Black Star

JUPITER 2000
FUNCTION GENERATOR

SERVICE MANUAL

Designed and manufactured in the U.K. by:

BLACK STAR
Glebe Road
Huntingdon
Cambs PE18 7DX

Tel. No: +44 1480 412451 Fax No: +44 1480 450409
e mail: sales@ttinst.co.uk web site: www.ttinst.co.uk

Part No. 48700-8040

WARNING

THE JUPITER 2000 IS A MAINS POWERED INSTRUMENT. THE FOLLOWING SERVICING AND CALIBRATION INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID PERSONAL INJURY DO NOT PERFORM ANY SERVICING UNLESS YOU ARE QUALIFIED TO DO SO.

SPECIFICATION

FUNCTIONS

Waveforms:	Sine, Square, Triangle, TTL
Sine Distortion:	0.2Hz to 200KHz — <1% 200KHz to 2MHz — All harmonics >30dB below fundamental
Triangle Linearity:	>99% to 200KHz
Square	
Rise Time:	<80ns
Mark/space ratio:	1:1 ±1% to 200KHz
TTL:	20 standard TTL loads
Symmetry Range:	Nom. 8:1 on Sine, Square, Triangle and TTL

FREQUENCY

Frequency Range:	<0.2Hz to >2MHz in 7 overlapping ranges with calibrated 10:1 vernier
Frequency Accuracy:	<±5% of range

OUTPUTS

50Ω and 600Ω:	0dB, −20dB, −40dB switchable attenuator with >30dB vernier control
Output Level:	0 to 20Vp-p 0dB 0 to 2Vp-p −20dB 0 to 0.2Vp-p −40dB } open circuit output
Level Flatness:	±0.2dB up to 200KHz; ±1dB to 2MHz
DC Offset:	±10V from both outputs. DC offset plus peak signal limited to ±20Vp-p with open circuit output. Offset level and signal attenuated proportionally in −20dB and −40dB positions.
TTL:	Capable of driving 20 standard TTL loads

SWEEP INPUT

Sweep Range:	>1000:1 All ranges >2000:1 With reduced linearity and distortion to 4MHz
Input Impedance:	nom. 9KΩ
Input Sensitivity	
10:1 sweep	≈17.1Vp-p
100:1 sweep	≈18.8Vp-p
1000:1 sweep	≈19Vp-p
2000:1 sweep	≈19.1Vp-p
Sweep Linearity:	< ±1%
Maximum input voltage:	±50V
Maximum input slew rate:	0.1V / us

GENERAL

Power Requirement:	220/240V or 110V (set internally) 50/60Hz AC
Power Consumption:	Typically 24VA
Operating Temp Range:	0°C to 40°C (10%-80% RH non-condensing)
Supplied Accessories:	Instruction Manual, Mains lead, Spare fuse.
Optional Accessories:	Service manual
Size:	219mm x 240mm x 98mm (product only) 310mm x 330mm x 135mm (packed)
Weight:	1.6kg (product only) 2.0kg (packed)

INTRODUCTION

TEST EQUIPMENT

In order to fully test and calibrate the J2000 function generator the following test equipment is required.

1. Dual beam 20MHz oscilloscope with x10 probes.
2. 4½ digit multimeter with a resolution of 10uV.
3. A general purpose counter/timer with both frequency and period functions.
4. Distortion analyser with 1% full scale range.

DISMANTLING THE INSTRUMENT

WARNING!

High voltages are present inside this instrument. Disconnect all voltage sources before opening the case. If adjustments are required with power applied to the instrument these should only be carried out by suitably qualified persons who are aware of the hazards.

1. Invert the instrument and remove the metal leg by firmly pushing inwards on one side.
2. Remove the 4 screws recessed in the feet.
3. Carefully remove the lower case half by pulling upwards.
4. If only calibration is required then further dismantling is not necessary.
5. If component replacement is necessary then proceed as follows.
6. Remove the two side expansion pieces.
7. De-solder the four screened cables from the front panel B.N.C. connectors.
8. Remove the ribbon cable assembly from the socket on the main p.c.b., taking care to avoid damage to the connector pins.
9. De-solder the earth wire and the three transformer secondary wires from the rear of the main p.c.b.
10. Remove the four screws securing the main p.c.b. to the case.
    N.B. Do not lose the four fibre washers located under the screw heads.
11. The main p.c.b. front and rear panels may now be removed from the case.

RE-ASSEMBLY

To re-assemble the unit follow the above procedure in reverse order.

FUNCTIONAL DESCRIPTION

Referring to the Block Diagram on page 10.

The summing amplifier adds the voltage from the Frequency control to the voltage (if any) at the sweep input. The output from the summing amp is used to control the current level in the two current, sources I+ and I−.

The diode gate under the control of the comparator output steers current into and out of the range capacitors. Current from the I+ source charges the range capacitor when the comparator output is high producing a positive going linear ramp. When the comparator output is low the range capacitor charges linearly in the opposite direction producing a negative going ramp. The repetitive charging and discharging of the range capacitors produce a triangle wave.

The buffer amplifier is a unit gain amplifier with a very high input impedance, to avoid loading the triangle wave, and a low output impedance to drive the comparator and sine converter circuits.

The comparator is used to define the peak to peak amplitude of the triangle wave. The comparator thresholds are adjusted to give a triangle amplitude of 1V p-p. The comparator has two outputs, one of which is used to control the diode gate, the other is used for driving the squarewave shaper and the TTL circuit.

The capacitance multiplier increases the effective capacitance of the 10Hz range capacitor by a factor of 10 to provide the 1Hz frequency range.

The sine shaper utilises the logarithmic relationship between Vbe and collector current of transistors to convert the triangle wave from the buffer amplifier to a sinewave.

