify the circuit configuration

Example C_{is} is input capacitance with grounded source

5. CHARACTERISTICS

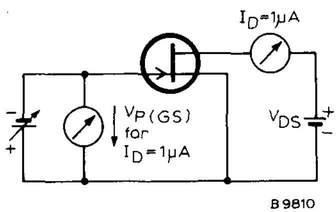
The characteristics are given in data sheets as either typical values and/or minimum and maximum values. Published curves are usually typical curves and are applicable only at the stated temperature.



5.1 Cut-off Voltage ($V_{P(GS)}$)

The cut-off voltage $V_{P(GS)}$ is the *gate-source voltage for a given* small value of drain current I_D at a stated drain source voltage V_{DS}

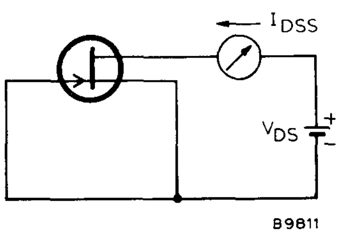
TEST CIRCUIT FOR $V_{P(GS)}$



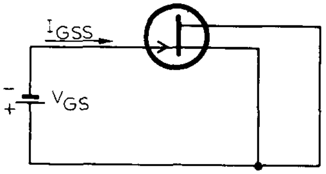
5.2 Drain-source short circuit current (I_{DSS})

The drain-source short circuit current $I_{(DSS)}$ is the current flowing between drain and source with the gate short-circuited to the source (V_{GS} = 0) and at a stated drain-source voltage (V_{DS})

TEST CIRCUIT FOR I_{DSS}

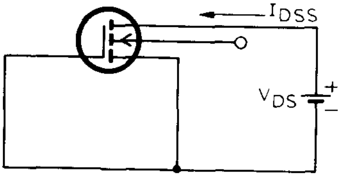


5.3 Leakage currents



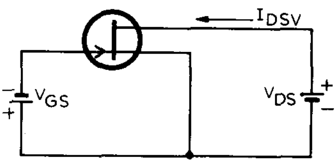
B9812

Gate-source leakage/current
I_{GSS}



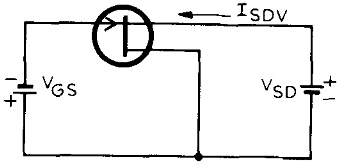
B9813

Drain-source leakage current
I_{DSS}
(enhancement mode device)



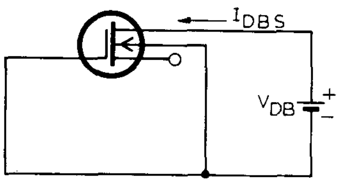
B9814

Drain-source leakage current
I_{DSV}, at specified V_{DS} and V_{GS}
and grounded source



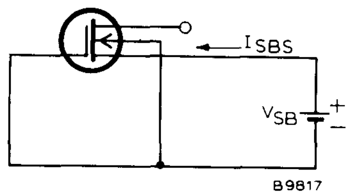
B9815

Source-drain leakage current
I_{SDV} with specified V_{SD} and V_{GS}
with grounded drain



B9816

Drain-substrate leakage current
I_{DBS}

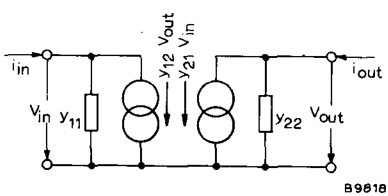


B9817

Source-substrate leakage current
I_{SBS}

6. SMALL SIGNAL-Y PARAMETERS

Four-pole equivalent circuit



B9818

$y_{11} = y_i = \frac{i_{in}}{V_{in}} \; V_{out} = 0$ input admittance with output short *circuited*

$y_{12} = y_r = \frac{i_{in}}{V_{out}} \; V_{in} = 0$ reverse transfer admittance with input short circuited

$y_{21} = y_f = \frac{i_{out}}{V_{in}} \; V_{out} = 0$ forward transfer admittance with output short circuited

$y_{22} = y_o = \frac{i_{out}}{V_{out}} \; V_{in} = 0$ Output admittance with input short circuited

A second subscript on the y-parameter indicates the circuit configuration

e.g. y_{is} = input admittance in common source configuration

where y_{is} is the complex form

$$y_{is} = g_{is} + jb_{is} \quad \text{and} \quad b_{is} = \omega c_{is}$$

For example

C_{is} = input capacitance in common source

and

C_{rs} = feedback capacitance in common source

The forward transfer admittance in common source configuration at low frequency (e.g. below about 1 MHz) is indicated in the following forms

$$gm = g_{21S} = g_{fs} = |y_{fs}|$$

at high frequency this parameter is a complex quantity and the modulus $|y_{fs}|$ is usually given in the data with a specified frequency of measurement.

ABSOLUTE MAXIMUM RATING SYSTEM

7. Absolute maximum ratings are limiting values of operating and environmental conditions applicable to any device of a specified type as defined by the published data, and should not be exceeded under the worst probable conditions.

These values are chosen by the device manufacturer to provide acceptable serviceability of the device, taking no responsibility for variation in equipment or environment, and the effects of changes in operating conditions due to variations in the characteristics of the device under consideration and of all other devices in the equipment.

The equipment manufacturer should design so that initially and throughout life no absolute maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to variations in supply voltage, environment, equipment components, equipment control adjustment, load, signal or characteristics of the device under consideration and of all other devices in the equipment.

7.1 Ratings (maximum permissible values)

V_{DS} max — Drain-source voltage
V_{DB} max — Drain-substrate voltage
V_{SB} max — Source-substrate voltage
V_{GD} max — Gate-drain voltage
V_{GS} max — Gate-source voltage
V_{GB} max — Gate-substrate voltage
I_D max — Drain current
I_S max — Source current
*I_G max — Gate Current

*applies only to junction F.E.T.'s if a forward-voltage is applied to the gate.

7.2 Power Dissipation

where T_j max = maximum permitted junction temperature
T_{amb} max = maximum permitted ambient temperature
T_{case} max = maximum permitted case temperature
$R_{th(j-amb)}$ = Thermal resistance junction to ambient
$R_{th(case-amb)}$ = Thermal resistance case to ambient.

The limiting value of the maximum permitted device dissipation P_{tot} max is stated for either

$$T_{amb} = \frac{T_j \max - T_{amb} \max}{R_{th(j-amb)}}$$

and

$$P_{tot} \max = \frac{T_j \max - T_{case} \max}{R_{th(case-amb)}}$$

8. SOLDERING AND WIRING RECOMMENDATIONS

8.1 When using a soldering iron, transistors may be soldered directly into the circuit, but heat conducted to the junction should, if possible, be kept to a minimum by the use of a thermal shunt.

8.2 Transistors may be dip-soldered at a solder temperature of 245°C for a maximum soldering time of five seconds. The case temperature during soldering must not at any time exceed the maximum storage temperature. These recommendations apply to a transistor mounted flush on a board having punched-through holes, or spaced at least 1·5mm above a board having plated-through holes.

8.3 Care should be taken not to bend the leads nearer than 1·5mm from the seal.

8.4 If devices are stored at temperatures above 100°C before incorporation into equipment, some deterioration of the external surface is likely to occur which may make soldering into the circuit difficult. Under these circumstances, the leads should be retinned using a suitable activated flux.

9. OPERATING NOTE (M.O.S. insulated gate F.E.T.'s)

Mounting and handling instructions

To exclude the possibility of damage to the gate oxide layer by an electrostatic charge building up on the high resistance gate electrode, the device is fitted with a conductive rubber ring around the leads. This ring should not be removed until after the device has been mounted in the circuit.

SECTION VI

Safe Operating ARea for power transistors

INTRODUCTION

One of the main restrictions in the operation of power transistors is the phenomenon known as 'second breakdown'. This is the name given to a transistor condition whereby the collector-emitter voltage abruptly switches from a high to a low voltage with increased current.

A diagram illustrating the output characteristics of a power transistor is shown in Fig. 1. It is not representative of any particular device but merely serves to demonstrate the I_C against V_{CE} characteristics of a transistor as it goes into second breakdown. On the horizontal axis the forward and reverse-biased base regions are clearly grouped, with the base open-circuit condition dividing the two regions.

The transistor will enter second breakdown at a certain critical current value

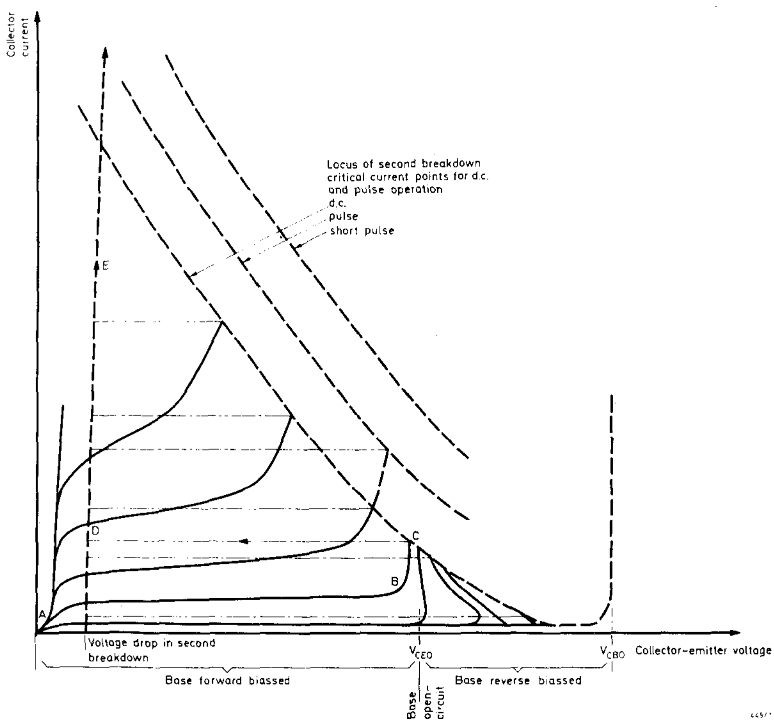


Fig. 1—Output characteristics of a power transistor

which is low at high collector-emitter voltages and higher at low voltages. Three loci for critical current values are shown on the diagram; these represent d.c., pulse, and short pulse operation. The extension of the second-breakdown locus for pulse operation is dependent on the pulse duration t_p and also, to a lesser extent, on the duty cycle d (see Figs. 2 and 3). Thus the greatest extension is permissible with single-shot pulses (d = 0·01) of short duration, say 10μs. (The value d = 0·01 can be considered as single-shot because there is ample time for cooling between power pulses).

Observation of second breakdown

Consider the I_C against V_{CE} characteristic ABCDE shown in Fig. 1. At point B the device goes into avalanche, otherwise known as first breakdown. At this point the collector current starts to rise sharply for very little increase in the collector-emitter voltage. If the current is allowed to increase up to a critical value at C the device will enter second breakdown. This is noted by an abrupt switching of the collector-emitter voltage to a low value at point D. In second breakdown the device offers only a very low resistance to collector current, and is invariably destroyed if the current is not specially limited by a circuit external to the transistor. Beyond point C the process is generally irreversible whereas up to point C in avalanche the trace can be returned with no serious alteration to the transistor properties. It is in the forward-biased mode of operation that the phenomenon of second breakdown has been extensively studied over recent years, and a method of presenting the Safe Operating ARea (abbreviated to SOAR) is now being published in Mullard data for power transistors.

In many applications, however, the reverse-bias breakdown characteristics are also of importance. For example, when a power transistor with an inductive load is turned off by reverse biasing the base, the collector voltage will rise above the supply voltage because of the stored inductive energy of the coil. For such applications transistors have been developed which permit excursions outside the V_{CEO}max rating under specified conditions.

With reverse bias on the base, second breakdown is always preceded by first-breakdown. At low collector currents the voltage across the transistor can exceed the V_{CEO} rating as shown in Fig. 1. In first breakdown, or avalanche, the device goes through a negative resistance region until a critical current value is reached at which point the collector-emitter voltage abruptly switches to a very low value in second breakdown.

Second breakdown in the transistor is usually caused by current concentration at a point in the emitter active area; this is described in detail elsewhere[1]

SIMPLE METHOD OF USING PUBLISHED SOAR CURVES

In addition to the methods described in the MTC article [1] sufficient SOAR information is provided in the published data of each power transistor to cover 90% of all applications.

[1] TP 1454 reprinted from MTC No. 122 APRIL 1974

Thus, in most cases the user will merely select the appropriate SOAR curve already constructed—without having to calculate and manipulate M_{SB} values.

In general, the data provides SOAR curves for pulse durations in multiples of 1, 2, 5, and 10, starting at pulse durations in the region 10 to 50μs. The families of curves are plotted at duty cycles of 0·01 (single-shot) 0·1, 0·2, 0·5, and 1·0 (d.c.). The transient thermal impedance curves are also included so that the operating mounting-base temperature can be calculated. Typical SOAR data curves for duty cycles of 0·2, 0·5 are illustrated in Figs. 4 and 5.

These curves will be used in the examples that follow.

In the few applications (about 10%) which are not covered by the published SOAR curves, the user can derive M_{SB} curves from the single-shot and d.c. SOAR information, and construct the boundaries using the method fully described in the reference TP 1454

All Mullard data, including pulsed power ratings, assume the use of square waves and resistive loads. Therefore, the system for using the SOAR and transient thermal impedance curves to be described deals with this type of waveform first, and then methods for other practical cases will be considered. It is assumed that the electrical and time conditions are the fixed parameters of an application at the design stage, and that the thermal conditions can be most easily adjusted. The maximum

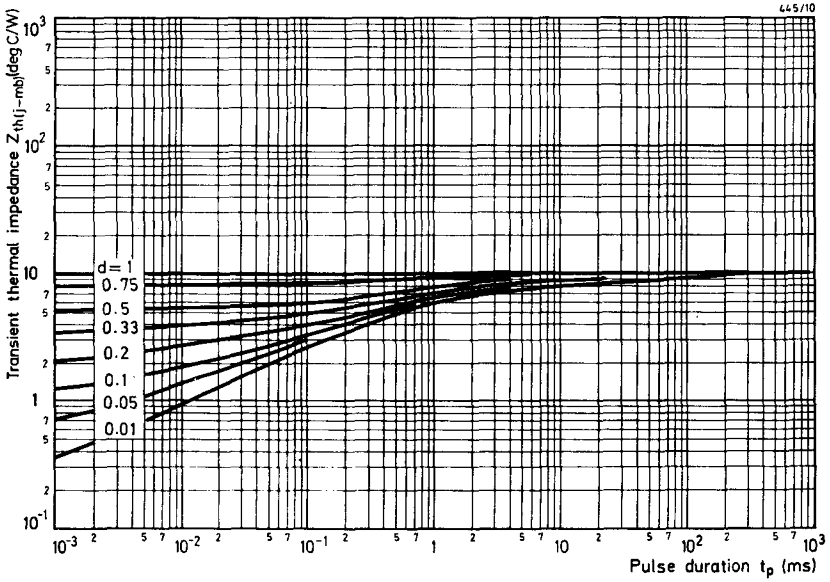


Fig. 2—Typical thermal impedance curves at various duty cycles

power must be calculated at the worst-case condition; when the worst-case condition is not obvious, all discrete sets of conditions need to be assessed.

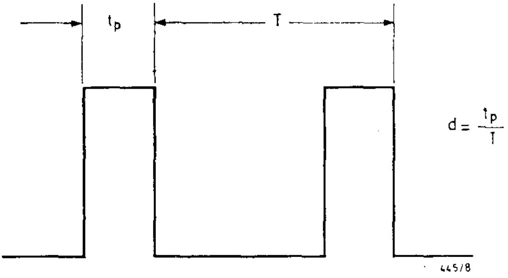


Fig. 3—Relationship between duty cycle (d), pulse duration (t_p) and period (T)

Construction of SOAR using published data

The procedure for constructing a SOAR for one specific set of conditions is described with reference to the curves shown in Figs. 4 and 5, and to the transient thermal impedance curves in Fig. 2.

1) Note the pulse duration t_p (for example, 1·7ms).
2) Note the time between pulses ($T - t_p$) (for example, 2·9ms).
3) Calculate the dutycycle d from the equation $d = t_p/T$ (in this example 0·37).
4) Note the peak collector current I_{CM} (for example 300mA).
5) Note the peak collector emitter voltage V_{CEM} (for example, 35V).
6) Select the SOAR curve with time conditions greater than or equal to the time conditions of the application (in this example, for $d = 0{\cdot}37$ use $d = 0{\cdot}5$ and for $t_p = 1{\cdot}7$ms use $t_p = 2{\cdot}0$ms).
7) Plot the point given by the specific I_{CM} and V_{CEM} values, shown as point Q in Fig. 5.
8) The point Q is acceptable if it is contained within the area of the 2ms/0·5 SOAR as shown in this example.

Thermal calculations

The maximum permissible mounting base temperature is now determined as follows:—

1) Determine peak power by multiplying I_{CM} by V_{CEM}.

2) Calculate the transient thermal impedance for 1·7ms at 0·37 duty cycle.

The equation used is:

$$Z_{th(td)} = \{R_{th} - Z_{th(to)}\}d + Z_{th(to)},$$

Where $Z_{th(td)}$ is the thermal impedance for pulse duration t at duty cycle d, and $Z_{th(to)}$ is the thermal impedance for pulse duration t at duty cycle $d = 0{\cdot}01$ (from Fig. 2).

3) Calculate the difference between the junction and mounting-base temperature from:

$$(T_j - T_{mb}) = Z_{th(td)} \times I_{CM} \times V_{CEM}.$$

4) Calculate the maximum permissible mounting-base temperature $T_{mb}max$ from:

$$T_{mb}max = T_j max - (T_j - T_{mb}).$$

5) A heatsink which limits the mounting-base temperature to this value is required. The thermal capacity of the heatsink will be such that the transient effect of the power will be averaged. Hence the thermal resistance is calculated using average power. Thus:

$$R_{th(h-a)} = \frac{T_{mb}max - T_{amb}}{I_{CM} \times V_{CEM} \times d} - R_{th(mb-h)} \text{degC/W},$$

Where $R_{th(h-a)}$ is the thermal resistance of heatsink to ambient and $R_{th(mb-h)}$ is the contact thermal resistance.

6) The physical size of the required heatsink can be determined from heatsink published data or from the nomogram in Appendix 1.

Operating selected outside SOAR

Suppose the application had required an I_{CM} of 400mA instead of 300mA. In this case the point P on Fig. 4 would be given. Point P is outside the 2ms area which indicates that the condition may be unacceptable. Thus a closer approximation to the true conditions is necessary.

1) Using linear interpolation between the 1 and 2ms curves at d = 0·5 (Fig. 5) draw a SOAR curve for t_p = 1·7ms. If point P is within this area then the conditions are acceptable and the heatsink thermal resistance can be calculated.

2) If point P is outside the 1·7ms area, then determine the 1·7ms area on the family of curves for d = 0·2 (Fig. 4). A further linear interpolation between the two 1·7ms areas is then needed to approximate to the 1·7ms SOAR at duty cycle of 0·37.

3) If point P is outside this area, then the condition is unacceptable, and a different transistor should be considered.

The above method is not absolutely accurate, but the approximation errors involved are allowed for in the published data tolerances. More accurate calculations can be made by going back to first principles, and calculating the multiplying factor for the specific condition. [1]

[1] TP 1454 reprinted from MTC No. 122 APRIL 1974

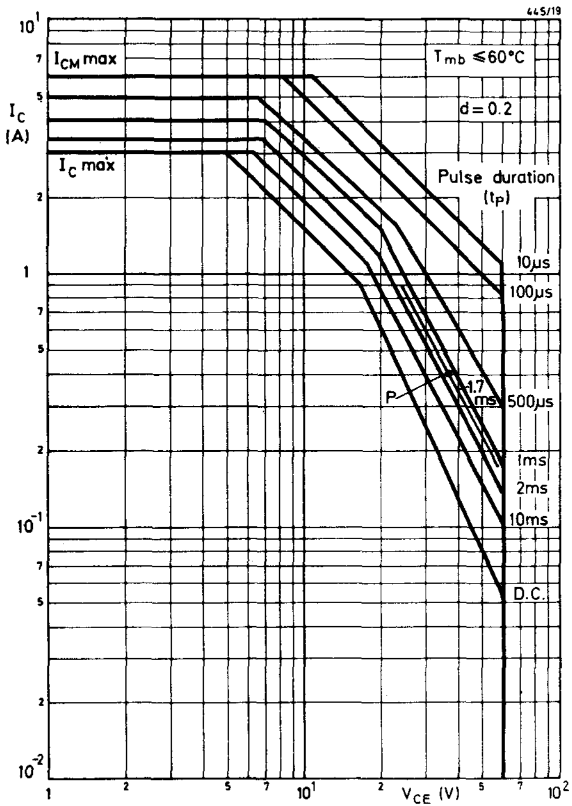


Fig. 4 —Typical SOAR family for d = 0·2 (20% duty cycle)

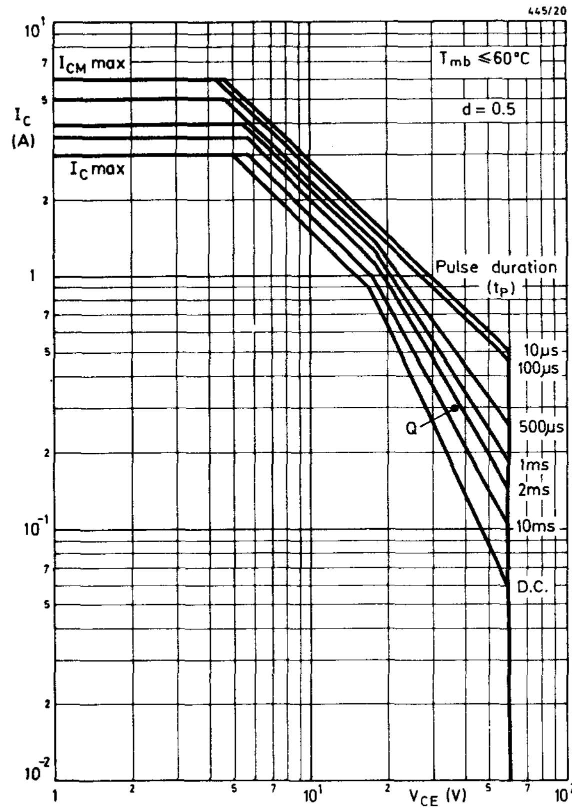


Fig. 5 —Typical SOAR family for d = 0·5 (50% duty cycle)

Mullard

PRACTICAL APPLICATION

This section discusses a typical application in which power transistors are used.

Audio application

The example describes how the output transistors of an audio amplifier are checked for excursions outside the specified SOAR when the amplifier is being tested under a sinewave overdrive condition.

This example describes how the SOAR curves are used to check the suitability of the BD131 power transistors in a television audio amplifier application. The amplifier is a class A design capable of delivering an output of 2W. The circuit configuration is shown in Fig. 6.

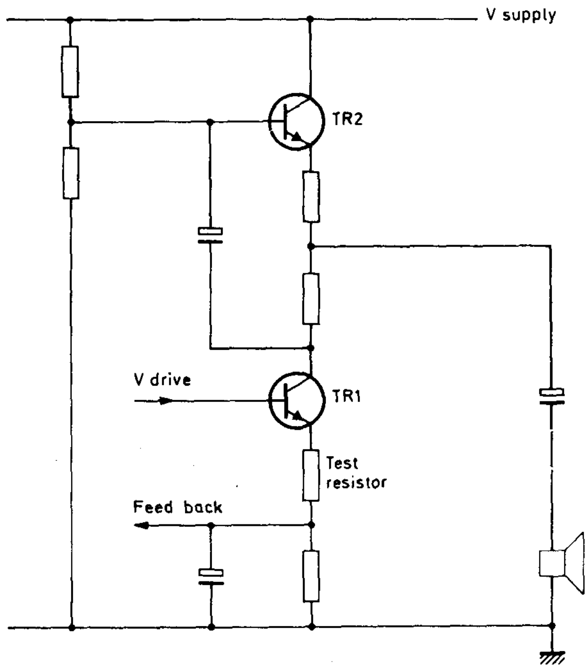


Fig. 6—Circuit configuration of television audio output stage

The amplifier provides the required output power but the second breakdown acceptability has to be checked, and the thermal requirements of the heatsinks are to be calculated.

In this example the SOAR acceptability is considered in the event of the transistors being overdriven by a sinewave signal of period 960μs. A test resistor of 0·1Ω is

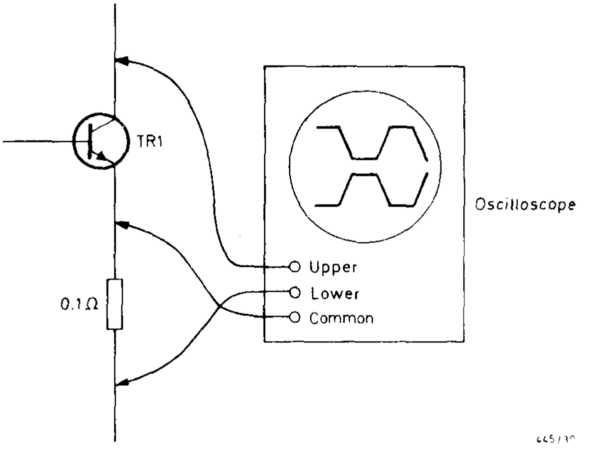


Fig. 7—Method of connecting dual-trace oscilloscope to obtain simultaneous display of I_C and V_{CE}

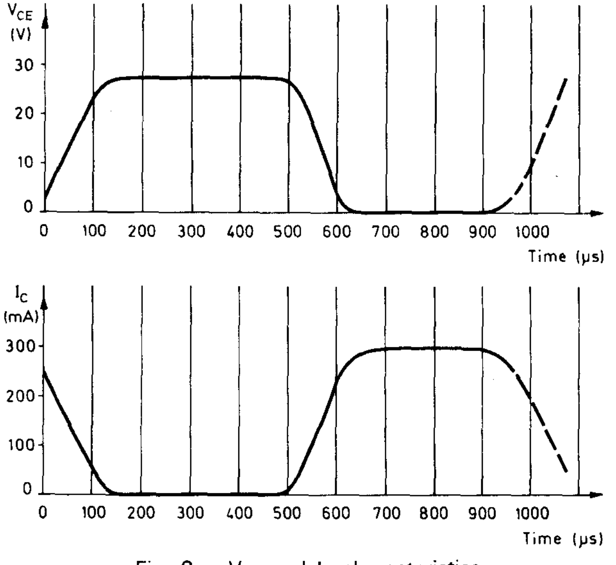


Fig. 8—V_{CE} and I_C characteristics

inserted in the emitter circuit of the lower transistor TR_1. A simultaneous display of the V_{CE} and I_C waveforms is then obtained by connecting the probes of a dual-trace oscilloscope in the manner shown in Fig. 7. The traces of V_{CE} and I_C taken from the oscilloscope are shown in Fig. 8 and the measurements from the waveforms are recorded in Table 1. These readings were recorded every 20μs through the complete cycle of 960μs. In the final column of Table 1, values of instantaneous power are calculated and plotted against time in Fig. 9. This curve is then converted into a series of equivalent squarewave pulses having the same peak power values as the actual pulses. The equivalent squarewave pulses are shown by the dashed line and are marked P_1, P_2, and P_3 in Fig. 9.

Each pulse is then checked individually. The duty cycle for each equivalent squarewave pulse is calculated, and the V_{CE} and I_C values recorded over the duration of the pulse are checked on the appropriate SOAR curve.

TABLE 1

Measured values of I_C and V_{CE} and derived $P_{(tot)}$ obtained from oscilloscope display

Time (μs)	I_C (mA)	V_{CE} (V)	$P_{(tot)}$ (W)
0	260	2	0·52
20	220	6	1·32
40	180	12	2·16
60	140	16	2·24
80	90	20	1·80
100	50	25	1·25
120	5	29	0·15
then no important changes until			
500	5	25	0·14
520	40	25	1·00
540	80	20	1·60
560	130	15	1·95
580	180	10	1·80
600	220	5	1·10
620	260	1	0·26
until			
940	280	1	0·28
960	260	2	0·52

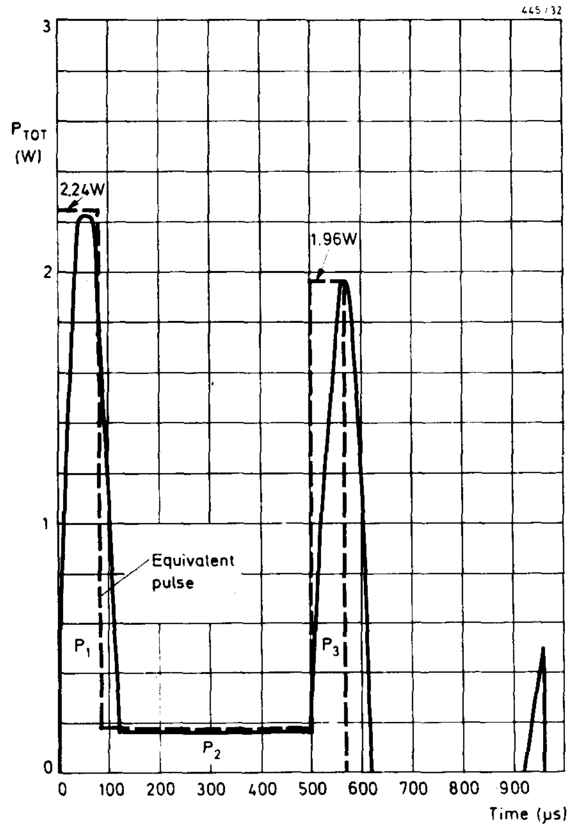


Fig. 9— P_{tot} against time characteristic showing equivalent *squarewave pulses*

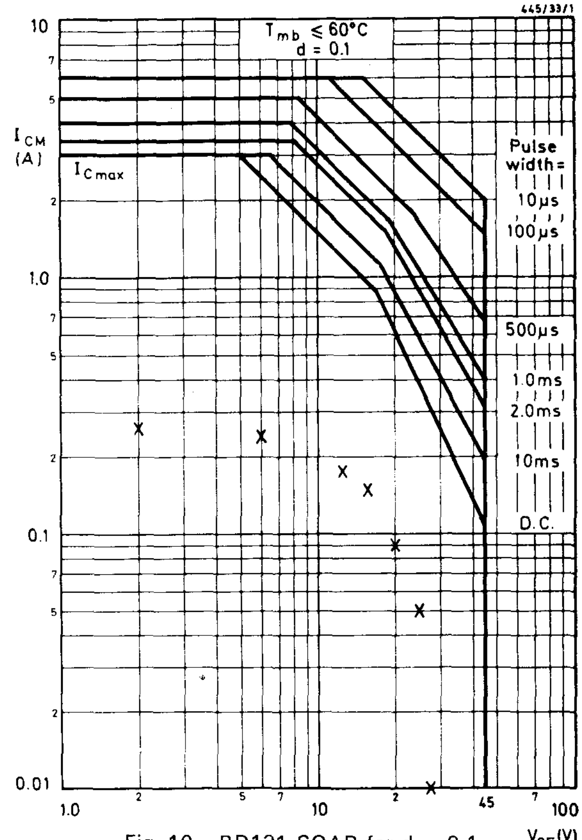


Fig. 10—BD131 SOAR for d = 0·1 (acceptability check for pulse P_1)

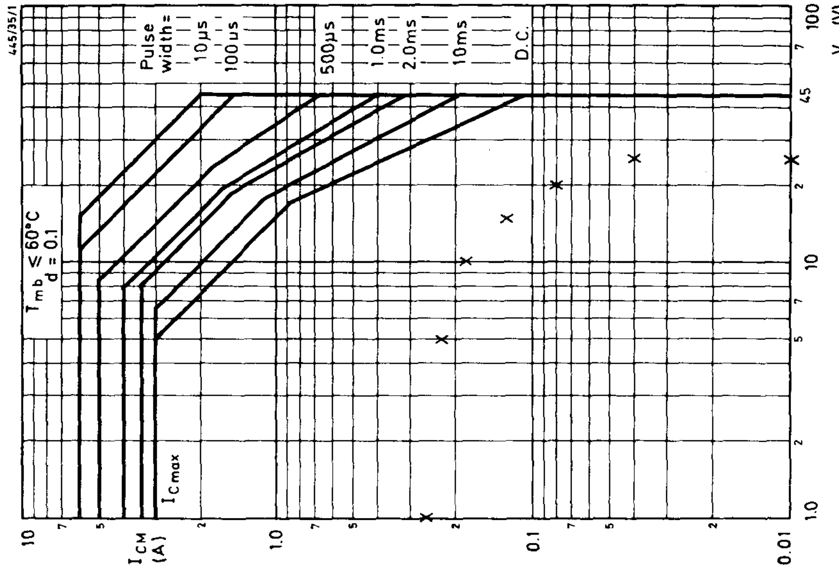


Fig. 12—BD131 SOAR for d = 0·1 (acceptability check for pulse P_3)

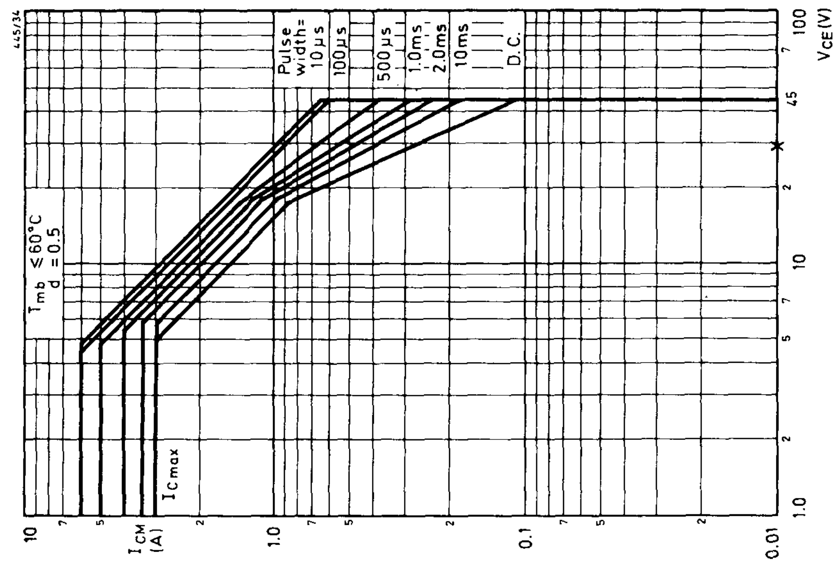


Fig. 11—BD131 SOAR for d = 0·5 (acceptability check for pulse P_2)

Consider pulse P_1: the equivalent pulse time t_{p1} is 82·5µs and the total cycle time T is 960µs. Therefore the duty cycle d_1 is 82·5/960 or 0·086. The V_{CE} and I_C values recorded up to the end of the pulse time t_{p1} are then plotted on the SOAR curve for d = 0·1 as shown in Fig. 10. The locus of this plot falls well within the t_p = 100µs limit, therefore this condition is acceptable. In figs. 10 to 12, the 5mA point is plotted on the 10mA line for convenience, this makes no difference to the result.

The same procedure is followed for checking the acceptability of pulses P_2 and P_3. For P_2 the duty cycle is 420/960 or 0·44; thus the V_{CE} and I_C measurements recorded for pulse P_2 are plotted on the SOAR curve for d = 0·5 as shown in Fig. 11. For P_3 the duty cycle is 70/960 or 0·073, so the V_{CE} and I_C measurements recorded for pulse P_3 are again plotted on the SOAR curve for d = 0·1 as in Fig. 12.

In all three cases the pulse conditions are acceptable since not even the d.c. SOAR limits are exceeded. Thus, the transistor will not fail through second breakdown even when the amplifier is continuously overdriven.

Heatsink calculations

The heatsinks have to be designed to keep the junction temperature below the rating of 150°C. The known thermal restraints are the standard ambient temperature of 60°C allowed for in television enclosures, and the thermal impedances associated with the BD131. The thermal impedance curves for the BD131 are shown in Fig. 13, and the contact thermal resistance $R_{th(mb-h)}$ is 1 degC/W.

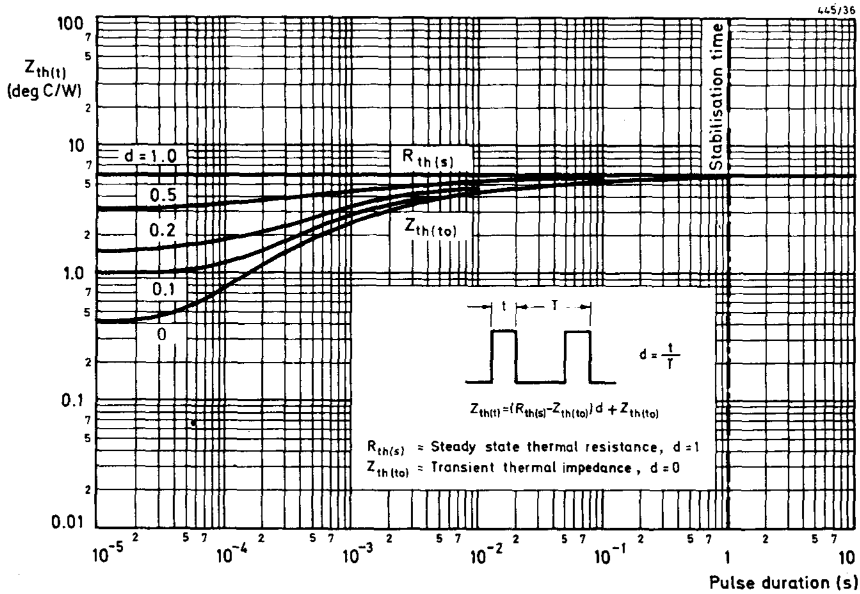


Fig. 13—Thermal impedance curves for BD131

The calculations used to determine the size of the required heatsinks involve average power values, as follows:

$$R_{th(h-a)} = \frac{T_{mb}\max - T_a}{P_{av}} - R_{th(mb-h)}, \qquad \ldots(1)$$

where:

$$T_{mb}\max = T_j\max - (T_j - T_{mb})\max. \qquad \ldots(2)$$

Therefore:

$$R_{th(h-a)} = \left(\frac{T_j\max - (T_j - T_{mb})\max - T_a}{P_{av}}\right) - R_{th(mb-h)} \qquad \ldots(3)$$

Two average powers have to be considered; that during the overload condition and that during the quiescent state. Since this is a class A amplifier, 2W will be dissipated in each of the output transistors during the quiescent condition, and this will be the d.c. bias condition. Under the overload condition the average power value is calculated as follows:

average heat input per cycle

$$= [(t_{p1} \times P_1) + (t_{p2} \times P_2) + (t_{p3} \times P_3)]/T, \qquad \ldots(4)$$

$$= [(82.5 \times 2.24) + (420 \times 0.15) + (70 \times 1.96)]/960 = \frac{385\mu sW}{960\mu s} = 0.4W.$$

The calculation of heatsink sizes should be determined under worst-case conditions. This occurs when the quiescent state is followed by the overload conditions. Since the average overload power is less than the quiescent power the first cycle of overload will define the $(T_j—T_{mb})$max.

The maximum value of $(T_j—T_{mb})$ is to be the greater of the two values given by the equations (5) and (6) below.

$$(T_j - T_{mb})\max = P_Q \times R_{th} + (P_1 - P_Q)Z_{th}t_{p1}, \qquad \ldots(5)$$

$$\text{and } (T_j - T_{mb})\max = P_Q \times R_{th} + (P_1 - P_Q)Z_{th}(t_{p1} + t_{p2} + t_{p3})$$
$$- (P_1 - P_2)Z_{th}(t_{p2} + t_{p3}) + (P_3 - P_2)Z_{th}t_{p3}, \qquad \ldots(6)$$

where:

quiescent power $P_Q = 2W$
$P_1 = 2.24W$
$P_2 = 0.15W$
$P_3 = 1.96W$
$t_{p1} = 82.5\mu s$
$t_{p1} + t_{p2} + t_{p3} = 572.5\mu s$
$t_{p2} + t_{p3} = 490.0\mu s$

$t_{p3} = 70\mu s$
$R_{th} = 6$degC/W
$Z_{th}t_{p1} = 0.72$degC/W
$Z_{th}(t_{p1} + t_{p2} + t_{p3}) = 2.0$degC/W
$Z_{th}(t_{p2} + t_{p3}) = 1.8$degC/W
$Z_{th}t_{p3} = 0.63$degC/W.

Thus, Eq. 5 becomes:

$$(T_j - T_{mb})max = (2 \times 6) + (0.24 \times 0.72) \quad = (12 + 0.2) \quad = 12.2degC.$$

Eq. 6 becomes:

$$(T_j - T_{mb})max = (2 \times 6) + (0.24 \times 2) - (2.09 \times 1.8) + (1.81 \times 0.63),$$

$$= 12 + 0.48 - 3.76 + 1.14 \quad = 9.9degC.$$

Therefore the maximum value of $(T_j - T_{mb})$ is 12.2degC from Eq. 5 .

Thus Eq. 3 becomes:

$$R_{th(h-a)} = \left(\frac{150 - 12.2 - 60}{2}\right) - 1 \quad = 37.9degC/W.$$

Therefore the maximum value of $(T_j - T_{mb})$ is 12.2 degC from Eq. 5.

Therefore heatsinks used for the BD131 transistors in this application should each have a thermal resistance of 37degC/W or less. The foregoing calculations assume a contact thermal resistance value of 1degC/W, which is true only if a heat-sink mounting compound is used.

APPENDIX I
Transistor heatsink sizes

The heatsink size for any transistor can be found from the nomogram shown in Fig. 14 provided that the power dissipation is no greater than 100W, and that the heat is dissipated by free convection. This nomogram should not be used where forced air cooling is employed, or where heatsink material other than aluminium is desired. The nomogram is operated as follows, with reference to the simplified curves in Fig. 15.

1) Calculate the worst-case dissipation $P_{tot}max$ and hence the thermal resistance of heatsink to ambient $R_{th}(h-a)$. Thus:

$$R_{th(h-a)} = \frac{T_{mb}max - T_{amb}}{P_{tot}} - R_{th(mb-h)}$$

2) Enter the nomogram in section I of Fig. 15. Move horizontally to the left until the appropriate orientation (either horizontal or vertical) and the appropriate surface finish is reached.
3) Move vertically upwards to intersect appropriate power dissipation curve (P_{tot}) in section II.
4) Move horizontally to intersect the curve in section III for the desired thickness of sheet aluminium heatsink. If an extrusion is required, move vertically upwards

from the point of intersection on the chosen extrusion curve and read off the required length on the top horizontal scale. (The 30D and 40D are shown in outline in Fig. 16. These types belong to the family of extrusions which has been used with Mullard power devices requiring special heatsink considerations, such as thyristor stacks and power rectifiers. Similar curves for alternative extrusions could also be plotted in section III using the heatsink manufacturer's data relating $R_{th(h-a)}$ and power, and length).

5) Move vertically down from point A in section III to intersect with the appropriate curve for the transistor encapsulation style.
6) Move horizontally to the left and read off the required area of one side of flat aluminium heatsink.
7) The heatsink dimensions of height to width should not exceed the ratio 1·25:1.

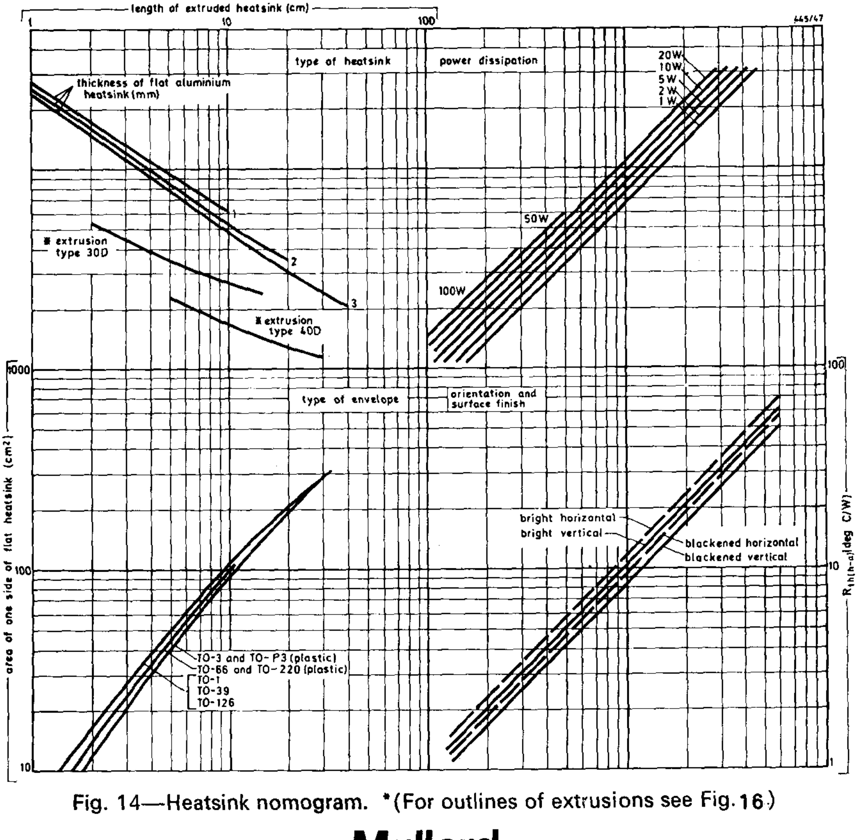


Fig. 14—Heatsink nomogram. *(For outlines of extrusions see Fig. 16)

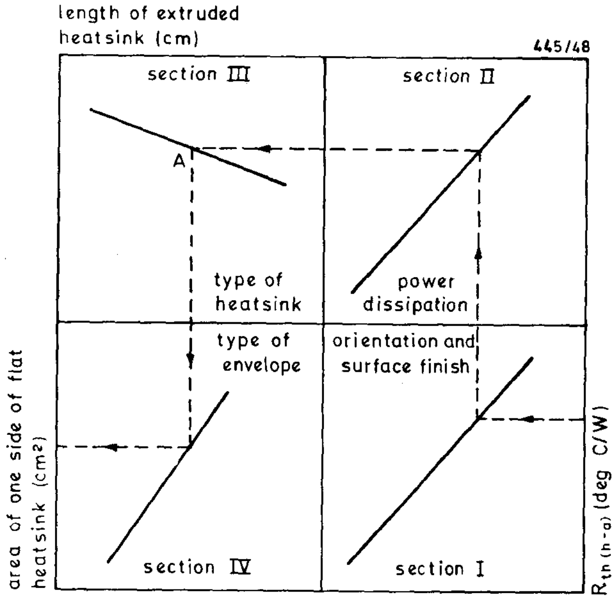


Fig. 15—Simplified nomogram

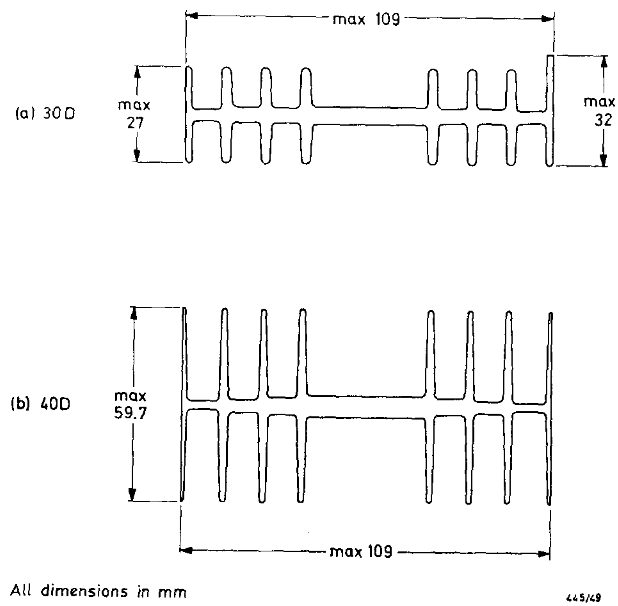


Fig. 16—Outlines of extrusions: (a) 30D, (b) 40D

TRANSISTORS

B

GERMANIUM N-P-N HIGH-GAIN TRANSISTOR

AC127

Germanium n-p-n high gain alloy junction transistor intended for complementary symmetrical Class 'B' output stages. TO-1 construction with envelope isolated.

QUICK REFERENCE DATA		
V_{CB} max. ($I_E = 0$)	+32	V
V_{CER} max. ($R_{BE} < 60\Omega$)	+32	V
I_{CM} max.	500	mA
P_{tot} max. ($T_{amb} = 25^{o}C$)	340	mW
h_{FE} (typ) ($I_C = 500mA$)	50	
f_T (typ)	2.5	Mc/s

RATINGS

Limiting values of operation according to the absolute maximum system as defined in publication 134 of the International Electrotechnical Commission.

Electrical

V_{CB} max. ($I_E = 0$)	+32	V
V_{CER} max. ($R_{BE} < 60\Omega$) (see page C1)	+32	V
I_{CM} max.	500	mA
*$I_{C(AV)}$ max.	500	mA
I_{EM} max.	525	mA
*$I_{E(AV)}$ max.	525	mA
I_{BM} max.	25	mA
*$I_{B(AV)}$ max.	25	mA
P_{tot} max.	340	mW

*Averaged over any 20ms period.

Thermal

T_{stg} min.	-55	^{o}C
T_{stg} max.	90	^{o}C
T_j max.	90	^{o}C
T_j max. (intermittent operation, total duration = 200 hours)	100	^{o}C

THERMAL CHARACTERISTICS

$\Theta_{j\text{-amb}}$ (in free air)	0.37	deg C/mW
$\Theta_{j\text{-case}}$	0.11	deg C/mW
$\Theta_{j\text{-amb}}$ in free air with cooling clip as shown on page D4	0.22	deg C/mW
$\Theta_{j\text{-amb}}$ in free air with cooling clip giving good thermal contact mounted on a heatsink of 16 s.w.g. aluminium, minimum area 12.5 cm^2	0.16	deg C/mW

ELECTRICAL CHARACTERISTICS (T_{amb} = 25 °C unless otherwise stated)

		Min.	Typ.	Max.	
Collector-base breakdown voltage	$V_{(BR)CBO}$				
I_C = 500μA		+32	-	-	V
Emitter-base breakdown voltage	$V_{(BR)EBO}$				
I_E = 200μA		+10	-	-	V
Collector knee voltage	$V_{CE(knee)}$				
I_C = 500mA, (see fig. 1)		-	-	+1.2	V
Base emitter voltage	V_{BE}				
V_{CB} = +5V, I_E = 2mA		-	+120	-	mV
V_{CB} = 0, I_E = 500mA		-	-	+1.2	V
Collector cut-off current	I_{CBO}				
V_{CB} = +0.5V		-	-	10	μA
Emitter cut-off current	I_{EBO}				
V_{EB} = +5V, T_j = 75 °C		-	-	550	μA
Large signal forward current transfer ratio	h_{FEL}				
V_{CB} = 0, I_C = 20mA		50	-	200	
I_C = 500mA		25	-	143	

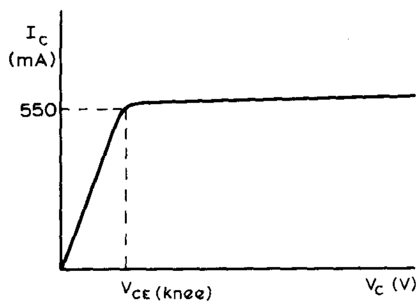


Fig I.

		Min.	Typ.	Max.	
Intrinsic base resistance	$r_{bb'}$				
V_{CB}=+5V, I_E=1mA, f=450kc/s		-	70	-	Ω
Collector depletion capacitance	c_{tc}				
V_{CB}=+5V, I_E=0, f=450kc/s		-	70	-	pF
Transition frequency	f_T				
V_{CB}=+2V, I_E=10mA		1.5	2.5	-	Mc/s
Common emitter cut-off frequency	f_{hfe}				
V_{CB}=+2V, I_E=10mA		10	20	-	kc/s
Noise figure	NF				
V_{CB}=+5V, I_E=500μA, f=1kc/s		-	4	10	dB

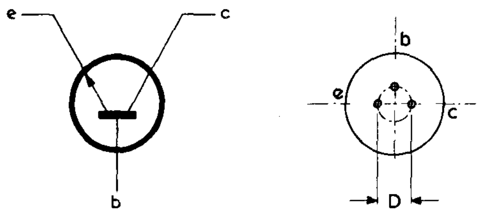
SOLDERING AND WIRING RECOMMENDATIONS

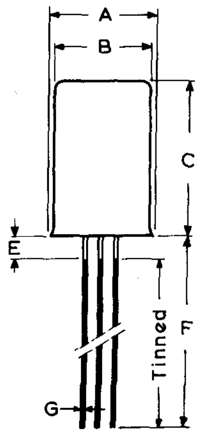
1. When using a soldering iron, the transistor may be soldered directly into a circuit, but heat conducted to the junction should if possible be kept to a minimum by the use of a heat shunt.

2. The transistor may be dip-soldered at a solder temperature of 245°C for a maximum time of 5 seconds. The case temperature during dip-soldering may exceed the maximum storage temperature for a period not greater than 2 minutes, provided that it at no time exceeds 115°C. This recommendation applies to a transistor mounted flush on a board having punched-through holes, or spaced at least 1.5mm away from a board having plated-through holes.

3. Care should be taken not to bend the leads nearer than 1.5mm from the seal.

Conforms to V.A.S.C.A. SO-21/SB3-10
J.E.D.E.C. TO-1



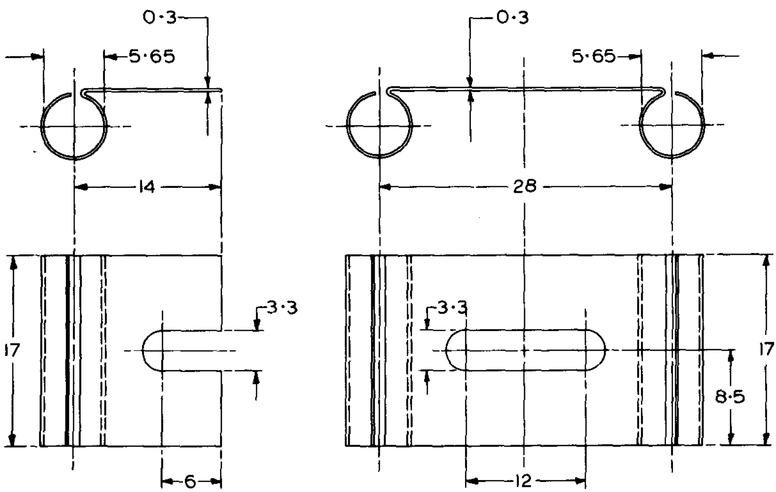


B3263

DIMENSIONS (in millimetres)

	Min.	Nom.	Max.
A	-	-	6.5
B	-	-	6.1
C	-	-	9.4
D	-	1.8	-
E	-	-	1.5
F	38	-	-
G	-	0.43	-

OUTLINE AND DIMENSIONS OF COOLING CLIPS



Nominal dimensions in mm

B3121

Type a.

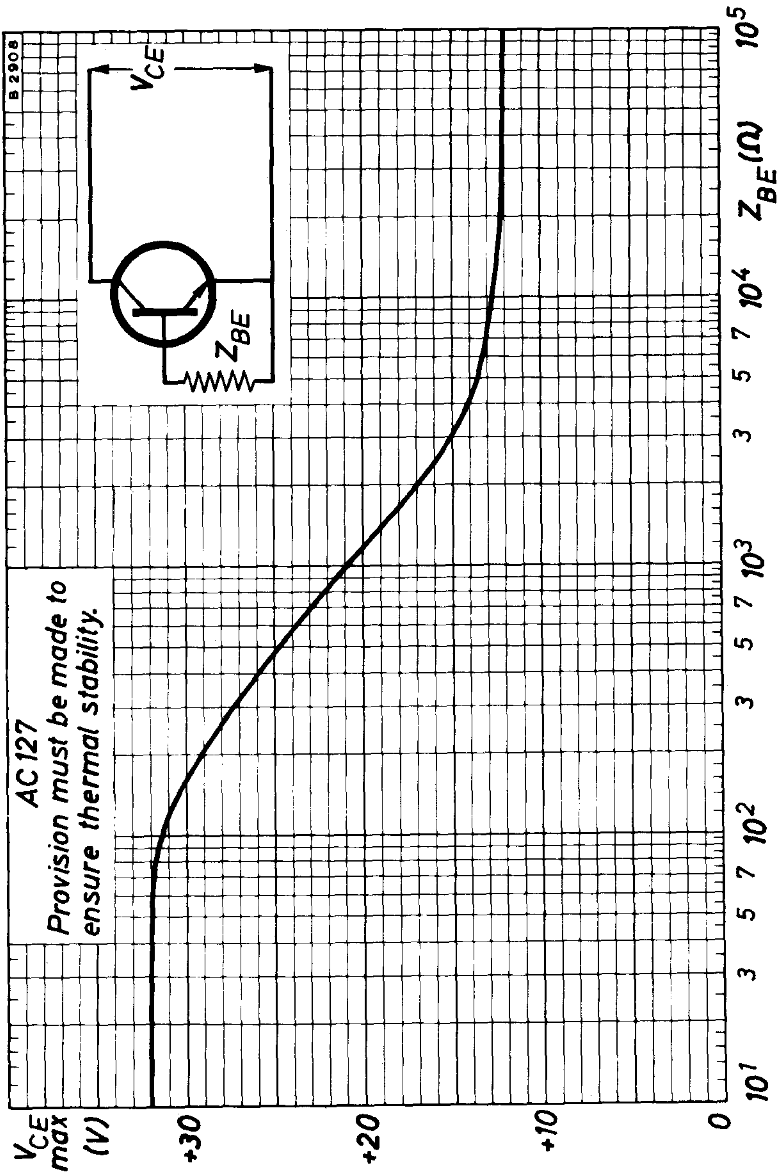
Part No. 56227

Type b.

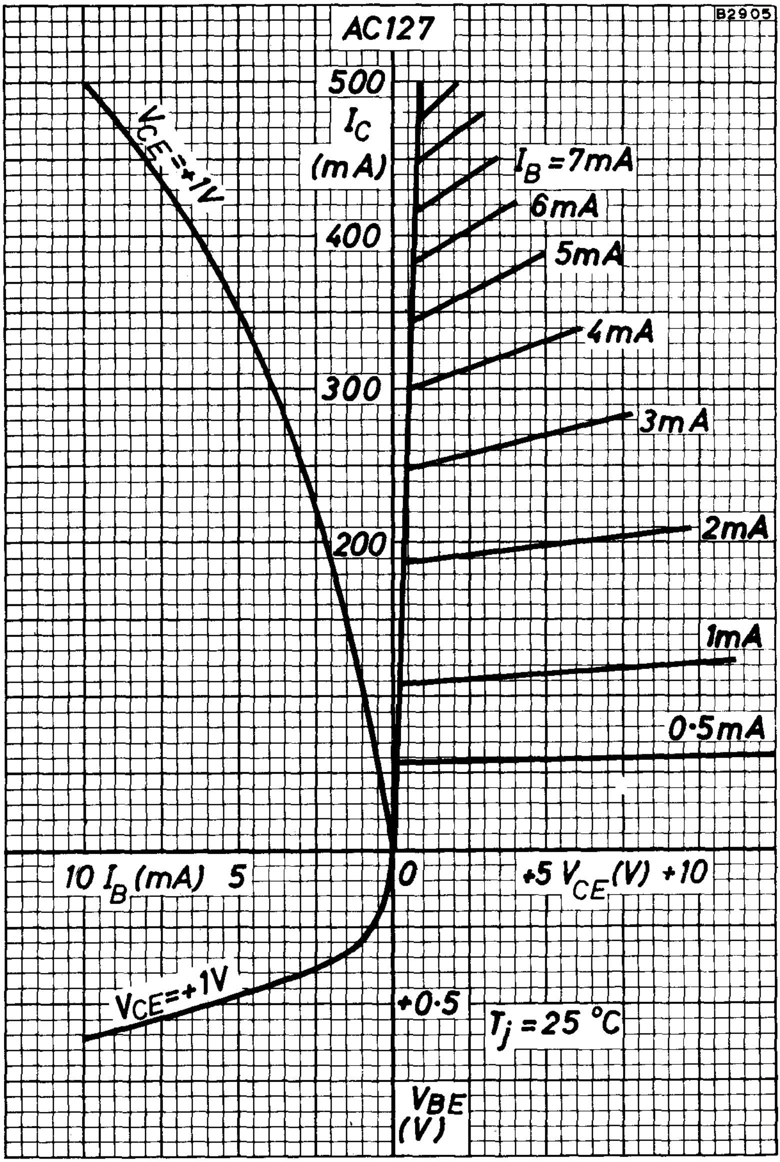
Part No. 56226

GERMANIUM N-P-N HIGH-GAIN TRANSISTOR

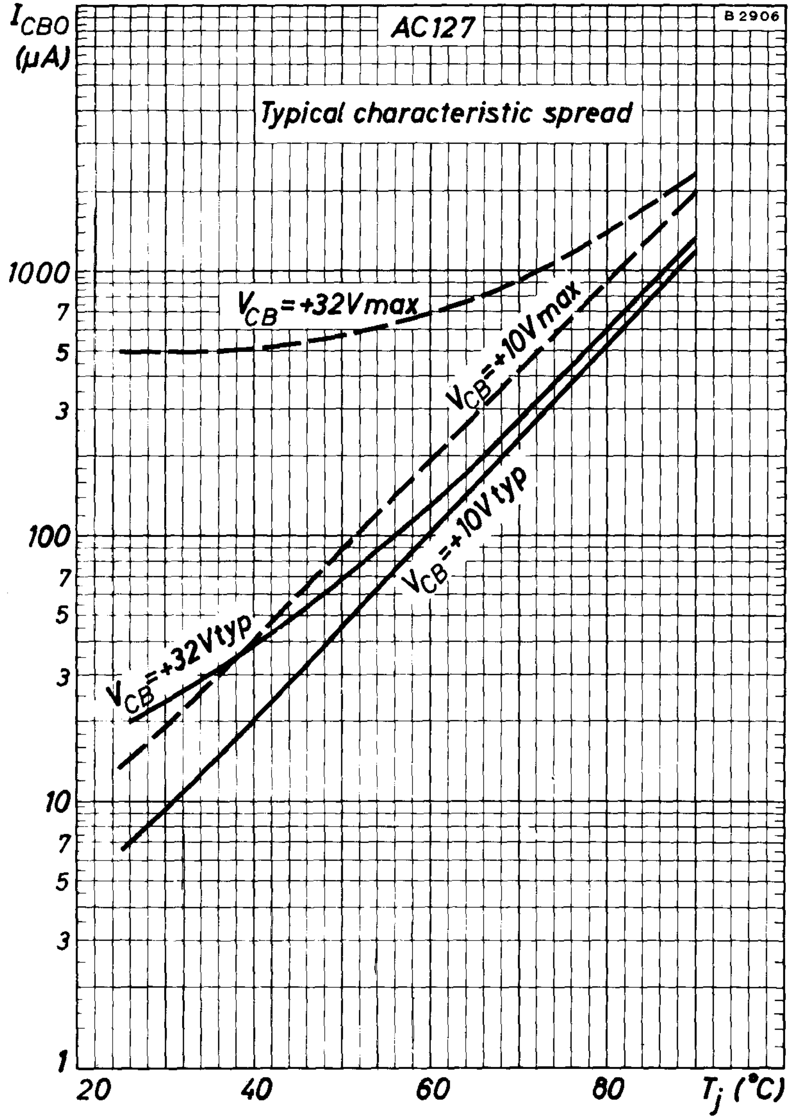
AC127



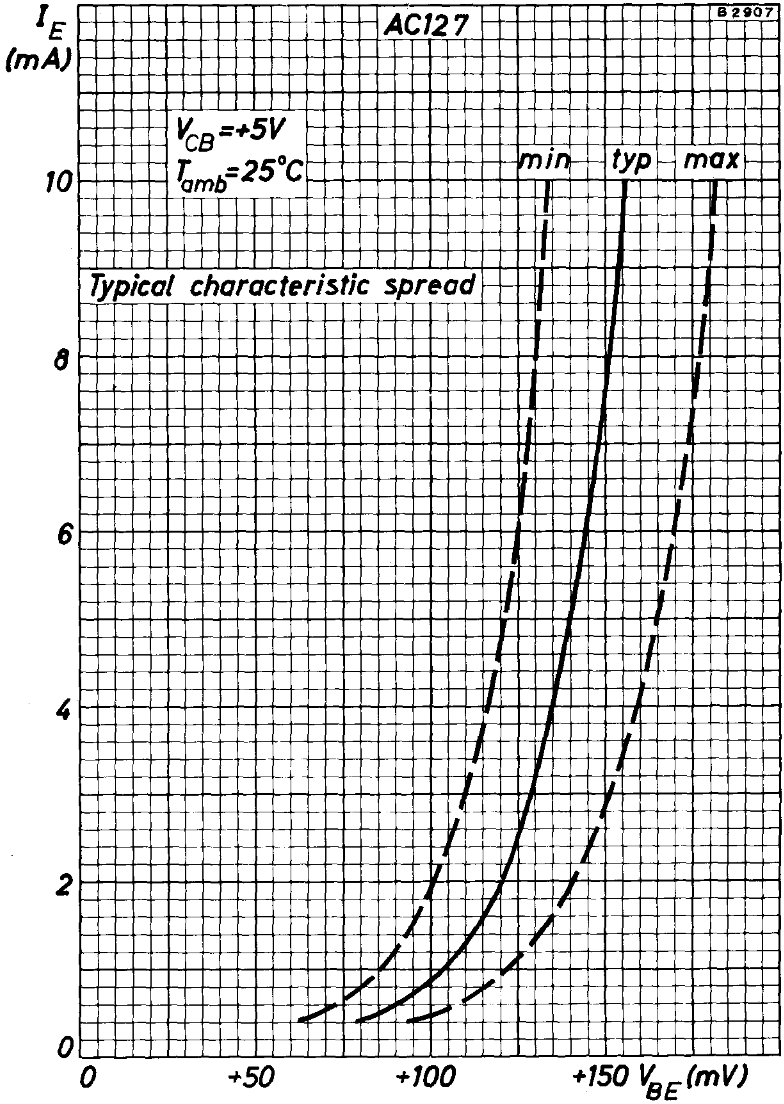
MAXIMUM COLLECTOR-EMITTER VOLTAGE PLOTTED AGAINST BASE EMITTER IMPEDANCE



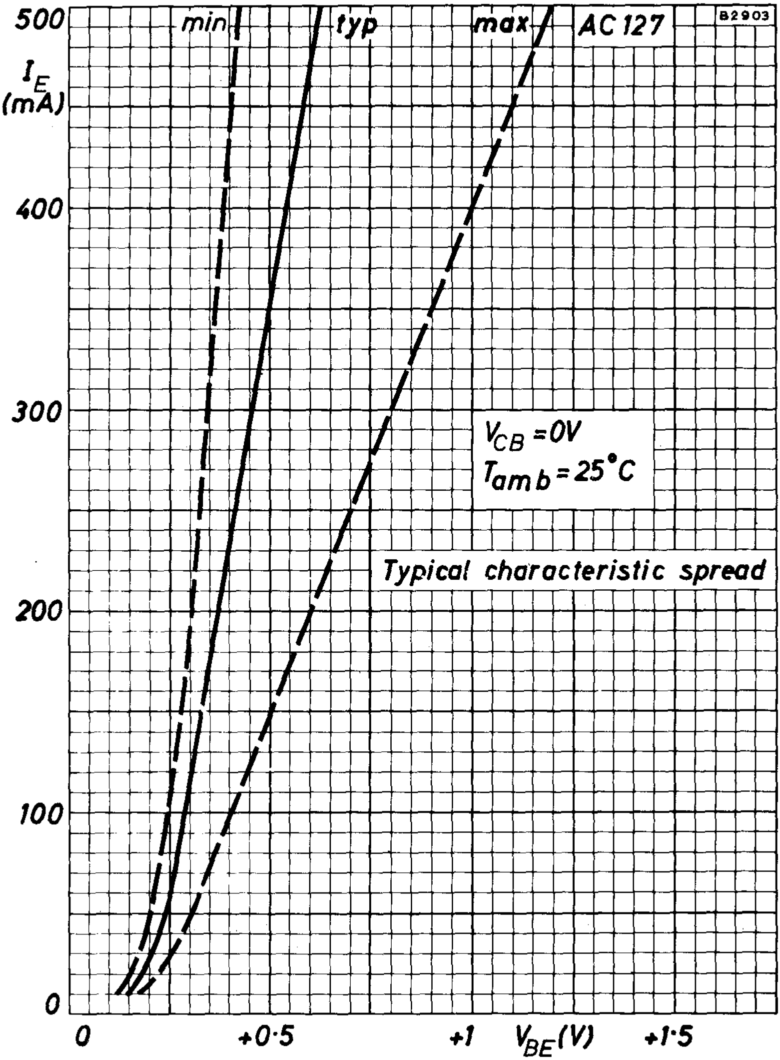
TYPICAL CHARACTERISTICS



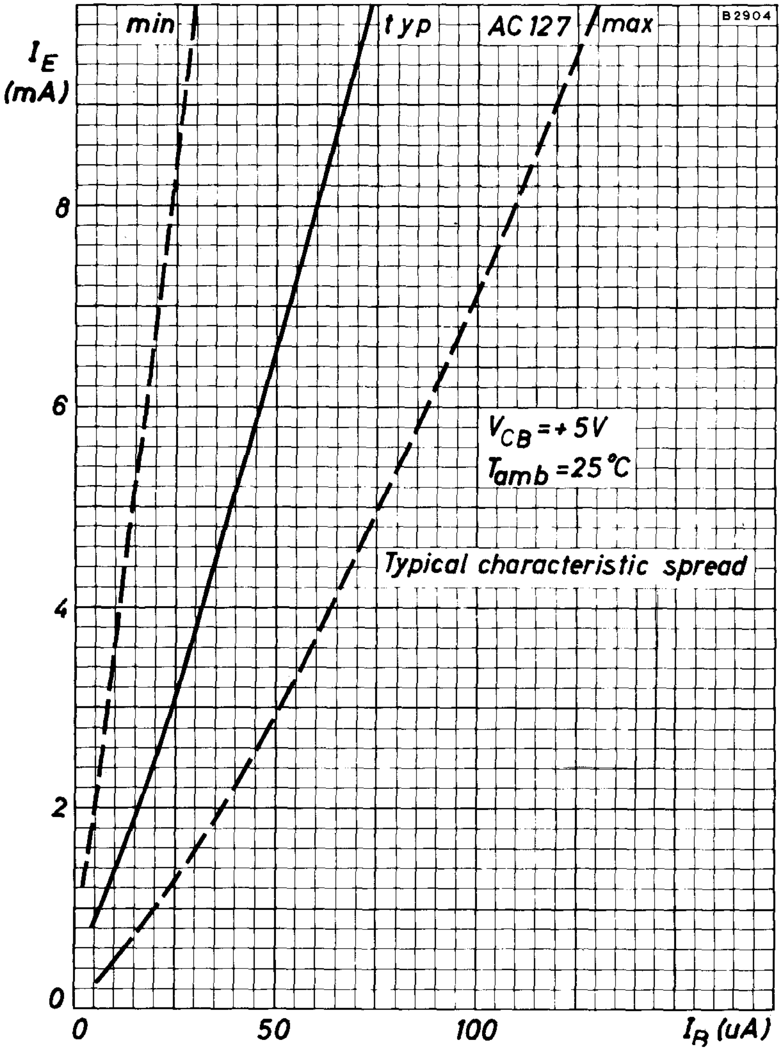
COLLECTOR-BASE CUT-OFF CURRENT PLOTTED AGAINST JUNCTION TEMPERATURE



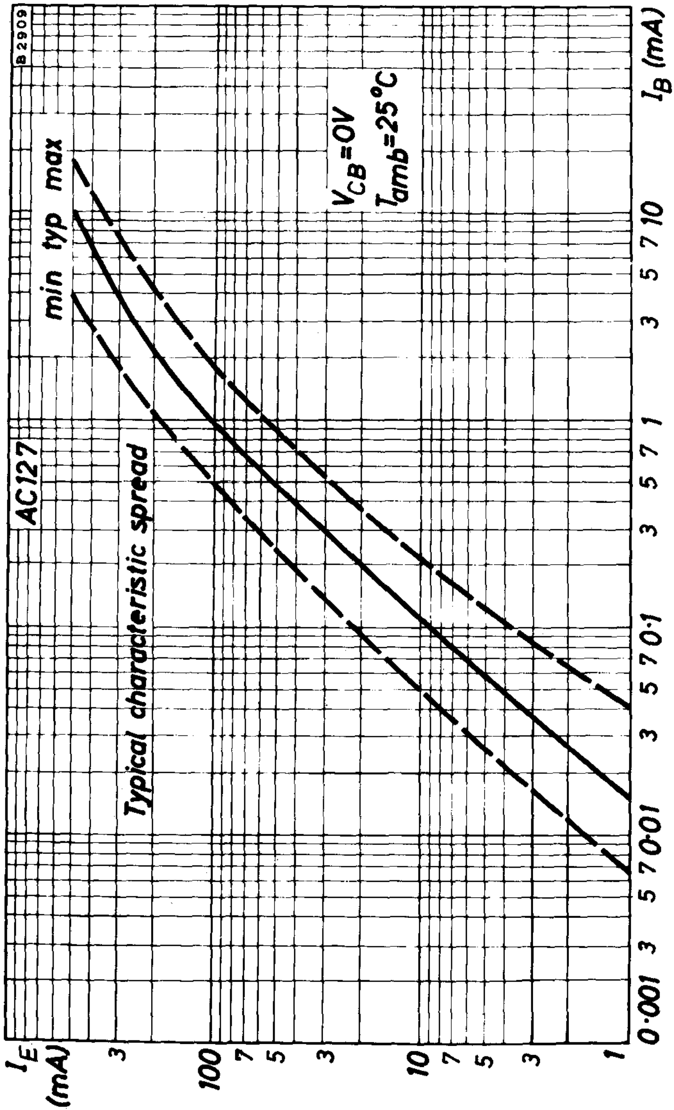
COMMON EMITTER INPUT CHARACTERISTICS FOR LOW EMITTER CURRENTS



COMMON EMITTER INPUT CHARACTERISTICS FOR HIGH EMITTER CURRENTS



COMMON EMITTER TRANSFER CHARACTERISTICS FOR LOW EMITTER CURRENTS



COMMON EMITTER TRANSFER CHARACTERISTICS FOR HIGH EMITTER CURRENTS

P-N-P GERMANIUM MEDIUM POWER TRANSISTORS

AC128 AC128/01 2-AC128 2-AC128/01

The AC128 is a p-n-p alloy junction medium power audio transistor in a TO-1 envelope, primarily intended for operation in class A and class B output stages.

The AC128/01 is electrically equivalent to the AC128, constructed integrally with a heat conducting block.

The 2-AC128 and 2-AC128/01 consist of two AC128 and two AC128/01 transistors respectively, matched to operate in low distortion class B circuits.

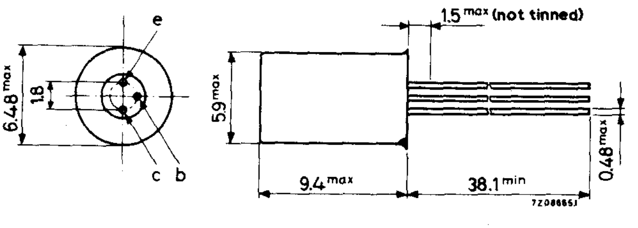
QUICK REFERENCE DATA

$-V_{CBO}$ max.	32	V
$-V_{CEO}$ max.	16	V
$-I_{CM}$ max.	2.0	A
P_{tot} max. ($T_{amb} \leq 20^{o}C$)	1.0	W
T_j max.	90	^{o}C
h_{FE} ($-I_C$ = 50mA, V_{CB} = 0)	55 - 175	
f_T typ. ($-I_C$ = 10mA, $-V_{CE}$ = 2V)	1.5	MHz

OUTLINE AND DIMENSIONS (see also page 2)

Conforms to BS3934 SO-21/SB3-10
J.E.D.E.C. TO-1

AC128



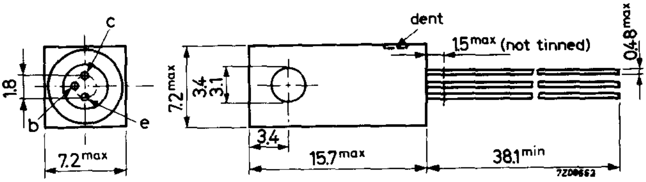
All dimensions in mm

The coloured dot indicates the collector

Accessories available: 56226, 56227

OUTLINE AND DIMENSIONS (contd.)

AC128/01



All dimensions in mm

The dent indicates the collector

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

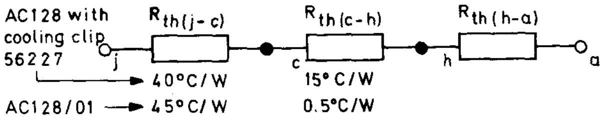
$-V_{CBO}$ max.	32	V
$-V_{CEO}$ max.	16	V
$-V_{CER}$ max. ($R_{BE} \leq 400\Omega$)	32	V
$-V_{EBO}$ max.	10	V
$-I_C$ max.	1.0	A
$-I_{CM}$ max.	2.0	A
I_{EM} max.	2.0	A
P_{tot} max. ($T_{amb} \leq 20^{o}C$, with cooling clip 56227 on a 1.5mm blackened aluminium heatsink of 12.5cm^2; see also page 4)	1.0	W

Temperature

T_{stg}	-55 to +100	^{o}C
T_j max. (continuous)	90	^{o}C

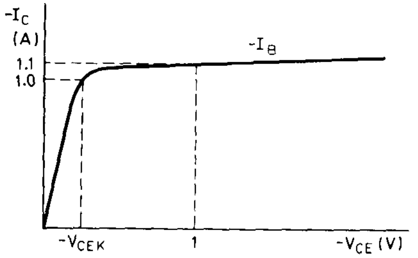
THERMAL CHARACTERISTICS

		AC128	AC128/01	
$R_{th(j-a)}$	Thermal resistance from junction to ambient in free air			
	without cooling clip	290	180	$^{o}C/W$
	with cooling clip 56227	140	-	$^{o}C/W$
	with cooling clip 56227 on a 1.5mm blackened aluminium heatsink of 12.5cm^2	80	70.5	$^{o}C/W$
	with cooling clip 56227 on infinite heatsink	55	-	$^{o}C/W$
$R_{th(j-c)}$	Thermal resistance from junction to case	40	45	$^{o}C/W$



ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise stated)

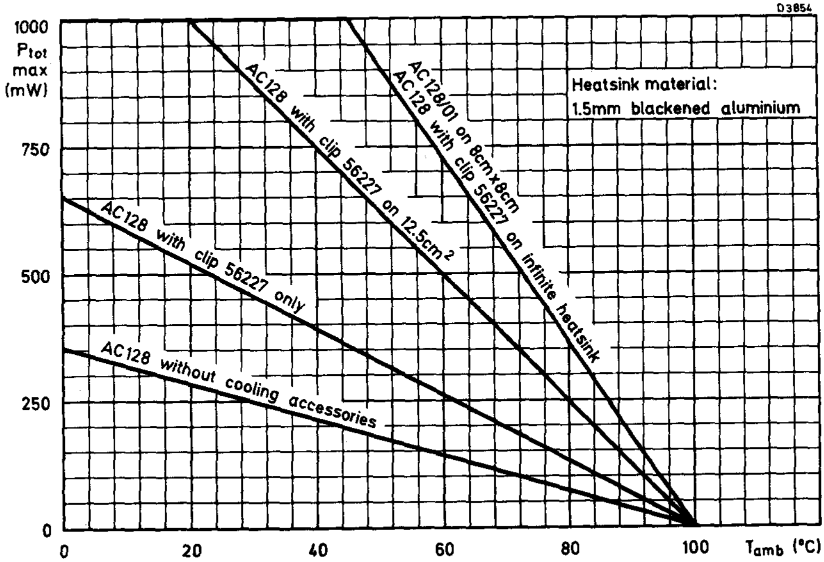
		Min.	Typ.	Max.	
$-I_{CBO}$	Collector cut-off current				
	$I_E = 0$, $-V_{CB} = 10V$, $T_j = 25^oC$	-	-	10	μA
	$I_E = 0$, $-V_{CB} = 32V$, $T_j = 25^oC$	-	-	200	μA
$-I_{EBO}$	Emitter cut-off current				
	$I_C = 0$, $-V_{EB} = 10V$, $T_j = 25^oC$	-	-	200	μA
	$I_C = 0$, $-V_{EB} = 5V$, $T_j = 75^oC$	-	-	500	μA
$-V_{BE}$	Base-emitter voltage				
	$I_E = 50mA$, $V_{CB} = 0$	-	-	300	mV
	$I_E = 300mA$, $V_{CB} = 0$	-	-	450	mV
$-V_{CEK}$	Collector knee voltage				
	$-I_C = 1A$, $-I_B$ = the value for which $-I_C = 1.1A$ at $-V_{CE} = 1V$	-	-	0.6	V

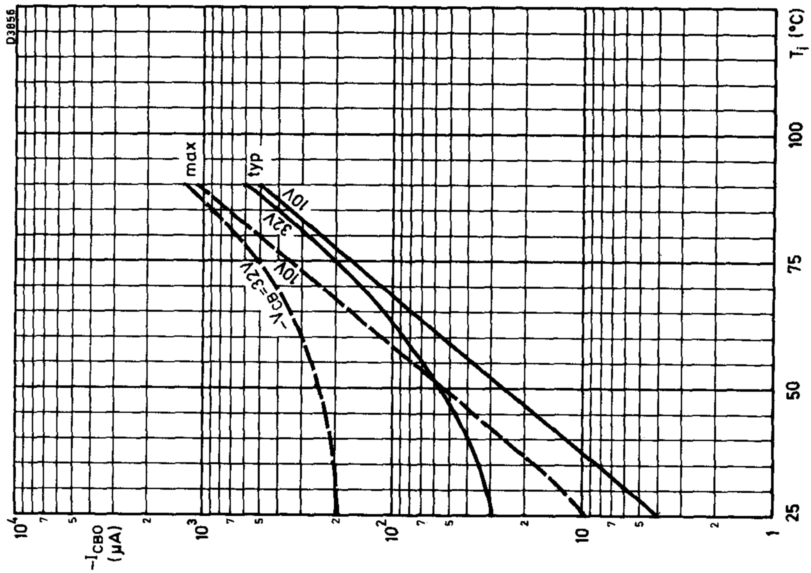


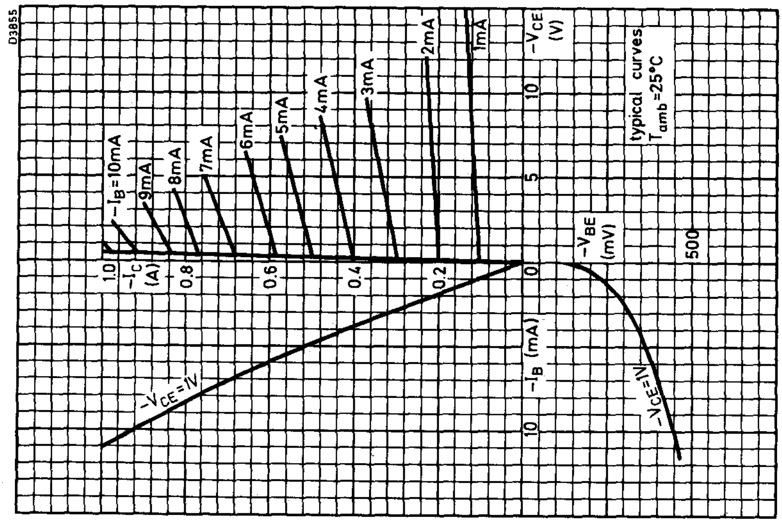
		Min.	Typ.	Max.	
h_{FE}	Static forward current transfer ratio				
	$-I_C = 50mA$, $V_{CB} = 0$	55	90	175	
	$-I_C = 300mA$, $V_{CB} = 0$	60	90	175	
	$-I_C = 1A$, $V_{CB} = 0$	45	80	165	
f_T	Transition frequency				
	$-I_C = 10mA$, $-V_{CE} = 2V$	1.0	1.5	-	MHz
f_{hfe}	Cut-off frequency				
	$-I_C = 10mA$, $-V_{CE} = 2V$	10	15	-	kHz
C_{Tc}	Collector capacitance				
	$I_E = I_e = 0$, $-V_{CB} = 5V$	-	100	-	pF
$r_{bb'}$	Base resistance				
	$-I_C = 1mA$, $-V_{CE} = 5V$	-	25	-	Ω

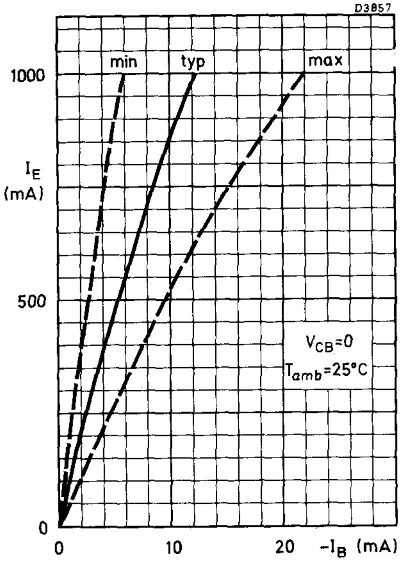
ELECTRICAL CHARACTERISTICS (contd.)

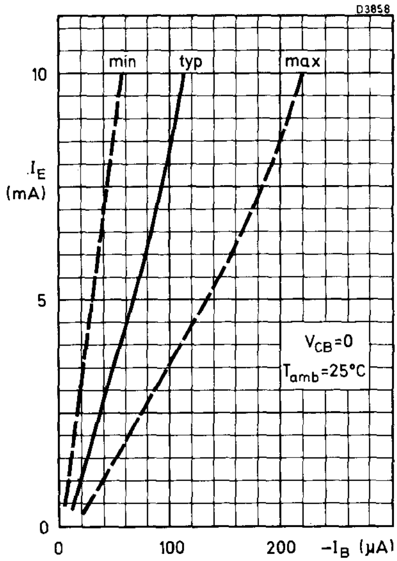
		Min.	Typ.	Max.
Small signal current gain linearity				
$\frac{A_i \text{ at } 500mA}{A_i \text{ max.}}$, where A_i = loaded small signal current gain		0.50	0.60	-
$\frac{h_{FE1}}{h_{FE2}}$	Ratio of static forward current transfer ratios of matched pair 2-AC128			
	$\lvert I_C \rvert$ = 50mA, V_{CB} = 0	-	1.1	1.25
	$\lvert I_C \rvert$ = 300mA, V_{CB} = 0	-	1.1	1.25

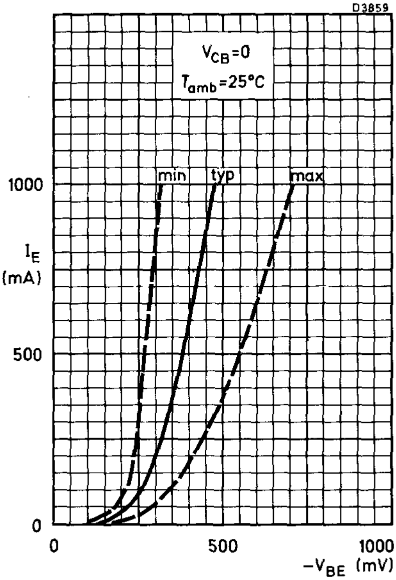


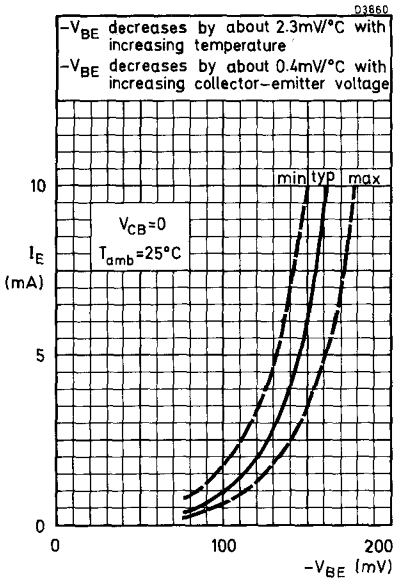

D3856
$-I_{CBO}$ (μA)
10^4
10^3
10^2
10
1
T_j (°C)
25
50
75
100
max
typ
10V
32V
$-V_{CB}$=32V
10V

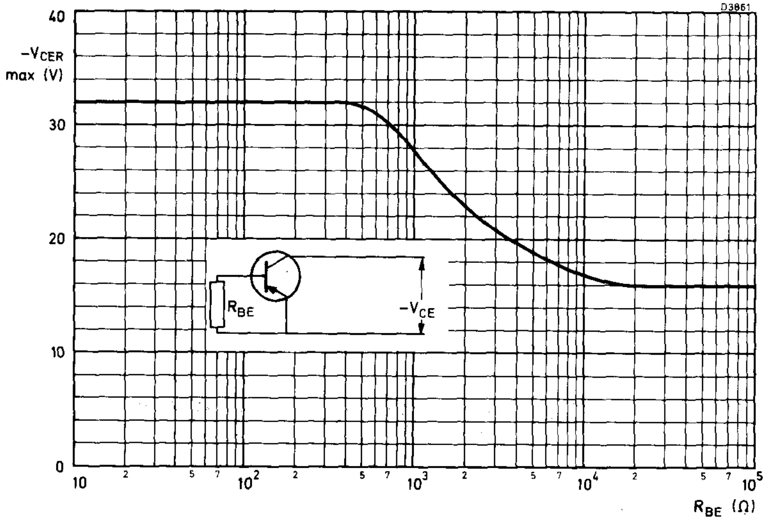

D3855
$-V_{CE}$ (V)
typical curves
T_{amb}=25°C
$-I_B$=10mA
9mA
8mA
7mA
6mA
5mA
4mA
3mA
2mA
1mA
$-I_C$ (A)
1.0
0.8
0.6
0.4
0.2
0
5
10
$-V_{BE}$ (mV)
500
$-I_B$ (mA)
$-V_{CE}$=1V
$-V_{CE}$=1V

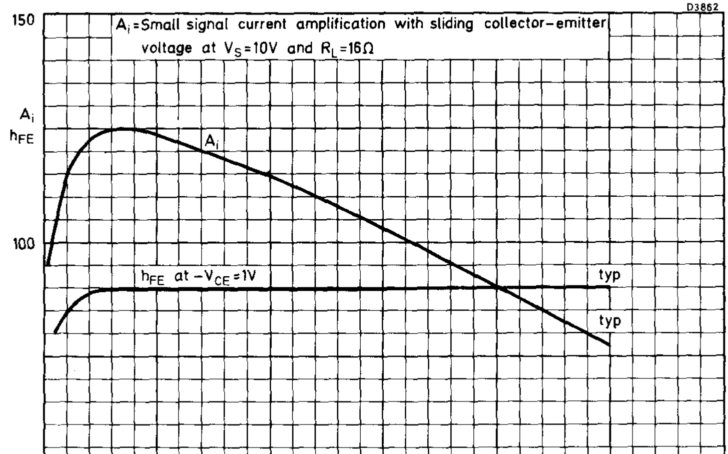

D3857
min
typ
max
1000
I_E
(mA)
500
0
V_{CB}=0
T_{amb}=25°C
0
10
20
$-I_B$ (mA)


D3858
min
typ
max
10
I_E
(mA)
5
0
V_{CB}=0
T_{amb}=25°C
0
100
200
$-I_B$ (µA)


D3859
V_{CB}=0
T_{amb}=25°C
min
typ
max
1000
I_E
(mA)
500
0
0
500
1000
$-V_{BE}$ (mV)


D3860
$-V_{BE}$ decreases by about 2.3mV/°C with increasing temperature
$-V_{BE}$ decreases by about 0.4mV/°C with increasing collector–emitter voltage
min
typ
max
10
I_E
(mA)
5
0
V_{CB}=0
T_{amb}=25°C
0
100
200
$-V_{BE}$ (mV)


D3861
40
$-V_{CER}$ max (V)
30
20
10
0
R_{BE}
$-V_{CE}$
10
10^2
10^3
10^4
10^5
R_{BE} (Ω)


D3862
A_i = Small signal current amplification with sliding collector-emitter voltage at V_S = 10V and R_L = 16Ω
150
A_i
h_{FE}
100
50
A_i
h_{FE} at $-V_{CE}$ = 1V
typ
typ
0
100
200
300
400
500
$-I_C$ (mA)

COMPLEMENTARY GERMANIUM MEDIUM POWER TRANSISTORS

AC128 AC176

N-P-N (AC176) and P-N-P (AC128) germanium alloy junction transistors for use in complementary symmetrical class 'B' output stages for radio receivers, amplifiers and tape recorders. For information on the individual types reference should be made to the relevant data sheets.

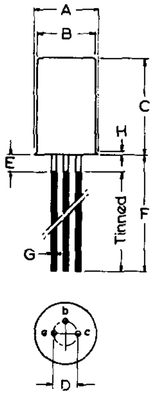
QUICK REFERENCE DATA

	AC128	AC176	
V_{CB} max.	-32	+32	V
V_{CE} max. (cut-off)	-32	+32	V
I_C max.	1.0	1.0	A
P_{tot} max. (T_{amb} = 45°C)	155	155	mW
(T_{case} = 60°C)	700	700	mW
T_j max.	90	90	°C
h_{FE} typ. (V_{CB}=0, I_E=1.0A)	80	83	
f_T min.	1.0	1.0	Mc/s

Matching ratio for matched pairs see page 3.

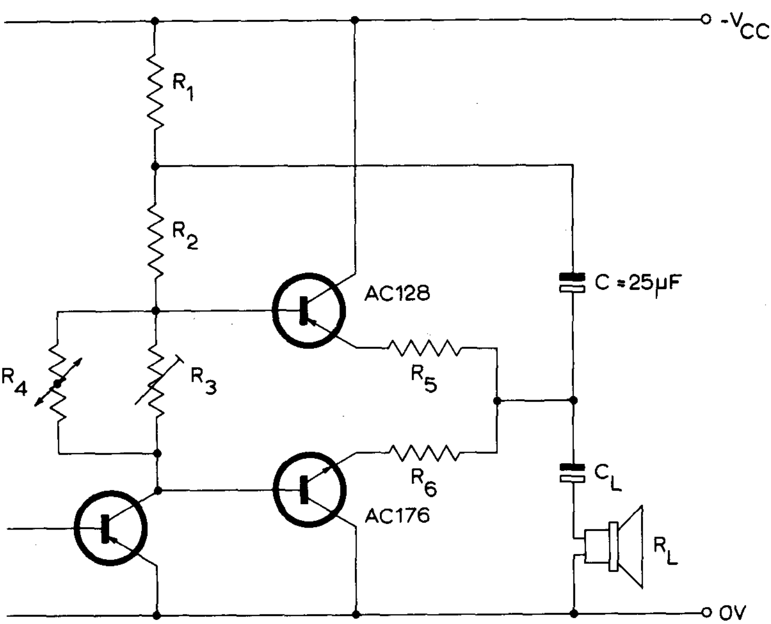
OUTLINE AND DIMENSIONS

Conforms to J.E.D.E.C. TO-1
V.A.S.C.A. SO-21/SB3-10



	Millimetres		
	Min.	Nom.	Max.
A	-	-	6.48
B	-	-	6.1
C	-	-	9.4
D	-	1.8	-
E	-	-	1.5
F	38	-	-
G	-	-	0.48
H	-	-	2.05

OPERATING CONDITIONS IN CLASS 'B' COMPLEMENTARY SYMMETRICAL OUTPUT STAGE



*Nominal supply voltage	-24	-24	V
Power supply internal resistance	20	20	Ω
Load resistance	25	15	Ω
**Thermal resistance $\Theta_{case-amb}$ per transistor	40	20	degC/W
†Load power			
Speech and music	2.0	3.0	W
Sustained music	1.8	2.7	W
Sinewave	1.4	2.1	W
Driver quiescent current	11.5	18	mA
Nominal driver current (r.m.s.) for P_{load} = 50mW	0.65	0.8	mA
Peak collector current	485	675	mA
Peak load current	405	620	mA
R_1	330	180	Ω
R_2	680	470	Ω
††R_3	100	40	Ω

R_4	VA1077	VA1077	
R_5	2.2	2.2	Ω
R_6	2.2	2.2	Ω
†††C_L	120	200	μF

*Based on an absolute maximum supply voltage of 26.5V for this circuit.

**Based on $T_{amb} = 45^{\circ}C$. These maximum values of $\Theta_{case-amb}$ include the thermal resistance of the transistor mounting.

†The P_{load} figures are at the onset of clipping and approximately 10% more output can be obtained for $D_{tot} = 10\%$.
The P_{load} figures take account of the fact that a practical power supply has a finite internal resistance. For a value of 20Ω internal resistance three values of P_{load} are given.

1. The speach and music value is the output which will be obtained when peaks occur in low level passages.
2. The sustained music value is the equivalent sinewave power output which will be obtained during sustained high level passages of music.
3. Normal sinewave rating.

The first two values constitute a useful measure of the power output capability of the circuit. The sinewave value is quoted because it is load power which will be obtained when, for test purposes, the equipment is driven with a sinewave because of the internal resistance of the power supply, the dissipations with sinewave drive are lower than with a constant line voltage. The thermal resistances required are given assuming these lower dissipations. The value of the supply impedance is, therefore, important and the regulation should not be improved without making compensating changes in the thermal resistance Θ_{j-amb}.

††Preset to give $I_q = 3.0mA$ at $T_{amb} = 25^{\circ}C$.

†††Value of C_L for L.F. response -3.0dB at 50c/s. The results obtained are with a series resistance of $C_L \leq 1.0\Omega$.

CHARACTERISTICS FOR MATCHED PAIR

$\frac{h_{FEL1}}{h_{FEL2}}$	Ratio of large signal forward current transfer ratio of the two transistors $I_E = 500mA$, $V_{CB} = 0$	<1.2

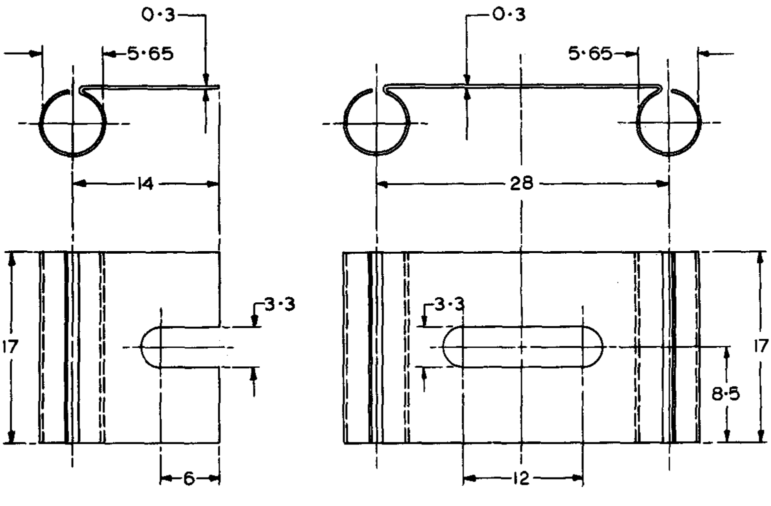
SOLDERING AND WIRING RECOMMENDATIONS

1. When using a soldering iron, transistors may be soldered directly into the circuit, but heat conducted to the junction should if possible be kept to a minimum by the use of a thermal shunt.

2. Transistors may be dip-soldered at a solder temperature of 245°C for a maximum soldering time of 5 seconds. The case temperature during dip-soldering may exceed the maximum storage temperature for a period not greater than 2 minutes, provided that it at no time exceeds 115°C. These recommendations apply to a transistor mounted flush on a board having punched-through holes, or spaced at least 1.5mm away from a board having plated-through holes.

3. Care should be taken not to bend the leads nearer than 1.5mm from the seal.

OUTLINE AND DIMENSIONS OF COOLING CLIP



Nominal dimensions in mm

Type a
Part No.56227

Type b.
Part No.56226

NOTE - Fitting of cooling clips
To ensure good thermal contact with the transistor envelope, the cooling clips should not be distorted by forcing it over the "belling" at the base of the transistors.

N-P-N GERMANIUM MEDIUM POWER TRANSISTOR

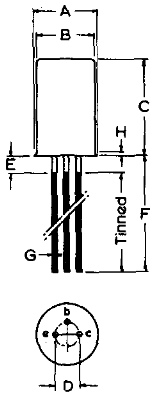
AC176

Germanium n-p-n high gain alloy junction transistor for audio applications. Primarily intended for use in mains operated audio amplifiers with class 'B' output stages.

QUICK REFERENCE DATA		
V_{CB} max. ($I_E = 0$)	32	V
V_{CE} max. (cut-off)	32	V
I_{CM} max.	1.0	A
P_{tot} max.	700	mW
h_{FE} (I_E = -500mA, V_{CB} = 0)	52-180	
f_{hfe} (I_E = -10mA, V_{CB} = 2.0V)	>10	kc/s

OUTLINE AND DIMENSIONS

Conforming to J.E.D.E.C. TO-1
V.A.S.C.A. SO-21/SB3-10



Millimetres	Min.	Nom.	Max.
A	-	-	6.5
B	-	-	6.1
C	-	-	9.4
D	-	1.8	-
E	-	-	1.5
F	38	-	-
G	-	0.43	-

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

V_{CBM} max. ($I_E = 0$)	32	V
V_{CEM} max. (cut-off)	32	V
V_{CEM} max. ($I_C = 0.5A$, $R_B = 27\Omega$, $R_E = 2.2\Omega$)	25.5	V
V_{CEM} max. ($I_B = 0$, $T_j \leq 55^oC$, see page C6)	20	V
V_{EBM} max.	5.0	V
I_C max.	1.0	A
*$I_{C(AV)}$ max.	350	mA
I_{BM} max.	40	mA
*$I_{B(AV)}$ max.	40	mA
P_{tot} max.	700	mW

*Maximum averaging time = 20ms

Temperature

T_{stg} min.	-55	^oC
T_{stg} max.	75	^oC
T_j max. (continuous operation)	90	^oC

THERMAL CHARACTERISTICS

θ_{j-case}		40	deg C/W
θ_{j-amb}	(in free air)	300	deg C/W
θ_{j-amb}	(in free air with cooling clips as on page D4)	150	deg C/W
θ_{j-amb}	(with cooling clip mounted on heatsink of at least $12.5cm^2$)	80	deg C/W

N-P-N GERMANIUM MEDIUM POWER TRANSISTOR

AC176

ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise stated)

		Min.	Typ.	Max.	
I_{CBO}	Collector cut-off current				
	V_{CB} = 10V, I_E = 0	-	12.5	30	μA
	V_{CB} = 10V, I_E = 0, T_j = 90°C	-	1.2	2.75	mA
I_B	Base current				
	V_{CB} = 0, I_E = -0.5A	2.8	-	9.5	mA
I_{EBO}	Emitter cut-off current				
	V_{EB} = 5.0V, I_C = 0, T_j = 90°C	-	-	2.25	mA
V_{BE}	Base-emitter voltage				
	V_{CB} = 10V, I_E = -5.0mA	120	135	150	mV
	V_{CB} = 0, I_E = -0.5A	-	-	650	mV
	V_{CB} = 0, I_E = -1.0A	-	-	1.1	V
$V_{CE(knee)}$	Collector-emitter knee voltage				
	I_C = 800mA	-	500	650	mV
h_{FE}	Large signal forward current transfer ratio				
	I_E = -50mA, V_{CB} = 0	52	-	-	
	I_E = -500mA, V_{CB} = 0	52	100	180	
	I_E = -1.0A, V_{CB} = 0	45	83	165	
f_{hfe}	Common emitter cut-off frequency	10	-	-	kc/s
	Small signal loaded common emitter forward current transfer ratio linearity				
	V_{CE} = 14V, R_L = 16Ω				
	$\frac{A_i \text{ at } I_C = 0.75A}{A_i \text{ max.}}$	0.33	0.42	-	
f_T	Transition frequency				
	I_E = -10mA, V_{CB} = 2.0V	1.0	-	-	Mc/s

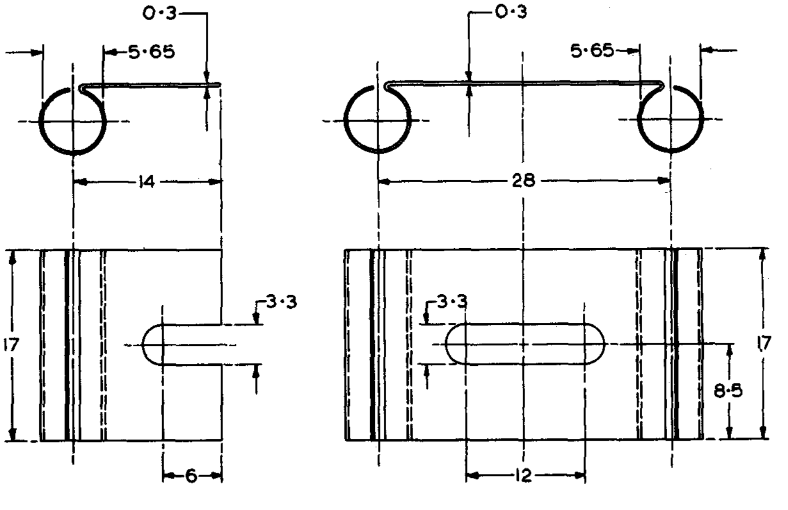
CHARACTERISTICS FOR MATCHED PAIRS OF AC176

$\frac{h_{FEL1}}{h_{FEL2}}$	Ratio of large signal forward current transfer ratio of the two transistors $I_E = -500mA, V_{CB} = 0$	-	-	1.2

SOLDERING AND WIRING RECOMMENDATIONS

1. When using a soldering iron, transistors may be soldered directly into the circuit, but heat conducted to the junction should if possible be kept to a minimum by the use of a thermal shunt.
2. Transistors may be dip-soldered at a solder temperature of 245°C for a maximum soldering time of 5 seconds. The case temperature during dip-soldering may exceed the maximum storage temperature for a period not greater than 2 minutes, provided that it at no time exceeds 115°C. These recommendations apply to a transistor mounted flush on a board having punched-through holes, or spaced at least 1.5mm away from a board having plated-through holes.
3. Care should be taken not to bend the leads nearer than 1.5mm from the seal.

OUTLINE AND DIMENSIONS OF COOLING CLIP



Nominal dimensions in mm

Type a. Part No.56227

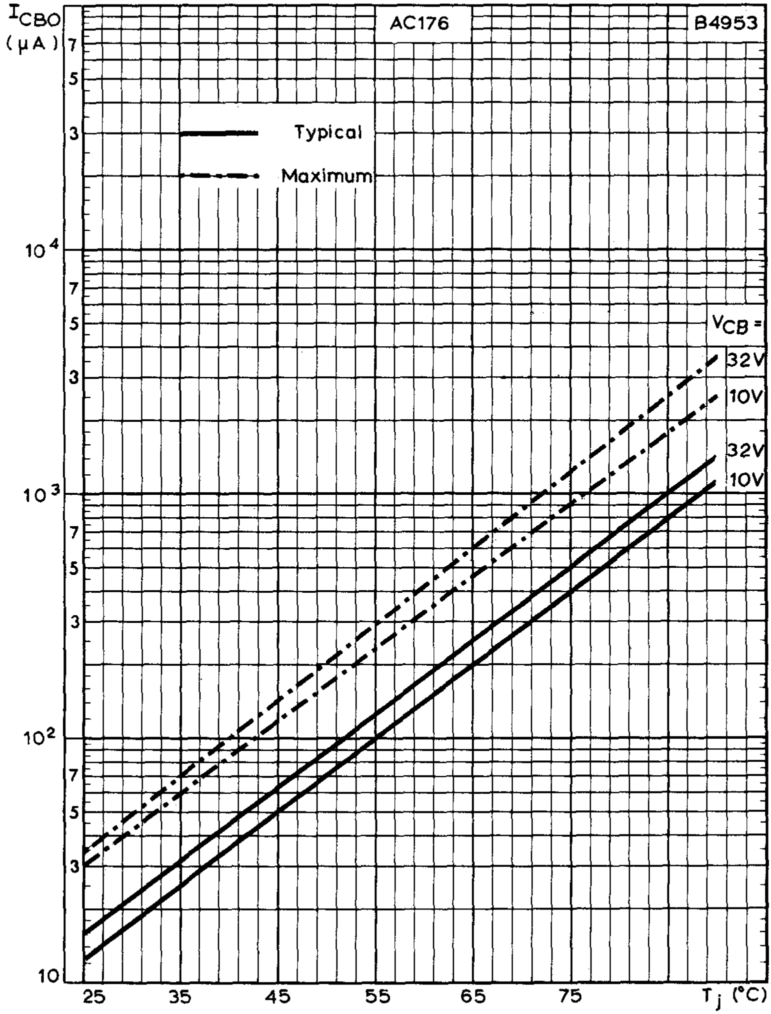
Type b. Part No.56226

NOTE - *Fitting of cooling clip*

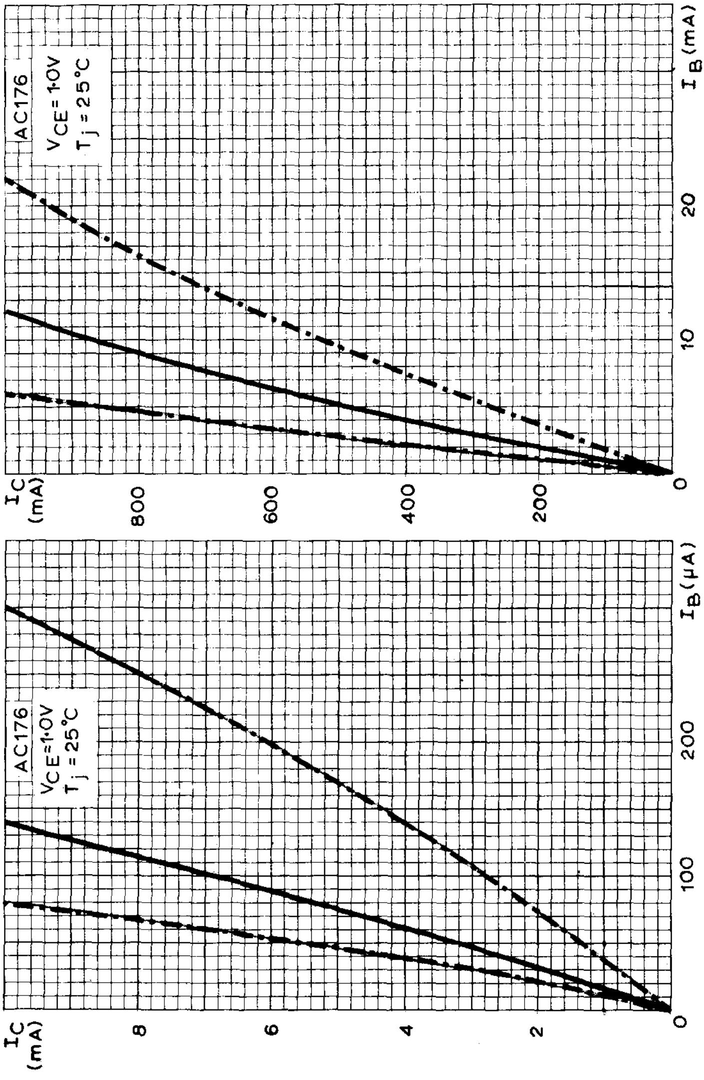
To ensure good thermal contact with the transistor envelope, the cooling clips should not be distorted by forcing it over the "belling" at the base of the transistor.

N-P-N GERMANIUM MEDIUM POWER TRANSISTOR

AC176



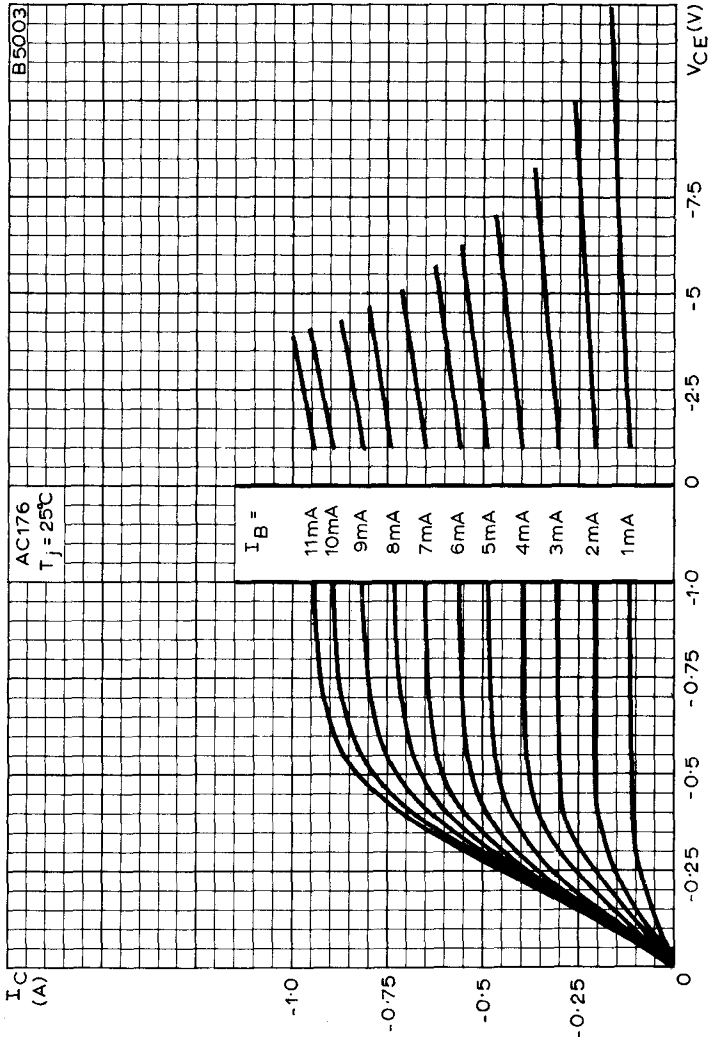
COLLECTOR CUT-OFF CURRENT PLOTTED AGAINST JUNCTION TEMPERATURE WITH COLLECTOR-BASE VOLTAGE AS A PARAMETER



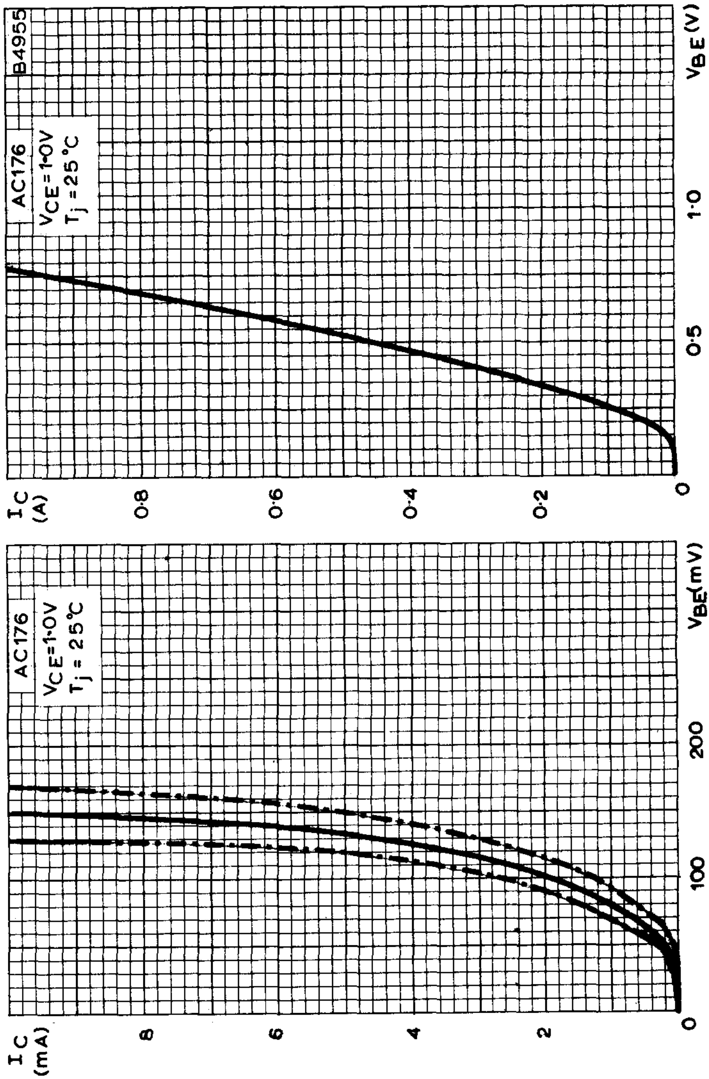
TRANSFER CHARACTERISTICS FOR LOW AND HIGH COLLECTOR CURRENTS

N-P-N GERMANIUM MEDIUM POWER TRANSISTOR

AC176



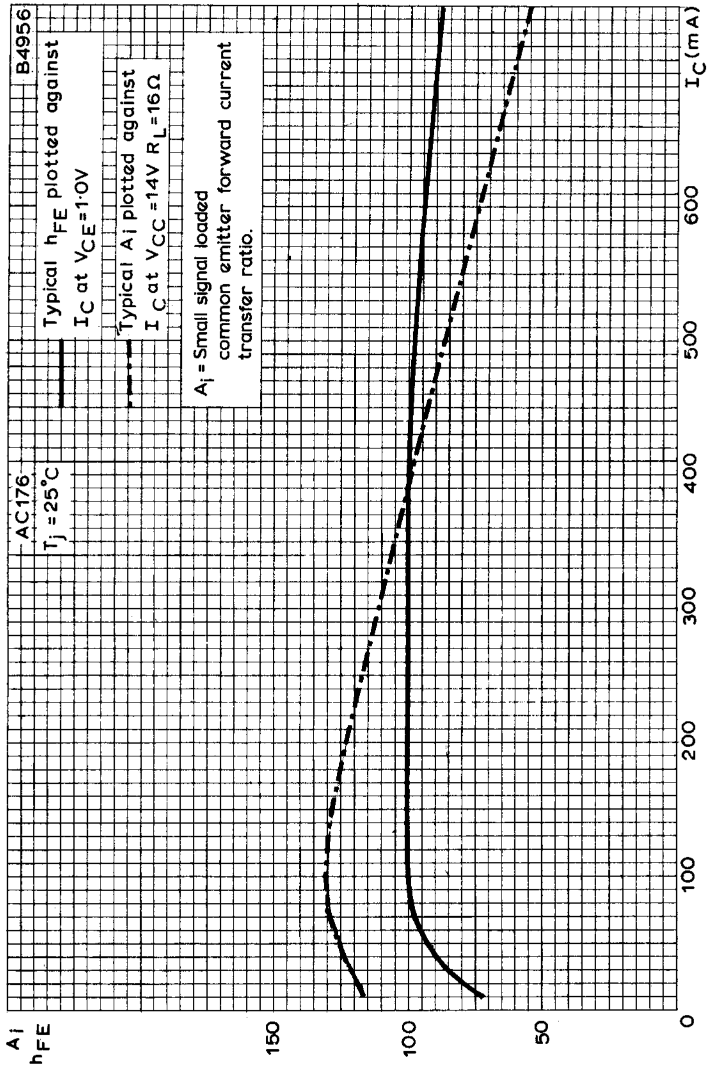
TYPICAL OUTPUT CHARACTERISTICS. $T_j = 25^oC$



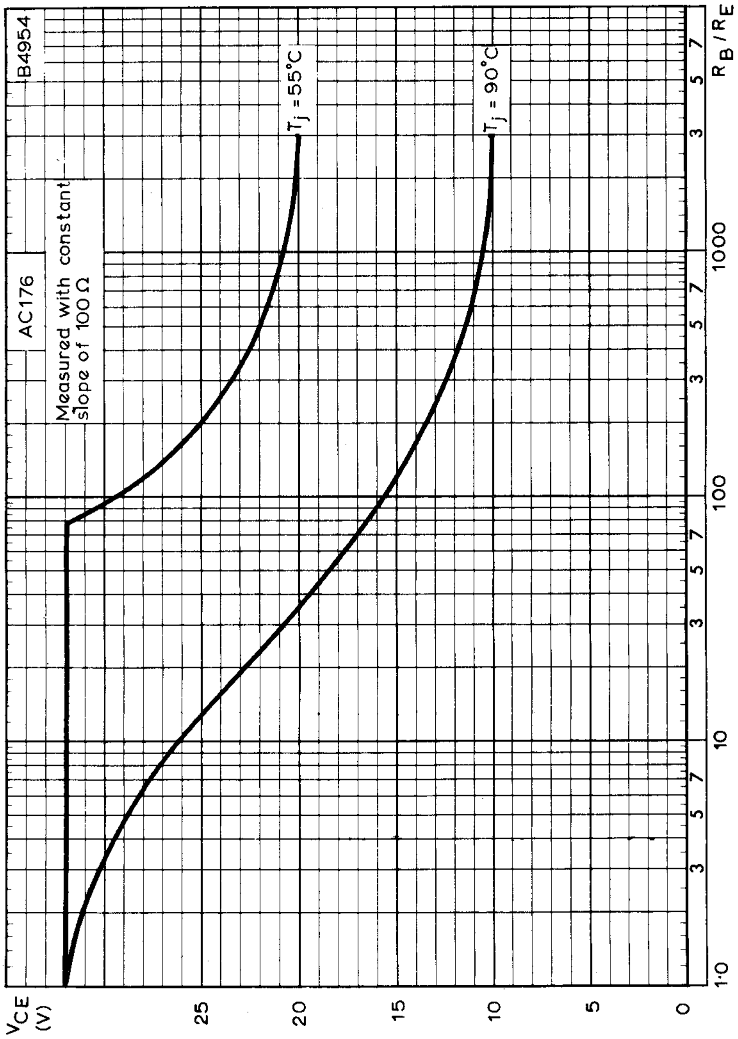
INPUT CHARACTERISTICS FOR LOW AND HIGH COLLECTOR CURRENTS

N-P-N GERMANIUM MEDIUM POWER TRANSISTOR

AC176



TYPICAL LARGE SIGNAL FORWARD CURRENT TRANSFER RATIO AND TYPICAL LOADED SMALL SIGNAL FORWARD CURRENT TRANSFER RATIO PLOTTED AGAINST COLLECTOR CURRENT



MAXIMUM COLLECTOR-EMITTER VOLTAGE PLOTTED AGAINST RATIO OF R_B/R_E

N-P-N GERMANIUM MEDIUM POWER TRANSISTORS

AC187 AC187/01

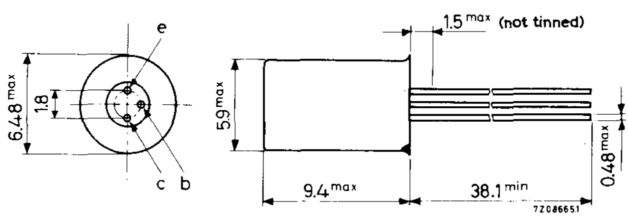
The AC187 is an n-p-n alloy junction medium power audio transistor in a TO-1 metal envelope. Primarily intended for use together with the p-n-p transistor AC188 as a matched pair AC187/AC188 in complementary class B output stages with output power up to 3W.
The AC187/01 is electrically equivalent to the AC187, constructed integrally with a heat conducting block.
The AC187/01 is also available as a matched pair with the AC188/01.

QUICK REFERENCE DATA			
V_{CBO}	max.	25	V
V_{CEO}	max.	15	V
I_{CM}	max.	2.0	A
P_{tot}	max. ($T_{amb} \leq 35^{o}C$)	1.0	W
T_j	max.	90	^{o}C
h_{FE}	($I_C = 300mA$, $V_{CE} = 1V$)	100-500	
f_{hfe}	typ. ($I_C = 10mA$, $V_{CE} = 2V$)	20	kHz

OUTLINE AND DIMENSIONS (see also page 2)

Conforming to BS3934 SO-21/SB3-10
J.E.D.E.C. TO-1

AC187



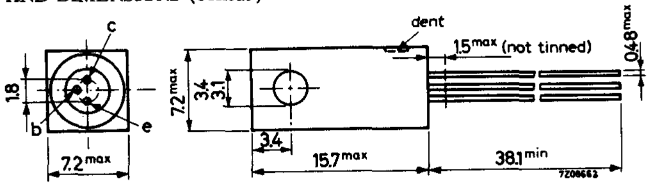
All dimensions in mm

The coloured dot indicates the collector

Accessories available: 56226, 56227

OUTLINE AND DIMENSIONS (contd.)

AC187/01



All dimensions in mm

The dent indicates the collector

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

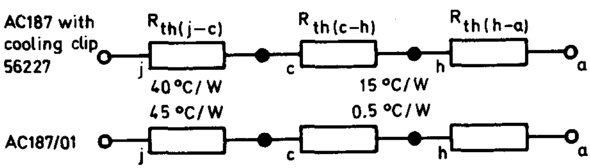
V_{CBO} max.	25	V
V_{CEO} max.	15	V
V_{CER} max. ($I_C \leq 600$mA, $R_{BE} \leq 1\Omega$)	18	V
V_{EBO} max.	10	V
I_C max. (d.c. or averaged over any 50ms period)	1.0	A
I_{CM} max. (peak)	2.0	A
P_{tot} max. ($T_{amb} \leq 35^{o}$C, see also graph on page 5)	1.0	W

Temperature

T_{stg}	-55 to +75	^{o}C
T_j max.	90	^{o}C

THERMAL CHARACTERISTICS

		AC187	AC187/01	
$R_{th(j-a)}$	Thermal resistance from junction to ambient in free air			
	without cooling clip	290	180	^{o}C/W
	with cooling clip 56227	140	-	^{o}C/W
	with cooling clip 56227 on 1.5mm blackened aluminium heatsink of 12.5cm^2	80	70.5	^{o}C/W
	with cooling clip 56227 on infinite heatsink	55	-	^{o}C/W
$R_{th(j-c)}$	Thermal resistance from junction to case	40	45	^{o}C/W

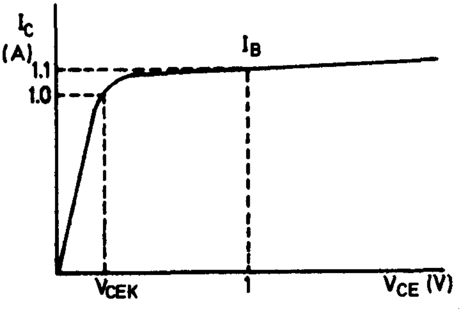


N-P-N GERMANIUM MEDIUM POWER TRANSISTORS

AC187 AC187/01

ELECTRICAL CHARACTERISTICS ($T_j = 25^oC$ unless otherwise stated)

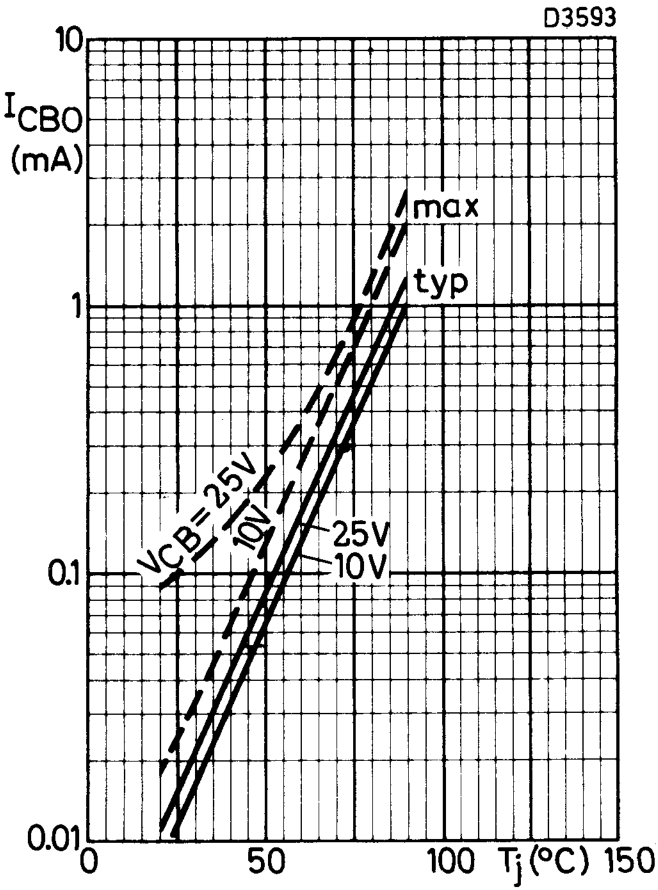
		Min.	Typ.	Max.	
	Collector cut-off current				
I_{CBO}	$I_E = 0,\ V_{CB} = 25V$	-	15	100	μA
I_{CBO}	$I_E = 0,\ V_{CB} = 25V,\ T_j = 90^oC$	-	-	2.5	mA
I_{CEX}	$-V_{BE} = 1.0V,\ V_{CE} = 25V$	-	-	100	μA
I_{EBO}	Emitter cut-off current				
	$I_C = 0,\ V_{EB} = 10V$	-	15	100	μA
	$I_C = 0,\ V_{EB} = 10V,\ T_j = 90^oC$	-	1.2	2.5	mA
V_{BE}	Base-emitter voltage				
	$I_C = 5.0mA,\ V_{CE} = 10V$	95	-	135	mV
	$I_C = 300mA,\ V_{CE} = 1.0V$	-	-	550	mV
$V_{EB(fl)}$	Emitter-base floating voltage				
	$I_E = 0,\ V_{CB} = 25V,\ T_j = 90^oC$	-	-	400	mV
V_{CEK}	Collector knee voltage				
	$I_C = 1.0A,\ I_B =$ the value for which $I_C = 1.1A$ at $V_{CE} = 1.0V$	-	-	800	mV

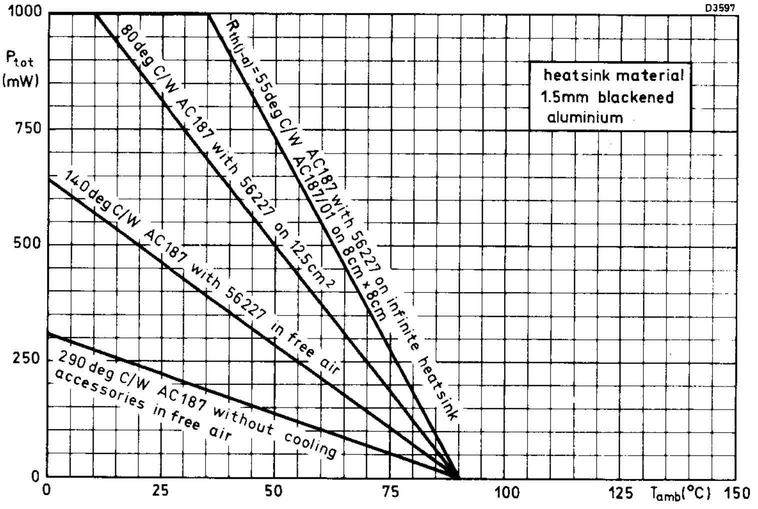


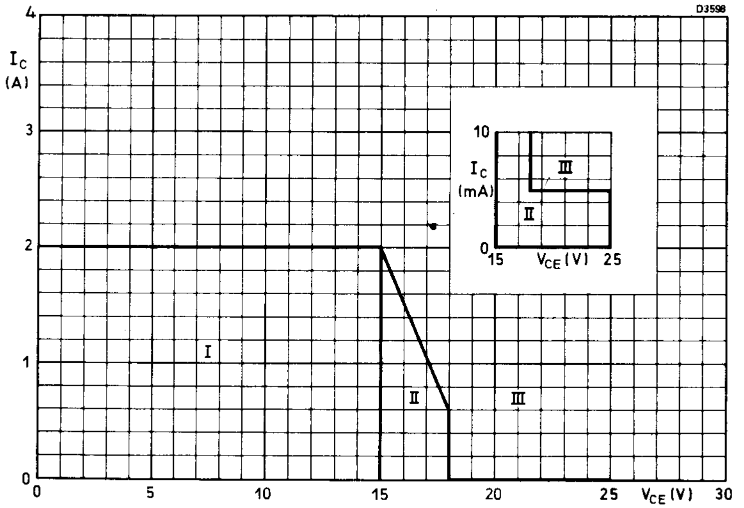
		Min.	Typ.	Max.
h_{FE}	Static forward current transfer ratio			
	$I_C = 5.0mA,\ V_{CE} = 10V$	70	-	-
	$I_C = 300mA,\ V_{CE} = 1.0V$	100	200	500
	$I_C = 1.0A,\ V_{CE} = 1.0V$	50	-	-

ELECTRICAL CHARACTERISTICS (contd.)

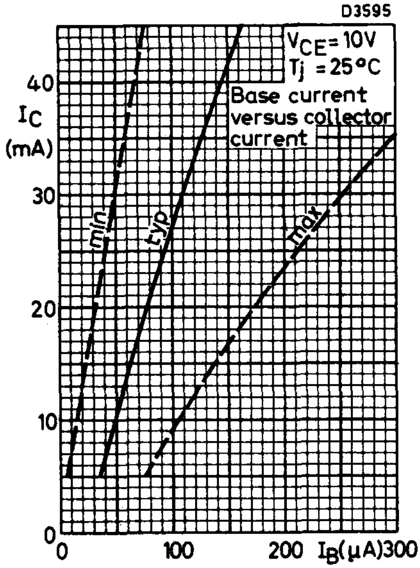
		Min.	Typ.	Max.	
f_T	Transition frequency $I_C = 10mA$, $V_{CE} = 2.0V$	1.0	5.0	-	MHz
f_{hfe}	Cut-off frequency $I_C = 10mA$, $V_{CE} = 2.0V$	-	20	-	kHz
C_{Tc}	Collector capacitance $I_E = I_e = 0$, $V_{CB} = 5.0V$, $f = 450kHz$	-	150	180	pF
$\frac{h_{FE1}}{h_{FE2}}$	D.C. current gain ratio of matched pairs AC187/AC188, AC187/01/AC188/01 $\lvert I_C \rvert = 500mA$, $\lvert V_{CE} \rvert = 1.0V$	-	-	1.25	

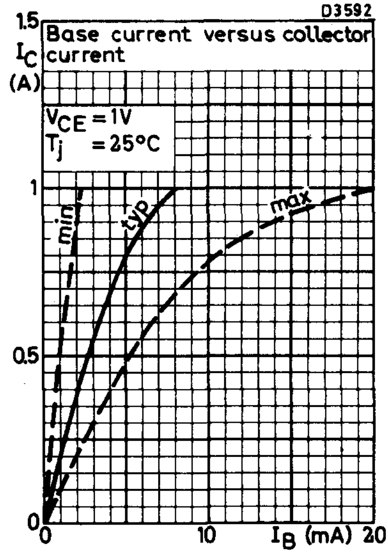


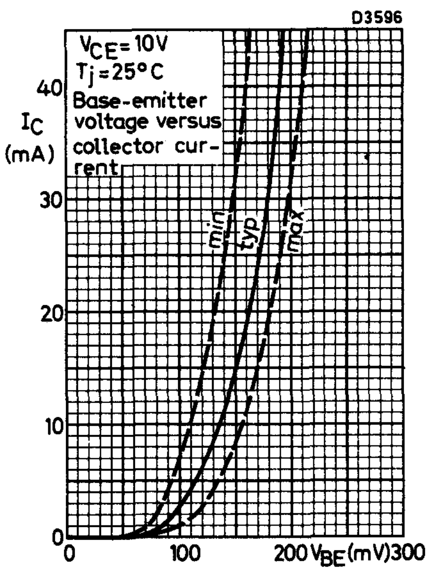


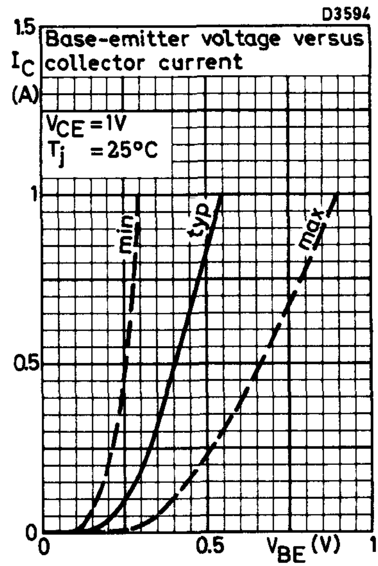


I = Region of permissible operation under all base-emitter conditions
II = Additional region of operation when the transistor is cut-off
III = Outside regions I and II, the transistor can withstand transient energies of 1.0mWs, provided it is cut-off with $V_{EB(fl)} > 0.6V$


D3595
V_{CE} = 10V
T_j = 25°C
Base current versus collector current
min
typ
max
I_C (mA)
40
30
20
10
0
0
100
200
I_B (μA) 300


D3592
Base current versus collector current
V_{CE} = 1V
T_j = 25°C
min
typ
max
I_C (A)
1.5
1
0.5
0
0
10
I_B (mA) 20


D3596
V_{CE} = 10V
T_j = 25°C
Base-emitter voltage versus collector current
min
typ
max
I_C (mA)
40
30
20
10
0
0
100
200 V_{BE} (mV) 300


D3594
Base-emitter voltage versus collector current
V_{CE} = 1V
T_j = 25°C
min
typ
max
I_C (A)
1.5
1
0.5
0
0
0.5
V_{BE} (V)
1

P-N-P GERMANIUM MEDIUM POWER TRANSISTORS

AC188 AC188/01

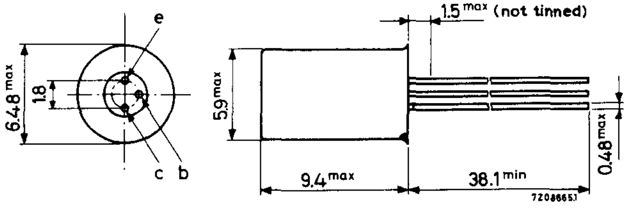
The AC188 is a p-n-p alloy junction medium power audio transistor in a TO-1 metal envelope. Primarily intended for use as a matched pair 2-AC188 or together with the AC187 as a matched pair in complementary class B output stages with output power up to 3W.
The AC188/01 is electrically equivalent to the AC188, constructed integrally with a heat conducting block. It is also available as a matched pair with the AC187/01 or as 2-AC188/01.

QUICK REFERENCE DATA		
$-V_{CBO}$ max.	25	V
$-V_{CEO}$ max.	15	V
$-I_{CM}$ max.	2.0	A
P_{tot} max. ($T_{amb} \leq 35^oC$)	1.0	W
T_j max.	90	^oC
h_{FE} ($-I_C = 300mA$, $-V_{CE} = 1V$)	100 to 500	
f_{hfe} typ. ($-I_C = 10mA$, $-V_{CE} = 2V$)	10	kHz

OUTLINE AND DIMENSIONS (see also page 2)

Conforming to BS 3934 SO-21/SB3-10
J.E.D.E.C. TO-1

AC188



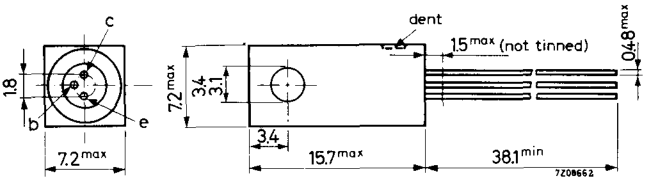
All dimensions in mm

The coloured dot indicates the collector

Accessories available: 56226, 56227

OUTLINE AND DIMENSIONS (contd.)

AC188/01



All dimensions in mm
The dent indicates the collector

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

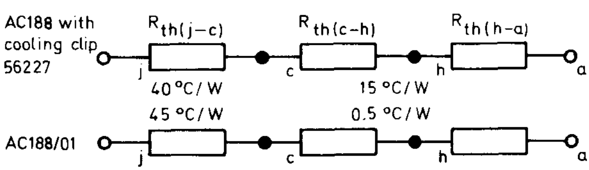
$-V_{CBO}$ max.	25	V
$-V_{CEO}$ max.	15	V
$-V_{CER}$ max. ($-I_C \leq 600$mA, $R_{BE} \leq 1\Omega$)	18	V
$-V_{EBO}$ max.	10	V
$-I_C$ max. (d.c. or averaged over any 50ms period)	1.0	A
$-I_{CM}$ max. (peak)	2.0	A
P_{tot} max. ($T_{amb} \leq 35^oC$, see also graph on page 5)	1.0	W

Temperature

T_{stg}	-55 to +75	^oC
T_j max.	90	^oC

THERMAL CHARACTERISTICS

		AC188	AC188/01	
$R_{th(j-a)}$	Thermal resistance from junction to ambient in free air			
	without cooling clip	290	180	$^oC/W$
	with cooling clip 56227	140	-	$^oC/W$
	with cooling clip 56227 on 1.5mm blackened aluminium heatsink of 12.5cm^2	80	70.5	$^oC/W$
	with cooling clip 56227 on infinite heatsink	55	-	$^oC/W$
$R_{th(j-c)}$	Thermal resistance from junction to case	40	45	$^oC/W$

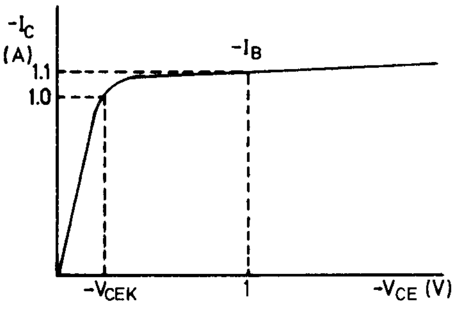


P-N-P GERMANIUM MEDIUM POWER TRANSISTORS

AC188 AC188/01

ELECTRICAL CHARACTERISTICS ($T_j = 25^oC$ unless otherwise stated)

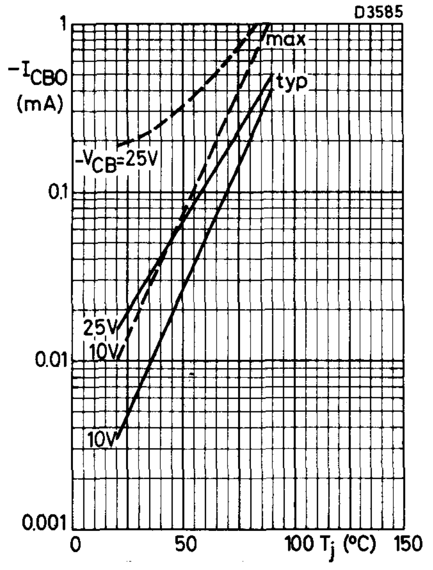
		Min.	Typ.	Max.	
	Collector cut-off current				
$-I_{CBO}$	$I_E = 0$, $-V_{CB} = 25V$	-	20	200	μA
$-I_{CBO}$	$I_E = 0$, $-V_{CB} = 25V$, $T_j = 90^oC$	-	-	1.4	mA
$-I_{CEX}$	$+V_{BE} = 1.0V$, $-V_{CE} = 25V$	-	-	200	μA
$-I_{EBO}$	Emitter cut-off current				
	$I_C = 0$, $-V_{EB} = 10V$	-	15	200	μA
	$I_C = 0$, $-V_{EB} = 10V$, $T_j = 90^oC$	-	0.4	1.4	mA
$-V_{BE}$	Base-emitter voltage				
	$-I_C = 5.0mA$, $-V_{CE} = 10V$	115	-	145	mV
	$-I_C = 300mA$, $-V_{CE} = 1.0V$	-	-	450	mV
$-V_{EB(fl)}$	Emitter-base floating potential				
	$I_E = 0$, $-V_{CB} = 25V$, $T_j = 90^oC$	-	-	400	mV
$-V_{CEK}$	Collector knee voltage				
	$-I_C = 1.0A$, $-I_B$ = the value for which $-I_C = 1.1A$ at $-V_{CE} = 1.0V$	-	-	600	mV

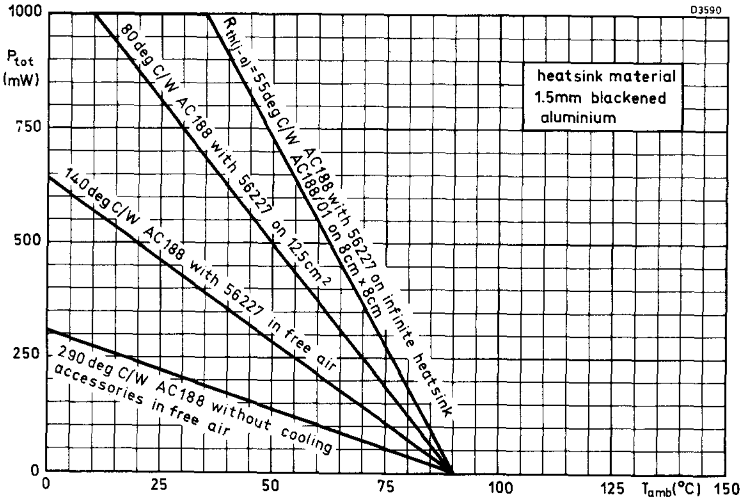


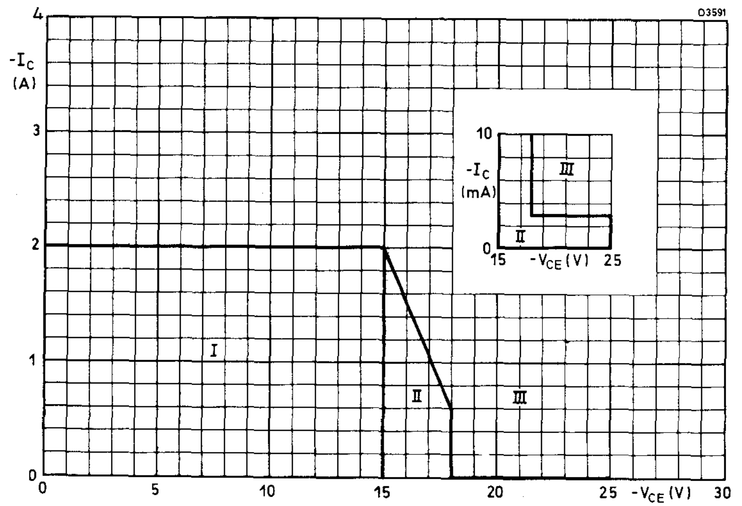
		Min.	Typ.	Max.
h_{FE}	Static forward current transfer ratio			
	$-I_C = 5.0mA$, $-V_{CE} = 10V$	70	-	-
	$-I_C = 300mA$, $-V_{CE} = 1.0V$	100	200	500
	$-I_C = 1.0A$, $-V_{CE} = 1.0V$	80	-	-

ELECTRICAL CHARACTERISTICS (contd.)

		Min.	Typ.	Max.	
f_T	Transition frequency $-I_C = 10mA$, $-V_{CE} = 2.0V$	1.0	1.5	-	MHz
f_{hfe}	Cut-off frequency $-I_C = 10mA$, $-V_{CE} = 2.0V$	-	10	-	kHz
C_{Tc}	Collector capacitance $I_E = I_e = 0$, $-V_{CB} = 5.0V$, $f = 450kHz$	-	90	110	pF
$\frac{h_{FE1}}{h_{FE2}}$	D.C. current gain ratio of matched pairs AC187/AC188; AC187/01/AC188/01				
	$\lvert I_C \rvert = 500mA$, $\lvert V_{CE} \rvert = 1.0V$	-	-	1.25	
	matched pairs 2-AC188; 2-AC188/01				
	$-I_C = 50mA$ $-V_{CE} = 1.0V$	-	-	1.25	
	$-I_C = 500mA$, $-V_{CE} = 1.0V$	-	-	1.25	



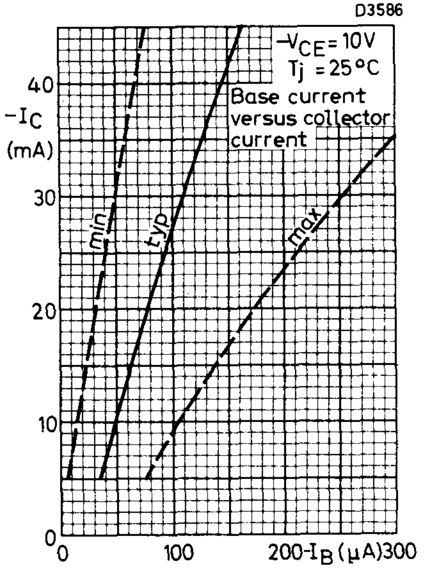


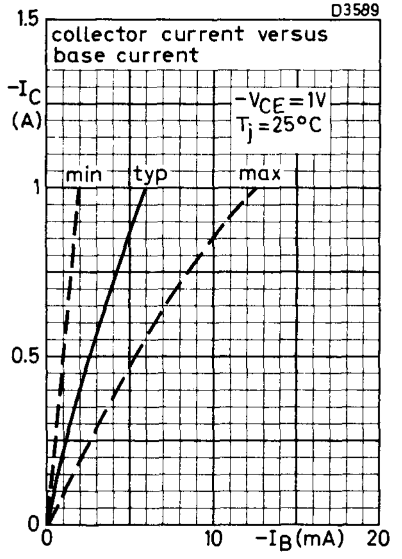


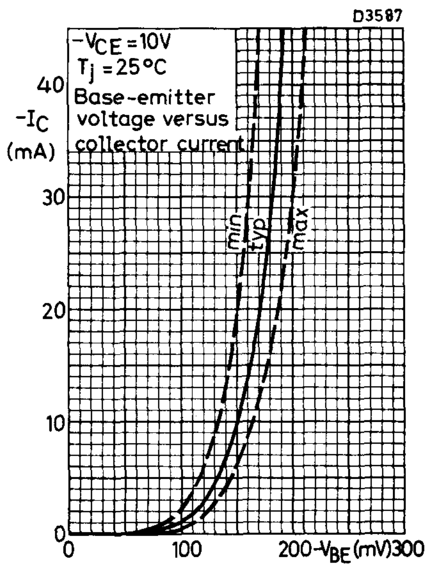
I = Region of permissible operation under all base-emitter conditions

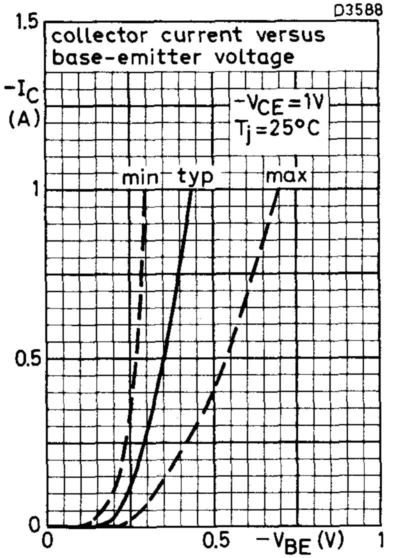
II = Additional region of operation when the transistor is cut-off

III = Outside regions I and II, the transistor can withstand transient energies of 1.0mWs, provided it is cut-off with $-V_{EB(fl)} > -0.6V$


D3586
$-V_{CE}$ = 10V
T_j = 25°C
Base current versus collector current
$-I_C$ (mA)
0
10
20
30
40
min
typ
max
0
100
200
300
$-I_B$ (µA)


D3589
collector current versus base current
$-I_C$ (A)
$-V_{CE}$ = 1V
T_j = 25°C
0
0.5
1
1.5
min
typ
max
0
10
20
$-I_B$ (mA)


D3587
$-V_{CE}$ = 10V
T_j = 25°C
Base-emitter voltage versus collector current
$-I_C$ (mA)
0
10
20
30
40
min
typ
max
0
100
200
300
$-V_{BE}$ (mV)


D3588
collector current versus base-emitter voltage
$-I_C$ (A)
$-V_{CE}$ = 1V
T_j = 25°C
0
0.5
1
1.5
min
typ
max
0
0.5
1
$-V_{BE}$ (V)

GERMANIUM P-N-P L.F. POWER TRANSISTOR

AD149
2-AD149

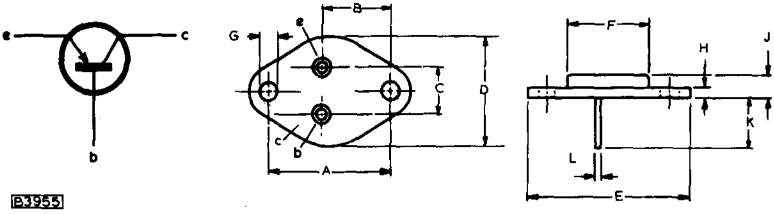
Germanium p-n-p alloy junction transistor in TO-3 metal case, primarily intended for use in class B push-pull output stages with a power output up to 20W and frame deflection output stages.

QUICK REFERENCE DATA		
V_{CB} max.	-50	V
V_{CE} max.	-50	V
I_{CM} max.	3.5	A
h_{FE} (I_C = 1.0A)	30 - 100	
f_{hfe} (I_C = 500mA, V_{CE} = -2.0V)	10	kc/s
P_{tot} max. (T_{amb} = 50°C)	22.5	W
T_j max. (continuous operation)	100	°C

OUTLINE AND DIMENSIONS

Conforming to J.E.D.E.C. TO-3

V.A.S.C.A. SO-5B/SB2-2



B3955

	Millimetres		Millimetres
A	30.1 ± 0.2	G	4.2 max.
B	16.9 ± 0.25	H	3.15 ± 0.25
C	10.9 ± 0.25	J	8.0 max.
D	26.2 max.	K	12.0 ± 1.0
E	39.5 max.	L	1.0 ± 0.05
F	20.3 max.		

		Min.	Typ.	Max.	
$\lvert z_{rb} \rvert$	Intrinsic base impedance				
	$I_E = 1.0mA$, $V_{CB} = -5.0V$, f = 450kc/s	-	30	-	Ω
c_{tc}	Collector depletion capacitance				
	$V_{CB} = -5.0V$, $I_E = 0$, f = 450kc/s	-	220	-	pF
c_{te}	Emitter depletion capacitance				
	$V_{EB} = -5.0V$, $I_C = 0$, f = 450kc/s	-	140	-	pF
f_T	Transition frequency				
	$I_C = 500mA$, $V_{CE} = -2.0V$	-	500	-	kc/s
f_{hfe}	Common emitter cut-off frequency				
	$I_C = 500mA$, $V_{CE} = -2.0V$	-	10	-	kc/s

Forward current transfer ratio linearity

	Min.	Typ.	Max.
$\frac{A_i \text{ at } 3.0A}{A_i \text{ at } 0.1A}$, $V_{CC} = -14V$, $R_L = 4\Omega$	0.2	0.35	-

See curve B on page C9

ELECTRICAL CHARACTERISTICS OF MATCHED PAIRS

		Min.	Typ.	Max.
$\frac{h_{FE1}}{h_{FE2}}$	Ratio of large signal forward current transfer ratio			
	$I_C = 300mA$	-	1.1	1.25
	$I_C = 3.0A$	-	1.1	1.25

GERMANIUM P-N-P L.F. POWER TRANSISTOR

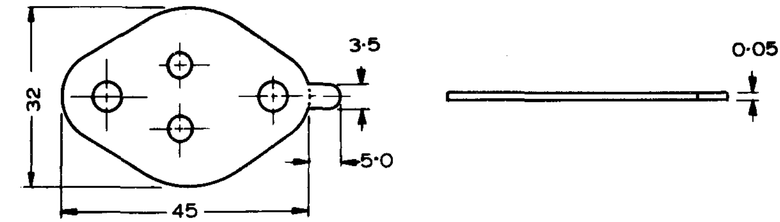
AD149 2-AD149

ACCESSORIES

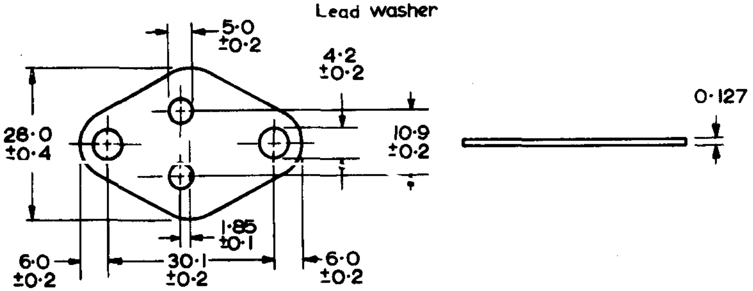
Acessories must be specifically ordered

Accessory	Code No.
Insulating bush	56201A
Mica washer	56201B
Lead washer	56214

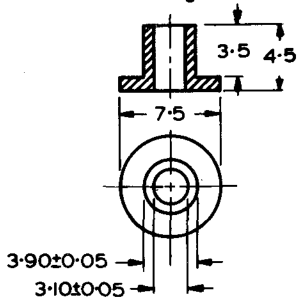
Mica washer



Lead washer

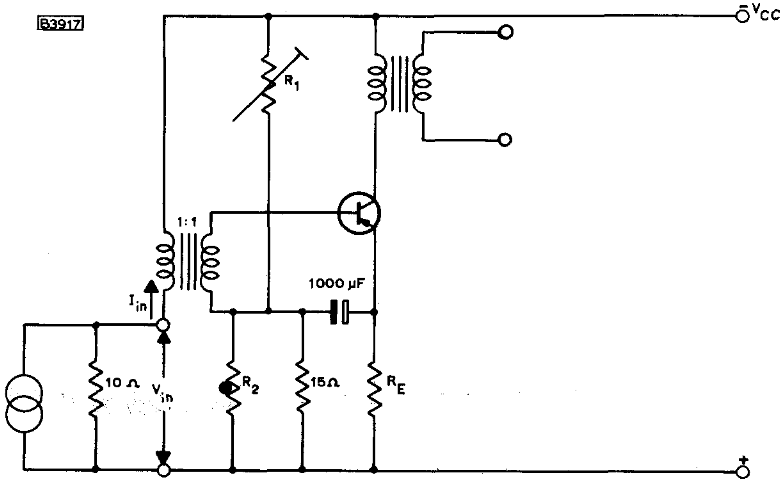


Insulating bush



All dimensions in mm

OPERATING CONDITIONS FOR A CLASS 'A' AMPLIFIER

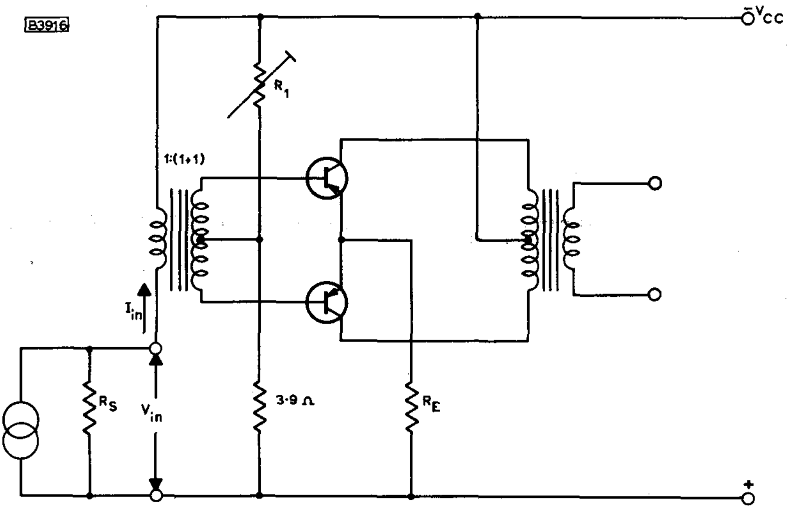


	Condition 1	Condition 2	
V_{CC} (supply voltage)	7.0 (max. 8.0)	14 (max. 16)	V
I_C (V_{in} = 0)	1.8	0.72	A
R_1	50	200	Ω
R_2	VA1034	VA1034	
R_E	0.3	0.5	Ω
R_{load}	4.0	23	Ω
P_C max. (output power of the transistor)	4.3	4.1	W
P_{out} max. (power delivered to the primary of the output transformer)	4.0	4.0	W
$v_{in(pk)}$ (P_{out} = 4.0W)	480	400	mV
$i_{in(pk)}$ (P_{out} = 4.0W)	35	12	mA
D_{tot} (P_{out} = 4.0W)	9.5	7.5	%
$i_{in(pk)}$ (P_{out} = 50mW)	2.5	1.0	mA
D_{tot} (P_{out} = 50mW)	2.5	1.5	%

NOTES

1. R_2, VA1034 should be mounted on the heatsink near the transistor.
2. Stable continuous operation is ensured up to $T_{amb} = 55^{o}C$, provided the transistor has been mounted on a 1.5mm copper heatsink of at least 18 × 18cm^2 (condition 1) or 15 × 15cm^2 (condition 2).

OPERATING CONDITIONS FOR A MATCHED PAIR 2-AD149 AS CLASS 'B' OUTPUT AMPLIFIER



	Condition 1	Condition 2	
V_{CC} (supply voltage)	7.0 (max. 8.0)	14 (max. 16)	V
I_C (V_{in} = 0)	2 × 30	2 × 30	mA
R_1	200	350	Ω
R_E	0	0.47	Ω
R_S	450	370	Ω
R_{load} (collector to collector)	9.0	16	Ω
P_C max. (output power of two transistors)	9.75	20	W
P_{out} max. (power delivered to the primary of the output transformer)	9.75	17.9	W
I_{CM} (P_{out} ≈ max.)	3.0	3.0	A
I_C (P_{out} = max.)	2 × 480	2 × 480	mA
$v_{in(pk)}$ (P_{out} = max.)	0.81	2.2	V

	Condition 1	Condition 2	
$i_{in(pk)}$ (P_{out} = max.)	75	75	mA
D_{tot} (P_{out} = max.)	10	10	%
$i_{in(pk)}$ (P_{out} = 50mW)	4.0	2.5	mA
D_{tot} (P_{out} = 50mW)	2.5	2.0	%

NOTE

Stable continuous operation is ensured up to $T_{amb} = 55^{o}C$, provided each transistor has been mounted on a 1.5mm copper heatsink of at least $5 \times 5cm^2$ (condition 1) or $6 \times 6cm^2$ (condition 2).

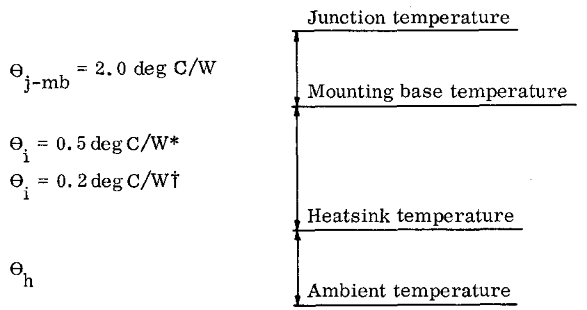
OPERATING NOTES

1. Dissipation and heatsink considerations.
The maximum total dissipation, P_{tot} max. = $(V_{CE} \times I_C) + (V_{BE} \times I_B)$ is given by the relationship:-

$$P_{tot} \text{ max.} = \frac{T_j \text{ max.} - T_{amb}}{\Theta_{j-mb} + \Theta_i + \Theta_h}$$

Where $\Theta_{j-mb} + \Theta_i + \Theta_h$ is equal to the junction temperature rise per watt above ambient.

The various components of the rise of junction temperature above ambient are illustrated below:-



*With mica insulation.

†Mounted directly on to a heatsink with thin film of silicone grease between contacting surfaces.

Θ_h depends on the cooling conditions under which the transistor is used i.e. dimensions, position and surface conditions of heatsink etc. An air-cooled heatsink (7" x 7" x 1/16" blackened aluminium) will have an approximate value of Θ_h = 2.2 deg C/W.

Θ_h can be determined for a given collector dissipation and ambient temperature by measuring the mounting base temperature.

$$\Theta_h = \frac{T_{mb} - T_{amb}}{P_{tot\ max.}} - \Theta_i \text{ deg C/W}$$

The following example illustrates the temperatures which occur at various points on the transistor at $P_{tot} = 8W$, $T_j = 90^oC$, $\Theta_h = 2.2$ deg C/W.

Transistor with mica insulation

Junction temperature = 90^oC

Mounting-base temperature = $90-(8 \times 2.0) = 74^oC$

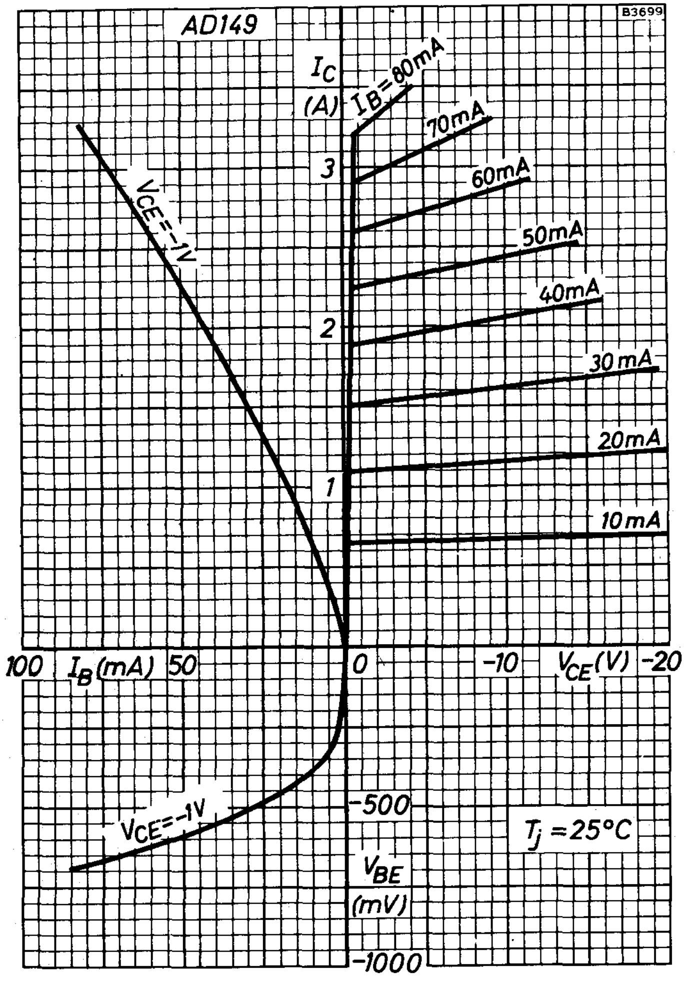
Heatsink temperature = $74-(8 \times 0.5) = 70^oC$

Ambient temperature = $70-(8 \times 2.2) = 52.4^oC$

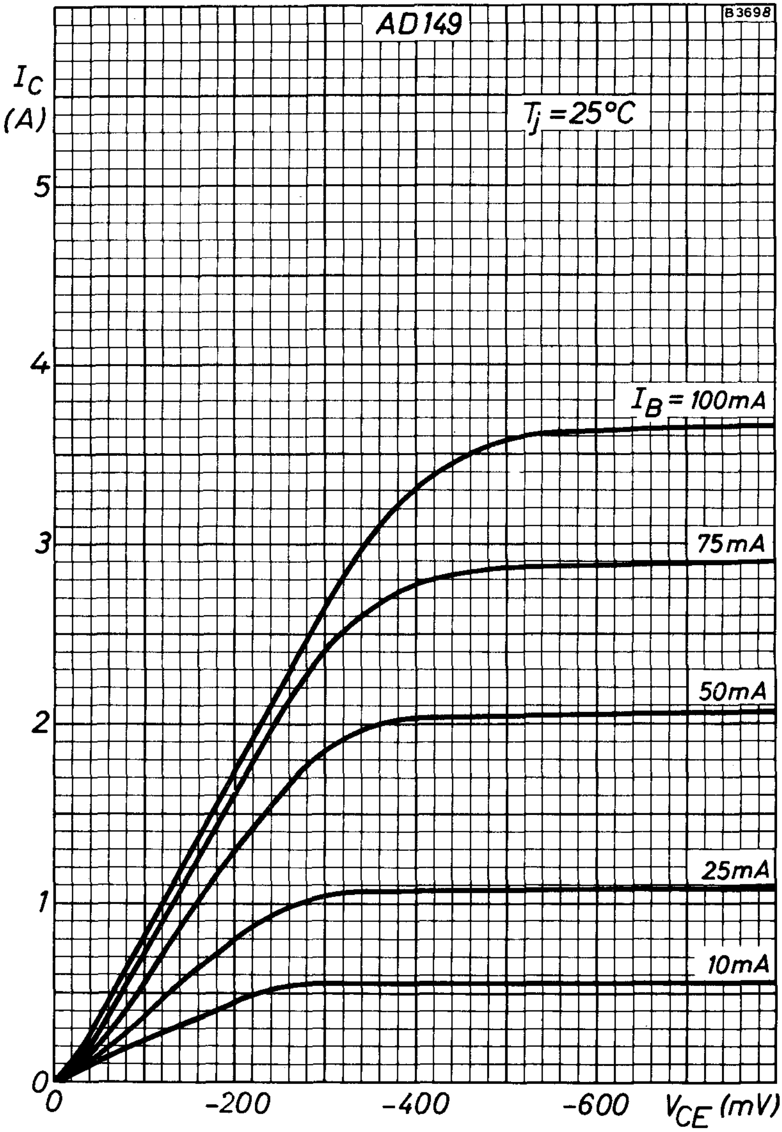
The suitability of any design can be checked by measuring with a thermocouple the mounting base temperature of the transistor operating at the selected collector dissipation and maximum ambient temperature . The point defined by the mounting-base temperature and the total dissipation must lie within the permissible area of operation on the curve on page C13. If the point lies outside this area the design is inadmissible and the dissipation must be reduced or the heatsink improved. The selected total dissipation should be the maximum attained by any transistor in the design being checked.

2. Transistors may be dip soldered at a solder temperature of 240^oC for a maximum of 10 seconds up to a point 2mm from the seal.

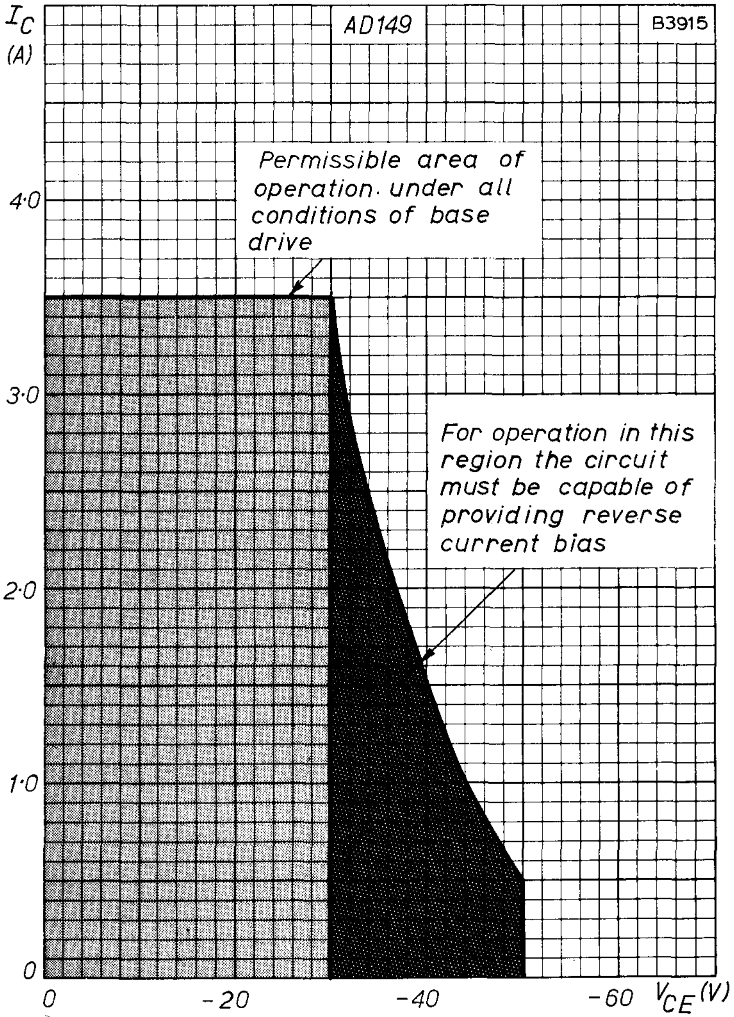
3. Care must be taken to ensure good thermal contact between the transistor and heat sink. Burrs or thickening at the edges of the four holes must be removed and the transistor bolted down on a plane surface.



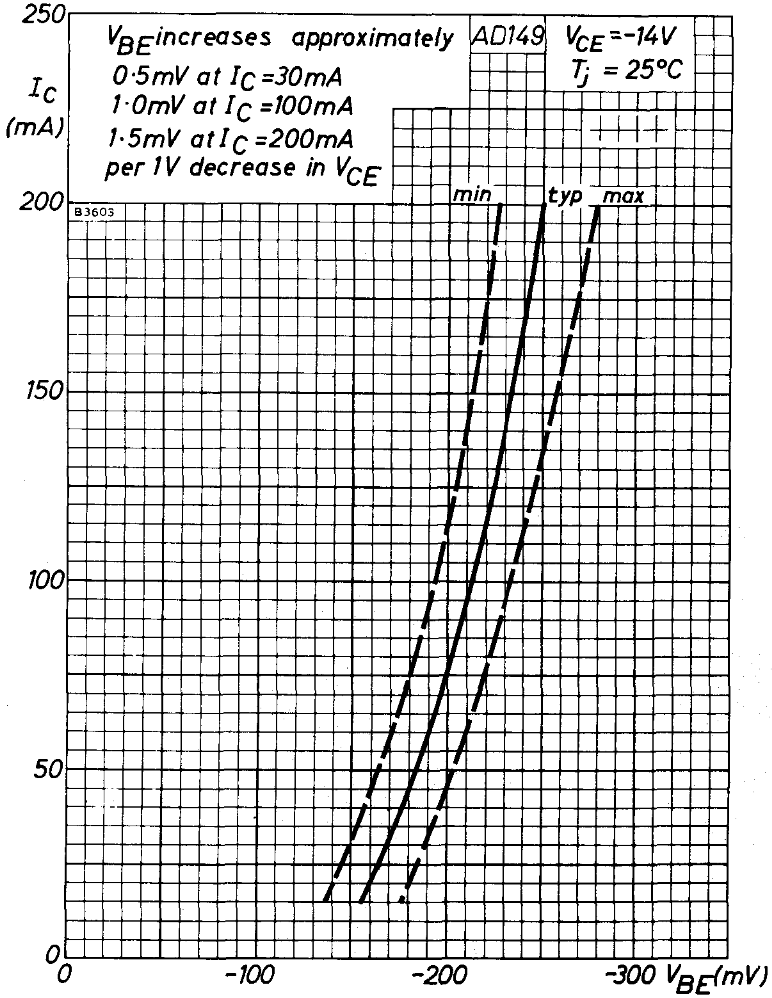
TYPICAL CHARACTERISTICS



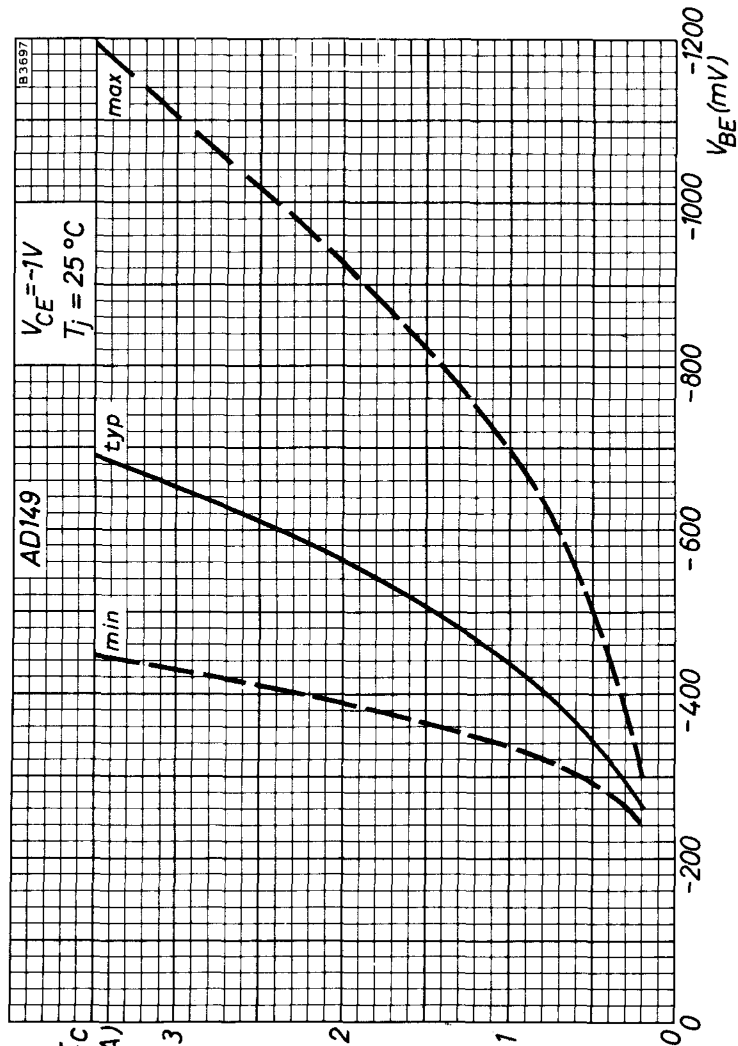
TYPICAL COMMON EMITTER OUTPUT CHARACTERISTICS



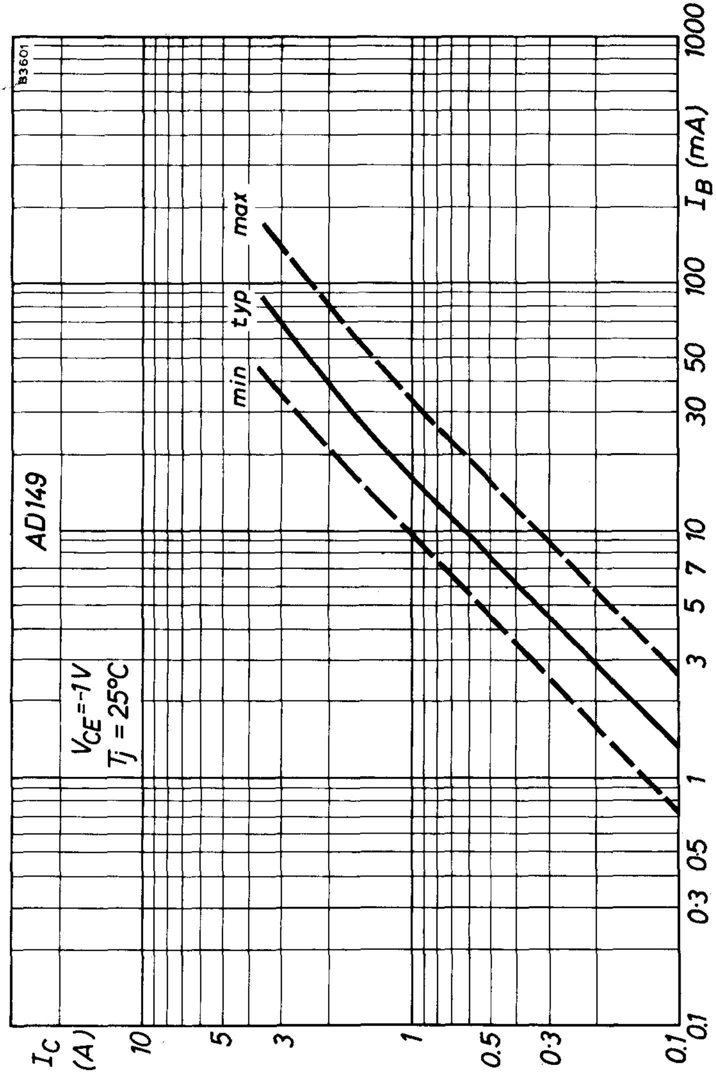
MAXIMUM COLLECTOR CURRENT PLOTTED AGAINST MAXIMUM COLLECTOR-EMITTER VOLTAGE



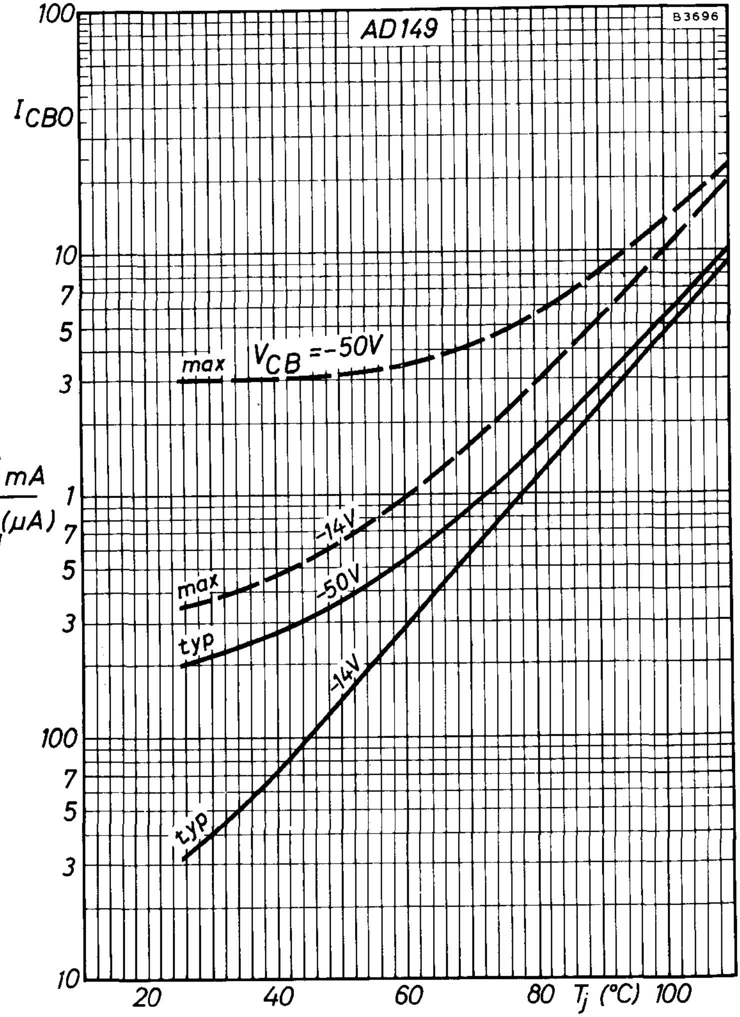
BASE-EMITTER VOLTAGE AS A FUNCTION OF COLLECTOR CURRENT



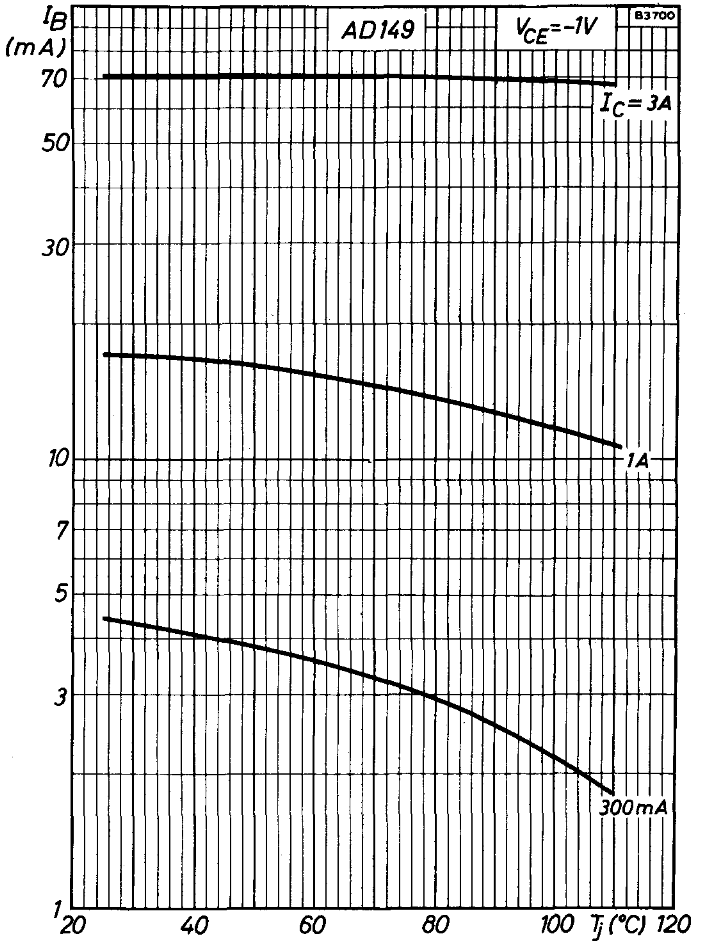
BASE-EMITTER VOLTAGE AS A FUNCTION OF COLLECTOR CURRENT



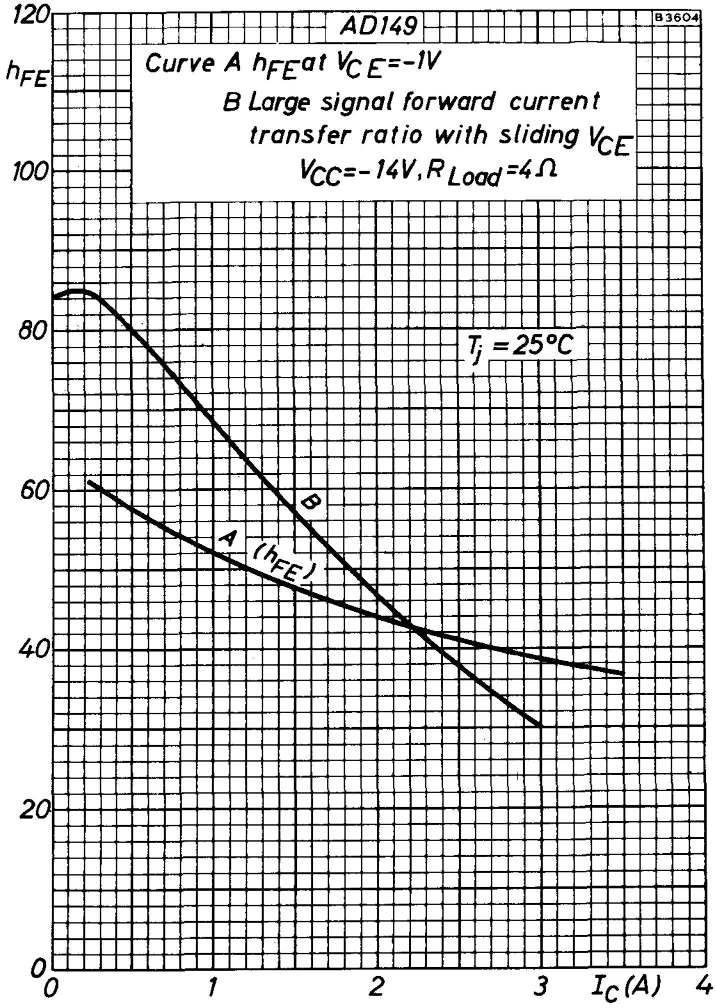
TRANSFER CHARACTERISTICS. COMMON EMITTER



VARIATION OF COLLECTOR CUT-OFF CURRENT
WITH TEMPERATURE



TYPICAL VARIATION OF BASE CURRENT WITH TEMPERATURE



CURVE A. TYPICAL FORWARD CURRENT TRANSFER RATIO PLOTTED AGAINST COLLECTOR CURRENT. $V_{CE} = -1V$.

CURVE B. TYPICAL LARGE SIGNAL FORWARD CURRENT TRANSFER RATIO PLOTTED AGAINST COLLECTOR CURRENT AT SLIDING V_{CE}, $V_{CC} = -14V$, $R_{load} = 4\Omega$.

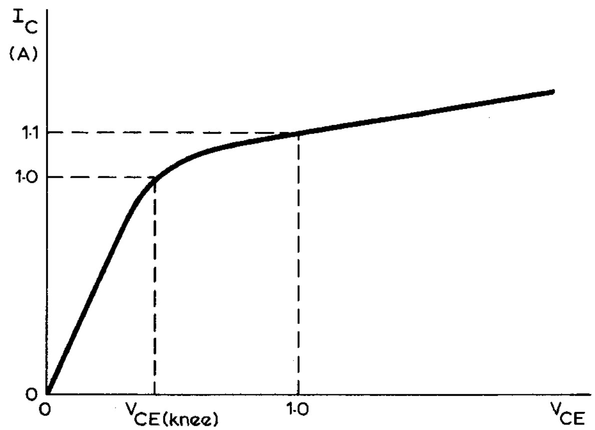
ELECTRICAL CHARACTERISTICS (cont'd)

		Min.	Typ.	Max.	
f_T	Transition frequency $V_{CE}=2.0V$, $I_C=10mA$	1.0	3.0	-	MHz
f_{hfe}	Common emitter cut-off frequency $V_{CE}=2.0V$, $I_C=300mA$	20	35	-	kHz
c_{tc}	Collector capacitance $V_{CB}=5.0V$, $I_E=I_e=0$, $f=450kHz$	-	150	-	pF

For a matched pair of AD161/AD162 the maximum value of the ratio of the static forward current transfer ratios, at I_C = 500mA and V_{CE} = 1.0V, is 1.25:1 and a typical value is 1.1:1.

NOTES

2. Collector-emitter knee voltage at $I_C=1.0A$, and at that value of I_B occurring at $I_C=1.1A$ and $V_{CE}=1.0V$.



3. V_{BE} decreases by approximately 2.0mV/degC with increasing temperature.

OPERATING NOTES

1. Dissipation and heatsink considerations:

   The maximum total dissipation, P_{tot} max. = $(V_{CE} \times I_C) + (V_{BE} \times I_B)$, is given by:

$$P_{tot}\ \text{max.} = \frac{T_j\ \text{max.} - T_{amb}}{\Theta_{j-mb} + \Theta_i + \Theta_h}$$

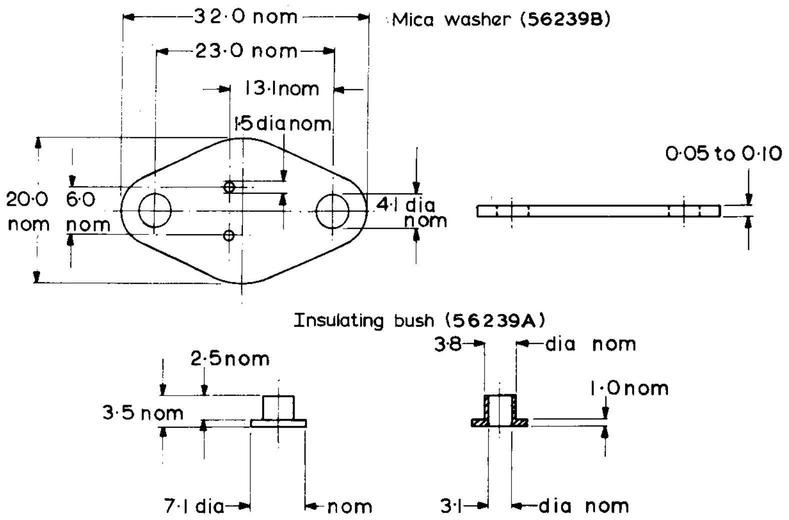
   where $\Theta_{j-mb} + \Theta_i + \Theta_h$ is the junction temperature rise per watt above ambient, Θ_i is the constant thermal resistance, and Θ_h is the thermal resistance of the heatsink.

2. Care must be taken to ensure good thermal contact between the mounting base and the heatsink. Burrs or thickening at the edges of the holes must be removed and the transistor bolted down on a plane surface.

