

Black★Star

JUPITER 2010
Function Generator
Service Manual

Designed and Manufactured in the U.K. by:

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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 \pm 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 10:1 vernier control
Frequency Accuracy: < \pm 0.1% of reading

OUTPUTS

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

SWEEP INPUT

Sweep Range: >1000:1 1k, 10k, 100k, 1M ranges
> 100:1 100Hz range
> 20:1 10Hz, 1Hz ranges
>2000:1 With reduced linearity and distortion to 4MHz
Input Impedance: nom. 9K Ω
Input Sensitivity
10:1 sweep \approx 17.1Vpp
100:1 sweep \approx 18.8Vpp
1000:1 sweep \approx 19.0Vpp
2000:1 sweep \approx 19.1Vpp
Sweep Linearity: < \pm 1%
Max input voltage: \pm 50V
Max input slew rate: 0.1V/ μ s

FREQUENCY COUNTER

INTERNAL

Measurement type: Reciprocal, single cycle and multiple period average
Gate: Automatic, 1s or 1 period whichever is greater
Accuracy: 0.01%
Stability: 50ppm -10 $^{\circ}$ C to +50 $^{\circ}$ C
Resolution: 4 digits
Annunciators: mHz, Hz, kHz, MHz
Display: 4 digit, 7 segment, 0.56" LED

EXTERNAL

Input Impedance: 1M Ω , AC coupled, -3dB @ 5Hz
Max. Input: 100VDC, 250VAC, 50Hz derating with frequency
Sensitivity: 25mV to 10MHz, 50mV to 20MHz, AC RMS Sinewave
Max. Frequency: 20MHz

GENERAL

Power Requirement: 220V/240V or 110V (set internally) 50/60Hz
AC Power Consumption: Typically 25VA
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: 219 x 240 x 98mm (product only)
310 x 330 x 135mm (packed)
Weight: 2.0kg (product only) 2.3kg (packed)

INTRODUCTION

PLEASE READ ALL OF THIS INTRODUCTION BEFORE SERVICING THIS INSTRUMENT.

This manual has been prepared to aid the engineer in the maintenance and repair of the Black Star 2010 Function Generator. This manual should be used in conjunction with the 2010 Instruction Manual.

SAFETY INSTRUCTIONS

These servicing instructions are for use by qualified personnel only. To reduce the risk of electric shock, the equipment must be disconnected from the mains supply before dismantling.

WARNING. Any internal or external interruption of the instruments protective earth conductor, or disconnection of the protective earth terminal, is likely to make the instrument dangerous. Do not disconnect or interrupt the protective earth conductor.

When working on the instrument ensure all sleeving and shrouds covering the AC line (live and neutral conductors) are in place.

GENERAL

While the Black Star 2010 Function Generator has been designed to be rugged, severe shocks can be destructive and should be avoided. Do not expose the instrument to radiant heat, including direct sunlight for prolonged periods, or high humidity. When servicing suitable precautions should be taken against static discharge as the unit contains CMOS components.

If power is applied to the instrument DO NOT do any of the following:

- Remove or replace any component
- Disconnect any circuit board or cable
- Solder any PCB joint

Servicing and recalibration should only be attempted by skilled engineers in conjunction with high quality test equipment.

TEST EQUIPMENT

- 1) Dual beam 20MHz oscilloscope with x10 probes.
- 2) $4\frac{1}{2}$ digit multimeter with a resolution of $10\mu\text{V}$.
- 3) A 25Mhz (or greater) signal generator.
- 4) Distortion analyser with 1% full scale range.

OPERATING PRINCIPLE

SIGNAL GENERATOR

Referring to the Block diagram (page -15-).

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 output is used to control the diode gate and drive the squarewave shaper and 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 V_{be} and collector current of transistors to convert the triangle wave from the buffer amplifier to a sine wave.

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 20Vpp to drive the 50 Ω and 600 Ω attenuators. The two output attenuators provide attenuation of 0dB, -20dB and -40dB.