The three waveforms are fed via the function selector switch to the amplitude control and then to the output amplifier. The output amplifier adds the d.c. offset voltage to the output signal and amplifies the result to 20V p-p to drive the 50Ω and 600Ω attenuators. The two output attenuators provide attenuation of 0db, −20db and −40dB.

The power supply circuitry provides the ±15V, ±10V, +5Vaux and +5Vttl supplies.

CIRCUIT DESCRIPTION

Refer to the Circuit Diagrams on pages 11 and 12.

Power Supply

The incoming mains supply is switched by S15 to the stepdown transformer T1. F1 provides protection against fault currents. D21 to D24 rectify the transformer secondary voltage. C20 and C21 smooth the d.c. output of the rectifier. TR22, TR24 and ½IC10 form the +15V regulator. TR23, TR25 and ½IC10 form the −15V regulator. ZD1 is a stable reference voltage for the +15V power supply. The −15V regulator tracks the +15V output by taking its reference voltage from the +15V output via the voltage divider R98 and R99. The +10V and −10V supplies are developed from the + 15V and − 15V by ZD2 and ZD5. ZD3, TR26 and D20 form a current limited shunt regulator to produce the 5Vttl supply. Note that D10 is also the front panel power indicator. ZD4 forms a 5Vaux supply for the sine converter circuit.

Triangle Generator

IC1 and TR1 form a voltage controlled current source, the output current being determined by the sum of the voltages at the sweep input and the frequency control VR1. VR2 and VR4 are used to calibrate the front panel frequency scale. The output current of TR1 is mirrored by the complementary current source IC2 and TR2 by monitoring the voltage across R13.

The actual current flowing in these current sources is determined by the voltage across R13 and R16 and ranges from 400uA with the front panel control set to 0.2 to 4mA with the front panel control set to 2.0. The current flowing in these current sources causes a control voltage to be developed across R12 and R17. This voltage controls the current in the two current sources formed by IC3, TR3 and IC4, TR4. These current sources have three ranges set by R18, R19 and R20 for the positive current source (IC3, TR3) and R21, R22 and R23 for the negative current source (IC4, TR4). The three current ranges are: 4µA to 40µA, 40µA to 400µA and 400µA to 4mA. The current from these two current sources is steered into the range capacitors by the diode gate D1 to D4 under the control of the comparator output.

The symmetry function is performed by unbalancing the currents in the current sources. This is achieved by switching in the components R14, VR6 and R15 and adjusting the symmetry control VR6. Note that when the symmetry function is selected the effective resistance in the emitter circuits of TR2 and TR3 is increased to $\simeq 3K\Omega$, (with the symmetry control set to its centre position), this decreases the frequency of oscillation by a factor of approximately 10.

S1 to S7 is the frequency range switchbank.
Capacitors C1 to C4 are the range capacitors. The 2Hz to 2KHz frequency ranges use capacitor C1 and the current range resistors R18, R19, R20 and R21, R22, R23 set the operating frequency. When the 2Hz range is selected the capacitance multiplier circuit IC5 increases the effective capacitance of C1 to 10µF. The multiplication factor of the multiplier circuit is:

$1 + {}^{1}|R25/R24|$.

To ensure that a linear triangle wave is produced the range capacitors must be buffered by a high impedance amplifier with a very low input bias current. The triangle amplifier consists of the monolithic dual FET TR5 connected as a source follower. The unity gain amplifier formed by the transistor array IC6 buffers the output of the source follower and ensures a low impedance drive for the comparator and sine converter circuits. VR9 is used to adjust out any initial offset in this stage.

The comparator stage formed by IC7, D5 to D8 and its associated components acts as a window comparator and determines the triangle wave amplitude. The triangle wave is attenuated by R37 and R38 and sent to the comparator input (pin 3 of IC7), C9 provides high frequency compensation for the attenuator. TR6 level shifts the TTL output of IC7 to drive the diode gate D5 to D8. VR10 and VR11 are used to adjust the positive and negative threshold voltages of the comparator.

The comparator circuit operates as follows:- As the triangle wave at the buffer amplifier output (TP9) reaches +0.5V the comparator output switches the diode gate low and sets the comparator threshold voltage to −0.25V, the triangle wave then ramps down to −0.5V at which point the diode gate output switches high and sets the comparator threshold to +0.25V and the triangle wave then ramps up again towards the positive threshold.

TR7 and TR8 buffer the output of the level shifter TR6 to provide a low impedance drive for the diode gate D1 to D4.

Sine Shaper

The sine shaping circuit utilizes the non-linear, logarithmic relationship between Vbe and collector current in transistors to smooth the triangle wave into a close approximation of a sinewave. IC8 performs the sine shaping function. The two transistor differential amplifier operating off the 5Vaux supply converts the triangle wave into a sinusoidal current which flows in R52. The three remaining transistors in IC8 along with TR9 and TR10 form a current to voltage converter to produce a sinusoidal voltage at TP10. VR12 adjusts the bias voltage at the input of the sine converter and determines the symmetry of the resultant sinewave. VR13 attenuates the triangle wave to the optimum amplitude for the sine shaper, VR16 is used to trim out any offset and VR14 adjusts the gain of the current to voltage converter to produce an output sinewave amplitude at TP10 of 1Vp-p.

Squarewave Shaper and TTL Output

The TTL output from pin 11 of IC7 (the comparator), is level shifted by TR11 and fed to the diode gate D12 to D15, current is steered into and out of the load (R4+VR15) to produce a squarewave with controlled rise and fall times. VR15 is adjusted to give a squarewave amplitude of 1Vp-p. IC9 buffers the output of the comparator to provide the TTL output.

