

**TG200 SERIES
FUNCTION/SWEEP GENERATORS
SERVICE MANUAL**

COVERS

TG-200

TO

TG-250

INCLUSIVE

FOR SERVICE MANUALS
CONTACT:
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Part No. 48591-0400

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GENERAL

Service Handling Precautions

Service work or calibration should only be carried out by skilled engineers. Please note the following points before commencing work.

The tracks on the printed circuit board are very fine and may lift if subjected to excessive heat. Use only a miniature temperature controlled soldering iron and remove all solder (on both sides of the joint) with solder wick or suction before attempting to remove a component.

Many of the integrated circuits are CMOS devices and care should be taken when handling to avoid damage by static discharge.

Dismantling the instrument

1. Invert the instrument and remove the 4 screws next to the rubber feet.
2. Lift off the case lower ensuring the front and rear panels stay with the case upper.
3. To remove the pcbs and front panel assembly, remove the 6 screws securing the main pcb to the case upper. The 2 central screws are accessible through holes in the control and sweep pcbs.
4. Reassemble in the reverse order.

SPECIFICATION

FREQUENCY

Frequency Range: 0.002Hz to 2MHz in 7 overlapping decade ranges with fine adjustment by a vernier.
Vernier Range: 1000:1 on each range.
Vernier Accuracy: Typically +/- 5% of full scale (TG210 only).

SWEEP MODES

INTERNAL (TG220/230 only)

Sweep Range: 1000:1 within each range.
Sweep Rate: Adjustable, typically 20ms to 20 secs.
Sweep Mode: Linear or logarithmic. Sweep start and stop frequencies displayed at the press of a button.

EXTERNAL

Input Impedance: 10kOhm
Input Sensitivity: 0 to 3V for 1000:1 sweep
Maximum Allowable Input Voltage: +/-10V
Sweep Linearity: Better than 1%
Maximum Slew Rate of sweep voltage: 0.1V/us

AMPLITUDE MODULATION (TG230 only)

Depth: Variable 0 to 100%
Frequency: 400Hz (internal). DC to 100kHz (external).
External Sensitivity: Approximately 2V peak-to-peak for 50% modulation.

METER ACCURACY (TG215/230 only)

Frequency: +/- 1 digit on 2k to 2M ranges; better than 1% of full scale on 2 to 200 ranges.
Amplitude: Typically 5% of range
DC offset: Typically 2%
Resolution: 0.05% maximum on all ranges (1 in 2000)
Update rate: Varies with range; at least 2 updates per second

OPERATING MODES

(Specifications apply for the top decade of each frequency range and output 10V peak-to-peak into 50 Ohm termination)

SINE

Distortion: Less than 0.5% on 100, 1k and 10k ranges;
less than 1% on 10 and 100k ranges;
all harmonics >25dB below fundamental on 1M range.
Amplitude Flatness: +/-0.2dB to 200kHz; +/-1dB to 2MHz.

TRIANGLE

Linearity: Better than 99% to 200kHz

SQUARE WAVE
Rise and Fall Times: <100ns
Mark:Space Ratio: 1:1 +/- 1% to 100kHz

DC
Range: +/-10V from 50 Ohm

SYMMETRY

Symmetry Range: Variable typically between 1:9 to 9:1,
frequency divided by 10.

OUTPUTS

50 OHM. (Two switch-selectable ranges with 30dB vernier control
within each attenuator range.)

0dB Range: 0.6V to 20V peak-to-peak from 50 Ohms (0.3V to 10V
into 50 Ohms).

-20dB Range: 60mV to 2V peak-to-peak (30mV to 1V into 50 Ohms)

DC Offset

Control Range: +/-10V from 50 Ohm. DC offset plus signal peak limited
to
+/-10V (+/-5V into 50 Ohm). DC offset plus waveform
attenuated proportionally in -20dB position.

TTL Capable of driving CMOS and 2 standard TTL loads.

SWEEP OUT 6V ramp from 600 Ohms.
(TG220/230 only)

GENERAL

POWER REQUIREMENTS

Input Voltage: 110/120 volts AC nominal 50/60Hz or 220/240 volts AC
nominal 50/60Hz by rear panel adjustment. The instru-
ment will operate safely and meet specification within
normal AC supply variations viz. 99-132 volts AC and
198-264 volt AC respectively.

Power Consumption: 15VA max.

ENVIRONMENTAL

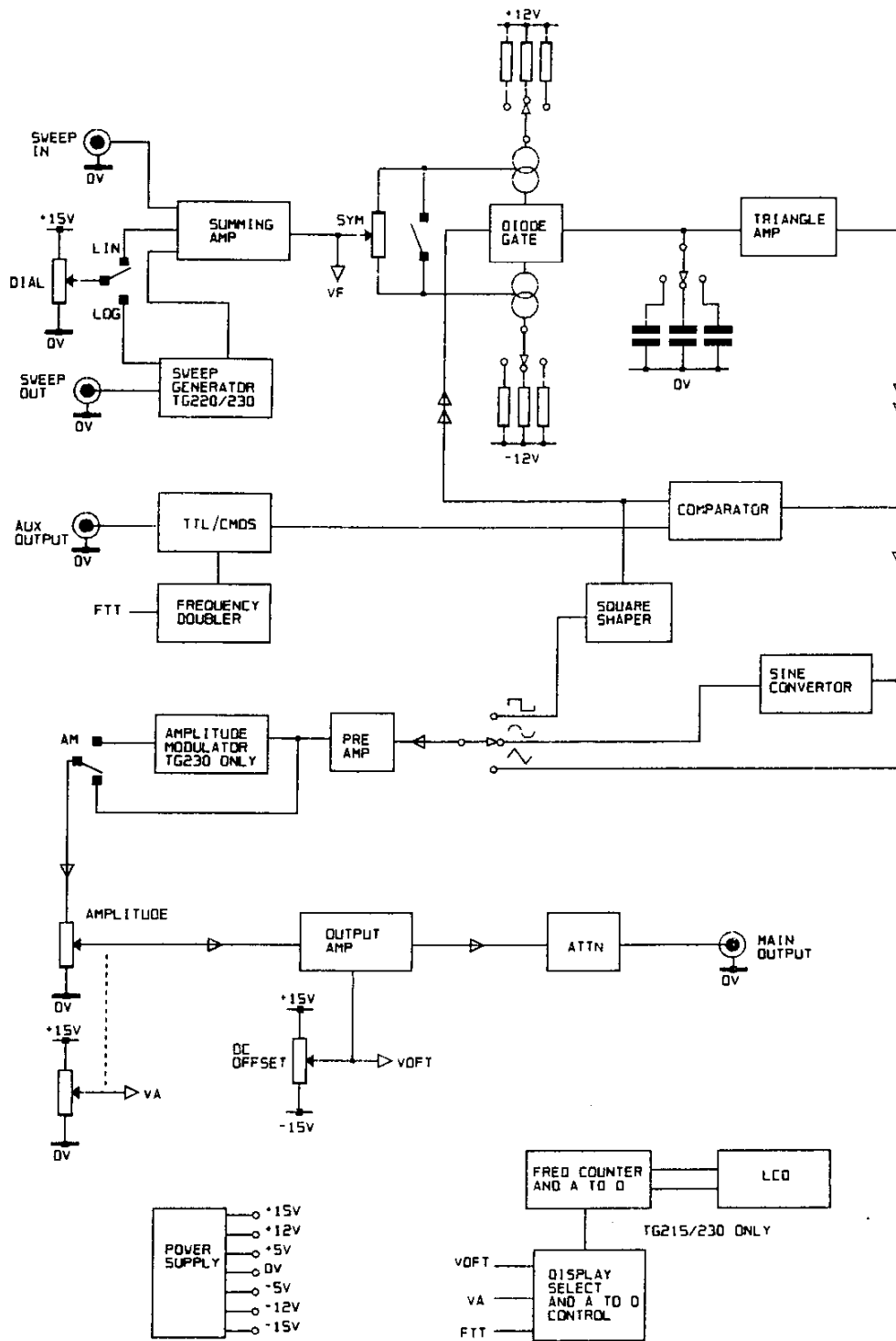
Operating Range: +5°C to +40°C, 20% to 80% RH.

Storage Range: -10°C to +65°C

SIZE: 260(W) x 88(H) x 235(D)mm (10.2 x 3.4 x 9.2"), exclud-
ing handle and feet.

WEIGHT: 1.9kg (4.2lb)

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Function Block Diagram

FUNCTIONAL DESCRIPTION

The relationships between the major circuit elements are shown in the block diagram.

The summing amplifier sums the voltages from the dial, sweep input and the sweep board and its output controls the magnitude of the complimentary current source and current sink. This current varies from approximately 1.7uA to 1.7mA for a 1000:1 frequency change (.002 - 2.0). The symmetry control adjusts the ratio between the current source and current sink.

The diode gate steers current into and out of the range multiplier capacitor and is controlled by the comparator output. When the comparator output is high the charge on the capacitor will rise, linearly, producing the positive going triangle slope. When the comparator output is low the charge on the capacitor will fall linearly producing the negative going triangle slope.

The triangle amplifier has unity gain and buffers the triangle wave on the multiplier capacitor to drive the comparator and output circuits.

The comparator operates as a window detector with fixed limit points set to the triangle peaks. One of its two outputs drives the TTL/CMOS output. The other output is level shifted to drive the diode gate and squarewave shaper. When the comparator output to the diode gate is high the triangle wave is positive going until this reaches approximately +1V, when the comparator output switches low. When the comparator output is low the triangle wave is negative going until it reaches approximately -1V, when the comparator goes high, and the cycle is repeated. This basic function generator loop is shown by the double arrows in the block diagram. Triangle and squarewave are generated simultaneously as shown.

To achieve the 20Hz and 2Hz ranges, the currents into the diode gate are divided by 10 and 100 respectively.

The sinewave converter uses the non-linear characteristics of a transistor pair to convert the triangle wave into a sinewave. The selected function is amplified by the pre-amp and applied to the amplitude control directly or via the amplitude modulator. The signal is summed with the voltage from the DC offset control at the output amplifier, which amplifies the signal up to 20V peak to peak to drive the main output socket.

The digital display measures frequency on the 2kHz to 2MHz ranges, and measures voltage at the summing amplifier on the 2Hz to 200Hz ranges. Amplitude and offset are measured in the voltage mode.

The sweep generator provides a triangle wave with variable amplitude and speed that is summed with the dial at the summing amplifier.

The power supply converts the incoming AC line voltage to the DC rails required by the instrument.

CIRCUIT DESCRIPTIONS

Power Supply - Mains Operating Voltage

The operating voltage is indicated by the orientation of the fuseholder. When the 230V marking is upwards the unit is set for operation over the range 198V to 264V. When the 115V marking is upwards the unit is set for operation over the range 99V to 132V. To change the operating voltage range, remove the AC line plug, pull out the fuse holder, replace the fuse with one of the appropriate rating (see below) and rotate the fuse holder before pushing it firmly back into place.

(The transformer is also tapped at 100V for special requirements).

Fuse

The correct fuse must be fitted after an operating voltage change. Only a time-lag fuse should be fitted.

For 230V operation use 125mA 250V time-lag

For 115V operation use 250mA 250V time-lag.

WARNING ! - THIS INSTRUMENT MUST BE EARTHED

Any interruption of the protective conductor inside or outside the instrument or disconnection of the protective earth terminal is likely to make the apparatus dangerous. Intentional interruption is prohibited.

Power Supply - DC Regulation

Diode bridge comprising D32 to D35 rectifies the transformer output and C32 and C33 are the reservoir capacitors which supply the +/-15V regulators; fine adjustment is provided by VR16 and VR17.

The +/-12V rails are derived from the +/-15V rails with D37 and D39. IC24 is a +5V regulator and D2 generates the -5V.

Waveform Generation - Summing Amplifier and Current Sources

The dial and sweep voltages are summed by IC2D; the output range of the amplifier is approximately -4mV to -4V for a 1000:1 frequency change. Q1 gives increased current drive to drive R39 and R47. When the symmetry button is depressed R39 and R47 are increased by a factor of 10 with the symmetry control in mid-position, decreasing the output frequency by a factor of 10. This allows a symmetry range of 10:1. On the 2Hz to 200Hz ranges on TG215/230, Q33 and IC17B signal the voltmeter to divide by 10 in frequency mode.

IC2C refers the output of IC2D to the +12V rail, IC4 and Q5 mirror this into the diode gate. IC2A inverts the output of IC2D, IC2B refers it to the -12V rail, IC9 and Q17 mirror this into the diode gate.

Waveform Generation - Range Selection and Triangle Amplifier

Ranges 200Hz to 2MHz use decade steps of range capacitor. The 20Hz range uses C11 and reduces the charging current one decade by selecting R61 and R51; the 2Hz range also uses C11 and reduces the charging current by another decade by selecting R59 and R50.

The triangle amplifier uses Q7 as a source follower and Q8 as a current source; Q7 and Q8 are I_{DSS} matched. Q9 is an emitter follower to give low output impedance. The stage has unity gain and the offset is trimmed by VR5.

Waveform Generation - Comparator and Aux Output

IC5 operates as a window detector and determines the peak to peak amplitude of the triangle wave on the range capacitor, which is approximately $\pm 1V$. Capacitors C15 to C19 compensate for comparator delay ensuring that the triangle wave amplitude remains constant with increase in frequency. The two internal NAND gates in IC5 are wired as a flip-flop to ensure positive switching of the comparator. C71 and C77 provide a small amount of positive feedback to ensure jitter-free operation.

Q6 level shifts the output of IC5 to be about ground, to drive the diode gate. IC6 drives the Aux Output with a TTL/CMOS compatible signal.

