Specification 157A
September 24, 1968

ENGINEERING INSTRUMENT SPECIFICATION

TYPE 454/R454 OSCILLOSCOPE

FOR INTERNAL USE ONLY
TEKTRONIX, INC.

Specification 157A
September 24, 1968

ENGINEERING

INSTRUMENT SPECIFICATION

TYPE 454/R454

OSCILLOSCOPE

Prepared by Engineering Writing Dept.

Engineering Writer R W ANDERSON Dick Anderson

Approval:

Project Manager O. Dalton Oliver Dalton

Project Engineer, Electrical Carl R Battjes Carl Battjes

Project Engineer, Mechanical Dick Duggan Dick Duggan

Evaluation Engineer, Electrical Bill Snell Bill Snell

Evaluation Engineer, Mechanical Jesse Chappell Jesse Chappell

FOR INTERNAL USE ONLY

TEKTRONIX, INC.

PREFACE

This Engineering Instrument Specification is the reference document for all company activity concerning the electrical, environmental, and physical characteristics of the subject instrument. This document is printed in two issues: a tentative copy printed on or before Prototype Release of the instrument, and a final copy printed following Engineering Release. Occasionally, if justified by the number of changes, the final copy is updated and reissued following Pilot Production.

The major function of the Engineering Instrument Specification is to provide electrical, environmental, and physical characteristics to the following departments:

Manuals	Advertising
Product Technical Information	International Manufacturing Technical Support
Engineering Product Reliability	International Marketing
Marketing Technical Training	Manufacturing Quality Assurance
Product Manufacturing Staff Engineering	Manufacturing Management

Electrical and environmental characteristics listed in Section 1 are *worst case*, and are to be treated as described on page 1-1. *Factory test limits are excluded from the Engineering Instrument Specification.* Factory test limits are established by Product Manufacturing Staff Engineering, and appear in documents issuing from that department.

Periodically, an Engineering Instrument Specification may be revised and reprinted. The revised Engineering Instrument Specification will then have a 3-digit specification number followed by a capital letter printed in the upper right corner of the front cover, e.g. 000A for the first revision, 000B for the second revision, etc.

Changes in the Engineering Instrument Specification may be made *only* via the Instrument Performance Characteristic Change Request form of which 3 are included at the back of this document (contact the PE&M Engineering Writing Department for additional forms).

Abbreviations and symbols appearing in the Engineering Instrument Specification conform to Tektronix Standard No. A-100, *Recommended Short Forms*.

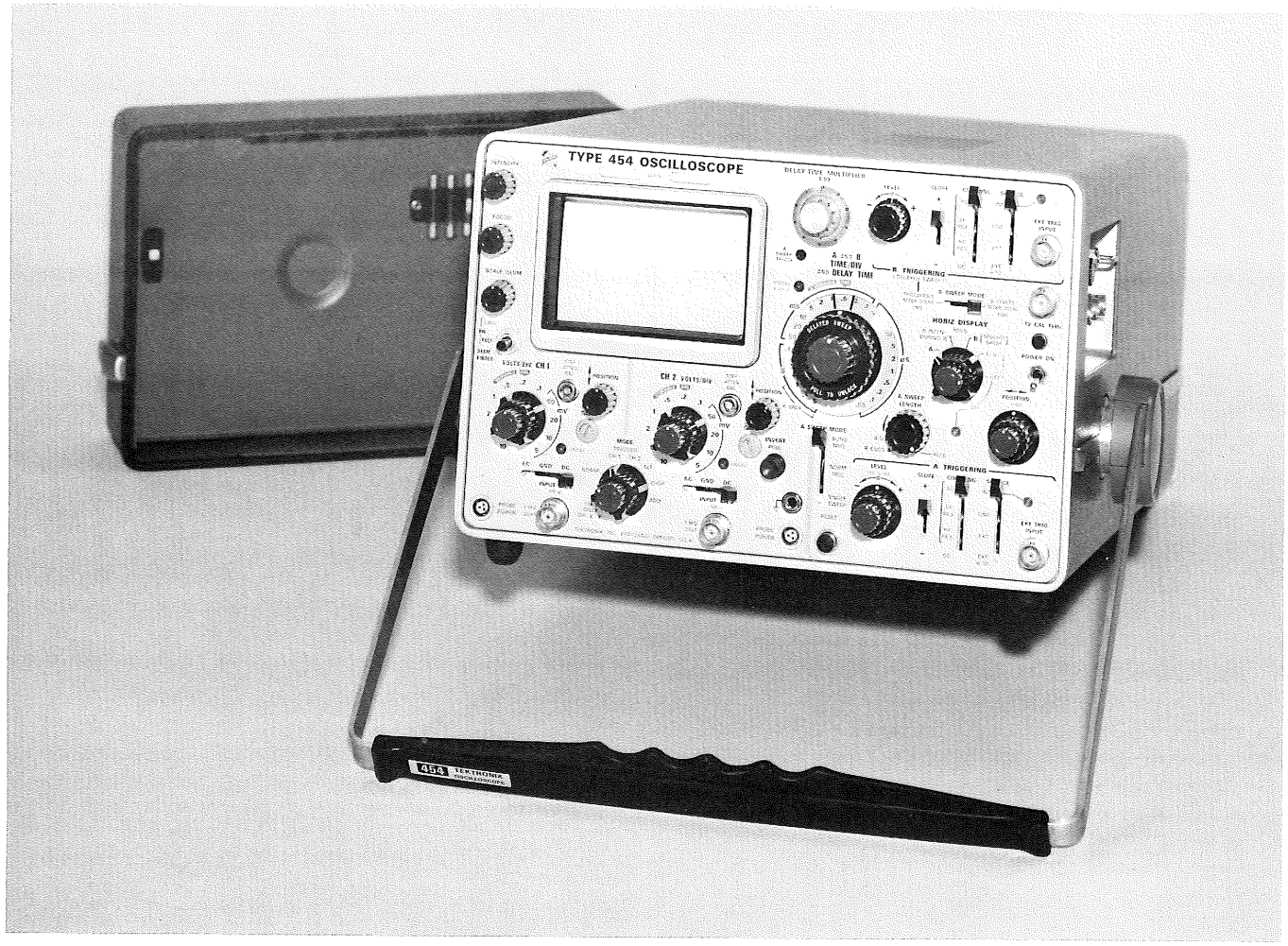
CHANGE INFORMATION LOG

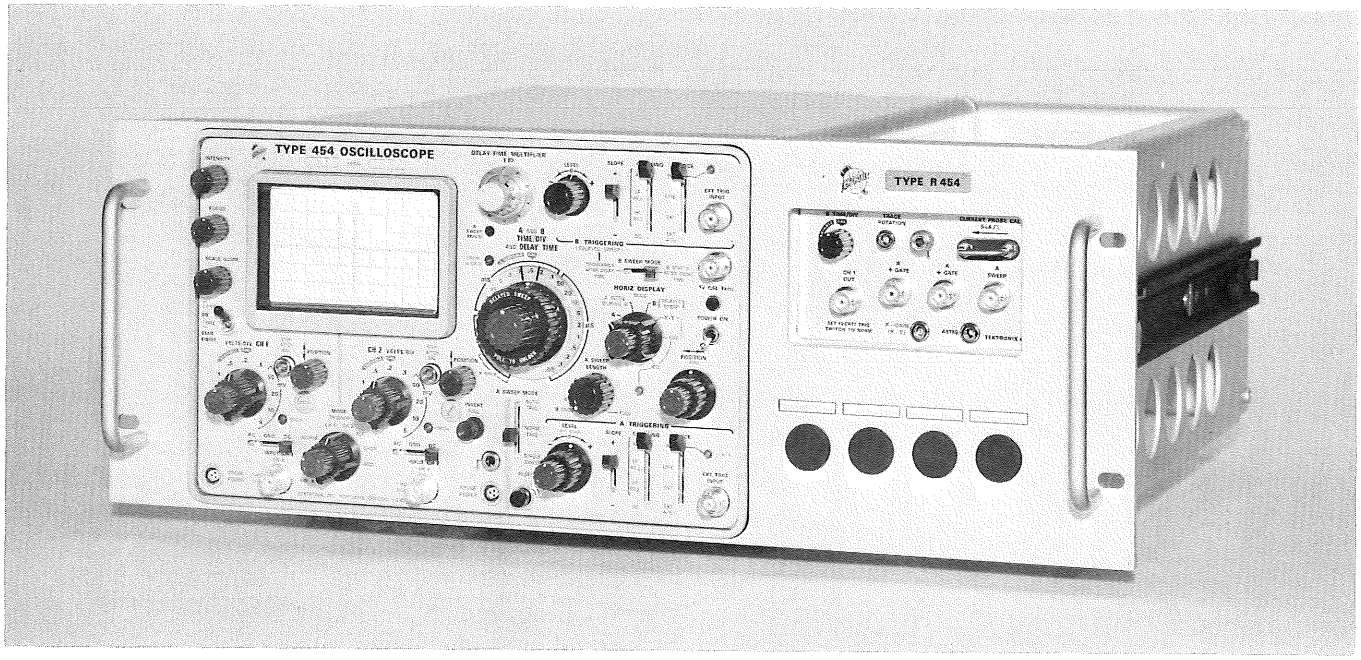
This page is used as a guide to insure that all change pages have been inserted. When change pages are received, log them on this page, then insert the change pages in their appropriate place. Change numbers (located in upper right corner of Change Notice form) are assigned in sequence. Absence of a number from the sequence indicates a change which has not been inserted.

CHANGE NOTICE NUMBER	EFFECTIVE DATE OF CHANGE	DESCRIPTION

CONTENTS

CONTENTS (cont)





THIS IS A PHOTO OF AN
ENGINEERING MODEL AND
MAY DIFFER FROM THE
PRODUCTION INSTRUMENT.

INTRODUCTION

This is the Engineering Instrument Specification for the Type 454/R454 Oscilloscope.

Description

The Type 454/R454 is a general-purpose, environmentalized, high-performance, portable, wide-band oscilloscope featuring DC to 150 MHz bandwidth combined with a dual-channel vertical amplifier and delaying sweep. The Type 454/R454 has a 5 ns sweep rate with X10 magnifier, stable triggering to bandwidth limits, and calibrated X-Y capabilities. A 5 MHz bandwidth limiter switch provides for viewing low-frequency, low-level signals with reduced noise and RF interference.

Functions of Controls, Indicators, and Connectors

POWER ON Switch

Turns instrument on or off.

1 V CAL 1 kHz Connector

BNC connector for calibrator output signal.

INTENSITY Control

Controls brightness of writing beam.

FOCUS Control

Permits adjustment of beam for optimum definition.

SCALE ILLUM Control

Controls light level of graticule.

BEAM FINDER 5 MHz BW Switch

Down position compresses trace within graticule area independent of position control settings or signal applied. Center position permits normal operation. Up position limits main vertical amplifier bandwidth to ≃ 5 MHz.

PROBE POWER

Two connectors provide correct operating voltages for P6045 FET probes.

CH 2

Displays CH 2 only.

ALT

Selects alternate mode of operation (triggered electronic switching between channels during the beam retrace interval).

CHOP

Displays both vertical channels simultaneously by electronic switching.

ADD

Algebraically adds CH 1 and CH 2 input signals.

MODE Switch

TRIGGER

Selects NORM (normal or CH 1) as an internal trigger source. CH 1 ONLY OR X-Y must be selected for X-Y operation.

