thandar

TG 102 FUNCTION GENERATOR

SERVICE MANUAL

CONTENTS

GENERAL

Service Handling Precautions

Service work should only be carried out by skilled engineers. Please note that 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 with solder wick or suction before attempting to remove a component.

Dismantling the Instrument

WARNING!
Opening the instrument is likely to expose live parts. The instrument shall be disconnected from all voltage sources before any adjustment, replacement or maintenance and repair during which it shall be opened. If afterwards, any adjustment, maintenance or repair of the opened instrument under voltage is inevitable, it shall be carried out only by a skilled person who is aware of the hazard involved.

1. Invert the instrument and remove the 4 rubber feet.

2. Remove the 4 recessed and one surface screw.

3. Holding the case upper and lower together, turn the instrument the right way up and lift off the top.

4. If further dismantling is required to replace components, proceed as follows.

   Remove the two pcb retaining screws and washers. The complete pcb assembly can then be lifted out of the case lower with transformer, chassis and front panel attached.

   The transformer and chassis can be separated from the pcb by desoldering the appropriate connections and removing the nuts from the three pcb studs, two of which also clamp the voltage regulators to the chassis. Note that TR13 and TR16 are insulated from the metal chassis. It is generally simpler to de-solder the four mains leads from the ON/OFF switch (taking careful note of their positions) and the green/yellow earth lead from the SWEEP IN socket.

   The front panel can be removed as follows. Desolder the two connections from the output attenuator switch and the screened cable connections to the BNC sockets, noting which lead goes to which socket. Desolder the L.E.D. leads from the pcb.

   The moulded range knob is a push fit on its shaft and the aluminium knobs are retained by grubscrews. Note that only the grubscrews in the smaller shaft of the vernier dial assembly need be loosened. Bend the front panel forward slightly to remove the nut from the pcb stud which holds the front panel earthing strip. The front panel can now be removed with the dial and collar still in place.

5. Reassemble in reverse order.

Operating Voltage

See the Power Supply section for details of changing the operating voltage from 220/240 to 110/120 and vice-versa.

TECHNICAL SPECIFICATION

OPERATING RANGE

Frequency Range	<0.2Hz to 2MHz in 6 overlapping decade ranges with fine adjustment by a calibrated vernier.

Internal Mode

Vernier Range:	>1000:1 on each range, except 10Hz range: >100:1
Vernier Accuracy:	Better than ± 5% of full scale 1k to 1M ranges; better than ±8% on 10 and 100 ranges.

External (Sweep) Mode

Sweep Range:	>1000:1 within each range, except 10Hz range: >100:1
Input Impedance:	10kΩ

Input sensivity:
- Input for 10:1 sweep ~ 4.5V peak-to-peak
- Input for 100:1 sweep ~ 4.95V peak-to-peak
- Input for 1000:1 sweep ~ 5V peak-to-peak

Max. allowable input voltage	± 10V
Sweep linearity:	Better than 1%
Maximum slew rate of sweep voltage	0.1V/µs

OPERATING MODES

(Specifications apply for vernier between 0.2 and 2.0 and output 10V peak-to-peak into 50Ω 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:	<80ns
Mark:Space ratio:	1:1 ± 1% to 100kHz

DC

Range:	± 10V from 50Ω

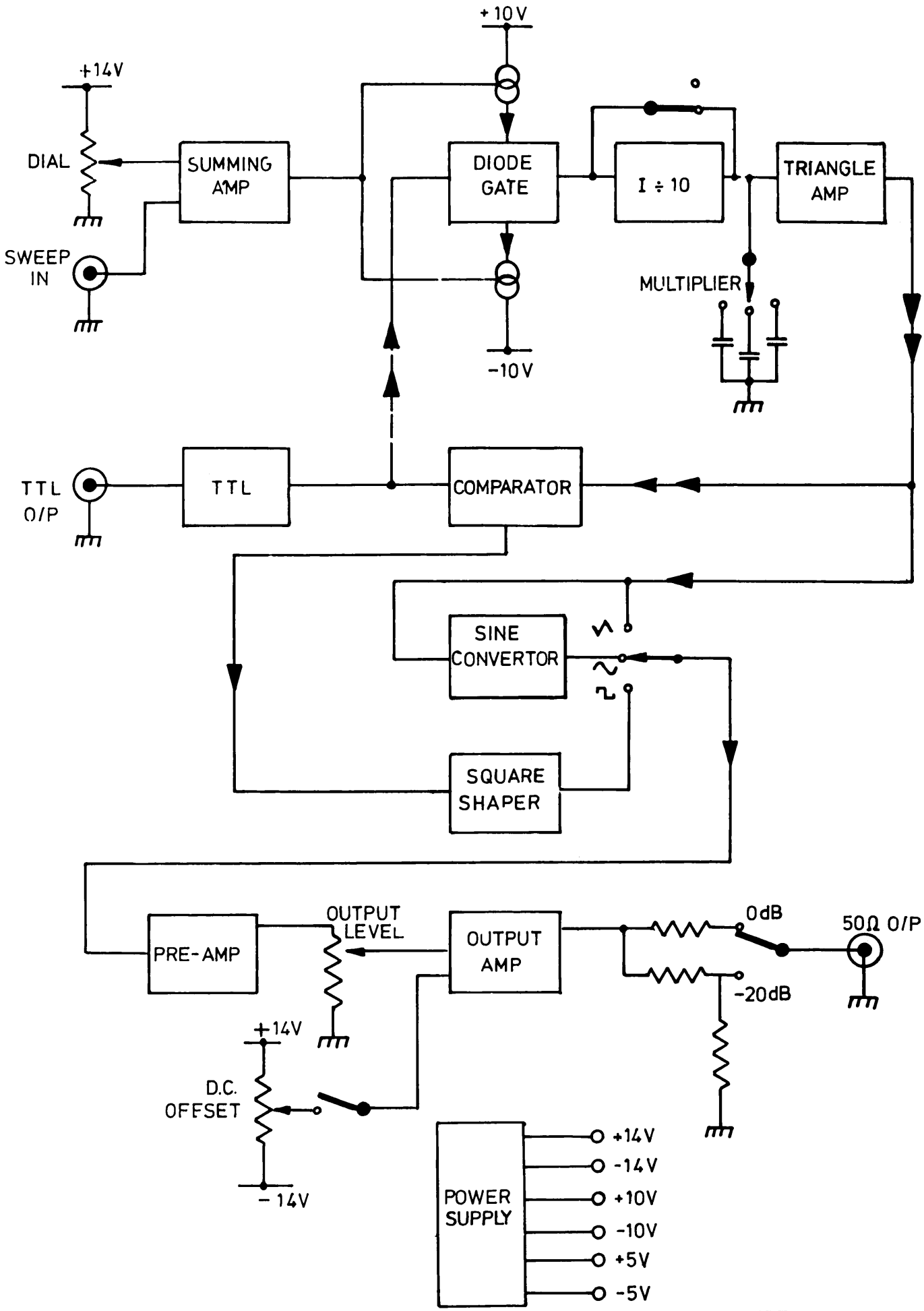
OUTPUTS

50Ω	Two switch-selectable ranges with >30dB vernier control within each range.
0dB:	0.6V to 20V peak-to-peak from 50Ω (0.3V to 10V into 50Ω).
−20dB:	60mV to 2V peak-to-peak from 50Ω (30mV to 1V into 50Ω)
DC offset control range:	± 10V from 50Ω . DC offset plus signal peak limited to ± 10V (± 5V into 50Ω). DC offset plus waveform attenuated proportionally in −20dB position.
TTL	Capable of driving 20 standard TTL loads

GENERAL

Power Requirements

Input Voltage:	110/120 volts AC nominal 50/60 Hz or 220/240 volts AC nominal 50/60Hz, adjustable internally. The TG102 will operate safely, and meet specification, within normal AC supply variations viz. 100-130 volts and 200-260 volts AC respectively.
Power Consumption:	Typically 15VA
Environmental Operating Range	+5°C to +40°C, RH <80%
Storage Temperature Range	−40°C to +70°C
Size	255 x 150 x 50mm
Weight	1200gms (including mains lead)


+10V
+14V
DIAL
SUMMING AMP
DIODE GATE
I ÷ 10
TRIANGLE AMP
SWEEP IN
MULTIPLIER
-10V
TTL O/P
TTL
COMPARATOR
SINE CONVERTOR
SQUARE SHAPER
PRE-AMP
OUTPUT LEVEL
OUTPUT AMP
0dB
50Ω O/P
-20dB
+14V
D.C. OFFSET
-14V
POWER SUPPLY
+14V
-14V
+10V
-10V
+5V
-5V

FUNCTIONAL DESCRIPTION

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

The summing amplifier sums the voltages from the dial and from the sweep input, and its output controls the magnitude of the complementary current source and current sink. This current varies from approximately 5μA to 5mA for a 1000:1 frequency change (.002 - 2.0).