Waveform Generation - Waveform Shaping

The sine shaper comprises a monolithic transistor array IC12 which is driven by the triangle amplifier. The circuit has two non linear stages. A pair of emitter followers A and D round the peaks of the triangle; the output of this stage is impressed across R80 and R82 in series and applied to the second stage. This comprises a differential pair B and C driven almost into cut-off and converts the clipped triangle into a sinewave. VR7 adjusts the gain of this pair to bring them close to cut off and therefore minimum sinewave distortion. VR27 adjusts the dc operating point of the sinewave converter to give symmetrical operation on both positive and negative halves of the waveform.

The squarewave shaper is a diode bridge D13 to D16, driven by a level shifter Q10, which steers current into and out of R55 and C61. This gives a clean waveform which is symmetrical about ground. When square wave is not selected SW10B connects R77 to +5V turning off Q10.

Preamplifier

The selected waveform passes to the preamplifier. Q19 and Q20 form a long tailed pair and are in thermal contact. Emitter follows Q21 and Q22 give low output impedance and gain is set by feedback resistor R163. The amplifier is inverting.

Output Amplifier

The output amplifier is non-inverting. Q23 and Q24 form a long-tailed pair and are in thermal contact. Q25 operates in common base and forms a cascode stage in conjunction with Q24. The collector load for Q25 is current source Q27. Q26 and Q28 are complementary emitter followers. The gain of approximately 10 is set by R136 and R134.

The DC Offset control is buffered by IC18D and applied via R133.

Amplitude Modulator (TG230)

When the AM button is depressed, the amplitude modulator is inserted between the preamplifier and the output amplifier. IC19 is a balanced modulator. Q29 to Q32 form a differential amplifier which amplifies the difference between the open collector outputs of IC19. IC18B is a 400Hz Wien Bridge oscillator; LP1 provides amplitude stabilisation. IC18A buffers the signal on the modulation depth control VR22 and also sets the dc bias for IC19.

Sweep (TG220/230)

RAMP GENERATOR

The rate control VR20 determines the magnitude of the current source IC7A and Q18. This current is steered into and out of C54 by the operational transconductance amplifier (OTA) IC8. The voltage on C54 is buffered by IC7B to drive the stop control VR21 and the window comparator IC10A and IC10B. The thresholds of the window comparator determine the limits of the ramp which are 0V and +4V. Q13 and Q14 are level shifters to drive flip flop IC11A. the output of IC11A is level shifted by R20 and R30 and clamped by D5 and D6 to be symmetrical about 0V. When the input to IC8 is high the OTA sources current into C54; when the input is low the OTA sinks current from C54. This loop is very similar to a function generator. If either the set start or set stop buttons are depressed the loop is closed around the ramp generator forcing the ramp to be held precisely at its lower or upper limit. IC10D buffers the signal on VR21 to drive the main board directly or via the log converter.

LOG CONVERTER

IC3D sums the output of the ramp generator with an offset current to drive the logging transistors IC13A and IC13B. Temperature compensation of the log converter is by TDR1 which has a temperature coefficient of $+0.3\%/^{\circ}\text{C}$. The log converter itself simply uses the exponential relationship between Vbe and collector current. IC13 is a matched transistor array. The right hand transistor is the logging transistor and its emitter is driven by the input voltage via the left hand transistor which compensates for the logging transistor Vbe. The left hand transistor's collector current is defined by R33 and is held constant by IC3A; its Vbe is therefore constant and so the input voltage at the junction of R36 and TDR1 is impressed across the Vbe of the logging transistor. The logarithmic change in collector current of the logging transistor is converted into a voltage by IC3B. The log convertor is actually an antilog converter.

Digital Display

IC1 is an A to D and a frequency counter combined and directly drives the triplexed LCD. Ring counter IC20 and IC21A is incremented each time the display select button is depressed, giving 3 display modes of frequency, amplitude and offset. The frequency mode has 2 methods of measurement; on the 2k to 2M ranges the auto-ranging frequency counter is used and on the 2 to 200Hz ranges the A to D is used to measure the dial voltage Vf. When symmetry is selected IC17B signals the A to D to divide the measured Vf voltage by 10. When IC1 is used as an A to D the decimal point is positioned by IC17D, IC17C and D25 to D28. When IC1 is used as an auto-ranging frequency counter the decimal point is automatically placed.

Some early instruments are fitted with a 40kHz crystal and the frequency doubler IC25 is not fitted and LK4 is fitted instead.

When amplitude is selected the A to D measures the voltage on VR11B. When offset is selected the A to D measures the voltage on the output of IC18C. IC14 and IC16A select the voltage to be measured. IC15 and IC16c drive the annunciators by connecting to ANN to turn it on and connecting to BP1 to turn it off.

Auto-ranging of the frequency counter occurs at 1999 going up and 180 coming down. If the dial is set to between 1800 and 1999 and the frequency multiplier is then changed or the display select is cycled through, it is possible that one digit of resolution may be lost because of the counter auto-ranging down. To overcome this R25 and C72 delays the counter input, forcing it to always auto-range up.

Some of IC1s inputs are dual purpose and are listed below

pin 19 - range/freq. In frequency mode this is the counter input.
In voltage mode, when pulled high, it divides the measured voltage by 10 (symmetry). When open the measured voltage is displayed. This pin has an internal 5uA pulldown to DGND.

pin 24 - freq/volts. When pulled high frequency counting is selected.
When open the A to D is selected. This pin has an internal 5uA pulldown to DGND.

pins 20 and 21 are decoded by the IC only in the voltage mode, to place the decimal point.

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CALIBRATION

Equipment Required

Oscilloscope
Distortion meter
4.5 digit battery powered multimeter

Only the case lower need be removed to gain access to all adjustments.
Allow 5 minute warm-up before commencing. For best results, use the following procedure.

1. Power Supply

+15V	+/-20mV	- VR16	-15V	+/-20mV	- VR17
+12V	+/-0.5V		-12V	+/-0.5V	
+5V	+/-0.25V		-5V	+/-0.3V	

2. Offset Nulling

Select: 2k range, frequency vernier to 1.0, sweep off

IC	TP	Adjust	DVM Reading
4	19	VR32	<40uV
9	20	VR31	<40uV

3. Nulling of the triangle amplifier is achieved by shorting its input (TP1) and adjusting VR5 to give <2mV on TP17.

4. Preamplifier and Output Amplifier DC Offsets

Ensure the DC offset control is at its centre detent. Release all 3 function buttons. Amplitude control to minimum, adjust VR13 for <5mV at the main output.

Amplitude control to maximum, adjust VR9 for <5mV at the main output.

5. Waveform Symmetry

2k range, vernier at approximately 1.5, squarewave, adjust VR3 for equal mark:space ratio using the oscilloscope x10 X-multiplier to increase resolution and the trigger slope switch.

2M range, vernier to approximately .002 to give 2kHz to 3kHz, adjust VR4 for equal mark:space ratio.

6. Frequency Calibration

TG210/220

20k range, dial at 2.0, adjust VR25 for 20kHz

2M range, adjust VC1 for 2MHz

dial to minimum .002, adjust VR26 for 1.7kHz to 1.9kHz

TG215/230

The instrument makes direct frequency measurement on the 2k to 2M ranges and the accuracy of +/-1 digit is determined by XTL1.

200 range, vernier to approximately 1.8, adjust VR6 for the same reading as the external counter.

Dial to minimum .002, 200k range, adjust VR26 for 170Hz to 190Hz

7. **Sinewave Distortion**

Select sinewave, 2k range, 1kHz. Adjust VR7 and VR27 for minimum distortion.

8. **AM TG230**

200k range, approximately 100kHz, sinewave, modulation to minimum, amplitude to maximum (20V pk-pk),
Select AM, check output drops to half (10V pk-pk) adjusted by VR18
Release all 3 function buttons, increase the oscilloscope gain and adjust VR19 for minimum output of the 400Hz modulation source.
Adjust VR28 for 0V +/-50mV output.

9. **Meter Calibration**

Calibration of the frequency meter was covered in 6 above.

Display select to amplitude, 2k range, squarewave, adjust the amplitude control to give 16V pk-pk (8V pk-pk into 50 Ohm) then adjust VR23 for 1600 on the display.

Display select to offset, release all 3 function buttons, amplitude to minimum, offset control fully clockwise, connect a multimeter to the main output, adjust VR15 so that both meters read the same.

Offset control at centre detent, adjust VR14 so both meters read the same.

Offset control fully clockwise, readjust VR15 so that both meters read the same within 1%.

10. **Sweep**

TG220

Sweep to on, stop control to maximum, 2M range, dial to minimum .002, fit a shorting block to TP18 and adjust VR29 for 1.7kHz to 1.9kHz. Pull for LOG and adjust VR24 for 1.7kHz to 1.9kHz.

Remove shorting block from TP18 and hold in set stop, adjust VR30 for 2MHz.

TG230

Sweep to on, stop control to maximum, 2M range, vernier to minimum (.002), hold in set start and adjust VR29 for 1.7kHz to 1.9kHz. Pull for LOG, hold in set start and adjust VR24 for 1.7kHz to 1.9kHz.

200k range, hold in set stop and adjust VR30 for 200kHz.

11. **Power Consumption**

230V < 100mA

115V < 200mA

PARTS LIST

PCB Assy Main TG215/230
 consisting of
 Resistors

(+) See Manufacturing changes, page 27

Ref	Description	Part No	Ref	Description	Part No
R1	See Control PCB Assy		R65	1K50F W25 MF	23202-2150
R2	150KF W25 MF	23202-4150	R66	220RF W25 MF	23202-1220
R3	39K0F W25 MF	23202-3390	R67	680RF W25 MF	23202-1680
R4	39K0F W25 MF	23202-3390	R68	130RF W25 MF	23202-1130
R5	5K10F W25 MF	23202-2510	R69	130RF W25 MF	23202-1130
R6	27R0F W25 MF	23202-0270	R70	680RF W25 MF	23202-1680
R7	10K0F W25 MF	23202-3100	R71	220RF W25 MF	23202-1220
R8	Not used		R72	16K0F W25 MF	23202-3160
R9	See Control PCB Assy		R73	220RF W25 MF	23202-1220
R10	to		R74	16K0F W25 MF	23202-3160
R12	See Sweep PCB Assy		R75	150RF W25 MF	23202-1150
R13	See Control PCB Assy		R76	100KF W25 MF	23202-4100
R14	to		R77	4K70F W25 MF	23202-2470
R16	See Sweep PCB Assy		R78	47R0F W25 MF	23202-0470
R17	27K0F W25 MF	23202-3270	R79	22K6F W25 MF	23202-3226
R18	to		R80	1K10F W25 MF	23202-2110
R23	See Sweep PCB Assy		R81	15K0F W25 MF	23202-3150
R24	10M0F W25 MF	23202-6100	R82	226RF W25 MF	23202-1226
R25	300KF W25 MF (+)	23202-4300	R83	120RF W25 MF	23202-1120
R26	See Sweep PCB Assy		R84	180RF W25 MF	23202-1180
R27	See Sweep PCB Assy		R85	10K0F W25 MF (+)	23202-3100
R28	39K0F W25 MF	23202-3390	R86	24K9F W25 MF	23202-3249
R29	to		R87	47R0F W25 MF	23202-0470
R37	See Sweep PCB Assy		R88	15K0F W25 MF	23202-3150
R38	100KF W25 MF	23202-4100	R89	See Control PCB Assy	
R39	to		R90	to	
R41	620RF W25 MF	23202-1620	R96	See Display PCB Assy	
R42	715RF W25 MF	23202-1715	R97	See Control PCB Assy	
R43	10K0F W25 MF	23202-3100	R98	6K20F W25 MF	23202-2620
R44	1K43F W25 MF	23202-2143	R99	560RF W25 MF	23202-1560
R45	270KF W25 MF	23202-4270	R100	to	
R46	1K43F W25 MF	23202-2143	R118	See Control PCB Assy	
R47	620RF W25 MF	23202-1620	R119	150RF W25 MF	23202-1150
R48	715RF W25 MF	23202-1715	R120	3K60F W25 MF	23202-2360
R49	1K37F W25 MF	23202-2137	R121	6K20F W25 MF	23202-2620
R50	270KD W60 MF	23221-4270	R122	47R0F W25 MF	23202-0470
R51	27K0D W60 MF	23221-3270	R123	3K30F W25 MF	23202-2330
R52	2K70D W60 MF	23221-2270	R124	1K50F W25 MF	23202-2150
R53	12K0F W25 MF	23202-3120	R125	to	
R54	12K0F W25 MF	23202-3120	R130	See Control PCB Assy	
R55	1K00F W25 MF	23202-2100	R131	470RF W25 MF	23202-1470
R56	1K00F W25 MF	23202-2100	R132	1K20F W25 MF	23202-2120
R57	1K65F W25 MF	23202-2165	R133	8K87F W25 MF	23202-2887
R58	715RF W25 MF	23202-1715	R134	1K00F W25 MF	23202-2100
R59	270KD W60 MF	23221-4270	R135	270KF W25 MF	23202-4270
R60	2K70D W60 MF	23221-2270	R136	9K10F W25 MF	23202-2910
R61	27K0D W60 MF	23221-3270	R137	2K70F W25 MF	23202-3270
R62	1K50F W25 MF	23202-2150	R138	27K0F W25 MF	23202-3270
R63	2K20F W25 MF	23202-2220	R139	1K80F W25 MF	23202-2180
R64	470RF W25 MF	23202-1470	R140	150RF W25 MF	23202-1150

Resistors (continued)