CH 1 Indicator

Lights when TRIGGER switch is set at CH 1 ONLY.

CH 1 and CH 2

VOLTS/DIV Switch

Selects calibrated deflection factors from 5 mV/div to 10 V/div in a 1-2-5 sequence.

VARIABLE VOLTS/DIV Control

Provides uncalibrated continuously variable deflection factor to ≈ 2.5 X the calibrated setting (uncalibrated deflection factor range is extended to 25 V/div).

GAIN Control

Screwdriver adjustment allows calibration of vertical deflection factor.

STEP ATTEN BAL Control

Screwdriver adjustment balances the Input Amplifier in the 5, 10, 20 mV and 50 mV positions of the VOLTS/DIV switch.

Input Selector Switch

AC

Capacitively couples input signal to vertical amplifier.

GND

Grounds input attenuator.

DC

Signal is directly coupled to vertical amplifier.

INPUT CH 1 OR X Connector

BNC connector for applying external signals.

INPUT CH 2 OR Y Connector

BNC connector for applying external signals.

POSITION Controls

Vertically positions the display. In X-Y mode, CH 1 positions in X axis, CH 2 positions in Y axis.

INVERT PULL Switch (CH 2 only)

Inverts CH 2 display.

HORIZ-DISPLAY Switch

A

Displays A sweep.

A INTEN DURING B

Displays A sweep, intensified (after the delay time) for the duration of B sweep.

DELAYED SWEEP (B)

Displays DELAYED SWEEP (B)

X-Y

Permits X-Y operation *only* when vertical TRIGGER switch is set to CH 1 ONLY OR X-Y. Signals applied to CH 2 are displayed in the Y axis. (Overrides vertical MODE switch setting).

MAG Switch

Expands the horizontal display from graticule center by a factor of 10. Extends the fastest sweep rate to 5 ns/div. Inoperative in X-Y mode.

A & B TRIGGERING

SOURCE Switch

INT

Uses a portion of the signal applied to the vertical channels as a triggering signal when TRIGGER is set at NORM. Uses a portion of the CH 1 signal as a triggering signal when TRIGGER is set at CH 1 ONLY.

LINE

Uses a portion of line-frequency voltage as a trigger signal.

EXT

Permits triggering on signals applied to the EXT TRIG INPUT connector.

EXT ÷ 10

Attenuates external trigger signal 10 times.

COUPLING Switch

AC

Blocks the DC component of the triggering signal and allows triggering only on the AC portion of the signal.

LF REJ

Attenuates triggering signal below about 30 kHz, allowing the trigger circuit to respond only to higher frequencies.

HF REJ

Rejects DC, passes signals between 30 Hz and 50 kHz, and attenuates all other signals.

DC

Couples triggering signals from DC to at least 150 MHz.

EXT TRIG INPUT Connector

BNC connector providing input for external triggering.

SLOPE Switch

+ and -

Permits triggering the sweep on the positive-or-negative-going portion of the trigger signal.

HF STAB (A only)

Decreases display jitter when triggering on frequencies above 40 MHz.

LEVEL Control

Selects amplitude point on the triggering signal where sweep-triggering occurs.

A SWEEP TRIG'D Indicator

Lights when A sweep is triggered.

A SWEEP MODE Switch

AUTO TRIG

Permits normal triggering on waveforms with repetition rates at least 20 Hz. Sweep free-runs with no trigger signal or with a lower repetition rate.

NORM TRIG

Permits normal triggering.

SINGLE SWEEP

Displays one sweep only until reset.

RESET

Pushbutton resets sweep circuits when in Single Sweep mode.

A SWEEP LENGTH Control

Varies A sweep length from 4 divisions or less to ≃ 11 divisions in FULL position. In B ENDS A position, A sweep is reset at the end of B sweep.

DELAY-TIME MULTIPLIER 1-10 Control

Delays B sweep start from 0.1 to 10.1 X the Time Base A TIME/DIV setting after A sweep start.

B SWEEP MODE Switch

TRIGGERABLE AFTER DELAY TIME

Permits B (DELAYED SWEEP) triggering after delay time.

B STARTS AFTER DELAY TIME

B (DELAYED SWEEP) starts after delay time.

A TIME/DIV AND DELAY TIME Switch

Selects calibrated sweep rates and delay range from 5 s/div to 0.05 μs/div in a 1-2-5 sequence.

A VARIABLE Control

Provides uncalibrated continuously variable A sweep rate to ≃ 2.5X the calibrated setting (uncalibrated sweep rate is extended to 12.5 s/div).

B TIME/DIV Switch

Selects calibrated sweep rates and delay range from 0.5 s/div to 0.05 μs/div in a 1-2-5 sequence.

POSITION (horizontal) Control

Horizontally positions trace. Inoperative in X-Y mode.

SIDE PANEL

B TIME/DIV VARIABLE Control

Provides uncalibrated continuously variable B sweep rate to ≃ 2.5X the calibrated setting (uncalibrated sweep rate is extended to 1.25 s/div).

TRACE ROTATION Adjustment

Screwdriver adjustment aligns trace with horizontal graticule lines.

ASTIG Control

Screwdriver adjustment of beam for optimum definition.

X-GAIN (X-Y)

Screwdriver adjustment permits calibration of CH 1 (X) in X-Y mode.

CH 1 OUT

BNC connector providing a portion of CH 1 signal.

B + GATE

BNC connector providing a positive-going squarewave coincident with B sweep.

A + GATE

BNC connector providing a positive-going squarewave coincident with A sweep.

A SWEEP

BNC connector providing a portion of A sawtooth generator signal.

CURRENT PROBE CAL

Current Loop providing five-milliampere square-wave current from calibrator circuit.

REAR PANEL

Z AXIS INPUT

5-way input connector for intensity modulation of the CRT display.

Line Voltage Selector

Screw-down cover contains 2 fuses, a 2 A SLOW for 115 VAC operation and a 1 A SLOW for 230 VAC. Two range selector plugs inside can be switched to desired range.

Line Cord

Power cord is a 3-wire, permanently attached cable, approximately 7.5 feet in length

SECTION 1

CHARACTERISTICS

Characteristics are attributes or capabilities of a product described in terms of acceptable qualitative or quantative limits. The characteristics in this section are categorized as electrical, environmental and physical.

The electrical and environmental characteristics together with their related validation procedures in Section 2 and 3 comprise a complete statement of the electrical and environmental performance of a calibrated instrument. Thus, the electrical and environmental characteristics are valid only: (1) if the instrument is operating under the conditions described in this section *and* in Section 2 and 3, and (2) if the instrument is calibrated and operating in a calibrated system.

Information in this section is tabulated as follows:

1. ITEM	Titles of specific attributes or capabilities of a product.
2. QUOTABLE	Characteristics describing the measurement capabilities or limitations and physical attributes of a product. These characteristics are considered necessary to qualify a product for a particular application(s). These characteristics are a commitment between Tektronix, Inc., and the customer.
3. MAINTENANCE & OPERATION	Characteristics that, when met, will insure optimum instrument operation. These characteristics may be given to a customer as maintenance or operational aids, but are *not* a commitment between Tektronix, Inc., and the customer
4. TEST RATE	Engineering's *recommendations* (not binding on Manufacturing) regarding the minimum percentage of instruments which are tested for specific characteristics; i.e. 100%, 10%, 1% or 0.1%. These recommendations are based on confidence level, and on the importance of the characteristic.
5. VAL. STEP	The step number in Section 2 or 3 where the validation procedure for the characteristic can be found.
6. ENGINEERING NOTES	Reserved for Engineering information. This information is not to be printed in any publication normally available to the customer and may not be given to a customer except under special circumstances. This information is not intended to be a commitment between the customer and Tektronix, Inc.

NOTE

The electrical characteristics in this section are applicable for an instrument calibrated with ambient temperature between +20°C and +30°C, and after a 20 minute warm-up. Unless otherwise stated, electrical characteristics apply over an operating temperature range from -15°C to +55°C and to an altitude of 15,000 feet.

1.1 ELECTRICAL

1.1.1 VERTICAL AMPLIFIER CH 1 & CH2

ITEM	QUOTABLE		MAINTENANCE & OPERATION	TEST RATE	VAL. STEP	ENGINEERING NOTES
Deflection Factor CH 1 and CH 2						
Calibrated Range	5 mV/div to 10 V/div. Eleven steps in a 1-2-5 sequence. 1 mV/div uncalibrated in Cascaded mode			100%	2.2.1	
With P6047	50 mV/div to 100 V/div. Eleven steps in a 1-2-5 sequence					
Accuracy	Without Probe	With P6047		100%	2.2.1	
	Within 3% with GAIN adj. at 0.2 V/DIV	Within 3% with GAIN adj. at 20 mV/DIV				
Added Mode	Within 3% within calibrated range	Within 3% within calibrated range				
Uncalibrated (Variable) Range	Continuously variable between calibrated settings. Extends deflection factor to at least 25 V/div		At least 2.5:1	100%	2.2.2	
Low-Frequency Linearity	0.1 or less division compression or expansion of 2 div signal at graticule center when positioned to top and bottom of graticule			100%	2.2.3	
Gain Range (1 Volt Input, 0.2 V/Div)						
GAIN (Preamp)			700 mV to 800 mV at delay line input	100%	2.2.4	

1.1.1 VERTICAL AMPLIFIER CH 1 & CH 2 (cont)

ITEM	QUOTABLE	MAINTENANCE & OPERATION	TEST RATE	VAL. STEP	ENGINEERING NOTES
R365 (Main Amp) CW		At least 24 V P-P at CRT deflection plates measured differentially	100%	2.2.5	
CCW		22 V P-P or less at CRT deflection plates measured differentially			
Frequency Response Bandwidth (VARIABLE VOLTS/DIV at CAL) CH 1 and CH 2	See Table, page 1-6		100%	2.2.6	
Added Mode (4 Div Reference)	See Table page 1-6				
AC (Capacitive) Coupled (4 Div Reference) Lower Bandwidth Frequency	10 Hz or less at all deflection factors (with P6047 1 Hz or less at all deflection factors)				
Cascaded (CH 1 OUT Connected to INPUT CH 2 OR Y)	DC to at least 33 MHz (50 Ω 18" RG 58 A/U cable and TRIGGER set to NORM)				
Step Response CH 1 and CH 2 Risetime	See Table, page 1-6		100%	2.2.7	

1.1 ELECTRICAL

1.1.1 VERTICAL AMPLIFIER CH 1 & CH 2 (cont)

ITEM	QUOTABLE	MAINTENANCE & OPERATION	TEST RATE	VAL. STEP	ENGINEERING NOTES
Cascaded (CH 1 OUT Connected to INPUT CH 2 OR Y)	11 ns or less (50 Ω 18" RG 58 A/U cable, CH 1 and CH 2 deflection factors set at 5 mV/div, unterminated, TRIGGER set to NORM		100%	2.2.7	
Aberrations	(25 Ω source; positive-going step; variables at CAL; CH 2 at NORMAL; without probe; after 20 minute warm-up at 25°C within 5°C). All aberrations measured within 50 ns after step. See page 1-6		100%	2.2.8	