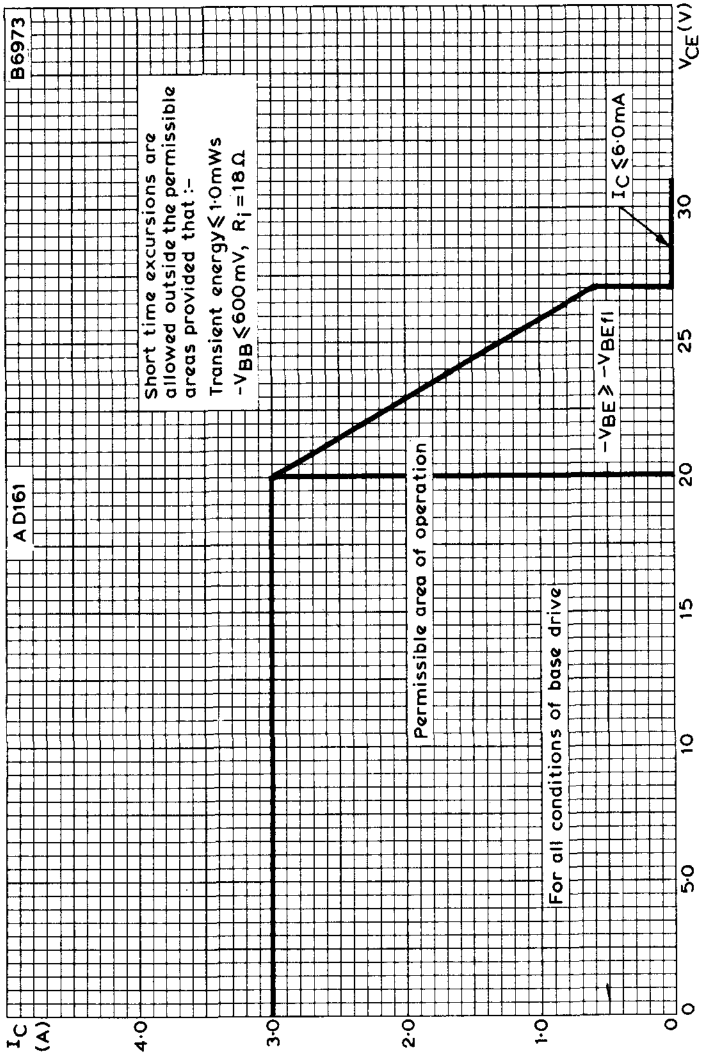
SOLDERING AND WIRING RECOMMENDATIONS

1. When using a soldering iron, transistors may be soldered directly into the circuit, but heat conducted to the junction should if possible be kept to a minimum by the use of a thermal shunt

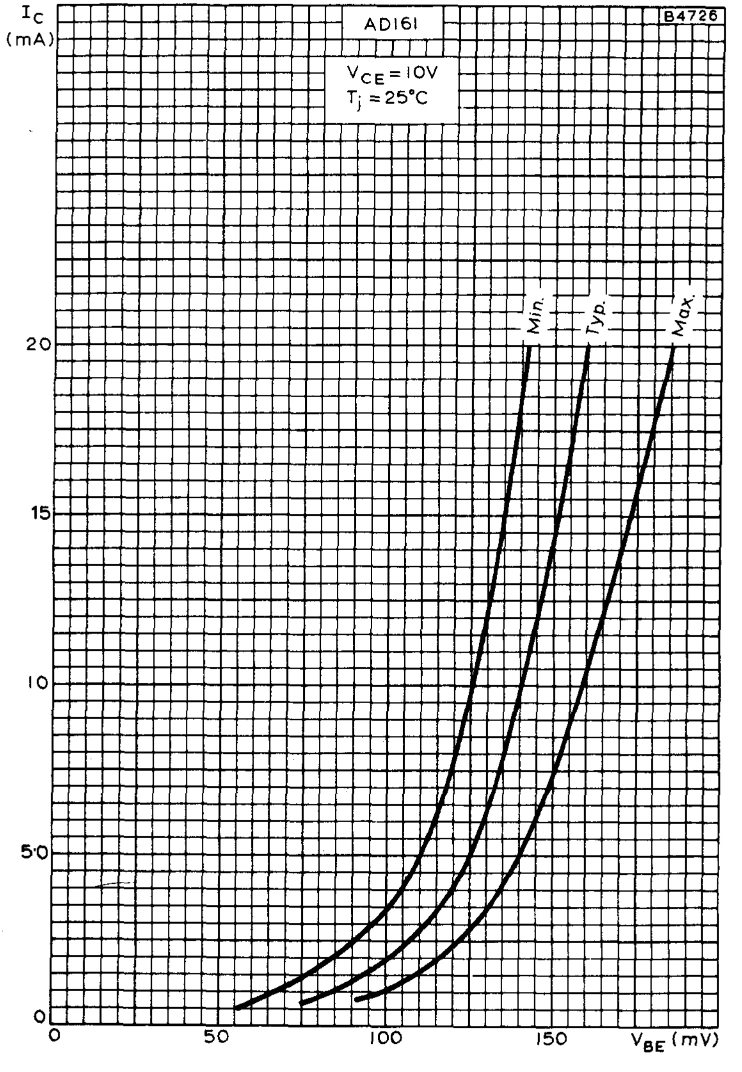
ACCESSORIES



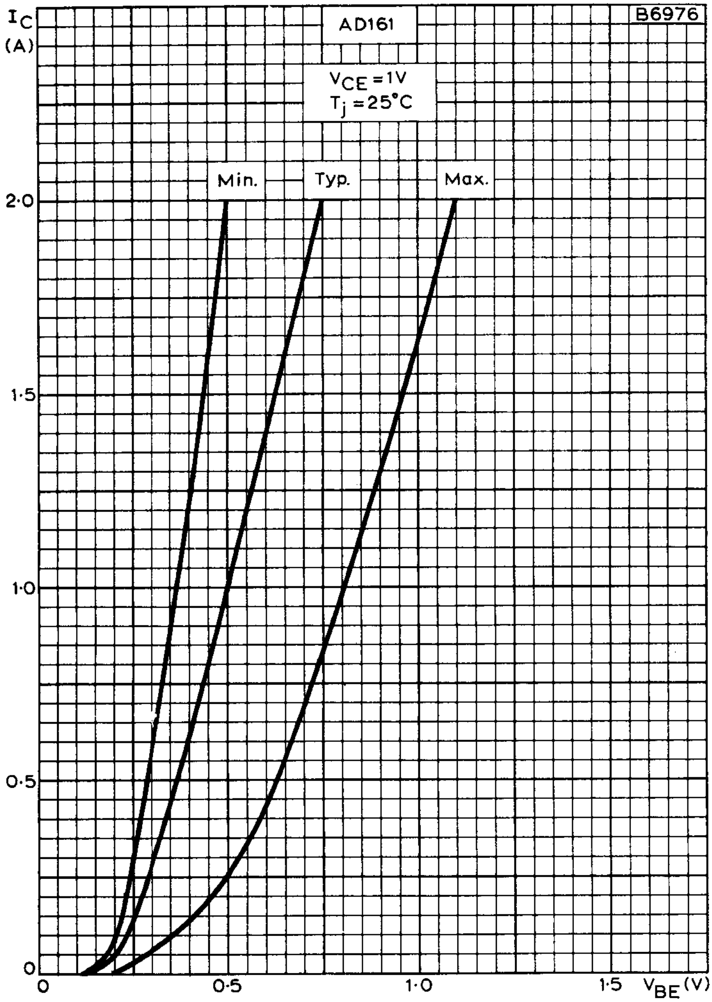
All dimensions in mm



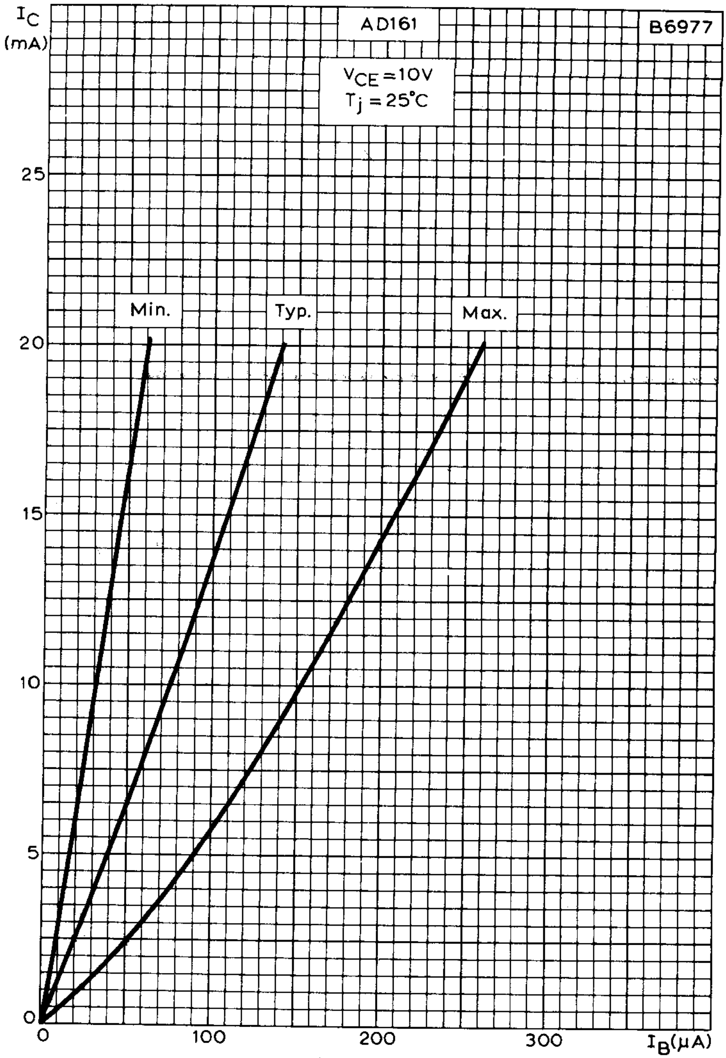
MAXIMUM COLLECTOR CURRENT PLOTTED AGAINST MAXIMUM COLLECTOR-EMITTER VOLTAGE



COLLECTOR CURRENT PLOTTED AGAINST BASE-EMITTER VOLTAGE



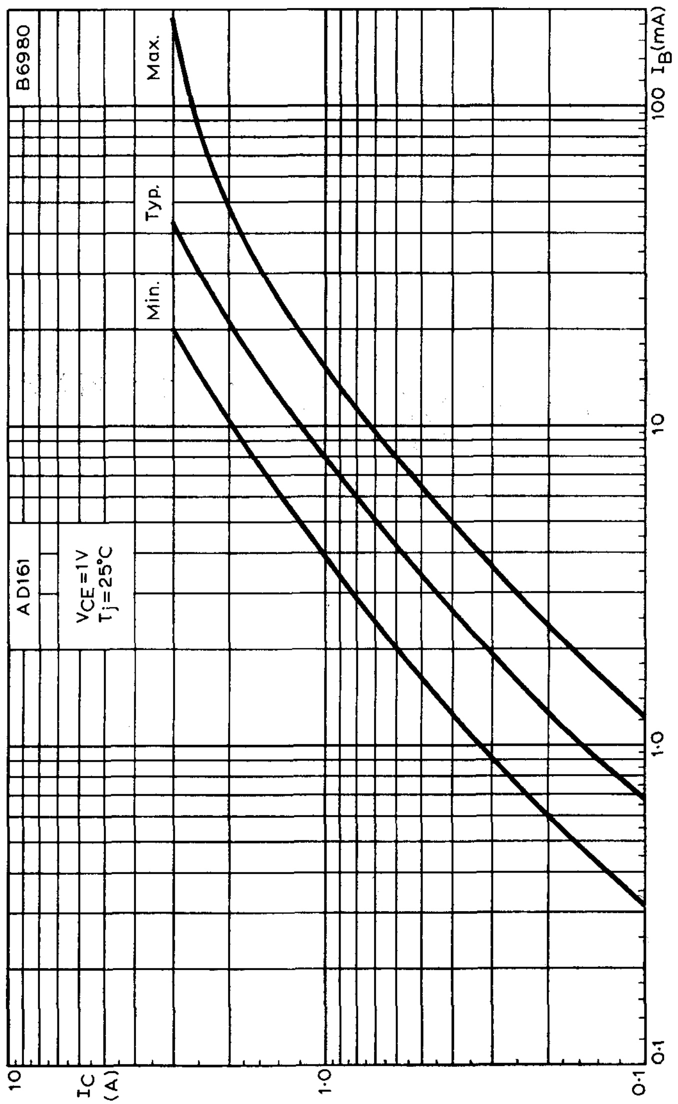
COLLECTOR CURRENT PLOTTED AGAINST BASE-EMITTER VOLTAGE



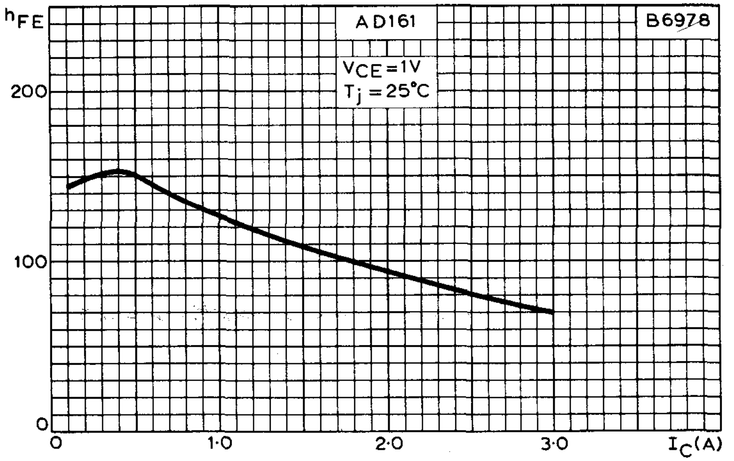
COMMON EMITTER TRANSFER CHARACTERISTICS
AT LOW COLLECTOR CURRENTS

GERMANIUM A.F. POWER TRANSISTOR

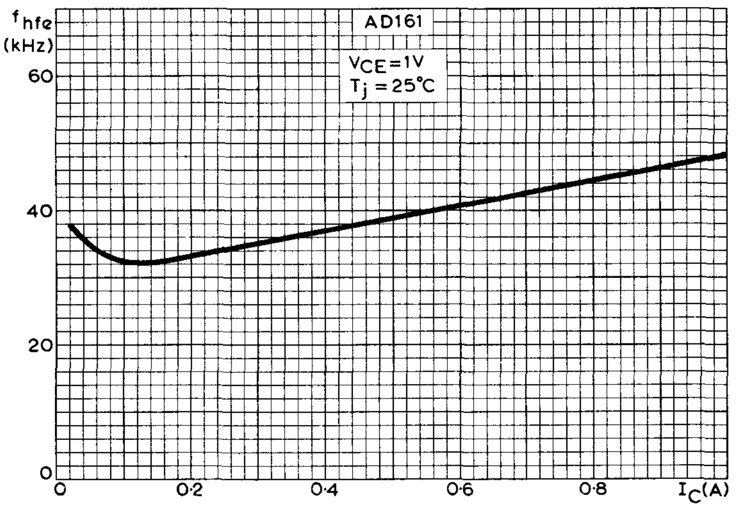
AD161



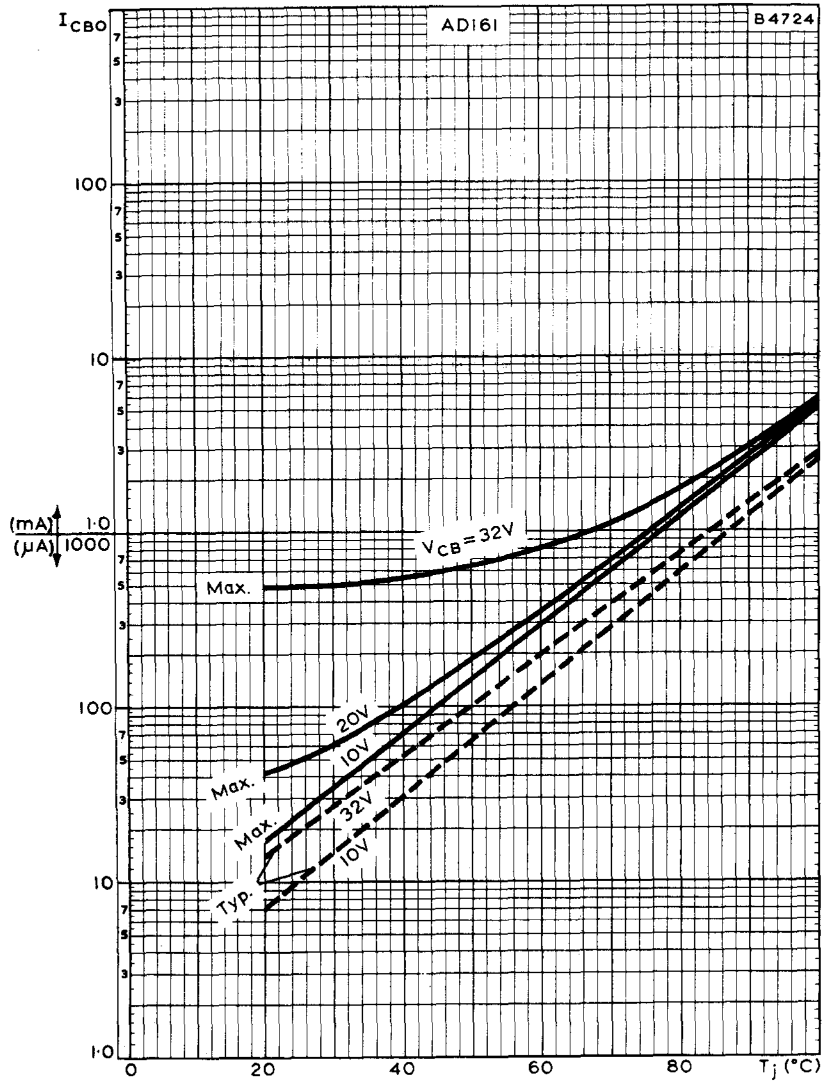
COMMON EMITTER TRANSFER CHARACTERISTICS
AT HIGH COLLECTOR CURRENTS



TYPICAL STATIC FORWARD CURRENT TRANSFER RATIO PLOTTED AGAINST COLLECTOR CURRENT



TYPICAL COMMON EMITTER CUT-OFF FREQUENCY PLOTTED AGAINST COLLECTOR CURRENT



COLLECTOR CUT-OFF CURRENT PLOTTED AGAINST
JUNCTION TEMPERATURE

COMPLEMENTARY GERMANIUM POWER TRANSISTORS

AD161 AD162

N-P-N (AD161) and P-N-P (AD162) germanium alloy junction transistors for use in complementary symmetry class 'B' output stages for mains operated amplifiers and radio receivers.
For information on the individual types reference should be made to the relevant data sheets.

QUICK REFERENCE DATA

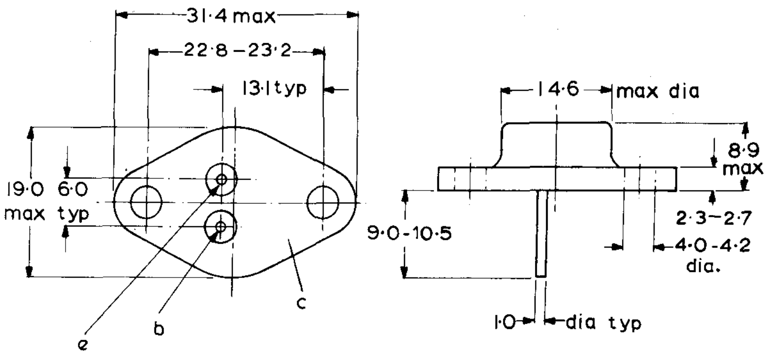
		AD161	AD162	
V_{CBO} max.	See note below	+32	-32	V
V_{CEO} max.	See note below	+20	-20	V
I_{CM} max.		+2.0	-2.0	A
P_{tot} max.		3.0	6.0	W
T_j max.		90	90	^oC
h_{FE} (V_{CE}=1.0V, I_C=500mA)*		50-300	50-300	
f_T typ. (V_{CE}=2.0V, I_C=10mA)*		3.0	1.5	MHz
f_{hfe} min. (V_{CE}=2.0V, I_C=300mA)*		>20	>10	kHz

*Polarity positive for AD161 and negative for AD162

Note:- For max. supply voltage see recommended circuit details

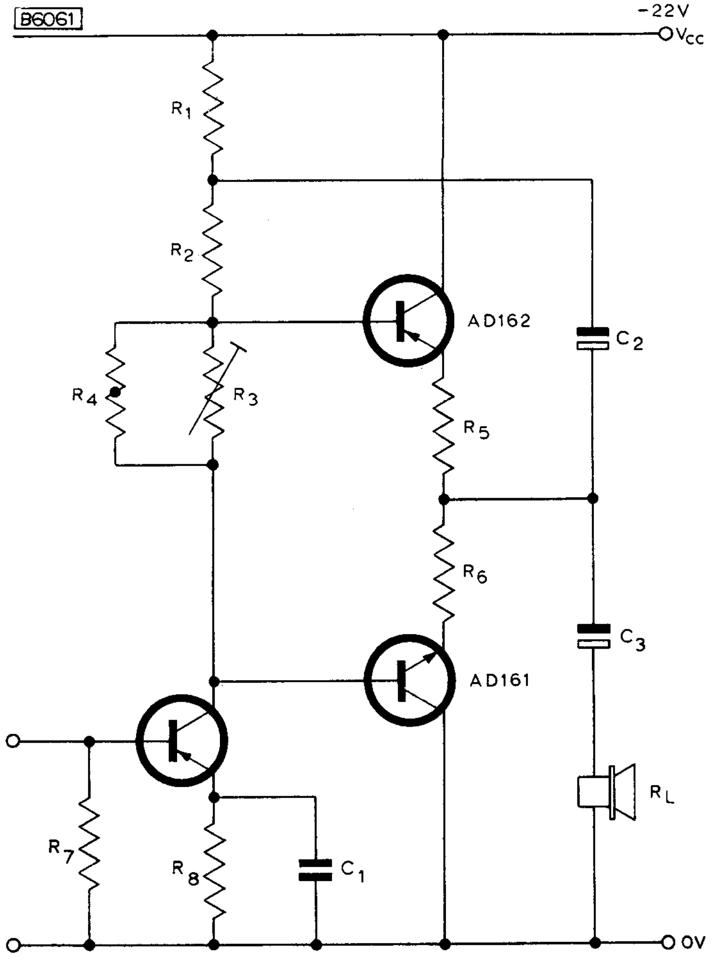
OUTLINE AND DIMENSIONS

Conforms to B.S. 3934 SO-55/SB2-5



All dimensions in mm

OPERATING CONDITIONS IN CLASS 'B' COMPLEMENTARY SYMMETRY OUTPUT STAGE



*Nominal supply voltage	-22	V
Load impedance (R_L)	5.0	Ω
Load power	8.0	W
Total quiescent current	5.0 to 10	mA
Driver quiescent current	62	mA
Peak collector current	1.85	A
Max. mean current	550	mA

R_1	68	Ω
R_2	100	Ω
R_3 (variable preset)	100	Ω
R_4 (N.T.C. resistor)	15	Ω
R_5 and R_6	0.5	Ω
R_7 (depends on T_j max. of driver)	220	Ω
R_8	15	Ω
C_1	500	μF
C_2	50	μF
C_3	2000	μF

*Based on an absolute maximum supply voltage of 24V for this circuit. With 1.0Ω emitter resistors 26.5V absolute maximum is permissible.

For a matched pair of AD161/AD162 the maximum value of the ratio of the static forward current transfer ratios at I_C = 500mA and V_{CE} = 1.0V is 1.25:1 and a typical value is 1.1:1.

OPERATING NOTES

1. Dissipation and heatsink considerations:

   The maximum total dissipation, P_{tot} max. = $(V_{CE} \times I_C) + (V_{BE} \times I_B)$, is given by:

$$P_{tot}\ \text{max.} = \frac{T_j\ \text{max.} - T_{amb}}{\Theta_{j\text{-}mb} + \Theta_i + \Theta_h}$$

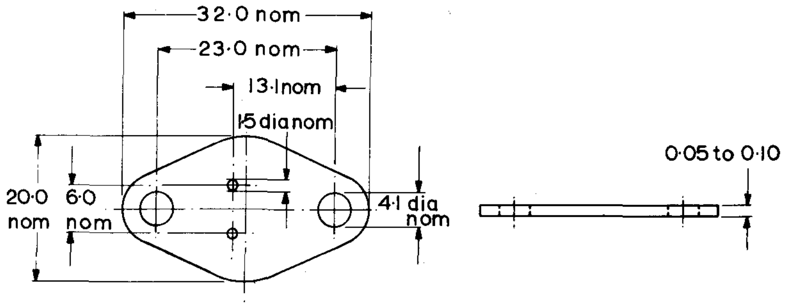
   where $\Theta_{j\text{-}mb} + \Theta_i + \Theta_h$ is the junction temperature rise per watt above ambient, Θ_i is the constant thermal resistance, and Θ_h is the thermal resistance of the heatsink.

2. Care must be taken to ensure good thermal contact between the mounting base and the heatsink. Burrs or thickening at the edges of the holes must be removed and the transistor bolted down on a plane surface.

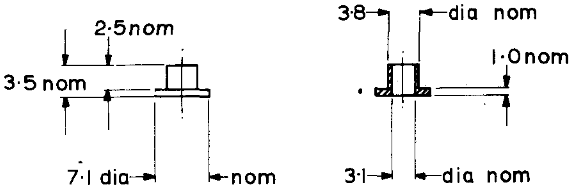
SOLDERING AND WIRING RECOMMENDATIONS

1. When using a soldering iron, transistors may be soldered directly into the circuit, but heat conducted to the junction should if possible be kept to a minimum by the use of a thermal shunt.

Mica washer (56239B)



Insulating bush (56239A)



All dimensions in mm

B3072

GERMANIUM A.F. POWER TRANSISTOR

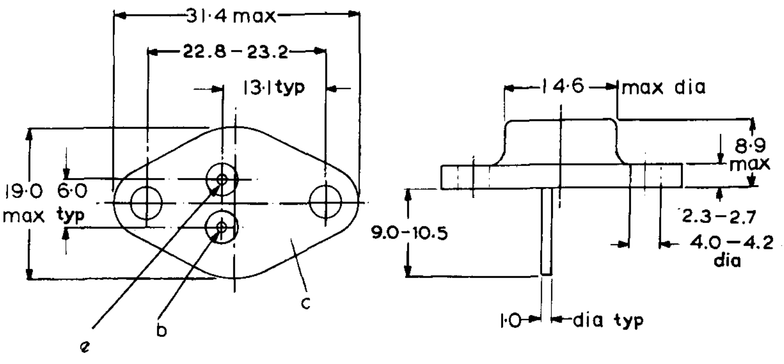
AD162

Germanium p-n-p alloy junction transistor, with type AD161 it forms a symmetrical complementary pair for use in mains driven output stages for amplifiers and radio receivers.

QUICK REFERENCE DATA		
$-V_{CBO}$ max. ($I_E = 0$)	32	V
$-V_{CEO}$ max. ($I_B = 0$)	20	V
$-I_{CM}$ max.	3.0	A
P_{tot} max. ($T_{mb} \leq 63^{o}C$)	6.0	W
T_j max. (operating)	90	^{o}C
h_{FE} ($-V_{CE} = 1.0V$, $-I_C = 500mA$)	80-320	
f_T typ. ($-V_{CE} = 2.0V$, $-I_C = 10mA$)	1.5	MHz
f_{hfe} typ. ($-V_{CE} = 2.0V$, $-I_C = 300mA$)	15	kHz

OUTLINE AND DIMENSIONS

Conforming to B.S. 3934 SO-55/SB2-5



All dimensions in mm

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

$-V_{CBO}$ max. ($I_E = 0$)	32	V
$-V_{CEO}$ max. ($I_B = 0$, see page C1)	20	V
$-V_{CEX}$ max. ($V_{BE} = 0.6V$, see page C1)	32	V
$-V_{EBO}$ max. ($I_C = 0$)	10	V
*$-I_{C(AV)}$ max.	1.0	A
$-I_{CM}$ max.	3.0	A
$-I_B$ max.	0.1	A
*$I_{E(AV)}$ max.	1.1	A
I_{EM} max.	3.1	A
P_{tot} max. ($T_{mb} \leq 63^oC$)	6.0 see curve on page C2	W

*Maximum averaging time = 50ms.

Temperature

T_{stg} min.	-65	^oC
T_{stg} max.	90	^oC
T_j max. (operating)	90	^oC
T_j max. (see note 1)	100	^oC

THERMAL CHARACTERISTICS

θ_{j-mb}		4.5	degC/W
θ_i	with mica washer	1.5	degC/W
	without mica washer	0.5	degC/W

NOTE

1. Operation up to $T_j = 100^oC$ is permissible during short term overload conditions.

GERMANIUM A.F. POWER TRANSISTOR

AD162

ELECTRICAL CHARACTERISTICS ($T_j = 25^oC$ unless otherwise stated)

		Min.	Typ.	Max.	
$-I_{CBO}$	Collector cut-off current				
	$-V_{CB} = 10V$, $I_E = 0$	-	8.0	20	µA
	$-V_{CB} = 20V$, $I_E = 0$	-	-	40	µA
	$-V_{CB} = 32V$, $I_E = 0$	-	15	200	µA
	$-V_{CB} = 32V$, $I_E = 0$, $T_j = 90^oC$	-	-	2.0	mA
$-I_{CEX}$	Collector-emitter cut-off current				
	$-V_{CE} = 32V$, $V_{BE} = 0.6V$, $T_j = 90^oC$	-	-	2.0	mA
$-I_{EBO}$	Emitter cut-off current				
	$-V_{EB} = 10V$, $I_C = 0$	-	15	200	µA
	$-V_{EB} = 10V$, $I_C = 0$, $T_j = 90^oC$	-	-	2.0	mA
$-V_{EB(fl)}$	Floating potential				
	$-V_{CB} = 32V$, $T_j = 90^oC$	-	-	400	mV
$-V_{CE(knee)}$	Collector-emitter knee voltage				
	$-I_C = 1.0A$, see note 2	-	-	400	mV
$-V_{BE}$	Base-emitter voltage (see note 3)				
	$-V_{CE} = 10V$, $-I_C = 5.0mA$	115	-	145	mV
	$-V_{CE} = 1.0V$, $-I_C = 50mA$	-	-	300	mV
	$-V_{CE} = 1.0V$, $-I_C = 500mA$	-	-	550	mV
	$-V_{CE} = 1.0V$, $-I_C = 2.0A$	-	-	850	mV
$-I_B$	Base current				
	$-V_{CB} = 10V$, $I_E = 5.0mA$	-	-	82	µA
	$V_{CB} = 0$, $I_E = 50mA$	0.16	-	0.67	mA
	$V_{CB} = 0$, $I_E = 500mA$	1.56	-	6.2	mA
	$V_{CB} = 0$, $I_E = 2.0A$	-	-	33	mA
h_{FE}	Static forward current transfer ratio				
	$-V_{CE} = 10V$, $-I_C = 5.0mA$	60	-	-	
	$-V_{CE} = 1.0V$, $-I_C = 50mA$	74	-	300	
	$-V_{CE} = 1.0V$, $-I_C = 500mA$	80	150	320	
	$-V_{CE} = 1.0V$, $-I_C = 2.0A$	60	-	-	

ELECTRICAL CHARACTERISTICS (cont'd)

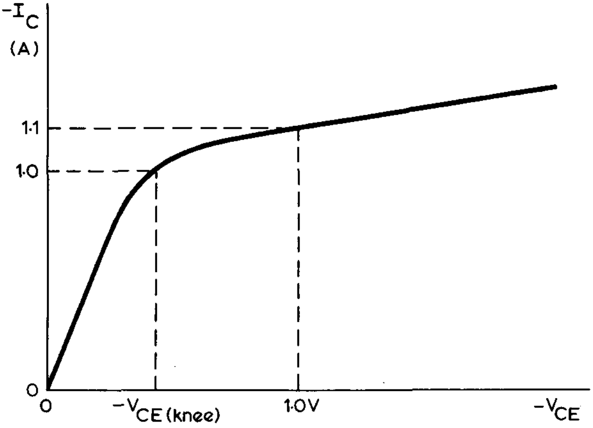
		Min.	Typ.	Max.	
f_T	Transition frequency $-V_{CE}=2.0V$, $-I_C=10mA$	1.0	1.5	-	MHz
f_{hfe}	Common emitter cut-off frequency $-V_{CE}=2.0V$, $-I_C=300mA$	8.0	15	-	kHz
c_{tc}	Collector capacitance $-V_{CB}=5.0V$, $I_E=I_e=0$, f=450kHz	-	115	-	pF

For a matched pair of AD161/AD162 the maximum value of the ratio of the static forward current transfer ratios, at $-I_C=500mA$ and $-V_{CE}=1.0V$, is 1.25:1 and a typical value is 1.1:1.

For a matched pair of 2-AD162 the maximum value of the ratio of the static forward current transfer ratios, at $-I_C=50$ and 500mA and $-V_{CE}=1.0V$, is 1.25:1 and a typical value is 1.1:1.

NOTES

2. Collector-emitter knee voltage at $-I_C=1.0A$, and at that value of I_B occurring at $-I_C=1.1A$ and $-V_{CE}=1.0V$.



3. V_{BE} decreases by approximately 2.0mV/degC with increasing temperature.

GERMANIUM A.F. POWER TRANSISTOR

AD162

OPERATING NOTES

1. Dissipation and heatsink considerations:

   The maximum total dissipation, P_{tot} max. = $(V_{CE} \times I_C) + (V_{BE} \times I_B)$, is given by:

$$P_{tot}\ \text{max.} = \frac{T_j\ \text{max.} - T_{amb}}{\Theta_{j\text{-}mb} + \Theta_i + \Theta_h}$$

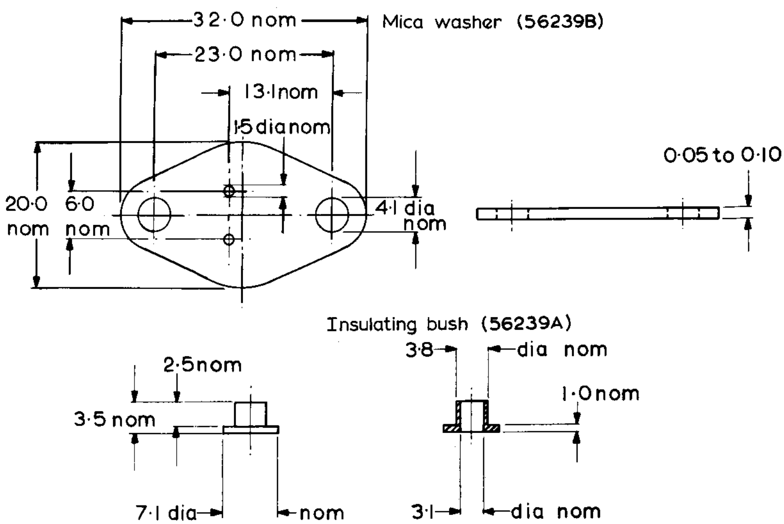
   where $\Theta_{j\text{-}mb} + \Theta_i + \Theta_h$ is the junction temperature rise per watt above ambient, Θ_i is the contact thermal resistance, and Θ_h is the thermal resistance of the heatsink.

2. Care must be taken to ensure good thermal contact between the mounting base and the heatsink. Burrs or thickening at the edges of the holes must be removed and the transistor bolted down on a plane surface.

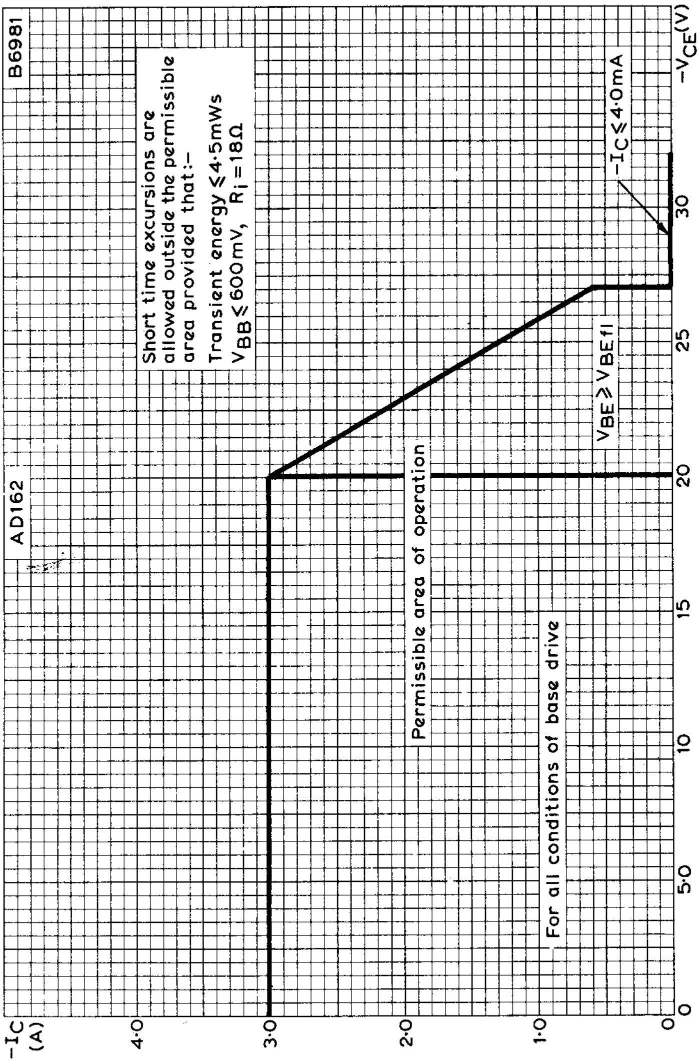
SOLDERING AND WIRING RECOMMENDATIONS

1. When using a soldering iron, transistors may be soldered directly into the circuit, but heat conducted to the junction should if possible be kept to a minimum by the use of a thermal shunt.

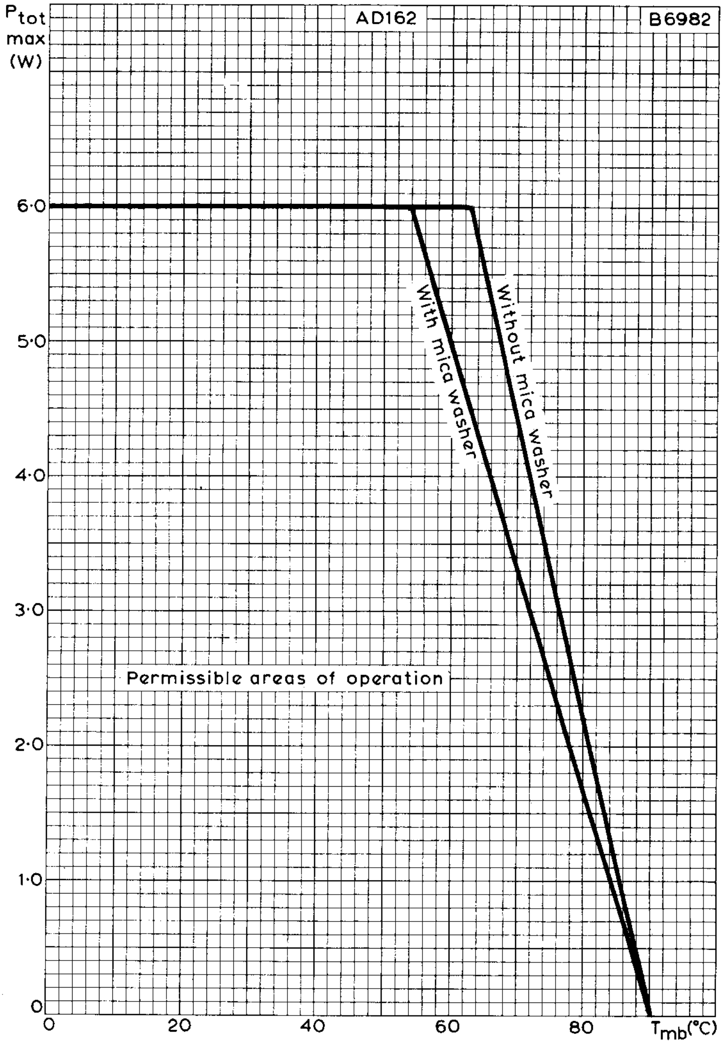
ACCESSORIES



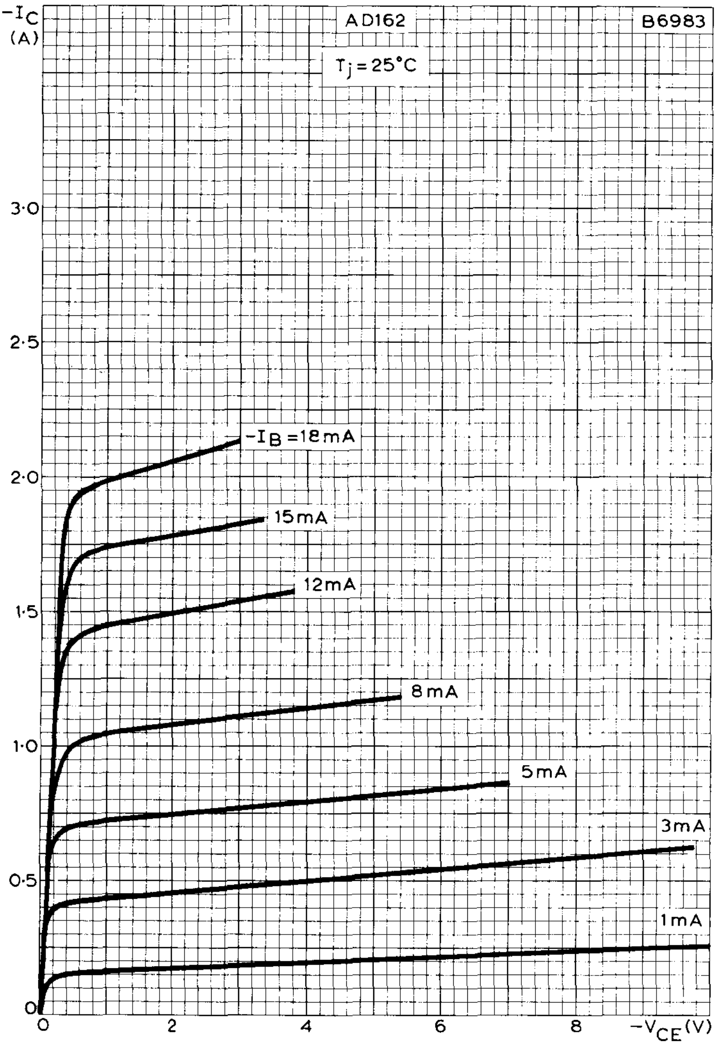
All dimensions in mm



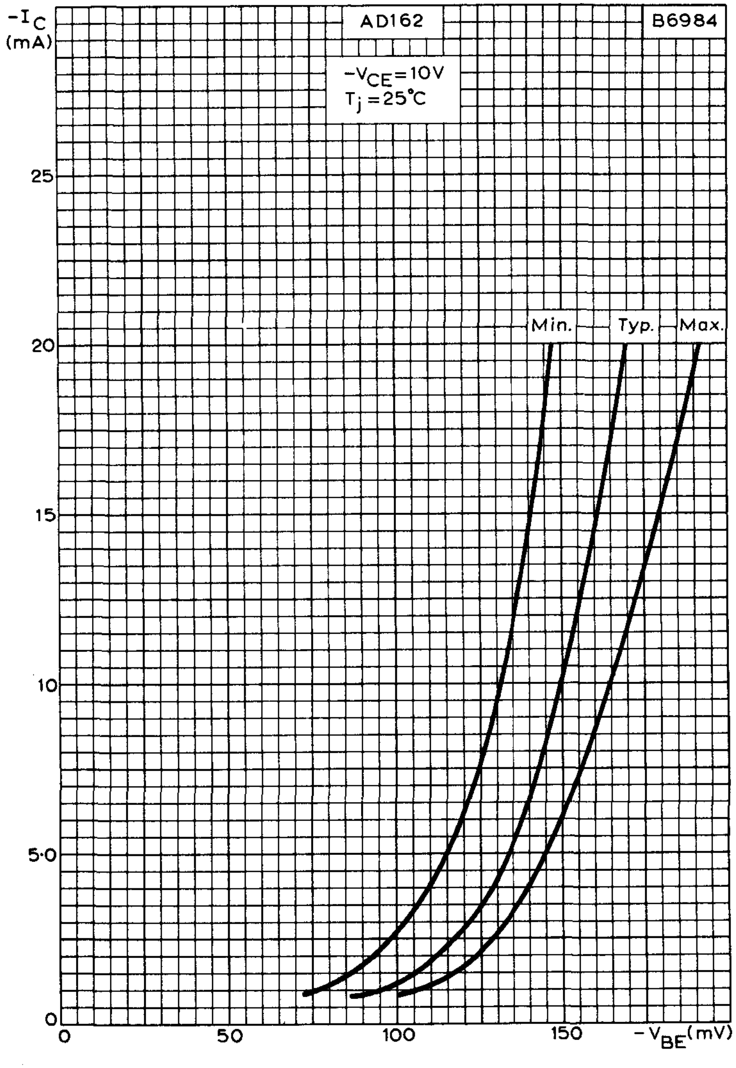
MAXIMUM COLLECTOR CURRENT PLOTTED AGAINST MAXIMUM COLLECTOR-EMITTER VOLTAGE



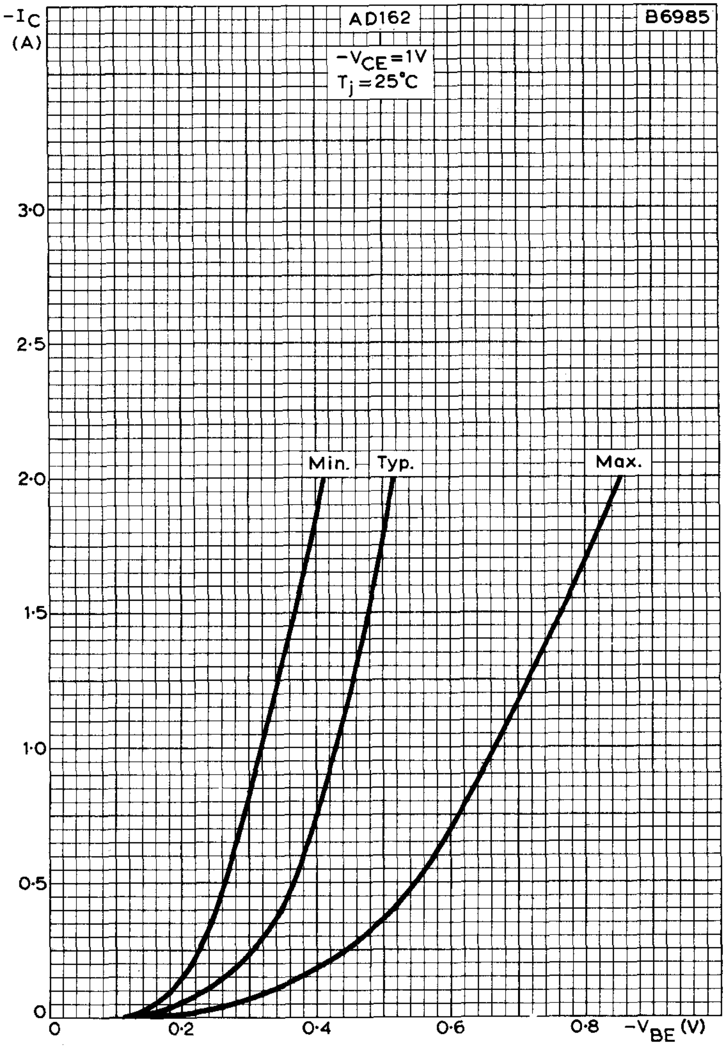
MAXIMUM TOTAL DISSIPATION PLOTTED AGAINST
MOUNTING-BASE TEMPERATURE



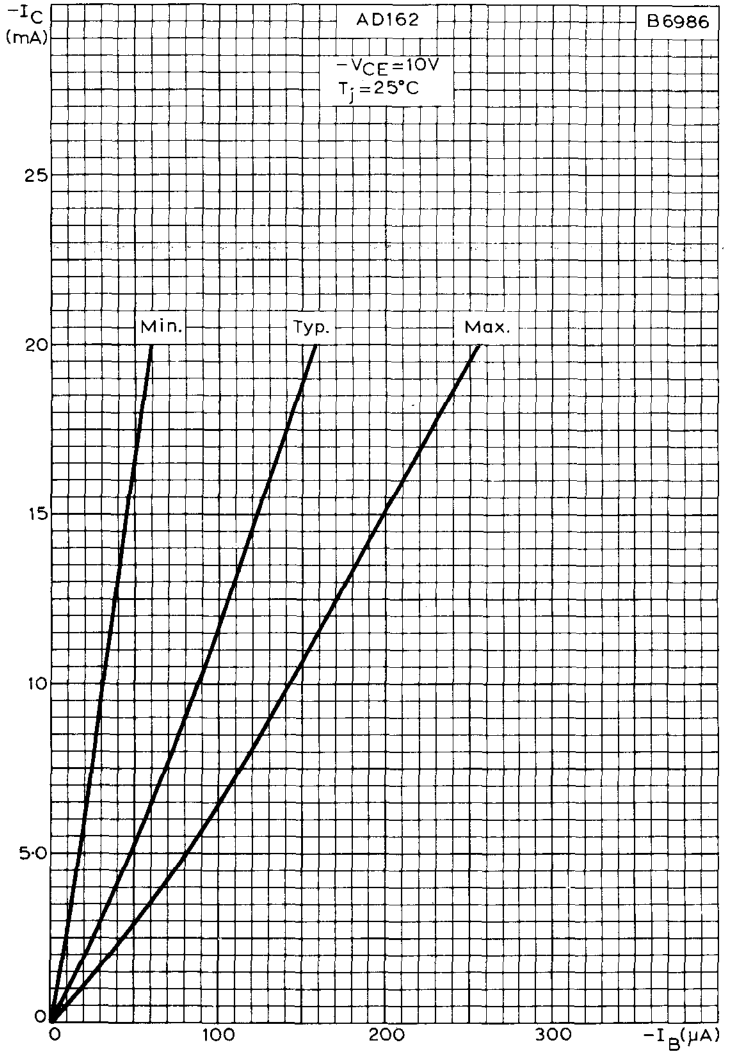
TYPICAL OUTPUT CHARACTERISTICS



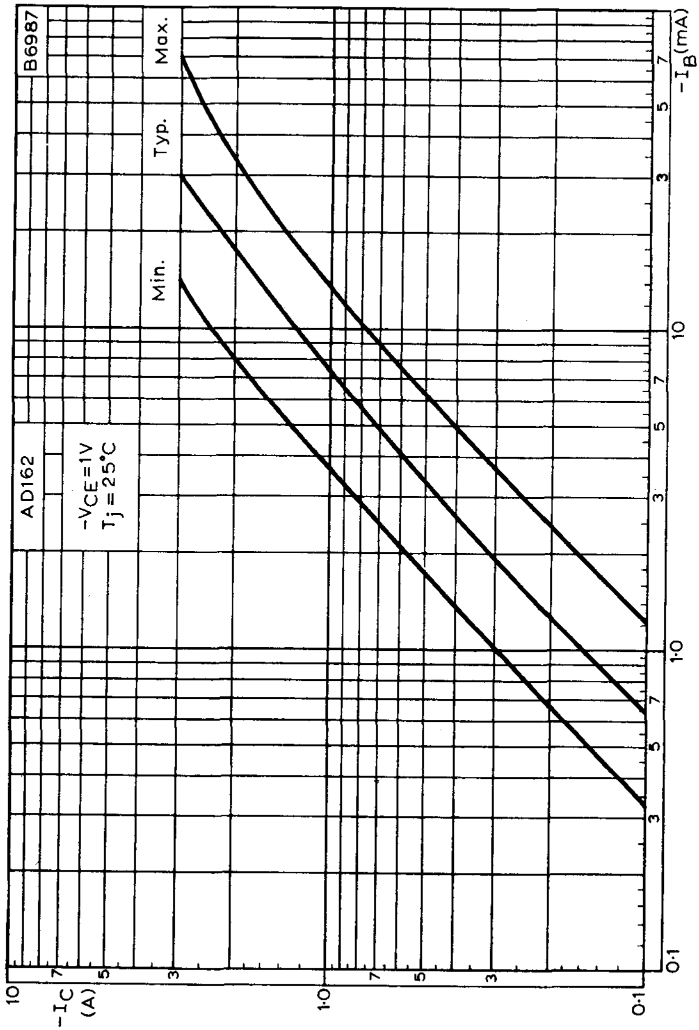
COLLECTOR CURRENT PLOTTED AGAINST BASE-EMITTER VOLTAGE



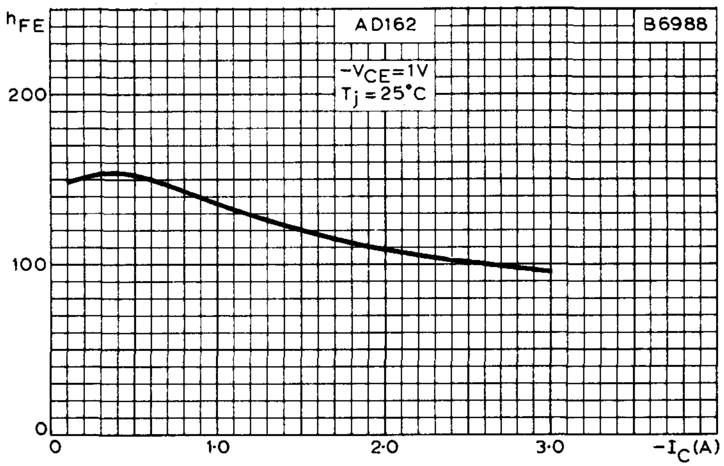
COLLECTOR CURRENT PLOTTED AGAINST BASE-EMITTER VOLTAGE



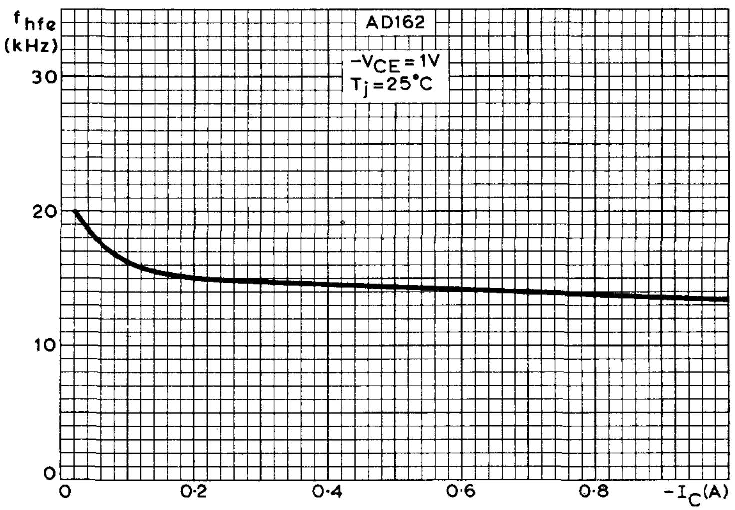
COMMON EMITTER TRANSFER CHARACTERISTICS
AT LOW COLLECTOR CURRENTS



COMMON EMITTER TRANSFER CHARACTERISTICS
AT HIGH COLLECTOR CURRENTS



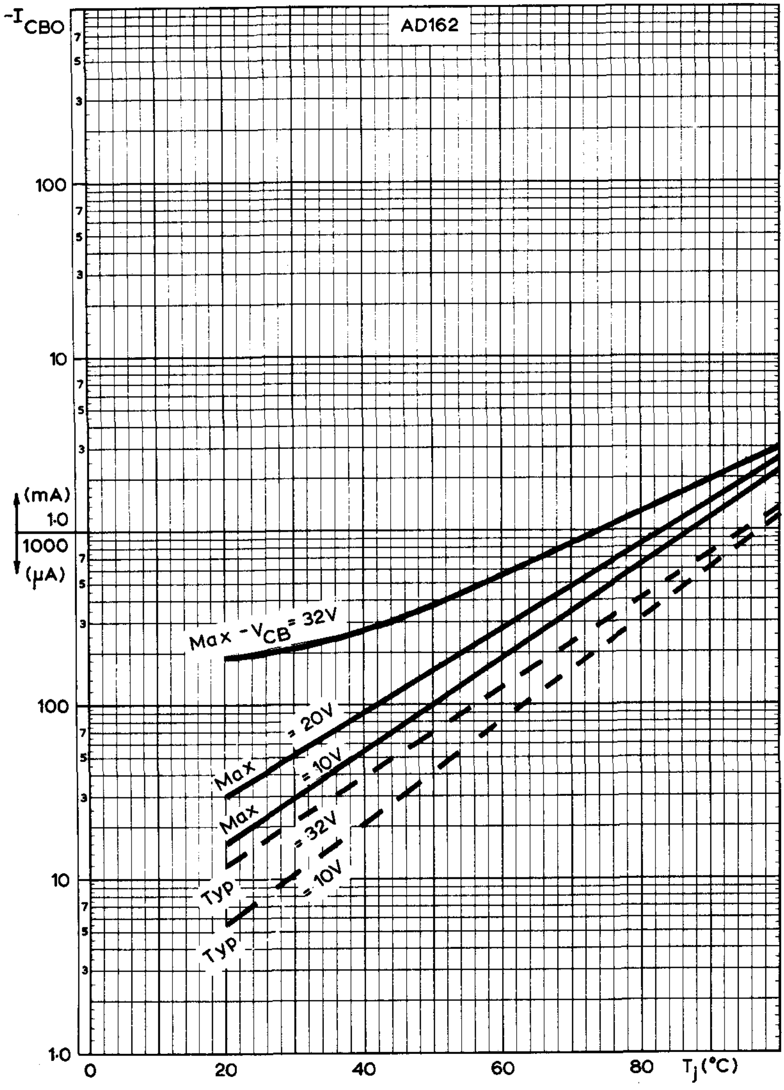
TYPICAL STATIC FORWARD CURRENT TRANSFER RATIO PLOTTED AGAINST COLLECTOR CURRENT



TYPICAL COMMON EMITTER CUT-OFF FREQUENCY PLOTTED AGAINST COLLECTOR CURRENT

GERMANIUM A.F. POWER TRANSISTOR

AD162



COLLECTOR CUT-OFF CURRENT PLOTTED AGAINST JUNCTION TEMPERATURE

SILICON N-P-N PLANAR EPITAXIAL TRANSISTORS

BC107 BC108 BC109

Also available to BS9365—F112

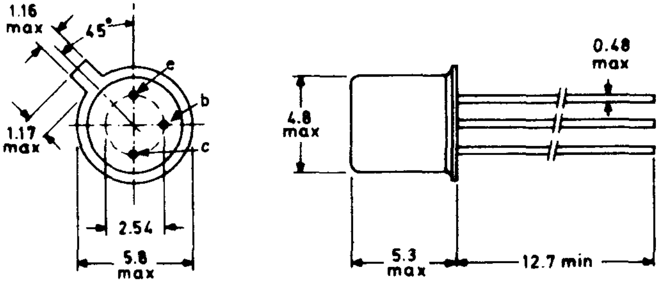
N-P-N silicon planar epitaxial transistors in TO-18 encapsulation.
The BC107 is primarily intended for use in audio driver stages and television signal processing circuits.
The BC108 is a general purpose l.f. transistor.
The BC109 is primarily intended for low noise audio input stages.

QUICK REFERENCE DATA

			BC107	BC108	BC109	
V_{CES} max.			50	30	30	V
V_{CEO} max.			45	20	20	V
I_{CM} max.			200	200	200	mA
P_{tot} max. ($T_{amb} \leq 25^oC$)			300	300	300	mW
T_j max.			175	175	175	^oC
h_{fe}	(I_C = 2mA, V_{CE} = 5V, f = 1kHz)	min.	125	125	240	
		max.	500	900	900	
f_T	(I_C = 10mA, V_{CE} = 5V, f = 35MHz)	typ.	300	300	300	MHz
N	(I_C = 200μA, V_{CE} = 5V, R_S = 2kΩ)					
	f = 30Hz to 15kHz	typ.	-	-	1.4	dB
		max.	-	-	4.0	dB
	f = 1kHz, B = 200Hz	typ.	2.0	2.0	1.2	dB
		max.	10	10	4.0	dB

OUTLINE AND DIMENSIONS

Conforms to B.S. 3934 SO-12A/SB3-6A
J.E.D.E.C. TO-18



All dimensions in mm

D3648

Collector connected to case
Accessories available: 56246, 56263

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

	BC107	BC108	BC109	
V_{CBO} max.	50	30	30	V
V_{CES} max.	50	30	30	V
V_{CEO} max.	45	20	20	V
V_{EBO} max.	6.0	5.0	5.0	V
I_C max.	100	100	100	mA
I_{CM} max.	200	200	200	mA
$-I_{EM}$ max.	200	200	200	mA
I_{BM} max.	200	200	200	mA
P_{tot} max. ($T_{amb} \leq 25^oC$)	300	300	300	mW

Temperature

T_{stg} range	-65 to +175	^oC
T_j max.	175	^oC

THERMAL CHARACTERISTICS

$R_{th(j-amb)}$	0.5	$^oC/mW$
$R_{th(j-case)}$	0.2	$^oC/mW$

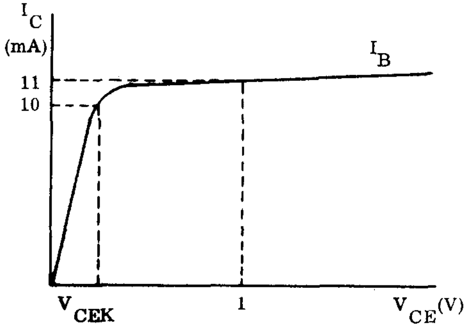
ELECTRICAL CHARACTERISTICS ($T_j = 25^oC$ unless otherwise stated)

		Min.	Typ.	Max.	
I_{CBO}	Collector cut-off current $V_{CB} = 20V$, $I_E = 0$, $T_j = 150^oC$	-	-	15	μA
V_{BE}	Base-emitter voltage $I_C = 2.0mA$, $V_{CE} = 5.0V$	550	620	700	mV
	$I_C = 10mA$, $V_{CE} = 5.0V$	-	-	770	mV
$V_{CE(sat)}$	Collector-emitter saturation voltage $I_C = 10mA$, $I_B = 0.5mA$	-	90	250	mV
	$I_C = 100mA$, $I_B = 5.0mA$	-	200	600	mV
$V_{BE(sat)}$	Base-emitter saturation voltage $I_C = 10mA$, $I_B = 0.5mA$	-	700	-	mV
	$I_C = 100mA$, $I_B = 5.0mA$	-	900	-	mV

SILICON N-P-N PLANAR EPITAXIAL TRANSISTORS

BC107 BC108 BC109

ELECTRICAL CHARACTERISTICS (contd.)			Min.	Typ.	Max.	
V_{CEK}	Collector knee voltage $I_C = 10mA$, I_B = the value for which $I_C = 11mA$ at $V_{CE} = 1.0V$		-	300	600	mV



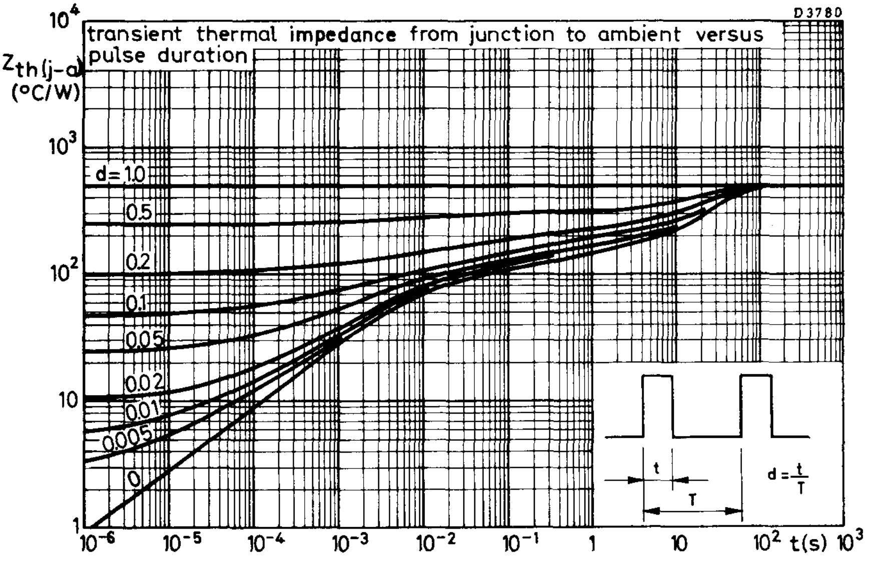
			Min.	Typ.	Max.	
h_{FE}	Static forward current transfer ratio $I_C = 2.0mA$, $V_{CE} = 5.0V$	BC107	110	-	450	
		BC108	110	-	800	
		BC109	200	-	800	
h_{fe}	Small signal forward current transfer ratio $I_C = 2.0mA$, $V_{CE} = 5.0V$, $f = 1.0kHz$	BC107	125	-	500	
		BC108	125	-	900	
		BC109	240	-	900	
f_T	Transition frequency $I_C = 10mA$, $V_{CE} = 5.0V$, $f = 35MHz$		-	300	-	MHz
C_{Tc}	Collector capacitance $I_E = I_e = 0$, $V_{CB} = 10V$, $f = 1.0MHz$		-	2.5	4.5	pF
C_{Te}	Emitter capacitance $I_C = I_c = 0$, $V_{EB} = 0.5V$, $f = 1.0MHz$		-	9.0	-	pF
N	Noise figure $I_C = 0.2mA$, $V_{CE} = 5.0V$, $R_S = 2.0k\Omega$					
	$f = 30Hz$ to $15kHz$	BC109	-	1.4	4.0	dB
	$f = 1.0kHz$, $B = 200Hz$	BC107/108	-	2.0	10	dB
		BC109	-	1.2	4.0	dB

Mullard

ELECTRICAL CHARACTERISTICS (contd.)

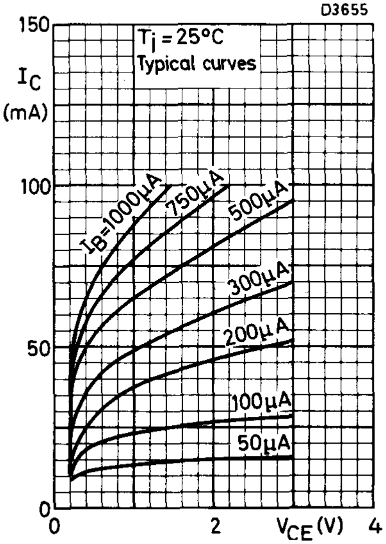
The following supplementary gain groups are available on request: -

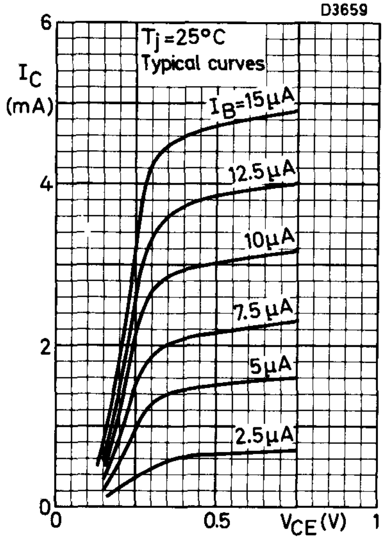
			BC107A BC108A	BC107B BC108B BC109B	BC108C BC109C	
h_{FE}	Static forward current transfer ratio					
	$I_C = 10\mu A$, $V_{CE} = 5.0V$	min.	-	40	100	
		typ.	90	150	270	
	$I_C = 2.0mA$, $V_{CE} = 5.0V$	min.	110	200	420	
		typ.	180	290	520	
		max.	220	450	800	
h parameters						
	$I_C = 2.0mA$, $V_{CE} = 5.0V$, $f = 1.0kHz$					
h_{ie}	Input impedance	min.	1.6	3.2	6.0	kΩ
		typ.	2.7	4.5	8.7	kΩ
		max.	4.5	8.5	15	kΩ
h_{re}	Voltage feedback ratio	typ.	1.5	2.0	3.0	$\times 10^{-4}$
h_{fe}	Small signal current gain	min.	125	240	450	
		typ.	220	330	600	
		max.	260	500	900	
h_{oe}	Output admittance	typ.	18	30	60	μA/V
		max.	30	60	110	μA/V

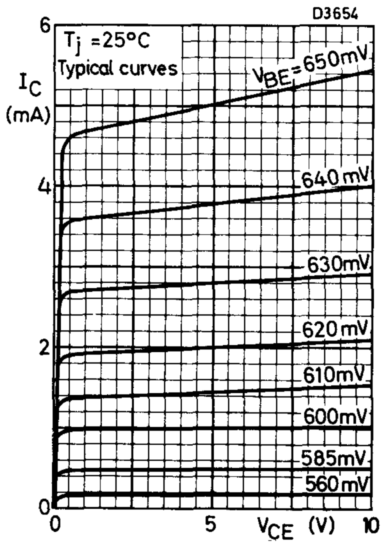


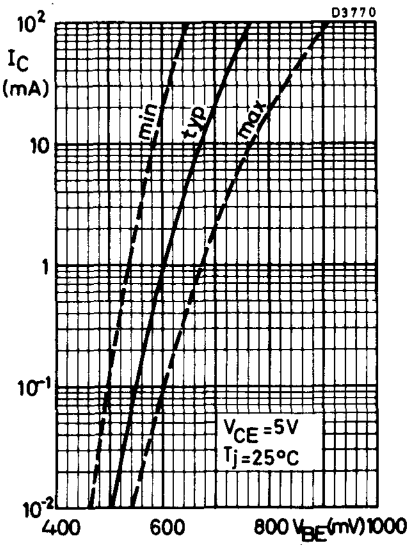
SILICON N-P-N PLANAR EPITAXIAL TRANSISTORS

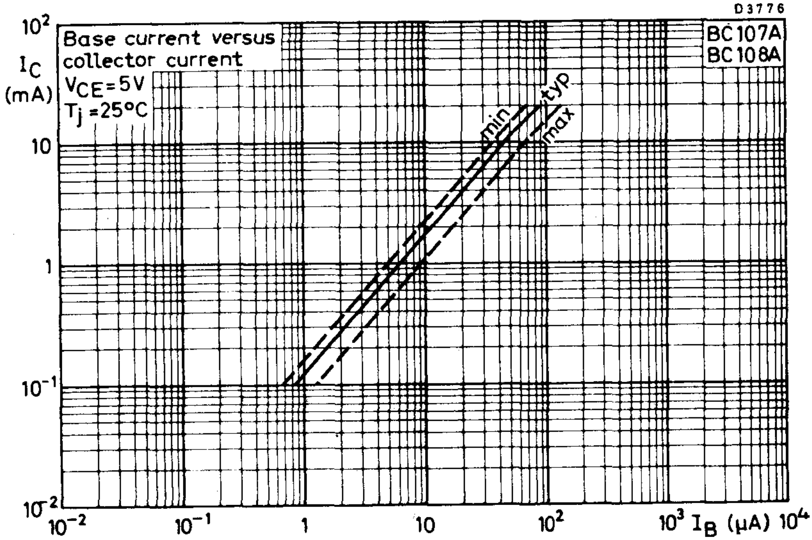
BC107 BC108 BC109

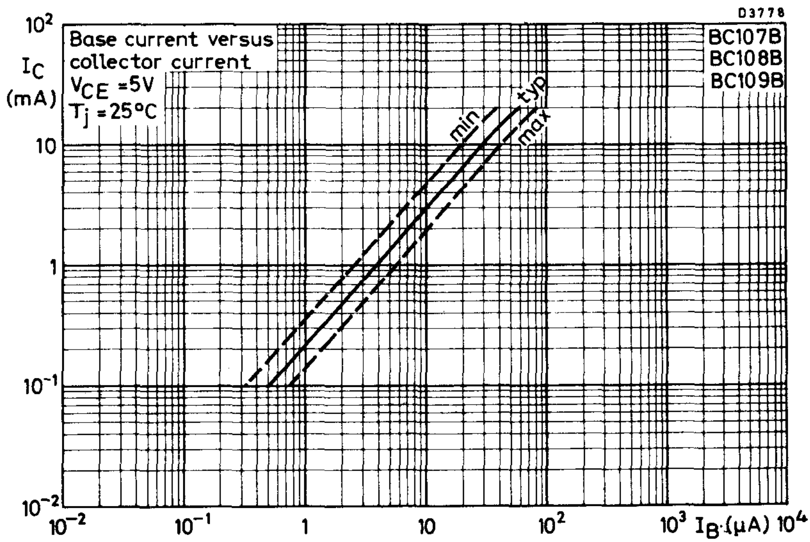






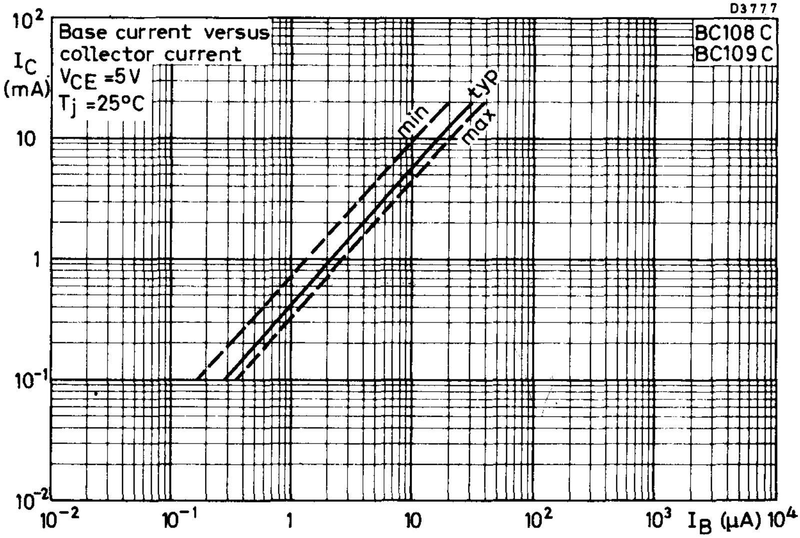


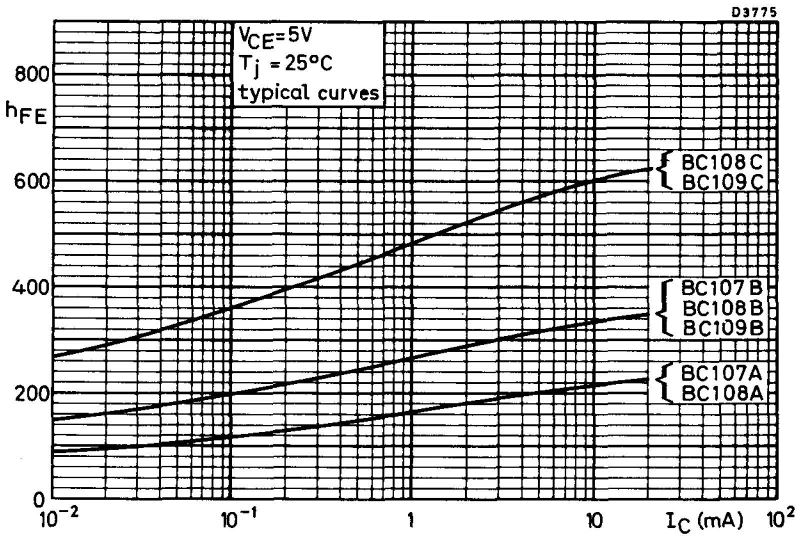

D3776
Base current versus
collector current
V_{CE} = 5V
T_j = 25°C
BC107A
BC108A
I_C (mA)
10^2
10
1
10^{-1}
10^{-2}
min
typ
max
10^{-2}
10^{-1}
1
10
10^2
10^3 I_B (μA) 10^4

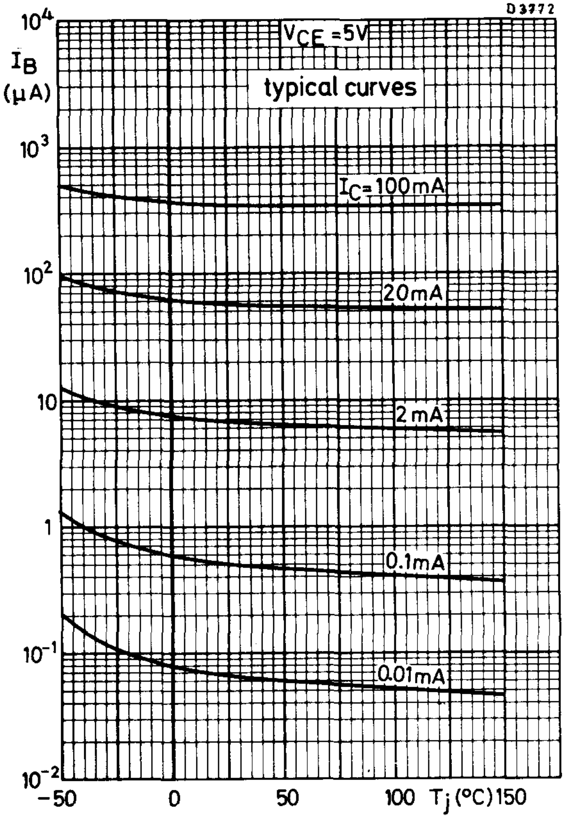

D3778
Base current versus
collector current
V_{CE} = 5V
T_j = 25°C
BC107B
BC108B
BC109B
I_C (mA)
10^2
10
1
10^{-1}
10^{-2}
min
typ
max
10^{-2}
10^{-1}
1
10
10^2
10^3 I_B (μA) 10^4

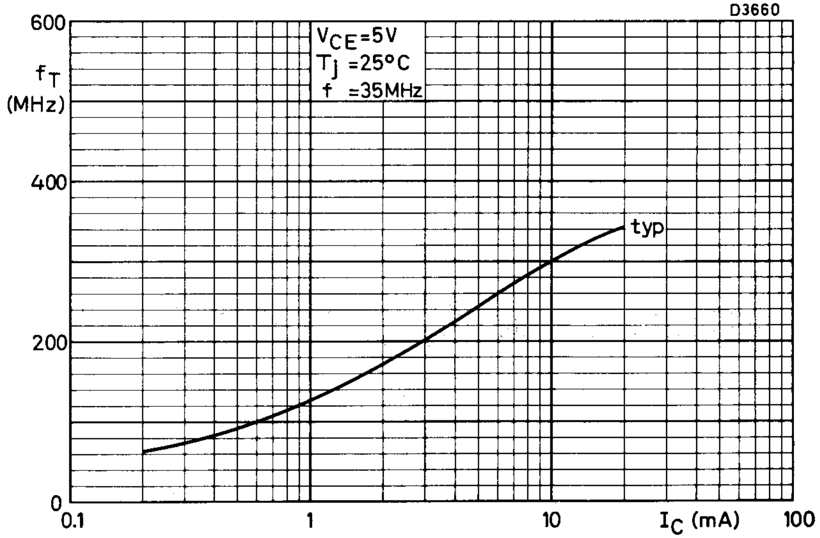
SILICON N-P-N PLANAR EPITAXIAL TRANSISTORS

BC107 BC108 BC109

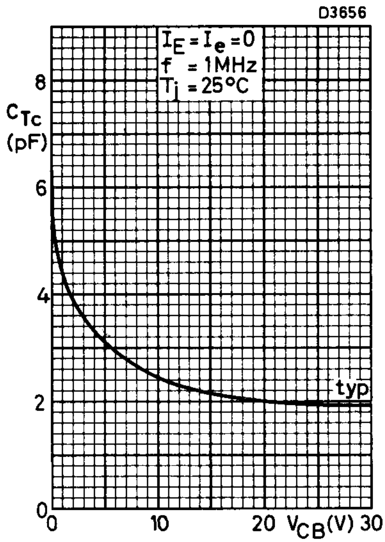




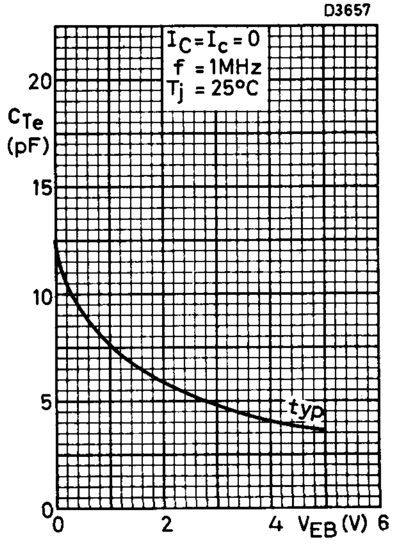

D3772
10^4
I_B
(μA)
V_{CE} = 5V
typical curves
10^3
I_C = 100mA
10^2
20mA
10
2 mA
1
0.1mA
10^{-1}
0.01mA
10^{-2}
−50
0
50
100
T_j (°C)
150



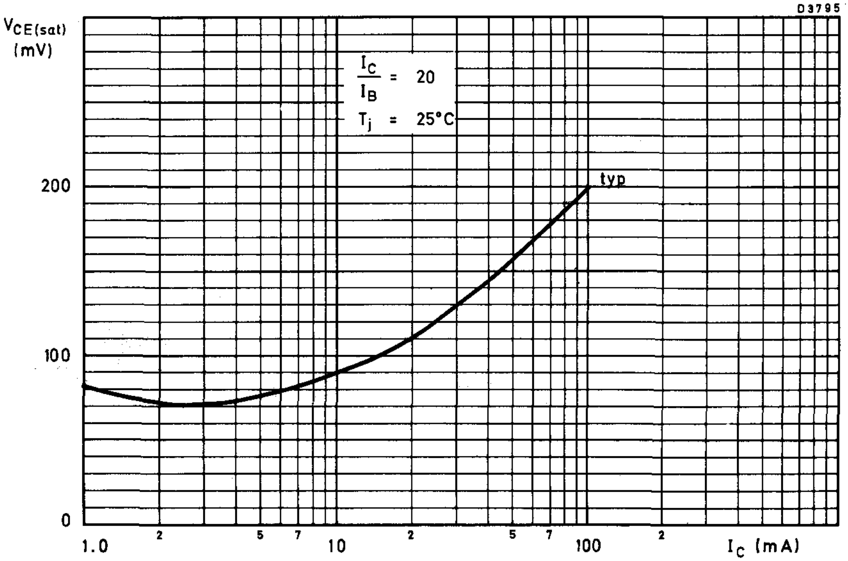
D3660
600
f_T (MHz)
400
200
0
V_{CE}=5V
T_j =25°C
f =35MHz
typ
0.1
1
10
I_C (mA)
100

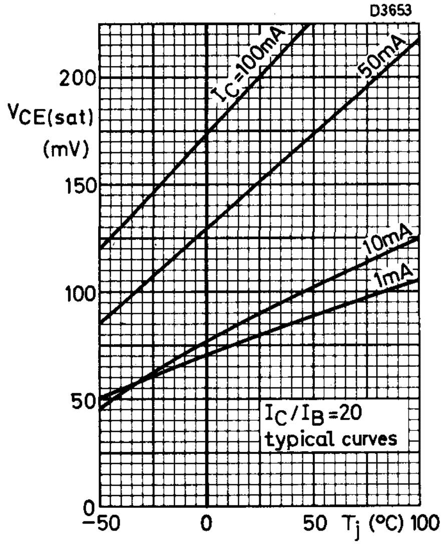


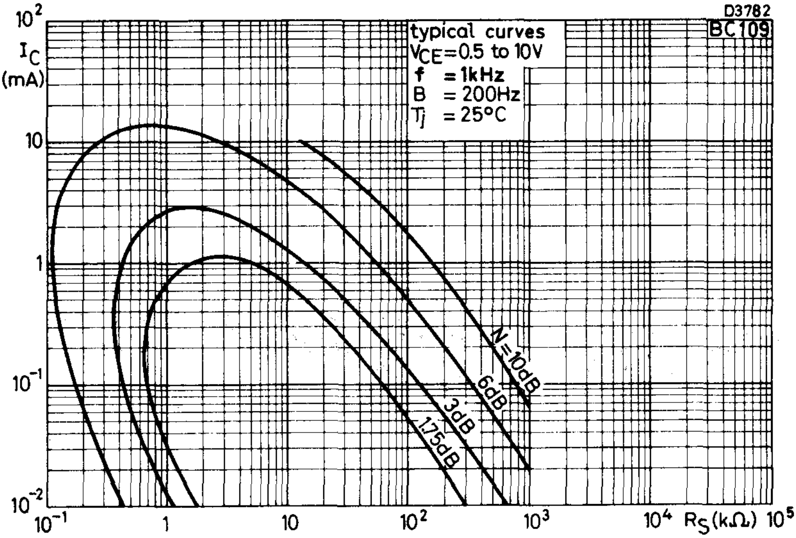
D3656
$I_E = I_e = 0$
f = 1MHz
T_j = 25°C
8
C_{Tc} (pF)
6
4
2
0
typ
0
10
20
V_{CB}(V)
30

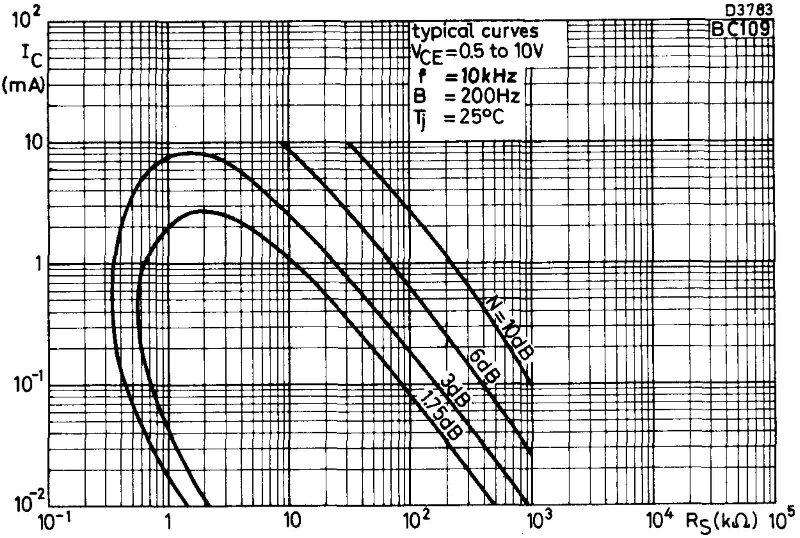


D3657
$I_C = I_c = 0$
f = 1MHz
T_j = 25°C
20
C_{Te} (pF)
15
10
5
0
typ
0
2
4
V_{EB} (V)
6

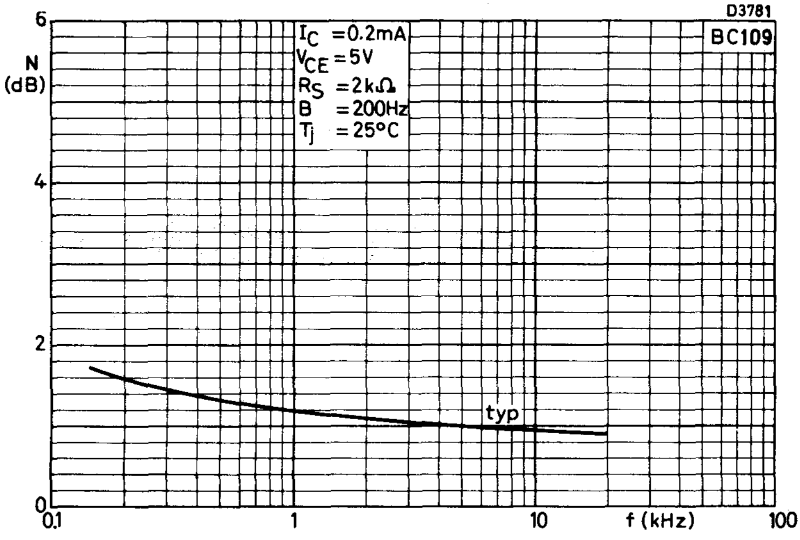

D3795
VCE(sat) (mV)
200
100
0
IC/IB = 20
Tj = 25°C
typ
1.0
2
5
7
10
2
5
7
100
2
IC (mA)


D3653
200
VCE(sat) (mV)
150
100
50
0
IC=100mA
50mA
10mA
1mA
IC/IB=20
typical curves
−50
0
50
Tj (°C)
100

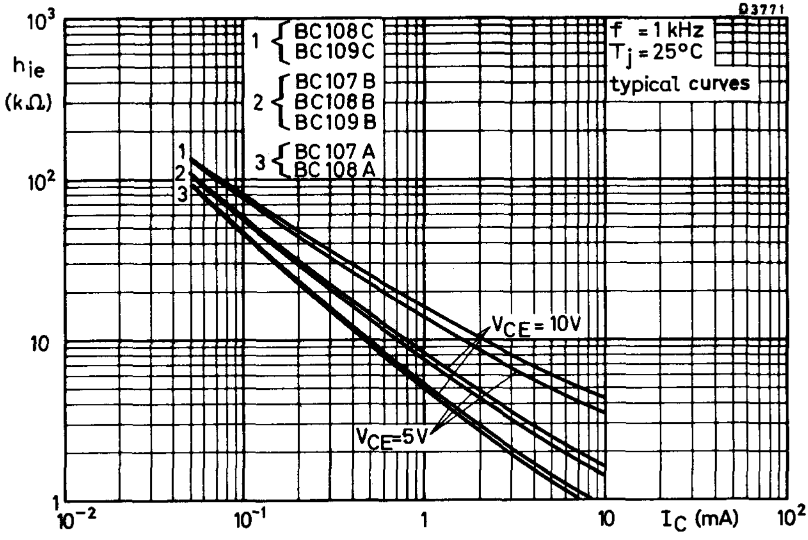


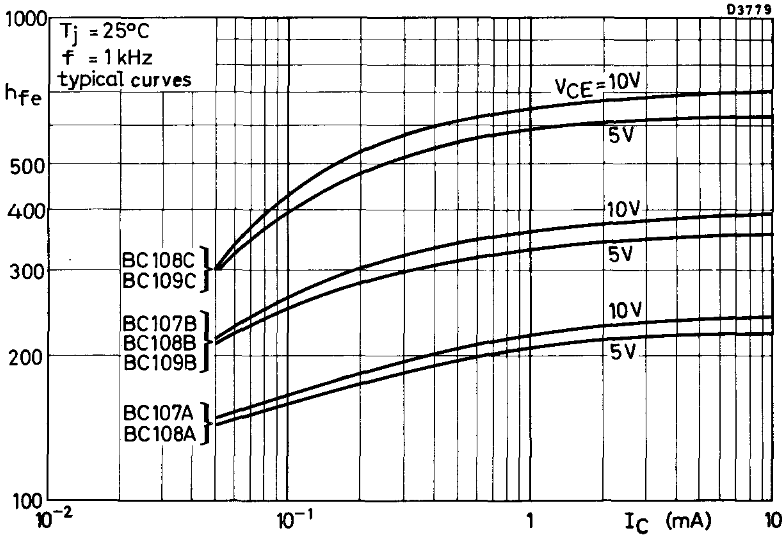


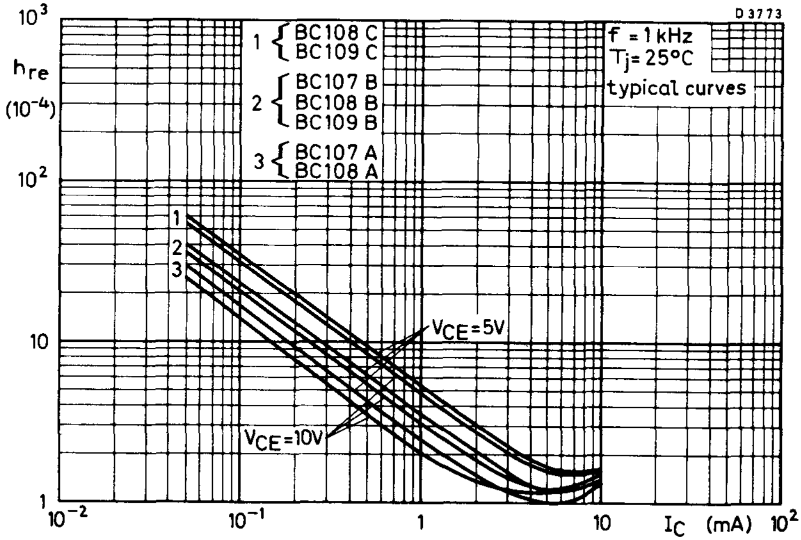
TYPICAL CURVES OF CONSTANT NOISE FIGURE

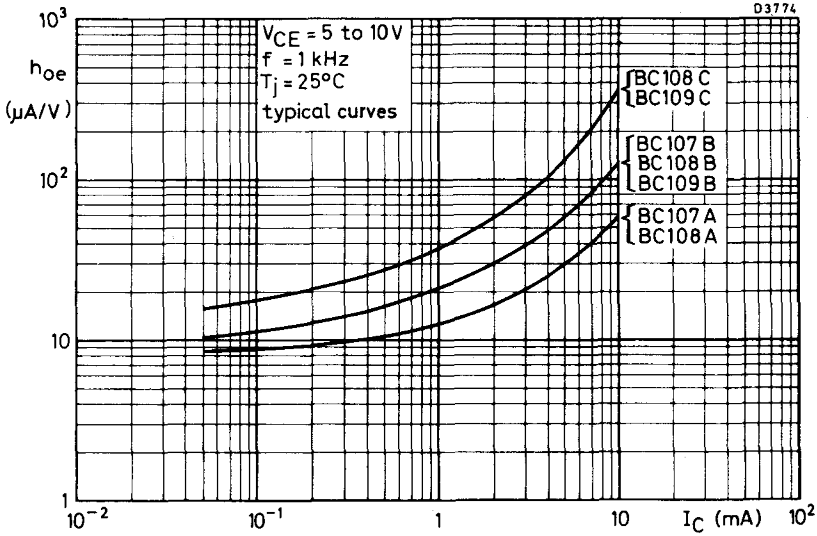


D3781
BC109
N
(dB)
6
4
2
0
0.1
1
10
f (kHz)
100
I_C =0.2mA
V_{CE} =5V
R_S =2kΩ
B =200Hz
T_j =25°C
typ


D3771
10^3
h_{ie}
(kΩ)
10^2
10
1
1 { BC108C BC109C
2 { BC107B BC108B BC109B
3 { BC107A BC108A
f = 1 kHz
T_j = 25°C
typical curves
1
2
3
V_{CE} = 10V
V_{CE}=5V
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2


D3779
1000
h_{fe}
500
400
300
200
100
T_j = 25°C
f = 1 kHz
typical curves
V_{CE}=10V
5V
10V
5V
10V
5V
BC108C
BC109C
BC107B
BC108B
BC109B
BC107A
BC108A
10^{-2}
10^{-1}
1
I_C (mA)
10


D 3773
10^3
h_{re}
(10^{-4})
10^2
10
1
1 {BC108 C
BC109 C
2 {BC107 B
BC108 B
BC109 B
3 {BC107 A
BC108 A
f = 1 kHz
Tj = 25°C
typical curves
1
2
3
VCE = 5V
VCE = 10V
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2


D3774
10^3
h_{oe}
(µA/V)
10^2
10
1
VCE = 5 to 10V
f = 1 kHz
Tj = 25°C
typical curves
{BC108 C
BC109 C
{BC107 B
BC108 B
BC109 B
{BC107 A
BC108 A
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2

N-P-N SILICON PLANAR EPITAXIAL TRANSISTORS

BC147 BC148 BC149

N-P-N silicon planar epitaxial transistors in plastic encapsulation with three rigid self-locking strips suitable for insertion in printed circuit boards using standard grids.

The BC147 is primarily intended for use in audio driver stages and television signal processing circuits.

The BC148 is a general purpose l.f. transistor.

The BC149 is primarily intended for low noise audio input stages.

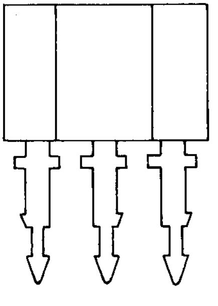
QUICK REFERENCE DATA

		BC147	BC148	BC149	
V_{CES} max.		50	30	30	V
V_{CEO} max.		45	20	20	V
I_{CM} max.		200	200	200	mA
P_{tot} max. ($T_{amb} \leq 25^{\circ}C$)		350	350	350	mW
T_j max.		125	125	125	$^{\circ}C$
h_{fe} ($I_C = 2mA$, $V_{CE} = 5V$, $f = 1kHz$)	min.	125	125	240	
	max.	500	900	900	
f_T ($I_C = 10mA$, $V_{CE} = 5V$, $f = 35MHz$)	typ.	300	300	300	MHz
N ($I_C = 200\mu A$, $V_{CE} = 5V$, $R_S = 2k\Omega$)					
f = 30Hz to 15kHz	typ.	-	-	1.4	dB
	max.	-	-	4.0	dB
f = 1kHz, B = 200Hz	max.	10	10	4.0	dB

Unless otherwise stated data are applicable to all types

OUTLINE AND DIMENSIONS

For details see page 5.



Front View
Scale 3:1

D5542

N.B. Devices in this Data Sheet should be ordered by the type number followed by Reference 0220.

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

	BC147	BC148	BC149	
V_{CBO} max.	50	30	30	V
V_{CES} max.	50	30	30	V
V_{CEO} max.	45	20	20	V
V_{EBO} max.	6.0	5.0	5.0	V
I_C max.	100	100	100	mA
I_{CM} max.	200	200	200	mA
$-I_{EM}$ max.	200	200	200	mA
I_{BM} max.	200	200	200	mA
P_{tot} max. ($T_{amb} \leq 25^oC$)	350	350	350	mW

Temperature

T_{stg} range	-65 to +125	^oC
T_j max.	125	^oC

THERMAL CHARACTERISTICS

$R_{th(j-amb)}$	0.275	$^oC/mW$

ELECTRICAL CHARACTERISTICS ($T_j = 25^oC$ unless otherwise stated)

		Min.	Typ.	Max.	
I_{CBO}	Collector cut-off current				
	$V_{CB}=20V,\ I_E=0,\ T_j=125^oC$	-	-	5.0	μA
	$V_{CB}=20V,\ I_E=0$	-	0.01	0.6	μA
V_{BE}	*Base-emitter voltage				
	$I_C=2.0mA,\ V_{CE}=5.0V$	550	620	700	mV
	$I_C=10mA,\ V_{CE}=5.0V$	-	-	770	mV
$V_{CE(sat)}$	Collector-emitter saturation voltage				
	$I_C=10mA,\ I_B=0.5mA$	-	90	250	mV
	$I_C=100mA,\ I_B=5.0mA$	-	200	600	mV
$V_{BE(sat)}$	†Base-emitter saturation voltage				
	$I_C=10mA,\ I_B=0.5mA$	-	700	-	mV
	$I_C=100mA,\ I_B=5.0mA$	-	900	-	mV

*V_{BE} decreases by about $2mV/^oC$ with increasing temperature.

†$V_{BE(sat)}$ decreases by about $1.7mV/^oC$ with increasing temperature.

N-P-N SILICON PLANAR EPITAXIAL TRANSISTORS

BC147 BC148 BC149

ELECTRICAL CHARACTERISTICS (contd.)			Min.	Typ.	Max.	
V_{CEK}	Collector knee voltage (see Fig. 1) $I_C = 10mA$, I_B = the value for which $I_C = 11mA$ at $V_{CE} = 1.0V$		-	300	600	mV

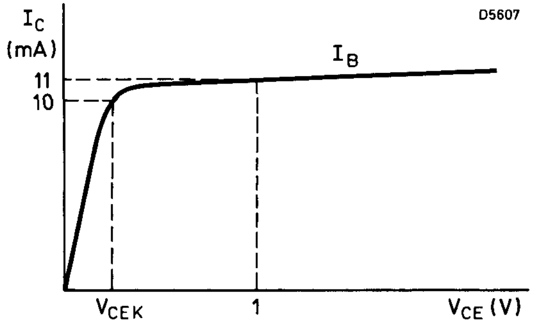


Fig. 1

			Min.	Typ.	Max.	
h_{FE}	Static forward current transfer ratio $I_C = 2.0mA$, $V_{CE} = 5.0V$	BC147	110	-	450	
		BC148	110	-	800	
		BC149	200	-	800	
h_{fe}	Small signal forward current transfer ratio $I_C = 2.0mA$, $V_{CE} = 5.0V$, $f = 1.0kHz$	BC147	125	-	500	
		BC148	125	-	900	
		BC149	240	-	900	
f_T	Transition frequency $I_C = 10mA$, $V_{CE} = 5.0V$, $f = 35MHz$		-	300	-	MHz
C_{Tc}	Collector capacitance $I_E = I_e = 0$, $V_{CB} = 10V$, $f = 1.0MHz$		-	2.5	4.5	pF
C_{Te}	Emitter capacitance $I_C = I_c = 0$, $V_{EB} = 0.5V$, $f = 1.0MHz$		-	9.0	-	pF
N	Noise figure $I_C = 0.2mA$, $V_{CE} = 5.0V$, $R_S = 2.0k\Omega$					
	f = 30Hz to 15kHz	BC149	-	1.4	4.0	dB
	f = 1.0kHz, B = 200Hz	BC147/148	-	2.0	10	dB
		BC149	-	1.2	4.0	dB

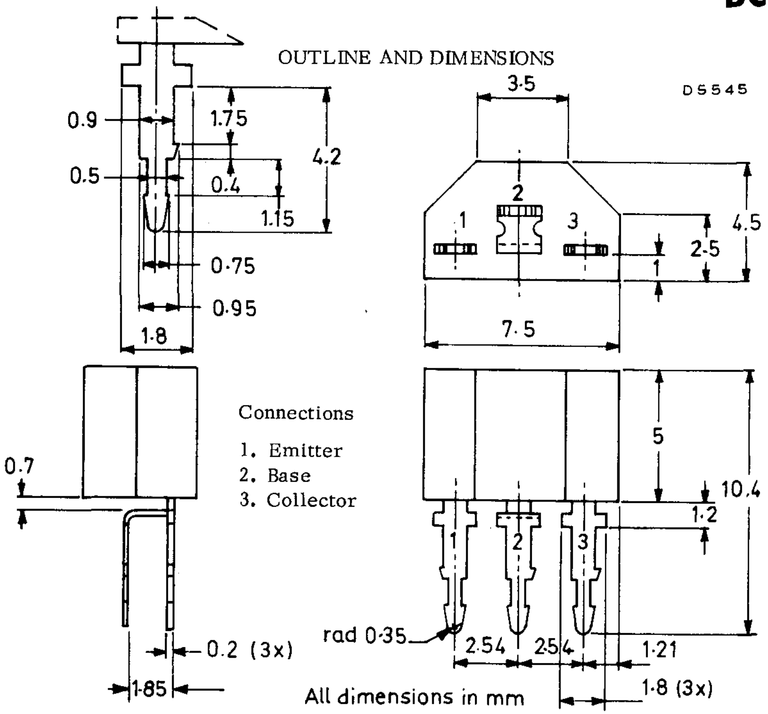
ELECTRICAL CHARACTERISTICS (contd.)

The following supplementary gain groups are available on request: -

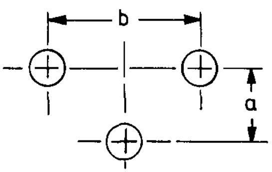
				BC147A BC148A	BC147B BC148B BC149B	BC148C BC149C	
h_{FE}	Static forward current transfer ratio						
	$I_C = 10\mu A$, $V_{CE} = 5.0V$	min.		-	40	100	
		typ.		90	150	270	
	$I_C = 2.0mA$, $V_{CE} = 5.0V$	min.		110	200	420	
		typ.		180	290	520	
		max.		220	450	800	
h parameters							
	$I_C = 2.0mA$, $V_{CE} = 5.0V$, $f = 1.0kHz$						
h_{ie}	Input impedance	min.		1.6	3.2	6.0	kΩ
		typ.		2.7	4.5	8.7	kΩ
		max.		4.5	8.5	15	kΩ
h_{re}	Voltage feedback ratio	typ.		1.5	2.0	3.0	$\times 10^{-4}$
h_{fe}	Small signal current gain	min.		125	240	450	
		typ.		220	330	600	
		max.		260	500	900	
h_{oe}	Output admittance	typ.		18	30	60	μA/V
		max.		30	60	110	μA/V

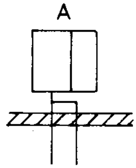
N-P-N SILICON PLANAR EPITAXIAL TRANSISTORS

BC147
BC148
BC149



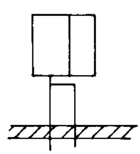
Mounting details





Maximum thickness of printed board = 1.7mm

Recommended hole diameter = 1.0 to 1.1mm (1.0 to 1.3mm allowable)



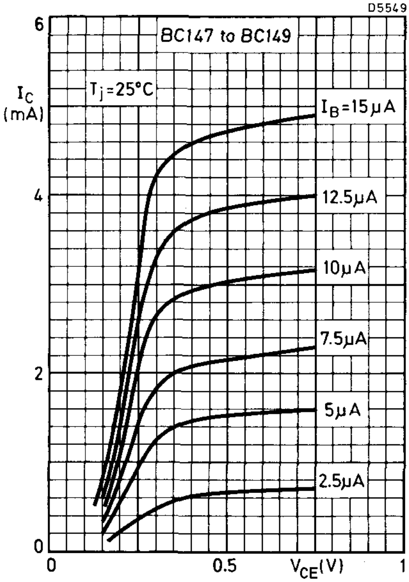
Maximum thickness of printed board = 1.1mm

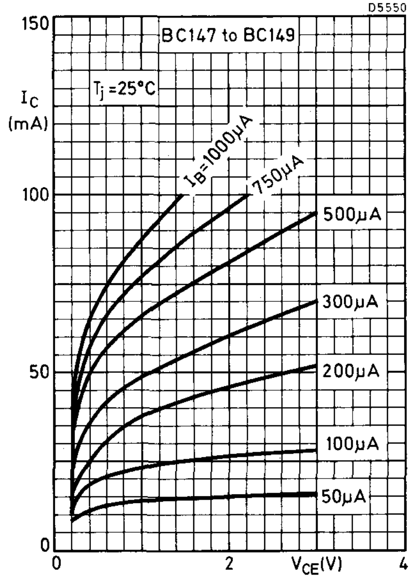
Hole diameter = 0.77 to 0.83mm

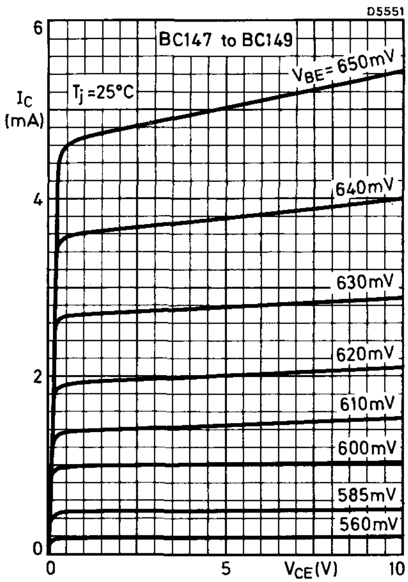
a = 2.49 to 2.59mm

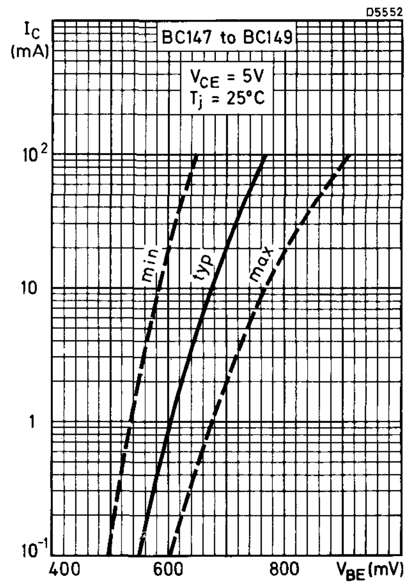
b = 5.03 to 5.13mm

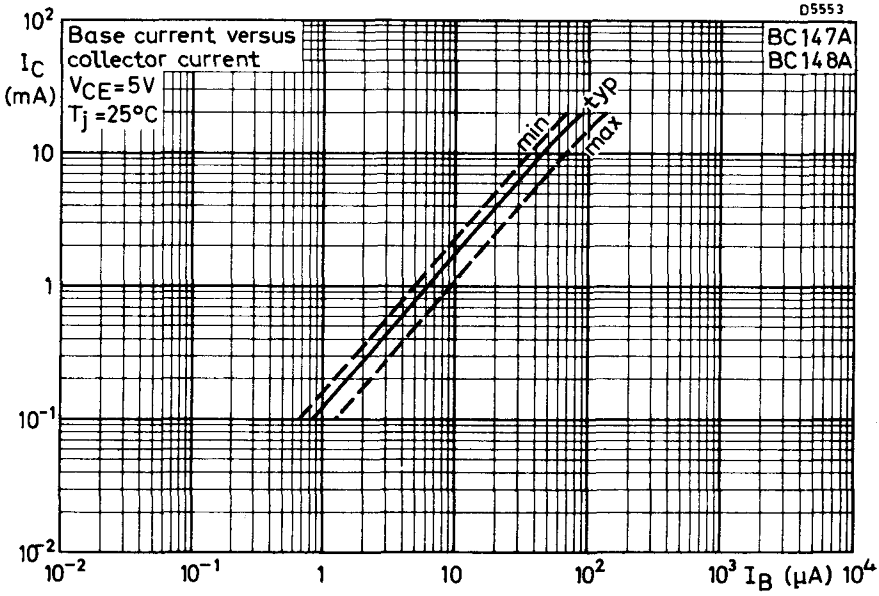
See also General Explanatory Notes Section IV.


D5549
BC147 to BC149
Tj=25°C
IC (mA)
IB=15μA
12.5μA
10μA
7.5μA
5μA
2.5μA
0
2
4
6
0
0.5
VCE(V)
1

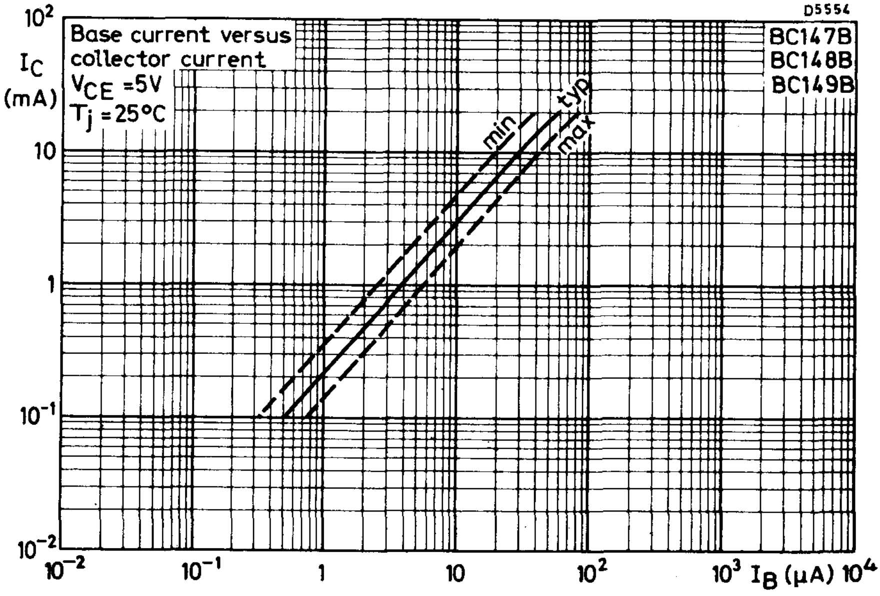

D5550
BC147 to BC149
Tj=25°C
IC (mA)
IB=1000μA
750μA
500μA
300μA
200μA
100μA
50μA
0
50
100
150
0
2
VCE(V)
4


D5551
BC147 to BC149
Tj=25°C
IC (mA)
VBE=650mV
640mV
630mV
620mV
610mV
600mV
585mV
560mV
0
2
4
6
0
5
VCE(V)
10

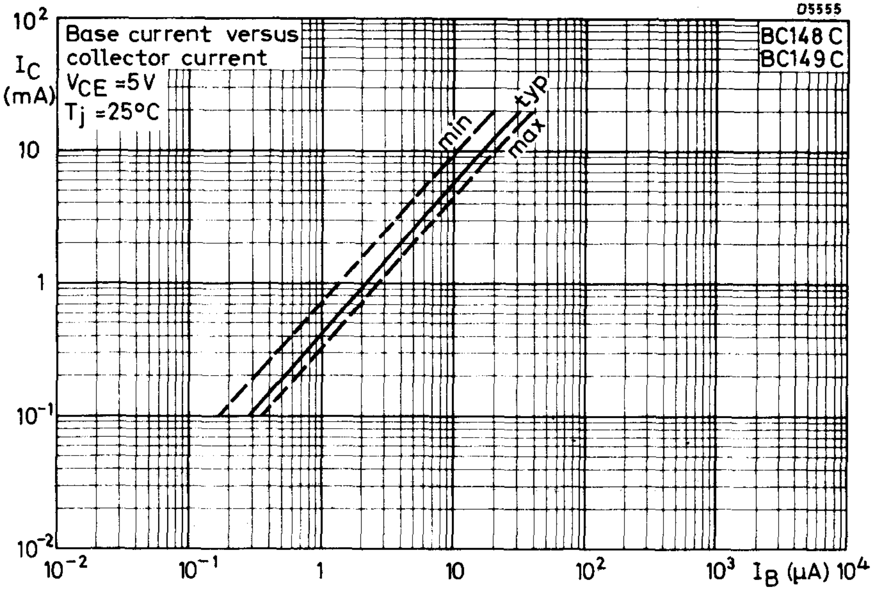

D5552
BC147 to BC149
VCE = 5V
Tj = 25°C
IC (mA)
min
typ
max
10^-1
1
10
10^2
400
600
800
VBE(mV)

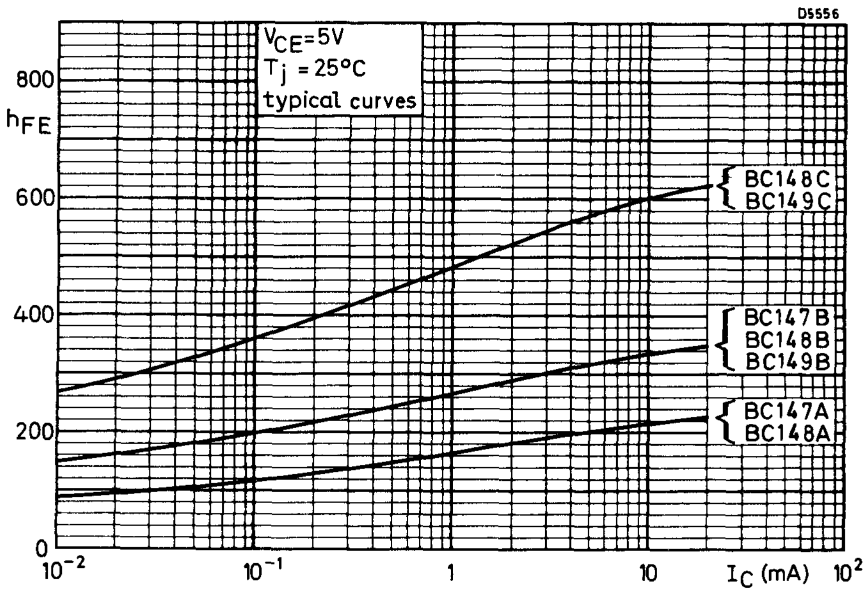


D5553
Base current versus collector current
V_{CE}=5V
T_j=25°C
BC147A
BC148A
I_C (mA)
10^2
10
1
10^{-1}
10^{-2}
min
typ
max
10^{-2}
10^{-1}
1
10
10^2
10^3
I_B (μA)
10^4



D5554
Base current versus collector current
V_{CE}=5V
T_j=25°C
BC147B
BC148B
BC149B
I_C (mA)
10^2
10
1
10^{-1}
10^{-2}
min
typ
max
10^{-2}
10^{-1}
1
10
10^2
10^3
I_B (μA)
10^4

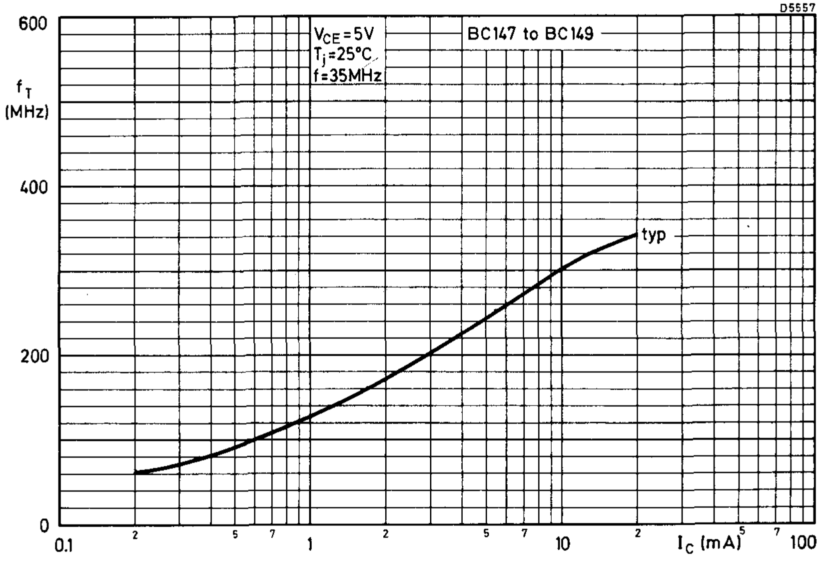

D5555
Base current versus collector current
V_{CE} = 5 V
T_j = 25°C
BC148 C
BC149 C
I_C (mA)
10^2
10
1
10^{-1}
10^{-2}
min
typ
max
10^{-2}
10^{-1}
1
10
10^2
10^3
I_B (µA)
10^4

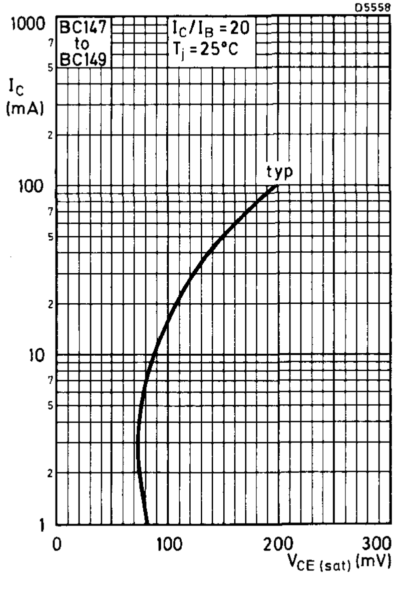

D5556
V_{CE} = 5V
T_j = 25°C
typical curves
h_{FE}
800
600
400
200
0
BC148C
BC149C
BC147B
BC148B
BC149B
BC147A
BC148A
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2

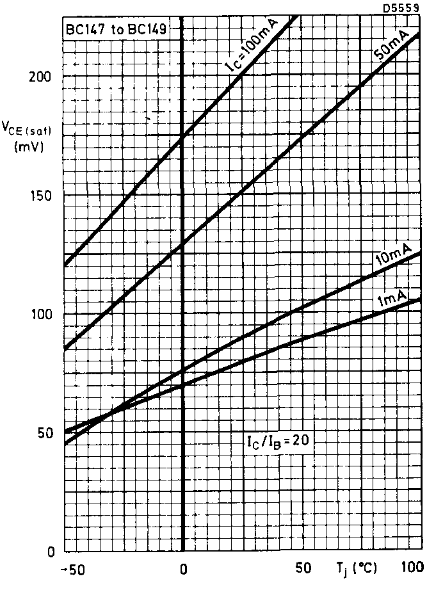
Mullard

N-P-N SILICON PLANAR EPITAXIAL TRANSISTORS

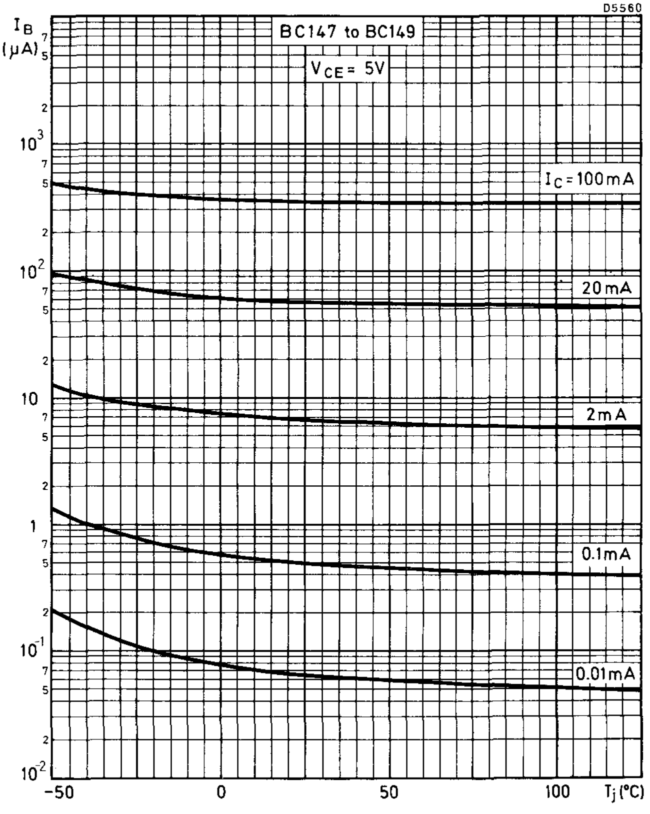
BC147
BC148
BC149





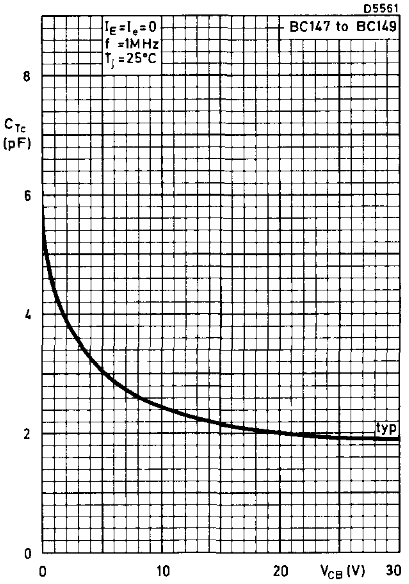


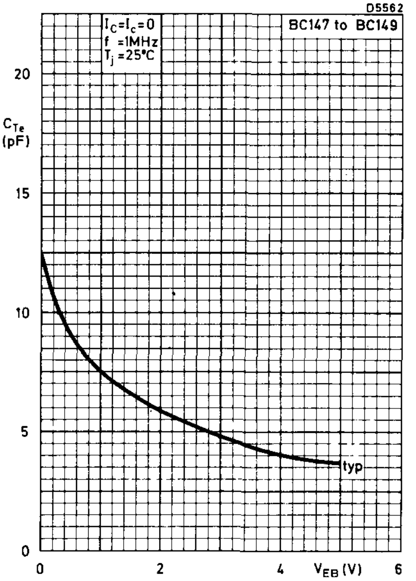
Mullard

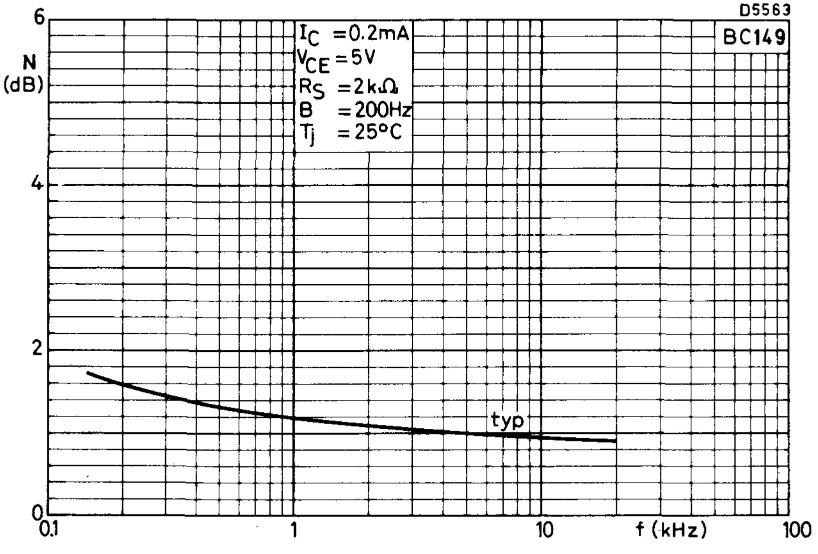

D5560
BC147 to BC149
V_{CE} = 5V
I_B (μA)
10^3
10^2
10
1
10^{-1}
10^{-2}
I_C = 100mA
20mA
2mA
0.1mA
0.01mA
-50
0
50
100
T_j (°C)

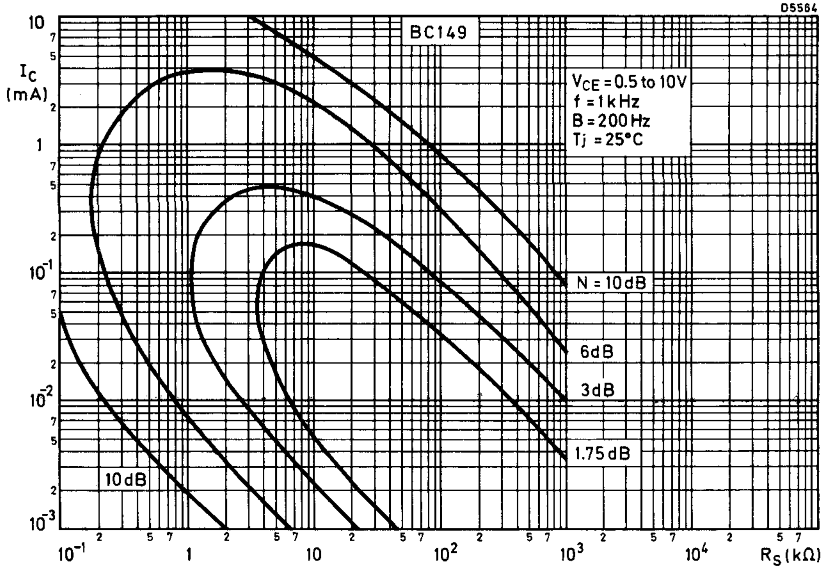
N-P-N SILICON PLANAR EPITAXIAL TRANSISTORS

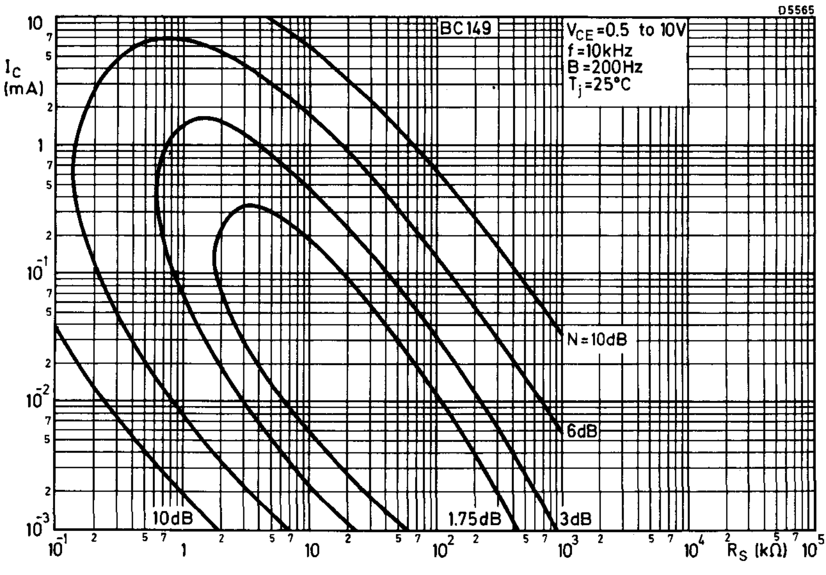
BC147
BC148
BC149







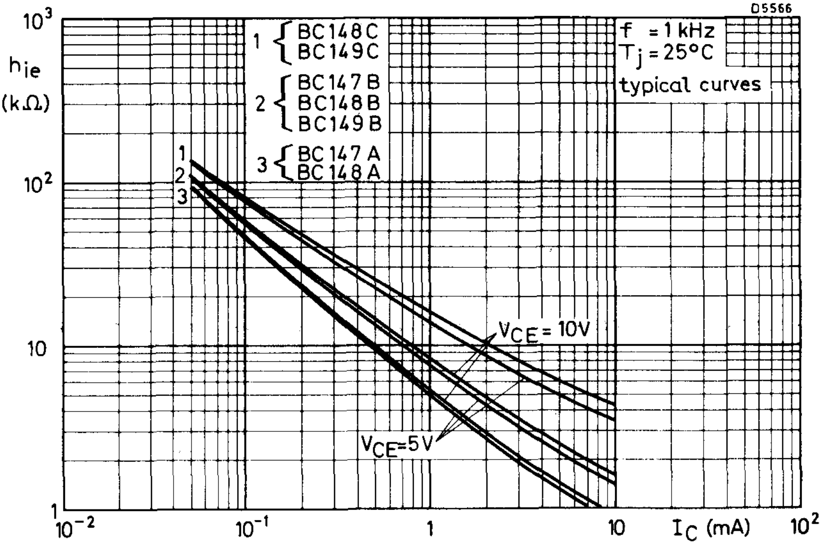


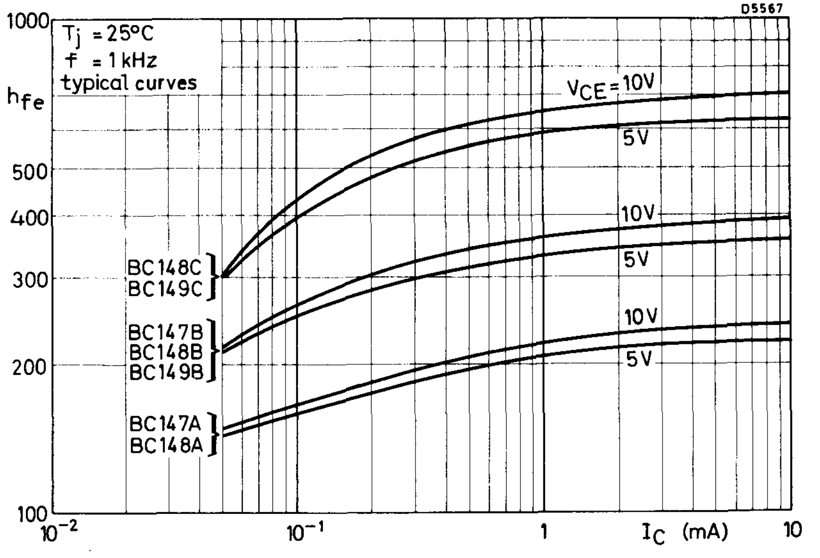


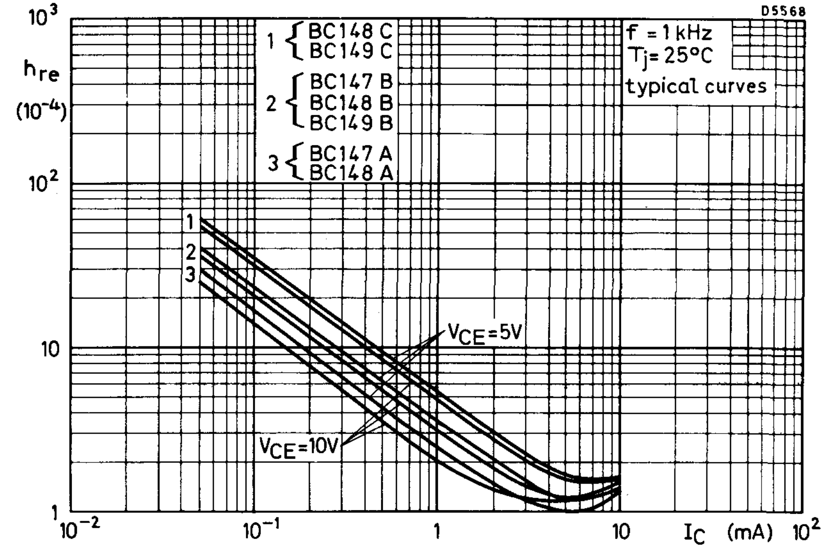
TYPICAL CURVES OF CONSTANT NOISE FIGURE

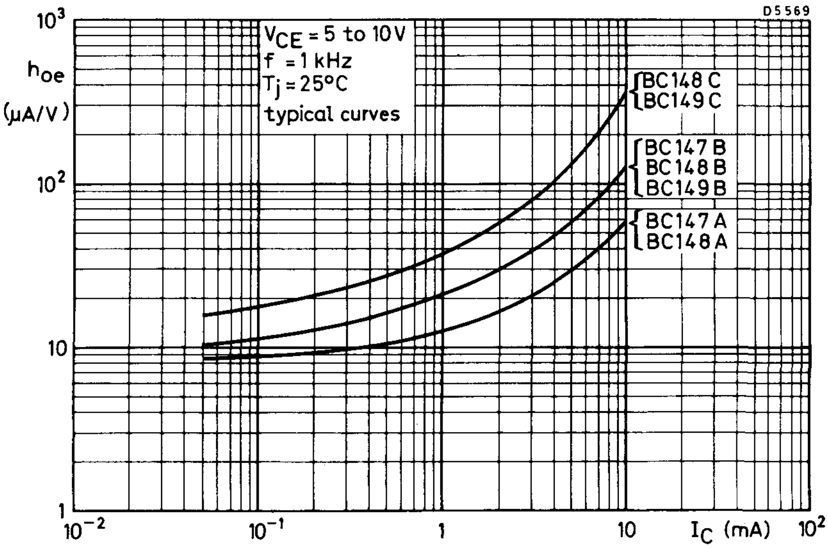
N-P-N SILICON PLANAR EPITAXIAL TRANSISTORS

BC147 BC148 BC149






D5568
h_{re}
(10^{-4})
1 { BC148 C, BC149 C
2 { BC147 B, BC148 B, BC149 B
3 { BC147 A, BC148 A
f = 1 kHz
Tj = 25°C
typical curves
V_{CE} = 5V
V_{CE} = 10V
I_C (mA)


D5569
h_{oe}
(µA/V)
V_{CE} = 5 to 10 V
f = 1 kHz
Tj = 25°C
typical curves
BC148 C
BC149 C
BC147 B
BC148 B
BC149 B
BC147 A
BC148 A
I_C (mA)

P-N-P SILICON PLANAR EPITAXIAL TRANSISTORS

BC157 BC158 BC159

P-N-P silicon planar epitaxial transistors in plastic encapsulation with three rigid self-locking strips suitable for insertion in printed circuit boards using standard grids.
The BC157 is primarily intended for use in audio driver stages and television signal processing circuits.
The BC158 is a general purpose l.f. transistor.
The BC159 is primarily intended for low noise audio input stages.

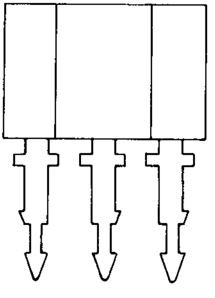
QUICK REFERENCE DATA

		BC157	BC158	BC159	
$-V_{CEX}$ max. ($+V_{BE}$ = 1V)		50	30	25	V
$-V_{CEO}$ max.		45	25	20	V
$-I_{CM}$ max.		200	200	200	mA
P_{tot} max. ($T_{amb} \leq 25^{o}C$)		350	350	350	mW
T_j max.		125	125	125	^{o}C
h_{fe} ($-I_C$ = 2mA, $-V_{CE}$ = 5V, f = 1kHz)	min.	75	75	125	
	max.	260	500	500	
f_T typ. ($-I_C$ = 10mA, $-V_{CE}$ = 5V, f = 35MHz)		150	150	150	MHz
N ($-I_C$ = 200μA, $-V_{CE}$ = 5V, R_S = 2kΩ)					
f = 30Hz to 15kHz	typ.	-	-	1.2	dB
	max.	-	-	4.0	dB
f = 1kHz, B = 200Hz	max.	10	10	4.0	dB

Unless otherwise stated data are applicable to all types

OUTLINE AND DIMENSIONS

For details see page 5



Front View
Scale 3:1

D5542

N.B. Devices in this Data Sheet should be ordered by the type number followed by Reference 0220.

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

	BC157	BC158	BC159	
$-V_{CBO}$ max.	50	30	25	V
$-V_{CEX}$ max. ($+V_{BE}$ = 1V)	50	30	25	V
$-V_{CEO}$ max.	45	25	20	V
$-V_{EBO}$ max.	5.0	5.0	5.0	V
$-I_C$ max.	100	100	100	mA
$-I_{CM}$ max.	200	200	200	mA
I_{EM} max.	200	200	200	mA
$-I_{BM}$ max.	200	200	200	mA
P_{tot} max. ($T_{amb} \leq 25^oC$)	350	350	350	mW

Temperature

T_{stg} range	-65 to +125	^oC
T_j max.	125	^oC

THERMAL CHARACTERISTICS

$R_{th\ (j\text{-}amb)}$	0.275	$^oC/mW$

ELECTRICAL CHARACTERISTICS (T_j = 25^oC unless otherwise stated)

		Min.	Typ.	Max.	
$-I_{CBO}$	Collector cut-off current				
	$I_E = 0$, $-V_{CB}$ = 20V	-	2.0	100	nA
	$I_E = 0$, $-V_{CB}$ = 20V, T_j = 125^oC	-	-	5.0	μA
$-V_{BE}$	*Base-emitter voltage				
	$-I_C$ = 2mA, $-V_{CE}$ = 5V	600	650	750	mV
$-V_{CE\ (sat)}$	Collector-emitter saturation voltage				
	$-I_C$ = 10mA, $-I_B$ = 0.5mA	-	75	300	mV
	$-I_C$ = 100mA, $-I_B$ = 5mA	-	250	-	mV
$-V_{BE\ (sat)}$	Base-emitter saturation voltage				
	$-I_C$ = 10mA, $-I_B$ = 0.5mA	-	700	-	mV
	$-I_C$ = 100mA, $-I_B$ = 5mA	-	850	-	mV

* $-V_{BE}$ decreases by about 2mV/^oC with increasing temperature

P-N-P SILICON PLANAR EPITAXIAL TRANSISTORS

BC157 BC158 BC159

ELECTRICAL CHARACTERISTICS (cont'd)

			Min.	Typ.	Max.	
$-V_{CEK}$	Collector knee voltage (see Fig. 1) $-I_C = 10mA$, $-I_B$ = the value for which $-I_C = 11mA$ at $-V_{CE} = 1V$		-	250	600	mV

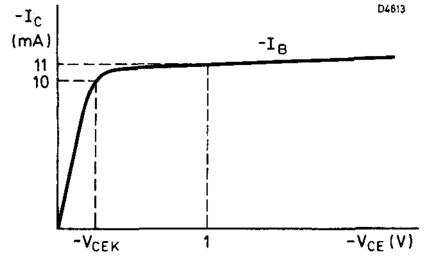


Fig. 1

			Min.	Typ.	Max.	
h_{FE}	Static forward current transfer ratio $-I_C = 2mA$, $-V_{CE} = 5V$	BC157	-	140	-	
		BC158	-	210	-	
		BC159	-	230	-	
h_{fe}	Small signal forward current transfer ratio $-I_C = 2mA$, $-V_{CE} = 5V$, f = 1kHz	BC157	75	-	260	
		BC158	75	-	500	
		BC159	125	-	500	
f_T	Transition frequency $-I_C = 10mA$, $-V_{CE} = 5V$, f = 35MHz		-	150	-	MHz
C_{Tc}	Collector capacitance $I_E = I_e = 0$, $-V_{CB} = 10V$, f = 1MHz		-	4.5	-	pF
N	Noise figure $-I_C = 200\mu A$, $-V_{CE} = 5V$, $R_S = 2k\Omega$ f = 30Hz to 15kHz	BC159	-	1.2	4.0	dB
	f = 1kHz, B = 200Hz	BC157, 158	-	-	10	dB
		BC159	-	1.0	4.0	dB

ELECTRICAL CHARACTERISTICS (cont'd)

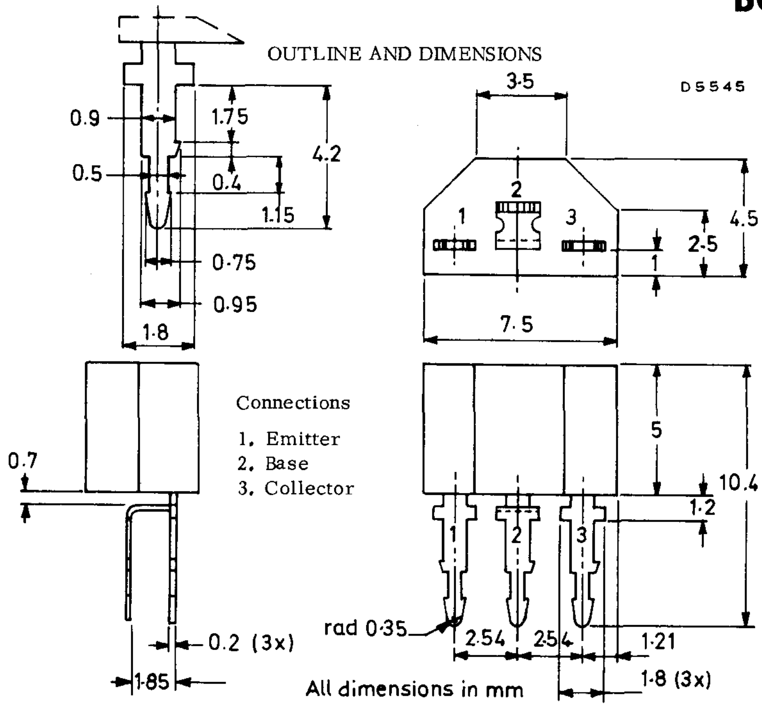
The following supplementary gain groups are available on request:

				BC157	BC158A BC159A	BC158B BC159B
h_{FE}	Static forward current transfer ratio $-I_C = 2mA$, $-V_{CE} = 5V$	typ.		140	180	290
h_{fe}	Small signal forward current transfer ratio $-I_C = 2mA$, $-V_{CE} = 5V$,	min.		75	125	240
	$f = 1kHz$	max.		260	260	500

P-N-P SILICON PLANAR EPITAXIAL TRANSISTORS

BC157
BC158
BC159

OUTLINE AND DIMENSIONS

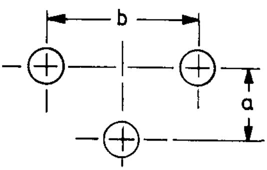


Connections

1. Emitter
2. Base
3. Collector

All dimensions in mm

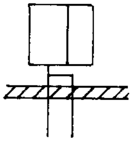
Mounting details



a = 2.49 to 2.59mm

b = 5.03 to 5.13mm

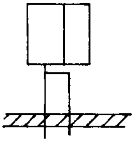
A



Maximum thickness of printed board = 1.7mm

Recommended hole diameter = 1.0 to 1.1mm (1.0 to 1.3mm allowable)

B

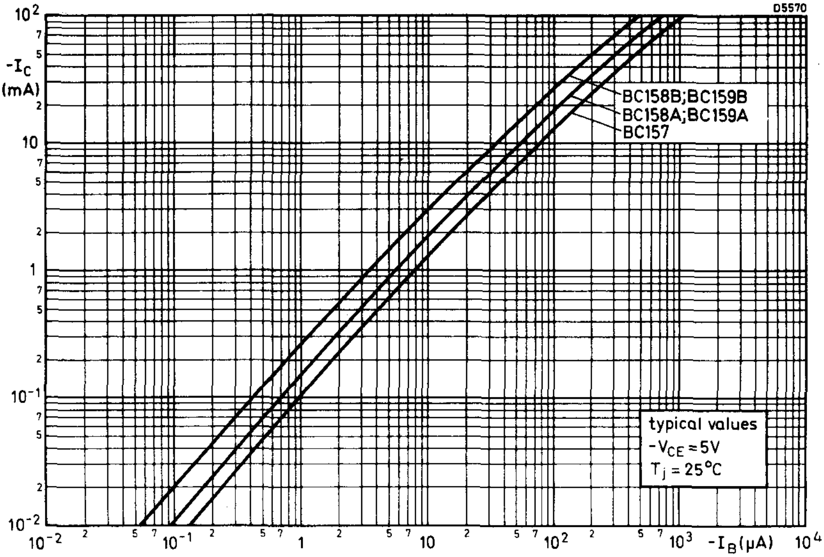


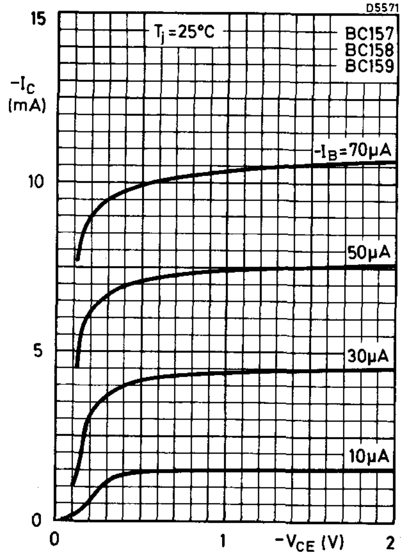
D5546

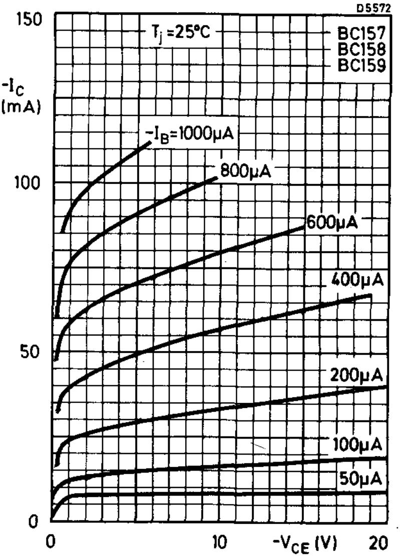
Maximum thickness of printed board = 1.1mm

Hole diameter = 0.77 to 0.83mm

See also General Explanatory Notes Section IV.

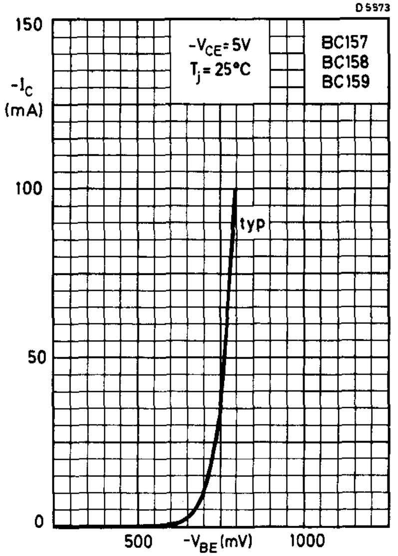

D5570
$-I_C$ (mA)
BC158B;BC159B
BC158A;BC159A
BC157
typical values
$-V_{CE} = 5V$
$T_j = 25°C$
$-I_B$ (μA)

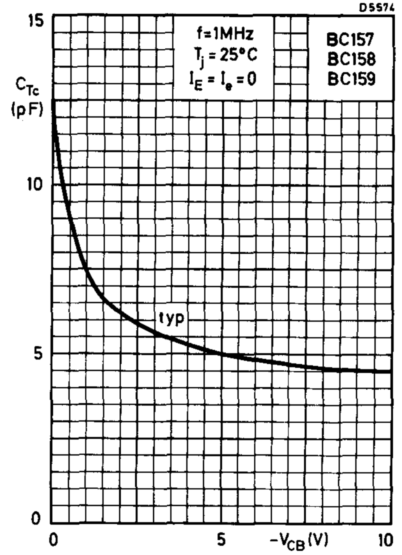

D5571
$-I_C$ (mA)
$T_j = 25°C$
BC157
BC158
BC159
$-I_B = 70μA$
50μA
30μA
10μA
$-V_{CE}$ (V)

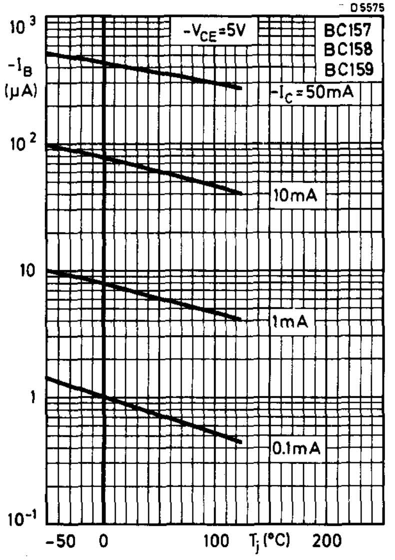

D5572
$-I_C$ (mA)
$T_j = 25°C$
BC157
BC158
BC159
$-I_B = 1000μA$
800μA
600μA
400μA
200μA
100μA
50μA
$-V_{CE}$ (V)

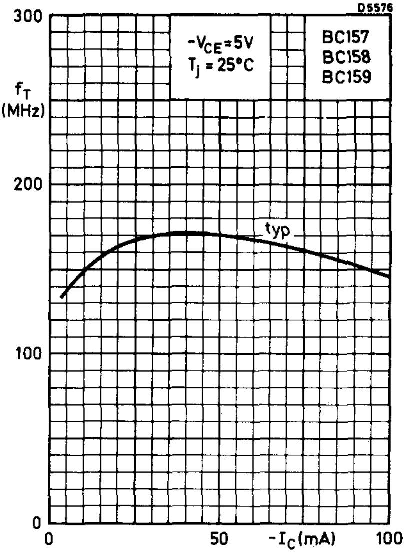
P-N-P SILICON PLANAR EPITAXIAL TRANSISTORS

BC157
BC158
BC159

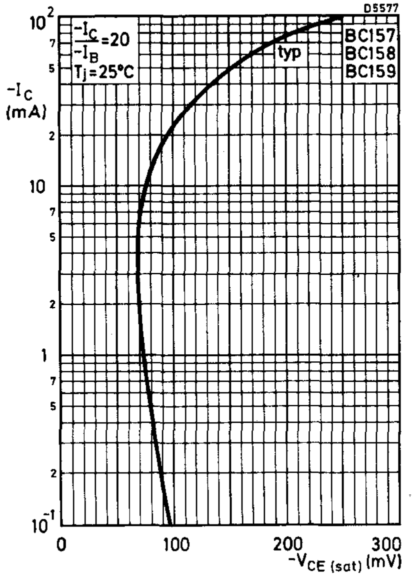


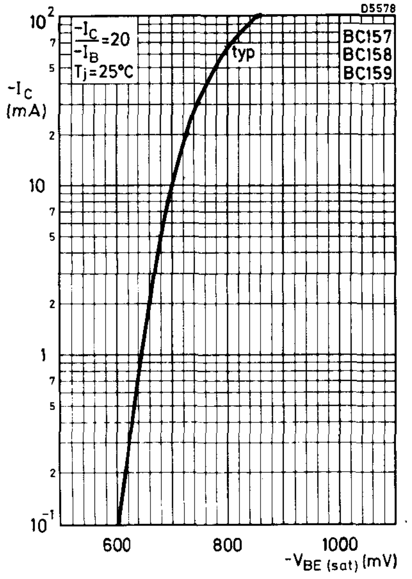


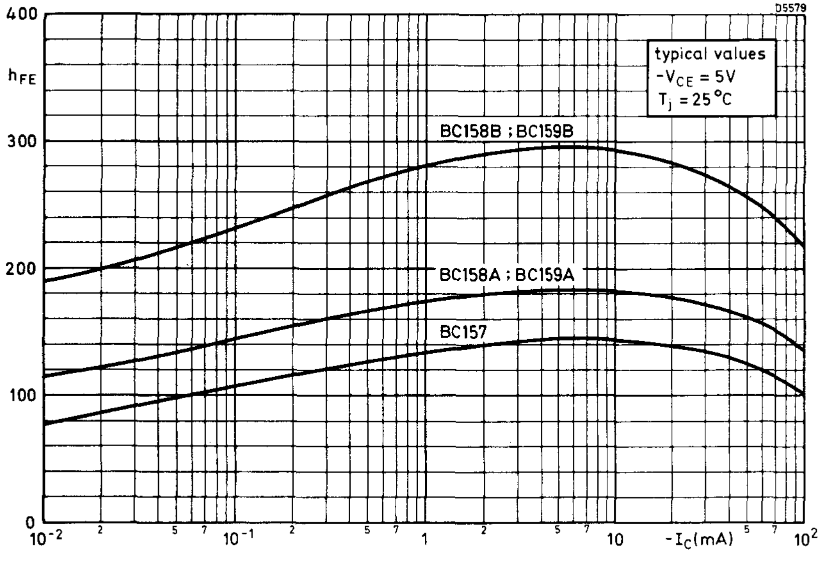




Mullard

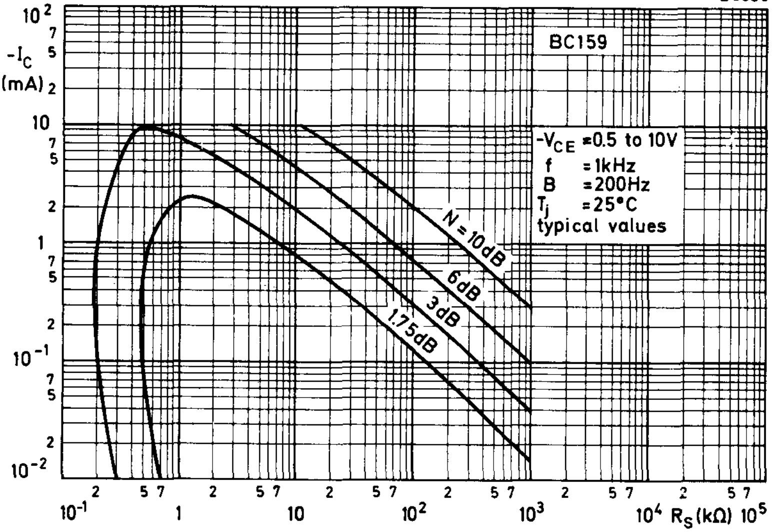

D5577
-IC/-IB = 20
Tj = 25°C
typ
BC157
BC158
BC159
-IC (mA)
-VCE (sat) (mV)


D5578
-IC/-IB = 20
Tj = 25°C
typ
BC157
BC158
BC159
-IC (mA)
-VBE (sat) (mV)

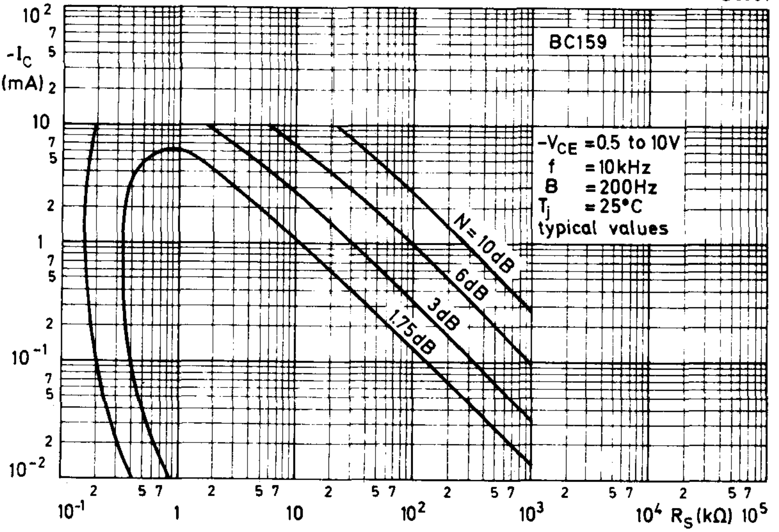

D5579
typical values
-VCE = 5V
Tj = 25 °C
hFE
BC158B ; BC159B
BC158A ; BC159A
BC157
-IC (mA)

Mullard

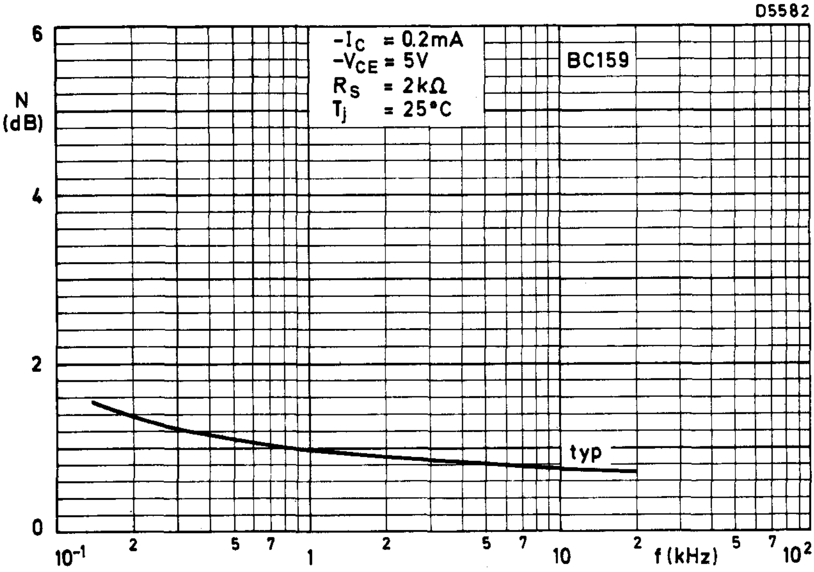
D5580

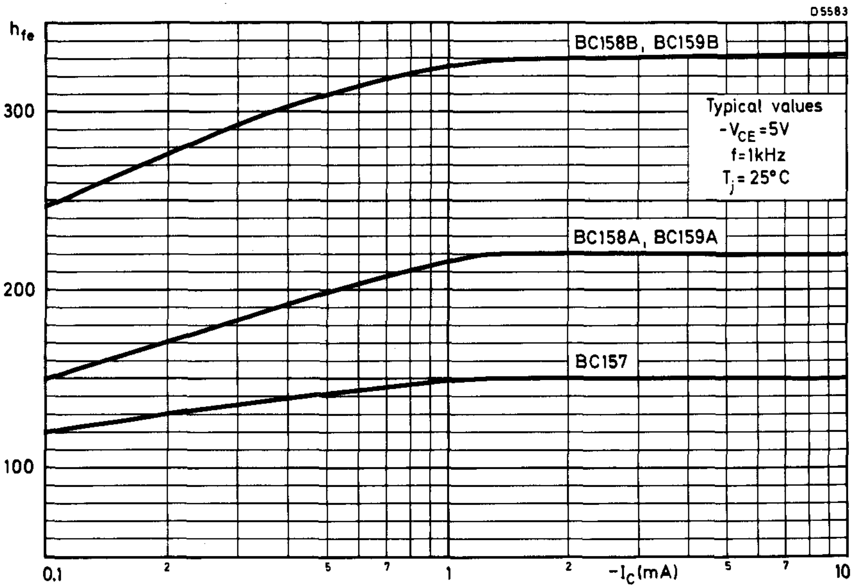


D5581



TYPICAL CURVES OF CONSTANT NOISE FIGURE


D5582
$-I_C$ = 0.2mA
$-V_{CE}$ = 5V
R_S = 2kΩ
T_j = 25°C
BC159
N (dB)
typ
f (kHz)


D5583
h_{fe}
BC158B, BC159B
Typical values
$-V_{CE}$ = 5V
f = 1kHz
T_j = 25°C
BC158A, BC159A
BC157
$-I_C$(mA)

P-N-P SILICON PLANAR EPITAXIAL TRANSISTORS

BC327
BC328

P-N-P silicon planar epitaxial transistors in plastic envelopes, primarily intended for use in driver and output stages of audio amplifiers.
The BC327, BC328 are complementary to the BC337 and BC338 respectively.

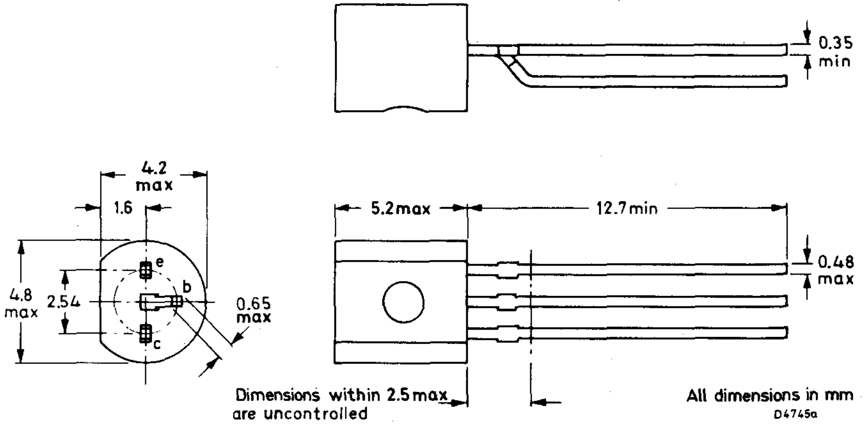
QUICK REFERENCE DATA

	BC327	BC328	
$-V_{CES}$ max.	50	30	V
$-V_{CEO}$ max.	45	25	V
$-I_{CM}$ max.	1000		mA
P_{tot} max. ($T_{case} \leq 45\,^{o}C$)	625		mW
T_j max.	150		^{o}C
f_T typ. ($-I_C = 10mA$, $-V_{CE} = 5V$, $f = 35MHz$)	100		MHz

Unless otherwise stated data are applicable to both types

OUTLINE AND DIMENSIONS

Similar to TO-92



RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

		BC327	BC328	
$-V_{CES}$ max. ($V_{BE}=0$)		50	30	V
$-V_{CEO}$ max. ($-I_C=10mA$)		45	25	V
$-V_{EBO}$ max.		5.0		V
$-I_C$ max.		500		mA
$-I_{CM}$ max.		1000		mA
I_{EM} max.		1000		mA
$-I_B$ max.		100		mA
$-I_{BM}$ max.		200		mA
P_{tot} max.	$T_{amb}=25^{o}C$	500		mW
	*$T_{amb} \leq 25^{o}C$	625		mW
	$T_{case} \leq 45^{o}C$	625		mW

Temperature

T_{stg}	-65 to +150	^{o}C
T_j max.	150	^{o}C

THERMAL CHARACTERISTICS

$R_{th(j-amb)}$ in free air	0.25	$^{o}C/mW$
*$R_{th(j-amb)}$	0.20	$^{o}C/mW$
$R_{th(j-case)}$	0.17	$^{o}C/mW$

*The transistor mounted on a printed circuit board, max. lead length 3mm, mounting pad for collector lead min. 10 x 10mm.

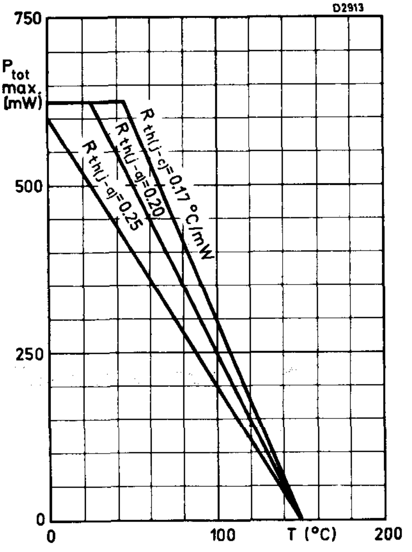
ELECTRICAL CHARACTERISTICS ($T_j=25^{o}C$ unless otherwise stated)

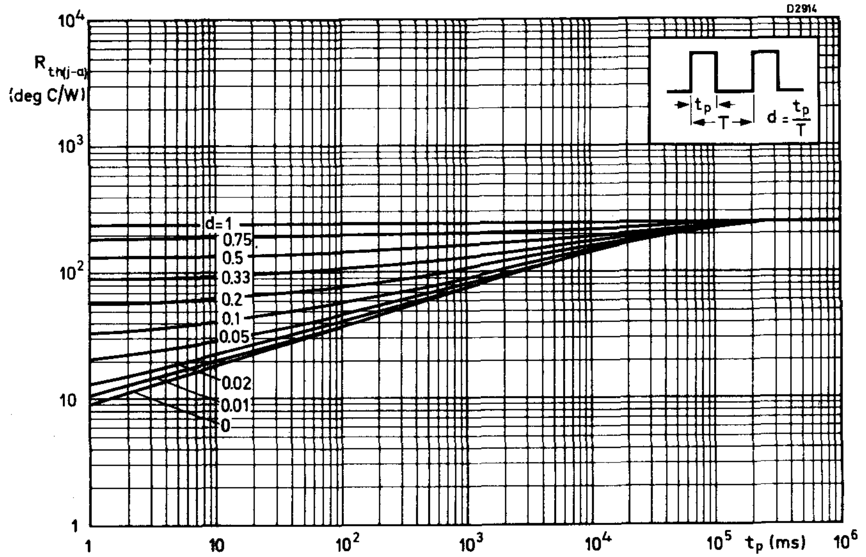
		Min.	Typ.	Max.	
$-I_{CBO}$	Collector cut-off current				
	$I_E=0$, $-V_{CB}=20V$	-	-	100	nA
	$I_E=0$, $-V_{CB}=20V$, $T_j=150^{o}C$	-	-	5.0	μA
$-I_{EBO}$	Emitter cut-off current				
	$I_C=0$, $-V_{EB}=5V$	-	-	10	μA

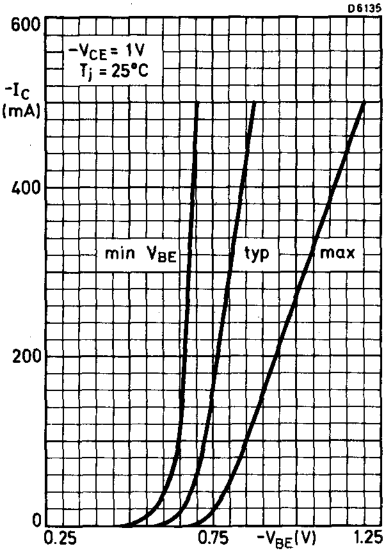
ELECTRICAL CHARACTERISTICS (contd.)

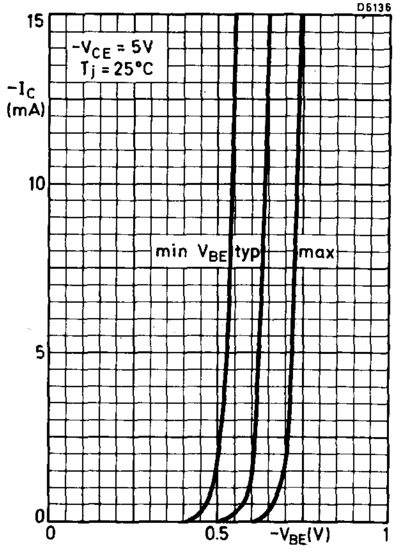
		Min.	Typ.	Max.	
$-V_{BE}$	**Base-emitter voltage				
	$-I_C = 500mA$, $-V_{CE} = 1V$	-	-	1.2	V
$-V_{CE(sat)}$	Collector-emitter saturation voltage				
	$-I_C = 500mA$, $-I_B = 50mA$	-	-	700	mV
h_{FE}	Static forward current transfer ratio				
	$-I_C = 100mA$, $-V_{CE} = 1V$	100	-	600	
	$-I_C = 500mA$, $-V_{CE} = 1V$	40	-	-	
f_T	Transition frequency				
	$-I_C = 10mA$, $-V_{CE} = 5V$, $f = 35MHz$	-	100	-	MHz
C_{Tc}	Collector capacitance				
	$I_E = I_e = 0$, $-V_{CB} = 10V$, $f = 1MHz$	-	8.0	-	pF
$\frac{h_{FE1}}{h_{FE2}}$	D. C. current gain ratio of matched pairs BC327/BC337 BC328/BC338				
	$\lvert I_C \rvert = 100mA$, $\lvert V_{CE} \rvert = 1V$	-	1.25	1.40	

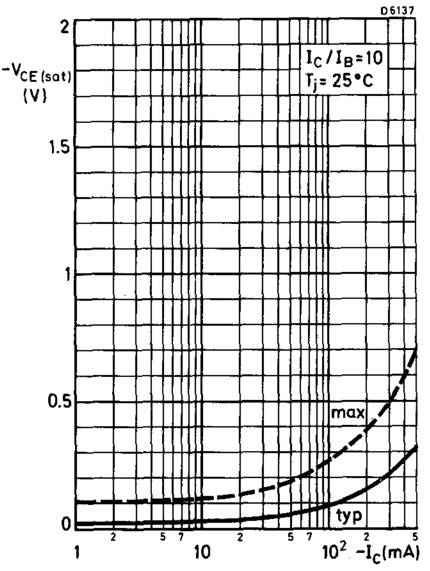
**$-V_{BE}$ decreases by about $2mV/^{o}C$ with increasing temperature.

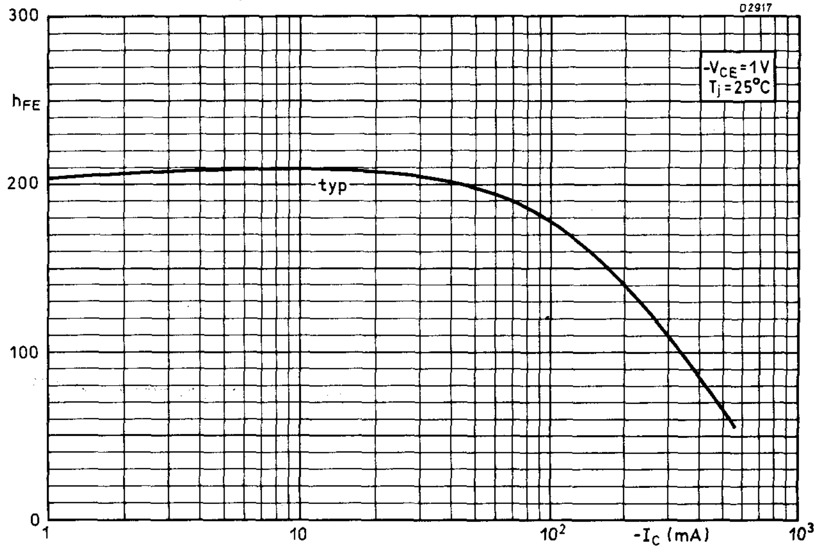

D2913
750
P_{tot} max. (mW)
500
250
0
0
100
T (°C)
200
R th(j-c)=0.17 °C/mW
R th(j-a)=0.20
R th(j-a)=0.25

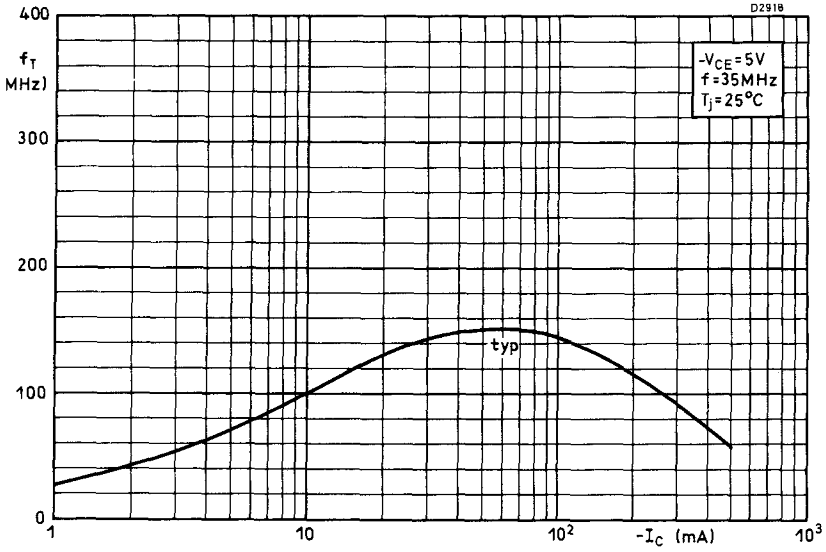

D2914
10^4
$R_{th(j-a)}$ (deg C/W)
10^3
10^2
10
1
1
10
10^2
10^3
10^4
10^5
t_p (ms)
10^6
d=1
0.75
0.5
0.33
0.2
0.1
0.05
0.02
0.01
0
t_p
T
$d = \frac{t_p}{T}$


D6135
600
400
200
0
$-I_C$ (mA)
$-V_{CE}$ = 1V
T_j = 25°C
min V_{BE}
typ
max
0.25
0.75
$-V_{BE}$(V)
1.25


D6136
15
10
5
0
$-I_C$ (mA)
$-V_{CE}$ = 5V
T_j = 25°C
min V_{BE}
typ
max
0
0.5
$-V_{BE}$(V)
1

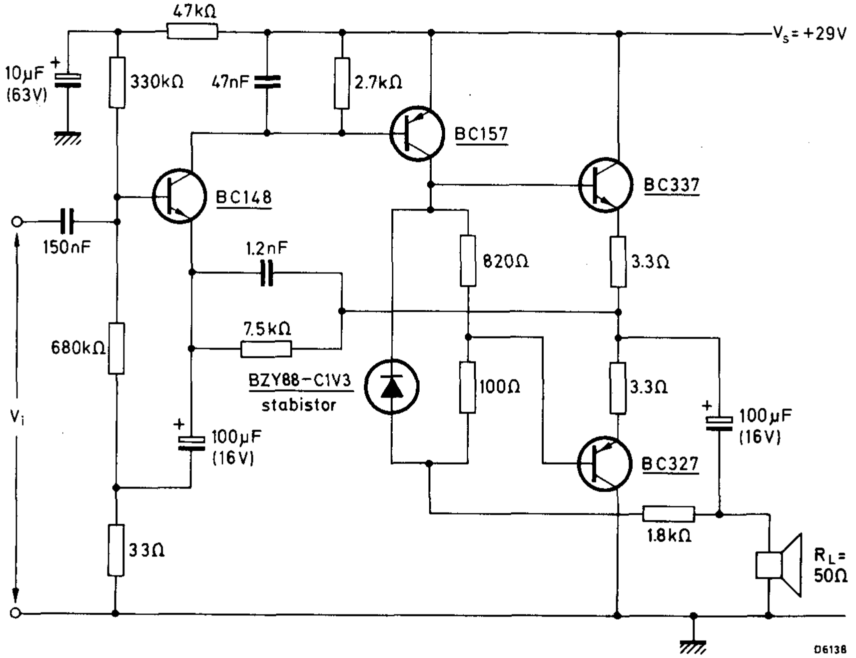

D6137
2
1.5
1
0.5
0
$-V_{CE(sat)}$ (V)
I_C/I_B=10
T_j= 25°C
max
typ
1
10
10^2
$-I_C$(mA)


D2917
300
h_{FE}
200
100
0
$-V_{CE}=1V$
$T_j=25°C$
typ
1
10
10^2
$-I_C$ (mA)
10^3


D2918
400
f_T
MHz)
300
200
100
0
$-V_{CE}=5V$
f = 35MHz
$T_j=25°C$
typ
1
10
10^2
$-I_C$ (mA)
10^3

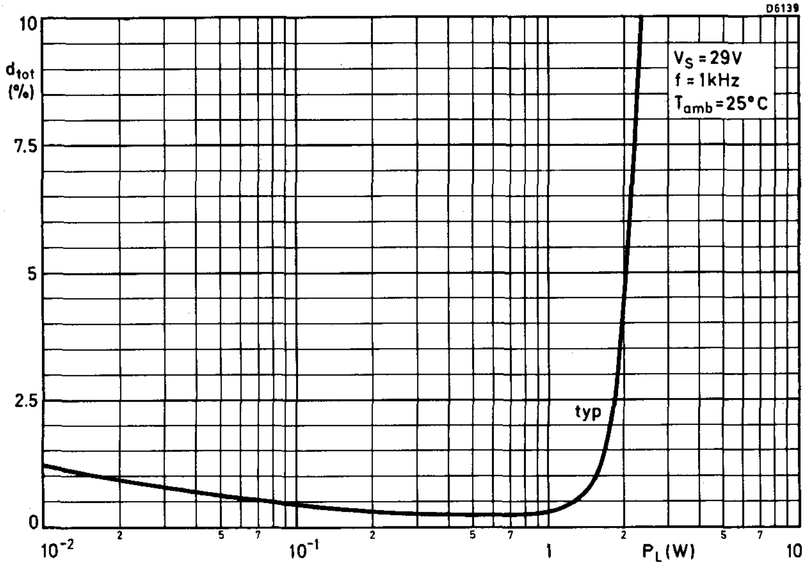
APPLICATION INFORMATION

2.2W transformerless audio frequency amplifier with matched pair BC327/BC337 in complementary class B output stage; $T_{amb} \leq 50^oC$



Performance at V_S = 29V, R_L = 50Ω				
Collector quiescent current of BC337	I_{CQ}	typ.	1	mA
Input voltage for P_o = 50mW	V_i	typ	7	mV
Input voltage for P_o = 2W	V_i	typ.	46	mV
Output power at f = 1kHz, d_{tot} = 10%	P_L	typ.	2.2	W
Frequency response (3dB)		50 to 15 000		Hz

This amplifier needs no external cooling fin, provided each output transistor is mounted with its leads not longer than 3mm. The collector lead must, in addition, be soldered to a copper area of at least 10mm × 10mm. (See page 2).


D6139
10
d_{tot}
(%)
7.5
5
2.5
0
$V_S = 29V$
f = 1kHz
$T_{amb} = 25°C$
typ
10^{-2}
2
5
7
10^{-1}
2
5
7
1
2
P_L (W)
5
7
10

N-P-N SILICON PLANAR EPITAXIAL TRANSISTORS

BC337 BC338

N-P-N silicon planar epitaxial transistors in plastic envelopes, primarily intended for use in driver and output stages of audio amplifiers.
The BC337, BC338 are complementary to the BC327 and BC328 respectively.

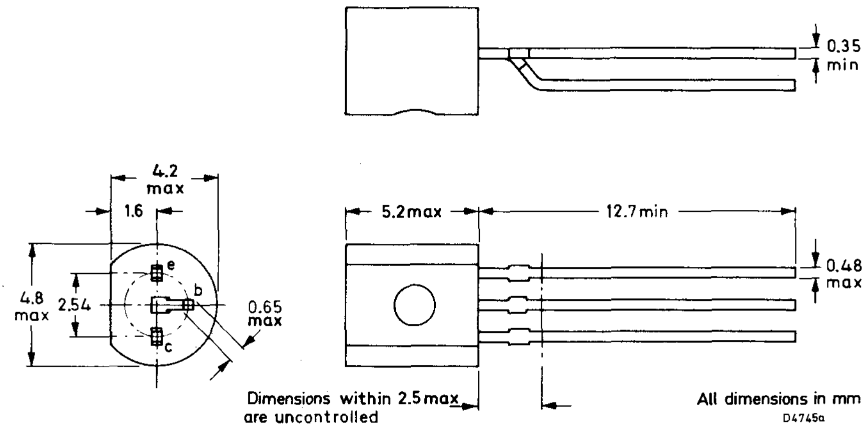
QUICK REFERENCE DATA

	BC337	BC338	
V_{CES} max.	50	30	V
V_{CEO} max.	45	25	V
I_{CM} max.	1000		mA
P_{tot} max. ($T_{case} \leq 45^{o}C$)	625		mW
T_j max.	150		^{o}C
f_T typ. ($I_C = 10mA$, $V_{CE} = 5V$, $f = 35MHz$)	200		MHz

Unless otherwise stated data are applicable to both types

OUTLINE AND DIMENSIONS

Similar to TO-92



RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

		BC337	BC338	
V_{CES} max. ($V_{BE}=0$)		50	30	V
V_{CEO} max.		45	25	V
V_{EBO} max.		5.0		V
I_C max.		500		mA
I_{CM} max.		1000		mA
$-I_{EM}$ max.		1000		mA
I_B max.		100		mA
I_{BM} max.		200		mA
P_{tot} max.	$T_{amb}=25^oC$	500		mW
	*$T_{amb} \leq 25^oC$	625		mW
	$T_{case} \leq 45^oC$	625		mW

Temperature

T_{stg}	-65 to +150	^oC
T_j max.	150	^oC

THERMAL CHARACTERISTICS

$R_{th(j-amb)}$ in free air	0.25	$^oC/mW$
*$R_{th(j-amb)}$	0.20	$^oC/mW$
$R_{th(j-case)}$	0.17	$^oC/mW$

*The transistor mounted on a printed circuit board, max. lead length 3mm, mounting pad for collector lead min. 10 x 10mm.

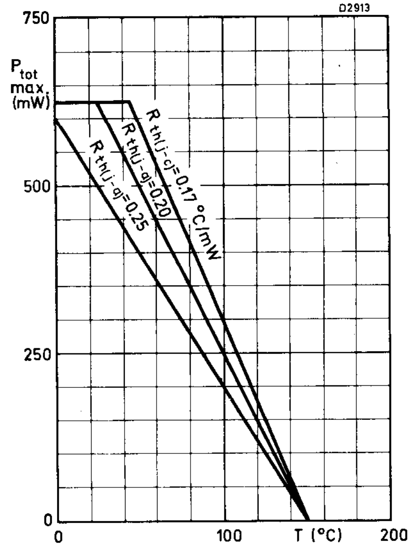
ELECTRICAL CHARACTERISTICS ($T_j=25^oC$ unless otherwise stated)

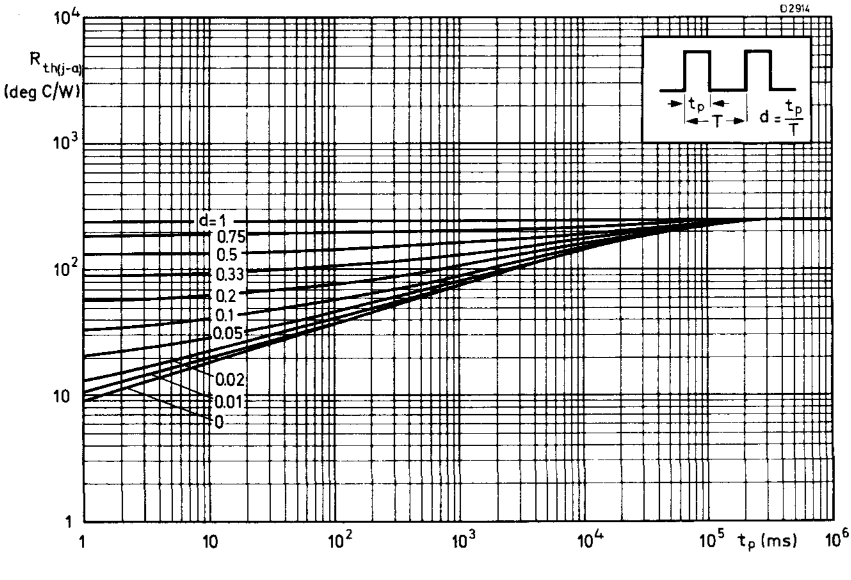
		Min.	Typ.	Max.	
I_{CBO}	Collector cut-off current				
	$I_E=0$, $V_{CB}=20V$	-	-	100	nA
	$I_E=0$, $V_{CB}=20V$, $T_j=150^oC$	-	-	5.0	μA
I_{EBO}	Emitter cut-off current				
	$I_C=0$, $V_{EB}=5V$	-	-	10	μA

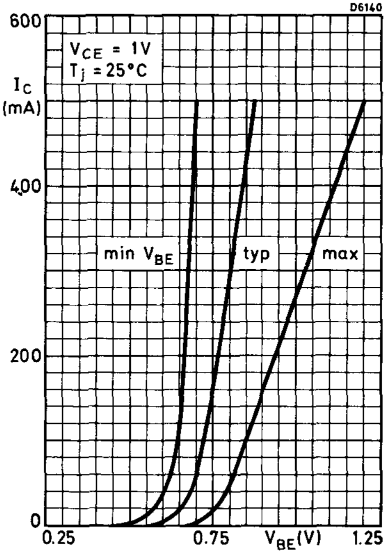
ELECTRICAL CHARACTERISTICS (contd.)

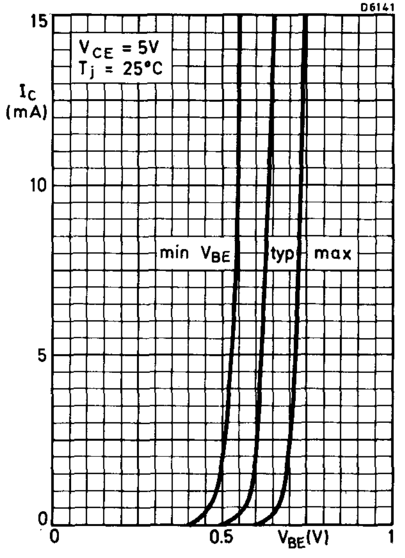
		Min.	Typ.	Max.	
V_{BE}	**Base-emitter voltage				
	$I_C = 500mA$, $V_{CE} = 1V$	-	-	1.2	V
$V_{CE(sat)}$	Collector-emitter saturation voltage				
	$I_C = 500mA$, $I_B = 50mA$	-	-	700	mV
h_{FE}	Static forward current transfer ratio				
	$I_C = 100mA$, $V_{CE} = 1V$	100	-	600	
	$I_C = 500mA$, $V_{CE} = 1V$	40	-	-	
f_T	Transition frequency				
	$I_C = 10mA$, $V_{CE} = 5V$, $f = 35MHz$	-	200	-	MHz
C_{Tc}	Collector capacitance				
	$I_E = I_e = 0$, $V_{CB} = 10V$, $f = 1MHz$	-	5.0	-	pF
$\frac{h_{FE1}}{h_{FE2}}$	D.C. current gain ratio of matched pairs BC337/BC327 BC338/BC328				
	$\|I_C\| = 100mA$, $\|V_{CE}\| = 1V$	-	1.25	1.40	

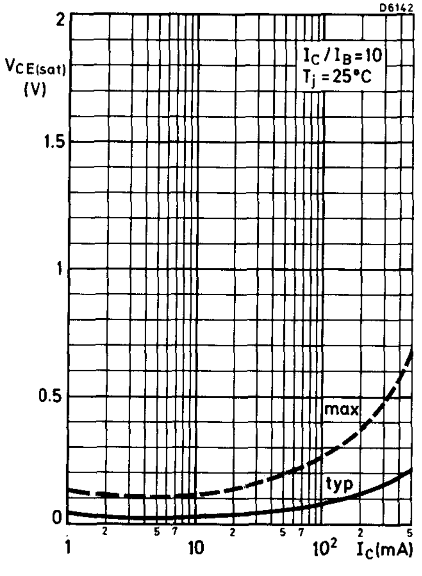
**V_{BE} decreases by about $2mV/^{o}C$ with increasing temperature.

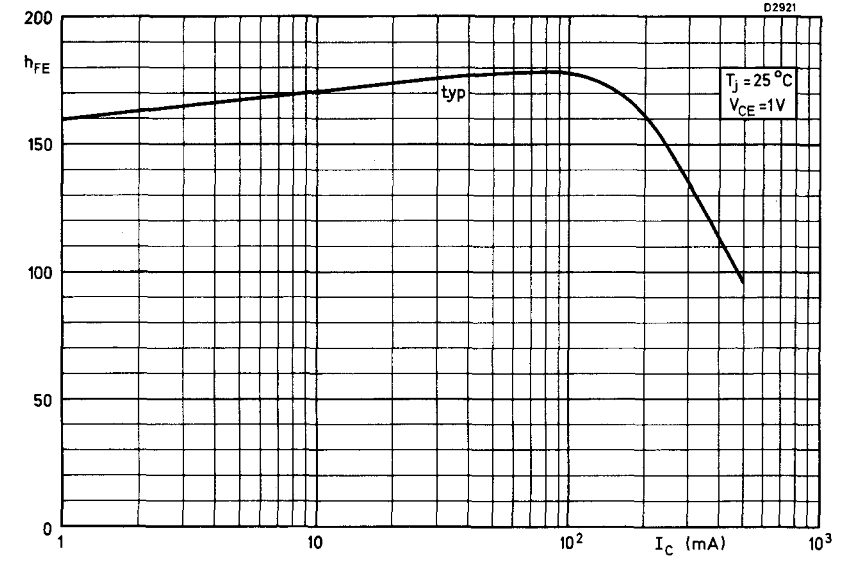

D2913
750
P_{tot} max. (mW)
500
250
0
0
100
T (°C)
200
$R_{th(j-c)}$=0.17 °C/mW
$R_{th(j-a)}$=0.20
$R_{th(j-a)}$=0.25

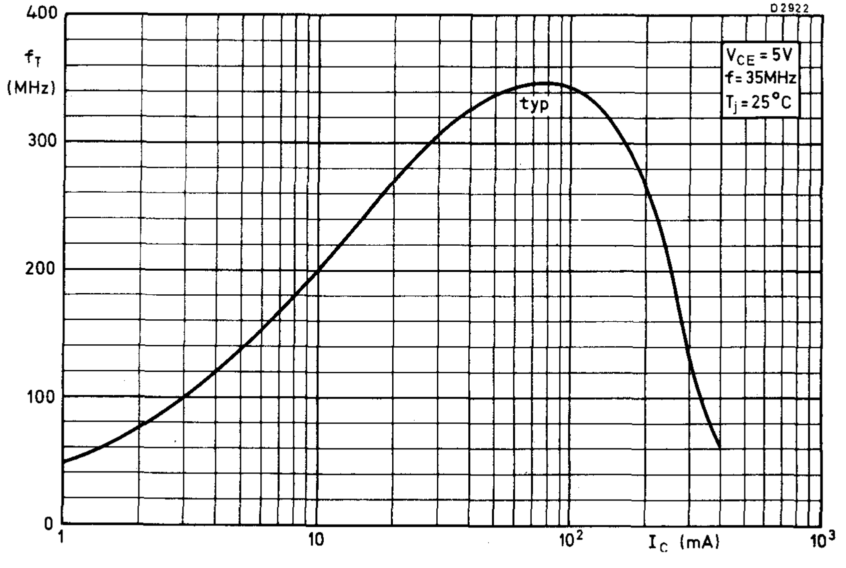

D2914
10^4
$R_{th(j-a)}$ (deg C/W)
10^3
10^2
10
1
1
10
10^2
10^3
10^4
10^5
t_p (ms)
10^6
d=1
0.75
0.5
0.33
0.2
0.1
0.05
0.02
0.01
0
t_p
T
$d = \frac{t_p}{T}$


D6140
600
400
200
0
I_C (mA)
V_{CE} = 1V
T_j = 25°C
min V_{BE}
typ
max
0.25
0.75
V_{BE}(V)
1.25


D6141
15
10
5
0
I_C (mA)
V_{CE} = 5V
T_j = 25°C
min V_{BE}
typ
max
0
0.5
V_{BE}(V)
1


D6142
2
1.5
1
0.5
0
$V_{CE(sat)}$ (V)
I_C/I_B=10
T_j = 25°C
max
typ
1
10
10^2
I_C(mA)


D2921
200
h_{FE}
150
100
50
0
1
10
10^2
I_C (mA)
10^3
typ
$T_j = 25\,°C$
$V_{CE} = 1V$


D2922
400
f_T
(MHz)
300
200
100
0
1
10
10^2
I_C (mA)
10^3
typ
$V_{CE} = 5V$
$f = 35MHz$
$T_j = 25\,°C$

N-P-N SILICON PLANAR EPITAXIAL A.F. TRANSISTORS

BC547 BC548 BC549

Silicon planar epitaxial n-p-n transistors in plastic envelopes. The BC547 is primarily intended for use in driver stages of audio amplifiers and in signal processing circuits of television receivers. The BC548 is suitable for low voltage applications e.g. driver stages or audio pre-amplifiers and in signal processing circuits of television receivers.
The BC549 is primarily intended for low noise input stages in tape recorders, high quality amplifiers and other audio frequency equipment.