(+) See Manufacturing Changes, page 27

Ref	Description	Part No
R141	150RF W25 MF	23202-1150
R142	to	
R145	10R0F W60 MF	23206-0100
R146	to	
R149	200RF W60 MF	23206-1200
R150	41R2F W60 MF	23206-0412
R152	41R2F W60 MF	23206-0412
R151	10R2F W25 MF	23202-0102
R153	to	
R155	See Control PCB Assy	
R156	2K20F W25 MF	23202-2220
R157	2K20F W25 MF	23202-2220
R158	220RF W25 MF	23202-1220
R159	220RF W25 MF	23202-1220
R160	2K20F W25 MF	23202-2220
R161	2K20F W25 MF	23202-2220
R162	470RF W25 MF	23202-1470
R163	1K80F W25 MF	23202-2180
R164	47R0F W25 MF	23202-0470
R165	2K20F W25 MF	23202-2220
R166	270KF W25 MF	23202-4270
R167	47R0F W25 MF	23202-0470
R168	See Control PCB Assy	
R169	See Control PCB Assy	
R170	47R0F W25 MF	23202-0470
R171	100KF W25 MF	23202-4100
R172	100KF W25 MF	23202-4100
R173	10K0F W25 MF	23202-3100
R174	15K0F W25 MF	23202-3150
R175	10K0F W25 MF	23202-3100
R176	47K0F W25 MF	23202-3470
R177	to	
R181	See Sweep PCB Assy	
R184	47R0F W25 MF (+)	23202-0470
VR1	See Case Parts	
VR2	See Control PCB Assy	
VR3	100R PS/H CF	23377-1100
VR4	22K PS/H CF	23377-3220
VR5	470R PS/H CF	23377-1470
VR6	470R PS/H CF	23377-1470
VR7	100R PS/H Cermet	23379-1100
VR8	10K PS/H CF (+)	23377-3100
VR9	22K PS/H CF	23377-3220
VR10	Not fitted	
VR11	See Control PCB Assy	
VR12	" " " "	
VR13	22K PS/H CF	23377-3220
VR14	See Control PCB Assy	
VR15	" " " "	
VR16	470R PS/H Cermet	23379-1470
VR17	470R PS/H Cermet	23379-1470
VR18	See Control PCB Assy	
VR19	" " " "	

Ref	Description	Part No
VR20	See Sweep PCB Assy	
VR21	" " " "	
VR22	See Control PCB Assy	
VR23	" " " "	
VR24	See Sweep PCB Assy	
VR25	Not fitted	
VR26	22K PS/H CF	23377-3220
VR27	22K PS/H CF	23377-3220
VR28	See Control PCB Assy	
VR29	See Sweep PCB Assy	
VR30	" " " "	
VR31	10K PS/H CF	23377-3100
VR32	10K PS/H CF	23377-3100

Capacitors

Ref	Description	Part No
C1	100NK 63V P/E	23620-0246
C2	10PC 63V Cer	23427-0328
C3	10PC 63V Cer	23427-0328
C4	100NK 63V P/E	23620-0246
C5	100NK 63V P/E	23620-0246
C6	120PH 160V P/S	23647-0512
C7	68PH 160V P/S	23647-0526
C8	2N0F 160V P/S	23647-0525
C9	22NJ 100V P/E	23620-0248
C10	220NK 63V P/E	23620-0247
C11	2U2K 100V P/E	23620-0257
C12	10NZ 63V Cer	23427-0325
C13	100NK 63V P/E	23620-0246
C14	100NK 63V P/E	23620-0246
C15	10PC 63V Cer	23427-0328
C16	120PC 63V Cer	23427-0342
C17	120PC 63V Cer	23427-0342
C18	3N3F 160V P/S	23646-0007
C19	3N3F 160V P/S	23646-0007
C20	10NZ 63V Cer	23427-0325
C21	10NZ 63V Cer	23427-0325
C22	10NZ 63V Cer	23427-0325
C23	100NK 63V P/E	23620-0246
C24	100NK 63V P/E	23620-0246
C25	2P2C 63V Cer	23427-0524
C26	2P2C 63V Cer	23427-0524
C27	100NK 63V P/E	23620-0246
C28	100NK 63V P/E	23620-0246
C29	100NK 63V P/E	23620-0246
C30	10UM 35V Elec	23557-0647
C31	10UM 35V Elec	23557-0647
C32	1000U 35V Elec	23557-0664
C33	1000U 35V Elec	23557-0664
C34	to	
C39	10UM 35V Elec	23557-0647

Capacitors (continued)

Ref	Description	Part No
C40	to	
C47	See Display PCB Assy	
C48	to	
C53	See Control PCB Assy	
C54	to	
C57	See Sweep PCB Assy	
C58	Not fitted	
C59	Not fitted	
C60	See Sweep PCB Assy	
C61	47PG 63V Cer	23427-0329
C62	100NK 63V P/E	23620-0246
C63	See Control PCB Assy	
C64	10NZ 63V Cer	23427-0325
C65	10UM 35V Elec	23557-0647
C66	Not fitted	
C67	10NZ 63V Cer	23427-0325
C68	See Control PCB Assy	
C69	100NK 63V P/E	23620-0246
C70	100NK 63V P/E	23620-0246
C71	10PC 63V Cer	23427-0328
C72	10UM 35V Elec	23557-0647
C73	1NOK 63V Cer	23427-0331
C74	Not fitted	
C75	Not fitted	
C76	33PG 100V Cer	23427-0333
C77	2P2C 63V Cer	23427-0524

Semiconductors

Ref	Description	Part No
D1	1N4148	25021-0901
D2	5V1 Zener	25130-0903
D3	to	
D6	See Sweep PCB Assy	
D7	1N4148	25021-0901
D8	1N4148	25021-0901
D9	to	
D12	1N916	25021-0903
D13	to	
D23	1N4148	25021-0901
D24	See Display PCB Assy	
D25	to	
D28	1N4148	25021-0901
D29	See Control PCB Assy	
D30	1N4148	25021-0901
D31	1N4148	25021-0901
D32	to	
D36	1N4002	25115-0907
D37	3V0 Zener	25130-0911
D38	1N4002	25115-0907
D39	3V0 Zener	25130-0911
D40	See Sweep PCB Assy	
D41	1N4148	25021-0901

Semiconductors (continued)

Ref	Description	Part No
Q1	BC559/ZTX214L	25341-0214
Q2	BC559/ZTX214L	25341-0214
Q3	BC549C	25377-5790
Q4	BC549	25380-0229
Q5	BC559C	25336-5590
Q6	2N3904	25381-0404
Q7	BF245 Matched	25601-0103
Q8	BF245 Matched	25601-0103
Q9	BC559/ZTX214L	25341-0214
Q10	BC549	25380-0229
Q11	Not used	
Q12	Not used	
Q13	to	
Q15	See Sweep PCB Assy	
Q16	BC559C	25336-5590
Q17	BC549C	25377-5490
Q18	See Sweep PCB Assy	
Q19	BC549	25380-0229
Q20	BC549	25380-0229
Q21	2N3904	25381-0404
Q22	2N3904	25381-0404
Q23	2N3904	25381-0404
Q24	2N3904	25381-0404
Q25	2N3906	25341-0218
Q26	2N2219A	25377-0700
Q27	2N3904	25381-0404
Q28	2N2905A	25344-0500
Q29	to	
Q32	See Control PCB Assy	
Q33	BC559/ZTX214L	25341-0214
IC1	See Display PCB Assy	
IC2	LM324	27106-0506
IC3	See Sweep PCB Assy	
IC4	LF351	27106-0508
IC5	75107	27254-0008
IC6	4049	27226-0490
IC7	See Sweep PCB Assy	
IC8	" " " "	
IC9	LF351	27106-0608
IC10	See Sweep PCB Assy	
IC11	" " " "	
IC12	CA3046	27164-0503
IC13	See Sweep PCB Assy	
IC14	to	
IC16	4053B	27226-0530
IC17	4081B	27226-0810
IC18	See Control PCB Assy	
IC19	" " " "	
IC20	4013B	27226-0130
IC21	4013B	27226-0130
IC22	LM317-T	27160-0200
IC23	LM337-T	27160-0210
IC24	7805	27160-0009

Semiconductors (continued)

Ref	Description	Part No
IC25	HEF4070	(+) 27226-0701

(+) See Manufacturing Changes,
page 27

Other Parts on TG230 Main PCB Assy

Description	Part No
Header 2 Way (TP1,19,20)	3 off 22573-0041
Header 3W Str.156P (PJ7)	0.5 off 25573-0203
Header 10W Straight (PJ3)	22575-0062
Header 14W Straight (PJ5)	22575-0068
Header 16W Straight (PJ2)	22575-0103
Transistor pad (for Q26,28)	2 off 20661-0801
Heatsink TO5 (for Q26,28)	2 off 20670-0040
Heatsink PCB mounting 50mm high (for IC22,23)	20670-0200
Attachment Parts for IC22,23	
Screw M3 x 10mmL	20234-0011
Washer M3 plain	20030-0263
Washer M3 Spring	20038-9501
Nut M3	20210-0101
Bush TO220	20611-0003
Insulating Washer TO220	20613-0006
Bead, ferrite (FB)	22040-0901
Res Zero Ohm (LK2)	23185-0000
Switchbank 8 Bank (SW1-8)	22225-0710
Switchbank 4 Bank (SW9-12)	22225-0700
PCB - Main - TG230	35555-1770

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PCB Assy Main TG210/220
consisting of

Resistors

(+) See Manufacturing Changes, page 27

Ref	Description	Part No	Ref	Description	Part No
R2	150KF W25 MF	23202-4150	R84	180RF W25 MF	23202-1180
R3	39K0F W25 MF	23202-3390	R85	10K0F W25 MF (+)	23202-3100
R4	39K0F W25 MF	23202-3390	R86	24K9F W25 MF	23202-3249
R7	10K0F W25 MF	23202-3100	R87	47R0F W25 MF	23202-0470
R24	10M0F W25 MF	23202-6100	R88	15K0F W25 MF	23202-3150
R25	Not fitted		R119	150RF W25 MF	23202-1150
R28	39K0F W25 MF	23202-3390	R120	3K60F W25 MF	23202-2360
R38	100KF W25 MF	23202-4100	R121	6K20F W25 MF	23202-2620
R39	to		R122	47R0F W25 MF	23202-0470
R41	620RF W25 MF	23202-1620	R123	3K30F W25 MF	23202-2330
R42	715RF W25 MF	23202-1715	R124	1K50F W25 MF	23202-2150
R43	10K0F W25 MF	23202-3100	R131	470RF W25 MF	23202-1470
R44	1K43F W25 MF	23202-2143	R132	1K20F W25 MF	23202-2120
R45	270KF W25 MF	23202-4270	R133	8K87F W25 MF	23202-2887
R46	1K43F W25 MF	23202-2143	R134	1K00F W25 MF	23202-2100
R47	620RF W25 MF	23202-1620	R135	270KF W25 MF	23202-4270
R48	715RF W25 MF	23202-1715	R136	9K10F W25 MF	23202-2910
R49	1K37F W25 MF	23202-2137	R137	2K70F W25 MF	23202-3270
R50	270KD W60 MF	23221-4270	R138	27K0F W25 MF	23202-3270
R51	27K0D W60 MF	23221-3270	R139	1K8J W25 CF	23185-2180
R52	2K70D W60 MF	23221-2270	R140	150RJ W25 CF	23185-1150
R53	12K0F W25 MF	23202-3120	R141	150RJ W25 CF	23185-1150
R54	12K0F W25 MF	23202-3120	R142	to	
R55	1K00F W25 MF	23202-2100	R145	10R0F W60 MF	23206-0100
R56	1K00F W25 MF	23202-2100	R146	to	
R57	1K65F W25 MF	23202-2165	R149	200RF W60 MF	23206-1200
R58	715RF W25 MF	23202-1715	R150	41R2F W60 MF	23206-0412
R59	270KD W60 MF	23221-4270	R151	10R2F W25 MF	23202-0102
R60	2K70D W60 MF	23221-2270	R152	41R2F W60 MF	23206-0412
R61	27K0D W60 MF	23221-3270	R156	2K20F W25 MF	23202-2220
R62	1K50F W25 MF	23202-2150	R157	2K20F W25 MF	23202-2220
R63	2K20F W25 MF	23202-2220	R158	220RF W25 MF	23202-1220
R64	470RF W25 MF	23202-1470	R159	220RF W25 MF	23202-1220
R65	1K50F W25 MF	23202-2150	R160	2K20F W25 MF	23202-2220
R66	220RF W25 MF	23202-1220	R161	2K20F W25 MF	23202-2220
R67	680RF W25 MF	23202-1680	R162	470RF W25 MF	23202-1470
R68	130RF W25 MF	23202-1130	R163	18K0F W25 MF	23202-3180
R69	130RF W25 MF	23202-1130	R164	47R0F W25 MF	23202-0470
R70	680RF W25 MF	23202-1680	R165	2K20F W25 MF	23202-2220
R71	220RF W25 MF	23202-1220	R166	270KF W25 MF	23202-4270
R72	16K0F W25 MF	23202-3160	R167	47R0F W25 MF	23202-0470
R73	220RF W25 MF	23202-1220	R173	10K0F W25 MF	23202-3100
R74	16K0F W25 MF	23202-3160	R174	15K0F W25 MF	23202-3150
R75	150RF W25 MF	23202-1150	R176	47K0F W25 MF	23202-3470
R77	4K70F W25 MF	23202-2470	R183	2K20F W25 MF	23202-2220
R78	47R0F W25 MF	23202-0470	R184	47R0F W25 MF (+)	23202-0470
R79	22K6F W25 MF	23202-3226			
R80	1K10F W25 MF	23202-2110	VR3	100R PS/H CF	23377-1100
R81	15K0F W25 MF	23202-3150	VR4	22K PS/H CF	23377-3220
R82	226RF W25 MF	23202-1226	VR5	470R PS/H CF	23377-1470
R83	120RF W25 MF	23202-1120	VR6	470R PS/H CF	23377-1470

Resistors (continued)

Ref	Description	Part No
VR7	100R PS/H Cermet	23379-1100
VR8	10K PS/H CF (+)	23377-3100
VR9	22K PS/H CF	23377-3220
VR13	22K PS/H CF	23377-3220
VR16	470R PS/H Cermet	23379-1470
VR17	470R PS/H Cermet	23379-1470
VR25	10K PS/H CF	23377-3100
VR26	22K PS/H CF	23377-3220
VR27	22K PS/H CF	23377-3220
VR31	10K PS/H CF	23377-3100
VR32	10K PS/H CF	23377-3100