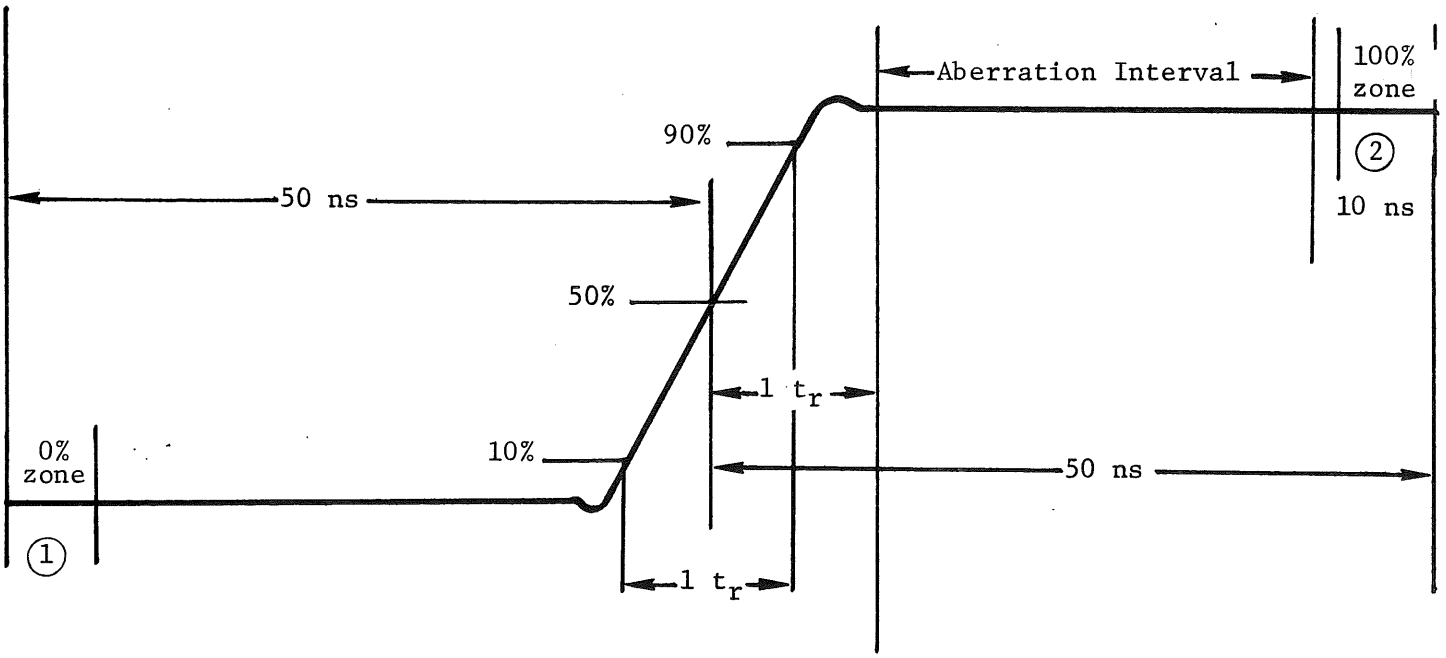
	+% or less	-% or less	Total % or less (P-P)		+% or less	-% or less	Total % or less (P-P)
5 mV	7	7	7		5	5	5
10 mV	6	6	6		3	3	5
20 mV	5	5	5		3	3	3
50 mV	5	5	5		3	3	4
100 mV	7	7	7		5	5	5
0.2 V 0.5 V					5	5	5
1.0 V					5	5	6
2.0 V					5	5	7.5
5.0 V					8	8	10
10.0 V					10	10	12

1.1.1 VERTICAL AMPLIFIER CH 1 & CH 2 (cont)

ITEM	QUOTABLE	MAINTENANCE & OPERATION	TEST RATE	VAL. STEP	ENGINEERING NOTES
Negative Step Response		P-P aberrations must be within 2% of P-P aberrations with positive input. Difference may exceed 2% if P-P value, with negative input, is 3% or less	100%	2.2.8	
Position Effect on Aberrations			100%	2.2.9	6% or less rolloff

Minimum Bandwidth and Maximum Risetime

CH 1 and CH 2 and ADDED 4 Div Reference DC (Direct) Coupled				
0°C to +40°C			-15°C to +55°C	
Deflection Factor	P6047 or 25 Ω Source Z	P6045	P6047 or 25 Ω Source Z	P6045
5 mV/div	60 MHz 5.9 ns	58 MHz 6 ns		
10 mV/div	100 MHz 3.5 ns	95 MHz 3.7 ns		
20 mV/div to 10 V/div	150 MHz 2.4 ns	130 MHz 2.7 ns		



(1) 0% Amplitude reference level

(2) 100% Amplitude reference level, Aberration reference level

1.1.1 VERTICAL AMPLIFIER CH 1 & CH 2 (cont)

ITEM	QUOTABLE	MAINTENANCE & OPERATION	TEST RATE	VAL. STEP	ENGINEERING NOTES
Common-Mode Rejection Ratio AC (Capacitive) and DC (Direct) Coupled	At least 10:1 at 50 MHz for common mode signals 400 mV P-P or less with optimized setting of GAIN at 50 MHz at 50 mV/div		100%	2.2.10	
Maximum Input Voltage DC (Direct) Coupled and AC (Capacitive) Coupled	600 V (DC + peak AC), 600 V (P-P AC) at 1 kHz or less		0.1%	2.2.11	
Input R and C Input Resistance	1 MΩ within 2%		100%	2.2.12	
Input Capacitance	20 pF within 1 pF				
Input Grid Current	2 nA or less (0.4 div at 5 mV/div)		100%	2.2.13	
STEP ATTEN BAL 5 mV/Div to 10 V/Div	Within 1 div trace shift when deflection factor switch is changed to adjacent setting		100%	2.2.14	
Range		At least 16 div when turning STEP ATTEN BAL fully cw to fully ccw at 50 mV/div			
INVERT Zero		Within 1 div from graticule center	100%	2.2.15	

1.1 ELECTRICAL

1.1.1 VERTICAL AMPLIFIER CH 1 & CH 2 (cont)

ITEM	QUOTABLE	MAINTENANCE & OPERATION	TEST RATE	VAL. STEP	ENGINEERING NOTES
POSITION Range		+ and - 10 div to 15 div from graticule center	100%	2.2.16	
Microphonics			100%	2.2.17	1 div or less
Channel Isolation	At least 100:1 at 50 MHz		100%	2.2.18	
Attenuator Isolation	At least 10,000:1 at 50 MHz		100%	2.2.19	
Chopped Mode					
Chopped Repetition Rate	1 MHz within 20%		100%	2.2.20	
Channel Time Segment	400 ns to 650 ns		100%		
Display Factor		At least 60%	100%		
Time Delay Between Channels	0.25 ns or less		0%		
5 MHz Bandwidth	4 MHz to 6 MHz		100%	2.2.21	
Attenuation Ratio of Signal at least 65 MHz	At least 10:1				

1.1.2 TIME BASE A & B

ITEM	QUOTABLE				MAINTENANCE & OPERATION	TEST RATE	VAL. STEP	ENGINEERING NOTES
Sweep Rate Calibrated Range	5 s/div (A only) to 0.05 µs/div, 25 steps in a 1-2-5 sequence. X10 magnifier extends sweep rate to 5 ns/div					100%	2.3.1	
Sweep Accuracy	[1]0°C to +40°C		[2]-15°C to +55°C			[1]100% [2]0.1%	2.3.1	
Time Interval Over Center 8 Div	Unmag	Mag	Unmag	Mag				
5 s/Div to 1 s/Div	Within 3%	Within 4%	Within 5%	Within 6%				
0.5 s/Div to 0.1 µs/Div			Within 4%	Within 5%				
0.05 µs/Div			Within 4%	Within 6%				
Over any 2 Div Interval Within Center 8 Div	Within 5%	Within 5%	Within 5%	Within 10%				

Exclude Following Portions of Magnified Sweep	Start of Sweep	End of Sweep
5 ns/Div	14 Div	7 Div
10 ns/Div	7 Div	4 Div
20 ns/Div	3.5 Div	1.5 Div

1.1.2 TIME BASE A & B (cont)

ITEM	QUOTABLE	MAINTENANCE & OPERATION	TEST RATE	VAL. STEP	ENGINEERING NOTES
Variable Range	Continuously variable between calibrated sweep rates. Extends A sweep rate to at least 12.5 s/div	At least 2.5:1	100%	2.3.2	
Sweep Length A	Variable from 4 div or less to within 0.5 div of 11 div		100%	2.3.3	
A Sweep Hold-Off Time			100%	2.3.4	
0.1 ms/Div to 5 s/Div	A TIME/DIV setting or less				
1 µs/Div to 50 µs/Div	2X A TIME/DIV setting or less (HF STAB fully ccw)				
0.5 µs/Div to 0.05 µs/Div	2 µs or less (HF STAB fully ccw)				
Normal/Mag Registration		Within 0.2 div from graticule center. 5 s/div to 1 µs/div (MAG ON to OFF)	100%	2.3.5	
Position Range			100%	2.3.6	
Fully Cw (MAG X1 FINE midrange)		Start of sweep must position to right of graticule center			
Fully Ccw (MAG X1 FINE midrange)		End of sweep must position to left of graticule center			
FINE Range (MAG X10)		5 div to 8 div	100%	2.3.6	

1.1.3 VARIABLE TIME DELAY

ITEM	QUOTABLE		MAINTENANCE & OPERATION	TEST RATE	VAL. STEP	ENGINEERING NOTES
DTM Range	0.1 to at least 10.1 times A TIME/DIV setting			100%	2.4.1	
Accuracy	[1]0°C to +40°C	[2]−15°C to +55°C		[1]100% [2]0.1%	2.4.1	
5 s/div to 0.1 s/div	Within 2.5%	Within 3.5%				
50 ms/div to 1 µs/div	Within 1.5%	Within 2%				
Multiplier Incremental Linearity	Within 0.2%	Within 0.3%		100%	2.4.3	
Jitter	1 part or less in 20,000 of 10X the A TIME/DIV setting			100%	2.4.2	