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

FREQUENCY COUNTER

Referring to the Block diagram (page -15-).

The external input signal is amplified by a high gain amplifier with input protection. The amplifier output signal is passed through a Schmitt trigger input gate. The external signal and the TTL output is connected to Input Select.

Either the internal TTL or the external frequency source is output from Input Select, depending upon the position of the INT/EXT switch.

Depending upon the range selected by the controller, the gate switches high for a predetermined number of cycles of the signal from Input Select.

When the measurement being made is averaged over 1 cycle (first two ranges), the frequency comparator is enabled. If the input signal increases to a frequency >1.2MHz the output of the frequency comparator switches low. This interrupts the CPU controller, which then switches to the correct range and disables the frequency comparator.

At the start of a measurement cycle, the CPU controller enables the gate generator. On the next positive edge of the input signal, the gate switches high and the CPU controller starts counting the internal clock pulses. When the gate switches low the count is inverted and the new frequency reading is displayed on the 4 digit display.

CIRCUIT DESCRIPTION

Refer to the circuit diagrams.

Power Supply

The incoming mains supply is switched by S15 to the step-down 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 $\frac{1}{2}$ IC10 form the +15V regulator. TR23, TR25 and $\frac{1}{2}$ IC10 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. ZD4 forms a 5Vaux supply for the sine converter circuit.

Triangle Generator

IC1 and TR1 form a voltage controlled current source; the output current is 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 400µA with the frequency set to min, to 4mA with the frequency set to max. 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 ≈3kΩ, (with the symmetry control set to its centre position), this decreases the frequency of oscillation by a factor of ≈10.

S1 to S7 is the frequency range switch-bank.

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:

$$1 + \frac{R25}{R24}$$

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 convertor 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 Ic in transistors to smooth the triangle wave into a close approximation of a sine wave. 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 convertor to produce a sinusoidal voltage at TP10. VR12

adjusts the bias voltage at the input of the sine convertor 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 convertor to produce an output sinewave amplitude at TP10 of 1Vp-p.

Squarewave Shaper and TTL Output

The TTL output from 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 switch-bank S12 to S14 giving attenuation factors of 0dB, -20dB and -40dB.

Frequency Counter

The controller IC200 reads the program instructions from program memory PROM IC202. IC201 is an address latch as port 0 of IC200 is a dual address/data port; when a valid address is present address strobe /AS switches low. The controller clock speed is governed by XTAL, CV1 and C202. The clock is preset to 8MHz. R200 and C201 provide power up RESET.

The 4 digit reading is output to the display by a serial link. IC203 and IC204 form a serial to parallel data convertor. The data is clocked to IC203 and IC204 while enable is low to prevent ghosting on the display. For a particular segment to illuminate the appropriate output from IC203 switches high and the appropriate digit output from IC204 switches low. As the display is multiplexed each digit is updated in turn. The required annunciator is illuminated by the appropriate output from IC204 switching low.

When the controller requires a measurement cycle to begin, RESET1 is set high. This enables the gate generator IC207 to switch the GATE high at the next (1st) +ve edge of Fin. This also enables the decade counters IC203, IC204 and IC205 to start counting -ve edges. Depending upon the range selected by the controller, the 8 input multiplexer IC206 connects one of the decade counter outputs to the clock input of IC207a. If B is high (Range 3), the output of IC203b switches high on the 10th -ve edge. This sets the data input of IC207b low. On the next (11th) +ve edge of Fin the GATE switches low. Therefore GATE has been high for 10 complete cycles. As GATE switches low, IC207b resets the decade counters. Any further transitions of Fin cannot alter the state of GATE until RESET1 is taken low and the measurement cycle is re-enabled by the controller. The controller allows a time between measurements of 200ms.