Capacitors

Ref	Description	Part No
C1	100NK 63V P/E	23620-0246
C2	10PC 63V Cer	23427-0328
C3	10PC 63V Cer	23427-0328
C4	100NK 63V P/E	23620-0246
C5	100NK 63V P/E	23620-0246
C6	120PH 160V P/S	23647-0512
C7	56PH 160V P/S	23647-0524
C8	2N0F 160V P/S	23647-0525
C9	22NJ 100V P/E	23620-0248
C10	220NK 63V P/E	23620-0247
C11	2U2K 100V P/E	23620-0257
C12	10NZ 63V Cer	23427-0325
C13	100NK 63V P/E	23620-0246
C14	100NK 63V P/E	23620-0246
C15	10PC 63V Cer	23427-0328
C16	120PG 63V Cer	23427-0342
C17	120PG 63V Cer	23427-0342
C18	3N3F 160V P/S	23646-0007
C19	3N3F 160V P/S	23646-0007
C20	10NZ 63V Cer	23427-0325
C21	10NZ 63V Cer	23427-0325
C22	10NZ 63V Cer	23427-0325
C23	100NK 63V P/E	23620-0246
C24	100NK 63V P/E	23620-0246
C25	2P2C 63V Cer	23427-0524
C26	2P2C 63V Cer	23427-0524
C27	100NK 63V P/E	23620-0246
C28	100NK 63V P/E	23620-0246
C29	100NK 63V P/E	23620-0246
C30	10UM 35V Elec	23557-0647
C31	10UM 35V Elec	23557-0647
C32	1000U 35V Elec	23557-0664
C33	1000U 35V Elec	23557-0664
C34	to	
C39	10UM 35V Elec	23557-0647
C61	47PG 63V Cer	23427-0329
C62	100NK 63V P/E	23620-0246
C69	100NK 63V P/E	23620-0246
C70	100NK 63V P/E	23620-0246
C71	10PC 63V Cer	23427-0328
C73	1NOK 63V Cer	23427-0331
C77	2P2C 63V Cer	23427-0524

Semiconductors

Ref	Description	Part No
VC1	4-65P P/P	23984-0001
D2	5V1 Zener	25130-0903
D7	1N4148	25021-0901
D8	1N4148	25021-0901
D9	to	
D12	1N916	25021-0903
D13	to	
D23	1N4148	25021-0901
D30	1N4148	25021-0901
D31	1N4148	25021-0901
D32	to	
D36	1N4002	25115-0907
D37	3V0 Zener	25130-0911
D38	1N4002	25115-0907
D39	3V0 Zener	25130-0911
LED	LED 3mm	25061-0200
Q1	BC559/ZTX214L	25341-0214
Q3	BC549C	25377-5790
Q4	BC549	25380-0229
Q5	BC559C	25336-5490
Q6	2N3904	25381-0404
Q7	BF245 Matched	25601-0103
Q8	BF245 Matched	25601-0103
Q9	BC559/ZTX214L	25341-0214
Q10	BC549	25380-0229
Q16	BC559C	25336-5590
Q17	BC549C	25377-5490
Q19	BC549	25380-0229
Q20	BC549	25380-0229
Q21	2N3904	25381-0404
Q22	2N3904	25381-0404
Q23	2N3904	25381-0404
Q24	2N3904	25381-0404
Q25	2N3906	25341-0218
Q26	2N2219A	25377-0700
Q27	2N3904	25381-0404
Q28	2N2905A	25344-0500
IC2	LM324	27106-0506
IC4	LF351	27106-0608
IC5	75107	27254-0008
IC6	4049	27226-0490
IC9	LF351	27106-0608
IC12	CA3046	27164-0503
IC22	LM317	27160-0200
IC23	LM337	27160-0210
IC24	7805	27160-0009

(+) See Manufacturing Changes,
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Other Parts on TG210/220
Main PCB Assy

Description	Part No
Header 2 Way (TP1,19,20)	3 off 22573-0041
Header 3W Str.156P (PJ7)	25573-0203
Header 10W Straight (PJ3)	22575-0062
Header 14W Straight (PJ5)	22575-0068
Transistor pad (for Q26,28)	2 off 20661-0801
Heatsink TO5 (for Q26,28)	2 off 20670-0040
Heatsink PCB mounting 50mm high (for IC22,23)	20670-0200
Attachment Parts for IC22,23	
Screw M3 x 10mmL	20234-0011
Washer M3 Spring	20038-9501
Nut M3	20210-0101
Bush TO220	20611-0003
Insulating Washer TO220	20613-0006
Bead, ferrite (FB)	22040-0901
Res Zero Ohm (LK2)	23185-0000
Switchbank 8 Bank (SW1-8)	22225-0710
Switchbank 4 Bank (SW9-12)	22225-0700
PCB - Main - TG230	35555-1770

PCB Assy Control TG230
consisting of

Resistors

Ref	Description	Part No
R1	8R20F W25 MF	23202-0082
R9	18K0F W25 MF	23202-3180
R13	39K0F W25 MF	23202-3390
R89	10K0F W25 MF	23202-3100
R97	3K00F W25 MF	23202-2300
R100	39K0F W25 MF	23202-3390
R101	39K0F W25 MF	23202-3390
R102	Not used	
R103	100KF W25 MF	23202-4100
R104	30K0F W25 MF	23202-3300
R105	43K0F W25 MF	23202-3430
R106	13K0F W25 MF	23202-3130
R107	10K0F W25 MF	23202-3100
R108	6K65F W25 MF	23202-2665
R109	100RF W25 MF	23202-1100
R110	4K02F W25 MF	23202-2402
R111	12K0F W25 MF	23202-3120
R112	30K0F W25 MF	23202-3300
R113	100RF W25 MF	23202-1100
R114	6K80F W25 MF	23202-2680
R115	510RF W25 MF	23202-1510
R116	510RF W25 MF	23202-1510
R117	1K00F W25 MF	23202-2100
R118	2K20F W25 MF	23202-2220
R125	1K80F W25 MF	23202-2180
R126	1K00F W25 MF	23202-2100
R127	7K50F W25 MF	23202-2750
R128	2K00F W25 MF	23202-2200
R129	3K30F W25 MF	23202-2330
R130	1K50F W25 MF	23202-2150
R153	150KF W25 MF	23202-4150
R154	4M70F W25 MF	23202-5470
R155	910RF W25 MF	23202-1910
R168	56K0F W25 MF	23202-3560
R169	27R0F W25 MF	23202-0270
VR2	Pot 10K Lin	23347-0160
VR11	Pot 1K + 1K - ganged	23347-0520
VR12	Pot 10K Lin - centre detent	23347-0300
VR14	PS/H 22K CF	23377-3220
VR15	PS/H 220R CF	23377-1220
VR18	PS/H 10K CF	23377-3100
VR19	PS/H 22K CF	23377-3220
VR22	Pot 10K Lin	23347-0160
VR23	PS/H 47K CF	23377-3470
VR28	PS/H 470R CF	23377-1470

Capacitors

Ref	Description	Part No
C48	10NK 100V P/E	23620-9007
C49	10NK 100V P/E	23620-9007
C50	100NK 63V P/E	23620-0246
C51	100NK 63V P/E	23620-0246
C52	100NK 63V P/E	23620-0246
C53	2P2C 63V Cer	23427-0524
C63	100NK 63V P/E	23620-0246
C68	10NK 100V P/E	23620-9007

Semiconductors

Ref	Description	Part No
D29	6V8 Zener	25130-9206
Q29	BC559/ZTX214L	25341-0214
Q30	BC559/ZTX214L	25341-0214
Q31	2N3904	25381-0404
Q32	2N3906	25341-0218
IC18	MC3403P	27106-0518
IC19	MC1496P	27151-0110

Other Parts on Control PCB Assy

Description	Part No
Switchbank 2 Bank	
SW14,15	22225-0740
Res Zero Ohm	
(LK7,8,9,11,12) 5 off	23185-0000
Lamp, filament 14V 14mA	
LP1	28201-0010
PCB - Control TG230	35555-1170
Connector Assy - Control PCB to Main PCB	43171-1040

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PCB Assy Control TG210/215/220
consisting of

Resistors

Ref	Description	Part No
R9	18K0F W25 MF	23202-3180
R13	39K0F W25 MF	23202-3390
R153	150KF W25 MF (*)	23202-4150
R154	1M00F W25 MF (*)	23202-5100
R155	910RF W25 MF (*)	23202-1910
R168	56K0F W25 MF (*)	23202-3560
R169	8R20F W25 MF (*)	23202-0082
VR2	Pot 10K Lin	23347-0160
VR11	Pot 1K + 1K - ganged	23347-0520
VR12	Pot 10K Lin - centre detent	23347-0300
VR14	22K PS/H CF (*)	23377-3220
VR15	220R PS/H CF (*)	23377-1220
VR23	47K PS/H CF (*)	23377-3470

(*) = Applicable to TG215 only.

Capacitors

Ref	Description	Part No
C52	100NK 63V P/E	23620-0246
C63	100NK 63V P/E	23620-0246
C68	10NK 100V P/E	23620-9007

Semiconductors

Ref	Description	Part No
IC18	MC3403P	27106-0518

Other Parts on Control PCB Assy

Description	Part No
Res Zero Ohm (LK1,8,9,11,12) 5 off	23185-0000
PCB - Control TG230	35555-1170

**PCB Assy Sweep TG230
consisting of**

Resistors

Ref	Description	Part No
R10	180KF W25 MF	23202-4180
R11	47K0F W25 MF	23202-3470
R12	150RF W25 MF	23202-1150
R14	2K20F W25 MF	23202-2220
R15	150RF W25 MF	23202-1150
R16	180KF W25 MF	23202-4180
R17	Not used	
R18	36K0F W25 MF	23202-3360
R19	7K50F W25 MF	23202-2750
R20	15K0F W25 MF	23202-3150
R21	15K0F W25 MF	23202-3150
R22	10K0F W25 MF	23202-3100
R23	10K0F W25 MF	23202-3100
R26	10K0F W25 MF	23202-3100
R27	10K0F W25 MF	23202-3100
R29	10K0F W25 MF	23202-3100
R30	2K20F W25 MF	23202-2220
R31	10K0F W25 MF	23202-3100
R32	33K0F W25 MF	23185-3330
R33	30K0F W24 MF	23202-3300
R34	7K50F W25 MF	23202-2750
R35	2K20F W25 MF	23202-2220
R36	10K7F W25 MF	23202-3107
R37	4K30F W25 MF	23202-2430
R177	4M70F W25 MF	23202-5470
R178	600RF W60 MF	23206-1600
R179	11K0F W25 MF	23202-3110
R180	4K02F W25 MF	23202-2402
TDR1	680RJ Temp Dep	23387-1680
VR20	Pot 500K Log with SW18 switch	23349-0100
VR21	Pot 10K Lin with SW19 switch	23349-0110
VR24	PS/H 22K CF	23377-3220
VR29	PS/H 22K CF	23377-3220
VR30	PS/H 10K CF	23377-3100

Capacitors

Ref	Description	Part No
C54	1U0K 63V P/E	23620-0256
C55	10PC 63V Cer	23427-0328
C56	10PC 63V Cer	23427-0328
C57	10NZ 63V Cer	23427-0325
C60	100PG 63V Cer	23427-0322

Semiconductors

Ref	Description	Part No
D3 to		
D6	1N4148	25021-0901
D40	1N4148	25021-0901
Q13	BC549	25380-0229
Q14	BC549	25380-0229
Q15	BC549	25380-0229
Q18	BC559/ZTX214L	25341-0214
IC3	LM324	27106-0506
IC7	TL072	27106-0606
IC8	CA3080	27106-0500
IC10	LM324	27106-0506
IC11	74LS74	27223-0740
IC13	CA3046	27164-0503

Other Parts on Sweep PCB Assy

Description	Part No.
Switchbank 2 Bank	
SW16,17	22225-0720
PCB - Sweep - TG230	35555-1780
Connector Assy - Sweep PCB to Main PCB	43171-1030

PCB Assy Sweep TG220
consisting of

Resistors

Ref	Description	Part No
R9	360RF W25 MF	23202-1360
R10	180KJ W25 CF	23185-4180
R11	47KJ W25 CF	23185-3470
R12	150RJ W25 CF	23185-1150
R14	2K2J W25 CF	23185-2220
R15	150RJ W25 CF	23185-1150
R16	180KJ W25 CF	23185-4180
R17	10KJ W25 CF	23185-3100
R18	Not used	
R19	7K50F W25 MF	23202-2750
R20	15KJ W25 CF	23185-3150
R21	15K0F W25 MF	23202-3150
R22	10KJ W25 CF	23185-3100
R23	10KJ W25 CF	23185-3100
R26	10KJ W25 CF	23185-3100
R27	10KJ W25 CF	23185-3100
R29	10KJ W25 CF	23185-3100
R30	2K2J W25 CF	23185-2220
R31	10K0F W25 MF	23202-3100
R32	33KJ W25 CF	23185-3330
R33	30K0F W24 MF	23202-3300
R34	7K50F W25 MF	23202-2750
R35	2K2J W25 CF	23185-2220
R36	10K7F W25 MF	23202-3107
R37	4K30F W25 MF	23202-2430
R177	4M7J W25 CF	23185-5470
R178	600RF W60 MF	23206-1600
R179	11K0F W25 MF	23202-3110
R180	4K02F W25 MF	23202-2402
R181	10K0F W24 MF	23202-3100
TDR1	680RJ Temp Dep	23387-1680
VR20	Pot 500K Log with	
SW18	switch	23349-0100
VR21	Pot 10K Lin with	
SW19	switch	23349-0110
VR24	PS/H 22K CF	23377-3220
VR29	PS/H 22K CF	23377-3220
VR30	PS/H 10K CF	23377-3100

Capacitors

Ref	Description	Part No
C54	1U0K 63V P/E	23620-0256
C55	10PC 63V Cer	23427-0328
C56	10PC 63V Cer	23427-0328
C57	10NZ 63V Cer	23427-0325
C60	100PG 63V Cer	23427-0322