The diode gate steers current into or 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 circuit and is also level shifted to drive the diode gate. The other output drives the squarewave shaper. When the comparator output to the diode gate is high the triangle wave is positive going until this reaches approximately +1V, the comparator output then switches low. When the comparator output is low the triangle wave is negative going until this reaches approximately −1V, when the comparator output 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 10Hz range, the current steered by the diode gate is divided by 10 and the same capacitor is used as on the 100Hz range.

The TTL circuit buffers one of the comparator outputs to drive the TTL output socket.

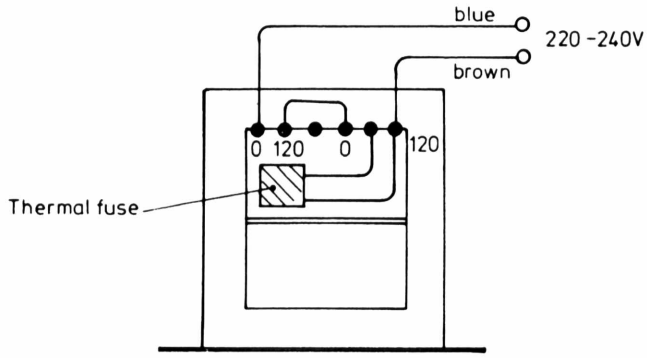
The square shaper converts the comparator output to a current signal and applies it to the square wave function switch. The sinewave converter uses the non-linear characteristics of its diodes to convert the triangle wave into a sinusoidal current, which is applied to the sinewave function switch. The selected function is sent to the pre-amplifier, where it is inverted and buffered and applied to the output level control. The signal is summed with the voltage from the DC offset control at the output amplifier. This amplifier inverts and amplifies the signal up to 20V peak-peak to drive the 50Ω output connector.

CIRCUIT DESCRIPTIONS

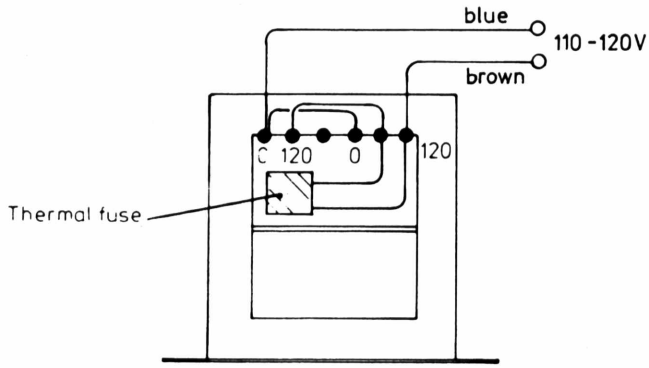
Power Supply - mains connections

The operating voltage of the instrument is shown on the rear panel label. Should it be necessary to change the operating range from 220/240V AC to 110/120V or vice-versa, change the transformer connections following the appropriate diagram below.

220/240V Operation: Primaries in series



110/120V Operation: Primaries in parallel



If a change is made, the operating voltage label should also be changed.

Note: A thermal fuse is fitted in the primary circuit of the transformer. This will become 'open circuit' in the event of a fault occuring in the instrument which would cause excessive temperature rise of the transformer. Should such a fault occur the thermal fuse should only be replaced with the correct spare part.

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 instrument dangerous. Intentional interruption is prohibited.

Power Supply - DC Regulation

Diodes D9 to D12 rectify the transformer output and C27 and C28 are the reservoir capacitors of the unregulated DC rails.

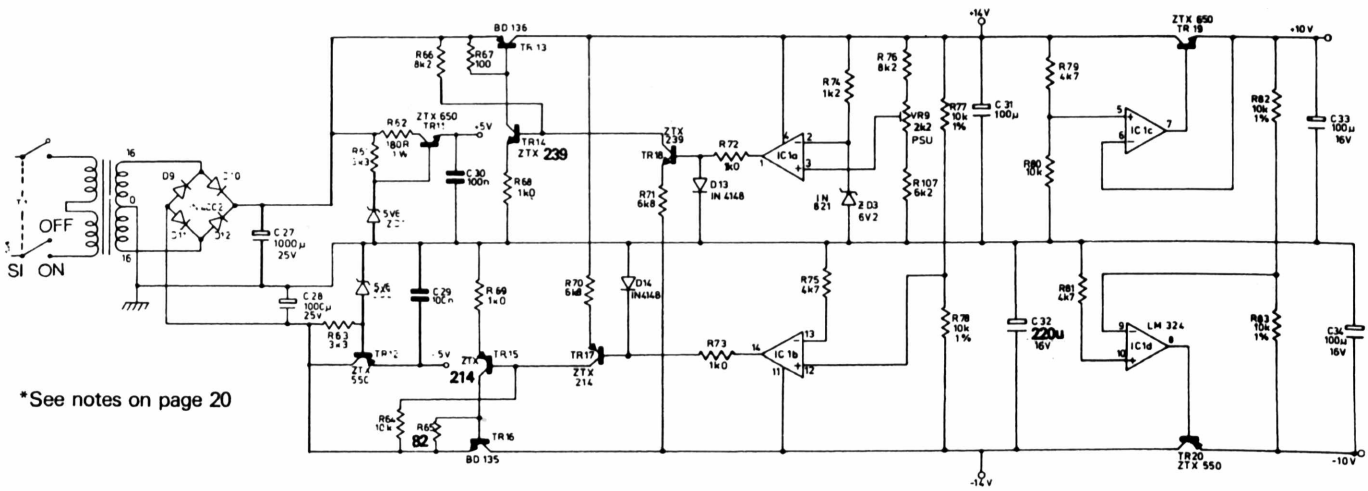
TR11, ZD1 and associated components form the +5 volt regulator and TR12 and ZD2 the -5 volt regulator.

TR13, TR14, TR18 and IC1a form the +14 volt regulator, TR13 being the series pass transistor and TR14 its driver. TR18 inverts the output of IC1a to ensure start-up. The reference voltage is provided by a temperature compensated zener ZD3, and the output level is set to +14 volts by VR9.

The -14 volt regulator is made up of TR16, TR15, TR17 and IC1b and is the complement of the +14 volt regulator. The -14 volt tracks the +14 volt by driving the input of IC1b from the centre-tap of R77, R78.

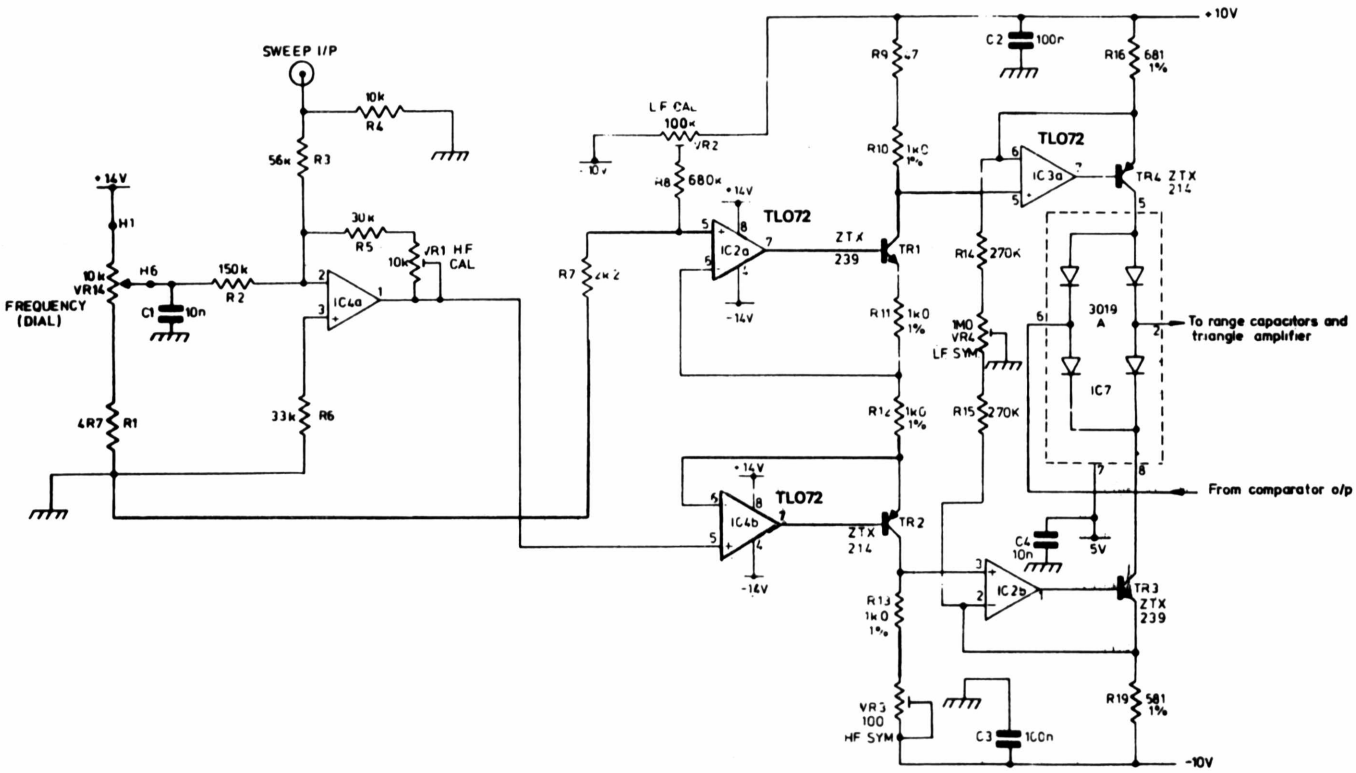
The +10 volt rail is derived by potting down the +14 volt rail; R79 and R80 provide the reference from the +14 volts for the regulator IC1c and TR19.