Function Selector

Function selection is achieved by S9 to S11 switching the selected waveform onto the (mixsig) line. Note that S10 isolates both the input and output of the diode gate when the squarewave is deselected.

Output Amplifier

The input stage is formed by two symmetrical differential amplifiers TR12 to TR15. TR16 to TR19 are current mirrors with a current gain of approximately 3 determined by the emitter resistors. D18 and D19 bias the class B output stage TR20 and TR21. Short circuit protection is provided by R75 and R78. The voltage gain of the amplifier is given by $1+(R79/R72)=22.3$. VR18 is used to trim out any residual offset voltage. VR19 is the front panel d.c. offset control.

Attenuators

R80 to R87 form the 50Ω attenuator. R88 to R94 form the 600Ω attenuator. The attenuators are controlled by a three way interlocking switchbank S12 to S14 giving attenuation factors of 0dB, −20dB and −40dB.

CALIBRATION PROCEDURE

Refer to the component layouts on pages 10 and 13 to locate the test points and variable resistors.

Before proceeding to calibrate the function generator set the following controls as shown below.

Frequency Range	—	1kHz
Function	—	Triangle
Attenuator	—	0dB
DC offset	—	Centre off position
Amplitude	—	Centre

1. Power Supply

a) Check Voltage at TP7 is +15v ± 0.3v
b) Check Voltage at TP8 is −15v ± 0.45v

2. IC1, 2, 3, 4 DC Offset

a) Set VR4 fully anti-clockwise.
b) Measure the voltage at TP5 w.r.t 0V, adjust VR1 to give reading of — 10.00mV ± 0.04mV.
c) Measure the voltage at TP6 w.r.t 0v, adjust VR3 to give reading of + 10.00mV ± 0.10mV.
d) Measure the voltage at TP4 w.r.t oV, adjust VR5 to give a reading of — 10.00mV ± 0.10mV.
e) Measure the voltage at TP2 w.r.t TP7, adjust VR7 to give a reading of — 33.33mV ± 0.17mV.
f) Measure the voltage at TP3 w.r.t TP8, adjust VR8 to give a reading of + 33.33mV ± 0.17mV.
g) Re-check the voltage at TP5 and repeat the above if it has changed.
h) Set VR1 to 2.0.

3. Triangle Buffer DC Offset

a) Turn off the power to the unit, and using a short length of wire short the junction of D2 and D4 to the ground plane.
b) Connect a voltmeter between TP9 and ground and turn the power back on.
c) Adjust VR9 for a reading of 0.0mv ± 0.5mv.
d) Turn off the power to the unit and disconnect the short circuit.
e) Turn on the power to the unit.

4. Triangle Amplitude

a) Connect an oscilloscope and a voltmeter to TP9.
b) Set the Amplitude control to minimum.
c) Adjust VR10 and VR11 until the triangle wave is 1.0Vp-p and the d.c. offset is < 1.0mV.

5. Output Amplifier DC Offset

a) Monitor the 50Ω output with a voltmeter.
b) Set the Amplitude control to its mid position and adjust VR18 for < 10.0mv.
c) Rotate the Amplitude control from minimum to maximum and check that the dc offset does not exceed ± 50mV.

6. Frequency Calibration

a) Select the 10kHz frequency range.
b) Connect a frequency counter to the TTL output.
c) Set the frequency control to 0.2 and adjust VR4 for a reading of 2.0kHz ± 0.8kHz.

d) Set the frequency control to 2.0 and adjust VR2 for a reading of 20.0kHz ± 0.8kHz.
e) Set the frequency control to 1.0 and check the frequency is 10.0kHz ± 0.8kHz.
f) Set the frequency control to 0.6 and check the frequency is 6.0kHz ± 0.8kHz.
g) Set the frequency control to 1.5 and check the frequency is 15.0kHz ± 0.8kHz.
h) Select the 1MHz range.
i) Set the frequency control fully clockwise and check that the frequency is greater than 2MHz.
j) Set the frequency control to 2.0 and check the frequency is 2.0MHz ± 80kHz.
k) Set the frequency control to 0.2 and check the frequency is 200kHz ± 80kHz.
l) If the frequency is outside the specified limits adjust VR2 and VR4 and repeat steps a) to k) until the frequency is within specification.

7. Sinewave

a) Monitor TP10 with an oscilloscope using a x10 probe.
b) Set the frequency range to 1kHz and frequency control to 1.0.
c) Select the sine wave function.
d) Set VR12, 13, 14, 15, 16 to their mid positions.
e) Adjust VR14 to give a peak to peak amplitude of ≃ 1V.
f) Adjust VR16 to give minimum offset i.e. the positive and negative peaks symmetrical about ground.
g) Adjust VR12 and VR13 to produce the best sine wave trace on the oscilloscope.
h) Adjust VR14 to give a sine wave amplitude of 1V p-p.

8. Sinewave Distortion

a) Measure the sinewave distortion at the 50 output with a distortion analyser.
b) Adjust VR12 and VR13 for < 0.5% distortion. Note that adjusting VR12 and VR13 may change the signal amplitude, re-adjust VR14 as necessary to maintain the amplitude at 1Vp-p.

9. Amplitude Calibration

a) Monitor the 50Ω output with an oscilloscope.
b) Select trianglewave.
c) Set the frequency to 1kHz and the amplitude to 20Vp-p.
d) Select the sinewave and adjust VR14 to give an amplitude of 20Vp-p.
e) Select the squarewave and adjust VR15 to give an amplitude of 20Vp-p.