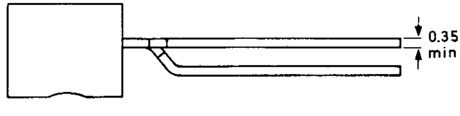
QUICK REFERENCE DATA

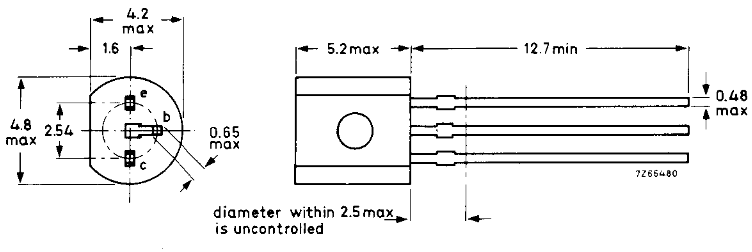
		BC547	BC548	BC549	
V_{CES} max.		50	30	30	V
V_{CEO} max.		45	20	20	V
I_{CM} max.		200	200	200	mA
P_{tot} max. ($T_{amb} \leq 25^{o}C$)		300	300	300	mW
T_j max.		150	150	150	^{o}C
h_{fe} (I_C = 2mA, V_{CE} = 5V, f = 1kHz)		125-500	125-900	240-900	
f_T typ. (I_C = 10mA, V_{CE} = 5V, f = 35MHz)		300	300	300	MHz
N (I_C = 200μA, V_{CE} = 5V, R_S = 2kΩ)					
f = 30Hz to 15kHz	typ.	-	-	1.4	dB
	max.	-	-	4.0	dB
f = 1kHz, B = 200Hz	typ.	2.0	2.0	1.2	dB
	max.	10	10	4.0	dB

Unless otherwise stated data are applicable to all types

OUTLINE AND DIMENSIONS

Similar to TO-92





All dimensions in mm

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

	BC547	BC548	BC549	
V_{CBO} max.	50	30	30	V
V_{CES} max.	50	30	30	V
V_{CEO} max.	45	20	20	V
V_{EBO} max.	6.0	5.0	5.0	V
I_C max.		100		mA
I_{CM} max.		200		mA
$-I_{EM}$ max.		200		mA
I_{BM} max.		200		mA
P_{tot} max. ($T_{amb} \leq 25^oC$)		300		mW

Temperature

T_{stg}	-65 to +150	^oC
T_j max.	150	^oC

THERMAL CHARACTERISTICS

$R_{th(j\text{-}amb)}$ in free air	0.25	$^oC/mW$
$R_{th(j\text{-}case)}$	0.17	$^oC/mW$

ELECTRICAL CHARACTERISTICS ($T_j = 25^oC$ unless otherwise stated)

		Min.	Typ.	Max.	
I_{CBO}	Collector cut-off current $I_E = 0, V_{CB} = 20V, T_j = 125^oC$	-	-	5.0	μA
V_{BE}	*Base-emitter voltage $I_C = 2mA, V_{CE} = 5V$	550	620	700	mV
	$I_C = 10mA, V_{CE} = 5V$	-	-	770	mV

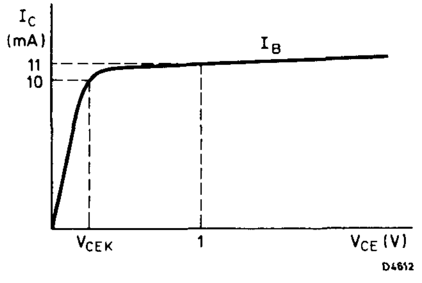
*V_{BE} decreases by about $2mV/^oC$ with increasing temperature

N-P-N SILICON PLANAR EPITAXIAL A.F. TRANSISTORS

BC547 BC548 BC549

ELECTRICAL CHARACTERISTICS (cont'd)

			Min.	Typ.	Max.	
$V_{CE(sat)}$	Collector-emitter saturation voltage					
	I_C = 10mA, I_B = 0.5mA		-	90	250	mV
	I_C = 100mA, I_B = 5mA		-	200	600	mV
$V_{BE(sat)}$	†Base-emitter saturation voltage					
	I_C = 10mA, I_B = 0.5mA		-	700	-	mV
	I_C = 100mA, I_B = 5mA		-	900	-	mV
V_{CEK}	Collector knee voltage					
	I_C = 10mA, I_B = the value for which I_C = 11mA, at V_{CE} = 1V		-	300	600	mV



			Min.	Typ.	Max.	
h_{fe}	Small signal current gain					
	I_C = 2mA, V_{CE} = 5V, f = 1kHz,	BC547	125	-	500	
		BC548	125	-	900	
		BC549	240	-	900	
f_T	Transition frequency					
	I_C = 10mA, V_{CE} = 5V, f = 35MHz		-	300	-	MHz
C_{Tc}	Collector capacitance					
	$I_E = I_e$ = 0, V_{CB} = 10V, f = 1MHz		-	2.5	4.5	pF
C_{Te}	Emitter capacitance					
	$I_C = I_c$ = 0, V_{EB} = 0.5V, f = 1MHz		-	9.0	-	pF
N	Noise figure					
	I_C = 200µA, V_{CE} = 5V, R_S = 2kΩ					
	f = 30Hz to 15kHz	BC549	-	1.4	4.0	dB
	f = 1kHz, B = 200Hz	BC547, 548	-	2.0	10	dB
		BC549	-	1.2	4.0	dB

†$V_{BE(sat)}$ decreases by about 1.7mV/°C with increasing temperature

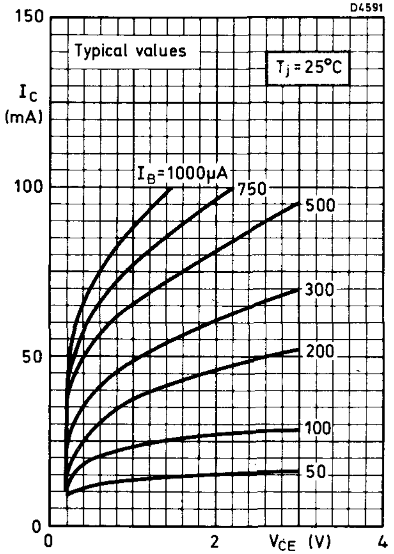
ELECTRICAL CHARACTERISTICS (cont'd)

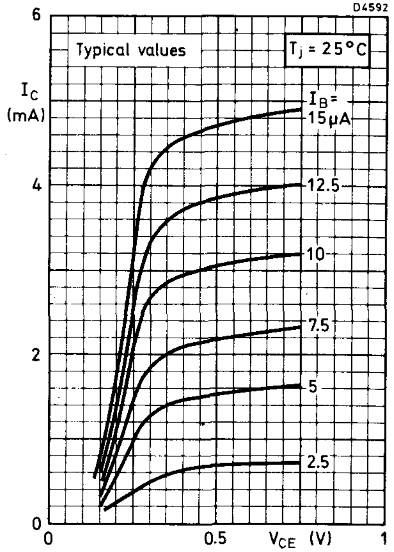
The following supplementary gain groups are available on request:

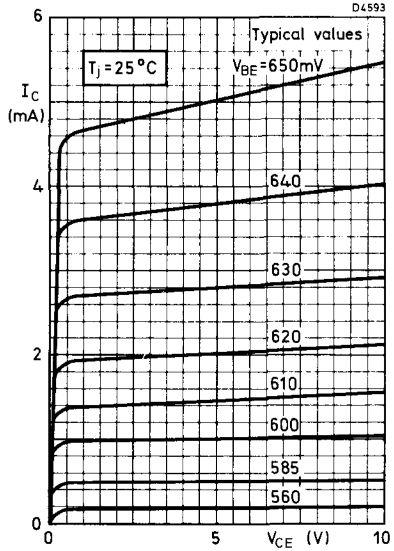
			BC547A BC548A	BC547B BC548B BC549B	BC548C BC549C	
h_{FE}	Static forward current transfer ratio					
	$I_C = 10\mu A$, $V_{CE} = 5V$	typ.	90	150	270	
	$I_C = 2mA$, $V_{CE} = 5V$	min.	110	200	420	
		typ.	180	290	520	
		max.	220	450	800	
h parameters (common emitter)	$I_C = 2mA$, $V_{CE} = 5V$, $f = 1kHz$					
h_{ie}	Input impedance	min	1.6	3.2	6.0	kΩ
		typ.	2.7	4.5	8.7	kΩ
		max.	4.5	8.5	15	kΩ
h_{re}	Voltage feedback ratio	typ.	1.5	2.0	3.0	$\times 10^{-4}$
h_{fe}	Small signal current gain	min.	125	240	450	
		typ.	220	330	600	
		max.	260	500	900	
h_{oe}	Output admittance	typ.	18	30	60	µmho
		max.	30	60	110	µmho

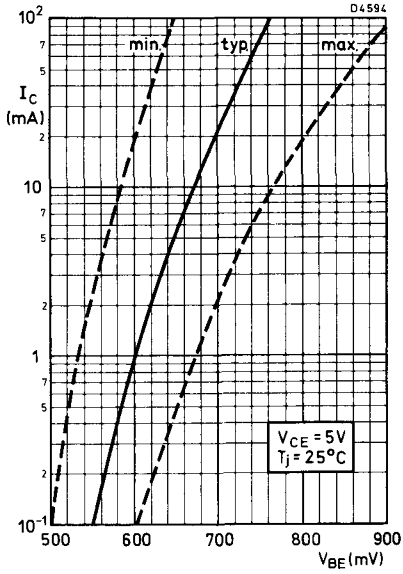
N-P-N SILICON PLANAR EPITAXIAL A.F. TRANSISTORS

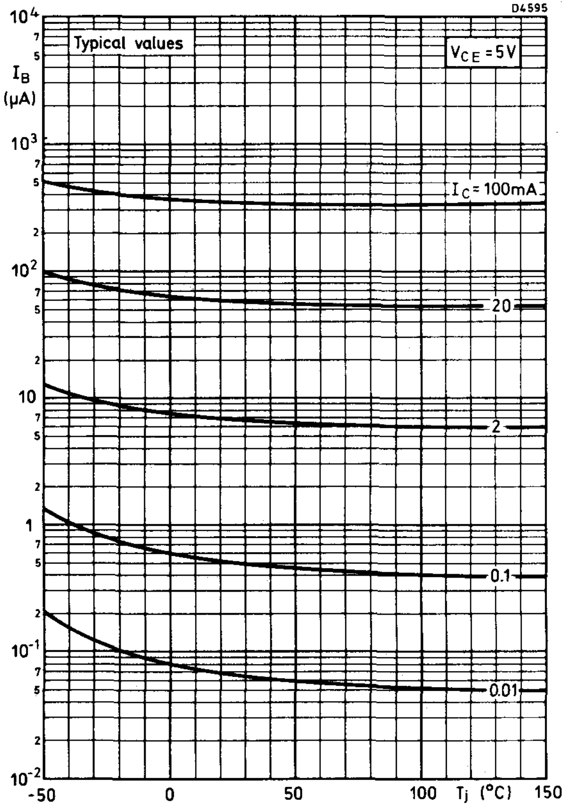
BC547 BC548 BC549

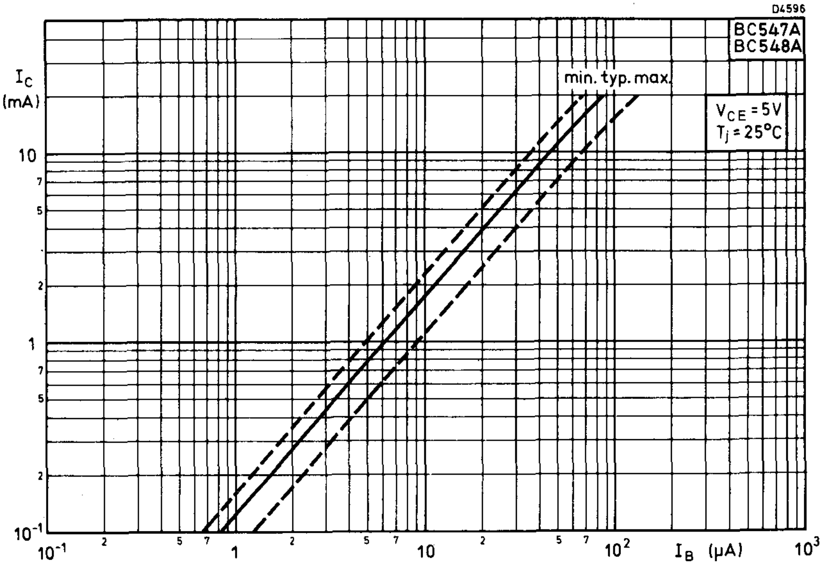


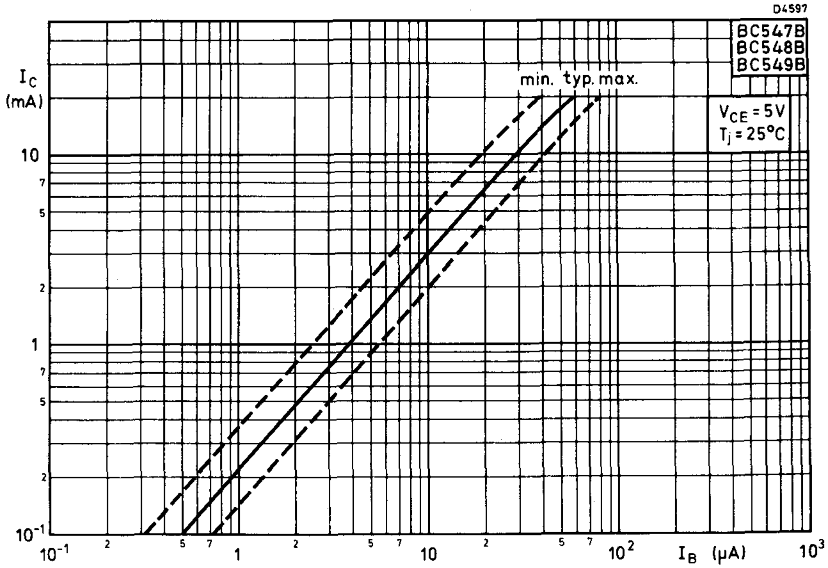


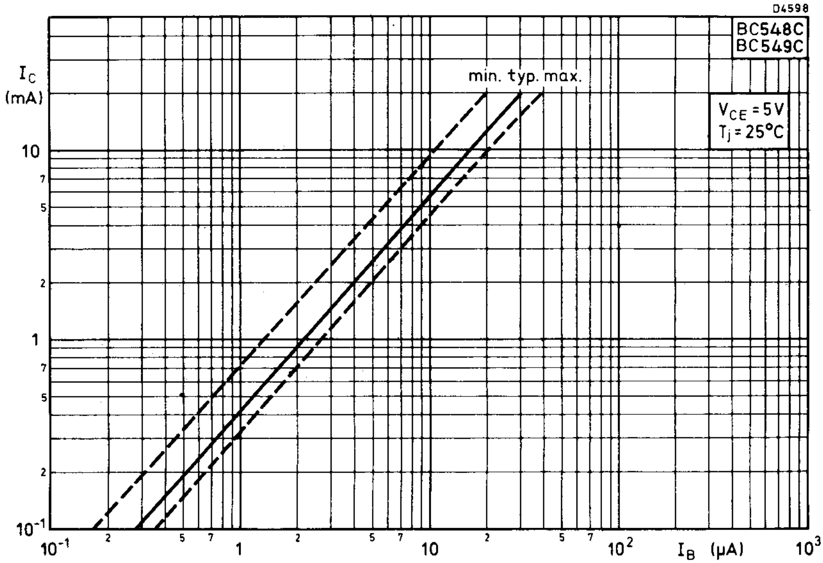


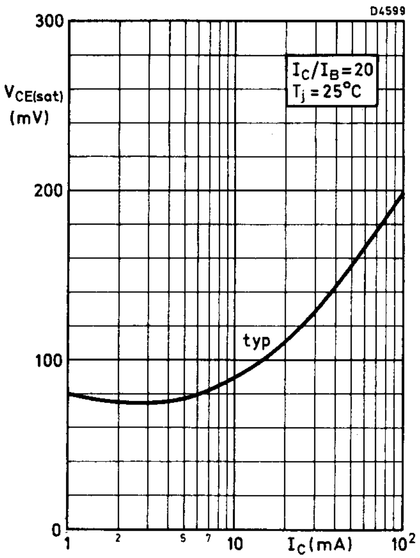


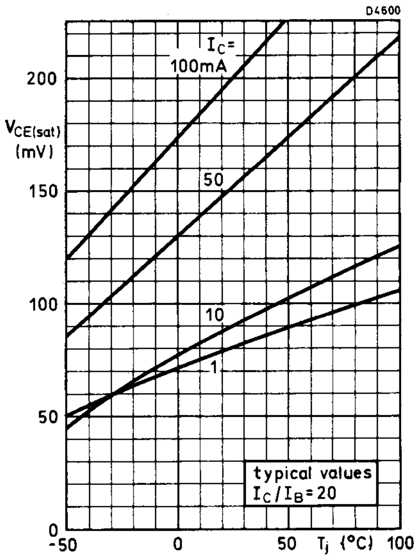

D4595
Typical values
V_{CE} = 5V
I_B (μA)
I_C = 100mA
20
2
0.1
0.01
T_j (°C)
-50
0
50
100
150
10^4
10^3
10^2
10
1
10^{-1}
10^{-2}


D4596
BC547A
BC548A
I_C (mA)
min. typ. max.
V_{CE} = 5V
T_j = 25°C
I_B (µA)


D4597
BC547B
BC548B
BC549B
I_C (mA)
min. typ. max.
V_{CE} = 5V
T_j = 25°C
I_B (µA)


D4598
BC548C
BC549C
I_C (mA)
min. typ. max.
V_{CE} = 5 V
T_j = 25°C
I_B (μA)

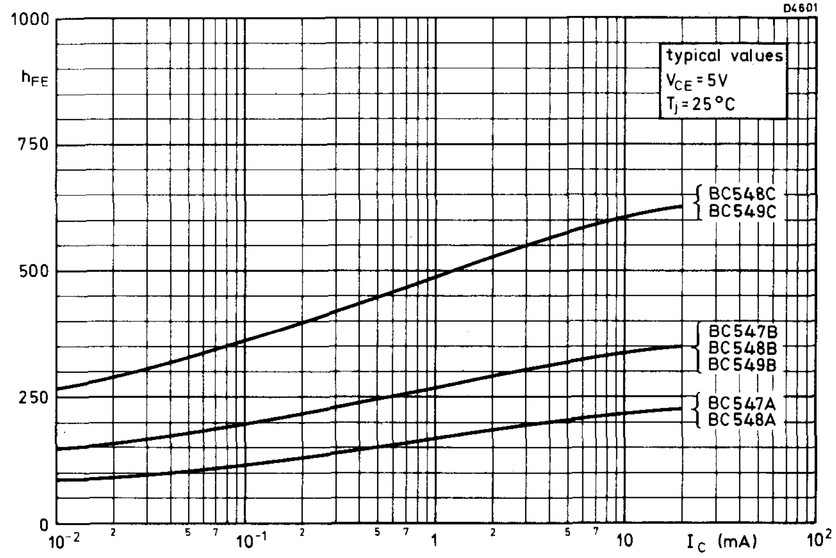

D4599
$V_{CE(sat)}$ (mV)
I_C/I_B = 20
T_j = 25°C
typ
I_C (mA)

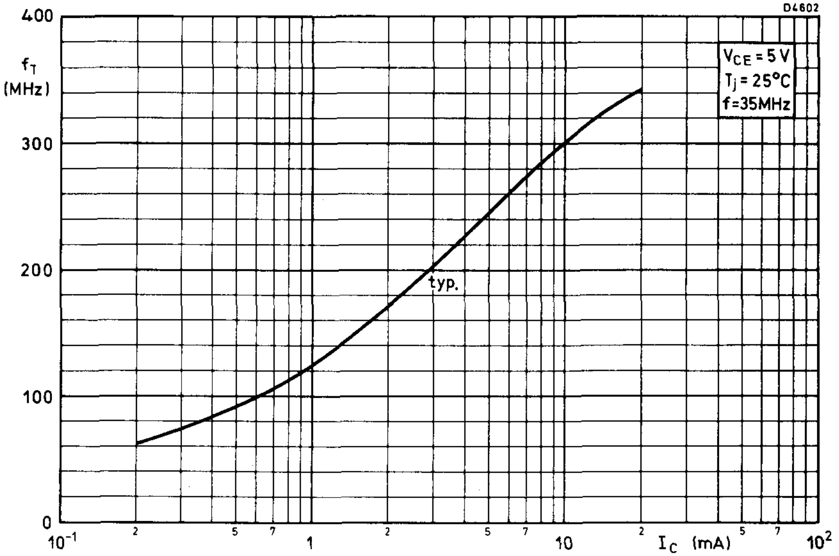

D4600
$V_{CE(sat)}$ (mV)
I_C = 100mA
50
10
1
typical values
I_C/I_B = 20
T_j (°C)

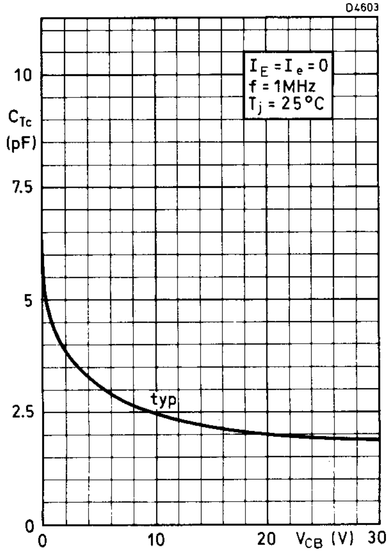
Mullard

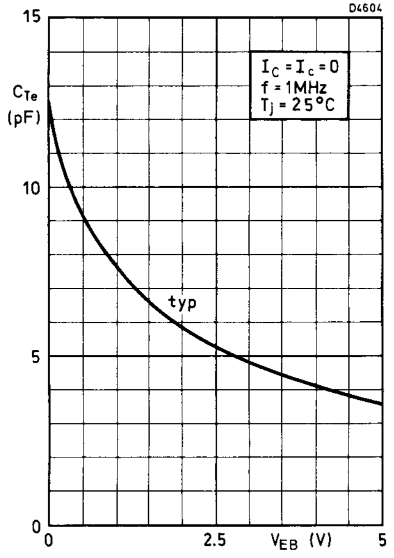
N-P-N SILICON PLANAR EPITAXIAL A.F. TRANSISTORS

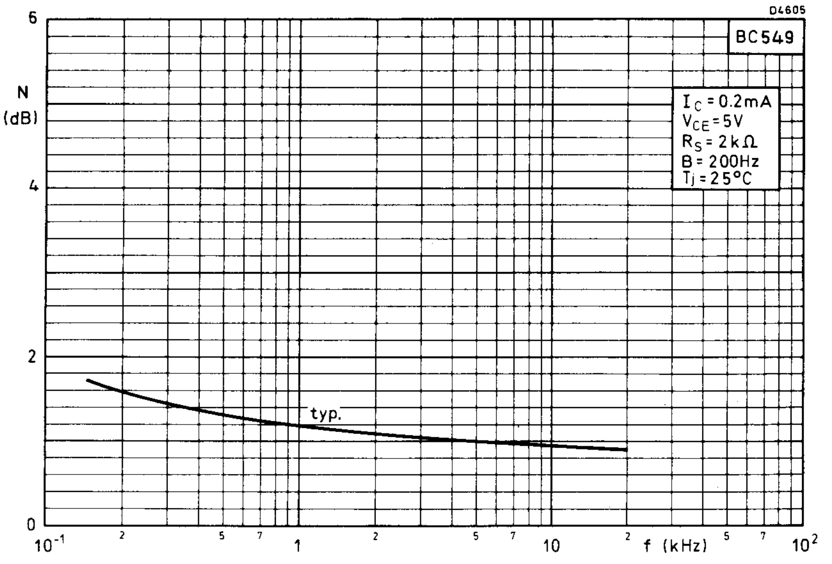
BC547 BC548 BC549

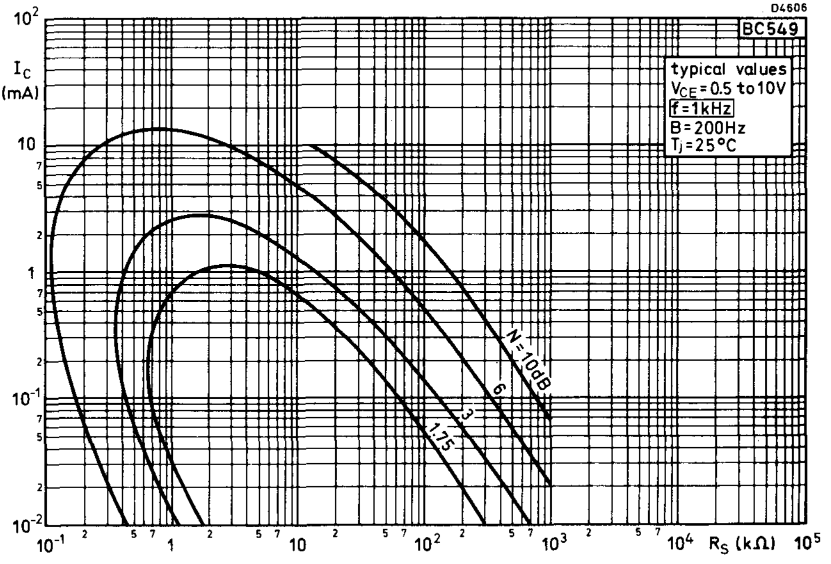


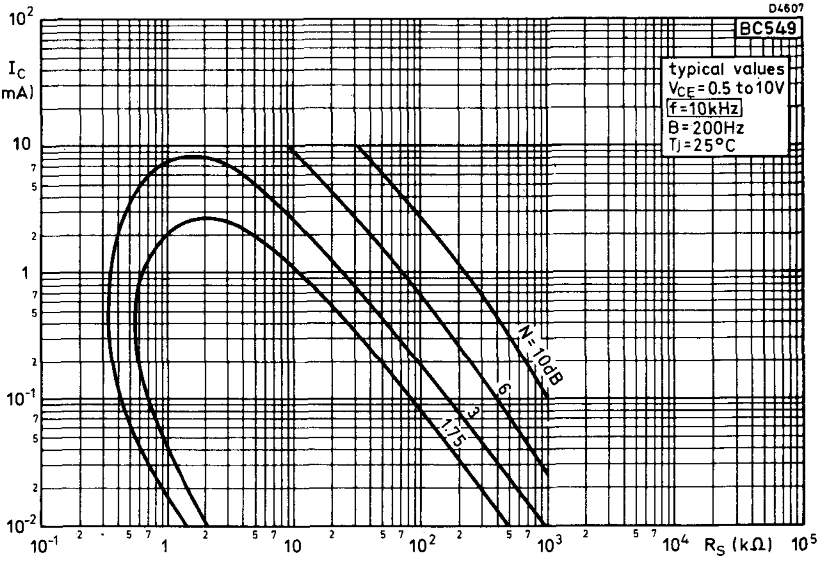



D4603
$I_E = I_e = 0$
f = 1MHz
T_j = 25°C
C_{Tc}
(pF)
10
7.5
5
2.5
0
typ
0
10
20
V_{CB} (V)
30

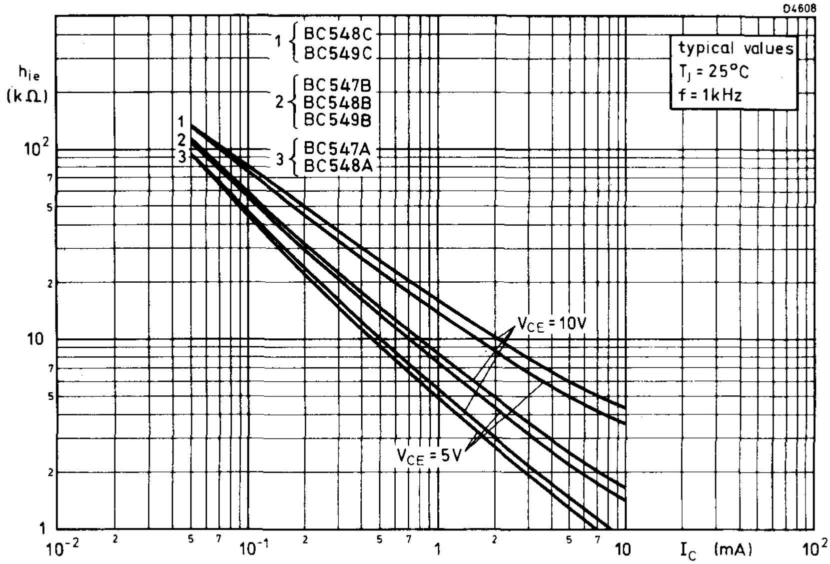

D4604
$I_C = I_c = 0$
f = 1MHz
T_j = 25°C
C_{Te}
(pF)
15
10
5
0
typ
0
2.5
V_{EB} (V)
5

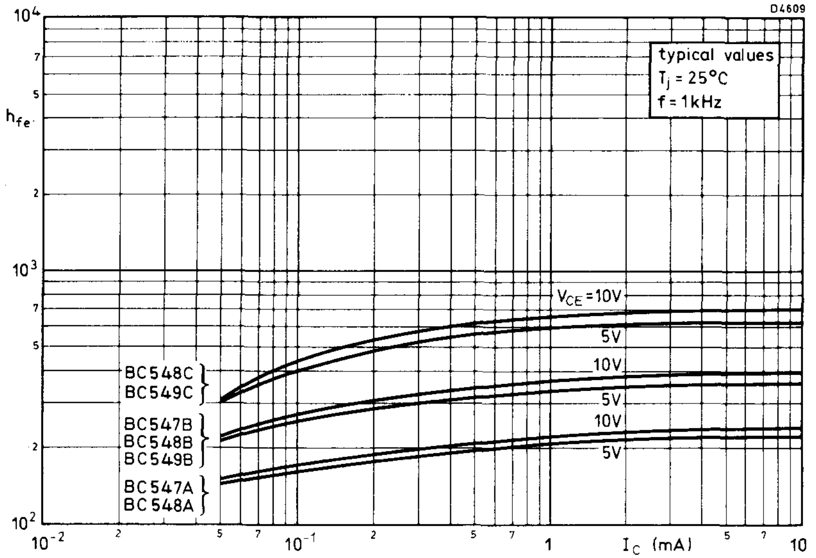

D4605
BC549
I_C = 0.2mA
V_{CE} = 5V
R_S = 2kΩ
B = 200Hz
T_j = 25°C
N
(dB)
6
4
2
0
typ.
10^{-1}
1
10
f (kHz)
10^2





Constant noise figure curves

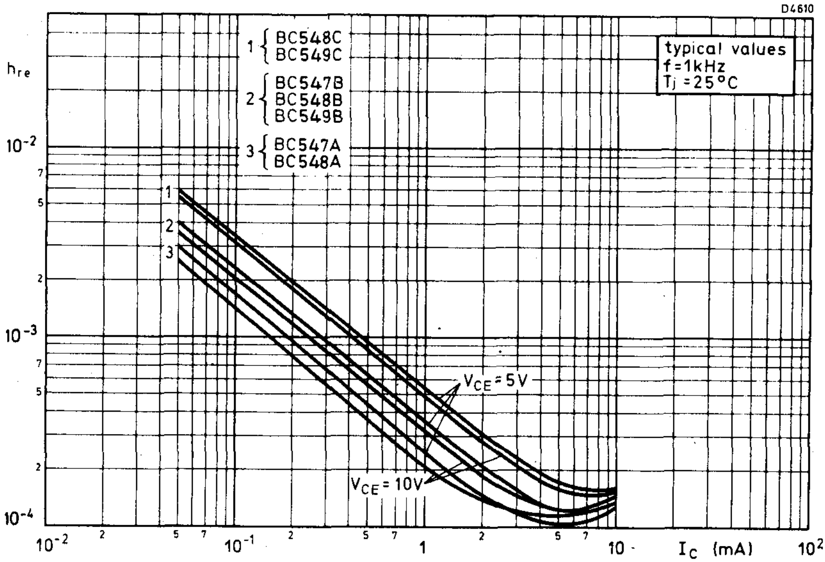

D4608
typical values
$T_j = 25°C$
f = 1kHz
h_{ie} (kΩ)
1 { BC548C BC549C
2 { BC547B BC548B BC549B
3 { BC547A BC548A
$V_{CE} = 10V$
$V_{CE} = 5V$
I_C (mA)

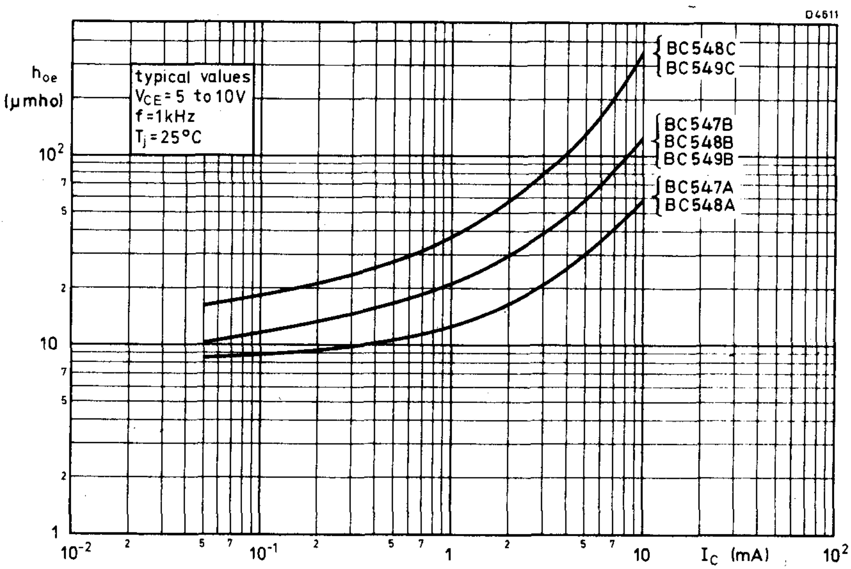

D4609
typical values
$T_j = 25°C$
f = 1kHz
h_{fe}
$V_{CE} = 10V$
5V
10V
5V
10V
5V
BC548C BC549C
BC547B BC548B BC549B
BC547A BC548A
I_C (mA)

Mullard

N-P-N SILICON PLANAR EPITAXIAL A.F. TRANSISTORS

BC547 BC548 BC549





Mullard

P-N-P SILICON PLANAR EPITAXIAL A.F. TRANSISTORS

BC557 BC558 BC559

Silicon planar epitaxial p-n-p transistors in plastic envelopes. The BC557 is primarily intended for use in driver stages of audio amplifiers and in signal processing circuits of television receivers. The BC558 is suitable for low voltage applications e.g. driver stages or audio pre-amplifiers and in signal processing circuits of television receivers.
The BC559 is primarily intended for low noise input stages in tape recorders, high quality amplifiers and other audio frequency equipment.

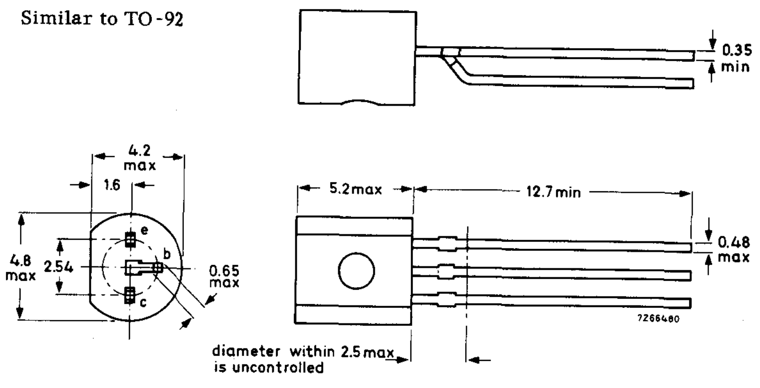
QUICK REFERENCE DATA

		BC557	BC558	BC559	
$-V_{CEX}$ max. ($+V_{BE} = 1V$)		50	30	25	V
$-V_{CEO}$ max.		45	25	20	V
$-I_{CM}$ max.		200	200	200	mA
P_{tot} max. ($T_{amb} \leq 25^{o}C$)		300	300	300	mW
T_j max.		150	150	150	^{o}C
h_{fe} ($-I_C = 2mA$, $-V_{CE} = 5V$, $f = 1kHz$)		75-260	75-500	125-500	
f_T typ. ($-I_C = 10mA$, $-V_{CE} = 5V$, $f = 35MHz$)		150	150	150	MHz
N ($-I_C = 200\mu A$, $-V_{CE} = 5V$, $R_S = 2k\Omega$)					
f = 30Hz to 15kHz	typ.	-	-	1.2	dB
	max.	-	-	4.0	dB
f = 1kHz, B = 200Hz	typ.	2.0	2.0	1.0	dB
	max.	10	10	4.0	dB

Unless otherwise stated data are applicable to all types

OUTLINE AND DIMENSIONS

Similar to TO-92



All dimensions in mm

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

	BC557	BC558	BC559	
$-V_{CBO}$ max.	50	30	25	V
$-V_{CEX}$ max. ($+V_{BE} = 1V$)	50	30	25	V
$-V_{CEO}$ max.	45	25	20	V
$-V_{EBO}$ max.	5.0	5.0	5.0	V
$-I_C$ max.		100		mA
$-I_{CM}$ max.		200		mA
I_{EM} max.		200		mA
$-I_{BM}$ max.		200		mA
P_{tot} max. ($T_{amb} \leq 25^oC$)		300		mW

Temperature

T_{stg}	-65 to +150	^oC
T_j max.	150	^oC

THERMAL CHARACTERISTICS

$R_{th(j-amb)}$ in free air	0.25	$^oC/mW$
$R_{th(j-case)}$	0.17	$^oC/mW$

ELECTRICAL CHARACTERISTICS ($T_j = 25^oC$ unless otherwise stated)

		Min.	Typ.	Max.	
$-I_{CBO}$	Collector cut-off current $I_E = 0$, $-V_{CB} = 20V$, $T_j = 25^oC$	-	1.0	100	nA
	$T_j = 125^oC$	-	-	4.0	μA
$-V_{BE}$	*Base-emitter voltage $-I_C = 2mA$, $-V_{CE} = 5V$	600	650	750	mV
	$-I_C = 10mA$, $-V_{CE} = 5V$	-	-	820	mV

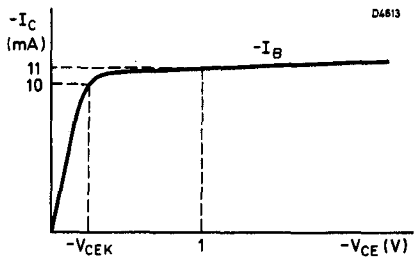
* $-V_{BE}$ decreases by about $2mV/^oC$ with increasing temperature

P-N-P SILICON PLANAR EPITAXIAL A.F. TRANSISTORS

BC557 BC558 BC559

ELECTRICAL CHARACTERISTICS (cont'd)

			Min.	Typ.	Max.	
$-V_{CE(sat)}$	Collector-emitter saturation voltage					
	$-I_C = 10mA, -I_B = 0.5mA$		-	75	300	mV
	$-I_C = 100mA, -I_B = 5mA$		-	250	650	mV
$-V_{BE(sat)}$	†Base-emitter saturation voltage					
	$-I_C = 10mA, -I_B = 0.5mA$		-	700	-	mV
	$-I_C = 100mA, -I_B = 5mA$		-	850	-	mV
$-V_{CEK}$	Collector knee voltage					
	$-I_C = 10mA$, $-I_B$ = the value for which $-I_C = 11mA$ at $-V_{CE} = 1V$		-	250	600	mV



			Min.	Typ.	Max.	
h_{fe}	Small signal current gain					
	$-I_C = 2mA, -V_{CE} = 5V, f = 1kHz$	BC557	75	-	260	
		BC558	75	-	500	
		BC559	125	-	500	
f_T	Transition frequency					
	$-I_C = 10mA, -V_{CE} = 5V, f = 35MHz$		-	150	-	MHz
C_{Tc}	Collector capacitance					
	$I_E = I_e = 0, -V_{CB} = 10V, f = 1MHz$		-	4.5	-	pF
N	Noise figure					
	$-I_C = 200\mu A, -V_{CE} = 5V, R_S = 2k\Omega$					
	f = 30Hz to 15kHz	BC559	-	1.2	4.0	dB
	f = 1kHz, B = 200Hz	BC557, 558	-	2.0	10	dB
		BC559	-	1.0	4.0	dB

† $-V_{BE(sat)}$ decreases by about 1.7mV/°C with increasing temperature

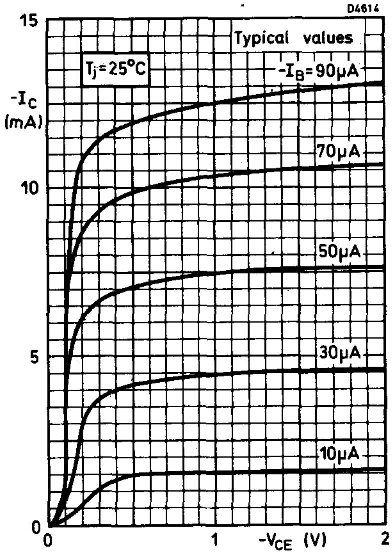
ELECTRICAL CHARACTERISTICS (cont'd)

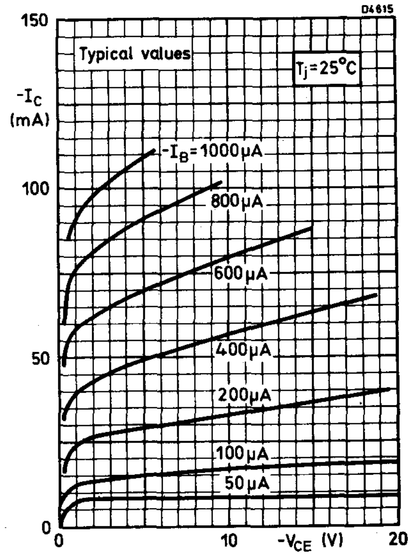
The following supplementary gain groups are available on request:

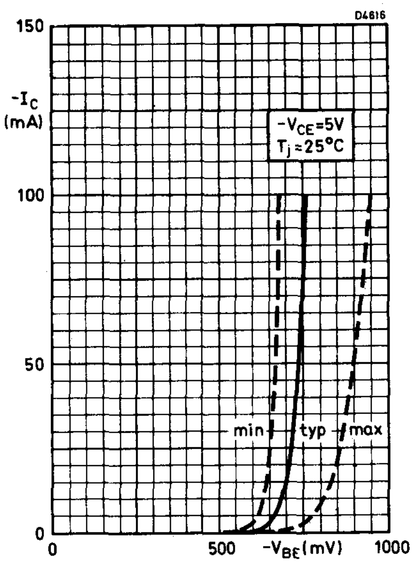
				BC557	BC558A BC559A	BC558B BC559B
h_{FE}	Static forward current transfer ratio $-I_C = 2mA$, $-V_{CE} = 5V$	Typ.		140	180	290
h_{fe}	Small signal current gain $-I_C = 2mA$, $-V_{CE} = 5V$, $f = 1kHz$	min.		75	125	240
		max.		260	260	500

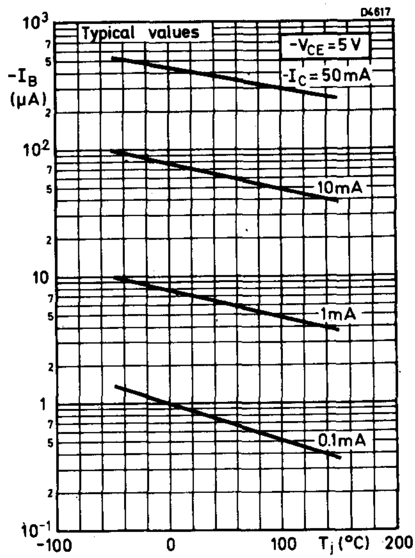
P-N-P SILICON PLANAR EPITAXIAL A.F. TRANSISTORS

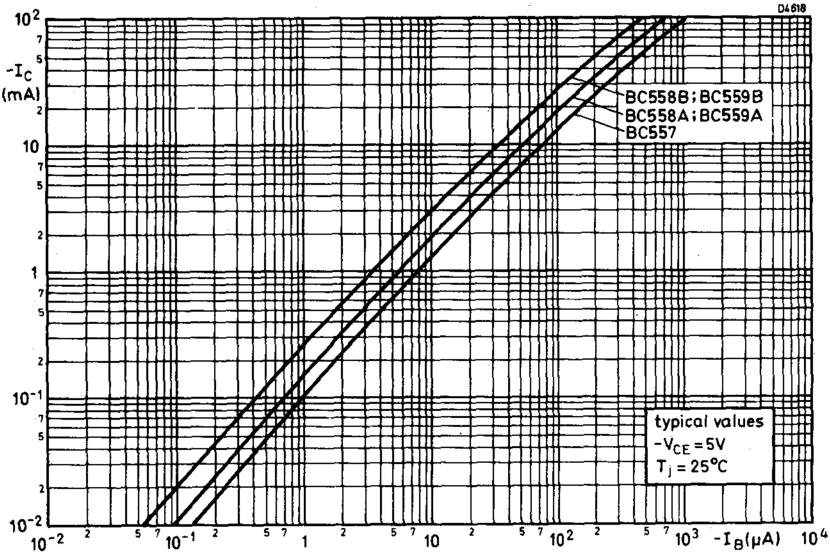
BC557 BC558 BC559

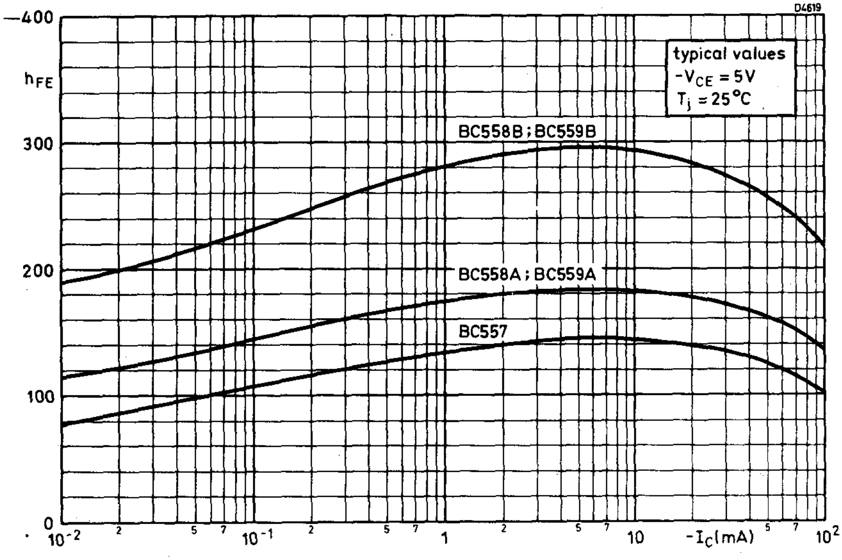


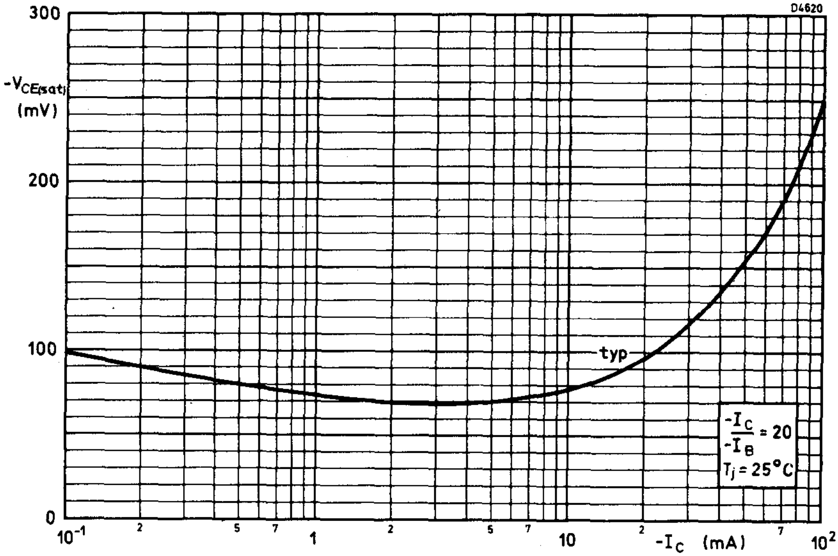


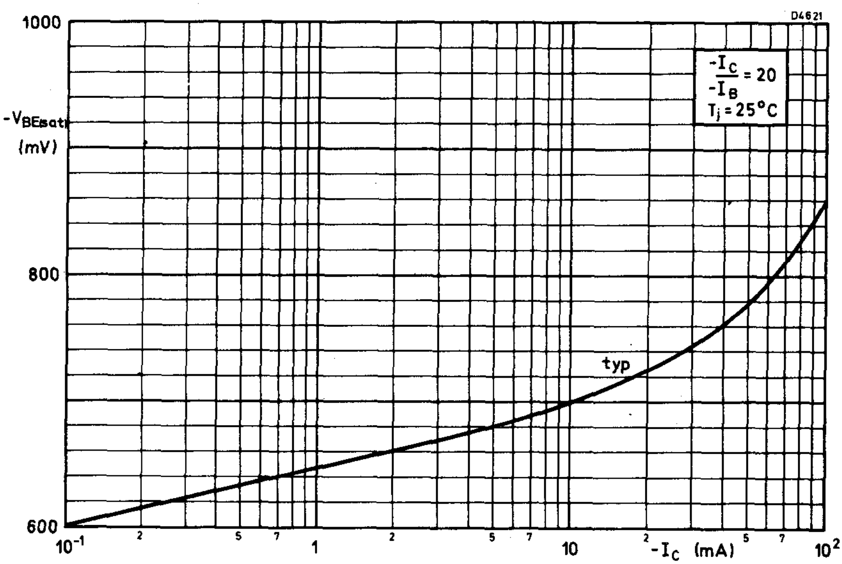


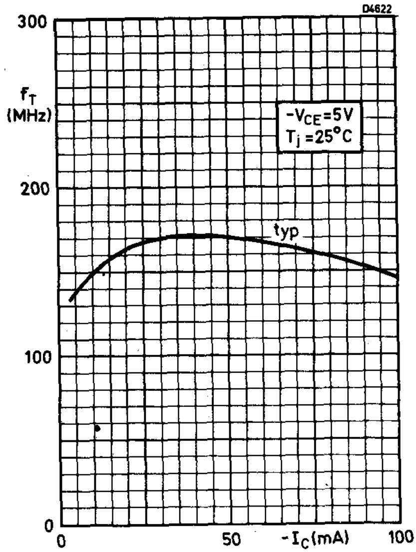


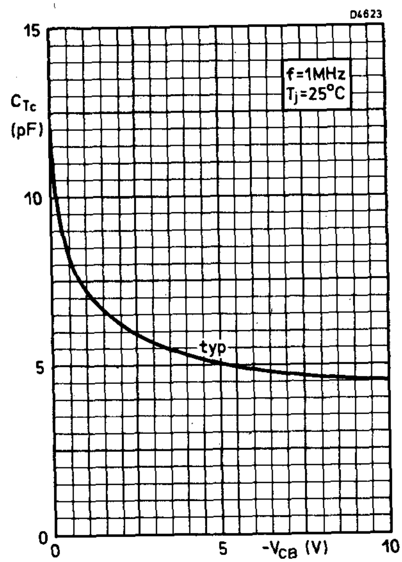

D4618
$-I_C$ (mA)
BC558B; BC559B
BC558A; BC559A
BC557
typical values
$-V_{CE}$ = 5V
T_j = 25°C
$-I_B$ (μA)

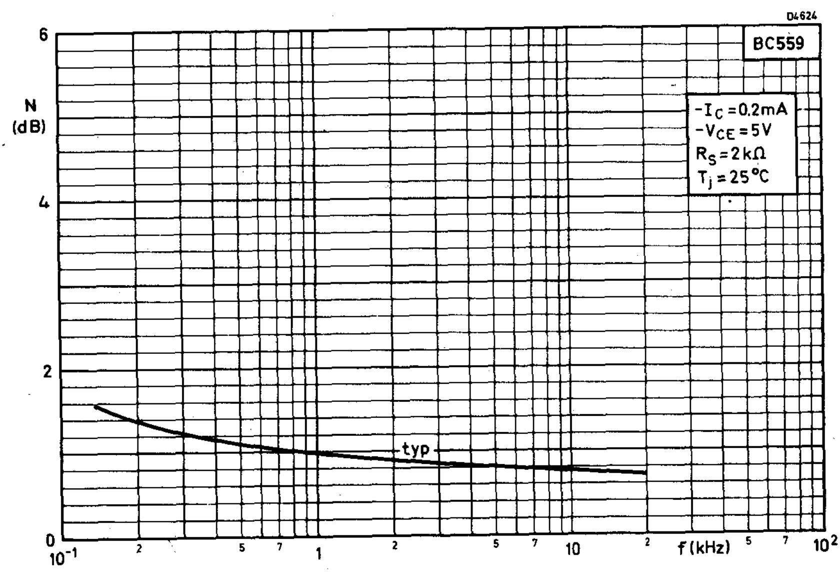

D4619
h_{FE}
typical values
$-V_{CE}$ = 5V
T_j = 25°C
BC558B; BC559B
BC558A; BC559A
BC557
$-I_C$ (mA)


D4620
300
$-V_{CE(sat)}$ (mV)
200
100
0
typ
$\frac{-I_C}{-I_B} = 20$
$T_j = 25°C$
10^{-1}
2
5
7
1
2
5
7
10
2
$-I_C$ (mA)
7
10^2


D4621
1000
$-V_{BE(sat)}$ (mV)
800
600
typ
$\frac{-I_C}{-I_B} = 20$
$T_j = 25°C$
10^{-1}
2
5
7
1
2
5
7
10
2
$-I_C$ (mA)
5
7
10^2

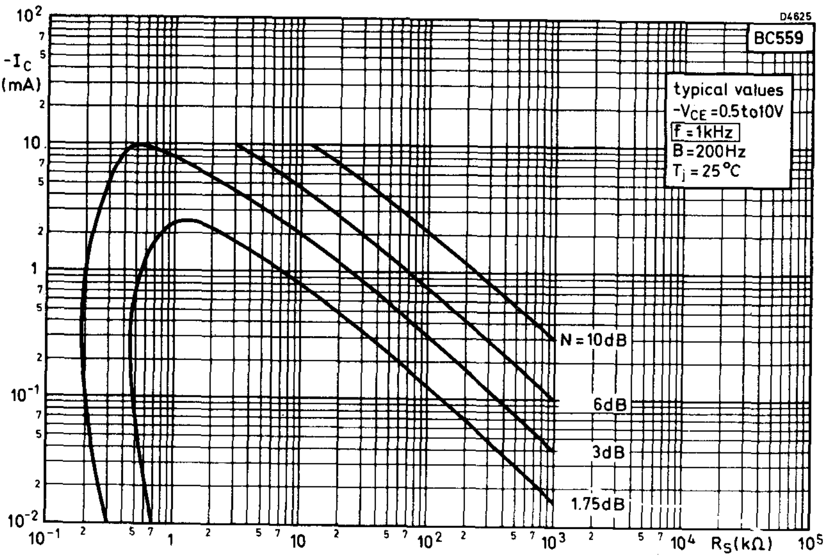

D4622
300
200
100
0
f_T
(MHz)
$-V_{CE}$=5V
T_j=25°C
typ
0
50
$-I_C$(mA)
100

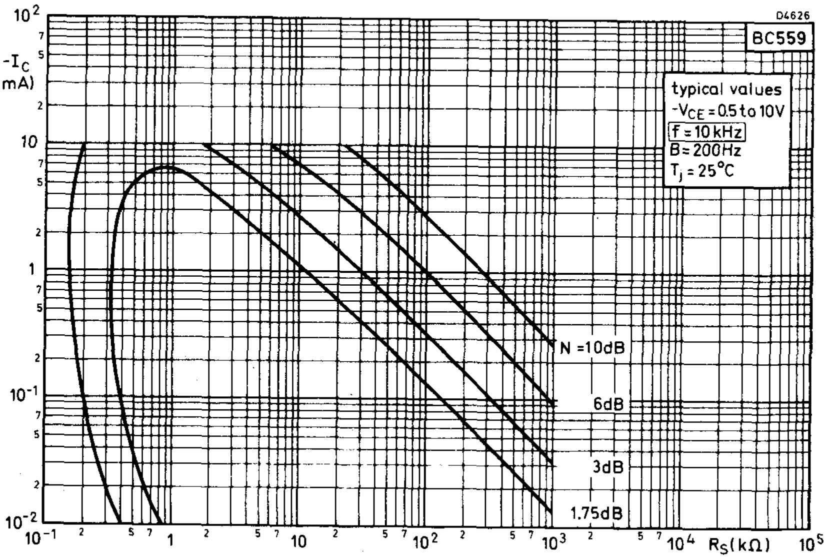

D4623
15
10
5
0
C_{Tc}
(pF)
f=1MHz
T_j=25°C
typ
0
5
$-V_{CB}$ (V)
10


D4624
BC559
6
4
2
0
N
(dB)
$-I_C$=0.2mA
$-V_{CE}$=5V
R_S=2kΩ
T_j=25°C
typ
10^{-1}
1
10
f(kHz)
10^2

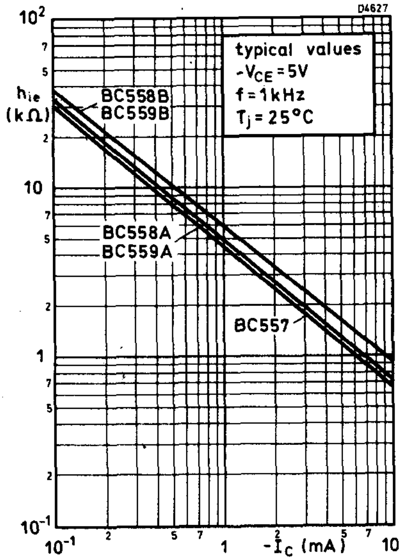
P-N-P SILICON PLANAR EPITAXIAL A.F. TRANSISTORS

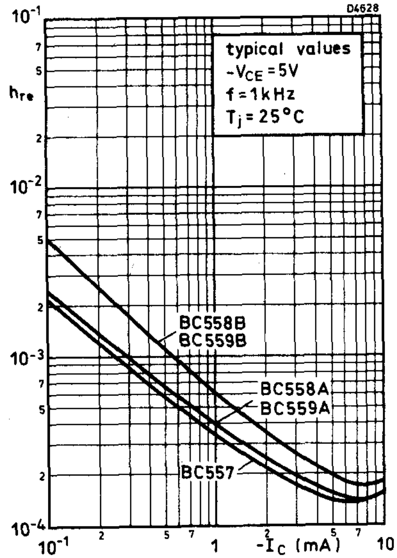
BC557 BC558 BC559

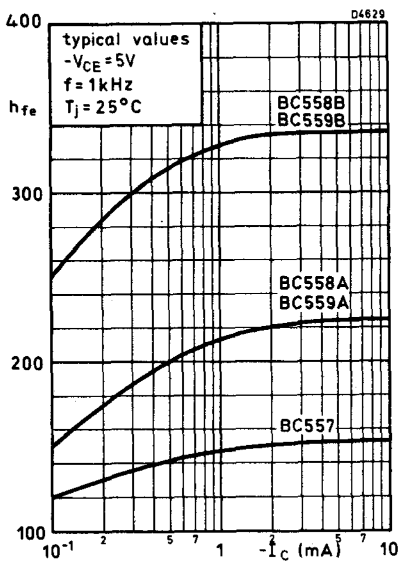


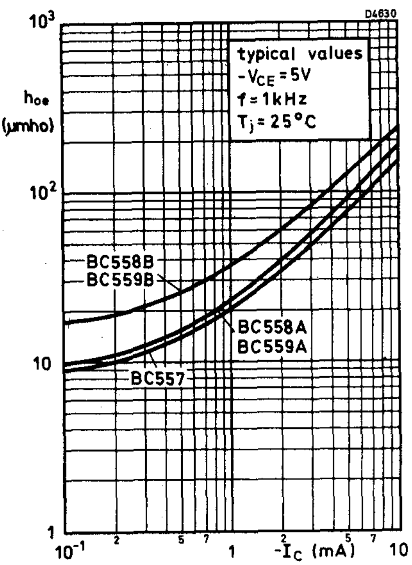


Constant noise figure curves


D4627
typical values
$-V_{CE}$ = 5V
f = 1kHz
T_j = 25°C
h_{ie} (kΩ)
BC558B
BC559B
BC558A
BC559A
BC557
$-I_C$ (mA)


D4628
typical values
$-V_{CE}$ = 5V
f = 1kHz
T_j = 25°C
h_{re}
BC558B
BC559B
BC558A
BC559A
BC557
$-I_C$ (mA)


D4629
typical values
$-V_{CE}$ = 5V
f = 1kHz
T_j = 25°C
h_{fe}
BC558B
BC559B
BC558A
BC559A
BC557
$-I_C$ (mA)


D4630
typical values
$-V_{CE}$ = 5V
f = 1kHz
T_j = 25°C
h_{oe} (µmho)
BC558B
BC559B
BC558A
BC559A
BC557
$-I_C$ (mA)

µ min. P-N-P SILICON PLANAR EPITAXIAL TRANSISTORS

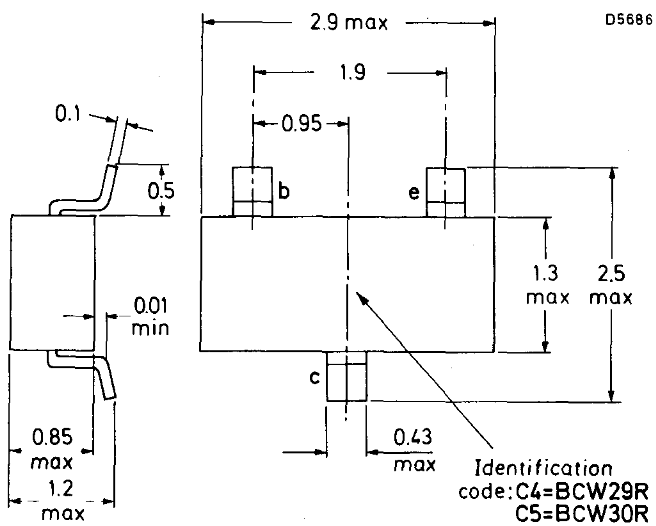
BCW29R BCW30R

Silicon p-n-p planar epitaxial transistors in microminiature plastic envelopes, intended for low level general purpose applications in thin and thick film circuits.

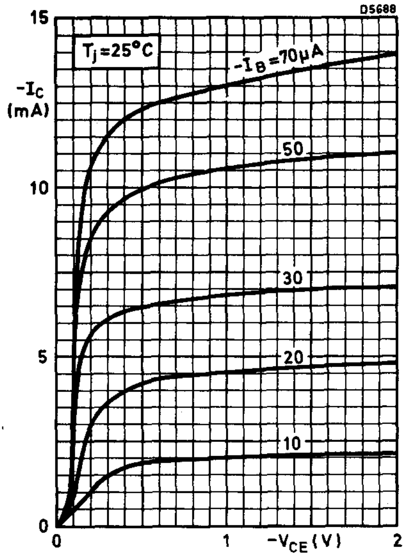
QUICK REFERENCE DATA				
$-V_{CBO}$	max.		30	V
$-V_{CEO}$	max.		20	V
$-I_{CM}$	max.		200	mA
P_{tot}	max., $T_{amb} \leq 25^{o}C$		200	mW
T_j	max.		150	^{o}C
h_{FE}	at $-I_C = 2mA$, $-V_{CE} = 5V$	BCW29R	120 - 260	
		BCW30R	215 - 500	
f_T	typ., $-I_C = 10mA$, $-V_{CE} = 5V$, $f = 35MHz$		150	MHz
N	max., $-I_C = 200\mu A$, $-V_{CE} = 5V$, $R_S = 2k\Omega$, $f = 1kHz$, $B = 200Hz$		10	dB

Unless otherwise stated data is applicable to both types

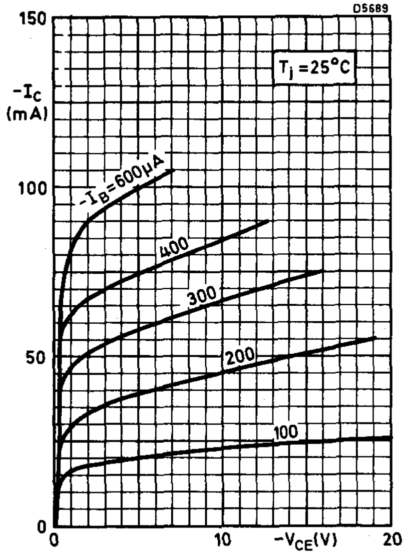
OUTLINE AND DIMENSIONS



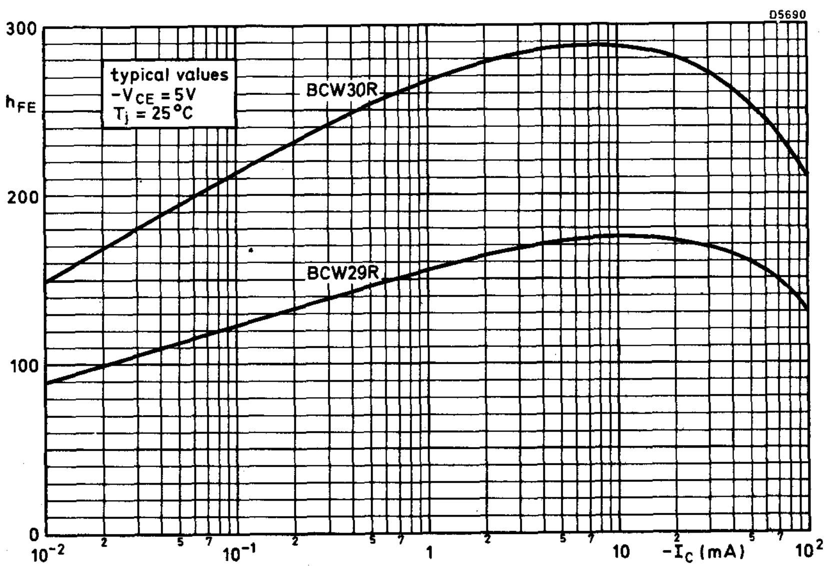
All dimensions in millimetres
Plan view from above



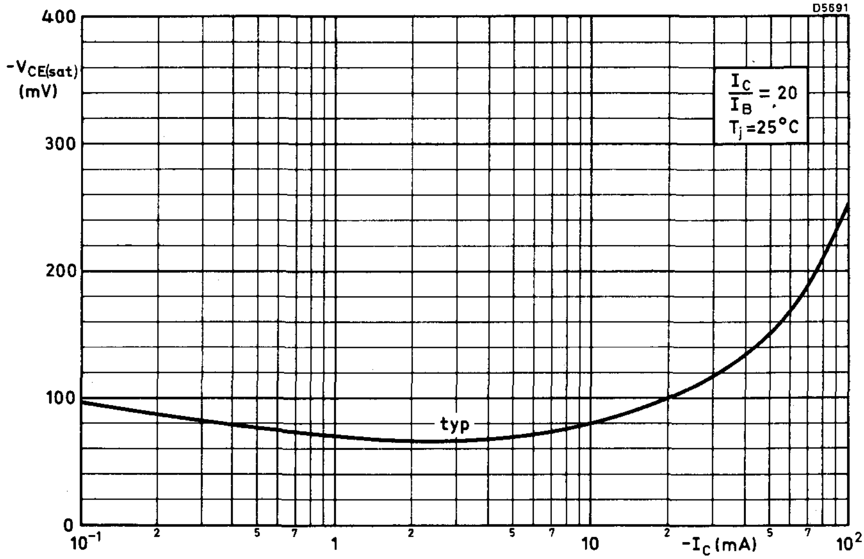
D5688
Tj = 25 °C
-IC (mA)
-IB = 70 μA
50
30
20
10
15
10
5
0
0
1
2
-VCE (V)

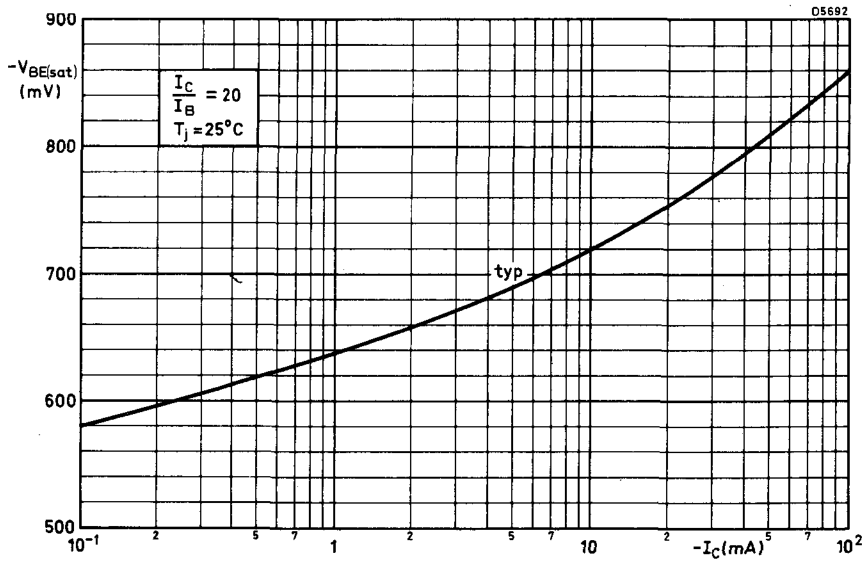


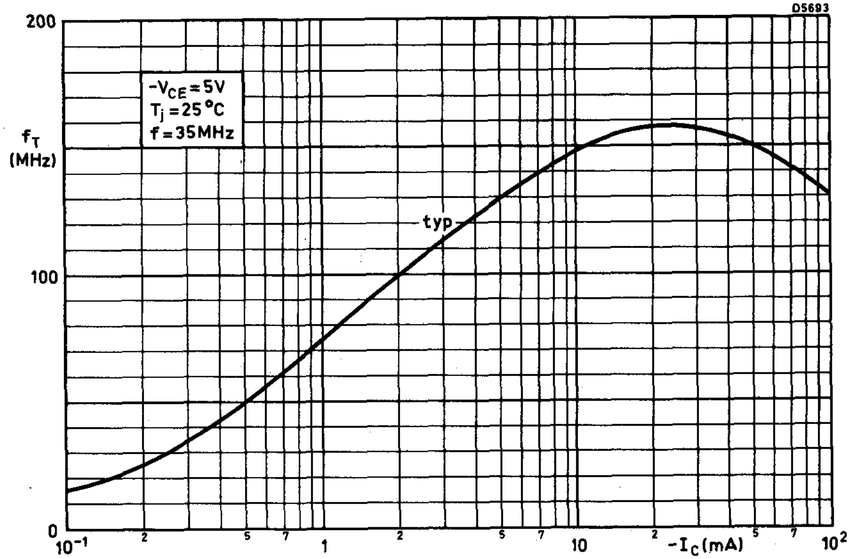
D5689
Tj = 25 °C
-IC (mA)
-IB = 600 μA
400
300
200
100
150
100
50
0
0
10
20
-VCE (V)

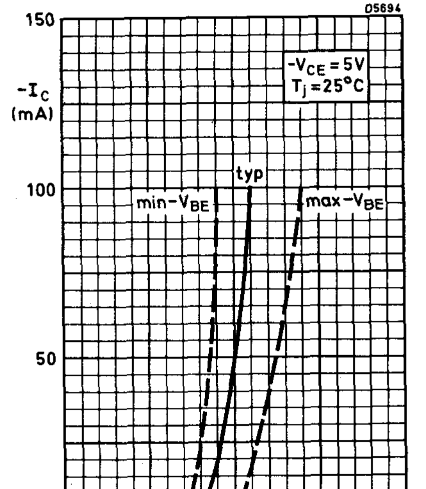


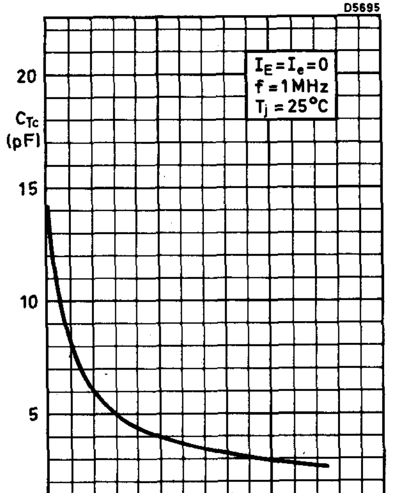
D5690
typical values
-VCE = 5V
Tj = 25 °C
hFE
BCW30R
BCW29R
300
200
100
0
10^-2
10^-1
1
10
10^2
-IC (mA)


D5691
400
$-V_{CE(sat)}$ (mV)
300
200
100
0
$\frac{I_C}{I_B} = 20$
$T_j = 25°C$
typ
10^{-1}
2
5
7
1
2
5
7
10
2
$-I_C$ (mA)
5
7
10^2


D5692
900
$-V_{BE(sat)}$ (mV)
800
700
600
500
$\frac{I_C}{I_B} = 20$
$T_j = 25°C$
typ
10^{-1}
2
5
7
1
2
5
7
10
2
$-I_C$ (mA)
5
7
10^2


D5693
200
100
0
f_T (MHz)
$-V_{CE} = 5V$
$T_j = 25°C$
f = 35MHz
typ
10^{-1}
2
5
7
1
10
$-I_C$ (mA)
10^2


D5694
150
100
50
0
$-I_C$ (mA)
$-V_{CE} = 5V$
$T_j = 25°C$
typ
min-V_{BE}
max-V_{BE}
250
500
750
1000
$-V_{BE}$(mV)


D5695
20
15
10
5
0
C_{Tc} (pF)
$I_E = I_e = 0$
f = 1MHz
$T_j = 25°C$
10
20
$-V_{CB}$(V)
30

µ min. N-P-N SILICON PLANAR EPITAXIAL TRANSISTORS

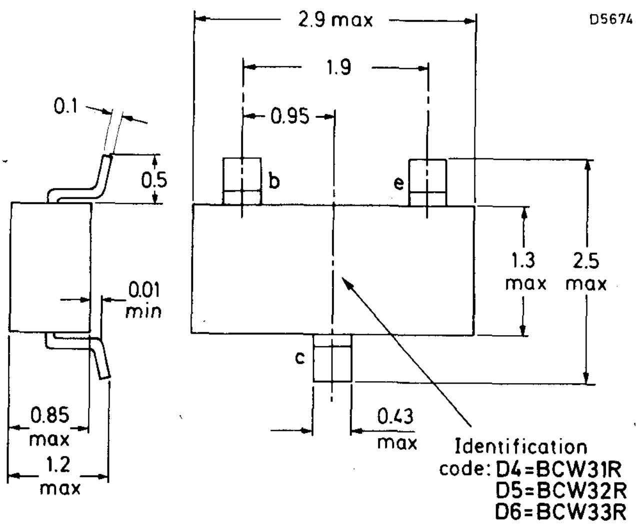
BCW31R BCW32R BCW33R

Silicon n-p-n planar epitaxial transistors in microminiature plastic envelopes, intended for low level general purpose applications in thin and thick film circuits.

QUICK REFERENCE DATA				
V_{CBO}	max.		30	V
V_{CEO}	max.		20	V
I_{CM}	max.		200	mA
P_{tot}	max., $T_{amb} \leq 25^{\circ}C$		200	mW
T_j	max.		150	$^{\circ}C$
h_{FE}	at I_C = 2mA, V_{CE} = 5V	BCW31R	110 - 220	
		BCW32R	200 - 450	
		BCW33R	420 - 800	
f_T	typ., I_C = 10mA, V_{CE} = 5V, f = 35MHz		300	MHz
N	max., I_C = 200µA, V_{CE} = 5V, R_S = 2kΩ, f = 1kHz, B = 200Hz		10	dB

Unless otherwise stated data is applicable to all types

OUTLINE AND DIMENSIONS



All dimensions in millimetres
Plan view from above

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

V_{CBO}	max.	30	V
V_{CEO}	max. (I_C = 2.0mA)	20	V
V_{EBO}	max.	5.0	V
I_C	max.	100	mA
I_{CM}	max.	200	mA
P_{tot}	max. $T_{amb} \leq 25^{o}C$, mounted on a ceramic substrate of 7 × 5 × 0.5mm	200	mW

Temperature

T_{stg}		-65 to +150	^{o}C
T_j	max.	150	^{o}C

THERMAL CHARACTERISTICS

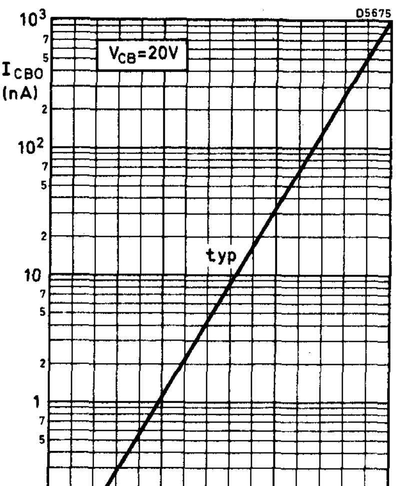
$R_{th(j-amb)}$	Thermal resistance between junction and ambient, the device mounted on a ceramic substrate of 7 × 5 × 0.5mm	0.62	$^{o}C/mW$

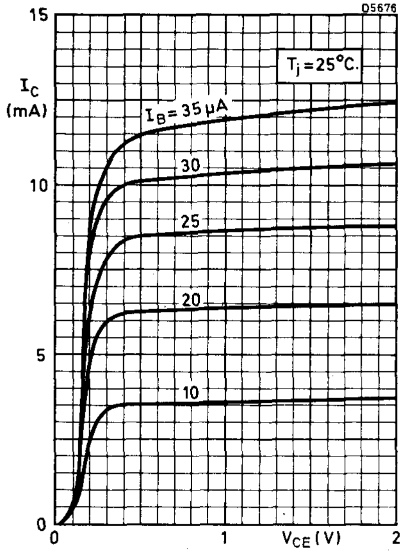
ELECTRICAL CHARACTERISTICS ($T_j = 25^{o}C$ unless otherwise stated)

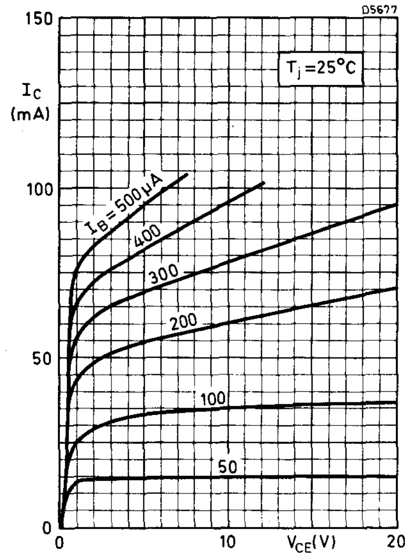
		Min.	Typ.	Max.	
I_{CBO}	Collector cut-off current				
	$I_E = 0$, $V_{CB} = 20V$	-	-	100	nA
	$I_E = 0$, $V_{CB} = 20V$, $T_j = 100^{o}C$	-	-	10	μA
V_{BE}	Base-emitter voltage				
	$I_C = 2.0mA$, $V_{CE} = 5.0V$	550	-	700	mV
$V_{CE(sat)}$	Collector-emitter saturation voltage				
	$I_C = 10mA$, $I_B = 0.5mA$	-	120	250	mV
	$I_C = 50mA$, $I_B = 2.5mA$	-	210	-	mV
$V_{BE(sat)}$	Base-emitter saturation voltage				
	$I_C = 10mA$, $I_B = 0.5mA$	-	750	-	mV
	$I_C = 50mA$, $I_B = 2.5mA$	-	850	-	mV

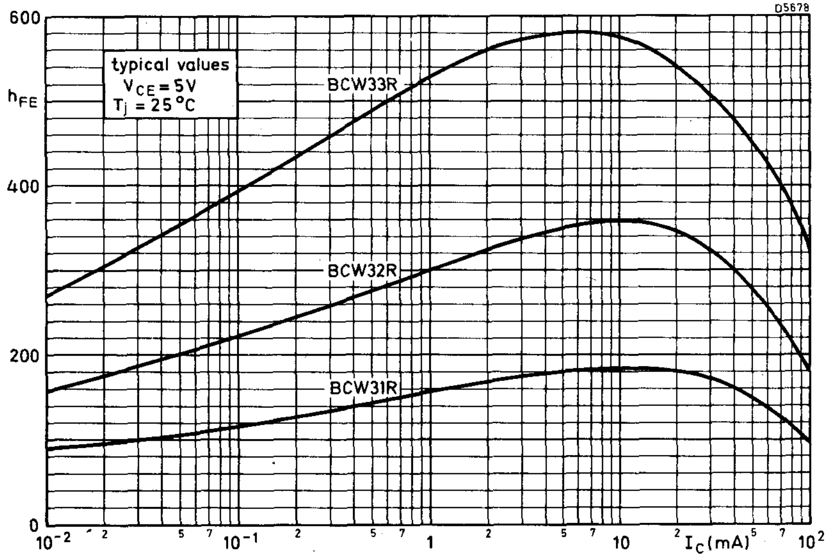
ELECTRICAL CHARACTERISTICS (contd.)

			Min.	Typ.	Max.	
h_{FE}	Static forward current transfer ratio					
	I_C = 10µA, V_{CE} = 5.0V	BCW31R	-	90	-	
		BCW32R	-	150	-	
		BCW33R	-	270	-	
	I_C = 2.0mA, V_{CE} = 5.0V	BCW31R	110	-	220	
		BCW32R	200	-	450	
		BCW33R	420	-	800	
f_T	Transition frequency I_C = 10mA, V_{CE} = 5.0V, f = 35MHz		-	300	-	MHz
C_{Tc}	Collector capacitance $I_E = I_e$ = 0, V_{CB} = 10V, f = 1.0MHz		-	-	4.0	pF
N	Noise figure I_C = 200µA, V_{CE} = 5.0V, R_S = 2.0kΩ, f = 1.0kHz, B = 200Hz		-	-	10	dB

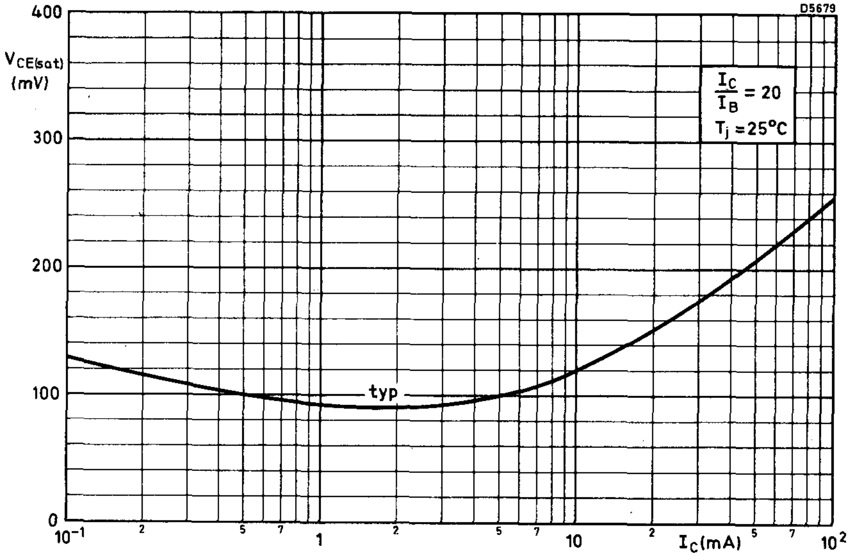


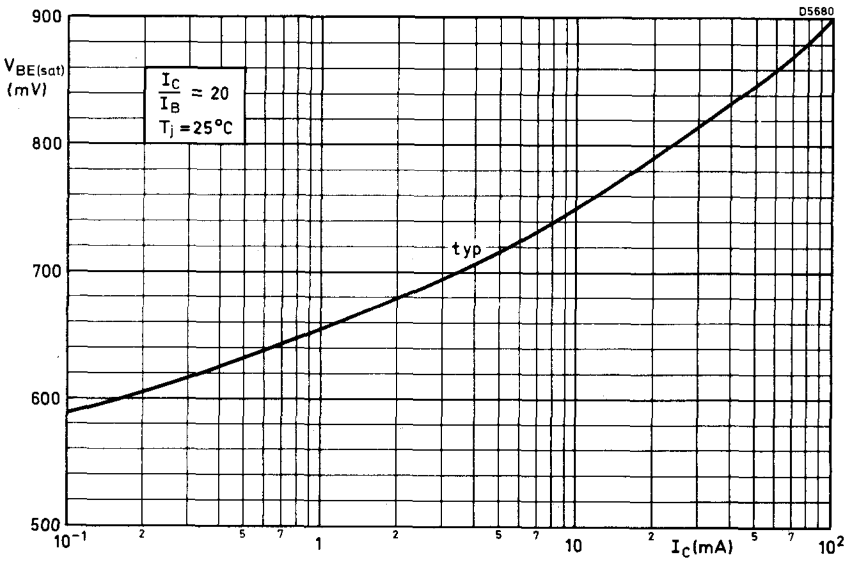

D5676
15
10
5
0
I_C (mA)
$T_j = 25°C$.
$I_B = 35 \mu A$
30
25
20
10
0
1
V_{CE} (V)
2

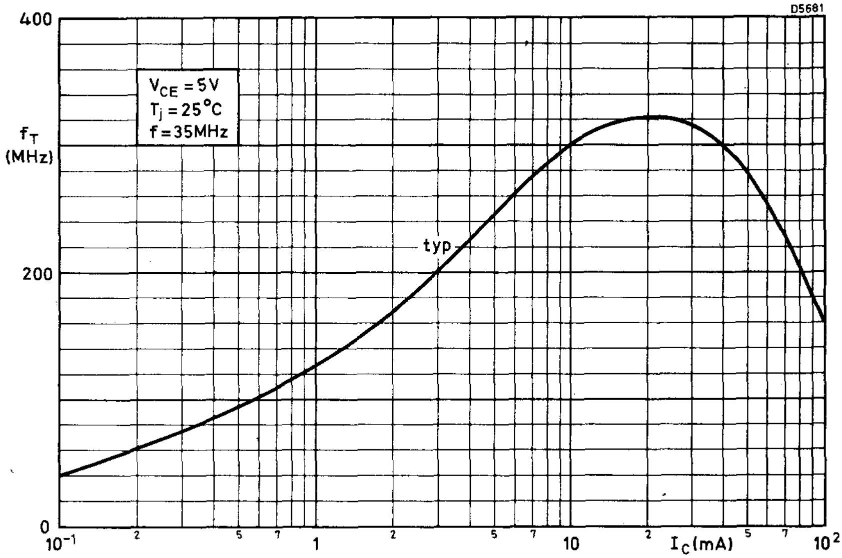

D5677
150
100
50
0
I_C (mA)
$T_j = 25°C$
$I_B = 500 \mu A$
400
300
200
100
50
0
10
V_{CE}(V)
20

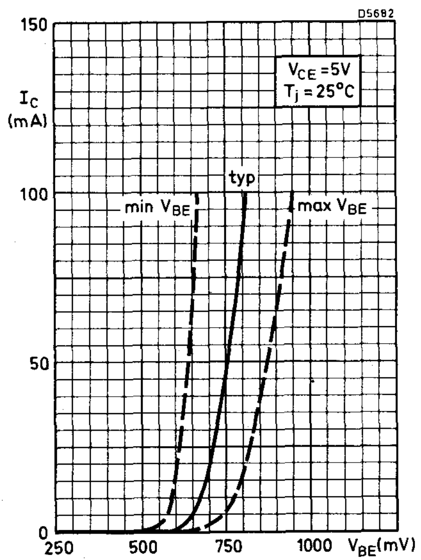

D5678
600
400
200
0
h_{FE}
typical values
$V_{CE} = 5V$
$T_j = 25°C$
BCW33R
BCW32R
BCW31R
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2

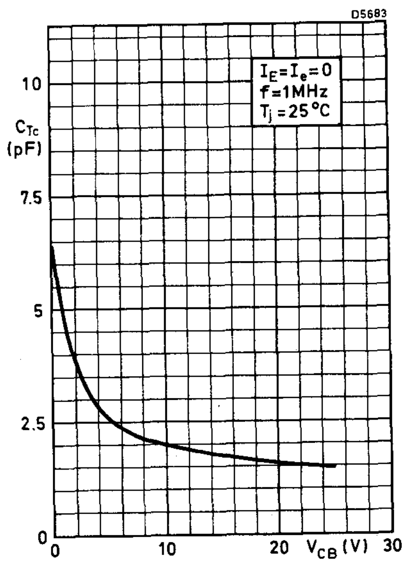
Mullard


D5679
$V_{CE(sat)}$ (mV)
400
300
200
100
0
$\frac{I_C}{I_B} = 20$
$T_j = 25°C$
typ
10^{-1}
2
5
7
1
2
5
7
10
2
I_C(mA)
5
7
10^2


D5680
$V_{BE(sat)}$ (mV)
900
800
700
600
500
$\frac{I_C}{I_B} = 20$
$T_j = 25°C$
typ
10^{-1}
2
5
7
1
2
5
7
10
2
I_C(mA)
5
7
10^2


D5681
400
200
0
f_T
(MHz)
V_{CE} = 5V
T_j = 25°C
f = 35MHz
typ
10^{-1}
2
5
7
1
2
5
7
10
2
I_C(mA)
5
7
10^2


D5682
150
100
50
0
I_C
(mA)
V_{CE} = 5V
T_j = 25°C
min V_{BE}
typ
max V_{BE}
250
500
750
1000
V_{BE}(mV)


D5683
10
7.5
5
2.5
0
C_{Tc}
(pF)
I_E = I_e = 0
f = 1MHz
T_j = 25°C
0
10
20
V_{CB} (V)
30

Mullard

μ min. P-N-P SILICON PLANAR EPITAXIAL TRANSISTORS

BCW69R BCW70R

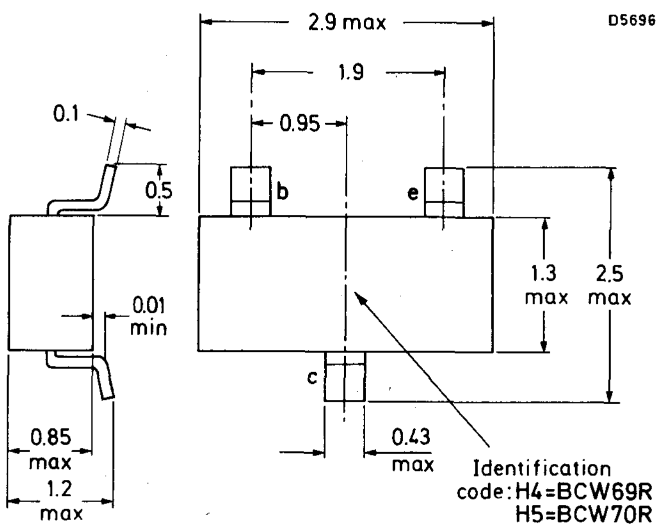
Silicon p-n-p planar epitaxial transistors in microminiature plastic envelopes, intended for low level general purpose applications in thin and thick film circuits.

QUICK REFERENCE DATA

$-V_{CBO}$	max.		50	V
$-V_{CEO}$	max.		45	V
$-I_{CM}$	max.		200	mA
P_{tot}	max. $T_{amb} \leq 25^{o}C$		200	mW
T_j	max.		150	^{o}C
h_{FE}	at $-I_C = 2mA$, $-V_{CE} = 5V$	BCW69R	120 to 260	
		BCW70R	215 to 500	
f_T	typ., $-I_C = 10mA$, $-V_{CE} = 5V$, $f = 35MHz$		150	MHz
N	max., $-I_C = 200\mu A$, $-V_{CE} = 5V$, $R_S = 2k\Omega$, $f = 1kHz$, $B = 200Hz$		10	dB

Unless otherwise stated data is applicable to both types

OUTLINE AND DIMENSIONS



All dimensions in millimetres
Plan view from above

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

$-V_{CBO}$	max.	50	V
$-V_{CES}$	max.	50	V
$-V_{CEO}$	max. ($-I_C$ = 2.0mA)	45	V
$-V_{EBO}$	max.	5.0	V
$-I_C$	max.	100	mA
$-I_{CM}$	max.	200	mA
P_{tot}	max. $T_{amb} \leq 25^{o}C$, mounted on a ceramic substrate of 7 × 5 × 0.5mm	200	mW

Temperature

T_{stg}		-65 to +150	^{o}C
T_j	max.	+150	^{o}C

THERMAL CHARACTERISTICS

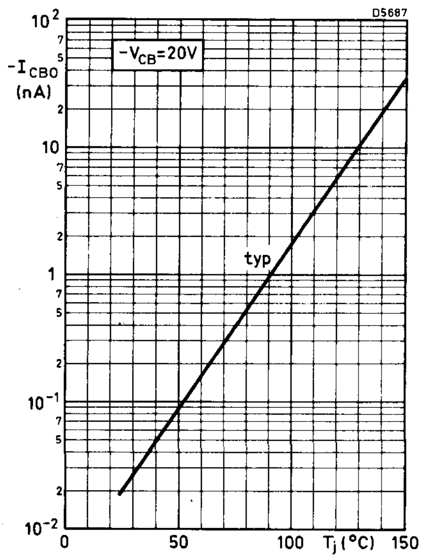
$R_{th(j-amb)}$	Thermal resistance between junction and ambient, the device mounted on a ceramic substrate of 7 × 5 × 0.5mm	0.62	$^{o}C/mW$

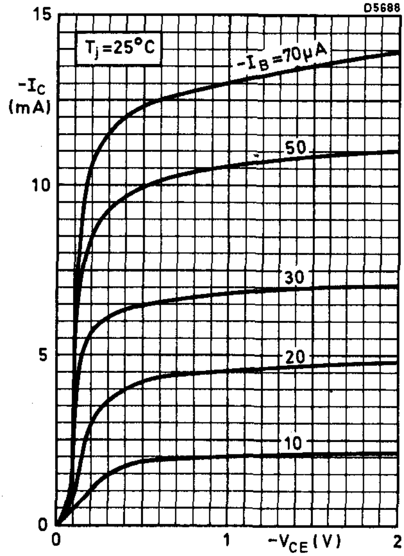
ELECTRICAL CHARACTERISTICS ($T_j = 25^{o}C$ unless otherwise stated)

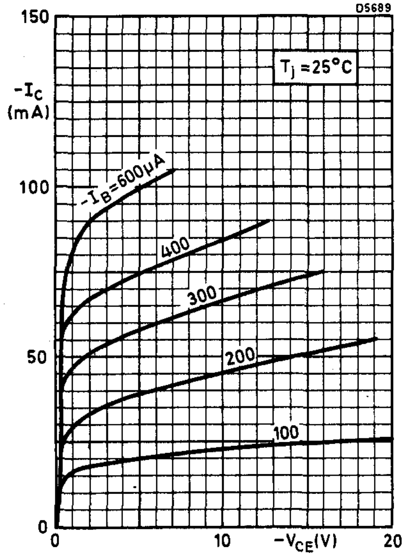
		Min.	Typ.	Max.	
$-I_{CBO}$	Collector cut-off current				
	$I_E = 0$, $-V_{CB}$ = 20V	-	-	100	nA
	$I_E = 0$, $-V_{CB}$ = 20V, $T_j = 100^{o}C$	-	-	10	μA
$-V_{BE}$	Base-emitter voltage				
	$-I_C$ = 2.0mA, $-V_{CE}$ = 5.0V	600	-	750	mV
$-V_{CE(sat)}$	Collector-emitter saturation voltage				
	$-I_C$ = 10mA, $-I_B$ = 0.5mA	-	80	300	mV
	$-I_C$ = 50mA, $-I_B$ = 2.5mA	-	150	-	mV
$-V_{BE(sat)}$	Base-emitter saturation voltage				
	$-I_C$ = 10mA, $-I_B$ = 0.5mA	-	720	-	mV
	$-I_C$ = 50mA, $-I_B$ = 2.5mA	-	810	-	mV

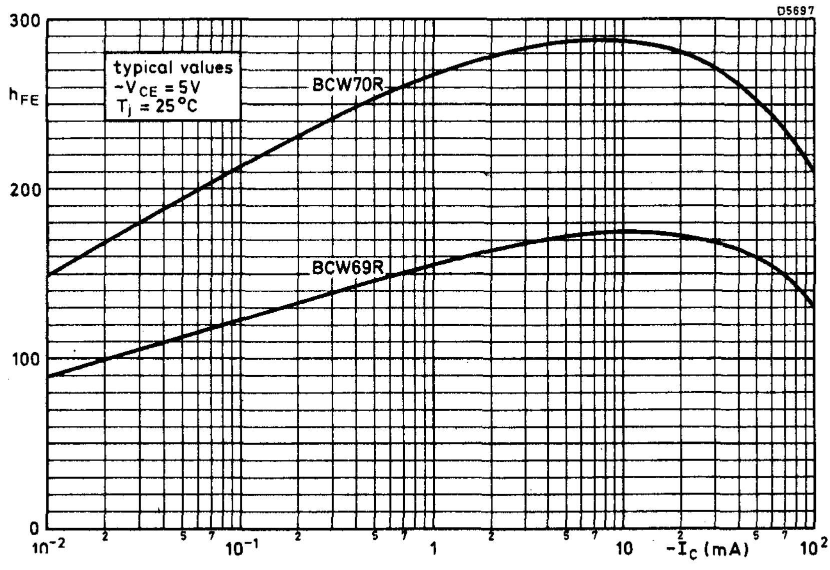
ELECTRICAL CHARACTERISTICS (contd.)

			Min.	Typ.	Max.	
h_{FE}	Static forward current transfer ratio					
	$-I_C = 10\mu A$, $-V_{CE} = 5.0V$	BCW69R	-	90	-	
		BCW70R	-	150	-	
	$-I_C = 2.0mA$, $-V_{CE} = 5.0V$	BCW69R	120	-	260	
		BCW70R	215	-	500	
f_T	Transition frequency					
	$-I_C = 10mA$, $-V_{CE} = 5.0V$, $f = 35MHz$		-	150	-	MHz
C_{Tc}	Collector capacitance					
	$I_E = I_e = 0$, $-V_{CB} = 10V$, $f = 1.0MHz$		-	-	7.0	pF
N	Noise figure					
	$-I_C = 200\mu A$, $-V_{CE} = 5.0V$, $R_S = 2.0k\Omega$, $f = 1.0kHz$, $B = 200Hz$		-	-	10	dB

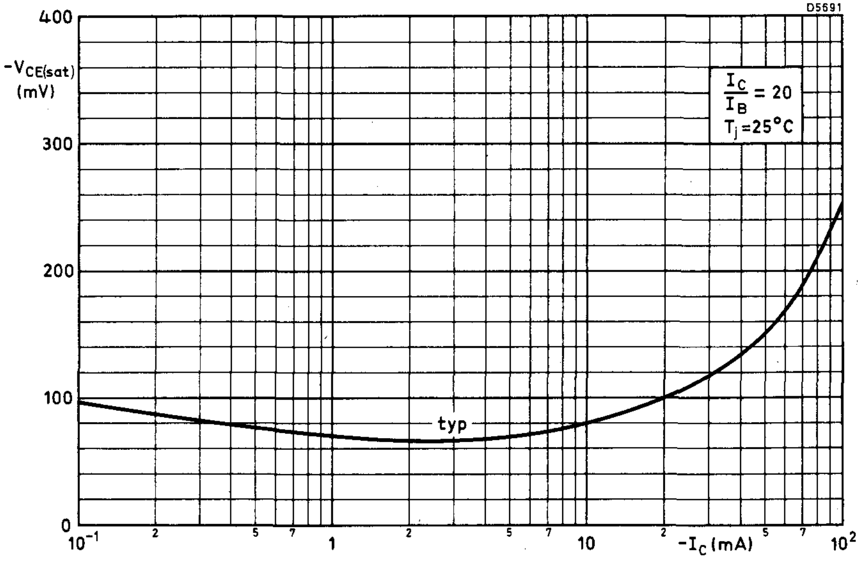


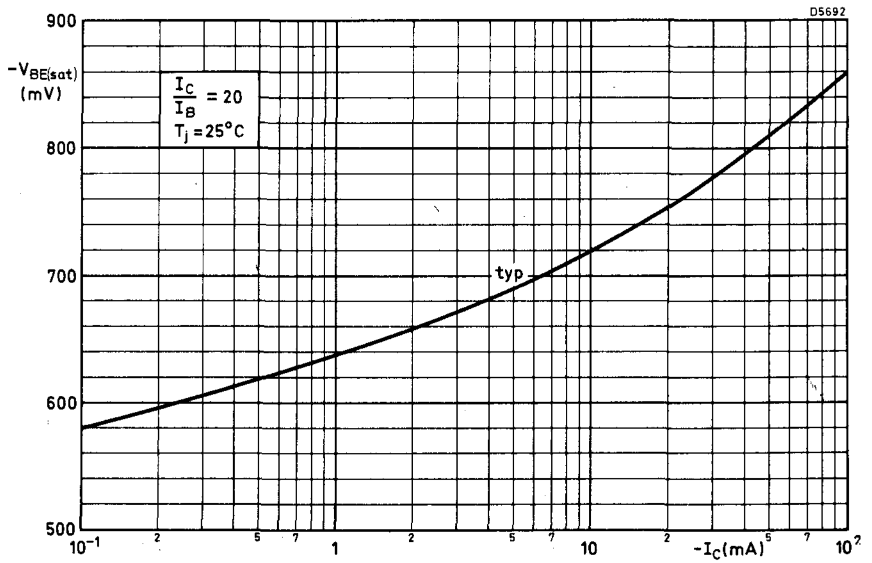

D5688
T_j = 25°C
$-I_C$ (mA)
$-I_B$ = 70μA
50
30
20
10
15
10
5
0
0
1
2
$-V_{CE}$ (V)

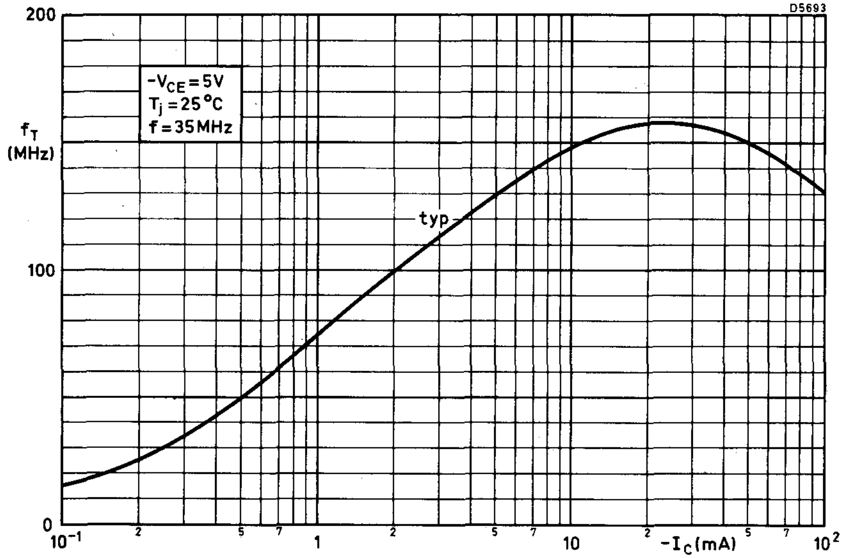

D5689
T_j = 25°C
$-I_C$ (mA)
$-I_B$ = 600μA
400
300
200
100
150
100
50
0
0
10
20
$-V_{CE}$ (V)

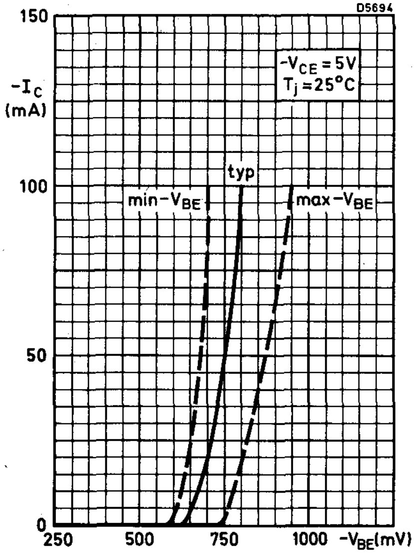

D5697
typical values
$-V_{CE}$ = 5V
T_j = 25°C
h_{FE}
BCW70R
BCW69R
300
200
100
0
10^{-2}
10^{-1}
1
10
10^2
$-I_C$ (mA)

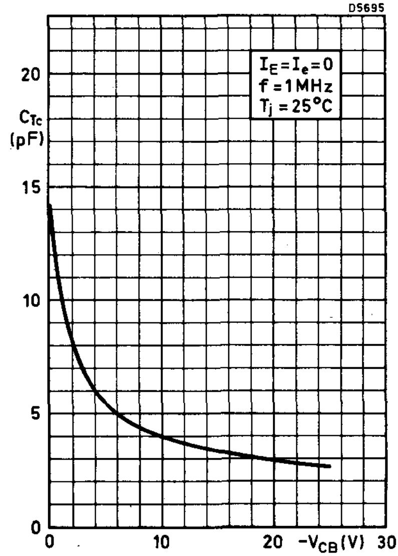
Mullard


D5691
400
$-V_{CE(sat)}$ (mV)
300
200
100
0
$\frac{I_C}{I_B} = 20$
$T_j = 25°C$
typ
10^{-1}
2
5
7
1
2
5
7
10
2
$-I_C$ (mA)
5
7
10^2


D5692
900
$-V_{BE(sat)}$ (mV)
800
700
600
500
$\frac{I_C}{I_B} = 20$
$T_j = 25°C$
typ
10^{-1}
2
5
7
1
2
5
7
10
2
$-I_C$ (mA)
5
7
10^2


D5693
200
100
0
f_T (MHz)
$-V_{CE} = 5V$
$T_j = 25°C$
f = 35 MHz
typ
10^{-1}
2
5
7
1
10
$-I_C$ (mA)
10^2


D5694
150
100
50
0
$-I_C$ (mA)
$-V_{CE} = 5V$
$T_j = 25°C$
min-V_{BE}
typ
max-V_{BE}
250
500
750
1000
$-V_{BE}$(mV)


D5695
20
15
10
5
0
C_{Tc} (pF)
$I_E = I_e = 0$
f = 1 MHz
$T_j = 25°C$
10
20
$-V_{CB}$ (V)
30

µ min. N-P-N SILICON PLANAR EPITAXIAL TRANSISTORS

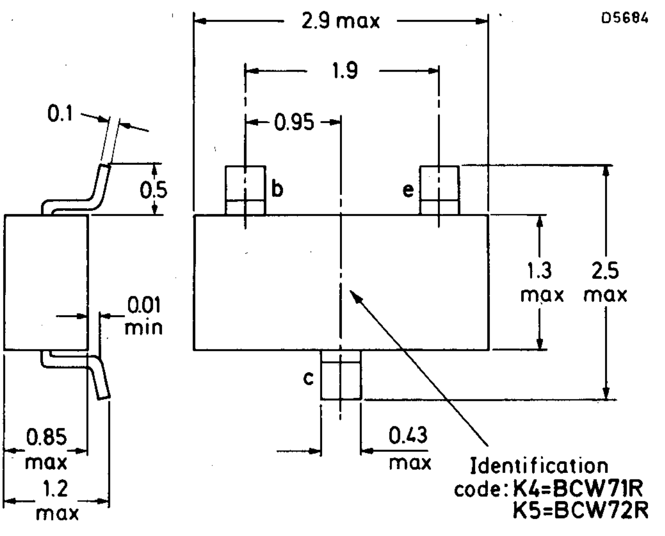
BCW71R BCW72R

Silicon n-p-n planar epitaxial transistors in microminiature plastic envelopes, intended for low level general purpose applications in thin and thick film circuits.

QUICK REFERENCE DATA					
V_{CBO}	max.			50	V
V_{CEO}	max.			45	V
I_{CM}	max.			200	mA
P_{tot}	max.	$T_{amb} \leq 25^{o}C$		200	mW
T_j	max.			150	^{o}C
h_{FE}	at	I_C = 2mA, V_{CE} = 5V	BCW71R	110 to 220	
			BCW72R	200 to 450	
f_T	typ.,	I_C = 10mA, V_{CE} = 5V, f = 35MHz		300	MHz
N	max.	I_C = 200µA, V_{CE} = 5V, R_S = 2kΩ, f = 1kHz, B = 200Hz		10	dB

Unless otherwise stated data is applicable to both types

OUTLINE AND DIMENSIONS



All dimensions in millimetres
Plan view from above

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

V_{CBO}	max.	50	V
V_{CEO}	max. (I_C = 2.0mA)	45	V
V_{EBO}	max.	5.0	V
I_C	max.	100	mA
I_{CM}	max.	200	mA
P_{tot}	max. $T_{amb} \leq 25^oC$, mounted on a ceramic substrate of 7 × 5 × 0.5mm	200	mW

Temperature

T_{stg}		-65 to +150	^oC
T_j	max.	150	^oC

THERMAL CHARACTERISTICS

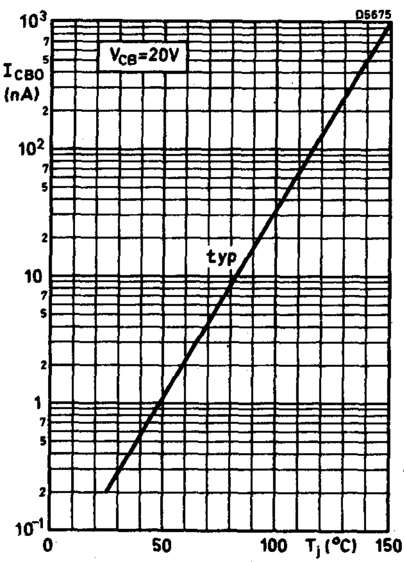
$R_{th(j-amb)}$	Thermal resistance between junction and ambient, the device mounted on a ceramic substrate of 7 × 5 × 0.5mm	0.62	$^oC/mW$

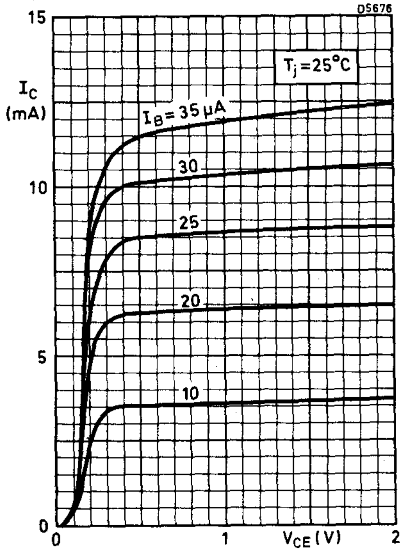
ELECTRICAL CHARACTERISTICS ($T_j = 25^oC$ unless otherwise stated)

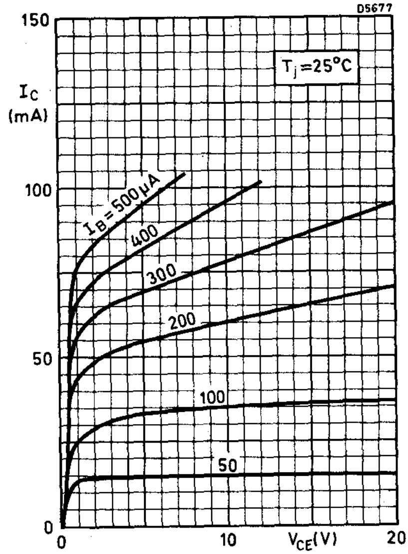
		Min.	Typ.	Max.	
I_{CBO}	Collector cut-off current				
	I_E = 0, V_{CB} = 20V	-	-	100	nA
	I_E = 0, V_{CB} = 20V, $T_j = 100^oC$	-	-	10	µA
V_{BE}	Base-emitter voltage				
	I_C = 2.0mA, V_{CE} = 5.0V	550	-	700	mV
$V_{CE(sat)}$	Collector-emitter saturation voltage				
	I_C = 10mA, I_B = 0.5mA	-	120	250	mV
	I_C = 50mA, I_B = 2.5mA	-	210	-	mV
$V_{BE(sat)}$	Base-emitter saturation voltage				
	I_C = 10mA, I_B = 0.5mA	-	750	-	mV
	I_C = 50mA, I_B = 2.5mA	-	850	-	mV

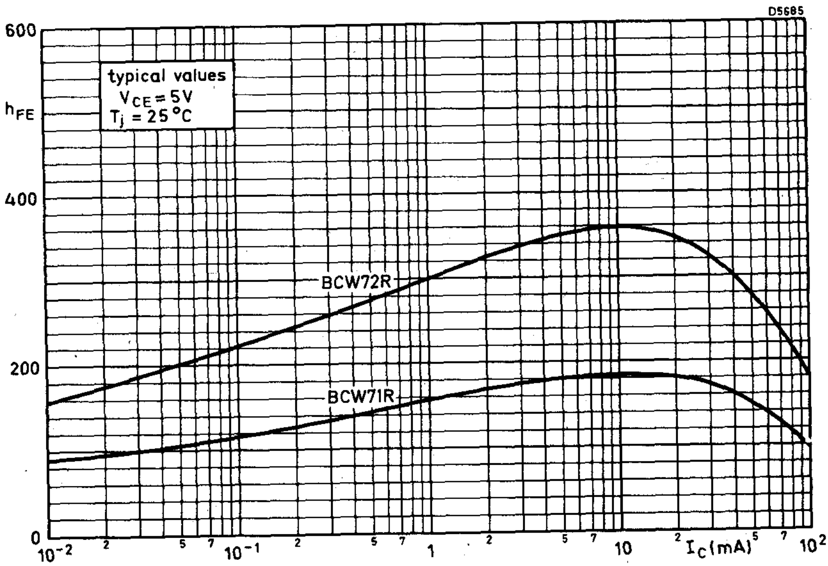
ELECTRICAL CHARACTERISTICS (contd.)

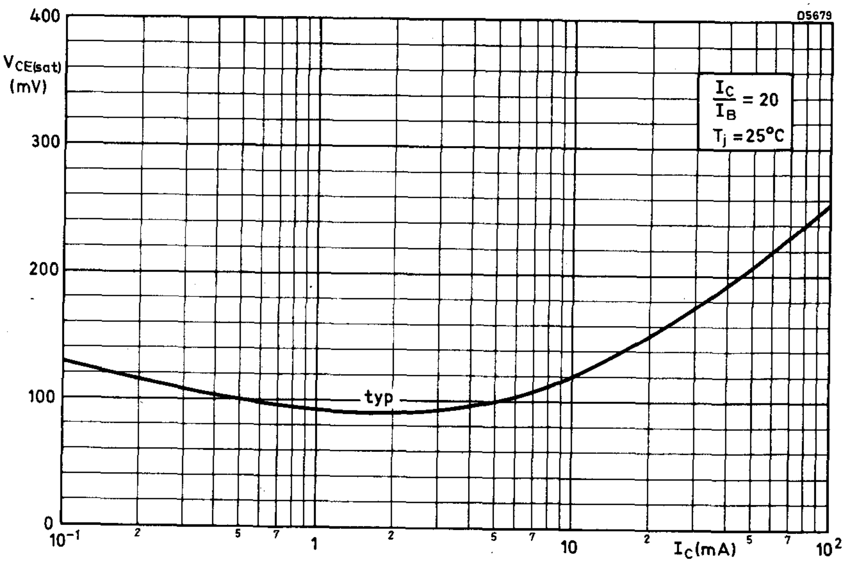
			Min.	Typ.	Max.	
h_{FE}	Static forward current transfer ratio					
	$I_C = 10\mu A$, $V_{CE} = 5.0V$	BCW71R	-	90	-	
		BCW72R	-	150	-	
	$I_C = 2.0mA$, $V_{CE} = 5.0V$	BCW71R	110	-	220	
		BCW72R	200	-	450	
f_T	Transition frequency					
	$I_C = 10mA$, $V_{CE} = 5.0V$, $f = 35MHz$		-	300	-	MHz
C_{Tc}	Collector capacitance					
	$I_E = I_e = 0$, $V_{CB} = 10V$, $f = 1.0MHz$		-	-	4.0	pF
N	Noise figure					
	$I_C = 200\mu A$, $V_{CE} = 5.0V$, $R_S = 2.0k\Omega$, $f = 1.0kHz$, $B = 200Hz$		-	-	10	dB



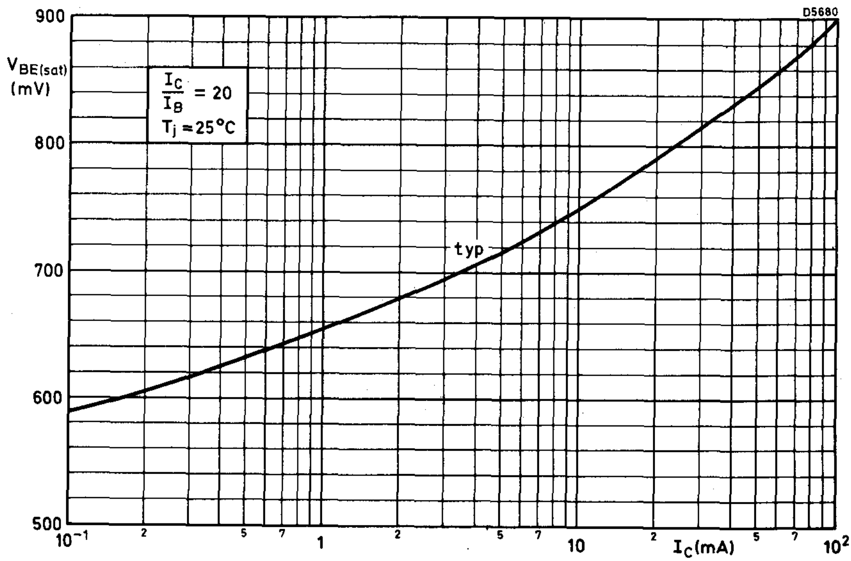

D5676
15
10
5
0
I_C (mA)
$T_j = 25°C$
$I_B = 35\ \mu A$
30
25
20
10
0
1
V_{CE} (V)
2


D5677
150
100
50
0
I_C (mA)
$T_j = 25°C$
$I_B = 500\ \mu A$
400
300
200
100
50
0
10
V_{CE} (V)
20

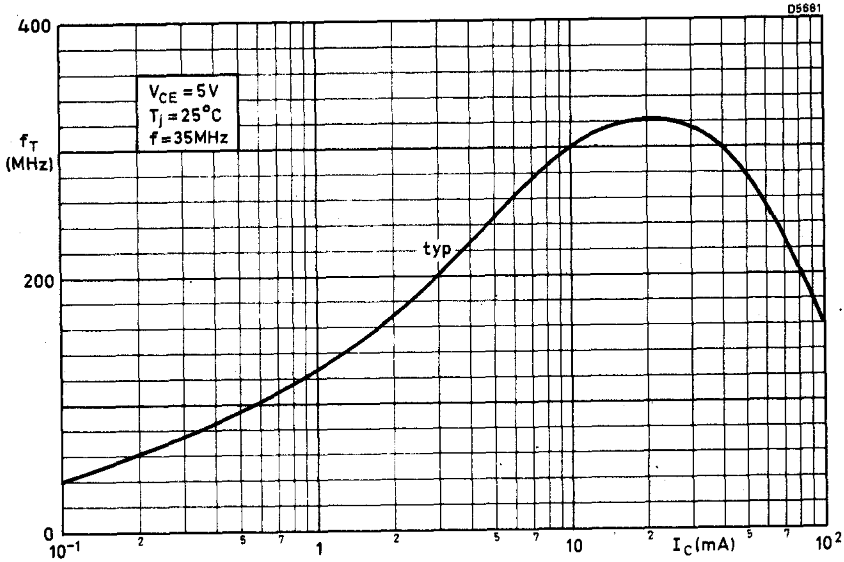

D5685
600
400
200
0
h_{FE}
typical values
$V_{CE} = 5V$
$T_j = 25°C$
BCW72R
BCW71R
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2

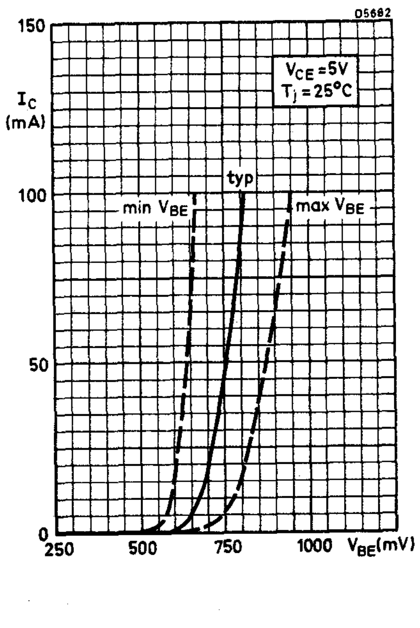


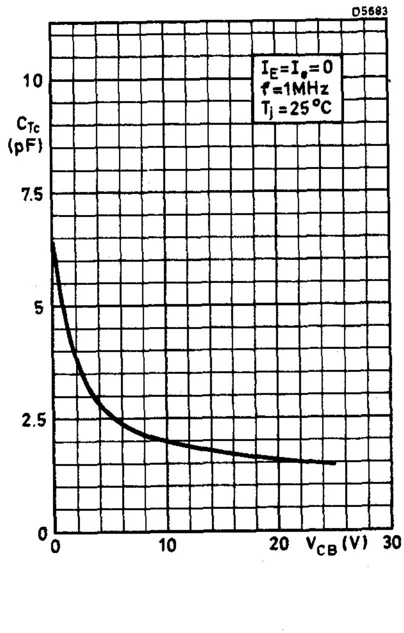
D5679
400
300
200
100
0
VCE(sat) (mV)
IC/IB = 20
Tj = 25°C
typ
10⁻¹
2
5
7
1
2
5
7
10
2
IC(mA)
5
7
10²



D5680
900
800
700
600
500
VBE(sat) (mV)
IC/IB = 20
Tj = 25°C
typ
10⁻¹
2
5
7
1
2
5
7
10
2
IC(mA)
5
7
10²


D5681
400
200
0
f_T (MHz)
V_{CE} = 5 V
T_j = 25 °C
f = 35 MHz
typ
10^{-1}
2
5
7
1
10
I_C (mA)
10^2


D5682
150
100
50
0
I_C (mA)
V_{CE} = 5 V
T_j = 25 °C
typ
min V_{BE}
max V_{BE}
250
500
750
1000
V_{BE} (mV)


D5683
10
7.5
5
2.5
0
C_{Tc} (pF)
$I_E = I_e = 0$
f = 1 MHz
T_j = 25 °C
0
10
20
V_{CB} (V)
30

µ min. P-N-P SILICON PLANAR EPITAXIAL TRANSISTORS

BCX17 BCX18

P-N-P silicon planar epitaxial transistors in a microminiature plastic envelope intended for application in thick and thin film circuits. These transistors are intended for general purposes as well as saturated switching and driver applications for industrial service.

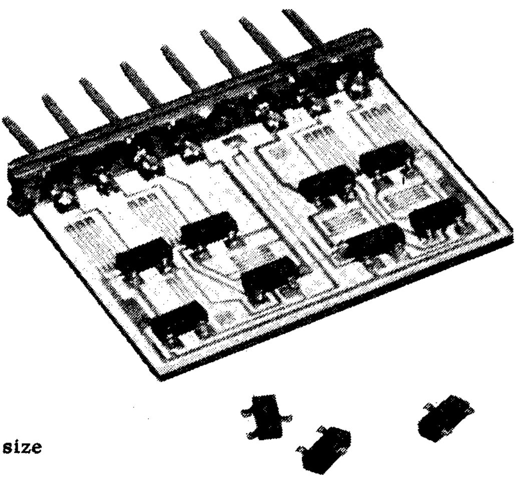
The BCX17 and BCX18 are complementary to the BCX19 and BCX20 respectively.

QUICK REFERENCE DATA

	BCX17	BCX18	
$-V_{CES}$ max.	50	30	V
$-V_{CEO}$ max.	45	25	V
$-I_{CM}$ max.	1000		mA
P_{tot} max. ($T_{amb} \leq 25^oC$)	310		mW
T_j max.	150		^oC
h_{FE} ($-I_C$ = 100mA, $-V_{CE}$ = 1.0V)	100 to 600		
f_T typ. ($-I_C$ = 10mA, $-V_{CE}$ = 5.0V, f = 35MHz)	100		MHz

Unless otherwise stated data are applicable to both types

OUTLINE AND DIMENSIONS - For details see page 2

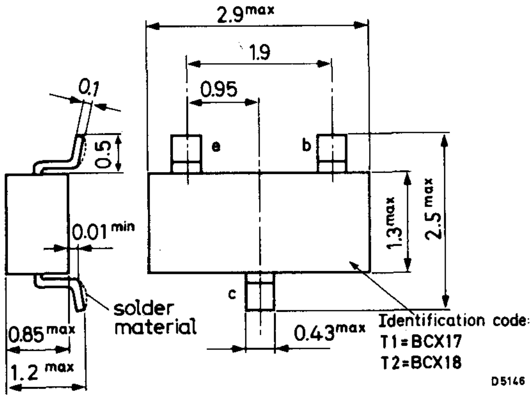


$2\frac{1}{2}$ × actual size

OUTLINE AND DIMENSIONS

All dimensions in millimetres

Plan view from above



RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

		BCX17		BCX18	
$-V_{CES}$ max.		50		30	V
$-V_{CEO}$ max.	($-I_C$ = 10mA)	45		25	V
$-V_{EBO}$ max.		5.0		5.0	V
$-I_C$ max.			500		mA
$-I_{CM}$ max.			1000.		mA
I_{EM} max.			1000		mA
$-I_B$ max.			100		mA
$-I_{BM}$ max.			200		mA
P_{tot} max.	$T_{amb} \leq 25^{\circ}C$, mounted on a ceramic substrate of 15 x 15 x 0.5mm		310		mW

Temperature

T_{stg}	-65 to +150	^{o}C
T_j max.	150	^{o}C

μ min. P-N-P SILICON PLANAR EPITAXIAL TRANSISTORS

BCX17 BCX18

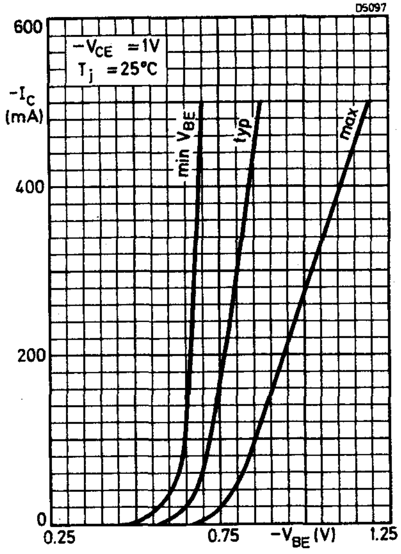
THERMAL CHARACTERISTIC

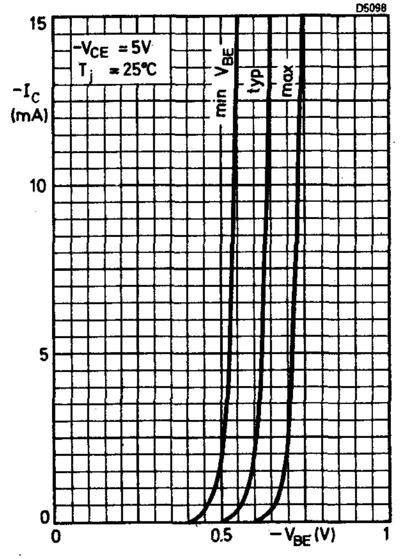
$R_{th(j-amb)}$	Thermal resistance between junction and ambient, the device mounted on a ceramic substrate of 15 x 15 x 0.5mm	0.4	°C/mW

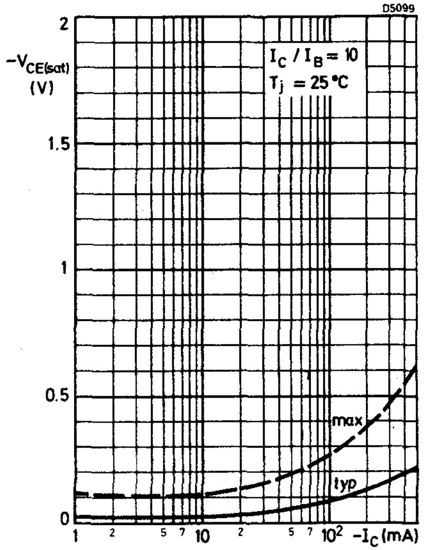
ELECTRICAL CHARACTERISTICS (T_j =25°C unless otherwise stated)

		Min.	Typ.	Max.	
$-I_{CBO}$	Collector cut-off current				
	$I_E = 0$, $-V_{CB} = 20V$	-	-	100	nA
	$I_E = 0$, $-V_{CB} = 20V$, $T_j = 150°C$	-	-	5.0	μA
$-I_{EBO}$	Emitter cut-off current				
	$I_C = 0$, $-V_{EB} = 5.0V$	-	-	10	μA
$-V_{BE}$	*Base emitter voltage				
	$-I_C = 500mA$, $-V_{CE} = 1.0V$	-	-	1.2	V
$-V_{CE(sat)}$	Collector-emitter saturation voltage				
	$-I_C = 500mA$, $-I_B = 50mA$	-	-	620	mV
h_{FE}	Static forward current transfer ratio				
	$-I_C = 100mA$, $-V_{CE} = 1.0V$	100	-	600	
	$-I_C = 300mA$, $-V_{CE} = 1.0V$	70	-	-	
	$-I_C = 500mA$, $-V_{CE} = 1.0V$	40	-	-	
f_T	Transition frequency				
	$-I_C = 10mA$, $-V_{CE} = 5.0V$, f = 35MHz	-	100	-	MHz
C_{Tc}	Collector capacitance				
	$I_E = I_e = 0$, $-V_{CB} = 10V$, f = 1.0MHz	-	8.0	-	pF

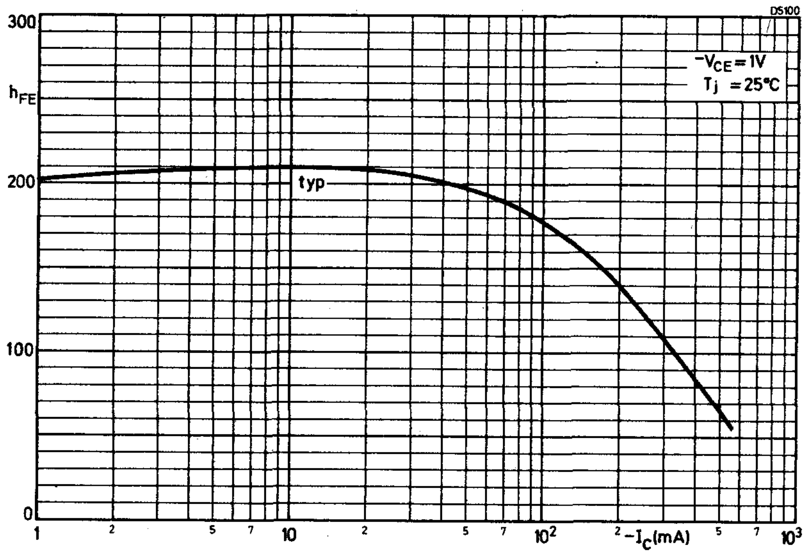
* $-V_{BE}$ decreases by about 2mV/°C with increasing temperature.

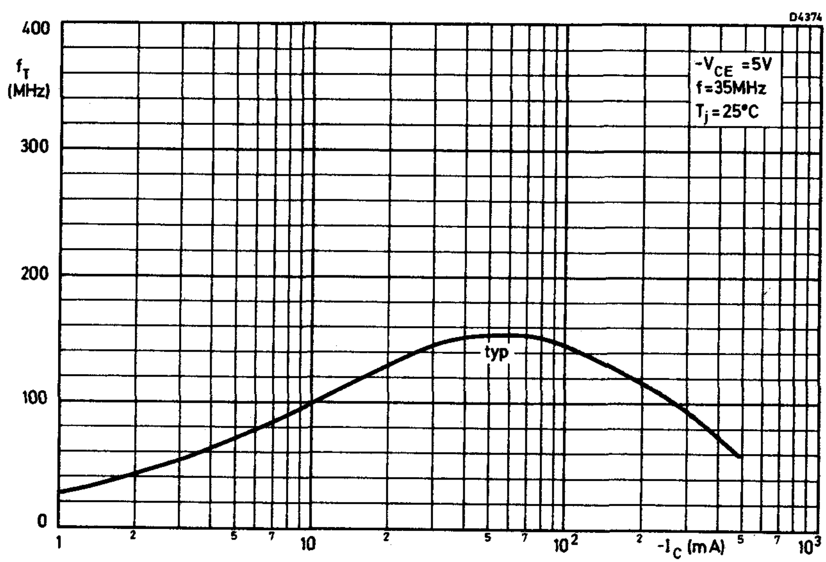

D5097
$-V_{CE}$ = 1V
T_j = 25°C
$-I_C$ (mA)
600
400
200
0
min V_{BE}
typ
max
0.25
0.75
$-V_{BE}$ (V)
1.25


D5098
$-V_{CE}$ = 5V
T_j = 25°C
$-I_C$ (mA)
15
10
5
0
min V_{BE}
typ
max
0
0.5
$-V_{BE}$ (V)
1


D5099
$-V_{CE(sat)}$ (V)
2
1.5
1
0.5
0
I_C / I_B = 10
T_j = 25°C
max
typ
1
2
5
7
10
2
5
7
10^2
$-I_C$ (mA)

Mullard

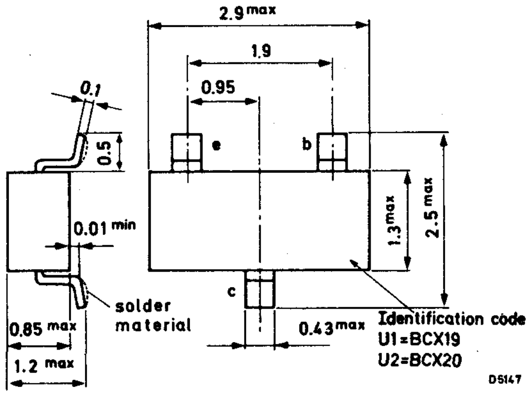

D5100
$-V_{CE}$ = 1V
T_j = 25°C
h_{FE}
300
200
100
0
typ
1
2
5
7
10
2
5
7
10^2
2
$-I_C$(mA)
5
7
10^3


D4374
$-V_{CE}$ = 5V
f = 35MHz
T_j = 25°C
f_T (MHz)
400
300
200
100
0
typ
1
2
5
7
10
2
5
7
10^2
2
$-I_C$ (mA)
5
7
10^3

OUTLINE AND DIMENSIONS

All dimensions in millimetres

Plan view from above



RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

	BCX19	BCX20	
V_{CES} max.	50	30	V
V_{CEO} max. (I_C = 10mA)	45	25	V
V_{EBO} max.	5.0	5.0	V
I_C max.	500		mA
I_{CM} max.	1000		mA
$-I_{EM}$ max.	1000		mA
I_B max.	100		mA
I_{BM} max.	200		mA
P_{tot} max., $T_{amb} \leq 25^oC$, mounted on a ceramic substrate of 15 × 15 × 0.5mm	310		mW

Temperature

T_{stg}	-65 to +150	^oC
T_j max.	150	^oC

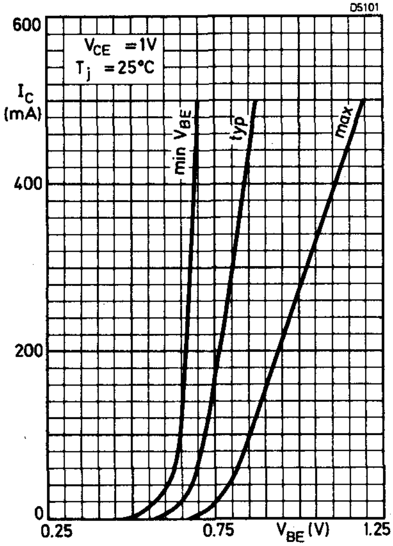
THERMAL CHARACTERISTIC

$R_{th(j\text{-}amb)}$	Thermal resistance between junction and ambient, the device mounted on a ceramic substrate of 15 × 15 × 0.5mm	0.4	$^oC/mW$

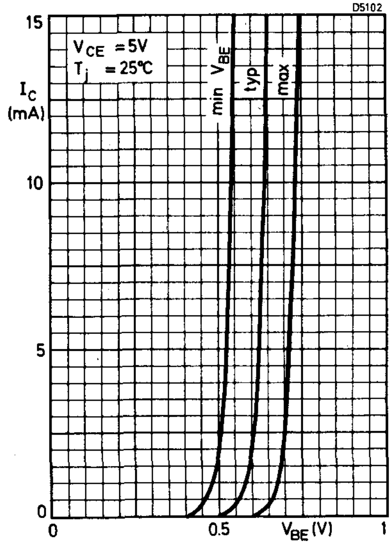
ELECTRICAL CHARACTERISTICS (T_j = 25°C unless otherwise stated)

		Min.	Typ.	Max.	
I_{CBO}	Collector cut-off current				
	$I_E = 0$, $V_{CB} = 20V$	-	-	100	nA
	$I_E = 0$, $V_{CB} = 20V$, $T_j = 150°C$	-	-	5.0	μA
I_{EBO}	Emitter cut-off current				
	$I_C = 0$, $V_{EB} = 5.0V$	-	-	10	μA
V_{BE}	*Base emitter voltage				
	$I_C = 500mA$, $V_{CE} = 1.0V$	-	-	1.2	V
$V_{CE(sat)}$	Collector-emitter saturation voltage				
	$I_C = 500mA$, $I_B = 50mA$	-	-	620	mV
h_{FE}	Static forward current transfer ratio				
	$I_C = 100mA$, $V_{CE} = 1.0V$	100	-	600	
	$I_C = 300mA$, $V_{CE} = 1.0V$	70	-	-	
	$I_C = 500mA$, $V_{CE} = 1.0V$	40	-	-	
f_T	Transition frequency				
	$I_C = 10mA$, $V_{CE} = 5.0V$, $f = 35MHz$	-	200	-	MHz
C_{Tc}	Collector capacitance				
	$I_E = I_e = 0$, $V_{CB} = 10V$, $f = 1.0MHz$	-	5.0	-	pF

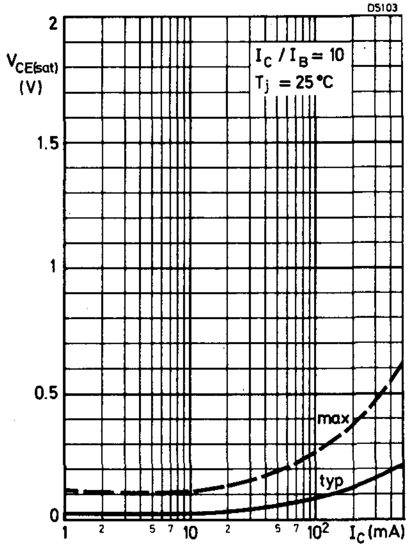
*V_{BE} decreases by about 2mV/°C with increasing temperature.



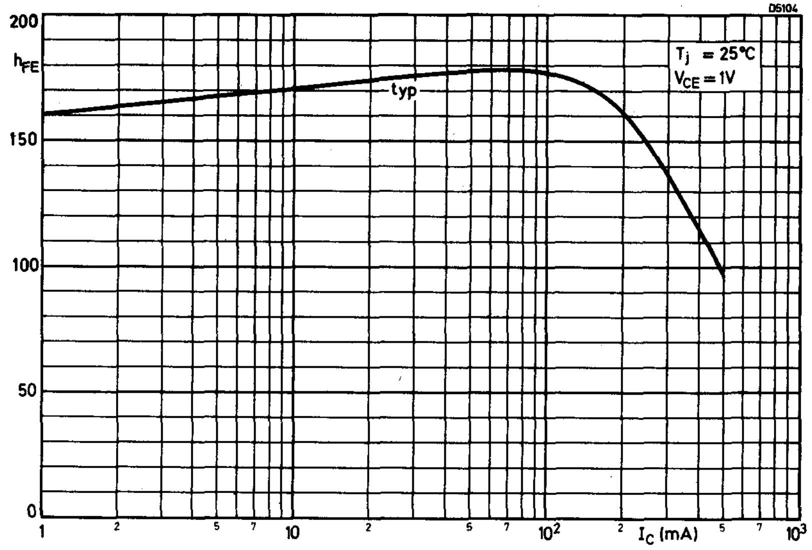
D5101
600
400
200
0
I_C (mA)
V_{CE} = 1V
T_j = 25°C
min V_{BE}
typ
max
0.25
0.75
V_{BE} (V)
1.25

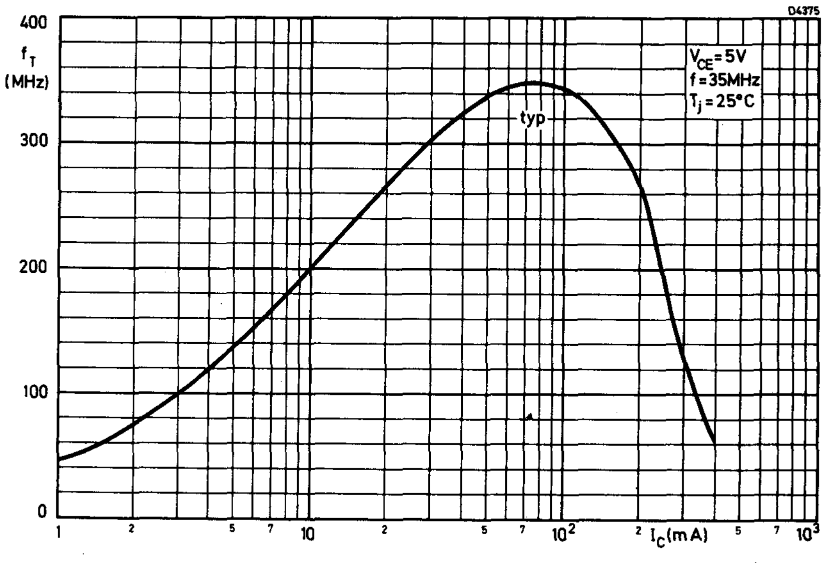


D5102
15
10
5
0
I_C (mA)
V_{CE} = 5V
T_j = 25°C
min V_{BE}
typ
max
0
0.5
V_{BE} (V)
1



D5103
2
1.5
1
0.5
0
$V_{CE(sat)}$ (V)
I_C / I_B = 10
T_j = 25 °C
max
typ
1
2
5
7
10
2
5
7
10^2
I_C (mA)


D5104
200
h_{FE}
150
100
50
0
T_j = 25°C
V_{CE} = 1V
typ
1
2
5
7
10
2
5
7
10^2
2
I_C (mA)
5
7
10^3


D4375
400
f_T
(MHz)
300
200
100
0
V_{CE} = 5V
f = 35MHz
T_j = 25°C
typ
1
2
5
7
10
2
5
7
10^2
2
I_C(mA)
5
7
10^3

N-P-N SILICON PLANAR DARLINGTON TRANSISTOR

BCX21

TENTATIVE DATA

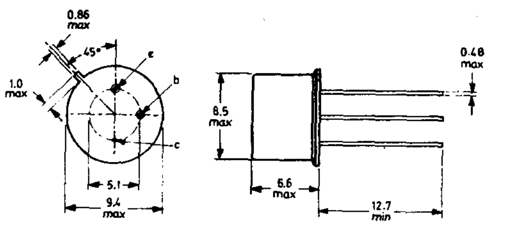
Silicon n-p-n planar Darlington transistor for industrial high gain linear applications. Encapsulated in the TO-39 envelope with the collector connected to the can.

QUICK REFERENCE DATA		
V_{CBO} max.	60	V
V_{CE} max.	45	V
I_C max.	1.0	A
P_{tot} max. ($T_{amb} \leq 25^oC$)	0.55	W
P_{tot} max. ($T_{case} \leq 25^oC$)	3.5	W
h_{FE} min. ($I_C = 150mA$, $V_{CE} = 10V$)	2000	
$V_{CE(sat)}$ max. ($I_C = 1.0A$, $I_B = 1.0mA$)	1.6	V
t_{off} typ. ($I_C = 500mA$, $I_{B(on)} = -I_{B(off)} = 0.5mA$)	700	ns

OUTLINE AND DIMENSIONS

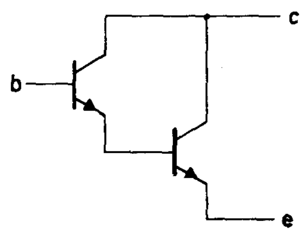
Conforms to B.S. 3934 SO-3/SB3-3B

J.E.D.E.C. TO-39



All dimensions in mm

D1574



D4810

Collector connected to case

Max. lead diameter is only guaranteed for 12.7mm from the can.

Accessories available: - 56218, 56245, 56265

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

V_{CBO} max.	60	V
V_{CE} max. (See note below)	45	V
V_{EBO} max.	10	V
I_C max.	1.0	A
I_B max.	0.1	A
P_{tot} max. ($T_{amb} \leq 25^{o}C$)	0.55	W
P_{tot} max. ($T_{case} \leq 25^{o}C$)	3.5	W

Temperature

T_{stg} range	-65 to +150	^{o}C
T_j max.	150	^{o}C

THERMAL CHARACTERISTICS

$R_{th(j-amb)}$	220	$^{o}C/W$
$R_{th(j-case)}$	35	$^{o}C/W$

Note: -

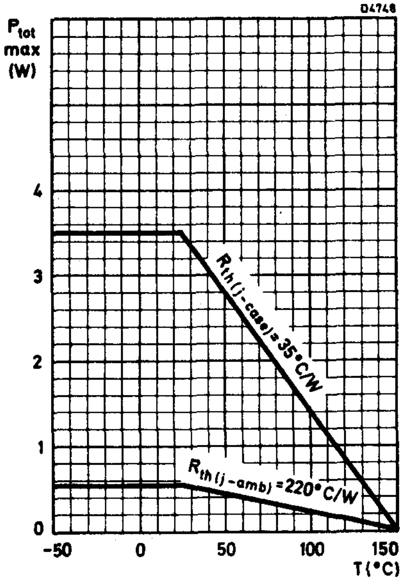
$R_{BE} \leq 39k\Omega$ essential to ensure thermal stability of input stage at T_j max.

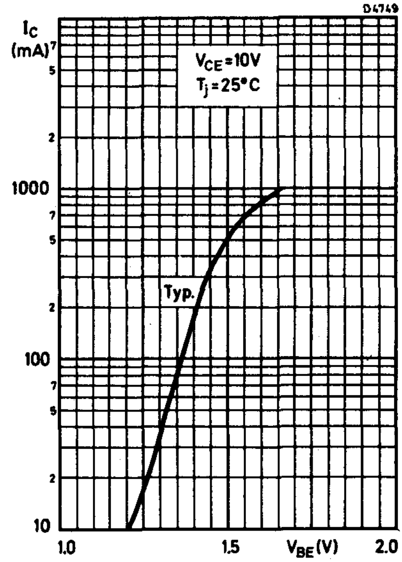
N-P-N SILICON PLANAR DARLINGTON TRANSISTOR

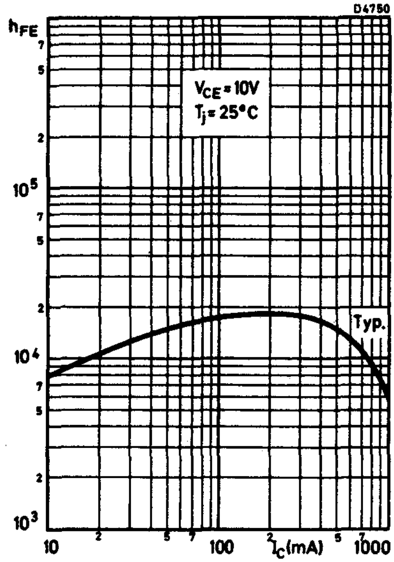
BCX21

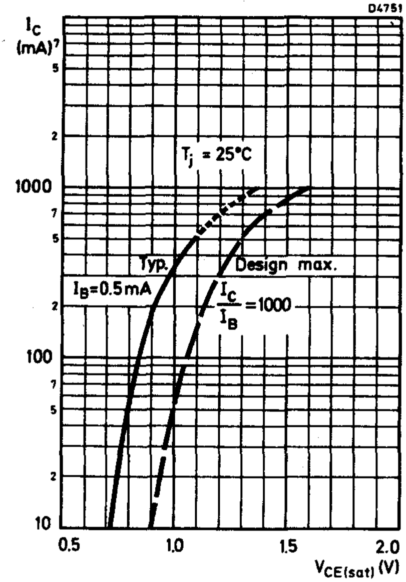
ELECTRICAL CHARACTERISTICS (T_j = 25°C unless otherwise stated)

		Min.	Typ.	Max.	
I_{CBO}	Collector cut-off current V_{CB} = 45V, I_E = 0	-	-	50	nA
I_{EBO}	Emitter cut-off current V_{EB} = 4.0V, I_C = 0	-	-	50	nA
h_{FE}	Static forward current transfer ratio				
	I_C = 10mA, V_{CE} = 10V	1500	-	-	
	I_C = 150mA, V_{CE} = 10V	2000	-	-	
	I_C = 500mA, V_{CE} = 10V	1500	-	-	
V_{BE}	Base-emitter voltage I_C = 10mA, V_{CE} = 10V	-	-	1.4	V
$V_{CE(sat)}$	Collector-emitter saturation voltage				
	I_C = 500mA, I_B = 0.5mA	-	-	1.3	V
	I_C = 1.0A, I_B = 1.0mA	-	-	1.6	V
$V_{BE(sat)}$	Base-emitter saturation voltage				
	I_C = 500mA, I_B = 0.5mA	-	-	1.9	V
	I_C = 1.0A, I_B = 1.0mA	-	-	2.2	V
h_{fe}	Small signal forward current transfer ratio I_C = 0.5A, V_{CE} = 5.0V, f = 35MHz	-	10	-	
C_{Tc}	Collector capacitance V_{CB} = 10V, I_E = I_e = 0, f = 1.0MHz	-	10	-	pF
	Switching times I_C = 500mA, $I_{B(on)}$ = $-I_{B(off)}$ = 0.5mA				
t_{on}	Turn-on time	-	-	400	ns
t_{off}	Turn-off time	-	700	1500	ns


D4748
Ptot max (W)
Rth(j-case)=35°C/W
Rth(j-amb)=220°C/W
T(°C)


D4749
IC (mA)
VCE=10V
Tj=25°C
Typ.
VBE(V)


D4750
hFE
VCE=10V
Tj=25°C
Typ.
IC(mA)


D4751
IC (mA)
Tj = 25°C
Typ.
Design max.
IB=0.5mA
IC/IB=1000
VCE(sat) (V)

Mullard

SILICON N-P-N EPITAXIAL PLANAR TRANSISTORS

BCX31 to BCX34

TENTATIVE DATA

Plastic-encapsulated high performance transistors with TO-5 compatible pinning, primarily intended for general purpose industrial applications, but also for audio drivers and audio output.

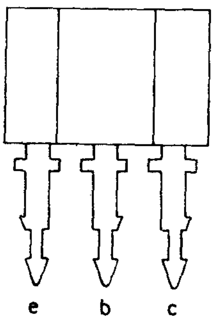
QUICK REFERENCE DATA

		BCX31	BCX32	BCX33	BCX34	
V_{CBO} max.		100	80	60	40	V
V_{CEO} max.		80	60	40	30	V
I_{CM} max.		1.0	2.0	2.0	2.0	A
P_{tot} max. $T_{amb} \leq 25^{o}C$,						
free air				0.73		W
on printed circuit (note 2)				1.0		W
h_{FE} $I_C = 150mA$, $V_{CE} = 10V$						
	min.	30	90	30	90	
	typ.	75	120	75	120	
f_T min. $I_C = 50mA$, $V_{CE} = 10V$,						
f = 35MHz				80		MHz

Data are applicable to all types unless otherwise stated.

OUTLINE AND DIMENSIONS

For details, see page 4



Front View
Scale 3:1

D5542/a

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical		BCX31	BCX32	BCX33	BCX34	
V_{CBO}	max.	100	80	60	40	V
V_{CEO}	max.	80	60	40	30	V
V_{EBO}	max.	6.0	6.0	6.0	6.0	V
I_C	max.	0.5	1.0	1.0	1.0	A
I_{CM}	max.	1.0	2.0	2.0	2.0	A
$-I_E$	max.	0.5	1.0	1.0	1.0	A
$-I_{EM}$	max.	1.0	2.0	2.0	2.0	A

I_B	max.	100	mA
$\pm I_{BM}$	max.	200	mA
P_{tot}	max., $T_{amb} \leq 25^{o}C$		
	1. Free air	0.73	W
	2. Mounted on typical printed circuit (Note 1)	0.83	W
	3. On printed circuit (Note 2)	1.0	W
	4. As in 3. but with $6cm^2$ heatsink attached to the body of the transistor	1.4	W
	5. Infinite heatsink case and leads	2.2	W

Temperature

T_{stg}	-65 to +150	^{o}C
T_j max.	150	^{o}C

THERMAL CHARACTERISTICS

$R_{th(j\text{-}amb)}$ in free air	170	$^{o}C/W$

NOTES

1. Printed circuit board with 1.5mm copper track.
2. Printed circuit board with collector mounting pad area 1.0 × 1.0cm (min.)

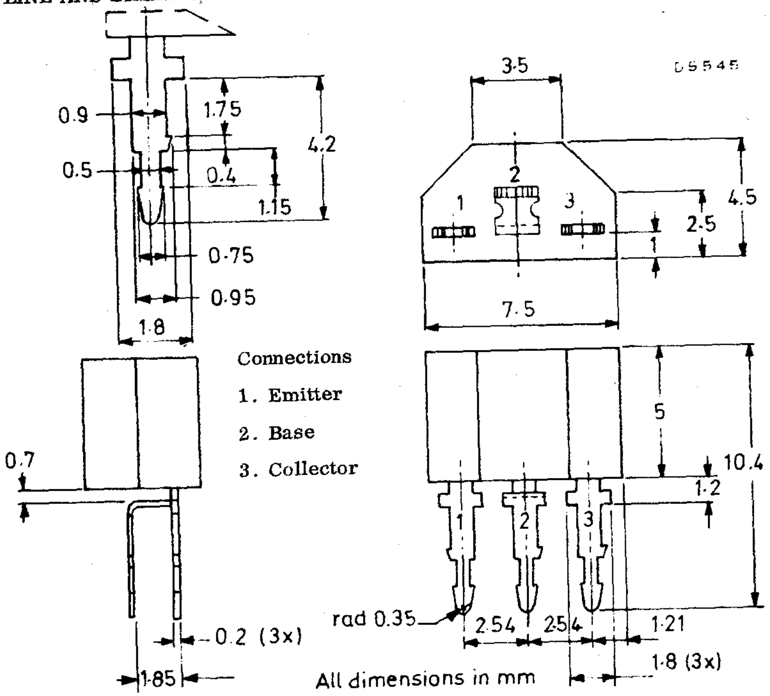
SILICON N-P-N EPITAXIAL PLANAR TRANSISTORS

BCX31 to BCX34

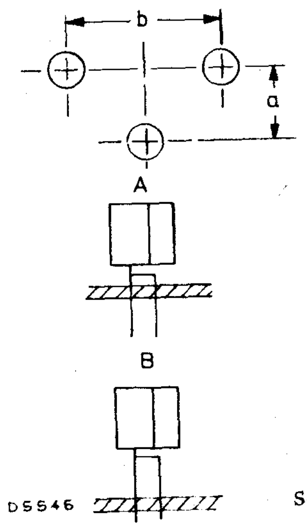
ELECTRICAL CHARACTERISTICS (T_j = 25°C unless otherwise stated)

			Min.	Typ.	Max.	
I_{CBO}	Collector cut-off current					
	$I_E = 0$, $V_{CB} = 80V$	BCX31	-	10	100	nA
	$I_E = 0$, $V_{CB} = 60V$	BCX32	-	10	100	nA
	$I_E = 0$, $V_{CB} = 40V$	BCX33	-	10	100	nA
	$I_E = 0$, $V_{CB} = 30V$	BCX34	-	10	100	nA
	$I_E = 0$, $V_{CB} = 80V$, $T_j = 100°C$	BCX31	-	-	5.0	μA
	$I_E = 0$, $V_{CB} = 60V$, $T_j = 100°C$	BCX32	-	-	5.0	μA
	$I_E = 0$, $V_{CB} = 40V$, $T_j = 100°C$	BCX33	-	-	5.0	μA
	$I_E = 0$, $V_{CB} = 30V$, $T_j = 100°C$	BCX34	-	-	5.0	μA
I_{EBO}	Emitter cut-off current					
	$I_C = 0$, $V_{EB} = 5V$		-	10	100	nA
h_{FE}	Static forward current transfer ratio					
	$I_C = 10mA$, $V_{CE} = 10V$	BCX31, BCX33	30	75	-	
		BCX32, BCX34	90	120	-	
	$I_C = 150mA$, $V_{CE} = 10V$	BCX31, BCX33	30	75		
		BCX32, BCX34	90	120	-	
	$I_C = 0.5A$, $V_{CE} = 10V$	BCX31, BCX33	20	40	-	
		BCX32, BCX34	35	50	-	
	$I_C = 1.0A$, $V_{CE} = 10V$	BCX32, BCX34	15	20	-	
		BCX33	15	20		
$V_{CE(sat)}$	Collector saturation voltage					
	$I_C = 150mA$, $I_B = 15mA$		-	125	350	mV
	$I_C = 0.5A$, $I_B = 50mA$		-	350	800	mV
	$I_C = 1.0A$, $I_B = 100mA$	BCX32, 33, 34	-	660	1600	mV
$V_{BE(sat)}$	Base-emitter saturation voltage					
	$I_C = 0.5A$, $I_B = 50mA$		-	1.15	1.5	V
	$I_C = 1.0A$, $I_B = 100mA$	BCX32, 33, 34	-	1.4	2.0	V
C_{Tc}	Collector capacitance					
	$I_E = I_e = 0$, $V_{CB} = 10V$, f = 1.0MHz		-	-	12	pF
f_T	Transition frequency					
	$I_C = 50mA$, $V_{CE} = 10V$, f = 35MHz		80	-	-	MHz

OUTLINE AND DIMENSIONS



Mounting details



a = 2.49 to 2.59mm

b = 5.03 to 5.13mm

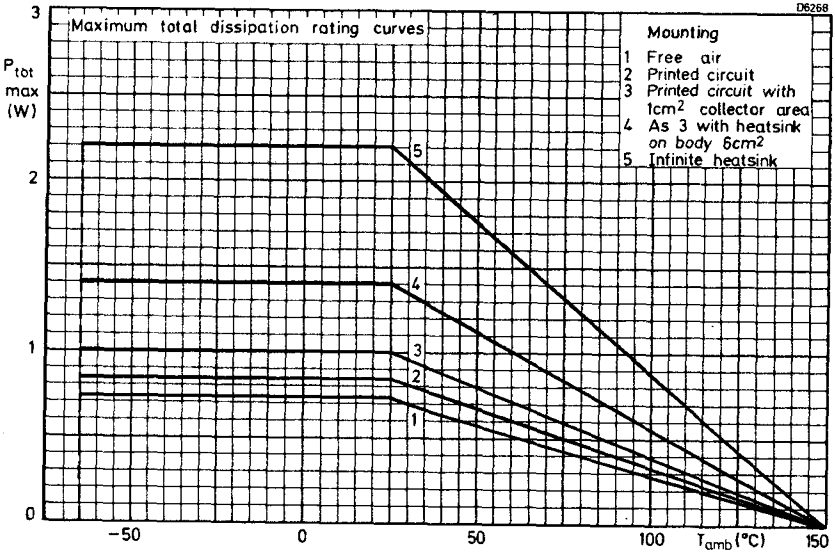
Maximum thickness of printed board = 1.7mm

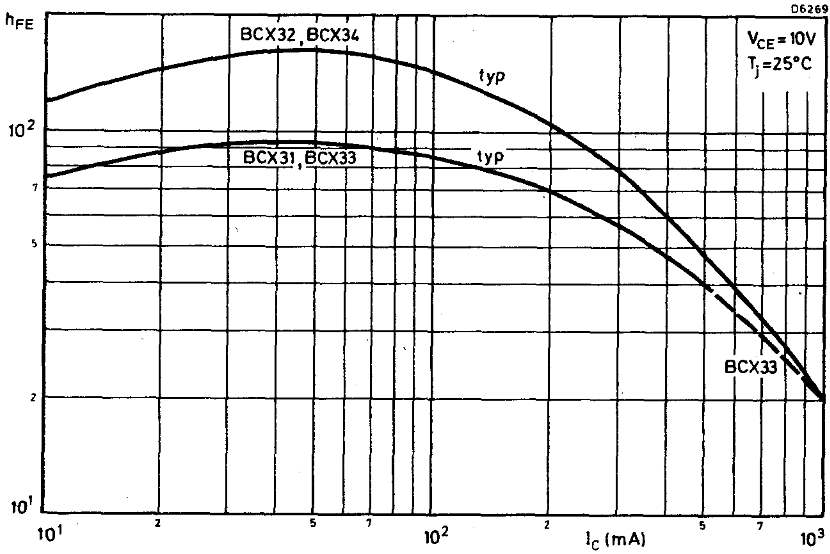
Recommended hole diameter = 1.0 to 1.1mm (1.0 to 1.3mm allowable)

Maximum thickness of printed board = 1.1mm

Hole diameter = 0.77 to 0.83mm

See also General Explanatory Notes Section IV.


D6268
Maximum total dissipation rating curves
P_{tot} max (W)
3
2
1
0
Mounting
1 Free air
2 Printed circuit
3 Printed circuit with 1cm² collector area
4 As 3 with heatsink on body 6cm²
5 Infinite heatsink
1
2
3
4
5
−50
0
50
100
T_{amb} (°C)
150


D6269
h_{FE}
BCX32, BCX34
typ
BCX31, BCX33
typ
BCX33
V_{CE} = 10V
T_j = 25°C
10^2
7
5
2
10^1
10^1
2
5
7
10^2
2
I_C (mA)
5
7
10^3

ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise stated)

		Min.	*Typ.*	*Max.*	
I_{CBO}	Collector cut-off current				
	$V_{CB} = -6V$, $I_E = 0$	—	1.0	50*	nA
	$V_{CB} = -6V$, $I_E = 0$, $T_{amb} = 100°C$	—	0.1	2.5	μA
I_{EBO}	Emitter cut-off current				
	$V_{EB} = -6V$, $I_C = 0$	—	1.0	50*	nA
	$V_{EB} = -6V$, $I_C = 0$, $T_{amb} = 100°C$	—	0.1	2.5	μA
$V_{CE(sat)}$	Collector-emitter saturation voltage				
	$I_C = 250\mu A$, $I_B = 50\mu A$	—	−55	−170	mV
	$I_C = 20mA$, $I_B = 3mA$	—	−130	−550*	mV
h_{fe}	Small signal forward current transfer ratio				
	$V_{CE} = -6V$, $I_C = 1mA$, $f = 1kc/s$	25*	35	60*	
f_T	Transition frequency				
	$V_{CE} = -6V$, $I_C = 1mA$	0.25*	1.7	—	Mc/s
h_{FE}	Large signal forward current transfer ratio				
	$V_{CE} = -4.5V$, $I_C = 20mA$	15	28	60	
V_{BE}	Base-emitter voltage				
	$V_{CE} = -4.5V$, $I_C = 20mA$	—	−0.80	−1.45	V
NF	Noise figure				
	$V_{CE} = -2V$, $I_E = 500\mu A$, $f = 1kc/s$, $R_s = 500\Omega$	—	8.0	20	dB
†r_e	$V_{CE} = -6V$, $I_C = 1mA$	—	25	—	Ω
$r_{bb'}$	$V_{CE} = -6V$, $I_C = 1mA$, $f = 500kc/s$	100	220	500	Ω
c_{tc}	$V_{CB} = -6V$, $I_E = 0$, $f = 500kc/s$	15	28	60	pF

h-parameters

$V_{CE} = -6.0V$, $I_C = 1.0mA$, $\omega = 10^4$ radians

Common emitter

h_{ie}	Input impedance	—	1.4	—	kΩ
h_{re}	Voltage feedback ratio	—	6.0	—	$\times 10^{-4}$
h_{oe}	Output admittance	—	25	—	μmho

†The value of r_e given here is $\frac{kT}{q} \cdot \frac{1}{I_E} \approx \frac{25}{I_E}$, where I_E is in mA and T is in °K.

*These are the characteristics which are recommended for acceptance testing purposes.

SILICON P-N-P TRANSISTORS

BCY30 Series

BCY32

ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise stated)

		Min.	*Typ.*	*Max.*	
I_{CBO}	Collector cut-off current				
	$V_{CB} = -6V$, $I_E = 0$	—	1.0	50*	nA
	$V_{CB} = -6V$, $I_E = 0$, $T_{amb} = 100°C$	—	0.1	2.5	μA
I_{EBO}	Emitter cut-off current				
	$V_{EB} = -6V$, $I_C = 0$	—	1.0	50*	nA
	$V_{EB} = -6V$, $I_C = 0$, $T_{amb} = 100°C$	—	0.1	2.5	μA
$V_{CE(sat)}$	Collector-emitter saturation voltage				
	$I_C = 250\mu A$, $I_B = 50\mu A$	—	-55	-170	mV
	$I_C = 20mA$, $I_B = 3mA$	—	-120	-550*	mV
h_{fe}	Small signal forward current transfer ratio				
	$V_{CE} = -6V$, $I_C = 1mA$, $f = 1kc/s$	35*	55	80*	
f_T	Transition frequency				
	$V_{CE} = -6V$, $I_C = 1mA$	250*	2.5	—	Mc/s
h_{FE}	Large signal forward current transfer ratio				
	$V_{CE} = -4.5V$, $I_C = 20mA$	20	35	70	
V_{BE}	Base-emitter voltage				
	$V_{CE} = -4.5V$, $I_C = 20mA$	—	-0.80	-1.45	V
NF	Noise figure				
	$V_{CE} = -2V$, $I_E = 500\mu A$, $f = 1kc/s$, $R_s = 500\Omega$	—	8.0	20	dB
†r_e	$V_{CE} = -6V$, $I_C = 1mA$	—	25	—	Ω
$r_{bb'}$	$V_{CE} = -6V$, $I_C = 1mA$, $f = 500kc/s$	110	230	500	Ω
c_{tc}	$V_{CB} = -6V$, $I_E = 0$, $f = 500kc/s$	15	28	60	pF

h-parameters

$V_{CE} = -6.0V$, $I_C = 1.0mA$, $\omega = 10^4$ radians

Common emitter

h_{ie}	Input impedance	—	1.7	—	kΩ
h_{re}	Voltage feedback ratio	—	5.0	—	$\times 10^{-4}$
h_{oe}	Output admittance	—	30	—	μmho

†The value of r_e given here is $\frac{kT}{q} \cdot \frac{1}{I_E} \approx \frac{25}{I_E}$, where I_E is in mA and T is in °K.

*These are the characteristics which are recommended for acceptance testing purposes.

ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise stated)

		Min.	Typ.	Max.	
I_{CBO}	Collector cut-off current				
	$V_{CB} = -6V$, $I_E = 0$	—	1.0	50*	nA
	$V_{CB} = -6V$, $I_E = 0$, $T_{amb} = 100°C$	—	0.1	2.5	μA
I_{EBO}	Emitter cut-off current				
	$V_{EB} = -6V$, $I_C = 0$	—	1.0	50*	nA
	$V_{EB} = -6V$, $I_C = 0$, $T_{amb} = 100°C$	—	0.1	2.5	μA
$V_{CE(sat)}$	Collector-emitter saturation voltage				
	$I_C = 250\mu A$, $I_B = 50\mu A$	—	−55	−170	mV
	$I_C = 20mA$, $I_B = 3mA$	—	−160	−550*	mV
h_{fe}	Small signal forward current transfer ratio				
	$V_{CE} = -6V$, $I_C = 1mA$, f = 1kc/s	15*	25	35*	
f_T	Transition frequency				
	$V_{CE} = -6V$, $I_C = 1mA$	0.4*	1.5	—	Mc/s
h_{FE}	Large signal forward current transfer ratio				
	$V_{CE} = -4.5V$, $I_C = 20mA$	10	18	35	
V_{BE}	Base-emitter voltage				
	$V_{CE} = -4.5V$, $I_C = 20mA$	—	−0.85	−1.45	V
NF	Noise figure				
	$V_{CE} = -2V$, $I_E = 500\mu A$, f = 1kc/s, $R_s = 500\Omega$	—	8.0	20	dB
†r_e	$V_{CE} = -6V$, $I_C = 1mA$	—	25	—	Ω
$r_{bb'}$	$V_{CE} = -6V$, $I_C = 1mA$, f = 500kc/s	60	190	500	Ω
c_{tc}	$V_{CB} = -6V$, $I_E = 0$, f = 500kc/s	15	28	60	pF

h-parameters

$V_{CE} = -6.0V$, $I_C = 1.0mA$, $\omega = 10^4$ radians

Common emitter

		Min.	Typ.	Max.	
h_{ie}	Input impedance	—	1.1	—	kΩ
h_{re}	Voltage feedback ratio	—	3.0	—	$\times 10^{-4}$
h_{oe}	Output admittance	—	17	—	μmho

†The value of r_e given here is $\frac{kT}{q} \cdot \frac{1}{I_E} \approx \frac{25}{I_E}$, where I_E is in mA and T is in °K.

*These are the characteristics which are recommended for acceptance testing purposes.

SILICON P-N-P TRANSISTORS

BCY30 Series

BCY34

ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise stated)

		Min.	Typ.	Max.	
I_{CBO}	Collector cut-off current				
	$V_{CB} = -6V$, $I_E = 0$	—	1.0	50*	nA
	$V_{CB} = -6V$, $I_E = 0$, $T_{amb} = 100°C$	—	0.1	2.5	μA
I_{EBO}	Emitter cut-off current				
	$V_{EB} = -6V$, $I_C = 0$	—	1.0	50*	nA
	$V_{EB} = -6V$, $I_C = 0$, $T_{amb} = 100°C$	—	0.1	2.5	μA
$V_{CE(sat)}$	Collector-emitter saturation voltage				
	$I_C = 250\mu A$, $I_B = 50\mu A$	—	−55	−170	mV
	$I_C = 20mA$, $I_B = 3mA$	—	−130	−550*	mV
h_{fe}	Small signal forward current transfer ratio				
	$V_{CE} = -6V$, $I_C = 1mA$, f = 1kc/s	25*	35	60*	
f_T	Transition frequency				
	$V_{CE} = -6V$, $I_C = 1mA$	0.6*	2.4	—	Mc/s
h_{FE}	Large signal forward current transfer ratio				
	$V_{CE} = -4.5V$, $I_C = 20mA$	15	28	60	
V_{BE}	Base-emitter voltage				
	$V_{CE} = -4.5V$, $I_C = 20mA$	—	−0.80	−1.45	V
NF	Noise figure				
	$V_{CE} = -2V$, $I_E = 500\mu A$, f = 1kc/s, $R_s = 500\Omega$	—	8 0	20	dB
†r_e	$V_{CE} = -6V$, $I_C = 1mA$	—	25	—	Ω
$r_{bb'}$	$V_{CE} = -6V$, $I_C = 1mA$, $f = 500kc/s$	50	235	500	Ω
c_{tc}	$V_{CB} = -6V$, $I_E = 0$, f = 500kc/s	15	28	60	pF

h-parameters

$V_{CE} = -6.0V$, $I_C = 1.0mA$, $\omega = 10^4$ radians

Common emitter

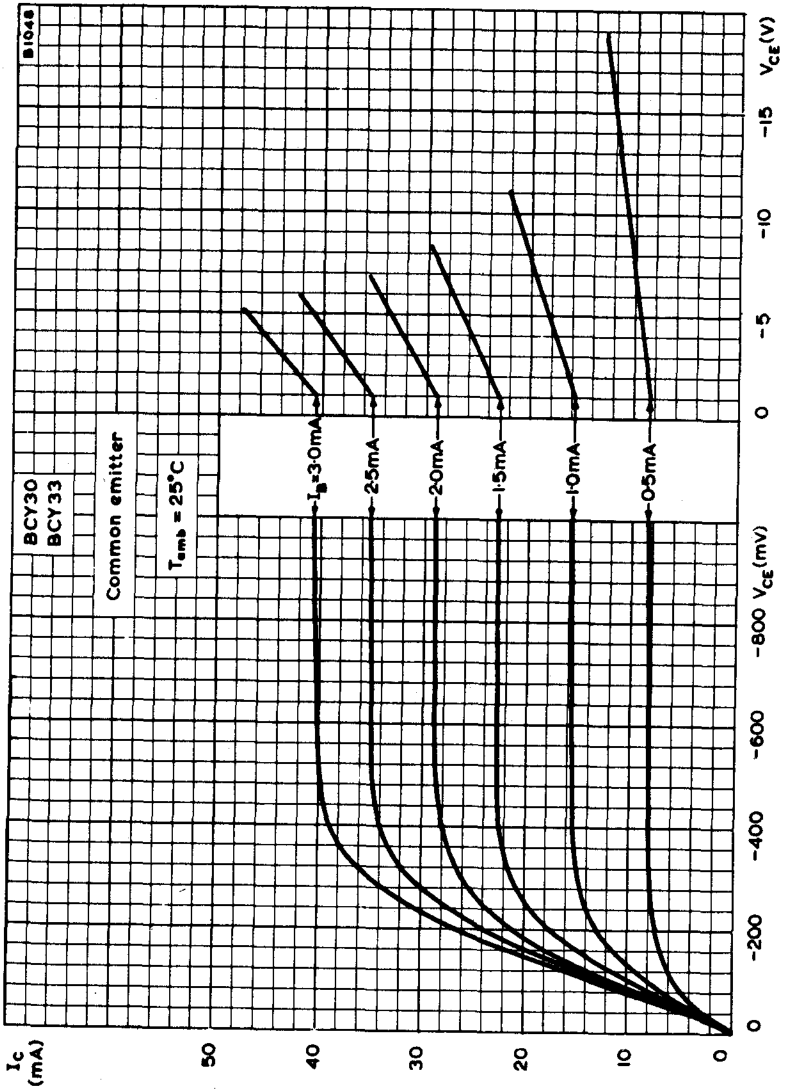
		Min.	Typ.	Max.	
h_{ie}	Input impedance	—	1.4	—	kΩ
h_{re}	Voltage feedback ratio	—	6.0	—	$\times 10^{-4}$
h_{oe}	Output admittance	—	25	—	μmho

†The value of r_e given here is $\frac{kT}{q} \cdot \frac{1}{I_E} \approx \frac{25}{I_E}$, where I_E is in mA and T is in °K.

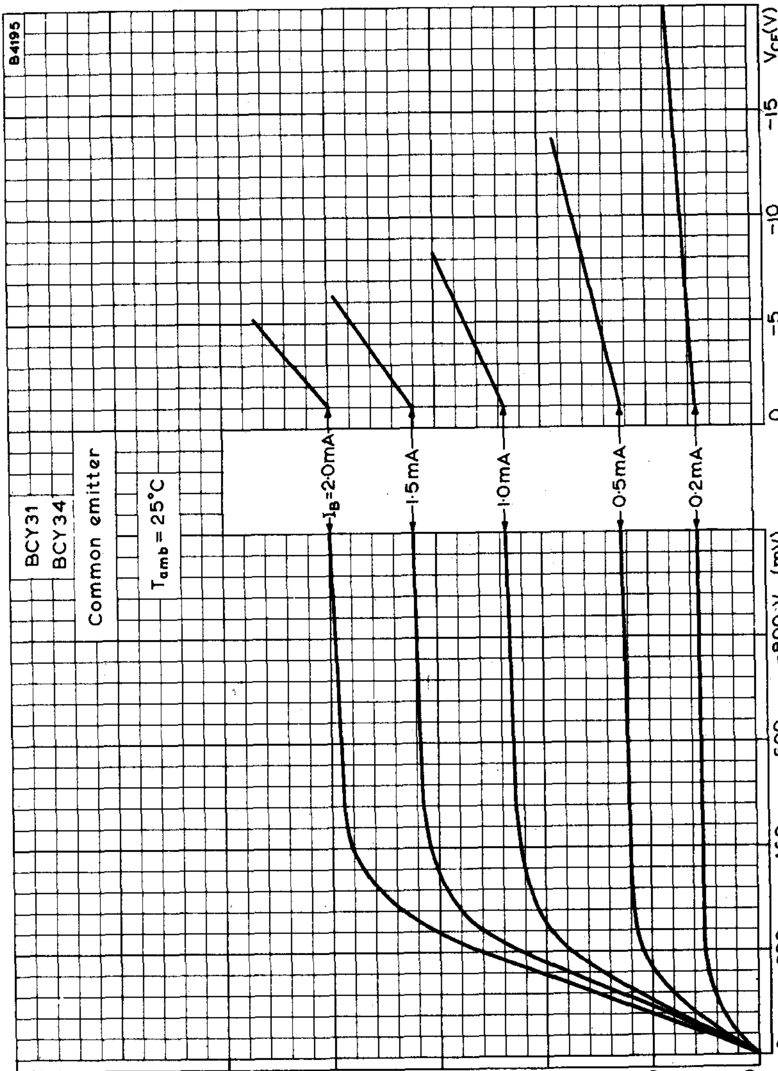
*These are the characteristics which are recommended for acceptance testing purposes.

SOLDERING AND WIRING RECOMMENDATIONS

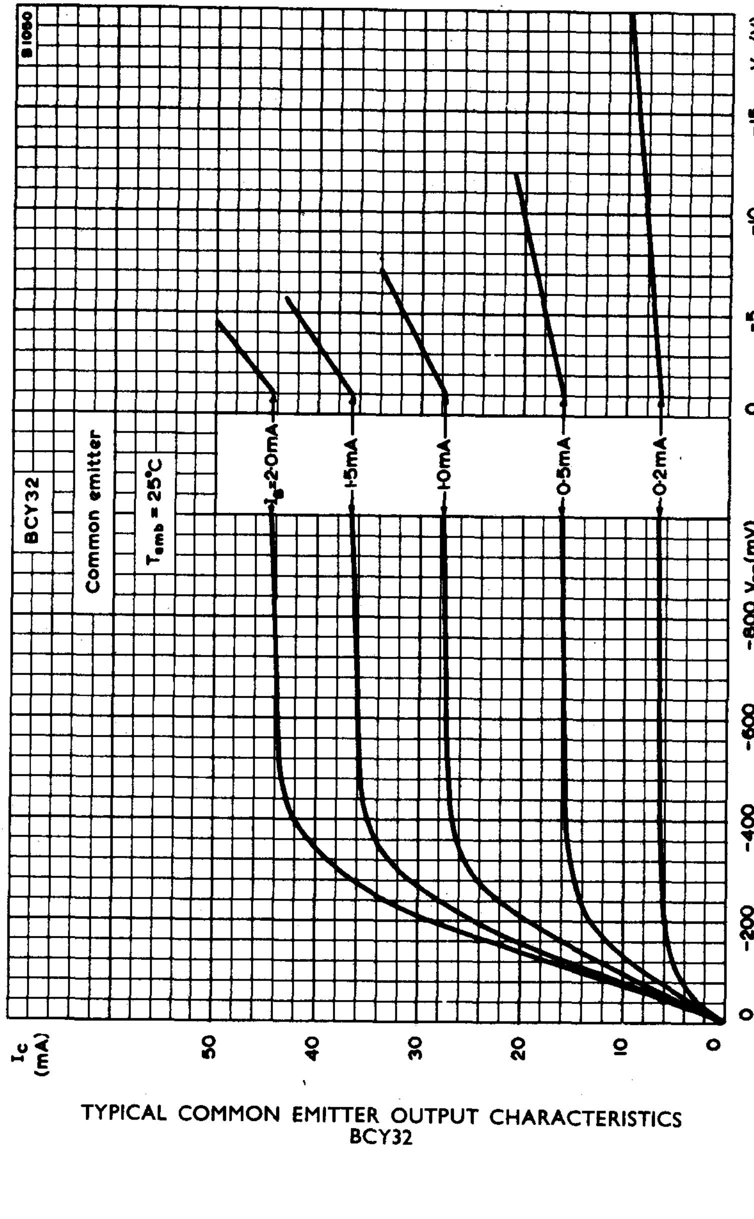
1. When using a soldering iron, transistors may be soldered directly into the circuit, but heat conducted to the junction should if possible be kept to a minimum by the use of a thermal shunt.
2. Transistors may be dip-soldered at a solder temperature of 245°C for a maximum soldering time of 5 seconds. The case temperature during soldering must not at any time exceed the maximum storage temperature. These recommendations apply to a transistor mounted flush on a board having punched-through holes, or spaced at least 1.5mm above a board having plated-through holes.
3. Care should be taken not to bend the leads nearer than 1.5mm from the seal.
4. If devices are stored above 100°C before incorporation into equipment some deterioration of the external surface is likely to occur which may make soldering into the circuit difficult. Under these circumstances the leads should be retinned using a suitable activated flux.