The -10 volt regulator is formed by TR20 and IC1d and is the complement of the +10 volt regulator. The -10 volts tracks the +10 volt rail by driving the input of IC1d from the centre-tap of R82, R83.



*See notes on page 20

Waveform generation - Summing Amplifier and Current Sources

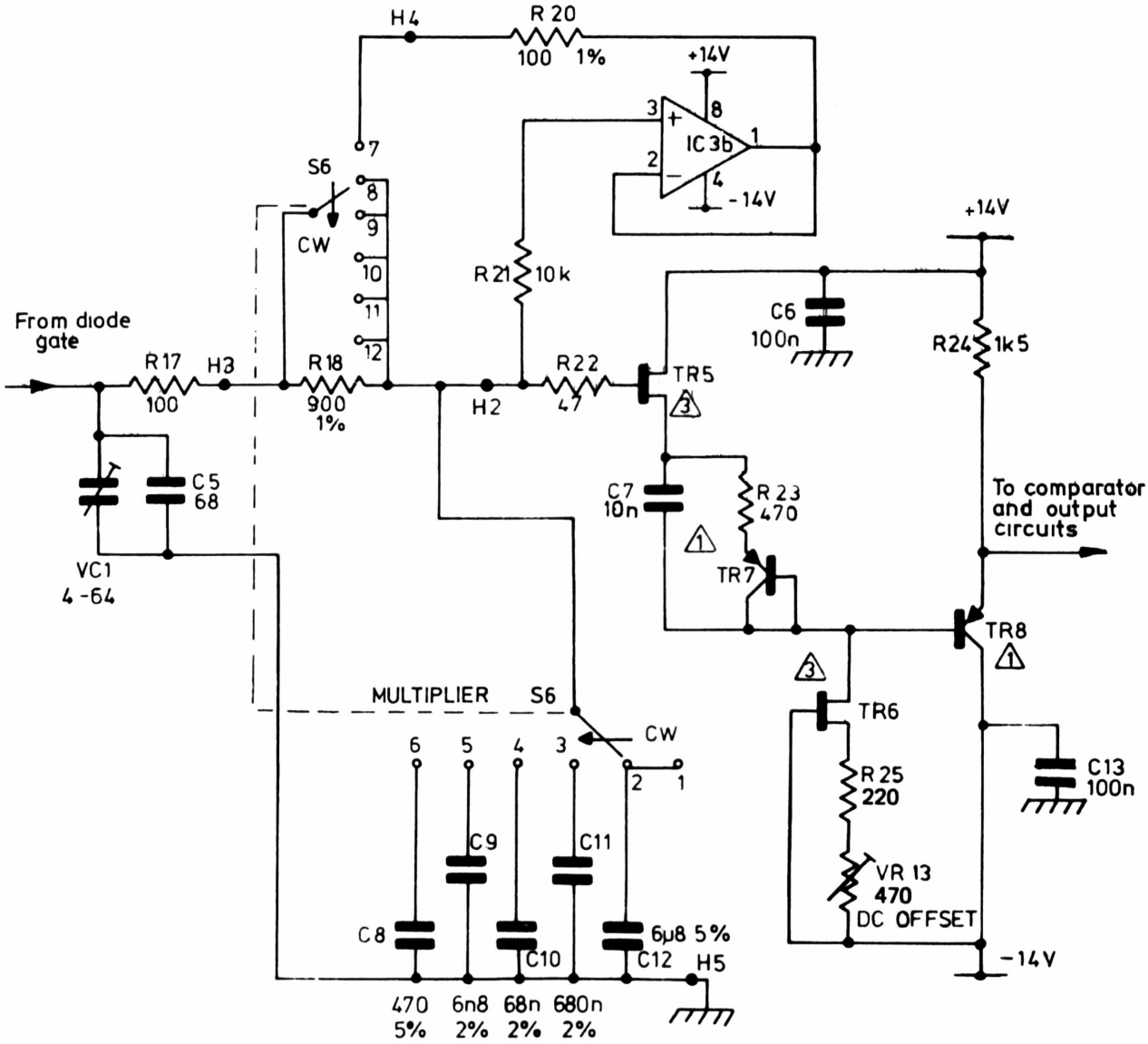


The dial and sweep voltages are summed by IC4a, the gain of which is set by VR1; VR1, in fact, is used to calibrate the high frequency end of the dial. The output range of this amplifier is from a few millivolts below ground (with the dial at .002) to approximately −3.2V (with the dial at 2.0). This voltage is used to control the complementary current source and current sink as follows.

The junction of R11 and R12 is held at pseudo ground by IC2a; the output voltage of IC4a is therefore impressed across R12 by IC4b, causing a current to flow in R12. For example, if the output of IC4a is −3V, the current in R12 is 3V/1kΩ = 3mA. This current must flow between the +10 volt and −10 volt rails via the resistor chain R9, R10, R11, R12, R13 and VR3 and in doing so provides two identical control voltages with respect to the +10 volt and −10 volt rails at the collectors of TR1 and TR2 respectively.

IC3a is a current source controlled by the voltage on the collector of TR1 and IC2b is the current sink controlled by the voltage on the collector of TR2. These two currents are steered by the diode gate IC7, under the control of the comparator output, into the appropriate range multiplier capacitor.