CIRCUIT POSITION	DESCRIPTION			PART No.
Resistors, Fixed				
R1	CF	W25	8K2	18-125
R2	CF	W25	82K	18-121
R3	CF	W25	1K2	18-021
R4	CF	W25	180R	18-062
R5	CF	W25	8K2	18-125
R6	CF	W25	82K	18-121
R7	CF	W25	27K	18-126
R8	CF	W25	82K	18-121
R9	CF	W25	82K	18-121
R10	CF	W25	82K	18-121
R11	CF	W25	39K	18-116
R12	MF1%	W25	1K	18-046
R13	MF1%	W25	300R	18-057
R14	MF1%	W25	348R	18-129
R15	MF1%	W25	348R	18-129
R16	MF1%	W25	300R	18-057
R17	MF1%	W25	1K	18-046
R18	MF1%	W25	100K	18-058
R19	MF1%	W25	10K	18-054
R20	MF1%	W25	1K	18-046
R21	MF1%	W25	100K	18-058
R22	MF1%	W25	10K	18-054
R23	MF1%	W25	1K	18-046
R24	MF1%	W25	2K	18-065
R25	MF1%	W25	18K	18-130
R26	CF	W25	470R	18-016
R27	CF	W25	390R	18-039
R28	CF	W25	3K9	18-026
R29	CF	W25	680R	18-018
R30	CF	W25	5K6	18-028
R31	CF	W25	2K2	18-024
R32	CF	W25	560R	18-017
R33	CF	W25	68R	18-089
R34	CF	W25	1K	18-020
R35	CF	W25	2K7	18-025
R36	CF	W25	1K	18-020
R37	CF	W25	2K2	18-024
R38	CF	W25	2K2	18-024
R39	CF	W25	82R	18-038
R40	CF	W25	220R	18-013
R41	CF	W25	47R	18-093
R42	CF	W25	10K	18-029
R43	CF	W25	10K	18-029
R44	CF	W25	2K2	18-024
R45	CF	W25	470R	18-016
R46	CF	W25	470R	18-016
R47	CF	W25	5K6	18-028
R48	CF	W25	5K6	18-028
R49	CF	W25	10K	18-029
R50	CF	W25	1K8	18-023
R51	CF	W25	5K6	18-028
R52	CF	W25	4K7	18-027
R53	CF	W25	1K	18-020
R54	CF	W25	56R	18-011
R55	CF	W25	82R	18-038
R56	CF	W25	1K	18-020
R57	CF	W25	1K8	18-023
R58	CF	W25	10K	18-029
R59	CF	W25	820R	18-019
R60	CF	W25	5K6	18-028
R61	CF	W25	390R	18-039
R62	CF	W25	150R	18-118
R63	CF	W25	390R	18-039
R64	CF	W25	2K2	18-024
R65	CF	W25	100R	18-012
R66	CF	W25	100R	18-012
R67	CF	W25	1K5	18-022
R68	CF	W25	1K5	18-022
R69	CF	W25	56K	18-128
R70	CF	W25	56K	18-128
R71	CF	W25	10K	18-029
R72	CF	W25	470R	18-016
R73	CF	W25	33R	18-071
R74	CF	W25	33R	18-071
R75	MF1%	W75	27R	18-139
R76	MF1%	W50	10R	18-141
R77	MF1%	W50	10R	18-141
R78	MF1%	W75	27R	18-139
R79	CF	W25	10K	18-029
R80	MF1%	W25	1K	18-046
R81	MF1%	W25	1K	18-046
R82	MF1%	W75	120R	18-140
R83	MF1%	W75	120R	18-140
R84	MF1%	W25	1K	18-046
R85	MF1%	W25	820R	18-132
R86	MF1%	W25	56R	18-122
R87	MF1%	W25	6K8	18-052
R88	MF1%	W25	150R	18-133
R89	MF1%	W25	1K2	18-047
R90	MF1%	W25	150R	18-133
R91	MF1%	W25	1K2	18-047
R92	MF1%	W25	150R	18-133
R93	MF1%	W25	390R	18-134
R94	MF1%	W25	75R	18-135
R95	CF	W25	4K7	18-027
R96	MF1%	W25	8K2	18-136
R97	MF1%	W25	1K6	18-137
R98	MF1%	W25	15K	18-055
R99	MF1%	W25	15K	18-055
R100	CF	W25	4K7	18-027
R101	CF	W25	4K7	18-027

CIRCUIT POSITION	DESCRIPTION			PART No.
R102	CF	W25	33K	18-084
R103	CF	W25	15K	18-036
R104	CF	W25	1K	18-020
R105	CF	W25	1K	18-020
R106	CF	W25	820R	18-019
R107	CF	W25	1K5	18-022
R108	CF	W25	22R	18-074
R109	CF	W25	270R	18-014
R110	CF	W25	390R	18-039
R111	MF1%	W25	750R	18-138
R112	CF	W25	220R	18-013
R113	CF	W25	150R	18-118
R114	CF	W25	47R	18-093
Rprot	MF	W75	51R	18-083