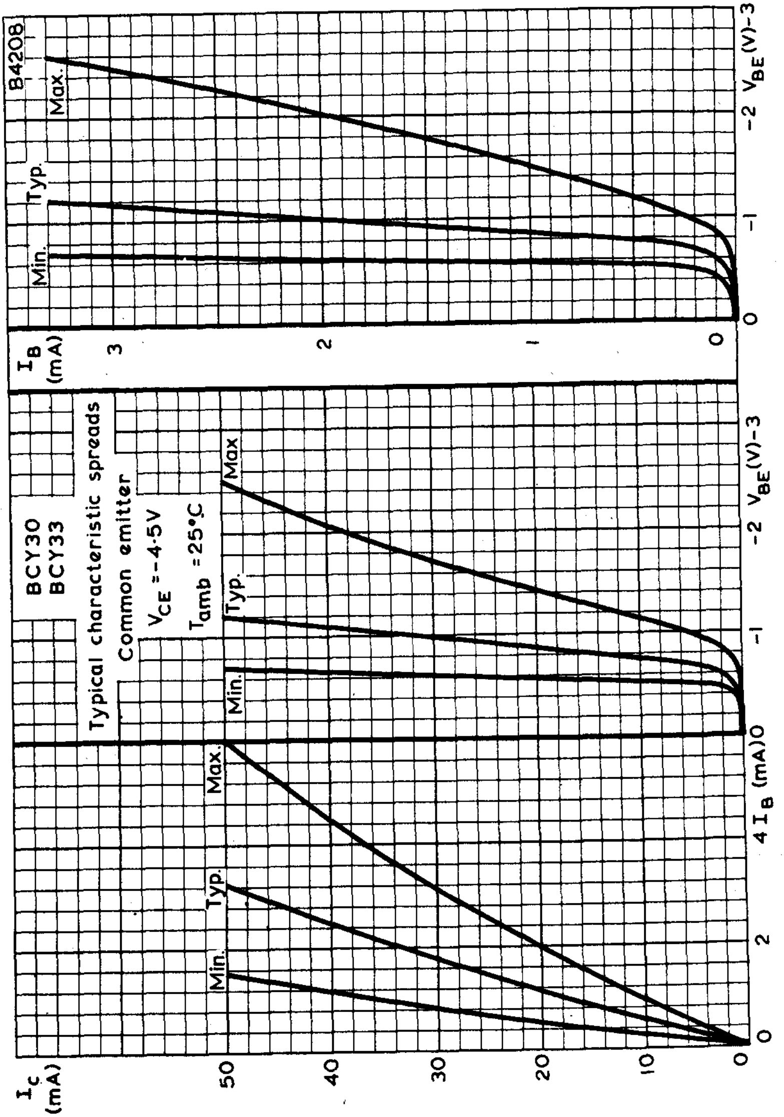
TYPICAL COMMON EMITTER OUTPUT CHARACTERISTICS
BCY30 AND BCY33



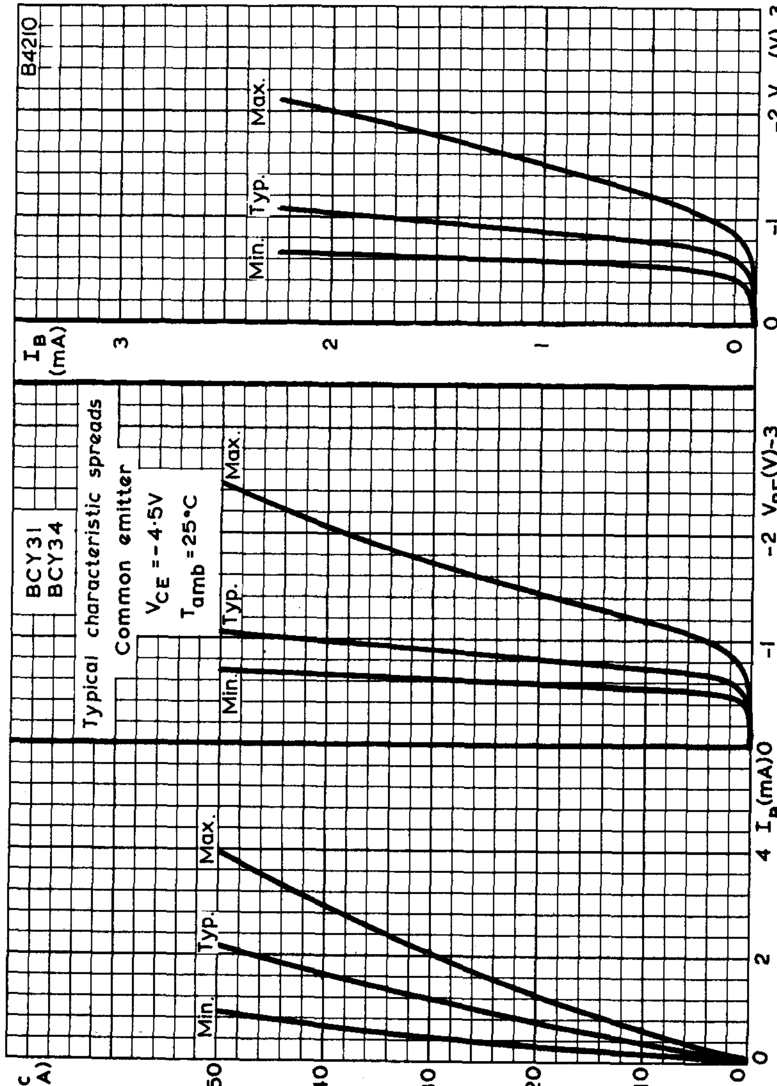
TYPICAL COMMON EMITTER OUTPUT CHARACTERISTICS
BCY31 AND BCY34



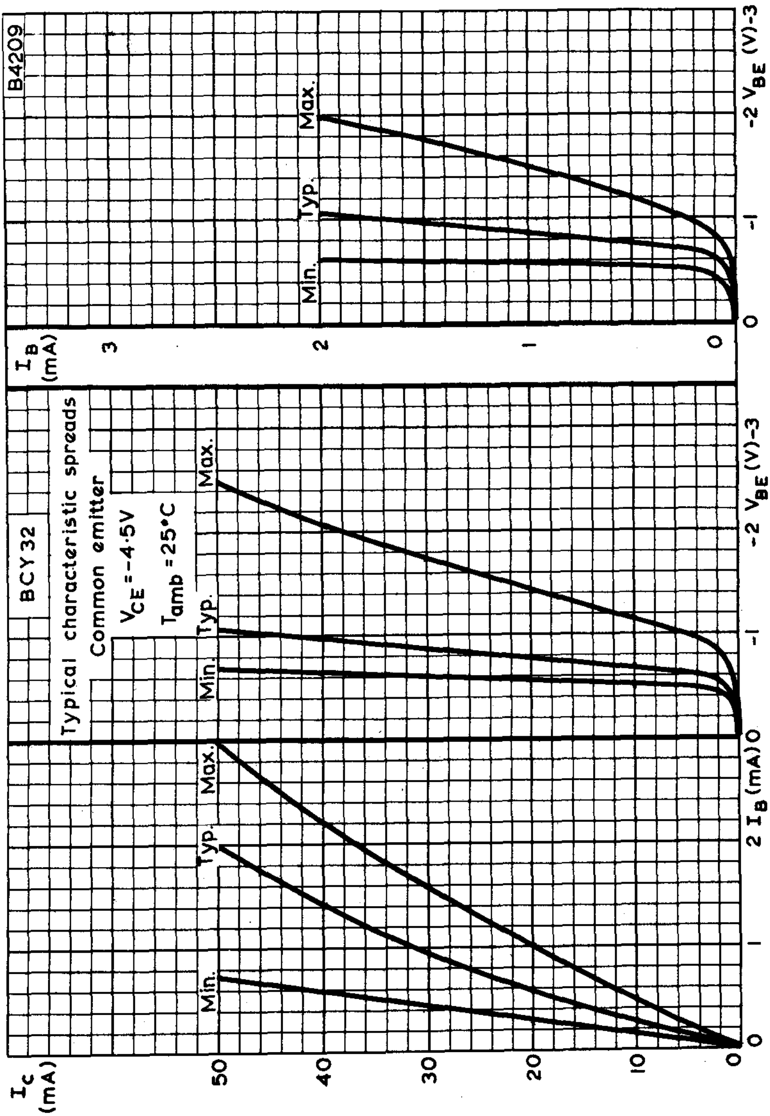
TYPICAL COMMON EMITTER OUTPUT CHARACTERISTICS
BCY32



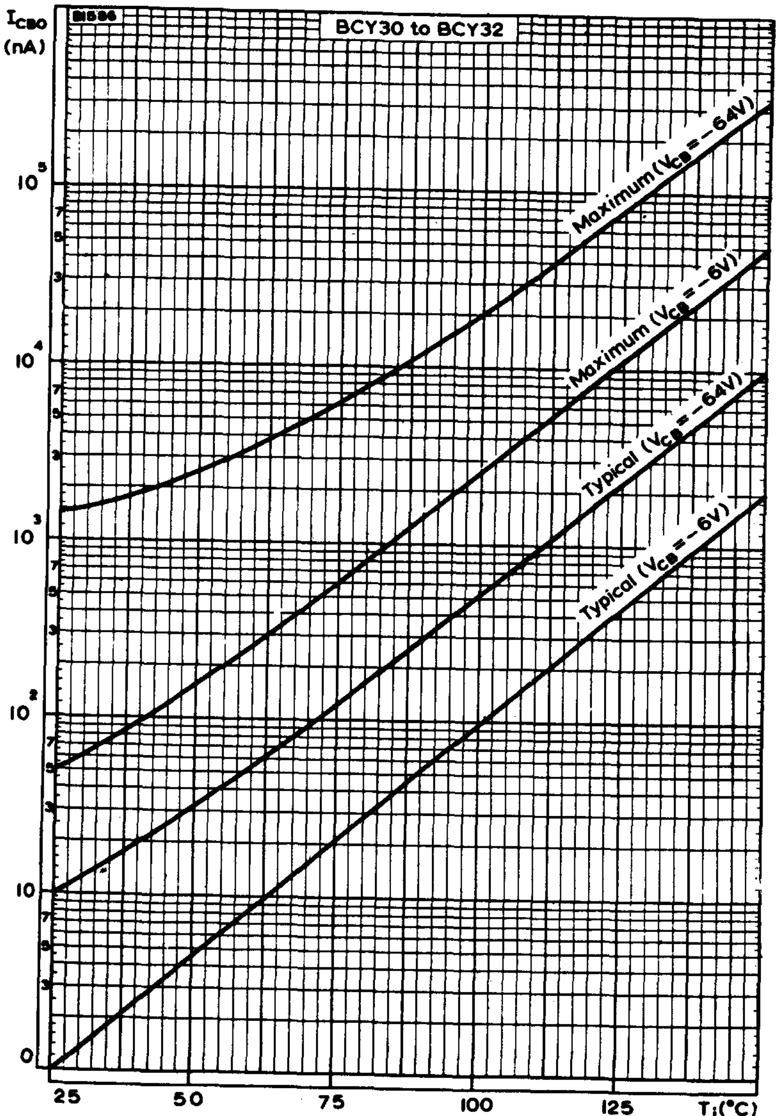
COMMON EMITTER TRANSFER, MUTUAL AND INPUT CHARACTERISTICS. BCY30 AND BCY33



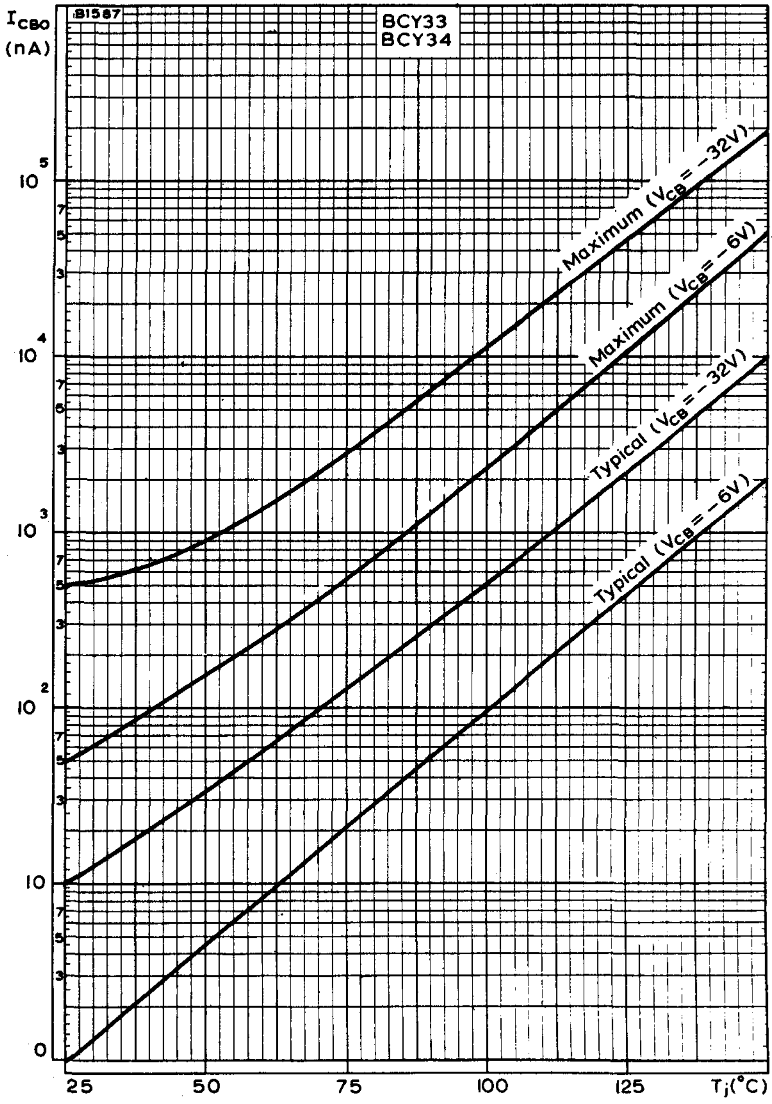
COMMON EMITTER TRANSFER, MUTUAL AND INPUT CHARACTERISTICS. BCY31 AND BCY34



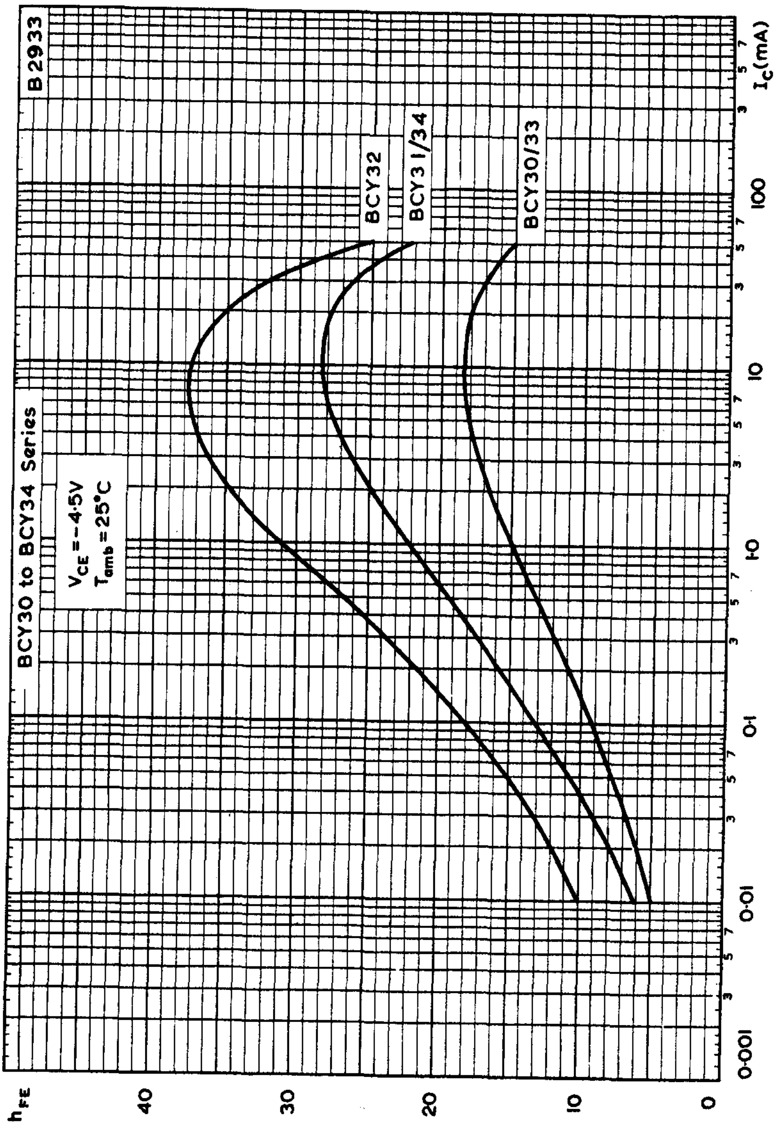
COMMON EMITTER TRANSFER, MUTUAL AND INPUT CHARACTERISTICS. BCY32



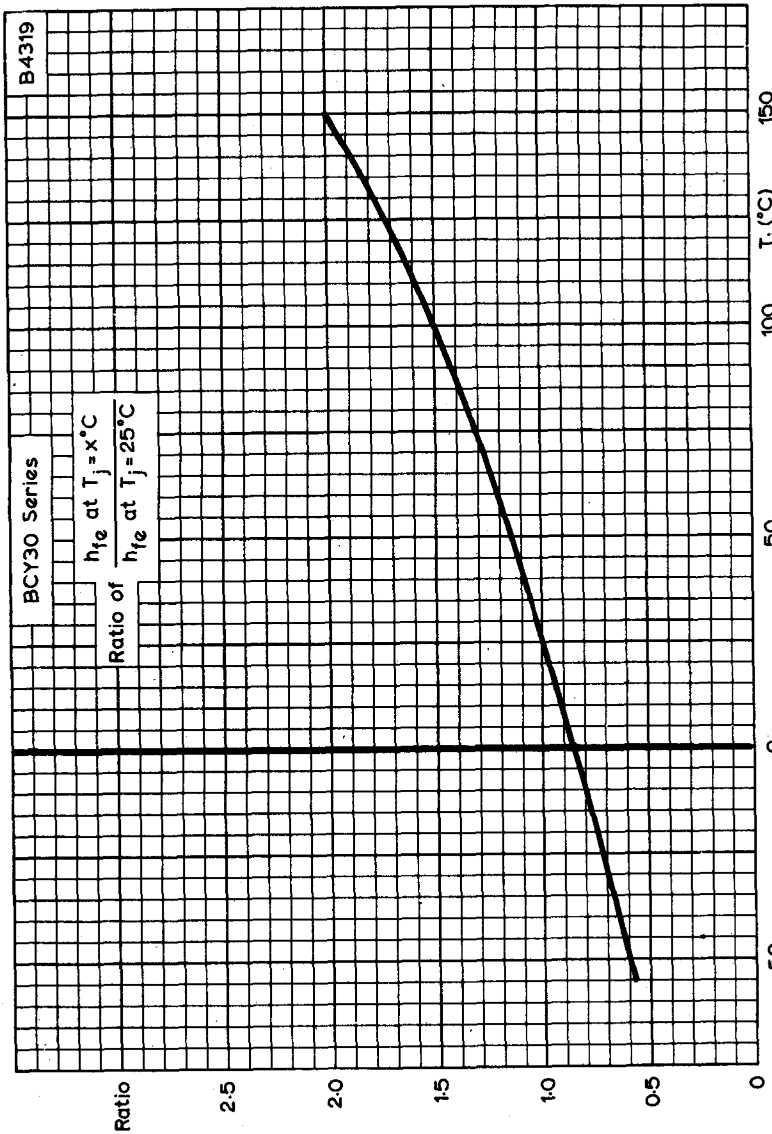
VARIATION OF COLLECTOR CUT-OFF CURRENT WITH JUNCTION TEMPERATURE. BCY30, BCY31 AND BCY32



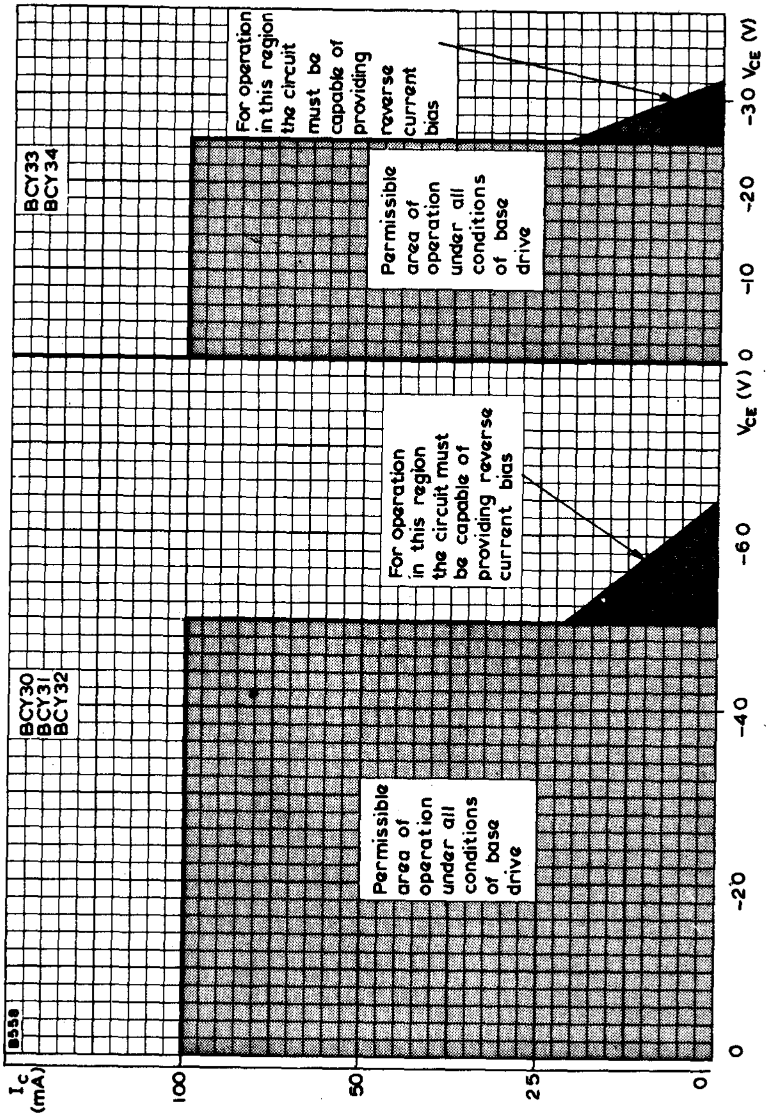
VARIATION OF COLLECTOR CUT-OFF CURRENT WITH JUNCTION TEMPERATURE. BCY33 AND BCY34



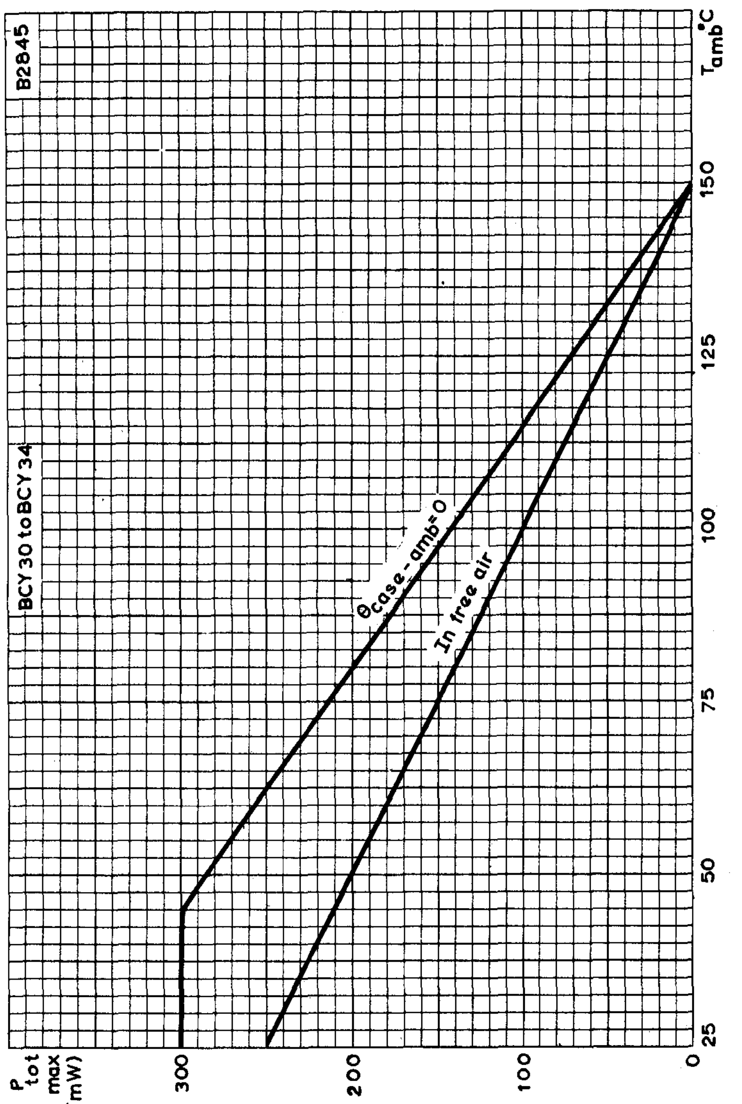
TYPICAL VARIATION OF LARGE SIGNAL FORWARD CURRENT TRANSFER RATIO WITH COLLECTOR CURRENT



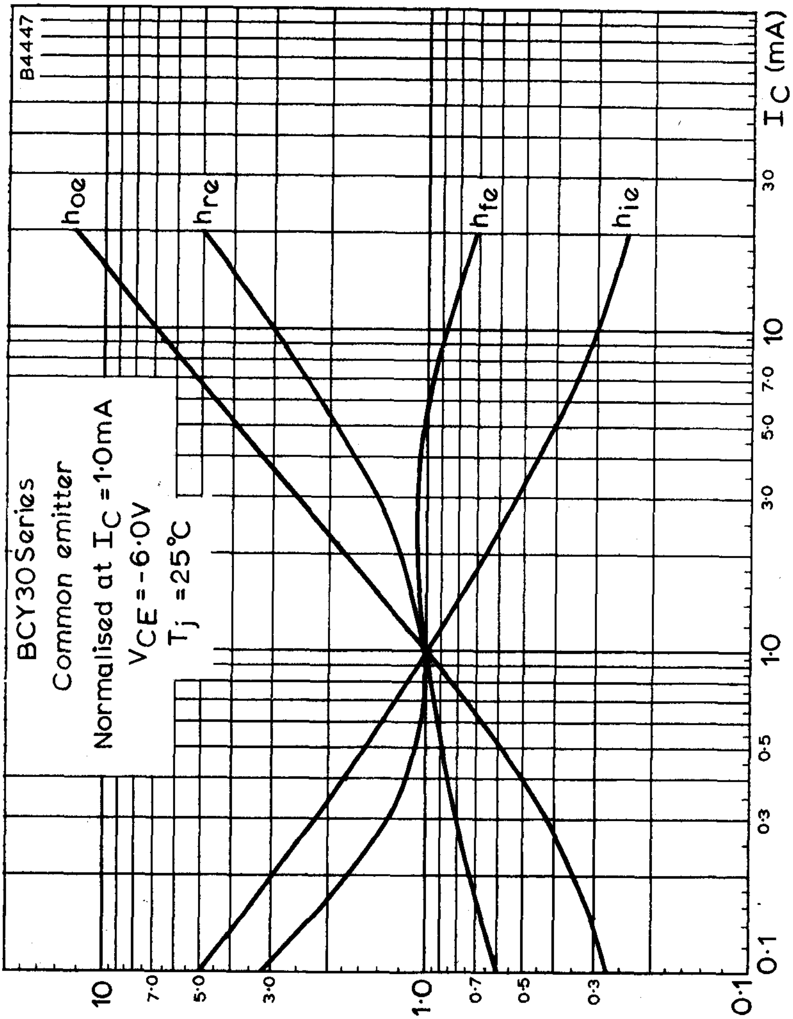
TYPICAL CHARACTERISTIC OF NORMALISED SMALL SIGNAL FORWARD CURRENT TRANSFER RATIO PLOTTED AGAINST JUNCTION TEMPERATURE



COLLECTOR CURRENT PLOTTED AGAINST
MAXIMUM COLLECTOR-EMITTER VOLTAGE



MAXIMUM TOTAL DISSIPATION PLOTTED AGAINST AMBIENT TEMPERATURE



TYPICAL VARIATION OF h PARAMETERS WITH COLLECTOR CURRENT NORMALISED AT I_C = 1.0mA. COMMON EMITTER

SILICON P-N-P JUNCTION TRANSISTORS

BCY38
BCY39
BCY40
BCY54

Silicon p-n-p alloy junction transistors for relay switching, resistor logic circuits and general industrial applications. TO-5 construction. The base of the transistor is connected to the metal envelope.

QUICK REFERENCE DATA

	BCY38	BCY39	BCY40	BCY54	
V_{CB} max. (I_E = 0)	-32	-64	-32	-50	V
V_{CE} max. (cut-off)	-32	-64	-32	-50	V
V_{CE} max. (I_C = 500mA)	-24	-60	-24	-50	V
I_{CM} max.				500	mA
P_{tot} max. (T_{amb} = 25°C)				410	mW
h_{FE} (I_C = 150mA)	10-30	10-50	15-120	12-70	
f_T typ.	1.5	1.5	2.5	2.0	Mc/s

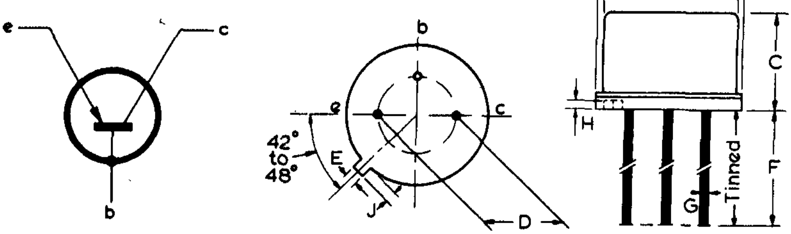
Unless otherwise shown data is applicable to all types in the series

OUTLINE AND DIMENSIONS

Conforming to V.A.S.C.A. SO-3/SB3-3A

J.E.D.E.C. TO-5

B2447



The base of the transistor is connected to the metal envelope

	Millimetres		Millimetres		Millimetres
A	$8.9^{+0.5}_{-0.26}$	D	5.08 nom.	G	0.45 nom.
B	$8.15^{+0.35}_{-0.4}$	E	$0.79^{+0.07}_{-0.08}$	*H	0.4 nom.
C	6.35 ± 0.25	F	38 min.	J	$0.85^{+0.16}_{-0.11}$

*Thickness of locating tab

RATINGS

Limiting values of operation according to the absolute maximum system as defined in publication 134 of the International Electrotechnical Commission.

Electrical

	BCY38	BCY39	BCY40	BCY54	
V_{CB} max. ($I_E = 0$)	-32	-64	-32	-50	V
V_{CE} max. (cut-off)	-32	-64	-32	-50	V
V_{CE} max. ($I_C = 500mA$)	-24	-60	-24	-50	V
V_{EB} max. ($I_C = 0$)				-12	V
I_{CM} max.				500	mA
*$I_{C(AV)}$ max.				250	mA
I_{EM} max.				500	mA
*$I_{E(AV)}$ max.				250	mA
I_{BM} max.				125	mA
*$I_{B(AV)}$ max.				125	mA
P_{tot} max.				410 See page C7	mW

*Averaged over any 20ms period.

Thermal

T_j max.	150	^oC
T_{stg} max.	150	^oC
T_{stg} min.	-55	^oC

THERMAL CHARACTERISTICS

θ_{j-amb} (in free air)	0.3 deg C/mW
θ_{j-case}	0.12deg C/mW

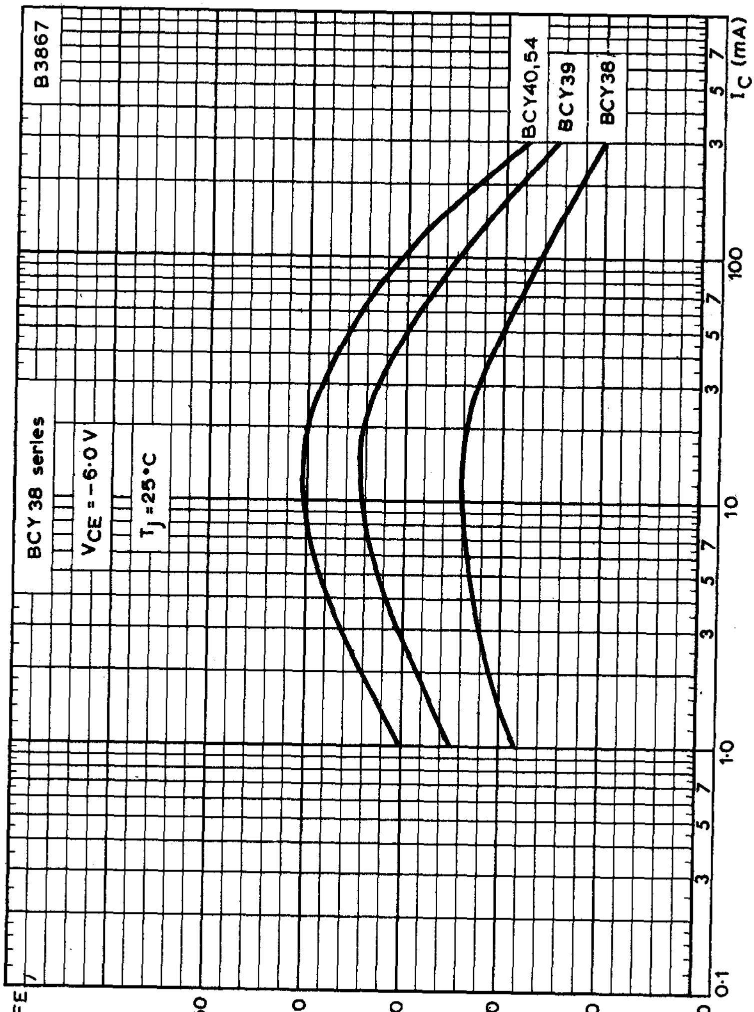
SOLDERING AND WIRING RECOMMENDATIONS

1. When using a soldering iron, transistors may be soldered directly into the circuit, but heat conducted to the junction should, if possible, be kept to a minimum by the use of a thermal shunt.

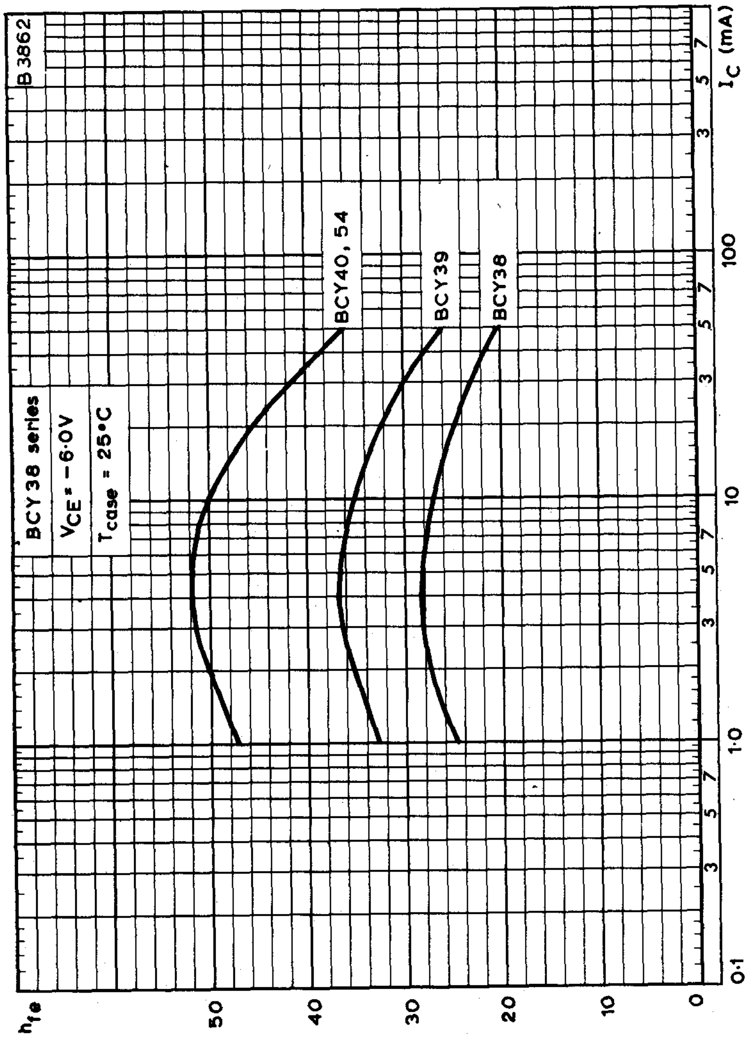
2. Transistors may be dip-soldered at a solder temperature of 245°C for a maximum soldering time of 5 seconds. The case temperature during soldering must not at any time exceed the maximum storage temperature. These recommendations apply to a transistor mounted flush on a board having punched-through holes, or spaced at least 1.5mm above a board having plated-through holes.

3. Care should be taken not to bend the leads nearer than 1.5mm from the seal.

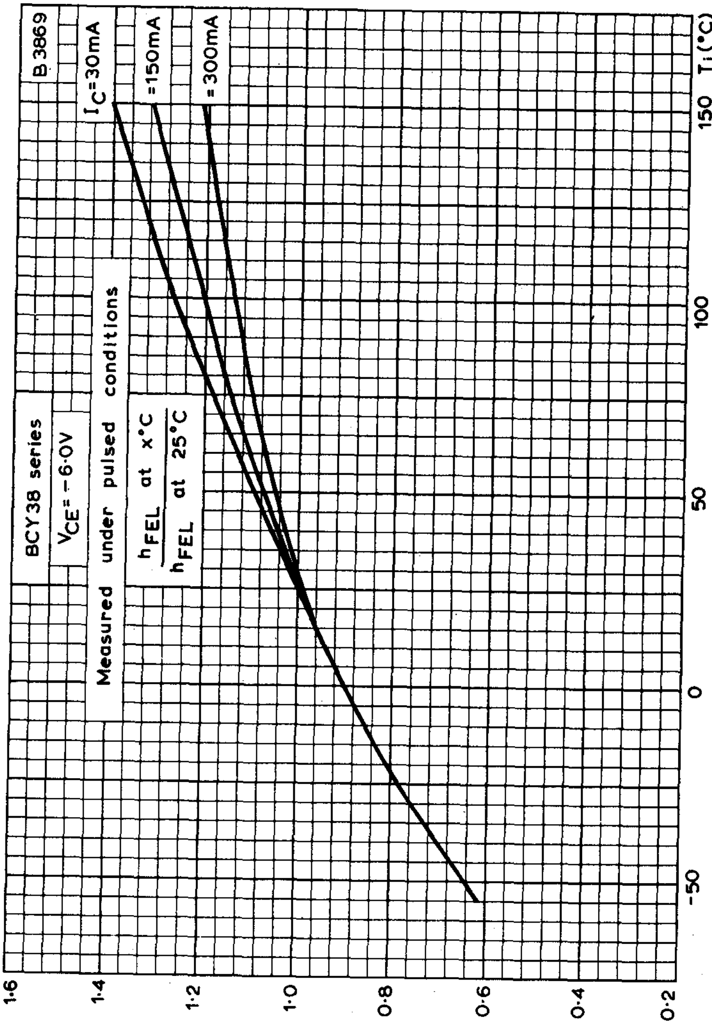
4. If devices are stored above 100°C before incorporation into equipment, some deterioration of the external surface is likely to occur which may make soldering into the circuit difficult. Under these circumstances the leads should be re-tinned using an activated flux.



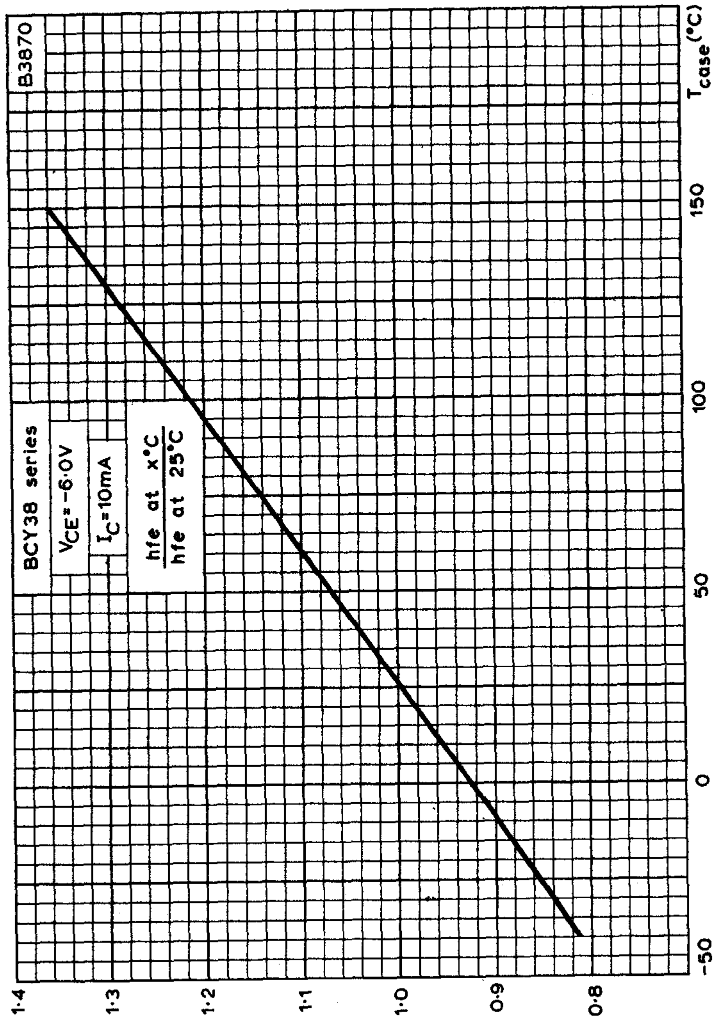
TYPICAL VARIATION OF COMMON EMITTER LARGE-SIGNAL FORWARD CURRENT TRANSFER RATIO WITH COLLECTOR CURRENT



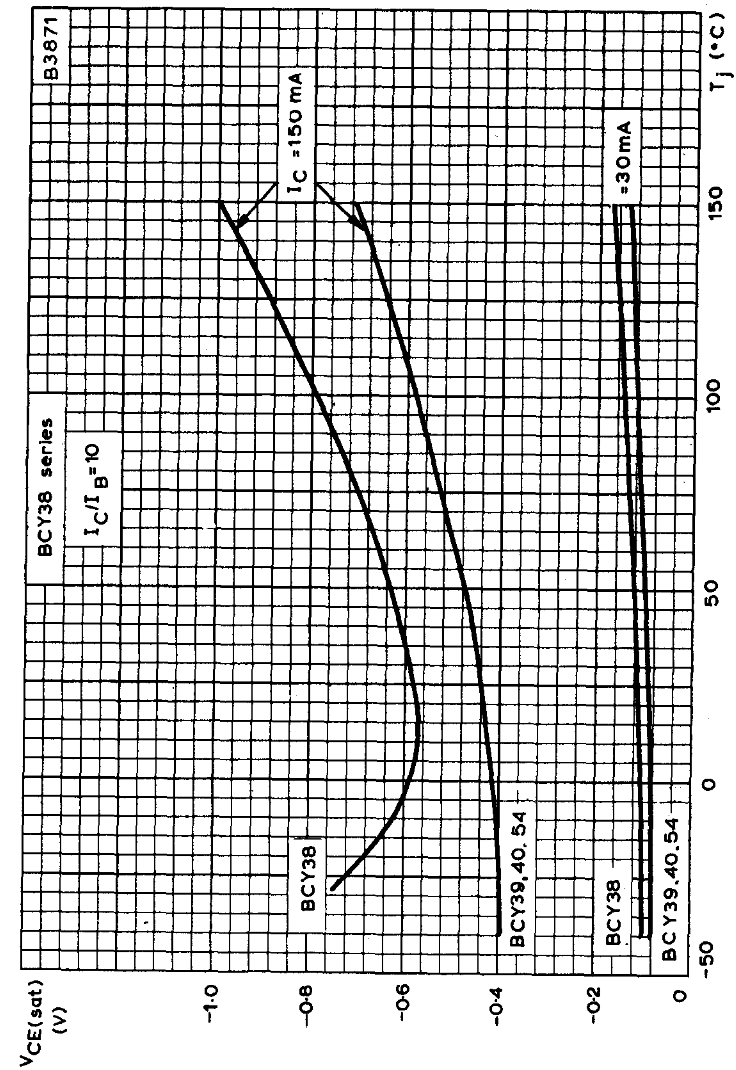
TYPICAL VARIATION OF COMMON EMITTER SMALL SIGNAL FORWARD CURRENT TRANSFER RATIO WITH COLLECTOR CURRENT



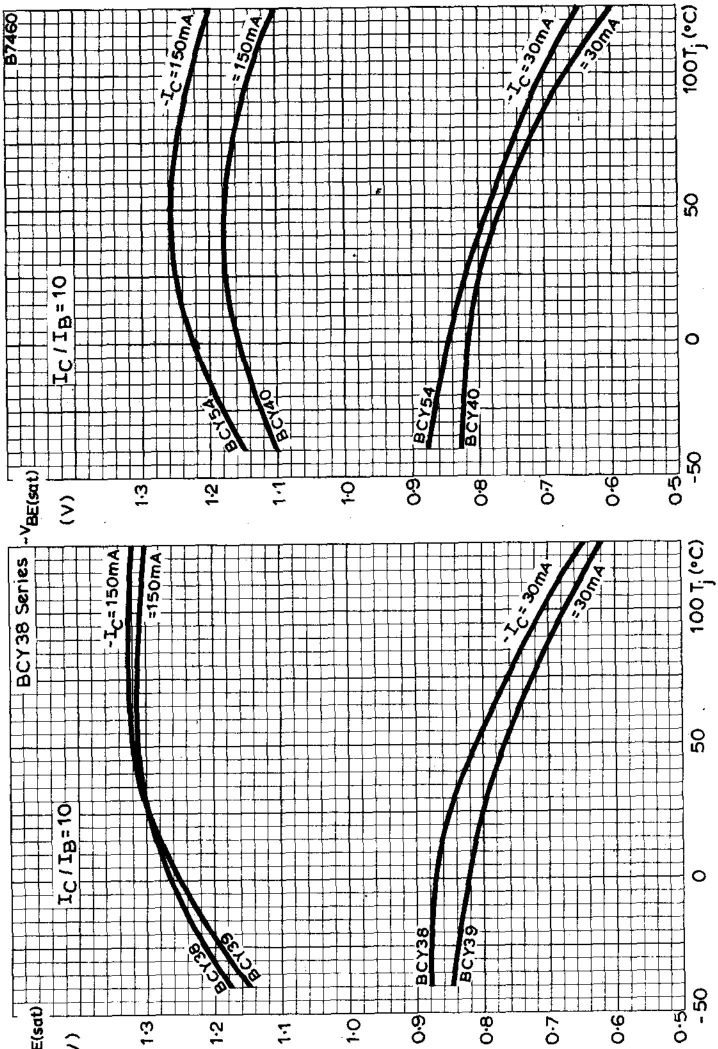
TYPICAL VARIATION OF LARGE SIGNAL FORWARD CURRENT TRANSFER RATIO WITH JUNCTION TEMPERATURE, NORMALISED AT 25°C



TYPICAL VARIATION OF SMALL SIGNAL FORWARD CURRENT TRANSFER RATIO WITH CASE TEMPERATURE, NORMALISED AT 25°C



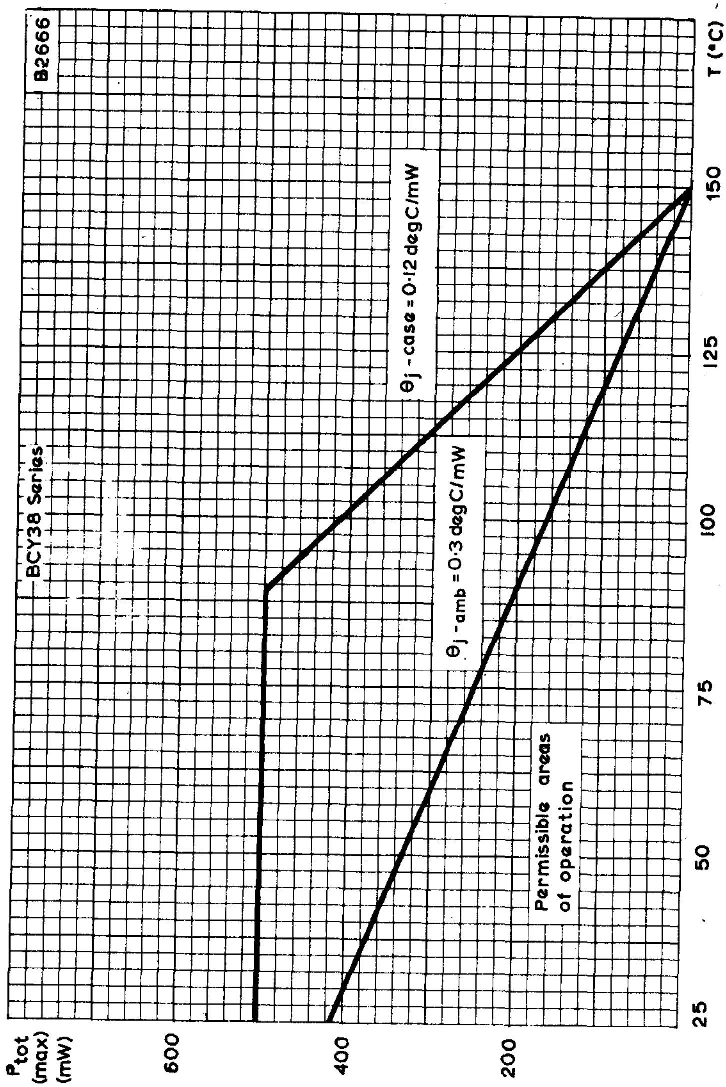
TYPICAL VARIATION OF COLLECTOR-EMITTER SATURATION VOLTAGE WITH JUNCTION TEMPERATURE



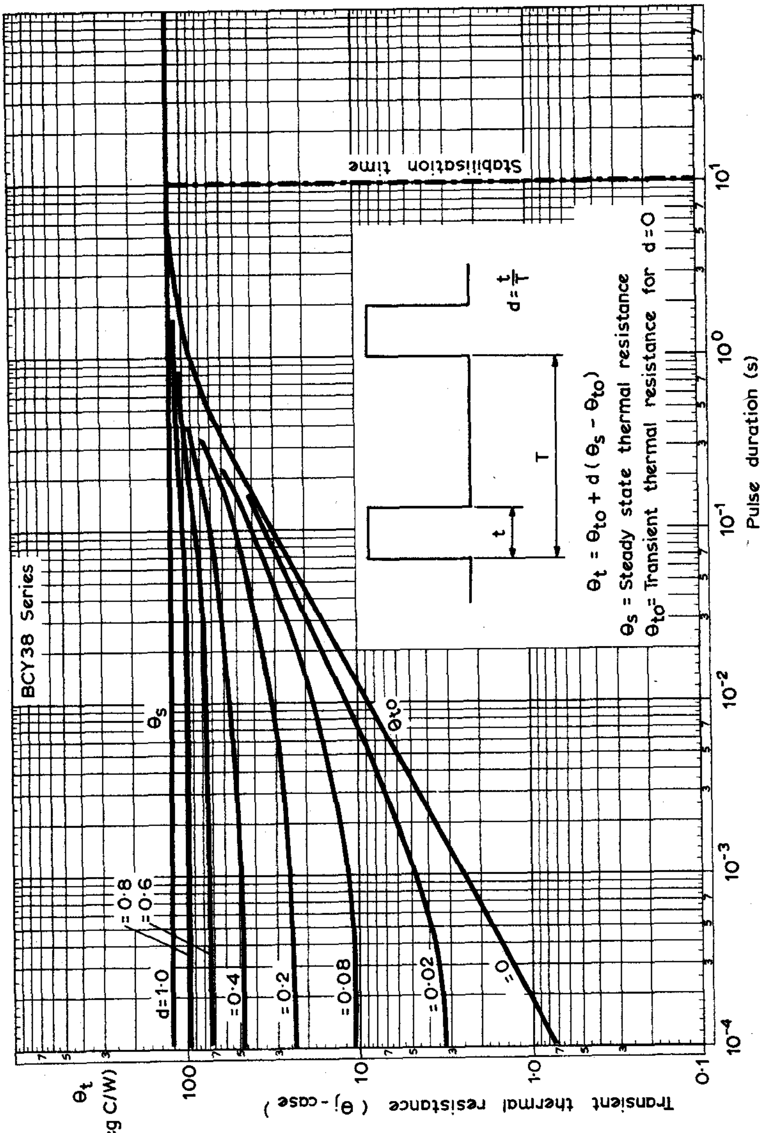
TYPICAL VARIATION OF BASE-EMITTER SATURATION VOLTAGE WITH JUNCTION TEMPERATURE

SILICON P-N-P JUNCTION TRANSISTORS

BCY38
BCY39
BCY40
BCY54



TOTAL DISSIPATION PLOTTED AGAINST AMBIENT TEMPERATURE



TRANSIENT THERMAL RESISTANCE FOR VARIOUS DUTY CYCLES
PLOTTED AGAINST PULSE DURATION

SILICON P-N-P JUNCTION TRANSISTOR

BCY38

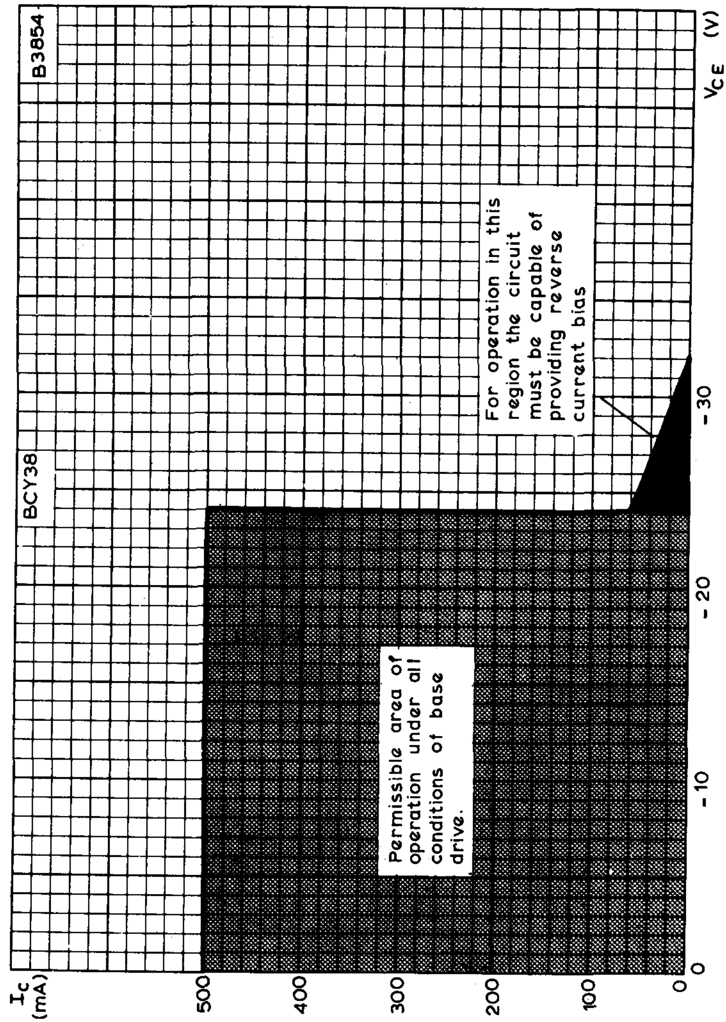
ELECTRICAL CHARACTERISTICS ($T_{amb} = 25^{\circ}C$ unless otherwise stated)

		Min.	Typ.	Max.	
I_{CBO}	Collector cut-off current				
	$V_{CB} = -6.0V$, $I_E = 0$	-	-	100*	nA
		-	1.0	-	nA
	$V_{CB} = -6.0V$, $I_E = 0$, $T_{amb} = 100^{\circ}C$	-	0.1	2.5	μA
I_{EBO}	Emitter cut-off current				
	$V_{EB} = -6.0V$, $I_C = 0$	-	-	100*	nA
		-	1.0	-	nA
	$V_{EB} = -6.0V$, $I_C = 0$, $T_{amb} = 100^{\circ}C$	-	0.1	2.5	μA
h_{FE}	Large signal forward current transfer ratio				
	$I_C = 30mA$, $V_{CE} = -1.0V$	12	20	-	
	$I_C = 150mA$, $V_{CE} = -1.0V$	10	-	30*	
		-	13	-	
	$I_{CM} = 300mA$, $V_{CE} = -6.0V$	-	10	-	
$V_{CE(sat)}$	Collector-emitter saturation voltage				
	$I_C = 150mA$, $I_B = 15mA$	-	-0.58	-1.1	V
V_{BE}	Base-emitter voltage				
	$I_C = 150mA$, $V_{CE} = -1.0V$	-	-	-1.9*	V
		-	-1.5	-	V
I_B	Base current				
	$I_E = 150mA$, $V_{CB} = 0$	5.0	-	14*	mA
NF	Noise figure				
	$I_C = 500\mu A$, $V_{CE} = -2.0V$, $f = 1.0kc/s$, $R_s = 500\Omega$	-	8.0	20	dB
$\dagger r_e$	$I_C = 1.0mA$, $V_{CE} = -6.0V$	-	25	-	Ω

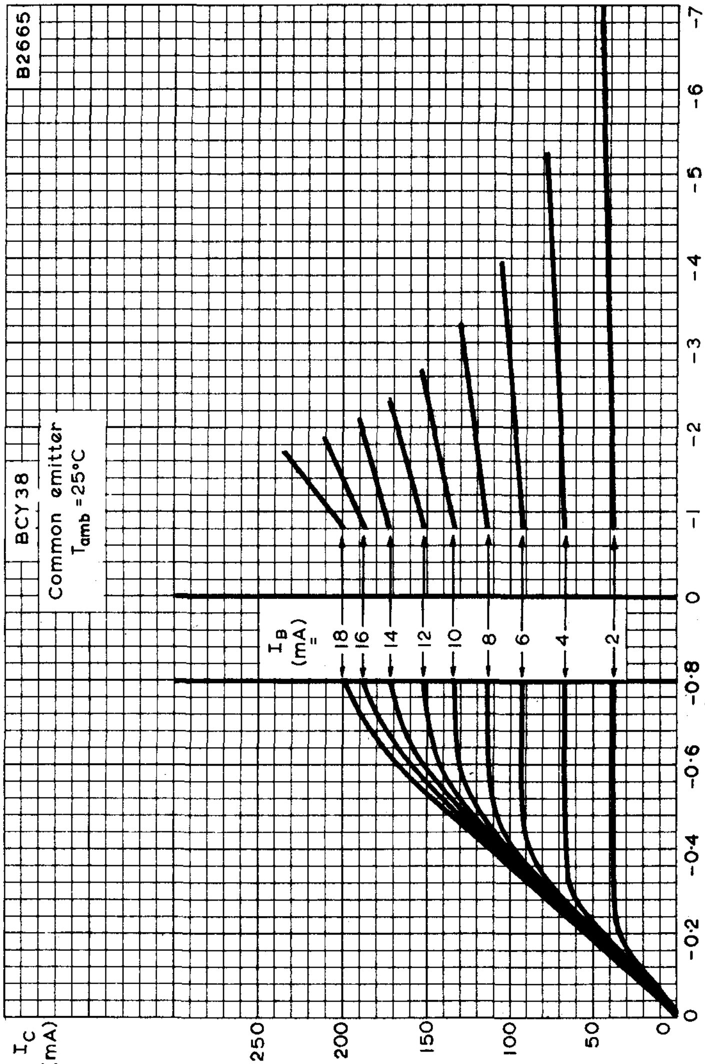
		Min.	Typ.	Max.	
$r_{bb'}$	$I_C = 1.0mA$, $V_{CE} = -6.0V$, $f = 500kc/s$	-	100	250	Ω
c_{tc}	$I_E = 0$, $V_{CB} = -6.0V$, $f = 500kc/s$	-	60	150	pF
h_{fe}	$I_C = 10mA$, $V_{CE} = -6.0V$, $f = 1.0kc/s$	15	27	100	
f_T	$I_C = 1.0mA$, $V_{CE} = -6.0V$	0.45	1.5	-	Mc/s

*These are the characteristics which are recommended for acceptance testing purposes.

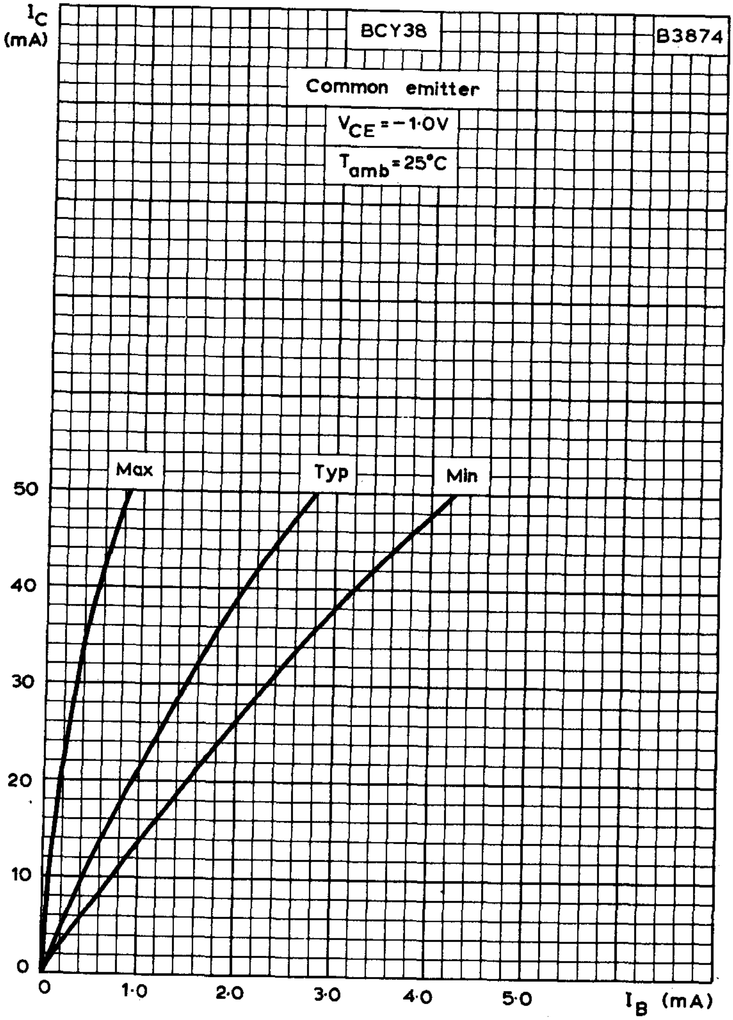
†The value of r_e given here is $\frac{kT}{q} \cdot \frac{1}{I_E} \approx \frac{25}{I_E}$ where I_E is in mA and T is in $^{\circ}$K.



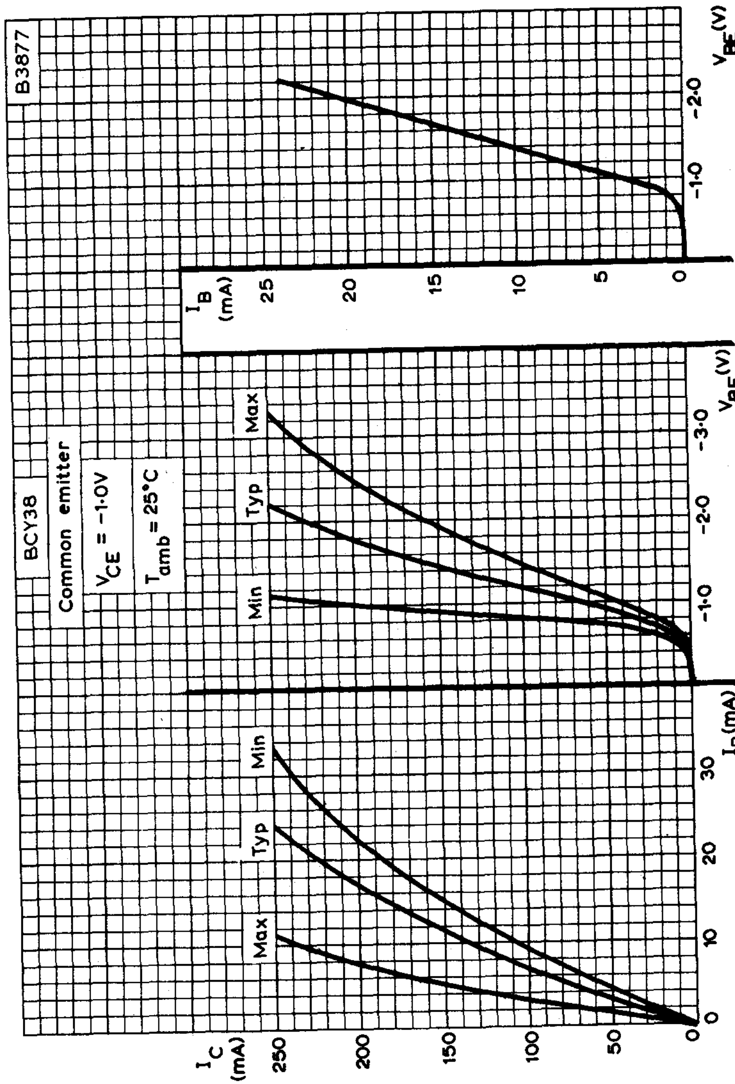
MAXIMUM COLLECTOR CURRENT PLOTTED AGAINST MAXIMUM COLLECTOR-EMITTER VOLTAGE



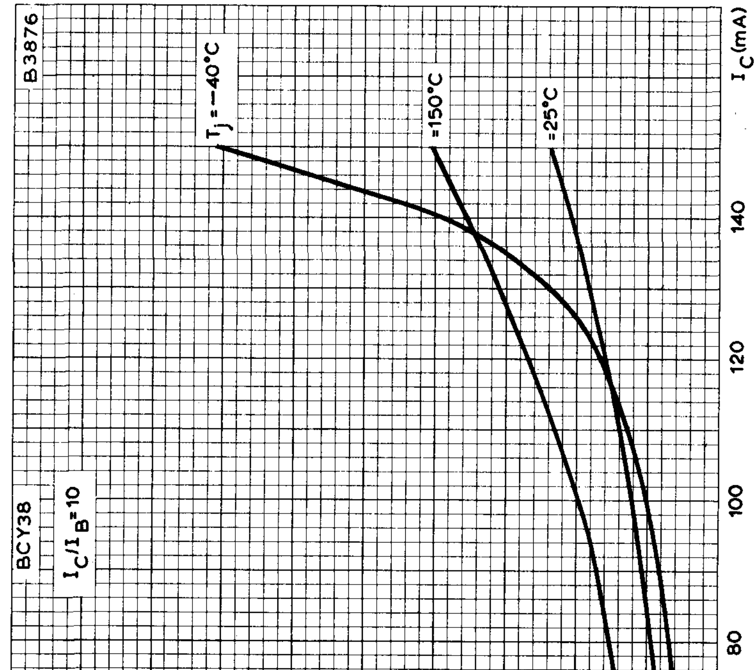
TYPICAL COMMON EMITTER OUTPUT CHARACTERISTIC



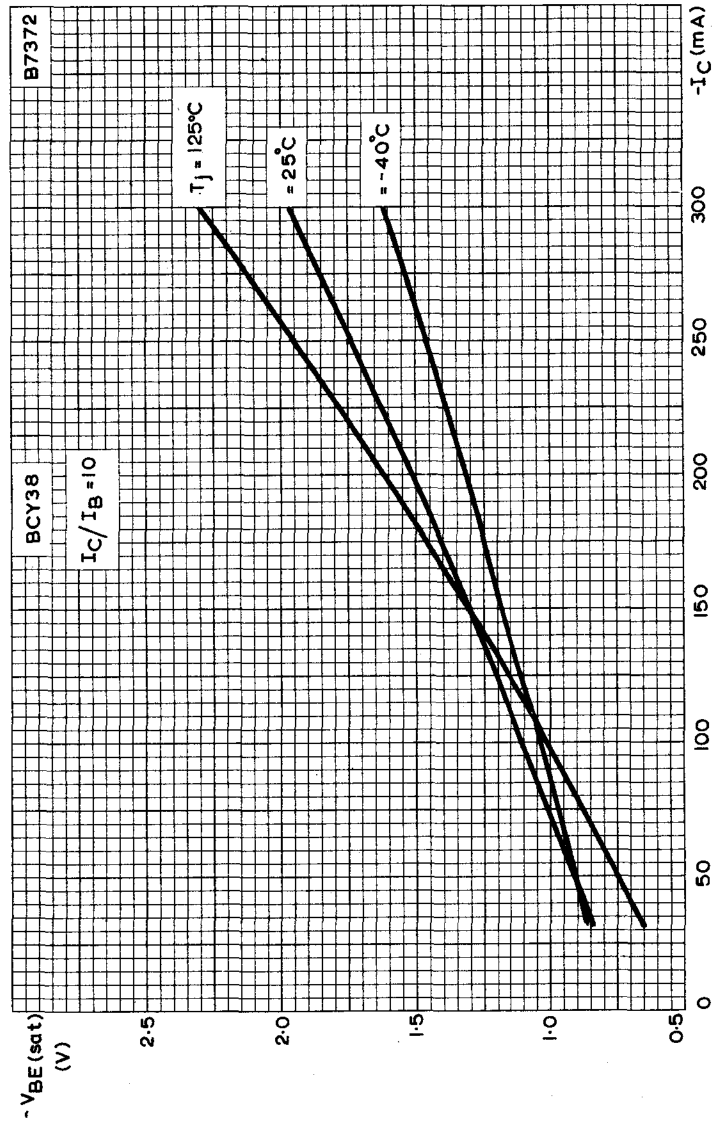
TYPICAL COMMON EMITTER TRANSFER CHARACTERISTIC AT LOW COLLECTOR CURRENTS



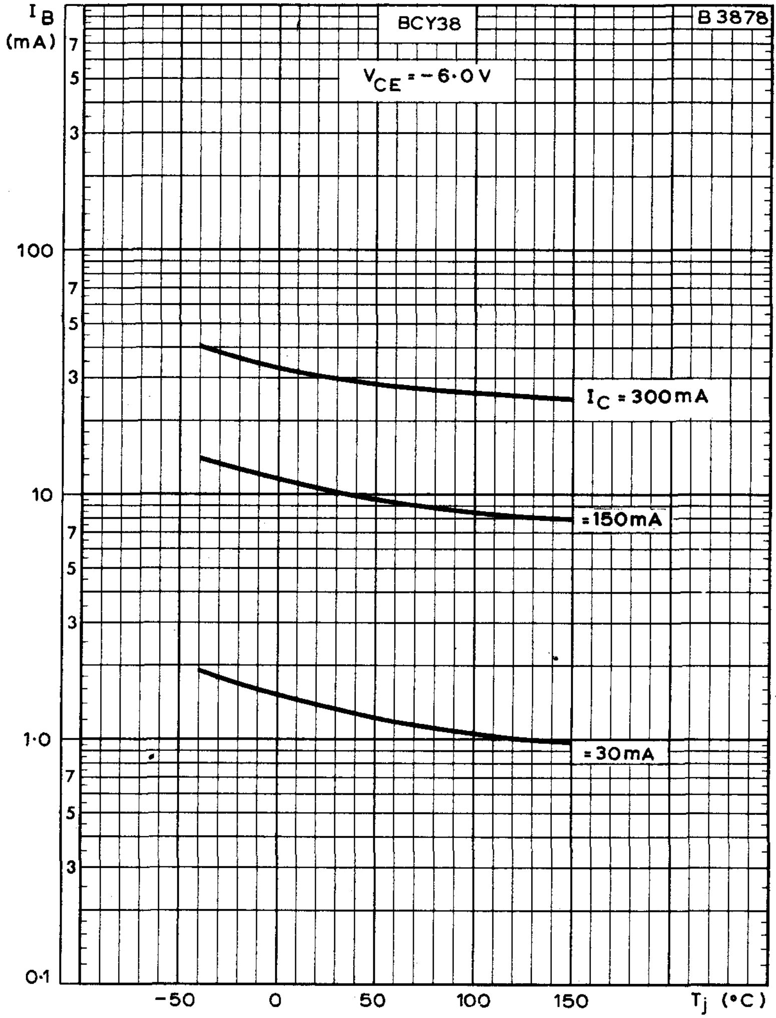
TYPICAL COMMON EMITTER TRANSFER, MUTUAL AND INPUT CHARACTERISTICS



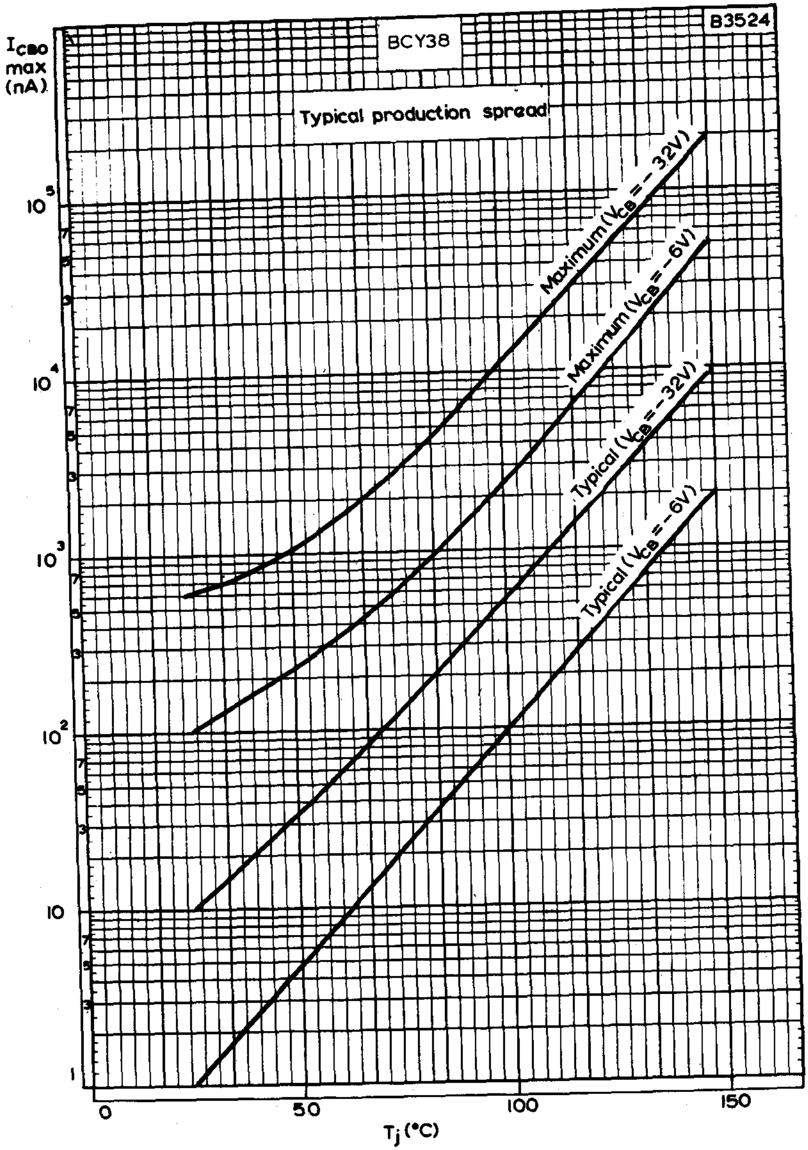
TYPICAL VARIATION OF COLLECTOR-EMITTER SATURATION VOLTAGE WITH COLLECTOR CURRENT



TYPICAL VARIATION OF BASE-EMITTER SATURATION VOLTAGE WITH COLLECTOR CURRENT, JUNCTION TEMPERATURE AS A PARAMETER



TYPICAL VARIATION OF BASE CURRENT WITH JUNCTION TEMPERATURE



COLLECTOR CUT-OFF CURRENT PLOTTED AGAINST JUNCTION TEMPERATURE

SILICON P-N-P JUNCTION TRANSISTOR

BCY39

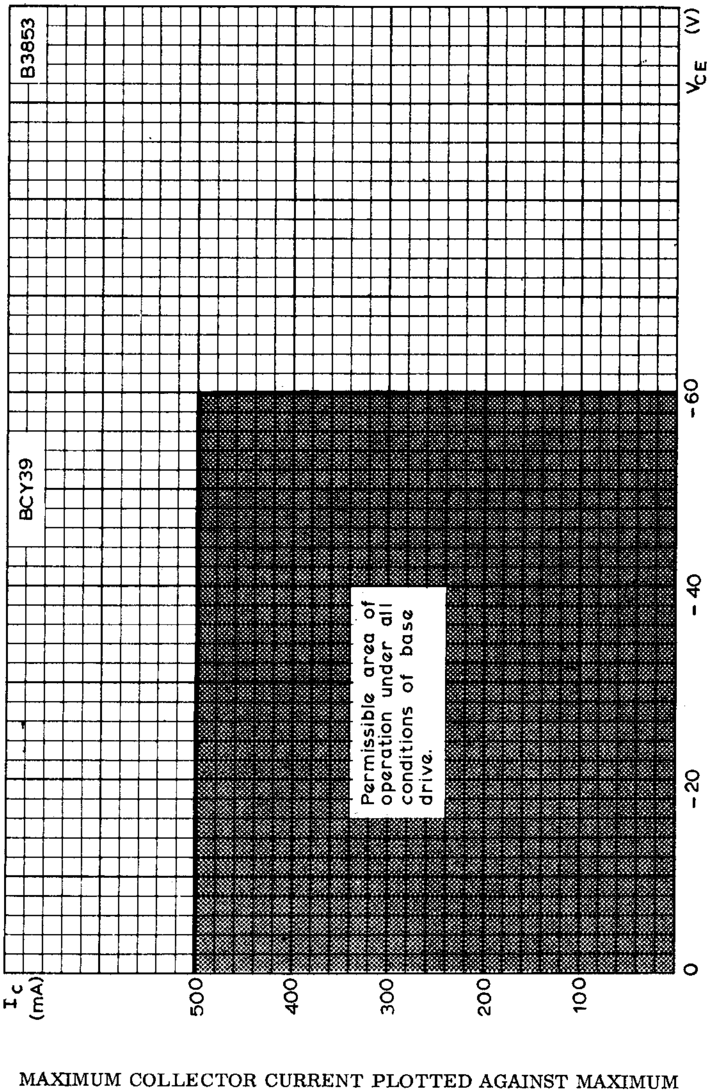
ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise stated)

		Min.	Typ.	Max.	
I_{CBO}	Collector cut-off current				
	V_{CB} = -6.0V, I_E = 0	-	-	100*	nA
		-	1.0	-	nA
	V_{CB} = -6.0V, I_E = 0, T_{amb} = 100°C	-	0.1	2.5	μA
I_{EBO}	Emitter cut-off current				
	V_{EB} = -6.0V, I_C = 0	-	-	100*	nA
		-	1.0	-	nA
	V_{EB} = -6.0V, I_C = 0, T_{amb} = 100°C	-	0.1	2.5	μA
h_{FE}	Large signal forward current transfer ratio				
	I_C = 30mA, V_{CE} = -1.0V	12	30	-	
	I_C = 150mA, V_{CE} = -1.0V	10	-	50*	
		-	19	-	
	I_{CM} = 300mA, V_{CE} = -6.0V	-	15	-	
$V_{CE(sat)}$	Collector-emitter saturation voltage				
	I_C = 150mA, I_B = 15mA	-	-0.46	-1.1	V
V_{BE}	Base-emitter voltage				
	I_C = 150mA, V_{CE} = -1.0V	-	-	-1.9*	V
		-	-1.5	-	V
I_B	Base current				
	I_E = 150mA, V_{CB} = 0	3.0	-	14*	mA
NF	Noise figure				
	I_C = 500μA, V_{CE} = -2.0V, f = 1.0kc/s, R_s = 500Ω	-	8.0	20	dB
†r_e	I_C = 1.0mA, V_{CE} = -6.0V	-	25	-	Ω

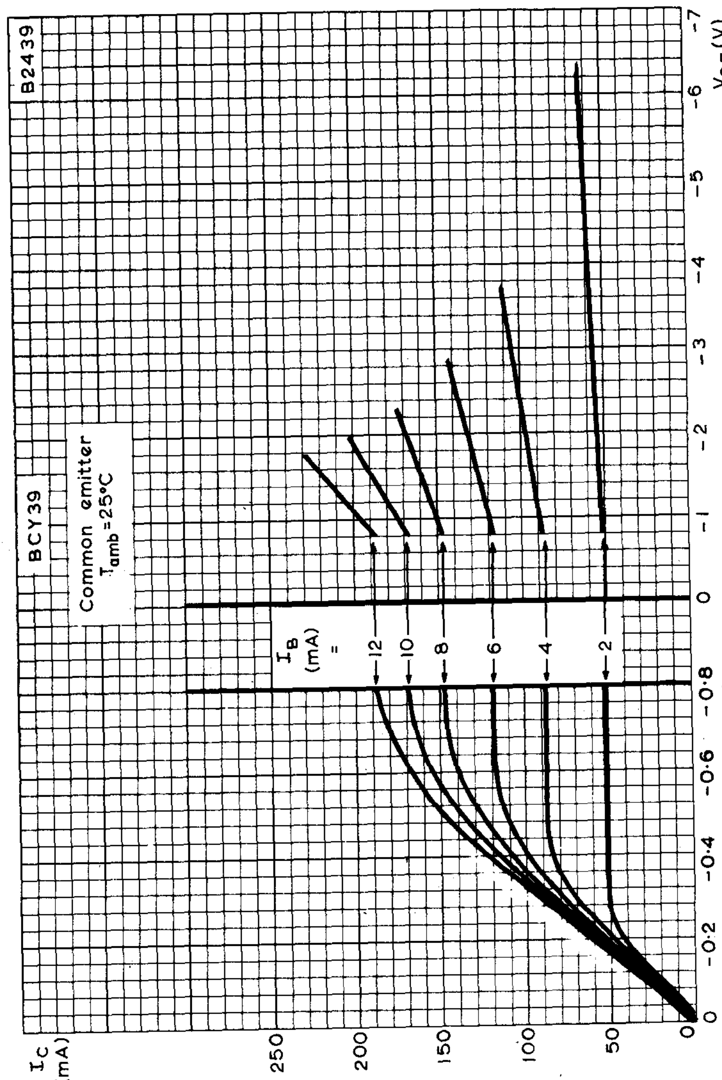
		Min.	Typ.	Max.	
$r_{bb'}$	$I_C = 1.0mA$, $V_{CE} = -6.0V$, f=500kc/s	-	110	250	Ω
c_{tc}	$I_E = 0$, $V_{CB} = -6.0V$, f=500kc/s	-	60	150	pF
h_{fe}	$I_C = 10mA$, $V_{CE} = -6.0V$, f=1.0kc/s	15	35	100	
f_T	$I_C = 1.0mA$, $V_{CE} = -6.0V$	0.45	1.5	-	Mc/s

*These are the characteristics which are recommended for acceptance testing purposes.

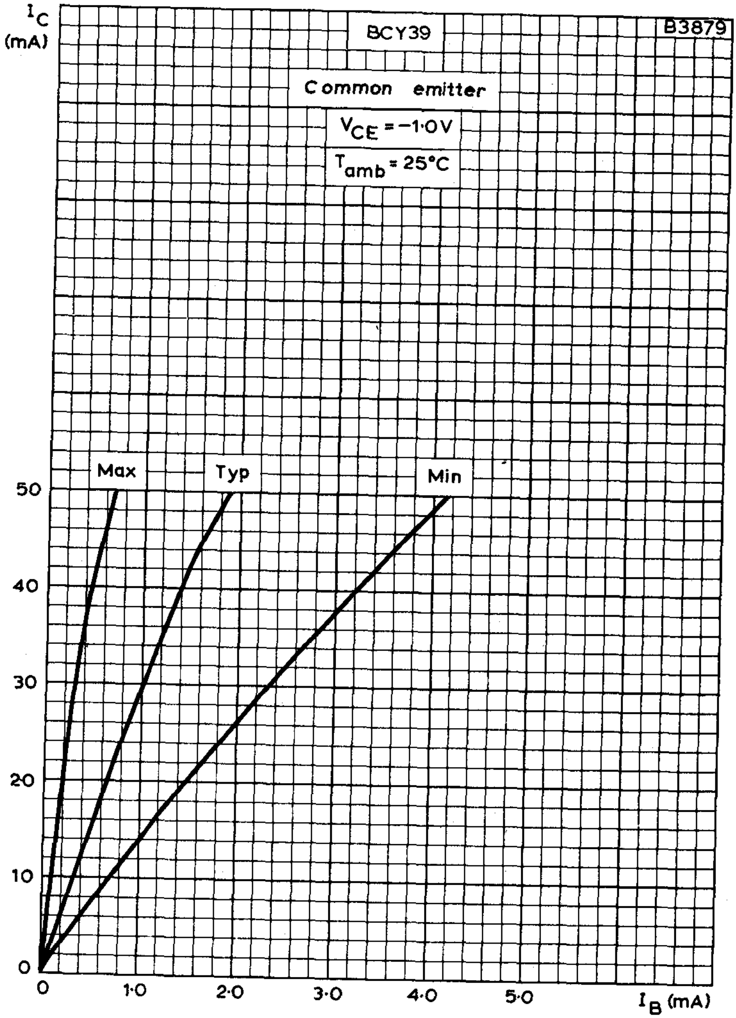
†The value of r_e given here is $\frac{kT}{q} \cdot \frac{1}{I_E} \approx \frac{25}{I_E}$ where I_E is in mA and T is in ^{o}K.



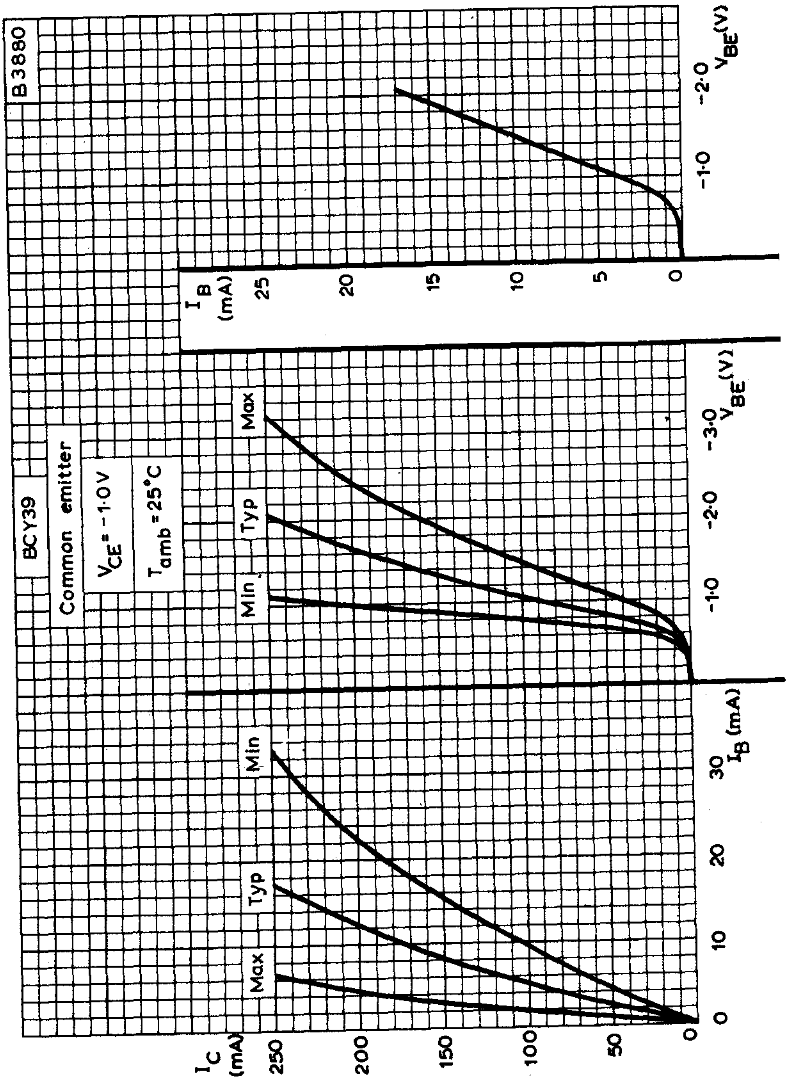
MAXIMUM COLLECTOR CURRENT PLOTTED AGAINST MAXIMUM COLLECTOR-EMITTER VOLTAGE



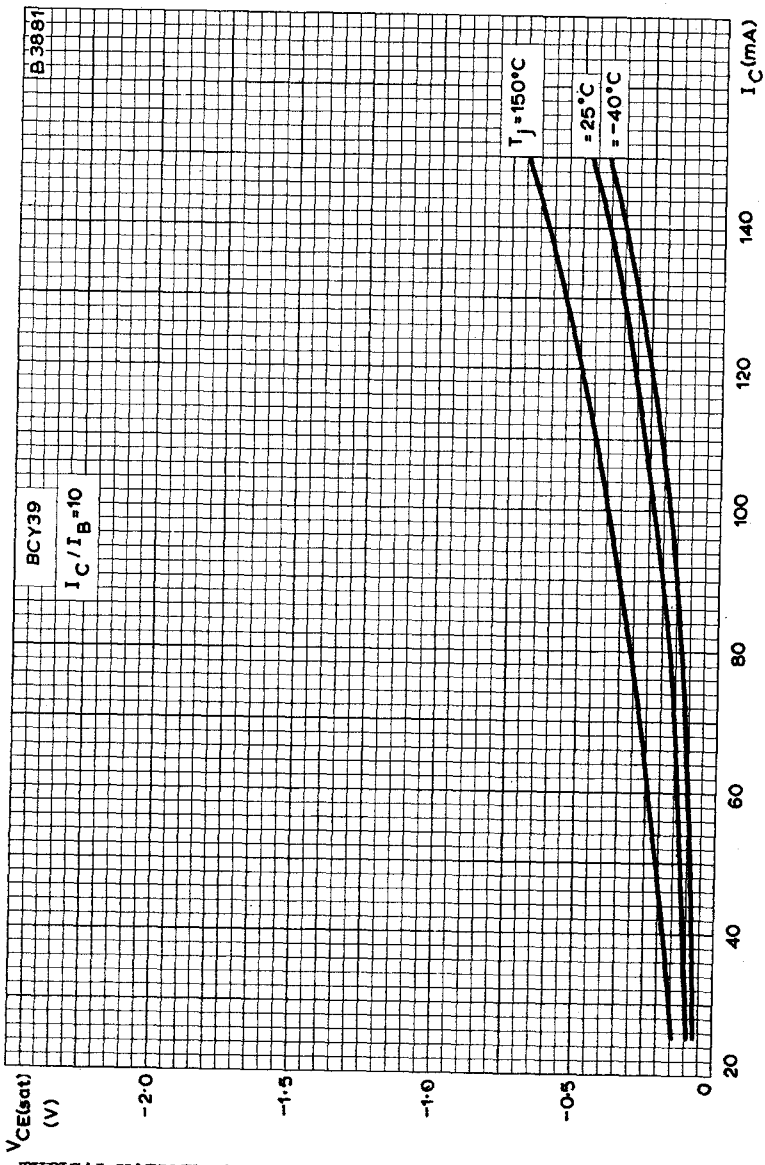
TYPICAL COMMON EMITTER OUTPUT CHARACTERISTIC



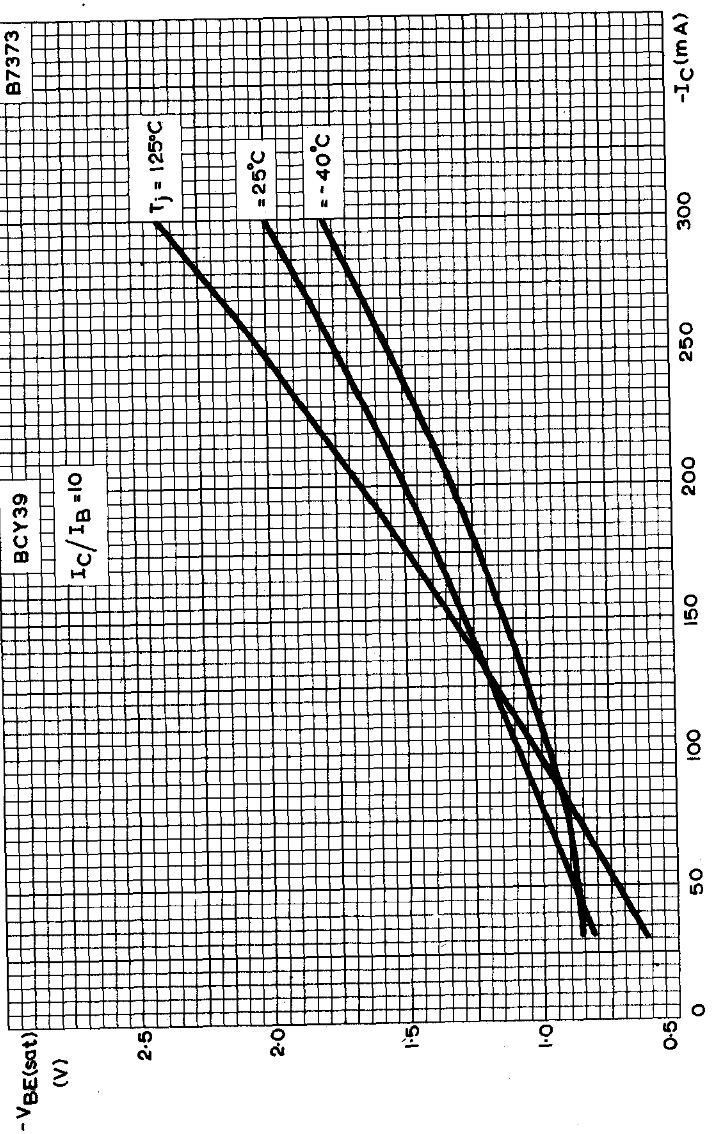
TYPICAL COMMON EMITTER TRANSFER CHARACTERISTIC AT LOW COLLECTOR CURRENTS



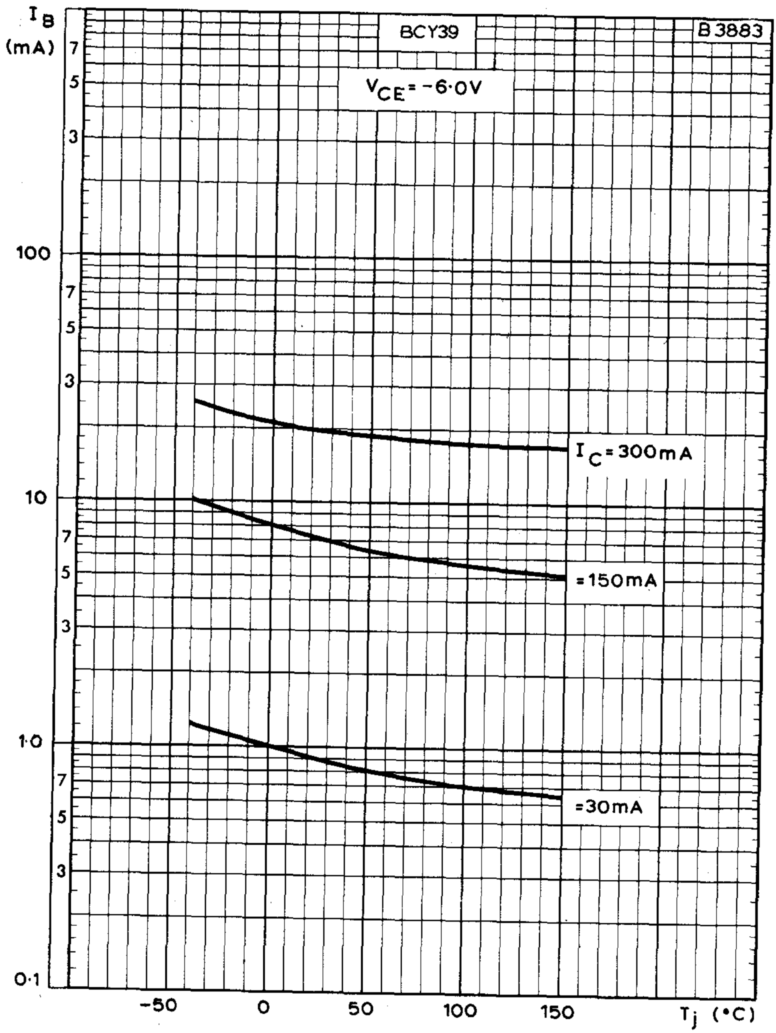
TYPICAL COMMON EMITTER TRANSFER, MUTUAL AND INPUT CHARACTERISTICS



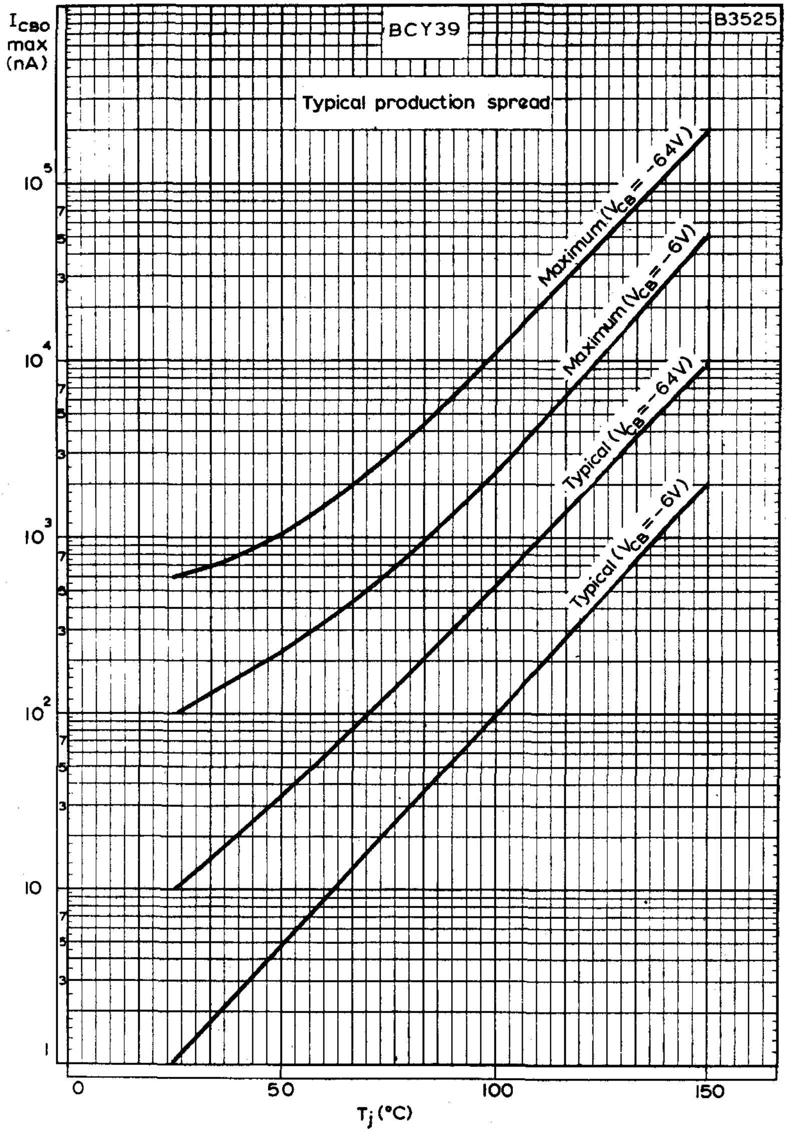
TYPICAL VARIATION OF COLLECTOR-EMITTER SATURATION VOLTAGE
WITH COLLECTOR CURRENT



TYPICAL VARIATION OF BASE-EMITTER SATURATION VOLTAGE WITH COLLECTOR CURRENT. JUNCTION TEMPERATURE AS A PARAMETER



TYPICAL VARIATION OF BASE CURRENT WITH JUNCTION TEMPERATURE



COLLECTOR CUT-OFF CURRENT PLOTTED AGAINST JUNCTION TEMPERATURE

SILICON P-N-P JUNCTION TRANSISTOR

BCY40

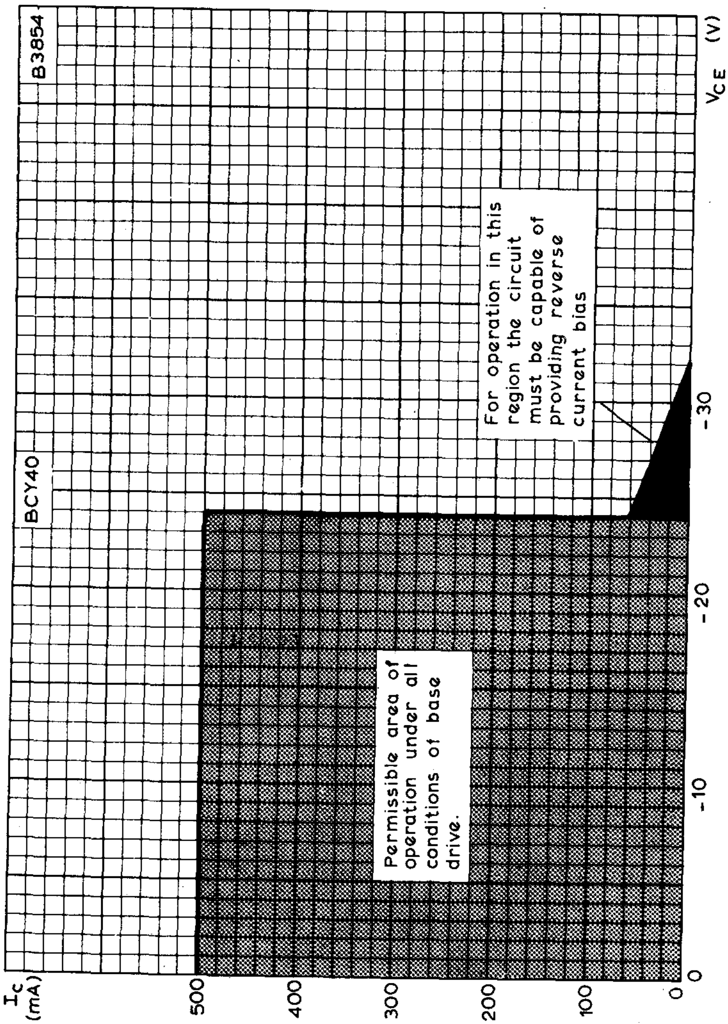
ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise stated)

Symbol	Characteristic / Conditions	Min.	Typ.	Max.	Unit
I_{CBO}	Collector cut-off current				
	V_{CB} = -6.0V, I_E = 0	-	-	100*	nA
		-	1.0	-	nA
	V_{CB} = -6.0V, I_E = 0, T_{amb} = 100°C	-	0.1	2.5	μA
I_{EBO}	Emitter cut-off current				
	V_{EB} = -6.0V, I_C = 0	-	-	100*	nA
		-	1.0	-	nA
	V_{EB} = -6.0V, I_C = 0, T_{amb} = 100°C	-	0.1	2.5	μA
h_{FE}	Large signal forward current transfer ratio				
	I_C = 30mA, V_{CE} = -1.0V	22	35	-	
	I_C = 150mA, V_{CE} = -1.0V	15	-	120*	
		-	23	-	
	I_{CM} = 300mA, V_{CE} = -6.0V	10	18	-	
$V_{CE(sat)}$	Collector-emitter saturation voltage				
	I_C = 150mA, I_B = 15mA	-	-0.44	-1.1	V
V_{BE}	Base-emitter voltage				
	I_C = 150mA, V_{CE} = -1.0V	-	-	-1.9*	V
		-	-1.4	-	V
I_B	Base current				
	I_E = 150mA, V_{CB} = 0	1.25	-	9.0*	mA
NF	Noise figure				
	I_C = 500μA, V_{CE} = -2.0V, f = 1.0kc/s, R_s = 500Ω	-	8.0	20	dB
†r_e	I_C = 1.0mA, V_{CE} = -6.0V	-	25	-	Ω

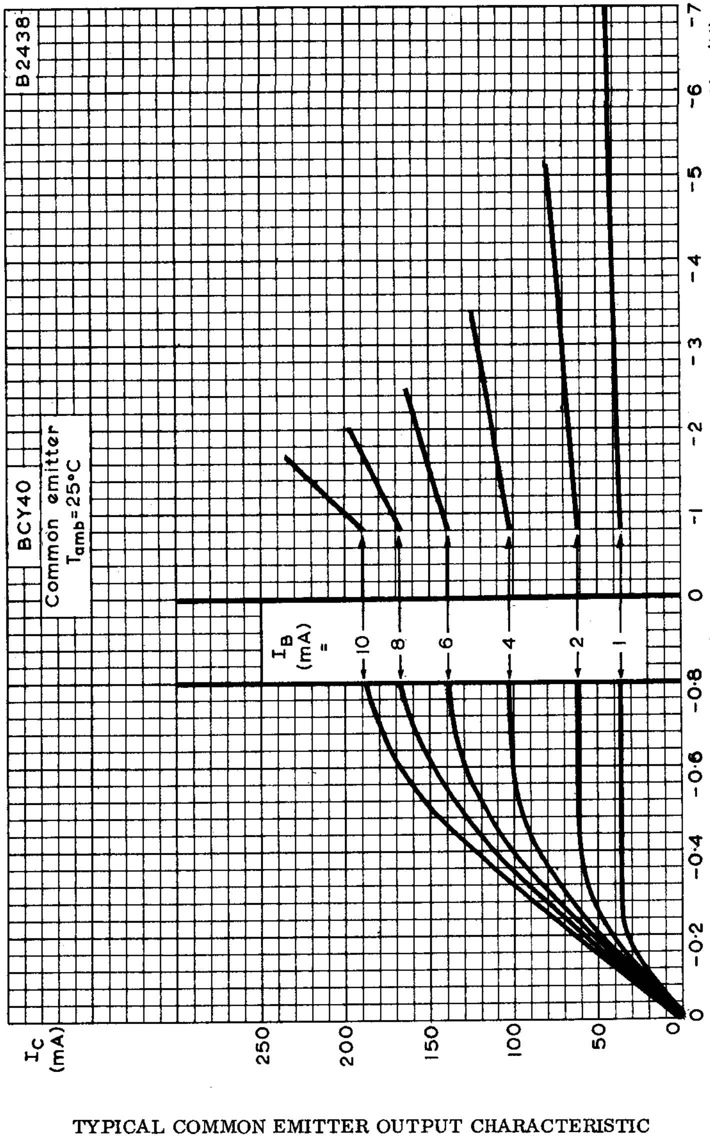
		Min.	Typ.	Max.	
$r_{bb'}$	$I_C = 1.0mA$, $V_{CE} = -6.0V$, f=500kc/s	-	140	250	Ω
c_{tc}	$I_E = 0$, $V_{CB} = -6.0V$, f=500kc/s	-	60	150	pF
h_{fe}	$I_C = 10mA$, $V_{CE} = -6.0V$, f=1.0kc/s	30	50	160	
f_T	$I_C = 1.0mA$, $V_{CE} = -6.0V$	0.85	2.5	-	Mc/s

*These are the characteristics which are recommended for acceptance testing purposes.

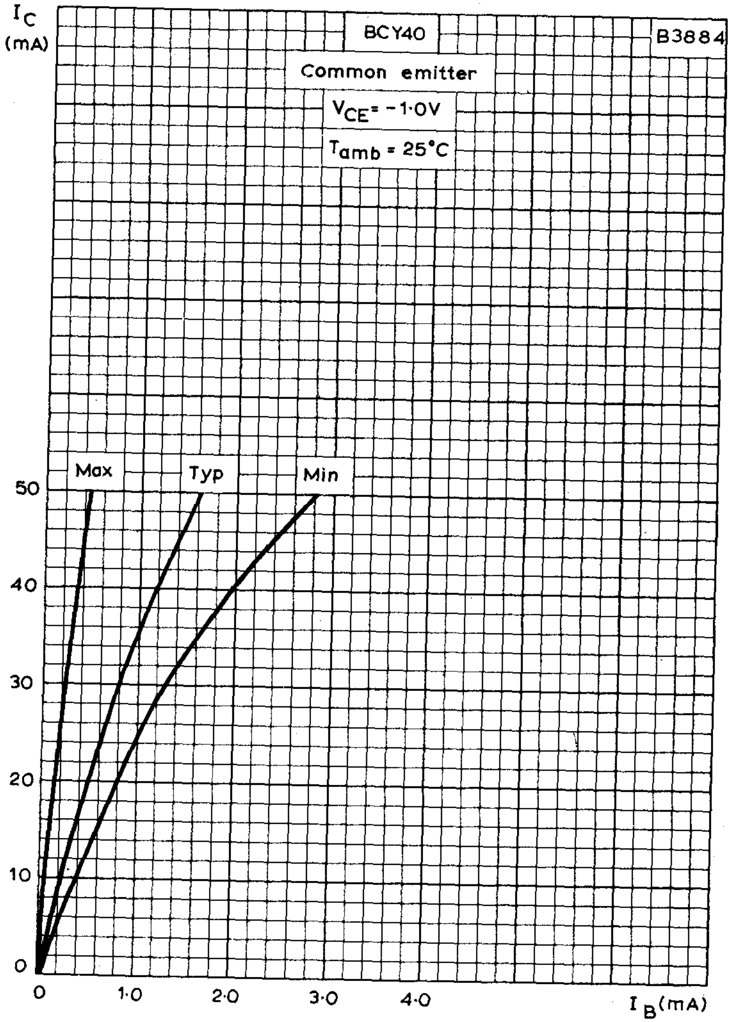
†The value of r_e given here is $\frac{kT}{q} \cdot \frac{1}{I_E} \approx \frac{25}{I_E}$ where I_E is in mA and T is in ^{o}K.



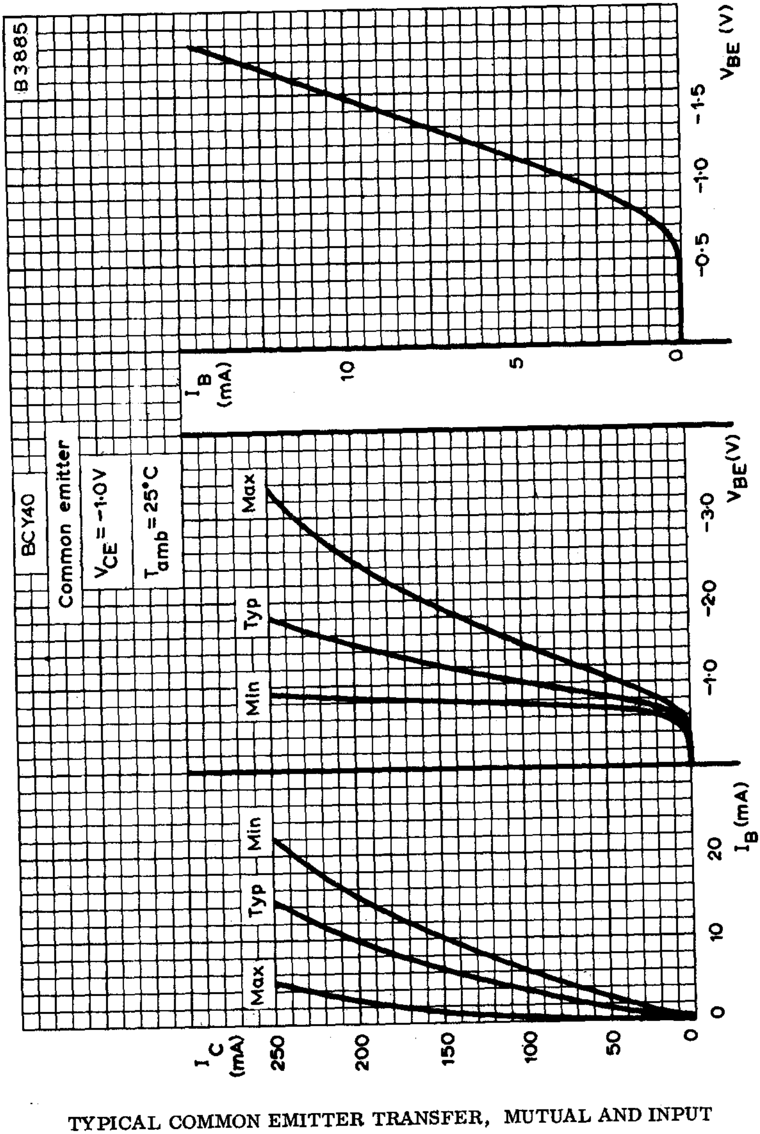
MAXIMUM COLLECTOR CURRENT PLOTTED AGAINST MAXIMUM COLLECTOR-EMITTER VOLTAGE



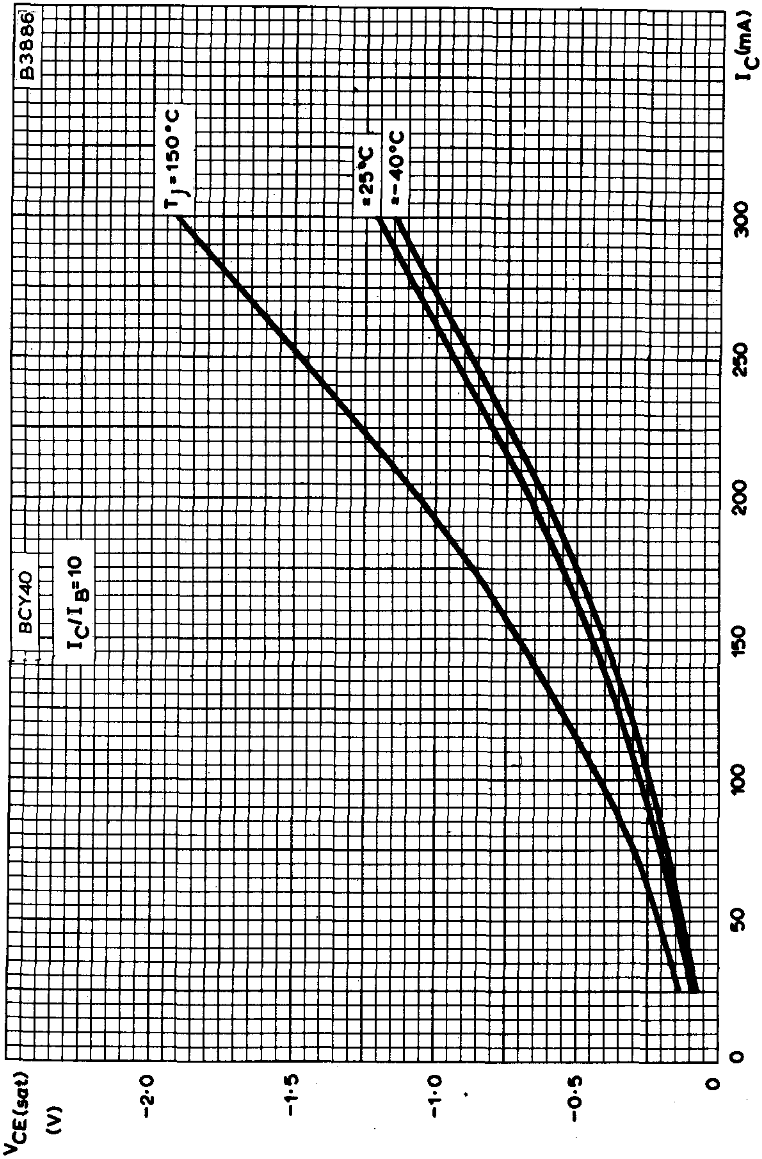
TYPICAL COMMON EMITTER OUTPUT CHARACTERISTIC



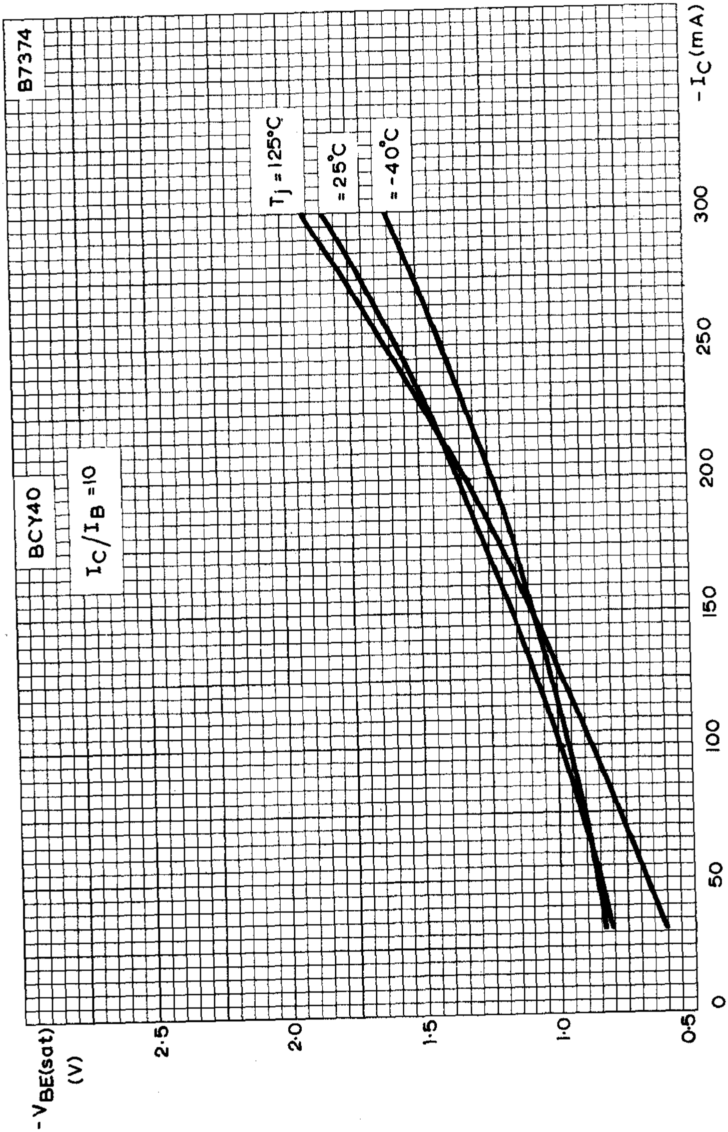
TYPICAL COMMON EMITTER TRANSFER CHARACTERISTIC AT LOW COLLECTOR CURRENTS



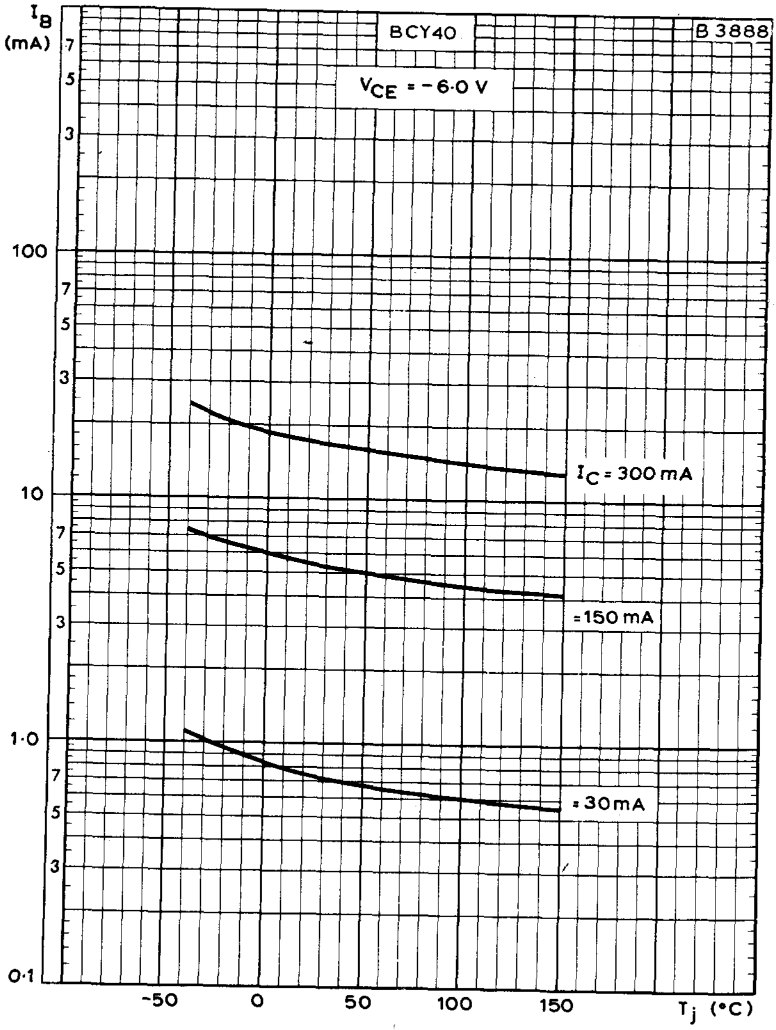
TYPICAL COMMON EMITTER TRANSFER, MUTUAL AND INPUT CHARACTERISTICS



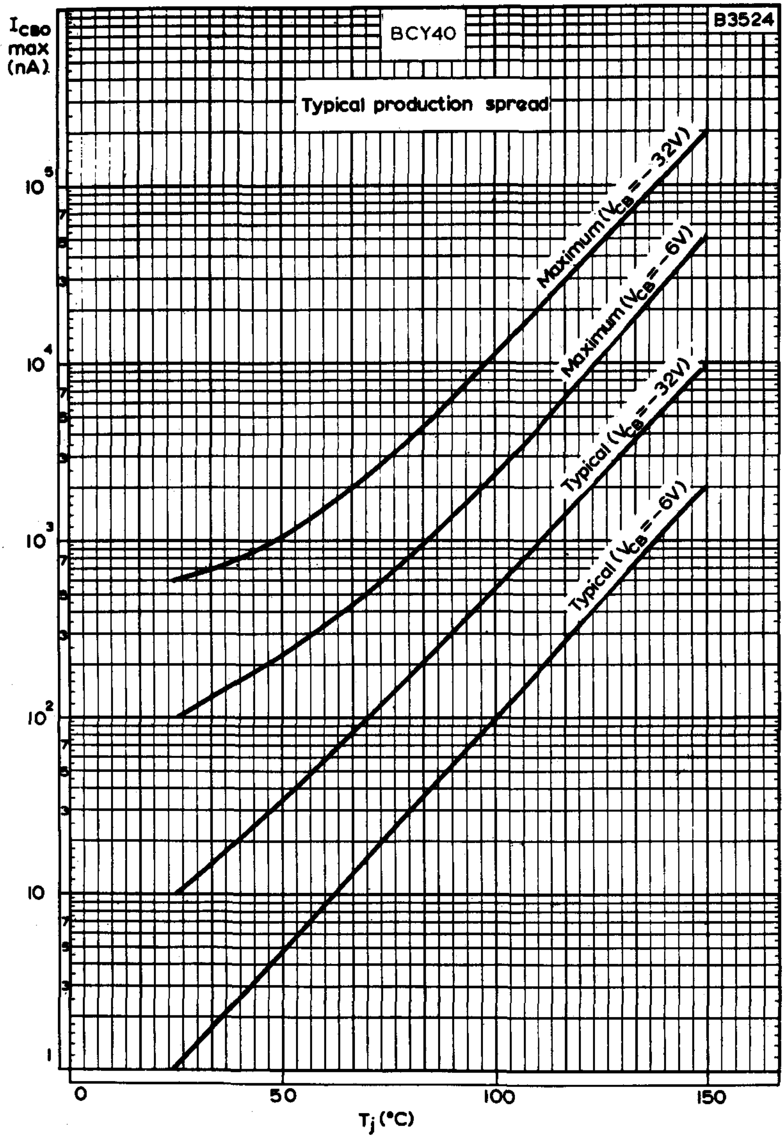
TYPICAL VARIATION OF COLLECTOR-EMITTER SATURATION VOLTAGE WITH COLLECTOR CURRENT



TYPICAL VARIATION OF BASE-EMITTER SATURATION VOLTAGE WITH COLLECTOR CURRENT, JUNCTION TEMPERATURE AS A PARAMETER



TYPICAL VARIATION OF BASE CURRENT WITH JUNCTION TEMPERATURE



COLLECTOR CUT-OFF CURRENT PLOTTED AGAINST JUNCTION TEMPERATURE

SILICON P-N-P JUNCTION TRANSISTOR

BCY54

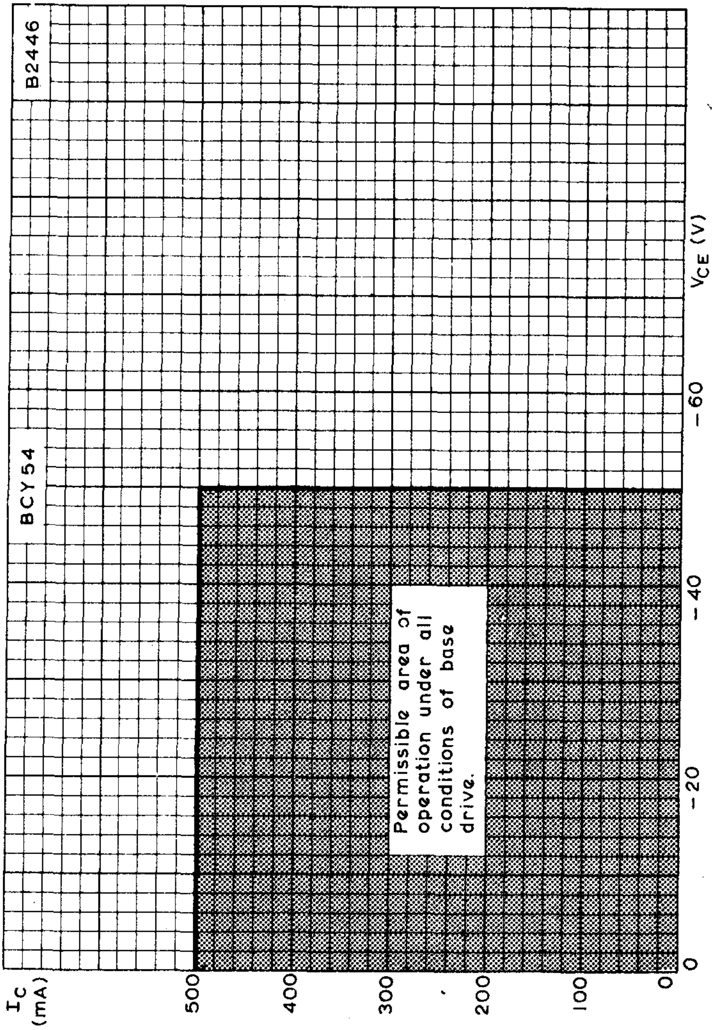
ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C unless otherwise stated)

			Min.	Typ.	Max.	
I_{CBO}	Collector cut-off current					
		V_{CB} = -6.0V, I_E = 0	-	-	100*	nA
			-	1.0	-	nA
		V_{CB} = -6.0V, I_E = 0, T_{amb} = 100°C	-	0.1	2.5	μA
I_{EBO}	Emitter cut-off current					
		V_{EB} = -6.0V, I_C = 0	-	-	100*	nA
			-	1.0	-	nA
		V_{EB} = -6.0V, I_C = 0, T_{amb} = 100°C	-	0.1	2.5	μA
h_{FE}	Large signal forward current transfer ratio					
		I_C = 30mA, V_{CE} = -1.0V	20	35	100	
		I_C = 150mA, V_{CE} = -1.0V	12	-	70*	
			-	23	-	
		I_{CM} = 300mA, V_{CE} = -6.0V	-	18	-	
$V_{CE(sat)}$	Collector-emitter saturation voltage					
		I_C = 150mA, I_B = 15mA	-	-0.44	-1.1	V
V_{BE}	Base-emitter voltage					
		I_C = 150mA, V_{CE} = -1.0V	-	-	-1.9*	V
			-	-1.4	-	V
I_B	Base current					
		I_E = 150mA, V_{CB} = 0	2.0	-	12	mA
NF	Noise figure					
		I_C = 500μA, V_{CE} = -2.0V, f = 1.0kc/s, R_s = 500Ω	-	8.0	20	dB
†r_e		I_C = 1.0mA, V_{CE} = -6.0V	-	25	-	Ω

		Min.	Typ.	Max.	
$r_{bb'}$	$I_C = 1.0mA$, $V_{CE} = -6.0V$, f = 500kc/s	-	130	250	Ω
c_{tc}	$I_E = 0$, $V_{CB} = -6.0V$, f = 500kc/s	-	60	150	pF
h_{fe}	$I_C = 10mA$, $V_{CE} = -6.0V$, f = 1.0kc/s	20	50	120	
f_T	$I_C = 1.0mA$, $V_{CE} = -6.0V$	0.45	2.0	-	Mc/s

*These are the characteristics which are recommended for acceptance testing purposes.

†The value of r_e given here is $\frac{kT}{q} \cdot \frac{1}{I_E} \approx \frac{25}{I_E}$ where I_E is in mA and T is in °K.



MAXIMUM COLLECTOR CURRENT PLOTTED AGAINST MAXIMUM COLLECTOR-EMITTER VOLTAGE

ELECTRICAL CHARACTERISTICS (contd.)

			Min.	Typ.	Max.	
f_T	Transition frequency					
	$-I_C = 10mA$, $-V_{CE} = 20V$, $f = 100MHz$		250	450	-	MHz
	$-I_C = 100\mu A$, $-V_{CE} = 20V$, $f = 10.7MHz$	BCY71	15	30	-	MHz
N	Noise figure					
	$-I_C = 100\mu A$, $-V_{CE} = 5.0V$, $f = 10Hz$ to $10kHz$,					
	$R_s = 2.0k\Omega$	BCY70/72	-	2.0	6.0	dB
		BCY71	-	0.8	2.0	dB

h-parameters BCY71

$-I_C = 1.0mA$, $-V_{CE} = 10V$, $f = 1.0kHz$,

		Min.	Typ.	Max.	
h_{ie}	Input impedance	2.0	4.0	12	kΩ
h_{re}	Voltage feedback ratio	-	2.1	20	$x10^{-4}$
h_{fe}	Forward current transfer ratio	150	325	400	
h_{oe}	Output admittance	10	20	60	μmho

P-N-P SILICON PLANAR EPITAXIAL TRANSISTORS

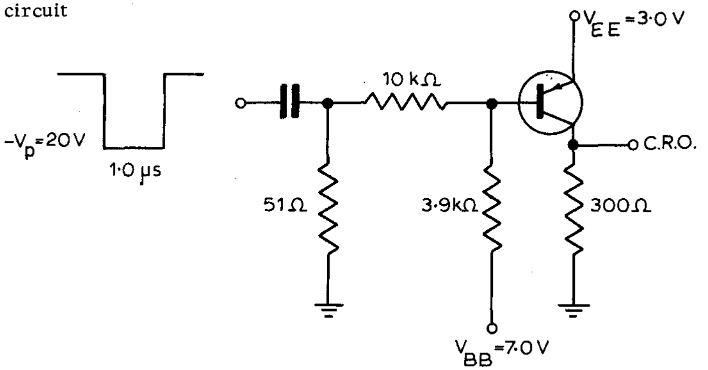
BCY70
BCY71
BCY72

SATURATED SWITCHING TIMES (BCY70, 72)

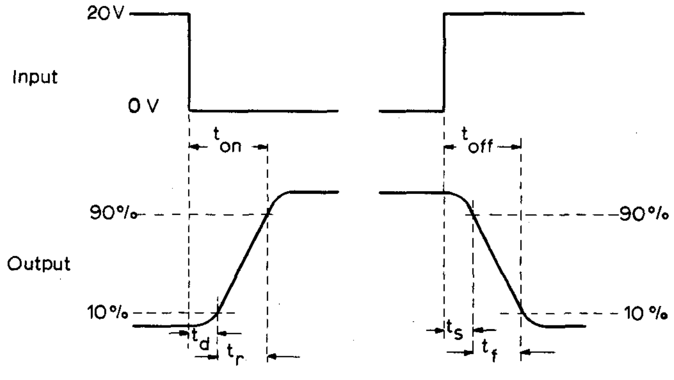
$-I_C = 10mA$, $-I_{Bon} = I_{Boff} = 1.0mA$

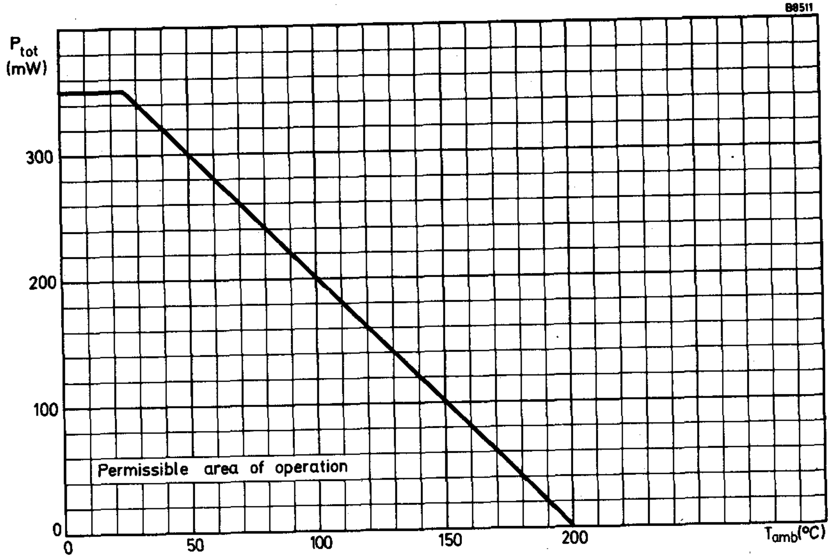
		Min.	Typ.	Max.	
t_d	Delay time	-	23	35	ns
t_r	Rise time	-	25	35	ns
t_{on}	Turn-on time	-	48	65	ns
t_s	Storage time	-	270	350	ns
t_f	Fall time	-	50	80	ns
t_{off}	Turn-off time	-	320	420	ns

Test circuit

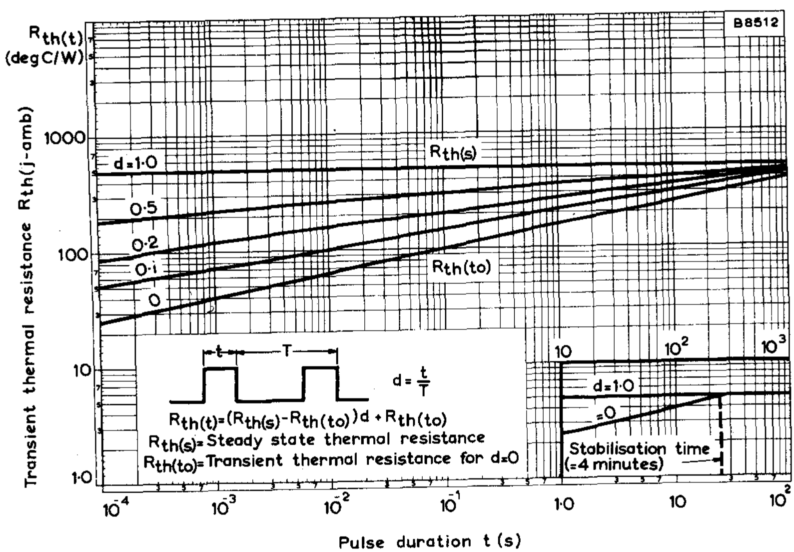


Switching waveforms

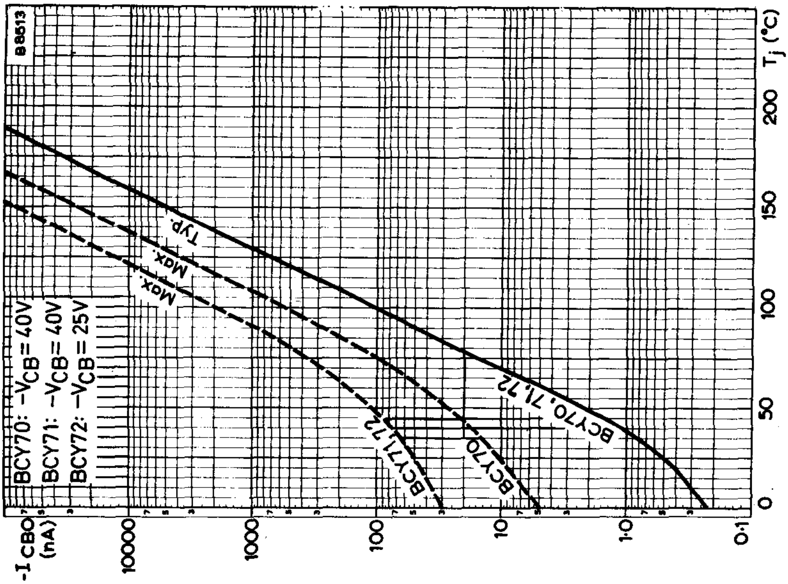


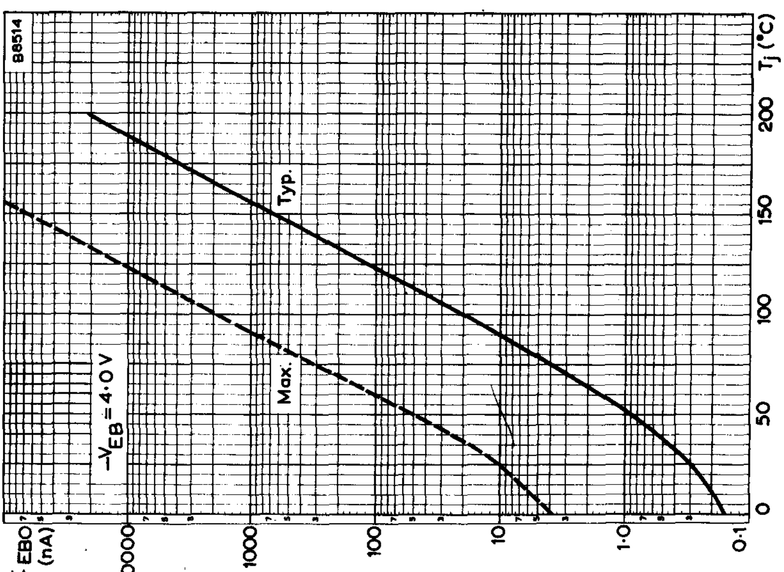


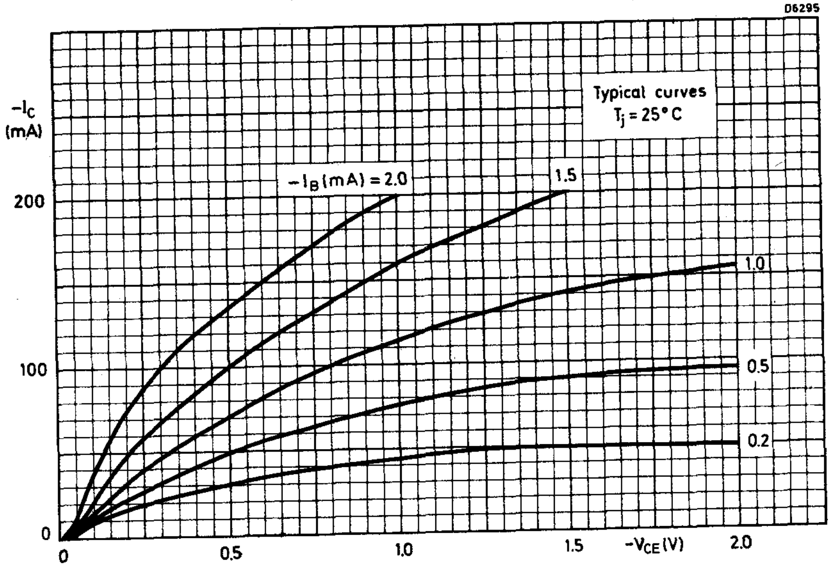
MAXIMUM TOTAL DISSIPATION PLOTTED AGAINST AMBIENT TEMPERATURE

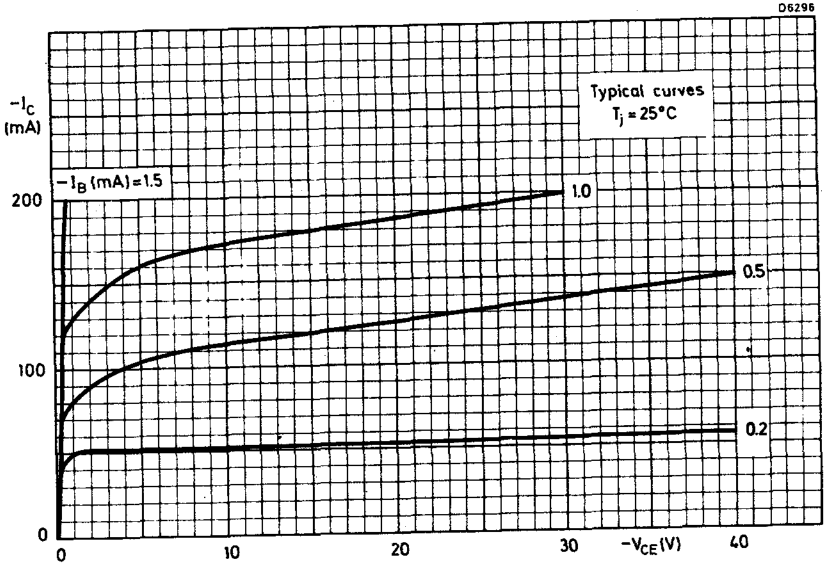


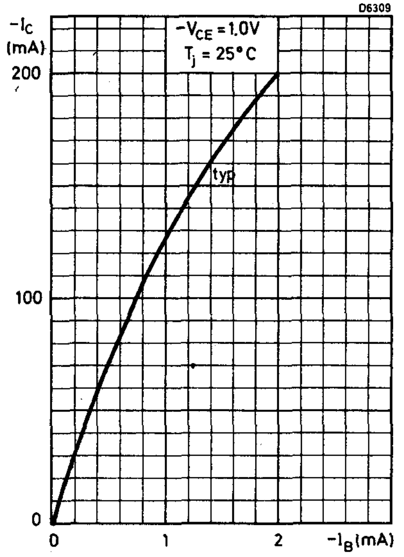
TRANSIENT THERMAL RESISTANCE FOR VARIOUS DUTY FACTORS PLOTTED AGAINST PULSE DURATION

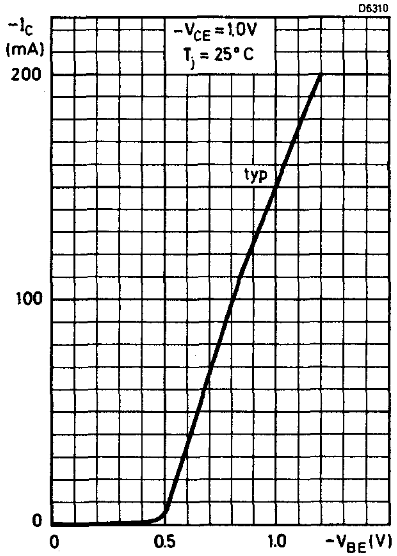

B8513
-I CBO (nA)
10000
1000
100
10
1·0
0·1
0
50
100
150
200
Tj (°C)
BCY70: −VCB = 40V
BCY71: −VCB = 40V
BCY72: −VCB = 25V
Typ.
Max.
Max.
BCY70, 71, 72
BCY70
BCY71, 72

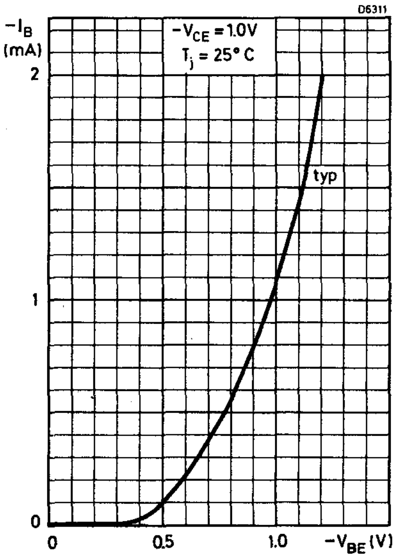

B8514
-I EBO (nA)
10000
1000
100
10
1·0
0·1
0
50
100
150
200
Tj (°C)
−VEB = 4·0 V
Typ.
Max.


D6295
Typical curves
$T_j = 25°C$
$-I_C$ (mA)
200
100
0
$-I_B$ (mA) = 2.0
1.5
1.0
0.5
0.2
0
0.5
1.0
1.5
$-V_{CE}$ (V)
2.0


D6296
Typical curves
$T_j = 25°C$
$-I_C$ (mA)
200
100
0
$-I_B$ (mA) = 1.5
1.0
0.5
0.2
0
10
20
30
$-V_{CE}$ (V)
40

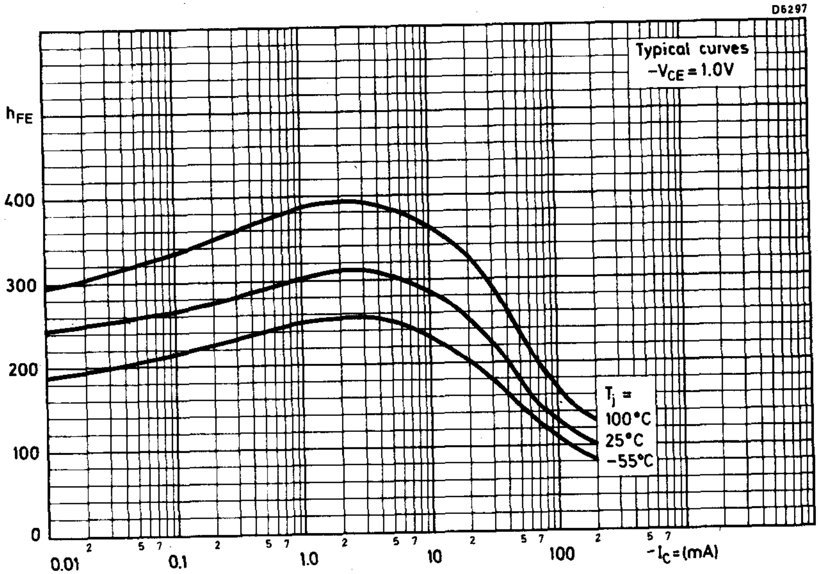




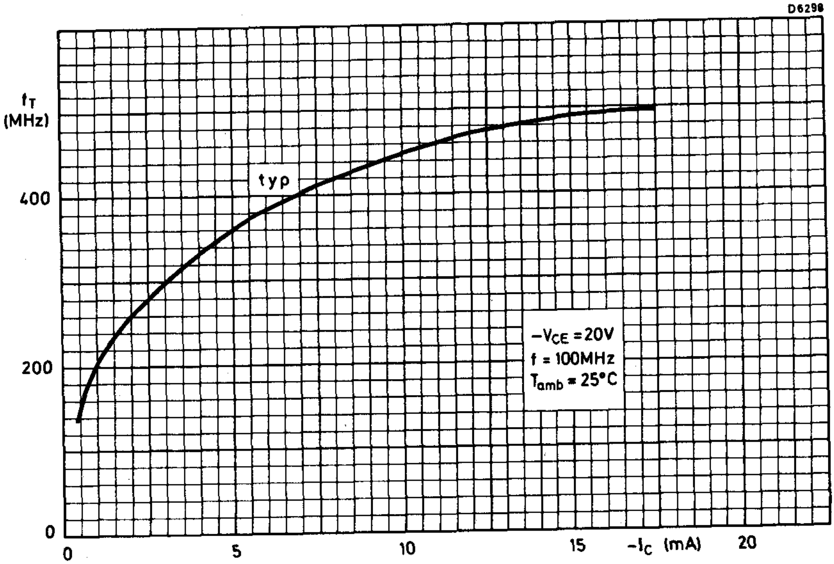


TYPICAL TRANSFER, MUTUAL AND INPUT CHARACTERISTICS

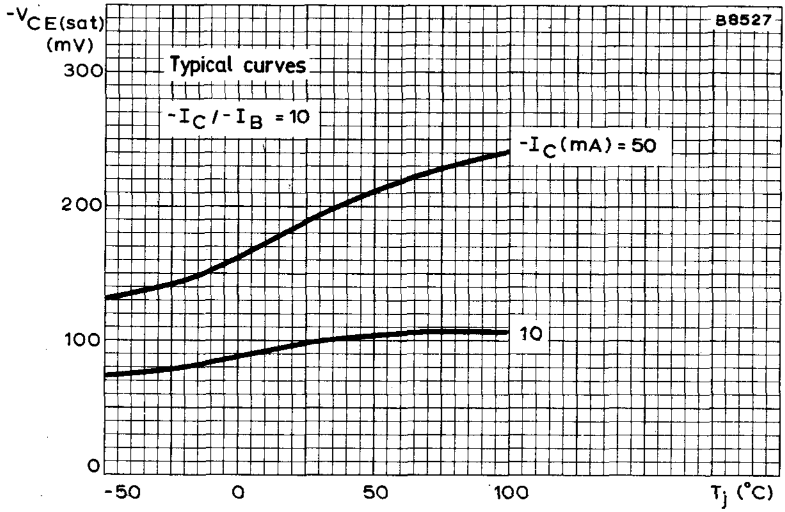
D6297

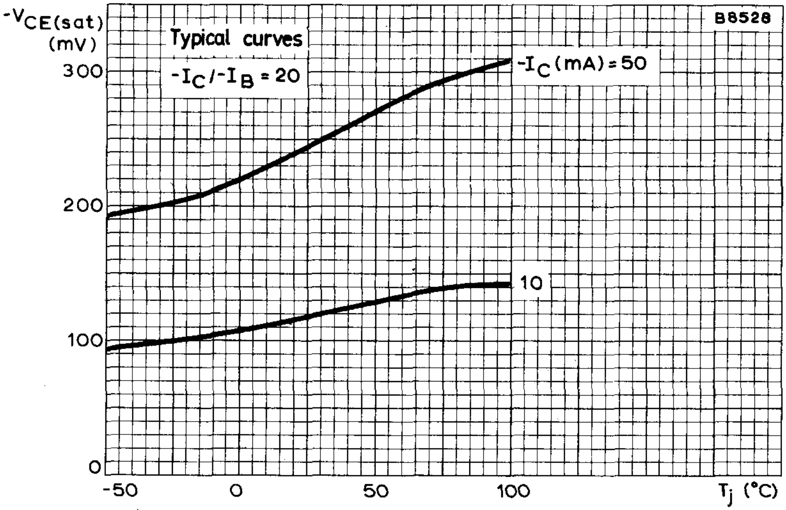


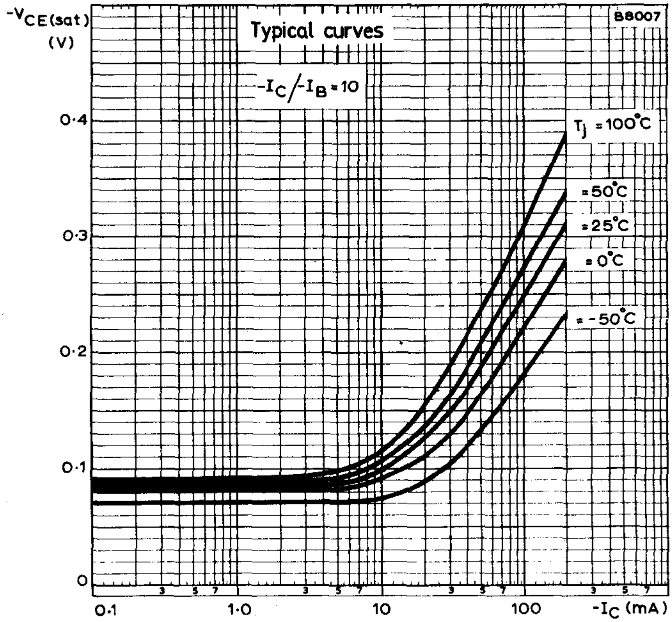
D6298

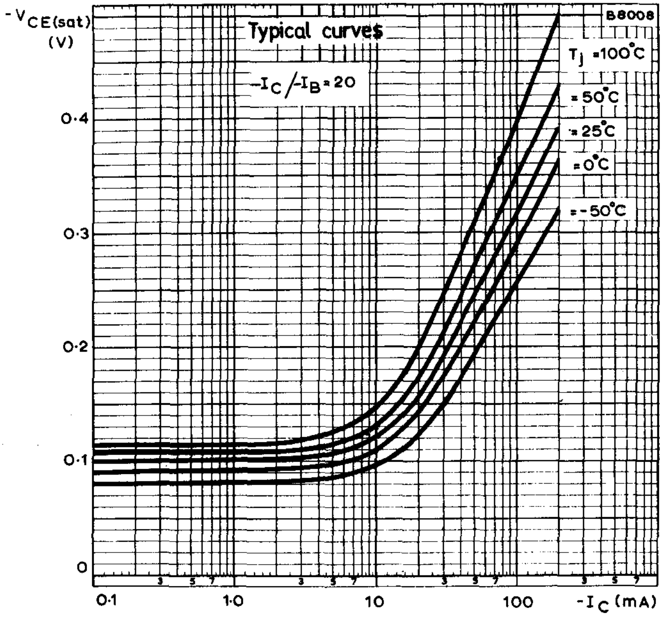


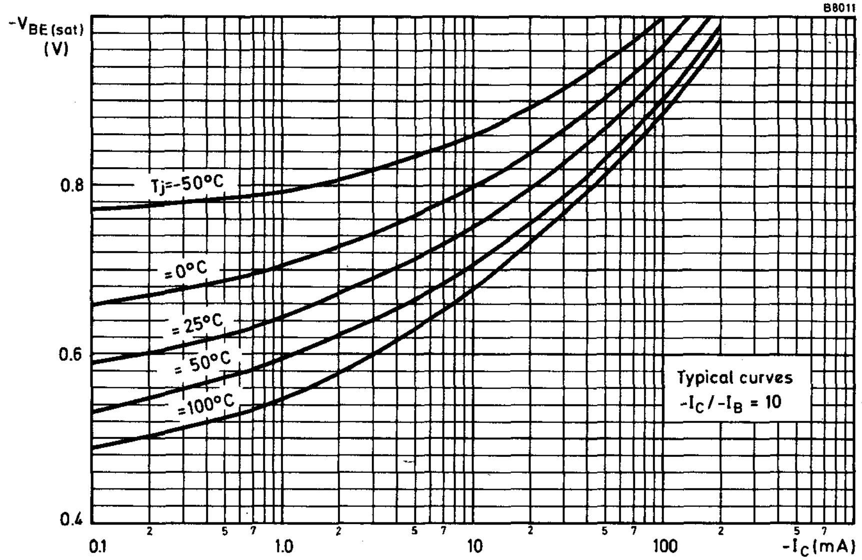
Mullard

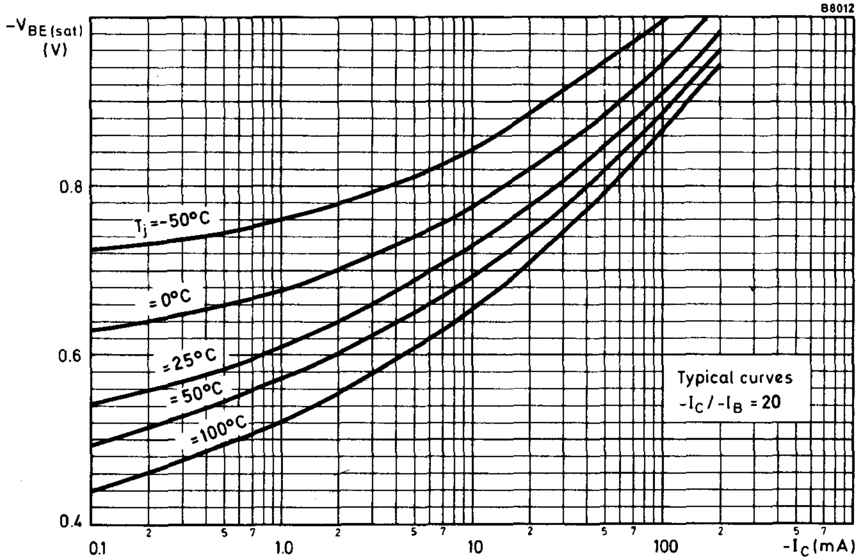

B8527
$-V_{CE(sat)}$ (mV)
Typical curves
$-I_C/-I_B = 10$
$-I_C$(mA) = 50
10
300
200
100
0
-50
0
50
100
T_j (°C)

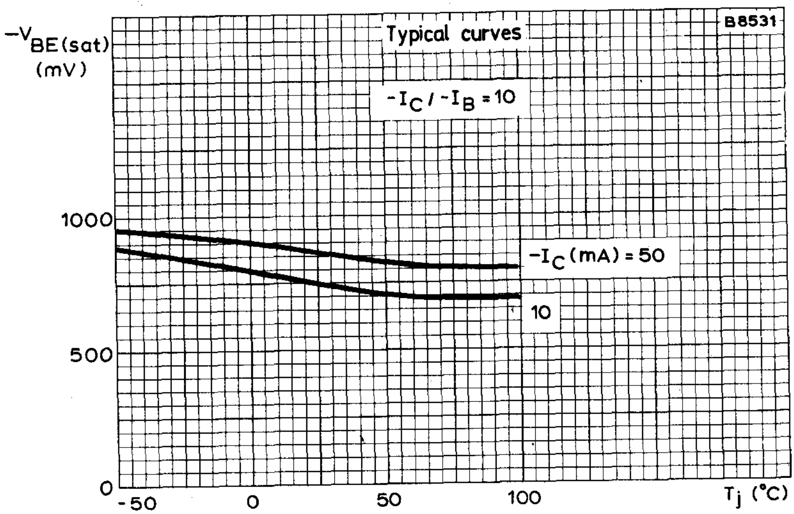

B8528
$-V_{CE(sat)}$ (mV)
Typical curves
$-I_C/-I_B = 20$
$-I_C$(mA) = 50
10
300
200
100
0
-50
0
50
100
T_j (°C)

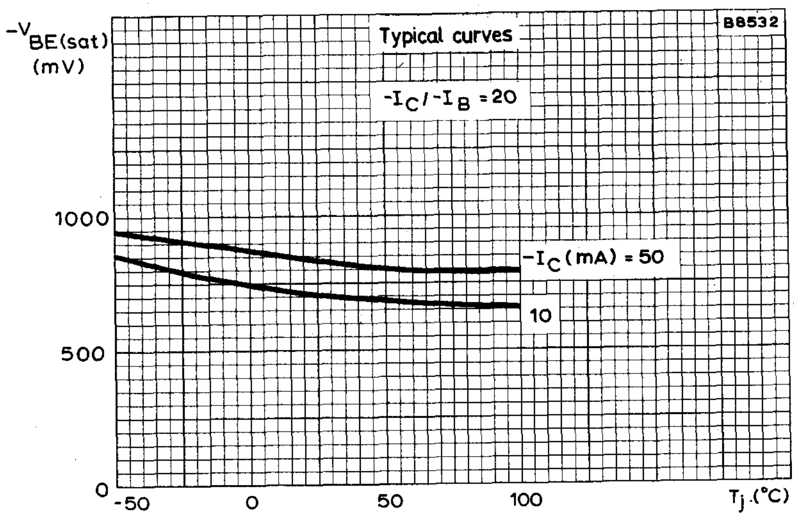

-$V_{CE(sat)}$ (V)
B8007
Typical curves
$-I_C/-I_B = 10$
T_j = 100°C
= 50°C
= 25°C
= 0°C
= -50°C
0·4
0·3
0·2
0·1
0
0·1
1·0
10
100
$-I_C$ (mA)

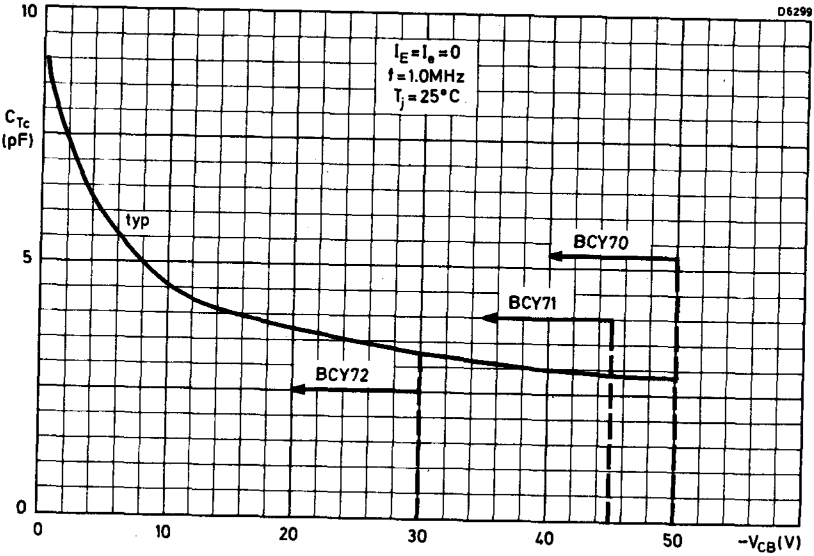

-$V_{CE(sat)}$ (V)
B8008
Typical curves
$-I_C/-I_B = 20$
T_j = 100°C
= 50°C
= 25°C
= 0°C
= -50°C
0·4
0·3
0·2
0·1
0
0·1
1·0
10
100
$-I_C$ (mA)


B8011
$-V_{BE(sat)}$ (V)
0.8
0.6
0.4
Tj=-50°C
=0°C
=25°C
=50°C
=100°C
Typical curves
$-I_C/-I_B = 10$
0.1
1.0
10
100
$-I_C$(mA)

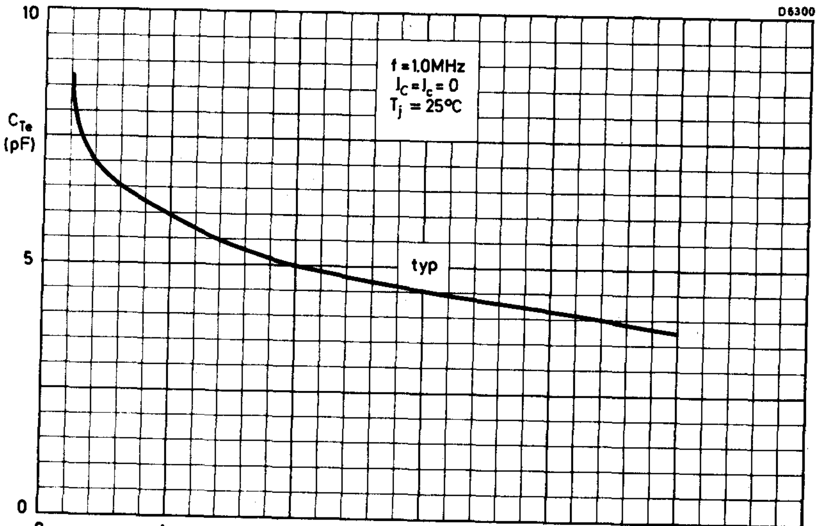

B8012
$-V_{BE(sat)}$ (V)
0.8
0.6
0.4
T_j=-50°C
=0°C
=25°C
=50°C
=100°C
Typical curves
$-I_C/-I_B = 20$
0.1
1.0
10
100
$-I_C$(mA)


B8531
$-V_{BE(sat)}$ (mV)
Typical curves
$-I_C/-I_B = 10$
1000
500
0
$-I_C$ (mA) = 50
10
-50
0
50
100
T_j (°C)

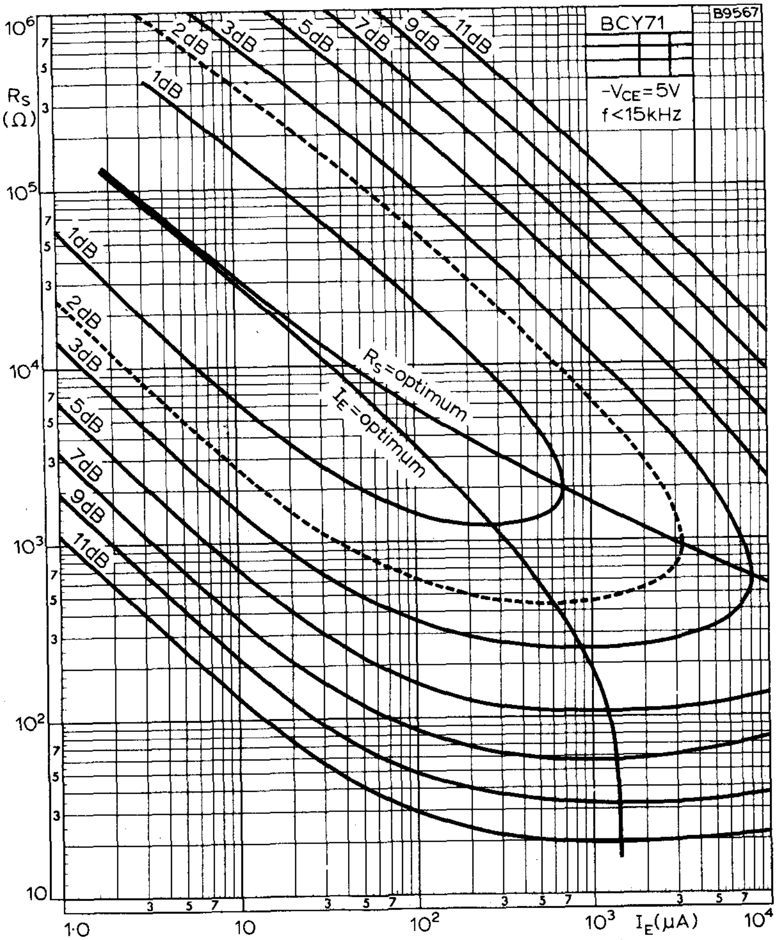

B8532
$-V_{BE(sat)}$ (mV)
Typical curves
$-I_C/-I_B = 20$
1000
500
0
$-I_C$ (mA) = 50
10
-50
0
50
100
T_j (°C)



D6299
$I_E = I_e = 0$
f = 1.0MHz
$T_j = 25°C$
C_{Tc} (pF)
typ
BCY70
BCY71
BCY72
10
5
0
0
10
20
30
40
50
$-V_{CB}$(V)

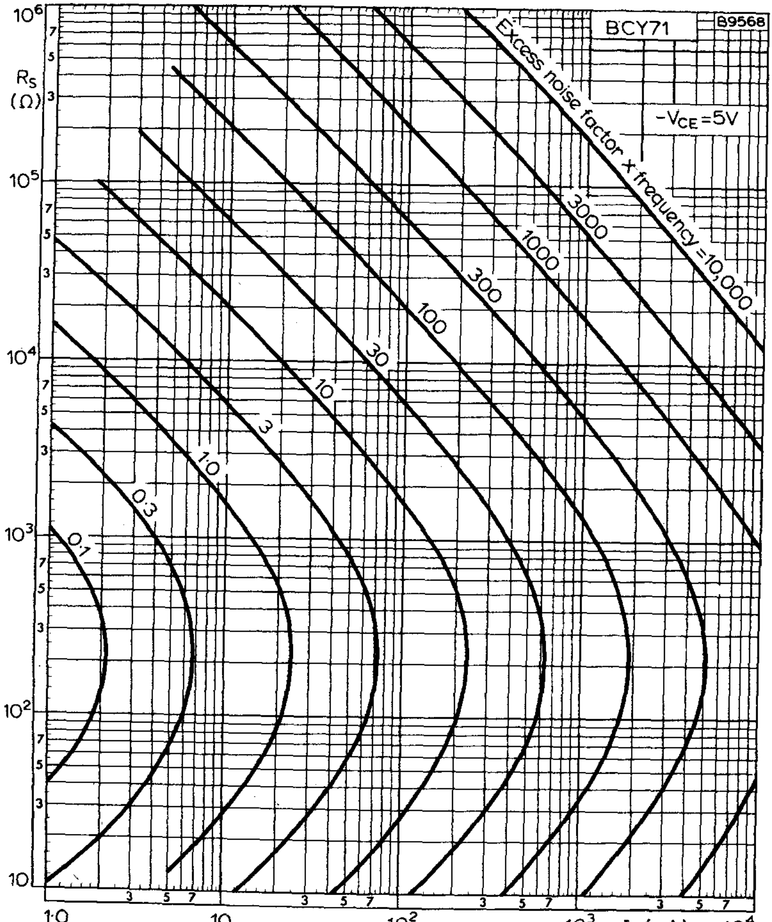


D6300
f = 1.0MHz
$I_C = I_c = 0$
$T_j = 25°C$
C_{Te} (pF)
typ
10
5
0
0
1
2
3
4
5
$-V_{EB}$(V)

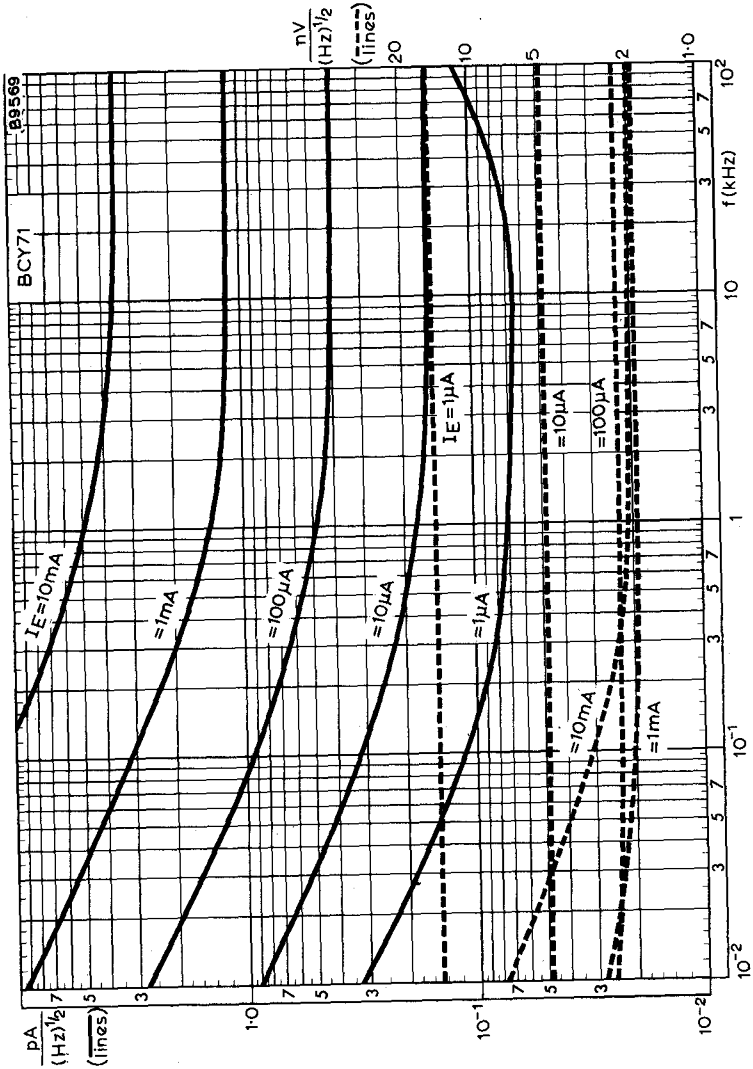


TYPICAL WHITE NOISE CONTOURS

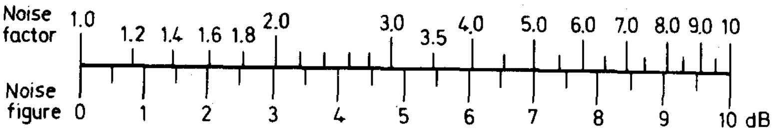
This graph should be read in conjunction with the note on page 19



TYPICAL FLICKER NOISE CONTOURS
This graph should be read in conjunction with the note on page 19



TYPICAL NOISE PERFORMANCE UNDER OPEN AND SHORT-CIRCUITED INPUT CONDITIONS
EQUIVALENT R.M.S. INPUT VALUES



At frequencies in the lower portion of the audio range, particularly when running under emitter current-source resistance conditions corresponding to the centre and upper right hand portion of the contour diagram (see page 16), flicker noise will add significantly to the white levels indicated.

As:

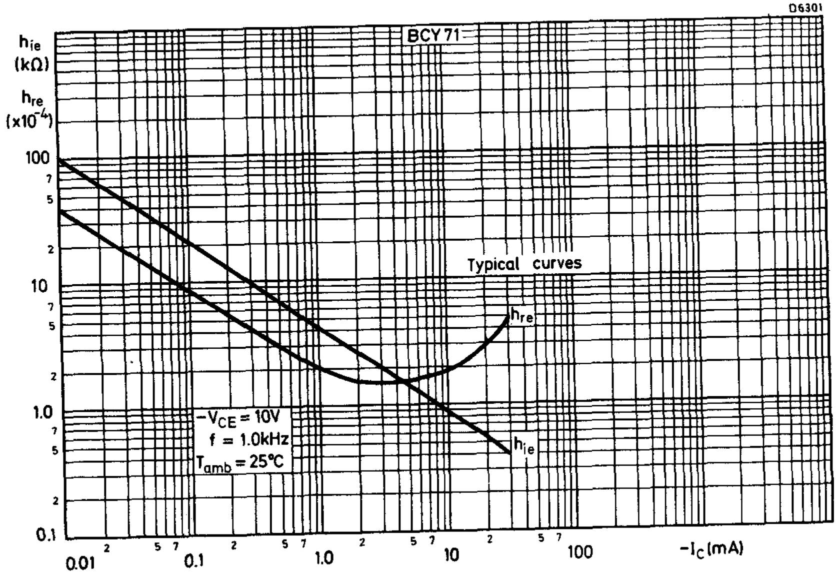
$$N = 1 + \frac{\text{internally generated white noise}}{\text{noise attributable to the source}} + \frac{\text{internally generated flicker noise}}{\text{noise attributable to the source}}$$

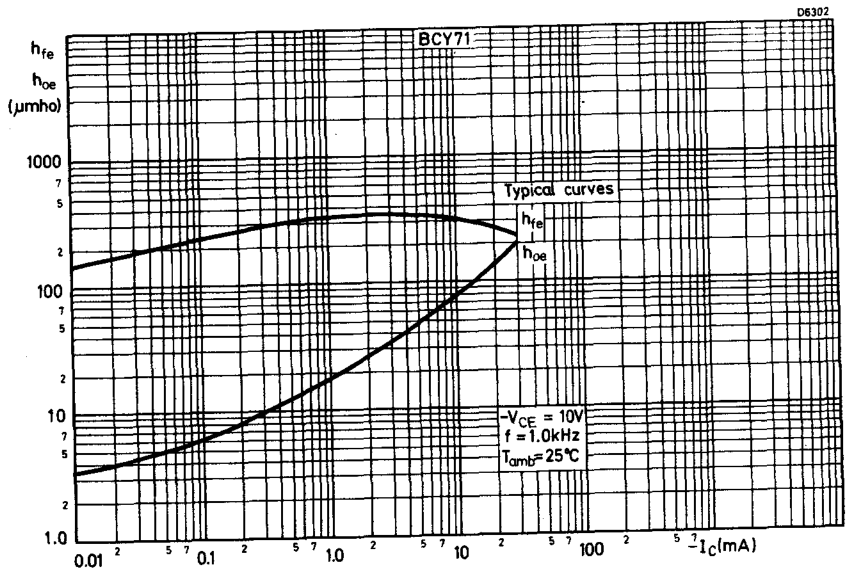
the complete noise factor (N) can be arrived at by adding the flicker excess noise factor (3rd term above) obtained from the flicker contours, to the white noise factor given via the conversion scale provided.

EXAMPLE

To obtain the typical noise figure at $f = 200\text{Hz}$ with $R_S = 10\text{k}\Omega$ and $I_E = 200\mu\text{A}$

	Figure	Factor
From the white noise figure contours	0.9dB	
From the conversion scale		1.23
From the flicker noise contours, the "excess noise factor × frequency" product ≈ 110: giving at 200Hz a flicker excess noise factor of:		0.55
Therefore complete noise factor is		1.78
or in noise figure	2.5dB	


D6301
BCY71
h_{ie} (kΩ)
h_{re} (x10^{-4})
100
10
1.0
0.1
Typical curves
h_{re}
h_{ie}
$-V_{CE}$ = 10V
f = 1.0kHz
T_{amb} = 25°C
0.01
0.1
1.0
10
100
$-I_C$(mA)


D6302
BCY71
h_{fe}
h_{oe} (μmho)
1000
100
10
1.0
Typical curves
h_{fe}
h_{oe}
$-V_{CE}$ = 10V
f = 1.0kHz
T_{amb} = 25°C
0.01
0.1
1.0
10
100
$-I_C$(mA)

Mullard

N-P-N SILICON PLANAR DUAL TRANSISTORS

BCY87 BCY88 BCY89

Matched dual n-p-n silicon planar transistors for use in differential amplifiers. The BCY87 and 88 are intended for applications in the pre-stages of differential amplifiers, where low offset, drift and noise are of prime importance.
The BCY89 is for second stages, long tail pairs and more general purposes.
The devices are encapsulated in TO-71 envelopes with all leads insulated from the case.

QUICK REFERENCE DATA

Ratings (each transistor)

V_{CBO} max.	45	V
V_{CEO} max.	40	V
P_{tot} ($T_{amb} \leq 25^{\circ}C$, complete device) max.	150	mW
T_j max.	175	$^{\circ}C$

Characteristics (complete device)

	BCY87	BCY88	BCY89	
I_{C1}/I_{C2} ratio, at equal V_{BE}	0.9-1.11	0.8-1.25	0.67-1.5	
$\left\|I_{B1} - I_{B2}\right\|$ max., at equal V_{BE}	25	80	300	nA
$\frac{\Delta V}{\Delta T}$ max., $T_{amb} = -20$ to $+90^{\circ}C$	3.0	6.0	10	µV/degC
$\frac{\Delta I}{\Delta T}$ max., $T_{amb} = -20$ to $+90^{\circ}C$	0.5	2.0	10	nA/degC

Unless otherwise stated data is applicable to all types

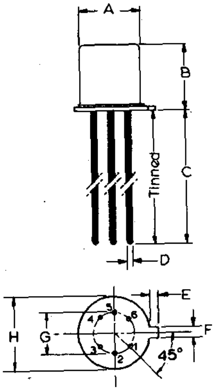
OUTLINE AND DIMENSIONS

Conforming to J.E.D.E.C. TO-71

For details see page 2.

OUTLINE AND DIMENSIONS

Conforming to J.E.D.E.C. TO-71



	Millimetres		
	Min.	Nom.	Max.
A	-	-	4.8
B	-	-	5.3
C	12.7	-	-
D	-	-	0.48
E	-	-	1.17
F	-	-	1.16
G	-	2.54	-
H	-	-	5.83

Connections
1. Emitter (1)
2. Emitter (2)
3. Collector (2)
4. Base (2)
5. Base (1)
6. Collector (1)

All leads are insulated from the case.

RATINGS (each transistor)

Limiting values of operation according to the absolute maximum system.

Electrical

V_{CBO} max.	45	V
V_{CEO} max.	40	V
V_{EBO} max.	5.0	V
I_C max.	30	mA
P_{tot} max. (complete device, $T_{amb} \leq 25^{o}C$)	150	mW

Temperature

T_{stg} max.	175	^{o}C
T_j max.	175	^{o}C

THERMAL CHARACTERISTIC

$R_{th(j-amb)}$	1.0	degC/mW

N-P-N SILICON PLANAR DUAL TRANSISTORS

BCY87 BCY88 BCY89

ELECTRICAL CHARACTERISTICS of individual transistors

$T_{amb} = 25^{o}C$ unless otherwise stated

			Min.	Max.	
I_{CBO}	Collector cut-off current				
	$V_{CB} = 20V$, $I_E = 0$	BCY89	-	10	nA
	$V_{CB} = 20V$, $I_E = 0$, $T_{amb} = 90^{o}C$	BCY87	-	5.0	nA
		BCY88	-	20	nA
h_{FE}	Static forward current transfer ratio				
	$I_C = 5.0\mu A$, $V_{CB} = 10V$	BCY87	80	-	
	$I_C = 50\mu A$, $V_{CB} = 10V$	BCY87, 8, 9	100	450	
	$I_C = 500\mu A$, $V_{CB} = 10V$	BCY88	120	600	
	$I_C = 10mA$, $V_{CB} = 10V$	BCY89	100	600	
f_T	Transition frequency				
	$-I_E = 50\mu A$, $V_{CB} = 10V$		10	-	MHz
	$-I_E = 500\mu A$, $V_{CB} = 10V$		50	-	MHz
C_{tc}	Collector capacitance				
	$I_E = I_e = 0$, $V_{CB} = 10V$, f = 1.0MHz		-	3.5	pF
N	Noise figure				
	$I_C = 50\mu A$, $V_{CE} = 5.0V$, $R_s = 10k\Omega$, Bandwidth = 10Hz to 15kHz	BCY87	-	3.0	dB
		BCY88, 9	-	4.0	dB
	1.0kHz spot noise figure, $I_C = 50\mu A$, $V_{CE} = 5.0V$, R_s = opt., Bandwidth = 200Hz	BCY87	-	4.0	dB
		BCY88, 9	-	5.0	dB

ELECTRICAL CHARACTERISTICS of complete device

The characteristics are valid under the following conditions:-

$V_{C1B1} = V_{C2B2} \leq 10V$, $-(I_{E1} + I_{E2}) = 10$ to $100\mu A$

Matching characteristics (see Fig.1)

			Min.	Max.	
I_{C1}/I_{C2}	Ratio of collector currents $V_{B1E1} = V_{B2E2}$	BCY87	0.9	1.11	
		BCY88	0.8	1.25	
		BCY89	0.67	1.5	
$\lvert V_{B1E1} - V_{B2E2} \rvert$	Difference between base-emitter voltages $I_{C1} = I_{C2}$	BCY87	-	3.0	mV
		BCY88	-	6.0	mV
		BCY89	-	10	mV
$\lvert I_{B1} - I_{B2} \rvert$	Difference between base currents $V_{B1E1} = V_{B2E2}$	BCY87	-	25	nA
		BCY88	-	80	nA
		BCY89	-	300	nA

Illustration of matching characteristics

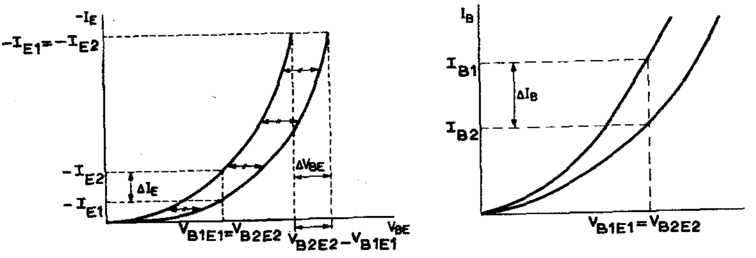


Fig.1

$I_{E2}/I_{E1} = \exp. \frac{q}{KT} . \Delta V_{BE}$

Where

I_{E2}/I_{E1} is measured at $\Delta V_{BE} = 0$

ΔV_{BE} is measured at $I_{E2}/I_{E1} = 1$

N-P-N SILICON PLANAR DUAL TRANSISTORS

BCY87
BCY88
BCY89

ELECTRICAL CHARACTERISTICS of complete device (cont'd)

Equivalent circuit for drift

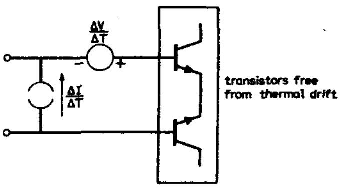
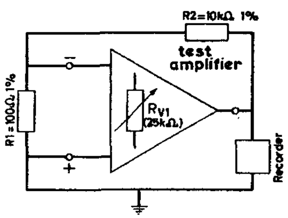


Fig.2

			Typ.	Max.	
$\frac{\Delta V}{\Delta T}$	Equivalent differential voltage change with temperature, T_{amb} = -20 to +90°C	BCY87	1.0	3.0	µV/degC
		BCY88	2.0	6.0	µV/degC
		BCY89	4.0	10	µV/degC
$\frac{\Delta I}{\Delta T}$	Equivalent differential current change with temperature, T_{amb} = -20 to +90°C	BCY87	-	0.5	nA/degC
		BCY88	-	2.0	nA/degC
		BCY89	-	10	nA/degC

Test circuit for $\frac{\Delta V}{\Delta T}$

(For details of test amplifier see page 7)



Test circuit for $\frac{\Delta I}{\Delta T}$

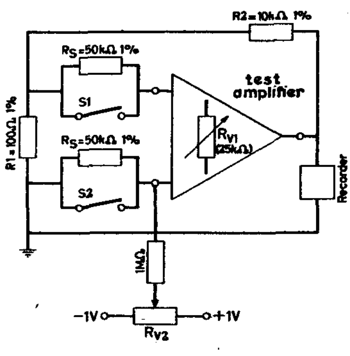


Fig.3

$$\frac{\Delta V}{\Delta T} = \frac{V_{T2} - V_{T1}}{T_2 - T_1} \cdot \frac{R_1}{R_2}$$

$$\frac{\Delta I}{\Delta T} = \frac{V_{T2} - V_{T1}}{T_2 - T_1} \cdot \frac{R_1}{R_2} \cdot \frac{1}{2R_s}$$

Amplification factor determined by feedback circuit: $R_2/R_1 = 100$

Output voltage is plotted against time on a recorder.

ELECTRICAL CHARACTERISTICS of complete device (cont'd)

Test procedure

The temperature of the amplifier is set to T_1 (between -20 and +90°C) and when it has stabilised, the output voltage is adjusted to zero (V_{T1} < 100mV)†. The amplifier temperature is then adjusted to T_2 (between -20 and +90°C) and when it has stabilised, the output voltage V_{T2} can be read off.

†For ΔV/ΔT: adjusted by R_{V1}, for ΔI/ΔT: first by R_{V1} with S_1 and S_2 closed, then by R_{V2} with the switches open.

Note

The ΔI/ΔT given is valid only when source resistances are almost equal.

The ΔV/ΔT given is valid only when base-emitter voltages are almost equal.

DIFFERENTIAL TEST AMPLIFIER

The test amplifier (including feedback resistors, source-resistors and biasing resistors) should be mounted in a small box to ensure a uniform temperature throughout.

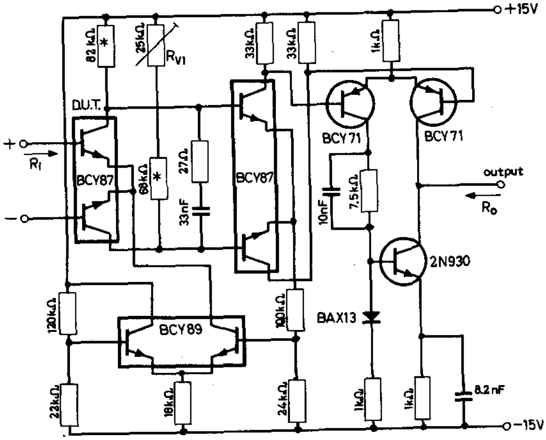


Fig.5

*Relative temperature coefficient $< 10^{-5}$/degC

D.U.T. = device under test

Performance of test amplifier

Open loop voltage gain ($Z_L = 10k\Omega$)	G_v	typ.	10^5	
Frequency at which $G_v = 1$	f_1	typ.	10	MHz
Max. common mode input voltage range			±10	V
Max. output current			±2.5	mA
Max. output voltage			±10	V
Input resistance	R_i		≥100	kΩ
Output resistance	R_o	typ.	20	kΩ
Common mode rejection ratio			10^5	

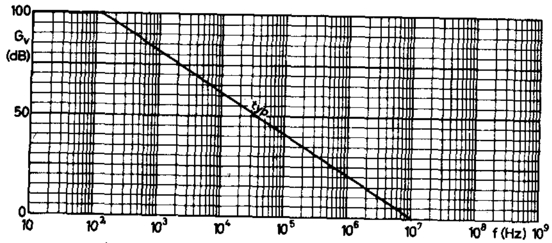


Fig.6

N-P-N SILICON PLANAR EPITAXIAL TRANSISTORS

BD131
2-BD131

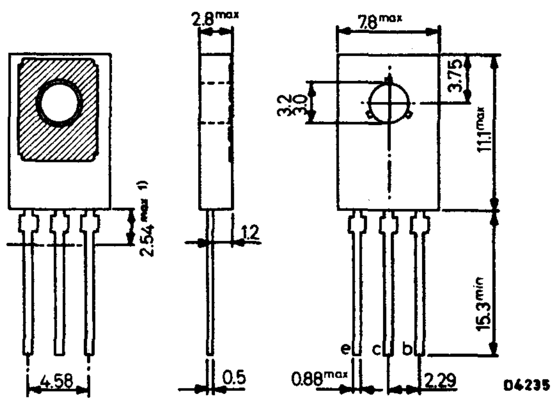
Silicon n-p-n planar epitaxial transistor for general purpose, medium power applications. The BD131 may also be used with the BD132 to form a complementary pair for push-pull, audio output stages. (See page 4 and BD132 data sheet).

QUICK REFERENCE DATA		
V_{CBO} max. ($I_C \leq 1.0$mA)	70	V
V_{CEO} max.	45	V
I_{CM} max.	6.0	A
P_{tot} max. ($T_{mb} \leq 60^{o}$C)	15	W
h_{FE} min. (I_C = 0.5A, V_{CE} =12V)	40	
f_T min. (I_C = 0.25A, V_{CE} = 5.0V, f = 35MHz, T_{amb} = 25°C)	60	MHz

OUTLINE AND DIMENSIONS

Conforms to J.E.D.E.C. TO-126

Collector connected to the metal part of the mounting surface.



All dimensions in mm

1) Within this region the cross-section of the leads is uncontrolled.

Care should be taken not to bend the leads nearer than 2.5mm from the body. The leads above this point should be clamped during any lead bending operation.

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

V_{CBO} max.	70	V
V_{CEO} max.	45	V
V_{EBO} max.	6.0	V
I_C max.	3.0	A
I_{CM} max.	6.0	A
$\pm I_{BM}$ max.	0.5	A
P_{tot} max. ($T_{mb} \leq 60^{o}C$)	15	W

Temperature

T_{stg} range	-55 to +150	^{o}C
T_j max.	+150	^{o}C

THERMAL CHARACTERISTICS

$R_{th(j-mb)}$	Thermal resistance junction to mounting base	6.0	$^{o}C/W$
$R_{th(mb-h)}$	Contact thermal resistance without insulating material	1.0	$^{o}C/W$
$R_{th(mb-h)}$	Contact thermal resistance with the mica washer 56301B	4.0	$^{o}C/W$

The use of a heatsink compound is essential. When the mica washer is used, the compound must be applied to both sides of the washer.

ELECTRICAL CHARACTERISTICS ($T_j = 25^{o}C$ unless otherwise stated)

		Min.	Max.	
I_{CBO}	Collector cut-off current			
	$V_{CB} = 50V,\ I_E = 0$	-	5.0	μA
	$V_{CB} = 50V,\ I_E = 0,\ T_j = 150^{o}C$	-	500	μA
I_{EBO}	Emitter cut-off current			
	$V_{EB} = 5.0V,\ I_C = 0$	-	5.0	μA
h_{FE}	Static forward current transfer ratio			
	$I_C = 0.5A,\ V_{CE} = 12V$	40	-	
	$I_C = 2.0A,\ V_{CE} = 1.0V$	20	-	
$V_{CE(sat)}$	Collector-emitter saturation voltage			
	$I_C = 0.5A,\ I_B = 50mA$	-	0.3	V
	$I_C = 2.0A,\ I_B = 200mA$	-	0.7	V

ELECTRICAL CHARACTERISTICS (contd.)

		Min.	Max.	
$V_{BE(sat)}$	Base-emitter saturation voltage			
	$I_C = 0.5A$, $I_B = 50mA$	-	1.2	V
	$I_C = 2.0A$, $I_B = 200mA$	-	1.5	V
C_{Tc}	Collector capacitance			
	$V_{CB} = 5.0V$, $I_E = I_e = 0$, $f = 1.0MHz$	-	60	pF
f_T	Transition frequency			
	$I_C = 0.25A$, $V_{CE} = 5.0V$			
	$f = 35MHz$, $T_{amb} = 25^oC$	60	-	MHz

MECHANICAL DATA

Maximum torque on nut	4.0	kg cm
	0.4	N m
Minimum torque on nut for good thermal contact	3.0	kg cm
	0.3	N m

ACCESSORIES

Accessory	Code No.	Note
1 Mica washer	56301B	Supplied on request
1 Plain washer	56326	

When mounted on a heatsink it is essential that the plain washer be used to prevent damage to the device while tightening the mounting screw.

ELECTRICAL CHARACTERISTICS OF COMPLEMENTARY PAIRS (BD131/BD132)

			Min.	Max.	
BD131	h_{FE}	$I_C = 0.5A$, $V_{CE} = 12V$	78	250	
		$I_C = 2.0A$, $V_{CE} = 1.0V$	40	-	
BD132	h_{FE}	$-I_C = 0.5A$, $-V_{CE} = 12V$	78	250	
		$-I_C = 2.0A$, $-V_{CE} = 1.0V$	40	-	

(See also page 10)

		Min.	Max.	
ΔI_B	Difference in base currents $(I_{B1} - I_{B2})$ at $I_C = 0.5A$, $V_{CE} = 12V$ (BD131) and $-I_C = 0.5A$, $-V_{CE} = 12V$ (BD132)	-	1.0	mA

(See General Operating Note)

ELECTRICAL CHARACTERISTICS OF MATCHED PAIRS (2-BD131)

		Min.	Max.	
h_{FE}	$I_C = 0.5A$, $V_{CE} = 12V$	40	280	
ΔI_B	Difference in base currents $(I_{B1} - I_{B2})$ at $I_C = 0.5A$, $V_{CE} = 12V$	-	2.0	mA

(See General Operating Note)

GENERAL OPERATING NOTE

		Min.	Max.
$\frac{h_{FE2}}{h_{FE1}}$	Ratio of static forward current transfer ratio for transistors with typical gain at: $I_C = 0.5A$, $V_{CE} = 12V$	-	1.2

For matched pairs with low gain, the resultant negative feedback is reduced and a lower h_{FE} ratio is required to maintain the necessary protection against distortion. Conversely, for matched pairs with a higher gain, the resultant negative feedback is increased and a higher h_{FE} ratio will maintain the necessary protection against distortion.

A general relationship for the approximate second harmonic distortion, d_2, generated by current gain mismatch, is given by the expression:

$$d_2 = \frac{\Delta I_B}{4I_C} \cdot \frac{1}{\beta}$$

where ΔI_B is the difference in base currents, and β the typical feedback ratio for that stage, assuming $\Delta I_B << I_{B2}$.

OPERATING NOTES

The rating graphs given in this data show the maximum permissible current and voltage for combinations of duty cycle and pulse width with a mounting-base temperature up to T_{mb}=60°C. In order to verify that the conditions of operation are within the ratings, note the voltage, current, pulse width and duty cycle applied to the transistor. Compare the application V_{CE} and I_C plot against the V_{CE} v I_C curve with the appropriate pulse width and duty cycle. (e.g. Actual pulse widths of 1.7ms will use the 2.0ms curve, and an actual duty cycle of 0.37 will use the d = 0.5 family of curves). If the application condition is always within the selected SOAR curve it is acceptable.

If the application condition just exceeds the selected SOAR curve, then linear interpolation between the family of curves used and the next lower duty cycle curves should indicate if the application is acceptable.

For applications using non-square-wave pulses, reference should be made to the General Explanatory Notes on SOAR where conversion to equivalent square-wave pulses is explained.

Having approved the transistor application for both electrical and time conditions, the maximum mounting-base temperature can be calculated using the thermal impedance curves * and the following equation: -

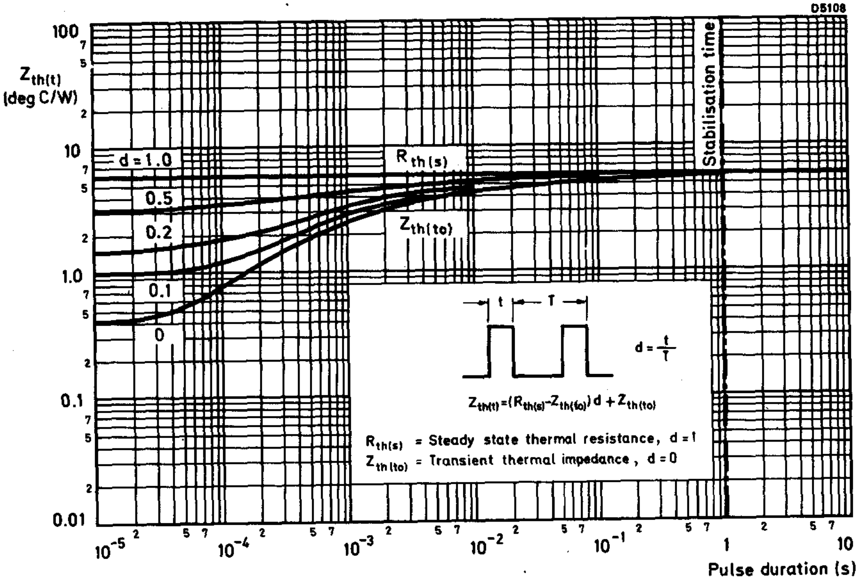
$$T_{mb}\ max = T_j\ max - (P_{pk} \times Z_{th(t)})\ ^{o}C$$

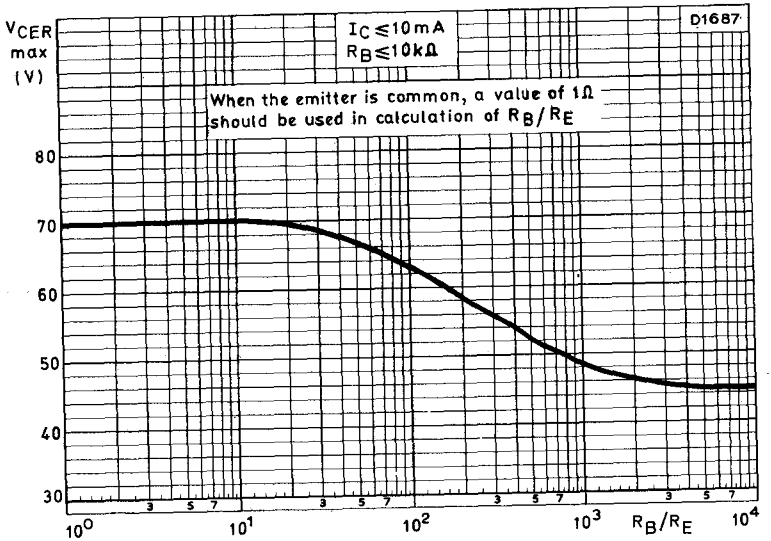
where $P_{pk} = V_{CEM} \times I_{CM}$ (For square-waves)

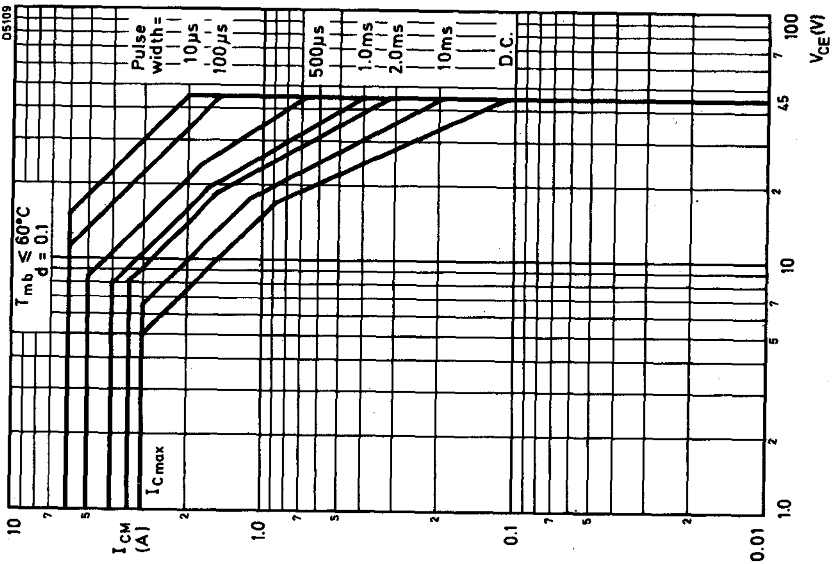
For non-square-waves use equivalent peak power figures.

and $Z_{th(t)}$ = Transient thermal impedance for application pulse width and duty cycle or equivalent pulse width for non-square-waves.