As the minimum gate input width of IC200 is 375ns, a frequency comparator is required for the first two ranges. The frequency comparator is formed by a re-triggerable monostable (IC210) and a D type flip-flop (IC209). The controller enables the frequency comparator on range 1 and 2 by setting RESET2 high. On every +ve edge of Fin, a 0.8μs pulse is output from IC210 to the data input of IC209. On the next +ve

edge of Fin, if the data input of IC209 is still high (ie cycle time $<0.8\mu s = >1.2\text{MHz}$) then FC switches low interrupting the controller. The controller then changes to range 7 and disables the frequency comparator.

The high input impedance wideband amplifier is formed by TR200 and its associated components. The input is AC-coupled by C203. R204, R205, D200 and D201 provide input voltage protection. R203 sets the input impedance to nominally $1\text{M}\Omega$. TR200 is a source follower with very high input impedance and an output impedance of 200Ω approx. The source follower output is AC-coupled to the inverting amplifier with shunt voltage feedback, formed by TR201, TR202 and their associated components. The closed loop gain is set as follows:

$$A_{o1} = \frac{R210}{R211} \approx 46.8 \quad \beta = \frac{200\Omega}{R208 + 200\Omega} \approx 0.0196$$

$$A_{c1} = \frac{R208}{R208 + 200\Omega} \frac{A_{o1}}{1 + \beta A_{o1}} \approx 24$$

VR200 sets the bias voltage for the Schmitt trigger Nand gate for best sensitivity. TR203 limits the maximum voltage level to $<5\text{V}$ at the input of IC208 and buffers the amplifier from the input capacitance of IC208.

The rest of IC208 is used for selecting one of the two possible inputs, depending upon the position of S200.

ACCESS TO PARTS

Ensure that all external leads are removed from the unit.

FUSE

- Prise out the fuse drawer located within the IEC socket.
- The spare fuse is located in the outer position.
- The fuse may be removed by sliding it left or right.

BOTTOM COVER

- Turn the instrument upside down.
- Remove the stand by pushing firmly inwards on one side.
- Remove the four recessed retaining screws in the units feet.
- Carefully remove the bottom cover.

TOP COVER

- Remove the bottom cover.
- Gently remove the side extensions that separate the top and bottom covers.
- Remove the four retaining screws that secure the main PCB to the top cover. N.B. Do not lose the four fibre washers located under the screw heads.
- Carefully lift the entire assembly from the bottom cover.

COUNTER AND DISPLAY BOARD ASSEMBLY

- Remove the top and bottom covers.
- The front assembly can be carefully turned upside down.
- Remove the knobs and nuts from the front panel potentiometers.
- Remove the 2 nuts from the back of the display board.
- The counter and display board assembly can now be removed from the front panel.

FRONT PANEL

- Remove the top and bottom covers.
- Remove the counter and display board assembly.
- Carefully de-solder the four screened cables from the front panel B.N.C connectors.
- The front panel can now be removed.

COUNTER BOARD

- Remove the top and bottom covers.
- Remove the counter and display board assembly.
- If necessary disconnect any leads to facilitate the removal of the counter board.
- Remove the screw that secures the display board bracket to the counter board.

REAR PANEL

- Remove the top and bottom covers.
- If necessary disconnect any leads to facilitate the removal of the rear panel.
- The rear panel can now be removed.

CALIBRATION PROCEDURE

Remove the bottom cover. Refer to the component layouts 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

RELEASE SYM BUTTON

1. Power Supply

- Check voltage at TP7 is $+15\text{v} \pm 0.3\text{V}$
- Check voltage at TP8 is $-15\text{V} \pm 0.45\text{V}$

2. IC1,2,3,4 DC Offset

- Set VR4 fully anti-clockwise.
- Measure the voltage at TP5 w.r.t 0V, adjust VR1,VR2 to give a reading of $-10.00\text{mV} \pm 0.04\text{mV}$.
- Measure the voltage at TP6 w.r.t 0V, adjust VR3 to give a reading of $+10.00\text{mV} \pm 0.1\text{mV}$.
- Measure the voltage at TP4 w.r.t 0V, adjust VR5 to give a reading of $-10.00\text{mV} \pm 0.1\text{mV}$.
- Measure the voltage at TP2 w.r.t TP7, adjust VR7 to give a reading of $-33.33\text{mV} \pm 0.17\text{mV}$.
- Measure the voltage at TP3 w.r.t TP8, adjust VR8 to give a reading of $+33.33\text{mV} \pm 0.17\text{mV}$.
- Re-check the voltage at TP5 and repeat the above if it has changed.
- Set VR1 to MAX.