Semiconductors

Ref	Description	Part No
D3 to		
D6	1N4148	25021-0901
D40	1N4148	25021-0901
Q2	BC549	25380-0229
Q13	BC549	25380-0229
Q14	BC549	25380-0229
Q15	BC549	25380-0229
Q18	BC559	25341-0214
IC3	LM324	27106-0506
IC7	TL072	27106-0606
IC8	CA3080	27106-0500
IC10	LM324	27106-0506
IC11	74LS74	27223-0740
IC13	CA3046	27164-0503

Other Parts on TG220 Sweep PCB Assy

Description	Part No
Header 2W St (TP18)	22573-0041
Switchbank	
SW17	22225-0730
Zero Ohm resistor LK5	23185-0000
PCB - Sweep - TG230	35555-1780

PCB Assy - Display TG215/230

Resistors

Ref	Description	Part No
R90	48K7F W25 MF	23202-4150
R91	1K00F W25 MF	23202-2100
R92	1M00F W25 MF	23202-5100
R93	100KF W25 MF	23202-4100
R94	470KF W25 MF	23202-4470
R95	10M0F W25 MF	23202-6100
R96	10M0F W25 CF	23202-6100

Capacitors

Ref	Description	Part No
C40 to		
C44	100NK 63V P/E	23620-0246
C45	470NK 63V P/E	23620-0244
C46	100NK 63V P/E	23620-0246
C47	1U0K 25V Sol A1	23578-0005

Semiconductors

Ref	Description	Part No
D24	1N4148	25021-0901
IC1	TSC821CPL	27153-0040

Other Parts on TG230 Display PCB Assy

Description	Part No
Xtal 80KHz (+)	28500-0040
Keyswitch SW13	22226-0140
LCD - TR300B	26100-0080
PCB - Display - TG230	35515-1180

Connector Assy - Display PCB to
Main PCB - 43171-1020
consisting of:

Description	Part No
Skt 16 Way IDC	22575-0060
Transition Conn 16 Way	22575-0047
Cable 16 Way flat grey 3 ins cut from 10148-0001	

(+) See manufacturing changes, page 27

FOR SERVICE MANUALS
CONTACT:
MAURITRON TECHNICAL SERVICES
www.mauritron.co.uk
TEL: 01844 - 351694
FAX: 01844 - 352554

Case Parts	TG210	TG215	TG220	TG230
Description	Part No			
Case Upper	33536-0810			
Case Lower	33536-0820			
Screw M3 x 40mmL (case upper to lower securing)	4 off 20234-0038			
Handle	31336-0250			
Foot	4 off 20662-0540			
Rivet Snap-Lock (feet securing)	4 off 20010-0253			
Washer M3 (feet (4), Mains Recep (2))	6 off 20030-0263			
Washer M3 Fibre	10 off 20612-0011			
Washer M3 spring	11 off 20038-9501			
Washer M4 spring	4 off 20038-9502			
Cable tie	3 off 20653-0204			
Skt 3W IDT	22575-0203			
Screw No 4 x 3/8" (pcb to case)	6 off 20065-0030			
Screw M3 x 6mmL (Display PCB)	*3 off Not used	20234-0027	Not used	20234-0027
Spacer plastic 1.5"L (sweep pcb)	*4 off Not used	Not used	20661-9402	20661-9402
Spacer nylon .125"L (sweep pcb)	*4 off Not used	Not used	20661-0256	20661-0256
Spacer nylon .250"L (main pcb/case)	2 off 20661-0258			
Spacer plastic .75"L (control/main pcb)	3 off 20661-0405			
Screw No 6 x 3/8"L (spacers)	*6 off 20062-9308	Qty 3 off	Qty 10 off	Qty 7 off
Screw No 6 x 1/2"L (PCB securing)	7 off 20062-9303			
Front Panel	*33331-1830	33331-1800	33331-1830	33331-1800
Overlay, front panel	*33331-1860	33331-1840	33331-1850	33331-1820
Bezel, display	*Not used	31711-0070	Not used	31711-0070
Pushbutton	*12 off 37113-0170	Qty 12 off	Qty 13 off	Qty 16 off
Knob 11mm	*3 off 20657-0080	Qty 3 off	Qty 5 off	Qty 6 off
Cap for 11mm knob	*3 off 20657-0081	Qty 3 off	Qty 5 off	Qty 6 off
Knob 21mm	20657-0070			
Cap for 21mm knob	20657-0071			
Pointer for 21mm knob	*20657-0073	Not used	20657-0073	Not used

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FAX: 01844 - 352554

Case Parts	TG210	TG215	TG220	TG230
Description	Part No			
Pot 10K (VR1)	23347-0170			
Washer s/proof Colvern	23348-0701			
BNC Skt	*3 off 22588-0004	Qty 4 off	Qty 4 off	Qty 4 off
Solder tag BNC	22588-9901			
Rear Panel	33331-1810			
Screw M4 x10 (Transf)	20234-0028			
Screw M4 x 16 (Earth)	20234-0016			
Solder tag s/proof 4BA (Earth)	2 off 20037-0401			
Nut M4 (Transf (2), Earth (2))	4 off 20210-0102			
AC Mains receptacle	22520-0140			
Fuse drawer	22520-0500			
Shroud, mains recep	22538-9404			
Fuse 125mA HRC	22315-0239			
Screw M3 x 10mm (AC mains recep securing)	2 off 20234-0011			
Washer M3 s/proof (AC mains recep securing)	2 off 20037-0301			
Nut M3	2 off 20210-0101			
Transformer, mains	22115-0180			
Switch, rocker for Mains	22219-0050			
Sleeve for switch	4 off 10232-0304			

* Denotes differences in models

Case Parts (continued)

Description	Part No
Label, On/Off	37511-0470
Label, Warning, rear panel	37559-0260
Label, Handle	37523-0170
Label, Serial No	37522-0160

Packaging Parts

Description	Part No
Carton	38113-0370
Sleeve printed	38181-0210
Aircap	.42M off 10612-0204
Mains Lead (240V) or	22491-0010
Mains Lead (220V)	22491-0020
Guarantee Card	48581-0230
Instruction Book	48591-0380

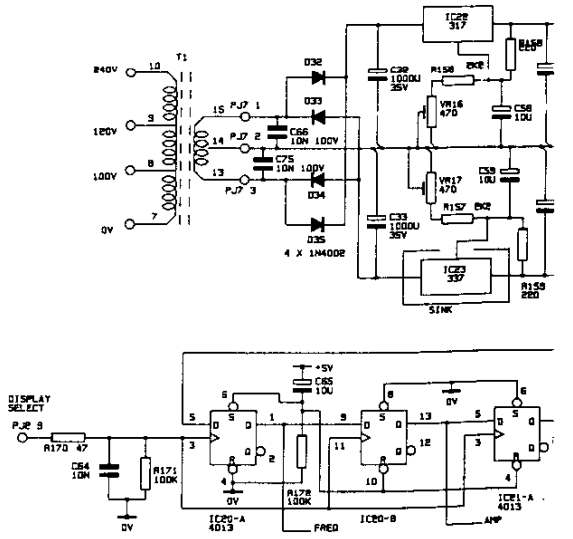
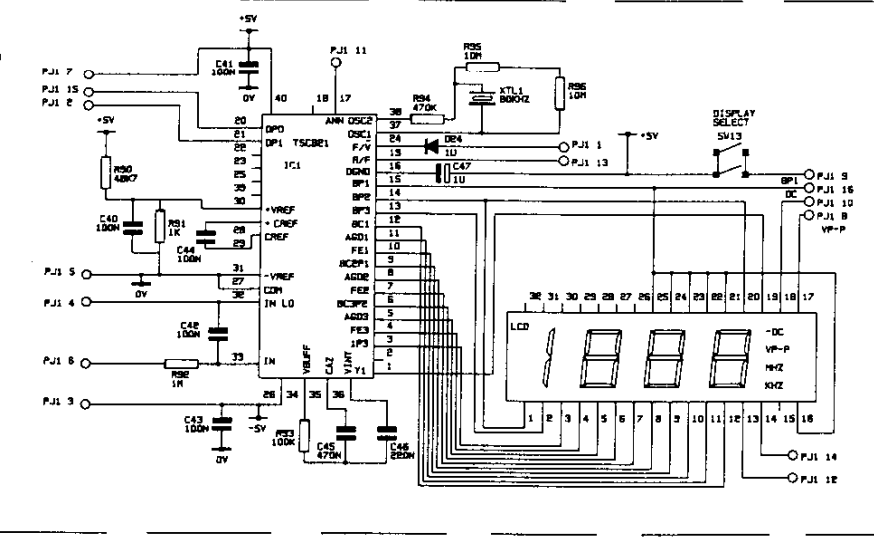
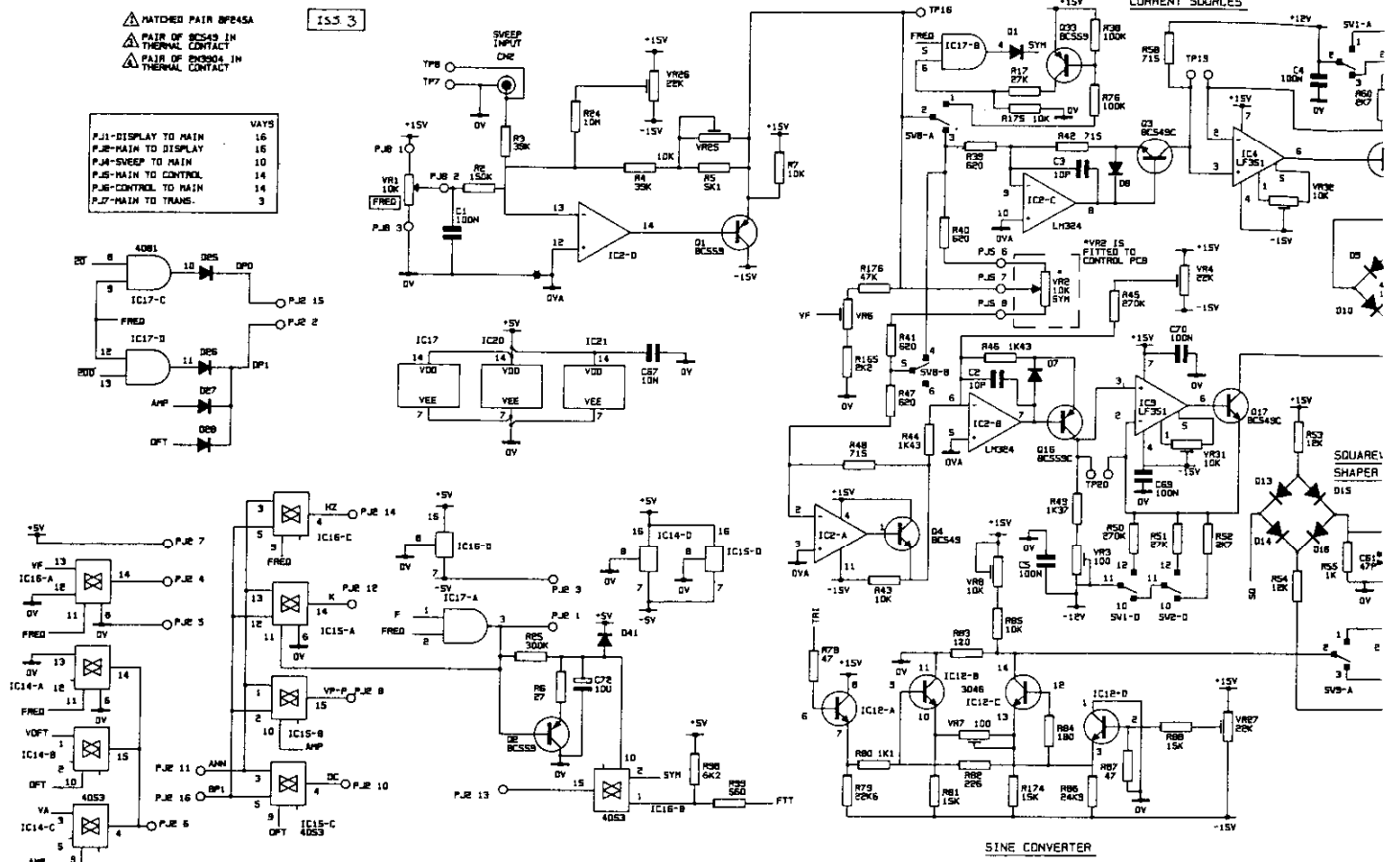
(+) Manufacturing Changes