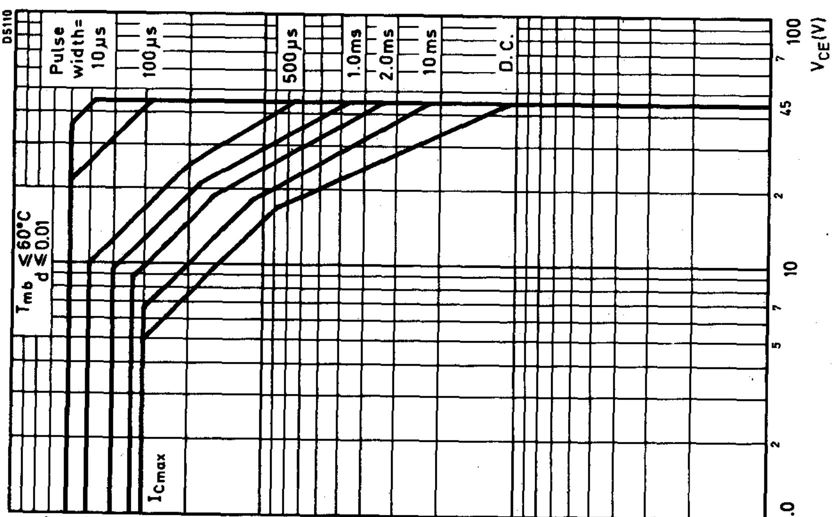
* See page 6


D5108
$Z_{th(t)}$ (deg C/W)
Stabilisation time
d = 1.0
0.5
0.2
0.1
0
$R_{th(s)}$
$Z_{th(to)}$
t
T
d = t/T
$Z_{th(t)} = (R_{th(s)} - Z_{th(to)})\,d + Z_{th(to)}$
$R_{th(s)}$ = Steady state thermal resistance, d = 1
$Z_{th(to)}$ = Transient thermal impedance, d = 0
Pulse duration (s)

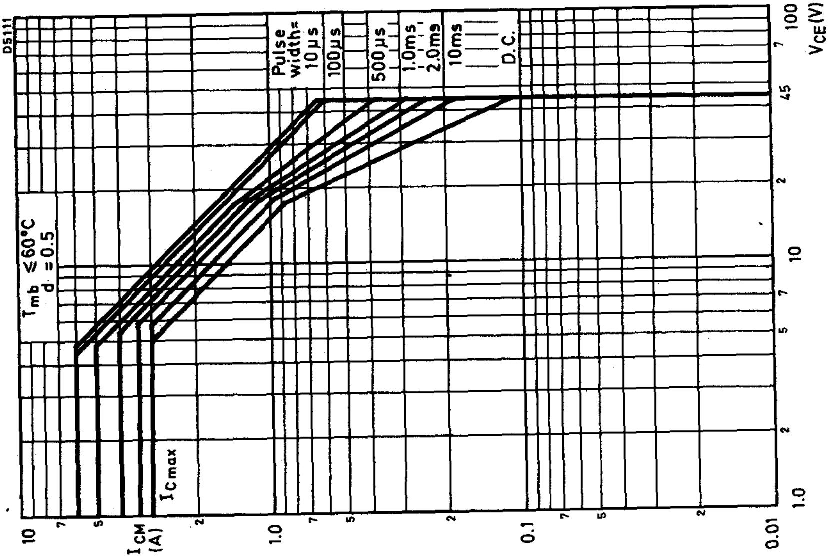

D1687
V_{CER} max (V)
$I_C \leq 10\,mA$
$R_B \leq 10\,k\Omega$
When the emitter is common, a value of 1Ω should be used in calculation of R_B/R_E
R_B/R_E

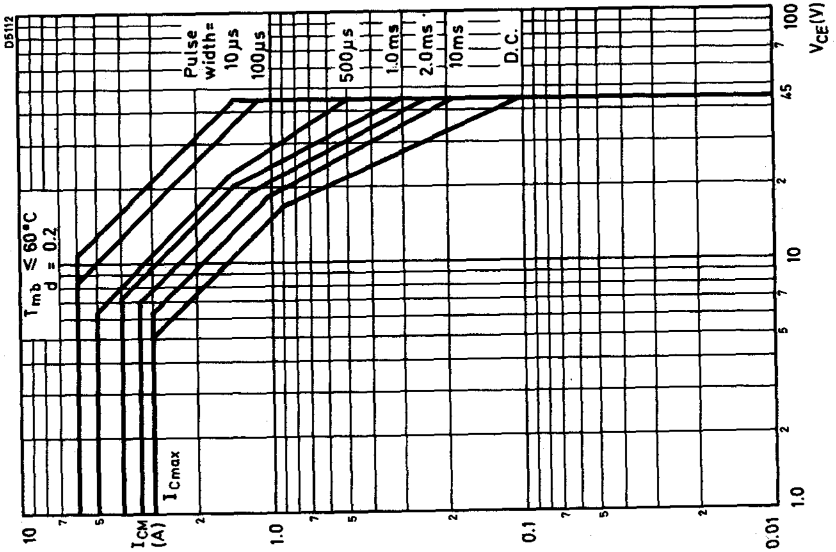


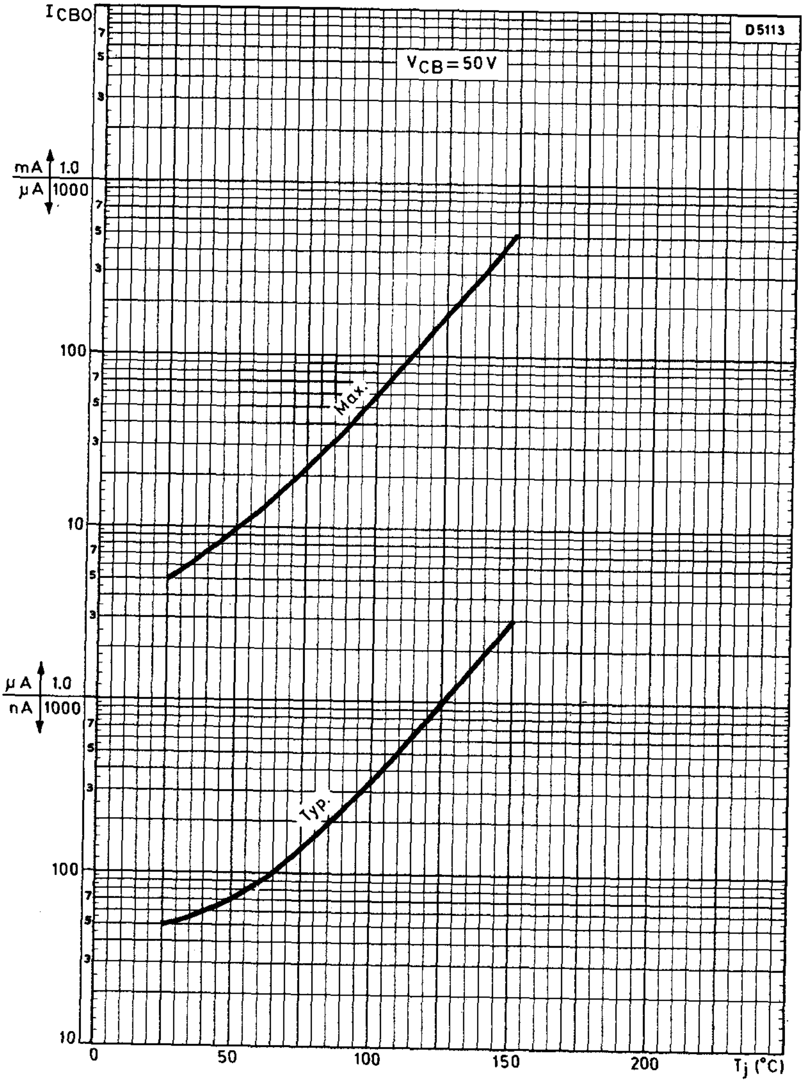
D5109
Pulse width =
10μs
100μs
500μs
1.0ms
2.0ms
10ms
D.C.
$T_{mb} \leqslant 60°C$
d = 0.1
$I_{C max}$
I_{CM} (A)
V_{CE}(V)

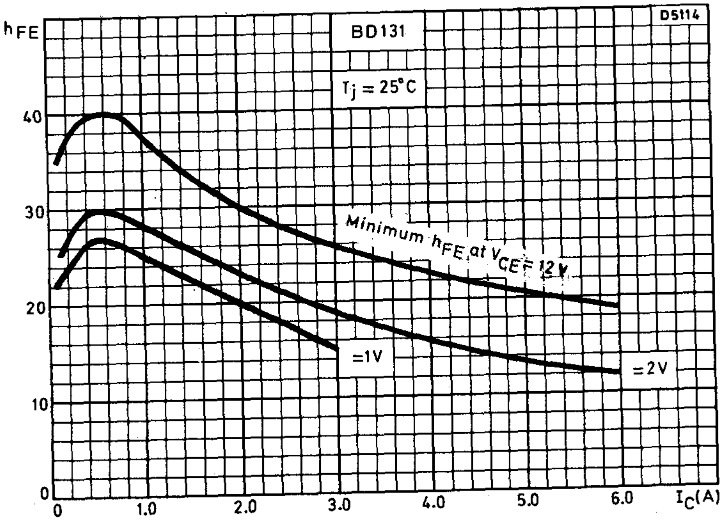


D5110
Pulse width =
10μs
100μs
500μs
1.0ms
2.0ms
10ms
D.C.
$T_{mb} \leqslant 60°C$
$d \leqslant 0.01$
$I_{C max}$
I_{CM} (A)
V_{CE}(V)

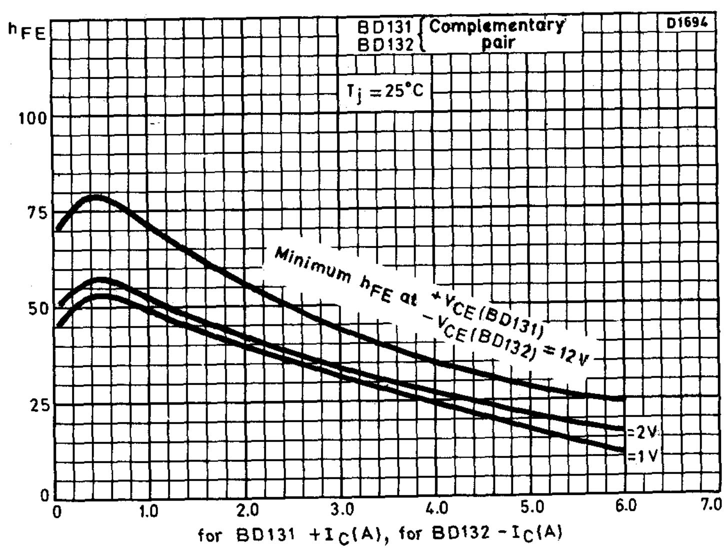

D5111
$T_{mb} \leq 60°C$
d = 0.5
Pulse width=
10 µs
100 µs
500 µs
1.0ms
2.0ms
10ms
D.C.
$I_{C max}$
I_{CM} (A)
V_{CE} (V)


D5112
$T_{mb} \leq 60°C$
d = 0.2
Pulse width=
10 µs
100 µs
500 µs
1.0ms
2.0ms
10ms
D.C.
$I_{C max}$
I_{CM} (A)
V_{CE} (V)

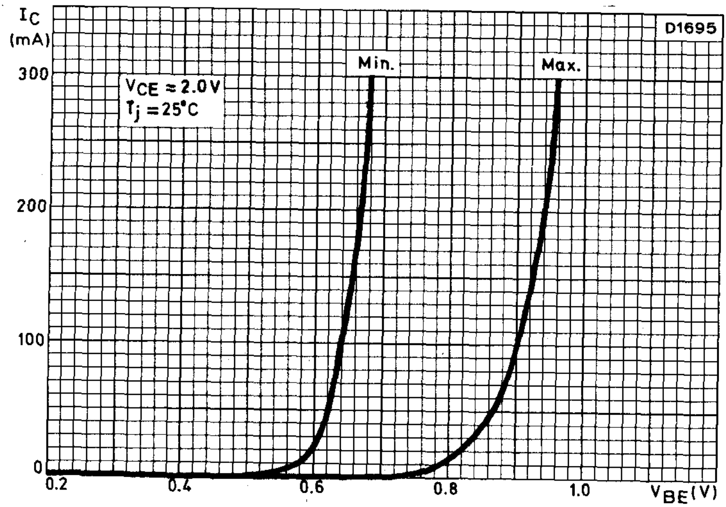

D5113
V_{CB} = 50 V
I_{CBO}
mA 1.0
µA 1000
100
10
µA 1.0
nA 1000
100
10
Max.
Typ.
0
50
100
150
200
T_j (°C)

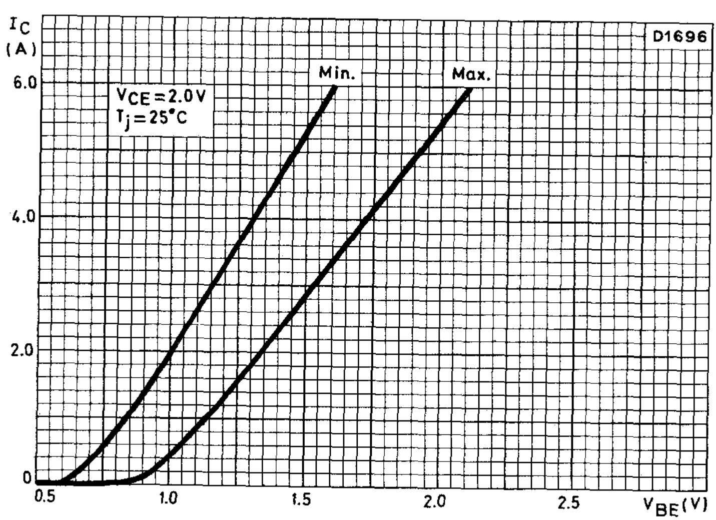


D5114
BD131
$T_j = 25°C$
h_{FE}
Minimum h_{FE} at V_{CE} = 12 V
=1V
=2V
I_C(A)



D1694
BD131 } Complementary pair
BD132 }
$T_j = 25°C$
h_{FE}
Minimum h_{FE} at $+V_{CE}$(BD131) $-V_{CE}$(BD132) = 12 V
=2V
=1V
for BD131 $+I_C$(A), for BD132 $-I_C$(A)


D1695
I_C (mA)
300
200
100
0
0.2
0.4
0.6
0.8
1.0
V_{BE}(V)
Min.
Max.
V_{CE} = 2.0 V
T_j = 25°C


D1696
I_C (A)
6.0
4.0
2.0
0
0.5
1.0
1.5
2.0
2.5
V_{BE}(V)
Min.
Max.
V_{CE} = 2.0 V
T_j = 25°C

P-N-P SILICON PLANAR EPITAXIAL TRANSISTOR

BD132

Silicon p-n-p planar epitaxial transistor for general purpose, medium power applications. The BD132 may also be used with the BD131 to form a complementary pair for push-pull, audio output stages. (See page 4 and BD131 data sheet).

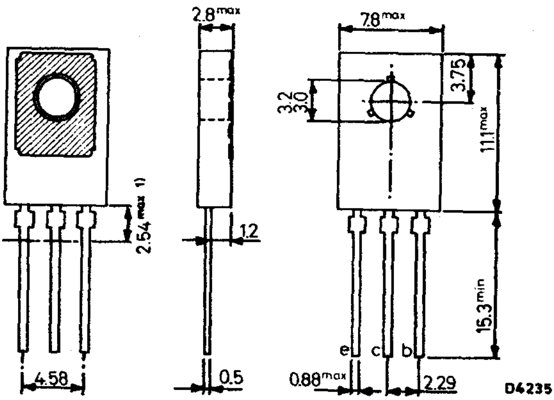
QUICK REFERENCE DATA

$-V_{CBO}$	max. ($-I_C \leq 1.0$mA)	45	V
$-V_{CEO}$	max.	45	V
$-I_{CM}$	max.	6.0	A
P_{tot}	max. ($T_{mb} \leq 60^oC$)	15	W
h_{FE}	min. ($-I_C = 0.5$A, $-V_{CE} = 12$V)	40	
f_T	min. ($-I_C = 0.25$A, $-V_{CE} = 5.0$V, $f = 35$MHz, $T_{amb} = 25^oC$)	60	MHz

OUTLINE AND DIMENSIONS

Conforms to J.E.D.E.C. TO-126

Collector connected to the metal part of the mounting surface.



All dimensions in mm

1) Within this region the cross-section of the leads is uncontrolled.

Care should be taken not to bend the leads nearer than 2.5mm from the body. The leads above this point should be clamped during any lead bending operation.

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

$-V_{CBO}$ max. ($-I_C \leq 1.0$mA)	45	V
$-V_{CEO}$ max.	45	V
$-V_{EBO}$ max.	4.0	V
$-I_C$ max.	3.0	A
$-I_{CM}$ max.	6.0	A
$\pm I_{BM}$ max.	0.5	A
P_{tot} max.($T_{mb} \leq 60^oC$)	15	W

Temperature

T_{stg} range	-55 to +150	^oC
T_j max.	+150	^oC

THERMAL CHARACTERISTICS

$R_{th(j-mb)}$	Thermal resistance junction to mounting-base	6.0	$^oC/W$
$R_{th(mb-h)}$	Contact thermal resistance without insulating material	1.0	$^oC/W$
$R_{th(mb-h)}$	Contact thermal resistance with the mica washer (56301B)	4.0	$^oC/W$

The use of a heatsink compound is essential. When the mica washer is used, the compound must be applied to both sides of the washer.

ELECTRICAL CHARACTERISTICS ($T_j = 25^oC$ unless otherwise stated)

		Min.	Max.	
$-I_{CBO}$	Collector cut-off current $-V_{CB} = 40V,\ I_E = 0$	-	5.0	µA
	$-V_{CB} = 40V,\ I_E = 0,\ T_j = 150^oC$	-	500	µA
$-I_{EBO}$	Emitter cut-off current $-V_{EB} = 3.0V,\ I_C = 0$	-	5.0	µA
h_{FE}	Satic forward current transfer ratio $-I_C = 0.5A,\ -V_{CE} = 12V$	40	-	
	$-I_C = 2.0A,\ -V_{CE} = 1.0V$	20	-	
$-V_{CE(sat)}$	Collector-emitter saturation voltage $-I_C = 0.5A,\ -I_B = 50mA$	-	0.3	V
	$-I_C = 2.0A,\ -I_B = 200mA$	-	0.7	V

P-N-P SILICON PLANAR EPITAXIAL TRANSISTOR

BD132

ELECTRICAL CHARACTERISTICS (contd.)

		Min.	Max.	
$-V_{BE(sat)}$	Base-emitter saturation voltage			
	$-I_C = 0.5A$, $-I_B = 50mA$	-	1.2	V
	$-I_C = 2.0A$, $-I_B = 200mA$	-	1.5	V
f_T	Transition frequency			
	$-I_C = 0.25A$, $-V_{CE} = 5.0V$			
	$f = 35MHz$, $T_{amb} = 25^oC$	60	-	MHz

MECHANICAL DATA

Maximum torque on nut	4.0	kg cm
	0.4	N m
Minimum torque on nut for good thermal contact	3.0	kg cm
	0.3	N m

ACCESSORIES

Accessory	Code No.	Note
1 Mica washer	56301B	Supplied on request
1 Plain washer	56326	

When mounted on a heatsink it is essential that the plain washer be used to prevent damage to the device while tightening the mounting screw.

ELECTRICAL CHARACTERISTICS OF COMPLEMENTARY PAIRS (BD131/BD132)

			Min.	Max.	
BD131	h_{FE}	$I_C = 0.5A,\ V_{CE} = 12V$	78	250	
		$I_C = 2.0A,\ V_{CE} = 1.0V$	40	-	
BD132	h_{FE}	$-I_C = 0.5A,\ -V_{CE} = 12V$	78	250	
		$-I_C = 2.0A,\ -V_{CE} = 1.0V$	40	-	
	(see also page 10)				
	ΔI_B	Difference in base currents ($I_{B1} - I_{B2}$) at $I_C = 0.5A,\ V_{CE} = 12V$ (BD131) and $-I_C = 0.5A,\ -V_{CE} = 12V$ (BD132)	-	1.0	mA
	(see General Operating Note)				

GENERAL OPERATING NOTE

$\frac{h_{FE2}}{h_{FE1}}$	Ratio of static forward current transfer ratio for transistors with typical gain at: $I_C = 0.5A,\ V_{CE} = 12V$ (BD131) and $-I_C = 0.5A,\ -V_{CE} = 12V$ (BD132)	-	1.2

For complementary pairs with low gain, the resultant negative feedback is reduced and a lower h_{FE} ratio is required to maintain the necessary protection against distortion. Conversely, for complementary pairs with a higher gain, the resultant negative feedback is increased and a higher h_{FE} ratio will maintain the necessary protection against distortion.

A general relationship for the approximate second harmonic distortion, d_2, generated by current gain mismatch, is given by the expression:

$$d_2 = \frac{\Delta I_B}{4I_C} \cdot \frac{1}{\beta}$$

where ΔI_B is the difference in base currents, and β the typical feedback ratio for that stage, assuming $\Delta I_B << I_{B2}$.

OPERATING NOTES

The rating graphs given in this data show the maximum permissible current and voltage for combinations of duty cycle and pulse width with a mountingbase temerature up to $T_{mb} = 60^oC$. In order to verify that the conditions of operation are within the ratings, note the voltage, current, pulse width and duty cycle applied to the transistor. Compare the application V_{CE} and I_C plot against the V_{CE} v. I_C curve with the appropriate pulse width and duty cycle. (e.g. Actual pulse widths of 1.7ms will use the 2.0ms curve, and an actual duty cycle of 0.37 will use the d = 0.5 family of curves). If the application condition is always within the selected SOAR curve it is acceptable.

If the application condition just exceeds the selected SOAR curve, then linear interpolation between the family of curves used and the next lower duty cycle curves should indicate if the application is acceptable.

For applications using non-square-wave pulses, reference should be made to the General Explanatory Notes on SOAR where conversion to equivalent square-wave pulses is explained.

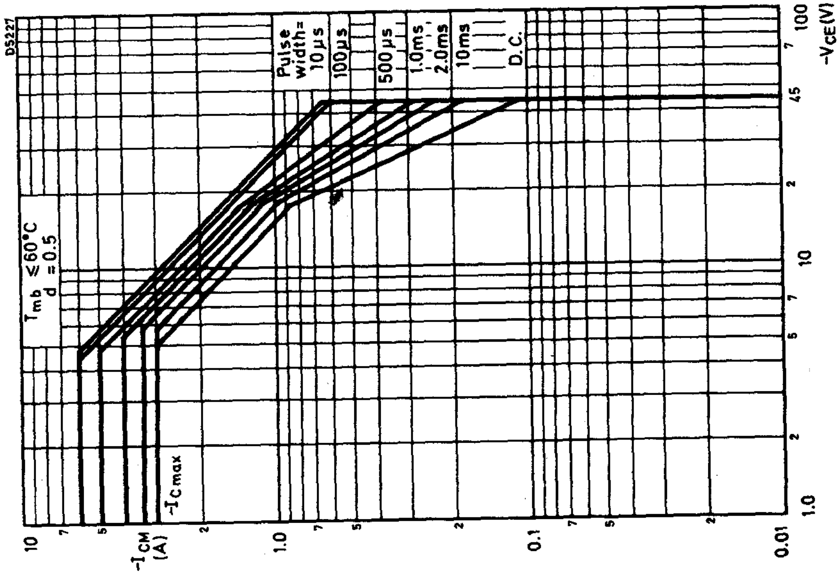
Having approved the transistor application for both electrical and time conditions, the maximum mounting-base temperature can be calculated using the thermal impedance curves * and the following equation: -

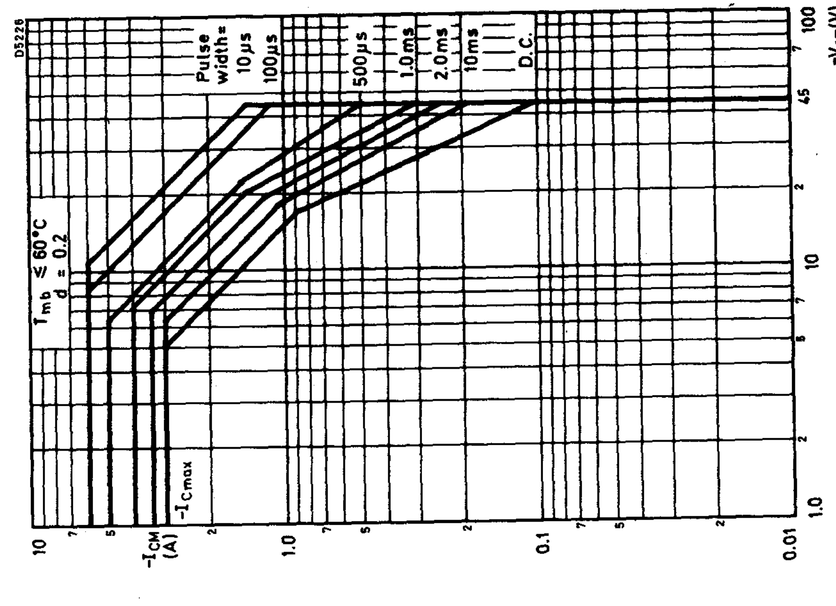
$$T_{mb}\ max. = T_j\ max. - (P_{pk} \times Z_{th(t)})^oC$$

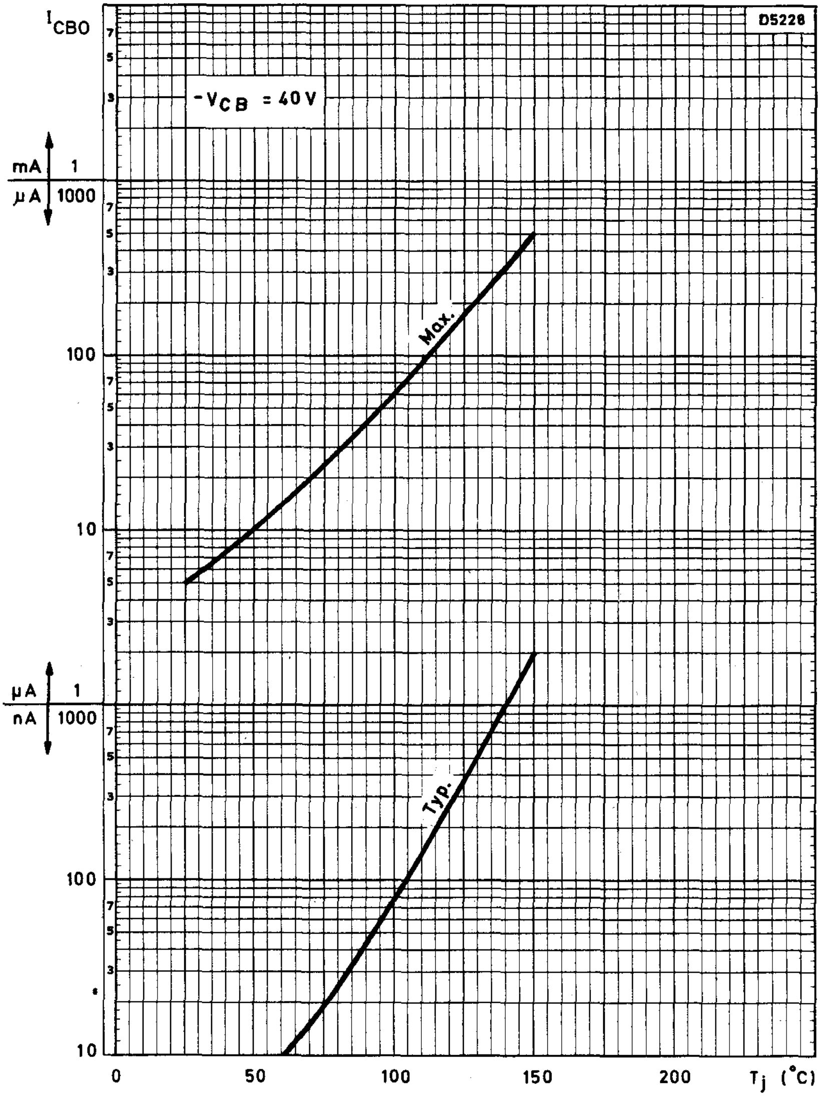
where $P_{pk} = V_{CEM} \times I_{CM}$ (For square waves)
For non-square-waves use quivalent peak power figures.

and $Z_{th(t)}$ = Transient thermal impedance for application pulse width and duty cycle or equivalent pulse width for non-square-waves.

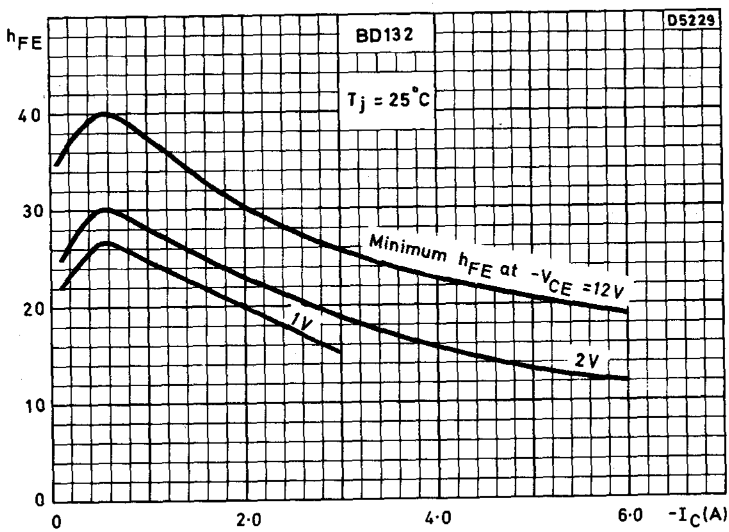
* See Page 6

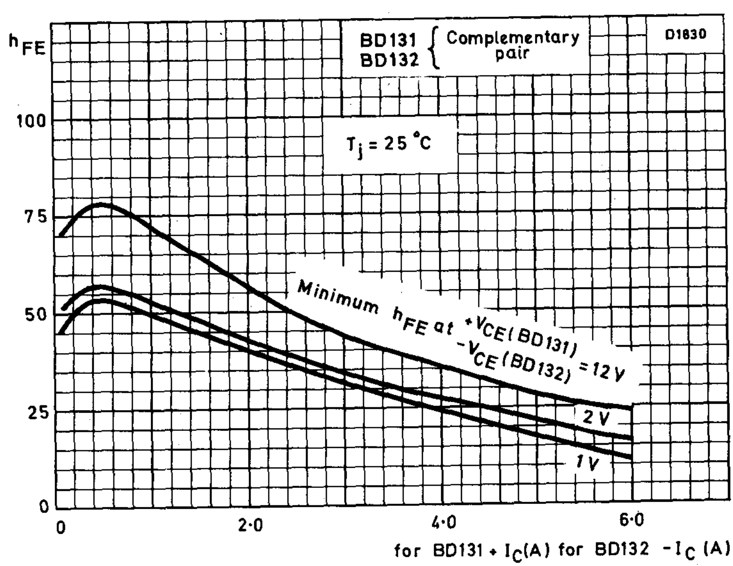

D5227
$T_{mb} \leq 60°C$
d = 0.5
Pulse width=
10 μs
100 μs
500 μs
1.0 ms
2.0 ms
10 ms
D.C.
$-I_{Cmax}$
$-I_{CM}$ (A)
$-V_{CE}$(V)
10
1.0
0.1
0.01
1.0
2
5
7
10
2
45
7
100

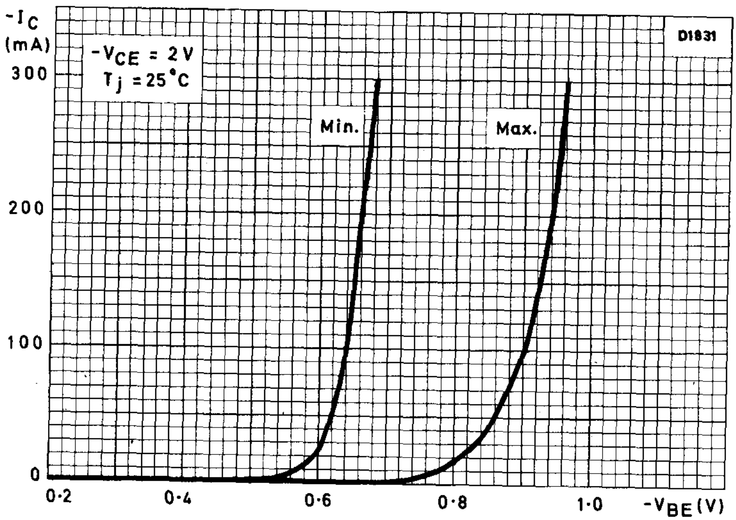

D5226
$T_{mb} \leq 60°C$
d = 0.2
Pulse width=
10 μs
100 μs
500 μs
1.0 ms
2.0 ms
10 ms
D.C.
$-I_{Cmax}$
$-I_{CM}$ (A)
$-V_{CE}$(V)
10
1.0
0.1
0.01
1.0
2
5
7
10
2
45
7
100



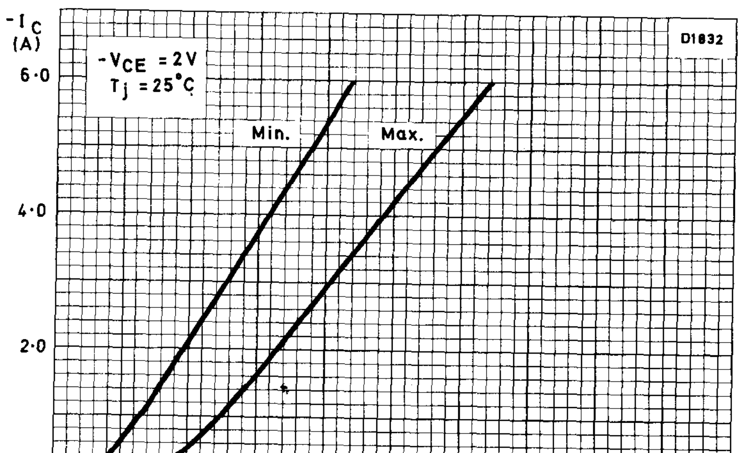
D5228
I_{CBO}
$-V_{CB}$ = 40 V
mA 1
μA 1000
100
10
μA 1
nA 1000
100
10
Max.
Typ.
0
50
100
150
200
T_j (°C)


D5229
BD132
T_j = 25°C
h_{FE}
40
30
20
10
0
Minimum h_{FE} at $-V_{CE}$ =12V
2V
1V
0
2·0
4·0
6·0
$-I_C$(A)


D1830
BD131 { Complementary pair
BD132
T_j = 25°C
h_{FE}
100
75
50
25
0
Minimum h_{FE} at $+V_{CE}$(BD131) $-V_{CE}$(BD132) =12V
2V
1V
0
2·0
4·0
6·0
for BD131 $+I_C$(A) for BD132 $-I_C$ (A)



$-I_C$ (mA)
$-V_{CE} = 2V$
$T_j = 25°C$
D1831
Min.
Max.
300
200
100
0
0·2
0·4
0·6
0·8
1·0
$-V_{BE}$ (V)



$-I_C$ (A)
$-V_{CE} = 2V$
$T_j = 25°C$
D1832
Min.
Max.
6·0
4·0
2·0
0
0·5
1·0
1·5
2·0
2·5
$-V_{BE}$ (V)

N-P-N SILICON PLANAR EPITAXIAL TRANSISTOR

BD133

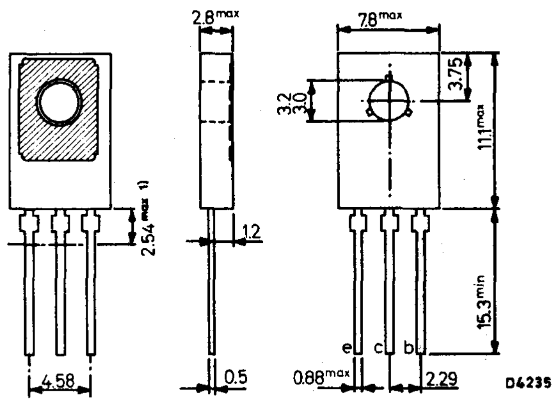
Silicon n-p-n planar epitaxial transistor for general purpose, medium power applications.

QUICK REFERENCE DATA			
V_{CBO}	max. (I_C = 1.0mA)	90	V
V_{CEO}	max.	60	V
I_{CM}	max.	6.0	A
P_{tot}	max. (T_{mb} ≤ 60°C)	15	W
h_{FE}	min. (I_C = 0.5A, V_{CE} = 12V)	40	
f_T	min. (I_C = 0.25A, V_{CE} = 5.0V f = 35MHz, T_{amb} = 25°C)	60	MHz

OUTLINE AND DIMENSIONS

Conforms to J.E.D.E.C. TO-126

Collector connected to the metal part of the mounting surface.



All dimensions in mm

1) Within this region the cross-section of the leads is uncontrolled.

Care should be taken not to bend the leads nearer than 2.5mm from the body. The leads above this point should be clamped during any lead bending operation.

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

V_{CBO}	max. (I_C = 1.0mA)	90	V
V_{CEO}	max.	60	V
V_{EBO}	max.	6.0	V
I_C	max.	3.0	A
I_{CM}	max.	6.0	A
$\pm I_{BM}$	max.	0.5	A
P_{tot}	max. ($T_{mb} \leq 60^oC$)	15	W

Temperature

T_{stg}	range	-55 to +150	^oC
T_j	max.	+150	^oC

THERMAL CHARACTERISTICS

$R_{th(j-mb)}$	Thermal resistance junction to mounting base	6.0	$^oC/W$
$R_{th(mb-h)}$	Contact thermal resistance without insulating material	1.0	$^oC/W$
$R_{th(mb-h)}$	Contact thermal resistance with the mica washer (56301B)	4.0	$^oC/W$

The use of a heatsink compound is essential. When the mica washer is used, the compound must be applied to both sides of the washer.

ELECTRICAL CHARACTERISTICS (T_j = 25^oC unless otherwise stated)

		Min.	Max.	
I_{CBO}	Collector cut-off current			
	V_{CB} = 60V, I_E = 0	-	5.0	μA
	V_{CB} = 60V, I_E = 0, T_j = 150^oC	-	500	μA
I_{EBO}	Emitter cut-off current			
	V_{EB} = 5.0V, I_C = 0	-	5.0	μA
h_{FE}	Static forward current transfer ratio			
	I_C = 0.5A, V_{CE} = 12V	40	-	
	I_C = 2.0A, V_{CE} = 1.0V	20	-	
$V_{CE(sat)}$	Collector-emitter saturation voltage			
	I_C = 0.5A, I_B = 50mA	-	0.3	V
	I_C = 2.0A, I_B = 200mA	-	0.7	V

ELECTRICAL CHARACTERISTICS (contd.)

		Min.	Max.	
$V_{BE(sat)}$	Base-emitter saturation voltage			
	$I_C = 0.5A$, $I_B = 50mA$	-	1.2	V
	$I_C = 2.0A$, $I_B = 200mA$	-	1.5	V
C_{Tc}	Collector capacitance $V_{CB} = 5.0V$, $I_E = I_e = 0$, f = 1.0MHz	-	60	pF
f_T	Transition frequency $I_C = 0.25A$, $V_{CE} = 5.0V$, f = 35MHz, $T_{amb} = 25^oC$	60	-	MHz

MECHANICAL DATA

Maximum torque on nut	4.0	kg cm
	0.4	N m
Minimum torque on nut for good thermal contact	3.0	kg cm
	0.3	N m

ACCESSORIES

Accessory	Code No.	Note
1 Mica washer	56301B	Suppied on request
1 Plain washer	56326	

When mounted on a heatsink it is essential that the plain washer be used to prevent damage to the device while tightening the mounting screw.

OPERATING NOTES

The rating graphs given in this data show the maximum permissible current and voltage for combinations of duty cycle and pulse width with a mountingbase temperature up to T_{mb} = 60°C. In order to verify that the conditions of operation are within the ratings, note the voltage, current, pulse width and duty cycle applied to the transistor. Compare the application V_{CE} and I_C plot against the V_{CE} v I_C curve with the appropriate pulse width and duty cycle. (e.g. Actual pulse widths of 1.7ms will use the 2.0ms curve, and an actual duty cycle of 0.37 will use the d = 0.5 family of curves). If the application condition is always within the selected SOAR curve it is acceptable.

If the application condition just exceeds the selected SOAR curve, then linear interpolation between the family of curves used and the next lower duty cycle curves should indicate if the application is acceptable.

For applications using non-square-wave pulses, reference should be made to the General Explanatory Notes on SOAR where conversion to equivalent square-wave pulses is explained.

Having approved the transistor application for both electrical and time conditions, the maximum mountingbase temperature can be calculated using the thermal impedance curves * and the following equation: -

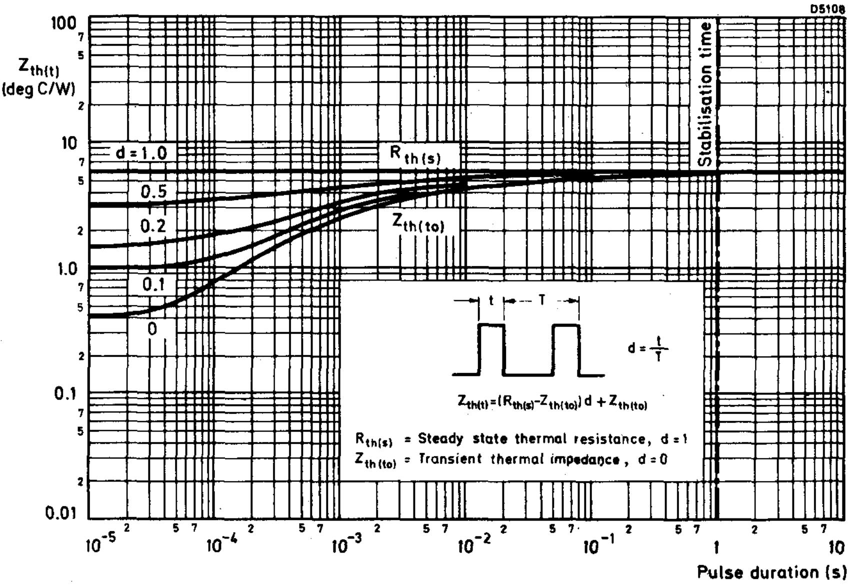
$$T_{mb}\,\text{max.} = T_j\,\text{max.} - (P_{pk} \times Z_{th(t)})\,^{o}C$$

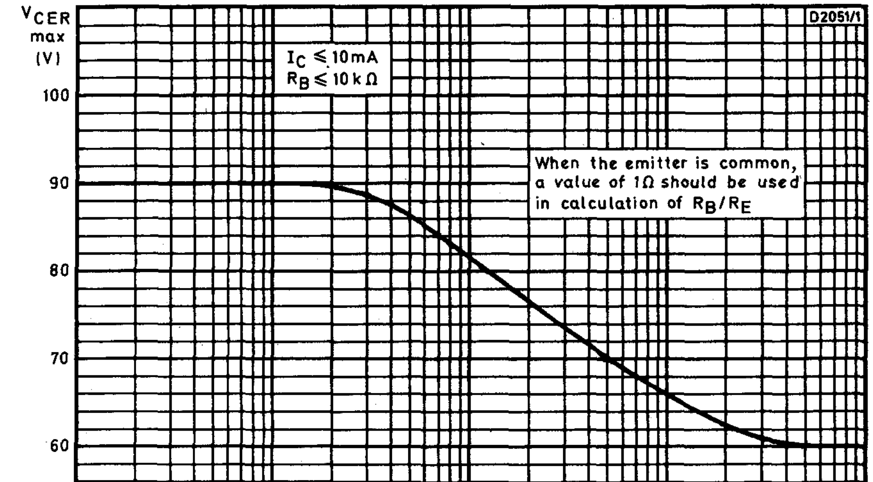
where $P_{pk} = V_{CEM} \times I_{CM}$ (For square waves)

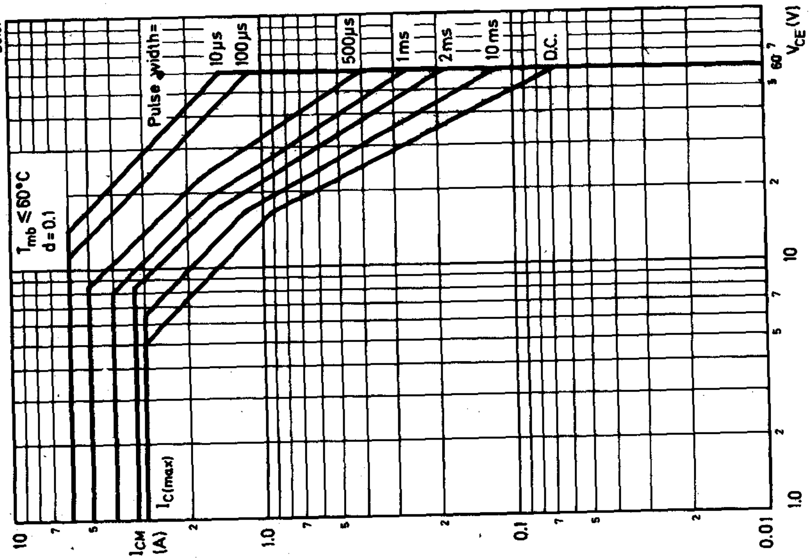
For non-square-waves use equivalent peak power figures.

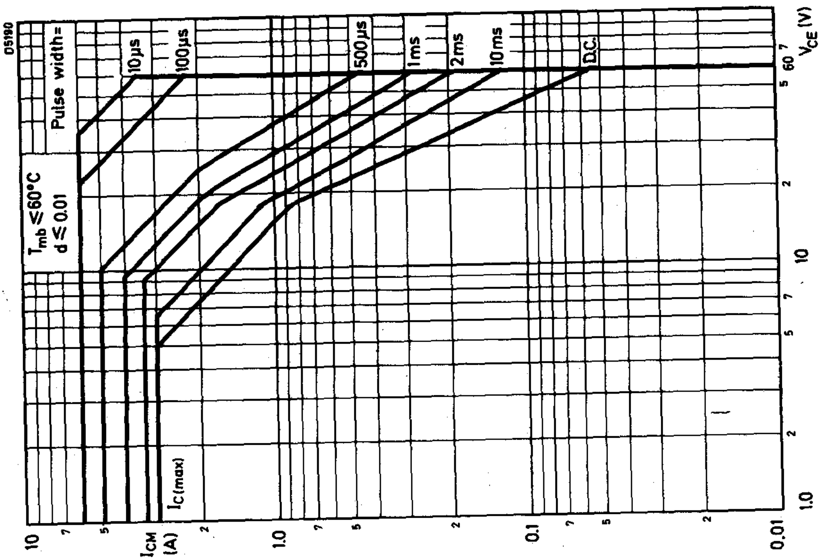
and $Z_{th(t)}$ = Transient thermal impedance for application pulse width and duty cycle or equivalent pulse width for non-square-waves.

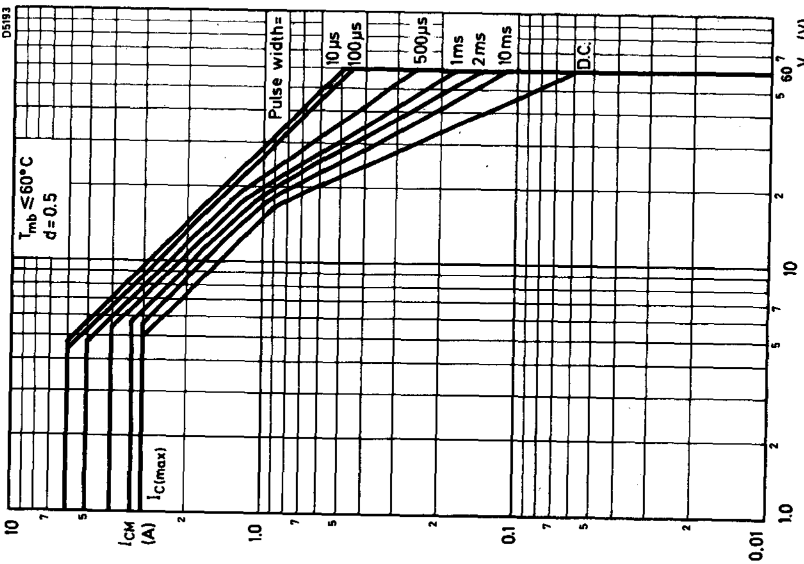
* See Page 5

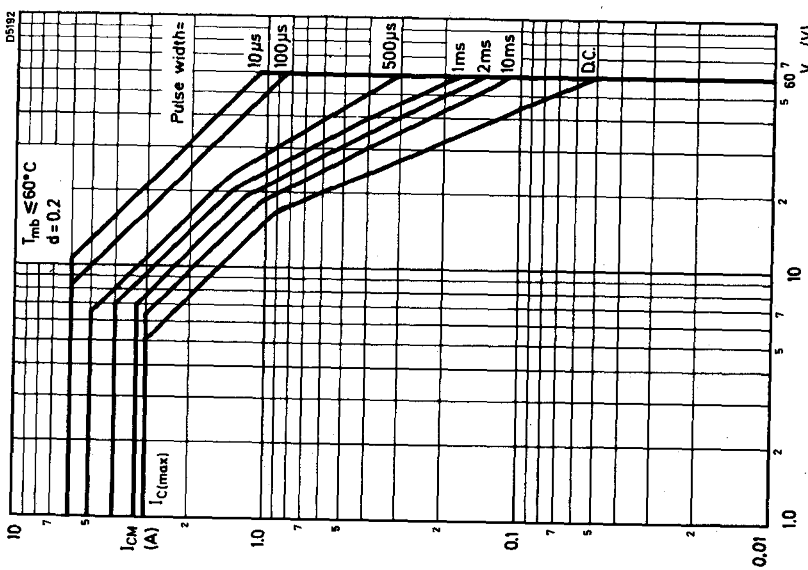

D5108
$Z_{th(t)}$ (deg C/W)
100
10
1.0
0.1
0.01
d = 1.0
0.5
0.2
0.1
0
$R_{th(s)}$
$Z_{th(to)}$
Stabilisation time
$d = \frac{t}{T}$
$Z_{th(t)} = (R_{th(s)} - Z_{th(to)})\,d + Z_{th(to)}$
$R_{th(s)}$ = Steady state thermal resistance, d = 1
$Z_{th(to)}$ = Transient thermal impedance, d = 0
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
Pulse duration (s)

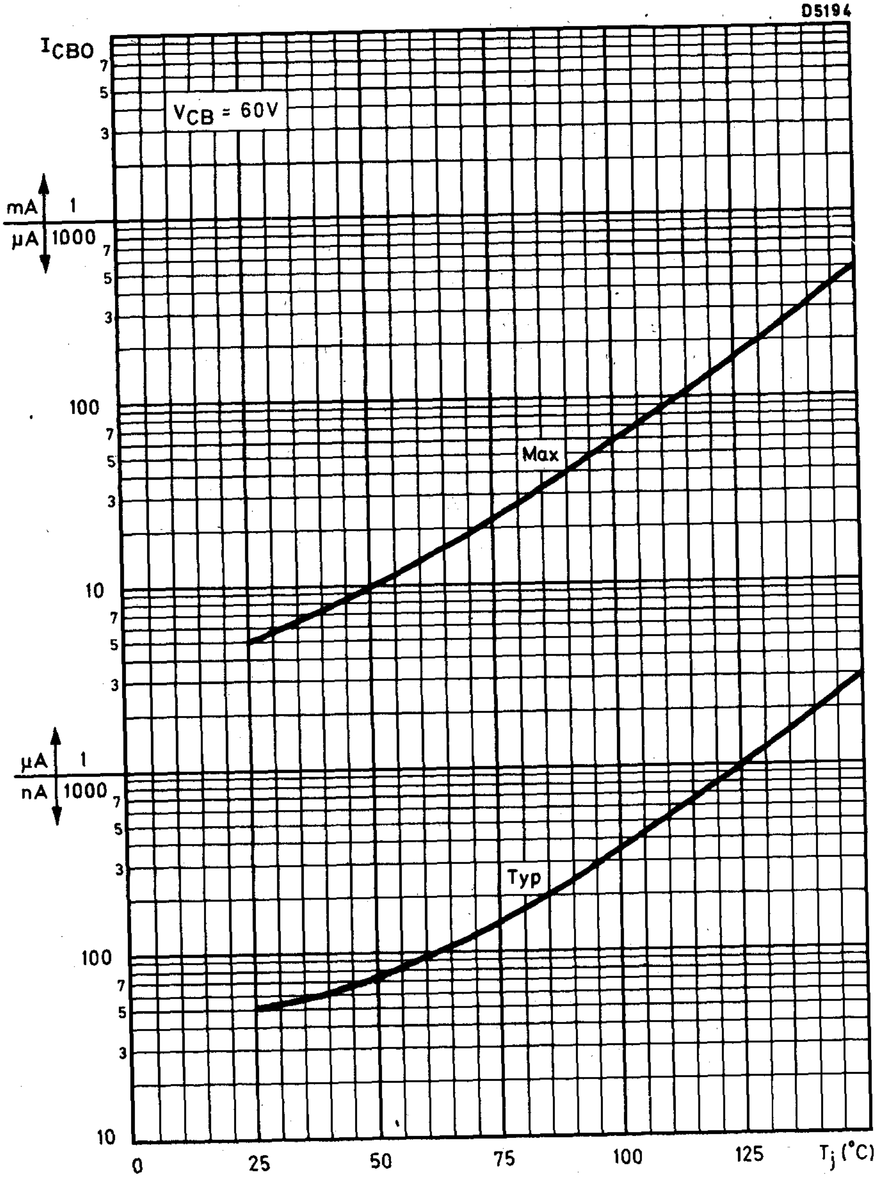

D2051/1
$V_{CER\,max}$ (V)
$I_C \leqslant 10\,mA$
$R_B \leqslant 10\,k\Omega$
When the emitter is common, a value of 1Ω should be used in calculation of R_B/R_E
100
90
80
70
60
50
1
10
10^2
10^3
R_B/R_E
10^4


D5191
$T_{mb} \leq 60°C$
d = 0.1
Pulse width =
10µs
100µs
500µs
1ms
2ms
10ms
D.C.
$I_{C(max)}$
I_{CM} (A)
V_{CE} (V)
10
1.0
0.1
0.01
60


D5190
$T_{mb} \leq 60°C$
$d \leq 0.01$
Pulse width =
10µs
100µs
500µs
1ms
2ms
10ms
D.C.
$I_{C(max)}$
I_{CM} (A)
V_{CE} (V)
10
1.0
0.1
0.01
60


D5193
$T_{mb} \leq 60°C$
d = 0.5
Pulse width=
10µs
100µs
500µs
1ms
2ms
10ms
D.C.
$I_{C(max)}$
I_{CM} (A)
V_{CE} (V)

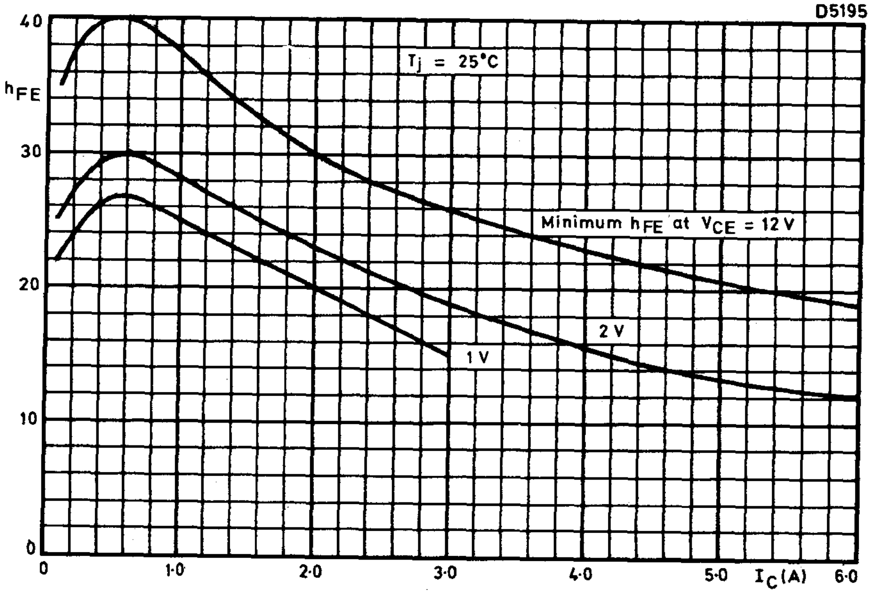

D5192
$T_{mb} \leq 60°C$
d = 0.2
Pulse width=
10µs
100µs
500µs
1ms
2ms
10ms
D.C.
$I_{C(max)}$
I_{CM} (A)
V_{CE} (V)

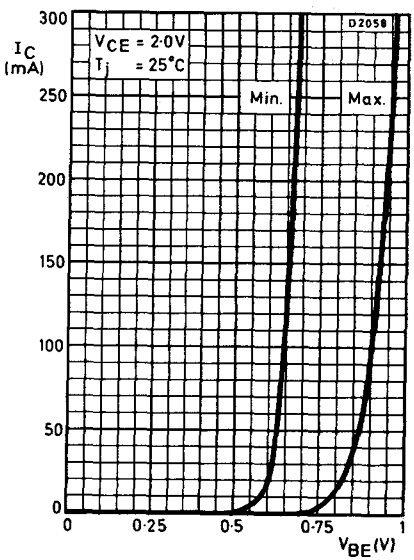


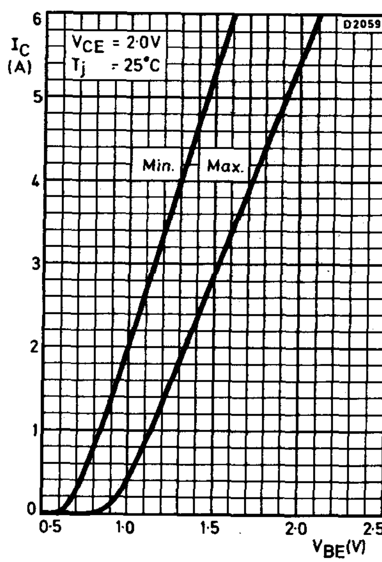
D5194
I_{CBO}
V_{CB} = 60V
mA
μA
μA
nA
1
1000
100
10
1
1000
100
10
7
5
3
Max
Typ
0
25
50
75
100
125
T_j (°C)

N-P-N SILICON PLANAR EPITAXIAL TRANSISTOR

BD133







RATINGS

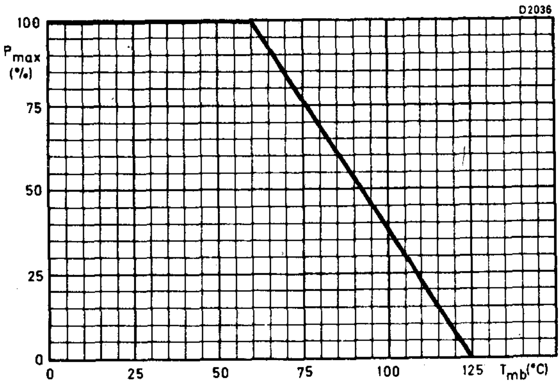
Limiting values of operation according to the absolute maximum system.

	BD136	BD138	BD140	
Electrical				
$-V_{CBO}$ max.	45	60	-	V
$-V_{CEO}$ max. ($-I_C = 30mA$)	45	60	80	V
$-V_{CER}$ max. ($R_B = 1k\Omega$)	-	-	100	V
$-V_{EBO}$ max.	5.0	5.0	5.0	V
$-I_C$ max.	0.5	0.5	0.5	A
$-I_{CM}$ max.	1.5	1.5	1.5	A
P_{tot} max. ($T_{mb} \leq 60^{o}C$, see also graph below)	6.5	6.5	6.5	W
Temperature				
T_{stg} range		-55 to +125		^{o}C
T_j max.		+125		^{o}C

THERMAL CHARACTERISTICS

$R_{th(j-amb)}$	Thermal resistance junction to ambient	100	degC/W
$R_{th(j-mb)}$	Thermal resistance junction to mounting base	10	degC/W
$R_{th(mb-h)}$	Contact thermal resistance without insulating material	1.0	degC/W
$R_{th(mb-h)}$	Contact thermal resistance with the mica washer in accessory 56301	4.0	degC/W

The use of a heatsink compound is essential. When the mica washer is used, the compound must be applied to both sides of the washer.



Mullard

P-N-P SILICON PLANAR EPITAXIAL TRANSISTORS

BD136 BD138 BD140

ELECTRICAL CHARACTERISTICS ($T_j = 25^oC$ unless otherwise stated)

			Min.	Max.	
$-I_{CBO}$	Collector cut-off current				
	$-V_{CB} = 30V,\ I_E = 0$		-	100	nA
	$-V_{CB} = 30V,\ I_E = 0,\ T_j = 125^oC$		-	10	μA
$-I_{EBO}$	Emitter cut-off current				
	$-V_{EB} = 5.0V,\ I_C = 0$		-	10	μA
h_{FE}	Static forward current transfer ratio				
	$-I_C = 5.0mA,\ -V_{CE} = 2.0V$		25	-	
	$-I_C = 150mA,\ -V_{CE} = 2.0V$	BD136	40	250	
		BD138	40	160	
		BD140	40	160	
	$-I_C = 500mA,\ -V_{CE} = 2.0V$		25	-	
$-V_{BE}$	Base-emitter voltage				
	$-I_C = 500mA,\ -V_{CE} = 2.0V$		-	1.0	V
$-V_{CE(sat)}$	Collector-emitter saturation voltage				
	$-I_C = 500mA,\ -I_B = 50mA$		-	0.5	V
f_T	Transition frequency				
	$-I_C = 50mA,\ -V_{CE} = 5.0V$				
	f = 35MHz		typical	75	MHz
$\frac{h_{FE1}}{h_{FE2}}$	Current gain ratio for complementary pairs				
	$-I_C = 150mA,\ -V_{CE} = 2.0V$		-	1.6	

MECHANICAL DATA

Maximum torque on nut	4	kg cm
	0.4	N m
Minimum torque for good thermal contact	3	kg cm
	0.3	N m

ACCESSORIES

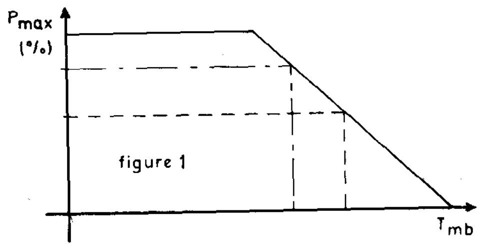
Accessory	Code No.	Note
1 Mica washer	56301B	Supplied on request
1 Plain washer	56326	

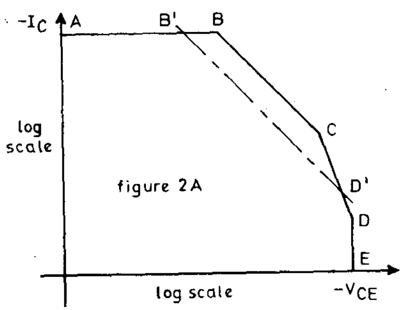
When mounted on a heatsink it is essential that a plain washer be used to prevent damage to the device while tightening the mounting screw.

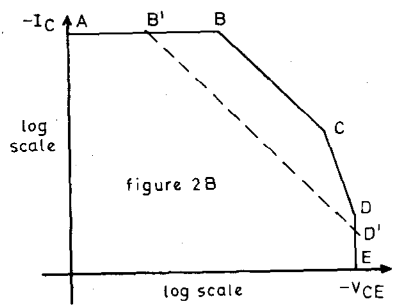
DERATING AGAINST MOUNTING-BASE TEMPERATURE

The maximum permissible power for selected pulse widths and/or mounting-base temperature can be obtained from the graphs on pages 5, 6, 7 and 8, where the P_{max} value for $T_{mb} \leq 60^oC$ is calculated from the line of constant power (i.e. that part of the curve which has a slope of -1), on the relevant $-I_C$ versus $-V_{CE}$ curve.

For mounting-base temperatures in excess of 60^oC, the constant power line BC in figures 2A and 2B is reduced to the % of P_{max} as read from the % P_{max} versus T_{mb} graph on page 2. The safe operating area for the higher temperature is defined either by the points A B' D' D E in figure 2A, or by the points A B' D' E in figure 2B. The second-breakdown power line is only modified by the intersection point D' and is not adjusted against temperature in any other way.

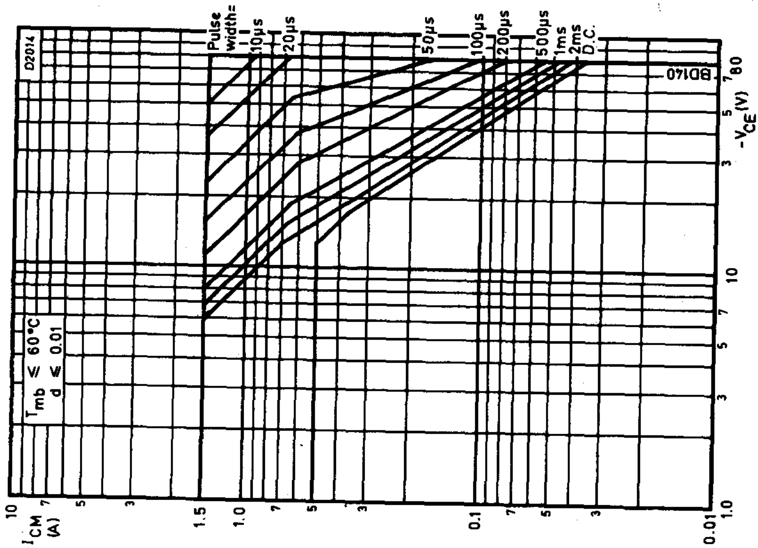


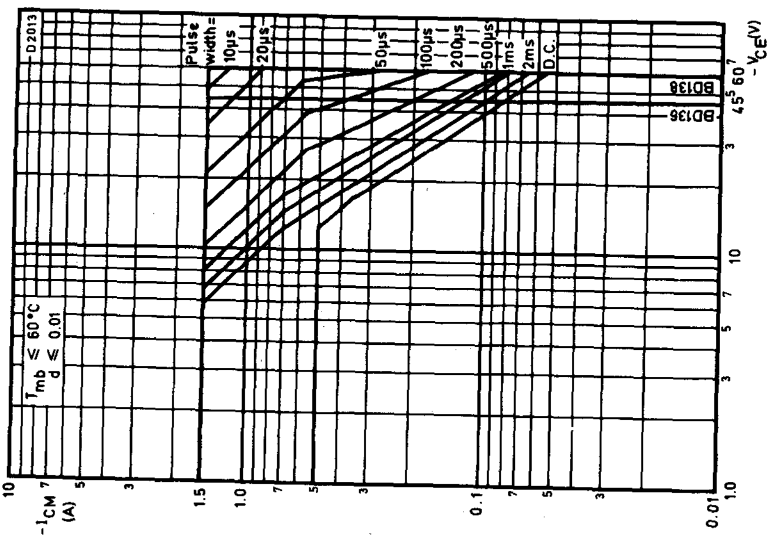


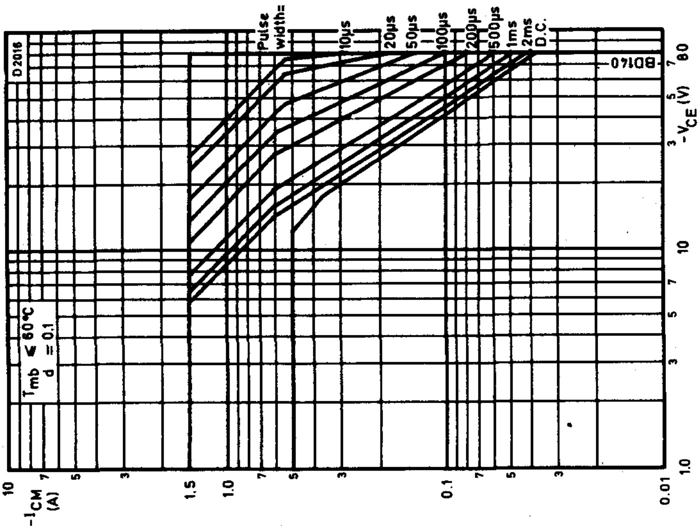


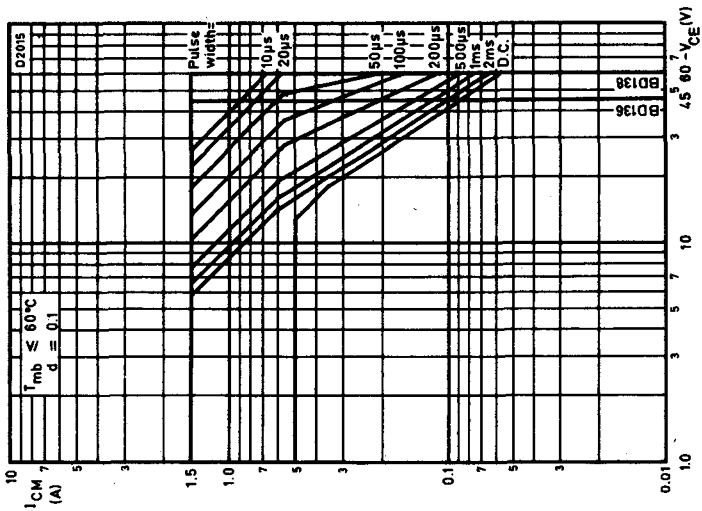
P-N-P SILICON PLANAR EPITAXIAL TRANSISTORS

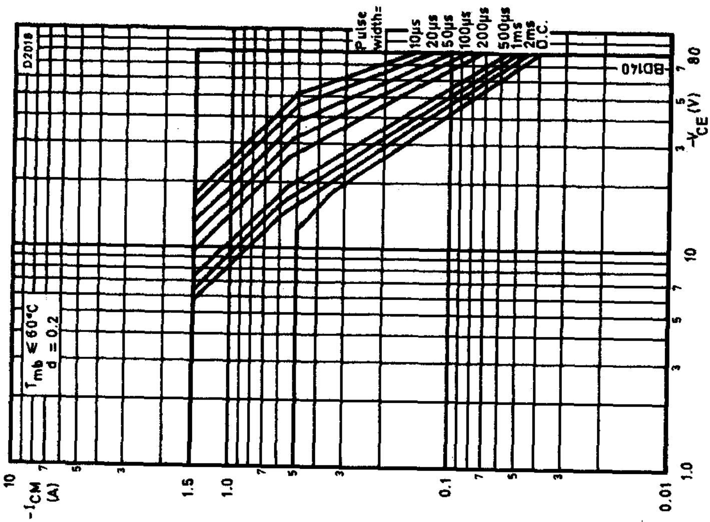
BD136
BD138
BD140

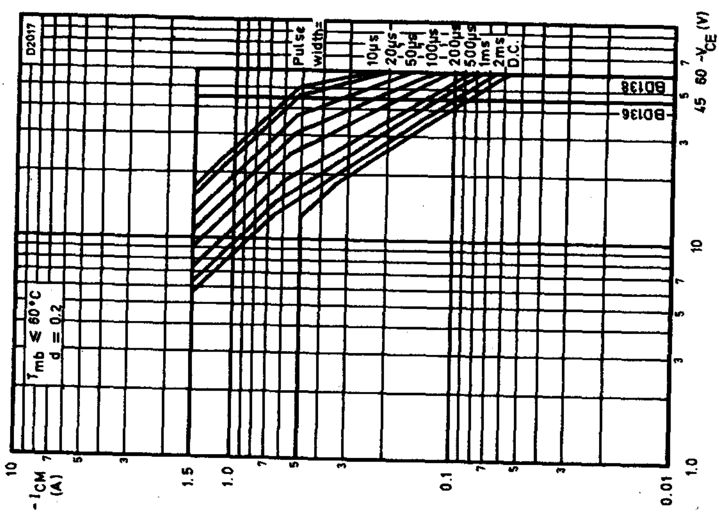


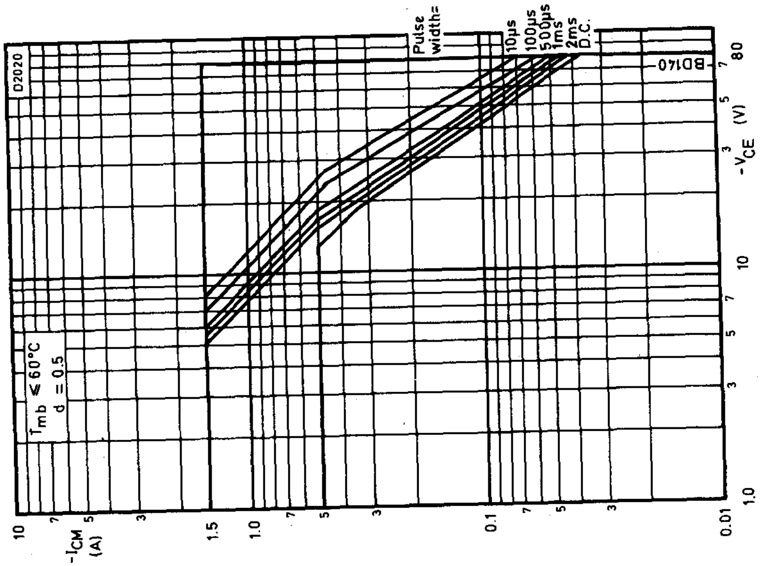


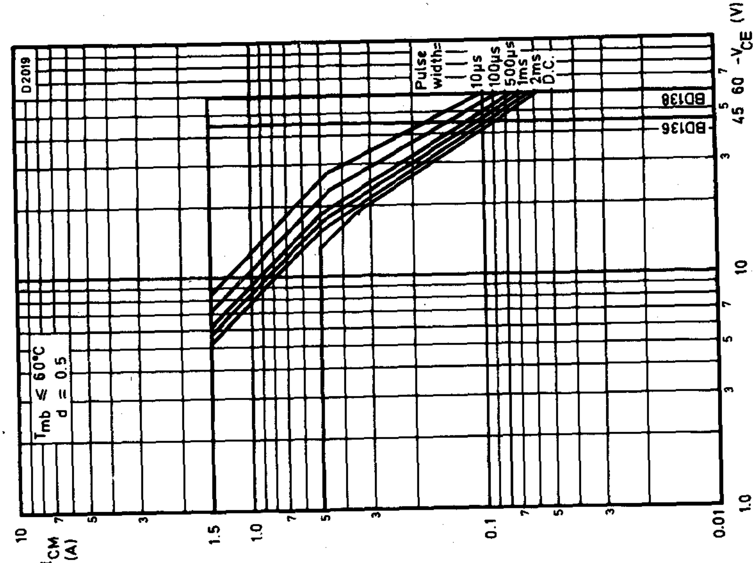

D2016
Tmb ≤ 60°C
d = 0.1
Pulse width=
10μs
20μs
50μs
100μs
200μs
500μs
1ms
2ms
D.C.
BD140
-ICM (A)
-VCE (V)
10 7 5 3 1.5 1.0 7 5 3 0.1 7 5 3 0.01
1.0 3 5 7 10 3 5 7 80

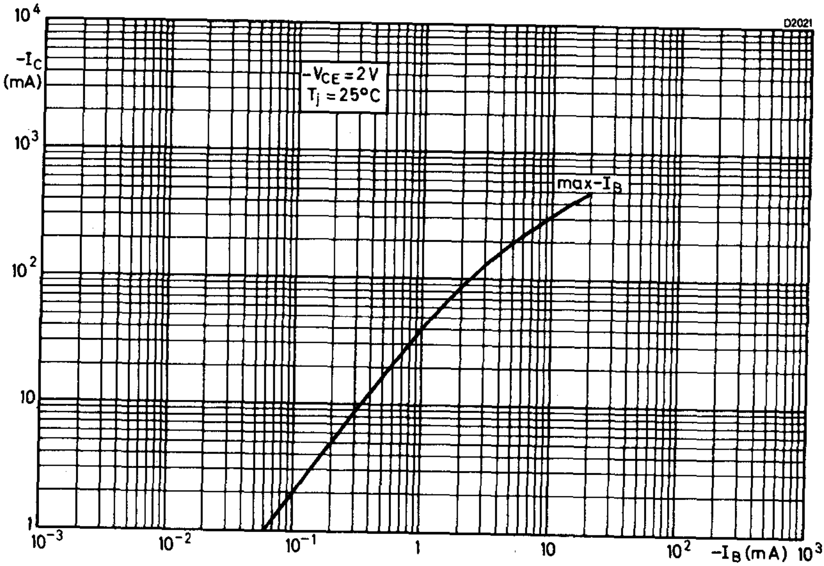

D2015
Tmb ≤ 60°C
d = 0.1
Pulse width=
10μs
20μs
50μs
100μs
200μs
500μs
1ms
2ms
D.C.
BD138
BD136
-ICM (A)
-VCE (V)
10 7 5 3 1.5 1.0 7 5 3 0.1 7 5 3 0.01
1.0 3 5 7 10 3 5 45 60 7

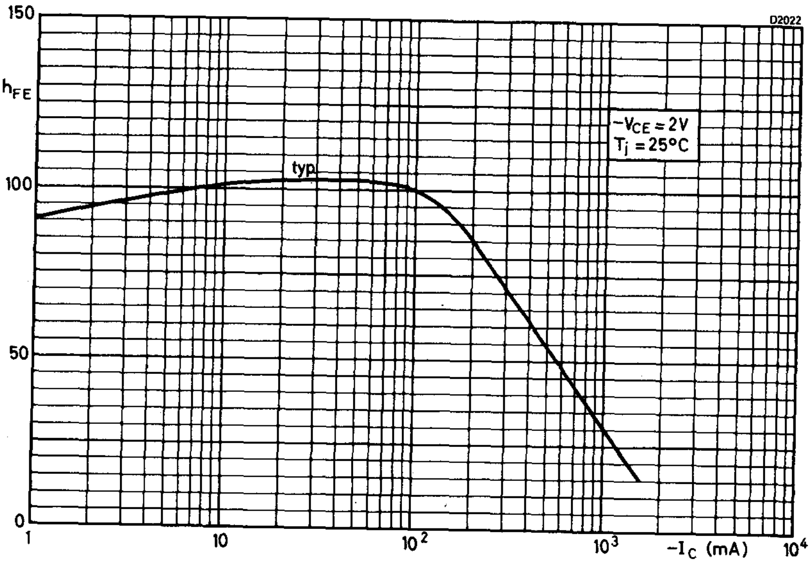

D2018
Pulse width=
10μs
20μs
50μs
100μs
200μs
500μs
1ms
2ms
D.C.
BD140
$T_{mb} \leq 60°C$
d = 0.2
$-I_{CM}$ (A)
$-V_{CE}$ (V)

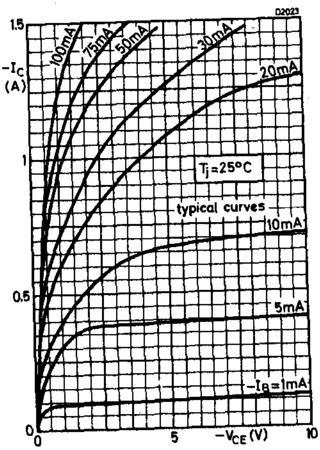

D2017
Pulse width=
10μs
20μs
50μs
100μs
200μs
500μs
1ms
2ms
D.C.
BD138
BD136
$T_{mb} \leq 60°C$
d = 0.2
$-I_{CM}$ (A)
$-V_{CE}$ (V)

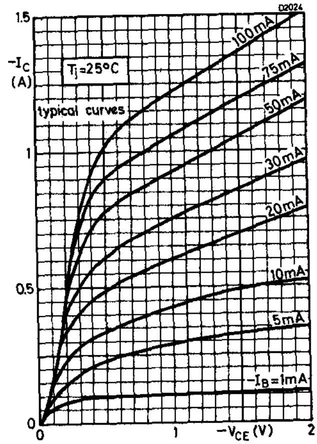

D2020
T_{mb} ≤ 60°C
d = 0.5
Pulse width=
10µs
100µs
500µs
1ms
2ms
D.C.
BD140
$-I_{CM}$ (A)
$-V_{CE}$ (V)

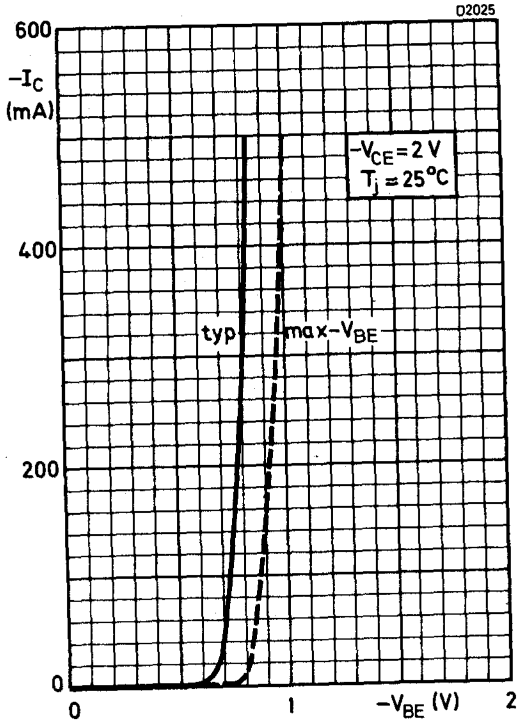

D2019
T_{mb} ≤ 60°C
d = 0.5
Pulse width=
10µs
100µs
500µs
1ms
2ms
D.C.
BD138
BD136
$-I_{CM}$ (A)
$-V_{CE}$ (V)

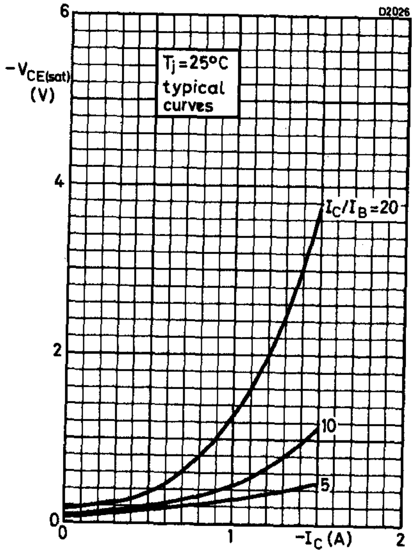

D2021
10^4
$-I_C$
(mA)
10^3
10^2
10
1
$-V_{CE} = 2\,V$
$T_j = 25°C$
max-I_B
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
$-I_B$ (mA)
10^3

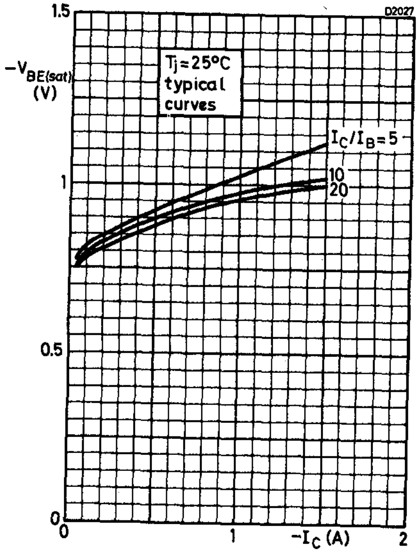

D2022
150
h_{FE}
100
50
0
$-V_{CE} = 2\,V$
$T_j = 25°C$
typ
1
10
10^2
10^3
$-I_C$ (mA)
10^4

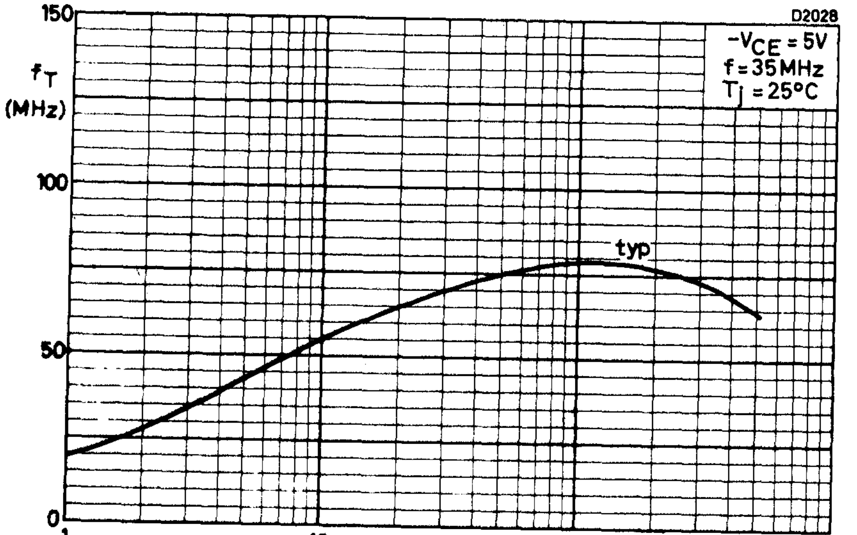

D2023
1.5
$-I_C$ (A)
1
0.5
0
100mA
75mA
50mA
30mA
20mA
T_j=25°C
typical curves
10mA
5mA
$-I_B$=1mA
0
5
$-V_{CE}$ (V)
10


D2024
1.5
$-I_C$ (A)
T_j=25°C
typical curves
1
0.5
0
100mA
75mA
50mA
30mA
20mA
10mA
5mA
$-I_B$=1mA
0
1
$-V_{CE}$ (V)
2


D2025
600
$-I_C$ (mA)
$-V_{CE}$ = 2 V
T_j = 25°C
400
typ
max-V_{BE}
200
0
0
1
$-V_{BE}$ (V)
2


D2026
$T_j = 25°C$
typical
curves
$-V_{CE(sat)}$
(V)
$I_C/I_B = 20$
10
5
$-I_C$ (A)


D2027
$T_j = 25°C$
typical
curves
$-V_{BE(sat)}$
(V)
$I_C/I_B = 5$
10
20
$-I_C$ (A)


D2028
$-V_{CE} = 5V$
f = 35 MHz
$T_j = 25°C$
f_T
(MHz)
typ
$-I_C$ (mA)

N-P-N SILICON DIFFUSED POWER TRANSISTORS

BD181
BD182
BD183
BD184

N-P-N silicon diffused power transistors primarily intended for use in domestic hi-fi and general high quality audio amplifiers.

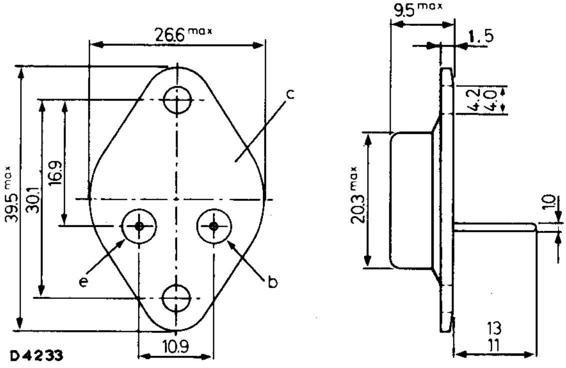
QUICK REFERENCE DATA

		BD181	BD182	BD183	BD184	
V_{CBO} max.		55	70	85	95	V
V_{CEO} max.		45	60	80	90	V
I_{CM} max.		15	15	15	15	A
P_{tot} max.	$T_{mb} \leq 25^oC$	-	117	117	117	W
	$T_{mb} \leq 80^oC$	78	-	-	-	W
T_j max.		200	200	200	200	^oC
h_{FE} range,	$I_C = 3A$, $V_{CE} = 4V$	20-70	-	20-70	-	
	$I_C = 4A$, $V_{CE} = 4V$	-	20-70	-	20-70	
f_{hfe} typ.	$I_C = 0.3A$, $V_{CE} = 4V$	20	20	20	15	kHz

Unless otherwise stated data are applicable to all types

OUTLINE AND DIMENSIONS

Conforms to BS 3934 SO-5A/SB2-2
J.E.D.E.C. TO-3



All dimensions in mm
Collector connected to envelope
Accessories available: 56201B (mica washer), 56214 (lead washer), 56239A (insulating bush)

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

	BD181	BD182	BD183	BD184	
V_{CBO} max.	55	70	85	95	V
V_{CEO} max.	45	60	80	90	V
V_{CER} max. ($R_{BE}=100\Omega$)	55	70	85	95	V
V_{EBO} max.	7	7	7	7	V
I_C max.	10	15	15	15	A
I_{CM} max.	15	15	15	15	A
$-I_{EM}$ max.	15	15	15	15	A
I_{BM} max.	7	7	7	7	A
P_{tot} max. $T_{mb}\leq 25^{o}C$	-	117	117	117	W
$T_{mb}\leq 80^{o}C$	78	-	-	-	W

Temperature

T_{stg} range	-65 to +200	^{o}C
T_j max.	200	^{o}C

THERMAL CHARACTERISTICS

$R_{th(j-mb)}$		1.5	degC/W
$R_{th(j-amb)}$	in free air	45	degC/W
$R_{th(mb-h)}$	contact thermal resistance with lead and mica washers (No. 56201)	0.75	degC/W

ELECTRICAL CHARACTERISTICS ($T_j = 25^{o}C$ unless otherwise stated)

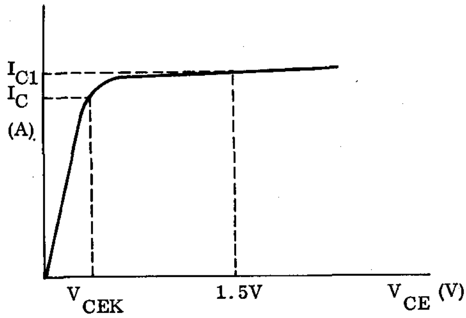
			Min.	Typ.	Max.	
I_{CBO}	Collector cut-off current					
	$V_{CB}=45V$, $I_E=0$, $T_j=200^{o}C$	BD181	-	0.5	2.0	mA
	$V_{CB}=60V$, $I_E=0$, $T_j=200^{o}C$	BD182	-	1.0	5.0	mA
	$V_{CB}=80V$, $I_E=0$, $T_j=200^{o}C$	BD183	-	1.0	5.0	mA
	$V_{CB}=90V$, $I_E=0$, $T_j=200^{o}C$	BD184	-	1.0	5.0	mA
I_{EBO}	Emitter cut-off current $V_{EB}=7V$, $I_C=0$		-	0.1	5.0	mA

ELECTRICAL CHARACTERISTICS (cont'd)

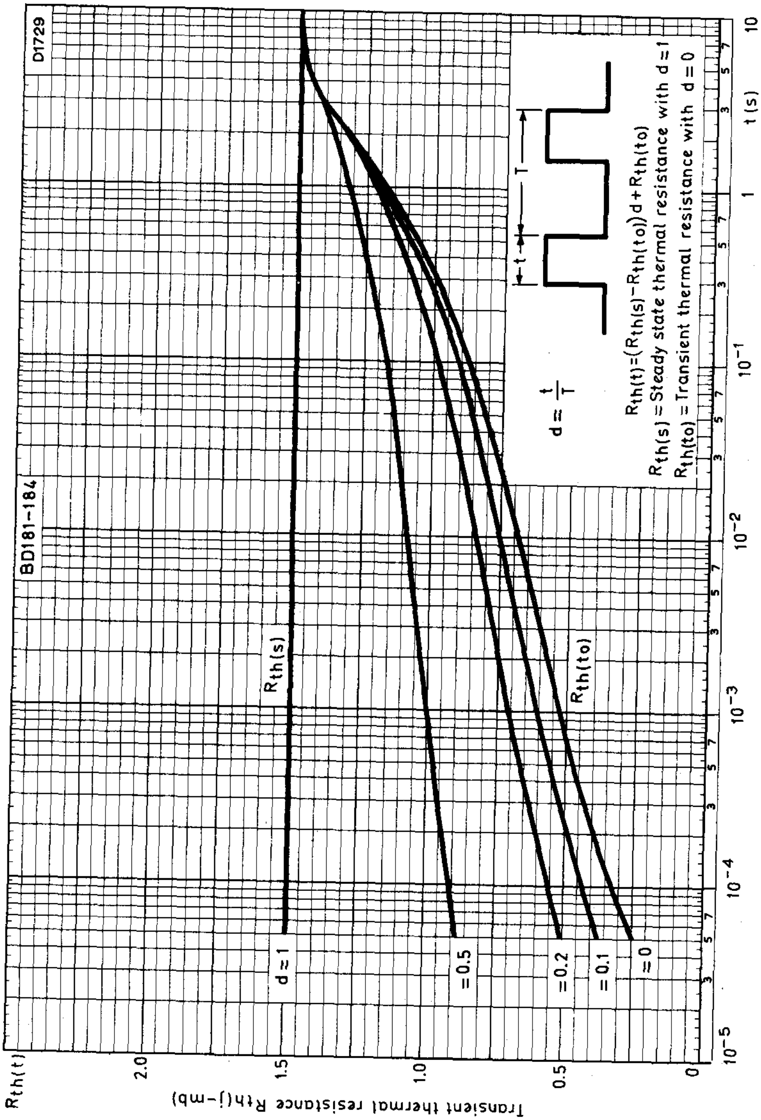
			Min.	Typ.	Max.	
$V_{(BR)CEO}$	Collector-emitter breakdown voltage					
	$I_C = 0.2A$, $I_B = 0$	BD181	45	-	-	V
		BD182	60	-	-	V
		BD183	80	-	-	V
		BD184	90	-	-	V
$V_{(BR)CER}$	Collector-emitter sustaining voltage					
	$I_C = 0.2A$, $R_{BE} = 100\Omega$	BD181	55	-	-	V
		BD182	70	-	-	V
		BD183	85	-	-	V
		BD184	95	-	-	V
V_{CEK}	Collector-emitter knee voltage					
	$I_C = 3A$, $I_B = I_{B1}$ (see note 1)	BD181, 3	-	0.5	1.0	V
	$I_C = 4A$, $I_B = I_{B1}$ (see note 1)	BD182, 4	-	0.55	1.0	V
h_{FE}	Static forward current transfer ratio					
	$I_C = 3A$, $V_{CE} = 4V$	BD181, 3	20	40	70	
	$I_C = 4A$, $V_{CE} = 4V$	BD182, 4	20	40	70	
$\frac{h_{FE} \text{ at } 0.3A}{h_{FE} \text{ at } I_C}$	Static forward current transfer ratio linearity					
	$I_C = 3A$, $V_{CE} = 4V$	BD181, 3	-	2.5	3.5	
	$I_C = 4A$, $V_{CE} = 4V$	BD182, 4	-	2.5	4.0	
f_{hfe}	Common emitter cut-off frequency					
	$I_C = 0.3A$, $V_{CE} = 4V$	BD181, 2, 3	-	20	-	kHz
		BD184	-	15	-	kHz
$\frac{h_{FE2}}{h_{FE1}}$	Ratio of static current gains of matched pairs					
	$I_C = 3A$, $V_{CE} = 4V$	2xBD181, 3	-	-	1.3	
	$I_C = 4A$, $V_{CE} = 4V$	2xBD182, 4	-	-	1.3	

NOTES

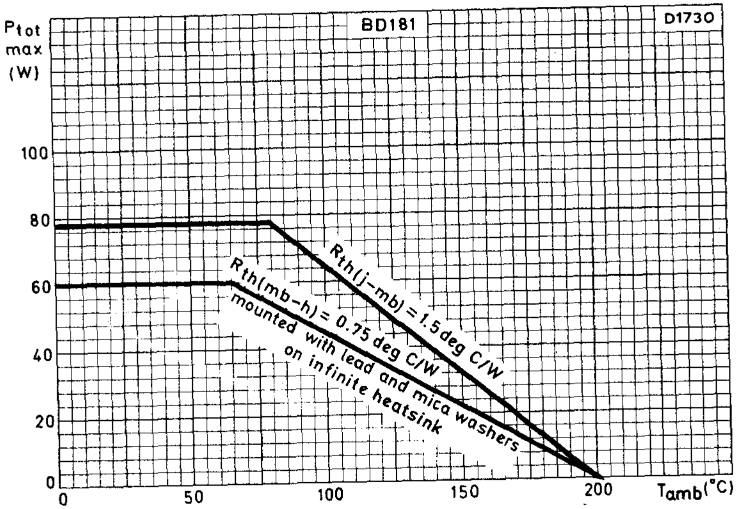
1. I_{B1} = the value for which $I_{C1} = 1.1 \times I_C$ at $V_{CE} = 1.5V$

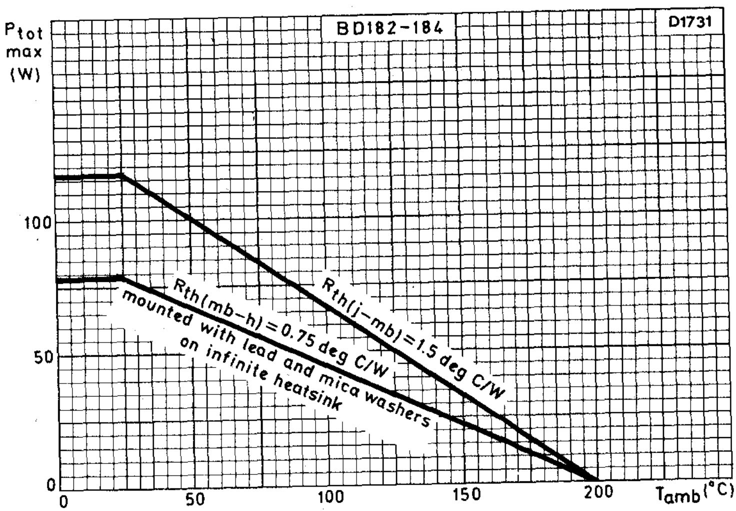


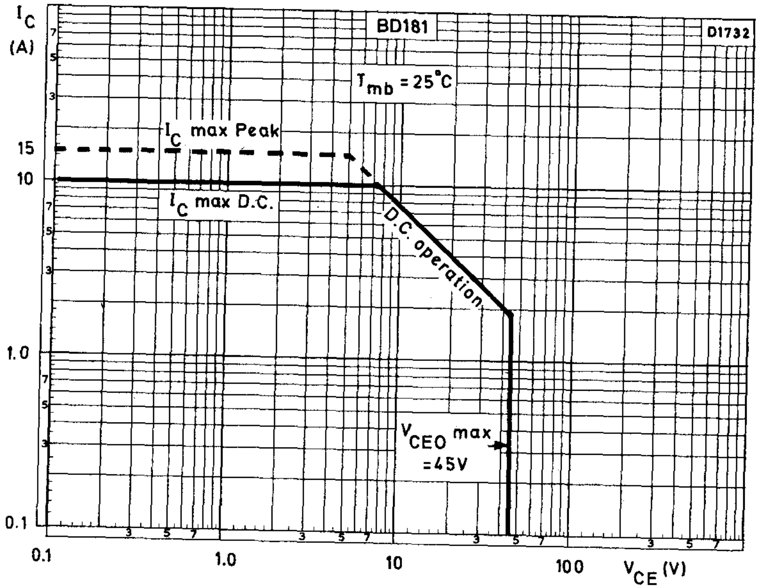
2. V_{BE} decreases by approximately 2.0mV/degC with increasing temperature.

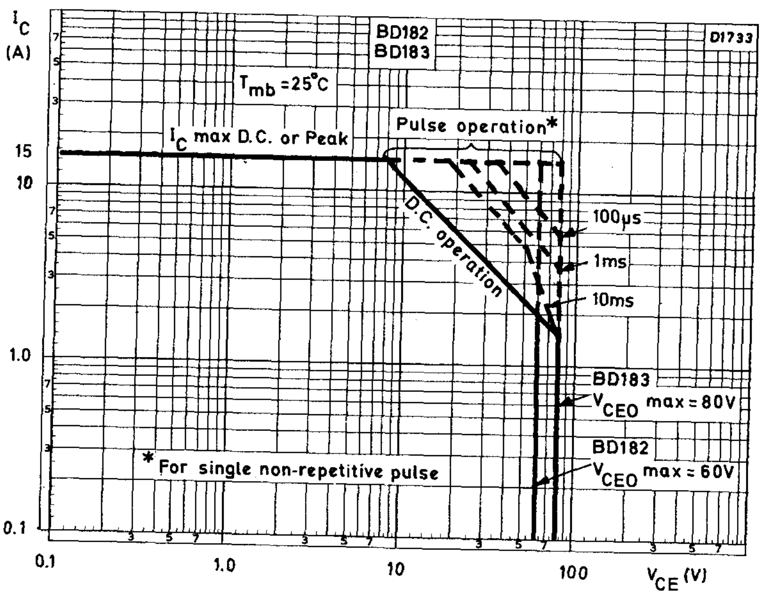


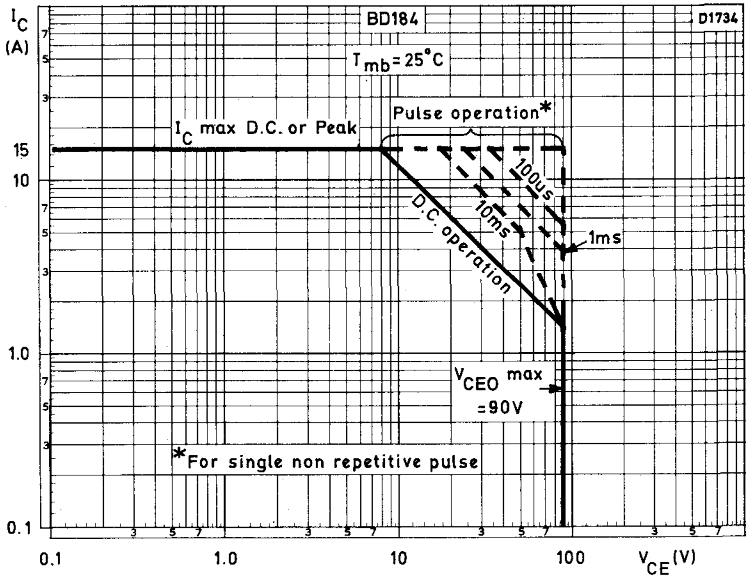
D1729
BD181-184
d = t/T
Rth(t)=(Rth(s)−Rth(to))d+Rth(to)
Rth(s) = Steady state thermal resistance with d=1
Rth(to) = Transient thermal resistance with d=0
t
T
Rth(s)
Rth(to)
d=1
=0.5
=0.2
=0.1
=0
Rth(t)
Transient thermal resistance Rth(j-mb)
2.0
1.5
1.0
0.5
0
t (s)
10^-5
10^-4
10^-3
10^-2
10^-1
1
10


BD181
D1730
Ptot max (W)
100
80
60
40
20
0
0
50
100
150
200
Tamb(°C)
Rth(j-mb) = 1.5 deg C/W
Rth(mb-h) = 0.75 deg C/W
mounted with lead and mica washers
on infinite heatsink

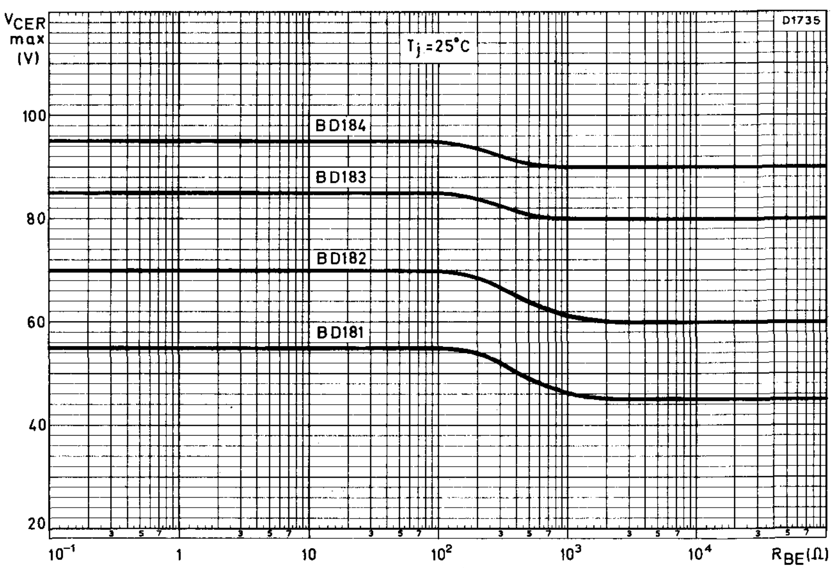

BD182-184
D1731
Ptot max (W)
100
50
0
0
50
100
150
200
Tamb(°C)
Rth(j-mb) = 1.5 deg C/W
Rth(mb-h) = 0.75 deg C/W
mounted with lead and mica washers
on infinite heatsink


D1732
BD181
T_{mb} = 25°C
I_C max Peak
I_C max D.C.
D.C. operation
V_{CEO} max =45V
I_C (A)
V_{CE} (V)
15
10
1.0
0.1
0.1
1.0
10
100

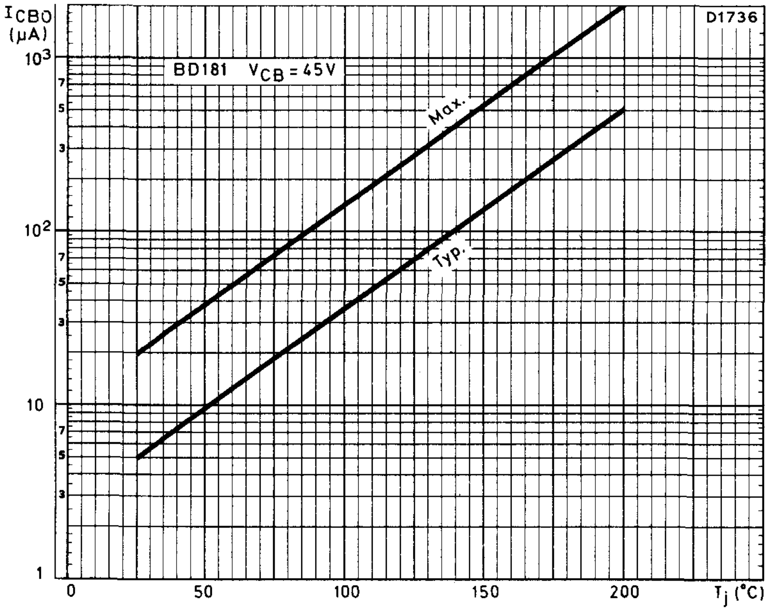

D1733
BD182
BD183
T_{mb} =25°C
I_C max D.C. or Peak
Pulse operation*
D.C. operation
100µs
1ms
10ms
BD183
V_{CEO} max = 80V
BD182
V_{CEO} max = 60V
* For single non-repetitive pulse
I_C (A)
V_{CE} (V)
15
10
1.0
0.1
0.1
1.0
10
100



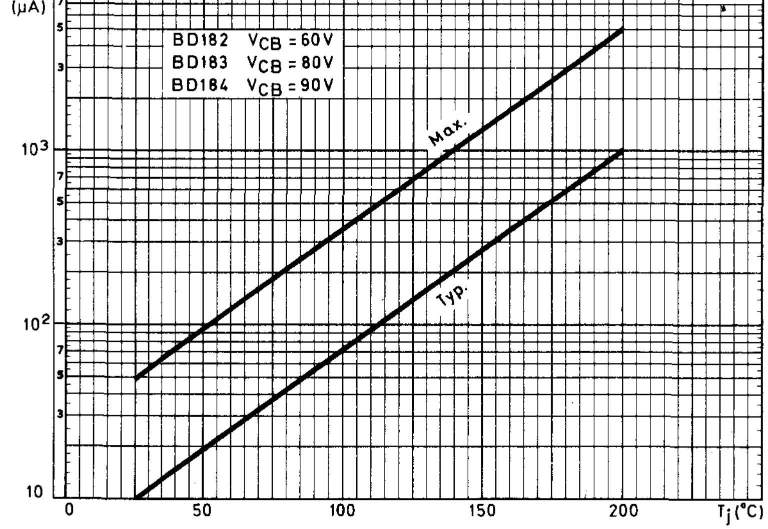
IC
(A)
BD184
D1734
Tmb = 25°C
Pulse operation*
IC max D.C. or Peak
100us
10ms
1ms
D.C. operation
VCEO max
=90V
*For single non repetitive pulse
15
10
1.0
0.1
0.1
1.0
10
100
VCE (V)



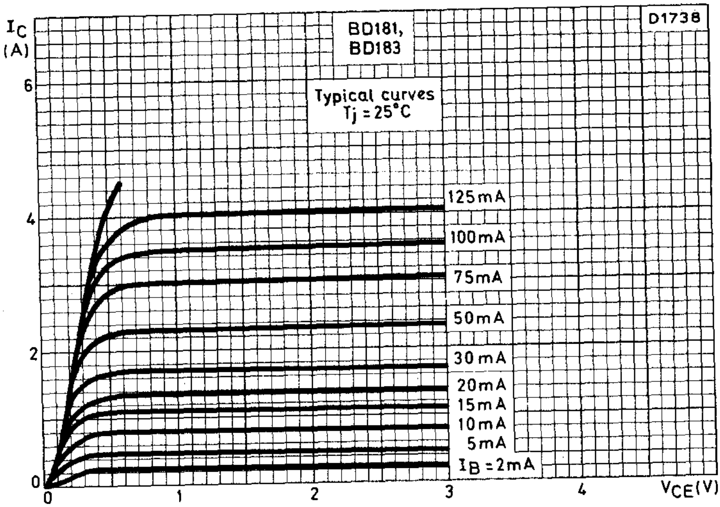
VCER
max
(V)
D1735
Tj = 25°C
BD184
BD183
BD182
BD181
100
80
60
40
20
10⁻¹
1
10
10²
10³
10⁴
RBE (Ω)



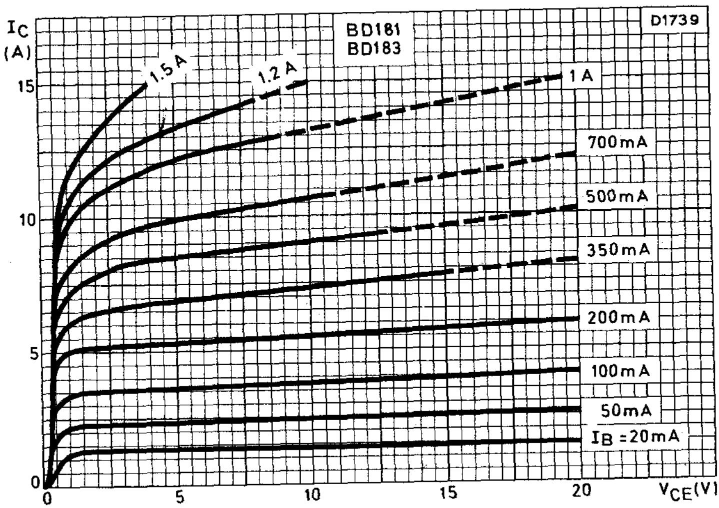
I_{CBO} (μA)
D1736
BD181 V_{CB} = 45V
Max.
Typ.
10^3
10^2
10
1
0
50
100
150
200
T_j (°C)



I_{CBO} (μA)
D1737
BD182 V_{CB} = 60V
BD183 V_{CB} = 80V
BD184 V_{CB} = 90V
Max.
Typ.
10^3
10^2
10
0
50
100
150
200
T_j (°C)



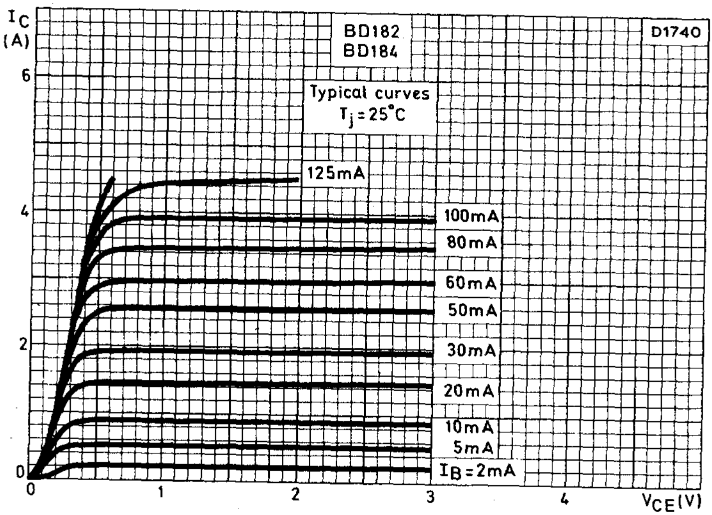
D1738
BD181,
BD183
Typical curves
$T_j = 25°C$
I_C (A)
6
4
2
0
125 mA
100 mA
75 mA
50 mA
30 mA
20 mA
15 mA
10 mA
5 mA
I_B = 2 mA
0
1
2
3
4
V_{CE} (V)

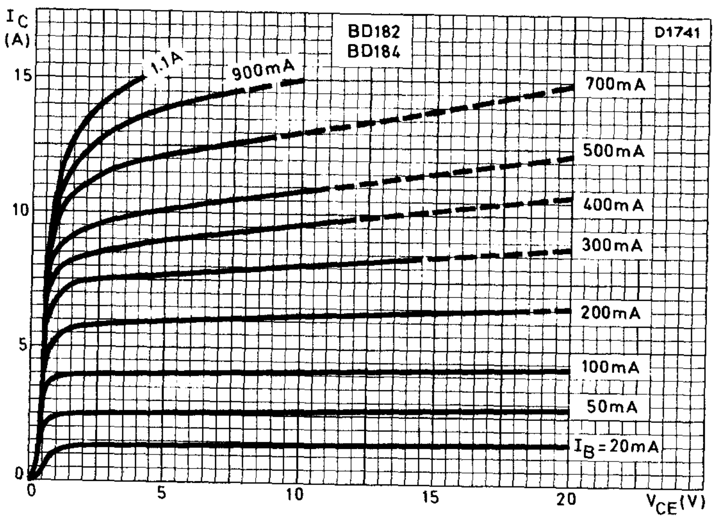


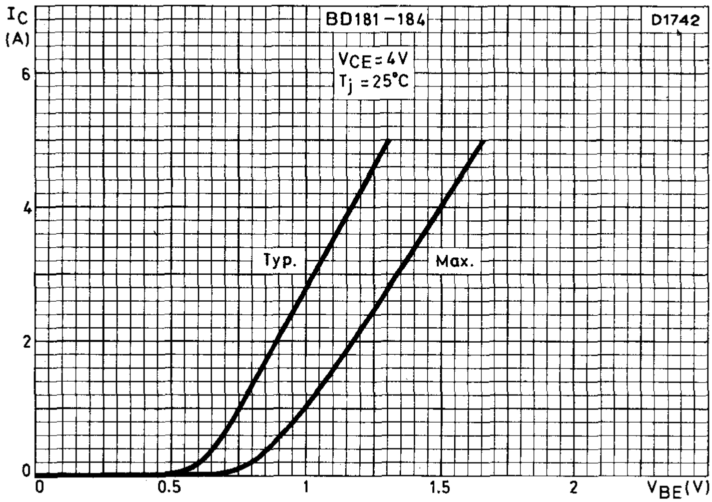
D1739
BD181
BD183
I_C (A)
15
10
5
0
1.5 A
1.2 A
1 A
700 mA
500 mA
350 mA
200 mA
100 mA
50 mA
I_B = 20 mA
0
5
10
15
20
V_{CE} (V)

N-P-N SILICON DIFFUSED POWER TRANSISTORS

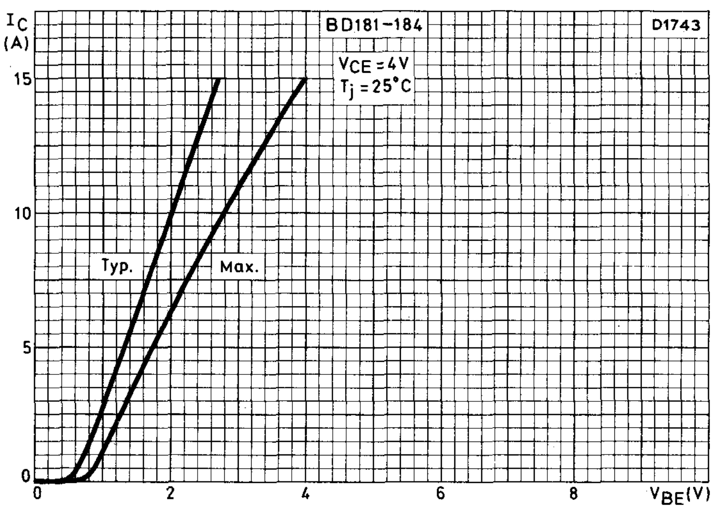
BD181
BD182
BD183
BD184







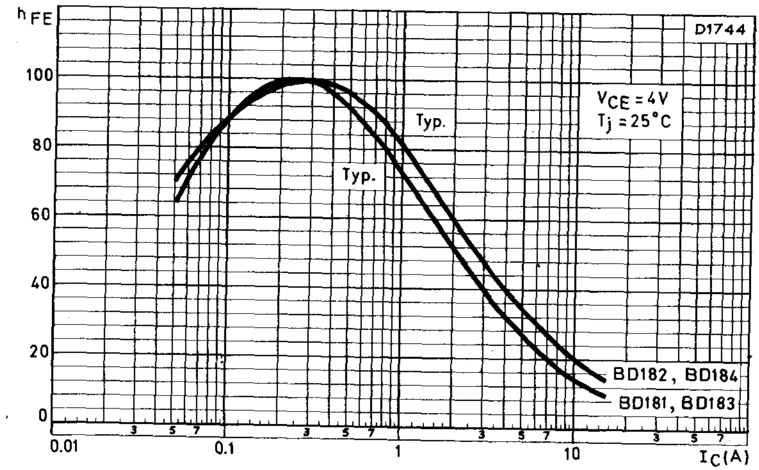
I_C (A)
BD181−184
D1742
V_{CE} = 4V
T_j = 25°C
Typ.
Max.
6
4
2
0
0
0.5
1
1.5
2
V_{BE}(V)

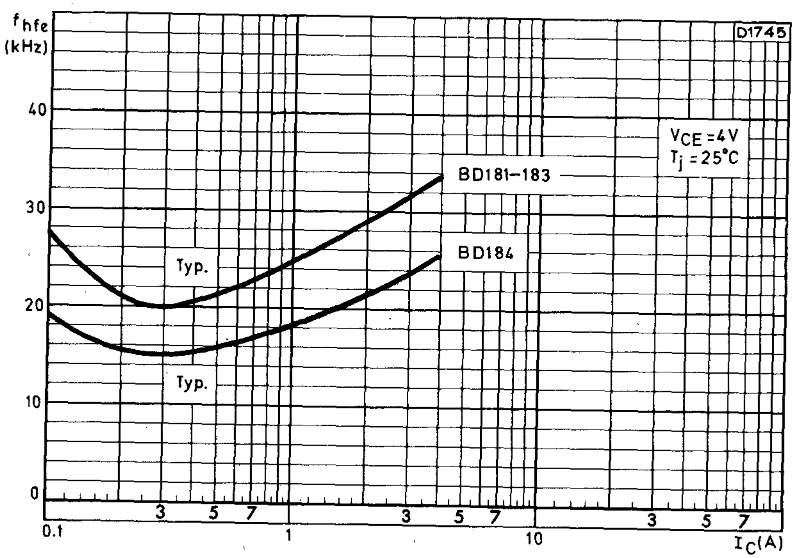


I_C (A)
BD181−184
D1743
V_{CE} = 4V
T_j = 25°C
Typ.
Max.
15
10
5
0
0
2
4
6
8
V_{BE}(V)

N-P-N SILICON DIFFUSED POWER TRANSISTORS

BD181
BD182
BD183
BD184





N-P-N SILICON EPITAXIAL-BASE A.F. POWER TRANSISTORS

BD201 BD203

N-P-N silicon epitaxial-base power transistors in a plastic envelope. With their p-n-p complements BD202 and BD204 they are primarily intended for use in hi-fi equipment delivering an output of 15 to 25W into 4 or 8Ω load.

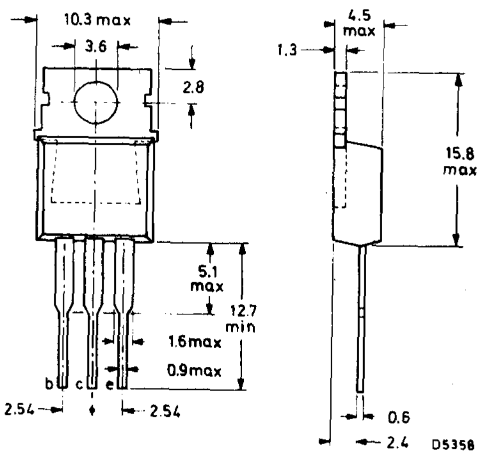
QUICK REFERENCE DATA

		BD201	BD203	
V_{CBO}	max.	60	60	V
V_{CEO}	max.	45	60	V
I_C	max.	8.0	8.0	A
P_{tot}	max. ($T_{mb} \leq 25^oC$)	60	60	W
T_j	max.	150	150	^oC
h_{FE}	min. (I_C = 3A, V_{CE} = 2V)	30	-	
	(I_C = 2A, V_{CE} = 2V)	-	30	
f_{hfe}	min. (I_C = 0.3A, V_{CE} = 3V)	25	25	kHz

Unless otherwise stated data are applicable to both types

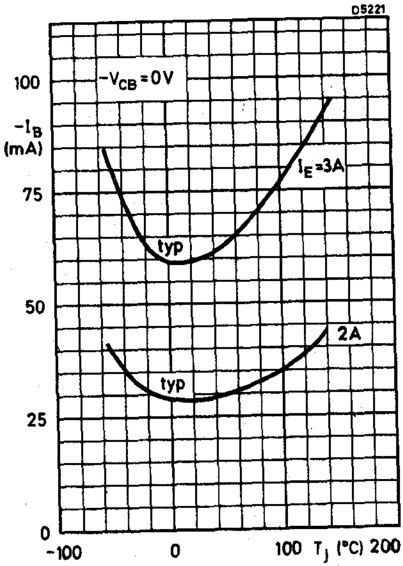
OUTLINE AND DIMENSIONS Similar to J.E.D.E.C. TO-220

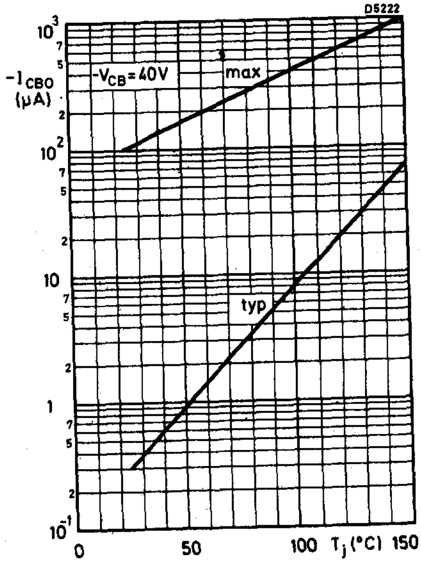
Collector connected to the metal part of the mounting surface.

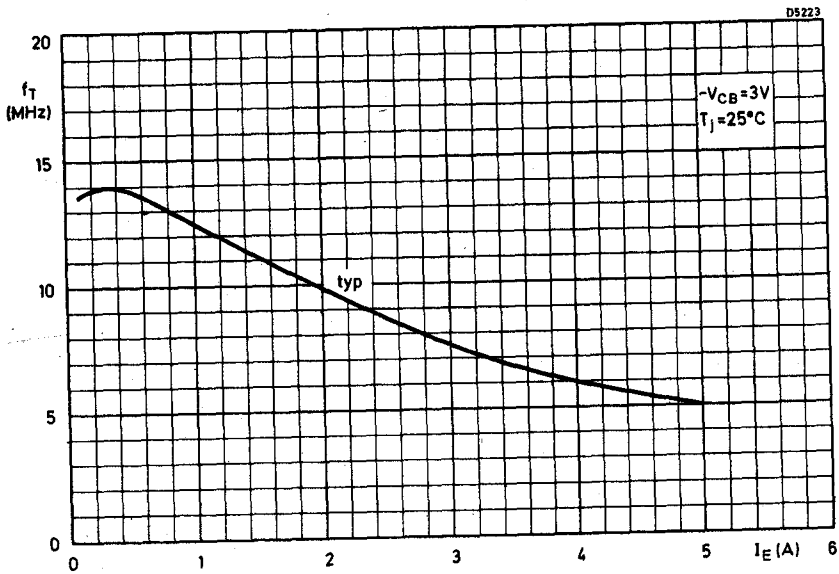


All dimensions in mm

Accessories available: 56338(insulating bush), 56325(mica washer)


D5221
$-V_{CB} = 0V$
100
75
50
25
0
$-I_B$ (mA)
$I_E = 3A$
typ
2A
typ
-100
0
100
T_j (°C)
200


D5222
$-I_{CBO}$ (μA)
$-V_{CB} = 40V$
max
typ
10^3
10^2
10
1
10^{-1}
0
50
100
T_j (°C)
150


D5223
f_T (MHz)
$-V_{CB} = 3V$
$T_j = 25°C$
typ
20
15
10
5
0
1
2
3
4
5
I_E (A)
6

N-P-N HIGH VOLTAGE SILICON TRANSISTOR

BD232

Triple diffused n-p-n silicon transistor in a plastic envelope, primarily intended for use as line driver in television receivers.

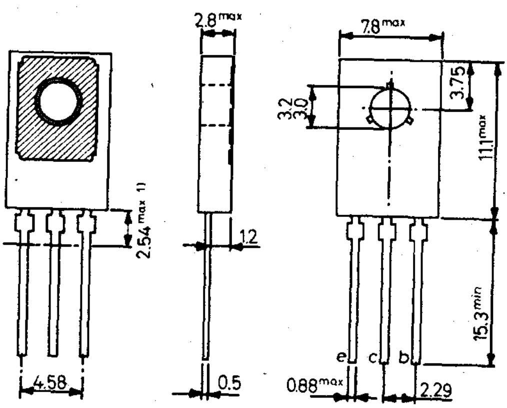
QUICK REFERENCE DATA

V_{CERM} max. ($R_{BE} \leq 1k\Omega$, $t_p < 10ms$)	500	V
V_{CEO} max.	300	V
I_C max.	0.25	A
I_{CM} max. ($t_p \leq 1ms$)	1.0	A
P_{tot} max. ($T_{mb} \leq 62^oC$)	7.0	W
T_j max.	125	^oC
h_{FE} min. ($I_C = 150mA$, $V_{CE} = 5V$)	20	
f_T typ. ($I_C = 50mA$, $V_{CE} = 10V$, $f = 5MHz$)	20	MHz

OUTLINE AND DIMENSIONS

Conforms to J.E.D.E.C. TO-126

Collector connected to the metal part of the mounting surface



All dimensions in mm

1) Within this region the cross-section of the leads is uncontrolled

Accessories available: 56301 (mica washer and torque washer)

Torque on nut: min. 3kg cm (0.3 Nm), max. 4kg cm (0.4 Nm)

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

V_{CERM} max. ($R_{BE} \leq 1k\Omega$, $t_p < 10ms$)	500	V
V_{CEO} max.	300	V
V_{EBO} max.	5.0	V
I_C max.	0.25	A
I_{CM} max. ($t_p \leq 1ms$)	1.0	A
I_B max.	0.25	A
P_{tot} max. ($T_{mb} \leq 62^oC$)	7.0	W

Temperature

T_{stg}	-55 to +125	^oC
T_j max.	125	^oC

THERMAL CHARACTERISTICS

$R_{th(j-mb)}$	9.0	$^oC/W$
$R_{th(j-amb)}$	100	$^oC/W$
$R_{th(mb-h)}$ with mica washer and heat conducting compound	3.0	$^oC/W$
$R_{th(mb-h)}$ for non-insulated mounting	1.0	$^oC/W$

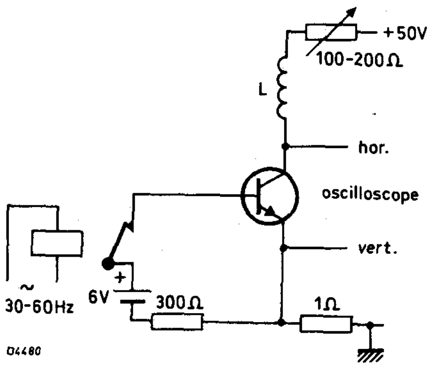
ELECTRICAL CHARACTERISTICS ($T_j = 25^oC$ unless otherwise stated)

		Min.	Typ.	Max.	
I_{CES}	*Collector cut-off current				
	$V_{BE} = 0$, $V_{CE} = 500V$	-	-	0.1	mA
	$V_{BE} = 0$, $V_{CE} = 500V$, $T_j = 125^oC$	-	-	1.0	mA

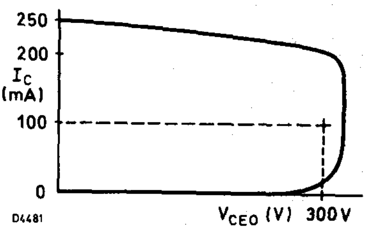
*Measured with a half sine wave voltage (curve tracer)

ELECTRICAL CHARACTERISTICS (contd)

		Min.	Typ.	Max.	
h_{FE}	Static forward current transfer ratio				
	I_C = 50mA, V_{CE} = 5V	25	-	150	
	I_C = 150mA, V_{CE} = 5V	20	-	-	
V_{BE}	Base-emitter voltage				
	I_C = 150mA, V_{CE} = 5V	-	-	1.0	V
$V_{CE(sat)}$	Collector-emitter saturation voltage				
	I_C = 150mA, I_B = 15mA	-	-	1.0	V
$V_{CEO(sust)}$	Collector-emitter sustaining voltage				
	I_B = 0, I_C = 100mA, L = 25mH	300	-	-	V

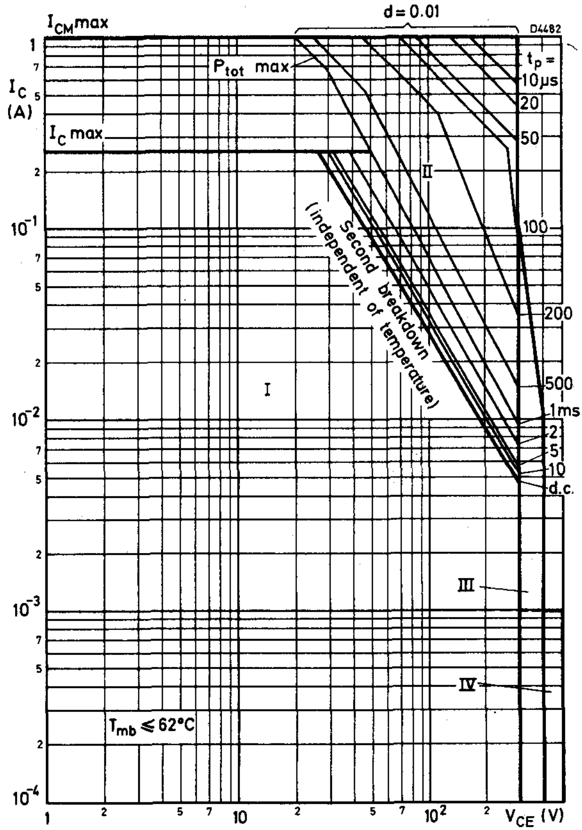


Test circuit for $V_{CEO(sust)}$



Oscilloscope display for $V_{CEO(sust)}$

		Min.	Typ.	Max.	
f_T	Transition frequency				
	I_C = 50mA, V_{CE} = 10V, f = 5MHz	-	20	-	MHz



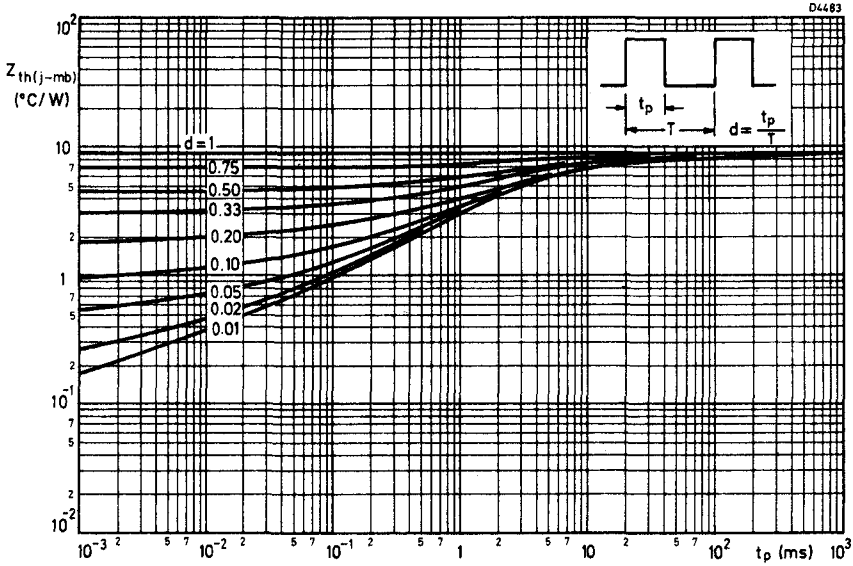
Safe Operating Areas (Regions I, II and III forward biased)

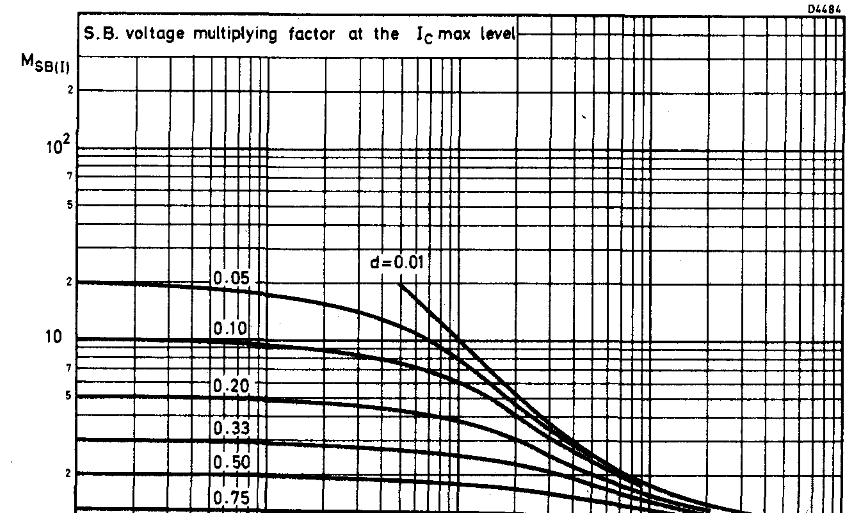
I Region of permissible d. c. operation

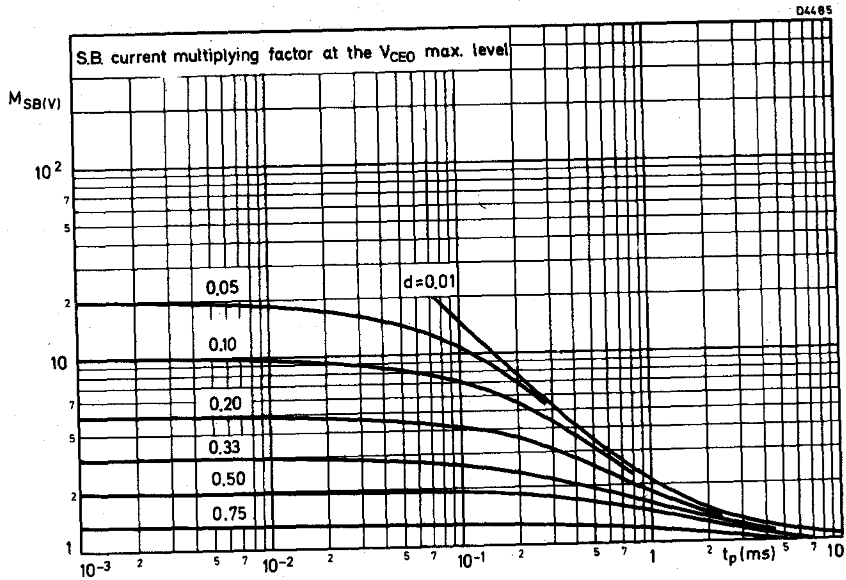
II Permissible extension for repetitive pulse operation

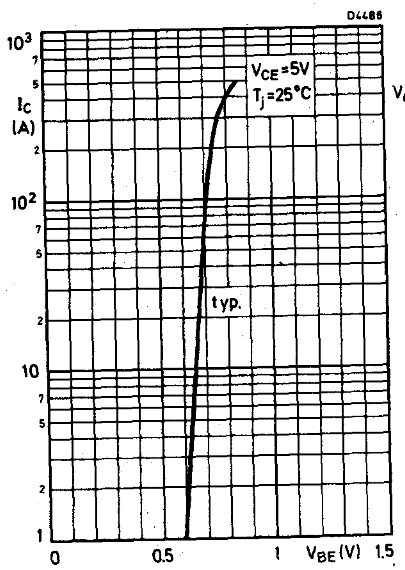
III Area of permissible operation during turn-on, provided $t_p \leq 0.3 \mu s$ and $R_{BE} \leq 1k\Omega$

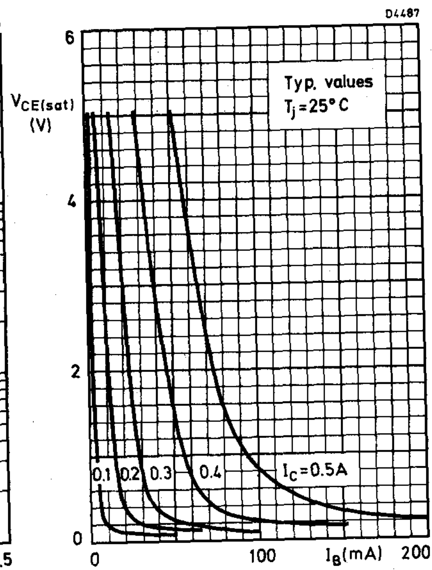
IV Repetitive pulse operation in this region is allowable, provided $R_{BE} \leq 1k\Omega$.

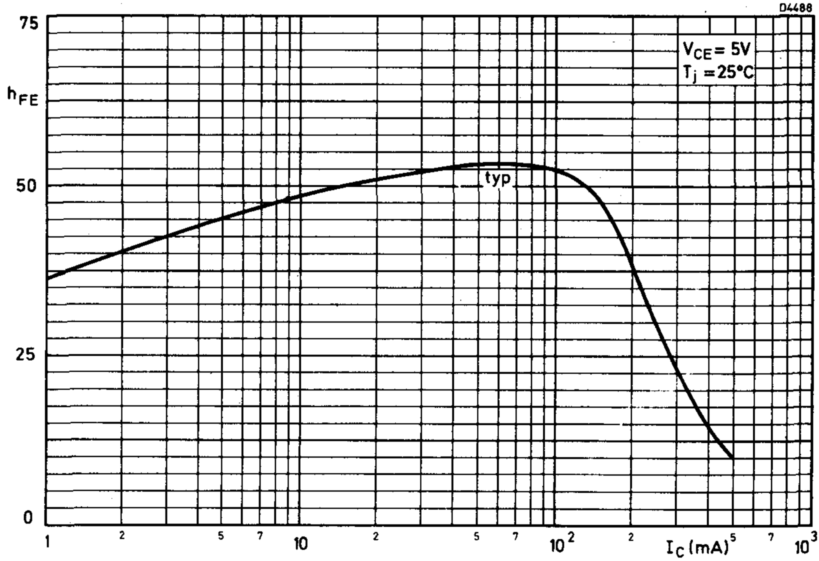

D4483
$Z_{th(j-mb)}$ (°C/W)
d = 1
0.75
0.50
0.33
0.20
0.10
0.05
0.02
0.01
t_p
T
$d = \frac{t_p}{T}$
t_p (ms)


D4484
S.B. voltage multiplying factor at the I_C max level
$M_{SB(I)}$
d = 0.01
0.05
0.10
0.20
0.33
0.50
0.75
t_p (ms)

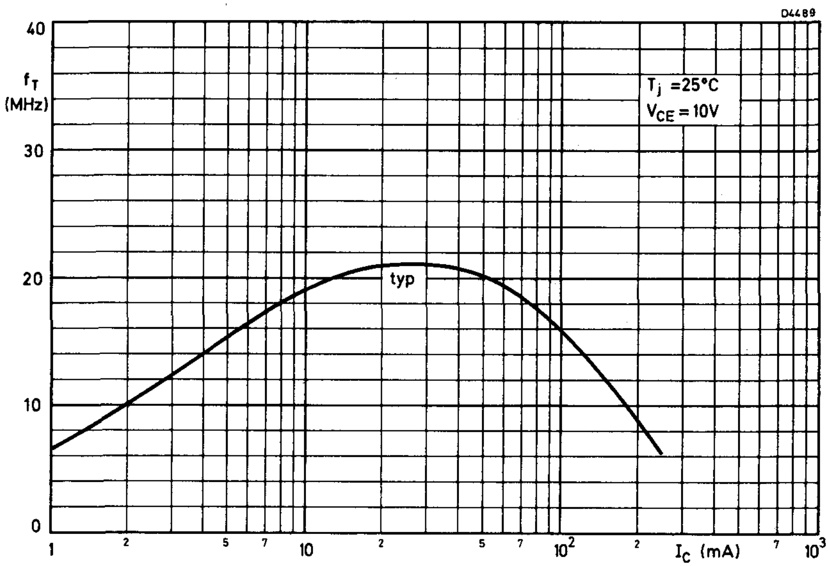

D4485
S.B. current multiplying factor at the V_{CEO} max. level
$M_{SB(V)}$
10^2
10
1
d=0.01
0.05
0.10
0.20
0.33
0.50
0.75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10


D4486
10^3
I_C
(A)
10^2
10
1
V_{CE}=5V
T_j=25°C
typ.
0
0.5
1
V_{BE} (V)
1.5


D4487
6
$V_{CE(sat)}$
(V)
4
2
0
Typ. values
T_j=25°C
0.1
0.2
0.3
0.4
I_C=0.5A
0
100
I_B (mA)
200



D4488
V_{CE} = 5V
T_j = 25°C
h_{FE}
75
50
25
0
typ
1
2
5
7
10
2
5
7
10^2
2
I_C (mA)
5
7
10^3



D4489
T_j = 25°C
V_{CE} = 10V
f_T
(MHz)
40
30
20
10
0
typ
1
2
5
7
10
2
5
7
10^2
2
I_C (mA)
7
10^3

N-P-N SILICON EPITAXIAL-BASE TRANSISTORS

BD233 BD235 BD237

N-P-N silicon epitaxial-base transistors in a TO-126 plastic envelope, intended for use in television and audio amplifier circuits where high peak powers can occur.

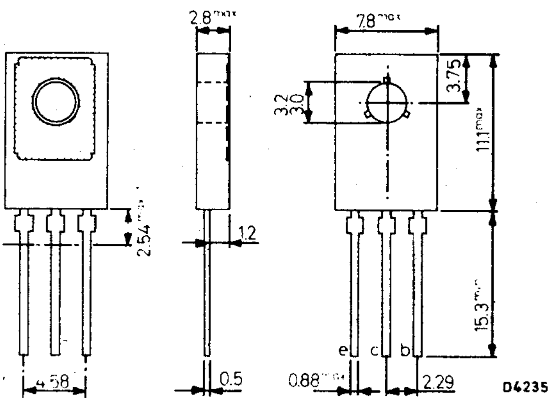
QUICK REFERENCE DATA

	BD233	BD235	BD237	
V_{CBO} max.	45	60	100	V
V_{CEO} max.	45	60	80	V
V_{CER} max. (R_{BE} = 1kΩ)	45	60	100	V
I_{CM} max.		6.0		A
P_{tot} max. ($T_{mb} \leq 25^{o}C$)		25		W
T_j max.		150		^{o}C
h_{FE} min. (I_C = 1A, V_{CE} = 2V)		25		
f_T min. (I_C = 250mA, V_{CE} = 10V, f = 1MHz)		3.0		MHz

Unless otherwise stated data is applicable to all types.

OUTLINE AND DIMENSIONS

Conforms to J.E.D.E.C. TO-126
Collector connected to the metal part of the mounting surface



Torque on nut:
min. 3kg cm
(0.3Nm)
Max. 4kg cm
(0.4Nm)

All dimensions in mm

1) Within this region the cross-section of the leads is uncontrolled.

Accessories available: 56301B (mica washer)
56326 (plain washer)

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

	BD233	BD235	BD237	
V_{CBO} max.	45	60	100	V
V_{CEO} max.	45	60	80	V
V_{CER} max. (R_{BE} = 1kΩ)	45	60	100	V
V_{EBO} max.	5.0	5.0	5.0	V
I_C max.		2.0		A
I_{CM} max.		6.0		A
P_{tot} max. ($T_{mb} \leq 25^{\circ}C$)		25		W

Temperature

T_{stg}	-55 to +150	^{o}C
T_j	150	^{o}C

THERMAL CHARACTERISTICS

$R_{th(j-amb)}$	(in free air)	100	$^{o}C/W$
$R_{th(j-mb)}$		5.0	$^{o}C/W$
$R_{th(mb-h)}$	using mica washer and compound	3.0	$^{o}C/W$
$R_{th(mb-h)}$	non-insulated mounting	1.0	$^{o}C/W$

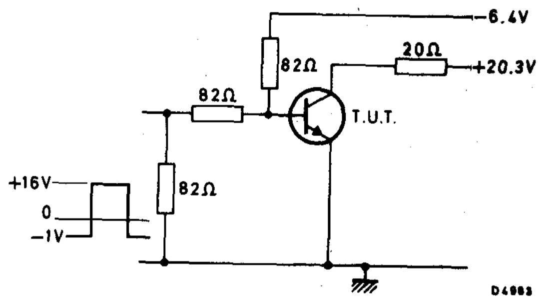
ELECTRICAL CHARACTERISTICS ($T_j = 25^{o}C$ unless otherwise stated)

			Min.	Max.	
I_{CBO}	Collector cut-off current				
	$I_E = 0$, $V_{CB} = V_{CBO}$ max.		-	100	μA
	$I_E = 0$, $V_{CB} = V_{CBO}$ max., $T_j = 150^{o}C$		-	3.0	mA
I_{EBO}	Emitter cut-off current				
	$I_C = 0$, $V_{EB} = 5V$		-	1.0	mA
V_{BE}	Base-emitter voltage				
	$I_C = 1A$, $V_{CE} = 2V$		-	1.3	V
$V_{CE(sat)}$	Collector-emitter saturation voltage				
	$I_C = 1A$, $I_B = 0.1A$		-	0.6	V
h_{FE}	Static forward current transfer ratio				
	$I_C = 150mA$, $V_{CE} = 2V$	BD233, BD235	40	250	
		BD237	40	160	
	$I_C = 1A$, $V_{CE} = 2V$		25	-	

ELECTRICAL CHARACTERISTICS (contd)

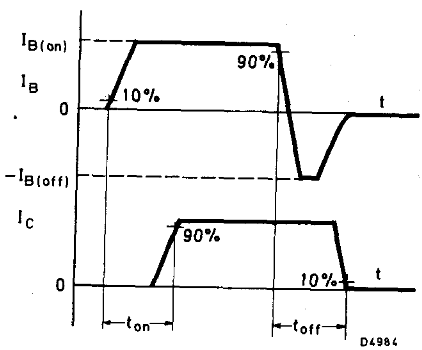
		Min.	Typ.	Max.	
f_T	Transition frequency I_C = 250mA, V_{CE} = 10V, f = 1MHz	3.0		-	MHz
	Switching characteristics I_C = 1A, $I_{B(on)}$ = $-I_{B(off)}$ = 0.1A				
t_{on}	Turn-on time		0.3		μs
t_{off}	Turn-off time		1.1		μs

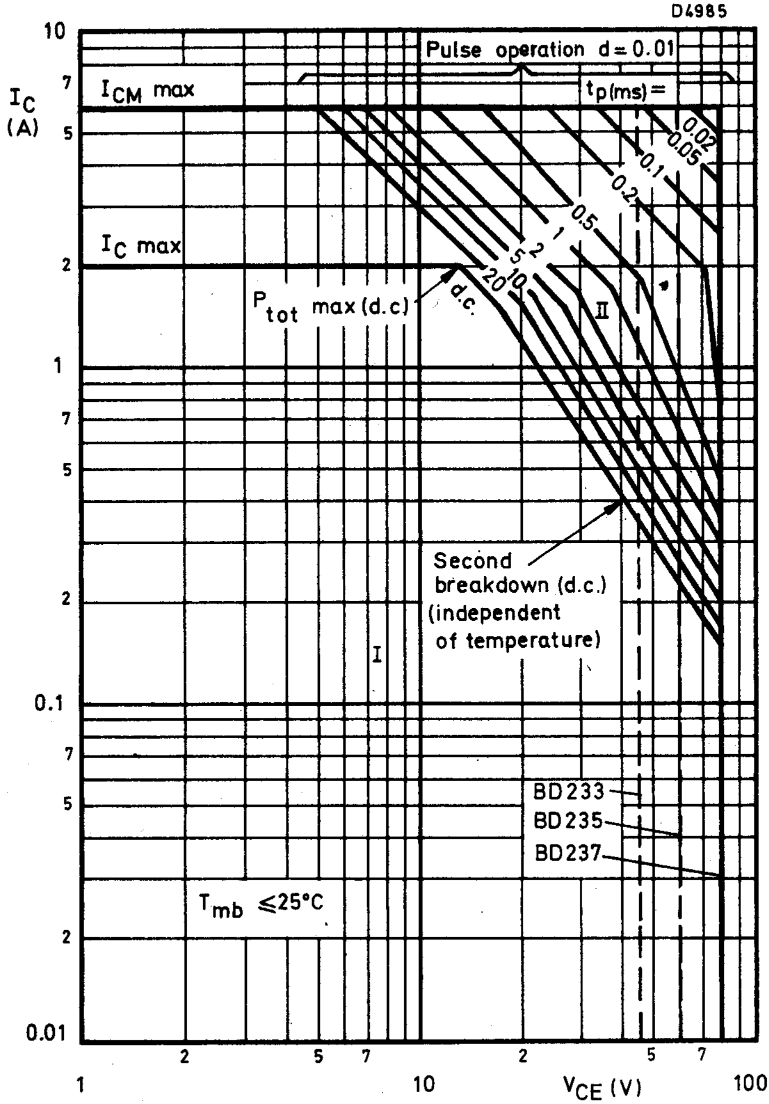
Test circuit



Input pulse:

t_r = t_f = 15ns
t_p = 10μs
T = 500μs

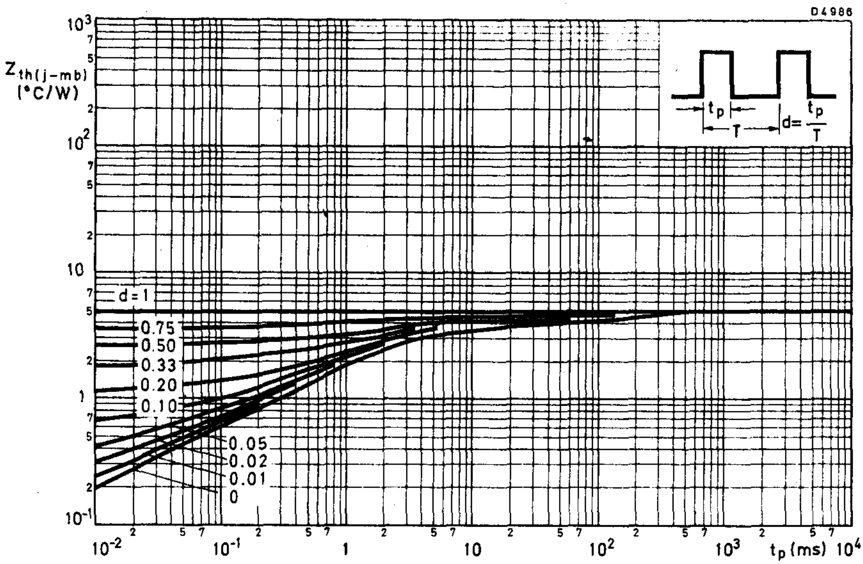


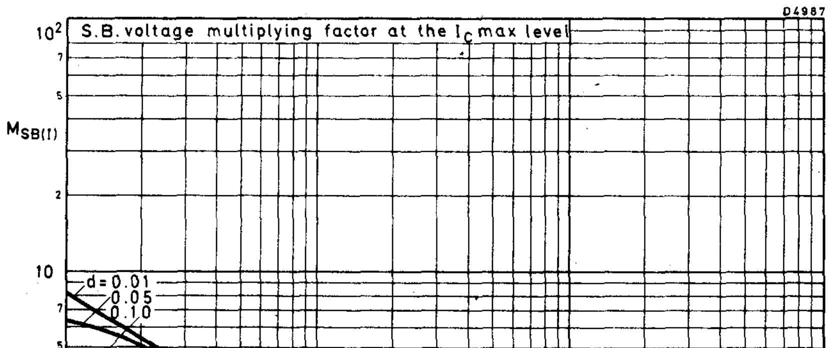


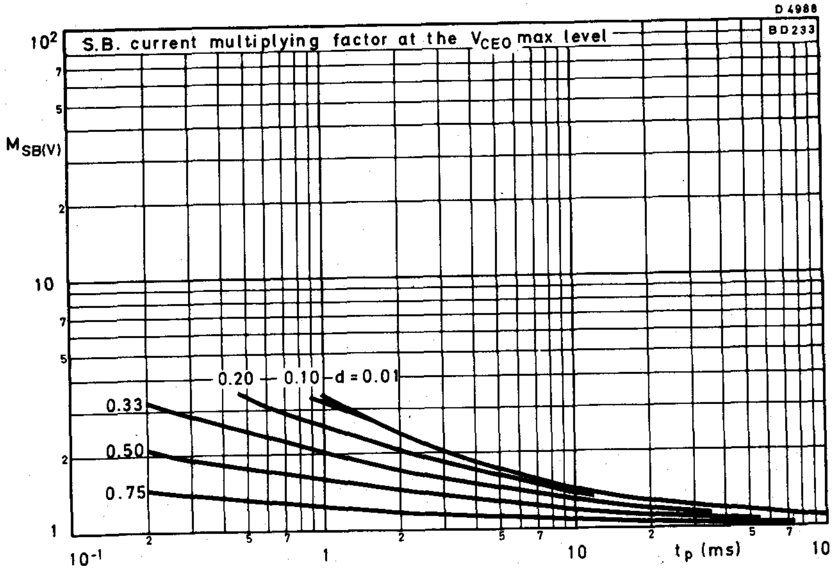
SAFE OPERATING AREAS WITH THE TRANSISTOR FORWARD BIASED

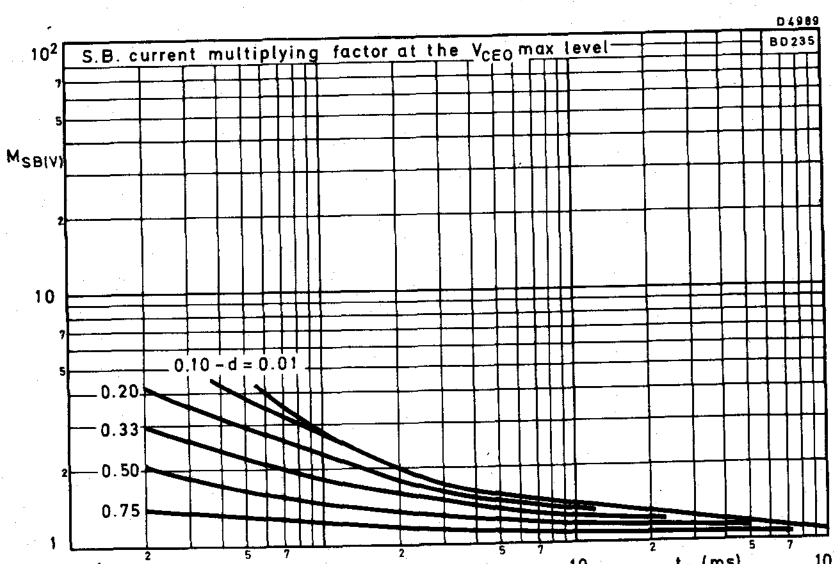
I Region of permissible d. c. operation

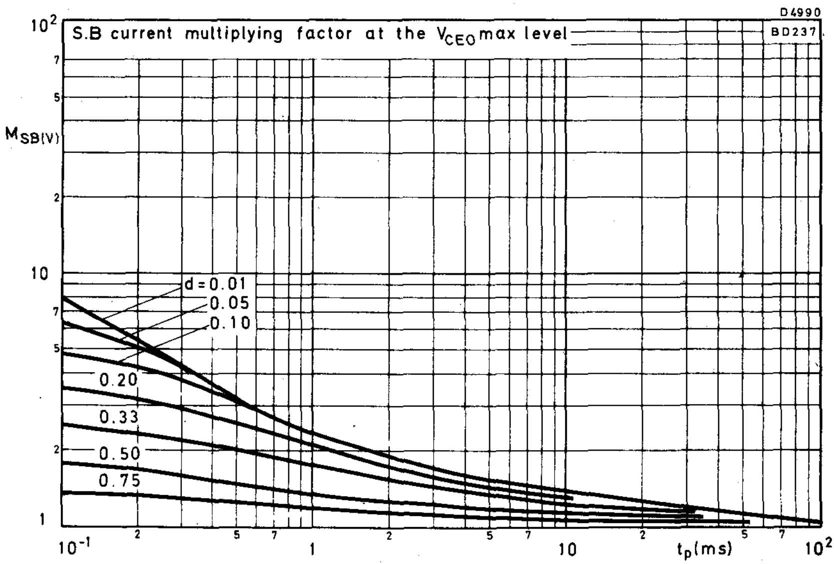
II Permissible extension for repetitive pulsed operation


D4986
$Z_{th(j-mb)}$ (°C/W)
d = 1
0.75
0.50
0.33
0.20
0.10
0.05
0.02
0.01
0
$d = \frac{t_p}{T}$
t_p (ms)

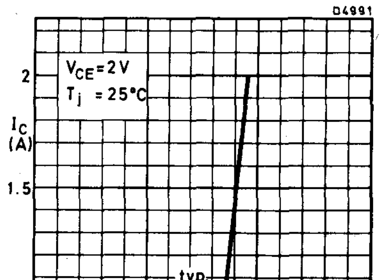

D4987
S.B. voltage multiplying factor at the I_C max level
$M_{SB(I)}$
d = 0.01
0.05
0.10
0.20
0.33
0.50
0.75
t_p(ms)


D 4988
BD233
S.B. current multiplying factor at the V_{CEO} max level
$M_{SB(V)}$
10^2
10
1
0.20
0.10
d = 0.01
0.33
0.50
0.75
10^{-1}
1
10
t_p (ms)
10^2

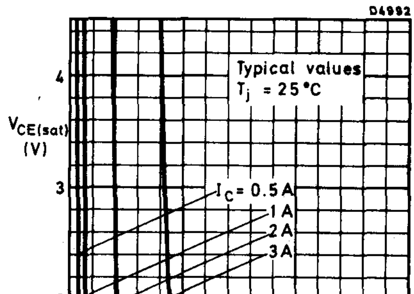

D 4989
BD235
S.B. current multiplying factor at the V_{CEO} max level
$M_{SB(V)}$
10^2
10
1
0.10
d = 0.01
0.20
0.33
0.50
0.75
10^{-1}
1
10
t_p (ms)
10^2



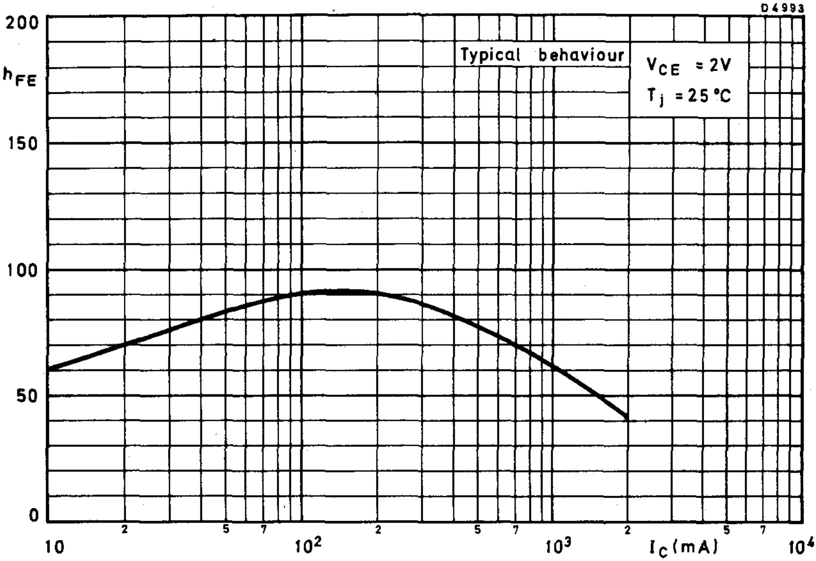
D4990
S.B current multiplying factor at the V_{CEO} max level
BD237
$M_{SB(V)}$
d = 0.01
0.05
0.10
0.20
0.33
0.50
0.75
t_p(ms)



D4991
V_{CE} = 2 V
T_j = 25 °C
I_C (A)
typ.
V_{BE} (V)



D4992
Typical values
T_j = 25 °C
$V_{CE(sat)}$ (V)
I_C = 0.5 A
1 A
2 A
3 A
I_B(mA)


D4993
200
h_{FE}
150
100
50
0
Typical behaviour
V_{CE} = 2V
T_j = 25 °C
10
2
5
7
10^2
2
5
7
10^3
2
I_C (mA)
5
7
10^4

P-N-P SILICON EPITAXIAL-BASE TRANSISTORS

BD234 BD236 BD238

P-N-P silicon epitaxial-base transistors in a TO-126 plastic envelope, intended for use in television and audio amplifier circuits where high peak powers can occur.

QUICK REFERENCE DATA

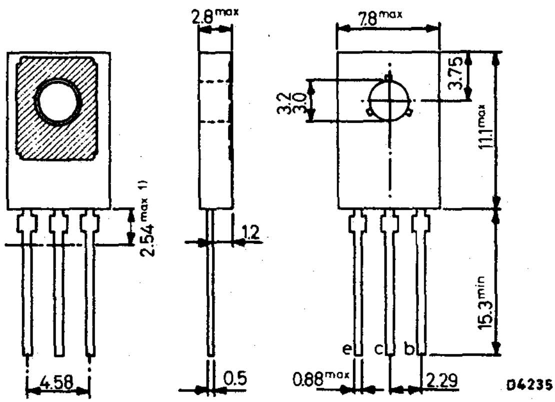
	BD234	BD236	BD238	
$-V_{CBO}$ max.	45	60	100	V
$-V_{CEO}$ max.	45	60	80	V
$-V_{CER}$ max. (R_{BE} = 1kΩ)	45	60	100	V
$-I_{CM}$ max.		6.0		A
P_{tot} max. ($T_{mb} \leq 25^{o}C$)		25		W
T_j max.		150		^{o}C
h_{FE} min. ($-I_C$ = 1A, $-V_{CE}$ = 2V)		25		
f_T min. ($-I_C$ = 250mA, $-V_{CE}$ = 10V, f = 1MHz)		3.0		MHz

Unless otherwise stated data is applicable to all types.

OUTLINE AND DIMENSIONS

Conforms to J.E.D.E.C. TO-126

Collector connected to the metal part of the mounting surface



Torque on nut:
min. 3kg cm (0.3Nm)
Max. 4kg cm (0.4Nm)

All dimensions in mm

1) Within this region the cross-section of the leads is uncontrolled.

Accessories available: 56301B (mica washer)
56326 (plain washer)

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

	BD234	BD236	BD238	
$-V_{CBO}$ max.	45	60	100	V
$-V_{CEO}$ max.	45	60	80	V
$-V_{CER}$ max. (R_{BE} = 1kΩ)	45	60	100	V
$-V_{EBO}$ max.	5.0	5.0	5.0	V
$-I_C$ max.		2.0		A
$-I_{CM}$ max.		6.0		A
P_{tot} max. ($T_{mb} \leq 25^{\circ}C$)		25		W

Temperature

T_{stg}	-55 to +150	$^{\circ}C$
T_j max.	150	$^{\circ}C$

THERMAL CHARACTERISTICS

$R_{th(j-amb)}$	(in free air)	100	$^{\circ}C/W$
$R_{th(j-mb)}$		5.0	$^{\circ}C/W$
$R_{th(mb-h)}$	using mica washer and compound	3.0	$^{\circ}C/W$
$R_{th(mb-h)}$	non-insulated mounting	1.0	$^{\circ}C/W$

ELECTRICAL CHARACTERISTICS ($T_j = 25^{\circ}C$ unless otherwise stated)

			Min.	Max.	
$-I_{CBO}$	Collector cut-off current				
	$I_E = 0$, $-V_{CB} = -V_{CBO}$ max.		-	100	µA
	$I_E = 0$, $-V_{CB} = -V_{CBO}$ max., $T_j = 150^{\circ}C$		-	3.0	mA
$-I_{EBO}$	Emitter cut-off current $I_C = 0$, $-V_{EB} = 5V$		-	1.0	mA
$-V_{BE}$	Base-emitter voltage $-I_C = 1A$, $-V_{CE} = 2V$		-	1.3	V
$-V_{CE(sat)}$	Collector-emitter saturation voltage, $-I_C = 1A$, $-I_B = 0.1A$		-	0.6	V
h_{FE}	Static forward current transfer ratio,				
	$-I_C = 150mA$, $-V_{CE} = 2V$	BD234, BD236	40	250	
		BD238	40	160	
	$-I_C = 1A$, $-V_{CE} = 2V$		25	-	

ELECTRICAL CHARACTERISTICS (contd.)

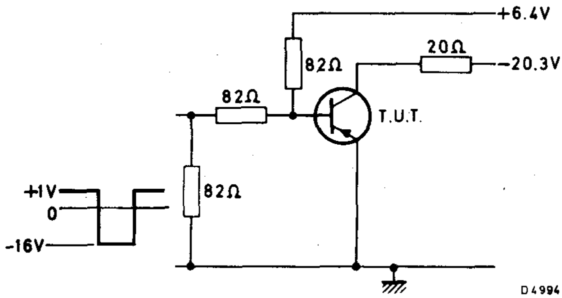
		Min.	Max.	
f_T	Transition frequency $-I_C = 250mA$, $-V_{CE} = 10V$, f = 1MHz	3.0	-	MHz

Switching characteristics

$-I_C = 1A$, $-I_{B(on)} = I_{B(off)} = 0.1A$

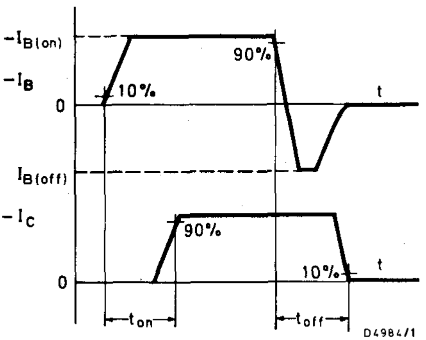
		Typ.	
t_{on}	Turn-on time	0.3	μs
t_{off}	Turn-off time	0.7	μs

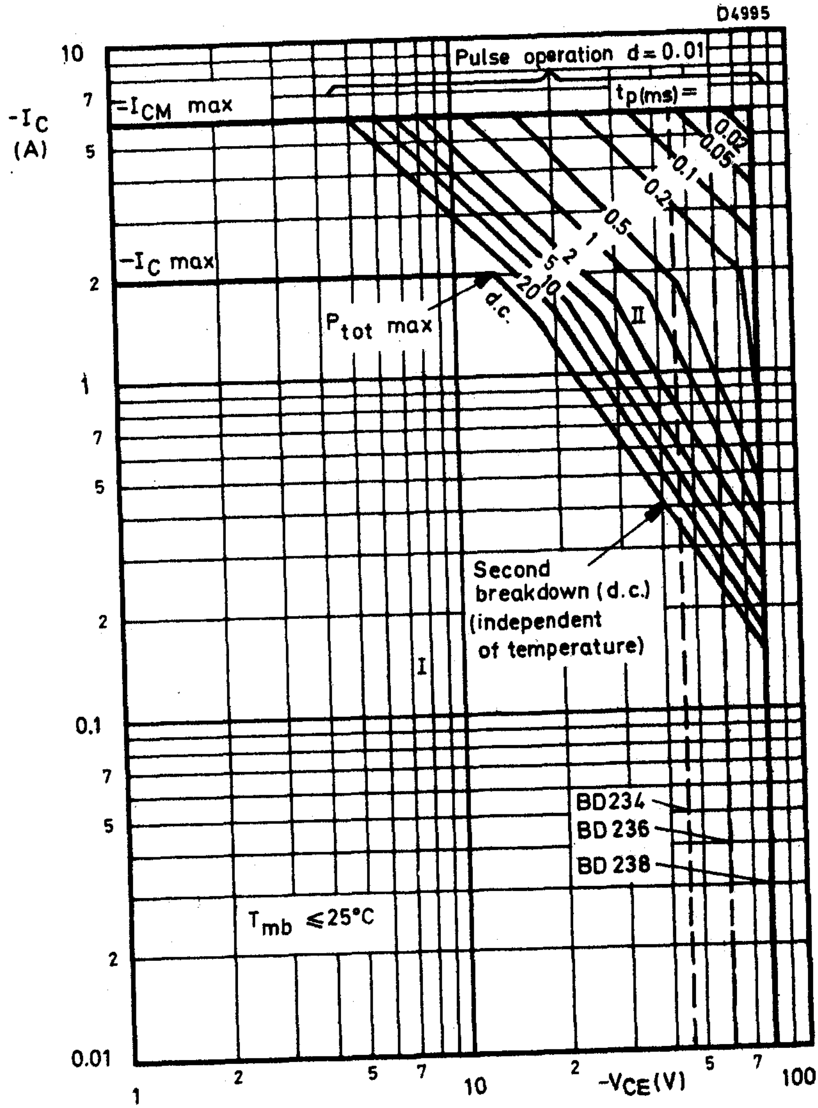
Test circuit



Input pulse:

$t_r = t_f =$ 15ns
$t_p =$ 10μs
T = 500μs





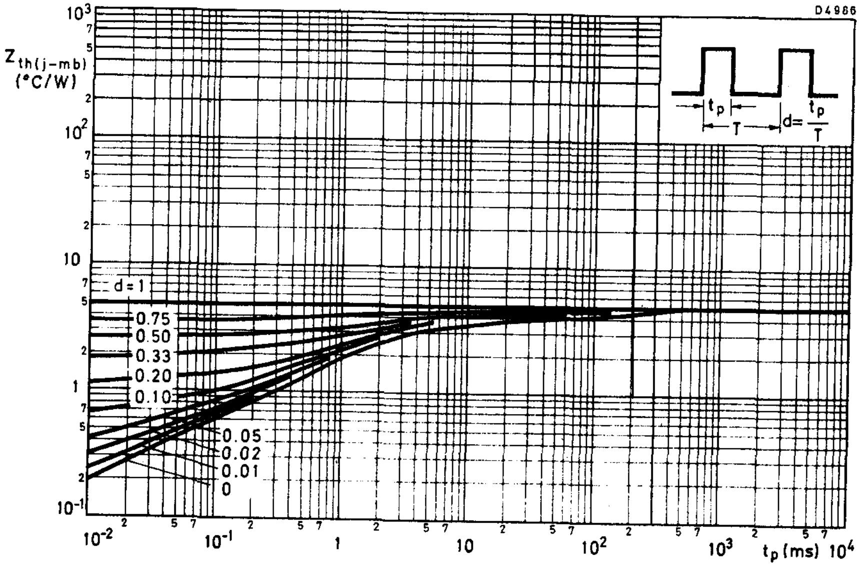
SAFE OPERATING AREAS WITH THE TRANSISTOR FORWARD BIASED

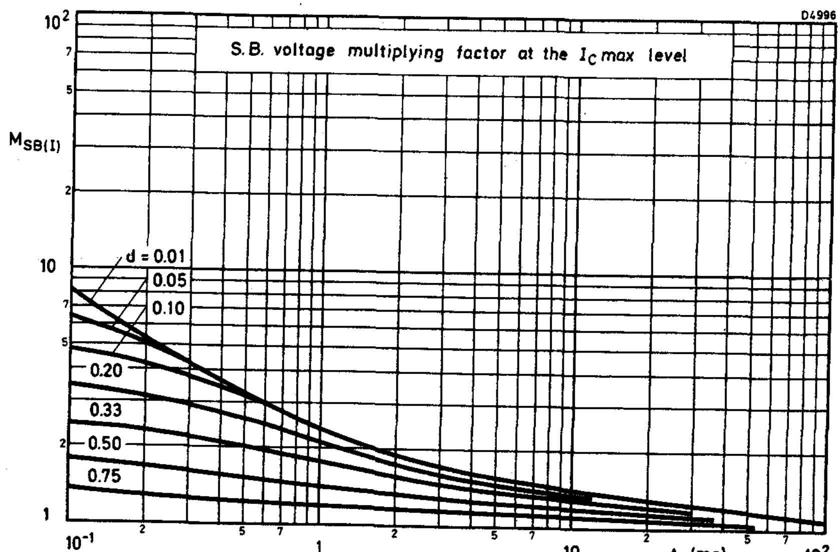
I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

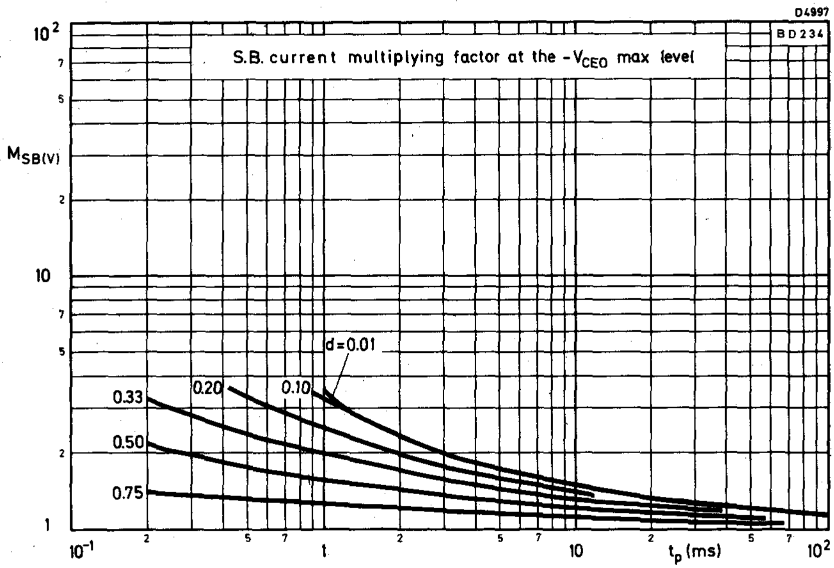
P-N-P SILICON
EPITAXIAL-BASE TRANSISTORS

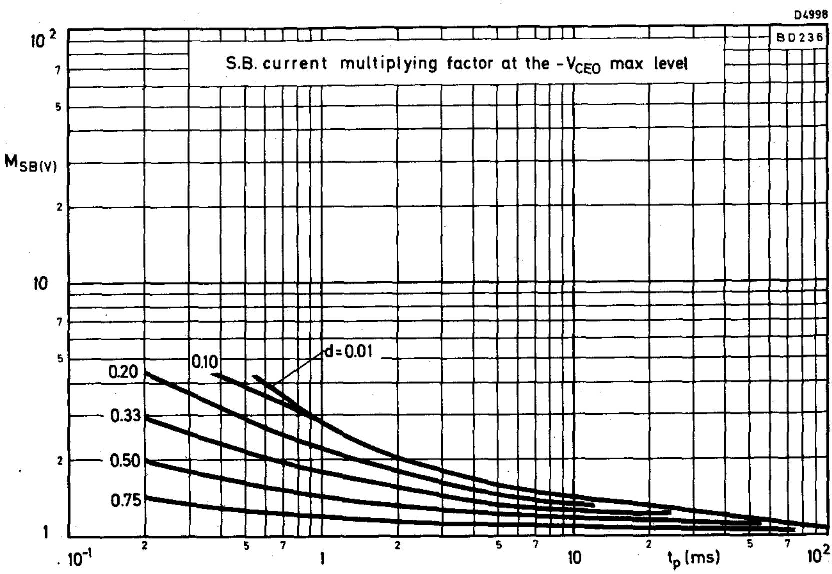
BD234
BD236
BD238

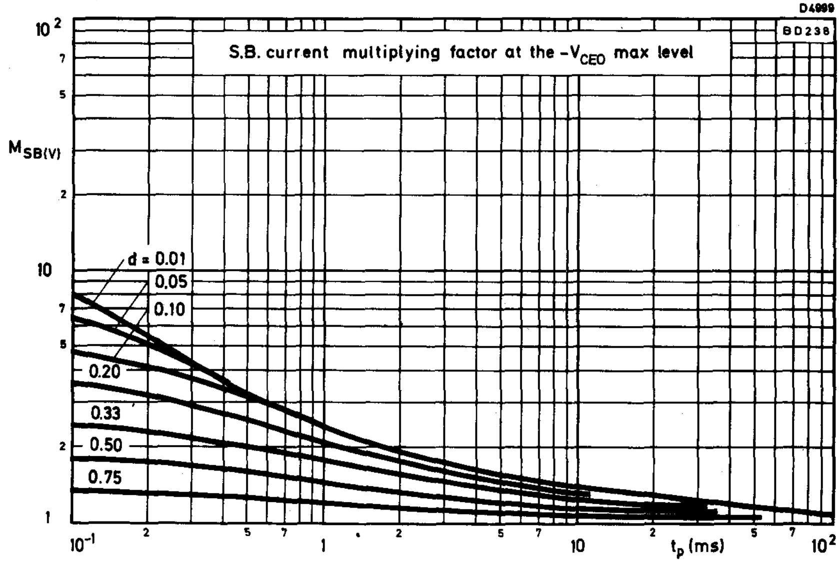


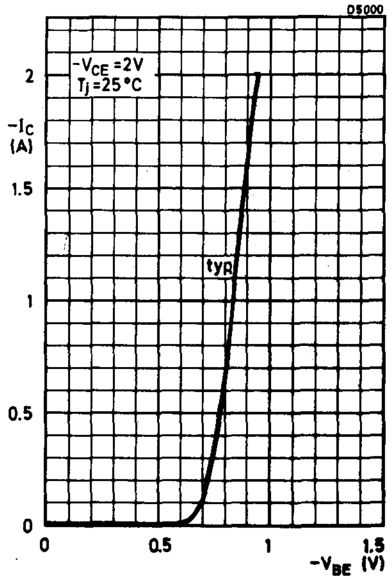


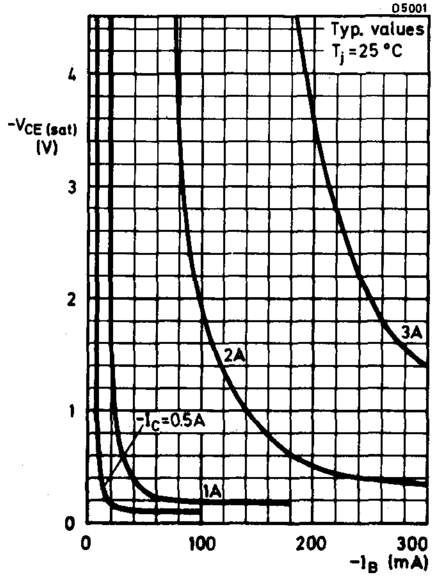
Mullard

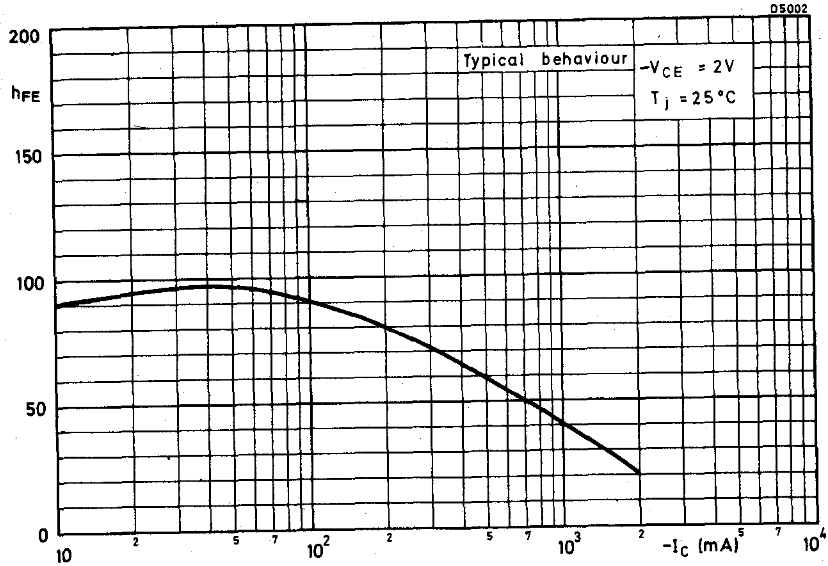

D4997
BD234
S.B. current multiplying factor at the $-V_{CEO}$ max level
$M_{SB(V)}$
10^2
7
5
2
10
7
5
2
1
d=0.01
0.20
0.10
0.33
0.50
0.75
10^{-1}
2
5
7
1
2
5
7
10
2
t_p (ms)
5
7
10^2


D4998
BD236
S.B. current multiplying factor at the $-V_{CEO}$ max level
$M_{SB(V)}$
10^2
7
5
2
10
7
5
2
1
d=0.01
0.10
0.20
0.33
0.50
0.75
10^{-1}
2
5
7
1
2
5
7
10
2
t_p (ms)
5
7
10^2


D4999
BD238
S.B. current multiplying factor at the $-V_{CEO}$ max level
$M_{SB(V)}$
d = 0.01
0.05
0.10
0.20
0.33
0.50
0.75
t_p (ms)


D5000
$-V_{CE}$ = 2V
T_j = 25 °C
$-I_C$ (A)
typ
$-V_{BE}$ (V)


D5001
Typ. values
T_j = 25 °C
$-V_{CE(sat)}$ (V)
$-I_C$ = 0.5A
1A
2A
3A
$-I_B$ (mA)


D5002
200
h_{FE}
150
100
50
0
10
2
5
7
10^2
2
5
7
10^3
2
$-I_C$ (mA)
5
7
10^4
Typical behaviour
$-V_{CE}$ = 2V
T_j = 25°C

P-N-P SILICON DARLINGTON POWER TRANSISTORS

BD262 BD262A BD262B

P-N-P silicon epitaxial base power transistors in monolithic Darlington circuit, intended for audio output stages and general amplifier and switching applications. Encapsulated in TO-126 plastic envelope. N-P-N complements are BD263, BD263A and BD263B respectively.

QUICK REFERENCE DATA

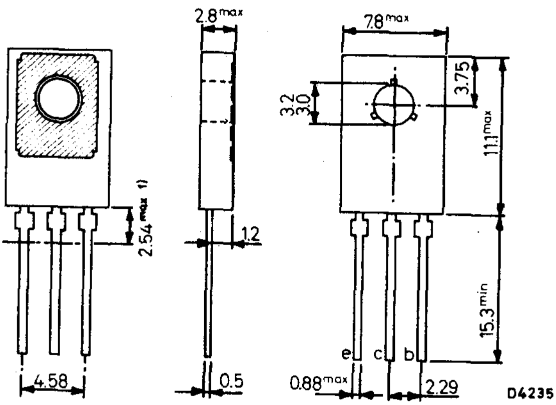
	BD262	BD262A	BD262B	
$-V_{CBO}$ max.	60	80	100	V
$-V_{CEO}$ max.	60	80	100	V
$-I_{CM}$ max.		6.0		A
P_{tot} max ($T_{mb} \leq 25^oC$)		36		W
T_j max.		150		^oC
h_{FE} typ. ($-I_C = 0.5A$, $-V_{CE} = 3.0V$)		1000		
min. ($-I_C = 1.5A$, $-V_{CE} = 3.0V$)		750		
f_T typ. ($-I_C = 1.5A$, $-V_{CE} = 3.0V$)		7.0		MHz

Unless otherwise stated data are applicable to all types.

OUTLINE AND DIMENSIONS

Conforms to J.E.D.E.C. TO-126

Collector connected to the metal part of the mounting surface



Torque on nut:

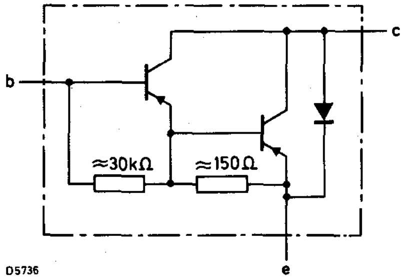
min. 3kg cm (0.3Nm)

max. 4kg cm (0.4Nm)

All dimensions in mm

1) Within this region the cross-section of the leads is uncontrolled.

CIRCUIT DIAGRAM



RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

	BD262	BD262A	BD262B	
$-V_{CBO}$ max.	60	80	100	V
$-V_{CEO}$ max.	60	80	100	V
$-V_{EBO}$ max.	5.0	5.0	5.0	V
$-I_C$ max.		4.0		A
$-I_{CM}$ max.		6.0		A
$-I_B$ max.		100		mA
P_{tot} max. ($T_{mb} \leq 25^oC$)		36		W

Temperature

T_{stg}	-55 to +150	^oC
T_j max.	150	^oC

THERMAL CHARACTERISTICS

$R_{th(j-amb)}$ in free air	100	$^oC/W$
$R_{th(j-mb)}$	3.5	$^oC/W$
$R_{th(mb-h)}$ using mica washer and compound	3.0	$^oC/W$
$R_{th(mb-h)}$ non-insulated mounting	1.0	$^oC/W$

ACCESSORIES

Accessory	Code No.	Note
1 Mica washer	56301B	Supplied
1 Plain washer	56326	on request

When mounted on a heatsink it is essential that a plain washer be used to prevent damage to the devices while tightening the mounting screw.

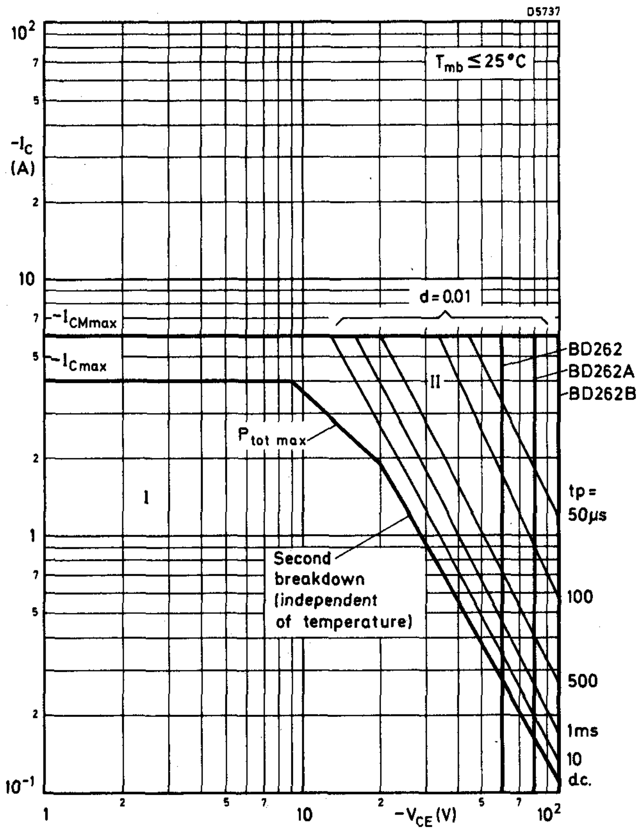
P-N-P SILICON DARLINGTON POWER TRANSISTORS

BD262 BD262A BD262B

ELECTRICAL CHARACTERISTICS (T_j = 25°C unless otherwise stated)

			Min.	Typ.	Max.	
	Collector cut-off current					
$-I_{CBO}$	$I_E = 0$, $-V_{CB} = -V_{CBO}$ max.		-	-	0.2	mA
$-I_{CBO}$	$I_E = 0$, $-V_{CB} = -V_{CBO}$ max., T_{mb} = 150°C		-	-	2.0	mA
$-I_{CEO}$	$I_B = 0$, $-V_{CE}$ = 30V	BD262	-	-	0.5	mA
$-I_{CEO}$	$I_B = 0$, $-V_{CE}$ = 40V	BD262A	-	-	0.5	mA
$-I_{CEO}$	$I_B = 0$, $-V_{CE}$ = 50V	BD262B	-	-	0.5	mA
$-I_{EBO}$	Emitter cut-off current					
	$I_C = 0$, $-V_{EB}$ = 5.0V		-	-	5.0	mA
h_{FE}	*Static forward current transfer ratio					
	$-I_C$ = 0.5A, $-V_{CE}$ = 3.0V		-	1000	-	
	$-I_C$ = 1.5A, $-V_{CE}$ = 3.0V		750	-	-	
	$-I_C$ = 4.0A, $-V_{CE}$ = 3.0V		-	500	-	
$-V_{BE}$	Base-emitter voltage					
	$-I_C$ = 1.5A, $-V_{CE}$ = 3.0V		-	-	2.5	V
$-V_{CE(sat)}$	Collector-emitter saturation voltage					
	$-I_C$ = 1.5A, $-I_B$ = 6.0mA		-	-	2.5	V
f_T	Transition frequency					
	$-I_C$ = 1.5A, $-V_{CE}$ = 3.0V		-	7.0	-	MHz
f_{hfe}	Cut-off frequency					
	$-I_C$ = 1.5A, $-V_{CE}$ = 3.0V		-	60	-	kHz
$W_{(SB)}$	Switch-off second breakdown energy					
	$-I_B$ <0, see circuit on page 8		30	-	-	mJ

*Measured under pulse conditions: pulse width ≤300μs, duty cycle ≤2%.