3. Triangle Buffer DC Offset

- Turn OFF the power to the unit, and using a short length of wire join the junction of TR5 gate and C1 to the ground plane.
- Connect a voltmeter between TP9 and ground and turn the power back ON.
- Adjust VR9 for a reading of $0.0\text{mV} \pm 0.5\text{mV}$.
- Turn OFF the power to the unit and disconnect the wire shorting C1 to ground.
- Turn ON the power to the unit.

4. Triangle Amplitude

- Connect an oscilloscope and a voltmeter to TP9 and ground.
- Set the Amplitude control to minimum.
- Adjust VR10 and VR11 until the triangle wave is 1.0Vp-p and the D.C offset is $< 1.0\text{mV}$.

5. Output Amplifier DC Offset

- Monitor the 50Ω output with a voltmeter.
- Set the Amplitude control to its middle position and adjust VR18 for $< 10.0\text{mV}$.
- Rotate the Amplitude control from minimum to maximum and check that the D.C offset does not exceed $\pm 50\text{mV}$.

6. Frequency Calibration

- a) Select the 10kHz frequency range.
- b) Using the internal frequency counter.
- c) Set Frequency control to MIN, Adjust VR4 for 1.9kHz \pm 0.5kHz.
- d) Set Frequency control to MAX, Adjust VR2 for 21kHz \pm 0.5kHz.
- e) Recheck readings, re-adjust VR4 and VR2 if necessary.

7. Sinewave

- a) Monitor TP10 with an oscilloscope using a X10 probe.
- b) Set the frequency range to 1kHz and frequency to 1kHz.
- c) Select the sinewave function.
- d) Set VR12,13,14,15 and 16 to their mid positions.
- e) Adjust VR14 to give a peak to peak amplitude of \approx 1V.
- f) Adjust VR16 to give minimum offset ie. 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 1Vp-p.

8. Sinewave Distortion

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

10. Amplitude Calibration

- a) Monitor the 50 Ω output with an oscilloscope.
- b) Select triangle-wave.
- c) Set the frequency to 1kHz and the amplitude to 20Vp-p.
- d) Select 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.

11. External Frequency Counter.

- a) Set frequency source to EXTERNAL.
- b) Check display shows 00.00MHz with no input.
- c) Input 10MHz 22mV RMS, adjust CV1 for 10.00MHz.
- d) Input 20MHz 48mV RMS, adjust VR200 for stable reading.
- e) Set frequency source to INTERNAL.

REASSEMBLY OF THE INSTRUMENT

Depending upon the extent of dismantling, the instrument needs careful reassembly to the following procedure.

Check interconnections using circuit diagrams and board layouts.

REAR PANEL

- Placing behind main board, attach any unsoldered leads.

COUNTER AND DISPLAY BOARD ASSEMBLY

- Replace the bracket joining the counter and display boards.
- Attach any unsoldered leads.

FRONT PANEL

- Carefully re-solder the four screened cables to the front BNC connectors.
- The counter and display board assembly can now be placed onto the front panel.
- Replace the two nuts on the back of the display board.
- Ensure the display board is not bowed, re-adjust the bracket on counter board.
- Replace the nuts and knobs onto the front panel potentiometers.

TOP COVER

- Replace the front assembly over the main board switches.
- Ensure the display screen earth lead is routed over the display board between the switchbanks.
- Place the complete assembly into the top cover, ensuring that the screw bushes line up with the four holes in the main board.
- Ensure that the front and rear panels are in their respective slots.
- Replace the four self tapping screws and their fibre washers.
- Replace the two side extensions.