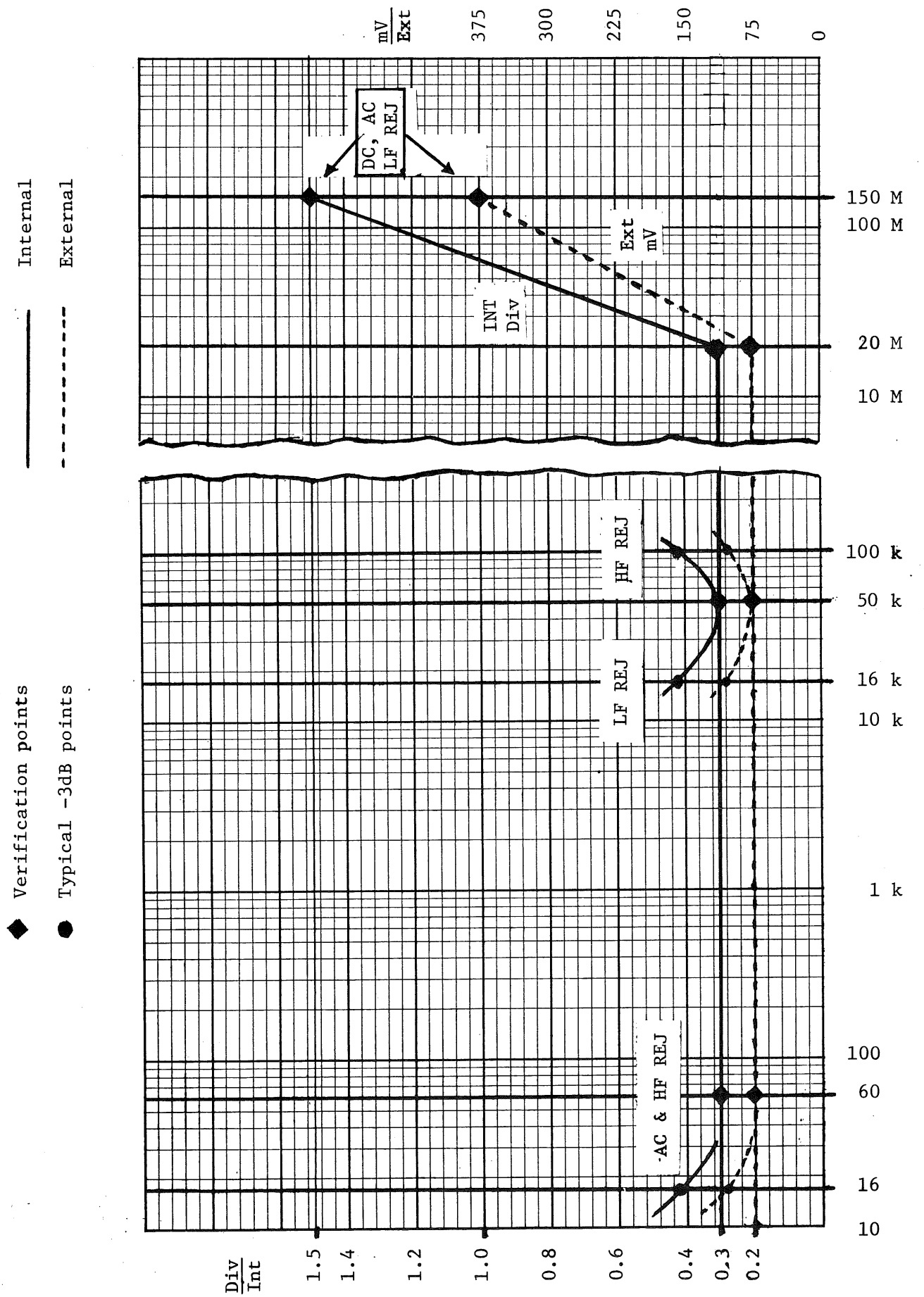
1.1 ELECTRICAL

1.1.4 X-Y MODE

ITEM	QUOTABLE	MAINTENANCE & OPERATION	TEST RATE	VAL. STEP	ENGINEERING NOTES
Deflection Factor					
Calibrated Range	5 mV/div to 10 V/div. Eleven steps in a 1-2-5 sequence. (VARIABLE CH 1 and HORIZONTAL POSITION are inoperative)		100%	2.5.1	
Accuracy	Within 3%				
Input R and C (See 1.1.1 for additional Input Characteristics)	1 MΩ Within 2% paralleled by 20 pF within 1 pF		0.1%	2.5.2	
Bandwidth	At least 2 MHz		100%	2.5.3	
Phase Shift Between CH 1 (X) and CH 2 (Y)	3° or less, DC to 2 MHz with MAG at OFF	1.5° or less DC to 2 MHz with MAG at OFF	100%	2.5.4	

1.1.5 TRIGGERING A & B

ITEM	QUOTABLE	MAINTENANCE & OPERATION	TEST RATE	VAL. STEP	ENGINEERING NOTES
Trigger Sensitivity			100%	2.6.1	
Externally Coupled	See Fig. 2, page 1-14				
Internally Coupled					
Single Sweep (A only)	Triggering level same as normal sweep. When triggered, A sweep generator produces one sweep only				
Jitter	1 ns or less at 150 MHz		100%	2.6.2	
External Trigger Input					
Maximum Input Voltage	500 V (DC + peak AC). 500 V (P-P AC) at 1 kHz or less		0.1%	2.6.3	
R and C	1 MΩ within 10%, paralleled by 27 pF within 5 pF		0.1%	2.6.4	
Level Range			100%	2.6.5	
EXT	At least + and - 2 V				
EXT ÷ 10	At least + and - 20 V				



Fig, 2 Trigger Sensitivity

1.1.6 CALIBRATOR

ITEM	QUOTABLE	MAINTENANCE & OPERATION	TEST RATE	VAL. STEP	ENGINEERING NOTES
Output Voltage (1 V)					
0°C to +40°C	Within 1%	Adjusted for 1 V within 0.3% at 25°C within 5°C	100%	2.7.1	
-15°C to +55°C	Within 1.5%		0.1%		
Output Current (5 mA)					
0°C to +40°C	Within 1%		100%	2.7.2	
-15°C to +55°C	Within 1.5%		0.1%		
Repetition Rate (1 kHz)					
0°C to +40°C	Within 0.5%	Adjusted for 1 kHz within 0.1% at 25°C within 5°C	100%	2.7.3	
-15°C to +55°C	Within 1%		0.1%		
Risetime	1 µs or less		100%	2.7.4	
Duty Cycle	49% to 51%		100%	2.7.5	
Output Resistance	250 Ω within 1%		100%	2.7.6	

1.1.7 Z AXIS INPUT

ITEM	QUOTABLE	MAINTENANCE & OPERATION	TEST RATE	VAL. STEP	ENGINEERING NOTES
Sensitivity	5 V P-P signal causes noticeable modulation at normal intensity. Positive signal decreases intensity		100%	2.8.1	
Usable Frequency Range	DC to 50 MHz		10%	2.8.2	
Maximum Input Voltage	200 V (DC to + peak AC, P-P AC must be 200 V or less, 1 kHz or less)		0.1%	2.8.3	
Input Resistance at DC		≃ 47 kΩ	0%		

1.1.8 SIGNAL OUTPUTS

ITEM	QUOTABLE	MAINTENANCE & OPERATION	TEST RATE	VAL. STEP	ENGINEERING NOTES
A Sweep					
Output Voltage	10 V within 10%, positive-going sawtooth	Starts 0 V within 1 V	100%	2.9.1	
Output Resistance		≃ 330 Ω			
A & B Gates					
Output Voltage	12.6 V within 10%, positive-going pulse	Starts at ≃ -0.6 V	100%	2.9.2	
Output Resistance		≃ 1 k Ω	0%		
CH 1 OUT DC (Direct) Coupled			100%	2.9.3	
Output Voltage	At least 25 mV/div into 1 MΩ				
Output Resistance		≃ 30 Ω			
Bandwidth	DC to at least 33 MHz				
DC Level		Adjusted to 0 V within 15 mV			

1.1 ELECTRICAL

1.1.9 POWER SOURCE

ITEM	QUOTABLE	MAINTENANCE & OPERATION	TEST RATE	VAL. STEP	ENGINEERING NOTES
Line Voltage Ranges	Grounded Neutral Distribution System				
115 V Low	90 to 110 V		0.1%	2.10.1	
115 V Medium	104 to 126 V		100%		
115 V High	112 to 136 V		0.1%		
230 V Low	180 to 220 V		0.1%		
230 V Medium	208 to 252 V		0.1%		
230 V High	224 to 272 V		0.1%		
Maximum Power Consumption	Line Selector Range: Low / Medium / High				
	90 V / 115 V / 136 V				
	48 Hz: 115 Watts 1.5 Amps / 130 Watts 1.4 Amps / 145 Watts 1.3 Amps				
	60 Hz: 110 Watts 1.4 Amps / 125 Watts 1.3 Amps / 140 Watts 1.2 Amps				
	440 Hz: 100 Watts 1.3 Amps / 115 Watts 1.2 Amps / 130 Watts 1.2 Amps				
Line Frequency	48 Hz to 440 Hz		0.1%	2.10.2	
Fuse Data					
90 V to 136 V		2.0 A fast-blowing type			
180 V to 272 V		1.0 A fast-blowing type			

1.1.9 POWER SOUCE (cont)

ITEM	QUOTABLE	MAINTENANCE & OPERATION	TEST RATE	VAL. STEP	ENGINEERING NOTES
Fuse Data					
High Voltage		2.0 A fast-blowing type			
-150 V Supply		0.25 A fast-blowing type			

1.1 ELECTRICAL

1.1.10 INTERNAL POWER SUPPLY

ITEM	QUOTABLE	MAINTENANCE & OPERATION			TEST RATE	VAL. STEP	ENGINEERING NOTES
Power Supply Accuracy at 25°C within 5°C		-12 V	+12.1 V	+75 V	100%		
Initial Setting		Within 0.27%	Within 1%	Within 0.37%		2.11.1	
Any 500 Hour Period After the First 200 Hours at 25°C within 5°C		Within 1%	Within 1.7%	Within 1%		2.11.2	
Ripple		2 mV or less	2 mV or less	2 mV or less	100%	2.11.3	
Variation From 25°C within 5°C; -15°C to +55°C		Within 0.5%	Within 0.75%	Within 0.75%	0.1%	2.11.4	
High Voltage Accuracy (CRT Cathode) at 25°C within 5°C						2.11.5	
Initial Setting		-1.96 kV within 1%			100%		
Any 500 Hour Period After the First 200 Hour at 25°C within 5°C		-1.96 kV within 3%					

1.1.11 CRT DISPLAY

ITEM	QUOTABLE	MAINTENANCE & OPERATION	TEST RATE	VAL. STEP	ENGINEERING NOTES
Horizontal Resolution	At least 15 lines in 1 div		100%	2.12.2	
Vertical Resolution	At least 15 lines in 1 div		100%	2.12.2	
Display Area	6 x 10 div (0.8 cm/div)		100%	2.12.3	
Geometry	0.1 div or less		100%	2.12.4	
Trace Rotation Range		At least 5.4°	100%	2.12.5	
Beam Locate	Positions trace within graticule area		100%	2.12.6	
Electrode Voltage Range to Ground					
Heater Voltage (Pins 1 and 14)					6.3 RMS at 103 mA (elevated to -1960 V)
Overall Accelerating Potential					14 kV
Post Accelerator					+12 kV
Cathode (Pin 2)					-1960 V
Post Accelerator Mesh (Pin 9)					0 V
D1-D2 Deflection Shield (Geometry Pin 9)					0 V to +90 V

1.1.11 CRT DISPLAY (cont)

ITEM	QUOTABLE	MAINTENANCE & OPERATION	TEST RATE	VAL. STEP	ENGINEERING NOTES
Average of Deflection Plates					
Horizontal					+65 V
Vertical					+41 V
Astigmatism (Pin 5)					0 V to +75 V
Accelerator (1st Anode) (Pin 7)					+41 V
Focus (Pin 4)					-1450 V to-1800 V
Grid No. 1 (Pin 3)					-2093 V to -1960 V
CRT Deflection Factor					
Vertical					4.3 V/div to 4.9 V/div
Horizontal					11 V/div to 12.6 V/div
Photographic Writing Speed (Without Film Fogging Techniques)				2.12.7	
C31 Camera with f1.2 lens, and 1:0.5 object-to-image ratio	At least 1600 div/μs (1280 cm/ μs) with Polaroid* type 410 film (10,000 ASA) and type P31 CRT phosphor				

1.1.11 CRT DISPLAY (cont)

ITEM	QUOTABLE	MAINTENANCE & OPERATION	TEST RATE	VAL. STEP	ENGINEERING NOTES
C31 Camera with f1.2 lens, and 1:0.5 object-to-image ratio (cont)	At least 3200 div/μs (2560 cm/μs) with Polaroid* type 410 film (10,000 ASA) and type P11 CRT phosphor			2.12.7	
C30 Camera with f1.9 lens, and 1:0.7 object-to-image ratio	At least 182 div/μs (146 cm/μs) with Polaroid* type 107 film (3000 ASA) and type P31 CRT phosphor				
C40 Camera with f1.3 lens, and 1:0.5 object-to-image ratio	At least 1250 div/μs (1000 cm/μs) with Polaroid* type 410 film (10,000 ASA) and type P31 CRT phosphor				
	At least 2500 div/μs (2000 cm/μs) with Polaroid* type 410 film (10,000 ASA) and type P11 CRT phosphor				
	* Registered Trade-Mark Polaroid Corp.				