Resistors, Variable

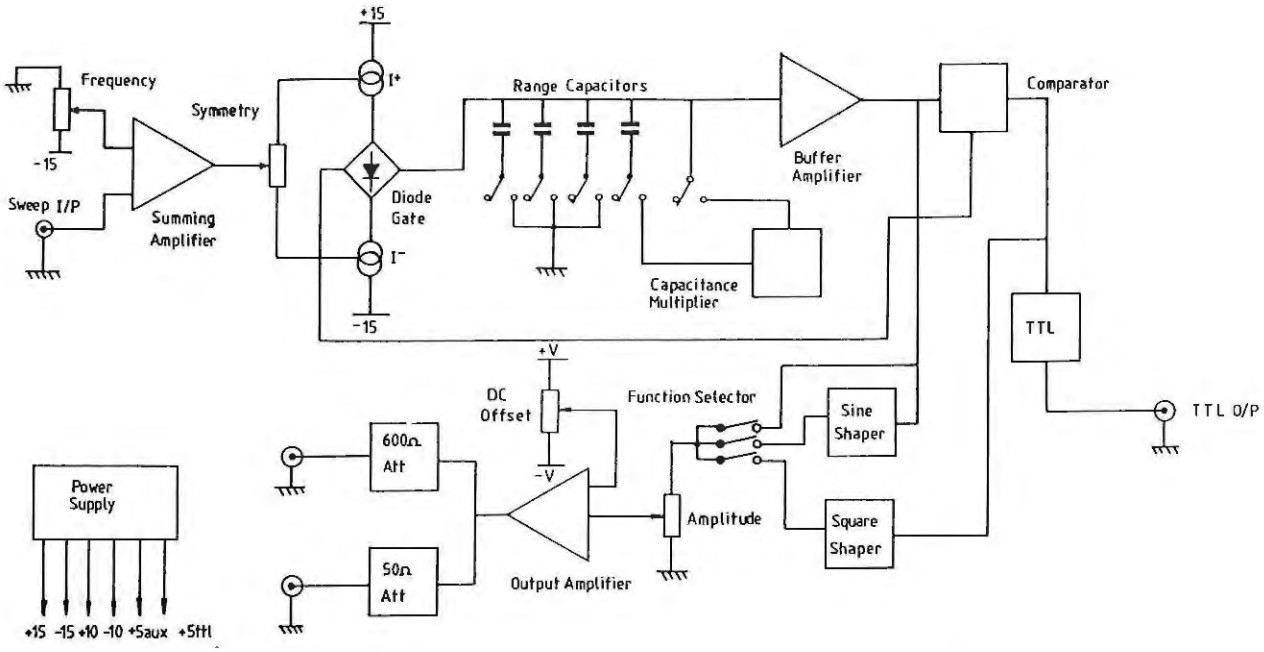
VR1	1K Linear	19-039
VR2	10K horiz preset	19-012
VR3	100K horiz preset	19-025
VR4	220R horiz preset	19-005
VR5	100K horiz preset	19-025
VR6	4K7 Linear	19-021
VR7	100K horiz preset	19-025
VR8	100K horiz preset	19-025
VR9	220R horiz preset	19-005
VR10	4K7 horiz preset	19-023
VR11	4K7 horiz preset	19-023
VR12	1K horiz preset	19-007
VR13	2K2 horiz preset cermet	19-024
VR14	2K2 horiz preset	19-008
VR15	100R horiz preset	19-004
VR16	22K horiz preset	19-009
VR17	2K2 Linear	19-020
VR18	470K horiz preset	19-016
VR19	47K Linear	19-022

Capacitors

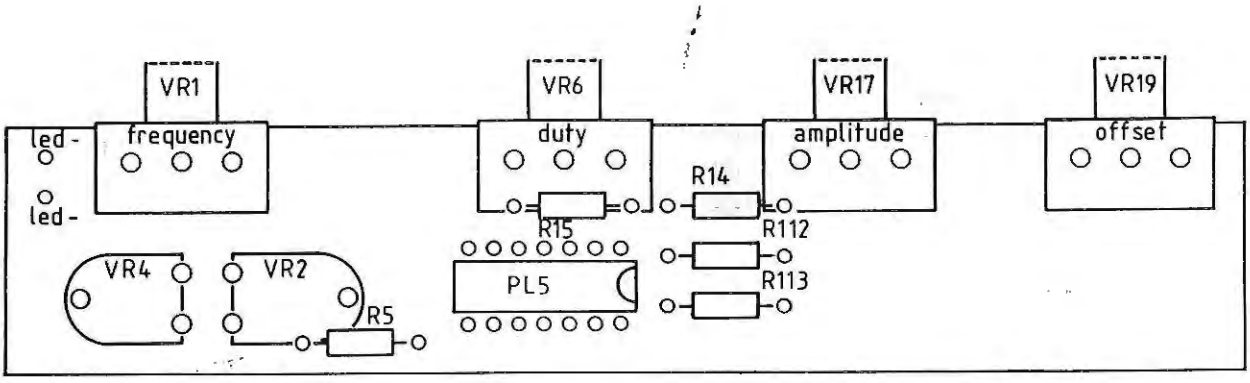
C1	Polycarb	1uF	63V	2%	20-098
C2	Polycarb	100nF	63V	2%	20-099
C3	Polystyrene	10nF	63V	2.5%	20-101
C4	Polystyrene	930p	30V	1%	20-100
C5	Ceramic	1p8	63V		20-103
C6	Ceramic disc	100nF	25V		20-020
C7	Ceramic disc	100nF	25V		20-020
C8	Ceramic disc	100nF	25V		20-020
C9	Ceramic	18p	63V		20-027
C10	Ceramic disc	100nF	25V		20-020
C11	Not used				
C12	Polystyrene	SOT			
C13	Ceramic disc	100nF	25V		20-020
C14	Ceramic disc	100nF	25V		20-020
C15	Ceramic disc	100nF	25V		20-020
C16	Ceramic	27p	63V		20-049
C17	Electrolytic	10uF	16V		20-018
C18	Electrolytic	10uF	16V		20-018
C19	Ceramic disc	100nF	25V		20-020
C20	Electrolytic	2200uF	25V		20-102
C21	Electrolytic	2200uF	25V		20-102
C22	Electrolytic	10uF	16V		20-018
C23	Electrolytic	10uF	16V		20-018
C24	Ceramic disc	100nF	25V		20-020
C25	Ceramic disc	100nF	25V		20-020
C26	Ceramic disc	100nF	25V		20-020
C27	Ceramic disc	100nF	25V		20-020
C28	Electrolytic	100uF	25V		20-005
C29	Electrolytic	100uF	25V		20-005
C30	Electrolytic	47uF	6V3		20-012
C31	Electrolytic	47uF	6V3		20-012
C32	Ceramic	27p	63V		20-049
C33	Ceramic	27p	63V		20-049
C34	Ceramic	27p	63V		20-049
C35	Ceramic disc	100nF	25V		20-020
C36	Not used				
C37	Not used				
C38	SOT				
C39	Ceramic disc	100nF	25V		20-020