BOTTOM COVER

- Carefully replace the bottom cover. Note: if the panels have seated in their correct slots the cover should push completely down.
- Replace the four screws in the feet.
- Replace the tilt stand between the front feet.

PARTS LIST

CIRCUIT POSITION	PART No.	CIRCUIT POSITION	PART No.
MAIN BOARD			
C1	1u 63V 2% polycarbonate 20-098	R21	100k MFR25 1% 18-058
C2	100n 63V 2% polycarbonate 20-099	R22	10k MFR25 1% 18-054
C3	10n 63V 2.5% polystyrene 20-101	R23	1k MFR25 1% 18-046
C4	930p 30v 1% polystyrene 20-100	R24	2k MFR25 1% 18-065
C5	1p8 63V plate ceramic 20-103	R25	18k MFR25 1% 18-069
C6	100n 25V disc ceramic 20-020	R26	470R CFR25 5% 18-016
C7	100n 25V disc ceramic 20-020	R27	390R CFR25 5% 18-039
C8	100n 25V disc ceramic 20-020	R28	3k9 CFR25 5% 18-026
C9	18p 63V plate ceramic 20-104	R29	680R CFR25 5% 18-018
C10	100n 25V disc ceramic 20-020	R30	5k6 CFR25 5% 18-028
C11	no longer used	R31	2k2 CFR25 5% 18-024
C12	10pF/16V polystyrene 20-110	R32	560R CFR25 5% 18-017
C13	100n 25V disc ceramic 20-020	R33	68R CFR25 5% 18-089
C14	100n 25V disc ceramic 20-020	R34	1k CFR25 5% 18-020
C15	100n 25V disc ceramic 20-020	R35	2k7 CFR25 5% 18-025
C16	27p 63V plate ceramic 20-049	R36	1k CFR25 5% 18-020
C17	10u 16V electrolytic 20-018	R37	2k2 CFR25 5% 18-024
C18	10u 16V electrolytic 20-018	R38	2k2 CFR25 5% 18-024
C19	100n 25V disc ceramic 20-020	R39	82R CFR25 5% 18-038
C20	2200u 25V electrolytic 20-102	R40	220R CFR25 5% 18-013
C21	2200u 25V electrolytic 20-102	R41	47R CFR25 5% 18-093
C22	10u 16V electrolytic 20-018	R42	10k CFR25 5% 18-029
C23	10u 16V electrolytic 20-018	R43	10k CFR25 5% 18-029
C24	100n 25V disc ceramic 20-020	R44	2k2 CFR25 5% 18-024
C25	100n 25V disc ceramic 20-020	R45	470R CFR25 5% 18-016
C26	100n 25V disc ceramic 20-020	R46	470R CFR25 5% 18-016
C27	100n 25V disc ceramic 20-020	R47	5k6 CFR25 5% 18-028
C28	100u 25V electrolytic 20-005	R48	5k6 CFR25 5% 18-028
C29	100u 25V electrolytic 20-005	R49	10k CFR25 5% 18-029
C30	47u 6V3 electrolytic 20-012	R50	1k8 CFR25 5% 18-023
C31	47u 6V3 electrolytic 20-012	R51	5k6 CFR25 5% 18-028
C32	27p 63V plate ceramic 20-049	R52	4k7 CFR25 5% 18-027
C33	27p 63V plate ceramic 20-049	R53	1k CFR25 5% 18-020
C34	27p 63V plate ceramic 20-049	R54	56R CFR25 5% 18-011
C35	100n 25V disc ceramic 20-020	R55	82R CFR25 5% 18-038
C36	Not used	R56	1k CFR25 5% 18-020
C37	Not used	R57	1k8 CFR25 5% 18-023
C38	SOT Parallel with C4	R58	10k CFR25 5% 18-029
R1	8k2 CFR25 5% 18-125	R59	820R CFR25 5% 18-019
R2	82k CFR25 5% 18-121	R60	5k6 CFR25 5% 18-028
R3	1k2 CFR25 5% 18-021	R61	390R CFR25 5% 18-039
R4	180R CFR25 5% 18-062	R62	150R CFR25 5% 18-118
R6	82k CFR25 5% 18-121	R63	390R CFR25 5% 18-039
R7	27k CFR25 5% 18-126	R64	2k2 CFR25 5% 18-024
R8	82k CFR25 5% 18-121	R65	100R CFR25 5% 18-012
R9	82k CFR25 5% 18-121	R66	100R CFR25 5% 18-012
R10	82k CFR25 5% 18-121	R67	3k3 CFR25 5% 18-063
R11	39k CFR25 5% 18-116	R68	3k3 CFR25 5% 18-063
R12	1k MFR25 1% 18-046	R69	56k CFR25 5% 18-128
R13	300R MFR25 1% 18-057	R70	56k CFR25 5% 18-128
R16	300R MFR25 1% 18-057	R71	10k CFR25 5% 18-029
R17	1k MFR25 1% 18-046	R72	470R CFR25 5% 18-016
R18	100k MFR25 1% 18-058	R73	33R CFR25 5% 18-071
R19	10k MFR25 1% 18-054	R74	33R CFR25 5% 18-071
R20	1k MFR25 1% 18-046	R75	27R MFR5 1% 18-139
		R76	10R MFR4 1% 18-141
		R77	10R MFR4 1% 18-141
		R78	27R MFR5 1% 18-139
		R79	10k CFR25 5% 18-029