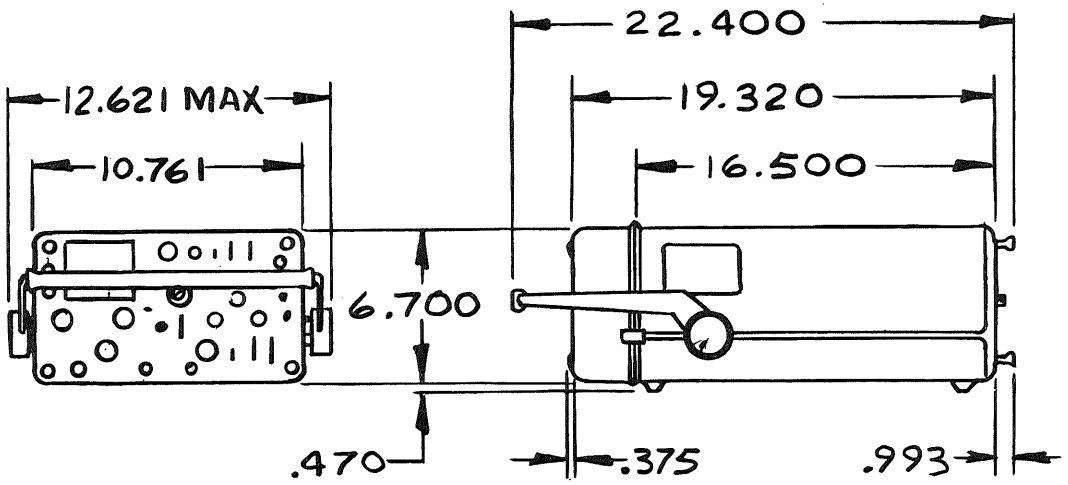
ITEM	QUOTABLE	MAINTENANCE & OPERATION	TEST RATE	VAL. STEP	ENGINEERING NOTES
Temperature					
Nonoperating	-55°C to +75°C		0.1%	3.1	
Operating	-15°C to +55°C		0.1%	3.1	
Altitude		May be tested during nonoperating temperature tests			
Nonoperating	To 50,000 feet		0.1%	3.2	
Operating	To 15,000 feet; maximum allowable ambient temperature decreased by 1°C/1000 feet from 5,000 feet to 15,000 feet		0.1%	3.2	
Humidity					
Nonoperating	5 cycles (120 hours) of MIL-STD-202C, Method 106B. Omit Freezing and Vibration and allow 24 hour post-test drying period at 25°C within 5°C at 20% to 80% relative humidity		0.1%	3.3	
Vibration					
Operating	15 minutes along each of the 3 major axes at a total displacement of 0.025" P-P (4 g's at 55 c/s) with frequency varied from 10 to 55 to 10 c/s in 1-minute sweeps. Hold for 3 minutes at 55 c/s. All major resonances must be above 55 c/s		0.1%	3.4	

ITEM	QUOTABLE	MAINTENANCE & OPERATION	TEST RATE	VAL. STEP	ENGINEERING NOTES
Shock Nonoperating and Operating	30 g's, 1/2 sine, 11 ms duration, 2 shocks per axis each direction for a total of 12 shocks		0.1%	3.5	
Electromagnetic Interference (Mod 163D only) As Tested in MIL-I-6181D and MIL-I-16910C Radiated Interference	From the instrument under test 14 kHz to 1000 MHz with Mesh Filter installed		0.1%	3.6	
Conducted Interference	Through the power cord, 150 kHz to 30 MHz				
Transportation	Qualified under National Safe Transit Committee test procedure 1A with a 30" drop		0.1%	3.7	

ITEM	QUOTABLE	MAINTENANCE & OPERATION	TEST RATE	VAL. STEP	ENGINEERING NOTES
Finish (Cabinet Model)	Front Panel is anodized aluminum; cabinet is vinyl-clad aluminum				
Weight					
Type 454	≃ 30 lbs				
Type R454	≃ 33.5 lbs				

Overall Dimensions

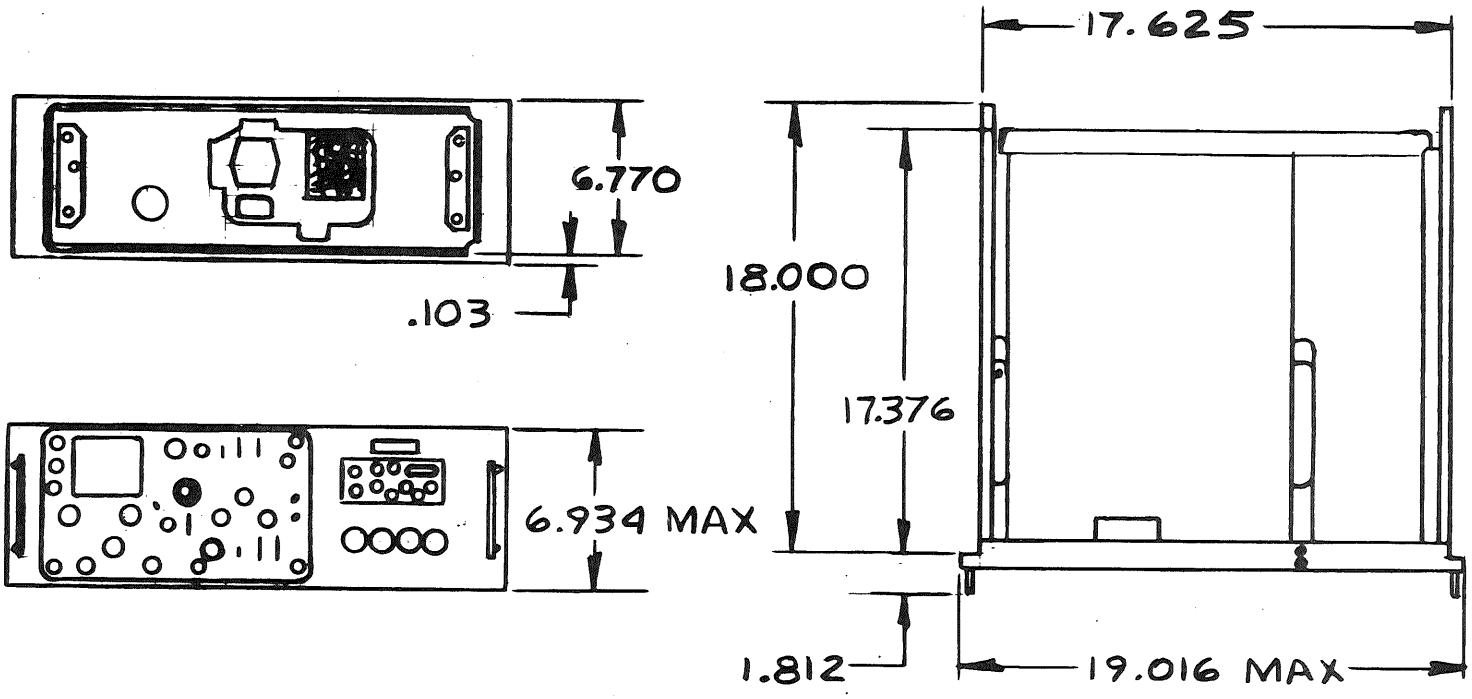
Type 454



ITEM	QUOTABLE	MAINTENANCE & OPERATION	TEST RATE	VAL. STEP	ENGINEERING NOTES

Overall Dimensions

Type R454



SECTION 2

ELECTRICAL PERFORMANCE VALIDATION

2.1 Test Equipment Required

1	Oscilloscope	:	Tektronix Type 540-Series
1	Micro-Shock Hammer	:	(PMPE Dwg. #1779-A)
1	Pulse Generator	:	Tektronix Type TU-5
1	Pulse Generator	:	Tektronix Type 109
1	Sinewave Generator	:	Tektronix Type 191
1	Adapter	:	Tektronix Type TU-5 to 105
1	Squarewave Generator	:	Tektronix Type 106
1	Time-Mark Generator	:	Tektronix Type 184
1	Standard Amplitude Calibrator	:	Tektronix Part No. 067-0502-00
1	Constant Amplitude Signal Generator	:	Tektronix Part No. 067-0532-00
1	Delay Cable	:	Tektronix Type 113
1	Capacitance Bridge	:	ESI 250 DA
1	Dual-Trace Unit	:	Tektronix Type 1A1
1	Current Probe	:	Tektronix Type P6019
1	Line Voltage Control Unit	:	Tektronix Type 76TU
1	DC Voltage Bridge	:	Tektronix Part No. 067-0543-99
1	Mercury Pulser	:	Special
1	Dual-Input Coupler	:	Tektronix Part No. 067-0525-00
1	Line Frequency Control Unit	:	Tel-Instrument Type 4100-I-H10S
1	Sine-Wave Generator	:	Tektronix Part No. 067-0542-99

2.2 Vertical Amplifier

2.2.1 Deflection Factor CH 1 and CH 2 Accuracy

Connect Standard Amplitude Calibrator to INPUT CH 1 OR X. Use either 4 or 5 div of displayed signal depending upon combination of calibrator signal and VOLTS/DIV setting to check each setting of VOLTS/DIV switch. Repeat for CH 2. Repeat with P6047. Repeat for ADD mode.

2.2.2 VARIABLE Range

Connect SAC to INPUT CH 1 OR X. Set vertical deflection factor to 1 V/div and apply 5 V from SAC. Turn VARIABLE VOLTS/DIV fully ccw. Check for VARIABLE Range. Repeat for CH 2.

2.2.3 Low-Frequency Linearity

Connect SAC to INPUT CH 1 OR X. Set vertical deflection factor to 1 V/div SAC to 2 V, and center the display. Position bottom of waveform to bottom graticule line and note change in pulse amplitude. Position top of waveform to top graticule line and note change in pulse amplitude. Linearity is the maximum change in pulse amplitude occurring at the defined limits.

2.2.4 GAIN (preamp)

Connect 1 V CAL signal to INPUT CH 1 OR X. Set deflection factor to 0.2 V/Div, Input Selector to DC, and position display about graticule center. Monitor delay line input with test scope in differential mode. Turn GAIN fully cw and check for at least 800 mV. Turn GAIN fully ccw and check for 700 mV or less. Adjust GAIN for 750 mV. Repeat for CH 2.

2.2.5 R365 (main amp)

Connect 1 V CAL signal to INPUT CH 1 OR X. Set deflection factor to 0.2 V/Div, Input Selector to DC, and position display about graticule center. Monitor CRT deflection plates with test scope in differential mode. Turn R365 cw and check for at least 24 V P-P. Turn R365 ccw and check for 22 V or less. Adjust R365 for 5 div display. NOTE: It may be necessary to adjust GAIN to obtain 5 div display.