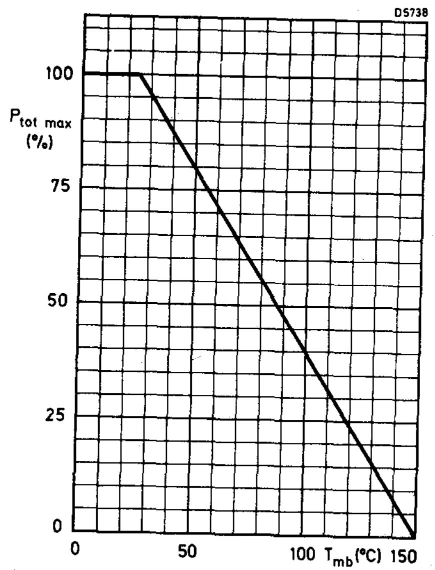
Safe Operating Area with the transistor forward biased

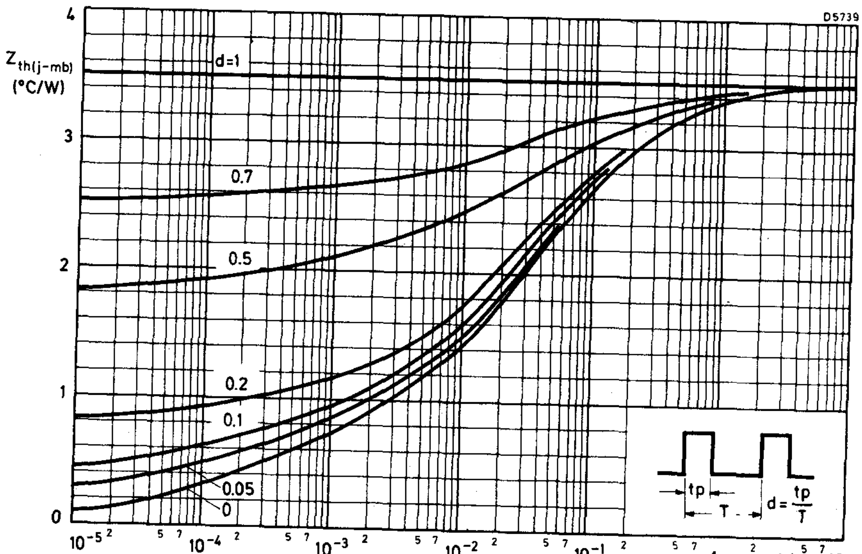
I Region of permissible d.c. operation

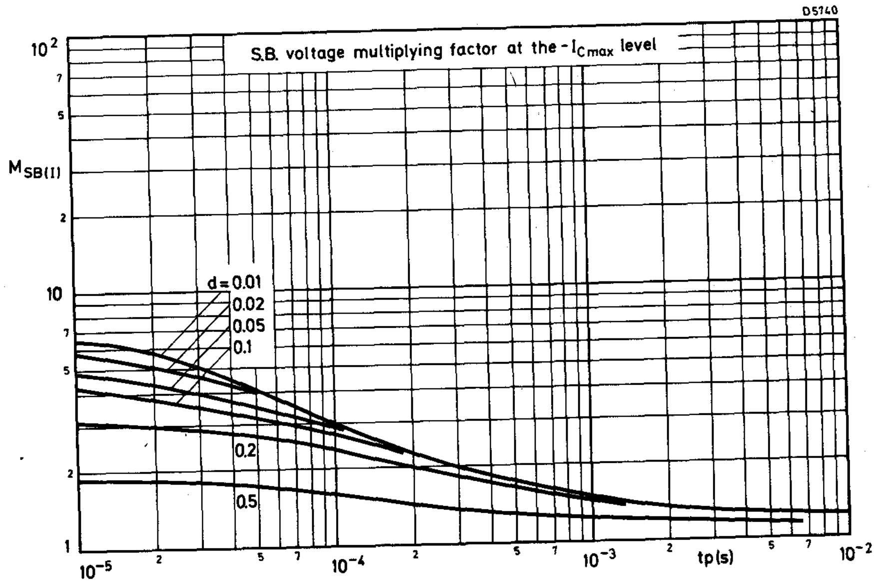
II Permissible extension for repetitive pulse operation

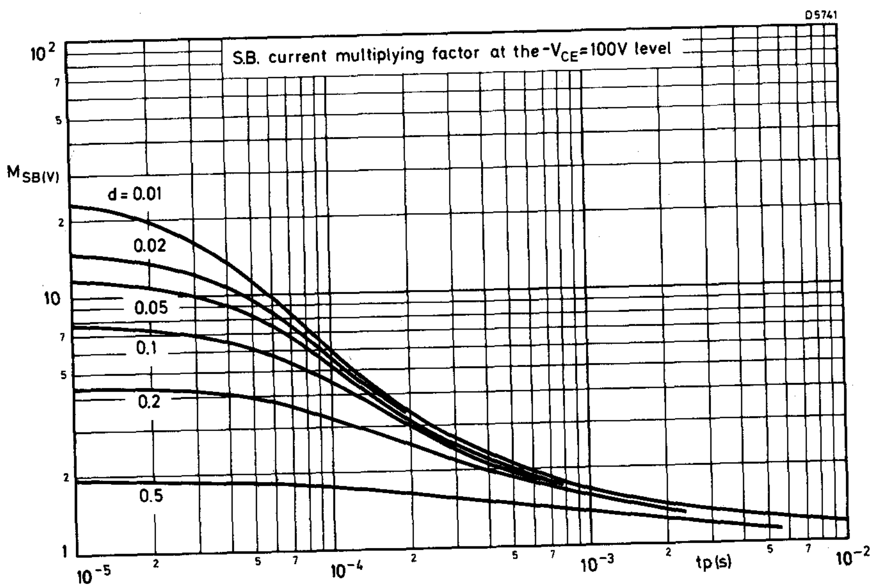
P-N-P SILICON DARLINGTON POWER TRANSISTORS

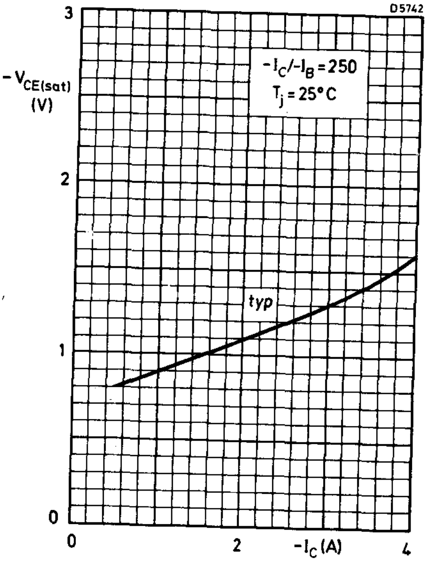
BD262 BD262A BD262B



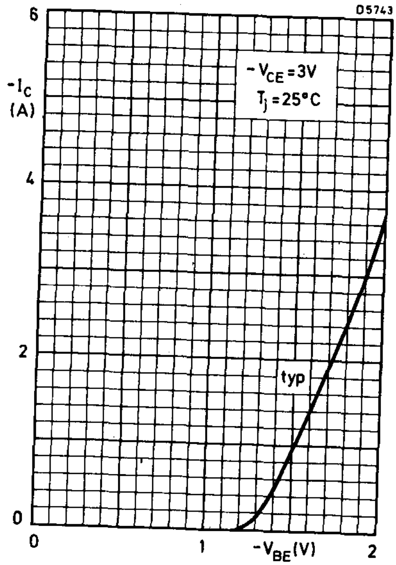



D5740
S.B. voltage multiplying factor at the -I_{Cmax} level
10^2
$M_{SB(I)}$
10
1
d = 0.01
0.02
0.05
0.1
0.2
0.5
10^{-5}
10^{-4}
10^{-3}
tp(s)
10^{-2}

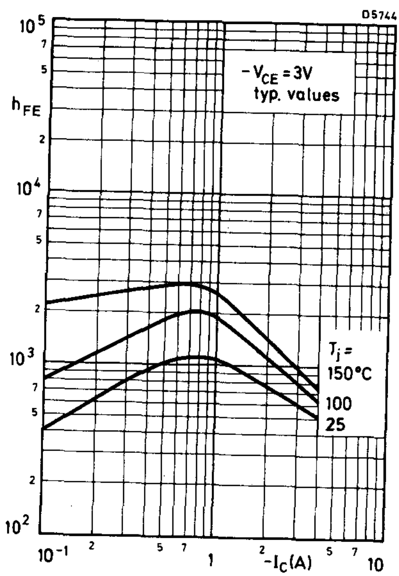

D5741
S.B. current multiplying factor at the -V_{CE}=100V level
10^2
$M_{SB(V)}$
10
1
d = 0.01
0.02
0.05
0.1
0.2
0.5
10^{-5}
10^{-4}
10^{-3}
tp(s)
10^{-2}



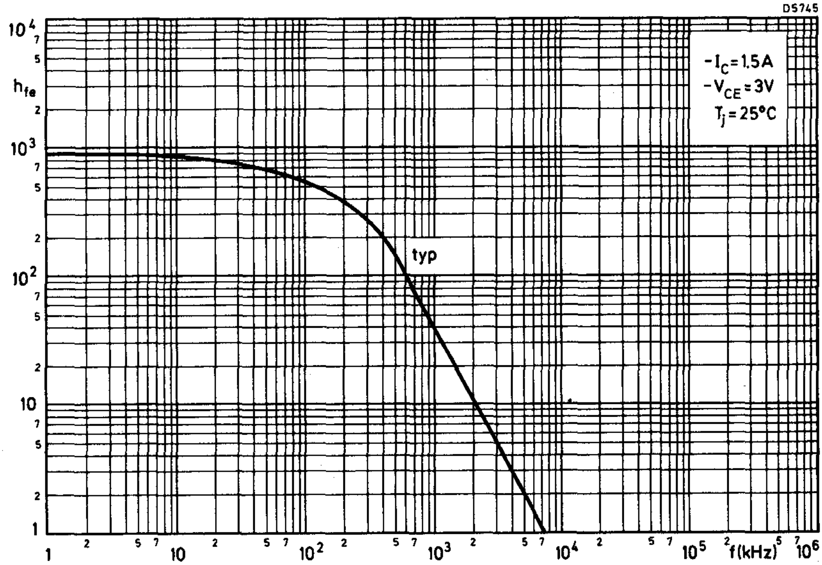
D5742
3
2
1
0
0
2
4
$-V_{CE(sat)}$ (V)
$-I_C$ (A)
$-I_C/-I_B = 250$
$T_j = 25°C$
typ

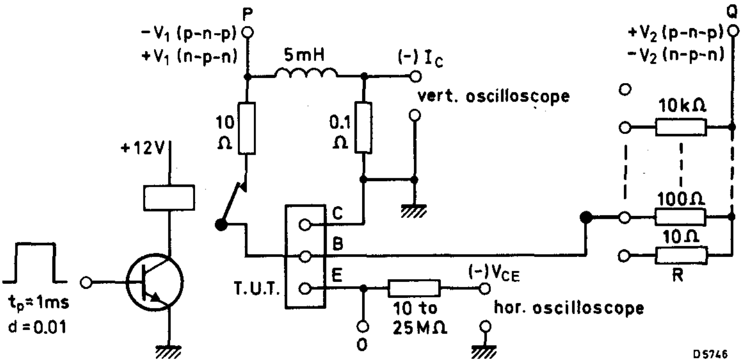


D5743
6
4
2
0
0
1
2
$-I_C$ (A)
$-V_{BE}$ (V)
$-V_{CE} = 3V$
$T_j = 25°C$
typ



D5744
h_{FE}
10^5
10^4
10^3
10^2
10^{-1}
1
10
$-I_C$ (A)
$-V_{CE} = 3V$
typ. values
$T_j =$
150°C
100
25





Circuit for measuring $W_{(SB)}$ (see page 3)

$-I_{CM}$ = 3.5A; $-I_{BM}$ max. 1.5A, but preferably substantially lower; V_1, V_2 and R should be adjusted so that the specified $-I_{CM}$ value is reached ($V_1 = V_2$ = about 15V, R = about 100Ω). O is the reference point for V_1 and V_2.

N-P-N SILICON DARLINGTON POWER TRANSISTORS

BD263
BD263A
BD263B

N-P-N silicon epitaxial base power transistors in monolithic Darlington circuit, intended for audio output stages and general amplifier and switching applications. Encapsulated in TO-126 plastic envelope. P-N-P complements are BD262, BD262A and BD262B respectively.

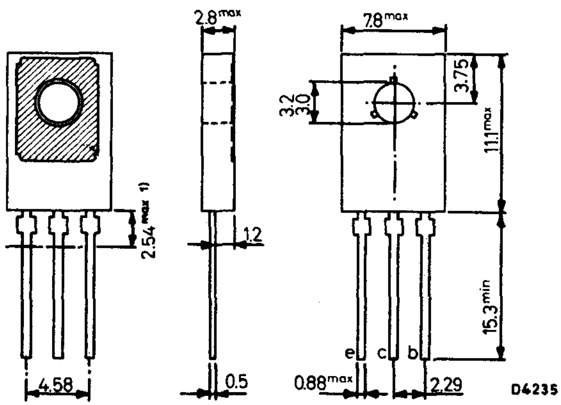
QUICK REFERENCE DATA

	BD263	BD263A	BD263B	
V_{CBO} max.	80	100	120	V
V_{CEO} max.	60	80	100	V
I_{CM} max.		6.0		A
P_{tot} max. ($T_{mb} \leq 25^{o}C$)		36		W
T_j max.		150		^{o}C
h_{FE} typ. ($I_C = 0.5A$, $V_{CE} = 3.0V$)		1000		
min. ($I_C = 1.5A$, $V_{CE} = 3.0V$)		750		
f_T typ. ($I_C = 1.5A$, $V_{CE} = 3.0V$)		7.0		MHz

Unless otherwise stated data are applicable to all types

OUTLINE AND DIMENSIONS

Conforms to J.E.D.E.C. TO-126
Collector connected to the metal part of the mounting surface



Torque on nut:

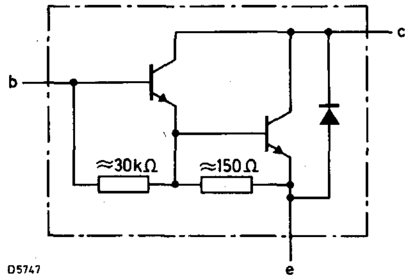
min. 3kg cm (0.3Nm)

max. 4kg cm (0.4Nm)

All dimensions in mm

1) Within this region the cross-section of the leads is uncontrolled.

CIRCUIT DIAGRAM



RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

	BD263	BD263A	BD263B	
V_{CBO} max.	80	100	120	V
V_{CEO} max.	60	80	100	V
V_{EBO} max.	5.0	5.0	5.0	V
I_C max.		4.0		A
I_{CM} max.		6.0		A
I_B max.		100		mA
P_{tot} max. ($T_{mb} \leq 25^oC$)		36		W

Temperature

T_{stg}	-55 to +150	^oC
T_j max.	150	^oC

THERMAL CHARACTERISTICS

$R_{th(j-amb)}$	in free air	100	$^oC/W$
$R_{th(j-mb)}$		3.5	$^oC/W$
$R_{th(mb-h)}$	using mica washer and compound	3.0	$^oC/W$
$R_{th(mb-h)}$	non-insulated mounting	1.0	$^oC/W$

→ ACCESSORIES

Accessory	Code No.	Note
1 Mica washer	56301B	Supplied on request
1 Plain washer	56326	Supplied on request

When mounted on a heatsink it is essential that a plain washer be used to prevent damage to the devices while tightening the mounting screw.

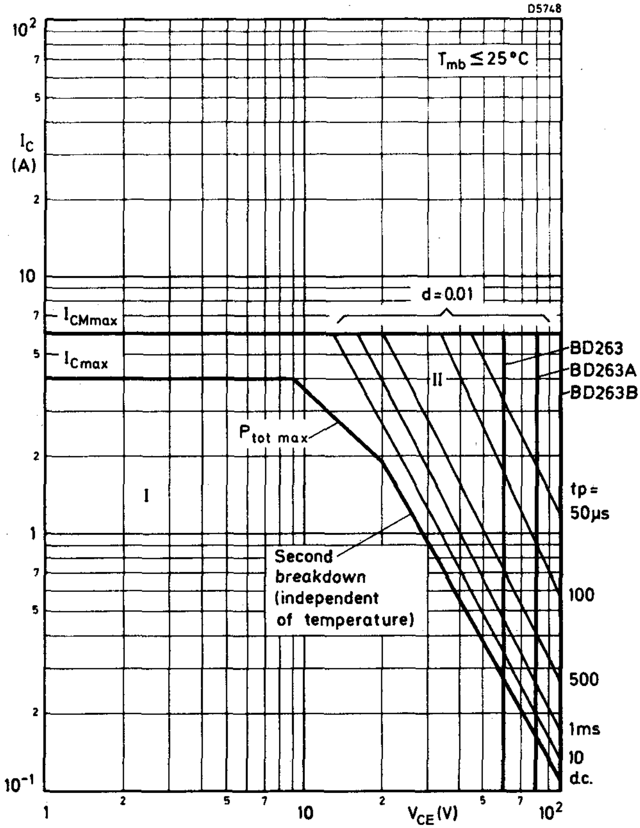
N-P-N SILICON DARLINGTON POWER TRANSISTORS

BD263 BD263A BD263B

ELECTRICAL CHARACTERISTICS (T_j = 25°C unless otherwise stated)

			Min.	Typ.	Max.	
	Collector cut-off current					
I_{CBO}	$I_E = 0$, $V_{CB} = 60V$	BD263	-	-	0.2	mA
I_{CBO}	$I_E = 0$, $V_{CB} = 80V$	BD263A	-	-	0.2	mA
I_{CBO}	$I_E = 0$, $V_{CB} = 100V$	BD263B	-	-	0.2	mA
I_{CBO}	$I_E = 0$, $V_{CB} = 60V$, $T_{mb} = 150°C$	BD263	-	-	2.0	mA
I_{CBO}	$I_E = 0$, $V_{CB} = 80V$, $T_{mb} = 150°C$	BD263A	-	-	2.0	mA
I_{CBO}	$I_E = 0$, $V_{CB} = 100V$, $T_{mb} = 150°C$	BD263B	-	-	2.0	mA
I_{CEO}	$I_B = 0$, $V_{CE} = 30V$	BD263	-	-	0.5	mA
I_{CEO}	$I_B = 0$, $V_{CE} = 40V$	BD263A	-	-	0.5	mA
I_{CEO}	$I_B = 0$, $V_{CE} = 50V$	BD263B	-	-	0.5	mA
I_{EBO}	Emitter cut-off current					
	$I_C = 0$, $V_{EB} = 5.0V$		-	-	5.0	mA
h_{FE}	*Static forward current transfer ratio					
	$I_C = 0.5A$, $V_{CE} = 3.0V$		-	1000	-	
	$I_C = 1.5A$, $V_{CE} = 3.0V$		750	-	-	
	$I_C = 4.0A$, $V_{CE} = 3.0V$		-	500	-	
V_{BE}	Base-emitter voltage					
	$I_C = 1.5A$, $V_{CE} = 3.0V$		-	-	2.5	V
$V_{CE(sat)}$	Collector-emitter saturation voltage					
	$I_C = 1.5A$, $I_B = 6.0mA$		-	-	2.5	V
f_T	Transition frequency					
	$I_C = 1.5A$, $V_{CE} = 3.0V$		-	7.0	-	MHz
f_{hfe}	Cut-off frequency					
	$I_C = 1.5A$, $V_{CE} = 3.0V$		-	60	-	kHz
$W_{(SB)}$	Switch-off second breakdown energy					
	$I_B < 0$, see circuit on page 8		30	-	-	mJ

*Measured under pulse conditions: pulse width ≤ 300μs, duty cycle ≤ 2%.



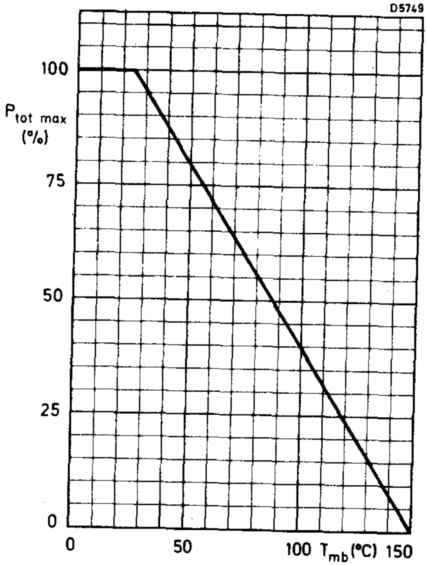
Safe Operating Area with the transistor forward biased

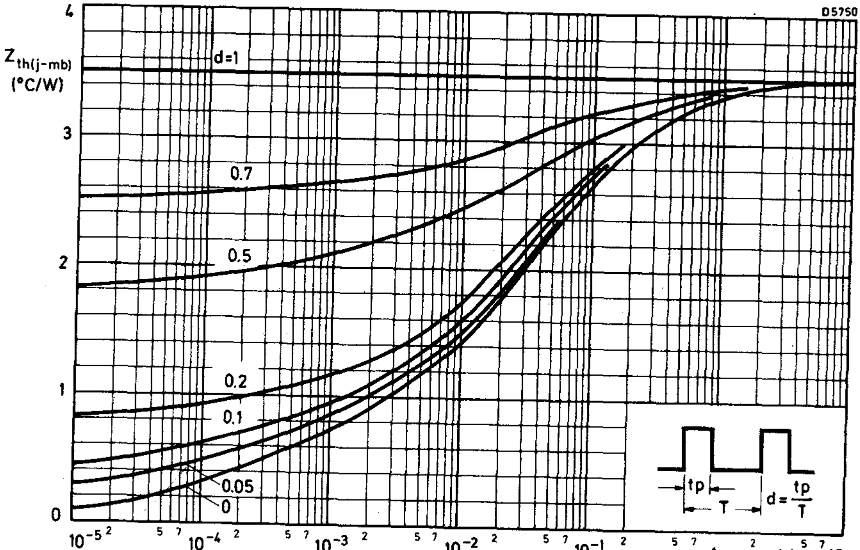
I Region of permissible d. c. operation

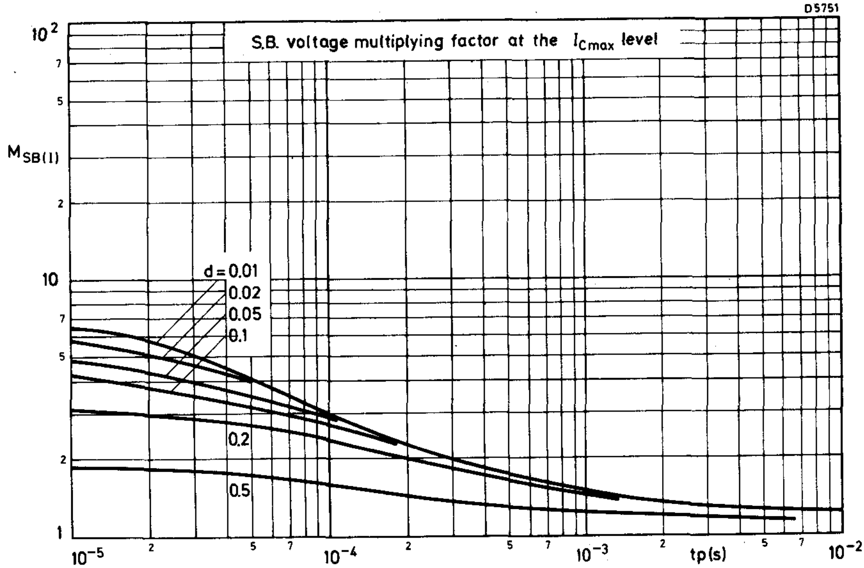
II Permissible extension for repetitive pulse operation

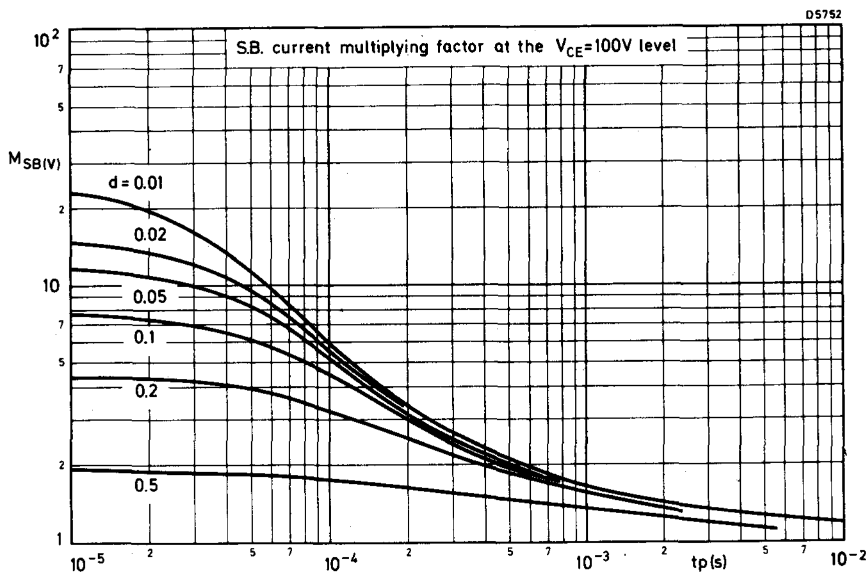
N-P-N SILICON DARLINGTON POWER TRANSISTORS

BD263 BD263A BD263B



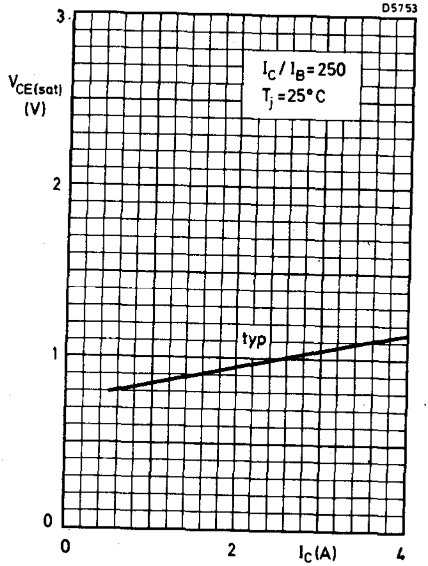


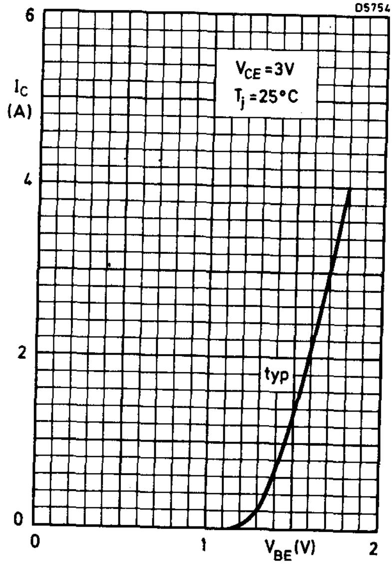

D5751
S.B. voltage multiplying factor at the I_{Cmax} level
$M_{SB(I)}$
d = 0.01
0.02
0.05
0.1
0.2
0.5
tp(s)

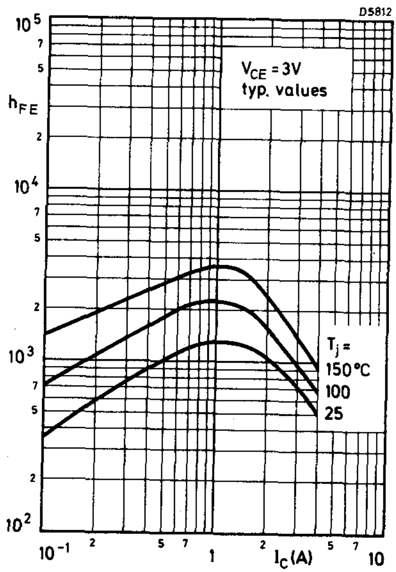

D5752
S.B. current multiplying factor at the V_{CE}=100V level
$M_{SB(V)}$
d = 0.01
0.02
0.05
0.1
0.2
0.5
tp(s)

N-P-N SILICON DARLINGTON POWER TRANSISTORS

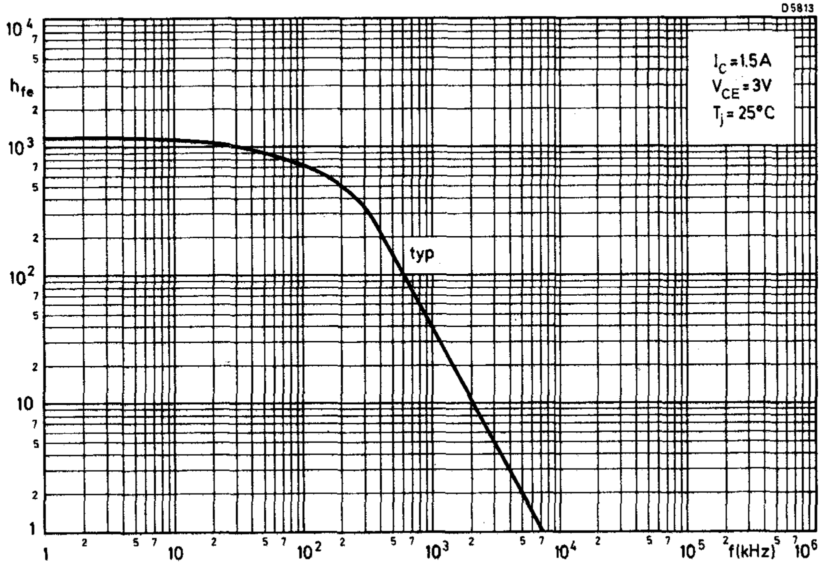
BD263 BD263A BD263B

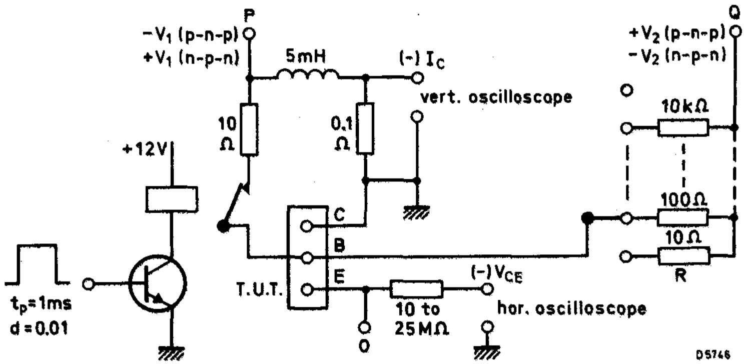






Mullard





Circuit for measuring $W_{(SB)}$ (see page 3)

I_{CM} = 3.5A; I_{BM} max. 1.5A, but preferably substantially lower; V_1, V_2 and R should be adjusted so that the specified I_{CM} value is reached ($V_1 = V_2$ = about 15V; R = about 100Ω).

O is the reference point for V_1 and V_2.

N-P-N SILICON POWER TRANSISTORS

BD433 BD435 BD437

N-P-N silicon epitaxial base power transistors in a TO-126 plastic envelope, intended for use in general l.f. applications.

The BD433 with its p-n-p complement BD434 is specially suitable for use in output stages of car radios.

The complementary pairs BD435/BD436 and BD437/BD438 are intended for use in mains operated amplifiers and radio receivers with output powers of up to 10 and 15W respectively.

QUICK REFERENCE DATA

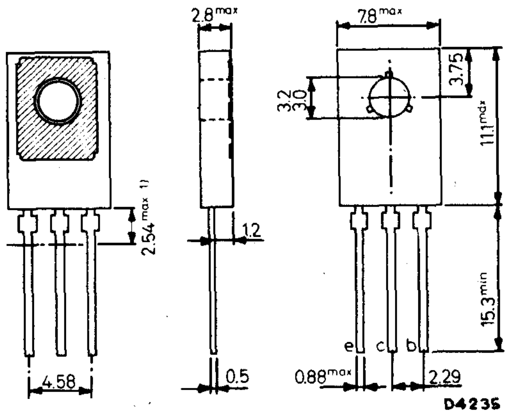
	BD433	BD435	BD437	
V_{CES} max.	22	32	45	V
V_{CEO} max.	22	32	45	V
I_{CM} max.	7.0	7.0	7.0	A
P_{tot} max., $T_{mb} \leq 25^oC$	36	36	36	W
T_j max.	150	150	150	^oC
h_{FE} min., $I_C = 2A$, $V_{CE} = 1V$	50	50	40	
$I_C = 3A$, $V_{CE} = 1V$	-	-	30	
f_T min., $I_C = 250mA$, $V_{CE} = 1V$, f = 1MHz	3.0	3.0	3.0	MHz

Unless otherwise stated data are applicable to all types

OUTLINE AND DIMENSIONS

Conforms to J.E.D.E.C. TO-126

Collector connected to the metal part of the mounting surface



Torque on nut:

min. 3kg cm (0.3N m)

max. 4kg cm (0.4N m)

All dimensions in mm

1) Within this region the cross-section of the leads is uncontrolled

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical	BD433	BD435	BD437	
V_{CBO} max.	22	32	45	V
V_{CES} max.	22	32	45	V
V_{CEO} max.	22	32	45	V
V_{EBO} max.	5.0	5.0	5.0	V
I_C max.		4.0		A
I_{CM} max.		7.0		A
I_B max.		1.0		A
P_{tot} max. ($T_{mb} \leq 25^oC$)		36		W

Temperature

T_{stg}	-55 to +150	^oC
T_j max.	150	^oC

THERMAL CHARACTERISTICS

$R_{th(j-amb)}$ in free air	100	$^oC/W$
$R_{th(j-mb)}$	3.5	$^oC/W$
$R_{th(mb-h)}$ using mica washer and compound	3.0	$^oC/W$
$R_{th(mb-h)}$ non-insulated mounting	1.0	$^oC/W$

ELECTRICAL CHARACTERISTICS ($T_j = 25^oC$ unless otherwise stated)

		Min.	Typ.	Max.	
I_{CBO}	Collector cut-off current				
	$I_E = 0$, $V_{CB} = V_{CBO}$ max.	-	-	100	μA
	$I_E = 0$, $V_{CB} = 10V$, $T_j = 150^oC$	-	-	1.0	mA
	$I_E = 0$, $V_{CB} = V_{CBO}$ max., $T_j = 150^oC$	-	-	3.0	mA
I_{EBO}	Emitter cut-off current				
	$I_C = 0$, $V_{EB} = 5.0V$	-	-	1.0	mA
V_{CEK}	Knee voltage				
	$I_C = 2.0A$, I_B = the value for which				
	$I_C = 2.2A$ at $V_{CE} = 1.0V$ BD433	-	-	0.8	V

N-P-N SILICON POWER TRANSISTORS

BD433 BD435 BD437

ELECTRICAL CHARACTERISTICS (contd.)

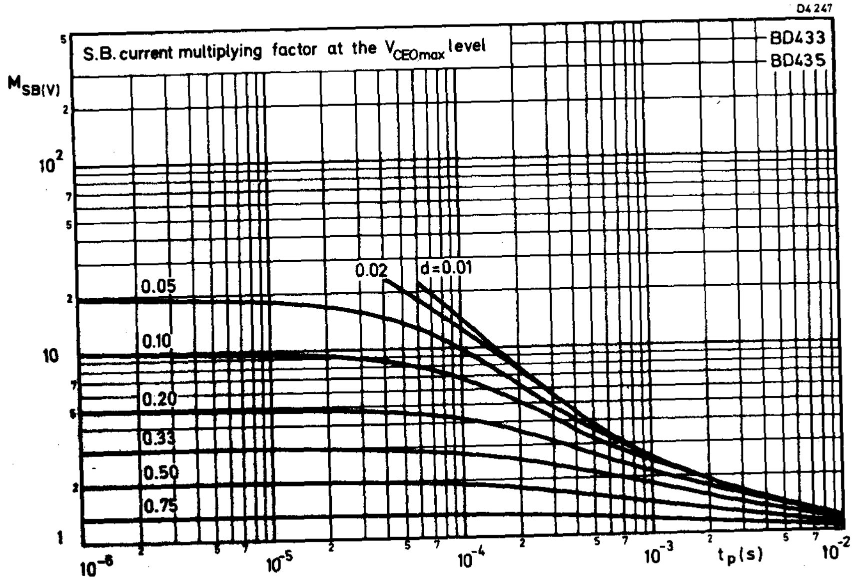
			Min.	Typ.	Max.	
$V_{CE(sat)}$	Collector-emitter saturation voltage					
	$I_C = 2.0A,\ I_B = 0.2A$	BD433, 435	-	-	0.5	V
	$I_C = 3.0A,\ I_B = 0.3A$	BD437	-	-	0.7	V
V_{BE}	*Base-emitter voltage					
	$I_C = 10mA,\ V_{CE} = 5.0V$		-	580	-	mV
	$I_C = 2.0A,\ V_{CE} = 1.0V$	BD433, 435	-	-	1.1	V
	$I_C = 3.0A,\ V_{CE} = 1.0V$	BD437	-	-	1.3	V
h_{FE}	Static forward current transfer ratio					
	$I_C = 10mA,\ V_{CE} = 5.0V$	BD433, 435	40	-	-	
		BD437	30	-	-	
	$I_C = 500mA,\ V_{CE} = 1.0V$	BD433, 435	85	-	475	
		BD437	85	-	375	
	$I_C = 2.0A,\ V_{CE} = 1.0V$	BD433, 435	50	-	-	
		BD437	40	-	-	
	$I_C = 3.0A,\ V_{CE} = 1.0V$	BD437	30	-	-	
f_T	Transition frequency					
	$I_C = 250mA,\ V_{CE} = 1.0V,\ f = 1.0MHz$		3.0	-	-	MHz
$\frac{h_{FE1}}{h_{FE2}}$	D.C. current gain ratio (complementary pairs)					
	$\lvert I_C \rvert = 500mA,\ \lvert V_{CE} \rvert = 1.0V$					
	BD433/BD434 and BD435/BD436		-	-	1.4	
	BD437/BD438		-	-	1.8	

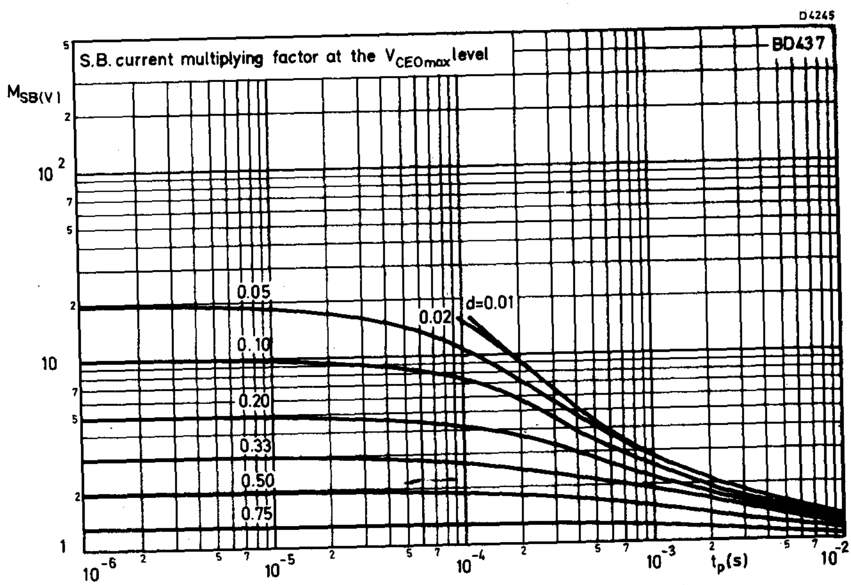
*V_{BE} decreases by about 2.3mV/°C with increasing temperature.

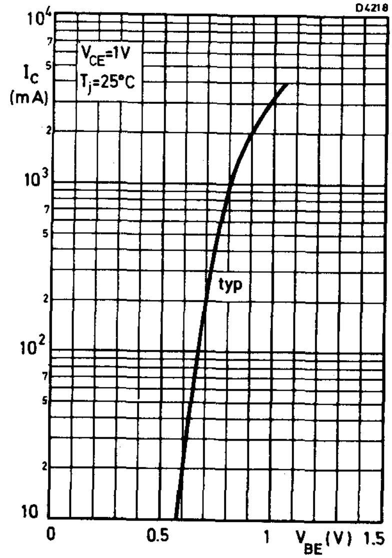
ACCESSORIES

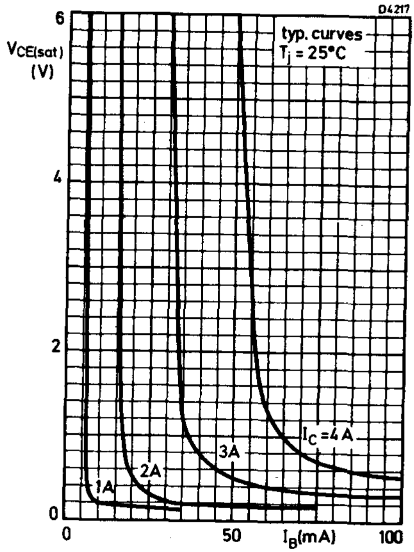
Accessory	Code No.	Note
1 Mica washer	56301B	Supplied on request
1 Plain washer	56326	

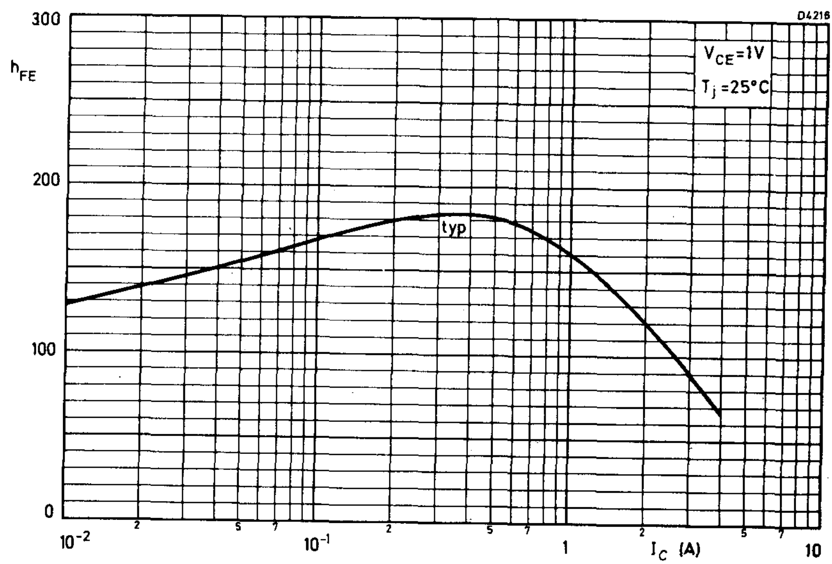
When mounted on a heatsink it is essential that a plain washer be used to prevent damage to the devices while tightening the mounting screw.

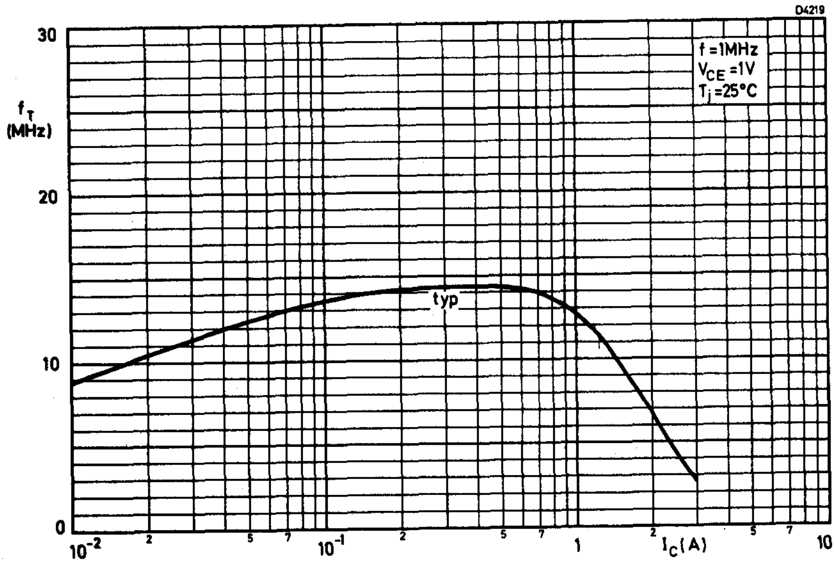

D4 247
S.B. current multiplying factor at the V_{CEOmax} level
BD433
BD435
$M_{SB(V)}$
0.02
d=0.01
0.05
0.10
0.20
0.33
0.50
0.75
t_p (s)


D4245
S.B. current multiplying factor at the V_{CEOmax} level
BD437
$M_{SB(V)}$
0.05
d=0.01
0.02
0.10
0.20
0.33
0.50
0.75
t_p (s)


D4218
V_{CE}=1V
T_j=25°C
I_C (mA)
typ
V_{BE} (V)
0
0.5
1
1.5
10
10^2
10^3
10^4


D4217
typ. curves
T_j = 25°C
$V_{CE(sat)}$ (V)
I_C = 4 A
3A
2A
1A
I_B(mA)
0
50
100
2
4
6


D4216
V_{CE}=1V
T_j =25°C
h_{FE}
typ
I_C (A)
10^{-2}
10^{-1}
1
10
0
100
200
300


D4219
f = 1MHz
V_{CE} = 1V
T_j = 25°C
f_T (MHz)
30
20
10
0
typ
10^{-2}
2
5
7
10^{-1}
2
5
7
1
2
I_C (A)
5
7
10

Mullard

P-N-P SILICON POWER TRANSISTORS

BD434 BD436 BD438

P-N-P silicon epitaxial base power transistors in a TO-126 plastic envelope, intended for use in general l.f. applications.

The BD434 with its n-p-n complement BD433 is specially suitable for use in output stages of car radios.

The complementary pairs BD435/BD436 and BD437/BD438 are intended for use in mains operated amplifiers and radio receivers with output powers of up to 10 and 15W respectively.

QUICK REFERENCE DATA

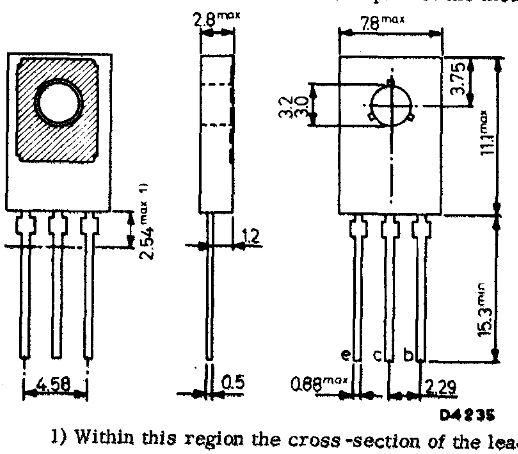
	BD434	BD436	BD438	
$-V_{CES}$ max.	22	32	45	V
$-V_{CEO}$ max.	22	32	45	V
$-I_{CM}$ max.	7.0	7.0	7.0	A
P_{tot} max., $T_{mb} \leq 25^{o}C$	36	36	36	W
T_j max.	150	150	150	^{o}C
h_{FE} min., $-I_C = 2A$, $-V_{CE} = 1V$	50	50	40	
$-I_C = 3A$, $-V_{CE} = 1V$	-	-	30	
f_T min., $-I_C = 250mA$, $-V_{CE} = 1V, f = 1MHz$	3.0	3.0	3.0	MHz

Unless otherwise stated data are applicable to all types

OUTLINE AND DIMENSIONS

Conforms to J.E.D.E.C. TO-126

Collector connected to the metal part of the mounting surface



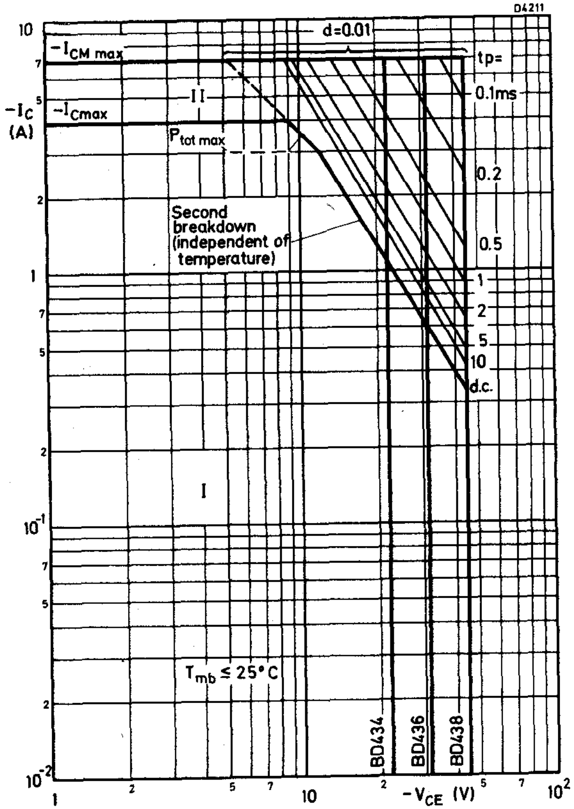
Torque on nut:

min. 3kg cm (0.3N m)

max. 4kg cm (0.4N m)

All dimensions in mm

1) Within this region the cross-section of the leads is uncontrolled



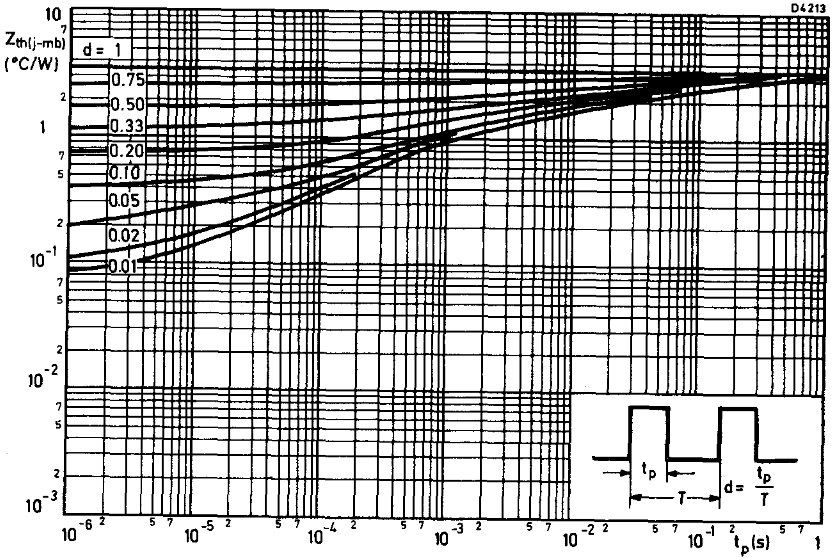
Safe operating area with the transistor forward biased

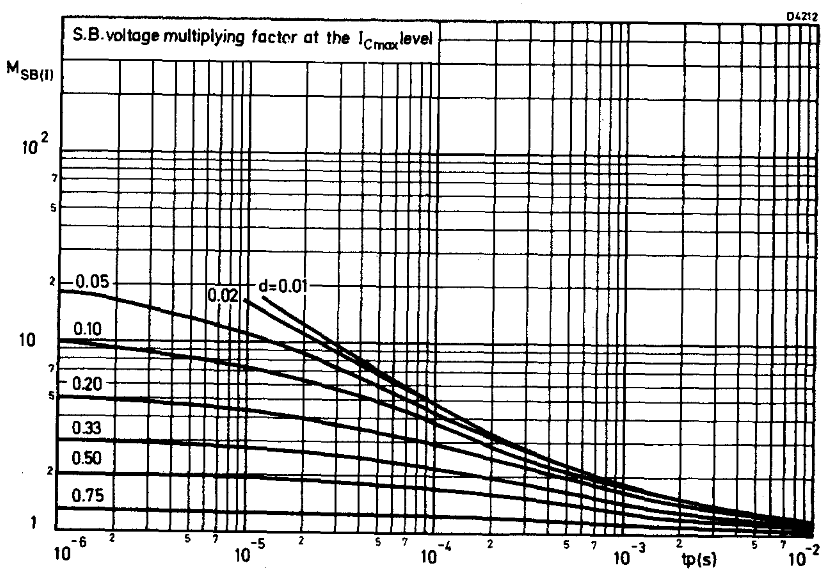
I Region of permissible d.c. operation

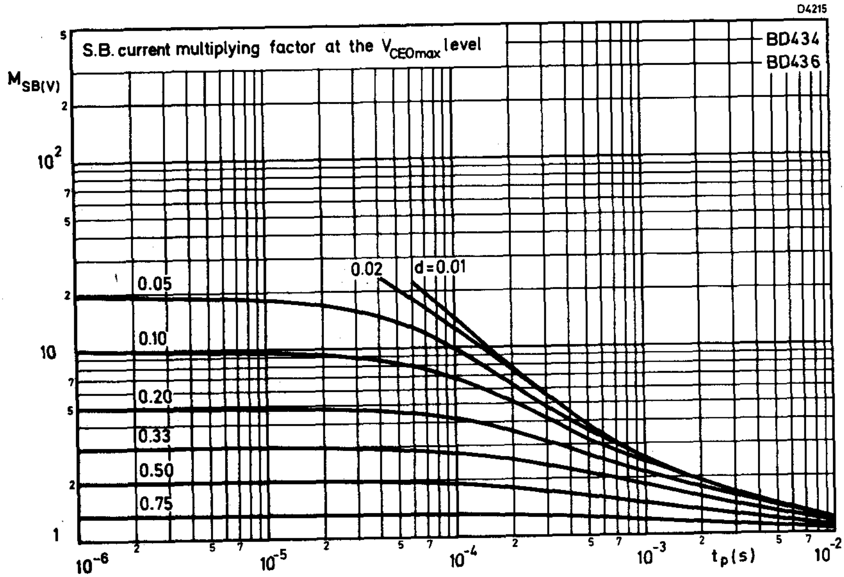
II Permissible extension for repetitive pulse operation

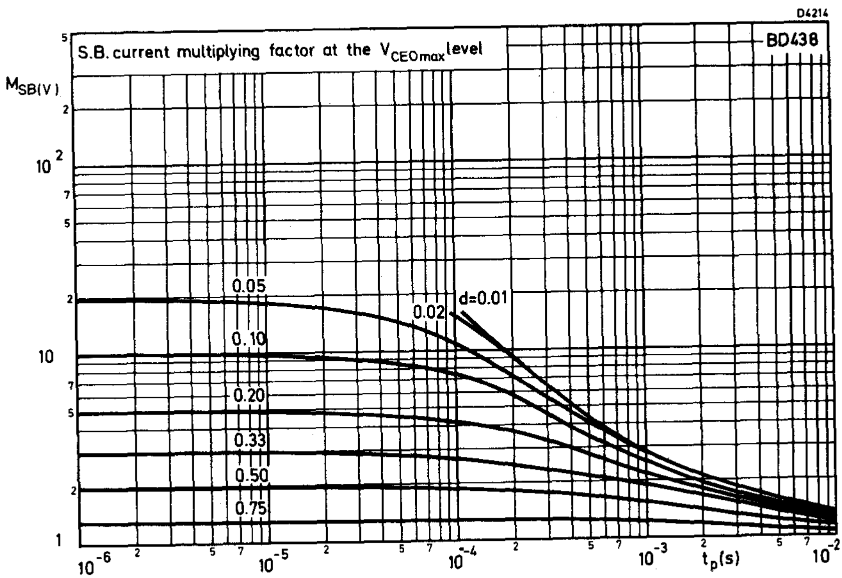
P-N-P SILICON POWER TRANSISTORS

BD434 BD436 BD438

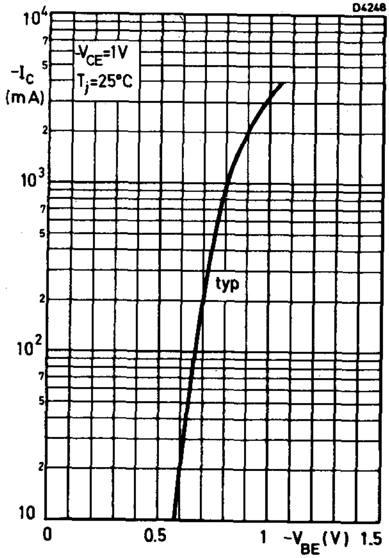


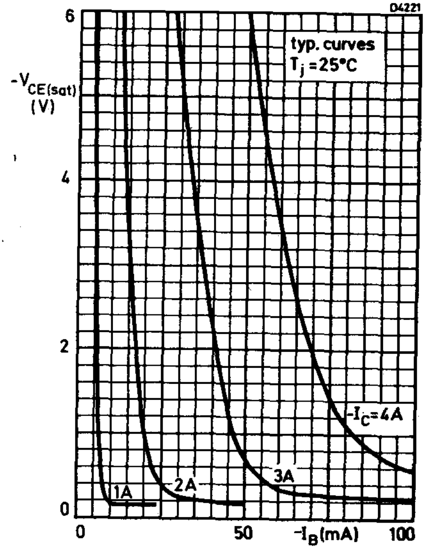


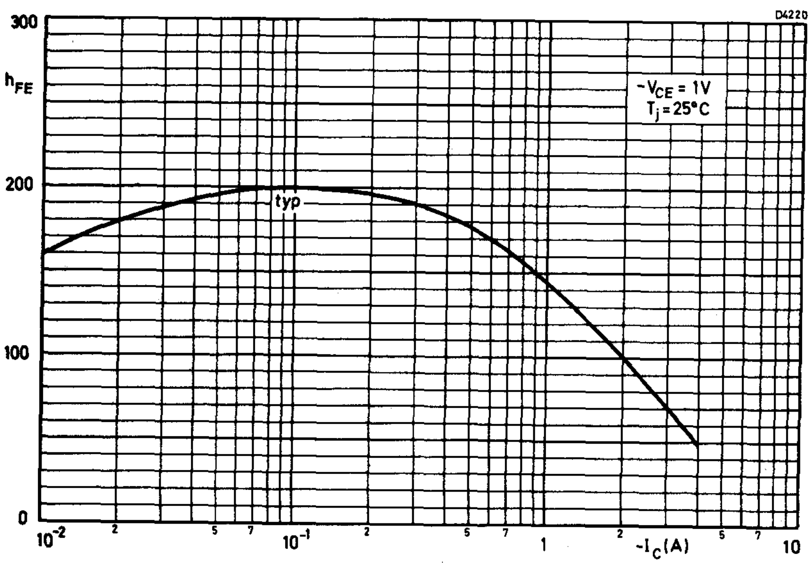

D4215
S.B. current multiplying factor at the V_{CEOmax} level
BD434
BD436
$M_{SB(V)}$
0.05
0.10
0.20
0.33
0.50
0.75
0.02
d=0.01
t_p(s)

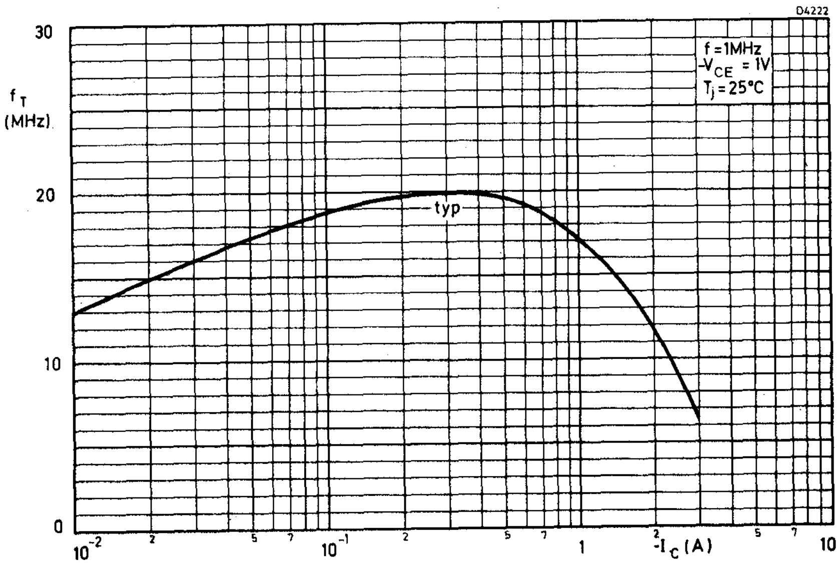

D4214
S.B. current multiplying factor at the V_{CEOmax} level
BD438
$M_{SB(V)}$
0.05
0.10
0.20
0.33
0.50
0.75
0.02
d=0.01
t_p(s)

Mullard


D4248
$-V_{CE}$=1V
T_j=25°C
$-I_C$ (mA)
typ
$-V_{BE}$(V)
0
0.5
1
1.5
10
10^2
10^3
10^4


D4221
typ. curves
T_j =25°C
$-V_{CE(sat)}$ (V)
$-I_C$=4A
3A
2A
1A
$-I_B$(mA)
0
50
100
2
4
6


D4220
h_{FE}
$-V_{CE}$ = 1V
T_j = 25°C
typ
$-I_C$(A)
10^{-2}
10^{-1}
1
10
0
100
200
300


D4222
f = 1MHz
$-V_{CE}$ = 1V
T_j = 25°C
f_T
(MHz)
30
20
10
0
typ
10^{-2}
2
5
7
10^{-1}
2
5
7
1
2
5
7
10
$-I_C$ (A)

SILICON N-P-N PLANAR EPITAXIAL POWER TRANSISTORS

BDX35 BDX36 BDX37

N-P-N silicon planar power switching transistors, mounted in a plastic envelope

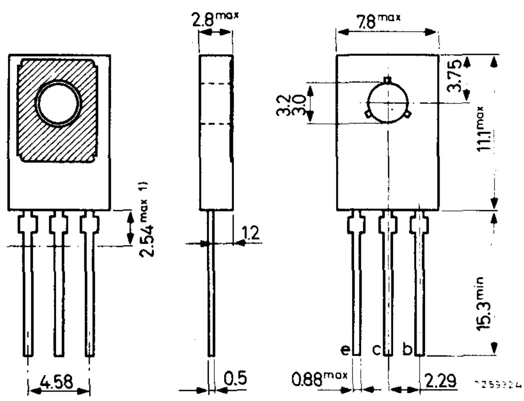
QUICK REFERENCE DATA

	BDX35	BDX36	BDX37	
V_{CBOM} max.	100	120	120	V
V_{CEO} max.	60	60	80	V
I_{CM} max.	10	10	10	A
P_{tot} max. ($T_{mb} \leq 100^{o}C$)	15	15	15	W
h_{FE} min. (I_C =0.5A, V_{CE} =10V)	45	45	45	
f_T typ. (I_C = 0.5A, V_{CE} =5.0V, f = 35MHz)	100	100	100	MHz
t_{off} typ. (I_C = 5.0A, $I_{B(on)}$ = $-I_{B(off)}$ = 0.5A)	350	350	350	ns

Unless otherwise stated, data is applicable to all types

OUTLINE AND DIMENSIONS

Conforms to J.E.D.E.C. TO-126
Collector connected to the metal part of the mounting surface



All dimensions in mm

1) Within this region the cross-section of the leads is uncontrolled.
Care should be taken not to bend the leads nearer than 2.5mm from the body.
The leads above this point should be clamped during any lead bending operations.

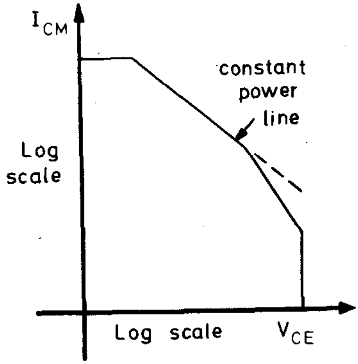
OPERATING NOTES

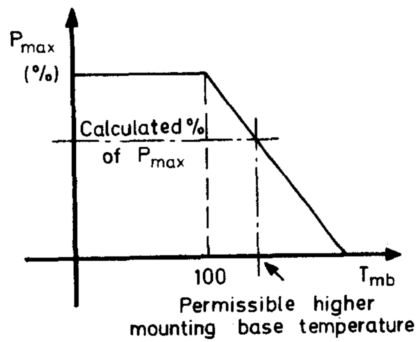
The rating graphs given in this data show the maximum permissible current for combinations of voltage, pulse width and duty cycle at a mounting-base temperature of 100^{o}C.

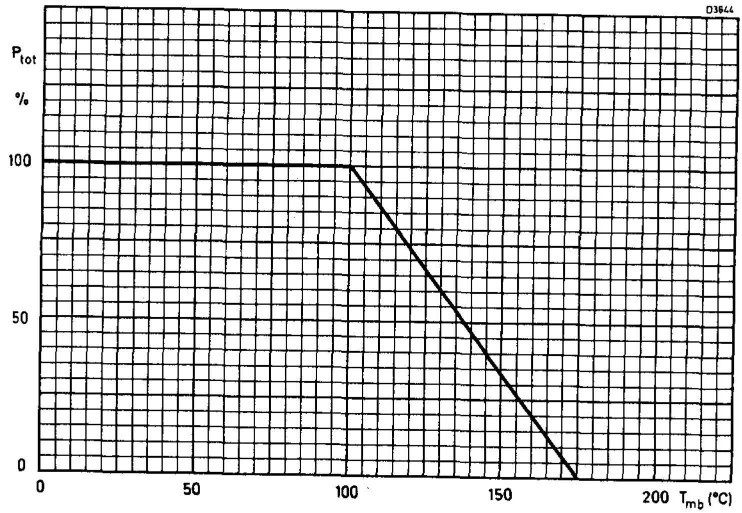
Should a lower value of current, and consequently power, be used, the mounting-base temperature is permitted to rise. To determine the value of this higher temperature, calculate the power at the new working point and its percentage of the maximum permissible power at the same duty cycle and pulse width as read from the relevant constant power line.

The higher temperature is read off the graph of % P_{max} vs. T_{mb} at the calculated percentage.

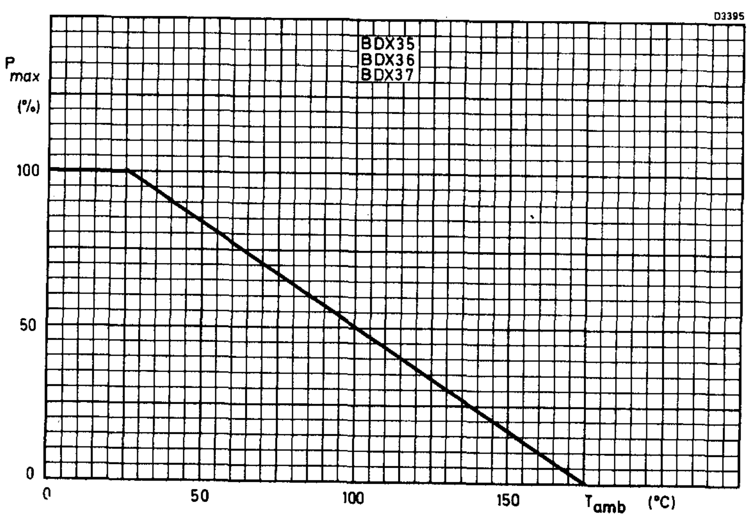
D3469



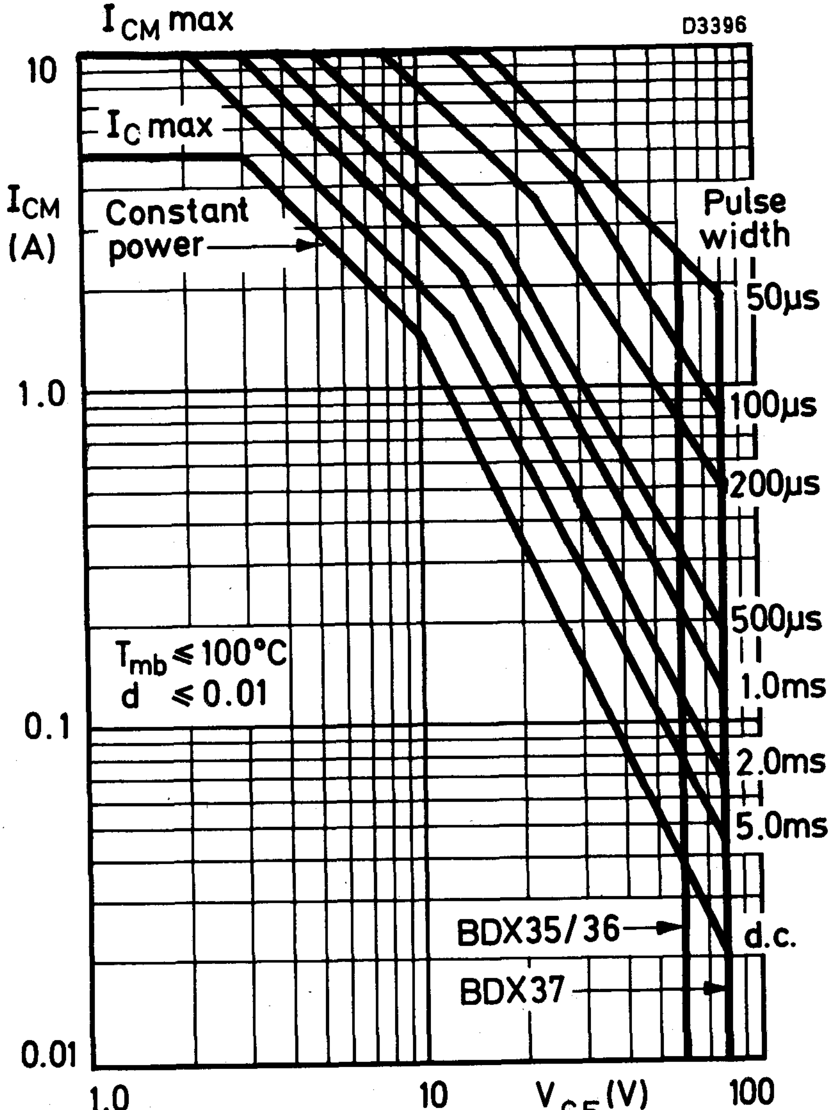


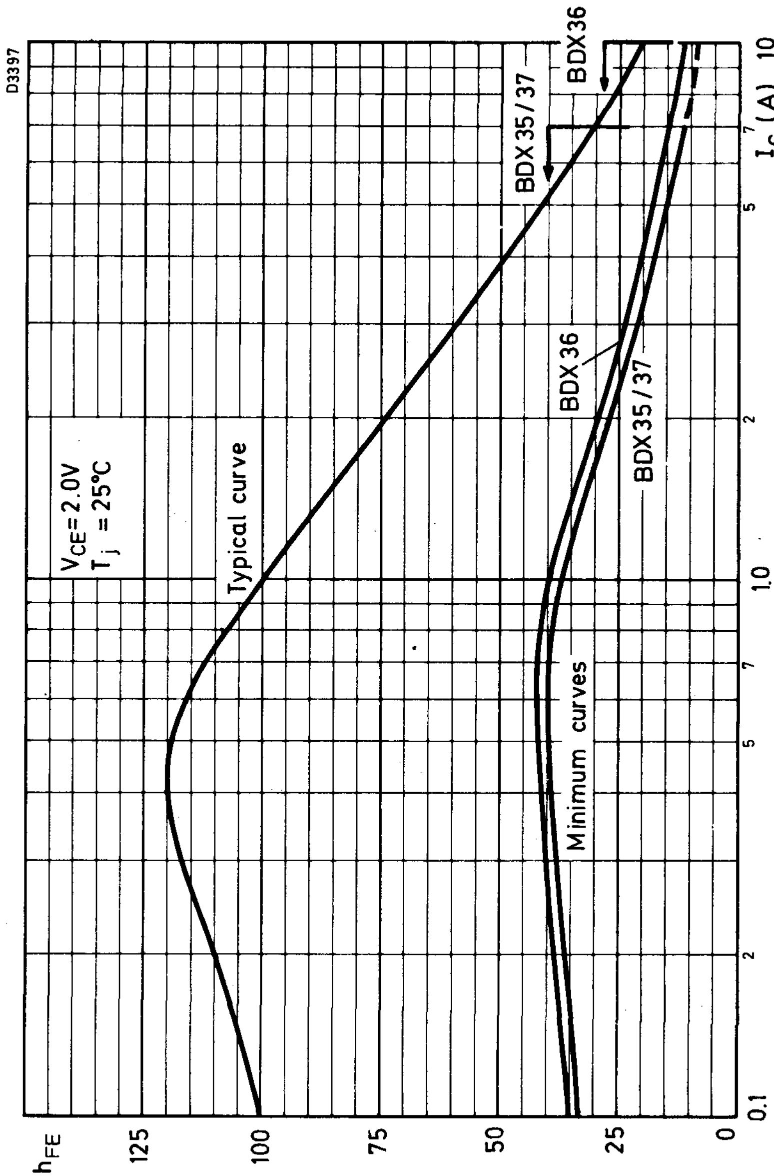


D3644
P_{tot}
%
100
50
0
0
50
100
150
200 T_{mb} (°C)



D3395
BDX35
BDX36
BDX37
P_{max}
(%)
100
50
0
0
50
100
150
T_{amb} (°C)


I CM max
D3396
10
I C max
I CM
(A)
Constant
power
Pulse
width
50µs
1.0
100µs
200µs
500µs
Tmb ≤ 100°C
d ≤ 0.01
1.0ms
0.1
2.0ms
5.0ms
BDX35/36
d.c.
BDX37
0.01
1.0
10
V CE (V)
100


D3397
V_{CE} = 2.0V
T_j = 25°C
Typical curve
Minimum curves
BDX35/37
BDX36
h_{FE}
125
100
75
50
25
0
0.1
2
5
7
1.0
2
5
7
10
I_C (A)

N-P-N SILICON PLANAR DARLINGTON TRANSISTORS

BDX42 BDX43 BDX44

TENTATIVE DATA

Silicon n-p-n planar Darlington transistors for industrial switching applications, e.g. print hammer, solenoid, relay and lamp driving. Encapsulated in a TO-126 plastic envelope with collector connected to the heatsink.

QUICK REFERENCE DATA

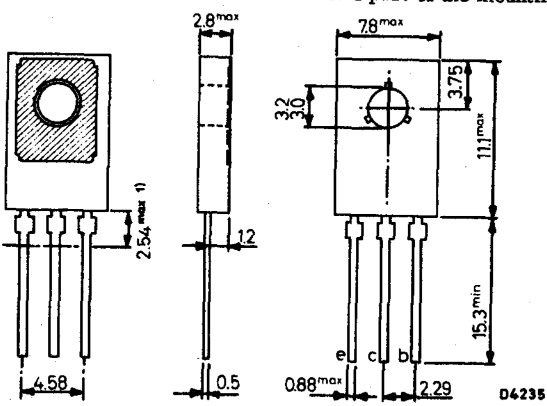
	BDX42	BDX43	BDX44	
V_{CBO} max.	60	80	100	V
V_{CE} max.	45	60	80	V
I_C max.	1.0	1.0	1.0	A
P_{tot} max. ($T_{amb} \leq 25^{\circ}C$)	1.25	1.25	1.25	W
P_{tot} max. ($T_{mb} \leq 100^{\circ}C$)	5.0	5.0	5.0	W
h_{FE} min. ($I_C = 500mA$, $V_{CE} = 10V$)	1500	1500	1500	
$V_{CE(sat)}$ max. ($I_C = 1.0A$, $I_B = 1.0mA$)	-	1.6	-	V
$V_{CE(sat)}$ max. ($I_C = 1.0A$, $I_B = 4.0mA$)	1.6	-	1.6	V
t_{off} typ. ($I_C = 500mA$, $I_{B(on)} = -I_{B(off)} = 0.5mA$)	1000	1000	1000	ns

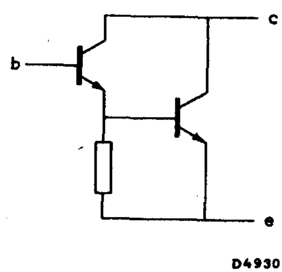
Unless otherwise stated data are applicable to all types.

OUTLINE AND DIMENSIONS

Conforms to J.E.D.E.C. TO-126

Collector connected to the metal part of the mounting surface





All dimensions in mm

1) Within this region the cross-section of the leads is uncontrolled

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

	BDX42	BDX43	BDX44	
V_{CBO} max.	60	80	100	V
V_{CE} max. (Max. external R_{BE} 100kΩ at $T_j = 150^oC$)	45	60	80	V
V_{EBO} max.	5.0	5.0	5.0	V
I_C max.	1.0	1.0	1.0	A
I_B max.	0.1	0.1	0.1	A
P_{tot} max. ($T_{amb} \leq 25^oC$)	1.25	1.25	1.25	W
P_{tot} max. ($T_{mb} \leq 100^oC$)	5.0	5.0	5.0	W

Temperature

T_{stg} range	-65 to +150	^oC
T_j max.	150	^oC

THERMAL CHARACTERISTICS

$R_{th(j-amb)}$	100	$^oC/W$
$R_{th(j-mb)}$	10	$^oC/W$

ELECTRICAL CHARACTERISTICS ($T_j = 25^oC$ unless otherwise stated)

			Min.	Typ.	Max.	
I_{CBO}	Collector cut-off current					
	$V_{CB} = 45V$, $I_E = 0$	BDX42	-	-	100	nA
	$V_{CB} = 60V$, $I_E = 0$	BDX43	-	-	100	nA
	$V_{CB} = 80V$, $I_E = 0$	BDX44	-	-	100	nA
I_{EBO}	Emitter cut-off current					
	$V_{EB} = 4.0V$, $I_C = 0$		-	-	100	nA
h_{FE}	Static forward current transfer ratio					
	$I_C = 150mA$, $V_{CE} = 10V$		1000	-	-	
	$I_C = 500mA$, $V_{CE} = 10V$		1500	-	-	
$V_{CE(sat)}$	Collector-emitter saturation voltage					
	$I_C = 500mA$, $I_B = 0.5mA$		-	-	1.3	V
	$I_C = 1.0A$, $I_B = 1.0mA$	BDX43	-	-	1.6	V
	$I_C = 1.0A$, $I_B = 4.0mA$	BDX42	-	-	1.6	V
		BDX44	-	-	1.6	V

ELECTRICAL CHARACTERISTICS (Contd.)

		Min.	Typ.	Max.	
	$I_C = 500mA$, $I_B = 0.5mA$, $T_j = 150^oC$	-	-	1.3	V
	$I_C = 1.0A$, $I_B = 1.0mA$, $T_j = 150^oC$				
	BDX43	-	-	1.8	V
	$I_C = 1.0A$, $I_B = 4.0mA$, $T_j = 150^oC$				
	BDX42	-	-	1.6	V
	BDX44	-	-	1.6	V
$V_{BE(sat)}$	Base-emitter saturation voltage				
	$I_C = 500mA$, $I_B = 0.5mA$	-	-	1.9	V
	$I_C = 1.0A$, $I_B = 1.0mA$ BDX43	-	-	2.2	V
	$I_C = 1.0A$, $I_B = 4.0mA$ BDX42	-	-	2.2	V
	BDX44	-	-	2.2	V
h_{fe}	Small signal forward current transfer ratio				
	$I_C = 0.5A$, $V_{CE} = 5.0V$, $f = 35MHz$	7.5	10	-	

Switching times (see also page 4):

		Min.	Typ.	Max.	
	$I_C = 500mA$, $I_{B(on)} = -I_{B(off)} = 0.5mA$				
t_{on}	Turn-on time	-	-	400	ns
t_{off}	Turn-off time	-	1000	2000	ns
	$I_C = 1.0A$, $I_{B(on)} = -I_{B(off)} = 1.0mA$				
t_{on}	Turn-on time	-	-	400	ns
t_{off}	Turn-off time	-	1000	2000	ns

MECHANICAL DATA

Maximum torque on nut	4.0	kg cm
	0.4	Nm
Minimum torque on nut for good thermal contact	3.0	kg cm
	0.3	N m

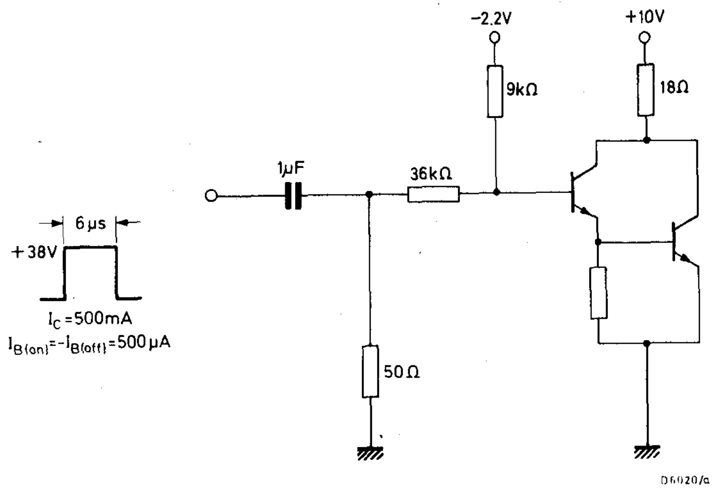
ACCESSORIES

Accessory	Code No.	Note
1 Mica washer	56301B	Supplied on request
1 Plain washer	56326	

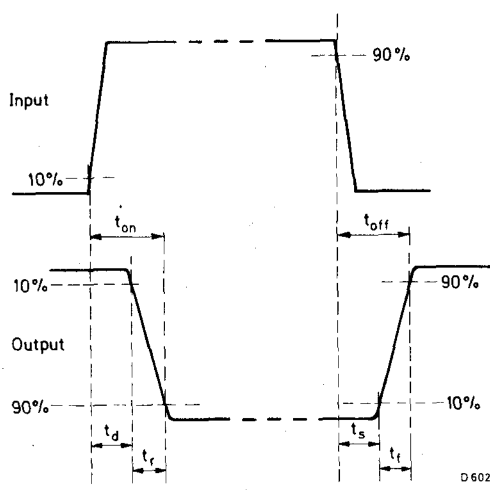
When mounted on a heatsink it is essential that a plain washer be used to prevent damage to the devices while tightening the mounting screw.

MEASUREMENT OF SATURATED SWITCHING TIMES

Test circuit for 500mA switching.

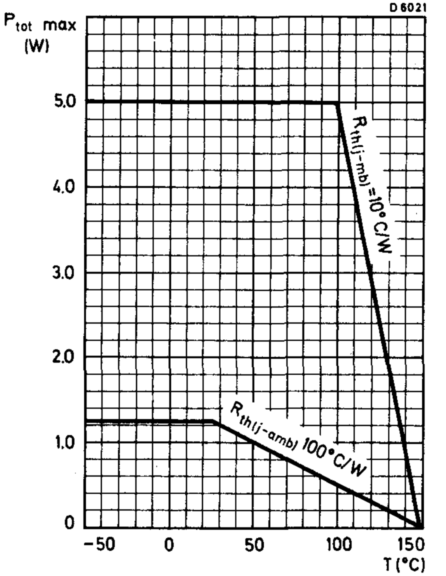


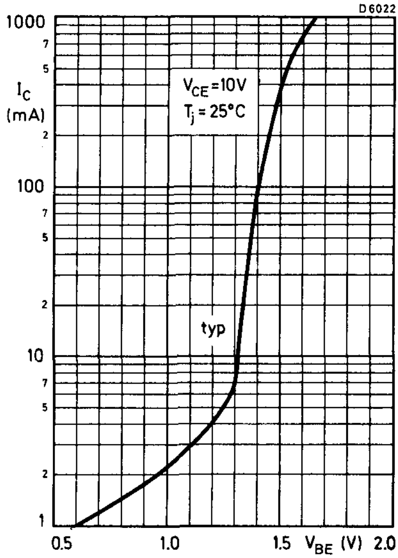
Switching waveforms

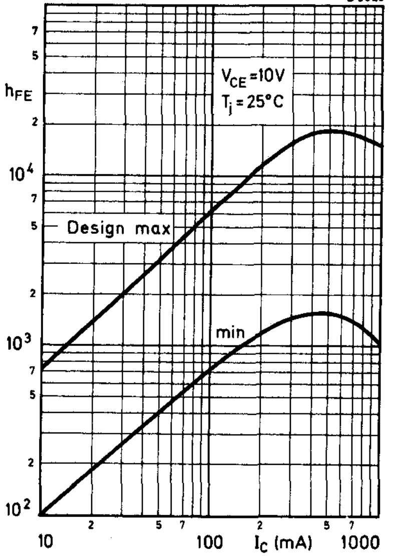


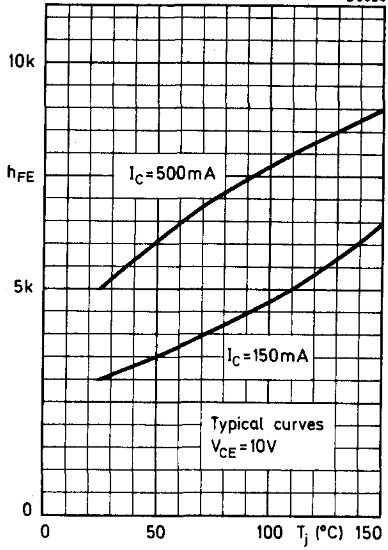
N-P-N SILICON PLANAR DARLINGTON TRANSISTORS

BDX42
BDX43
BDX44

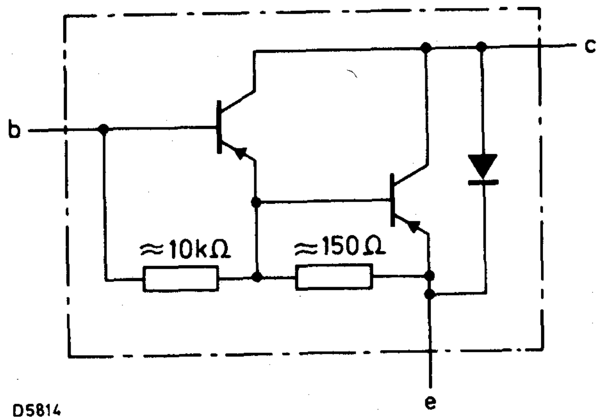








CIRCUIT DIAGRAM



RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

		BDX62	BDX62A	BDX62B	
$-V_{CBO}$	max.	60	80	100	V
$-V_{CEO}$	max.	60	80	100	V
$-V_{EBO}$	max.	5.0	5.0	5.0	V
$-I_C$	max.		8.0		A
$-I_{CM}$	max.		12		A
$-I_B$	max.		150		mA
P_{tot}	max. ($T_{mb} \leq 25^\circ C$)		90		W

Temperature

T_{stg}		-55 to +200	$^\circ C$
T_j	max.	200	$^\circ C$

THERMAL CHARACTERISTIC

$R_{th(j-mb)}$	1.94	$^\circ C/W$

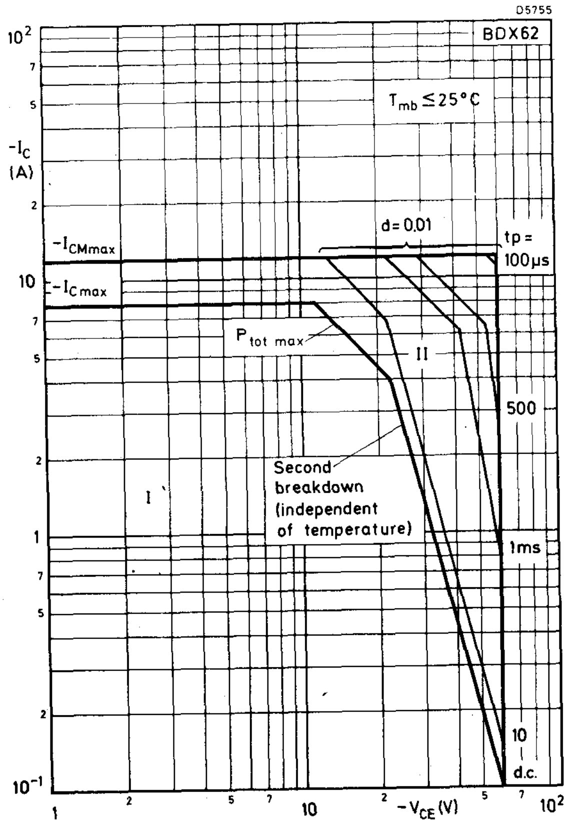
P-N-P SILICON DARLINGTON POWER TRANSISTORS

BDX62
BDX62A
BDX62B

ELECTRICAL CHARACTERISTICS (T_j = 25°C unless otherwise stated)

			Min.	Typ.	Max.	
	Collector cut-off current					
$-I_{CBO}$	$I_E = 0$, $-V_{CB} = -V_{CBO}$ max.		-	-	0.2	mA
$-I_{CBO}$	$I_E = 0$, $-V_{CB} = -V_{CBO}$ max., $T_j = 150°C$		-	-	2.0	mA
$-I_{CEO}$	$I_B = 0$, $-V_{CE} = 30V$	BDX62	-	-	0.5	mA
$-I_{CEO}$	$I_B = 0$, $-V_{CE} = 40V$	BDX62A	-	-	0.5	mA
$-I_{CEO}$	$I_B = 0$, $-V_{CE} = 50V$	BDX62B	-	-	0.5	mA
$-I_{EBO}$	Emitter cut-off current					
	$I_C = 0$, $-V_{EB} = 5.0V$		-	-	5.0	mA
h_{FE}	*Static forward current transfer ratio					
	$-I_C = 0.5A$, $-V_{CE} = 3.0V$		-	1500	-	
	$-I_C = 3.0A$, $-V_{CE} = 3.0V$		1000	-	-	
	$-I_C = 8.0A$, $-V_{CE} = 3.0V$		-	750	-	
$-V_{BE}$	Base-emitter voltage					
	$-I_C = 3.0A$, $-V_{CE} = 3.0V$		-	-	2.5	V
$-V_{CE(sat)}$	Collector-emitter saturation voltage					
	$-I_C = 3.0A$, $-I_B = 12mA$		-	-	2.0	V
f_T	Transition frequency					
	$-I_C = 3.0A$, $-V_{CE} = 3.0V$		-	7.0	-	MHz
f_{hfe}	Cut-off frequency					
	$-I_C = 3.0A$, $-V_{CE} = 3.0V$		-	60	-	kHz
$W_{(SB)}$	Switch-off second breakdown energy					
	$-I_B < 0$, see also page 8		50	-	-	mJ
V_F	Diode forward voltage					
	$I_F = 3.0A$		-	1.8	-	V

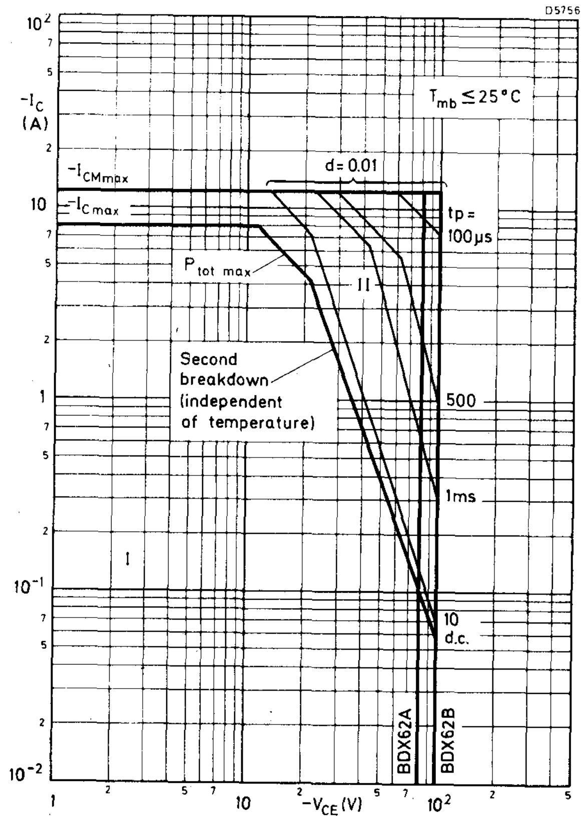
*Measured under pulse conditions: pulse width ≤300μs, duty cycle ≤2%.



Safe Operating Area with the transistor forward biased

I Region of permissible d. c. operation

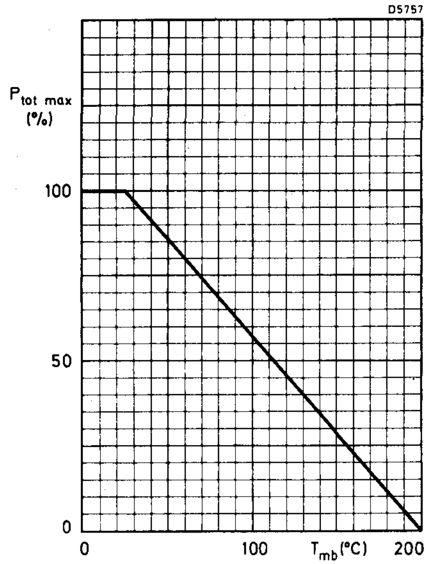
II Permissible extension for repetitive pulse operation

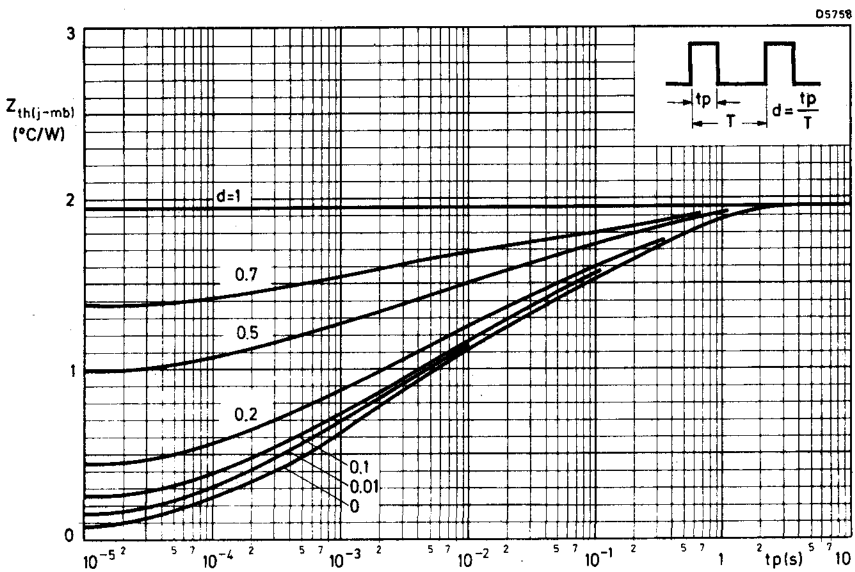


Safe Operating Area with the transistor forward biased

I Region of permissible d. c. operation

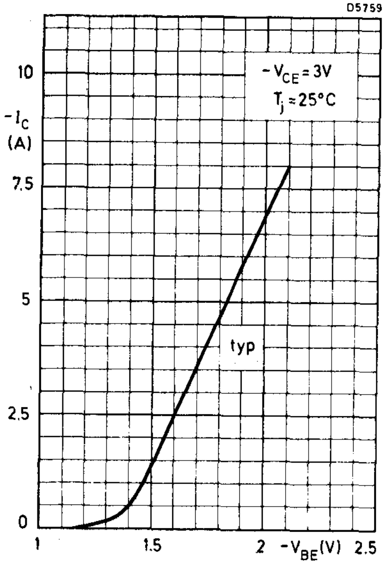
II Permissible extension for repetitive pulse operation

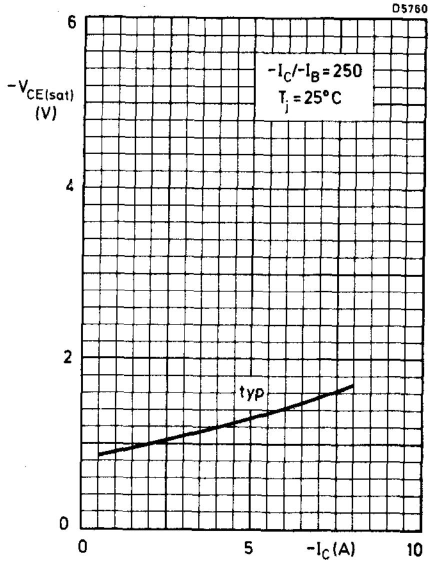

D5757
$P_{tot\ max}$ (%)
100
50
0
0
100
T_{mb}(°C)
200

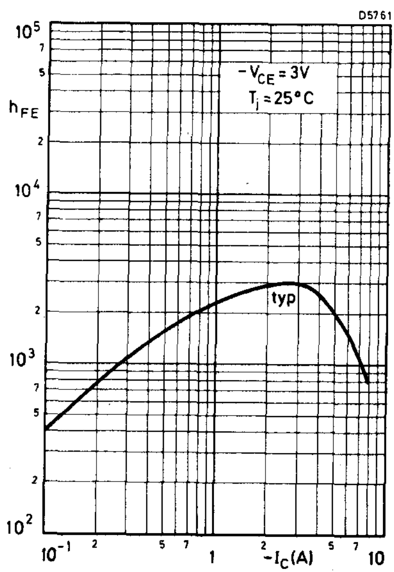

D5758
$Z_{th(j-mb)}$ (°C/W)
3
2
1
0
d=1
0.7
0.5
0.2
0.1
0.01
0
tp
T
$d = \frac{tp}{T}$
10^{-5} 2 5 7 10^{-4} 2 5 7 10^{-3} 2 5 7 10^{-2} 2 5 7 10^{-1} 2 5 7 1 2 tp(s) 5 7 10

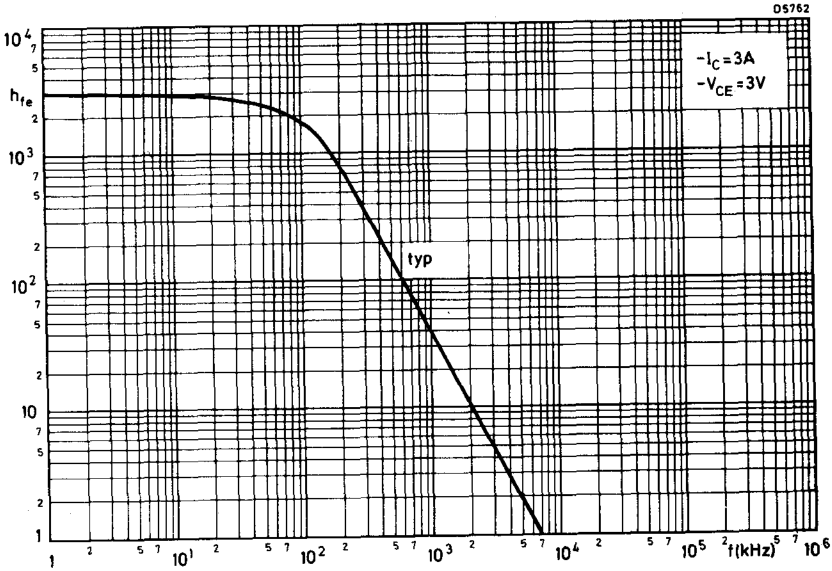
P-N-P SILICON DARLINGTON POWER TRANSISTORS

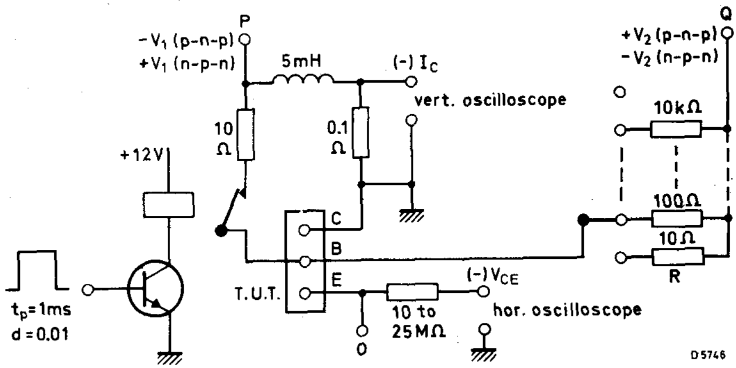
BDX62 BDX62A BDX62B











Circuit for measuring $W_{(SB)}$ (see page 3)

$-I_{CM}$ = 4.5A; $-I_{BM}$ max. 1.5A, but preferably substantially lower; V_1, V_2 and R should be adjusted so that the specified $-I_{CM}$ value is reached ($V_1 = V_2$ = about 15V; R = about 100Ω). O is the reference point for V_1 and V_2.

N-P-N SILICON DARLINGTON POWER TRANSISTORS

BDX63 BDX63A BDX63B

N-P-N silicon epitaxial base power transistors in monolithic Darlington circuit, intended for audio output stages and general amplifier and switching applications. Encapsulated in a TO-3 envelope. P-N-P complements are BDX62, BDX62A and BDX62B respectively.

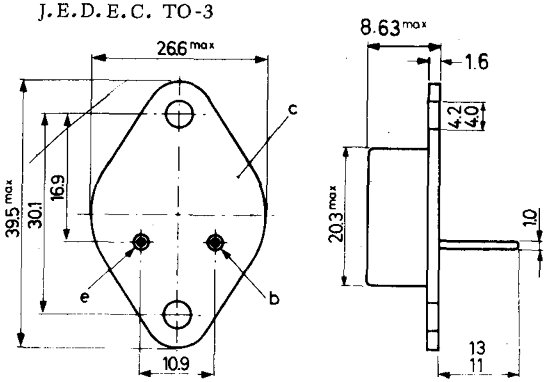
QUICK REFERENCE DATA

		BDX63	BDX63A	BDX63B	
V_{CBO}	max.	80	100	120	V
V_{CEO}	max.	60	80	100	V
I_{CM}	max.		12		A
P_{tot}	max. ($T_{mb} \leq 25^oC$)		90		W
T_j	max.		200		^oC
h_{FE}	typ. (I_C = 0.5A, V_{CE} = 3.0V)		1500		
	min. (I_C = 3.0A, V_{CE} = 3.0V)		1000		
f_T	typ. (I_C = 3.0A, V_{CE} = 3.0V)		7.0		MHz

Unless otherwise stated data are applicable to all types

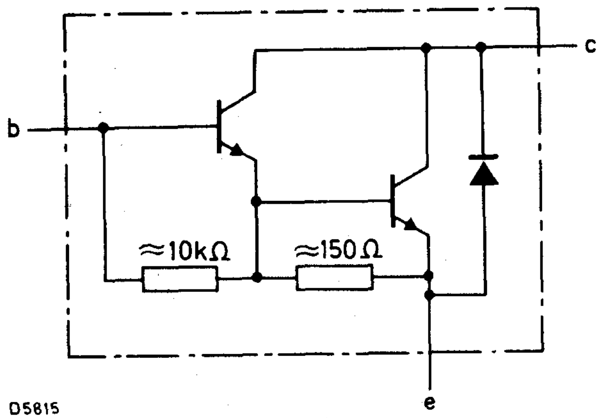
OUTLINE AND DIMENSIONS

Conforms to BS 3934 SO-5B/SB2-2
J.E.D.E.C. TO-3



All dimensions in mm
Collector connected to envelope
Accessories available: 56201A (insulating bush), 56201B(mica washer), 56214 (lead washer)

CIRCUIT DIAGRAM



RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

		BDX63	BDX63A	BDX63B	
V_{CBO}	max.	80	100	120	V
V_{CEO}	max.	60	80	100	V
V_{EBO}	max.	5.0	5.0	5.0	V
I_C	max.		8.0		A
I_{CM}	max.		12		A
I_B	max.		150		mA
P_{tot}	max. ($T_{mb} \leq 25^oC$)		90		W

Temperature

T_{stg}		-55 to +200	^oC
T_j	max.	200	^oC

THERMAL CHARACTERISTICS

$R_{th(j-mb)}$	1.94	$^oC/W$

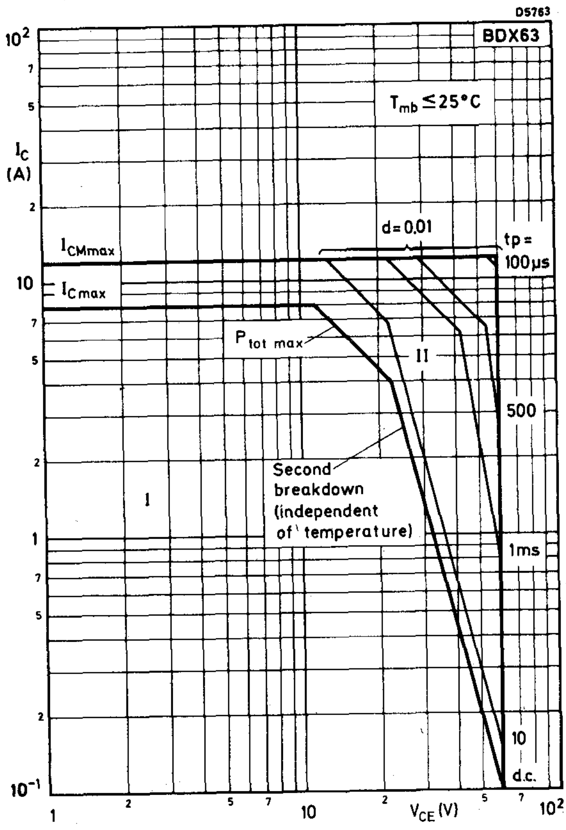
N-P-N SILICON DARLINGTON POWER TRANSISTORS

BDX63 BDX63A BDX63B

ELECTRICAL CHARACTERISTICS (T_j = 25°C unless otherwise stated)

Symbol	Characteristic / Conditions	Type	Min.	Typ.	Max.	Unit
	Collector cut-off current					
I_{CBO}	$I_E = 0$, $V_{CB} = 60V$	BDX63	-	-	0.2	mA
I_{CBO}	$I_E = 0$, $V_{CB} = 80V$	BDX63A	-	-	0.2	mA
I_{CBO}	$I_E = 0$, $V_{CB} = 100V$	BDX63B	-	-	0.2	mA
I_{CBO}	$I_E = 0$, $V_{CB} = 60V$, $T_{mb} = 150^{\circ}C$	BDX63	-	-	2.0	mA
I_{CBO}	$I_E = 0$, $V_{CB} = 80V$, $T_{mb} = 150^{\circ}C$	BDX63A	-	-	2.0	mA
I_{CBO}	$I_E = 0$, $V_{CB} = 100V$, $T_{mb} = 150^{\circ}C$	BDX63B	-	-	2.0	mA
I_{CEO}	$I_B = 0$, $V_{CE} = 30V$	BDX63	-	-	0.5	mA
I_{CEO}	$I_B = 0$, $V_{CE} = 40V$	BDX63A	-	-	0.5	mA
I_{CEO}	$I_B = 0$, $V_{CE} = 50V$	BDX63B	-	-	0.5	mA
I_{EBO}	Emitter cut-off current					
	$I_C = 0$, $V_{EB} = 5.0V$		-	-	5.0	mA
h_{FE}	*Static forward current transfer ratio					
	$I_C = 0.5A$, $V_{CE} = 3.0V$		-	1500	-	
	$I_C = 3.0A$, $V_{CE} = 3.0V$		1000	-	-	
	$I_C = 8.0A$, $V_{CE} = 3.0V$		-	750	-	
V_{BE}	Base-emitter voltage					
	$I_C = 3.0A$, $V_{CE} = 3.0V$		-	-	2.5	V
$V_{CE(sat)}$	Collector-emitter saturation voltage					
	$I_C = 3.0A$, $I_B = 12mA$		-	-	2.0	V
f_T	Transition frequency					
	$I_C = 3.0A$, $V_{CE} = 3.0V$		-	7.0	-	MHz
f_{hfe}	Cut-off frequency					
	$I_C = 3.0A$, $V_{CE} = 3.0V$		-	60	-	kHz
$W_{(SB)}$	Switch-off second breakdown voltage					
	$I_B < 0$ (see also page 8)		50	-	-	mJ
V_F	Diode forward voltage					
	$I_F = 3.0A$		-	1.8	-	V

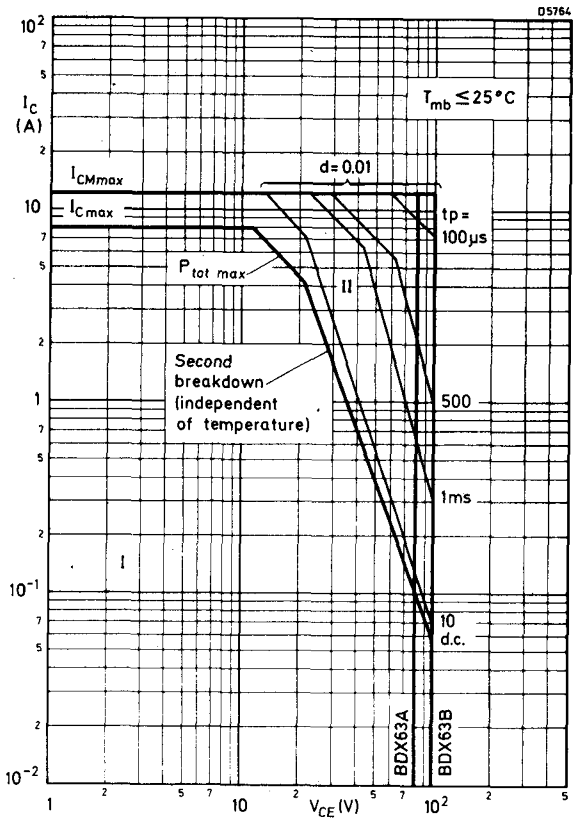
*Measured under pulse conditions: pulse width $\leq 300\mu s$, duty cycle $\leq 2\%$.



Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

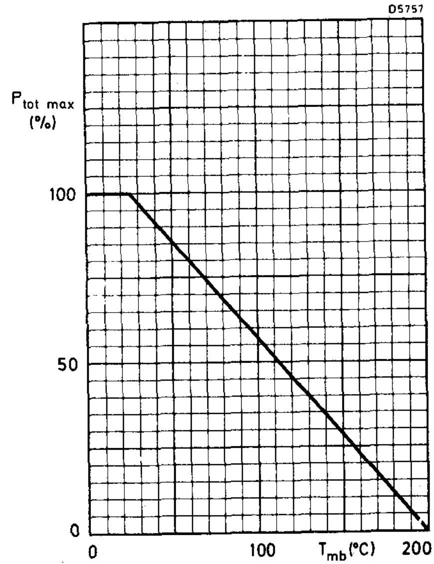
II Permissible extension for repetitive pulse operation

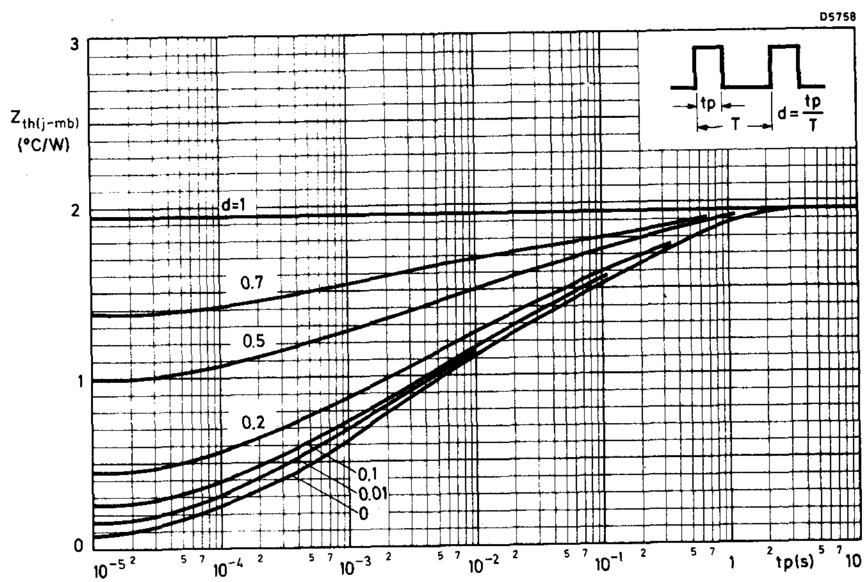


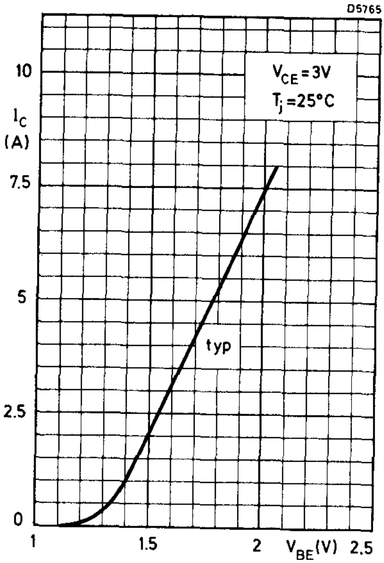
Safe Operating Area with the transistor forward biased

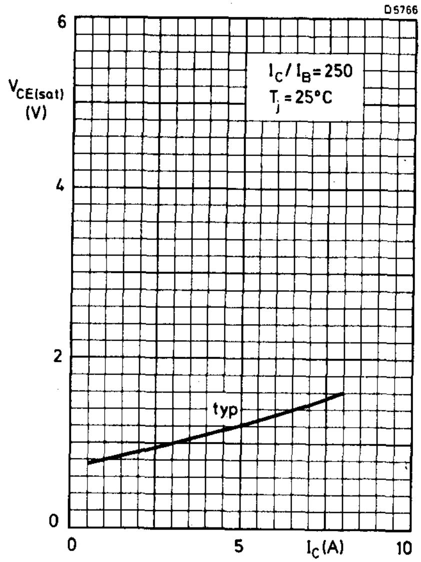
I Region of permissible d. c. operation

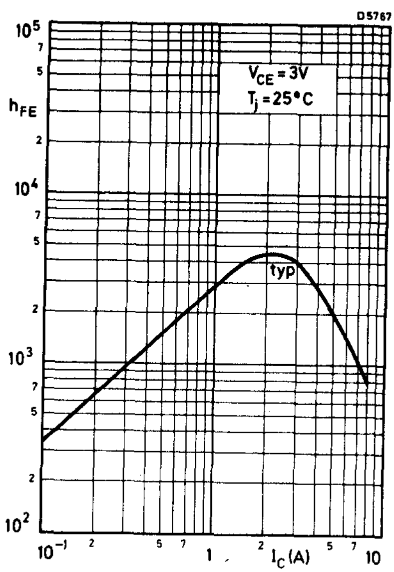
II Permissible extension for repetitive pulse operation

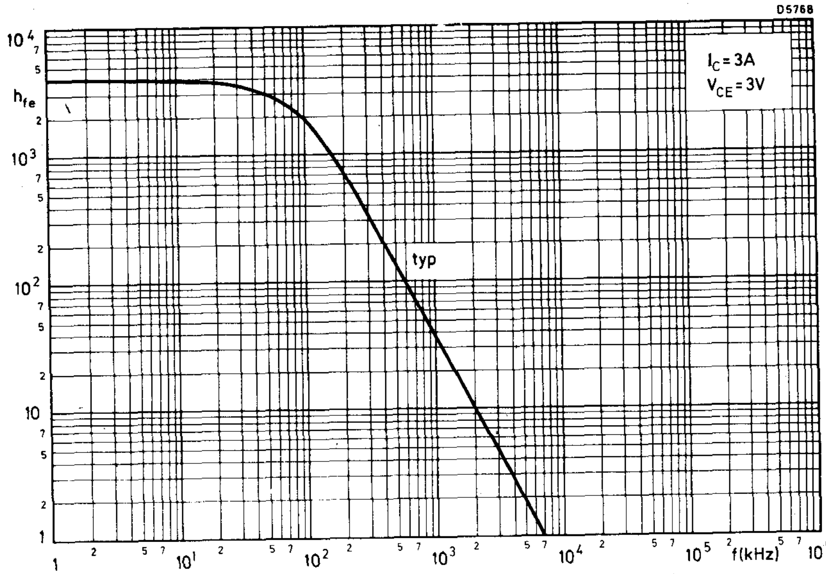

D5757
$P_{tot\ max}$ (%)
100
50
0
0
100
T_{mb} (°C)
200

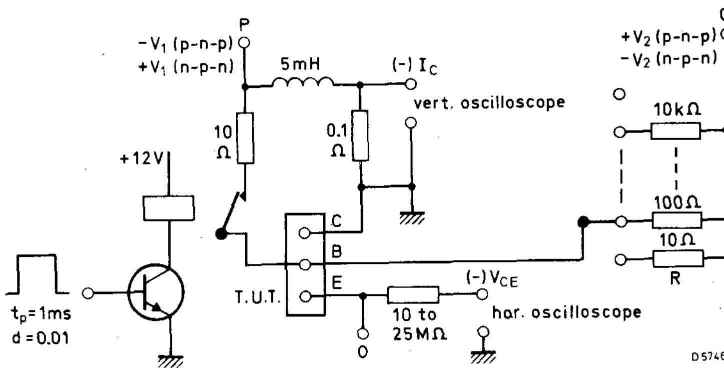

D5758
3
$Z_{th(j-mb)}$ (°C/W)
2
1
0
d=1
0.7
0.5
0.2
0.1
0.01
0
tp
T
d = tp/T
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
tp(s)
10


D5765
V_{CE} = 3V
T_j = 25°C
I_C
(A)
10
7.5
5
2.5
0
typ
1
1.5
2
V_{BE}(V)
2.5


D5766
I_C/I_B = 250
T_j = 25°C
$V_{CE(sat)}$
(V)
6
4
2
0
typ
0
5
I_C(A)
10


D5767
V_{CE} = 3V
T_j = 25°C
h_{FE}
10^5
10^4
10^3
10^2
typ
10^{-1}
1
I_C(A)
10





Circuit for measuring $W_{(SB)}$ (see page 3)

I_{CM} = 4.5A; I_{BM} max. 1.5A, but preferably substantially lower; V_1, V_2 and R should be adjusted so that the specified I_{CM} value is reached ($V_1 = V_2$ = about 15V; R = about 100Ω).

O is the reference point for V_1 and V_2.

P-N-P SILICON DARLINGTON POWER TRANSISTORS

BDX64
BDX64A
BDX64B

P-N-P silicon epitaxial base power transistors in monolithic Darlington circuit, intended for audio output stages and general amplifier and switching applications. Encapsulated in a TO-3 envelope. N-P-N complements are BDX65, BDX65A and BDX65B respectively.

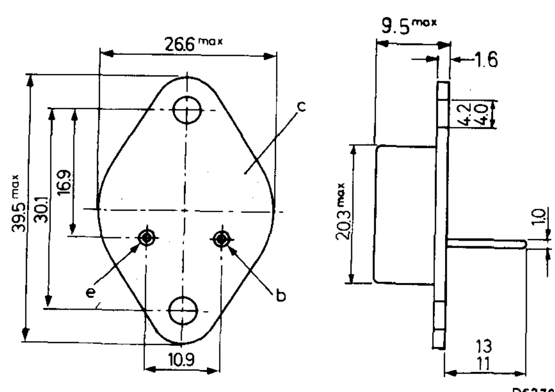
QUICK REFERENCE DATA

		BDX64	BDX64A	BDX64B	
$-V_{CBO}$	max.	60	80	100	V
$-V_{CEO}$	max.	60	80	100	V
$-I_{CM}$	max.		16		A
P_{tot}	max. ($T_{mb} \leq 25^{o}C$)		117		W
T_j	max.		200		^{o}C
h_{FE}	typ. ($-I_C = 1.0A$, $-V_{CE} = 3.0V$)		1500		
	min. ($-I_C = 5.0A$, $-V_{CE} = 3.0V$)		1000		
f_T	typ. ($-I_C = 5.0A$, $-V_{CE} = 3.0V$)		7.0		MHz

Unless otherwise stated data are applicable to all types.

OUTLINE AND DIMENSIONS

Conforms to BS 3934 SO-5A/SB2-2
J.E.D.E.C. TO-3

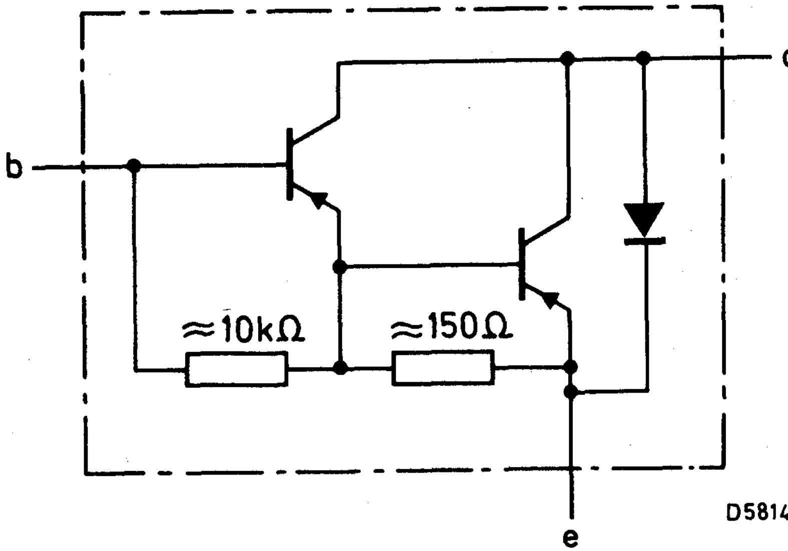


All dimensions in mm

Collector connected to envelope

Accessories available: 56239A (insulating bush), 56201B (mica washer), 56214 (lead washer)

CIRCUIT DIAGRAM



RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

	BDX64	BDX64A	BDX64B	
$-V_{CBO}$ max.	60	80	100	V
$-V_{CEO}$ max.	60	80	100	V
$-V_{EBO}$ max.	5.0	5.0	5.0	V
$-I_C$ max.		12		A
$-I_{CM}$ max.		16		A
$-I_B$ max.		200		mA
P_{tot} max. ($T_{mb} \leq 25^oC$)		117		W

Temperature

T_{stg}	-55 to +200	^oC
T_j max.	200	^oC

THERMAL CHARACTERISTIC

$R_{th(j-mb)}$	1.5	$^oC/W$

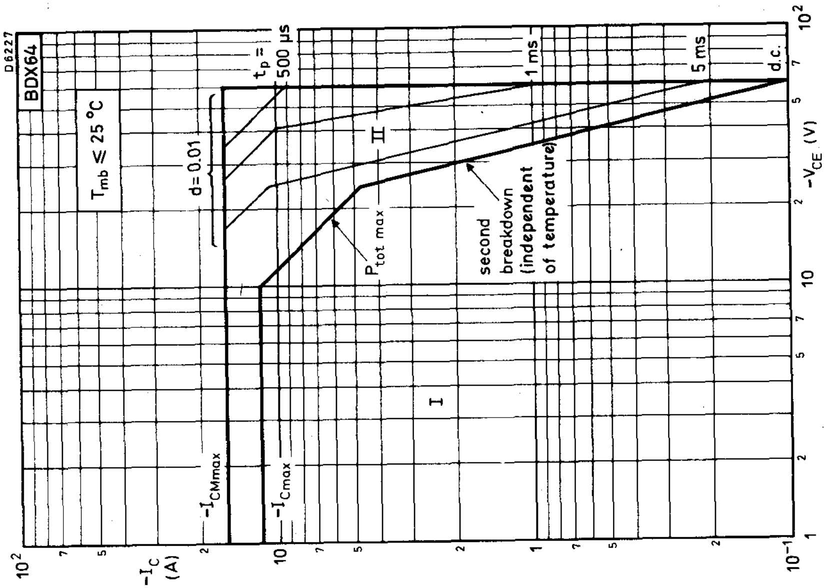
P-N-P SILICON DARLINGTON POWER TRANSISTORS

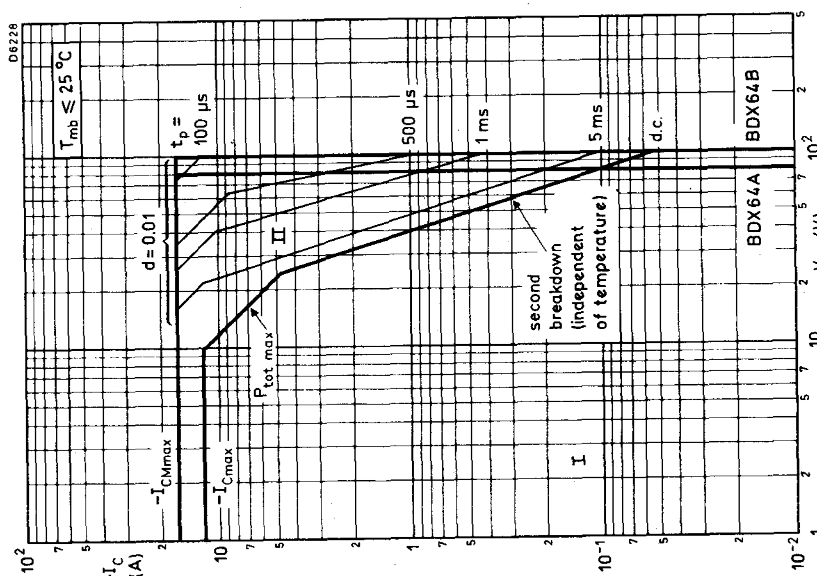
BDX64 BDX64A BDX64B

ELECTRICAL CHARACTERISTICS (T_j = 25°C unless otherwise stated)

			Min.	Typ.	Max.	
	Collector cut-off current					
$-I_{CBO}$	$I_E=0$, $-V_{CB}=-V_{CBO}$ max.		-	-	0.4	mA
$-I_{CBO}$	$I_E=0$, $-V_{CB}=-V_{CBO}$ max., $T_j=150°C$		-	-	3.0	mA
$-I_{CEO}$	$I_B=0$, $-V_{CE}=30V$	BDX64	-	-	1.0	mA
$-I_{CEO}$	$I_B=0$, $-V_{CE}=40V$	BDX64A	-	-	1.0	mA
$-I_{CEO}$	$I_B=0$, $-V_{CE}=50V$	BDX64B	-	-	1.0	mA
$-I_{EBO}$	Emitter cut-off current					
	$I_C=0$, $-V_{EB}=5.0V$		-	-	5.0	mA
h_{FE}	*Static forward current transfer ratio					
	$-I_C=1.0A$, $-V_{CE}=3.0V$		-	1500	-	
	$-I_C=5.0A$, $-V_{CE}=3.0V$		1000	-	-	
	$-I_C=10A$, $-V_{CE}=3.0V$		-	1500	-	
$-V_{BE}$	Base-emitter voltage					
	$-I_C=5.0A$, $-V_{CE}=3.0V$		-	-	3.0	V
$-V_{CE(sat)}$	Collector-emitter saturation voltage					
	$-I_C=5.0A$, $-I_B=20mA$		-	-	2.5	V
f_T	Transition frequency					
	$-I_C=5.0A$, $-V_{CE}=3.0V$		-	7.0	-	MHz
f_{hfe}	Cut-off frequency					
	$-I_C=5.0A$, $-V_{CE}=3.0V$		-	60	-	kHz
$W_{(SB)}$	Switch-off second breakdown energy					
	$-I_B<0$, see also page 8		100	-	-	mJ
V_F	Diode forward voltage					
	$I_F=5.0A$		-	1.8	-	V

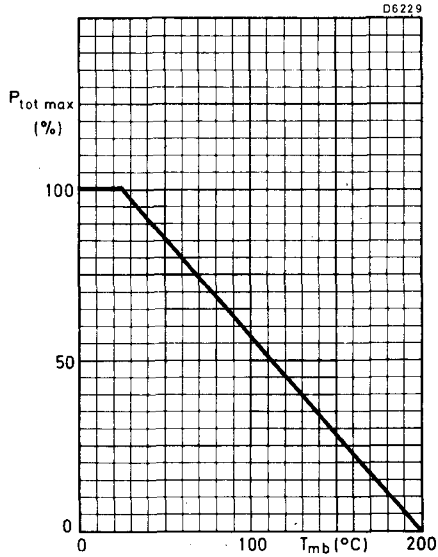
*Measured under pulse conditions: t_p <300µs, d <2%



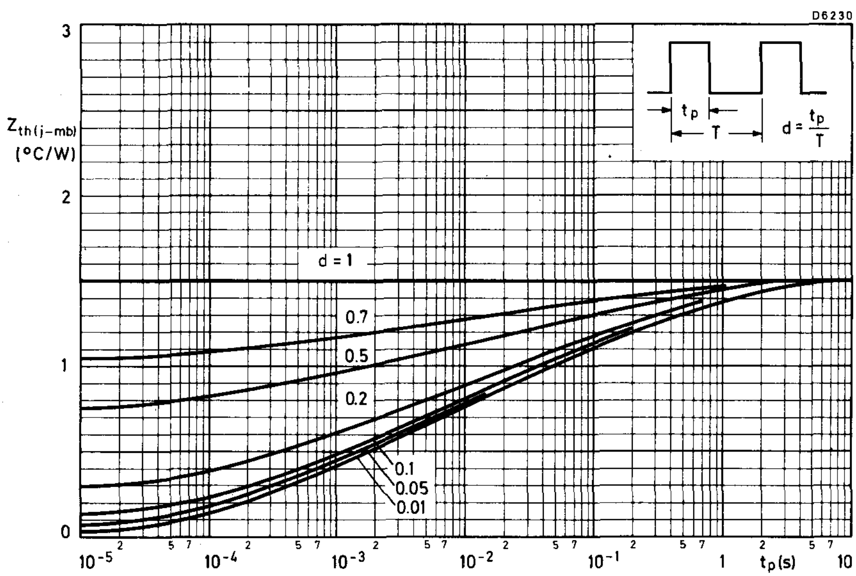


Safe Operating Areas with the transistor forward biased

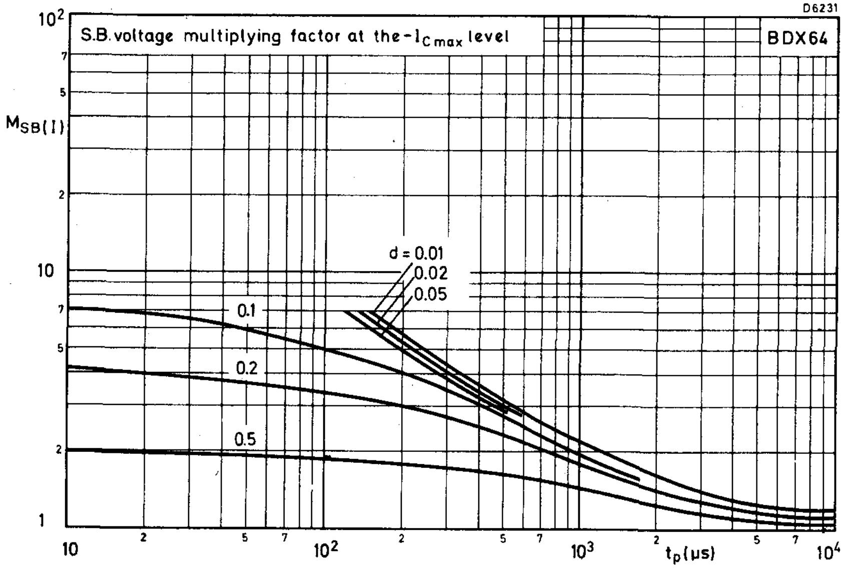
I Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation

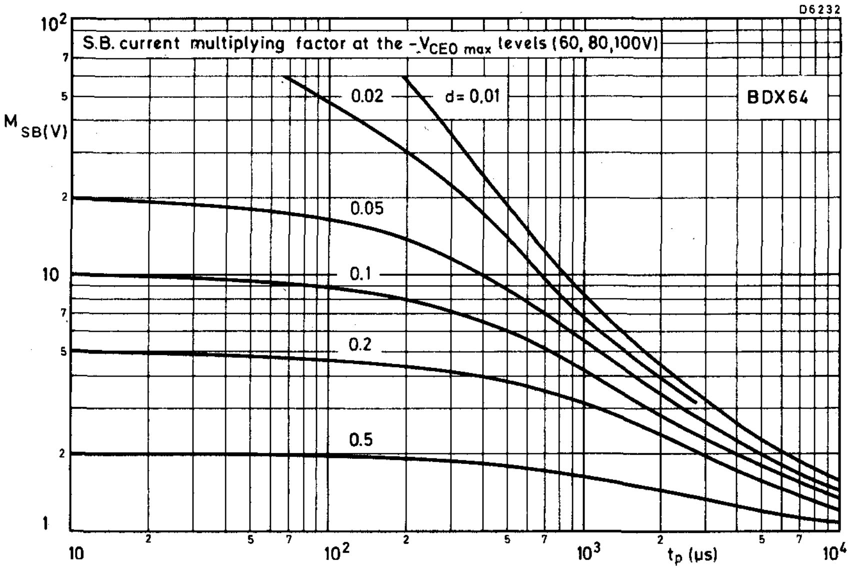


D6229
$P_{tot\ max}$ (%)
100
50
0
0
100
T_{mb} (°C)
200



D6230
$Z_{th(j-mb)}$ (°C/W)
3
2
1
0
d = 1
0.7
0.5
0.2
0.1
0.05
0.01
t_p
T
$d = \frac{t_p}{T}$
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
t_p (s)

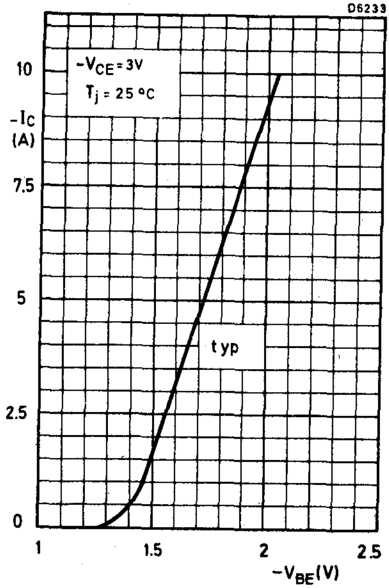

D6231
S.B. voltage multiplying factor at the $-I_{C max}$ level
BDX64
$M_{SB(I)}$
10^2
7
5
2
10
7
5
2
1
d = 0.01
0.02
0.05
0.1
0.2
0.5
10
2
5
7
10^2
2
5
7
10^3
2
t_p (μs)
5
7
10^4

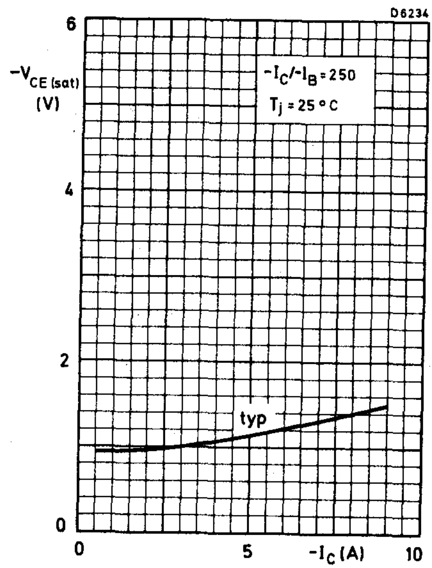

D6232
S.B. current multiplying factor at the $-V_{CEO max}$ levels (60, 80, 100V)
BDX64
$M_{SB(V)}$
10^2
7
5
2
10
7
5
2
1
0.02
d = 0.01
0.05
0.1
0.2
0.5
10
2
5
7
10^2
2
5
7
10^3
2
t_p (μs)
5
7
10^4

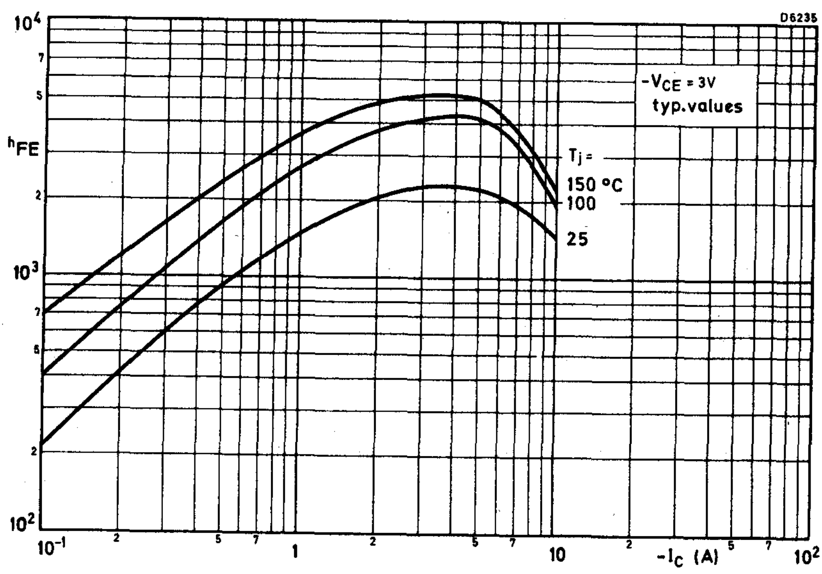
Mullard

P-N-P SILICON
DARLINGTON POWER TRANSISTORS

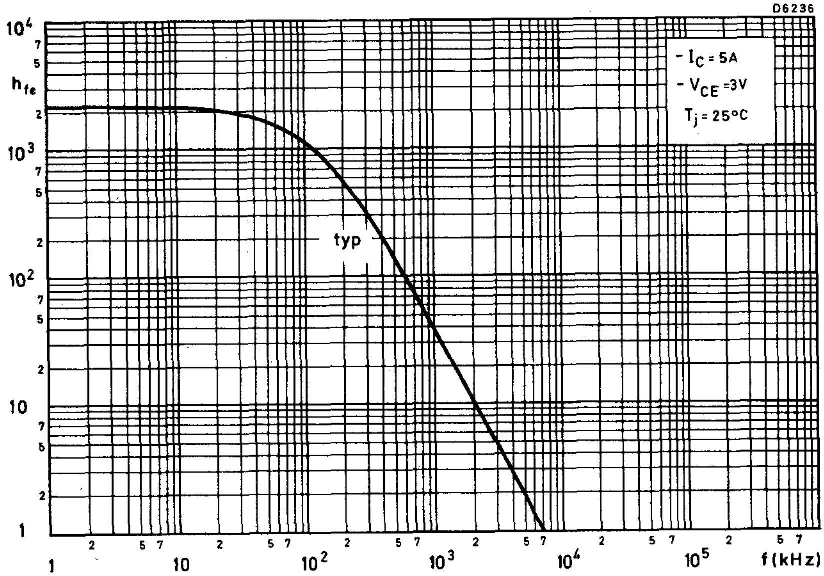
BDX64
BDX64A
BDX64B

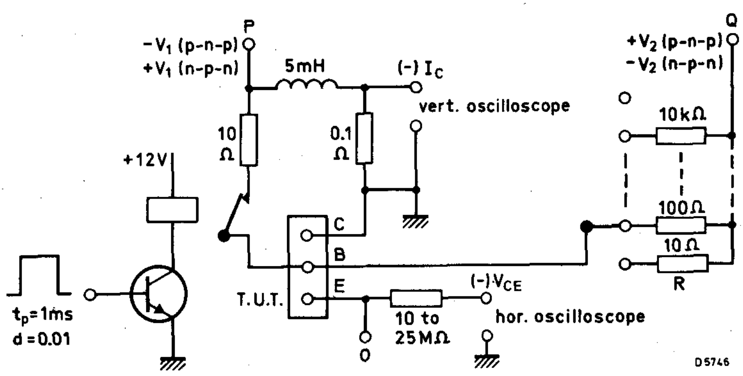






Mullard





Circuit for measuring $W_{(SB)}$ (see page 3)

$-I_{CM}$ = 6.3A; $-I_{BM}$ max. 3.5A, but preferably substantially lower; V_1, V_2 and R should be adjusted so that the specified $-I_{CM}$ value is reached ($V_1 = V_2$ = about 35V; R = about 100Ω.) O is the reference point for V_1 and V_2.

N-P-N SILICON DARLINGTON POWER TRANSISTORS

BDX65
BDX65A
BDX65B

N-P-N silicon epitaxial base power transistors in monolithic Darlington circuit, intended for audio output stages and general amplifier and switching applications. Encapsulated in a TO-3 envelope. P-N-P complements are BDX64, BDX64A and BDX64B respectively.

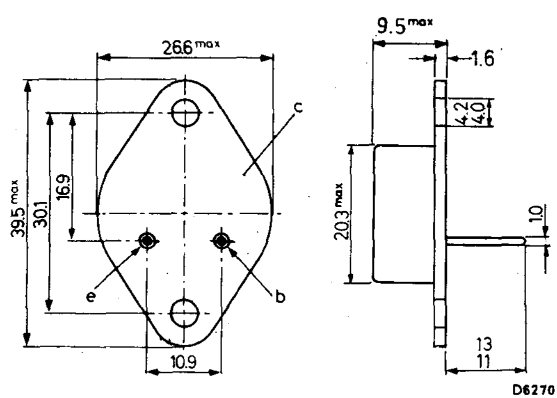
QUICK REFERENCE DATA

			BDX65	BDX65A	BDX65B	
V_{CBO}	max.		80	100	120	V
V_{CEO}	max.		60	80	100	V
I_{CM}	max.			16		A
P_{tot}	max.	($T_{mb} \leq 25^oC$)		117		W
T_j	max.			200		^oC
h_{FE}	typ.	($I_C = 1.0A$, $V_{CE} = 3.0V$)		1500		
	min.	($I_C = 5.0A$, $V_{CE} = 3.0V$)		1000		
f_T	typ.	($I_C = 5.0A$, $V_{CE} = 3.0V$)		7.0		MHz

Unless otherwise stated data are applicable to all types.

OUTLINE AND DIMENSIONS

Conforms to BS 3934 SO-5A/SB2-2
J.E.D.E.C. TO-3



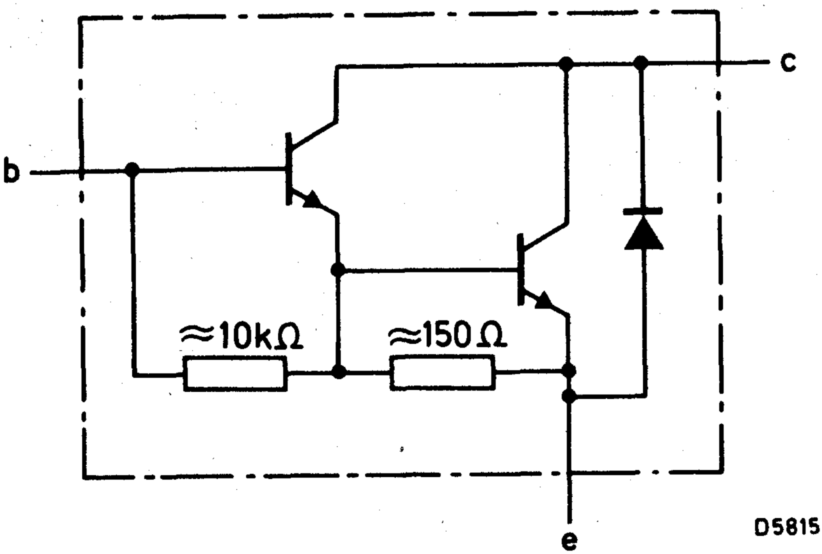
All dimensions in mm

Collector connected to envelope

Accessories available: 56239A (insulating bush), 56201B (mica washer), 56214 (lead washer).

Mullard

CIRCUIT DIAGRAM



RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

		BDX65	BDX65A	BDX65B	
V_{CBO}	max.	80	100	120	V
V_{CEO}	max.	60	80	100	V
V_{EBO}	max.	5.0	5.0	5.0	V
I_C	max.		12		A
I_{CM}	max.		16		A
I_B	max.		200		mA
P_{tot}	max. ($T_{mb} \leq 25^{\circ}C$)		117		W

Temperature

T_{stg}	-55 to +200	$^{\circ}C$
T_j max.	200	$^{\circ}C$

THERMAL CHARACTERISTIC

$R_{th(j-mb)}$	1.5	$^{\circ}C/W$

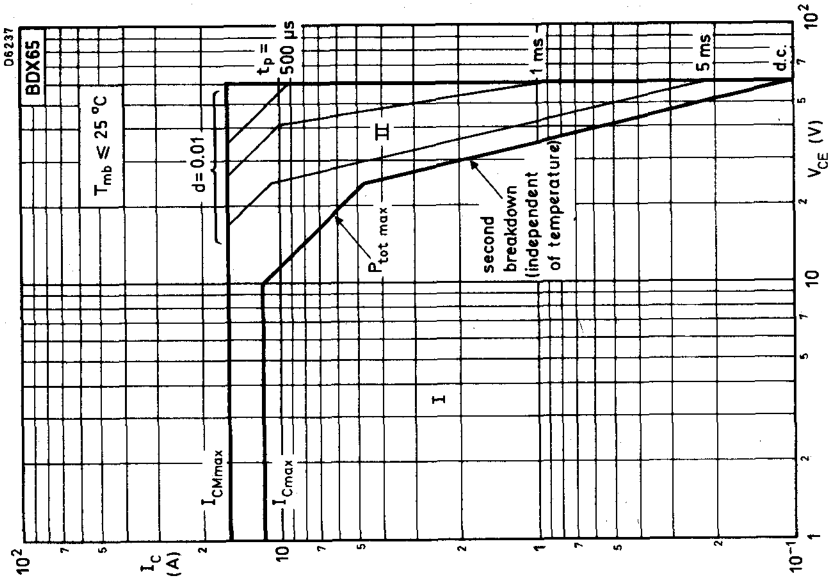
N-P-N SILICON DARLINGTON POWER TRANSISTORS

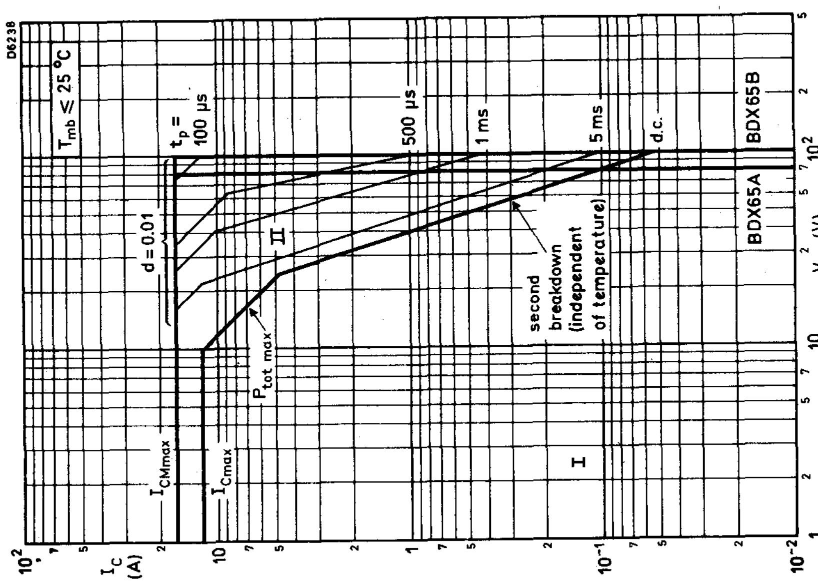
BDX65 BDX65A BDX65B

ELECTRICAL CHARACTERISTICS ($T_j = 25^oC$ unless otherwise stated)

			Min.	Typ.	Max.	
	Collector cut-off current					
I_{CBO}	$I_E = 0,\ V_{CB} = 60V$	BDX65	-	-	0.4	mA
I_{CBO}	$I_E = 0,\ V_{CB} = 80V$	BDX65A	-	-	0.4	mA
I_{CBO}	$I_E = 0,\ V_{CB} = 100V$	BDX65B	-	-	0.4	mA
I_{CBO}	$I_E = 0,\ V_{CB} = 60V,\ T_j = 150^oC$	BDX65	-	-	3.0	mA
I_{CBO}	$I_E = 0,\ V_{CB} = 80V,\ T_j = 150^oC$	BDX65A	-	-	3.0	mA
I_{CBO}	$I_E = 0,\ V_{CB} = 100V,\ T_j = 150^oC$	BDX65B	-	-	3.0	mA
I_{CEO}	$I_B = 0,\ V_{CE} = 30V$	BDX65	-	-	1.0	mA
I_{CEO}	$I_B = 0,\ V_{CE} = 40V$	BDX65A	-	-	1.0	mA
I_{CEO}	$I_B = 0,\ V_{CE} = 50V$	BDX65B	-	-	1.0	mA
I_{EBO}	Emitter cut-off current					
	$I_C = 0,\ V_{EB} = 5.0V$		-	-	5.0	mA
h_{FE}	*Static forward current transfer ratio					
	$I_C = 1.0A,\ V_{CE} = 3.0V$		-	1500	-	
	$I_C = 5.0A,\ V_{CE} = 3.0V$		1000	-	-	
	$I_C = 10A,\ V_{CE} = 3.0V$		-	1500	-	
V_{BE}	Base-emitter voltage					
	$I_C = 5.0A,\ V_{CE} = 3.0V$		-	-	3.0	V
$V_{CE(sat)}$	Collector-emitter saturation voltage					
	$I_C = 5.0A,\ I_B = 20mA$		-	-	2.5	V
f_T	Transition frequency					
	$I_C = 5.0A,\ V_{CE} = 3.0V$		-	7.0	-	MHz
f_{hfe}	Cut-off frequency					
	$I_C = 5.0A,\ V_{CE} = 3.0V$		-	60	-	kHz
$W_{(SB)}$	Switch-off second breakdown energy					
	$I_B < 0$, see also page 8		100	-	-	mJ
V_F	Diode forward voltage, $I_F = 5.0A$		-	1.8	-	V

*Measured under pulse conditions, $t_p < 300\mu s$, $d < 2\%$



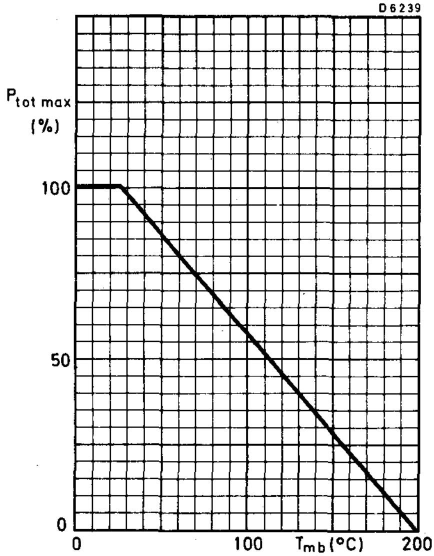


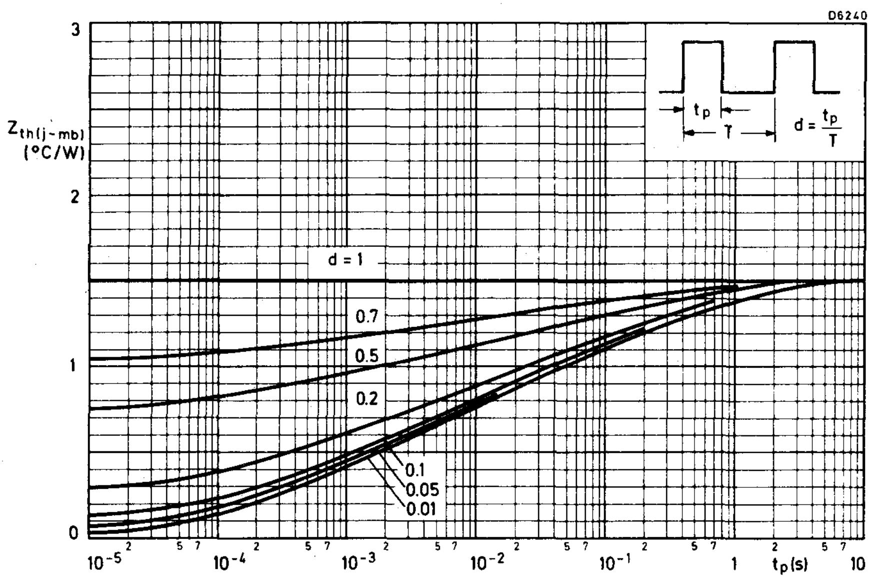
Safe Operating Areas with the transistor forward biased

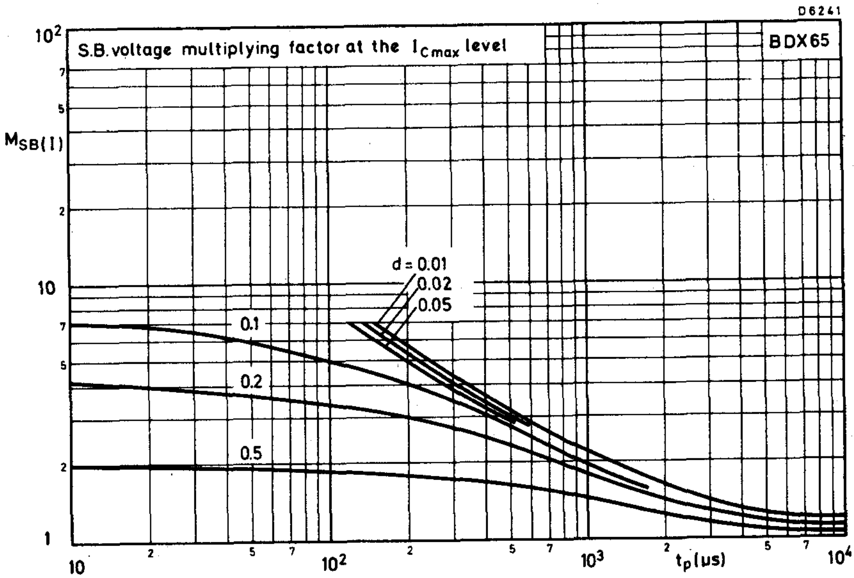
I Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation

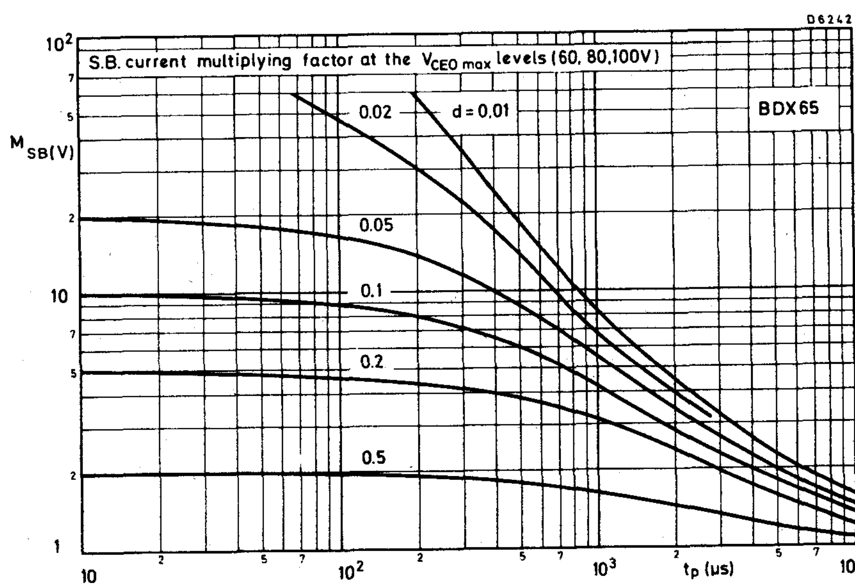
N-P-N SILICON DARLINGTON POWER TRANSISTORS

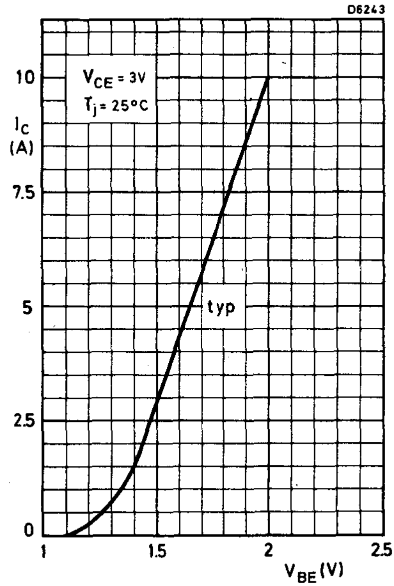
BDX65 BDX65A BDX65B

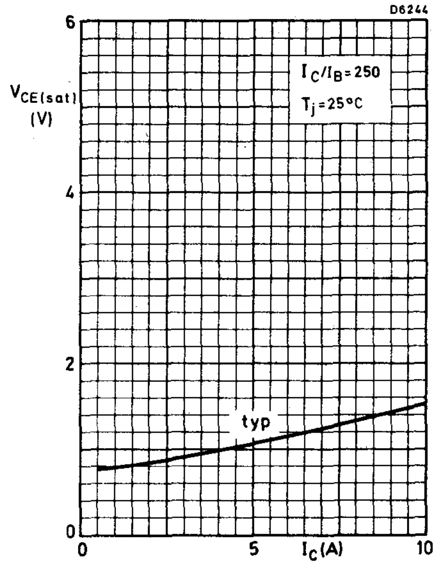


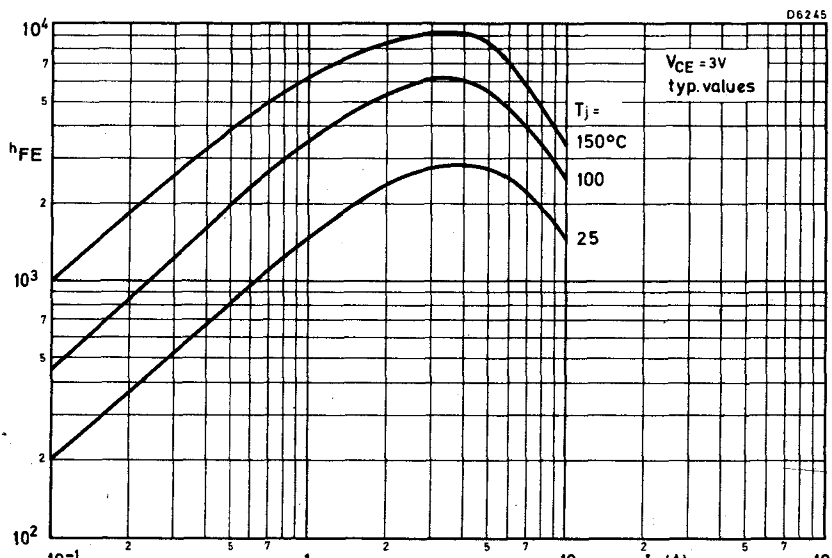


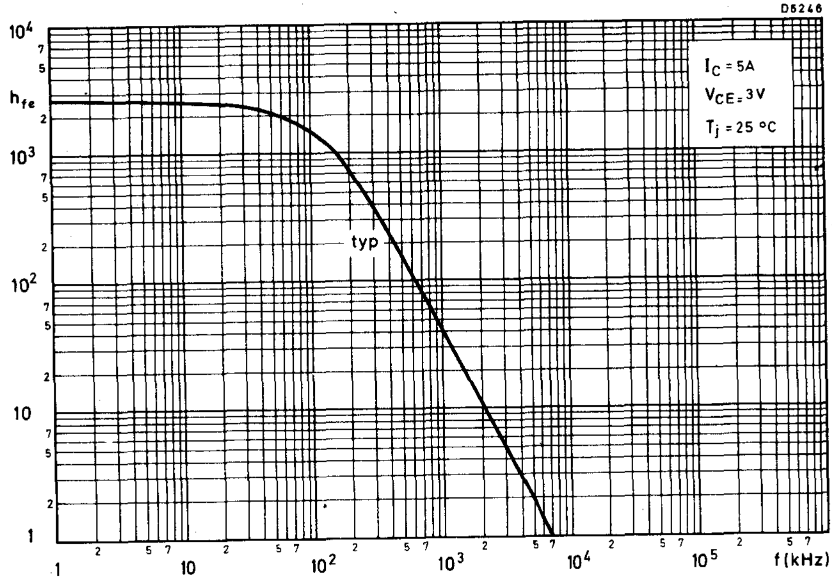

D6241
S.B. voltage multiplying factor at the $I_{C max}$ level
BDX65
$M_{SB(I)}$
d = 0.01
0.02
0.05
0.1
0.2
0.5
t_p (µs)

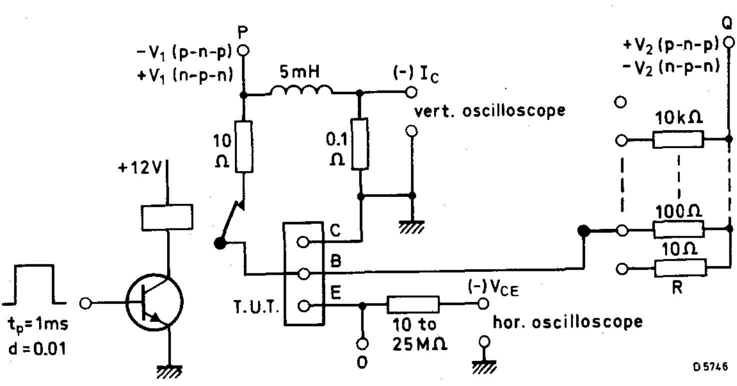

D6242
S.B. current multiplying factor at the $V_{CEO max}$ levels (60, 80, 100V)
BDX65
$M_{SB(V)}$
0.02
d = 0.01
0.05
0.1
0.2
0.5
t_p (µs)


D6243
V_{CE} = 3V
T_j = 25°C
I_C (A)
10
7.5
5
2.5
0
typ
1
1.5
2
2.5
V_{BE} (V)


D6244
I_C/I_B = 250
T_j = 25°C
$V_{CE(sat)}$ (V)
6
4
2
0
typ
0
5
I_C (A)
10


D6245
V_{CE} = 3V
typ. values
T_j =
150°C
100
25
h_{FE}
10^4
10^3
10^2
10^{-1}
1
10
I_C (A)
10^2





Circuit for measuring $W_{(SB)}$ (see page 3)

I_{CM} = 6.3A; I_{BM} max. 3.5A, but preferably substantially lower; V_1, V_2 and R should be adjusted so that the specified I_{CM} value is reached ($V_1 = V_2$ = about 35V; R = about 100Ω) O is the reference point for V_1 and V_2.

N-P-N SILICON DIFFUSED POWER TRANSISTOR

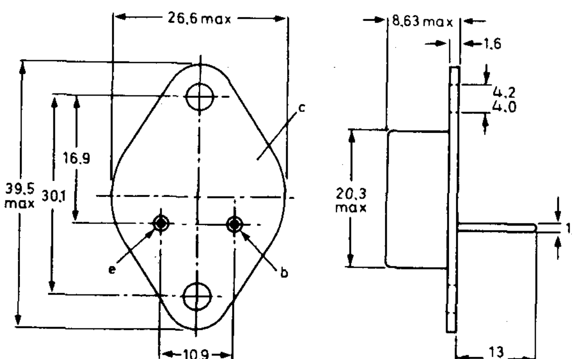
BDY20 2-BDY20

N-P-N silicon diffused power transistor, intended for high quality amplifiers, power supplies, inverters and similar industrial applications.

QUICK REFERENCE DATA		
V_{CBO} max.	100	V
V_{CEO} max.	60	V
I_{CM} max.	15	A
P_{tot} max. ($T_{mb} \leq 25^{o}C$)	115	W
T_j max.	200	^{o}C
h_{FE} (I_C=4.0A, V_{CE}=4.0V)	20 to 70	
f_T typ. (I_C=1.0A, V_{CE}=4.0V, f=1.0MHz)	1.0	MHz

OUTLINE AND DIMENSIONS

Conforming to B.S. 3934 SO-5B/SB2-2
J.E.D.E.C. TO-3



All dimensions in mm

D5811

Collector connected to envelope

Accessories available: 56239A (insulating bush), 56201B (mica washer), 56214 (lead washer)

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

V_{CBO} max.	100	V
V_{CEO} max. (I_C = 0.2A)	60	V
V_{CER} max. (R_{BE} = 100Ω, I_C = 0.2A)	70	V
V_{EBO} max.	7.0	V
I_C max.	15	A
I_{CM} max.	15	A
$-I_{EM}$ max.	15	A
P_{tot} max. ($T_{mb} \leq 25^{\circ}C$)	115	W

Temperature

T_{stg} min.	-65	$^{\circ}C$
T_{stg} max.	200	$^{\circ}C$
T_j max.	200	$^{\circ}C$

THERMAL CHARACTERISTICS

$R_{th(j-amb)}$	In free air	40	degC/W
$R_{th(j-mb)}$		1.5	degC/W
$R_{th(mb-h)}$	Contact thermal resistance without insulating material	0.5	degC/W
$R_{th(mb-h)}$	Contact thermal resistance with lead and mica washers, accessories 56214, 56201B	0.75	degC/W

ELECTRICAL CHARACTERISTICS ($T_j = 25^{\circ}C$ unless otherwise stated)

		Min.	Typ.	Max.	
	Collector cut-off current				
I_{CBO}	V_{CB} = 100V, I_E = 0	-	3.0μA	5.0	mA
I_{CEX}	V_{CE} = 100V, $-V_{BE}$ = 1.5V	-	4.0μA	5.0	mA
I_{CEX}	V_{CE} = 100V, $-V_{BE}$ = 1.5V, $T_j = 150^{\circ}C$	-	0.3	10	mA
I_{EBO}	Emitter cut-off current V_{EB} = 7.0V, I_C = 0	-	1.0nA	5.0	mA
V_{BE}	Base-emitter voltage I_C = 4.0A, V_{CE} = 4.0V	-	1.1	1.8	V

ELECTRICAL CHARACTERISTICS (cont'd)

		Min.	Typ.	Max.	
$V_{CE(sat)}$	Collector-emitter saturation voltage I_C=4.0A, I_B=0.4A	-	0.4	1.1	V
h_{FE}	Static forward current transfer ratio I_C=4.0A, V_{CE}=4.0V	20	-	70	
C_{tc}	Collector capacitance I_E=I_e=0, V_{CB}=20V, f=1.0MHz	-	250	-	pF
f_T	Transition frequency I_C=1.0A, V_{CE}=4.0V, f=1.0MHz	-	1.0	-	MHz
f_{hfe}	Cut-off frequency I_C=1.0A, V_{CE}=4.0V	-	15	-	kHz

Switching times (see Fig.1 and Fig.2)

I_C=4.0V, I_{Bon}=$-I_{Boff}$=0.4A

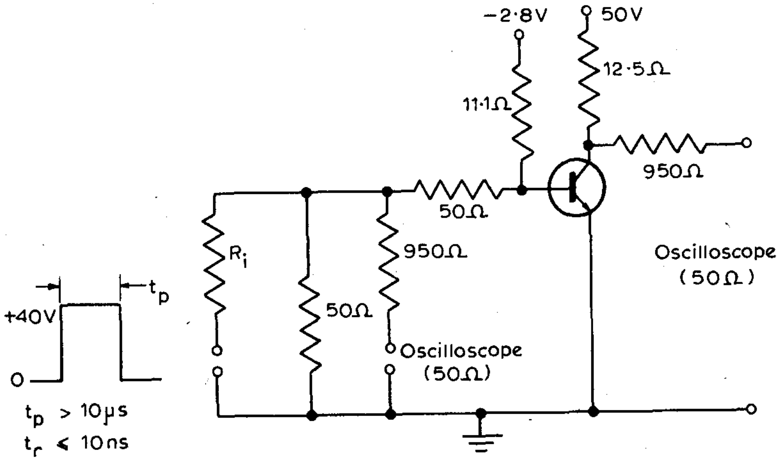
		Min.	Typ.	Max.	
Turn-on					
t_d	Delay time	-	0.4	-	µs
t_r	Rise time	-	2.0	-	µs
Turn-off					
t_s	Storage time	-	2.0	-	µs
t_f	Fall time	-	2.5	-	µs

CHARACTERISTICS OF MATCHED PAIRS

		Min.	Typ.	Max.
$\frac{h_{FE1}}{h_{FE2}}$	Ratio of static forward current transfer ratio of a matched pair			
	I_C=0.4A, V_{CE}=4.0V	-	-	1.6
	I_C=4.0A, V_{CE}=4.0V	-	-	1.3

Switching times

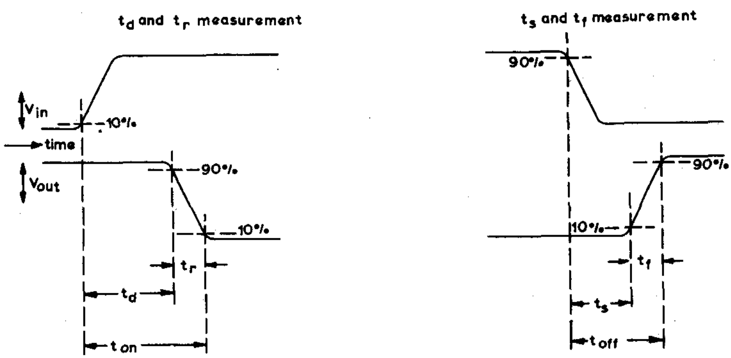
Test circuit

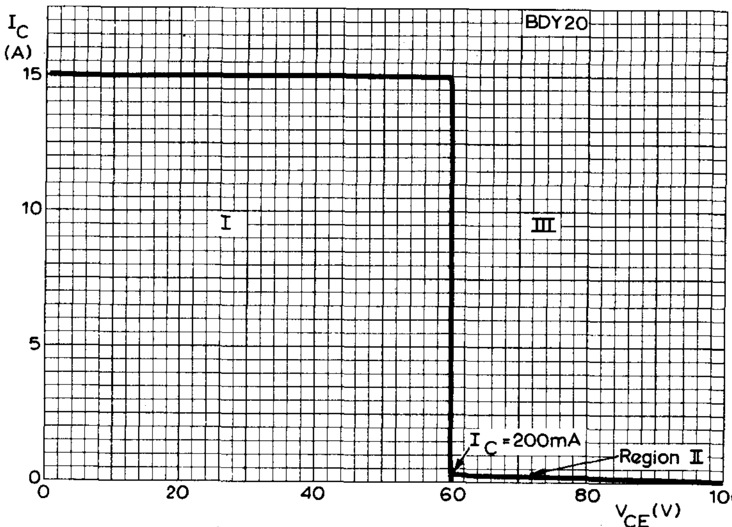


t_p > 10μs
t_r ⩽ 10ns
R_i = 50 Ω
Oscilloscope t_r ⩽ 10ns

Fig. 1

Waveforms



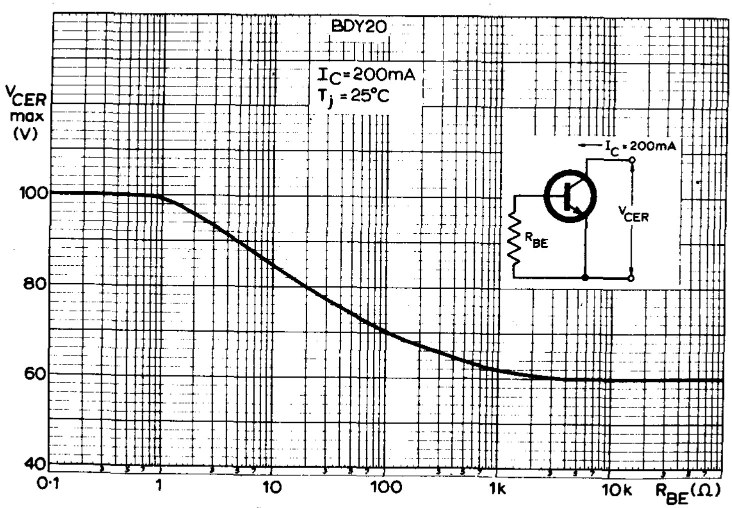


AREAS OF SAFE OPERATION

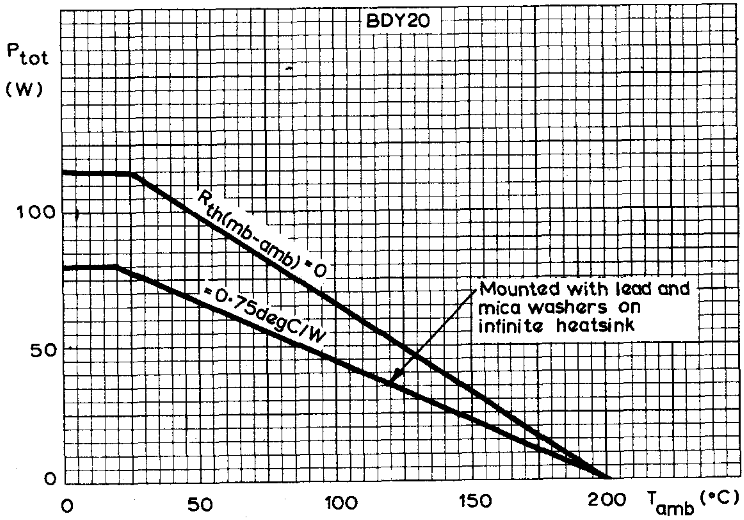
I. Operation is allowed under all base-emitter conditions, provided no limiting values are exceeded.

II. Operation is allowed when the transistor is cut-off, provided $-V_{BE} \leq 1.5V$.

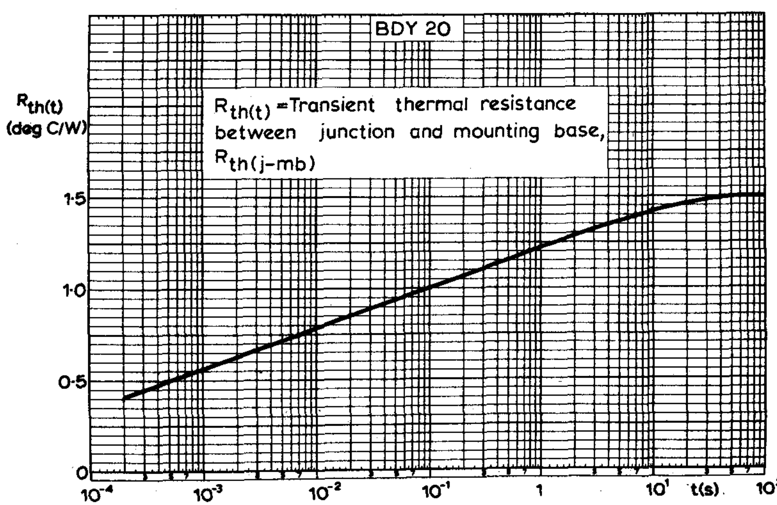
III. Operation is allowed during switch-off, provided the transistor is cut-off with $-V_{BE} \leq 1.5V$ and the transient energy does not exceed 75mWs.



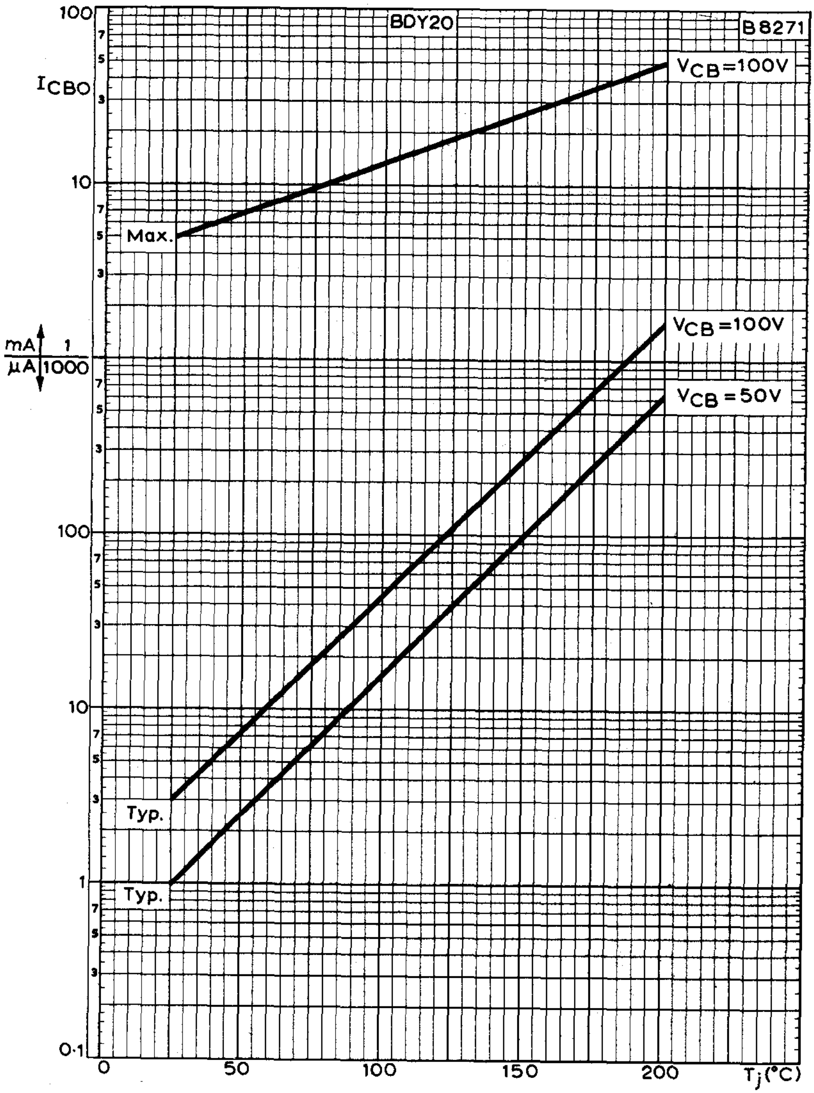
MAXIMUM ALLOWABLE COLLECTOR-EMITTER VOLTAGE PLOTTED AGAINST BASE-EMITTER RESISTANCE



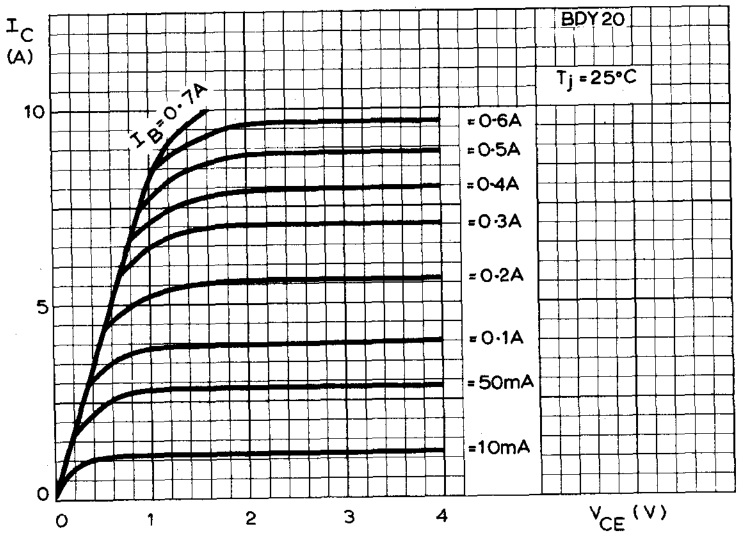
MAXIMUM PERMISSIBLE TOTAL DISSIPATION PLOTTED AGAINST AMBIENT TEMPERATURE



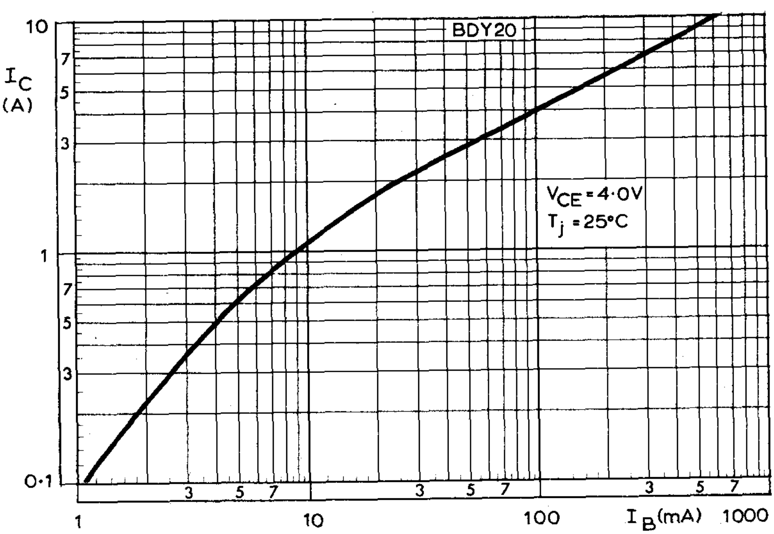
TRANSIENT THERMAL RESISTANCE PLOTTED AGAINST PULSE DURATION



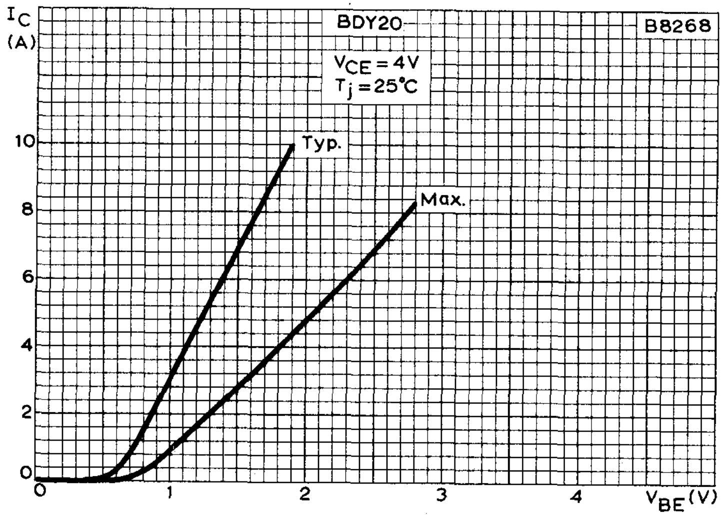
VARIATION OF COLLECTOR CUT-OFF CURRENT WITH JUNCTION TEMPERATURE



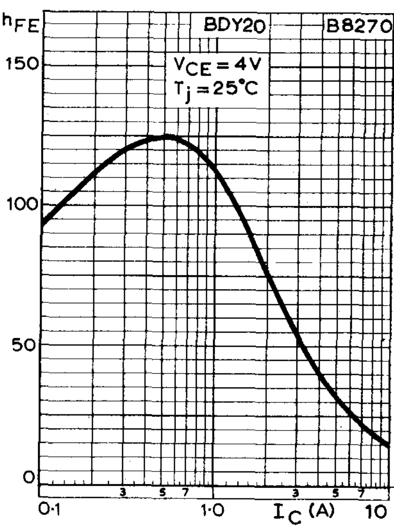
TYPICAL OUTPUT CHARACTERISTICS

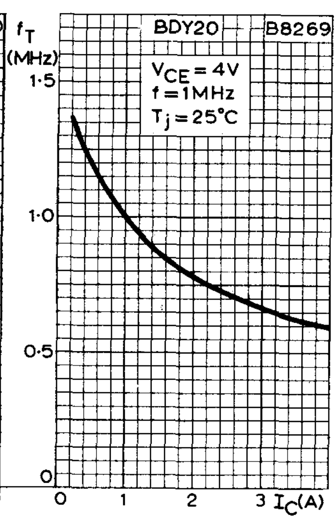


TYPICAL TRANSFER CHARACTERISTIC



MUTUAL CHARACTERISTICS





TYPICAL VARIATION OF STATIC FORWARD CURRENT TRANSFER RATIO AND TRANSITION FREQUENCY WITH COLLECTOR CURRENT

N-P-N SILICON DIFFUSED POWER TRANSISTOR

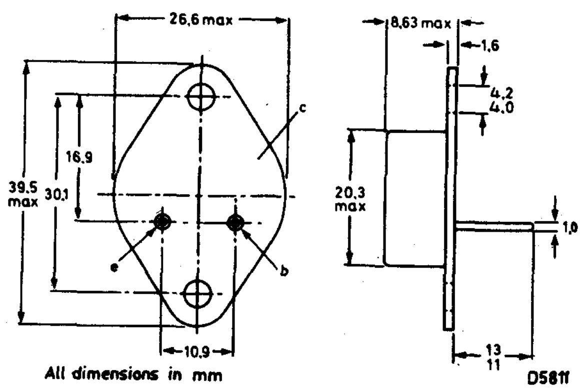
BDY38
2-BDY38

N-P-N silicon diffused power transistor, intended for amplifier, converter and voltage stabiliser applications.

QUICK REFERENCE DATA		
V_{CBO} max.	50	V
V_{CEO} max.	40	V
I_{CM} max.	6.0	A
P_{tot} max. ($T_{mb} \leq 25^{\circ}C$)	115	W
T_j max.	200	$^{\circ}C$
h_{FE} min. ($I_C = 2.0A$, $V_{CE} = 4.0V$)	30	
f_T typ. ($I_C = 1.0A$, $V_{CE} = 4.0V$, $f = 1.0MHz$)	1.0	MHz

OUTLINE AND DIMENSIONS

Conforming to B.S. 3934 SO-5B/SB2-2
J.E.D.E.C. TO-3



Collector connected to envelope

Accessories available: 56239A (insulating bush), 56201B (mica washer), 56214 (lead washer)

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

V_{CBO} max.	50	V
V_{CEO} max. (I_C=200mA)	40	V
V_{EBO} max.	7.0	V
I_C max.	6.0	A
I_{CM} max.	6.0	A
$-I_{EM}$ max.	8.0	A
I_{BM} max.	2.0	A
P_{tot} max. ($T_{mb}\leq 25^oC$)	115	W

Temperature

T_{stg} range	-65 to 200	^oC
T_j max.	200	^oC

THERMAL CHARACTERISTICS

$R_{th(j-amb)}$	In free air	40	degC/W
$R_{th(j-mb)}$		1.5	degC/W
$R_{th(mb-h)}$	Contact thermal resistance without insulating material	0.5	degC/W
$R_{th(mb-h)}$	Contact thermal resistance with lead and mica washers, accessories 56214, 56201B	0.75	degC/W

ELECTRICAL CHARACTERISTICS ($T_{amb}=25^oC$ unless otherwise stated)

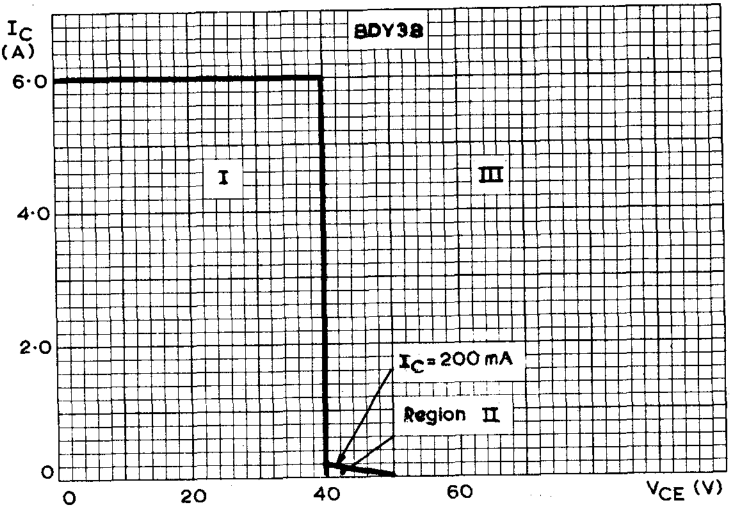
		Min.	Typ.	Max.	
	Collector cut-off current				
I_{CBO}	V_{CB}=50V, I_E=0	-	3.0μA	1.0	mA
I_{CES}	V_{CE}=50V, V_{BE}=0	-	3.0μA	1.0	mA
I_{EBO}	Emitter cut-off current V_{EB}=7.0V, I_C=0	-	1.0nA	5.0	mA
$V_{CE(sat)}$	Collector-emitter saturation voltage I_C=2.0A, I_B=0.2A	-	-	0.7	V
V_{BE}	Base-emitter voltage I_C=2.0A, V_{CE}=4.0V	-	-	2.0	V
h_{FE}	Static forward current transfer ratio				
	I_C=0.2A, V_{CE}=4.0V	30	-	-	
	I_C=2.0A, V_{CE}=4.0V	30	-	-	

ELECTRICAL CHARACTERISTICS (cont'd)

		Min.	Typ.	Max.	
f_T	Transition frequency I_C=1.0A, V_{CE}=4.0V, f=1.0MHz	-	1.0	-	MHz
C_{tc}	Collector depletion capacitance V_{CB}=20V, I_E=I_e=0, f=1.0MHz	-	250	-	pF

CHARACTERISTICS OF MATCHED PAIRS

		Min.	Typ.	Max.
$\frac{h_{FE1}}{h_{FE2}}$	Ratio of static forward current transfer ratio I_C=0.2A, V_{CE}=4.0V	-	-	1.5
	I_C=2.0A, V_{CE}=4.0V	-	-	1.3

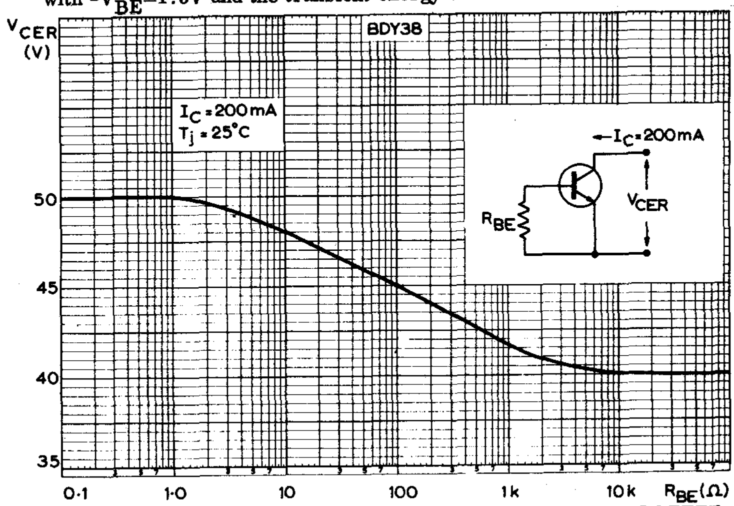


AREAS OF SAFE OPERATION

I. Operation is allowed under all base-emitter conditions, provided no limiting values are exceeded.

II. Operation is allowed when the transistor is cut-off, provided $-V_{BE} \leq 1.5V$.

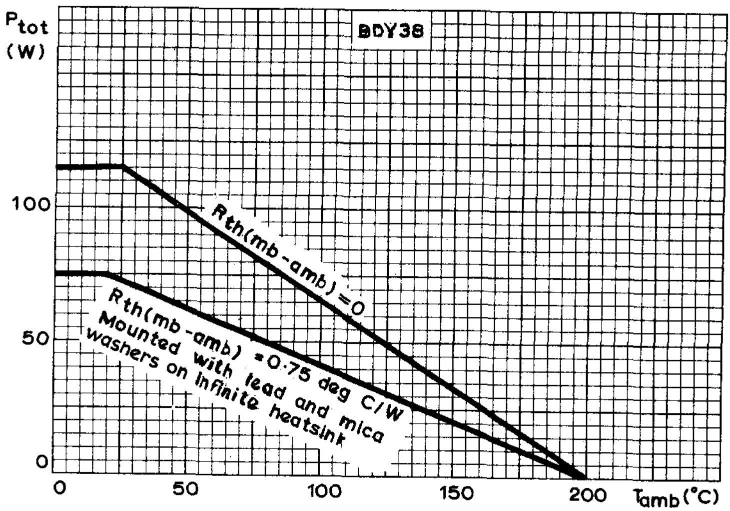
III. Operation is allowed during switch-off, provided the transistor is cut-off with $-V_{BE} \leq 1.5V$ and the transient energy does not exceed 75mWs.