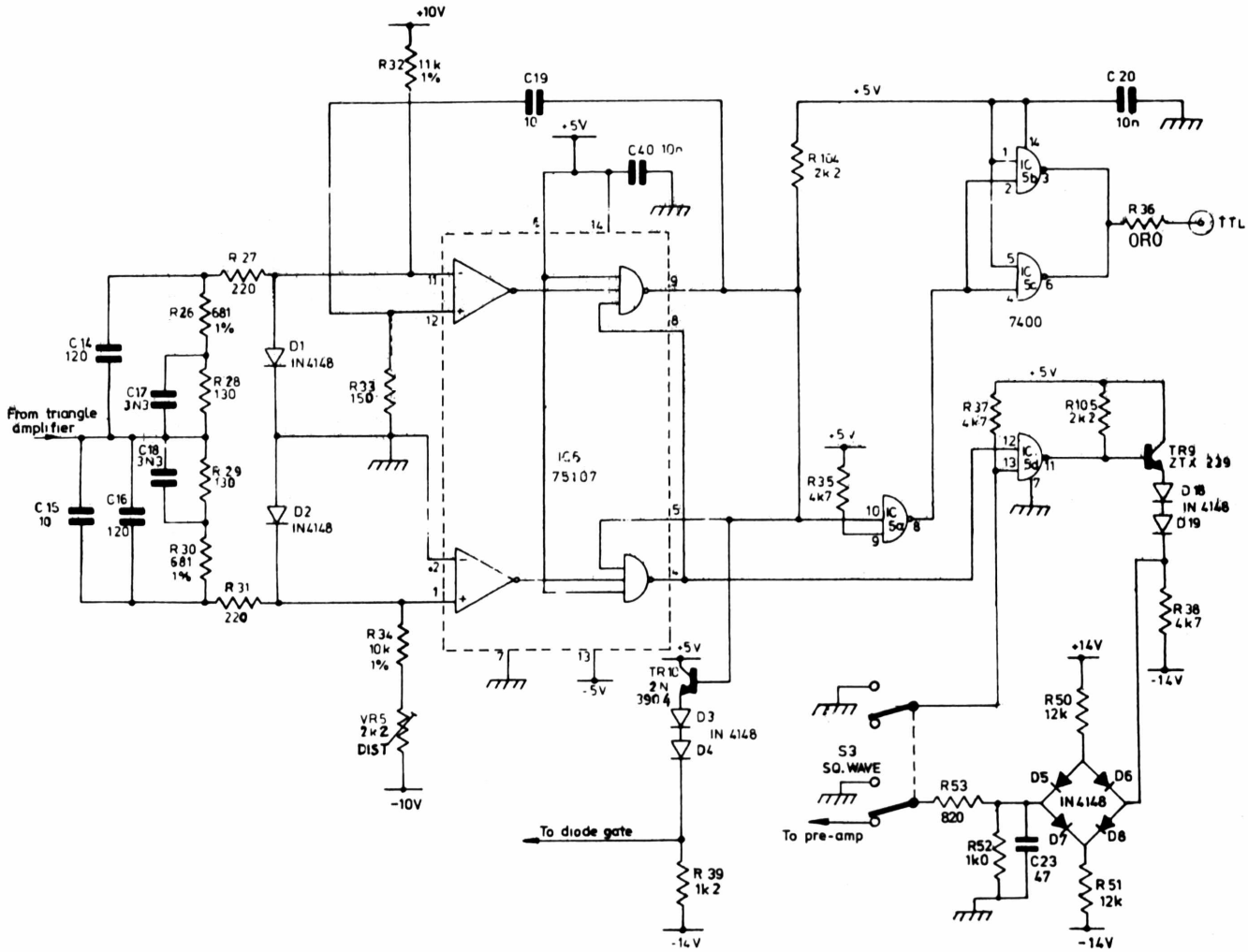
Waveform generation - range selection and triangle amplifier



Range selection is by six position 2-pole rotary switch which steers the current sources into the appropriate multiplier capacitor. C8, C9, C10, C11 and C12 are used for the 1M, 100k, 10k, 1k and 100 range respectively with the charging/discharging current direct from the diode gate array; C12 is used again for the 10Hz range, but with the current from the diode gate divided by 10 by IC3b, R18 and R20.

The triangle amplifier consists of a FET source follower TR5 with temperature compensation provided by current source TR6, which is I_{DSS} matched with TR5. TR8 is an emitter follower to provide a low output impedance and TR7 is included to temperature compensate for TR8's V_{BE}. VR13 trims the DC offset in this stage.

Waveform Generation - Comparator, TTL Output and Squarewave Shaper

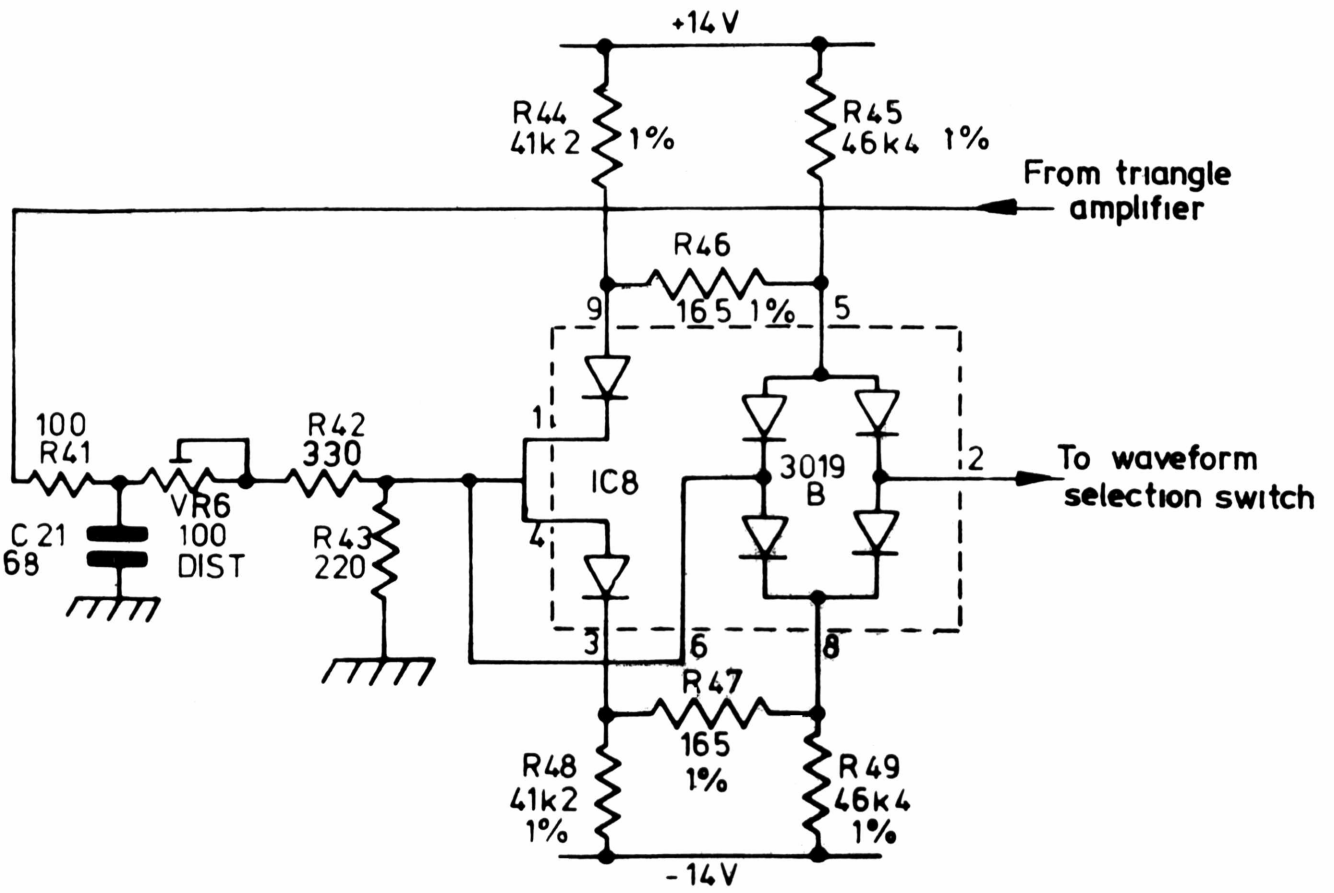


IC6 operates as a window detector and determines the peak to peak amplitude of the triangle wave on the range multiplier capacitor, which is approximately ± 1V. Capacitors C14-C18 compensate for comparator delay ensuring that the triangle wave amplitude remains constant with increase in frequency. The two internal NAND gates in IC6 are wired as a flip-flop to ensure positive switching of the comparator. C19 provides a small amount of positive feedback to ensure jitter free operation.

One of the comparator outputs is routed via IC5a, to parallel gates IC5b and c for the TTL output. TR10 level shifts the output of IC6 to be about ground instead of above ground to suit the diode gate.

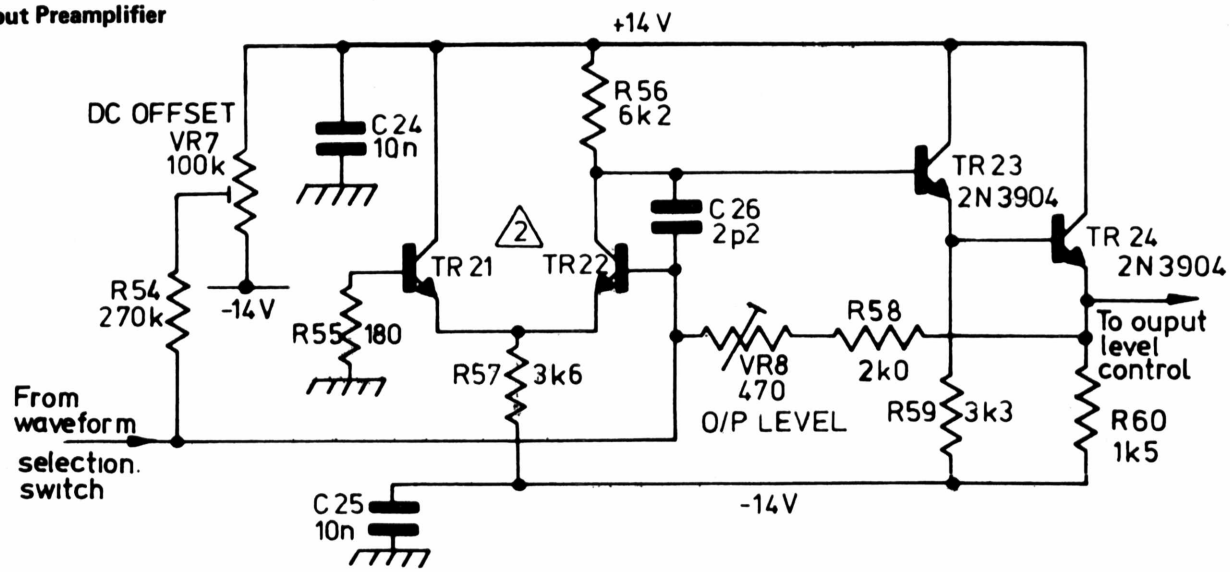
The square wave shaper is a diode bridge which steers current from either R50 or R51 into R52 and R53. This provides a squarewave with controlled rise/fall times, and thus no overshoot and ringing, which is symmetrical about ground. The drive signal comes via IC5d and level shifter TR2. When the square wave button is out pin 13 IC5d is held low and so the square wave is gated off at the source.