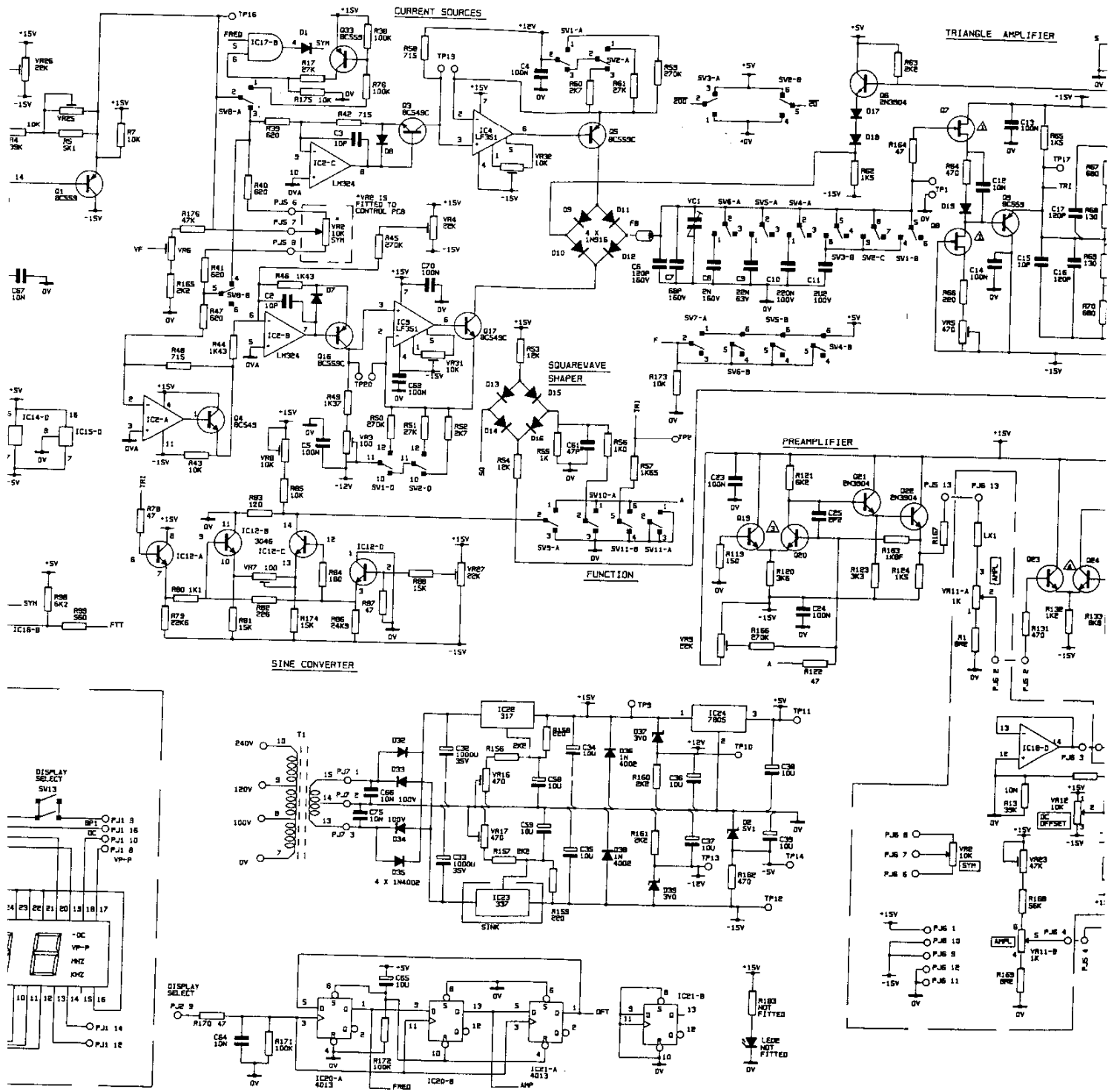
- 1) A few early models were fitted with a 40kHz crystal instead of 80kHz (on the Display PCB Assy).
In these models: R25 was 560KJ (23185-4560), IC25 (27226-0701) was omitted AND LK4 (23185-0000) fitted.
- 2) Prior to Issue 3 main pcbs, VR8 was not fitted and R85 was 15KF (23202-3150).
R184 in the TTL output, was not in circuit on pre-issue 3 pcbs.

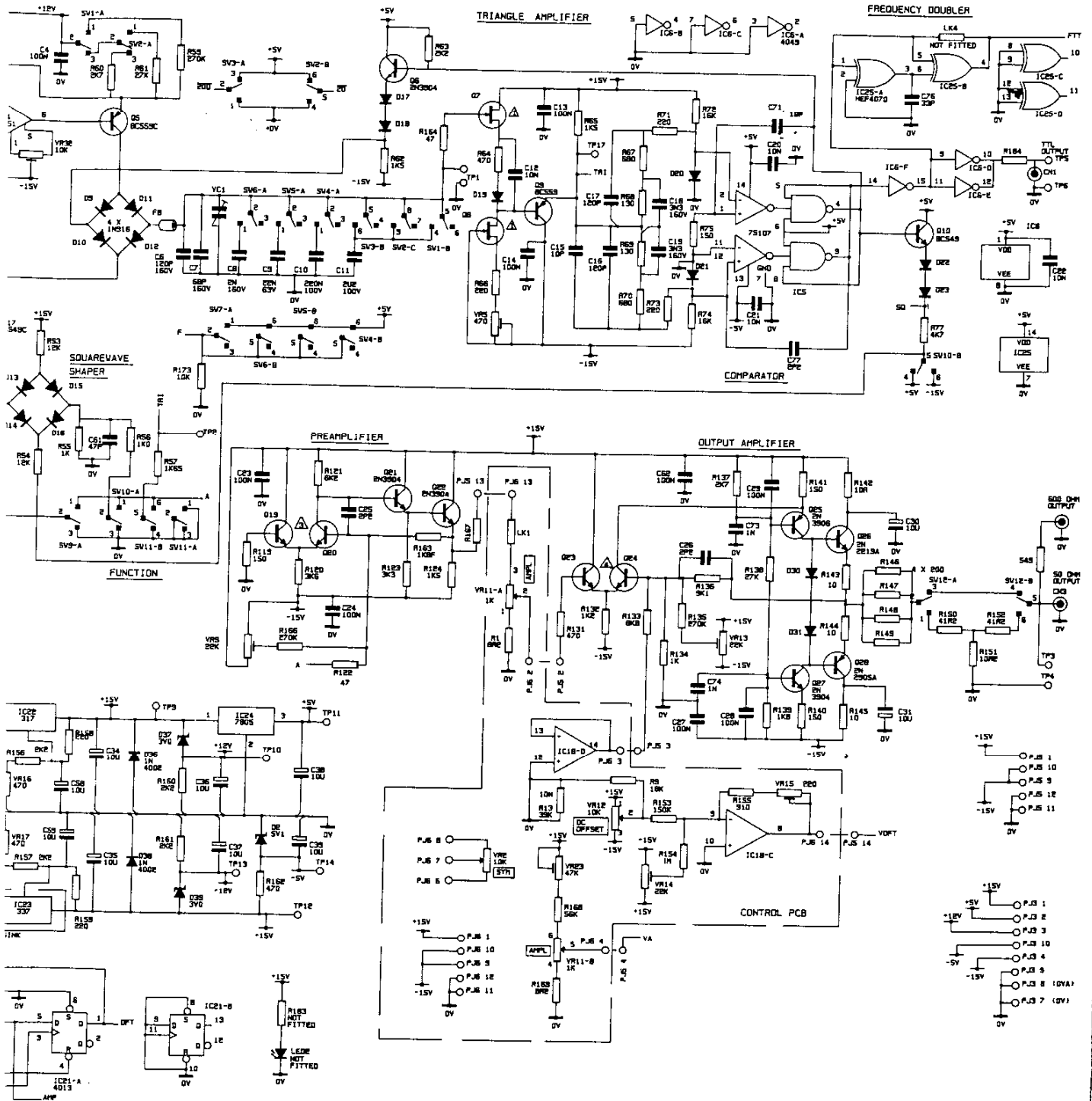
- ▲ MATCHED PAIR BP245A
- ▲ PAIR OF BC249 IN THERMAL CONTACT
- ▲ PAIR OF BC249 IN THERMAL CONTACT

IS5 3

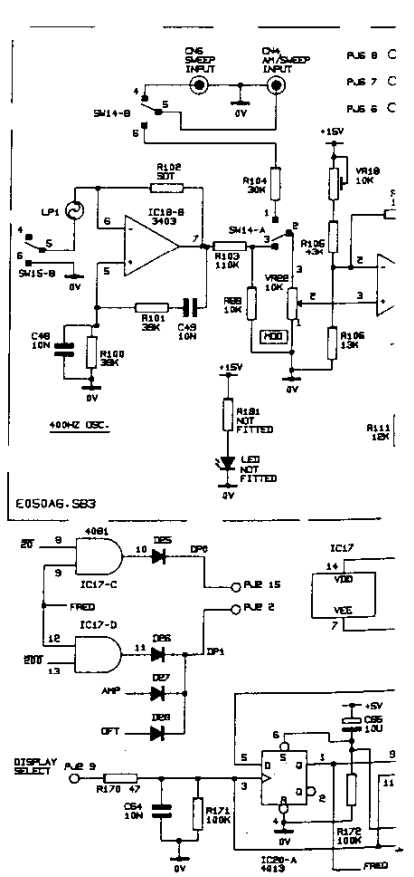
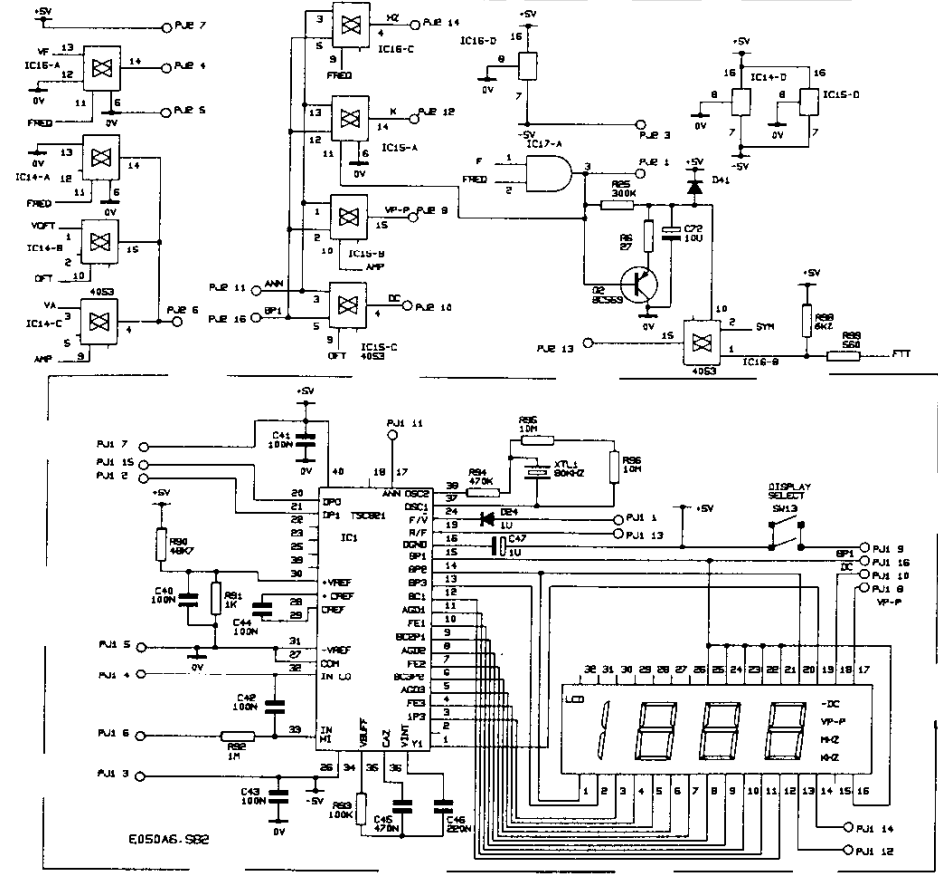
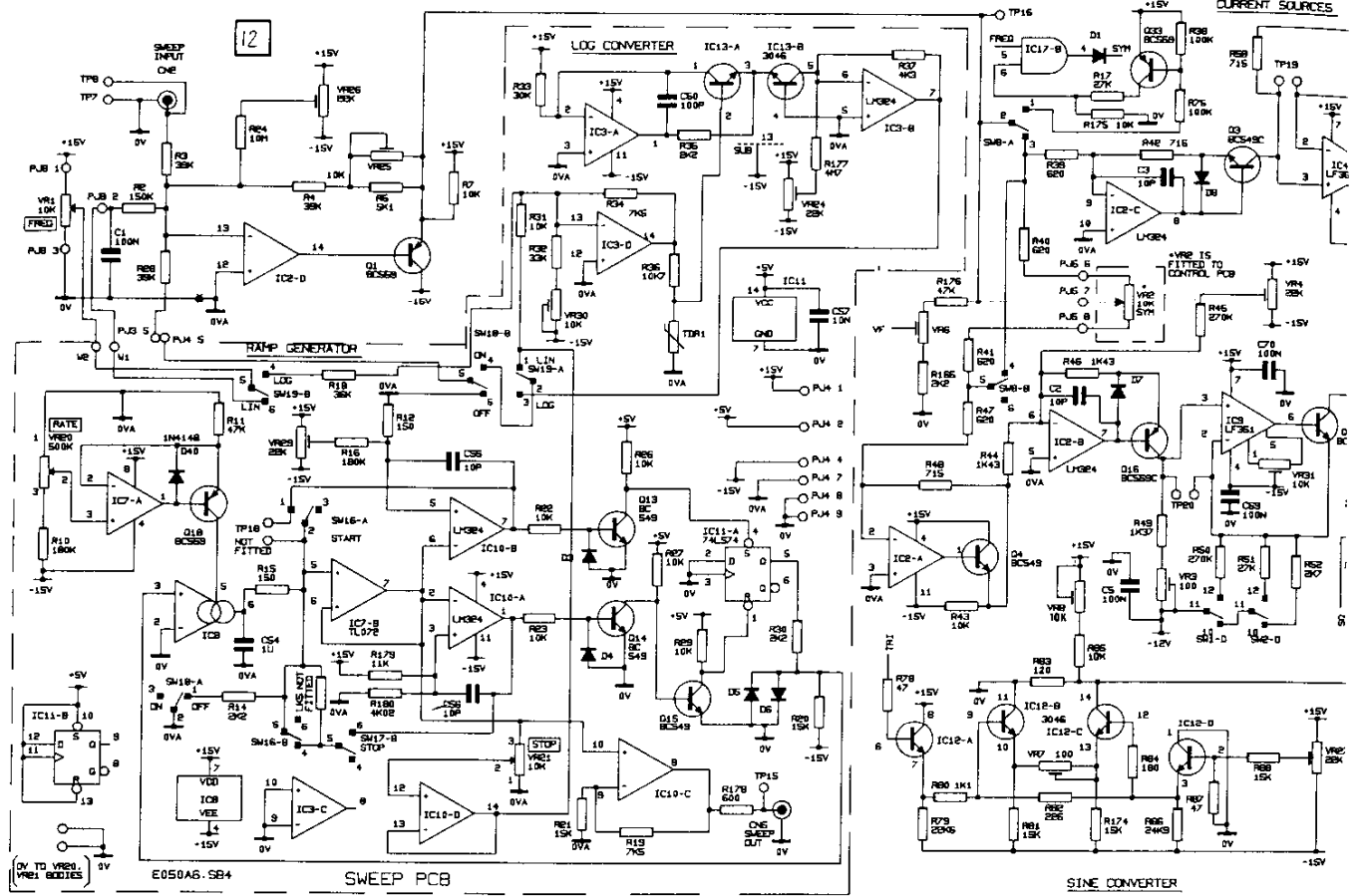
	VAYS
P.J1-DISPLAY TO MAIN	16
P.J2-MAIN TO DISPLAY	16
P.J4-SWEEP TO MAIN	10
P.J5-MAIN TO CONTROL	14
P.J6-CONTROL TO MAIN	14
P.J7-MAIN TO TRANS.	3