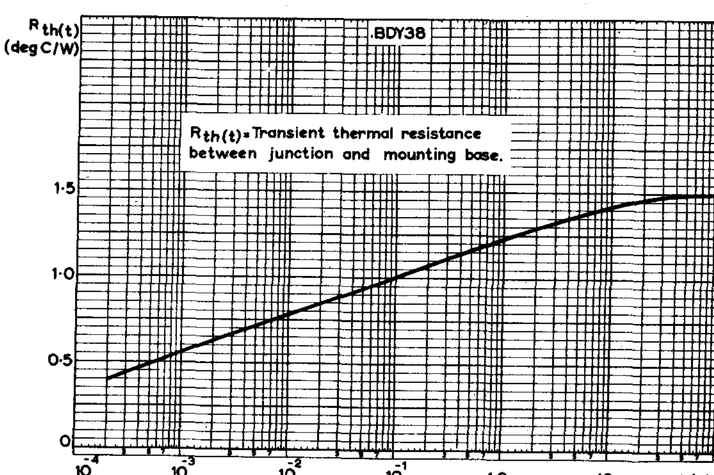
MAXIMUM ALLOWABLE COLLECTOR-EMITTER VOLTAGE PLOTTED AGAINST BASE-EMITTER RESISTANCE

N-P-N SILICON DIFFUSED POWER TRANSISTOR

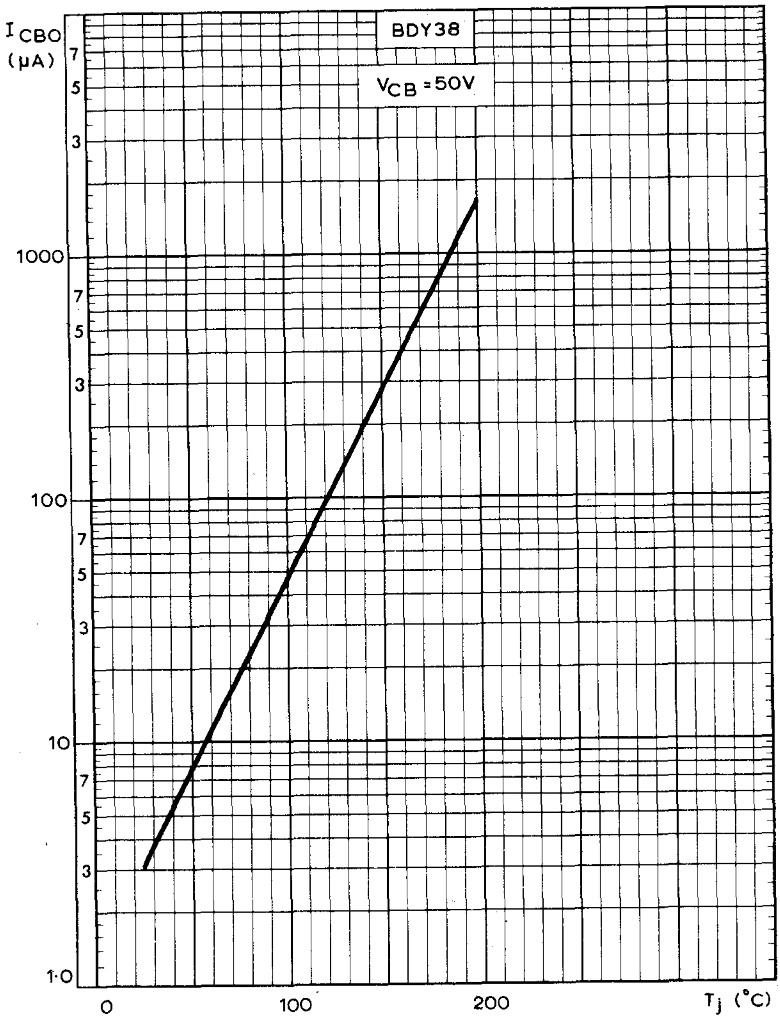
BDY38
2-BDY38



MAXIMUM PERMISSIBLE TOTAL DISSIPATION PLOTTED AGAINST AMBIENT TEMPERATURE



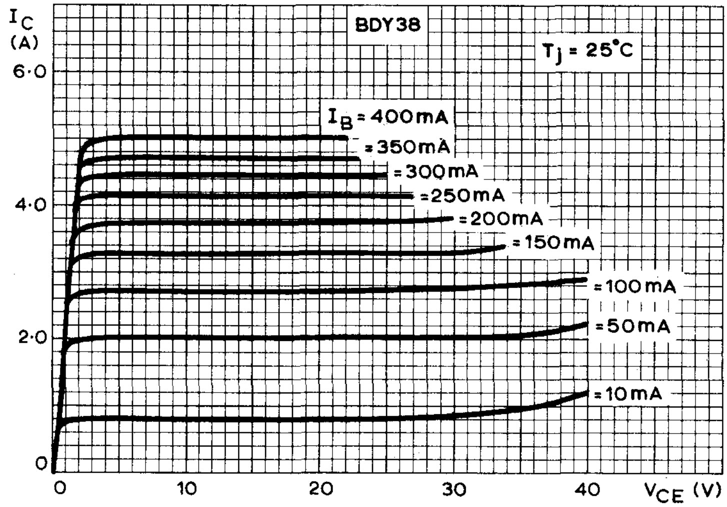
TRANSIENT THERMAL RESISTANCE PLOTTED AGAINST PULSE DURATION



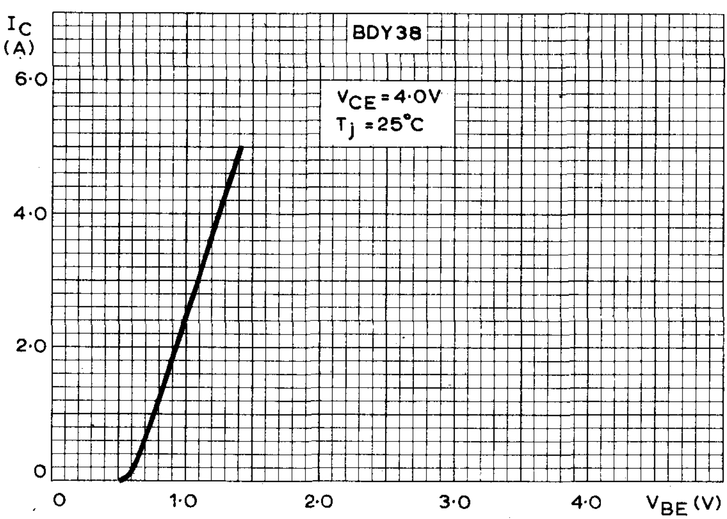
TYPICAL COLLECTOR CUT-OFF CURRENT PLOTTED AGAINST JUNCTION TEMPERATURE

N-P-N SILICON DIFFUSED POWER TRANSISTOR

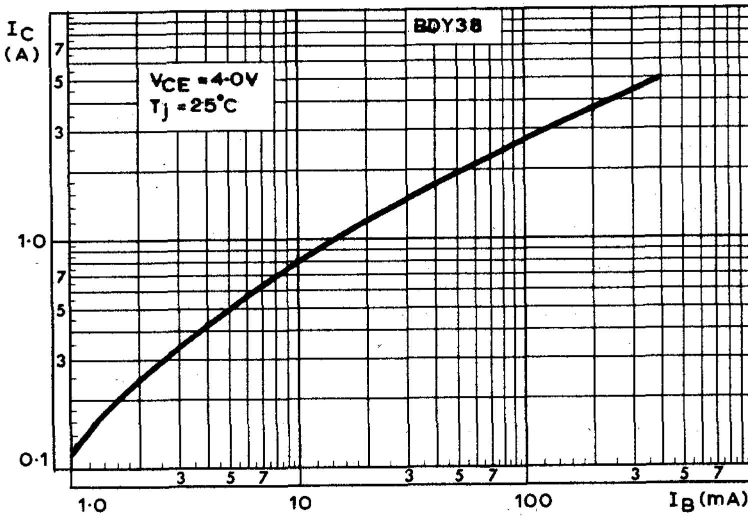
BDY38
2-BDY38



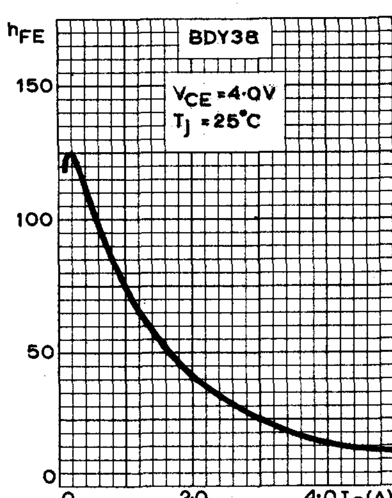
TYPICAL OUTPUT CHARACTERISTICS

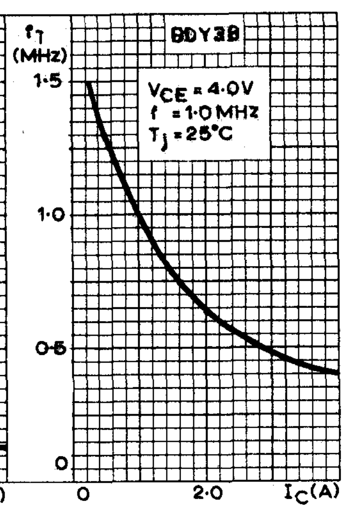


TYPICAL MUTUAL CHARACTERISTIC



TYPICAL TRANSFER CHARACTERISTIC





TYPICAL VARIATION OF STATIC FORWARD CURRENT TRANSFER RATIO AND TRANSITION FREQUENCY WITH COLLECTOR CURRENT

N-P-N SILICON HIGH-POWER TRANSISTORS

BDY90 BDY91 BDY92

N-P-N silicon high-power transistors in metal envelopes for use in converters, inverters, switching regulators and switching control amplifiers.

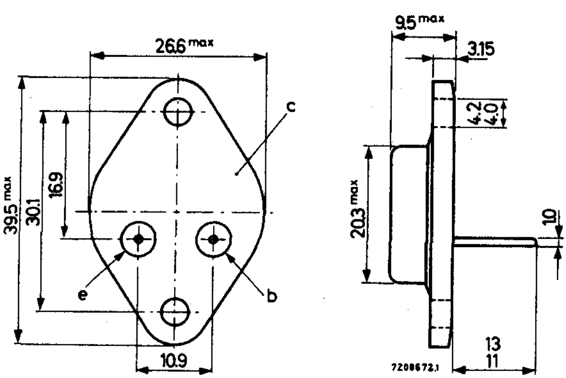
QUICK REFERENCE DATA

	BDY90	BDY91	BDY92	
V_{CBO} max.	120	100	80	V
V_{CEO} max.	100	80	60	V
I_{CM} max.	15	15	15	A
P_{tot} max. ($T_{mb} \leq 75^{o}C$)	40	40	40	W
$V_{CE(sat)}$ max. ($I_C = 10A$, $I_B = 1A$)	1.5	1.5	1.0	V
t_f max. ($I_C = 5A$, $I_{B(on)} = -I_{B(off)} = 0.5A$, $V_{CC} = 30V$)	0.2	0.2	0.2	μs
f_T typ. ($I_C = 0.5A$, $V_{CE} = 5V$, $f = 5MHz$)	70	70	70	MHz

Unless otherwise stated data are applicable to all types

OUTLINE AND DIMENSIONS

Conforms to BS 3934 SO-5A/SB2-2
J.E.D.E.C. TO-3



All dimensions in mm
Collector electrically connected to case

Accessories available: 56201A (insulating bush), 56201B (mica washer), 56214 (lead washer)

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical	BDY90	BDY91	BDY92	
V_{CBO} max.	120	100	80	V
V_{CEX} max. (V_{EB}=1.5V)	120	100	80	V
V_{CEO} max.	100	80	60	V
V_{EBO} max.	6.0	6.0	6.0	V
I_C max.		10		A
I_{CM} max.		15		A
I_B max.		2.0		A
I_{BM} max.		3.0		A
$-I_E$ max.		11		A
$-I_{EM}$ max.		15		A
P_{tot} max. ($T_{mb} \leq 75^oC$)		40		W
Temperature				
T_{stg}		-65 to +175		^oC
T_j max.		175		^oC

THERMAL CHARACTERISTIC

$R_{th(j-mb)}$	2.5	degC/W

ELECTRICAL CHARACTERISTICS ($T_j = 25^oC$ unless otherwise stated)

			Min.	Typ.	Max.	
I_{CEX}	Collector cut-off current, $T_{mb} = 150^oC$ V_{EB}=1.5V, $V_{CE} = V_{CEX}$ max.		-	-	3.0	mA
$V_{CE(sat)}$	Collector-emitter saturation voltage					
	I_C=5.0A, I_B=0.5A		-	-	0.5	V
	I_C=10A, I_B=1.0A	BDY90, 91	-	-	1.5	V
		BDY92	-	-	1.0	V
$V_{BE(sat)}$	Base-emitter saturation voltage					
	I_C=5.0A, I_B=0.5A		-	-	1.2	V
	I_C=10A, I_B=1.0A		-	-	1.5	V
h_{FE}	Static forward current transfer ratio					
	I_C=1.0A, V_{CE}=2.0V		35	-	-	
	I_C=5.0A, V_{CE}=5.0V		30	-	120	
	I_C=10A, V_{CE}=5.0V		20	-	-	
f_T	Transition frequency					
	I_C=0.5A, V_{CE}=5.0V, f=5.0MHz		-	70	-	MHz

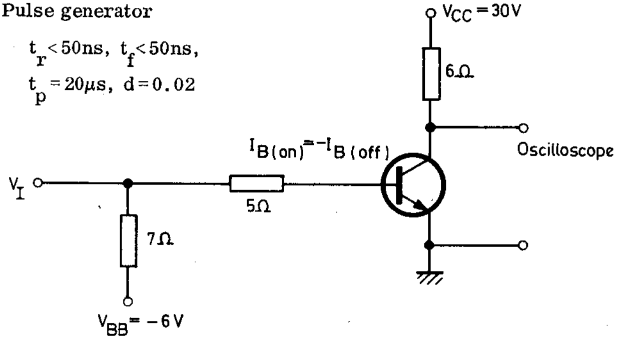
ELECTRICAL CHARACTERISTICS (contd.)

		Min.	Typ.	Max.	
Switching characteristics (see test circuit and waveforms)					
$I_C = 5.0A$, $I_{B(on)} = -I_{B(off)} = 0.5A$, $V_{CC} = 30V$					
t_{on}	Turn-on time	-	-	0.35	μs
t_s	Storage time	-	-	1.3	μs
t_f	Fall time	-	-	0.2	μs

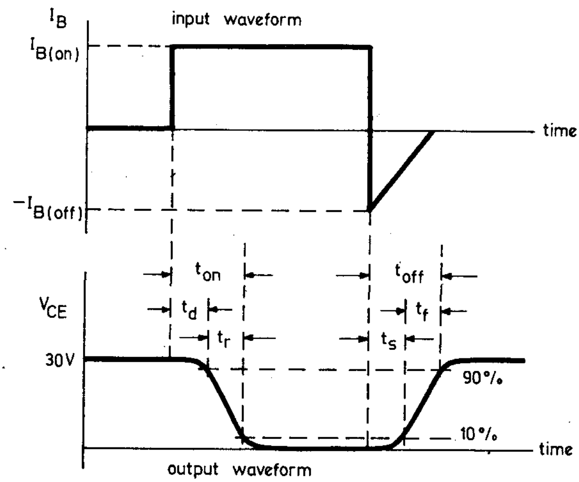
Test circuit

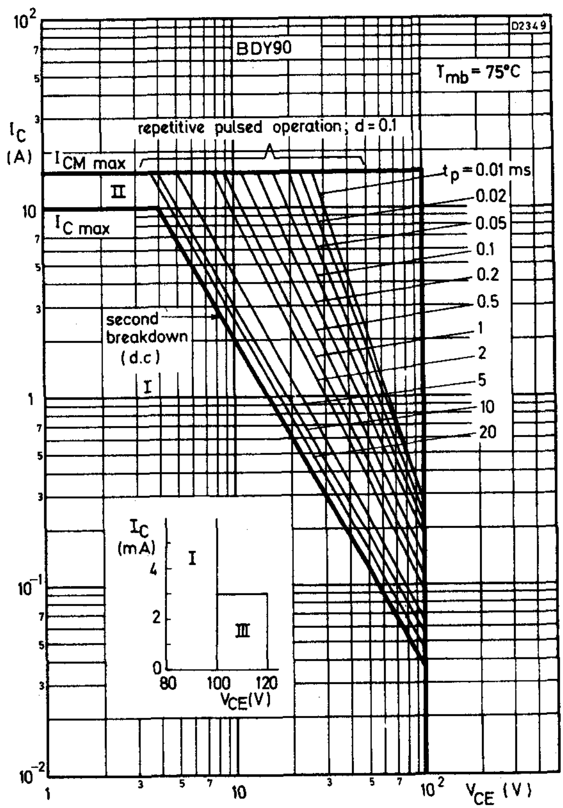
Pulse generator

$t_r < 50ns$, $t_f < 50ns$,
$t_p = 20\mu s$, $d = 0.02$



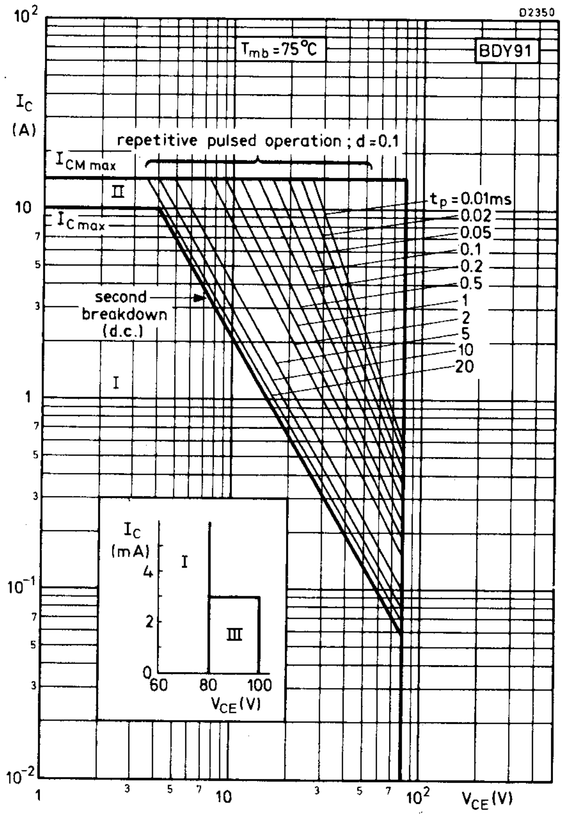
Waveforms





SAFE OPERATING AREAS (Regions I and II, forward biased)

I   Region of permissible d.c. operation
II   Permissible extension for repetitive pulsed operation
III   Repetitive pulsed operation in this region is allowable, provided $-V_{BE} \geq 1.5V$



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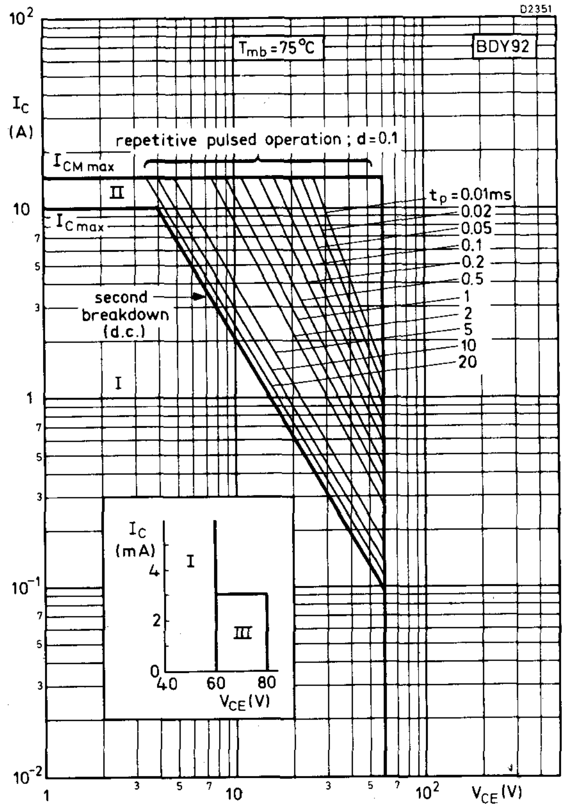

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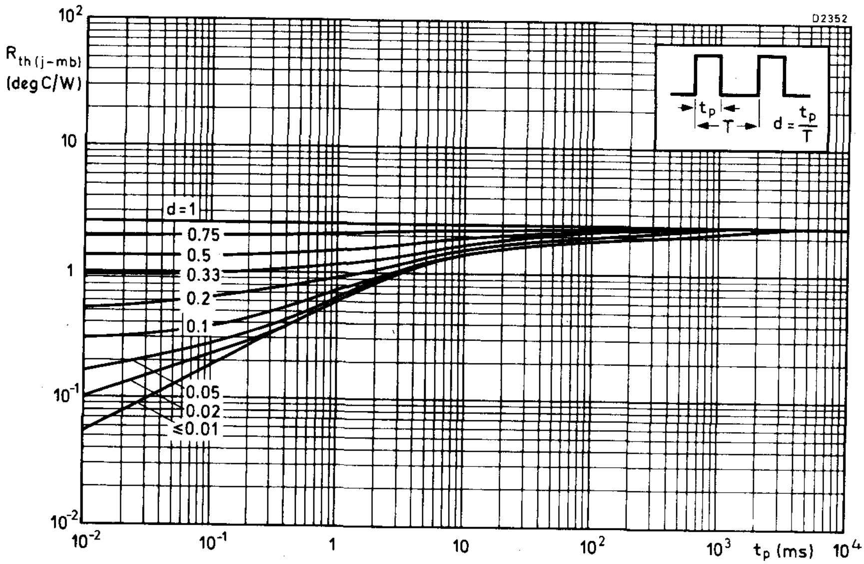
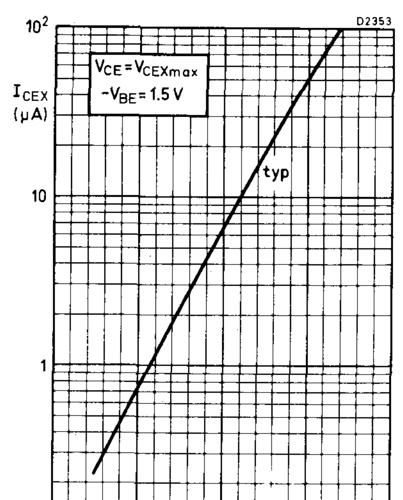
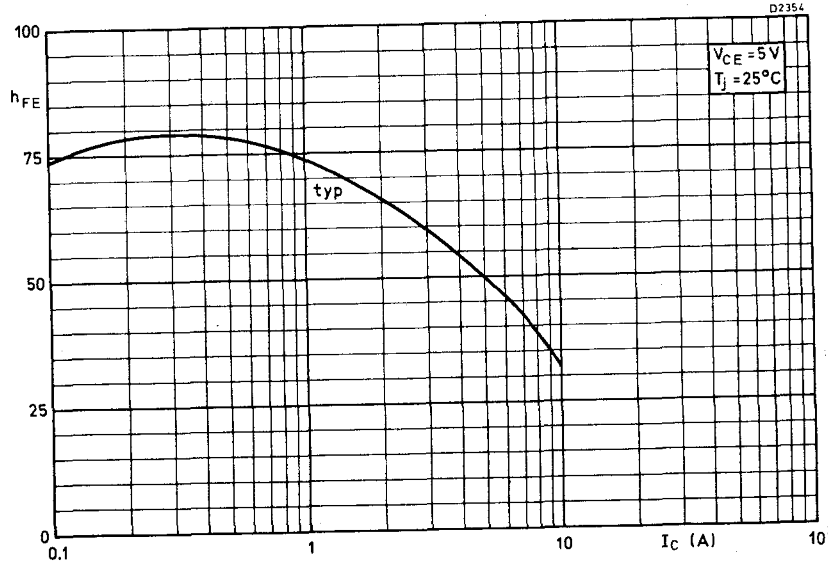
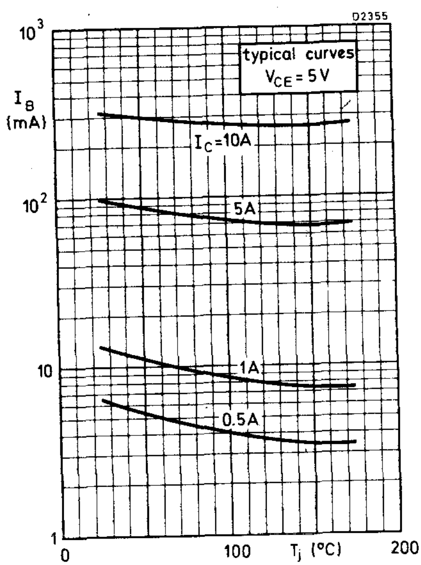
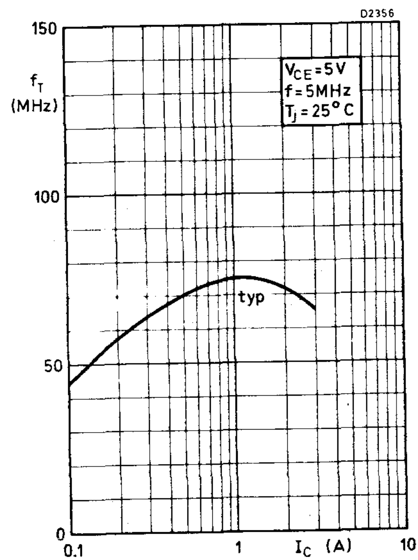
N-P-N SILICON HIGH-POWER TRANSISTORS





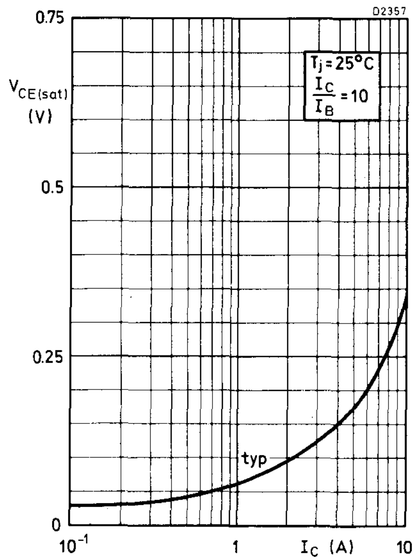

D2354
100
75
50
25
0
h_{FE}
V_{CE} = 5 V
T_j = 25°C
typ
0.1
1
10
I_C (A)
10^2

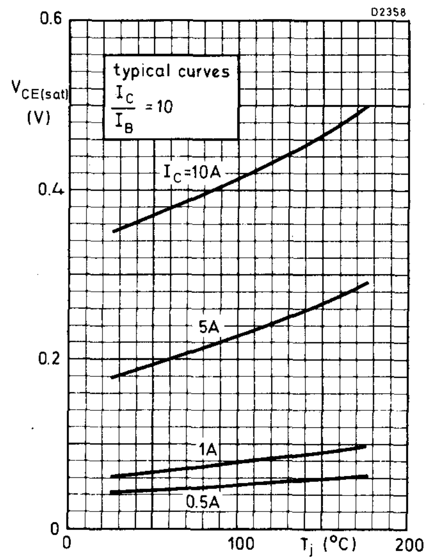

D2355
10^3
10^2
10
1
I_B (mA)
typical curves
V_{CE} = 5 V
I_C=10A
5A
1A
0.5A
0
100
T_j (°C)
200

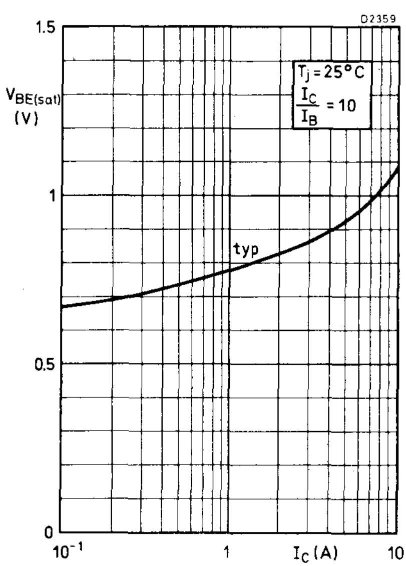

D2356
150
100
50
0
f_T (MHz)
V_{CE}=5 V
f=5 MHz
T_j=25° C
typ
0.1
1
I_C (A)
10

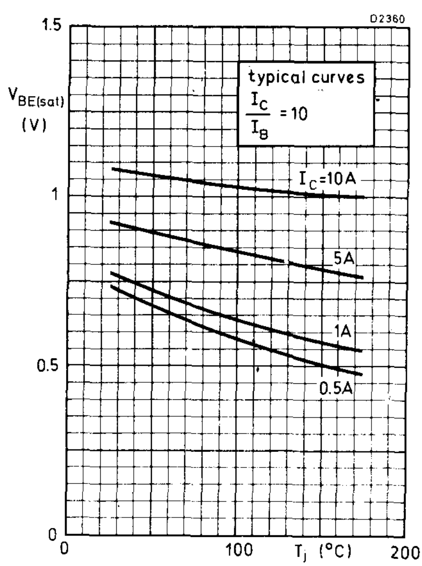
N-P-N SILICON HIGH-POWER TRANSISTORS

BDY90 BDY91 BDY92









N-P-N SILICON HIGH VOLTAGE POWER TRANSISTORS

BDY93 BDY94 BDY95

High voltage n-p-n silicon power transistors intended for use in converters, inverters, switching regulators and motor control systems.

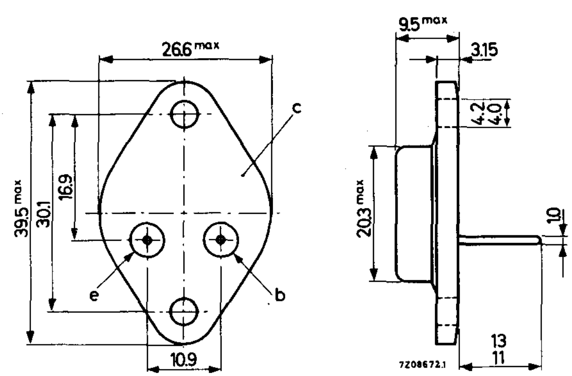
QUICK REFERENCE DATA

	BDY93	BDY94	BDY95	
V_{CESM} max.	750	750	600	V
V_{CEO} max.	350	300	250	V
I_{CM} max.	6.0	6.0	6.0	A
P_{tot} max. ($T_{mb} \leq 50^{o}C$)	30	30	30	W
$V_{CE(sat)}$ max. ($I_C = 2.5A$, $I_B = 0.5A$)	1.5	1.5	1.5	V
t_f typ. ($I_C = 2.5A$, $I_{B(on)} = -I_{B(off)} = 0.5A$, $V_{CC} = 125V$)	0.4	0.5	0.5	μs

Unless otherwise stated data are applicable to all types

OUTLINE AND DIMENSIONS

Conforms to BS3934 SO - 5A/SB2 - 2
J.E.D E.C. TO - 3



All dimensions in mm
Collector connected to case

Accessories available: 56201A (insulating bush), 56201B (mica washer), 56214 (lead washer).

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

		BDY93	BDY94	BDY95	
V_{CESM} max.		750	750	600	V
V_{CEXM} max.	$(-V_{BE} = 1.5V)$	750	750	600	V
V_{CEO} max.		350	300	250	V
I_C max.			3.0		A
I_{CM} max.			6.0		A
$-I_{CM}$ max.			3.0		A
I_B max.			2.0		A
I_{BM} max.			2.0		A
$-I_{B(AV)}$ max.	(reverse d.c. or averaged over any 20ms period)		100		mA
$-I_{BM}$ max.	(peak reverse value, turn-off current)		1.5		A
P_{tot} max.	$(T_{mb} \leq 50^{o}C)$		30		W

Temperature

T_{stg}	-65 to +125	^{o}C
T_j max.	125	^{o}C

THERMAL CHARACTERISTICS

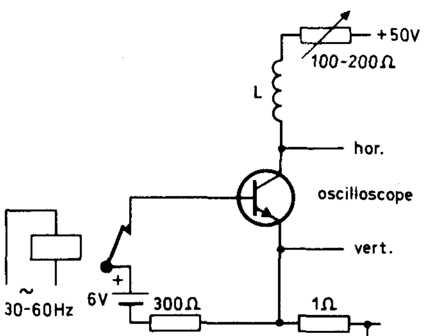
$R_{th(j-mb)}$		2.5	$^{o}C/W$
$R_{th(mb-h)}$	(with mica washer 56201B and lead washer 56214)	0.75	$^{o}C/W$
$R_{th(mb-h)}$	(with lead washer 56214 only)	0.5	$^{o}C/W$

N-P-N SILICON
HIGH VOLTAGE POWER TRANSISTORS

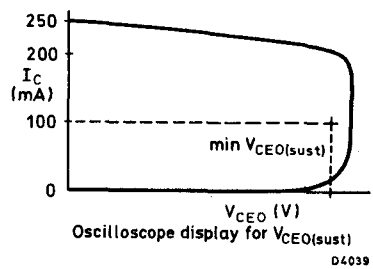
BDY93
BDY94
BDY95

ELECTRICAL CHARACTERISTICS (T_j = 25°C unless otherwise stated)

			Min.	Typ.	Max.	
I_{CES}	*Collector cut-off current					
	V_{CESM} = max., V_{BE} = 0		-	-	0.5	mA
	V_{CESM} = max., V_{BE} = 0, T_{mb} = 125°C		-	-	2.0	mA
I_{EBO}	Emitter cut-off current					
	I_C = 0, V_{EB} = 6.0V		-	-	5.0	mA
$V_{CEO(sust)}$	Collector-emitter sustaining voltage					
	I_B = 0, I_C = 100mA, L = 25mH	BDY93	350	-	-	V
		BDY94	300	-	-	V
		BDY95	250	-	-	V



Test circuit for $V_{CEO(sust)}$



Oscilloscope display for $V_{CEO(sust)}$

			Min.	Typ.	Max.	
$V_{CE(sat)}$	Collector-emitter saturation voltage					
	I_C = 1.0A, I_B = 0.1A		-	-	1.0	V
	I_C = 2.5A, I_B = 0.5A		-	-	1.5	V
$V_{BE(sat)}$	Base-emitter saturation voltage					
	I_C = 2.5A, I_B = 0.5A		-	-	1.5	V
h_{FE}	Static forward current transfer ratio					
	I_C = 3.0A, V_{CE} = 5.0V		5	-	-	
	I_C = 1.0A, V_{CE} = 5.0V	BDY93	15	-	60	
		BDY94	25	-	80	
		BDY95	25	-	80	

*Measured with a half sine wave voltage (curve tracer)

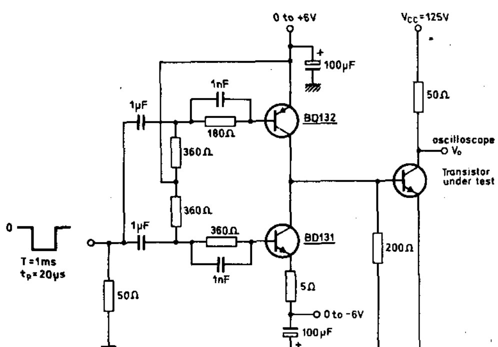
ELECTRICAL CHARACTERISTICS (contd)

			Min.	Typ.	Max.	
f_T	Transition frequency $I_C = 0.2A,\ V_{CE} = 10V,\ f = 1.0MHz$		-	8.0	-	MHz
C_{Tc}	Collector capacitance $I_E = I_e = 0,\ V_{CB} = 10V,\ f = 1.0MHz$		-	85	-	pF
C_{Te}	Emitter capacitance $I_C = I_c = 0,\ V_{EB} = 2.0V,\ f = 1.0MHz$		-	1.4	-	nF

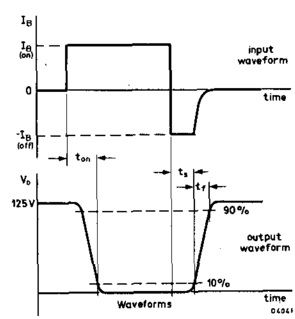
Switching characteristics

$I_C = 2.5A,\ I_{B(on)} = -I_{B(off)} = 0.5A,\ V_{CC} = 125V$

			Min.	Typ.	Max.	
t_{on}	Turn-on time		-	0.25	0.5	µs
t_s	Storage time	BDY93	-	2.0	3.0	µs
		BDY94,95	-	2.0	3.5	µs
t_f	Fall time	BDY93	-	0.4	0.6	µs
		BDY94,95	-	0.5	1.0	µs
t_f	Fall time at $T_{mb} = 95^{\circ}C$	BDY93	-	-	1.2	µs
		BDY94,95	-	-	2.0	µs

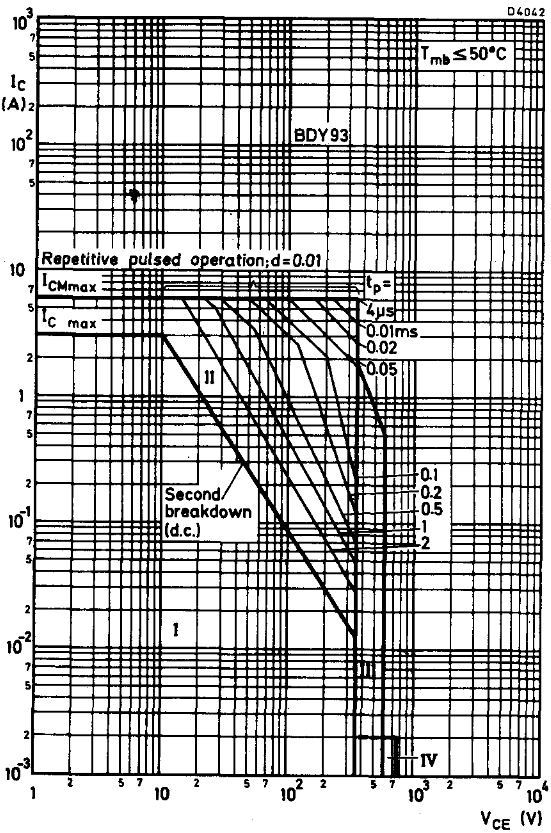


Test circuit



Waveforms

N-P-N SILICON HIGH VOLTAGE POWER TRANSISTORS



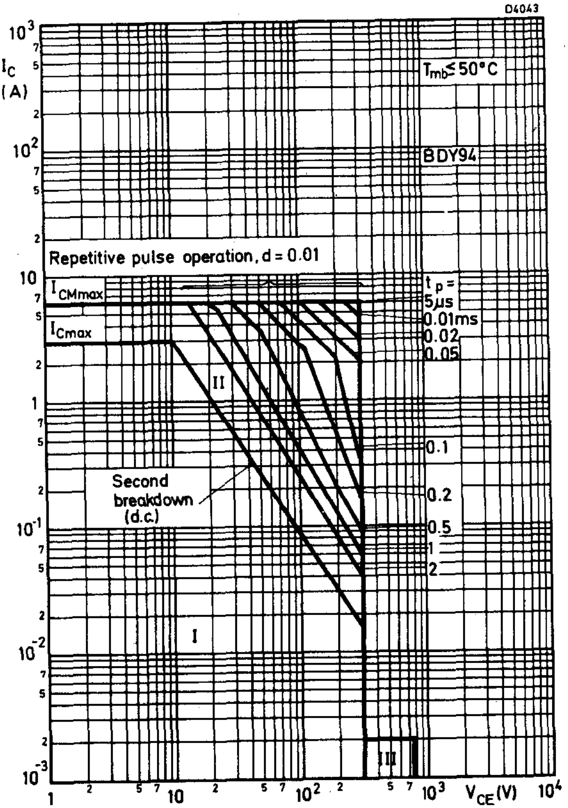
SAFE OPERATING AREAS (REGIONS I, II, AND III FORWARD BIASED)

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation.

III Area of permissible operation during turn-on in single- transistor converters, provided $t_p \leq 0.6\mu s$ and $R_{BE} \leq 100\Omega$.

IV Repetitive pulse operation in this region is allowable, provided $V_{BE} \leq 0$ and $t_p \leq 2ms$.



SAFE OPERATION AREAS (REGIONS I AND II FORWARD BIASED)

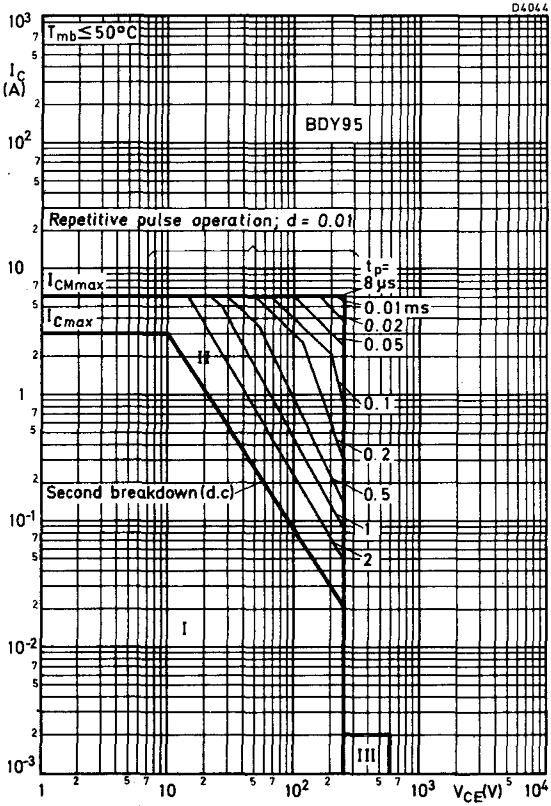
I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

III Repetitive pulse operation in this region is allowable, provided $V_{BE} \leq 0$ and $t_p \leq 2ms$.

N-P-N SILICON
HIGH VOLTAGE POWER TRANSISTORS

BDY93
BDY94
BDY95

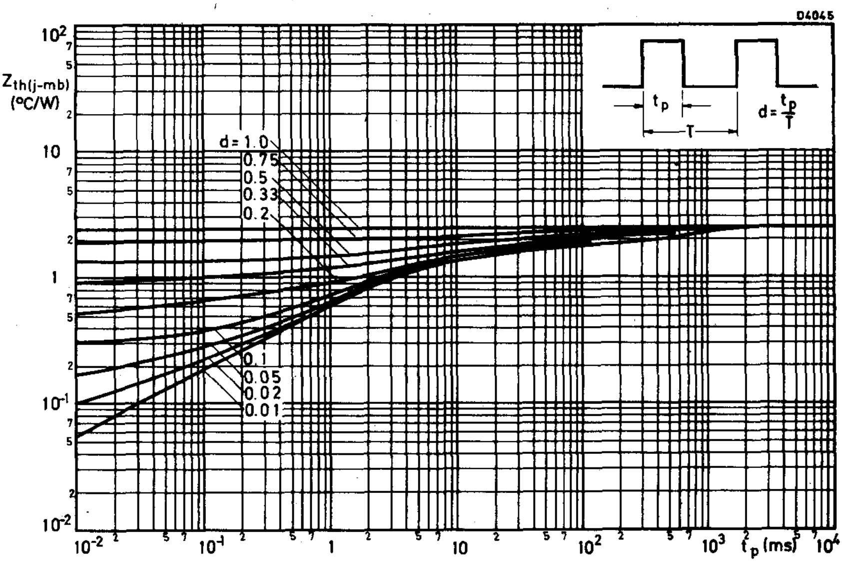


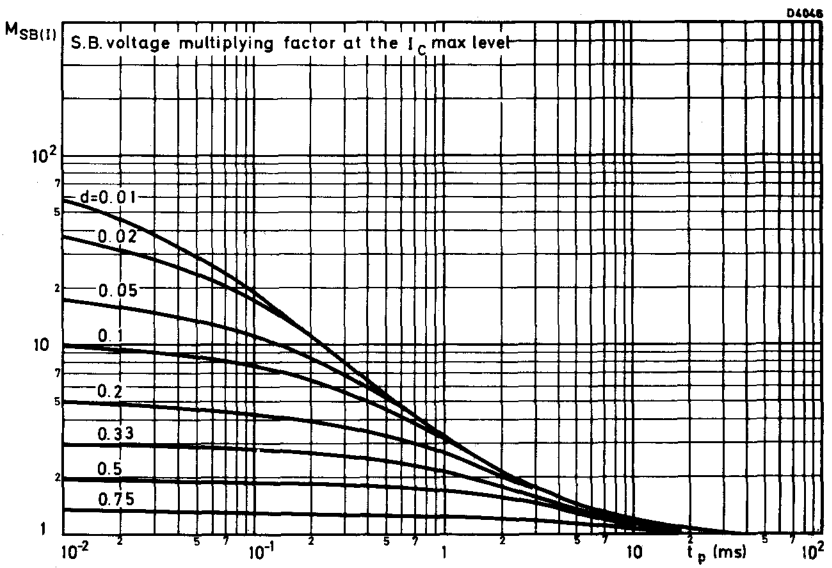
SAFE OPERATING AREAS (REGIONS I AND II FORWARD BIASED)

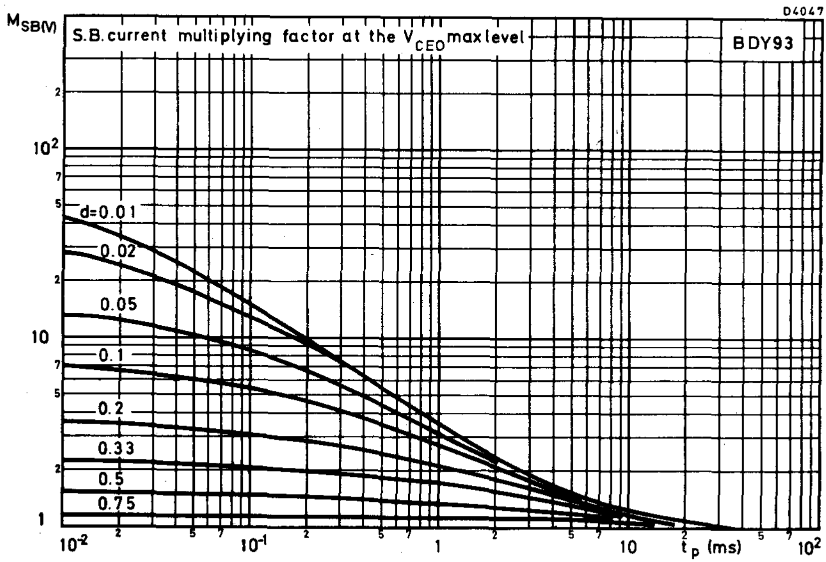
I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

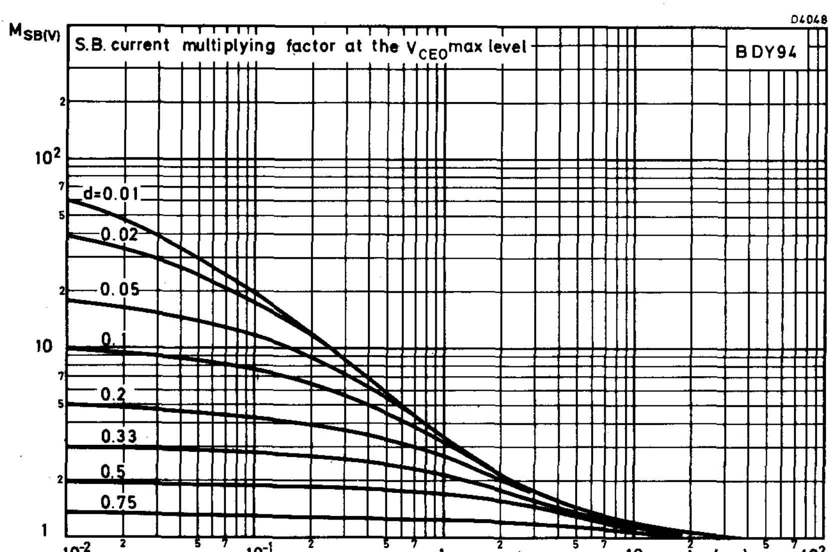
III Repetitive pulse operation in this region is allowable, provided $V_{BE} \leq 0$ and $t_p \leq 2ms$.


D4045
$Z_{th(j-mb)}$ (°C/W)
d = 1.0
0.75
0.5
0.33
0.2
0.1
0.05
0.02
0.01
t_p
T
$d = \frac{t_p}{T}$
t_p (ms)

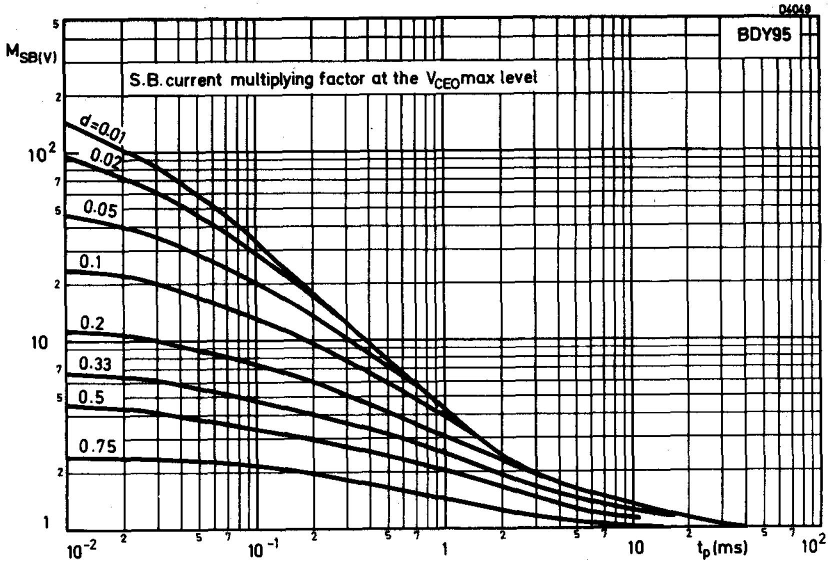

D4046
$M_{SB(I)}$
S.B. voltage multiplying factor at the I_C max level
d=0.01
0.02
0.05
0.1
0.2
0.33
0.5
0.75
t_p (ms)

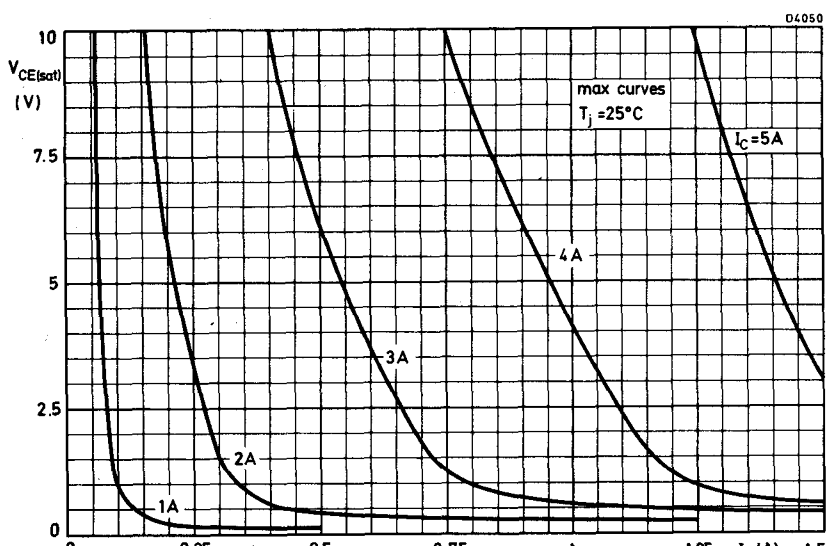


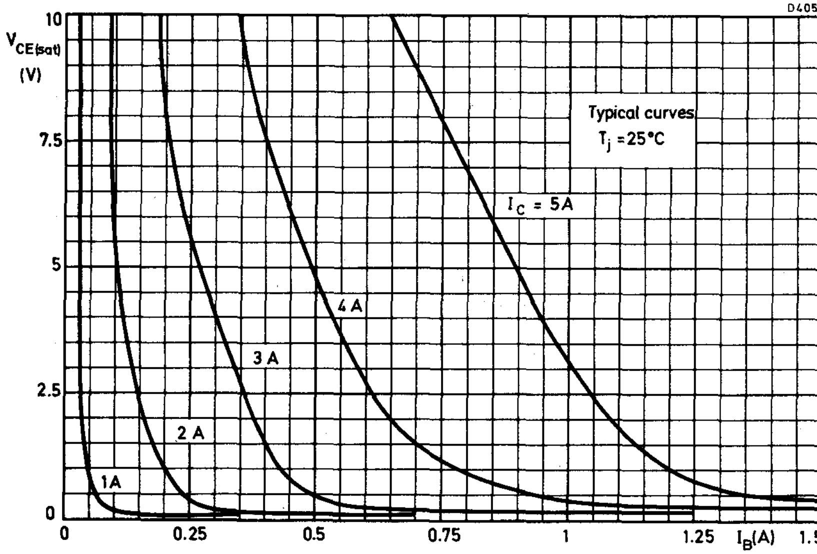
D4047
$M_{SB(V)}$
S.B. current multiplying factor at the V_{CEO}max level
BDY93
d=0.01
0.02
0.05
0.1
0.2
0.33
0.5
0.75
t_p (ms)



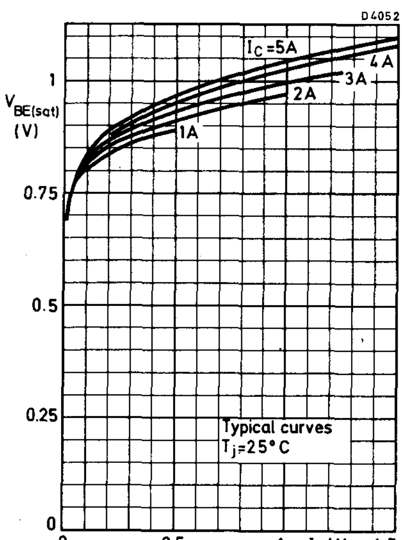
D4048
$M_{SB(V)}$
S.B. current multiplying factor at the V_{CEO}max level
BDY94
d=0.01
0.02
0.05
0.1
0.2
0.33
0.5
0.75
t_p (ms)


D4049
BDY95
$M_{SB(V)}$
S.B. current multiplying factor at the V_{CEO}max level
d=0.01
0.02
0.05
0.1
0.2
0.33
0.5
0.75
10^2
10
1
10^{-2}
10^{-1}
1
10
t_p(ms)
10^2

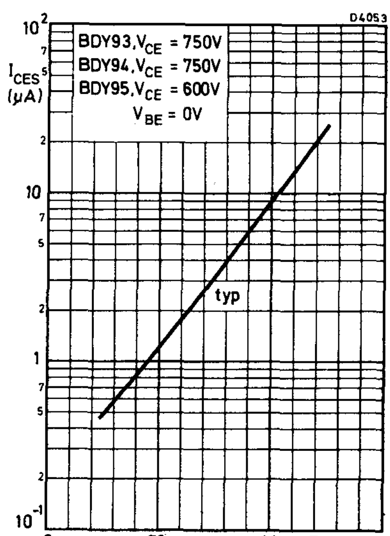

D4050
$V_{CE(sat)}$
(V)
10
7.5
5
2.5
0
max curves
T_j =25°C
I_C=5A
4A
3A
2A
1A
0
0.25
0.5
0.75
1
1.25
I_B(A)
1.5



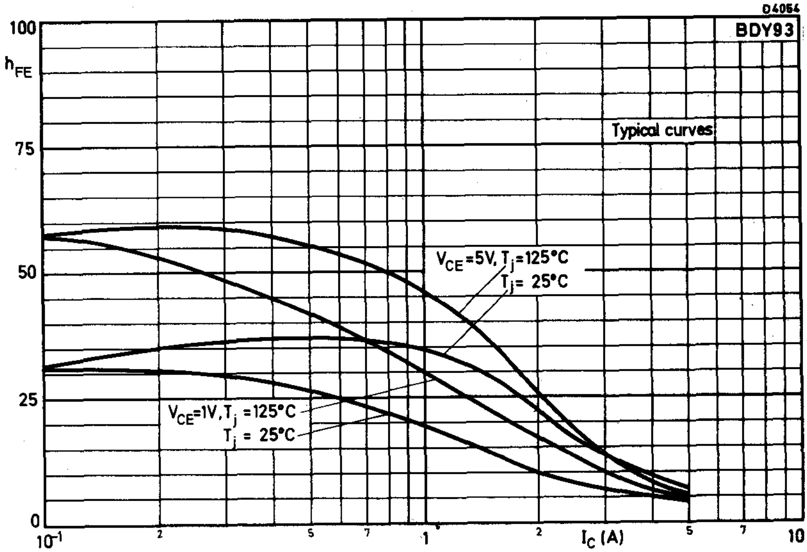
D4051
$V_{CE(sat)}$ (V)
10
7.5
5
2.5
0
Typical curves
T_j = 25°C
I_C = 5A
4 A
3 A
2 A
1A
0
0.25
0.5
0.75
1
1.25
I_B(A)
1.5

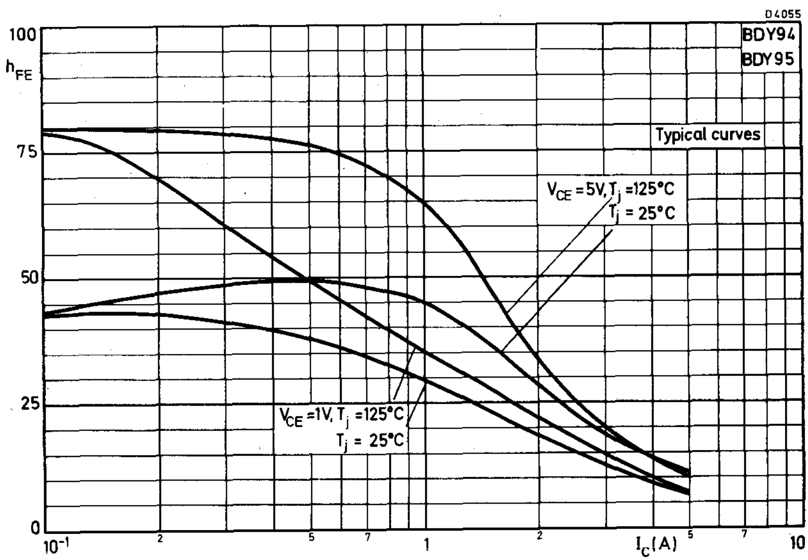


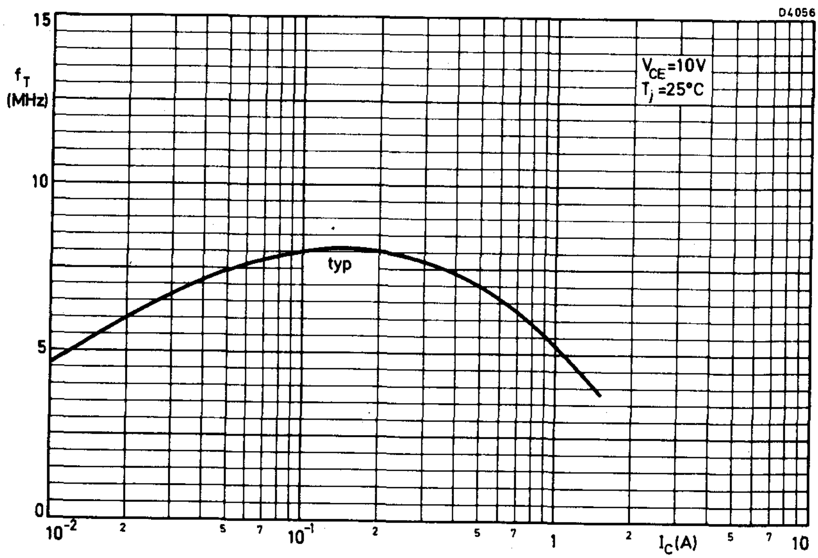
D4052
$V_{BE(sat)}$ (V)
1
0.75
0.5
0.25
0
I_C =5A
4 A
3A
2A
1A
Typical curves
T_j=25°C
0
0.5
1
I_B(A)
1.5



D4053
I_{CES} (μA)
10^2
10
1
10^{-1}
BDY93, V_{CE} = 750V
BDY94, V_{CE} = 750V
BDY95, V_{CE} = 600V
V_{BE} = 0V
typ
0
50
100
T_j(°C)
150


D4064
BDY93
100
h_{FE}
75
50
25
0
Typical curves
V_{CE}=5V, T_j=125°C
T_j= 25°C
V_{CE}=1V, T_j =125°C
T_j = 25°C
10^{-1}
2
5
7
1
2
I_C (A)
5
7
10


D4055
BDY94
BDY95
100
h_{FE}
75
50
25
0
Typical curves
V_{CE} =5V, T_j =125°C
T_j = 25°C
V_{CE} =1V, T_j =125°C
T_j = 25°C
10^{-1}
2
5
7
1
2
I_C(A)
5
7
10


D4056
f_T (MHz)
15
10
5
0
V_{CE}=10V
T_j=25°C
typ
10^{-2}
2
5
7
10^{-1}
2
5
7
1
2
I_C(A)
5
7
10

N-P-N SILICON HIGH VOLTAGE POWER TRANSISTORS

BDY96 BDY97 BDY98

High voltage n-p-n power transistors in a TO-3 envelope, intended for use in converters, inverters, switching regulators and motor control systems.

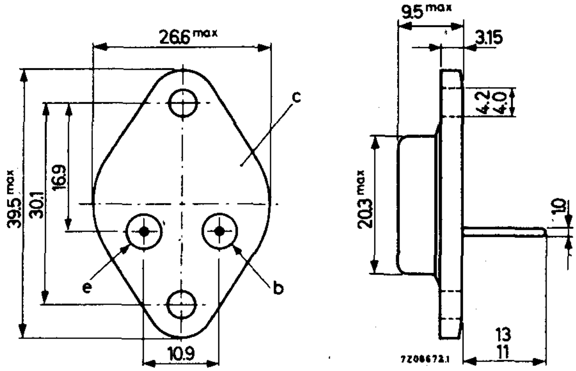
QUICK REFERENCE DATA

			BDY 96	BDY 97	BDY 98	
Collector-emitter voltage (V_{BE} = 0)	V_{CESM}	max.	750	750	600	V
Collector-emitter voltage (open base)	V_{CEO}	max.	350	300	250	V
Collector current (d.c.)	I_C	max.	10	10	10	A
Collector current (peak value)	I_{CM}	max.	15	15	15	A
Total power dissipation up to T_{mb} = 65 °C	P_{tot}	max.	40	40	40	W
Collector-emitter saturation voltage I_C = 5 A; I_B = 1 A	V_{CEsat}	<	1	1,5	1,5	V
Fall time I_C = 5 A; I_{B1} = $-I_{B2}$ = 1 A; V_{CC} = 250 V	t_f	typ.	0,3	0,5	0,5	μs

MECHANICAL DATA Dimensions in mm

TO-3

Collector connected to case



Accessories available: 56201A (insulating bush), 56201B (mica washer), 56214 (lead washer).

RATINGS Limiting values in accordance with the Absolute Maximum System

			BDY 96	BDY 97	BDY 98	
Voltage						
Collector-emitter voltage (V_{BE} = 0) peak value	V_{CESM}	max.	750	750	600	V
Collector-emitter voltage (open base)	V_{CEO}	max.	350	300	250	V
Current						
Collector current (d.c.)	I_C	max.		10		A
Collector current (peak value; $t_p \leq$ 1 ms)	I_{CM}	max.		15		A
Base current (d.c.)	I_B	max.		4		A
Base current (peak value; $t_p \leq$ 1 ms)	I_{BM}	max.		6		A
Reverse base current (d.c. or average over any 20 ms period)	$-I_{B(AV)}$	max.		100		mA
Reverse base current(peak value) [1])	$-I_{BM}$	max.		4		A
Power dissipation						
Total power dissipation up to T_{mb} = 65 °C	P_{tot}	max.		40		W
Temperature						
Storage temperature	T_{stg}			−65 to +125		°C
Junction temperature	T_j	max.		125		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,5	°C/W
From mounting base to heatsink: with mica washer and lead washer	$R_{th\ mb\text{-}h}$	=	0,75	°C/W
with lead washer only	$R_{th\ mb\text{-}h}$	=	0,5	°C/W

1) Turn-off current

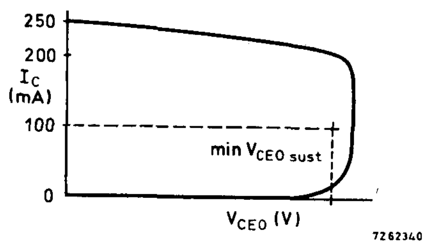
N-P-N SILICON
HIGH VOLTAGE POWER TRANSISTORS

BDY96
BDY97
BDY98

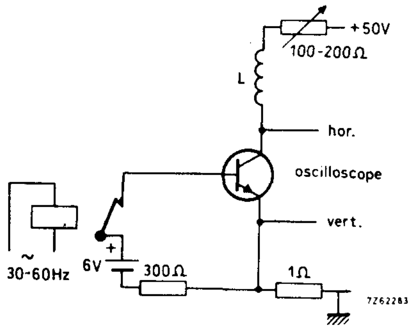
CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			BDY 96	BDY 97	BDY 98	
Collector cut-off current [1]						
V_{CE} = 600 V; V_{BE} = 0	I_{CES}	<	–	–	0,5	mA
V_{CE} = 750 V; V_{BE} = 0	I_{CES}	<	0,5	0,5	–	mA
V_{CE} = 600 V; V_{BE} = 0; T_j = 125 °C	I_{CES}	<	–	–	2	mA
V_{CE} = 750 V; V_{BE} = 0; T_j = 125 °C	I_{CES}	<	2	2	–	mA
Emitter cut-off current						
I_C = 0; V_{EB} = 6 V	I_{EBO}	<	5	5	5	mA
D.C. current gain						
I_C = 2 A; V_{CE} = 5 V	h_{FE}		15 to 60	25 to 80	25 to 80	
Saturation voltage						
I_C = 5 A; I_B = 1 A	V_{CEsat}	<	1	1,5	1,5	V
	V_{BEsat}	<	1,4	1,4	1,4	V
I_C = 10 A; I_B = 3.3 A	V_{CEsat}	<	3	5	5	V
	V_{BEsat}	<	2	2	2	V
Collector-emitter sustaining voltage						
I_C = 100 mA; I_B = 0; L = 25 mH	$V_{CEOsust}$	>	350	300	250	V



Oscilloscope display for $V_{CEOsust}$



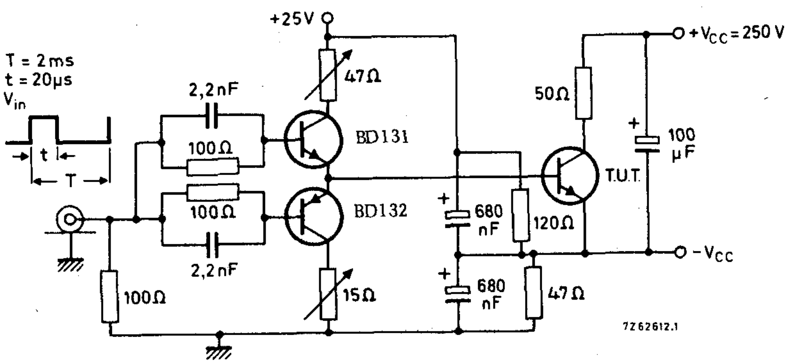
Test circuit for $V_{CEOsust}$

1) Measured with a half sine wave voltage (curve tracer).

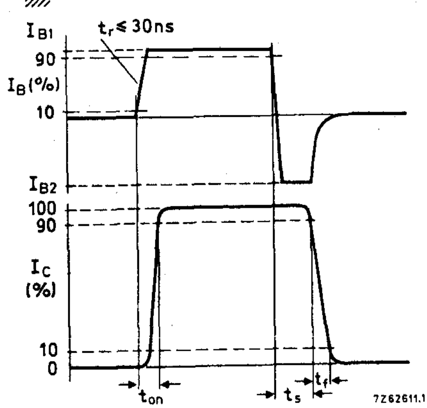
CHARACTERISTICS (continued)

T_j = 25 °C unless otherwise specified

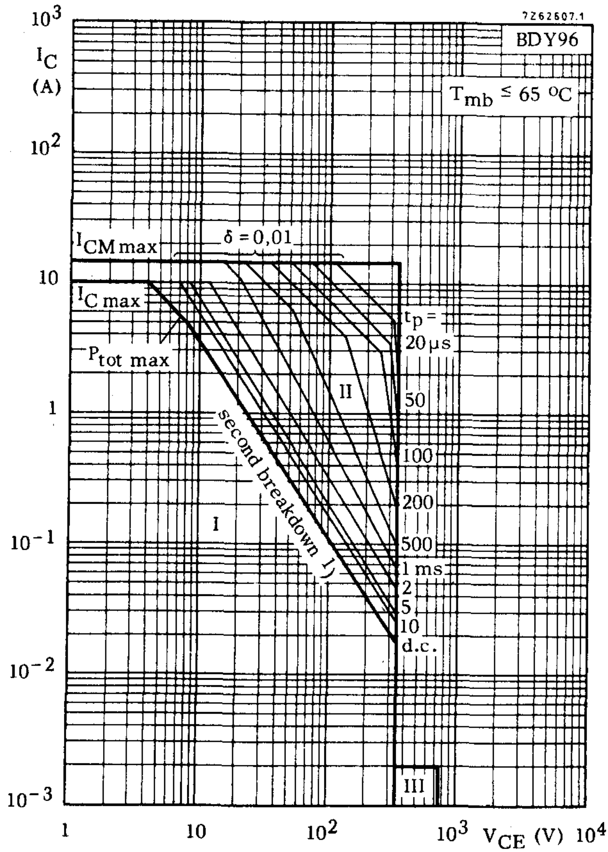
			BDY 96	BDY 97	BDY 98	
Transition frequency at f = 1 MHz						
I_C = 0,2 A; V_{CE} = 10 V	f_T	typ.	10	10	10	MHz
Switching times						
I_C = 5 A; I_{B1} = $-I_{B2}$ = 1 A, V_{CC} = 250 V						
Turn-on time	t_{on}	typ.	0,35	0,35	0,35	μs
		<	0,5	0,5	0,5	μs
Turn-off storage time	t_s	typ.	2,5	3,0	3,0	μs
		<	3,0	4,0	4,0	μs
Turn-off fall time	t_f	typ.	0,3	0,5	0,5	μs
		<	0,4	0,9	0,9	μs
Turn-off fall time, T_{mb} = 95 °C	t_f	<	1	2	2	μs



Test circuit



Waveform



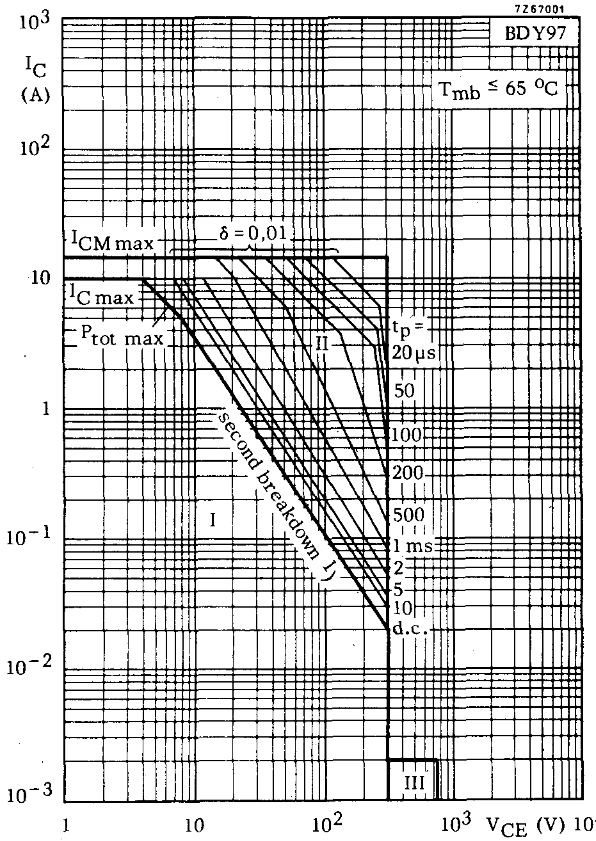
Safe Operating Area with the transistor forward biased (region I + II)

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

III Repetitive pulse operation in this region is allowable provided $V_{BE} \leq 0$ and $t_p \leq 2$ ms

1) Independent of temperature



Safe Operating Area with the transistor forward biased (region I + II)

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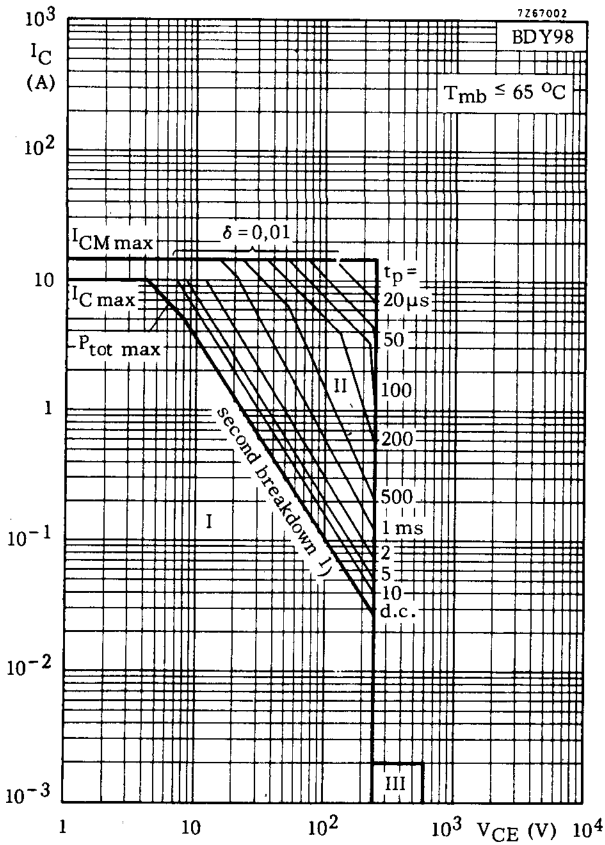
II Permissible extension for repetitive pulse operation

III Repetitive pulse operation in this region is allowable provided $V_{BE} \leq 0$ and $t_p \leq 2$ ms

1) Independent of temperature



Safe Operating Area with the transistor forward biased (region I + II)

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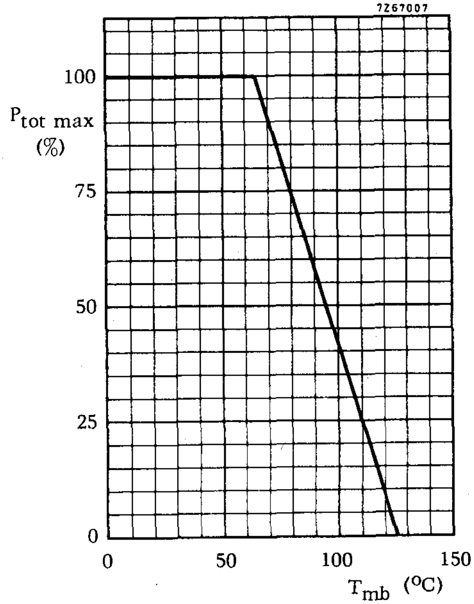
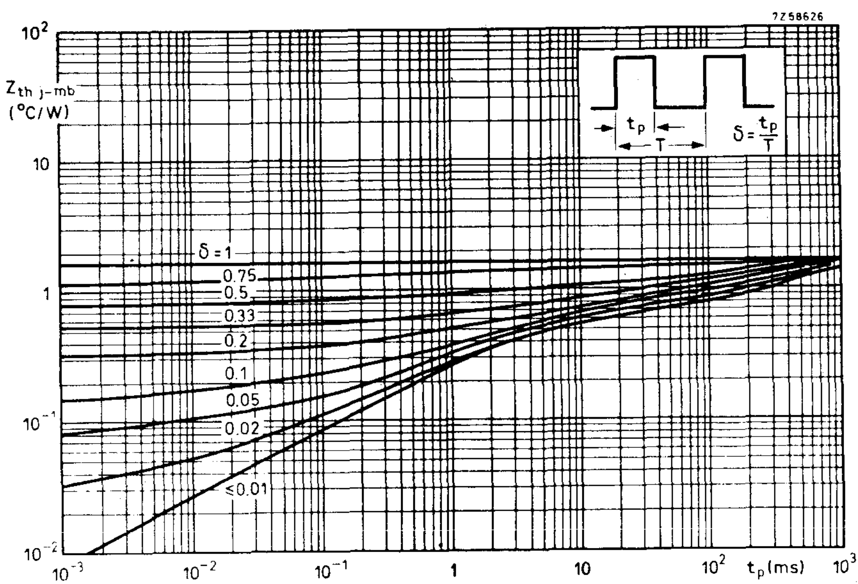
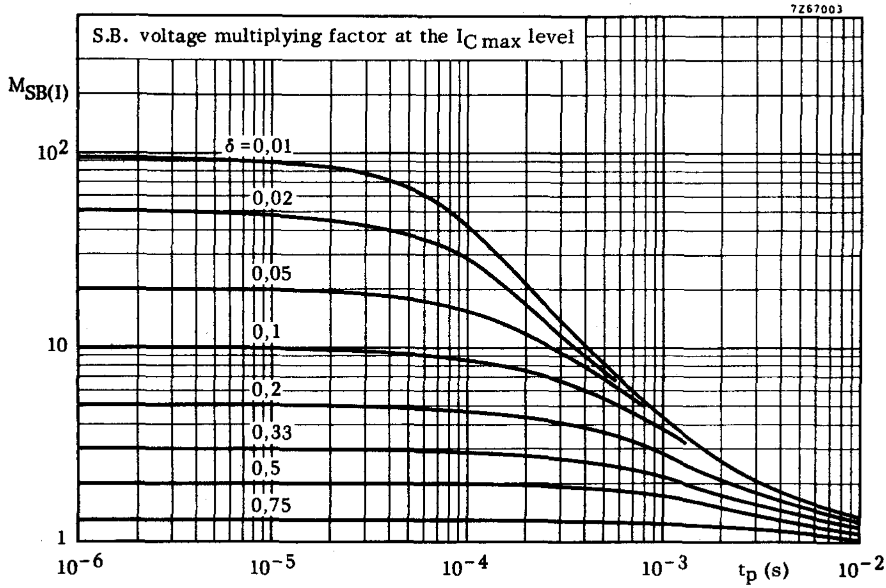
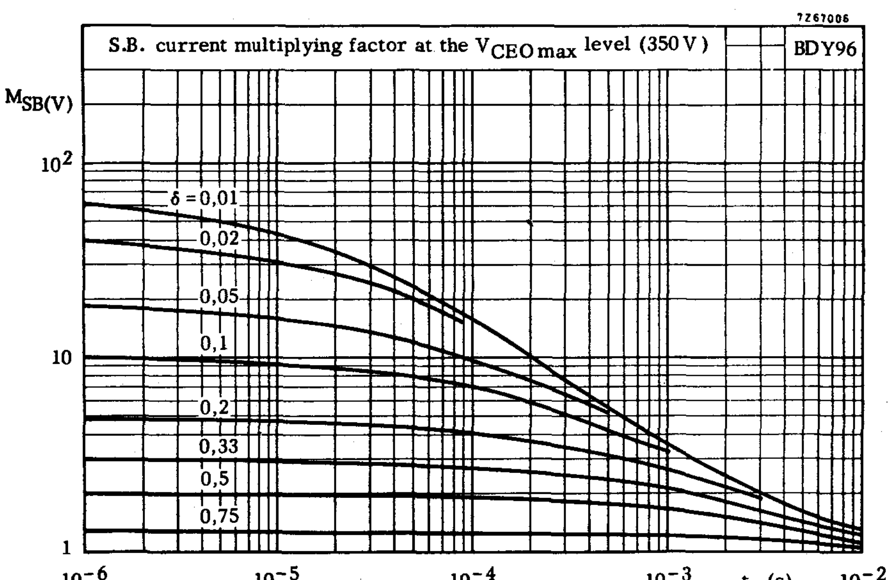
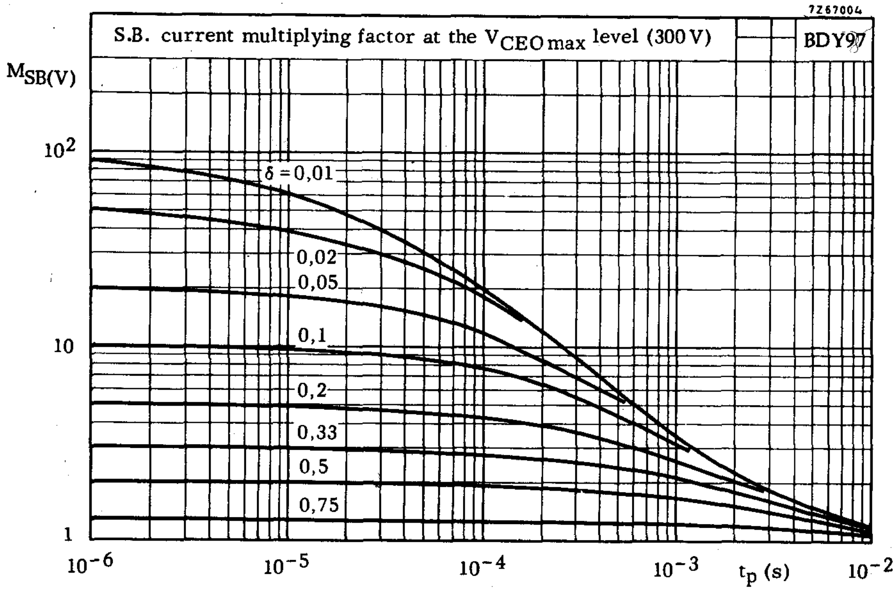

7Z67007
100
$P_{tot\ max}$ (%)
75
50
25
0
0
50
100
150
T_{mb} (°C)

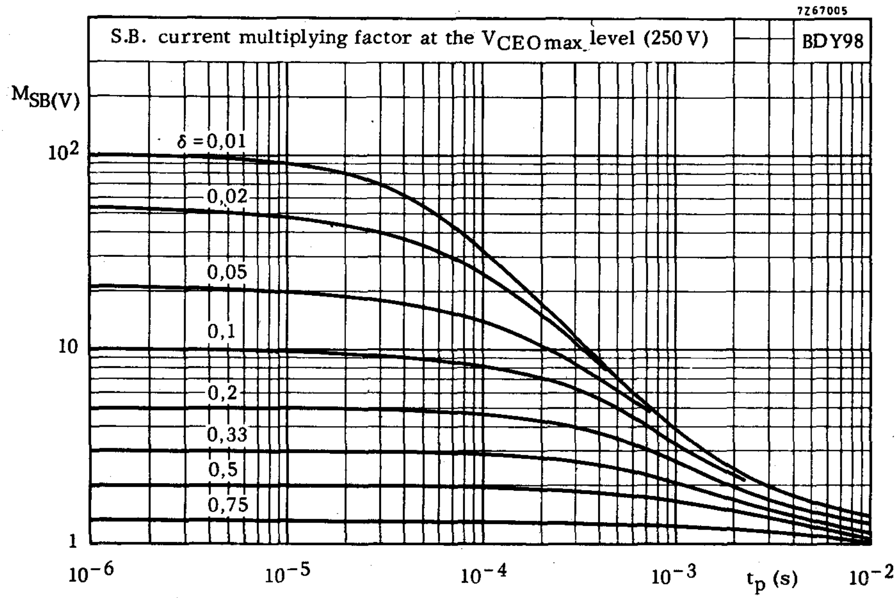

7Z58626
10^2
$Z_{th\ j-mb}$ (°C/W)
10
1
10^{-1}
10^{-2}
δ = 1
0.75
0.5
0.33
0.2
0.1
0.05
0.02
≤0.01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3

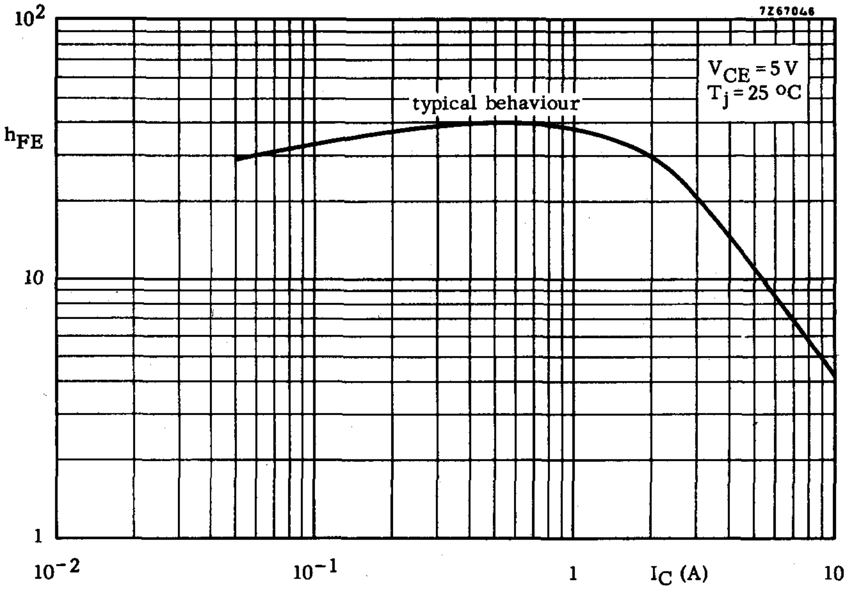
Mullard


7Z67003
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

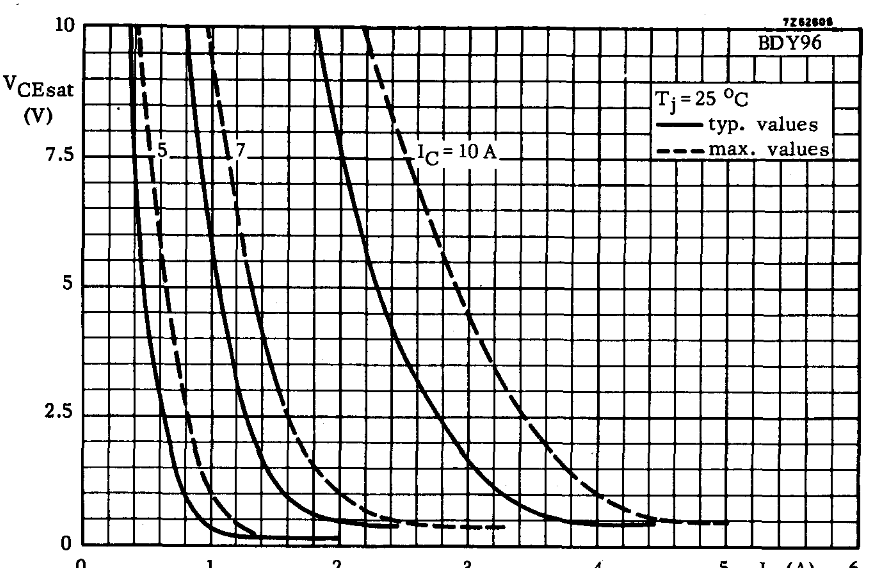

7Z67006
S.B. current multiplying factor at the $V_{CEO\,max}$ level (350 V)
BDY96
$M_{SB(V)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}


7Z67004
S.B. current multiplying factor at the $V_{CEO\,max}$ level (300 V)
BDY97
$M_{SB(V)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

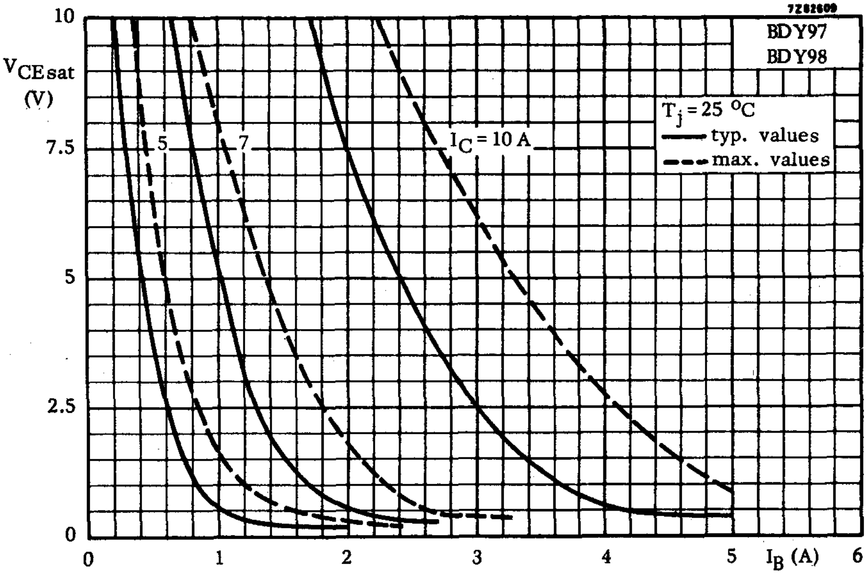

7Z67005
S.B. current multiplying factor at the $V_{CEO\,max}$ level (250 V)
BDY98
$M_{SB(V)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

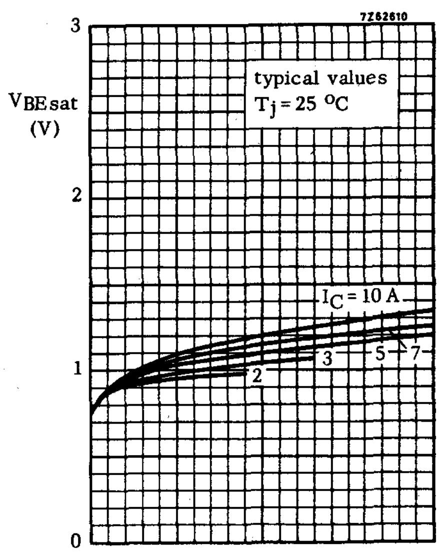


7Z67046
V_{CE} = 5 V
T_j = 25 °C
typical behaviour
h_{FE}
10^2
10
1
10^{-2}
10^{-1}
1
I_C (A)
10



7Z62608
BDY96
T_j = 25 °C
typ. values
max. values
V_{CEsat} (V)
I_C = 10 A
5
7
10
7.5
5
2.5
0
0
1
2
3
4
5
I_B (A)
6


7Z62609
BDY97
BDY98
T_j = 25 °C
typ. values
max. values
V_{CEsat} (V)
10
7.5
5
2.5
0
5
7
I_C = 10 A
0
1
2
3
4
5
I_B (A)
6


7Z62610
typical values
T_j = 25 °C
V_{BEsat} (V)
3
2
1
0
I_C = 10 A
2
3
5
7
0
2
I_B (A)
4

U.H.F. SILICON PLANAR N-P-N TRANSISTOR

BF180

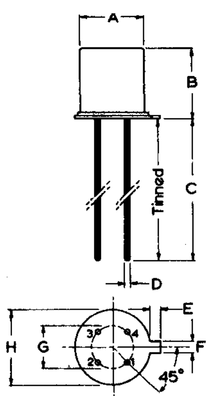
U.H.F. n-p-n silicon planar transistor with forward gain control characteristics, intended for use in the r.f. amplifier stage of television integrated tuners. TO-72 construction with the shield connected to envelope.

QUICK REFERENCE DATA

V_{CBO} max.	30	V
I_C max.	20	mA
P_{tot} max. ($T_{amb}=25^oC$)	150	mW
Max. unilateralised power gain typ.		
f = 200MHz	24	dB
f = 900MHz	12	dB
Noise figure typ.		
f = 200MHz, y_s = optimum	2.5	dB
f = 800MHz, y_s = optimum	5.7	dB

OUTLINE AND DIMENSIONS

Conforms to B.S. 3934 SO-12A/SB4-3
J.E.D.E.C. TO-72



Viewed from underside

	Millimetres		
	Min.	Nom.	Max.
A	-	-	4.8
B	-	-	5.3
C	12.7	-	-
D	-	0.43	-
E	-	1.0	-
F	-	1.05	-
G	-	2.54	-
H	5.3	5.55	5.8

Connections 1. Emitter 3. Collector

2. Base 4. Shield connected to envelope

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

V_{CBO} max.	30	V
V_{CEO} max.	20	V
V_{EBO} max.	3.0	V
I_C max.	20	mA
I_{CM} max.	20	mA
P_{tot} max. ($T_{amb} = 25^oC$)	150	mW

Temperature

T_{stg} min.	-65	^oC
T_{stg} max.	175	^oC
T_j max.	175	^oC

THERMAL CHARACTERISTIC

Θ_{j-amb} 1.0 degC/mW

ELECTRICAL CHARACTERISTICS ($T_{amb} = 25^oC$)

		Typ.	Max.	
I_B	Base current			
	$-I_E = 2.0mA$, $V_{CB} = 10V$	45	150	μA
	$-I_E = 12mA$, $V_{CB} = 7.0V$	-	2.2	mA
$-V_{EB}$	Emitter-base voltage $-I_E = 2.0mA$, $V_{CB} = 10V$	0.75	-	V
$-c_{re}$	Feedback capacitance $I_C = 1.0mA$, $V_{CE} = 10V$, f = 10.7MHz	0.280	-	pF
f_T	Transition frequency $I_C = 2.0mA$, $V_{CE} = 10V$	675	-	MHz

		Min.	Typ.	Max.	
F	*Noise figure				
	$-I_E=2.0mA$, $V_{CB}=10V$, $B_s=0$				
	$f=200MHz$, $G_s=40mmho$	-	4.5	-	dB
	$f=800MHz$, $G_s=10mmho$	-	7.0	9.5	dB
	*Stage gain				
	$-I_E=2.0mA$, $V_{CB}=10V$,				
	$f=200MHz$, $G_s=40mmho$ $B_s=0$, $G_L=1.0mmho$, B_L=tuned	-	16.5	-	dB
	$f=900MHz$, $G_s=20mmho$ $B_s=0$, $G_L=2.0mmho$, B_L=tuned	7.5	9.0	-	dB
	Stage gain control range				
	See graphs on page C4				
G_{UM}	*Max. unilateralised power gain				
	$G_{UM}=10\log\frac{\left|y_{fb}\right|^2}{4g_{ib}.g_{ob}}$				
	$-I_E=2.0mA$, $V_{CB}=10V$				
	$f=50MHz$	32	-	-	dB
	$f=200MHz$	-	24	-	dB
	$f=500MHz$	-	14	-	dB
	$f=900MHz$	-	12	-	dB

*All measurements taken in common base configuration with the metal envelope connected directly to earth and with the external lead length = 1mm.

SOLDERING AND WIRING RECOMMENDATIONS

1. When using a soldering iron, transistors may be soldered directly into the circuit, but heat conducted to the junction should if possible be kept to a minimum by the use of a thermal shunt.

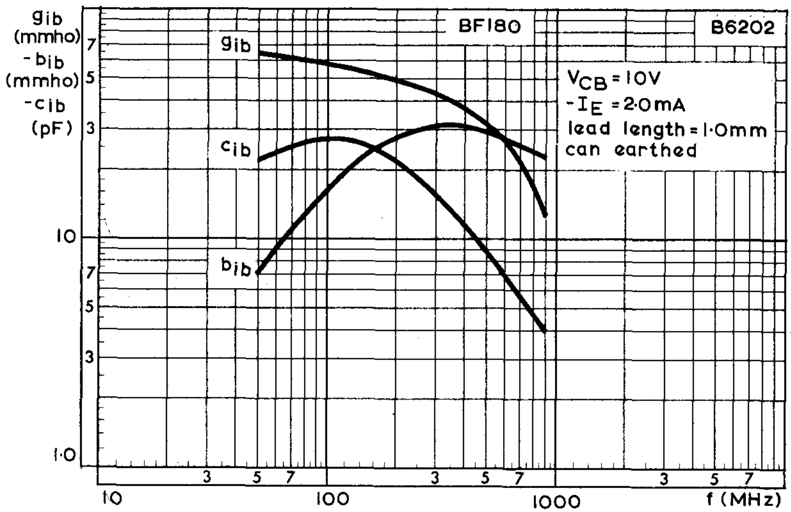
2. Transistors may be dip-soldered at a solder temperature of 245 °C for a maximum soldering time of 5 seconds. The case temperature during soldering must not at any time exceed the maximum storage temperature.

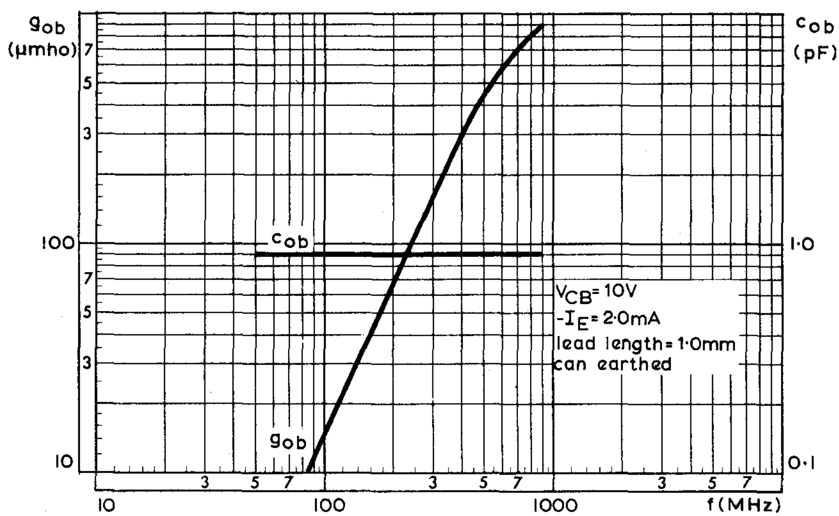
3. Care should be taken not to bend the leads nearer than 1.5mm from the seal.

4. If devices are stored above 100 °C before incorporation into equipment, some deterioration of the external surface is likely to occur which may make soldering into the circuit difficult. Under these circumstances the leads should be retinned using a suitable activated flux.

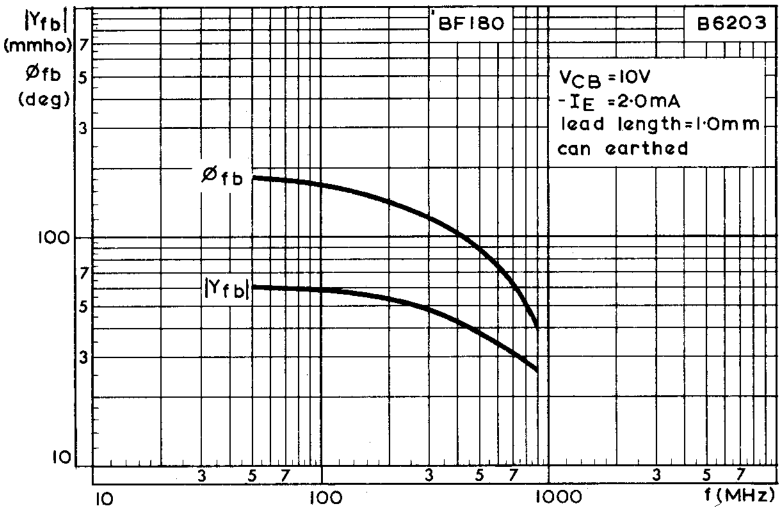
U.H.F. SILICON PLANAR N-P-N TRANSISTOR

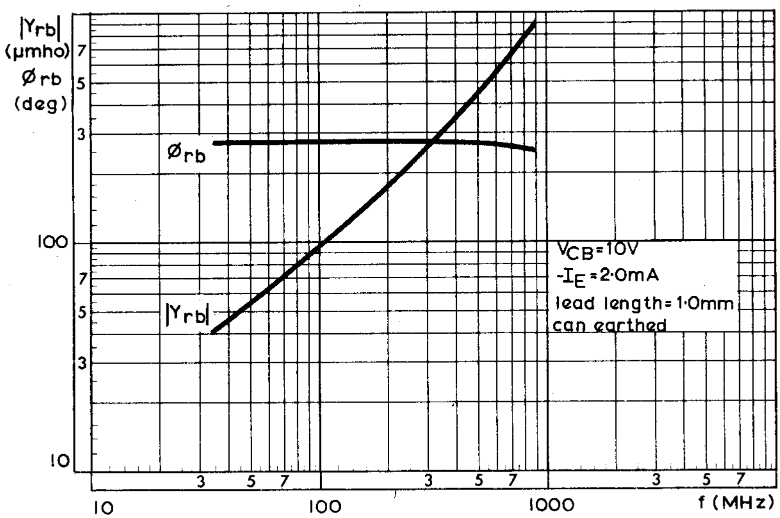
BF180





TYPICAL INPUT AND OUTPUT Y-PARAMETERS PLOTTED AGAINST FREQUENCY

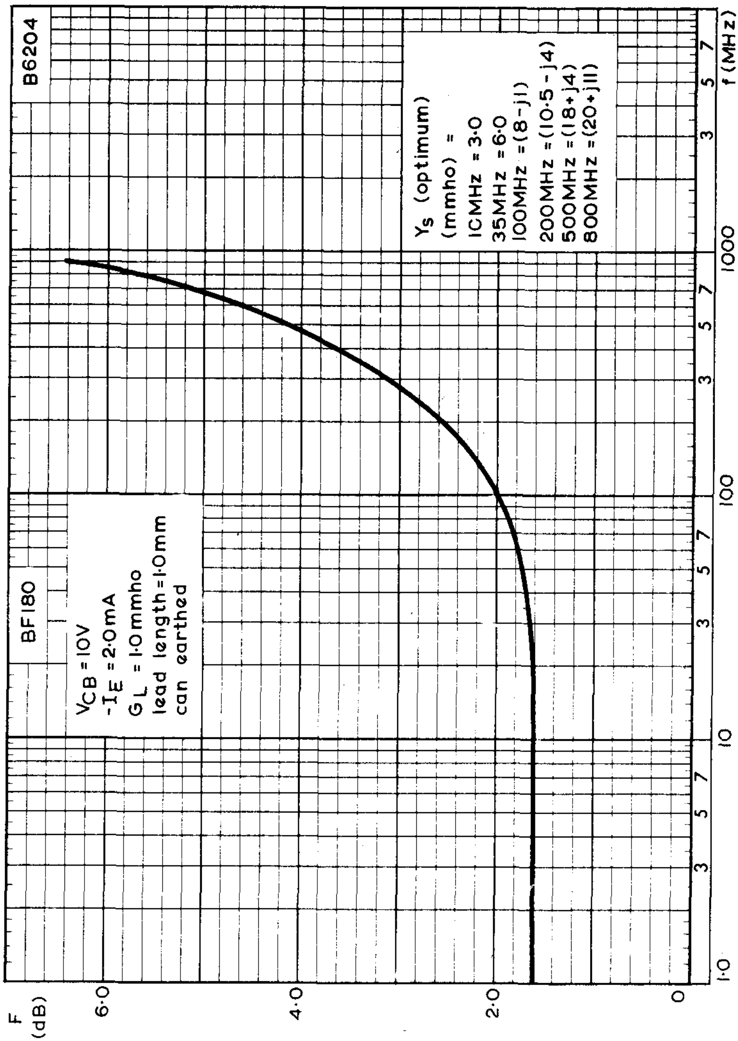




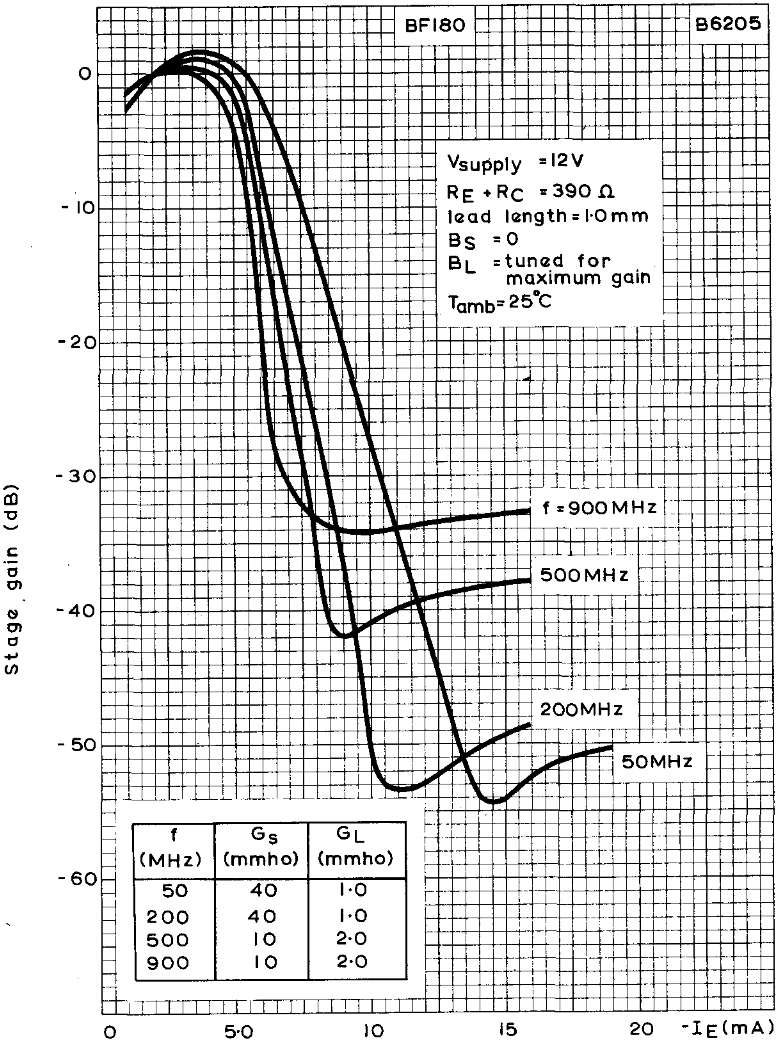
TYPICAL TRANSFER AND FEEDBACK Y-PARAMETERS PLOTTED AGAINST FREQUENCY

U.H.F. SILICON PLANAR N-P-N TRANSISTOR

BF180



TYPICAL NOISE FIGURE PLOTTED AGAINST FREQUENCY WITH OPTIMUM SOURCE ADMITTANCE INDICATED AT SPECIFIC FREQUENCIES



f (MHz)	G_S (mmho)	G_L (mmho)
50	40	1·0
200	40	1·0
500	10	2·0
900	10	2·0

CONTROL CHARACTERISTICS-STAGE GAIN PLOTTED AGAINST EMITTER CURRENT WITH FREQUENCY AS A PARAMETER

U.H.F. SILICON PLANAR N-P-N TRANSISTOR

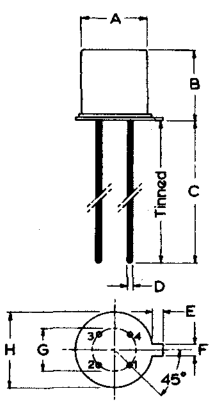
BF181

U.H.F. silicon planar n-p-n transistor intended for use as a self-oscillating mixer or mixer in television integrated tuners. TO-72 construction with shield connected to envelope.

QUICK REFERENCE DATA		
V_{CBO} max.	30	V
I_C max.	20	mA
P_{tot} max. (T_{amb} = 25 °C)	150	mW
Max. unilateralised power gain typ.		
f = 900MHz	11	dB
Noise figure typ.		
f = 900MHz, y_s = optimum	6.8	dB
f_T typ.	600	MHz

OUTLINE AND DIMENSIONS

Conforms to B.S. 3934 SO-12A/SB4-3
J.E.D.E.C. TO-72



	Millimetres		
	Min.	Nom.	Max.
A	-	-	4.8
B	-	-	5.3
C	12.7	-	-
D	-	0.43	-
E	-	1.0	-
F	-	1.05	-
G	-	2.54	-
H	5.3	5.55	5.8

Viewed from underside

Connections 1. Emitter 3. Collector

2. Base 4. Shield connected to envelope

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

V_{CBO} max.	30	V
V_{CEO} max.	20	V
V_{EBO} max.	3.0	V
I_C max.	20	mA
I_{CM} max.	20	mA
P_{tot} max. (T_{amb} = 25 °C)	150	mW

Temperature

T_{stg} min.	-65	°C
T_{stg} max.	175	°C
T_j max.	175	°C

THERMAL CHARACTERISTIC

$\Theta_{j\text{-}amb}$ 1.0 degC/mW

ELECTRICAL CHARACTERISTICS (T_{amb} = 25 °C)

		Typ.	Max.	
I_B	Base current $-I_E$ = 2.0mA, V_{CB} = 10V	70	150	μA
$-V_{EB}$	Emitter-base voltage $-I_E$ = 2.0mA, V_{CB} = 10V	0.75	-	V
$-c_{re}$	Feedback capacitance I_C = 1.0mA, V_{CE} = 10V, f = 10.7MHz	0.280	-	pF
f_T	Transition frequency I_C = 2.0mA, V_{CE} = 10V	600	-	MHz

		Typ.	Max.	
***Small signal y-parameters**				
$-I_E = 2.0mA,\ V_{CB} = 10V,\ f = 35MHz$				
g_{ob}	Output conductance	-	10	µmho
c_{ob}	Output capacitance	0.9	-	pF

G_{UM} *Maximum unilateralised power gain

$$G_{UM} = 10 \log \frac{|y_{fb}|^2}{4g_{ib} \cdot g_{ob}}$$

	Typ.	
$-I_E = 2.0mA,\ V_{CB} = 10V,\ f = 500MHz$	13.5	dB
$-I_E = 2.0mA,\ V_{CB} = 10V,\ f = 900MHz$	11	dB

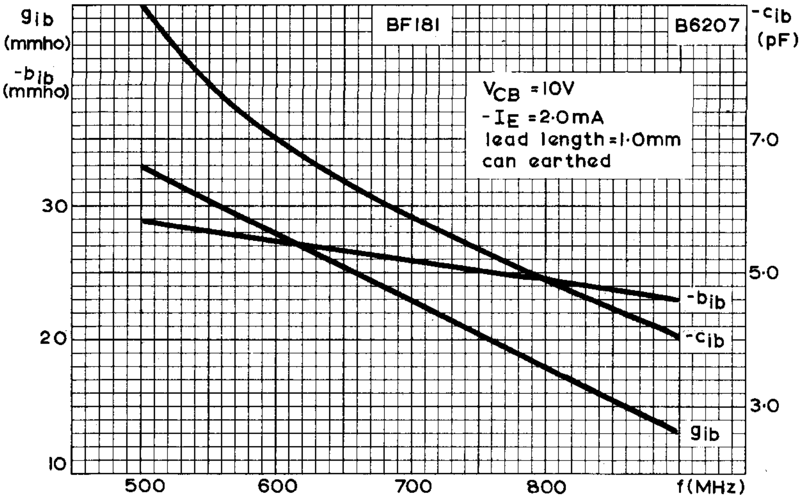
*Stage gain

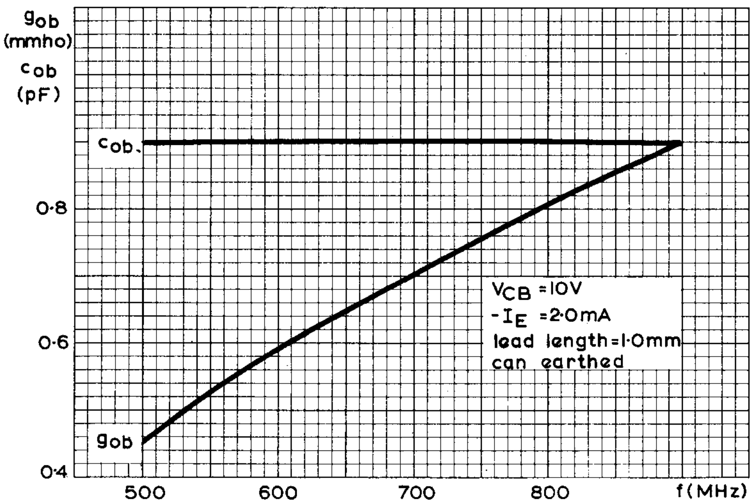
$-I_E = 2.0mA,\ V_{CB} = 10V,\ f = 900MHz$		
$G_s = 20mmho,\ B_s = 0,$		
$G_L = 2.0mmho,\ B_L = tuned$	8.0	dB

*All measurements taken in common base configuration with the metal envelope connected directly to earth and with the external lead length = 1mm.

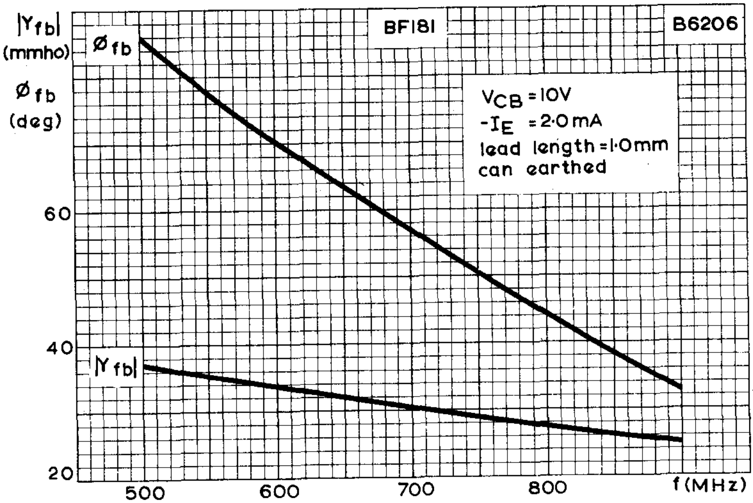
SOLDERING AND WIRING RECOMMENDATIONS

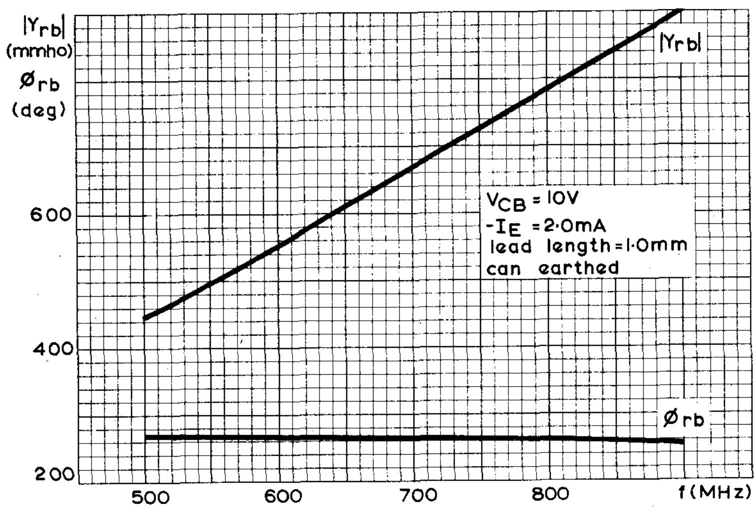
1. When using a soldering iron, transistors may be soldered directly into the circuit, but heat conducted to the junction should if possible be kept to a minimum by the use of a thermal shunt.
2. Transistors may be dip-soldered at a solder temperature of 245°C for a maximum soldering time of 5 seconds. The case temperature during soldering must not at any time exceed the maximum storage temperature.
3. Care should be taken not to bend the leads nearer than 1.5mm from the seal.
4. If devices are stored above 100°C before incorporation into equipment, some deterioration of the external surface is likely to occur which may make soldering into the circuit difficult. Under these circumstances the leads should be retinned using a suitable activated flux.



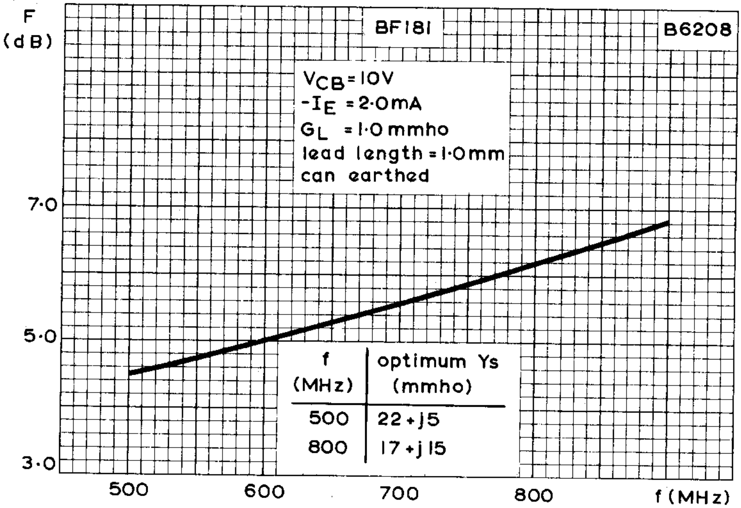


TYPICAL INPUT AND OUTPUT Y-PARAMETERS PLOTTED AGAINST FREQUENCY





TYPICAL TRANSFER AND FEEDBACK Y-PARAMETERS PLOTTED AGAINST FREQUENCY



TYPICAL NOISE FIGURE AT OPTIMUM SOURCE ADMITTANCE PLOTTED AGAINST FREQUENCY

SILICON PLANAR EPITAXIAL N-P-N TRANSISTOR

BF194

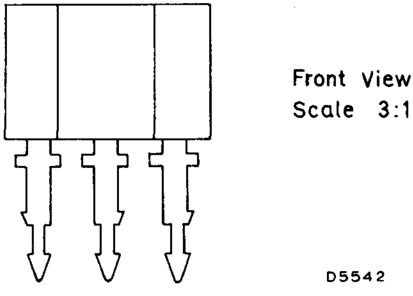
N-P-N transistor in plastic encapsulation with three rigid self-locking strips suitable for insertion into printed circuit boards using standard grids. The transistor is recommended for use in the i.f. amplifier stages of car radios and a.m./f.m. receivers, also for use in the sound i.f. stages of television receivers.

QUICK REFERENCE DATA

V_{CBO} max.	30	V
V_{CEO} max.	20	V
I_C max.	30	mA
P_{tot} max.	220	mW
T_j max.	125	^oC
h_{FE} typ. (I_C=1.0mA, V_{CE}=10V)	115	
f_T typ. (I_C=1.0mA, V_{CE}=10V)	260	MHz
N typ. (I_C=1.0mA, V_{CE}=10V, g_s=20mmho, f=100MHz)	4.0	dB
N_c typ. (I_C=1.0mA, V_{CE}=10V, g_s=10mmho, f=1.0MHz)	2.0	dB

OUTLINE AND DIMENSIONS

For details see page 4



N.B. Devices in this Data Sheet should be ordered by the type number followed by Reference 0220.

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

V_{CBO} max. ($I_E = 0$)	30	V
V_{CEO} max. ($I_B = 0$, see curve on page 7)	20	V
V_{EBO} max. ($I_C = 0$)	5.0	V
I_C max.	30	mA
I_{CM} max.	30	mA
P_{tot} max. ($T_{amb} \leq 25^{o}C$)	220	mW

Temperature

T_{stg} min.	-65	^{o}C
T_{stg} max.	125	^{o}C
T_j max.	125	^{o}C

THERMAL CHARACTERISTIC

$R_{th(j-amb)}$	0.45	degC/mW

ELECTRICAL CHARACTERISTICS ($T_{amb} = 25^{o}C$ unless otherwise stated)

		Min.	Typ.	Max.	
V_{BE}	Base-emitter voltage (see note 1) $I_C = 1.0mA$, $V_{CE} = 10V$	650	-	740	mV
I_B	Base current $I_C = 1.0mA$, $V_{CE} = 10V$	4.5	8.7	15	μA
$-C_{re}$	Feedback capacitance $I_C = 1.0mA$, $V_{CE} = 10V$, f = 0.45MHz	-	0.95	-	pF
f_T	Transition frequency $I_C = 1.0mA$, $V_{CE} = 10V$	-	260		MHz

NOTE

1. V_{BE} decreased by approximately 1.7mV/degC with increasing temperature.

SOLDERING NOTE

For soldering irons or for dip-soldering, the iron temperature or solder temperature may rise to 300°C for a maximum of three seconds, with the transistor lock-fitted on printed boards in either of the possible mounting positions.

ELECTRICAL CHARACTERISTICS (cont'd)

		Min.	Typ.	Max.	
N	Noise figure				
	$I_C = 1.0mA$, $V_{CE} = 10V$				
	$g_s = 2.0mmho$, $f = 0.2MHz$	-	1.5	-	dB
	$g_s = 1.5mmho$, $f = 1.0MHz$	-	1.2	-	dB
	$g_s = 10mmho$, $f = 100MHz$	-	4.0	-	dB
N_c	Conversion noise figure				
	$I_C = 1.0mA$, $V_{CE} = 10V$				
	$g_s = 0.6mmho$, $f = 0.2MHz$	-	3.0	-	dB
	$g_s = 1.2mmho$, $f = 1.0MHz$	-	2.0	-	dB

Typical y-parameters

Common base

$I_C = 1.0mA$, $V_{CE} = 10V$, $f = 100MHz$, lead length = 3.0mm

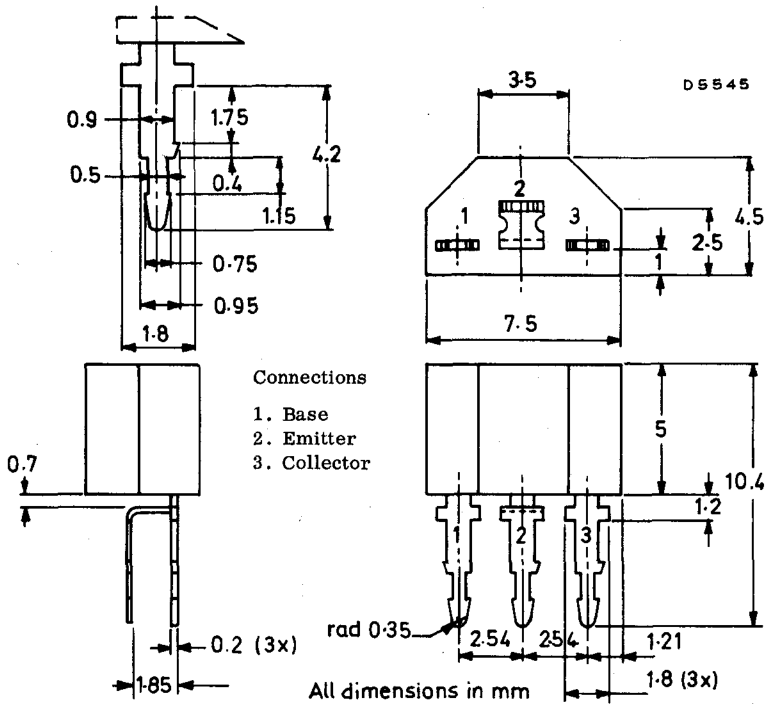
g_{ib}	Input conductance	36	mmho
$-b_{ib}$	Input susceptance	3.0	mmho
$\lvert y_{rb} \rvert$	Feedback admittance	450	µmho
ϕ_{rb}	Phase angle of feedback admittance	272	deg
$\lvert y_{fb} \rvert$	Transfer admittance	33	mmho
ϕ_{fb}	Phase angle of transfer admittance	146	deg
g_{ob}	Output conductance	22	µmho
b_{ob}	Output susceptance	1.1	mmho

Common emitter

$I_C = 1.0mA$, $V_{CE} = 10V$, lead length = 3.0mm

	f =	10.7	0.45	MHz
g_{ie}	Input conductance	<0.64	<0.54	mmho
g_{oe}	Output conductance	<13.5	<11.5	µmho

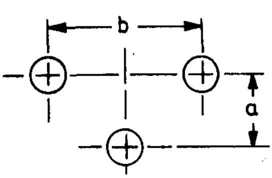
OUTLINE AND DIMENSIONS



Connections

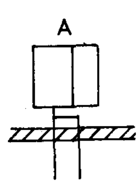
1. Base
2. Emitter
3. Collector

Mounting details



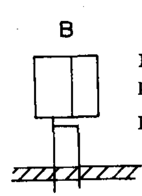
a = 2.49 to 2.59mm

b = 5.03 to 5.13mm



Maximum thickness of printed board = 1.7mm

Recommended hole diameter = 1.0 to 1.1mm (1.0 to 1.3mm allowable)



D5546

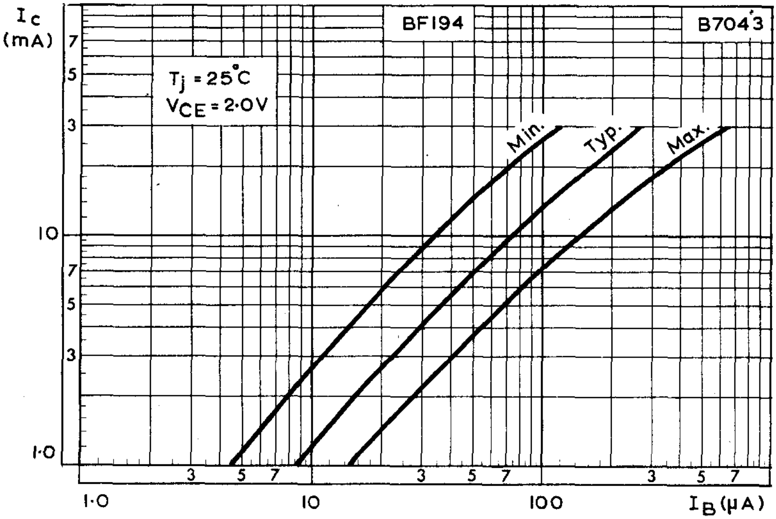
Maximum thickness of printed board = 1.1mm

Hole diameter = 0.77 to 0.83mm

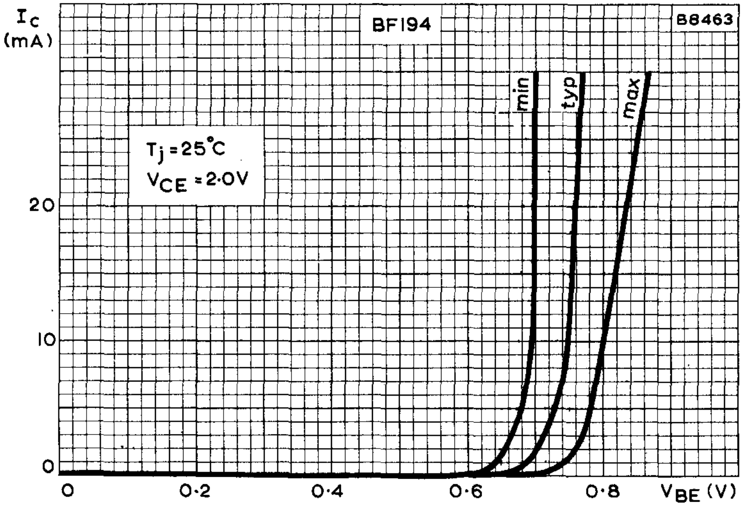
See also General Explanatory Notes Section IV.

SILICON PLANAR EPITAXIAL N-P-N TRANSISTOR

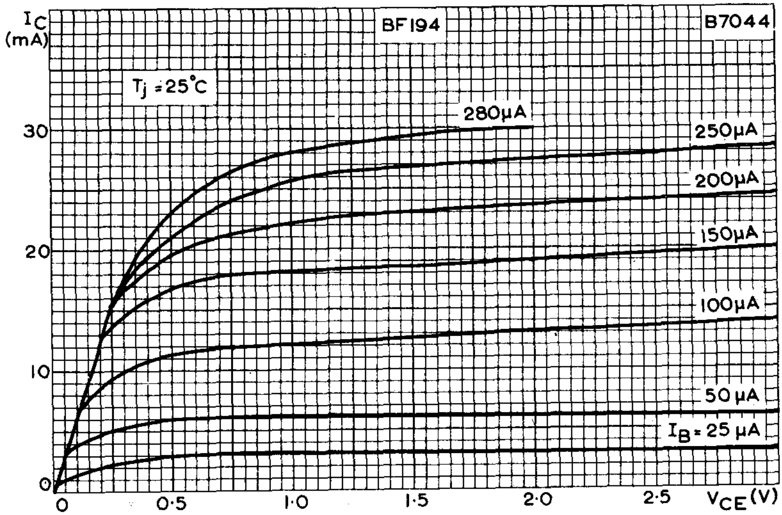
BF194



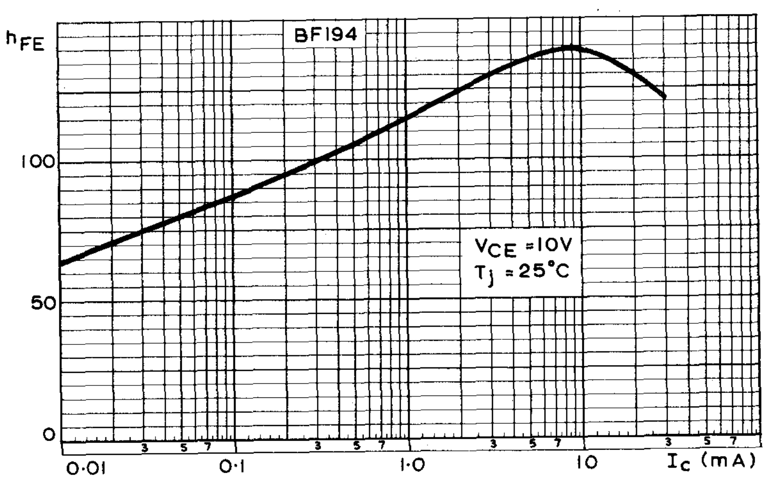
TRANSFER CHARACTERISTICS. $T_j = 25^oC$



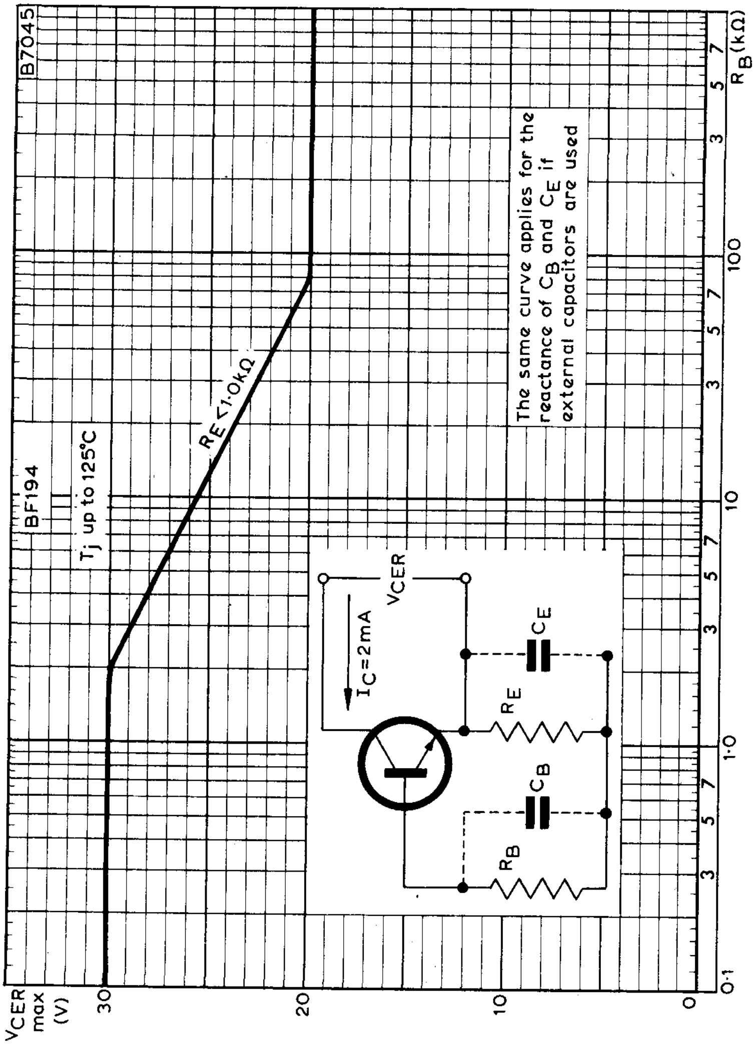
MUTUAL CHARACTERISTICS. $T_j = 25^oC$



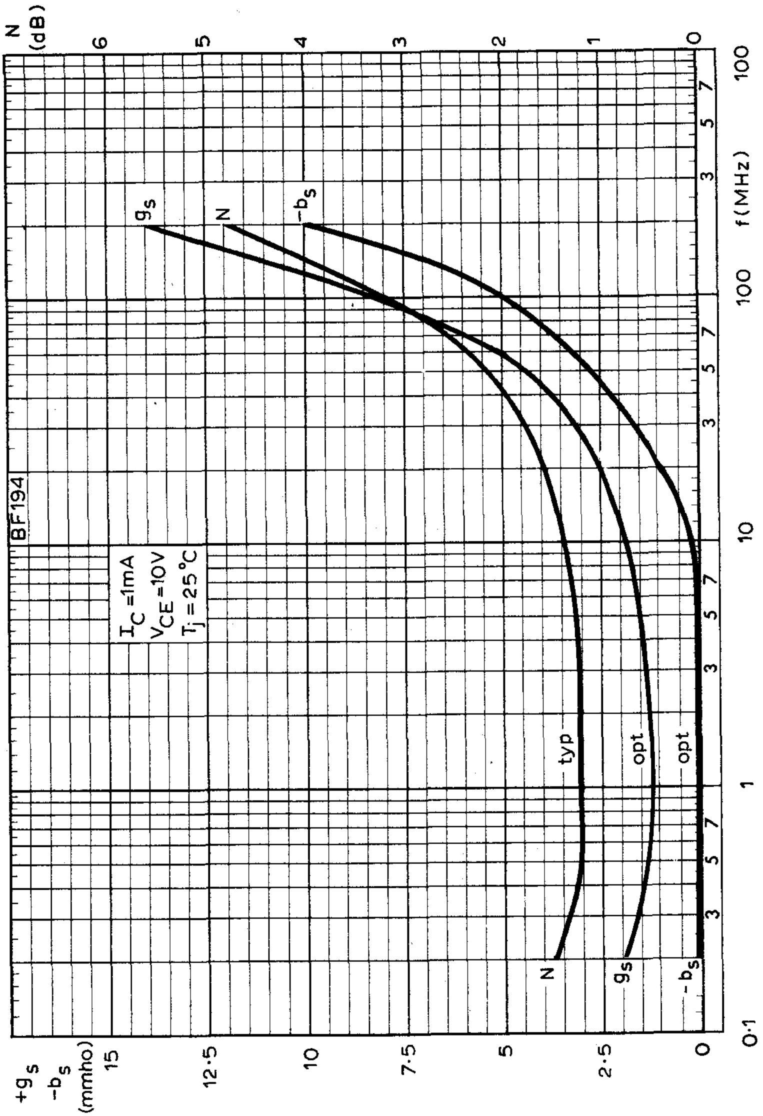
TYPICAL OUTPUT CHARACTERISTICS. $T_j = 25^{\circ}C$



TYPICAL STATIC FORWARD CURRENT TRANSFER RATIO PLOTTED AGAINST COLLECTOR CURRENT

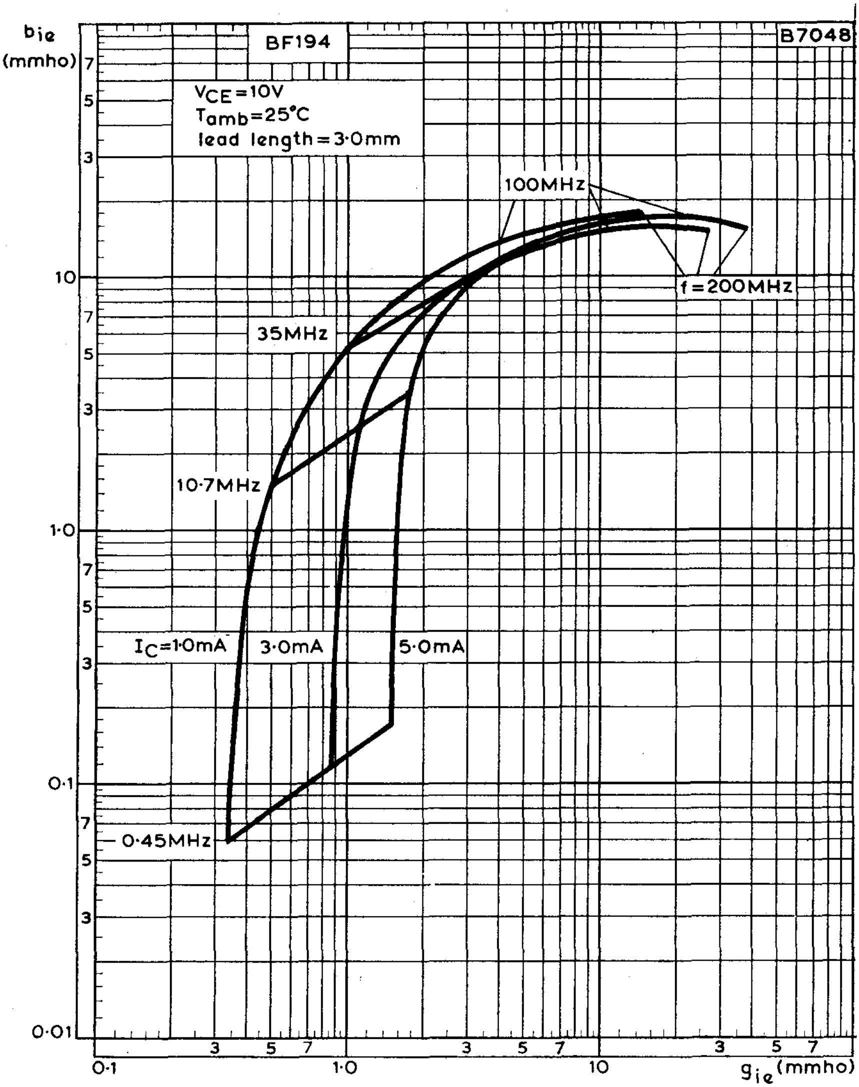


MAXIMUM COLLECTOR-EMITTER VOLTAGE PLOTTED AGAINST EXTERNAL BASE RESISTANCE

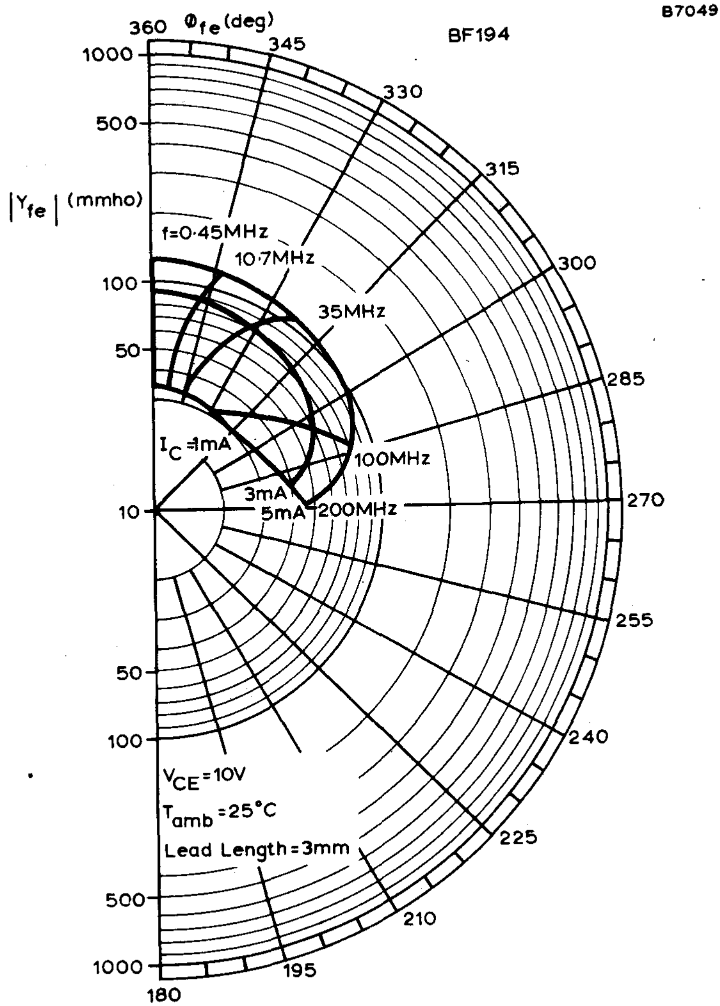


TYPICAL SOURCE CONDUCTANCE AND SOURCE SUSCEPTANCE PLOTTED AGAINST FREQUENCY AT OPTIMUM SOURCE ADMITTANCE

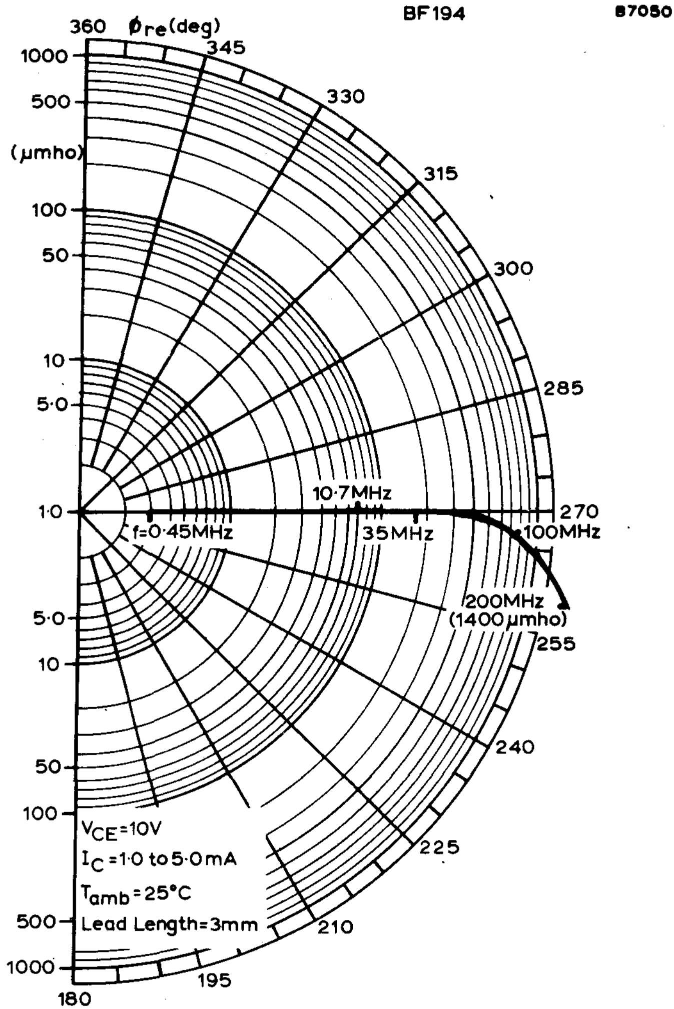
TYPICAL NOISE FIGURE PLOTTED AGAINST FREQUENCY AT OPTIMUM SOURCE CONDUCTANCE



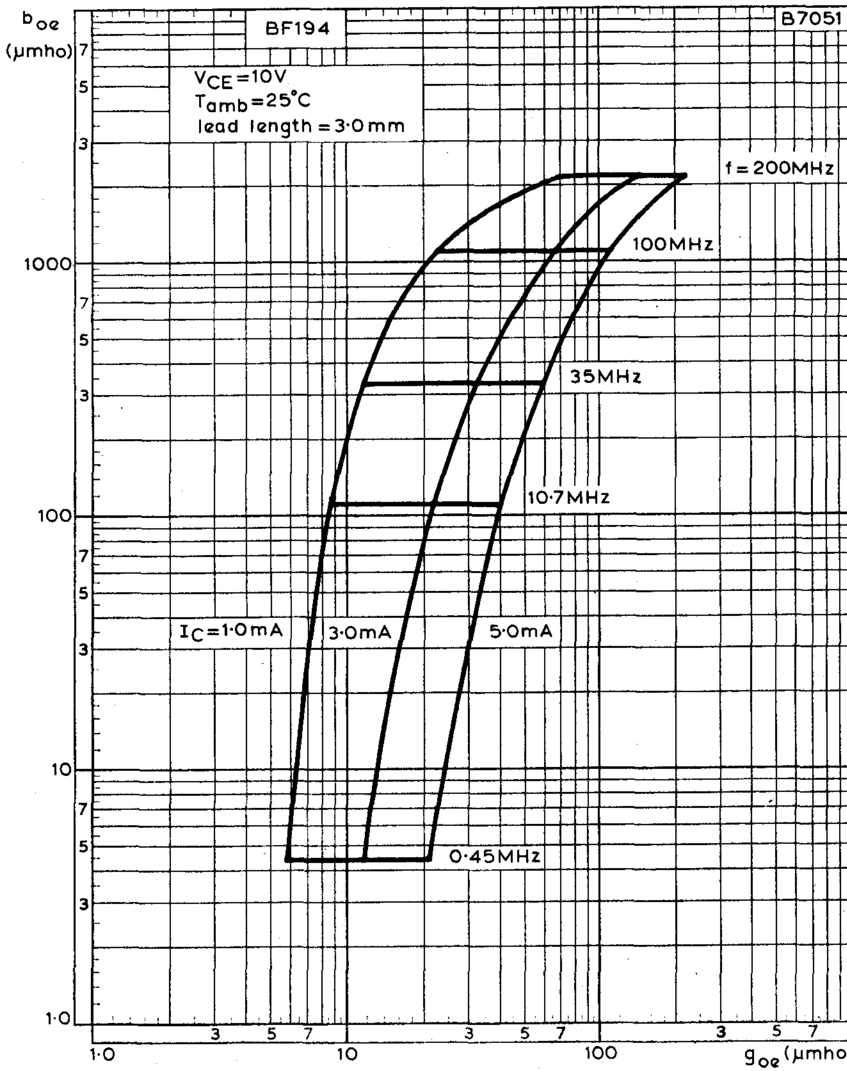
TYPICAL COMMON EMITTER INPUT ADMITTANCE WITH COLLECTOR CURRENT AND FREQUENCY AS PARAMETERS



TYPICAL COMMON EMITTER TRANSFER ADMITTANCE WITH COLLECTOR CURRENT AND FREQUENCY AS PARAMETERS



TYPICAL COMMON EMITTER FEEDBACK ADMITTANCE WITH COLLECTOR CURRENT AND FREQUENCY AS PARAMETERS



TYPICAL COMMON EMITTER OUTPUT ADMITTANCE WITH COLLECTOR CURRENT AND FREQUENCY AS PARAMETERS

SILICON PLANAR EPITAXIAL N-P-N TRANSISTOR

BF195

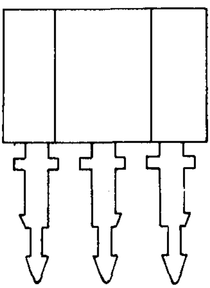
N-P-N low noise transistor in plastic encapsulation with three rigid self-locking strips suitable for insertion into printed circuit boards using standard grids. The transistor is recommended for use in the input stages of a.m./f.m. receivers, also for use in mixer and i.f. stages of a.m. battery operated receivers.

QUICK REFERENCE DATA

V_{CBO} max.	30	V
V_{CEO} max.	20	V
I_C max.	30	mA
P_{tot} max.	220	mW
T_j max.	125	^oC
h_{FE} typ. (I_C = 1.0mA, V_{CE} = 10V)	67	
f_T typ. (I_C = 1.0mA, V_{CE} = 10V)	200	MHz
N typ. (I_C = 1.0mA, V_{CE} = 10V, g_s = 20mmho, f = 1.0MHz)	3.5	dB
(I_C = 1.0mA, V_{CE} = 10V, g_s = 10mmho, f = 100MHz)	4.0	dB

OUTLINE AND DIMENSIONS

For details see page 4



Front View
Scale 3:1

D5542

N.B. Devices in this Data Sheet should be ordered by the type number followed by Reference 0220.

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

V_{CBO} max. ($I_E = 0$)	30	V
V_{CEO} max. ($I_B = 0$, see curve on page 7)	20	V
V_{EBO} max. ($I_C = 0$)	5.0	V
I_C max.	30	mA
I_{CM} max.	30	mA
P_{tot} max. ($T_{amb} \leq 25^{o}C$)	220	mW

Temperature

T_{stg} min.	-65	^{o}C
T_{stg} max.	125	^{o}C
T_j max.	125	^{o}C

THERMAL CHARACTERISTIC

$R_{th(j-amb)}$	0.45	degC/mW

ELECTRICAL CHARACTERISTICS ($T_{amb} = 25^{o}C$ unless otherwise stated)

		Min.	Typ.	Max.	
$-V_{BE}$	Base-emitter voltage (see note 1) $I_C = 1.0mA$, $V_{CE} = 10V$	650	-	740	mV
I_B	Base current $I_C = 1.0mA$, $V_{CE} = 10V$	8.0	15	28	μA
$-C_{re}$	Feedback capacitance $I_C = 1.0mA$, $V_{CE} = 10V$, f=0.45MHz	-	0.95	-	pF
f_T	Transition frequency $I_C = 1.0mA$, $V_{CE} = 10V$	-	200	-	MHz

NOTE

1. V_{BE} decreased by approximately 1.7mV/degC with increasing temperature.

SOLDERING NOTE

For soldering irons or for dip-soldering, the iron temperature or solder temperature may rise to 300°C for a maximum of three seconds, with the transistor lock-fitted on printed boards in either of the possible mounting positions.

ELECTRICAL CHARACTERISTICS (cont'd)

		Min.	Typ.	Max.	
N	Noise figure $I_C = 1.0mA$, $V_{CE} = 10V$,				
	$g_s = 20mmho$, $f = 1.0MHz$	-	3.5	-	dB
	$g_s = 10mmho$, $f = 100MHz$	-	4.0	-	dB
N_c	Conversion noise figure $I_C = 1.0mA$, $V_{CE} = 10V$,				
	$g_s = 1.2mmho$, $f = 0.2MHz$	-	4.0	-	dB
	$g_s = 1.5mmho$, $f = 1.0MHz$	-	2.5	-	dB

Typical y-parameters

Common base

$I_C = 1.0mA$, $V_{CE} = 10V$, $f = 100MHz$, lead length $= 3.0mm$

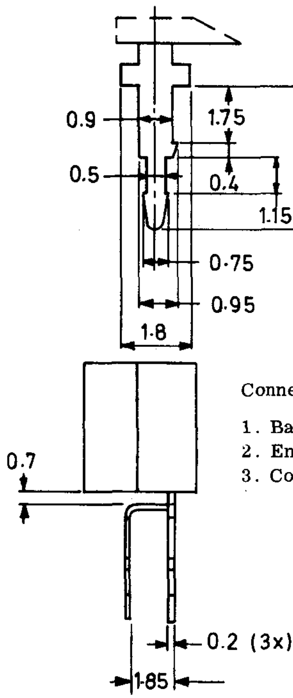
g_{ib}	Input conductance	38	mmho
$-b_{ib}$	Input susceptance	1.0	mmho
$\|y_{rb}\|$	Feedback admittance	440	µmho
$\varnothing_{rb}$	Phase angle of feedback admittance	275	deg
$\|y_{fb}\|$	Transfer admittance	34	mmho
$\varnothing_{fb}$	Phase angle of transfer admittance	140	deg
g_{ob}	Output conductance	12	µmho
b_{ob}	Output susceptance	1.1	mmho

Common emitter

$I_C = 1.0mA$, $V_{CE} = 10V$, lead length $= 3.0mm$

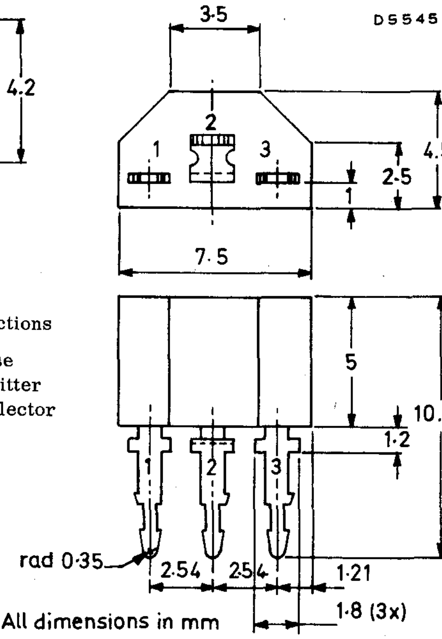
	f =	10.7	0.45	MHz
g_{ie}	Input conductance	<0.96	<0.86	mmho
g_{oe}	Output conductance	<9.5	<7.0	µmho

OUTLINE AND DIMENSIONS

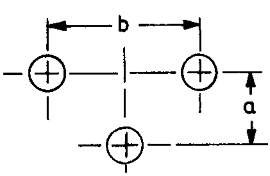


Connections

1. Base
2. Emitter
3. Collector

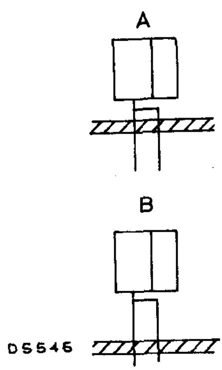


Mounting details



a = 2.49 to 2.59mm

b = 5.03 to 5.13mm



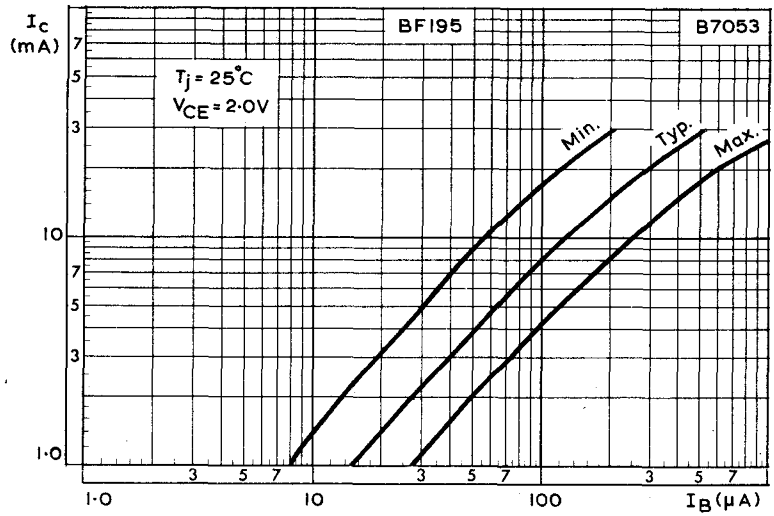
Maximum thickness of printed board = 1.7mm

Recommended hole diameter = 1.0 to 1.1mm (1.0 to 1.3mm allowable)

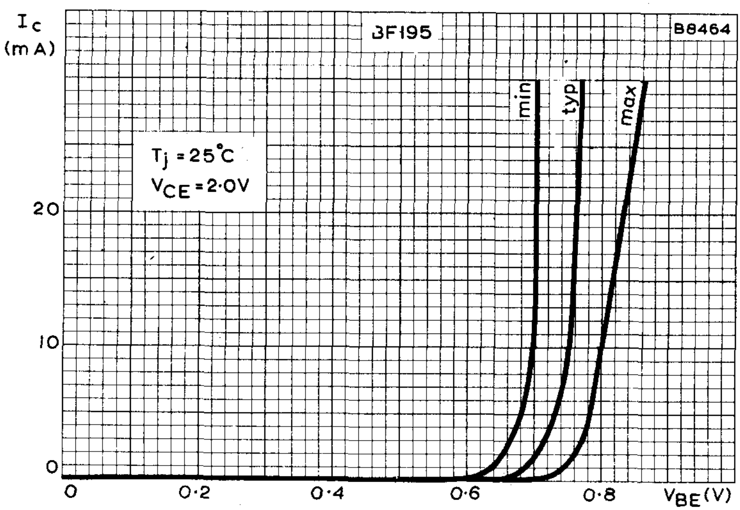
Maximum thickness of printed board = 1.1mm

Hole diameter = 0.77 to 0.83mm

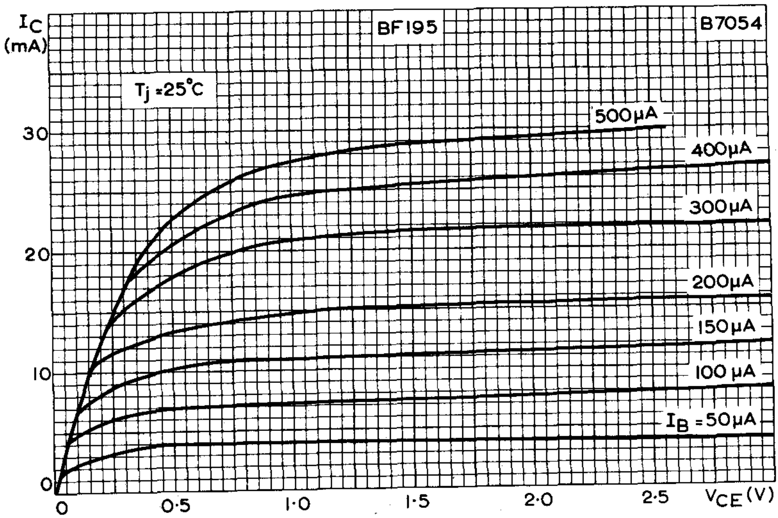
See also General Explanatory Notes Section IV.



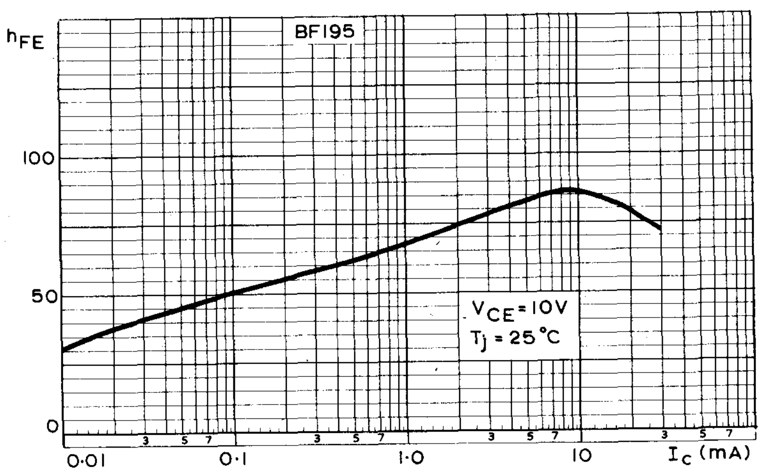
TRANSFER CHARACTERISTICS. $T_j = 25^oC$



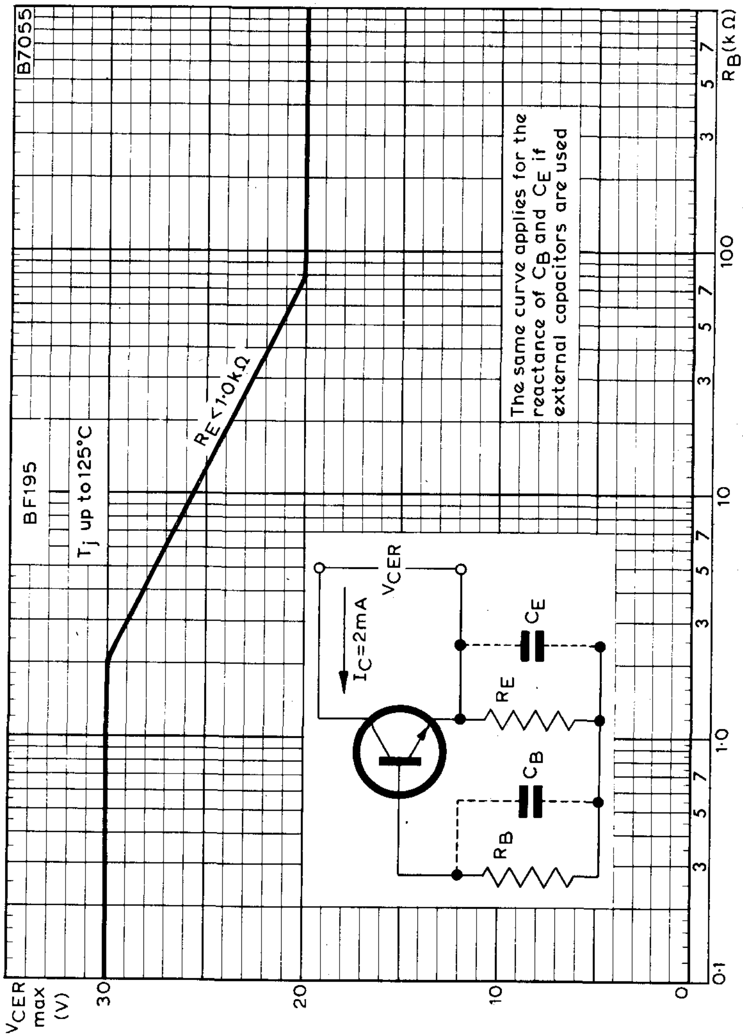
MUTUAL CHARACTERISTICS. $T_j = 25^oC$



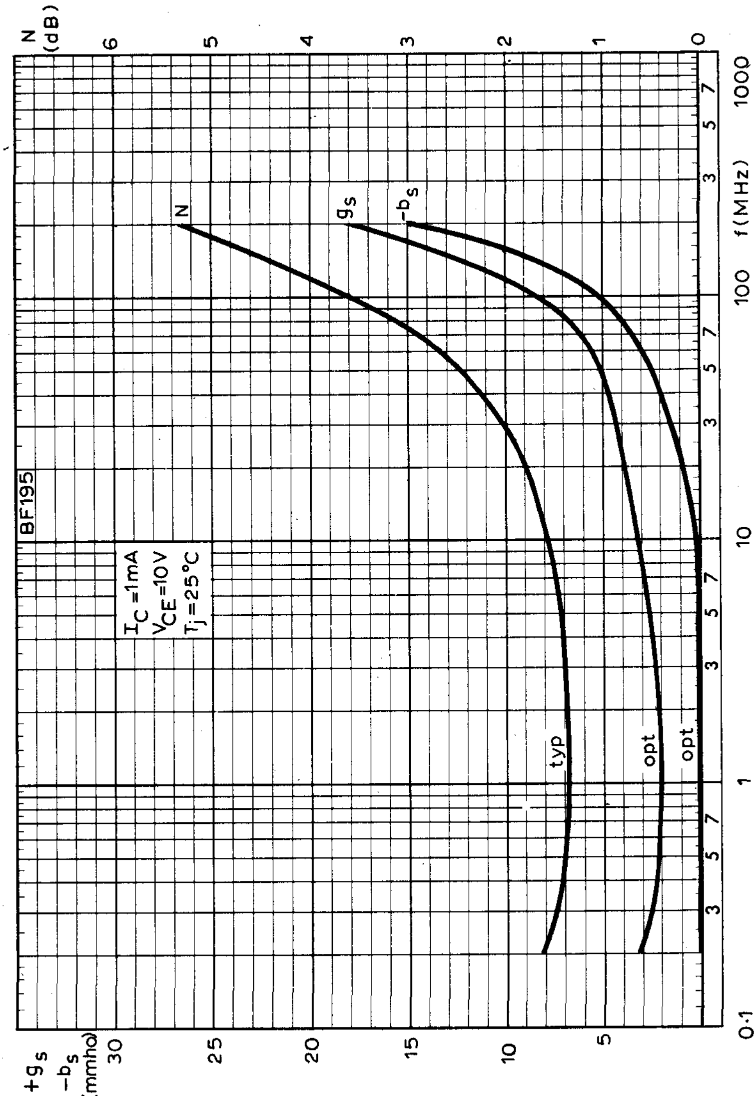
TYPICAL OUTPUT CHARACTERISTICS. $T_j = 25^{\circ}C$



TYPICAL STATIC FORWARD CURRENT TRANSFER RATIO PLOTTED AGAINST COLLECTOR CURRENT

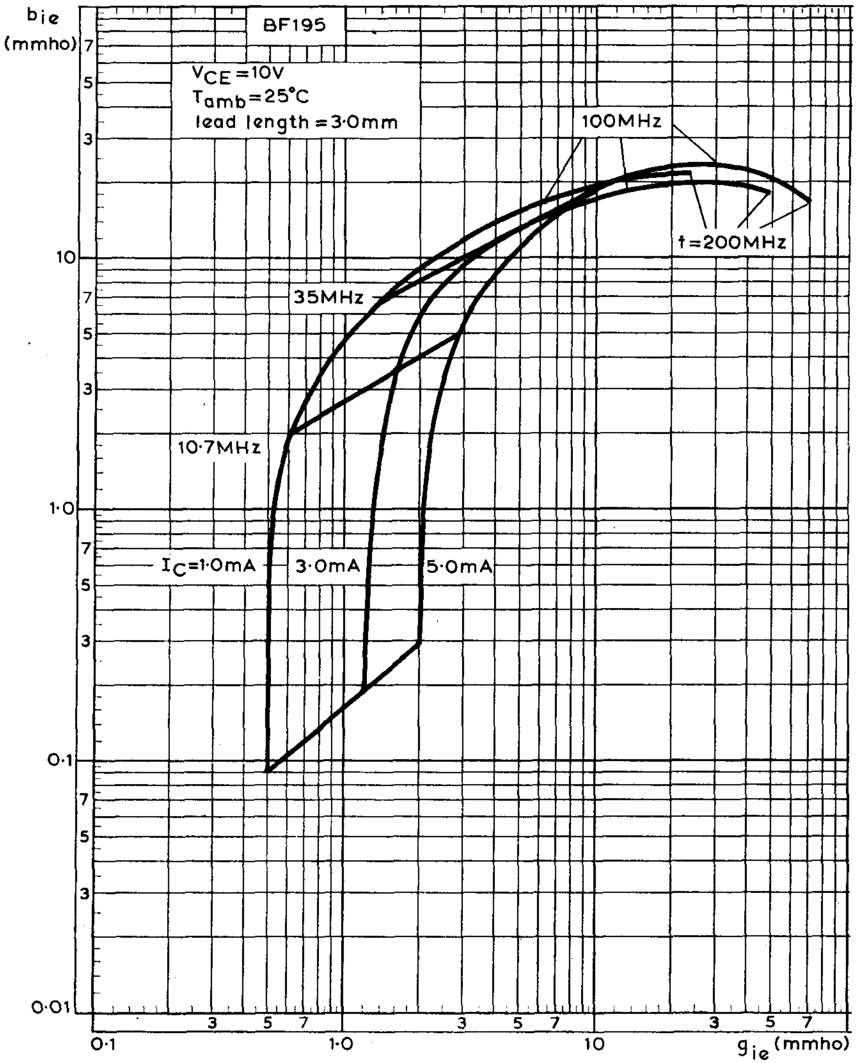


MAXIMUM COLLECTOR-EMITTER VOLTAGE PLOTTED AGAINST EXTERNAL BASE RESISTANCE

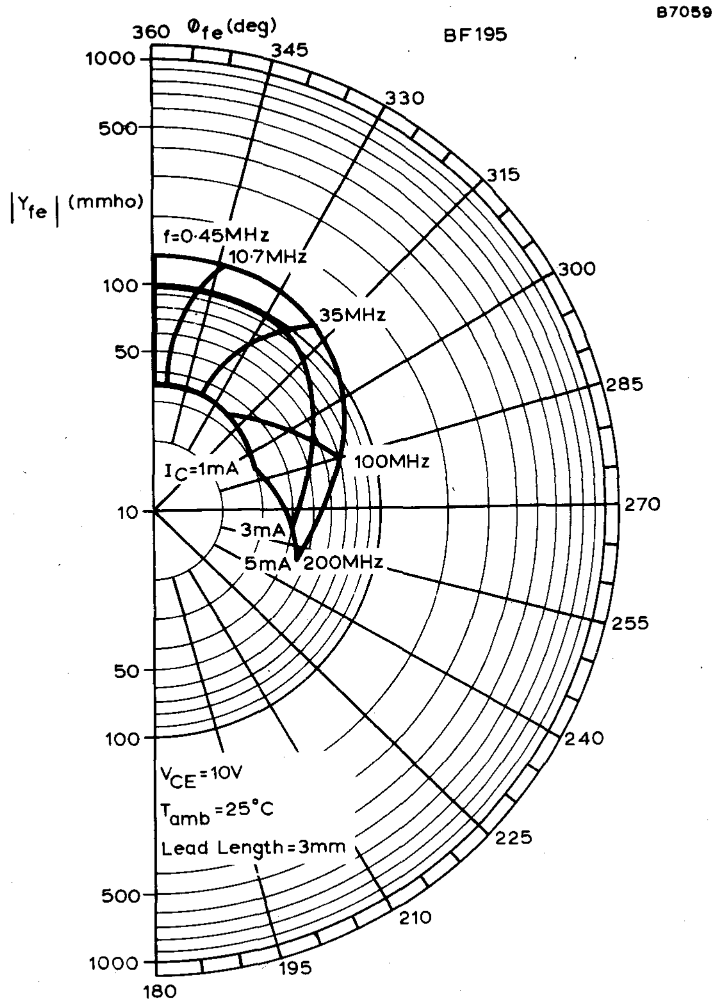


TYPICAL SOURCE CONDUCTANCE AND SOURCE SUSCEPTANCE PLOTTED AGAINST FREQUENCY AT OPTIMUM SOURCE ADMITTANCE

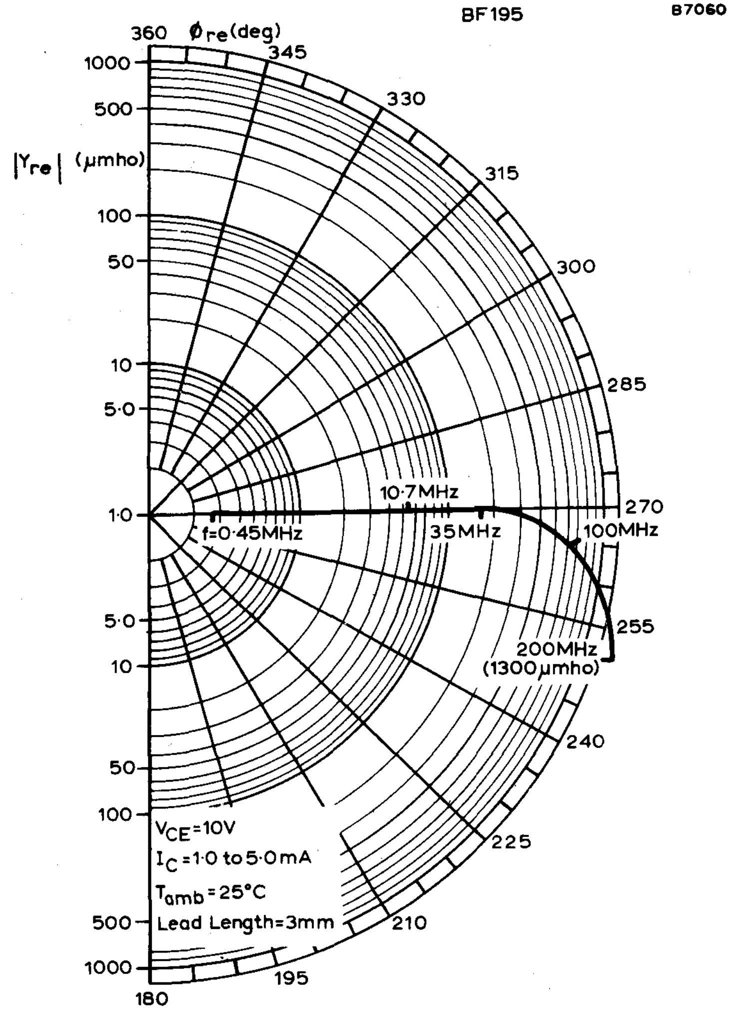
TYPICAL NOISE FIGURE PLOTTED AGAINST FREQUENCY AT OPTIMUM SOURCE CONDUCTANCE



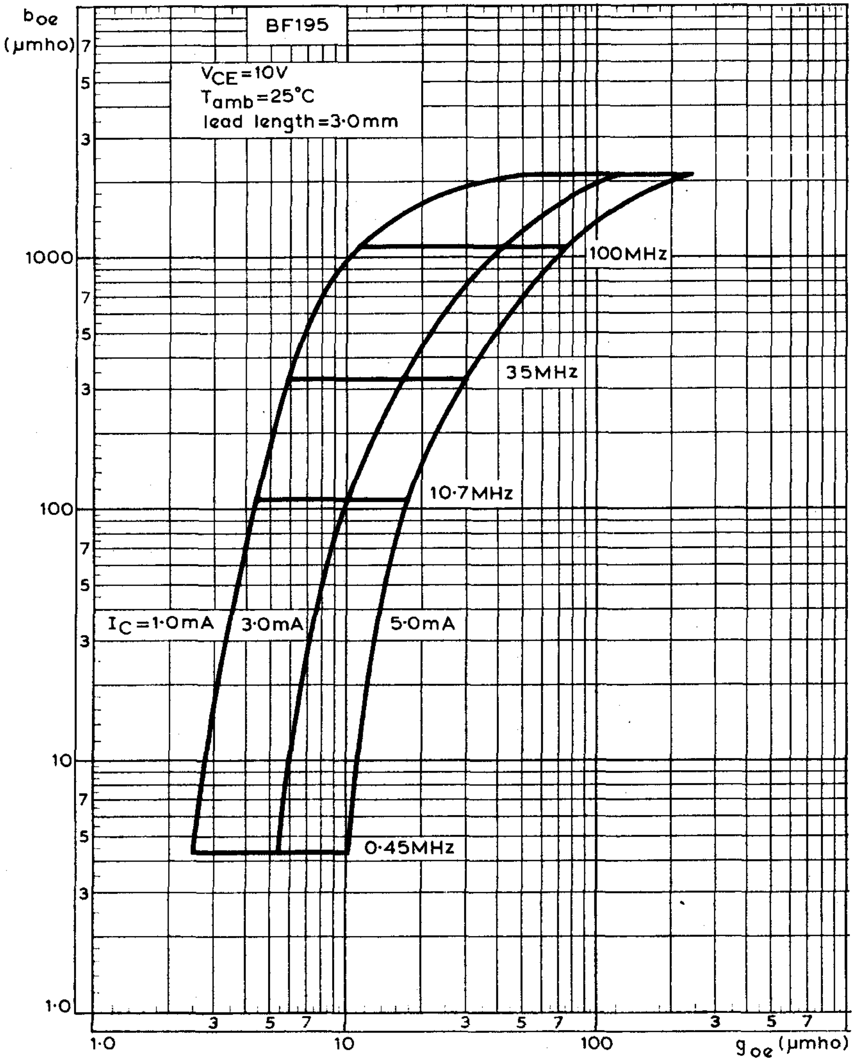
TYPICAL COMMON EMITTER INPUT ADMITTANCE WITH COLLECTOR CURRENT AND FREQUENCY AS PARAMETERS



TYPICAL COMMON EMITTER TRANSFER ADMITTANCE WITH COLLECTOR CURRENT AND FREQUENCY AS PARAMETERS



TYPICAL COMMON EMITTER FEEDBACK ADMITTANCE WITH COLLECTOR CURRENT AND FREQUENCY AS PARAMETERS



TYPICAL COMMON EMITTER OUTPUT ADMITTANCE WITH COLLECTOR CURRENT AND FREQUENCY AS PARAMETERS

N-P-N SILICON PLANAR TRANSISTOR

BF196

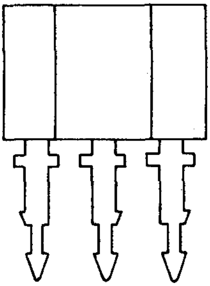
N-P-N silicon planar transistor in plastic encapsulation with three rigid self-locking strips suitable for insertion into printed circuit boards using standard grids. The transistor has a very low feedback capacitance and is intended for use in the forward gain control stage of the television i.f. amplifiers.

QUICK REFERENCE DATA

V_{CBO} max.		40	V
V_{CEO} max.		30	V
I_C max.		25	mA
P_{tot} max. (T_{amb} = 25°C)		250	mW
T_j max.		125	°C
f_T typ. (I_C = 4mA, V_{CE} = 10V, f = 100MHz)		400	MHz
$-C_{re}$ typ. (I_C = 1mA, V_{CE} = 10V, f = 10·7MHz)		0·2	pF
G_{UM} typ. (I_C = 4mA, V_{CE} = 10V)			
	f = 35MHz	42	dB
	f = 45MHz	39	dB
Gain control range, typ.		60	dB

OUTLINE AND DIMENSIONS

For details see page 4.



Front View
Scale 3:1

N.B. Devices in this Data Sheet should be ordered by the type number followed by Reference 0220.

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

V_{CBO} max.	40	V
V_{CEO} max. (see also page 5)	30	V
V_{EBO} max.	4·0	V
I_C max.	25	mA
I_{CM} max.	25	mA
P_{tot} max. (T_{amb} = 25°C)	250	mW

Temperature

T_{stg}	−65 to + 125	°C
T_j max.	125	°C

THERMAL CHARACTERISTIC

$R_{th(j-amb)}$ in free air — 0·4 degC/mW

ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C)

		Min.	*Typ.*	*Max.*	
I_B	Base current at about 50 dB gain control				
	I_C = 6·0mA, V_{CE} = 2·0V	—	—	270	μA
	I_C = 15mA, V_{CE} = 5·0V	—	—	1·5	mA
I_B	Base current				
	I_C = 4·0mA, V_{CE} = 10V	—	70	150	μA
V_{BE}	*Base-emitter voltage				
	I_C = 4·0mA, V_{CE} = 10V	—	750	840	mV
$-C_{re}$	Feedback capacitance				
	I_C = 1·0mA, V_{CE} = 10V, f = 10·7MHz	—	—	0·2	pF
f_T	Transition frequency				
	I_C = 4·0mA, V_{CE} = 10V, f = 100MHz	—	400	—	MHz
N	Noise figure				
	I_C = 4·0mA, V_{CE} = 10V, G_S = 10mmho, B_S = 0, f = 35MHz	—	3·0	—	dB

*V_{BE} decreases by about 1·7mV/degC with increasing temperature.

ELECTRICAL CHARACTERISTICS *(continued)*

Typical y-parameters (common emitter)
$I_C = 4{\cdot}0$mA, $V_{CE} = 10$V (mounted as in the Mounting Details, 1.)

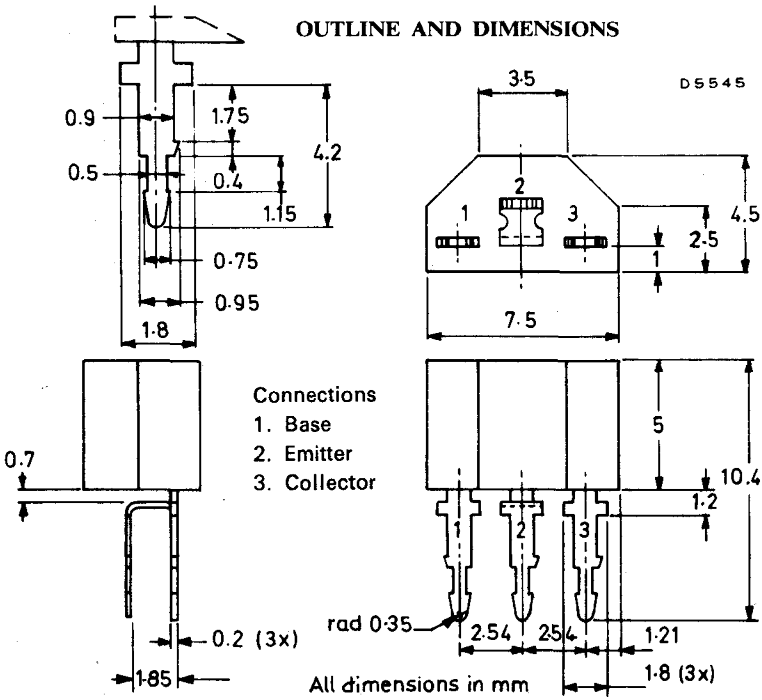
		f = 35	= 45	MHz
g_{ie}	Input conductance	3·2	4·8	mmho
C_{ie}	Input capacitance	37	35	pF
$\|y_{re}\|$	Feedback admittance	47	60	μmho
ϕ_{re}	Phase angle of feedback admittance	268	268	deg
$\|y_{fe}\|$	Transfer admittance	105	100	mmho
ϕ_{fe}	Phase angle of transfer admittance	340	340	deg
g_{oe}	Output conductance	50	60	μmho
C_{oe}	Output capacitance	1·3	1·3	pF

G_{UM} Maximum unilateralised power gain

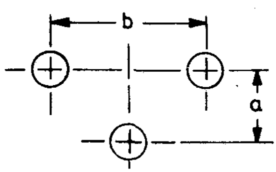
$$G_{UM} \text{ (in dB)} = 10 \log \frac{|y_{fe}|^2}{4 g_{ie} g_{oe}}$$

$I_C = 4{\cdot}0$mA, $V_{CE} = 10$V,	42	39	dB

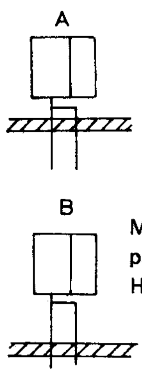
OUTLINE AND DIMENSIONS



MOUNTING DETAILS



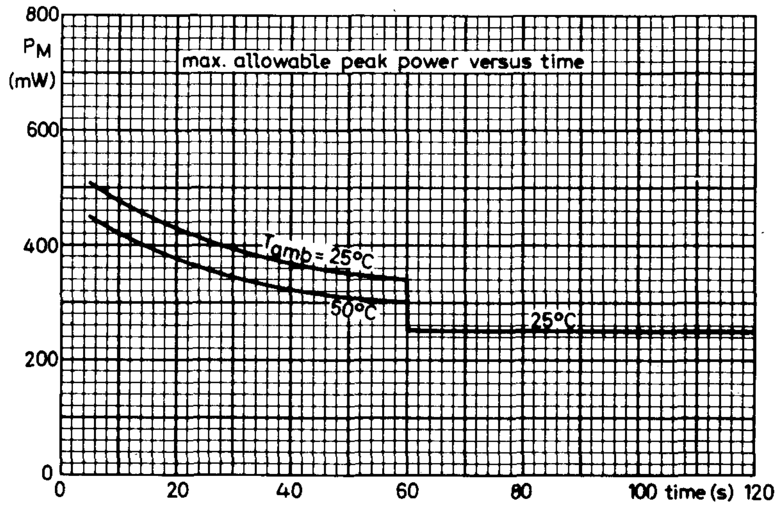
a = 2·49 to 2·59mm
b = 5·03 to 5·13mm

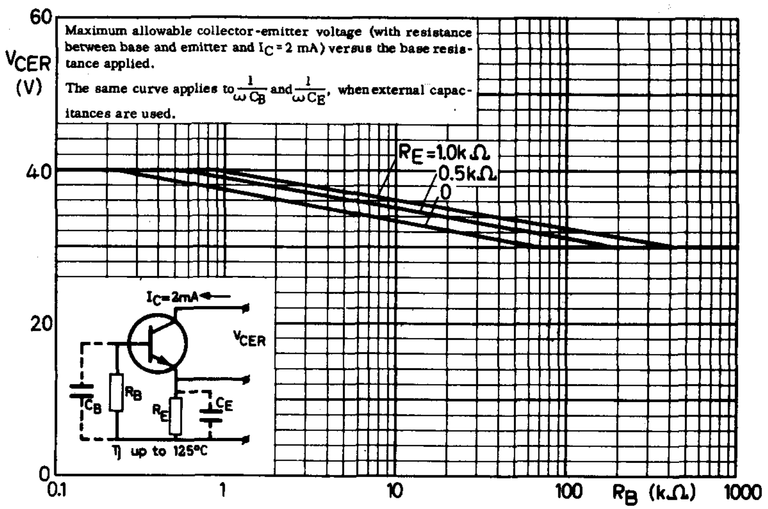


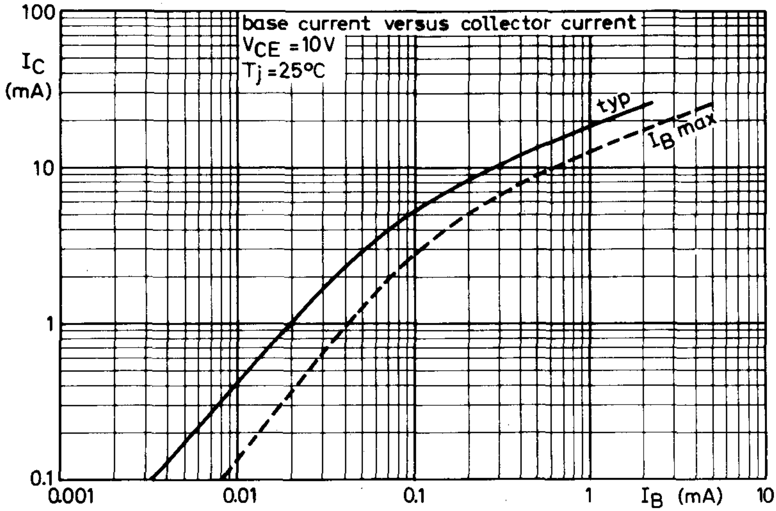
A: Maximum thickness of printed board = 1·7mm
Recommended hole diameter = 1·0 to 1·1 mm
(1·0 to 1·3 mm allowable)

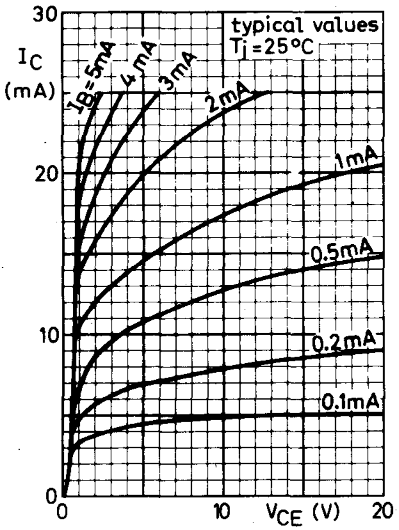
B: Maximum thickness of printed board = 1·1 mm
Hole diameter = 0·77 to 0·83 mm

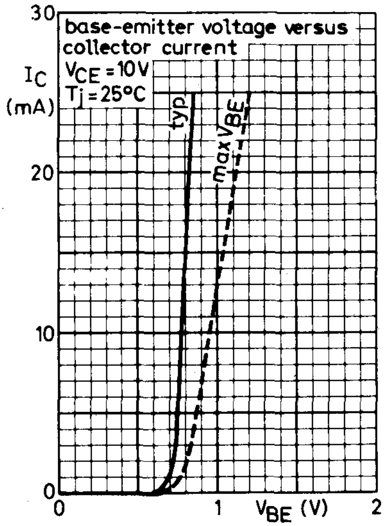
See also General Explanatory Notes, Section IV

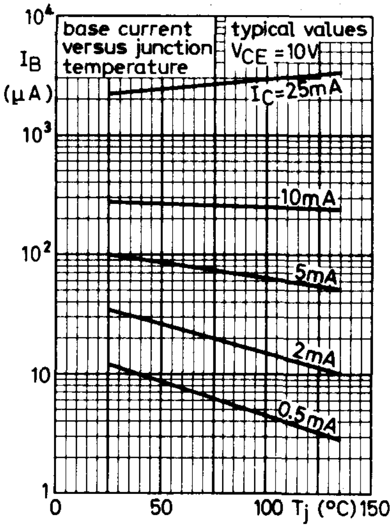

800
P_M
(mW)
600
400
200
0
max. allowable peak power versus time
Tamb = 25°C
50°C
25°C
0
20
40
60
80
100 time (s) 120

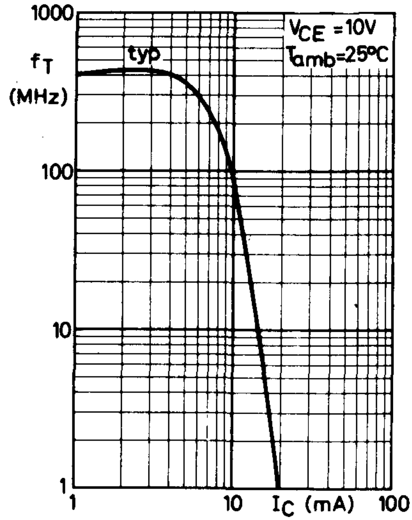

60
V_{CER}
(V)
40
20
0
Maximum allowable collector-emitter voltage (with resistance between base and emitter and I_C = 2 mA) versus the base resistance applied.
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$, when external capacitances are used.
R_E = 1.0kΩ
0.5kΩ
0
I_C = 2mA
V_{CER}
C_B
R_B
R_E
C_E
Tj up to 125°C
0.1
1
10
100
R_B (kΩ)
1000


base current versus collector current
VCE =10V
Tj =25°C
IC
(mA)
100
10
1
0.1
0.001
0.01
0.1
1
10
IB (mA)
typ
IB max


typical values
Tj =25°C
IC
(mA)
30
20
10
0
IB=5mA
4mA
3mA
2mA
1mA
0.5mA
0.2mA
0.1mA
10
VCE (V)
20


base-emitter voltage versus
collector current
VCE =10V
Tj =25°C
IC
(mA)
30
20
10
0
typ
max VBE
1
VBE (V)
2





EQUIVALENT GAIN CONTROL TRANSISTOR

When the BF196 is used in a gain controlled i.f. stage it is recommended to connect an optimum series base capacitor of 22pF and a bias resistor of 1kΩ (see fig. 1) to minimise the variation of input admittance and output conductance with gain control.