Waveform Generation - Sinewave Converter



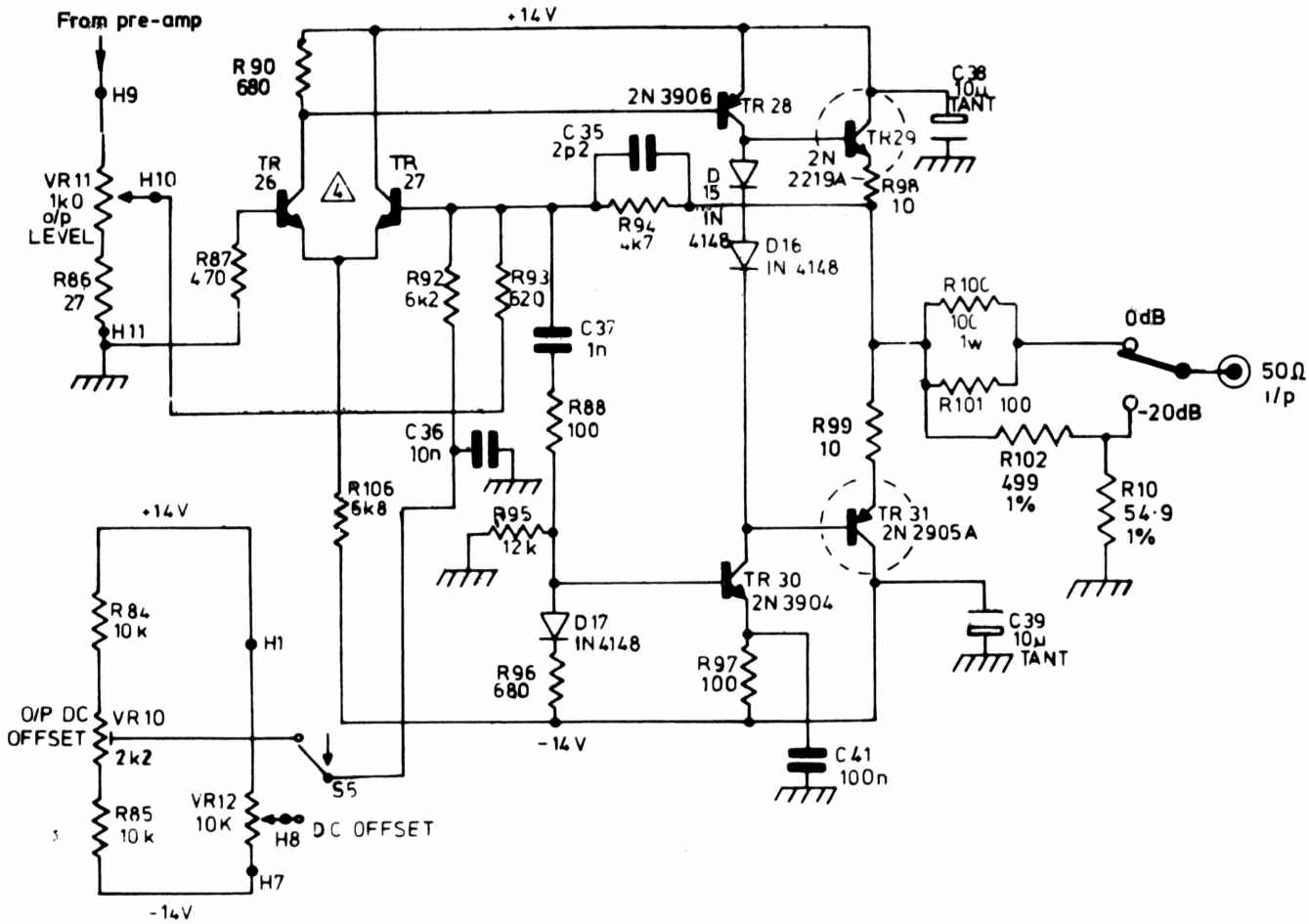
The sinewave converter consists of a diode array IC8 whose non-linear characteristic convert the triangle wave into a sinusoidal current. Two parameters affect sinewave distortion, the amplitude of the triangle wave at the converter which is adjusted by VR6, and the symmetry of the triangle wave about ground which is adjusted by VR5.

Output Preamplifier



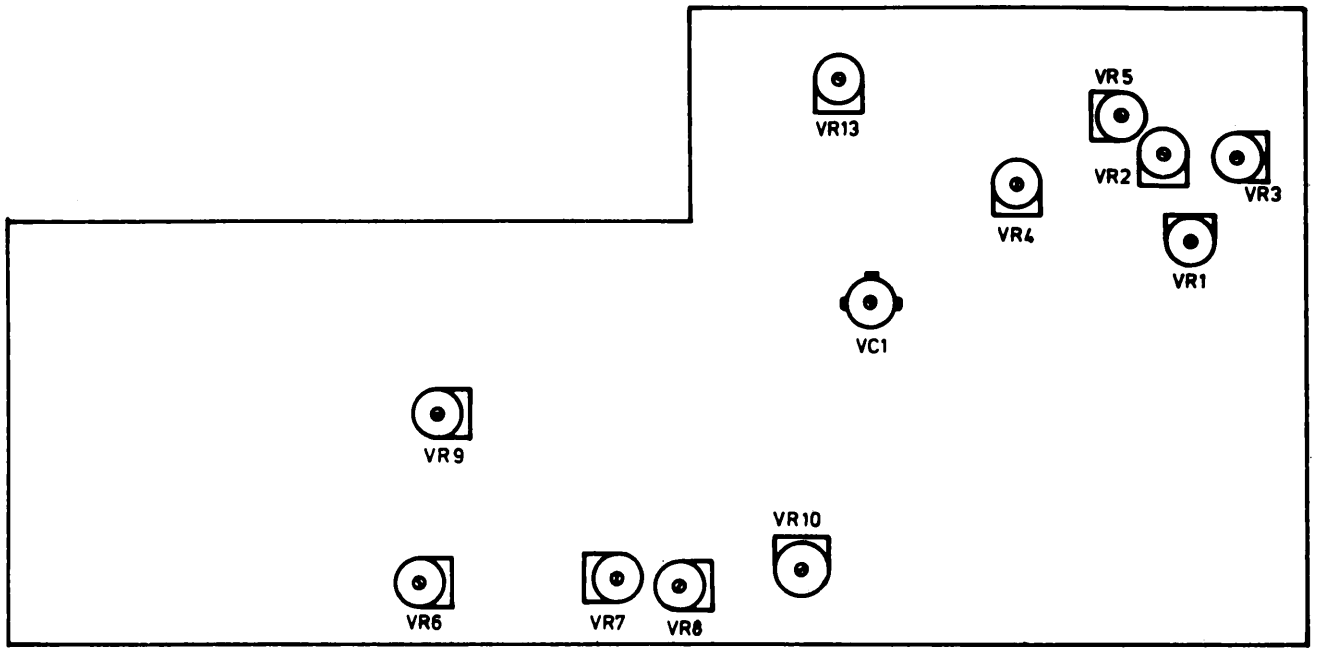
The selected waveform passes to the preamplifier. TR21 and TR22 form a long tailed pair and are in thermal contact with each other to reduce dc drift. TR23 and TR24 are two cascaded emitter followers; feedback is via R58 and VR8. VR8 sets the preamplifier gain and is adjusted to give 10V peak to peak into 50 ohms at the 50 ohms output.