Semiconductors

IC1-IC4	TL071CP	24-073
IC5	TL072CP	24-074
IC6	CA3086	24-075
IC7	NE527N	24-076
IC8	CA3086	24-075
IC9	74LS37N	24-011
ic10	TL072CP	24-074
TR1	BC184B	22-024
TR2-TR3	BC214B	22-025
TR4	BC184B	22-024
TR5	2N3958	22-010
TR6-TR7	2N3904	22-011
TR8	2N3906	22-006
TR9-TR12	2N3904	22-011
TR13	2N3906	22-006
TR14	2N3904	22-011
TR15-TR15	2N3906	22-006
TR17	2N3904	22-011
TR18	2N3906	22-006
TR19	2N3904	22-011
TR20	2N2219A	22-012
TR21	2N2905A	22-013
TR22	2N3904	22-011



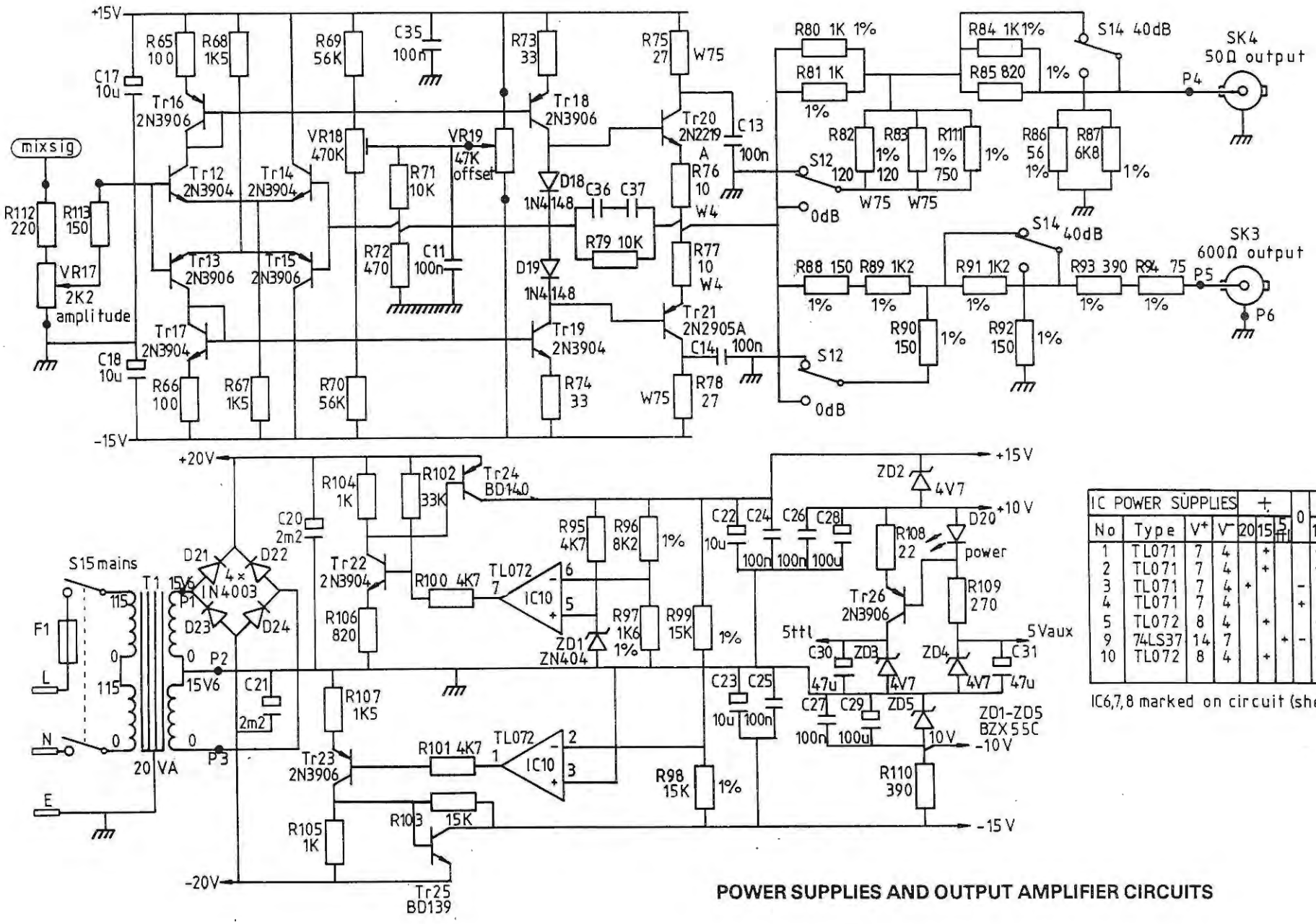
FUNCTIONAL BLOCK DIAGRAM



COMPONENT LAYOUT - Front Panel P.C.B.