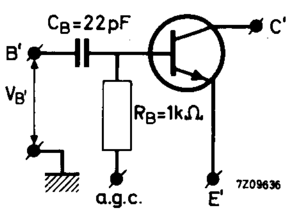
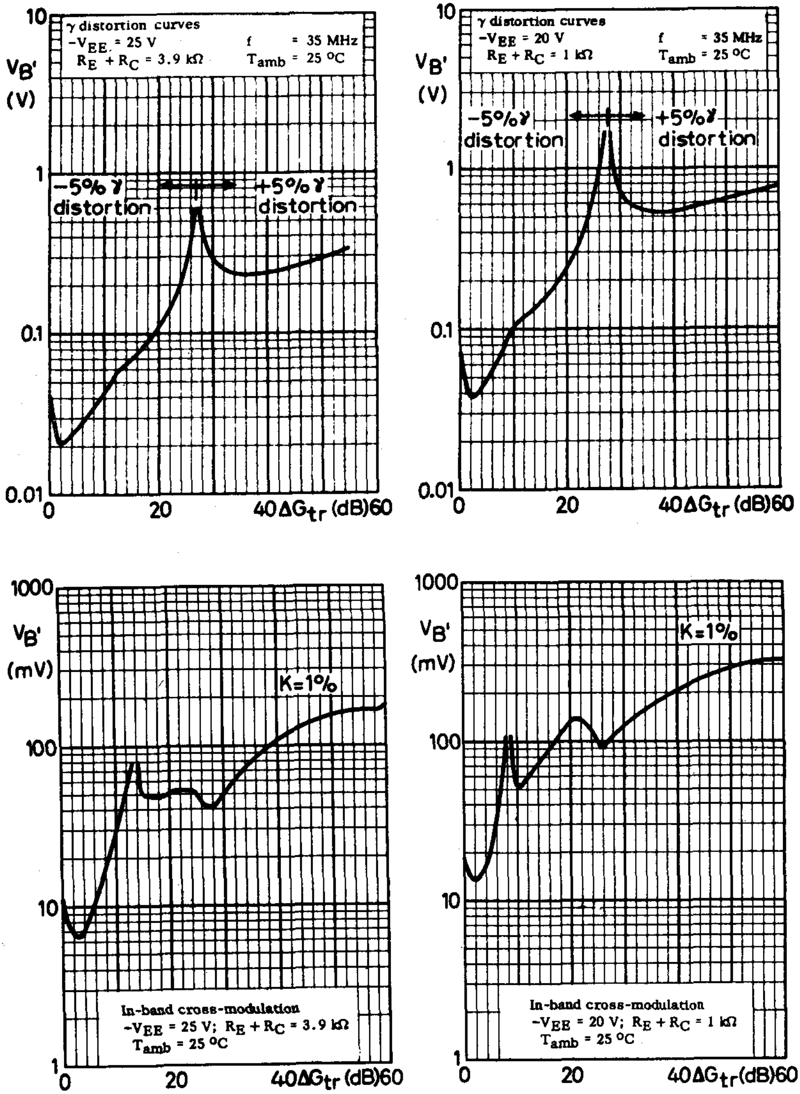


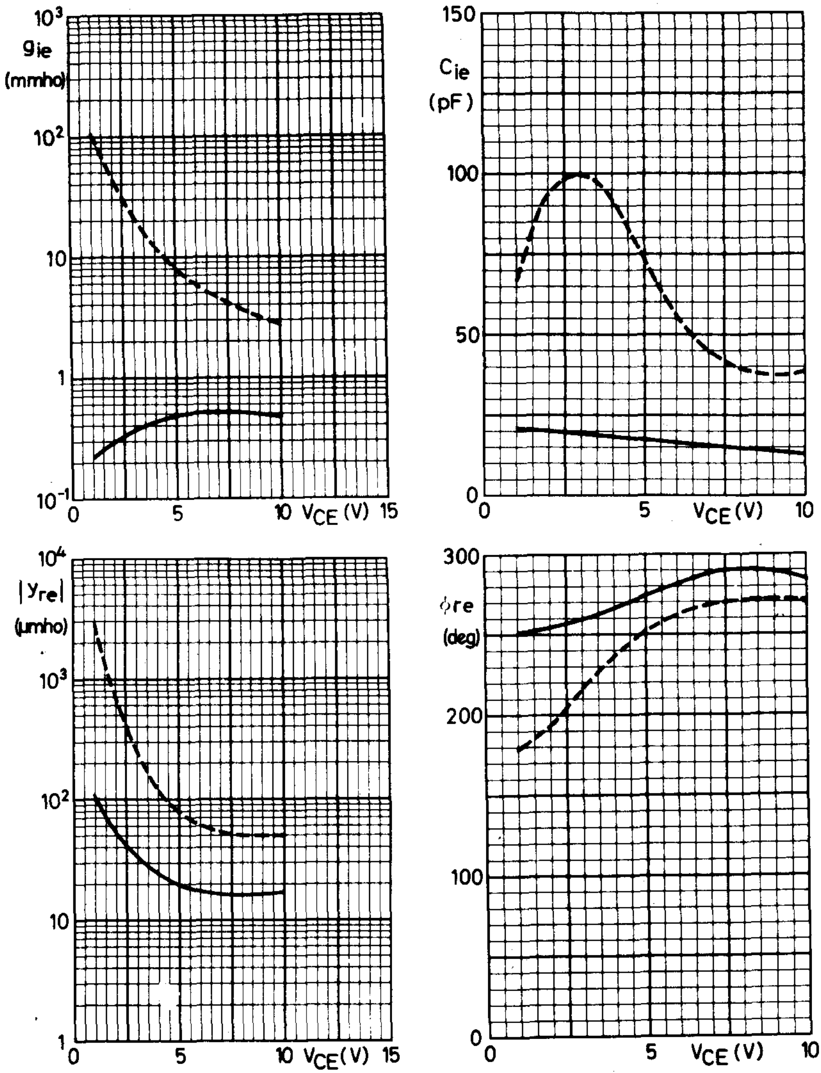
Fig. 1

The gain control performance of the BF196 is modified by these additional components and the combination is regarded as an 'equivalent transistor' (See the curves on pages 8 to 14)



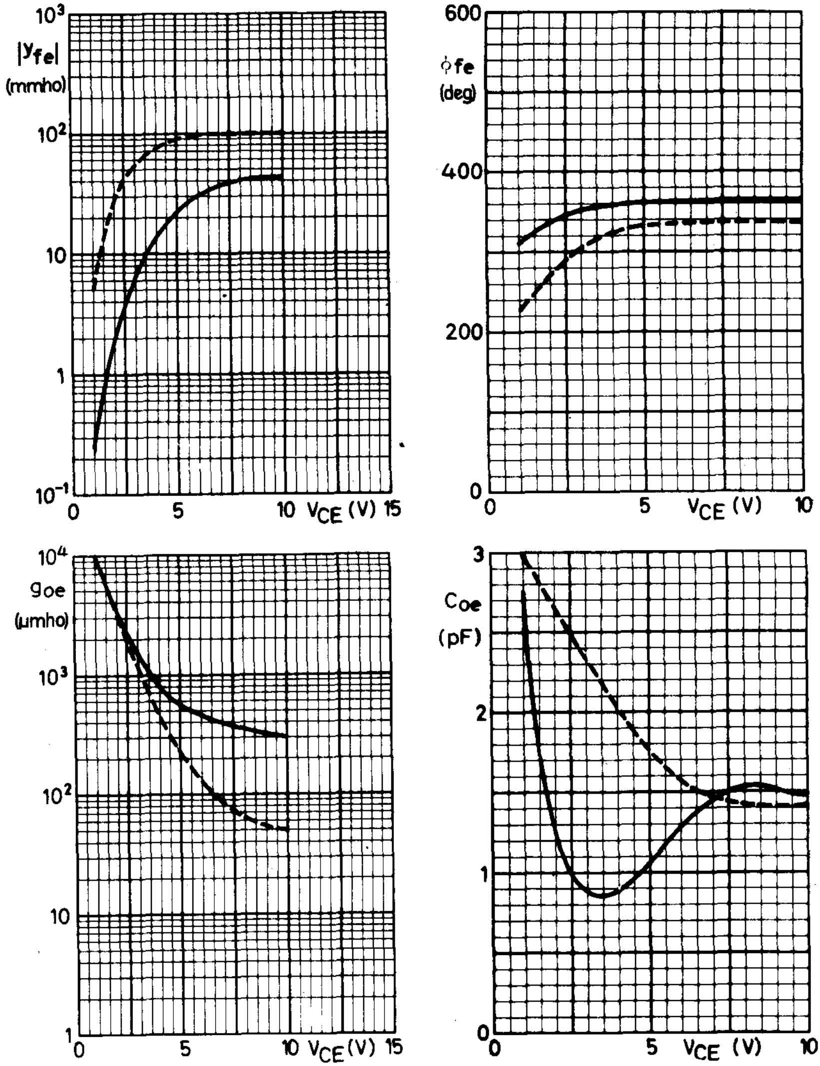
The signal handling capability of the equivalent transistor as a function of gain control.

Voltage control; $-V_{EE} = 25V$; $R_E + R_C = 3.9k\Omega$; $f = 35MHz$



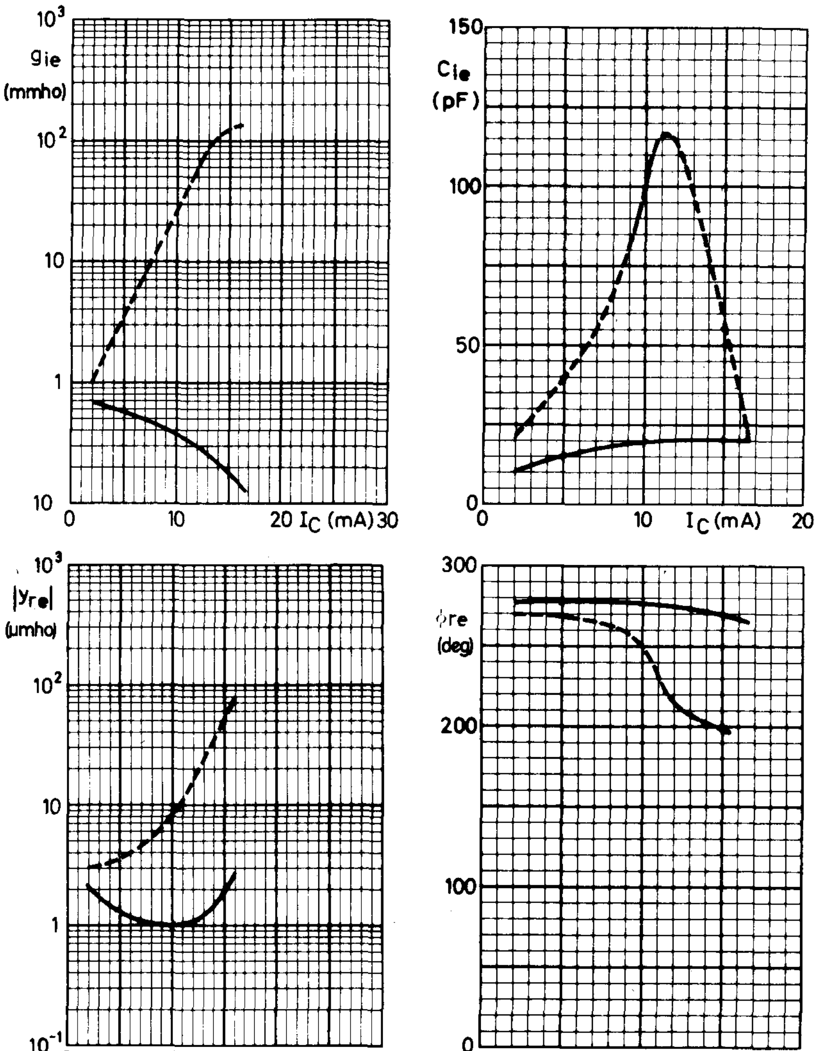
Typical y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on page 7 (dashed curves apply to the transistor only).

Voltage control; $-V_{EE} = 25V$; $R_E + R_C = 3{\cdot}9k\Omega$; $f = 35MHz$



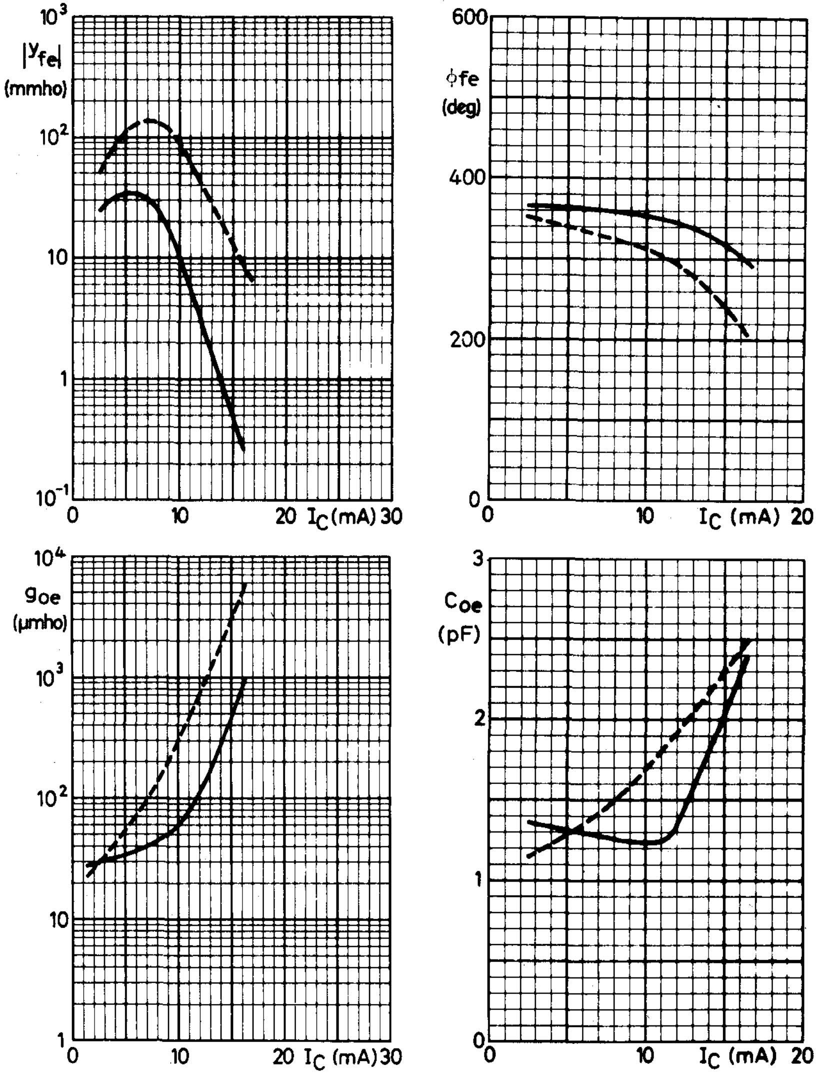
Typical y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on page 7 (dashed curves apply to the transistor only).

Current control; $-V_{EE} = 20V$; $R_E + R_C = 1k\Omega$; f = 35MHz



Typical y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on page 7 (dashed curves apply to the transistor only).

Current control; $-V_{EE} = 20V$; $R_E + R_C = 1k\Omega$; f = 35MHz

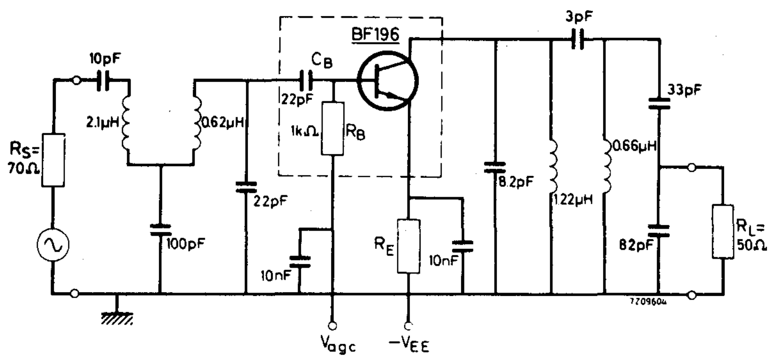


Typical y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on page 7 (dashed curves apply to the transistor only).

APPLICATION INFORMATION

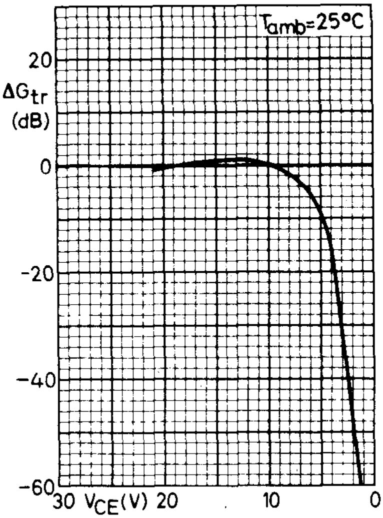
First stage of an i.f. amplifier

Basic circuit with voltage gain control: $R_E + R_C = 3{\cdot}9k\Omega$; $-V_{EE} = 25V$
current gain control: $R_E + R_C = 1k\Omega$; $-V_{EE} = 20V$

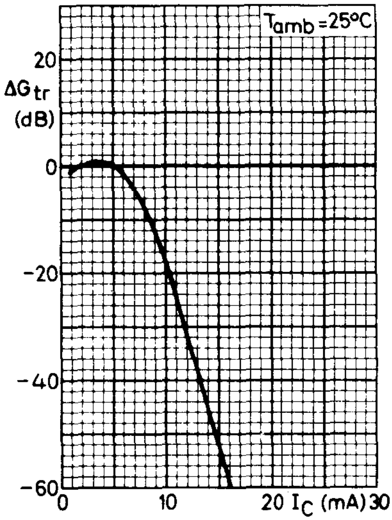


			Typ.	
G_{tr}	Transducer gain			
	$I_C = 4mA$, $-V_{EE} = 25V$, $R_E + R_C = 3{\cdot}9k\Omega$, $f = 36{\cdot}4MHz$		25·5	dB
	$G_{tr}\,(\text{in dB}) = 10\log\dfrac{\text{output power in load } R_L}{\text{available power from source } R_S}$			
ΔG_{tr}	Gain control range (see also the upper curves, page 14)		60	dB

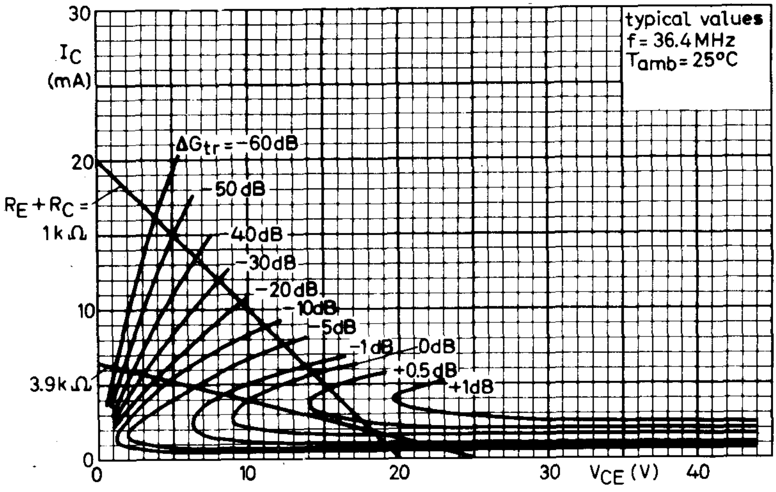
Voltage gain control
(In the circuit given on page 13)



Current gain control
(In the circuit given on page 13)



Curves of constant gain reduction
(In the circuit given on page 13)



N-P-N SILICON PLANAR TRANSISTOR

BF197

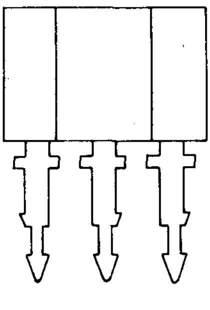
N-P-N silicon planar transistor in plastic encapsulation with three rigid self-locking strips suitable for insertion in printed circuit boards using standard grids. The transistor has a very low feedback capacitance and is primarily intended for use in the output stage of television video i.f. amplifiers.

QUICK REFERENCE DATA

V_{CBO} max.	40	V
V_{CEO} max.	25	V
I_C max.	25	mA
P_{tot} max. (T_{amb} = 25°C)	250	mW
T_j max.	125	°C
f_T typ. (I_C = 5mA, V_{CE} = 10V, f = 100MHz)	550	MHz
$-C_{re}$ typ. (I_C = 1mA, V_{CE} = 10V, f = 10·7MHz)	0·3	pF
G_{UM} typ. (I_C = 7mA, V_{CE} = 10V) f = 35MHz	43	dB
f = 45MHz	41	dB
Video detector output voltage, typ.	7·7	V

OUTLINE AND DIMENSIONS

For details see page 4



Front View
Scale 3:1

N.B. Devices in this Data Sheet should be ordered by the type number followed by Reference 0220.

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

V_{CBO} max.	40	V
V_{CEO} max. (see also page 5)	25	V
V_{EBO} max.	4.0	V
I_C max.	25	mA
I_{CM} max.	25	mA
P_{tot} max. (T_{amb} = 25°C)	250	mW

Temperature

T_{stg}	−65 to + 125	°C
T_j max.	125	°C

THERMAL CHARACTERISTIC

$R_{th(j-amb)}$ in free air	0·4	deg C/mW

ELECTRICAL CHARACTERISTICS (T_{amb} = 25°C)

		Min.	*Typ.*	*Max.*	
I_B	Base current				
	I_C = 7·0mA, V_{CE} = 10V	—	80	185	μA
V_{BE}	*Base-emitter voltage				
	I_C = 7·0mA, V_{CE} = 10V	—	750	900	mV
$-C_{re}$	Feedback capacitance				
	I_C = 1·0mA, V_{CE} = 10V, f = 10·7MHz	—	0·3	—	pF
f_T	Transition frequency				
	I_C = 5·0mA, V_{CE} = 10V, f = 100MHz	—	550	—	MHz

*V_{BE} decreases by about 1·7mV/degC with increasing temperature.

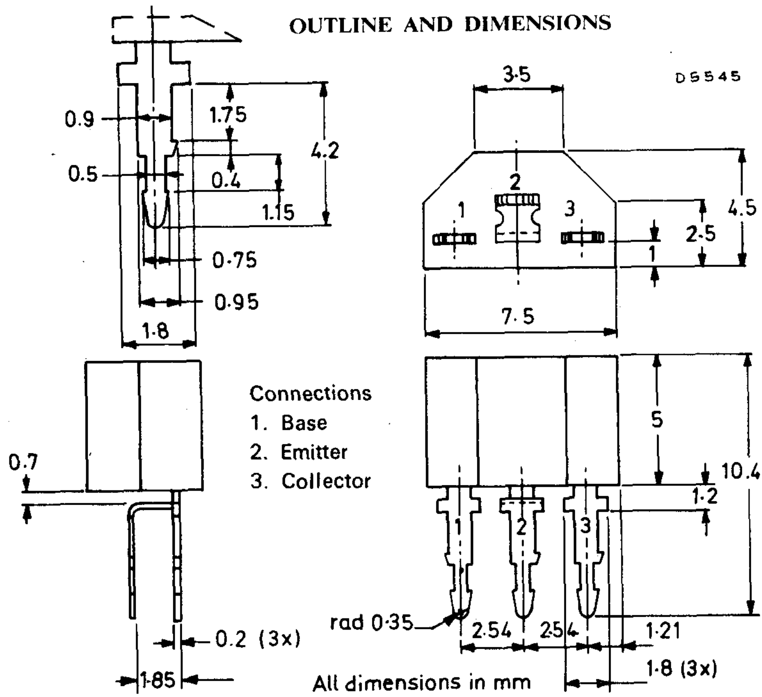
ELECTRICAL CHARACTERISTICS (*continued*)

Typical y-parameters (common emitter)

I_C = 7·0mA, V_{CE} = 10V (mounted as in the Mounting Details, 1.)

		f = 35	= 45	MHz
g_{ie}	Input conductance	4·5	5·5	mmho
C_{ie}	Input capacitance	45	45	pF
$\|y_{re}\|$	Feedback admittance	67	86	µmho
ϕ_{re}	Phase angle of feedback admittance	268	268	deg
$\|y_{fe}\|$	Transfer admittance	170	155	mmho
ϕ_{fe}	Phase angle of transfer admittance	338	335	deg
g_{oe}	Output conductance	85	95	µmho
C_{oe}	Output capacitance	1·8	1·8	pF
G_{UM}	Maximum unilateralised power gain			
	G_{UM} (in dB) = $10\log\frac{\|y_{fe}\|^2}{4g_{ie}g_{oe}}$			
	I_C = 7·0mA, V_{CE} = 10V	43	41	dB

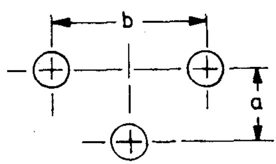
OUTLINE AND DIMENSIONS



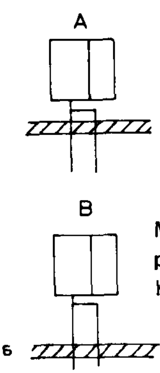
Connections
1. Base
2. Emitter
3. Collector

All dimensions in mm

MOUNTING DETAILS



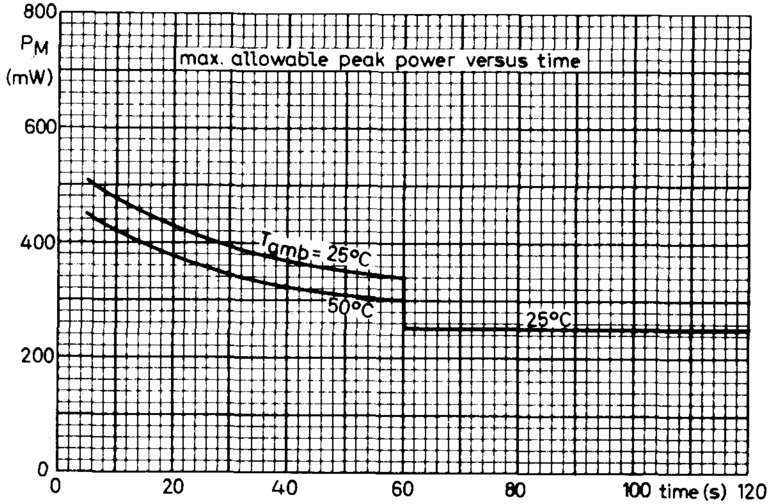
a = 2·49 to 2·59mm
b = 5·03 to 5·13mm



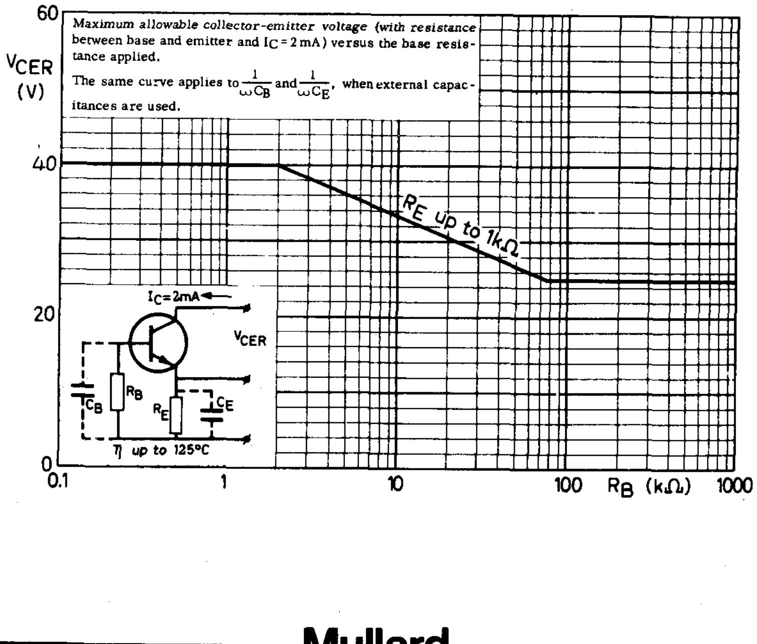
A: Maximum thickness of printed board = 1·7mm
Recommended hole diameter = 1·0 to 1·1 mm
(1·0 to 1·3 mm allowable)

B: Maximum thickness of printed board = 1·1 mm
Hole diameter = 0·77 to 0·83 mm

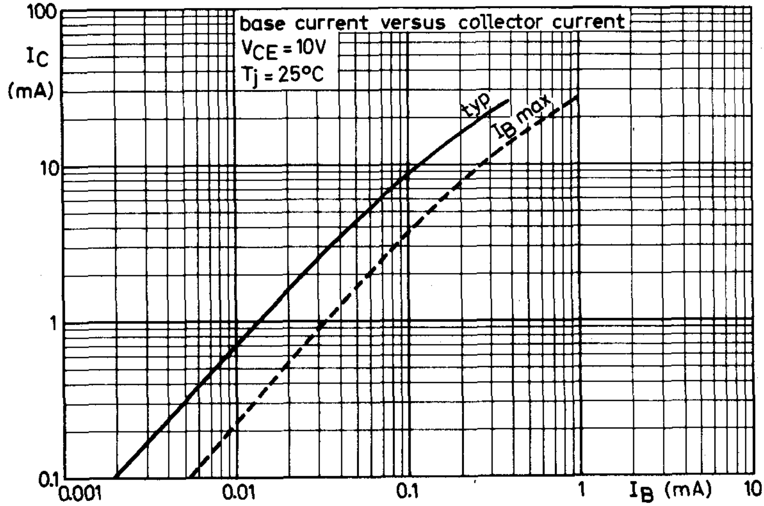
See also General Explanatory Notes, Section IV



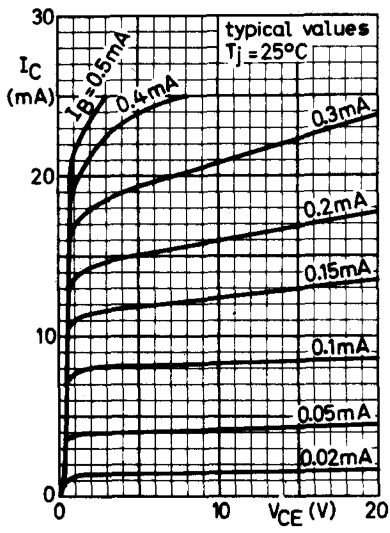
800
P_M (mW)
max. allowable peak power versus time
600
400
200
0
T_{amb} = 25°C
50°C
25°C
0
20
40
60
80
100 time (s) 120



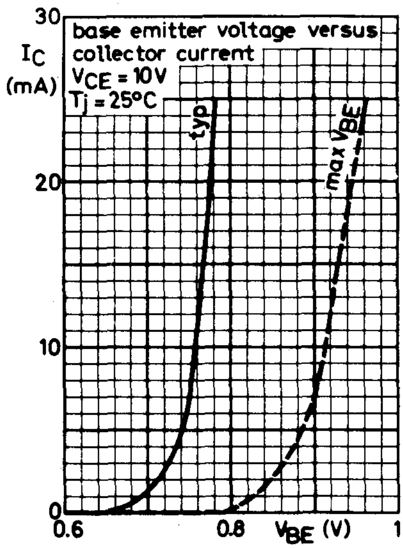
60
V_{CER} (V)
Maximum allowable collector-emitter voltage (with resistance between base and emitter and I_C = 2 mA) versus the base resistance applied.
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$, when external capacitances are used.
40
20
0
R_E up to 1kΩ
I_C=2mA
V_{CER}
C_B
R_B
R_E
C_E
Tj up to 125°C
0.1
1
10
100 R_B (kΩ) 1000



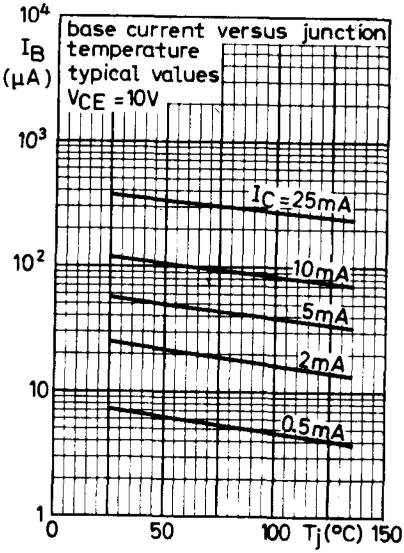
base current versus collector current
V_{CE} = 10V
T_j = 25°C
I_C (mA)
100
10
1
0.1
0.001
0.01
0.1
1
10
I_B (mA)
typ
I_B max

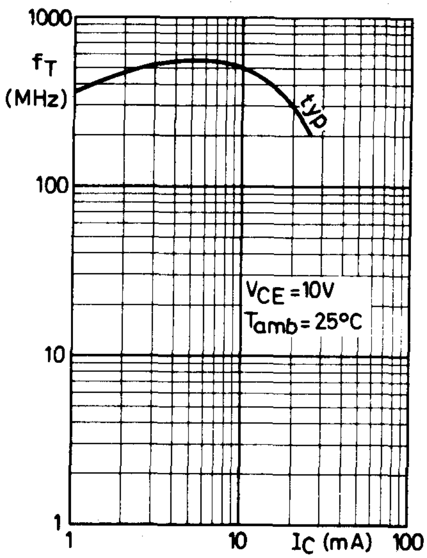


typical values
T_j = 25°C
I_C (mA)
30
20
10
0
I_B = 0.5mA
0.4mA
0.3mA
0.2mA
0.15mA
0.1mA
0.05mA
0.02mA
0
10
20
V_{CE} (V)



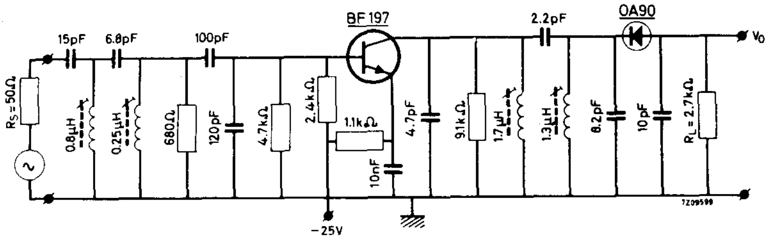
base emitter voltage versus collector current
V_{CE} = 10V
T_j = 25°C
I_C (mA)
30
20
10
0
typ
max V_{BE}
0.6
0.8
1
V_{BE} (V)


base current versus junction temperature
typical values
V_{CE} = 10V
10^4
I_B (μA)
10^3
10^2
10
1
I_C = 25mA
10mA
5mA
2mA
0.5mA
0
50
100
T_j (°C)
150


1000
f_T (MHz)
100
10
1
typ.
V_{CE} = 10V
T_{amb} = 25°C
1
10
I_C (mA)
100

APPLICATION INFORMATION

Output stage of a television video i.f. amplifier with the BF197 transistor followed by a video detector circuit.

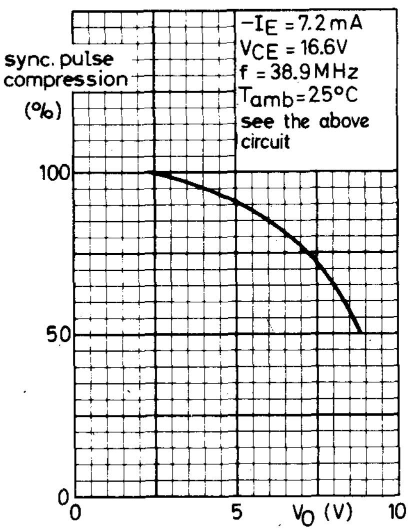


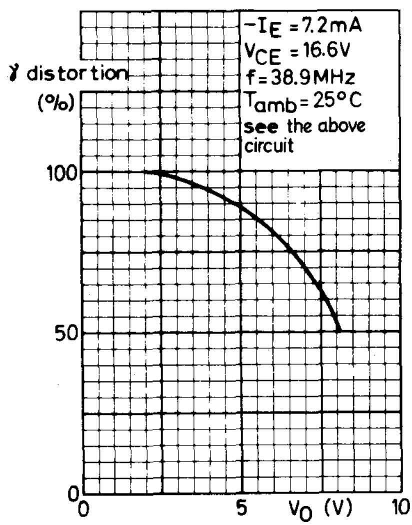
		Min.	Typ.	
†V_O	Video detector output voltage			
	I_C = 7·2mA, V_{CE} = 16·6V, f = 38·9MHz	6.0	7·7	V
G_{tr}	Transducer gain			
	I_C = 7·2mA, V_{CE} = 16·6V, f = 36·4MHz	—	25·5	dB

$$G_{tr}\,(\text{in dB}) = 10\log \frac{\text{output power in load } R_L}{\text{available power from source with } R_S}$$

Tuning frequency for all tuned circuits is 37MHz

†The output voltage V_O is defined as the voltage across the 2·7kΩ detector load R_L for 30% synchronisation pulse compression.





V.H.F. SILICON PLANAR N-P-N TRANSISTOR

BF200

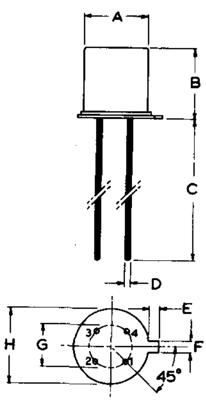
N-P-N silicon planar transistor in a TO-72 metal envelope with insulated electrodes and a shield lead connected to the case. The BF200 is primarily intended for application in a forward gain controlled pre-amplifier in v.h.f. television tuners and f.m. tuners.

QUICK REFERENCE DATA

V_{CBO} max.	30	V
V_{CEO} max.	20	V
I_C max.	20	mA
P_{tot} max. ($T_{amb} \leq 25^{\circ}C$)	150	mW
T_j max.	175	$^{\circ}C$
f_T min. ($-I_E = 2mA$, $V_{CB} = 10V$)	270	MHz
G_{UM} typ. ($-I_E = 3mA$, $V_{CB} = 10V$) f = 50MHz	30	dB
= 200MHz	22	dB
F typ. ($-I_E = 2mA$, $V_{CB} = 10V$, f = 100MHz)	2.0	dB
($-I_E = 3mA$, $V_{CB} = 10V$, f = 200MHz)	2.7	dB

OUTLINE AND DIMENSIONS

Conforming to B.S. 3934 SO-12A/SB4-3
J.E.D.E.C. TO-72



Viewed from underside

Millimetres

	Min.	Nom.	Max.
A	-	-	4.8
B	-	-	5.3
C	12.7	-	-
D	-	-	0.48
E	-	-	1.17
F	-	-	1.16
G	-	2.54	-
H	-	-	5.8

Connections 1. Emitter 3. Collector
2. Base 4. Shield connected to envelope

Accessories available: 56246, 56263

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

V_{CBO} max.	30	V
V_{CEO} max.	20	V
V_{CER} max. ($R_{BE} \leq 1k\Omega$)	30	V
V_{EBO} max.	3.0	V
I_C max. (d.c.)	20	mA
I_{CM} max. (peak)	20	mA
P_{tot} max. ($T_{amb} \leq 25^{o}C$)	150	mW

Temperature

T_{stg}	-65 to +175	^{o}C
T_j max.	175	^{o}C

THERMAL CHARACTERISTIC

$R_{th(j-amb)}$ (in free air)	1.0	degC/mW

ELECTRICAL CHARACTERISTICS ($T_{amb} = 25^{o}C$ unless otherwise stated)

		Min.	Typ.	Max.	
I_B	Base current				
	$-I_E = 3mA$, $V_{CB} = 10V$	-	100	200	μA
	$-I_E = 12mA$, $V_{CB} = 7V$	-	-	2.2	mA
$-V_{EB}$	Emitter-base voltage				
	$-I_E = 3mA$, $V_{CB} = 10V$	-	0.75	-	V
	$-I_E = 12mA$, $V_{CB} = 7V$	-	-	1.0	V
f_T	Transition frequency				
	$-I_E = 2mA$, $V_{CB} = 10V$	270	-	-	MHz
$-C_{re}$	Feedback capacitance				
	$I_C = 1mA$, $V_{CE} = 10V$, f = 10.7MHz	-	0.28	-	pF
F	Noise figure at optimum source admittance				
	$-I_E = 3mA$, $V_{CB} = 10V$, f = 50MHz	-	1.9	-	dB
	f = 200MHz	-	2.7	-	dB
	$-I_E = 2mA$, $V_{CB} = 10V$, f = 100MHz	-	2.0	-	dB

V.H.F. SILICON PLANAR N-P-N TRANSISTOR

BF200

ELECTRICAL CHARACTERISTICS (contd.)

			Min.	Typ.	Max.	
G_{UM}	*Maximum unilateralised power gain					

$$G_{UM} = \frac{|y_{fb}|^2}{4g_{ib}\, g_{ob}}$$

		Min.	Typ.	Max.	
$-I_E = 3mA$, $V_{CB} = 10V$, $f = 50MHz$		-	30	-	dB
	$f = 200MHz$	-	22	-	dB
$-I_E = 2mA$, $V_{CB} = 10V$, $f = 100MHz$		-	28	-	dB

Typical y-parameters (common emitter),

$I_C = 2mA$, $V_{CE} = 10V$

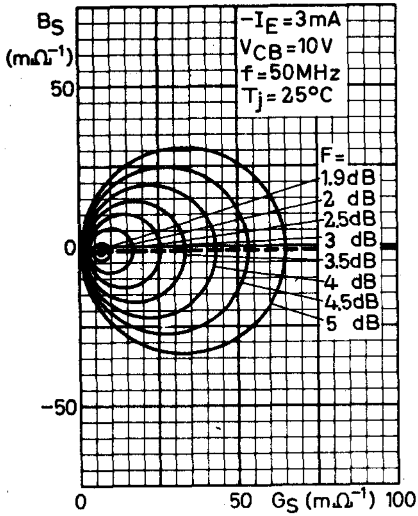
		f=100MHz	
g_{ie}	Input conductance	5.0	$m\Omega^{-1}$
C_{ie}	Input capacitance	16	pF
$\|y_{re}\|$	Feedback admittance	0.16	$m\Omega^{-1}$
ϕ_{re}	Phase angle of feedback admittance	270	deg
$\|y_{fe}\|$	Transfer admittance	56	$m\Omega^{-1}$
ϕ_{fe}	Phase angle of transfer admittance	340	deg
g_{oe}	Output conductance	15	$\mu\Omega^{-1}$
C_{oe}	Output capacitance	0.9	pF

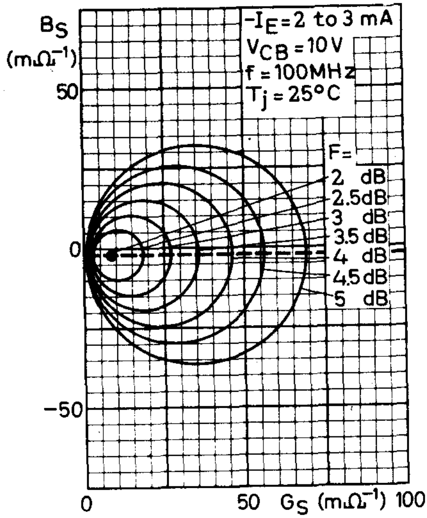
Typical y-parameters (common base)

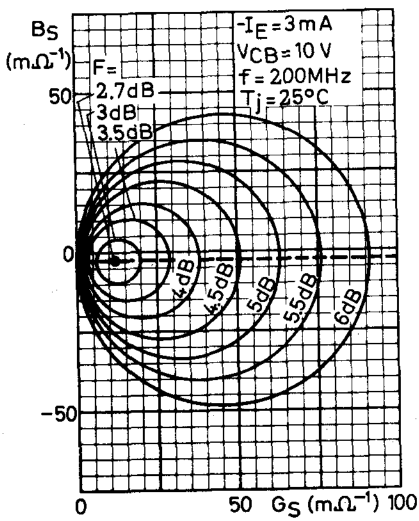
$-I_E = 3mA$, $V_{CB} = 10V$

		f=50MHz	=200MHz	
g_{ib}	Input conductance	85	62	$m\Omega^{-1}$
$-b_{ib}$	Input susceptance	15	38	$m\Omega^{-1}$
$\|y_{rb}\|$	Feedback admittance	55	180	$\mu\Omega^{-1}$
ϕ_{rb}	Phase angle of feedback admittance	270	270	deg
$\|y_{fb}\|$	Transfer admittance	85	70	$m\Omega^{-1}$
ϕ_{fb}	Phase angle of transfer admittance	165	145	deg
g_{ob}	Output conductance	15	150	$\mu\Omega^{-1}$
b_{ob}	Output susceptance	280	1100	$\mu\Omega^{-1}$

*Common base configuration, metal envelope connected directly to earth, external lead length = 3mm.

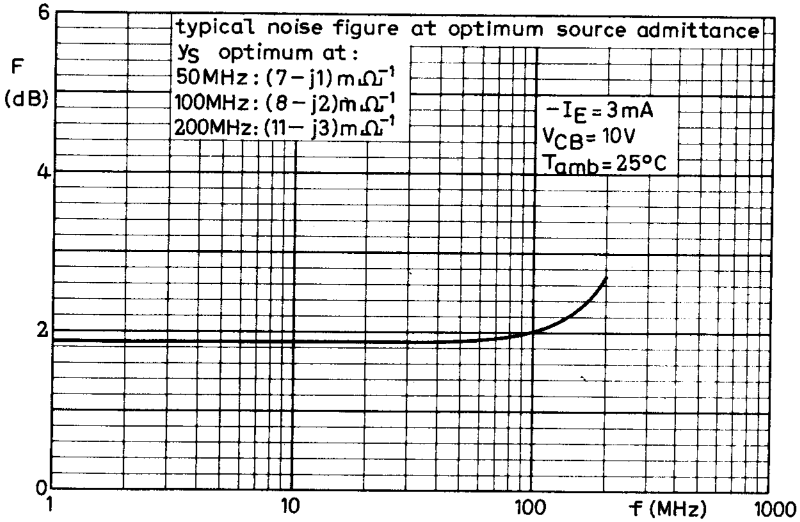

BS
(mΩ⁻¹)
50
0
−50
0
50 GS (mΩ⁻¹) 100
−IE = 3 mA
VCB = 10 V
f = 50 MHz
Tj = 25°C
F =
1.9 dB
2 dB
2.5 dB
3 dB
3.5 dB
4 dB
4.5 dB
5 dB

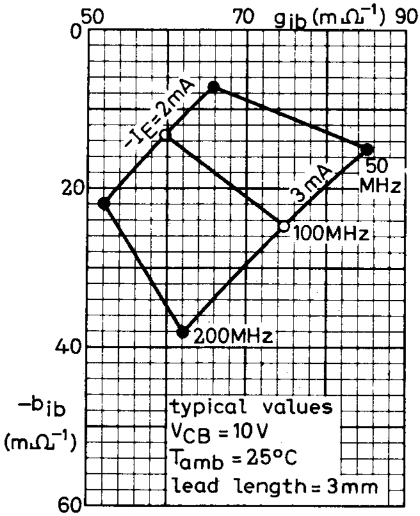

BS
(mΩ⁻¹)
50
0
−50
0
50 GS (mΩ⁻¹) 100
−IE = 2 to 3 mA
VCB = 10 V
f = 100 MHz
Tj = 25°C
F =
2 dB
2.5 dB
3 dB
3.5 dB
4 dB
4.5 dB
5 dB

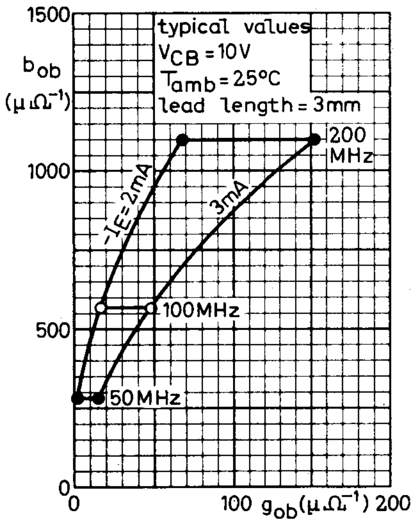

BS
(mΩ⁻¹)
50
0
−50
0
50 GS (mΩ⁻¹) 100
−IE = 3 mA
VCB = 10 V
f = 200 MHz
Tj = 25°C
F =
2.7 dB
3 dB
3.5 dB
4 dB
4.5 dB
5 dB
5.5 dB
6 dB

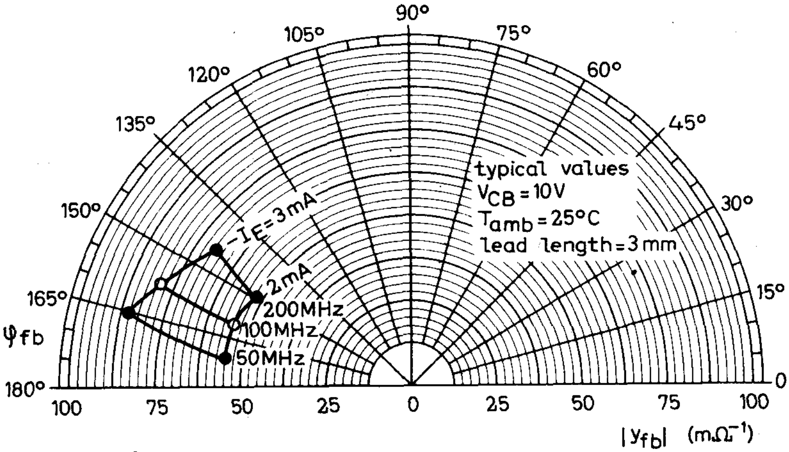
V.H.F. SILICON PLANAR N-P-N TRANSISTOR

BF200

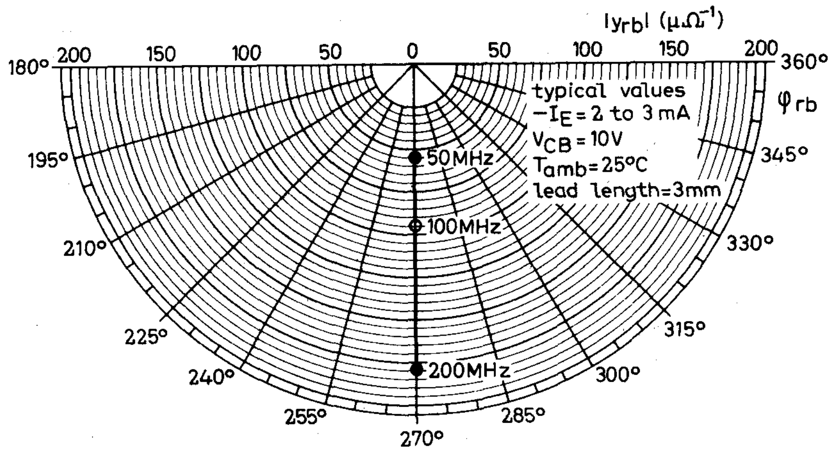




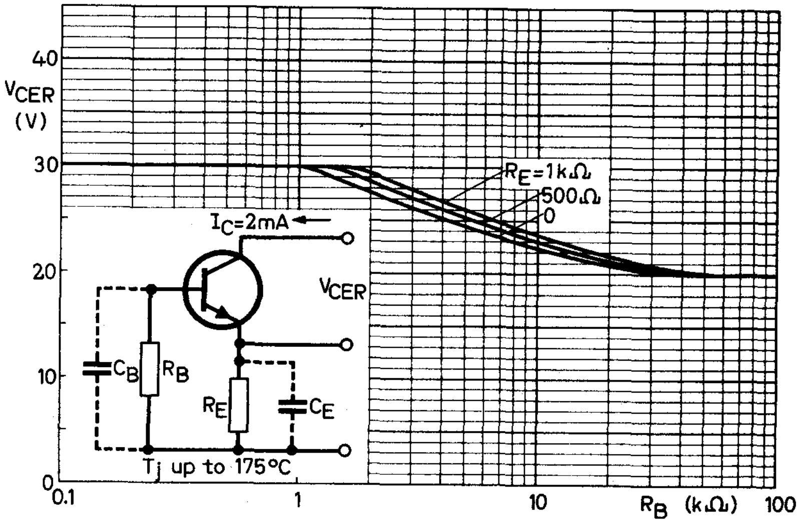




90°
105°
75°
120°
60°
135°
45°
150°
30°
165°
15°
180°
0
typical values
VCB = 10V
Tamb = 25°C
lead length = 3 mm
−IE = 3 mA
2 mA
200MHz
100MHz
50MHz
φfb
100
75
50
25
0
25
50
75
100
|yfb| (mΩ⁻¹)



|yrb| (μΩ⁻¹)
200
150
100
50
0
50
100
150
200
180°
360°
φrb
typical values
−IE = 2 to 3 mA
VCB = 10V
Tamb = 25°C
lead length = 3mm
50MHz
100MHz
200MHz
195°
345°
210°
330°
225°
315°
240°
300°
255°
285°
270°



Maximum permissible collector-emitter voltage (with resistance between base and emitter and I_C = 2mA) plotted against the base resistance applied.

The same curves apply to $\frac{1}{C_B}$ and $\frac{1}{C_E}$ when external capacitances are used.

N-CHANNEL SILICON FIELD EFFECT TRANSISTORS

BF245A BF245B BF245C

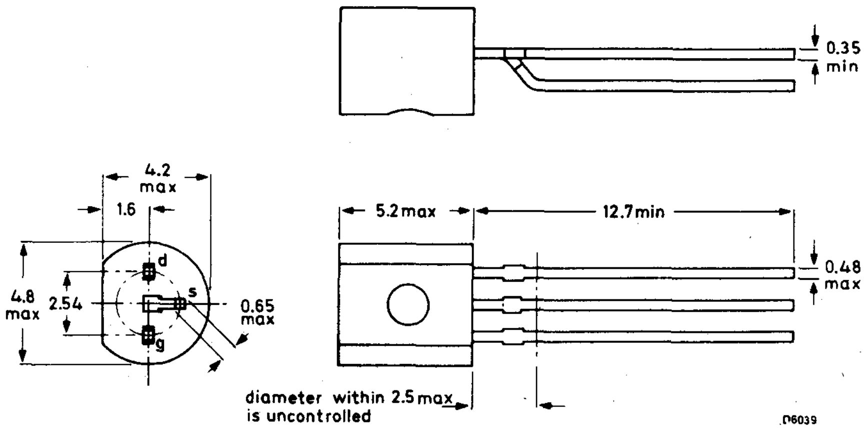
Symmetrical N-channel planar epitaxial junction field effect transistors in a plastic envelope. Intended for general purpose applications in l.f. and d.c. amplifiers, and in h.f. amplifiers.

QUICK REFERENCE DATA						
Drain-source voltage	$\pm V_{DS}$	max.	30			V
Gate-source voltage (open drain)	$-V_{GSO}$	max.	30			V
Total power dissipation up to $T_{amb} = 75^{o}C$	P_{tot}	max.	300			mW
			BF245A	B	C	
Drain current $V_{DS} = 15V$; $V_{GS} = 0$	I_{DSS}	>	2	6.0	12	mA
		<	6.5	15.0	25	mA
Gate-source cut-off voltage $I_D = 10nA$; $V_{DS} = 15V$	$-V_{(P)GS}$		0.5 to 8.0			V
Feedback capacitance at f = 1kHz $V_{DS} = 20V$; $-V_{GS} = 1V$; $T_{amb} = 25^{o}C$	C_{rs}	typ.	1.1			pF
Transfer admittance (common source) $V_{DS} = 15V$; $V_{GS} = 0$; f = 1kHz; $T_{amb} = 25^{o}C$	$\|y_{fs}\|$		3.0 to 6.5			mA/V

MECHANICAL DATA

Dimensions in mm

Similar to J.E.D.E.C. TO-92



RATINGS

Limiting values of operation according to the absolute maximum system.

Voltages				
Drain-source voltage	$\pm V_{DS}$	max.	30	V
Drain-gate voltage (open source)	V_{DGO}	max.	30	V
Gate-source voltage (open drain)	$-V_{GSO}$	max.	30	V
Currents				
Drain current	I_D	max.	25	mA
Gate current	I_G	max.	10	mA
Power dissipation				
Power dissipation up to $T_{amb} = 75^{o}C$	P_{tot}	max.	300	mW
up to $T_{amb} = 90^{o}C$	P_{tot}	max.	300	mW*
Temperatures				
Storage temperature	T_{stg}	-65 to +150		^{o}C
Junction temperature	T_j	max.	150	^{o}C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th(j-amb)}$	=	0.25	$^{o}C/mW$
From junction to ambient	$R_{th(j-amb)}$	=	0.20	$^{o}C/mW$*

* Transistor mounted on printed circuit board, max. lead length 3mm, mounting pad for drain lead minimum 10mm x 10mm.

N-CHANNEL SILICON FIELD EFFECT TRANSISTORS

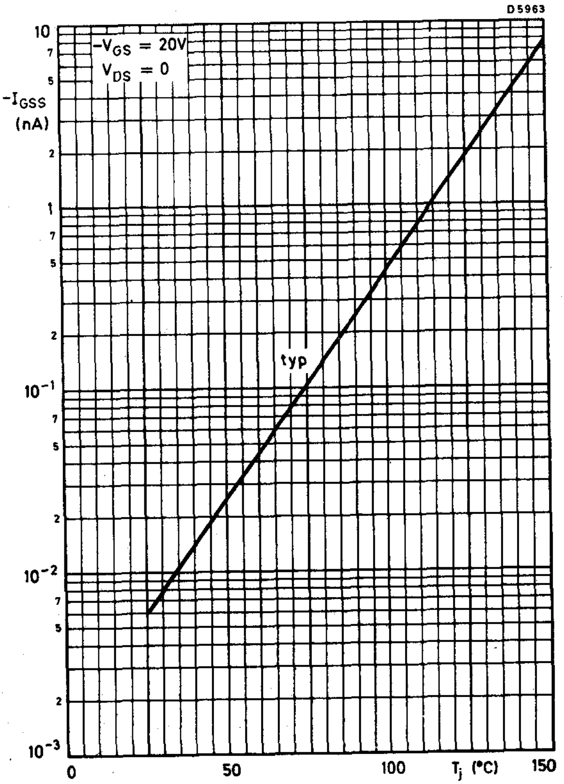
BF245A BF245B BF245C

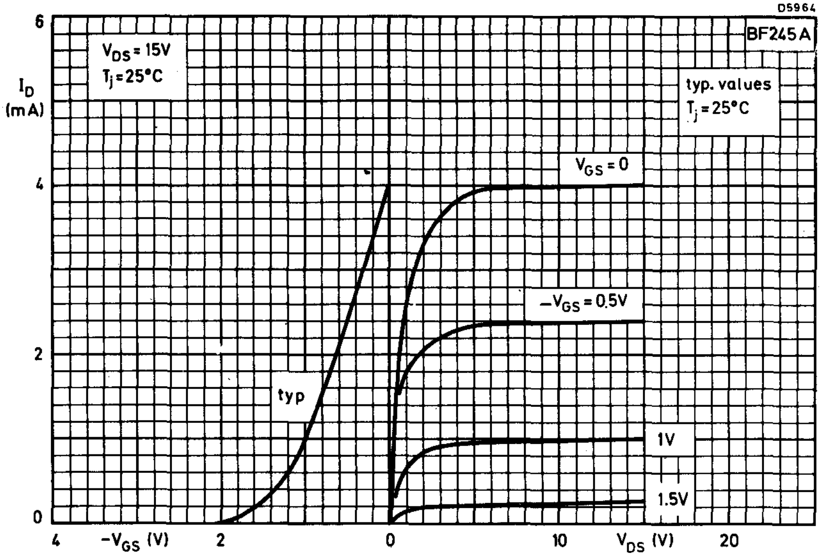
CHARACTERISTICS ($T_j = 25^oC$ unless otherwise specified

			BF245A	B	C	
Gate cut-off current						
$-V_{GS} = 20V;\ V_{DS} = 0$		$-I_{GSS}$	<5	5	5	nA
$-V_{GS} = 20V;\ V_{DS} = 0;\ T_j = 125^oC$		$-I_{GSS}$	<0.5	0.5	0.5	μA
Drain current [1]						
$V_{DS} = 15V;\ V_{GS} = 0$		I_{DSS}	>2	6.0	12	mA
			<6.5	15.0	25	mA
Gate-source breakdown voltage						
$-I_G = 1\mu A;\ V_{DS} = 0$		$-V_{(BR)GSS}$	>30	30	30	V
Gate-source voltage						
$I_D = 200\mu A;\ V_{DS} = 15V$		$-V_{GS}$	>0.4	1.6	3.2	V
			<2.2	3.8	7.5	V
Gate-source cut-off voltage						
$I_D = 10nA;\ V_{DS} = 15V$		$-V_{(P)GS}$		0.5 to 8.0		V
y-parameters at $T_{amb} = 25^oC$ (common source)						
$V_{DS} = 15V;\ V_{GS} = 0$						
f = 1kHz	Transfer admittance	$\lvert y_{fs} \rvert$		3.0 to 6.5		mA/V
	Output admittance	$\lvert y_{os} \rvert$	typ.	25		μA/V
f = 200MHz	Input conductance	g_{is}	typ.	250		μA/V
	Reverse transfer admittance	$\lvert y_{rs} \rvert$	typ.	1.4		mA/V
	Transfer admittance	$\lvert y_{fs} \rvert$	typ.	6		mA/V
	Output conductance	g_{os}	typ.	40		μA/V
$V_{DS} = 20V;\ -V_{GS} = 1V$						
f = 1MHz	Input capacitance	C_{is}	typ.	4.0		pF
	Feedback capacitance	C_{rs}	typ.	1.1		pF
	Output capacitance	C_{os}	typ.	1.6		pF
Cut-off frequency [2]						
$V_{DS} = 15V;\ V_{GS} = 0$		f_{gfs}	typ.	700		MHz
Noise figure at f = 100MHz; $R_G = 1k\Omega$ (common source)						
$V_{DS} = 15V;\ V_{GS} = 0;\ T_{amb} = 25^oC$ input tuned to minimum noise		N	typ.	1.5		dB

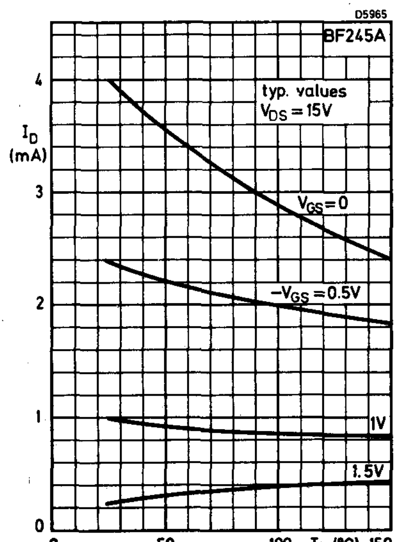
1) Measured under pulse condition: $t_p = 300\mu s;\ d \leq 0.02$

2) The frequency at which g_{fs} is 0.7 of its value at 1kHz.

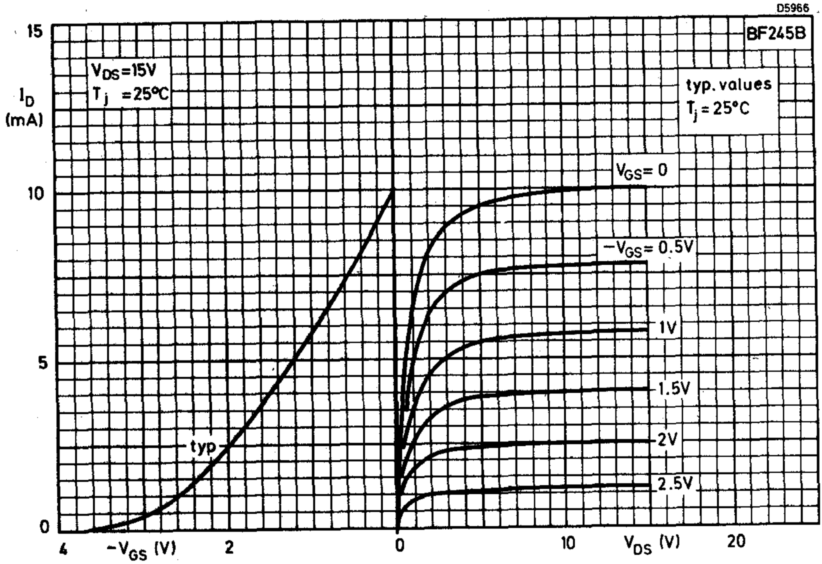

D5963
$-V_{GS}$ = 20V
V_{DS} = 0
$-I_{GSS}$ (nA)
typ
T_j (°C)
10
10^{-1}
10^{-2}
10^{-3}
0
50
100
150

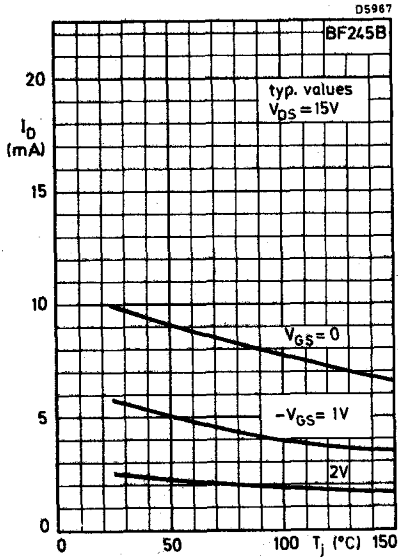


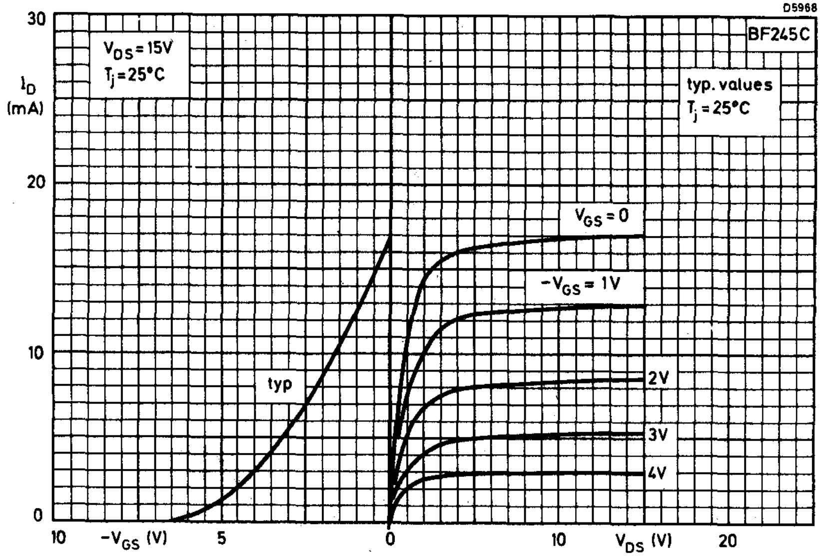
D5964
BF245A
V_{DS} = 15V
T_j = 25°C
I_D (mA)
typ. values
T_j = 25°C
V_{GS} = 0
$-V_{GS}$ = 0.5V
typ
1V
1.5V
6
4
2
0
4
$-V_{GS}$ (V)
2
0
10
V_{DS} (V)
20



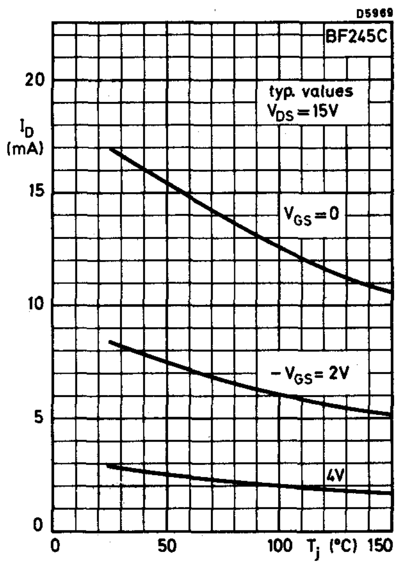
D5965
BF245A
typ. values
V_{DS} = 15V
I_D (mA)
V_{GS} = 0
$-V_{GS}$ = 0.5V
1V
1.5V
4
3
2
1
0
0
50
100
T_j (°C)
150


D5966
BF245B
15
10
5
0
I_D (mA)
V_{DS}=15V
T_j =25°C
typ. values
T_j = 25°C
V_{GS}= 0
$-V_{GS}$= 0.5V
1V
1.5V
2V
2.5V
typ
4
$-V_{GS}$ (V)
2
0
10
V_{DS} (V)
20

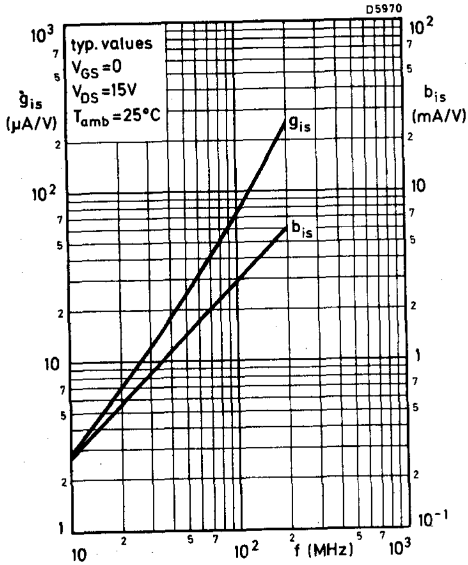

D5967
BF245B
20
15
10
5
0
I_D (mA)
typ. values
V_{DS} = 15V
V_{GS}= 0
$-V_{GS}$= 1V
2V
0
50
100
T_j (°C)
150

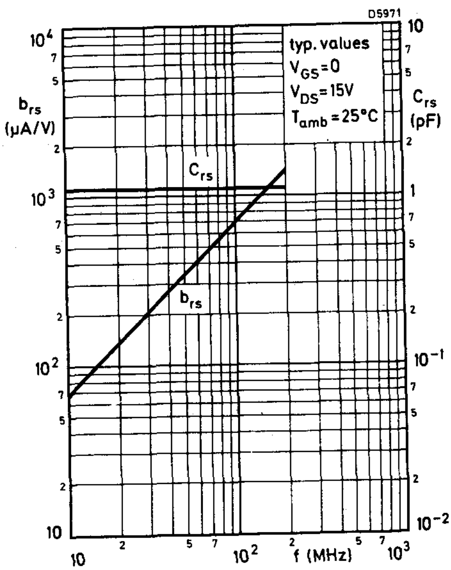


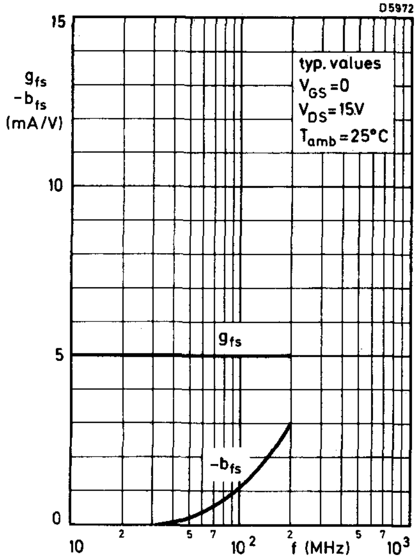
D5968
BF245C
V_{DS} = 15V
T_j = 25°C
I_D (mA)
typ. values
T_j = 25°C
V_{GS} = 0
$-V_{GS}$ = 1V
2V
3V
4V
typ
30
20
10
0
10
$-V_{GS}$ (V)
5
0
10
V_{DS} (V)
20



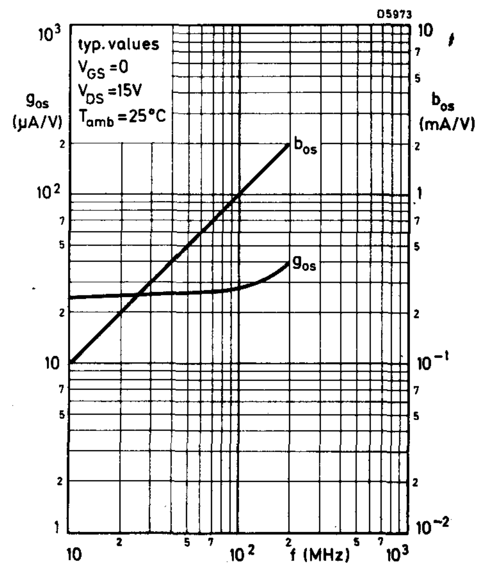
D5969
BF245C
typ. values
V_{DS} = 15V
I_D (mA)
V_{GS} = 0
$-V_{GS}$ = 2V
4V
20
15
10
5
0
0
50
100
T_j (°C)
150


D5970
typ. values
$V_{GS}=0$
$V_{DS}=15V$
$T_{amb}=25°C$
g_{is} (µA/V)
b_{is} (mA/V)
g_{is}
b_{is}
f (MHz)

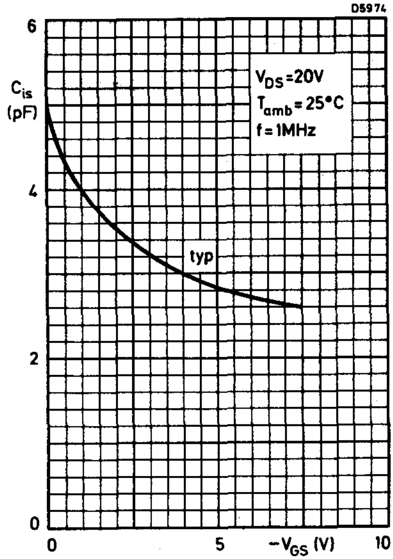

D5971
typ. values
$V_{GS}=0$
$V_{DS}=15V$
$T_{amb}=25°C$
b_{rs} (µA/V)
C_{rs} (pF)
C_{rs}
b_{rs}
f (MHz)

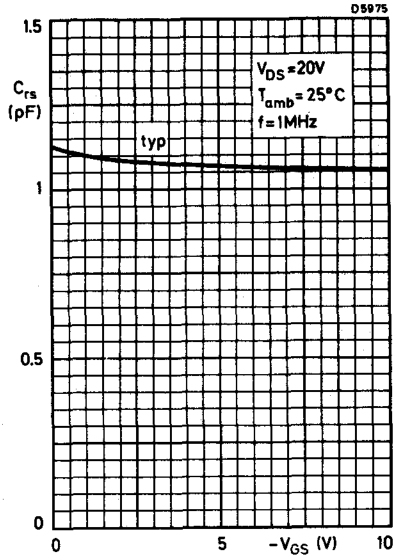


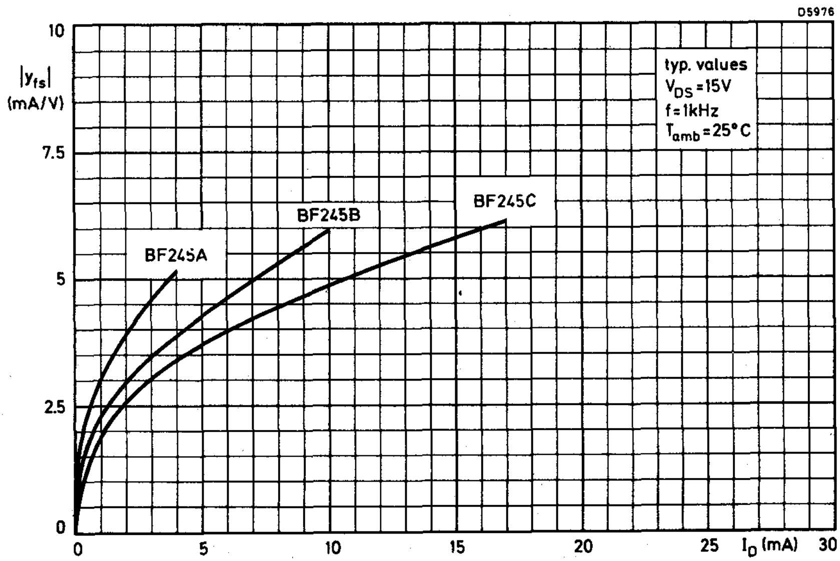
D5972
15
10
5
0
gfs
-bfs
(mA/V)
typ. values
VGS =0
VDS=15V
Tamb=25°C
gfs
-bfs
10
2
5
7
10 2
2
f (MHz)
5
7
10 3



D5973
10 3
2
10 2
7
5
2
10
7
5
2
1
gos
(µA/V)
typ. values
VGS =0
VDS =15V
Tamb =25°C
bos
gos
10
7
5
2
1
7
5
2
10 -1
7
5
2
10 -2
bos
(mA/V)
10
2
5
7
10 2
2
f (MHz)
5
7
10 3


D5974
6
4
2
0
C_{is}
(pF)
V_{DS}=20V
T_{amb}=25°C
f=1MHz
typ
0
5
$-V_{GS}$ (V)
10

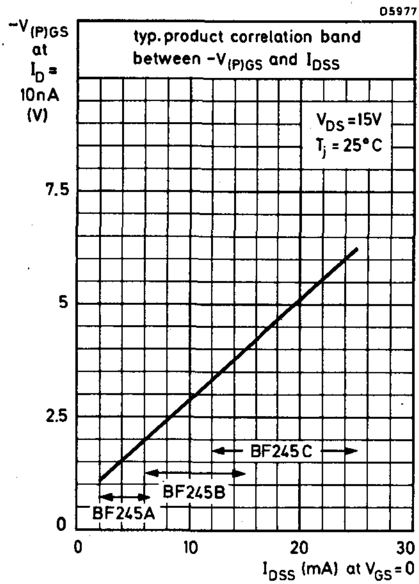

D5975
1.5
1
0.5
0
C_{rs}
(pF)
V_{DS}=20V
T_{amb}=25°C
f=1MHz
typ
0
5
$-V_{GS}$ (V)
10

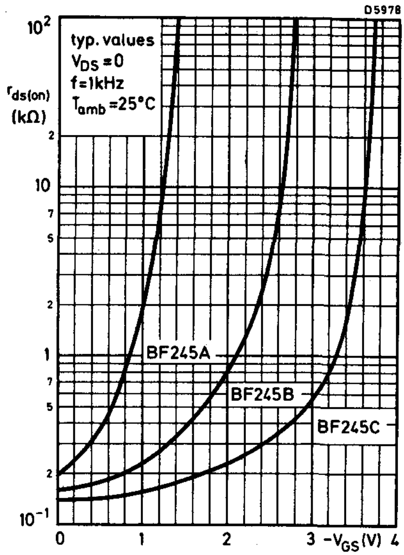

D5976
10
7.5
5
2.5
0
$|y_{fs}|$
(mA/V)
typ. values
V_{DS}=15V
f=1kHz
T_{amb}=25°C
BF245A
BF245B
BF245C
0
5
10
15
20
25
I_D (mA)
30

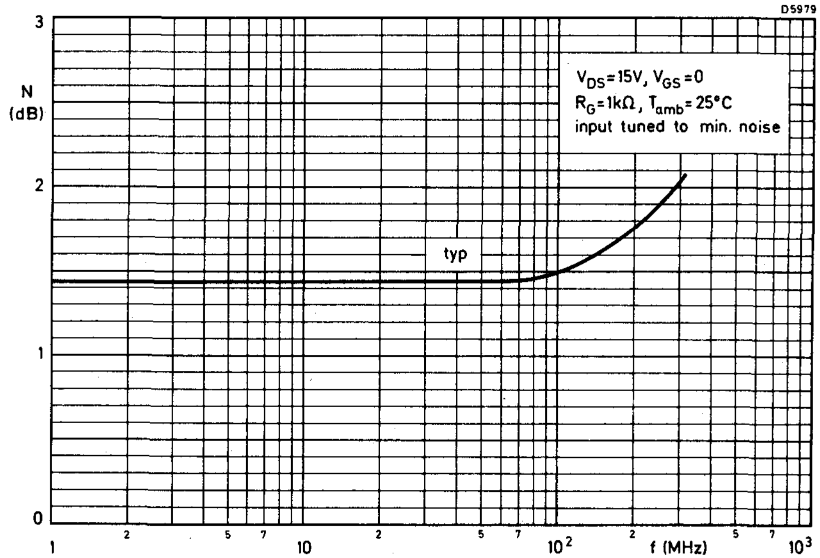
Mullard

N-CHANNEL SILICON FIELD EFFECT TRANSISTORS

BF245A
BF245B
BF245C







P-N-P SILICON PLANAR EPITAXIAL H.F. TRANSISTOR

BF324

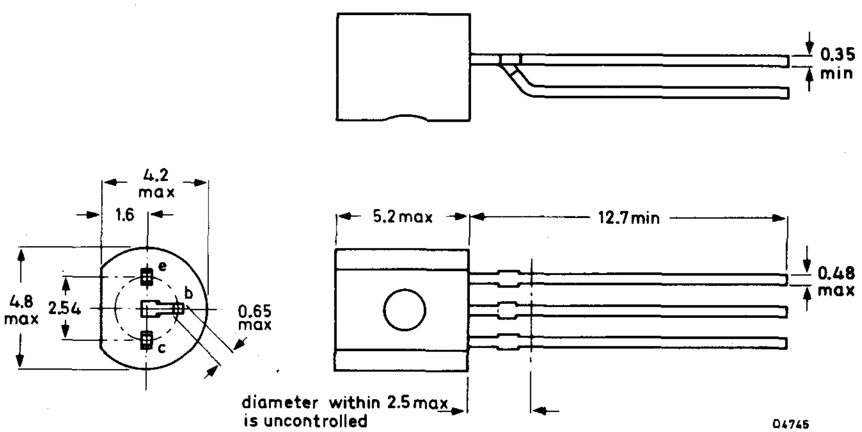
P-N-P transistor in a plastic envelope primarily intended for use in r.f. stages of f.m. tuners.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	30	V
Collector current (d.c.)	$-I_C$	max.	25	mA
Total power dissipation up to $T_{amb} = 45^\circ C$	P_{tot}	max.	250	mW
Junction temperature	T_j	max.	150	$^\circ C$
Base current $-I_C = 4mA$; $-V_{CE} = 10V$	$-I_B$	typ.	80	μA
		<	160	μA
Transition frequency $-I_C = 4mA$; $-V_{CE} = 10V$	f_T	typ.	550	MHz
Noise figure at f = 100MHz $-I_C = 2mA$; $-V_{CE} = 10V$; $G_S = 16.7mA/V$	N	typ.	3	dB
Feedback capacitance at f = 1MHz $V_{EB} = 0$; $-V_{CB} = 10V$	$-C_{rb}$	typ.	0.1	pF

MECHANICAL DATA

Dimensions in mm

Similar to: J.E.D.E.C. TO-92



Mullard

RATINGS

Limiting values of operation according to the absolute maximum system.

Voltages				
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	30	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	4	V
Current				
Collector current (d.c.)	$-I_C$	max.	25	mA
Power dissipation				
Total power dissipation up to $T_{amb} = 45^oC$	P_{tot}	max.	250	mW
Temperatures				
Storage temperature	T_{stg}		-55 to + 150	^oC
Junction temperature	T_j	max.	150	^oC

THERMAL RESISTANCE

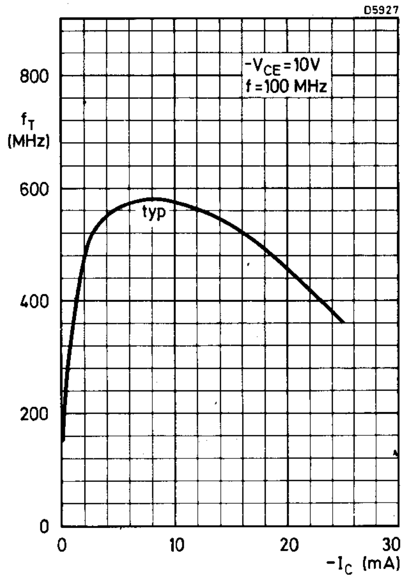
From junction to ambient in free air	$R_{th(j-amb)}$ =	0.42	$^oC/mW$

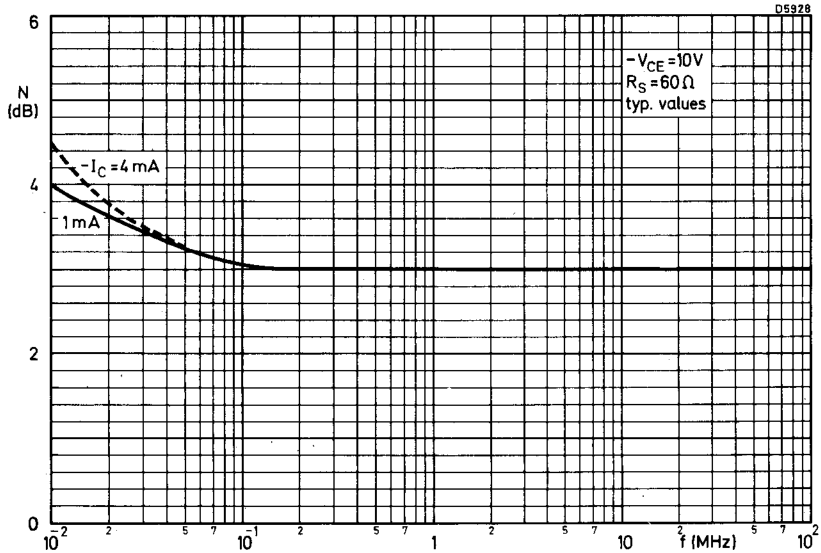
P-N-P SILICON PLANAR EPITAXIAL H.F. TRANSISTOR

BF324

CHARACTERISTICS ($T_j = 25^oC$)

Collector cut-off current				
$I_E = 0$; $-V_{CB} = 30V$	$-I_{CBO}$	<	50	nA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 4V$	$-I_{EBO}$	<	10	µA
Base current				
$-I_C = 4mA$; $-V_{CE} = 10V$	$-I_B$	typ. <	80 160	µA µA
$-I_C = 1mA$; $-V_{CE} = 10V$	$-I_B$	typ.	22	µA
Transition frequency at f = 100MHz				
$-I_C = 1mA$; $-V_{CE} = 10V$	f_T	typ.	380	MHz
$-I_C = 4mA$; $-V_{CE} = 10V$	f_T	typ.	550	MHz
$-I_C = 8mA$; $-V_{CE} = 10V$	f_T	typ.	580	MHz
Feedback capacitance at f = 1MHz				
$V_{EB} = 0$; $-V_{CB} = 10V$	$-C_{rb}$	typ.	0.1	pF
Noise factor at f = 100MHz				
$-I_C = 2mA$; $-V_{CE} = 10V$; $G_S = 16.7mA/V$	N	typ.	3	dB
$-I_C = 5mA$; $-V_{CE} = 10V$; $G_S = 6.7mA/V$; $-jB_S = 5mA/V$	N	typ.	3.5	dB
y-parameters (common base) at f = 100MHz				
$-I_C = 4mA$; $-V_{CB} = 10V$				
Input conductance	g_{ib}	typ.	110	mA/V
Input capacitance	$-C_{ib}$	typ.	64	pF
Transfer admittance	$\lvert y_{fb} \rvert$	typ.	100	mA/V
Phase angle of transfer admittance	φ_{fb}	typ.	150^o	
Output conductance	g_{ob}	typ.	40	µA/V
Output capacitance	C_{ob}	typ.	1.6	pF


D5927
800
600
400
200
0
f_T (MHz)
$-V_{CE}$ = 10V
f = 100 MHz
typ
0
10
20
30
$-I_C$ (mA)


D5928
6
4
2
0
N (dB)
$-V_{CE}$ = 10V
R_S = 60 Ω
typ. values
$-I_C$ = 4 mA
1 mA
10^{-2}
10^{-1}
1
10
10^2
f (MHz)

Mullard

N-P-N SILICON PLANAR TRANSISTORS

BF336 BF337 BF338

N-P-N silicon planar transistors intended for use in R-G-B and colour difference output circuits for colour television receivers.

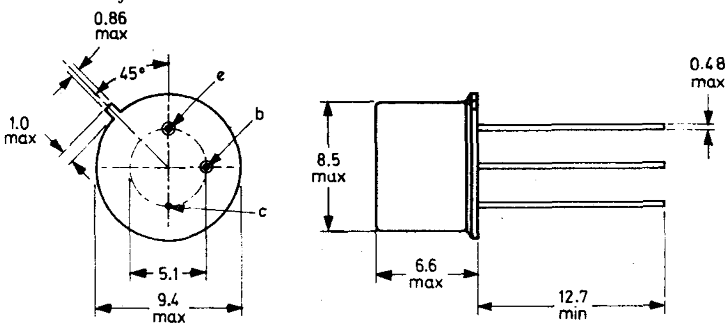
QUICK REFERENCE DATA

	BF336	BF337	BF338	
V_{CBO} max.	185	250	300	V
V_{CEO} max.	180	200	225	V
I_C max.		100		mA
P_{tot} max. $T_{mb} \leq 140^{o}C$		3.0		W
T_j max.		200		^{o}C
h_{FE} min.				
$I_C = 30mA,\ V_{CE} = 10V,\ T_j = 25^{o}C$		20		
f_T min.				
$I_C = 30mA,\ V_{CE} = 20V$		80		MHz
$-C_{re}$ max.				
$I_C = 10mA,\ V_{CE} = 20V,\ f = 0.5MHz$		3.5		pF

Unless otherwise stated information is applicable to all types

OUTLINE AND DIMENSIONS

Conforms to BS 3934 SO-3/SB3-3B
J.E.D.E.C. TO-39



All dimensions in mm D1574

Collector connected to case, max. lead diameter is guaranteed only for 12.7min.
Accessories available: - 56218, 56245, 56265

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

	BF336	BF337	BF338	
V_{CBO} max.	185	250	300	V
V_{CEO} max. (I_C = 4mA)	180	200	225	V
V_{CER} max. ($R_{BE} \leq 1k\Omega$, I_C = 1mA, $T_j \leq 150^oC$)	185	250	300	V
V_{EBO} max. (I_E = 0.1mA)		5.0		V
I_C max. (continuous)		100		mA
I_{BM} max. (peak)		20		mA
P_{tot} max. $T_{mb} \leq 140^oC$		3.0		W

Temperature

T_{stg}	-65 to +200	^oC
T_j max.	+200	^oC

THERMAL CHARACTERISTICS

$R_{th(j-amb)}$	220	degC/W
$R_{th(j-mb)}$	20	degC/W
$R_{th(j-case)}$	25	degC/W

ELECTRICAL CHARACTERISTICS (T_j = 25^oC unless otherwise stated)

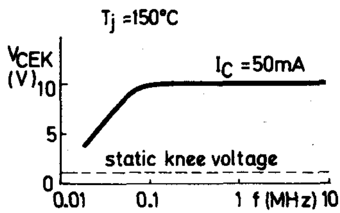
			Min.	Typ.	Max.	
I_{CER}	Collector cut-off current V_{CE} = 150V, R_{BE} = 1kΩ	BF336	-	10n	100μ	A
	V_{CE} = 200V, R_{BE} = 1kΩ	BF337	-	10n	100μ	A
	V_{CE} = 250V, R_{BE} = 1kΩ	BF338	-	10n	100μ	A

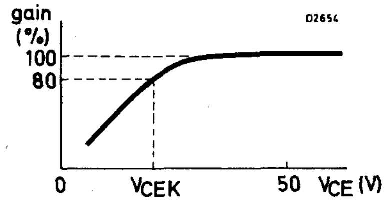
N-P-N SILICON PLANAR TRANSISTORS

BF336 BF337 BF338

ELECTRICAL CHARACTERISTICS (contd.)

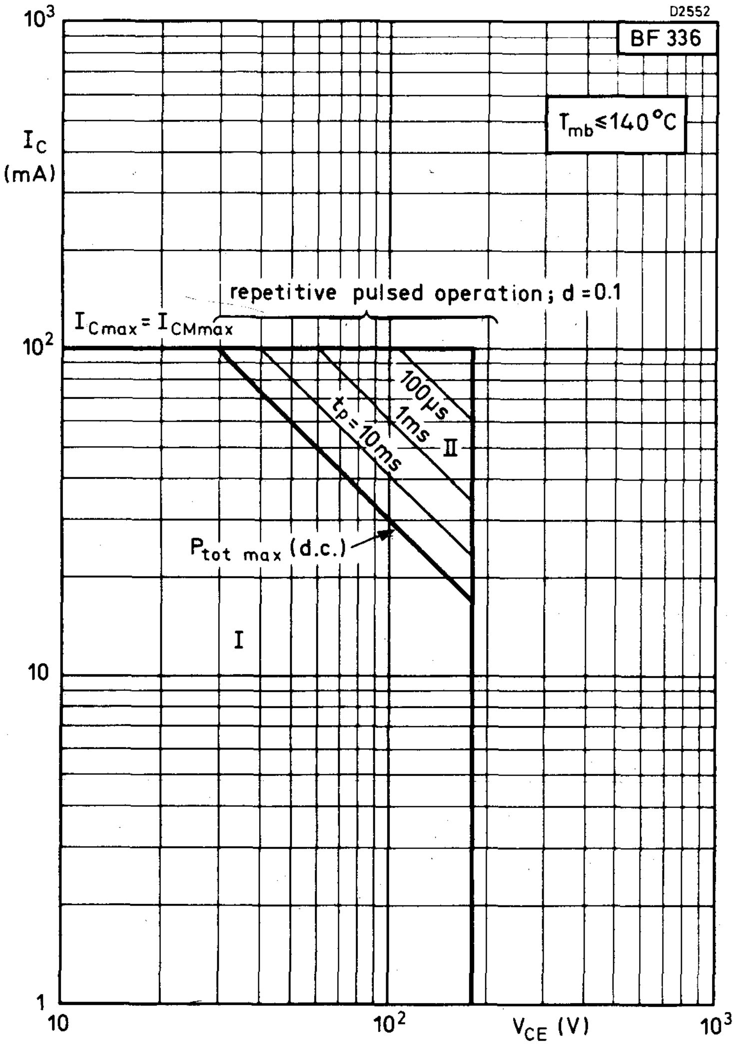
		Min.	Typ.	Max.	
h_{FE}	Static forward current transfer ratio $I_C = 30mA$, $V_{CE} = 10V$	20	60	-	
V_{BE}	Base-emitter voltage $I_C = 30mA$, $V_{CE} = 10V$	-	0.7	1.2	V
V_{CEK}	High-frequency knee voltage $I_C = 50mA$, $T_j = 150^oC$	-	10	-	V





The high-frequency knee voltage of a transistor is that value of the collector-emitter voltage at which the small signal gain, measured in a practical circuit has dropped to 80% of the gain at $V_{CE} = 50V$. A further decrease of the collector-emitter voltage results in a rapid increase of the distortion of the signal.

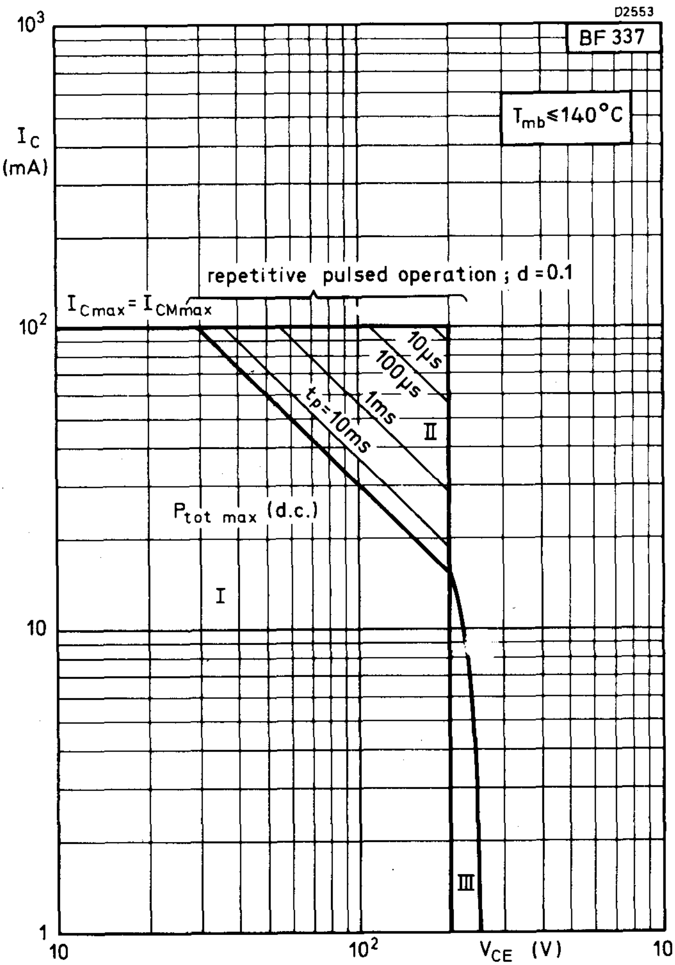
		Min.	Typ.	Max.	
$-C_{re}$	Feedback capacitance $I_C = 10mA$, $V_{CE} = 20V$, $f = 0.5MHz$	-	3.0	3.5	pF
$r_{bb'}C_{b'c}$	Feedback time constant $-I_E = 30mA$, $V_{CB} = 20V$, $f = 10MHz$	-	30	100	ps
f_T	Transition frequency $I_C = 30mA$, $V_{CE} = 20V$, $f = 100MHz$	80	130	-	MHz



Safe Operating Areas with the transistor forward biased

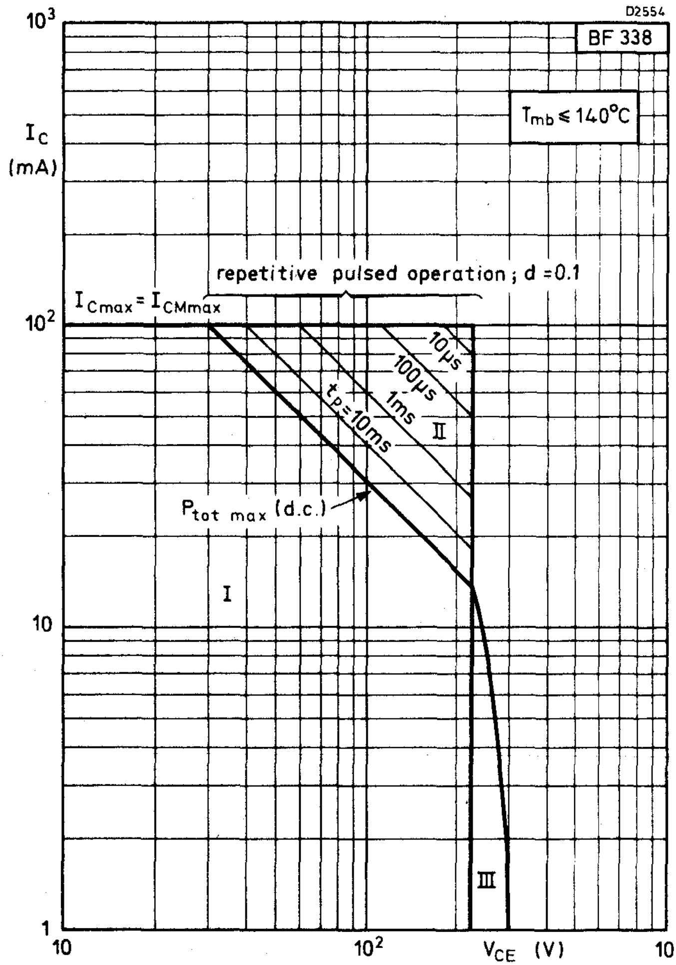
I Region of permissible d. c. operation

II Permissible extension for repetitive pulsed operation



Safe Operating Areas with the transistor forward biased

- I Region of permissible d. c. operation
- II Permissible extension for repetitive pulses operation
- III Repetitive pulsed operation in this region is permitted, provided that $R_{BE} \leq 1k\Omega$

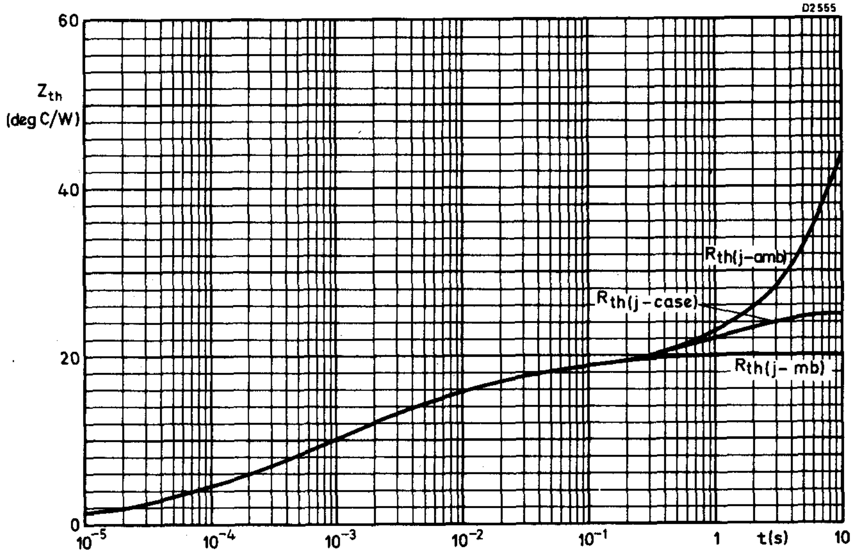


Safe Operating Areas with the transistor forward biased

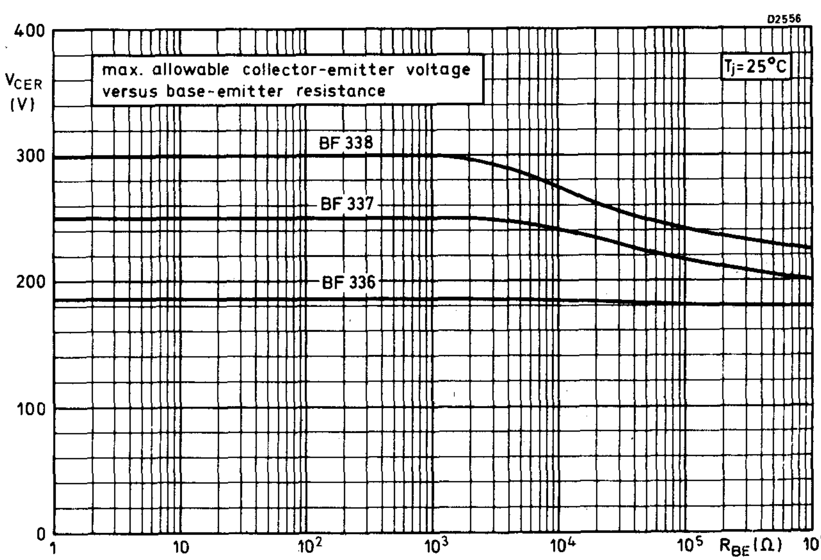
I Region of permissible d.c. operation

II Permissible extension for repetitive pulses operation

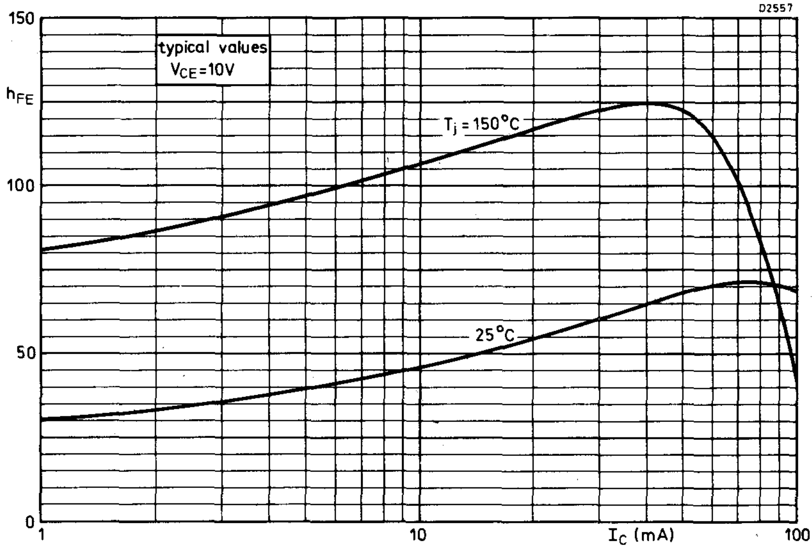
III Repetitive pulsed operation in this region is permitted, provided that $R_{BE} \leq 1k\Omega$

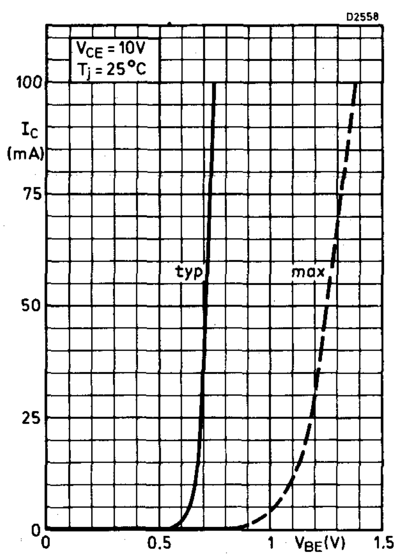


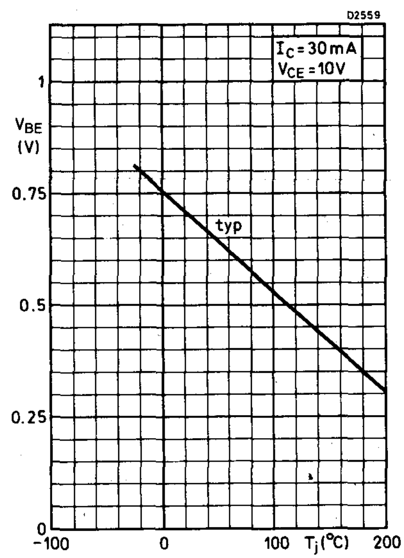
D2555
60
Z_{th}
(deg C/W)
40
20
0
$R_{th(j-amb)}$
$R_{th(j-case)}$
$R_{th(j-mb)}$
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
t(s)
10



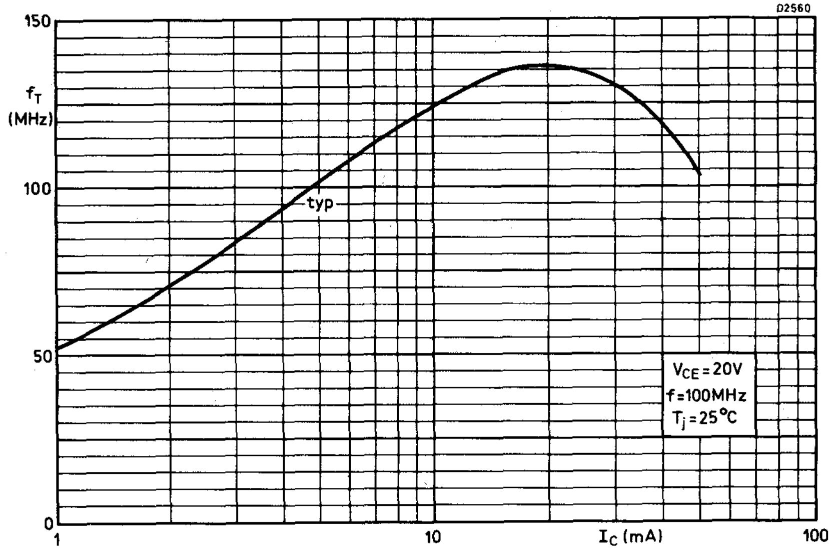
D2556
400
V_{CER}
(V)
300
200
100
0
max. allowable collector-emitter voltage
versus base-emitter resistance
$T_j = 25°C$
BF 338
BF 337
BF 336
1
10
10^2
10^3
10^4
10^5
R_{BE} (Ω)
10^6

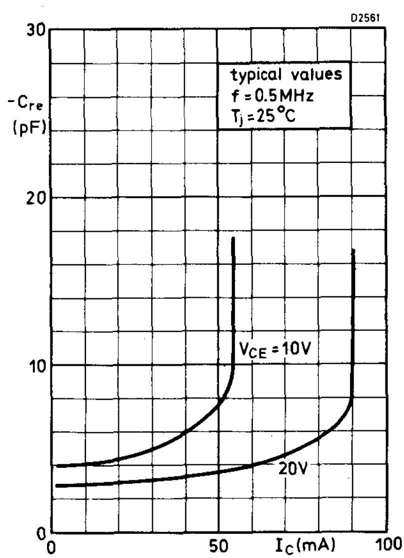

D2557
typical values
V_{CE}=10V
h_{FE}
150
100
50
0
T_j = 150°C
25°C
1
10
I_C (mA)
100

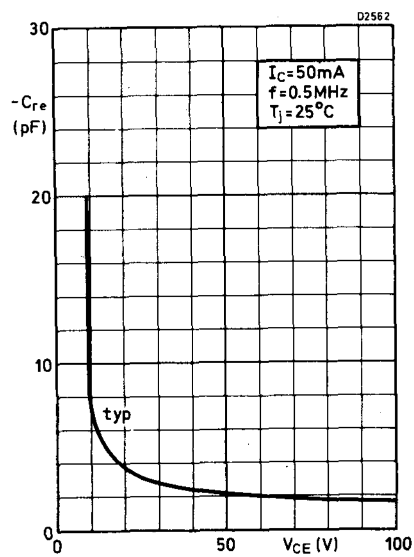

D2558
V_{CE} = 10V
T_j = 25°C
I_C
(mA)
100
75
50
25
0
typ
max
0
0.5
1
V_{BE}(V)
1.5

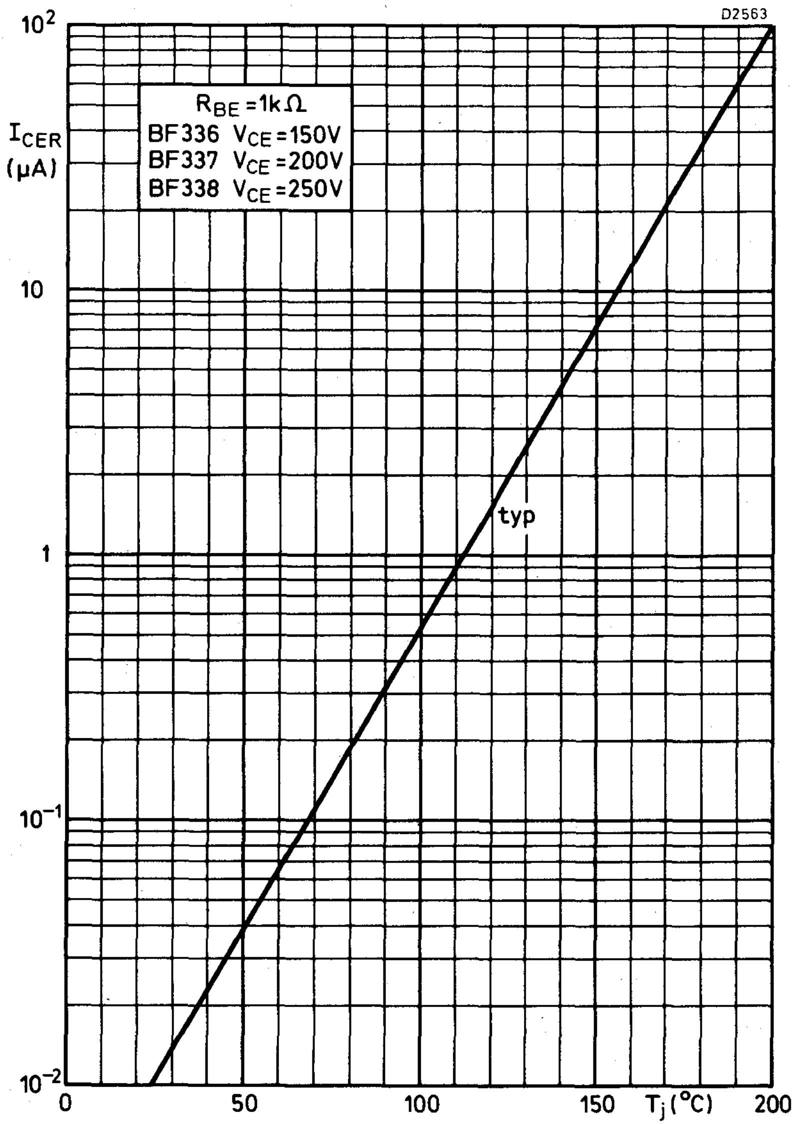

D2559
I_C=30 mA
V_{CE}=10V
V_{BE}
(V)
1
0.75
0.5
0.25
0
typ
−100
0
100
T_j(°C)
200

Mullard


D2560
150
f_T
(MHz)
100
typ
50
0
1
10
I_C (mA)
100
V_{CE} = 20V
f = 100MHz
T_j = 25°C


D2561
30
$-C_{re}$
(pF)
20
10
0
typical values
f = 0.5MHz
T_j = 25°C
V_{CE} = 10V
20V
0
50
I_C(mA)
100


D2562
30
$-C_{re}$
(pF)
20
10
0
I_C = 50mA
f = 0.5MHz
T_j = 25°C
typ
0
50
V_{CE} (V)
100



D2563
10^2
I_{CER}
(μA)
R_{BE} = 1kΩ
BF336 V_{CE} = 150V
BF337 V_{CE} = 200V
BF338 V_{CE} = 250V
10
typ
1
10^{-1}
10^{-2}
0
50
100
150
T_j (°C)
200

N-P-N SILICON PLANAR TRANSISTOR

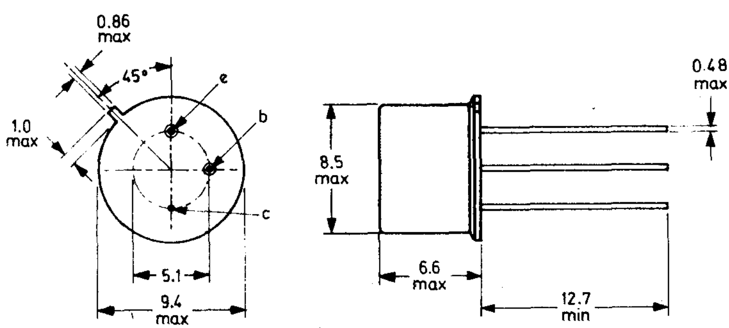
BF355

An n-p-n silicon planar transistor specifically intended for use as a driver for single transistor line output stages in monochrome and colour television receivers.

QUICK REFERENCE DATA		
V_{CBO} max.	300	V
V_{CEO} max.	225	V
I_C max.	100	mA
I_{CM} max. ($t_p = 35\mu s$, $T = 64\mu s$)	160	mA
P_{tot} max. ($T_{mb} \leq 140^oC$)	3.0	W
T_j max.	200	^oC
t_s typ.	0.5	μs

OUTLINE AND DIMENSIONS

Conforms to BS3934 SO-3/SB3-3B
J.E.D.E.C. TO-39



All dimensions in mm D1574

Collector connected to case, max. lead diameter is guaranteed only for 12.7min.
Accessories available: - 56218, 56245, 56265

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

V_{CBO} max.	300	V
V_{CEO} max.	225	V
V_{CER} max. ($R_{BE} \leq 1k\Omega$)	300	V
V_{EBO} max.	5.0	V
I_C max.	100	mA
I_{CM} max. ($t_p = 35\mu s$, $T = 64\mu s$)	160	mA
I_{CM} max. (Peak transient collector current, $t_p = 0.5\mu s$, $T = 64\mu s$, $T_{amb} = 55^oC$, see note 1)	200	mA
I_{BM} max.	20	mA
P_{tot} max., $T_{mb} \leq 140^oC$	3.0	W
$T_{amb} = 25^oC$	0.8	W

Temperature

T_{stg}	-65 to +200	^oC
T_j max.	200	^oC

THERMAL CHARACTERISTICS

$R_{th(j-amb)}$	220	$^oC/W$
$R_{th(j-mb)}$	20	$^oC/W$
$R_{th\ (j-case)}$	25	$^oC/W$

Note 1.

This rating applies during switch-on of the BF355 where an overshoot of current is liable to occur. The amplitude of the overshoot depends on the relative magnitude of stray external capacities to the transistor collector capacity. It is desirable to keep the stray capacities to a minimum by short lead lengths etc. so as to minimise the area of the switching path (see SOAR curve on page 5).

N-P-N SILICON PLANAR TRANSISTOR

BF355

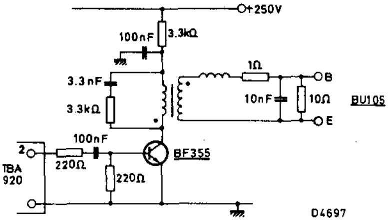
ELECTRICAL CHARACTERISTICS ($T_j = 25^oC$ unless otherwise stated)

		Min.	Typ.	Max.	
I_{CER}	Collector cut-off current $V_{CE} = 250V$, $R_{BE} = 1k\Omega$	-	0.01	100	μA
	Collector-emitter breakdown voltage (d.c. measurement)				
$V_{(BR)CER}$	$I_C = 1mA$, $R_{BE} = 1k\Omega$, $T_j \leq 150^oC$	300	-	-	V
$V_{(BR)CEO}$	$I_C = 4mA$, $I_B = 0$	225	-	-	V
$V_{(BR)CBO}$	Collector-base breakdown voltage $I_C = 1mA$, $I_E = 0$	300	-	-	V
$V_{(BR)EBO}$	Emitter-base breakdown voltage $I_E = 0.1mA$, $I_C = 0$	5.0	-	-	V
$V_{CE(sat)}$	Collector-emitter saturation voltage (see note 2 and typical circuit) $I_C = 160mA$, $I_B = 10mA$, $T_j = 125^oC$	-	-	25	V
t_s	Storage time (see note 3, page 4)	-	0.5	-	μs

Note 2.

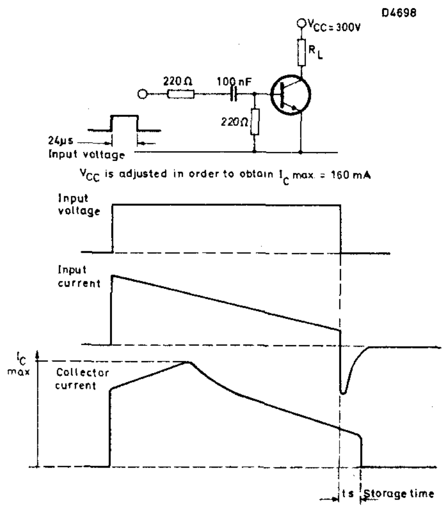
The BF355 is controlled to $V_{CE(sat)}$ max. = 25V, and is thermally stable under all operating conditions where T_j max. = 125°C is not exceeded. For the typical circuit shown below, a heatsink for operation from $T_{amb} = 60^oC$, having $R_{th(h-amb)} = 50^oC/W$, would be suitable.

Typical circuit



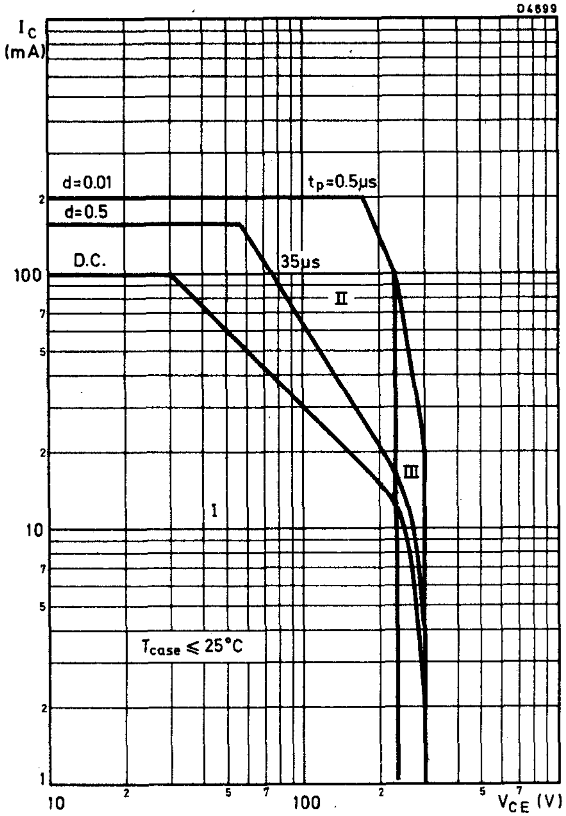
Note 3.

Storage time is measured in the following circuit: -



N-P-N SILICON PLANAR TRANSISTOR

BF355

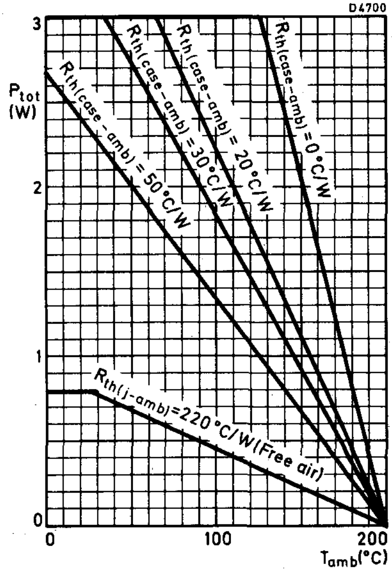


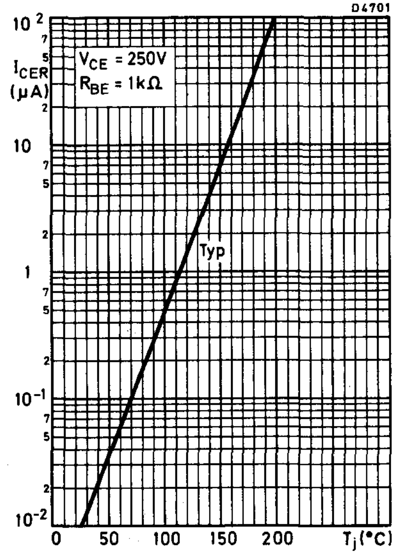
SAFE OPERATING AREAS

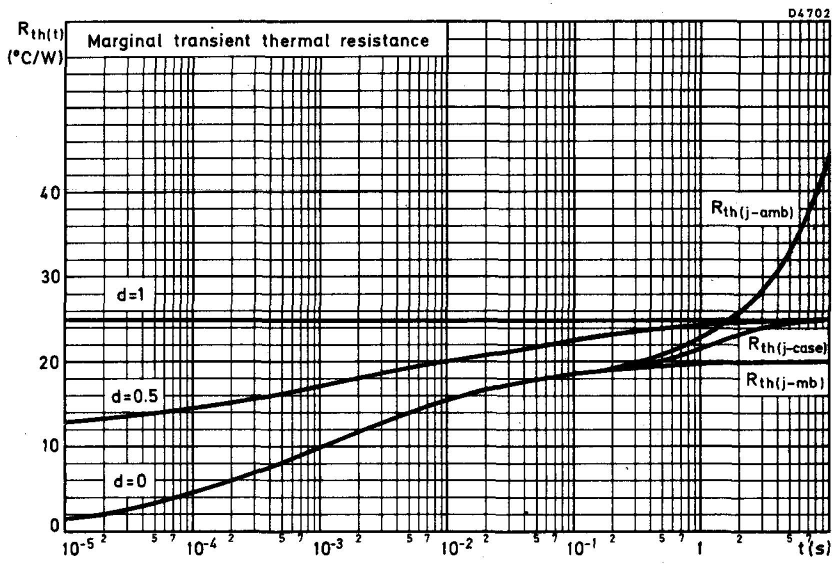
I - D.C. operation (forward)

II - Repetitive pulse operation (forward)

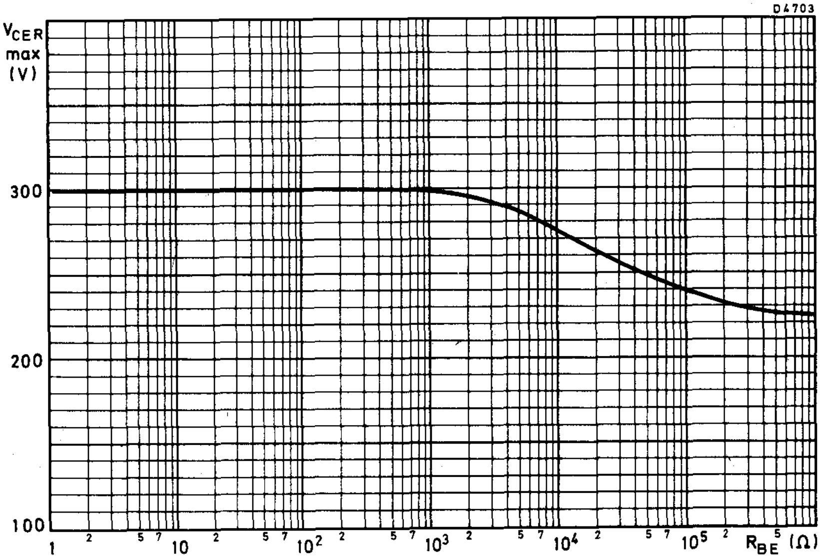
III - D.C. and repetitive pulse operation when base-emitter resistance ≤ 1kΩ (forward).

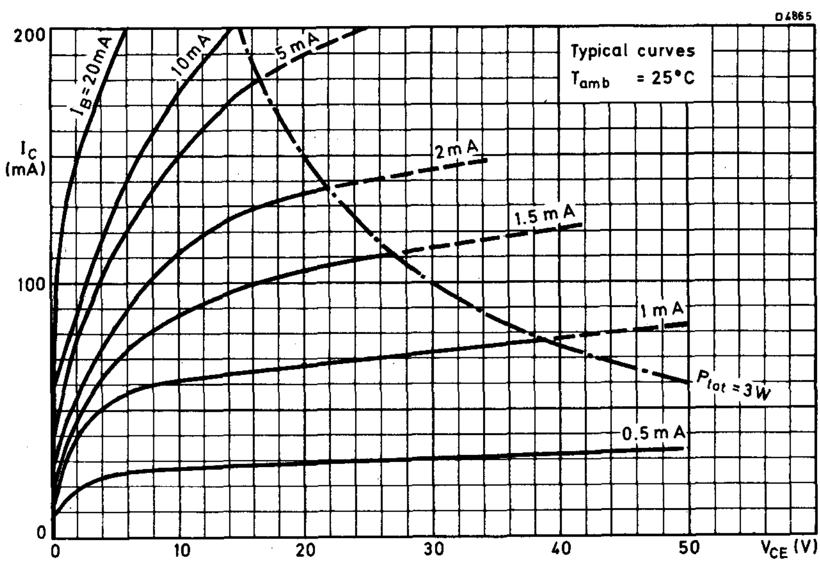

D4700
P_{tot} (W)
3
2
1
0
0
100
200
T_{amb}(°C)
$R_{th(case-amb)}$ = 0 °C/W
$R_{th(case-amb)}$ = 20 °C/W
$R_{th(case-amb)}$ = 30 °C/W
$R_{th(case-amb)}$ = 50 °C/W
$R_{th(j-amb)}$=220 °C/W(Free air)

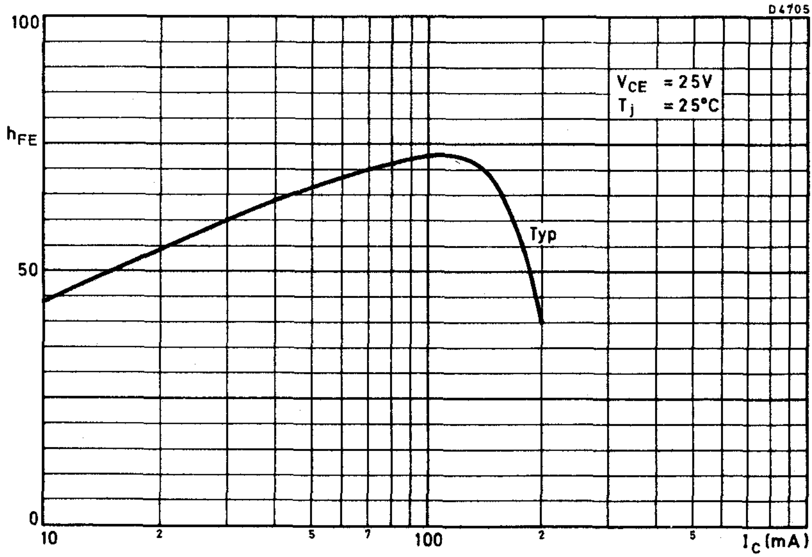

D4701
I_{CER} (μA)
V_{CE} = 250V
R_{BE} = 1kΩ
Typ
10^2
10
1
10^{-1}
10^{-2}
0
50
100
150
200
T_j(°C)

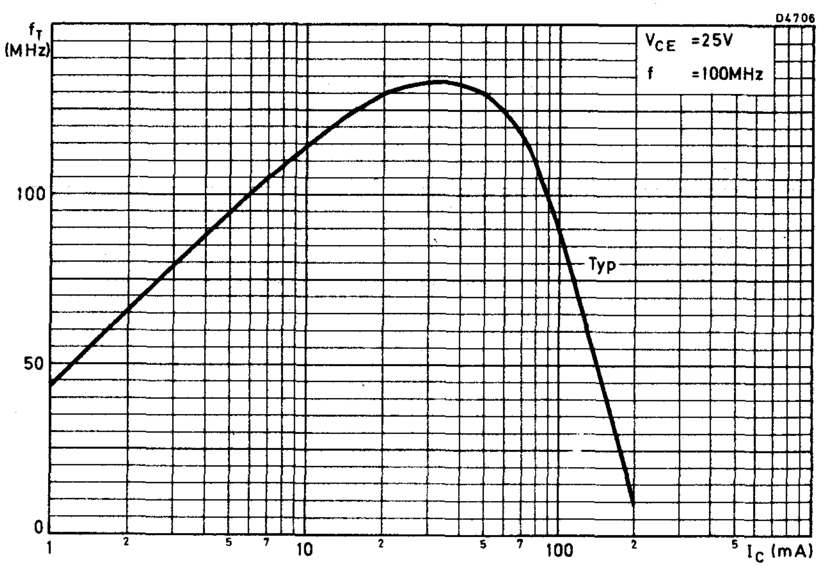

D4702
$R_{th(t)}$ (°C/W)
Marginal transient thermal resistance
40
30
20
10
0
d=1
d=0.5
d=0
$R_{th(j-amb)}$
$R_{th(j-case)}$
$R_{th(j-mb)}$
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
t(s)

N-P-N SILICON PLANAR TRANSISTOR






D4705
100
h_{FE}
50
0
V_{CE} = 25V
T_j = 25°C
Typ
10
2
5
7
100
2
5
I_C (mA)


D4706
f_T (MHz)
100
50
0
V_{CE} =25V
f =100MHz
Typ
1
2
5
7
10
2
5
7
100
2
5
I_C (mA)

N-P-N SILICON PLANAR U.H.F. TRANSISTORS

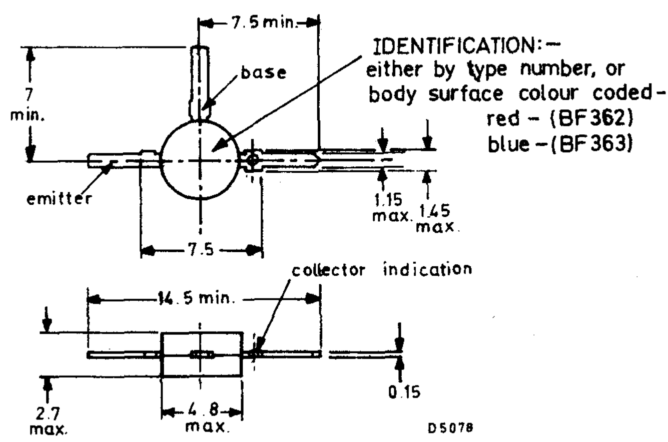
BF362 BF363

High gain n-p-n silicon planar transistors for use in the u.h.f. band. The BF362 is intended for use in the r.f. stage of television tuners and the BF363 is a self-oscillating mixer.

QUICK REFERENCE DATA			
V_{CBO} max.		30	V
V_{CEO} max.		20	V
I_C max.		20	mA
P_{tot} max. ($T_{amb} \leq 55^oC$)		120	mW
T_j max.		125	^oC
f_T	(I_C = 3.0mA, V_{CE} = 10V, f = 100MHz)		
	BF362 typ.	800	MHz
	BF363 min.	600	MHz
	max	820	MHz
Stage gain	min. (f = 900MHz)	11	dB
Noise figure	typ. (f = 800MHz)	5.0	dB

Unless otherwise shown, data are applicable to both types

OUTLINE AND DIMENSIONS



All dimensions in mm

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical

V_{CBO} max.	30	V
V_{CEO} max.	20	V
V_{EBO} max.	3.0	V
I_C max.	20	mA
I_{CM} max.	20	mA
P_{tot} max. ($T_{amb} \leq 55^oC$)	120	mW

Temperature

T_j max.	125	^oC

THERMAL CHARACTERISTIC

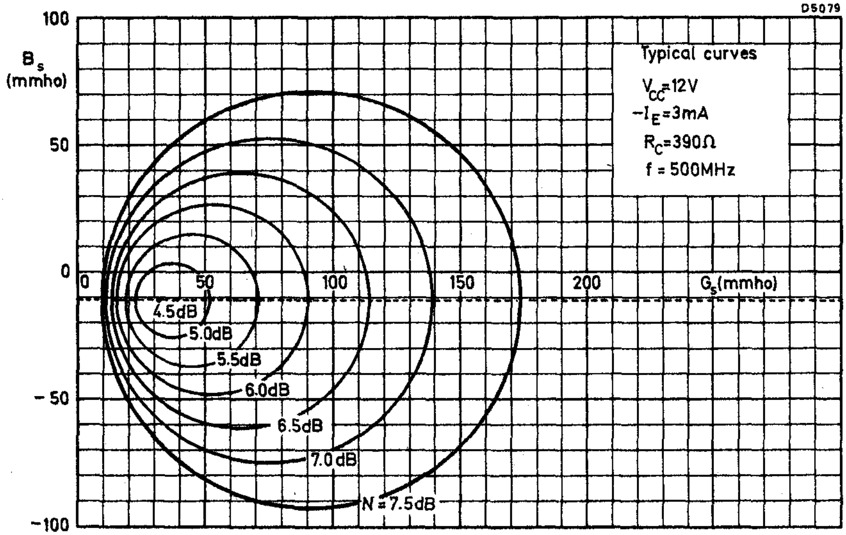
$R_{th(j\text{-}amb)}$	0.58	$^oC/mW$

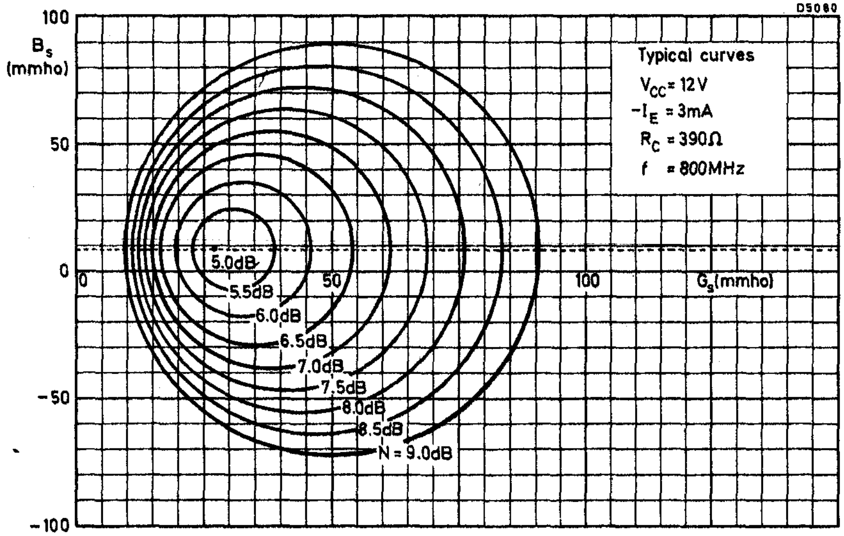
ELECTRICAL CHARACTERISTICS ($T_{amb} = 25^oC$ unless otherwise stated)

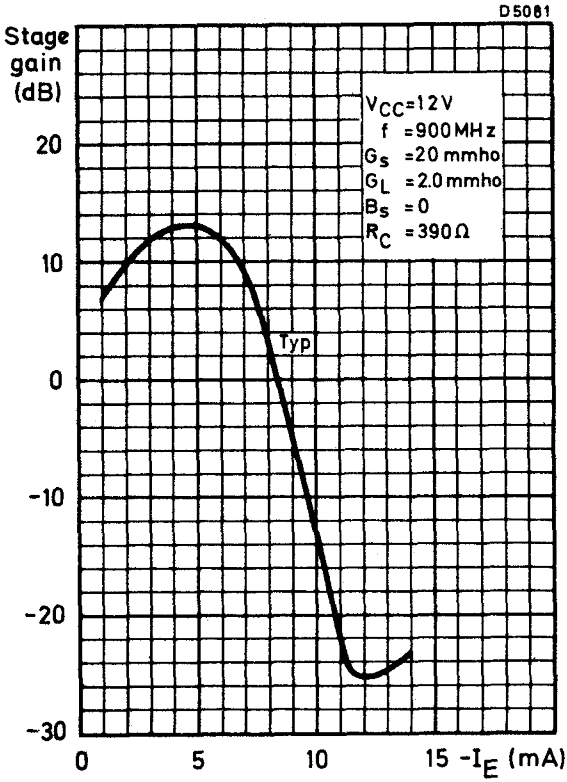
			Min.	Typ.	Max.	
I_B	Base current					
	$-I_E = 3.0mA$, $V_{CB} = 10V$		-	60	150	μA
	$-I_E = 12mA$, $V_{CB} = 7.0V$		-	0.3	1.0	mA
$-V_{EB}$	Emitter-base voltage					
	$-I_E = 3.0mA$, $V_{CB} = 10V$		-	0.75	-	V
	$-I_E = 12mA$, $V_{CB} = 7.0V$		-	0.8	-	V
f_T	Transition frequency					
	$I_C = 3.0mA$, $V_{CE} = 10V$, $f = 100MHz$	BF362	-	800	-	MHz
		BF363	600	-	820	MHz
$-C_{re}$	Feedback capacitance					
	$I_C = 1.0mA$, $V_{CE} = 10V$, $f = 10.7MHz$		-	0.25	-	pF
N	Noise figure					
	$-I_E = 3.0mA$, $V_{CC} = 12V$, $f = 800MHz$					
	$G_s = 27mmho$, $B_s = 9mmho$, $R_C = 390\Omega$		-	5.0	-	dB
	$-I_E = 3.0mA$, $V_{CC} = 12V$, $f = 500MHz$					
	$G_s = 26mmho$, $B_s = -11mmho$, $R_C = 390\Omega$		-	4.5	-	dB
Stage gain						
	$-I_E = 3mA$, $V_{CC} = 12V$, $f = 900MHz$					
	$G_s = 20mmho$, $G_L' = 2.0mmho$, $B_s = 0$					
	B_L = tuned, $R_C = 390\Omega$		11	12	-	dB

ELECTRICAL CHARACTERISTICS (contd.)

		Min.	Typ.	Max.	
	y-parameters				
	$-I_E = 3.0mA, V_{CB} = 10V, f = 500MHz$				
g_{ib}	Input conductance	-	18	-	mmho
$-b_{ib}$	Input susceptance	-	34	-	mmho
$\lvert y_{rb} \rvert$	Feedback admittance	-	500	-	µmho
ϕ_{rb}	Phase angle of feedback admittance	-	270	-	degrees
$\lvert y_{fb} \rvert$	Transfer admittance	-	45	-	mmho
ϕ_{fb}	Phase angle of transfer admittance	-	80	-	degrees
g_{ob}	Output conductance	-	0.6	-	mmho
C_{ob}	Output capacitance	-	0.5	-	pF
	y-parameters				
	$-I_E = 3.0mA, V_{CB} = 10V, f = 900MHz$				
g_{ib}	Input conductance	-	8.0	-	mmho
$-b_{ib}$	Input susceptance	-	30	-	mmho
$\lvert y_{rb} \rvert$	Feedback admittance	-	900	-	µmho
ϕ_{rb}	Phase angle of feedback admittance	-	270	-	degrees
$\lvert y_{fb} \rvert$	Transfer admittance	-	25	-	mmho
ϕ_{fb}	Phase angle of transfer admittance	-	40	-	degrees
g_{ob}	Output conductance	-	1.9	-	mmho ←
C_{ob}	Output capacitance	-	0.6	-	pF


D5079
100
B_s (mmho)
50
0
−50
−100
0
50
100
150
200
G_s(mmho)
Typical curves
V_{CC}=12V
$-I_E$=3mA
R_C=390Ω
f = 500MHz
4.5dB
5.0dB
5.5dB
6.0dB
6.5dB
7.0dB
N = 7.5dB


D5080
100
B_s (mmho)
50
0
−50
−100
0
50
100
G_s(mmho)
Typical curves
V_{CC}= 12V
$-I_E$ = 3mA
R_C = 390Ω
f = 800MHz
5.0dB
5.5dB
6.0dB
6.5dB
7.0dB
7.5dB
8.0dB
8.5dB
N = 9.0dB


D5081
Stage gain (dB)
20
10
0
-10
-20
-30
V_{CC}=12V
f =900MHz
G_s =20 mmho
G_L =2.0 mmho
B_s =0
R_C =390Ω
Typ
0
5
10
15 $-I_E$ (mA)

P-N-P SILICON PLANAR EPITAXIAL H.F. TRANSISTORS

BF450 BF451

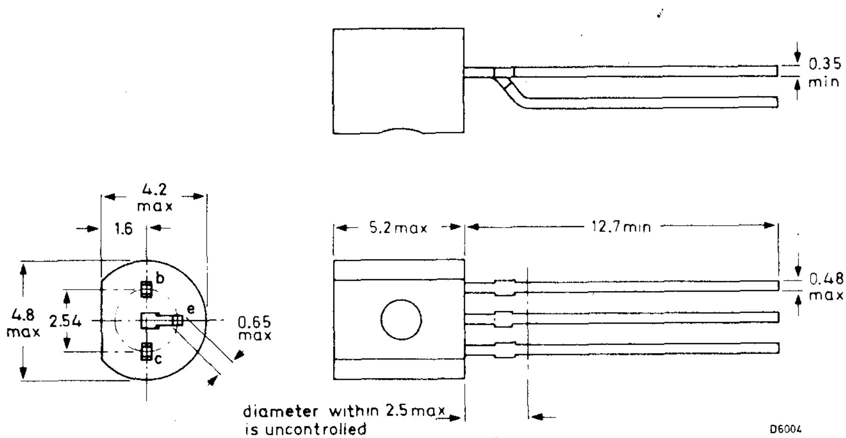
P-N-P transistors in a plastic envelope primarily intended for mixer stages in a.m. receivers and i.f. stages in a.m./f.m. receivers with negative earth.

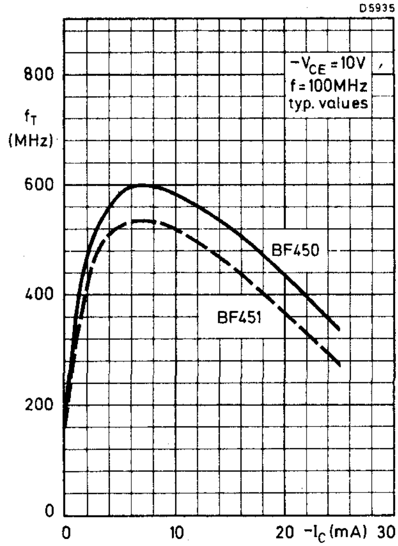
QUICK REFERENCE DATA					
Collector-base voltage (open emitter)		$-V_{CBO}$	max.	40	V
Collector-emitter voltage (open base)		$-V_{CEO}$	max.	40	V
Collector current (d.c.)		$-I_C$	max.	25	mA
Total power dissipation up to $T_{amb} = 45^oC$		P_{tot}	max.	250	mW
Junction temperature		T_j	max.	150	^oC
Base current $-I_C = 1mA$, $-V_{CE} = 10V$	BF450:	$-I_B$	<	16.5	μA
	BF451:	$-I_B$	<	33	μA
Transition frequency $-I_C = 1mA$, $-V_{CE} = 10V$		f_T	typ.	325	MHz
Noise figure at f = 100kHz $-I_C = 1mA$, $-V_{CE} = 10V$; $R_S = 300\Omega$		N	typ.	2	dB

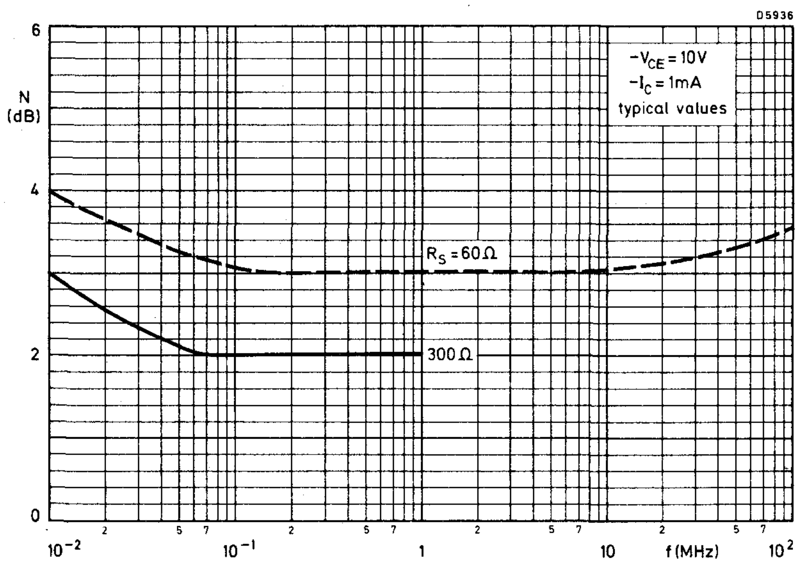
MECHANICAL DATA

Dimensions in mm

Similar to J.E.D.E.C. TO-92




D5935
$-V_{CE}$ = 10V
f = 100MHz
typ. values
f_T
(MHz)
800
600
400
200
0
BF450
BF451
0
10
20
$-I_C$ (mA)
30


D5936
$-V_{CE}$ = 10V
$-I_C$ = 1mA
typical values
N
(dB)
6
4
2
0
R_S = 60 Ω
300 Ω
10^{-2}
10^{-1}
1
10
f (MHz)
10^2

Mullard

ACCESSORIES

C

ACCESSORIES FOR TRANSISTORS

Section 1 Cooling Clips

PART NUMBER	FOR USE ON OUTLINES J.E.D.E.C.	BS 3934	PAGE
56200*	TO–1	SO–21/SB3–10	3
56207*	TO–7	SO–23/SB4–4	4
56209*	TO–1	SO–21/SB3–10	5
56226	TO–1	SO–21/SB3-10	6
56227	TO–1	SO–21/SB3–10	7
56263	TO–18	SO–12A/SB3–6A	8
	TO–71	SO–12A/SB8–1B	
	TO–72	SO–12A/SB4–3	
56265	TO–5	SO–3/SB3–3A	9
	TO–12	SO–3/SB4–1	
	TO–33	SO–3/SB4–1	
	TO–39	SO–3/SB3–3B	

*These devices are supplied on a maintenance basis only, they are not recommended for current design

Section 2 Mounting Accessories

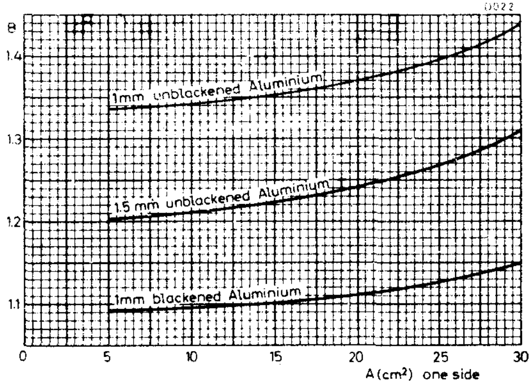
PART NUMBER	DESCRIPTION	FOR USE ON OUTLINES	PAGE
56201A	Insulating bush	TO–3 3.15mm (thick or medium with 56300)	10
56201B	Mica washer	TO–3 all	10
56239A	Insulating bush	TO–3 1.6mm (medium)	16
56336A	Insulating bush (2kV)	TO–3 3.15mm (thick)	17
56336B	Mica washer (2kV)	TO–3 all	17
56214	Lead washer	TO–3 all	10
56300	Steel spacer	TO–3 0.9 or 1.6mm (thin or medium)	11
56218	Top and bottom clamping washer and Mylar washer	TO–5, TO–39 (and TO–12, TO–33 for non-insulated mounting)	12
56245	Insulated distance disc	TO–5, TO–12, TO–33, TO–39	13
56246	Insulated distance disc	TO–18, TO–72	13
56301B	Mica washer	TO–126	14–15
56326	Flat metal washer	TO–126	14–15
56325	Mica washer	TO–220	18
56338	Insulating bush	TO–220	18
56239A	Insulating bush	— SO–55 (BS 3934)	16
56239B	Mica washer	— SO–55 (BS 3934)	16

All information on thermal resistance of the *accessories combined with flat heatsinks* is valid for **square** heatsinks of **blackened aluminium.**

For a few variations the thermal resistance may be derived as follows:

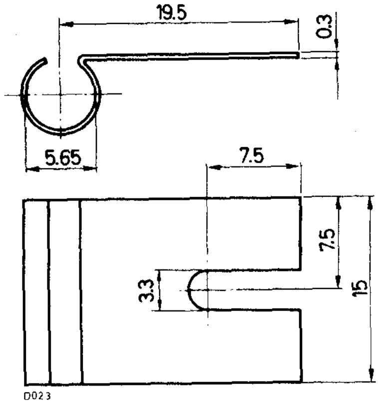
a. **Rectangular heatsinks** (sides a and 2a)
When mounted with long side horizontal, multiply by 0.95.
When mounted with short side horizontal, multiply by 1.10.

b. **Unblackened or thicker heatsinks**
Multiply by the factor B given below as a function of the heatsink size A.



COOLING CLIP

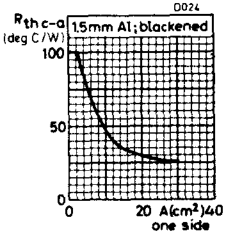
MECHANICAL DATA (Dimensions in mm)



Clip material: brass, nickel plated

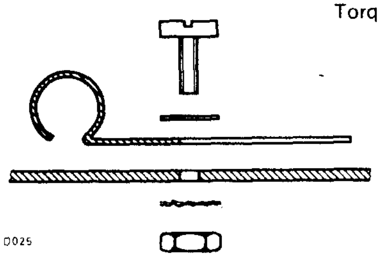
THERMAL CHARACTERISTICS

$R_{th(case-amb)}$	Thermal resistance case to ambient,	
	cooling clip only	100 degC/W
	with heatsink	see graph



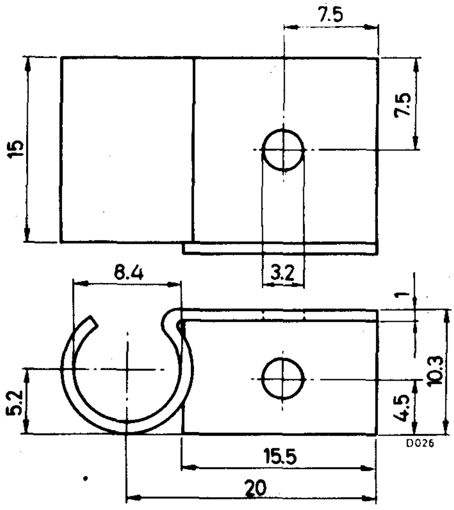
MOUNTING INSTRUCTIONS

Torque on nut for good heat transfer: 5kg cm



COOLING CLIP

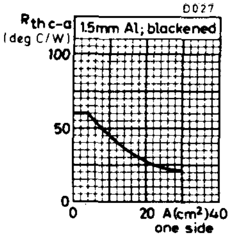
MECHANICAL DATA (Dimensions in mm)



Clip material: aluminium, blackened

THERMAL CHARACTERISTICS

$R_{th(case-amb)}$	Thermal resistance case to ambient,	
	cooling clip only	60 degC/W
	with heatsink	see graph



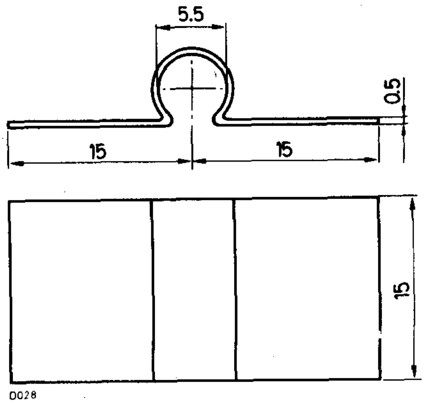
MOUNTING INSTRUCTIONS

Torque on M3 bolts for good heat transfer: 5kg cm

56209

COOLING CLIP

MECHANICAL DATA (Dimensions in mm)



Clip material: brass, nickel plated

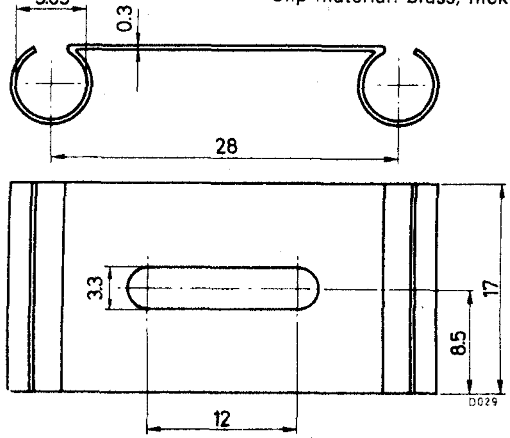
THERMAL CHARACTERICTIC

$R_{th(case-amb)}$	Thermal resistance case to ambient, cooling clip only	75 degC/W

COOLING CLIP

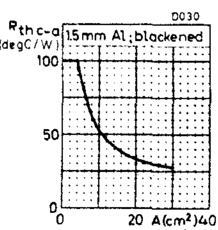
MECHANICAL DATA (Dimensions in mm)

Clip material: brass, nickel plated



THERMAL CHARACTERISTICS

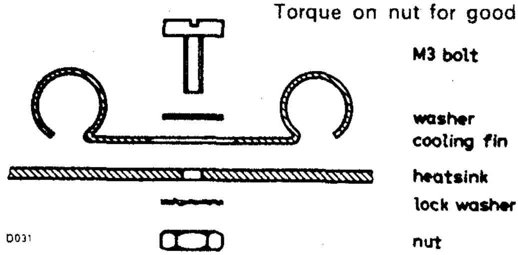
$R_{th(case\ amb)}$	Thermal resistance case to ambient,	
	cooling clip only	100 degC/W
	with heatsink	see graph



The thermal resistance values apply to each transistor, provided the two transistors have been mounted so that the heat flow from each one is equal.

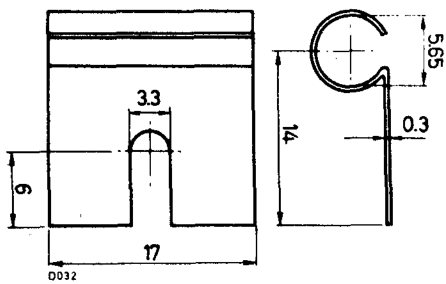
MOUNTING INSTRUCTIONS

Torque on nut for good heat transfer: 5kg cm.



COOLING CLIP

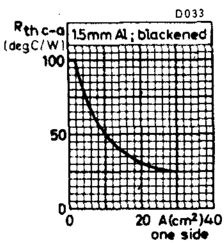
MECHANICAL DATA (Dimensions in mm)



Clip material: brass, nickel plated

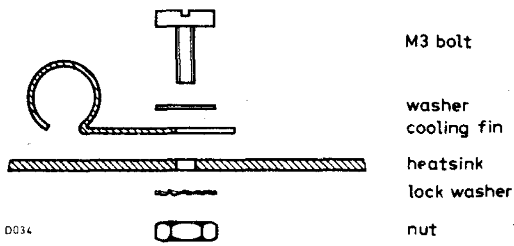
THERMAL CHARACTERISTICS

$R_{th(case-amb)}$	Thermal resistance case to ambient,	
	cooling clip only	100 degC/W
	with heatsink	see graph



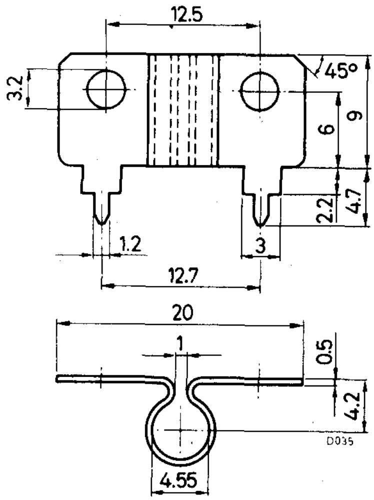
MOUNTING INSTRUCTIONS

Torque on nut for good heat transfer: 5kg cm



COOLING CLIP

MECHANICAL DATA (Dimensions in mm)



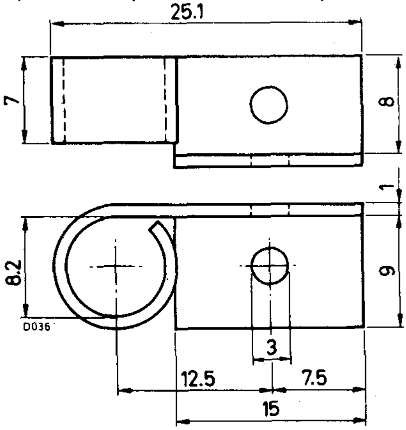
Clip material: copper, tin plated

THERMAL CHARACTERISTIC

$R_{th(case-amb)}$	Thermal resistance case to ambient	100 degC/W

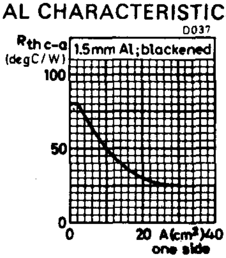
COOLING CLIP

MECHANICAL DATA (Dimensions in mm)



Clip material: aluminium, blackened

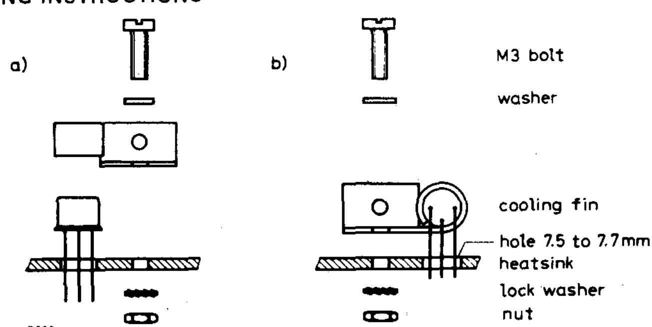
THERMAL CHARACTERISTICS



$R_{th(case-amb)}$ Thermal resistance case to ambient,

cooling clip only	80 degC/W
with heatsink	see graph

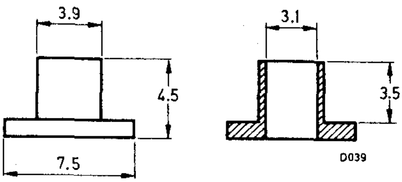
MOUNTING INSTRUCTIONS



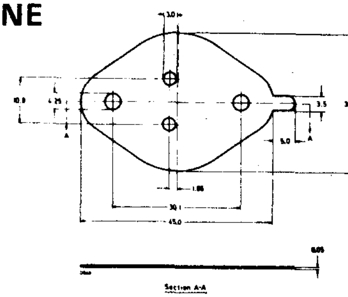
Torque on nut for good heat transfer: 5kg cm.

MOUNTING ACCESSORIES FOR TO-3 OUTLINE

MECHANICAL DATA (Dimensions in mm)



Insulating bush
56201A

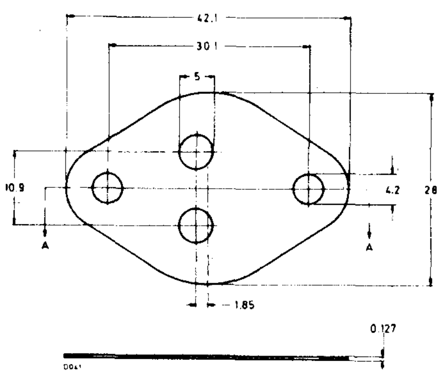


Mica washer
56201B

THERMAL CHARACTERISTIC

$R_{th(mb-h)}$	Thermal resistance mounting-base to heatsink	1 degC/W

56214 Lead washer
MECHANICAL DATA (Dimensions in mm)



THERMAL CHARACTERISTIC

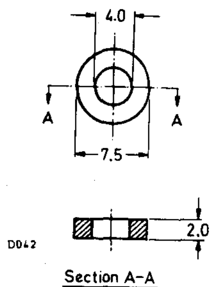
$R_{th(mb-h)}$	Thermal resistance mounting-base to heatsink, with mica washer and lead washer	0·75 degC/W

TEMPERATURE

T_{max}	Max. allowable temperature	150 °C

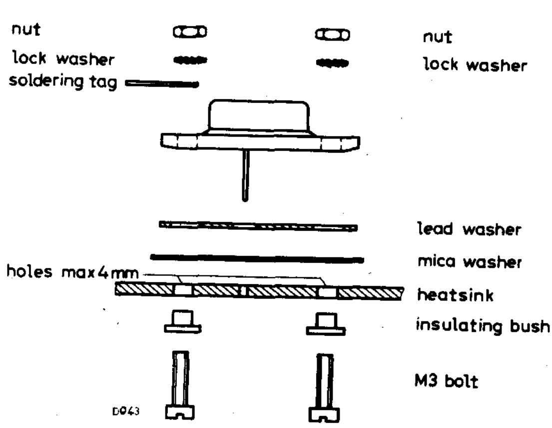
MOUNTING ACCESSORIES FOR TO-3 OUTLINE

56300 Steel spacer



For use with thin-base devices only.

MOUNTING INSTRUCTIONS

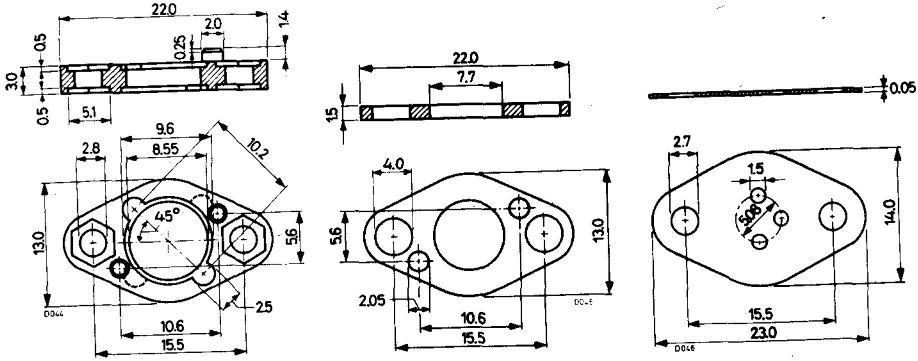


Torque on nut for good heat transfer: 5kg cm

MOUNTING ACCESSORIES FOR TO-5, TO-12, TO-33, TO-39 OUTLINES

56218 Top and bottom clamping washers and Mylar washer

MECHANICAL DATA (Dimensions in mm)



Top clamping washer of insulating material

Bottom clamping washer material: brass, tin plated

Mylar washer

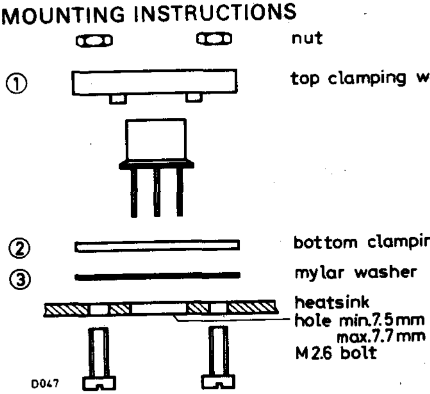
THERMAL CHARACTERISTICS

$R_{th(mb-h)}$	Thermal resistance mounting-base to heatsink,	
	non-insulated mounting	1 degC/W
	insulated mounting	6 degC/W

TEMPERATURE

T_{max}	Max. allowable temperature	100 °C

MOUNTING INSTRUCTIONS

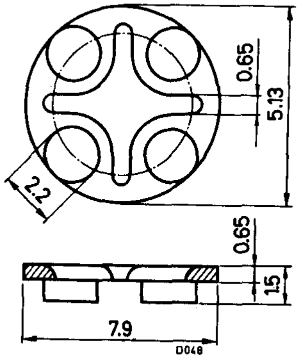


Non-insulated: without items 2 and 3
Note: Item 1 must then be mounted upside down.

MOUNTING ACCESSORIES FOR TO-5, TO-12, TO-33, TO-39 OUTLINES (cont'd)

56245 Distance disc

MECHANICAL DATA (Dimensions in mm)

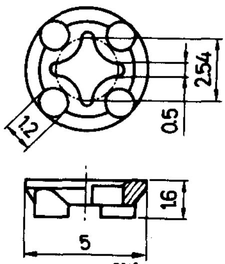


Insulating material

TEMPERATURE

T_{max}	Max. allowable temperature	100 °C

56246 Distance disc



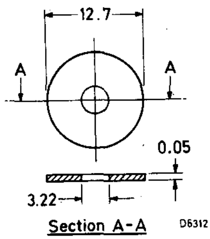
Insulating material

TEMPERATURE

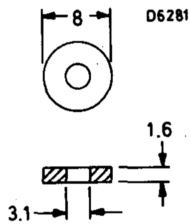
T_{max}	Max. allowable temperature	100 °C

MOUNTING ACCESSORIES FOR TO-126 OUTLINE

56301B Mica washer
56326 Steel washer
MECHANICAL DATA (Dimensions in mm)



Mica washer

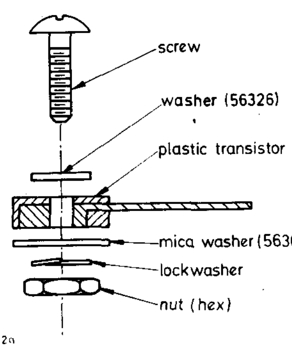


Steel washer

THERMAL CHARACTERISTICS

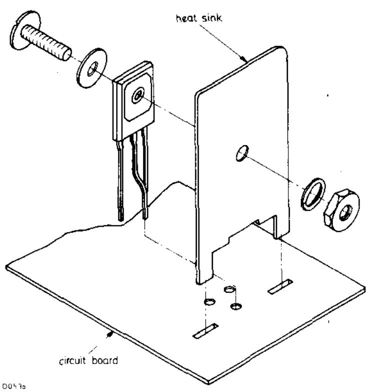
$R_{th(mb-h)}$	Thermal resistance mounting-base to heatsink,	
	without insulating material	1 degC/W
	with mica washer (56301B)	4 degC/W

MOUNTING INSTRUCTIONS

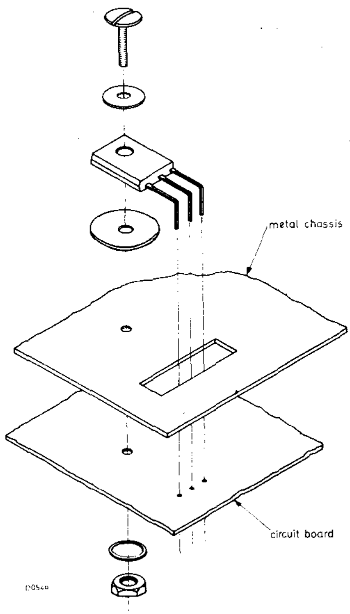


MOUNTING DETAILS
TO-126 OUTLINE

METHOD 1

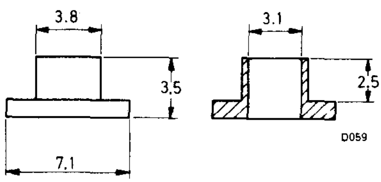


METHOD 2

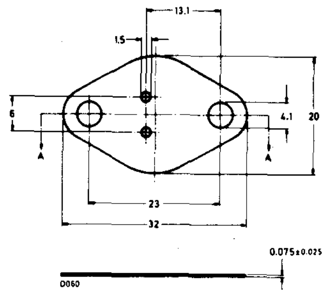


MOUNTING ACCESSORIES FOR BS 3934 SO-55B OUTLINE

MECHANICAL DATA (Dimensions in mm)



Insulating bush
56239A



Mica washer
56239B

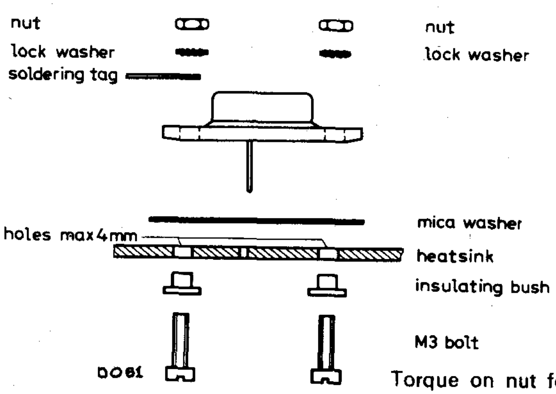
THERMAL CHARACTERISTIC

$R_{th(mb-h)}$	Thermal resistance mounting-base to heatsink	1·5 degC/W

TEMPERATURE

T_{max}	Max. allowable temperature	150 °C

MOUNTING INSTRUCTIONS

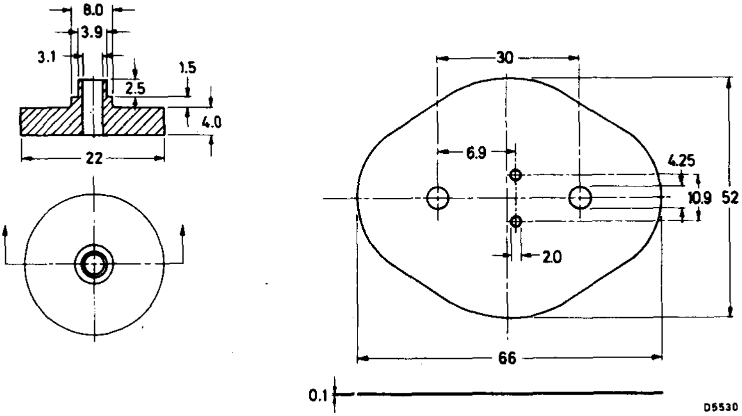


Torque on nut for good heat transfer: 5kg cm.

MOUNTING ACCESSORIES FOR TO-3 OUTLINE

(High Voltage Application, up to 2kV)

56336A **Insulating bush**
56336B **Mica washer**



Dimensions in mm

THERMAL CHARACTERISTICS

$R_{th(mb-h)}$	Thermal resistance, mounting-base to heatsink	1°C/W

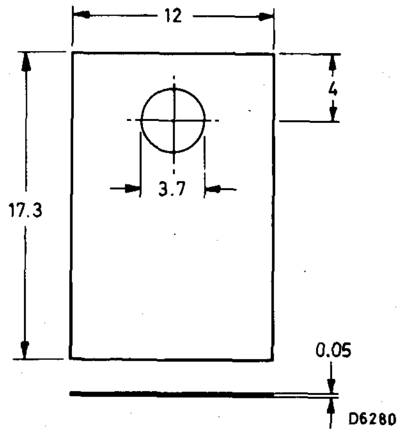
The use of a heatsink compound is essential.
When the mica washer is used, the compound must be applied to both sides of the washer.

MOUNTING ACCESSORIES FOR TO-220

56325 Mica washer

MECHANICAL DATA

Dimensions in mm



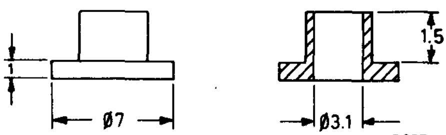
THERMAL RESISTANCE

From mounting base to heatsink $R_{th(mb-h)} = 2.5°C/W$.

56338 Insulating bush

MECHANICAL DATA

Dimension in mm



ABRIDGED DATA FOR EARLIER TYPES

D

ABRIDGED DATA FOR EARLIER TYPES

Abridged data only are given in these tables. Full data for these types are available on request

GERMANIUM TRANSISTORS

Type No.	Polarity	Outline	Maximum Ratings V_{CB} (V)	V_{CE} (V)	I_{CM} (mA)	$I_{C(AV)}$ (mA)	T_j (°C)	P_{tot} at 25°C (mW)	h_{fe} min.	h_{fe} max.	at I_C (mA)	f_T min. (MHz)	$V_{CE(sat)}$ max. (V)	at I_C (mA)	I_B (mA)	Typical power gain (dB)	at f (MHz)
ACY17	p-n-p	TO–5	–70	–60	2A	500	90	260	50**	150	300	1*	–0·35	500	25	—	—
ACY18	p-n-p	TO–5	–50	–40	2A	500	90	260	40**	120	300	1*	–0·35	500	25	—	—
ACY19	p-n-p	TO–5	–50	–40	2A	500	90	260	80**	250	300	1·3*	–0·35	500	25	—	—
ACY20	p-n-p	TO–5	–40	–32	2A	500	90	260	50**	145	50	1*	–0·2	50	1·3	—	—
ACY21	p-n-p	TO–5	–40	–32	2A	500	90	260	90**	250	50	1·3*	–0·2	50	1·3	—	—
ACY22	p-n-p	TO–5	–20	–20	2A	500	90	260	30**	300	300	1*	–0·35	500	25	—	—
ACY39	p-n-p	TO–5	–110	–75	2A	500	90	260	50**	150	300	1*	–0·35	500	25	—	—
ACY40	p-n-p	TO–5	–32	–32	2A	500	90	260	30**	70	300	0·8*	–0·35	500	25	—	—
ACY41	p-n-p	TO–5	–32	–32	2A	500	90	260	50**	250	300	0·6*	–0·35	500	25	—	—
ACY44	p-n-p	TO–5	–50	–40	2A	500	90	260	30	100	1	1*	–0·2	50	1·3	—	—
ADY26	p-n-p	TO–36	–80	–60	30A	25A	90	100W	40**	120	5A	—	–0·5	25A	2·5A	—	—
ADZ11	p-n-p	TO–36	–50	–40	20A	15A	90	45W	40**	120	1·2A	80kHz	–1·0	15A	2A	—	—
ADZ12	p-n-p	TO–36	–80	–60	20A	15A	90	45W	40**	120	1·2A	100kHz	–1·0	15A	2A	—	—
AF114	p-n-p	TO–7	–20	–20	10	10	75	85	40	—	1	75*	—	—	—	14	100
AF115	p-n-p	TO–7	–20	–20	10	10	75	85	40	—	1	75*	—	—	—	13	100
AF116	p-n-p	TO–7	–20	–20	10	10	75	85	40	—	1	75*	—	—	—	25	10·7
AF117	p-n-p	TO–7	–20	–20	10	10	75	85	40	—	1	75*	—	—	—	42	0·4
ASY26	p-n-p	TO–5	–30	–15	300	200	85	150	30**	80	20	4	–0·2	10	0·3	—	—
ASY27	p-n-p	TO–5	–25	–15	300	200	85	150	50**	150	20	6	–0·2	10	0·2	—	—
ASY28	n-p-n	TO–5	30	15	300	200	85	150	30**	80	20	4	0·2	10	0·3	—	—

*typical   **h_{FE}

GERMANIUM TRANSISTORS (cont.)

Type No.	Polarity	Outline	Maximum Ratings V_{CB} (V)	V_{CE} (V)	I_{CM} (mA)	$I_{C(AV)}$ (mA)	T_j (°C)	P_{tot} at 25°C (mW)	h_{fe} min.	h_{fe} max.	at I_C (mA)	f_T min. (MHz)	$V_{CE(sat)}$ max. (V)	at I_C (mA)	I_B (mA)	Typical Power gain (dB)	at f (MHz)
ASY29	n-p-n	TO–5	25	15	300	200	85	150	50**	150	20	10	0·2	10	0·2	—	—
ASZ21	p-n-p	TO–18	–20	–15	50	30	85	120	35	—	10	300	–0·35	10	1·0	—	—
OC20	p-n-p	TO–3	–100	–75	10A	8A	90	30W‡	25	75	1A	0·25	—	—	—	—	—
OC22	p-n-p	TO–3	–47	–32	2A	1A	90	22·5W†	50**	—	1A	2	–0·6*	1A	30	—	—
OC23	p-n-p	TO–3	–55	–40	2A	1A	90	22·5W†	50**	—	1A	2·5	–0·4*	1A	30	—	—
OC24	p-n-p	TO–3	–47	–40	2A	1A	90	22·5W†	50**	—	1A	2·5	–0·4*	1A	30	—	—
OC25	p-n-p	TO–3	–40	–40	4A	4A	90	22·5W†	15**	80	1A	0·25	—	—	—	—	—
OC41	p-n-p	SO–2	–16	–15	150	50	75	112	20	90	10	3	–0·2	50	3	—	—
OC42	p-n-p	SO–2	–16	–15	150	50	75	112	40	—	10	5·5	–0·2	50	1·5	—	—
OC43	p-n-p	SO–2	–15	–15	150	50	75	112	50	200	50	12	–0·28	125	7	—	—
OC44	p-n-p	SO–2	–15	–15	10	5	75	70	40	225	1	7·5	–0·15	8	0·5	—	—
OC45	p-n-p	SO–2	–15	–15	10	5	75	70	25	125	1	3	–0·15	8	0·5	—	—
OC70	p-n-p	SO–2	–30	–30	50	10	75	125	20	40	0·5	5kHz	–0·33	9	0·5	—	—
OC71	p-n-p	SO–2	–30	–30	50	10	75	125	41	—	1	5kHz	–0·21	9	0·5	—	—
OC72	p-n-p	SO–2	–32	–32	250	125	75	125	45	120	10	0·33	—	—	—	—	—
OC75	p-n-p	SO–2	–30	–30	50	10	75	125	60	130	3	0·9	–0·21	9	0·5	—	—
OC76	p-n-p	SO–2	–32	–32	250	125	75	125	45	—	10	0·35	—	—	—	—	—
OC77	p-n-p	SO–2	–60	–60	250	125	75	125	45	—	10	0·35	—	—	—	—	—
OC139	n-p-n	SO–2	20	20	250	250	75	145	20	84	15	3·5	0·22	50	3	—	—
OC140	n-p-n	SO–2	20	20	400	400	75	145	50	150	15	4·5	0·22	50	1·2	—	—
OC141	n-p-n	SO–2	20	20	400	400	75	145	80	200	15	9·0	0·22	50	0·7	—	—
OC170	p-n-p	TO–7	–20	–20	10	10	75	85	40	—	1	75*	—	—	—	25	10
OC171	p-n-p	TO–7	–20	–20	10	10	75	85	40	—	1	75*	—	—	—	14	100

*typical **h_{FE} †$T_{case} \leqslant 25$°C ‡$T_{case} \leqslant 45$°C

SILICON TRANSISTORS

Type No.	Polarity	Outline	Maximum Ratings V_{CBO} (V)	V_{CEO} (V)	I_{CM} (mA)	$I_{C(AV)}$ (mA)	T_j (°C)	P_{tot} at 25°C (mW)	h_{FE} min.	max.	at I_C (mA)	f_T min. (MHz)	$V_{CE(sat)}$ max. (V)	at I_C (mA)	I_B (mA)	t_{on} (ns)	t_{off} (ns)	at (mA)
BC146	n-p-n	μ min.	20	20	50	50	125	50	80	550	0.2	150*	0·18*	2·0	—	—	—	—
BC186	p-n-p	TO–18	–40	–25	200	100	175	300	40	200	2·0	50	–0·5	50	5	—	—	—
BC187	p-n-p	TO–18	–30	–25	200	100	175	300	100	500	2·0	50	–0·5	50	5	—	—	—
BC200	p-n-p	μ min.	–20	–20	50	50	125	50	50	400	0·2	90*	–0·2*	2·0	—	—	—	—
§BCY55	n-p-n	Block	45	45	60	30	125	300	200	600	1·0	50	1·0	10	0·5	—	—	—
BCZ11	p-n-p	SO–2	–30	–25	100	50	150	250	15	50	20	0·9	–0·55	20	3	—	—	—
BD115	n-p-n	TO–39	245	180	200	150	200	6†	22	—	50	145*	9·0	100	10	—	—	—
BD121	n-p-n	TO–3	60	35	5A	5A	175	45W	30	—	1A	60	0·65	1A	100	—	—	—
BD123	n-p-n	TO–3	90	60	5A	5A	175	45W	30	—	1A	60	0·65	1A	100	—	—	—
BD124	n-p-n	SO–55	70	45	4A	2A	175	15W	35	—	500	60	0·50	2A	200	—	—	—
BDY10	n-p-n	TO–3	50	40	4A	2A	175	150W†	10	50	2A	1·0	0·7	2A	400	—	—	—
BDY11	n-p-n	TO–3	100	70	4A	2A	175	150W†	10	50	2A	1·0	0·7	2A	400	—	—	—
BDY60	n-p-n	TO–3	120	60	10A	5A	175	15W	45	450	500	100*	0·7	5A	500	120	350	5A
BDY61	n-p-n	TO–3	100	60	10A	5A	175	15W	45	450	500	100*	0·9	5A	500	120	350	5A
BDY62	n-p-n	TO–3	60	30	10A	5A	175	15W	45	450	500	100*	0·9	5A	500	120	350	5A
BF115	n-p-n	TO–72	50	30	30	30	175	145	48	—	1	230*	—	—	—	—	—	—
BF167	n-p-n	TO–72	40	30	25	25	175	130	—	—	—	350*	—	—	—	—	—	—
BF173	n-p-n	TO–72	40	25	25	25	175	260	—	—	—	550*	—	—	—	—	—	—
BF177	n-p-n	TO–5	100	50	60	50	200	600	20	—	15	120*	—	—	—	—	—	—
BF178	n-p-n	TO–5	160	115	50	50	200	600	20	—	30	120*	—	—	—	—	—	—

*typical   †$T_{mb} \leqq 25°C$ §Dual transistor

SILICON TRANSISTORS (cont.)

Type No.	Polarity	Outline	Maximum Ratings V_{CBO} (V)	V_{CEO} (V)	I_{CM} (mA)	$I_{C(AV)}$ (mA)	T_j (°C)	P_{tot} at 25°C (mW)	h_{FE} min.	max.	at I_C (mA)	f_T min. (MHz)	$V_{CE(sat)}$ max. (V)	at I_C (mA)	I_B (mA)	t_{on} (ns)	t_{off} (ns)	at (mA)
BF179	n-p-n	TO–5	250	115	50	50	200	500	20	—	20	120*	—	—	—	—	—	—
BF182	n-p-n	TO–72	25	20	15	15	175	150	—	—	—	650*	—	—	—	—	—	—
BF183	n-p-n	TO–72	25	20	15	15	175	150	—	—	—	800*	—	—	—	—	—	—
BF262	n-p-n	T pack	30	20	20	20	125	120	—	—	—	650*	—	—	—	—	—	—
BF263	n-p-n	T pack	30	20	20	20	125	120	—	—	—	525	—	—	—	—	—	—
BF264	n-p-n	T pack	30	20	20	20	125	120	—	—	—	400	—	—	—	—	—	—
BFS18R	n-p-n	μ min.	30	20	30	30	125	110	35	125	1·0	200*	—	—	—	—	—	—
BFS19R	n-p-n	μ min.	30	20	30	30	125	110	65	225	1·0	260*	—	—	—	—	—	—
BFS92	p-n-p	TO–39	–100	–60	1A	1A	200	5W†	30	—	150	70*	–1·0	500	50	—	—	—
BFS93	p-n-p	TO–39	–100	–60	1A	1A	200	5W†	70	—	150	70*	–1·0	500	50	—	—	—
BFS94	p-n-p	TO–39	–80	–40	1A	1A	200	5W†	40	—	150	70*	–0·7	500	50	—	—	—
BFS95	p-n-p	TO–39	–40	–35	1A	1A	200	5W†	70	—	150	70*	–0·7	500	50	—	—	—
BFW16	n-p-n	TO–5	40	25	300	150	200	1·5W‡	25	—	150	1200*	—	—	—	—	—	—
BFW17	n-p-n	TO–5	40	25	300	150	200	1·5W‡	25	—	150	1100*	—	—	—	—	—	—
BFW45	n-p-n	TO–39	165	130	100	50	200	2·5W‡	20	120	50	80	3·0	10	1	—	—	—
BFW57	n-p-n	Lock-fit	80	60	1A	500	125	350	80	—	100	80	0·7	500	50	—	—	—
BFW58	n-p-n	Lock-fit	80	60	1A	500	125	350	50	—	100	80	0·7	500	50	—	—	—
BFW59	n-p-n	Lock-fit	40	35	1A	500	125	350	80	—	100	80	0·7	500	50	—	—	—
BFW60	n-p-n	Lock-fit	40	35	1A	500	125	350	50	—	100	80	0·7	500	50	—	—	—
BFW87	p-n-p	Lock-fit	–60	–60	500	500	125	300	80	320	150	100	–0·4	150	15	50	290	100

*typical ‡$T_{case} \leqslant 125$°C †$T_{mb} \leqslant 50$°C

SILICON TRANSISTORS (cont.)

Type No.	Polarity	Outline	Maximum Ratings V_{CBO} (V)	V_{CEO} (V)	I_{CM} (mA)	$I_{C(AV)}$ (mA)	T_j (°C)	P_{tot} at 25°C (mW)	h_{FE} min.	max.	at I_C (mA)	f_T min. (MHz)	$V_{CE(sat)}$ max. (V)	at I_C (mA)	I_B (mA)	t_{on} (ns)	t_{off} (ns)	at (mA)
BFW88	p-n-p	Lock-fit	–60	–60	500	500	125	300	40	130	150	100	–0·4	150	15	50	290	100
BFW89	p-n-p	Lock-fit	–40	–40	500	500	125	300	80	320	150	100	–0·4	150	15	50	290	100
BFW90	p-n-p	Lock-fit	–40	–40	500	500	125	300	40	120	150	100	–0·4	150	15	50	290	100
BFW91	p-n-p	Lock-fit	–20	–20	500	500	125	300	40	125*	150	100	–0·4	150	15	50	290	100
BFW92	n-p-n	T pack	25	15	50	25	125	130	20	150	2·0	1600*	0·75	20	—	—	—	—
BFX12	p-n-p	TO–18	–20	–15	140	100	200	300	20	60	10	150	–0·25	10	1	—	—	—
BFX13	p-n-p	TO–18	–20	–15	140	100	200	300	50	250	10	150	–0·25	10	1	—	—	—
BFX34	n-p-n	TO–39	120	60	5A	2A	200	870	40	150	2A	70	1·0	5A	500	210	340	5A
BFX37	p-n-p	TO–18	–60	–60	50	50	200	360	100	170*	10	—	–0·25	10	0·5	—	—	—
BLY17	n-p-n	TO–36	100	100**	10A	10A	175	100W†	5	—	5A	50	2·0	10A	2A	—	—	—
BSS27	n-p-n	TO–39	70	45	1A	1A	200	800	25	—	500	400*	0·4	500	35	25	40	500
BSS28	n-p-n	TO–39	50	30	1A	1A	200	800	30	—	500	400*	0·5	500	35	25	45	500
BSS29	n-p-n	TO–39	50	30	1A	1A	200	800	20	—	500	400*	0·5	500	35	30	50	500
BSW41	n-p-n	TO–18	40	25	500	300	200	1W	20	—	500	250	0·5	150	15	50	100	300
BSW65	n-p-n	TO–5	80	80	2A	1A	200	800	40	—	100	80*	0·4	500	5·0	—	—	—
BSW69	n-p-n	Plastic	150	150	50	50	125	125	30	—	4	130*	4·0	20	1·0	—	—	—
BSX12	n-p-n	TO–39	25	12	1A	1A	200	3W‡	30	120	300	450	0·33	300	30	11	19	1A
BSX12A	n-p-n	TO–39	25	15	1A	1A	200	3W‡	30	120	300	450	0·33	300	30	11	19	1A
BSX44	n-p-n	TO–18	15	6	200	—	200	300	30	150	20	600	0·45	50	5·0	20	15	20
BSX76	n-p-n	TO–18	20	20	400	200	200	350	35	—	10	50	0·35	50	2·5	40	80	100

*typical **V_{CER} ($R_{BE} \leqslant 10\Omega$) †$T_{mb} \leqslant 25°C$ ‡$T_{case} \leqslant 95°C$

SILICON TRANSISTORS (cont.)

Type No.	Polarity	Outline	Maximum Ratings V_{CBO} (V)	V_{CEO} (V)	I_{CM} (mA)	$I_{C(AV)}$ (mA)	T_j (°C)	P_{tot} at 25°C (mW)	h_{FE} min.	max.	at I_C (mA)	f_T min. (MHz)	$V_{CE(sat)}$ max. (V)	at I_C (mA)	I_B (mA)	t_{on} (ns)	t_{off} (ns)	at (mA)
BSX77	n-p-n	TO–18	40	20	400	200	200	350	40	120	10	100	0·35	50	2·5	40	80	100
BSX78	n-p-n	TO–18	40	20	400	200	200	350	80	240	10	100	0·35	50	2·5	40	80	100
BSY26	n-p-n	TO–18	20	15	200	100	175	300	20	60	10	200	0·35	10	1	27	130	10
BSY27	n-p-n	TO–18	20	15	200	100	175	300	40	120	10	200	0·35	10	1	27	130	10
BSY38	n-p-n	TO–18	20	15	200	100	175	300	15	45	100	350*	0·6	100	10	14	45	100
BSY39	n-p-n	TO–18	20	15	200	100	175	300	20	70	100	350*	0·6	100	10	14	45	100
BSY40	p-n-p	TO–18	–25	–20	140	100	200	300	25	60	10	140	–0·2	10	1	25	100	50
BSY41	p-n-p	TO–18	–25	–20	140	100	200	300	50	200	10	140	–0·2	10	1	25	100	50
BSY95	n-p-n	TO–18	20	15	200	100	140	150	50	200	10	200	–0·35	10	0·2	—	—	—
BU105	n-p-n	TO–3	1500	1500	2·5A	2·5A	115	10W	—	—	—	7·5*	5·0	2·5A	1·5A	—	750	2A
OC200	p-n-p	SO–2	–30	–25	100	50	150	250	10	50	20	0·45	–0·55	20	3	—	—	—
OC201	p-n-p	SO–2	–25	–20	100	50	150	250	10	70	20	2·0	–0·55	20	3	—	—	—
OC202	p-n-p	SO–2	–15	–10	100	50	150	250	24	125	20	1·4	–0·55	20	3	—	—	—
OC203	p-n-p	SO–2	–60	–50	100	50	150	250	10	50	20	0·3	–0·55	20	3	—	—	—
OC204	p-n-p	SO–2	–32	–32	500	250	150	125	10	30	150	0·45	–0·56	125	17	—	—	—
OC205	p-n-p	SO–2	–60	–60	500	250	150	125	10	50	150	0·45	–0·56	125	17	—	—	—
OC206	p-n-p	SO–2	–32	–32	500	250	150	125	16	120	150	0·85	–0·55	125	17	—	—	—
OC207	p-n-p	SO–2	–50	–50	500	250	150	310	12	70	150	2·0	–0·56	150	17	—	—	—

INDEX to Book 1 (Parts 1 & 2)

*Not recommended for the design of new equipment.
Full data for these types are available on request.

Type Number	Part/ Section	Suggested alternative	Type Number	Part/ Section	Suggested alternative
BF245A/B/C	1B		BFY50/1/2	2B	
BF262/3	D*	BF362/3	BFY53	2B	
BF264	D*		BFY90	2B	
BF324	1B		BGY22/A	2B	
BF336/7/8	1B		BGY23/A	2B	
BF355	1B		BLX13	2B	
BF362/3	1B		BLX14	2B	
BF450/1	1B		BLX65	2B	
BFQ10 to 16	2B		BLX66	2B	
BFR29	2B		BLX67	2B	
BFR30/1	2B		BLX69	2B	
BFR63/4	2B		BLX91	2B	
BFR90	2B		BLX92	2B	
BFR91	2B		BLX93	2B	
BFR92	2B		BLX94	2B	
BFR93	2B		BLY17	D*	BLX14
BFS17R	2B		BLY33/4	2B	
BFS18R/19R	D*	BFS20R	BLY35	2B	
BFS20R	2B		BLY36	2B	
BFS21/21A	2B		BLY53A	2B	
BFS28	2B		BLY55	2B	
BFS92 to 95	D*	BCX35-37	BLY83	2B	
BFT24	2B		BLY84	2B	
BFT25	2B		BLY85	2B	
BFW10/11	2B		BLY89A	2B	
BFW16	D*	BFW16A	BLY90	2B	
BFW16A	2B		BLY93A	2B	
BFW17	D*	BFW17A	BLY94	2B	
BFW17A	2B		BLY97	2B	
BFW30	2B		BRY39	2B	
BFW45	D*	BSX21	BSS27/8/9	D*	BSX59
BFW57/8/9/60	D*	BCX32-34	BSS40/1	2B	
BFW61	2B		BSS50/1/2	2B	
BFW87 to 91	D*	BFX85	BSV22	D*	BFR29/BSV81
BFW92	D*	BFS17R	BSV52R	2B	
BFW96	D*	BFR29/BSV81	BSV64	2B	
BFX12/13	D*	BCY70	BSV68	2B	
BFX29	2B		BSV78/9/80	2B	
BFX30	2B		BSV81	2B	
BFX34	D*	BSV64	BSW41	D*	
			BSW65	D*	BFX85
BFX37	D*	BCY70	BSW66/7/8	2B	
BFX63	D*	BFR29/BSV81	BSW69	D*	
BFX84/5/6	2B		BSX12/12A	D*	
BFX87/8	2B		BSX19/20	2B	
BFX89	2B		BSX21	2B	

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Type Number	Part/ Section	Suggested alternative	Type Number	Part/ Section	Suggested alternative
BSX44	D*	BSX19	2N3375	2B	
BSX59/60/61	2B		2N3442	2B	
BSX76/7/8	D*		2N3553	2B	
BSX82	D*	BFR29/BSV81	2N3632	2B	
BSY26/7	D*	BSX19/20	2N3823	2B	
BSY38/9	D*		2N3866	2B	
BSY40/1	D*	BCY70	2N3966	2B	
BSY95	D*		2N4091/2/3	2B	
BSY95A	2B		2N4347	2B	
BU126	2B		2N4391/2/3	2B	
BU133	2B		2N4427	2B	
BU204/5/6	2B		2N4856 to 4861	2B	
BU207/8/9	2B		56200	C	
OC20	D*		56201A	C	
OC22/3/4/5	D*		56201B	C	
OC26	*	AD149	56207	C	
OC28/9	2B		56209	C	
OC35/6	2B		56214	C	
OC41/2/3/4/5	D*		56218	C	
OC70/1/2	D*	AC128			
			56226	C	
OC75/6/7	D*	AC128	56227	C	
OC122/3	*	BFX87	56239A	C	
OC139/40/41	D*		56239B	C	
OC170/1	D*		56245	C	
OC200 to 207	D*				
			56246	C	
2N1613	2B		56263	C	
2N1711	2B		56265	C	
2N2297	2B		56300	C	
2N2369A	2B		56301B	C	
2N2904/4A	2B				
			56325	C	
2N2905/5A	2B		56326	C	
2N2906/6A	2B		56336A	C	
2N2907/7A	2B		56336B	C	
2N3053	2B		56338	C	
2N3055	2B				

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TRANSISTORS

CONTENTS