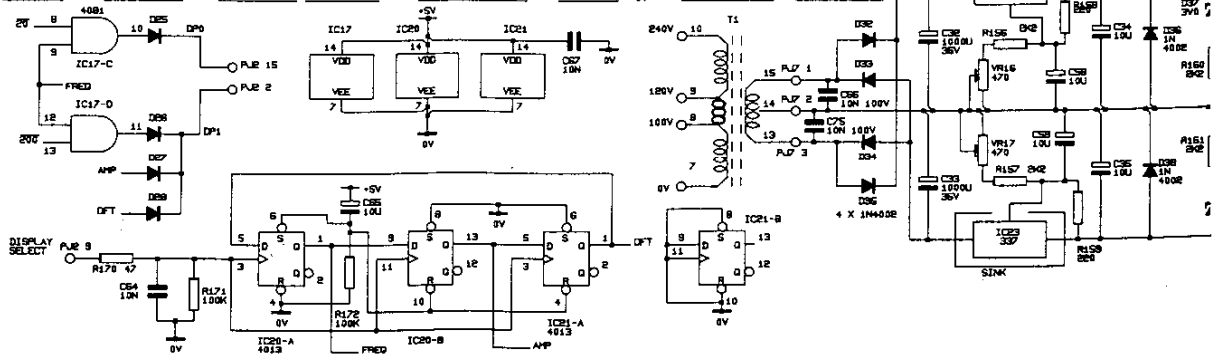
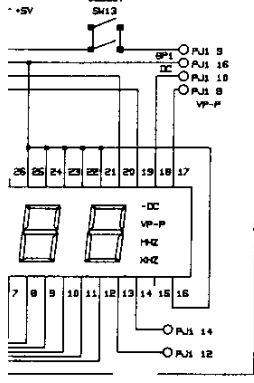
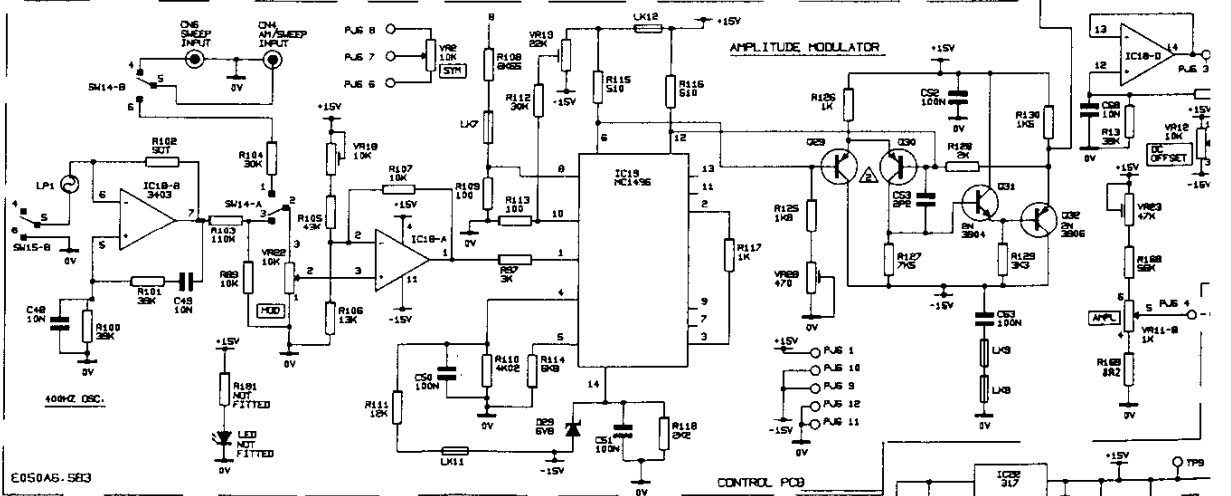
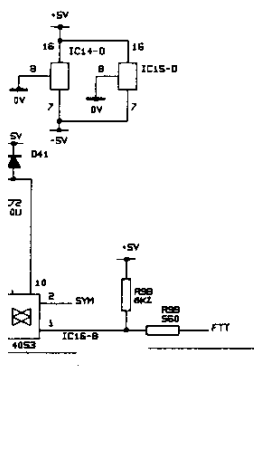
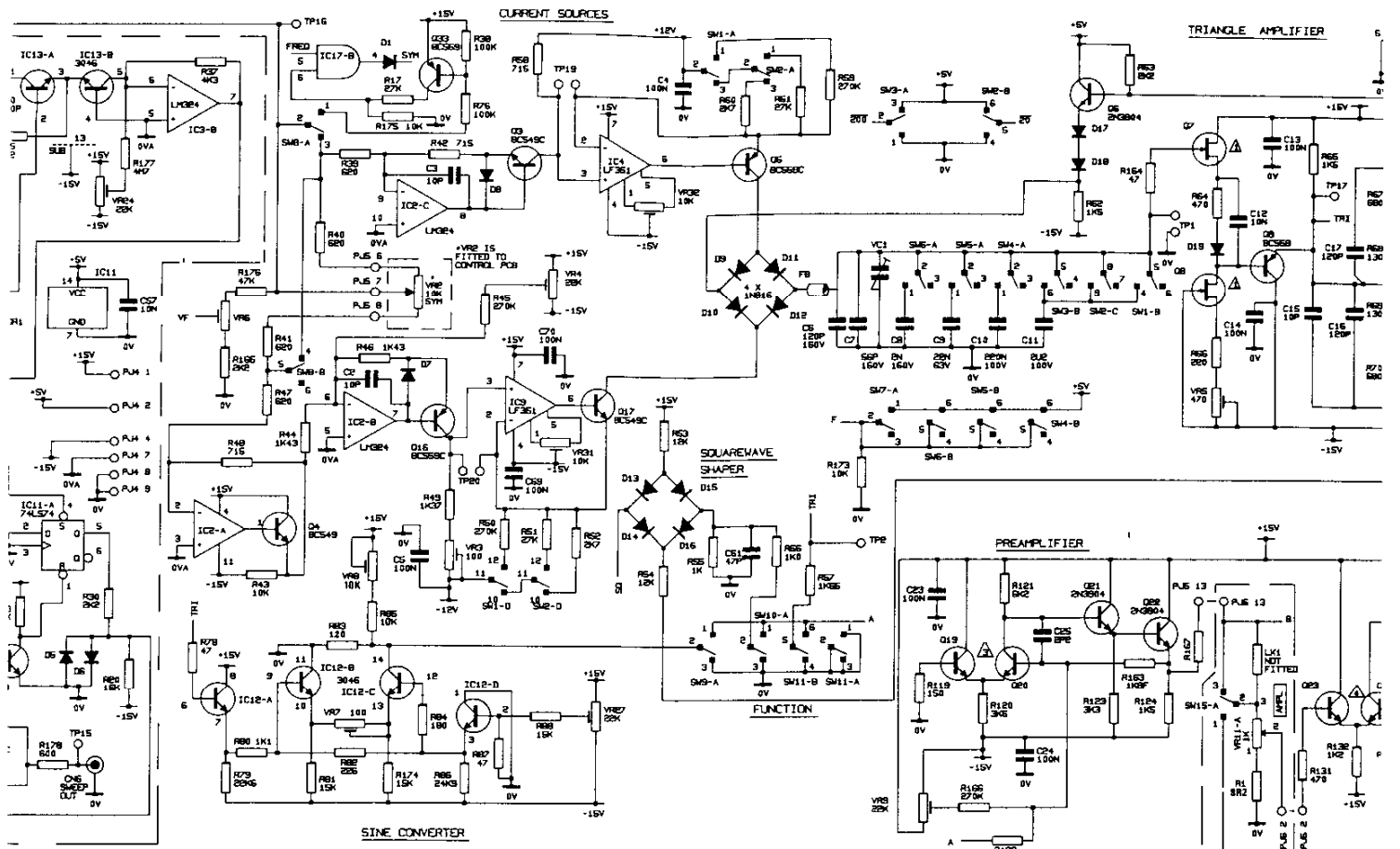


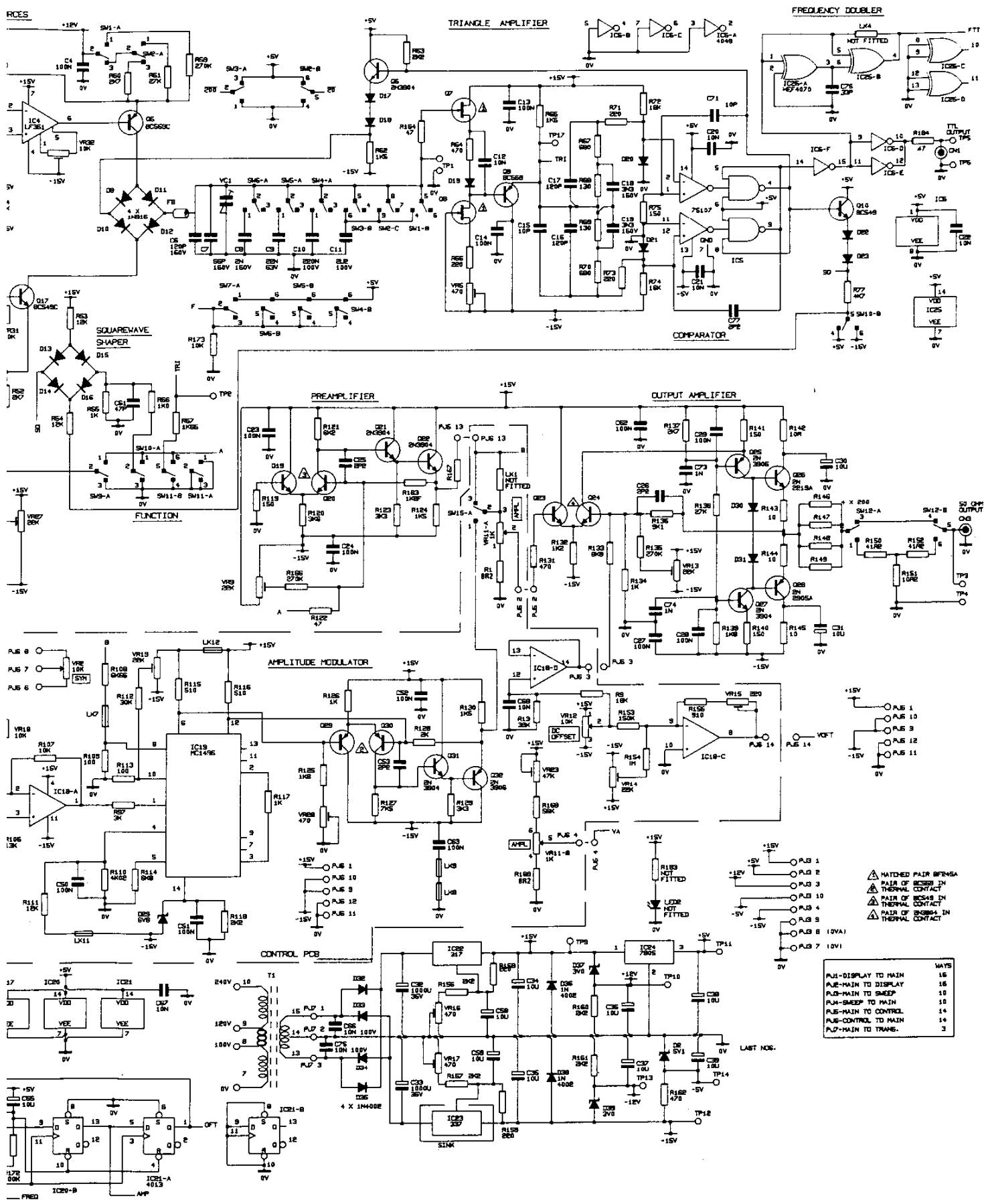




TG215 Circuit Diagram







- ▲ MATCHED PAIR 2N3638
- ▲ PAIR OF BC239 IN THERMAL CONTACT
- ▲ PAIR OF BC238 IN THERMAL CONTACT
- ▲ PAIR OF 2N3638 IN THERMAL CONTACT