Output Amplifier and DC offset



TR26 and TR27 form a long tailed pair and are in thermal contact with each other to reduce dc drift. TR28 is the driver transistor and TR30 its collector load. TR29 and TR31 are complementary output transistors and diodes D15 and D16 provide their bias. C37 and R88 are feedforward compensation components to increase the bandwidth of the amplifier. Feedback is via R94 and C35. The DC offset is summed with the signal at the base of TR27.

CALIBRATION



Calibration should be carried out after the instrument has been switched on for a few minutes.

The available calibration points are:

Dial calibration, high frequency (2.0) end, 10Hz to 100kHz ranges - VR1

Waveform symmetry, high frequency end of dial (2.0) VR3

Dial calibration, low frequency (.002) end, all ranges - VR2.

Waveform symmetry, low frequency end of dial (.002) VR4

Dial calibration 1MHz range - VC1

DC offset of triangle amplifier - VR13

Sinewave distortion - VR5 and VR6

DC offset of preamplifier - VR7

Maximum output level - VR8

DC offset of output amplifier - VR10

+14 volt rail - VR9

Because some of the above adjustments are interactive, fastest calibration and optimum performance are achieved if the calibrations are carried out in the following order.

1. Turn frequency vernier (VR14) fully clockwise; align the dial mark at .002 with the mark on the front panel; tighten both grub screws evenly.

2. Adjust +14 volt rail with VR9 to 14.00 ± 100mV.
   Check −14 volt rail is 14.00 ± 200mV
   Check +10 volt rail is 9.2 to 9.8V
   Check −10 volt rail is within 2% of +10 volt rail
   Check +5 volt rail is 5.0V ± 0.35V
   Check −5 volt rail is −5.0V ± 0.35V

3. To adjust VR13, the input to the triangle amplifier should be grounded, a test link position is provided for this purpose on the control pcb above the output level control. Fit a wire link here then connect a voltmeter to the output of the triangle amplifier; a test point is provided at one end of C17. Now adjust VR13 for 0 volts ± 2mV. Remove the voltmeter and cut the test link bending the wire ends away from the pcb.

4. Dial at 2.0, 100kHz range squarewave, adjust VR1 for approximately 200kHz.

5. Dial at .002 adjust VR2 for approximately 200Hz (note: if the oscillator stops adjust VR4).

6. Adjust VR4 for a symmetrical squarewave (note: if the oscillator stops readjust VR2).

7. Adjust VR2 for 200Hz ± 5%.

8. Dial at 2.0, 10kHz range. Select positive edge trigger on the oscilloscope and adjust its timebase to give one half cycle on the screen. Switch the X-amplifier to x10 and adjust the X-shift to show the falling edge of the squarewave at a convenient reference point on the screen. Now select negative edge trigger and adjust VR3 to bring the rising edge of the squarewave to the same reference point on the screen.

9. Select 100kHz range, adjust VR1 for 200kHz.

10. Select 1MHz range, adjust VC1 for 2MHz

11. Select 10kHz range, sinewave, dial at 1.0. To adjust the sinewave distortion an auto-nulling distortion meter is best used as when adjusting VR5 the frequency will change slightly. Simply adjust VR5 and VR6 for minimum distortion. If, however, an auto-nulling distortion meter is not available, an

ordinary distortion meter can be used in the following way. Set VR5 and VR6 to their mid-positions and observe the distortion output of the meter on the oscilloscope. To get a stable trace on the screen the TTL output can be used to trigger the timebase. VR5 should now be adjusted so that the spikes on the waveform are symmetrical while VR6 is adjusted for minimum amplitude.

12. Select squarewave and adjust VR8 for 10 volts peak-peak into a 50 ohm load with output level control at maximum.

13. Select DC output mode by releasing the three waveform selection buttons (achieved by half depressing one of the three). With the output level control at minimum adjust VR10 for 0 volts ± 10mV and with the output level control at maximum adjust VR7 for 0 volts ± 10mV, at the 50 ohm output.

Notes on Servicing

The white printing on the pcb also shows all the points which are top soldered. The circles show the track pins and the squares show which lead of a component is top soldered.

Heatsink compound is applied to the regulator transistors TR13 and TR16 and also between the following transistor pairs, TR7 and TR8, TR21 and TR22, TR26 and TR27.

To help with trouble shooting the power supply circuit which generates the ± 14V rails, an external dual power supply of ± 16 volts can be used, the ground of which going to the TG102 ground. Remove the transformer leads from the two pins in the pcb marked T1 and T2, and connect the positive and negative external power supply leads to these pins; polarity of these two connections is unimportant as the diode bridge, D9-D12 will account for this. IC1 can now be removed and the two ± 14V supply rails should pull up to approximately ± 15 volts. This is very useful because if IC1 was in and if a fault is present on either rail then the total power supply will malfunction making fault finding very difficult. IC1 **must not** be removed with supplies greater than ± 17 volts or when operated directly from its own transformer as excessive voltage on the ± 14 volt rails will damage the TG102. With the output level control at minimum the supply current is approximately ± 100mA rising to approximately ± 200mA at maximum output into 50 ohms.

Diode arrays IC7 and IC8 are hand preformed when fitted; if replacement is necessary ensure that their leads are correctly orientated.

FET's TR5 and TR6 have matched IDSS's; refer to parts list for colour identification.

When replacing any of the following transistors, TR26, TR27, TR28 and TR30 in the output amplifier, with devices of a different manufacture instability may arise. See parts list.

PARTS LIST

Resistors

Ref	Description	Part No.	Ref	Description	Part No.
R1	4R7J W25 CF	23185-0047	R31	220RJ W25 CF	23185-1220
R2	150KJ W25 CF	23185-4150	R32	11KF W25 MF	23202-3110
R3	56KJ W25 CF	23185-3560	R33	150RJ W25 CF	23185-1150
R4	10KJ W25 CF	23185-3100	R34	10KF W25 MF	23202-3100
R5	30KJ W25 CF	23187-3300	R35	4K7J W25 CF	23185-2470
R6	33KJ W25 CF	23185-3330	R36	0R0 W25 CF	23185-0000
R7	2K2J W25 CF	23185-2220	R37	4K7J W25 CF	23185-2470
R8	680KJ W25 CF	23185-4680	R38	4K7J W25 CF	23185-2470
R9	47RJ W25 CF	23185-0470	R39	1K2J W25 CF	23185-2120
R10	1K0F W25 MF	23202-2100	R40	1K5J W25 CF	23185-2150
R11	1K0F W25 MF	23202-2100	R41	100RJ W25 CF	23185-1100
R12	1K0F W25 MF	23202-2100	R42	330RJ W25 CF	23185-1330
R13	1K0F W25 MF	23202-2100	R43	220RJ W25 CF	23185-1220
R14	270KJ W25 CF	23185-4270	R44	41K2F W25 MF	23202-3412
R15	270KJ W25 CF	23185-4270	R45	46K4F W25 MF	23202-3464
R16	681RF W25 MF	23202-1681	R46	165RF W25 MF	23202-1165
R17	100RJ W25 CF	23185-1100	R47	165RF W25 MF	23202-1165
R18	909RF W25 MF	23202-1909	R48	41K2F W25 MF	23202-3412
R19	681RF W25 MF	23202-1681	R49	46K4F W25 MF	23202-3464
R20	100RF W25 MF	23202-1100	R50	12KJ W25 CF	23185-3120
R21	10KJ W25 CF	23185-3100	R51	12KJ W25 CF	23185-3120
R22	47RJ W25 CF	23185-0470	R52	1K0J W25 CF	23185-2100
R23	470RJ W25 CF	23185-1470	R53	820RJ W25 CF	23185-1820
R24	1K5J W25 CF	23185-2150	R54	270KJ W25 CF	23185-4270
R25	220RJ W25 CF	23185-1220	R55	180RJ W25 CF	23185-1180
R26	681RF W25 MF	23202-1681	R56	6K2J W25 CF	23187-2620
R27	220RJ W25 CF	23185-1220	R57	3K6J W25 CF	23187-2360
R28	130RJ W25 CF	23187-1130	R58	2K0J W25 CF	23187-2200
R29	130RJ W25 CF	23187-1130	R59	3K3J W25 CF	23185-2330
R30	681RF W25 MF	23202-1681	R60	1K5J W25 CF	23185-2150

Resistors (cont)