2.2.6 Bandwidth

Check bandwidth from 5 mV/DIV and cascade using Type 191. Set Type 191 to 50 kHz and obtain 4 div of display. Increase frequency until 2.8 div are displayed. Note frequency. From 10 mV/DIV to 1 V/DIV connect Constant Amplitude Signal Generator (067-0532-00). Obtain 4 div of display at 3 MHz. Increase frequency until 2.8 div are displayed. Note frequency. 1 V/DIV to 10 V/DIV bandwidth is calculated from risetime.

Set TRIGGER to NORM to check CH 1 OUT. CH 1 OUT connected to INPUT CH 2 OR Y to check cascaded bandwidth.

2.2.7 Risetime

Risetime from 5 mV/DIV to 0.5 V/DIV is calculated from bandwidth. Risetime from 1 V/DIV to 10 V/DIV is measured using the short pulse method. Connect an open-circuit charge line to Type 109 50 Ω CHG LINE that will produce a pulse 2.33 ns wide at the 50%

amplitude point. NOTE: Pulse width must be verified with a sampling system. Connect Type 113 Delay Cable to Type 109 50 Ω CHG LINE 2. Connect from Type 109 50 Ω OUTPUT---RG-8 A/U cable ---50 Ω 2 W termination---INPUT CH 1. Set CH 1 OR X deflection factor for 1 V/div, and adjust AMPLITUDE of Type 109 for a 4 div display. Adjust LEVEL to display 4 div reference pulse and short pulse. The short pulse amplitude must be at least 3.2 div. Repeat for 2 V/DIV, 5 V/DIV and 10 V/DIV.

Repeat for CH 2. Repeat to check ADD mode.

2.2.8 Aberrations

(For this check, it is essential that the geometry and trace rotation adjustments be optimized.) Connect 113 via an airline elbow to 109 50 Ω CHG LINE 2. Short 50 Ω CHG LINE 1 to ground. Connect 109 50 Ω OUTPUT---RG 213/U cable---50 Ω Termination--- INPUT CH 1. Center display and set sweep rate to 10 ns/div. Select attenuators to provide a 4 div display from 5 mV/DIV to 10 V/DIV. Measure total P-P pulse aberration in the form of overshoot, rounding, ringing, or tilt, during the aberration interval, expressed as a percentage of pulse amplitude. The pulse amplitude reference level is the average level in the 40-50 ns period after the step (see figure on pg 1-6). Return oscilloscope to 20 mV/DIV setting and again note aberrations with a 4 div display. Switch Type 109 to negative output and again center display. Check that negative step response is within specifications. Repeat for CH 2.

2.2.9 Position Effect on Aberrations

Connect Type 109 to INPUT CH 1 OR X. Connect Type 113 to 50 Ω CHG LINE 1. Set vertical deflection factor to 20 mV/div, and apply 4 div of supply from Type 109. Position top of waveform to bottom of graticule and measure total pulse aberration.

Set PULSE POLARITY to - . Position bottom of waveform to top of graticule and measure pulse aberration.

Repeat to check CH 2.

2.2.10 Common Mode Rejection Ratio

Apply 400 mV of 50 kHz from a Type 191 to CH 1 and CH 2 vertical input connectors. Set CH 1 and CH 2 VOLTS/DIV to 50 mV. Invert CH 2, set MODE to ADD and adjust CH 2 GAIN for maximum CMRR (minimum deflection). Increase frequency of generator to 50 MHz and note the P-P amplitude. Set MODE to CH 1 and check P-P amplitude. CMRR is the ratio of the CH 1 P-P amplitude to the P-P amplitude in the ADDED position.

2.2.11 Maximum Input Voltage

Set Input Coupling to DC, A SWEEP MODE to AUTO TRIG, and MODE to CH 1. Apply 600 VDC and switch deflection factor from 5 mV/div to 10 V/div. There must be no physical damage, discoloration of any component, or change in value of any component beyond its rated tolerance. The Type 454 must operate within its electrical characteristics after the Maximum Input Voltage test.

2.2.12 Input R and C

Connect ESI 250 DA Bridge to vertical input connector. Measure resistance and capacitance of INPUT CH 1 OR X and INPUT CH 2 OR Y.

2.2.13 Input Grid Current

Set vertical deflection factor to 5 mV/div. Position trace to graticule center. Set Input Selector to Gnd. Switch Input Selector to DC and note trace deflection. Indicated voltage is divided by 1 MΩ input resistance to determine grid current. Trace shift must be 0.4 div or less

2.2.14 STEP ATTEN BAL

Set A SWEEP MODE to AUTO TRIG, sweep rate to 1 ms/div, and position trace to graticule center. Check trace shift when deflection factor switch is changed to adjacent setting from 5 mV/div to 10 V/div.

Set CH 1 deflection factor to 50 mV/div, STEP ATTEN BAL fully cw and position trace to top of graticule. Turn STEP ATTEN BAL fully ccw and check range.

2.2.15 Invert Zero Shift Point

Set vertical deflection factor to 20 mV/div, Input Selector to GND. Adjust CH 2 POSITION to obtain a minimum trace shift while switching PULL TO INVERT from normal to inverted. When balanced, note trace position from graticule center.

2.2.16 Position Range

Set LEVEL fully cw. TRIGGER SOURCE to EXT, MODE to AUTO, sweep rate to 1 ms/div, vertical deflection factor to 0.1 V/div. Position trace to graticule center. Set Input Selector to AC. Connect Type 106 output to 10X atten---50 Ω Termination---CH 1 vertical input connector. Adjust Type 106 amplitude and symmetry

controls to obtain a 6 div display centered on screen. Set Vertical deflection factor to 50 mV/div. Turn POSITION fully cw. Top waveform must position between graticule center and 3 div down from graticule center.

Turn POSITION fully ccw. Bottom of waveform must position between graticule center and 3 div up from graticule center. Repeat for CH 2.

2.2.17 Microphonics at 5 mV/Div

Set deflection factor to 5 mV/div. Ground input through P6047. Place Micro-Shock Hammer on top on instrument. Operate Micro-Shock Hammer and check microphonic noise.

2.2.18 Channel Isolation

Set CH 1 vertical deflection factor to 0.2 V/div and apply 50 MHz signal from Type 191. Adjust amplitude of Type 191 to obtain 2 div display. Set CH 1 and CH 2 VOLTS/DIV to 20 mV/DIV and Input Selector to CH 2. Check for 0.2 div or less of amplifier crosstalk. Repeat to check CH 2.

2.2.19 Attenuator Isolation

Set CH 1 Input Selector to DC, deflection factor to 1 V/div. Set Ch 2 Input Selector to AC, deflection factor to 5 mV/div. Apply 50 MHz, 5 div signal from Type 191 to CH 1 vertical input connector. Set Vertical Mode to CH 2 and check for 0.1 div or less of deflection. Repeat above to check CH 1.

2.2.20 Chopped Repetition Rate

Set sweep rate to 0.5 μs/div and vertical MODE to CHOPPED. Adjust CH 1 and CH 2 POSITION to obtain 2 div of display. Adjust LEVEL Control to trigger display. Set INTENSITY to an above normal setting. Check for one-cycle over 1.6 div to 2.4 div of calirated sweep.

Check Channel Time Segment by noting duration of one-half cycle of chopped waveform including blanked portion. Turn intensity to normal and check Display Factor by comparing duration of unblanked one-half cycle to Channel Time Segment duration.

2.2.21 5 MHz Bandwidth

Set bandwidth limiter switch to 5 MHz BW. Set CH 1 vertical deflection factor to 1 V/div and connect Type 191 to INPUT CH 1

OR X. Set Type 191 to 50 kHz and obtain 4 div of display. Increase frequency until 2.8 div are displayed. Check that frequency is within specifications.

Connect Constant Amplitude Signal Generator (067-0532-00) to Type 454 INPUT CH 1. Set BW to FULL and adjust generator amplitude for a 5 div display. Set generator frequency to 65 MHz and BW to 5 MHz. Check for 0.5 div or less. Increase generator frequency to 200 MHz and check for 0.5 div or less.

2.3 Time Base A & B

2.3.1 Sweep Accuracy

Connect Type 184 to INPUT CH 1 OR X. Time marks and graticule line are counted beginning with zero (0-1-2-3 etc.). Time marks should be selected so there is 1 mark/div at all "1,5,10" ranges, and 2 marks/div at all 2 and 20 ranges. All timing measurements are made over middle 8 div of graticule. The first and last div should not be included in the measurement.

2.3.2 Variable Range

Connect Type 184 to INPUT CH 1 OR X. Apply 10 ms time marks from Type 184. Set sweep rate to 1 ms/div and obtain a stable display. Two 10 ms time marks will be displayed. Position the 1st mark behind the zero graticule line and the 2nd marker behind the 10th graticule line. Turn VARIABLE fully ccw and note the 2nd mark positions on, or to the left of, the 4th graticule line.

2.3.3 Sweep Length A

Connect Type 184 to INPUT CH 1 OR X. Apply 1 ms and 100 µs time marks from Type 184. Set sweep rate to 1 ms/div. Each 100 µs time mark represents 1/10th of a major div. Turn A SWEEP LENGTH fully cw and note A sweep length. Turn A SWEEP LENGTH ccw, not to detent, and note sweep length.

2.3.4 A Sweep Hold-Off Time

Monitor the + A GATE with test scope. Measure interval between + GATE waveforms to determine hold-off time.

2.3.5 Normal/Magnified Registration

Connect Type 184 to INPUT CH 1 OR X. Apply 5 ms time marks from Type 184. Set sweep rate to 1 ms/div and MAG to X10. Horizontally position sweep so middle time mark falls behind the center vertical graticule line. Switch MAG to NORM and note the deviation of the 5 ms time mark from graticule center.

2.3.6 Position Range

Sweep Length must be within its performance requirements prior to position range check. Connect Type 184 to INPUT CH 1 OR X. Apply 1 ms and 100 µs time marks from Type 184. Set sweep rate to 1 ms/div, HORIZ DISPLAY to A and A SWEEP MODE to AUTO. Turn coarse and FINE Horizontal POSITION fully cw and note start of sweep must position to right of graticule center.

Turn coarse and FINE Horizontal POSITION fully ccw and note that the end of sweep positions to left of graticule center. Set MAG to X10, FINE fully ccw, and horizontally position a 1 ms time mark to zero graticule line with coarse control. Turn FINE fully cw. The 1 ms time mark must position 5 div to 8 div to the right.

2.4 Variable Time Delay

2.4.1 Delay Time Accuracy

Connect Type 184 to INPUT CH 1 OR X. Set A sweep rate to 1 ms/div, HORIZ DISPLAY to A INTEN DURING B, B SWEEP MODE to B SWEEPS AFTER DELAY TIME, and B sweep rate to 10 µs/div. Apply 1 ms time marks from Type 184. Set DELAY-TIME MULTIPLIER to 100, and note the first time mark is intensified. Set HORIZ DISPLAY to DELAYED SWEEP (B) and adjust DTM so the 1st 1 ms time mark is at start of sweep. Note dial setting of DTM. Set HORIZ DISPLAY to A INTEN DURING B, and DTM to 900. The 9th time mark will be intensified. Set HORIZ DISPLAY to DELAYED SWEEP (B) and adjust DTM so the 9th, 1 ms time mark is at start of sweep. Subtract first dial reading from 2nd dial reading. Delay time accuracy is the percent of deviation from 800 div. Check from 5 s/DIV to 1 µs/DIV.