CIRCUIT POSITION	DESCRIPTION		PART No.
TR23	2N3906		22-006
TR24	2N3906		
TR24	BD140		22-015
TR25	BD139		22-014
TR26	2N3906		22-006
D1-D8	1N916		23-004
D9-D10	1N4148		23-005
D11	Not used		
D12-D15	1N916		23-004
D16	1N4148		23-005
D17	Not used		
D18-D19	1N4148		23-005
D20	LED lamp		26-001
D21-D24	1N4003		23-006
ZD1	ZN404	2V45	23-001
ZD2-ZD4	BZX55	4V7	23-011
ZD5	BZX55	10V	23-012
Switches			
S1-S7	Frequency Range	4P/2W	16-019
S8	Symmetry	2P/2W	16-020
S9-S11	Function	2P/2W	
S12-S13	Attenuator	2P/2W	
S14	Attenuator	4P/2W	
Miscellaneous			
SK5	IC socket 14-way		14-056
SK6	14 way ribbon assy		14-060
P1-10	Terminal pin		14-005
TP1-8	Header 8-way		14-061
TP8-10	Header 2-way		14-069
T1	Mains Transformer		40-005

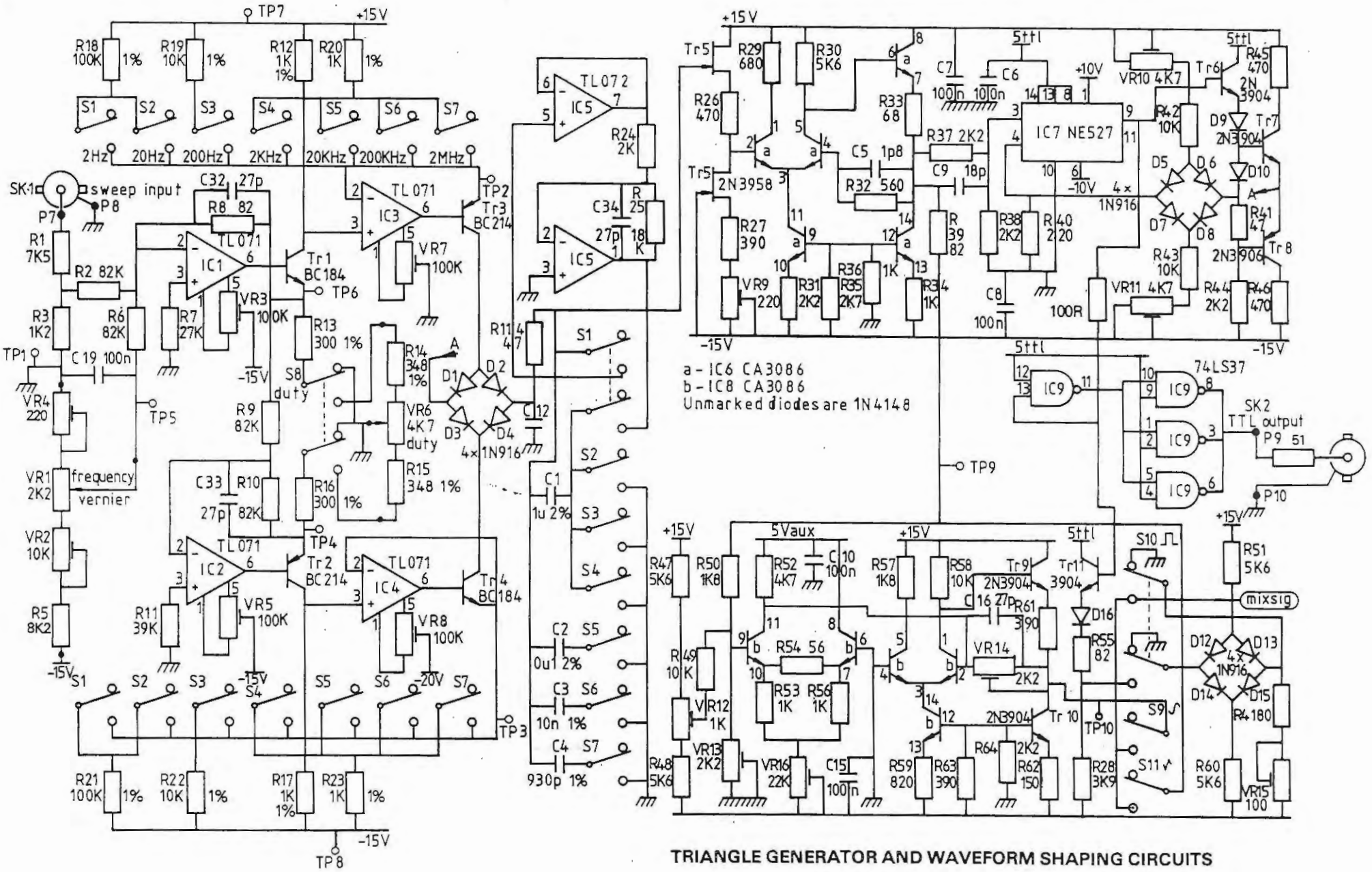
DESCRIPTION	PART No.
Mechanical Assembly/Packing/Misc.	
PCB Main	30-022
PCB Front panel	30-023
Solder tag BNC (3)	14-003
Sleeving H15 (8)	15-004
Shroud Mains skt	15-005
Rear panel printed	28-021
Tamperproof screw M3x6	13-035
Solder tag 5BA	14-035
Nut full M3 (5)	13-019
Screw M3x70 pozi (4)	13-003
Screw M3x10 c/sk (2)	13-023
Washer shakeproof M3 (5)	13-018
Case upper	27-001
Case lower	27-002
Expansion strip (2)	27-003
Foot A (2)	27-004
Foot B (2)	27-005
Pad (foot) (4)	27-009
Front panel printed	28-020
Leg	27-008
Knob K9 black + white line (3)	29-016
Knob K12 black + white line	29-017
Knob cap K9 grey + white line (3)	29-018
Knob cap K12 grey + white line	29-019
Button grey (14)	29-014
Screw self tap No. 4x⅜ (4)	13-044
Heatsink TV15-05 (2)	38-001
Mica washer (2)	13-004
Fibre washer (8)	13-005
Heatsink finned (2)	38-004
Screw M4x12 (2)	13-024
Nut full M4 (2)	13-025
Washer shakeproof M4 (2)	13-027
Screw M3x8 pozi (2)	13-032
Instruction manual	31-057
Polystyrene packing piece (2)	31-077
Carton	31-078
Fuse 250mA antisurge (2)	33-002
IEC mains socket	14-017
Mains Switch	16-011
50Ω BNC (4)	14-002
IEC mains socket	14-017