Ref	Description	Part No.
R61	3K3J W25 CF	23185-2330
R62	180RJ 1W CF	23183-1180
R63	3K3J W25 CF	23185-2330
R64	10KJ W25 CF	23185-3100
*R65	82RJ W25 CF	23185-0820
R66	8K2J W25 CF	23185-2820
R67	100RJ W25 CF	23185-1100
R68	1K0J W25 CF	23185-2100
R69	1K0J W25 CF	23185-2100
R70	6K8J W25 CF	23185-2680
R71	6K8J W25 CF	23185-2680
R72	1K0J W25 CF	23185-2100
R73	1K0J W25 CF	23185-2100
R74	1K2J W25 CF	23185-2120
R75	4K7J W25 CF	23185-2470
R76	8K2J W25 CF	23185-2820
R77	10KF W25 MF	23202-3100
R78	10KF W25 MF	23202-3100
R79	4K7J W25 CF	23185-2470
R80	10KJ W25 CF	23185-3100
R81	4K7J W25 CF	23185-2470
R82	10KF W25 MF	23202-3100
R83	10KF W25 MF	23202-3100
R84	10KJ W25 CF	23185-3100
R85	10KJ W25 CF	23185-3100
R86	27RJ W25 CF	23185-0270
R87	470RJ W25 CF	23185-1470
R88	100RJ W25 CF	23185-1100
R89	470RJ W25 CF	23185-1470
R90	680RJ W25 CF	23185-1680
R91		
R92	6K2J W25 CF	23187-2620
R93	620RJ W25 CF	23187-1620
R94	4K7J W25 CF	23185-2470
R95	12KJ W25 CF	23185-3120
R96	680RJ W25 CF	23185-1680
R97	100RJ W25 CF	23185-1100
R98	10RJ W25 CF	23185-0100
R99	10RJ W25 CF	23185-0100
R100	100RJ 1W CF	23183-1100
R101	100RJ 1W CF	23183-1100
R102	499RF W25 MF	23202-1499
R103	54R9F W25 MF	23202-0549
R104	2K2J W25 CF	23185-2220
R105	2K2J W25 CF	23185-2220
R106	6K8J W25 CF	23185-2680
R107	6K2J W25 CF	23187-2620
VR1	10K Preset	23377-3100
VR2	100K Preset	23377-4100
VR3	100R Preset	23377-1100
VR4	1M0 Preset	23377-5100
VR5	2K2 Preset	23377-2220
VR6	100R Preset	23377-1100
VR7	100K Preset	23377-4100
VR8	470R Preset	23377-1470
VR9	2K2 Preset	23377-2220
VR10	2K2 Preset	23377-2220
VR11	1K0 Lin Pot	23347-0040
VR12	10K Lin Pot	23347-0050
VR13	470R Preset	23377-1470
VR14	10K Lin Pot CP	23348-0002

* See notes on page 20

Capacitors

Ref	Description	Part No.
C1	10NZ 63V Cer	23427-0325
C2	100NM 63V Cer	23438-0007
C3	100NM 63V Cer	23438-0007
C4	10NZ 63V Cer	23427-0325
C5	68PC 63V Cer	23427-0332
C6	100NM 63V Cer	23438-0007
C7	10NZ 63V Cer	23427-0325
C8	470PF 160V Poly/S	23647-0513
C9	6N8G 100V Poly/E	23620-0800
C10	68NG 100V Poly/E	23620-0801
C11	680NG 100V Poly/E	23620-0802
C12	6U8J 100V Poly/E	23620-0234
C13	100NM 63V Cer	23438-0007
C14	120PG 100V Cer	23427-0342
C15	10PC 63V Cer	23427-0328
C16	120PG 100V Cer	23427-0342
C17	3N3F 63V Poly/S	23646-0007
C18	3N3F 63V Poly/S	23646-0007
C19	10PC 63V Cer	23427-0328
C20	10NZ 63V Cer	23427-0325
C21	68PC 63V Cer	23427-0332
C22	10NZ 63V Cer	23427-0325
C23	47PG 63V Cer	23427-0329
C24	10NZ 63V Cer	23427-0325
C25	10NZ 63V Cer	23427-0325
C26	2P2C 50V Cer	23427-0524
C27	1000UF 35V Elec	23557-0639
C28	1000UF 35V Elec	23557-0639
C29	100NM 63V Cer	23438-0007
C30	100NM 63V Cer	23438-0007

Ref	Description	Part No.
C31	100UF 16V Elec	23557-0635
*C32	220UF 16V Elec	23557-0641
C33	100UF 16V Elec	23557-0635
C34	100UF 16V Elec	23557-0635
C35	2P2C 63V Cer	23427-0524
C36	10NZ 63V Cer	23427-0325
C37	1N0K 63V Cer	23427-0331
C38	10UF 16V Tant	23594-0219
C39	10UF 16V Tant	23594-0219
C40	10NZ 63V Cer	23427-0325
C41	100NM 63V Cer	23438-0007
VC1	Trimcap 4 - 65pF	23984-0001

* See notes on page 20

Semiconductors

Ref	Description	Part No.
IC1	LM324N	27106-0506
IC2	TLO72CP	27106-0606
IC3	TLO72CP	27106-0606
IC4	TLO72CP	27106-0606
IC5	7400N	27220-0000
IC6	DS75107N	27254-0008
IC7	CA3019	27164-0600
IC8	CA3019	27164-0600

Ref	Description	Part No.
TR1	Tran NPN ZTX239	25380-0229
TR2	Tran PNP ZTX214	25341-0214
TR3	Tran NPN ZTX239	25380-0229
TR4	Tran PNP ZTX214	25341-0214
TR5)	Matched pair of	25601-0103
TR6)	Tran FET BF245A	25601-0103
TR7	Tran PNP ZTX214	25341-0214
TR8	Tran PNP ZTX214	25341-0214
TR9	Tran NPN ZTX239	25380-0229
TR10	Tran NPN 2N3904	25381-0404
TR11	Tran NPN ZTX650	25388-0206
TR12	Tran PNP ZTX550	25341-0215
TR13	Tran PNP BD136	25334-0010
TR14	Tran NPN ZTX239	25380-0229
TR15	Tran PNP ZTX214	25341-0214
TR16	Tran NPN BD135	25381-0502
TR17	Tran PNP ZTX214	25341-0214
TR18	Tran NPN ZTX239	25380-0229
TR19	Tran NPN ZTX650	25388-0206
TR20	Tran PNP ZTX550	25341-0215
TR21	Tran NPN ZTX239	25380-0229
TR22	Tran NPN ZTX239	25380-0229
TR23	Tran NPN 2N3904	25381-0404
TR24	Tran NPN 2N3904	25381-0404

Ref	Description	Part No.
TR25	Not used	
TR26	*Tran NPN 2N3904	25381-0404
TR27	*Tran NPN 2N3904	25381-0404
TR28	*Tran PNP 2N3906	25341-0218
TR29	Tran NPN 2N2219A	25377-0700
TR30	*Tran NPN 2N3904	25381-0404
TR31	Tran PNP 2N2905A	25344-0500

* Manufacturer - Ferranti

Ref	Description	Part No.
D1	Dio 1N4148	25021-0901
D2	Dio 1N4148	25021-0901
D3	Dio 1N4148	25021-0901
D4	Dio 1N4148	25021-0901
D5	Dio 1N4148	25021-0901
D6	Dio 1N4148	25021-0901
D7	Dio 1N4148	25021-0901
D8	Dio 1N4148	25021-0901
D9	Dio 1N4002	25115-0907
D10	Dio 1N4002	25115-0907
D11	Dio 1N4002	25115-0907
D12	Dio 1N4002	25115-0907
D13	Dio 1N4148	25021-0901
D14	Dio 1N4148	25021-0901
D15	Dio 1N4148	25021-0901

Semiconductors (cont)

Ref	Description		Part No.
D16	Dio	1N4148	25021-0901
D17	Dio	1N4148	25021-0901
D18	Dio	1N4148	25021-0901
D19	Dio	1N4148	25021-0901
ZD1	Dio	Zen 5V6 Sel.	25130-0808
ZD2	Dio	Zen 5V6 Sel.	25130-0808
ZD3	Dio	Zen 1N821	25130-0226
LED	LED Miniature		25061-0200
Adhesive Pad for LED			10300-0313
Sleeve insulating LED wire			10300-0404
PCB Track Pin		16 off	22469-0502
Res. Zero Ohm (LK1-23)		23 off	23185-0000
Test Point Pins (TP1, TP2)		2 off	22469-0200