2.4.2 Jitter

Connect Type 184 to INPUT CH 1 OR X. Set A sweep rate to 1 ms/div, HORIZ DISPLAY to A INTEN DURING B, B SWEEP MODE to B SWEEPS AFTER DELAY-TIME, and B sweep rate to 1 µs/div. Set DTM to 100 and note that 1st, 1 ms time mark is intensified. Set HORIZ DISPLAY to DELAYED SWEEP (B). Measure the horizontal excursion of the 1 ms time mark disregarding the drift.

Set HORIZ DISPLAY to A INTEN DURING B, and DTM to 900, and note the 9th, 1 ms time mark is intensified. Set HORIZ DISPLAY to DELAYED SWEEP (B). Measure the horizontal excursion of the 1 ms time marks disregarding the drift.

2.4.3 DTM Incremental Linearity

Determine DTM dial difference between the first and the ninth markers by the same procedure as in Par 2.4.1. Divide this difference by 8. (Delay Range checked). The result is the dial divisions/marker. To calculate ideal linearity points for each marker, start with 100 (first marker point) and add the dial divisions/marker figure determined above, to obtain the 2nd marker dial reading. Add the dial divisions/marker and the 2nd marker reading to determine the 3rd marker point; then add the dial division/marker to the 3rd marker point to get the 4th marker point and so on. (See example below). Align each marker to a reference point on the graticule and check that dial readings are within 4 divisions of the calculated values.

Example: first marker at 100
ninth marker at 908

difference: 808 divided by 8 = 101 dial divisions/marker

Ideal Linearity Points	Actual Readings	Divisions of Deviation
100	100	0
100 + 101 = 201	200	-1
201 + 101 = 302	301	-1
302 + 101 = 403	401	-2
403 + 101 = 504	502	-2
504 + 101 = 605	603	-2
605 + 101 = 706	705	-1
706 + 101 = 807	806	-1
807 + 101 = 908	908	0

The dial reading between any two markers shall be within 4 divisions of the difference between the calculated dial readings of these markers. (See example below).

8th marker at 807
3rd marker at 302

difference: 505 divisions within 4 divisions

2.5 X-Y MODE

2.5.1 Deflection Factor

Connect Standard Amplitude Calibrator to INPUT CH 1 OR X. Use either 4 or 5 div of displayed signal depending upon combination of calibrator signal and VOLTS/DIV setting to check each setting of VOLTS/DIV switch. Repeat to check CH 2.

2.5.2 Input R and C

Connect ESI 250 DA Bridge to INPUT CH 2 OR Y. Measure resistance and capacitance.

2.5.3 Bandwidth

Connect Type 191 to INPUT CH 1 OR X. Connect A SWEEP to INPUT CH 2 OR Y. Set HORIZ DISPLAY to X-Y. Adjust Type 191 amplitude to display 4 div of 50 kHz signal. Increase frequency until 2.8 div are displayed. Note frequency.

2.5.4 Phase Shift

Connect Type 191---Dual-Input Coupler (067-0525-00)---INPUT CH 1 OR X---INPUT CH 2 OR Y. Set CH 1 and CH 2 deflection factors to 20 mV/div, Type 191 to 2 MHz, and amplitude for a 6 div display. Set HORIZ DISPLAY to X-Y, MODE to CH 2, and TRIGGER to CH 1 ONLY OR X-Y. Measure the maximum separation of displayed ellipse along the vertical graticule line. The maximum separation measured vertically must be 0.15 div or less.

2.6 Triggering A & B

2.6.1 Trigger Sensitivity

Internal

Connect Type 191 ro 067-0532-00 generator to INPUT CH 1 OR X. Select proper mode of coupling, signal frequency, and amplitude as shown in Section 1.1.5. Trigger Sensitivity is defined as the minimum P-P signal required to obtain a stable display with an adjustment of LEVEL while switching from + slope to - slope.

To measure lower point of AC coupling, use the 067-0542-99 oscillator. Monitor the amplitude of the oscillator with a DC coupled test scope to insure constant amplitude.

External

Use same procedure as Internal Trigger Sensitivity except apply signal to INPUT CH 1 OR X and EXT TRIG INPUT.

2.6.2 Jitter

Connect Constant Amplitude Signal Generator (067-0532-00) to INPUT CH 1 OR X. Set generator frequency to 150 MHz, vertical deflection factor to 20 mV/div, and obtain 4 div of deflection. Set A SWEEP MODE to NORM TRIG, A TRIGGERING COUPLING to AC, sweep rate to 0.05 µs/div, MAG to X10, and A TRIGGERING SOURCE to INT. Adjust LEVEL and HF STAB to obtain a stable display. Check for 0.2 div or less of jitter.

2.6.3 Maximum Input Voltage

Apply 500 VDC to EXT TRIG connector. There must be no physical damage, discoloration of any component, or change in value of any component beyond its rated tolerance. The instrument must trigger within its performance requirements after the input voltage test.

2.6.4 R and C

Connect ESI 250 DA Bridge to EXT TRIG INPUT. Measure resistance and capacitance.

2.6.5 Level Range

Connect Type 191 to INPUT CH 1 OR X---EXT TRIG INPUT. Set vertical deflection factor to 1 V/div, A TRIGGERING SOURCE to EXT, A TRIGGERING COUPLING to AC, A SWEEP MODE to AUTO. Adjust LEVEL to obtain a stable display. Turn LEVEL fully cw and ccw. Display must free-run with LEVEL fully cw and fully ccw.

Set vertical deflection factor to 10 V/div and A TRIGGERING SOURCE to EXT ÷ 10. Connect Type 106 to INPUT CH 1 OR X---A EXT TRIG INPUT. Set Type 106 amplitude to 40 V. Display must free-run at the extremes of LEVEL.

Check B TRIGGER LEVEL using the same procedure as above. Set B SWEEP MODE to TRIGGERABLE AFTER DELAY TIME. HORIZ DISPLAY to A INTEN DURING B, DTM to 5.00, B TRIGGERING SOURCE to EXT, and B TRIGGERING COUPLING to AC. Adjust LEVEL until the last half of display intensifies. The display must return to normal intensity at extremes of LEVEL. Set vertical deflection factor to 10 V/div and B TRIGGERING SOURCE to EXT ÷ 10. Connect Type 106 to INPUT CH 1 OR X---B EXT TRIG INPUT. Set Type 106 amplitude to 40 V. Display must return to normal intensity at extremes of LEVEL.

2.7 Calibrator

2.7.1 Output Voltage (1 V)

Connect Standard Amplitude Calibrator to 1 V CAL 1 kHz. Set SAC to + DC, MIXED, and 1 V. Connect output of SAC to test scope. Set test scope vertical deflect on factor to 5 mV/div and note difference in chopped levels.

2.7.2 Output Current (5 mA)

Monitored with a Current Probe. If the calibrator voltage accuracy is within its performance requirements and a current is present in the current loop, it is within its performance requirement.

2.7.3 Repetition Rate (1 kHz)

Connect Type 184 to INPUT CH 1 OR X. Connect 1 V CAL 1 kHz to INPUT CH 2 OR Y. Set CH 1 and CH 2 deflection factors to 0.5 V/div, TRIGGER MODE to NORM, MODE to ALT, sweep rate to 1 ms/div, and adjust LEVEL for stable display. Position last time mark to graticule center and set MAG to X10. Note displacement of leading edge of Calibrator signal from leading edge of 1 ms time mark. The displacement must be 1/2 div or less.

2.7.4 Risetime

Monitor 1 V CAL 1 kHz with test scope. Measure the time interval between the 10% and 90% amplitude points on the leading edge of the calibrator signal.

2.7.5 Duty Cycle

Connect 1 V CAL 1 kHz to INPUT CH 2 OR Y. Set CH 2 deflection factor to 0.5 V/div, A sweep rate to 50 µs/div and obtain a stable display. Vertically position display about graticule center. Adjust A VARIABLE to obtain 5 div of positive half-cycle. Invert CH 2 and note displayed half-cycle is 5 div within 0.1 div.

2.7.6 Output Resistance

Connect Special 250 Ω within 0.25% resistor from 1 V CAL 1 kHz out to ground. Check for 0.5 V within 5 mV with DC VOLTAGE BRIDGE.

2.8 Z Axis Input

2.8.1 Sensitivity

Remove ground strap from Z Axis Input and connect SAC---Z Axis Input---INPUT CH 1 OR X. Set SAC to 5 V, A sweep rate to 0.5 ms/div, CH 1 vertical deflection factor to 1 V/div, and obtain a stable display. The positive portion of squarewave must dim at normal intensity.

2.8.2 Usable Frequency Range

Remove ground strap from Z Axis Input and connect Type 191---Z Axis Input---INPUT CH 1 OR X. Set A SWEEP MODE to NORMAL, A TRIGGERING SOURCE to EXT, and adjust LEVEL to obtain an intensity modulated sweep. Set frequency of Type 191 to 50 MHz, sweep rate to 0.1 µs/div, and MAG to X10. Check for 50 MHz intensity modulation.

2.8.3 Maximum Input Voltage

Apply 200 VDC to Z AXIS INPUT. There must be no physical damage, discoloration of any component, or change in value of any component beyond its rated tolerance. The Type 454 must operate within its electrical characteristics after the Maximum Input Voltage test.

2.9 Signal Outputs

2.9.1 A Sweep Output Voltage

Monitor A SWEEP with test scope.

2.9.2 A & B Gates Output Voltages

Monitor A & B GATE with test scope.

2.9.3 CH 1 OUT (DC Direct Coupled)

Output Voltage

Connect 1 V CAL 1 kHz to INPUT CH 1 OR X. Set CH 1 deflection factor to 0.2 V/div. Monitor CH 1 OUT with test scope.

Bandwidth

Connect Type 191 to INPUT CH 1 OR X. Set TRIGGER to NORM, MODE to CH 2, and connect CH 1 OUT to INPUT CH 2 OR Y. Set Type 191 frequency to 50 kHz and adjust amplitude to obtain 4 div of deflection. Increase frequency until 2.8 div are observed. Note frequency.

2.10 Power Source

2.10.1 Line Voltage Ranges

Vary line voltage with 76TU. Monitor regulated DC power supplies with test scope.

2.10.2 Line Frequency

Connect Type 454/R454 line cord to Tel-Instrument Type 4100-I-H10S. Monitor regulated DC supplies with test scope at frequency limits

2.11 Internal Power Supply

2.11.1 Initial Setting

The -12 V, +75 V, and High Voltage are set using DC Voltage Bridge. The +12.1 V is measured after 1 V CAL OUT is adjusted.

2.11.2 Long Term

The supplies, when measured with DC Voltage Bridge, will be within given tolerances at 25°C within 5°C for any 500 hour period after the first 200 hours.

2.11.3 Ripple

Monitor DC supplies with test scope. Measure P-P ripple.

2.11.4 Variation from 25°C within 5°C

Measured during environmental test phase.

2.11.5 High Voltage Accuracy (CRT Cathode)

Measure High Voltage with DC Voltage Bridge.

2.12 CRT Display

2.12.1 Horizontal Resolution

Connect Type 184 to INPUT CH 1 OR X. Set sweep rates to 1 ms/div and apply 1 ms and 100 µs time marks from Type 184. Adjust VARIABLE TIME/DIV for three 1 ms time marks every 2 div. Observe no overlap of 100 µs time marks over the scan area when center 4 div are focused.

2.12.2 Vertical Resolution

Connect 1 V CAL 1 kHz to INPUT CH 1 OR X. Set vertical deflection factor to 10 V/div, sweep rate to 0.1 ms/div, A SWEEP MODE to AUTO TRIG, and LEVEL fully cw, and position free-running trace over the vertical scan area. Check for no overlap of trace.