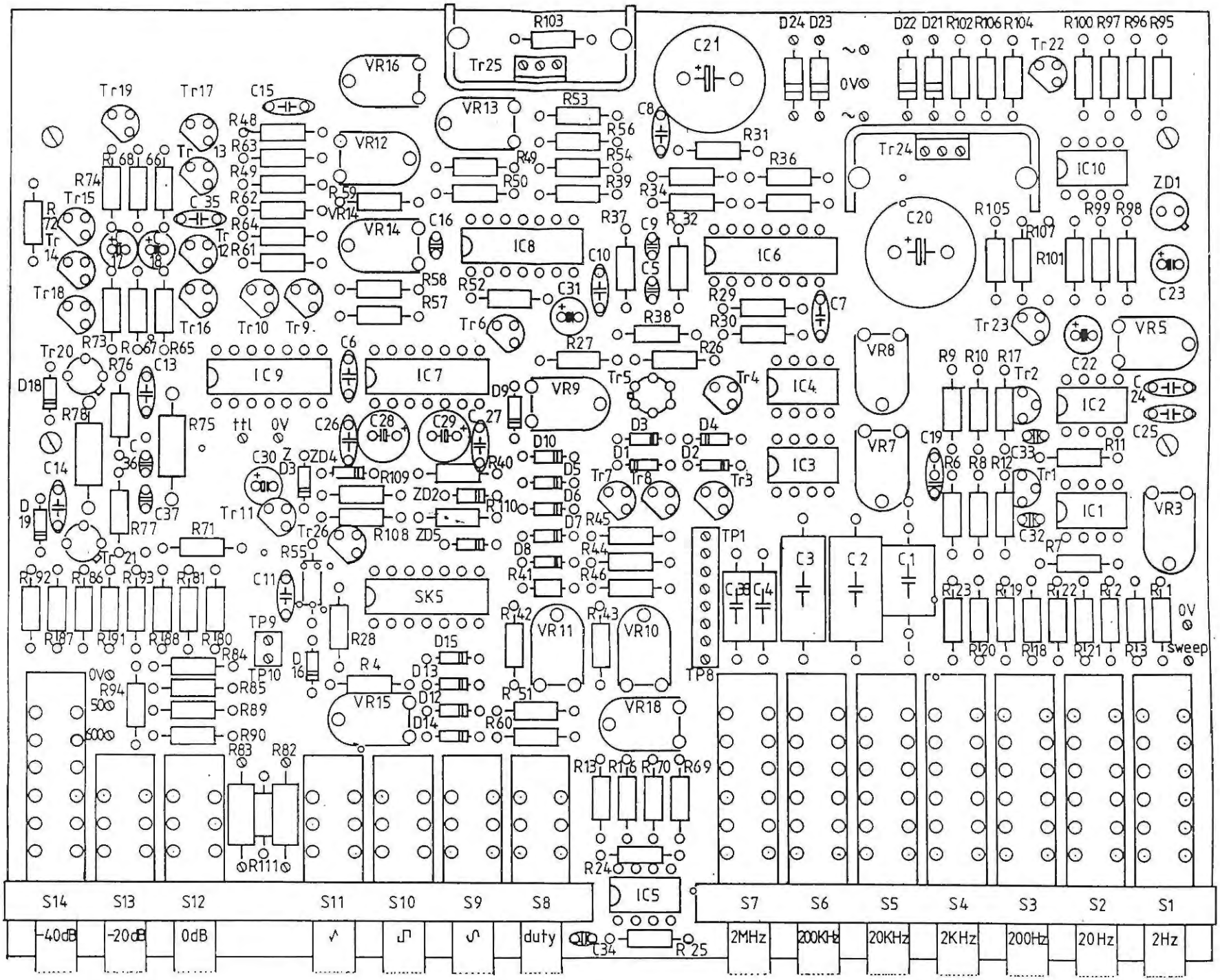
IC POWER SUPPLIES				+			0	−	
No	Type	V+	V−	20	15	5 ttl		15	20
1	TL071	7	4		+			−	
2	TL071	7	4		+			−	
3	TL071	7	4	+			−		
4	TL071	7	4				+		−
5	TL072	8	4		+			−	
9	74LS37	14	7			+	−		
10	TL072	8	4		+			−	

IC6,7,8 marked on circuit (sheet1)

POWER SUPPLIES AND OUTPUT AMPLIFIER CIRCUITS



TRIANGLE GENERATOR AND WAVEFORM SHAPING CIRCUITS



COMPONENT LAYOUT - Main P.C.B.

Addendum to J2000 Parts Lists

On some units the following changes have been made:-
1) The mains input socket (14-017) has been replaced with a mains socket with integral filter circuit (17-016).

2) The mains socket insulator (15-005) has been removed.