Electro/Mechanical, Mechanical & Packaging Parts

Description		Part No.
Adhesive Pad 12 x 15mm (for C27, C28)	2 off	10300-0313
Stud 10mm long (Regulators, Chassis & Front panel earthing Strip mounting)	4 off	20205-0610
PCB - Main & Control		35555-0290
Pushbutton red		37113-0020
Pushbutton grey	3 off	37113-0140
Pushbutton black		37113-0130
Switchbank		22225-0530
Rotary Switch		22220-0003
PCB Header 8 Way cut from		22573-0019
PCB Header 3 Way cut from		22573-0019
8 Pin DIL Socket	3 off	22574-0118
14 Pin DIL Socket	3 off	22574-0119
Slide Switch (Power)		22218-0205
Screws for Slide Switch	2 off	20234-0026
BNC Socket	3 off	22588-0004
Front Panel		33331-0430
Knob, aluminium	2 off	37151-0260
Knob, grey		37151-0270
Knob, aluminium (Dial)		37151-0280
Dial		37571-0050
Knob to Shaft Clip (for Grey Knob)		20620-0009
Collar, stepped, knob shaft		31125-0030
Bush, grey (front panel)	2 off	31122-0190
Insulating Washer (for TR13, TR16)	2 off	20613-0003
Spacer, transipad (for TR29, TR31)	2 off	20661-0801
Earthing Strip (front panel to Main PCB)		35358-0460
Cable tie	4 off	20653-0204
Mains Transformer		22115-0020
Chassis, transformer mounting		33145-0300
Heatsink (for TR29 & 31)	2 off	20670-0040

Description		Part No.
Solder tag - Shakeproof (transformer)		20037-0400
Mains input Receptacle		22520-0120
Support Bracket right angled	2 off	33141-0500
Nylon Spacer (Brackets to Control PCB)	2 off	20661-0223
Washer M3 (Power skt (2) Transformer (1) TR13(1) TR16(1) PCB to Case (2))	7 off	20030-0263
Washer shakeproof M3 (Power skt (2) Transformer (1) Chassis to PCB (1) Brackets to Main PCB (2))	6 off	20037-0301
Screw M3 x 5mm self tap (Brackets to Main PCB)	2 off	20062-0500
Screw M3 x 8mm self tap (Brackets to Control PCB)	2 off	20062-0501
Screw 6BA x 3/16" pan head (PCB to Case, Case upper to lower)	6 off	20134-0501
Screw M3 x 8mm countersunk head (Transformer)	2 off	20219-0006
Nut M3 (Power skt (2) Transformer (2) TR13 (1) TR16 (1) PCB to Chassis (1) Earthing strip to PCB (1))	8 off	20210-0101
Screw M2 x 5mm pan head (aluminium knobs (2) stepped collar (1))	3 off	20234-0026
Grubscrew M2 x 2.5mm (aluminium knob (dial) fixing)	2 off	20220-0001
Screw M3 x 10mm pan head (Power receptacle)	2 off	20234-0011
Fibre Washer (PCB to Case)	2 off	20612-0010

Description		Part No.
Screw 6BA x 1¼" pan head (Case upper to lower)		20134-0503
Case, lower		33537-0160
Case, upper		33537-0150
Side trim, front	2 off	31332-0490
Side trim, rear	2 off	31332-0500
Handle		31336-0200
Rear Panel		33331-0340
Foot, black PVC	4 off	31748-0190
Logo label		37522-0010
Instruction label		37558-0430
Mains lead, tinned ends		22491-0010
Label, wiring instructions, for tinned ends		37541-0490
Mains lead Euro plug		22491-0020
Mains lead USA plug		22491-0040
Warning label 220/240V		37559-0010
Warning label 110/120V		37559-0020
Serial No label		37522-0020
Aircap sheet	cut from	10612-0202
Carton		38113-0260
Printed Sleeve		38181-0140
Guarantee Card		48581-0230
Instruction Book		48591-0030

MANUFACTURING AND PARTS LIST CHANGES

From January 1988 the AC line switch (S1) of the switch-bank is obsolete. The PCB layout is modified (raised to Issue 7) such that the ON/OFF switch of the new switch-bank switches the DC secondary and not the AC line.

Additional components are included on this layout to ensure that the DC rails do not latch-up at switch-on.

Parts List changes are as follows:

PCB 35555-0290 revised to Issue 7.

Additions

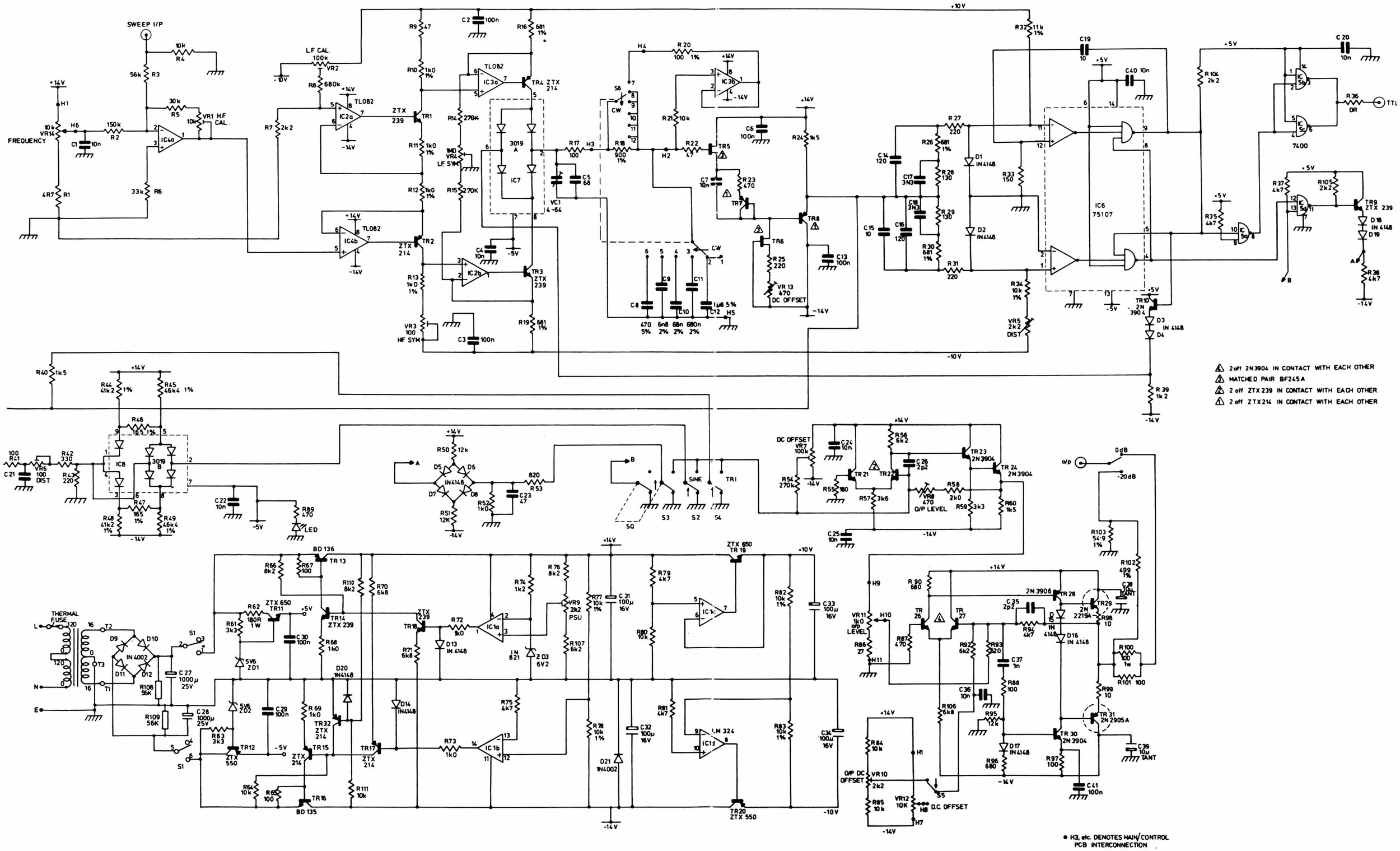
Ref	Description	Part No.
R108	56KJ W25 CF	23185-3560
R109	56KJ W25 CF	23185-3560
R110	8K2J W25 CF	23185-2820
R111	10Kj W25 CF	23185-3100
D20	1N4148	25021-0901
D21	1N4002	25115-0907
TR32	ZTX214	25341-0214
LK24	Zero ohm	23185-0000

Refer to the appropriate Circuit Diagram.

Replacements

Ref	Description		Part No.
R65	Was 82RJ now	100RJ	23185-1100
C32	Was 220U now	100U	23557-0635
	Switchbank	Was	22225-0530
		now	22225-0660

CIRCUIT DIAGRAM (Issue 7 onwards). See notes on page 20.



CIRCUIT DIAGRAM (prior to Issue 6 Pcb) See notes on page 20