2.12.3 Display Area

Connect Type 191 to INPUT CH 1 OR X. Set sweep rate to 1 ms/div, A SWEEP MODE to AUTO TRIG, and LEVEL fully cw. Check that the raster produced exceeds graticule limits.

2.12.4 Geometry

Connect Type 184 to INPUT CH 1 OR X. Apply 1 ms and 100 µs time marks and adjust deflection factor so time marks exceed graticule scan area. Set sweep rate to 1 ms/div. The 100 µs time marks will be 0.1 div apart. Position 100 µs time marks to bottom of a vertical graticule line. The adjacent 100 µs time marks must not cross the top of the same vertical graticule line.

Position a 0.5 ms/div, free-running sweep to top and bottom of graticule, and check the amount of sweep bowing.

2.12.5 Trace Rotation Range

Turn Trace Rotation (R1480) fully cw. Vertically center a free-running trace, and position start of trace to 0 graticule line. Note where trace intersects 10th graticule line below graticule center. Turn Trace Rotation fully ccw. Note where trace intersects 10th graticule line above graticule center. Total dispacement must be at least 0.95 div.

2.12.6 Beam Locate

Set A SWEEP MODE to AUTO TRIG, CH 1 POSITION fully cw, and horizontal POSITION fully cw. Set BEAM FINDER to down position. Check that trace is compressed to within graticule area. Set CH 1 POSITION fully ccw. Check that trace is compressed to within graticule area. Set horizontal POSITION fully ccw. Check that trace is compressed to within graticule area. Set CH 1 POSITION fully cw. Check that trace is compressed to within graticule area.

2.12.7 Writing Speed

C-31 Camera System

Set A SWEEP MODE to SINGLE SWEEP and adjust INTENSITY until a spot is just visible at sweep start. Decrease intensity setting so spot just extinguishes. Connect Damped Sinewave Generator to INPUT CH 1 OR X. Set A SWEEP MODE to NORM TRIG. Adjust LEVEL for a stable display and set sweep rate to display three cycles/div. Adjust FOCUS for optimum definition. Attach C-31 camera and set lens to f1.2. Use Polaroid Type 410 speed film (10,000 ASA). Focus camera on waveform. Turn SCALE ILLUM fully ccw. Close camera shutter. Set A SWEEP MODE to SINGLE SWEEP, remove signal and reset A sweep. Wait 5 minutes for phosphor to decay. Open camera shutter, and apply signal. Wait 5 seconds and close shutter. Develop film for 10 seconds. Make five exposures on five different rolls of film.

With the same setup, but no signal applied, photograph the graticule. Cut this photograph in half along the horizontal center line to use as a measuring scale.

Mask out sinewave peaks on each waveform photograph, leaving the central third amplitude visible. View photographs while backlighted. Determine first completely visible half cycle on each photograph. Remove the masks and measure peak-to-peak amplitudes of the selected half cycles with the previously prepared measuring scale. Calculate writing speed in div/μs (sw) from the formula $sw = \pi$ (P-P amplitude) (frequency). Average results from the five photographs.

C-30 Camera System

Use the procedure outlined on the preceding page for the C-31 Camera System except:

a. Attach C-30 camera to bezel.
b. Set camera lens to f1.9.
c. Use Polaroid 3,000 speed film.

C-40 Camera System

Use the procedure outlined on the preceding page for the C-31 Camera System except:

a. Attach C-40 camera to bezel.
b. Set camera lens to f1.3.

SECTION 3

ENVIRONMENTAL PERFORMANCE VALIDATION

3.1 Temperature

Perform all tests in a single chamber and, when changing chamber ambient temperature, do not exceed a change rate of 5°C per minute.

Nonoperating

Perform all electrical tests, described in Section 2, at 25°C. Then turn the instrument off and store at -55°C ambient for 4 hours. Change ambient temperature to +75°C and again store for 4 hours. Return the ambient temperature to 25°C, allow 4 hours for stabilization, and again perform all electrical tests.

Failure Criteria: Instrument and components must meet performance requirements before and after storage. If necessary, internal or external adjustments may be performed to meet required accuracies. Cracking, warping, discoloration or any deformation which interferes with a normal mechanical function also constitutes failure.

Operating

Perform all electrical tests, described in Section 2, at -15°C. With the instrument turned off, change ambient temperature to 0°C and allow the instrument to stabilize for 4 hours. At the end of this period, turn the instrument on, allow 20 minutes for warm-up, then check accuracy and operation of all front-panel functions. With the instrument operating, change the chamber ambient temperature to +55°C and allow 4 hours for stabilization. At the end of 4 hours, again check the accuracy and operation of all front-panel functions. Return the instrument to 25°C, allow 4 hours for stabilization, then perform all electrical tests described in Section 2.

Failure Criteria: Instrument must meet performance requirements at each step in the test. Controls and switches must operate normally.

3.2 Altitude

Altitudes described in this section are referred to sea level. "Normal altitude", when used, refers to the natural elevation (outside the chamber) of the test facility site.

Nonoperating

Perform all electrical tests described in Section 2 at 25°C and normal altitude. Then store, with the instrument turned off, for 4 hours at 50,000 feet. Return chamber to normal altitude and 25°C and allow 30 minutes for stabilization. At the end of this period, repeat the electrical tests. This test may be combined with the nonoperating temperature test (3.1).

3.2 Altitude (cont)

Failure Criteria: The instrument must meet performance requirements before and after the altitude test, and must experience no cracking or warping, nor any deformation which interferes with a normal mechanical function.

Operating

Perform all electrical tests described in Section 2 at 25°C and at normal altitude. Operate the instrument for 4 hours at 15,000 feet. At the end of this period, maintain that altitude and measure accuracy and operation of front-panel functions. When necessary, open the vacuum chamber and perform required switching as rapidly as possible. Then return chamber to the specified altitude and allow 1 hour for stabilization before continuing the tests. Return the instrument to normal altitude and repeat all electrical tests described in Section 2.

Failure Criteria: Instrument will meet performance requirements before, during, and after the operating altitude tests. Any evidence of malfunction constitutes failure.

3.3 Humidity

Nonoperating

Perform 5 cycles (120 hours) of MIL-STD-202C, Method 106B. Delete freezing and vibration. Allow to dry for 24 hours at room ambient conditions (25°C within 5°C, 20% to 80% relative humidity) prior to operating. Allow one hour warm-up before making measurements.

Failure Criteria: There shall be no significant deterioration of components, materials or finishes. Type 454/R454 and its components must meet their electrical performance requirements before and after the humidity test. Deformation which interferes with normal mechanical function will not be permitted.

3.4 Vibration

Operating

Perform all electrical tests described in Section 2 before vibrating the instrument. Remove any resilient mounting feet and fasten the instrument securely to the vibration platform. With the instrument operating, vibrate for 15 minutes along each of the three axes at a total displacement of 0.025 inches with the frequency varied from 10-50-10 c/s in 1 minute cycles. Hold at any resonant point for 3 minutes in each axis for a total vibration time of about 55 minutes. Turn off the vibration platform and repeat all electrical tests described in Section 2.

3.4 Vibration (cont)

Failure Criteria: The instrument must meet performance requirements before and after the vibration tests. (Sporadic output during vibration is permissible.) Mechanical failures are indicated by:

Broken leads
Broken chassis
Broken components
Loose parts
Excessive wear
Component fatigue
Change in component value outside rated tolerance
Deformation which interferes with a normal mechanical function

Test will be completely rerun after repairing any of these failures.

3.5 Shock

Nonoperating

Perform all electrical tests described in Section 2 before proceeding with the shock tests. Subject the instrument to shock of 30 g's, 1/2 sine, 11 ms duration; 2 such shocks each direction along each of the 3 major axes for a total of 12 shocks.

Failure Criteria: The instrument will meet performance requirements before and after the shock tests. There must be no cracked or broken chassis, components, or leads; component deformation of 0.100 inches or more; nor any deformation which interferes with a normal mechanical function.

3.6 Electromagnetic Interference (MOD 163D)

Operating

Use the test set-up procedures and limits described in specification MIL-I-6181D. The tests will be performed within an electrically shielded enclosure. The instrument must be equipped with a CRT mesh filter. EMI will be check over the following frequency range.

Radiated Interference - from the instrument under test 14 kHz to 1000 MHz

Conducted Interference - through the power cord 150 kHz to 30 MHz

3.7 Transportation

Perform all tests described in Section 2 before conducting the transportation tests, then place the instrument in the carton in the manner in which it is normally shipped.

Transportation tests performed in accordance with National Safe Transit Committee Test Procedure 1A.

After the transportation tests, repeat all electrical tests described in Section 2.

Failure Criteria: The instrument must meet performance requirements before and after the transportation tests. There must be no broken components, leads, or chassis members, nor any deformation which interferes with a normal mechanical function.

9-318 D

ENGINEERING INSTRUMENT SPECIFICATION

CHANGE REQUEST

This form requests changes in the Engineering Instrument Specification (EIS) or in performance characteristics quoted to the customer via publications such as the Catalog or Instruction Manual. When the instrument has an Engineering Instrument Specification, then it is the controlling document.

Return completed form to Product Evaluation and Modification Engineering Writing 50/425 for approval and distribution.

Instrument Type:_____

Publication affected:_____ No._____ Dated_____

Requested by:_____ Dept._____ Date_____

Change: Item_____ Page No._____

From:_____

To:_____

Reason for change:_____

Approval: (Initial in proper space)

Recommended Action	Proj. Mgr.	Proj. Eng.	Eval. Mgr.	Eval. Eng.		
Make change immediately						
Make change at next rewrite						
Reject						

Date Received_____ Date Filed_____

9-318 D

ENGINEERING INSTRUMENT SPECIFICATION

CHANGE REQUEST

This form requests changes in the Engineering Instrument Specification (EIS) or in performance characteristics quoted to the customer via publications such as the Catalog or Instruction Manual. When the instrument has an Engineering Instrument Specification, then it is the controlling document.

Return completed form to Product Evaluation and Modification Engineering Writing 50/425 for approval and distribution.

Instrument Type: _____

Publication affected: _____ No. _____ Dated _____

Requested by: _____ Dept. _____ Date _____

Change: Item _____ Page No. _____

From: _____

To: _____

Reason for change: _____

Approval: (Initial in proper space)

Recommended Action	Proj. Mgr.	Proj. Eng.	Eval. Mgr.	Eval. Eng.		
Make change immediately						
Make change at next rewrite						
Reject						

Date Received _____ Date Filed _____

9-318 D

ENGINEERING INSTRUMENT SPECIFICATION

CHANGE REQUEST

This form requests changes in the Engineering Instrument Specification (EIS) or in performance characteristics quoted to the customer via publications such as the Catalog or Instruction Manual. When the instrument has an Engineering Instrument Specification, then it is the controlling document.

Return completed form to Product Evaluation and Modification Engineering Writing 50/425 for approval and distribution.

Instrument Type: _____

Publication affected: _____ No. _____ Dated _____

Requested by: _____ Dept. _____ Date _____

Change: Item _____ Page No. _____

From: _____

To: _____

Reason for change: _____

Approval: (Initial in proper space)

Recommended Action	Proj. Mgr.	Proj. Eng.	Eval. Mgr.	Eval. Eng.		
Make change immediately						
Make change at next rewrite						
Reject						

Date Received _____ Date Filed _____