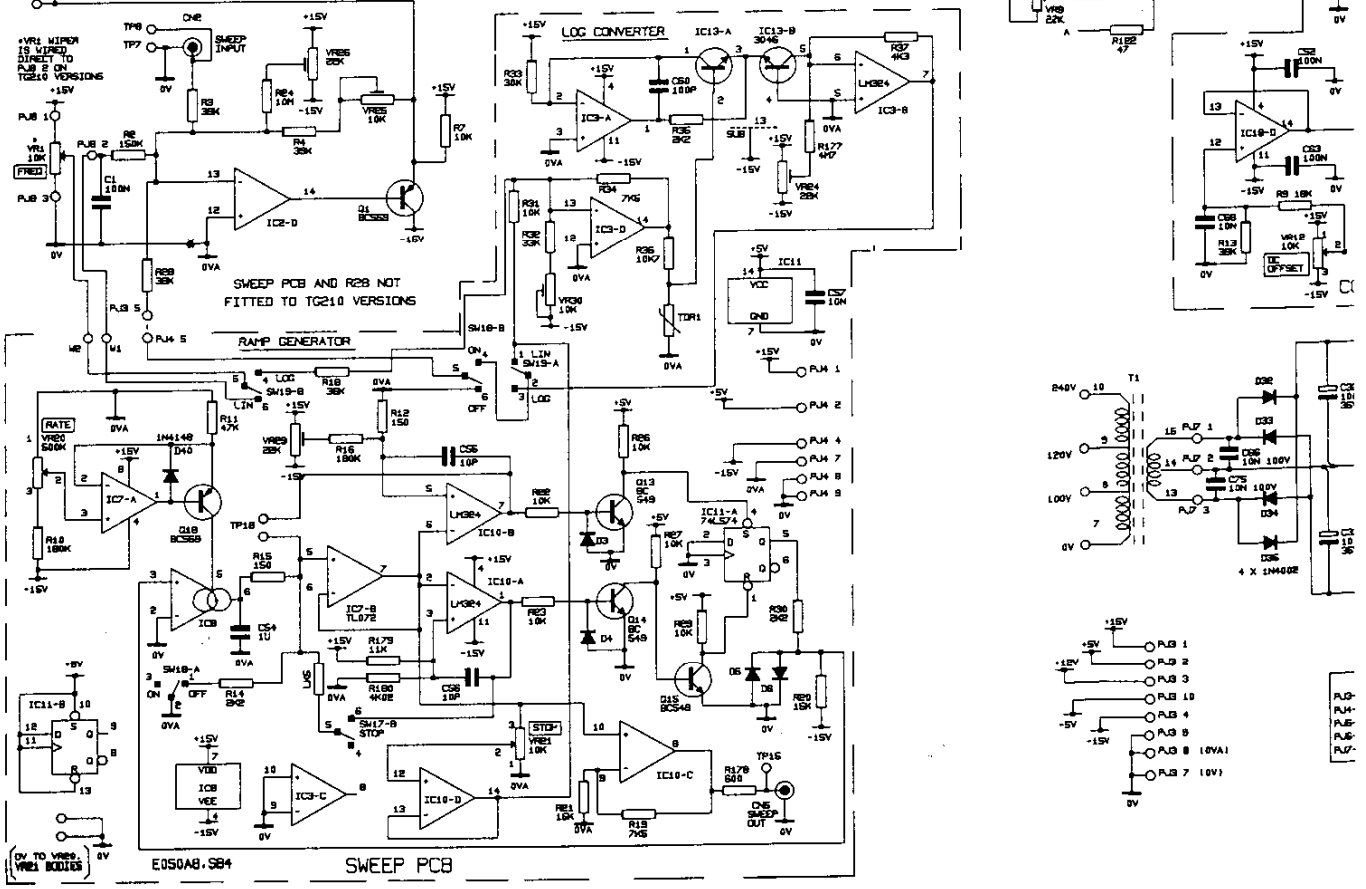
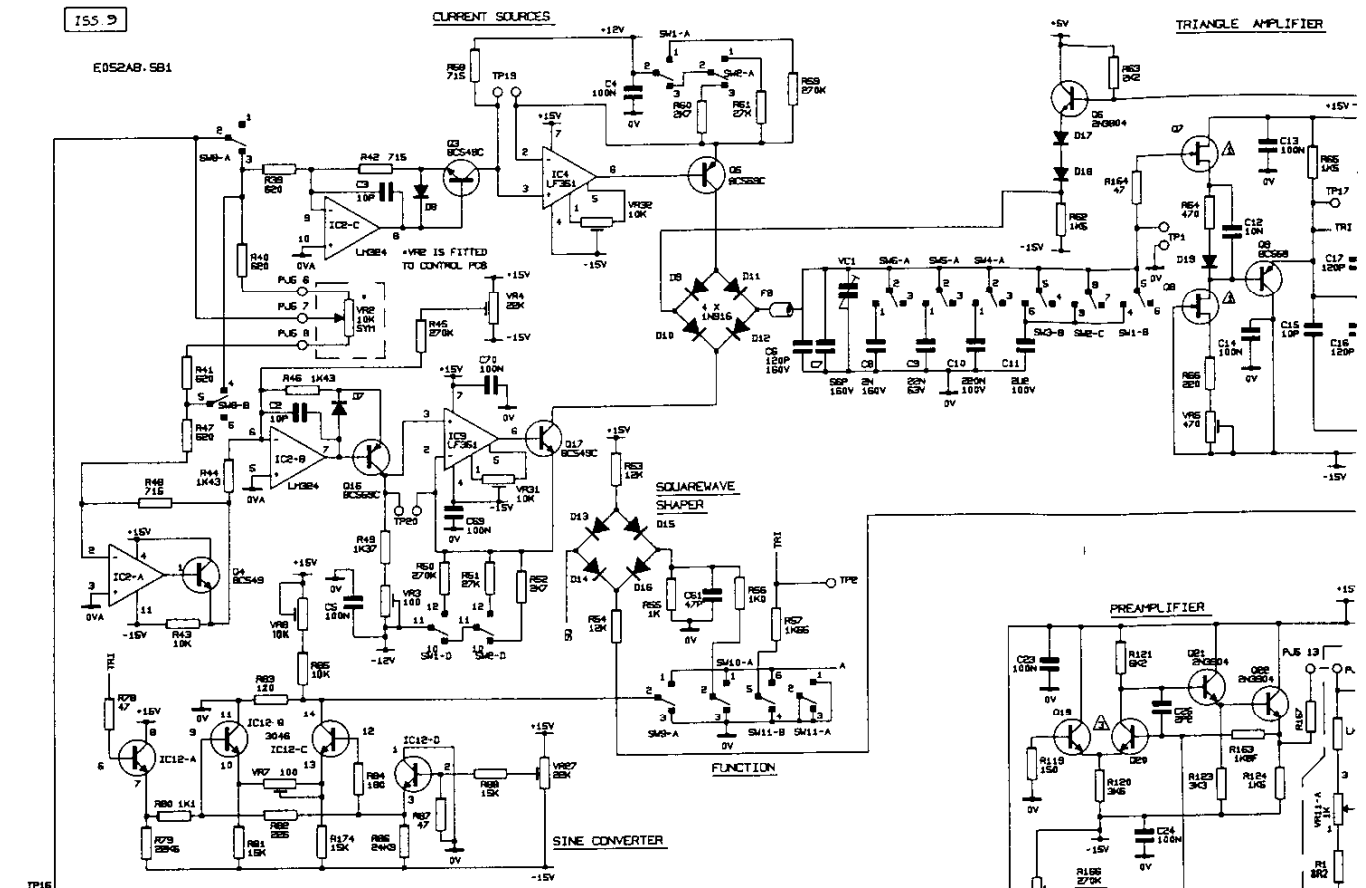
PL1-DISPLAY TO MAIN	WAYS
PL2-MAIN TO DISPLAY	16
PL3-MAIN TO SWEEP	10
PL4-SWEEP TO MAIN	10
PL5-MAIN TO CONTROL	14
PL6-CONTROL TO MAIN	14
PL7-MAIN TO TRANS.	3

TG230 Circuit Diagram

E052A8.5B1

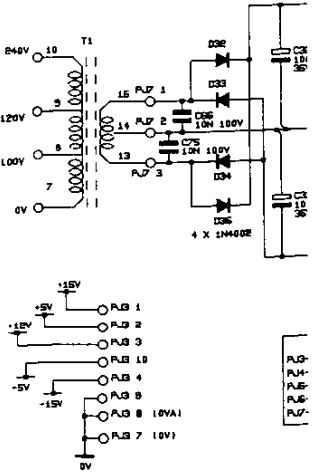
CURRENT SOURCES

TRIANGLE AMPLIFIER

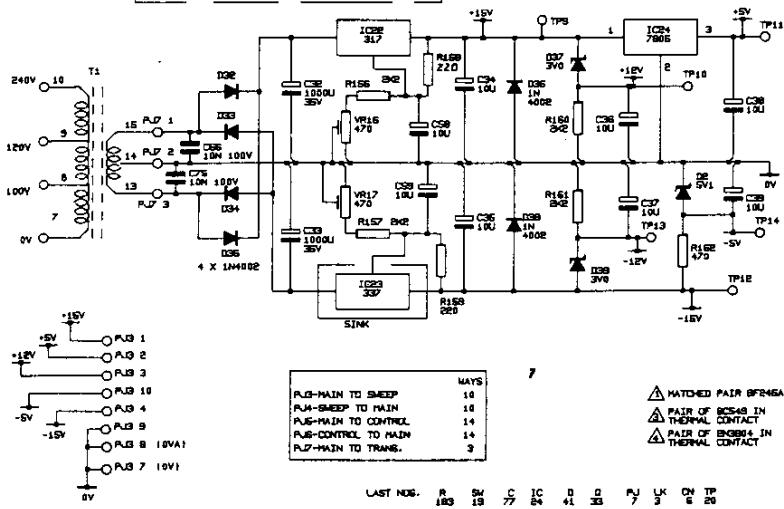
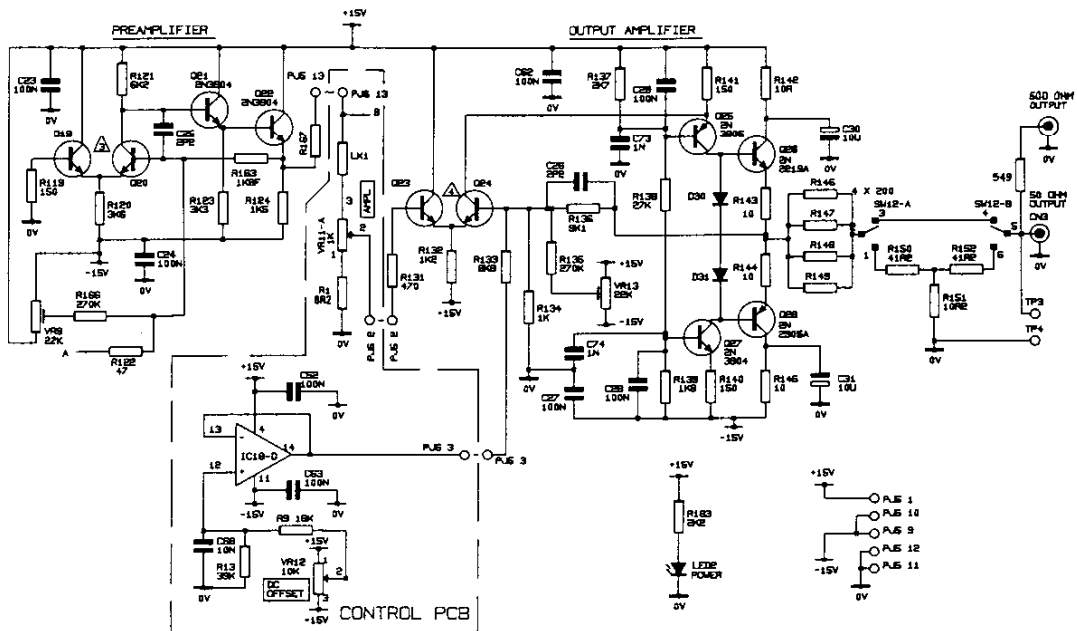
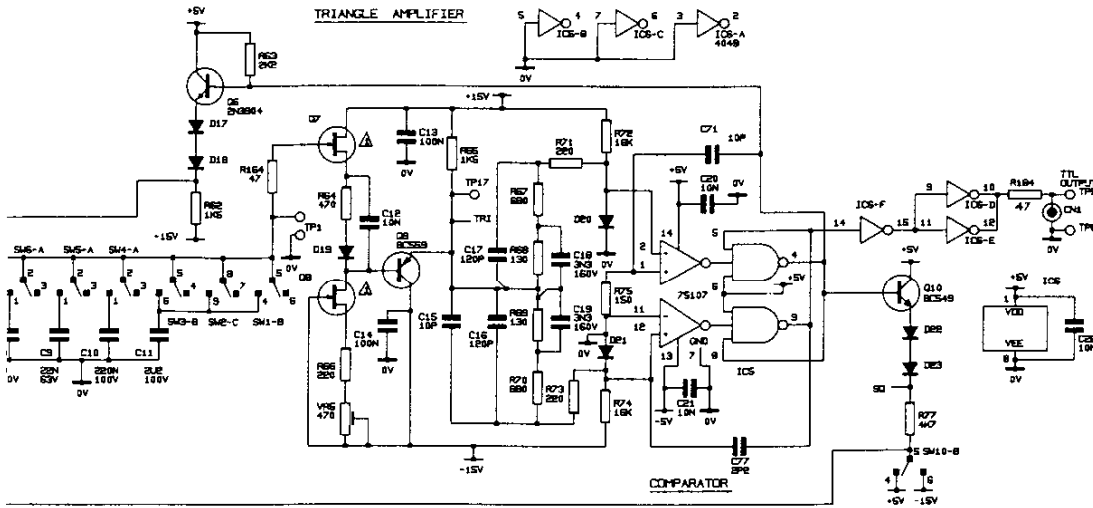


E050A8.5B4

SWEEP PCB



- P1
- P2
- P3
- P4
- P5
- P6
- P7



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- | WAYS | PL3-MAIN TO SLEEP |
|------|---------------------|
| 10 | 10 |
| 14 | PL4-SLEEP TO MAIN |
| 14 | PL5-MAIN TO CONTROL |
| 14 | PL6-CONTROL TO MAIN |
| 14 | PL7-MAIN TO TRANS. |
| 3 | |
- △ MATCHED PAIR BFE464
 - △ PAIR OF BC348 IN THERMAL CONTACT
 - △ PAIR OF BC338 IN THERMAL CONTACT

LAST NOG.	R	SM	C	IC	D	PJ	UX	DN	TP
SPARE	103	13	77	54	41	35	3	6	20

Q1.1.1E

E052AB.CSD

TG210/220 Circuit Diagram