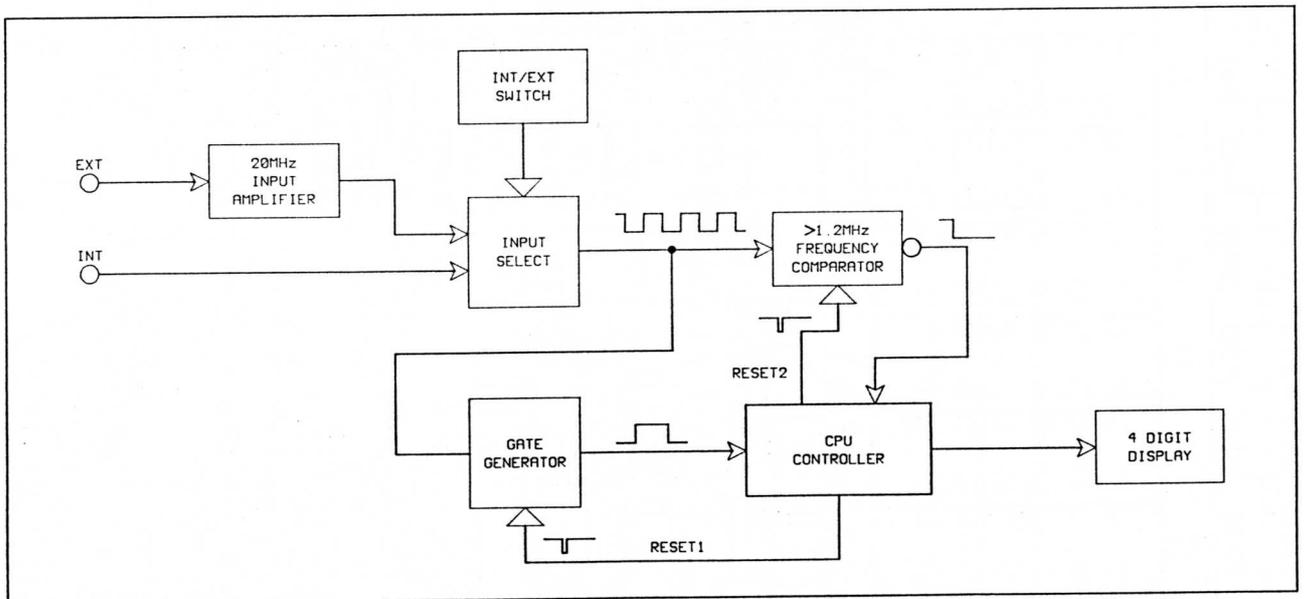
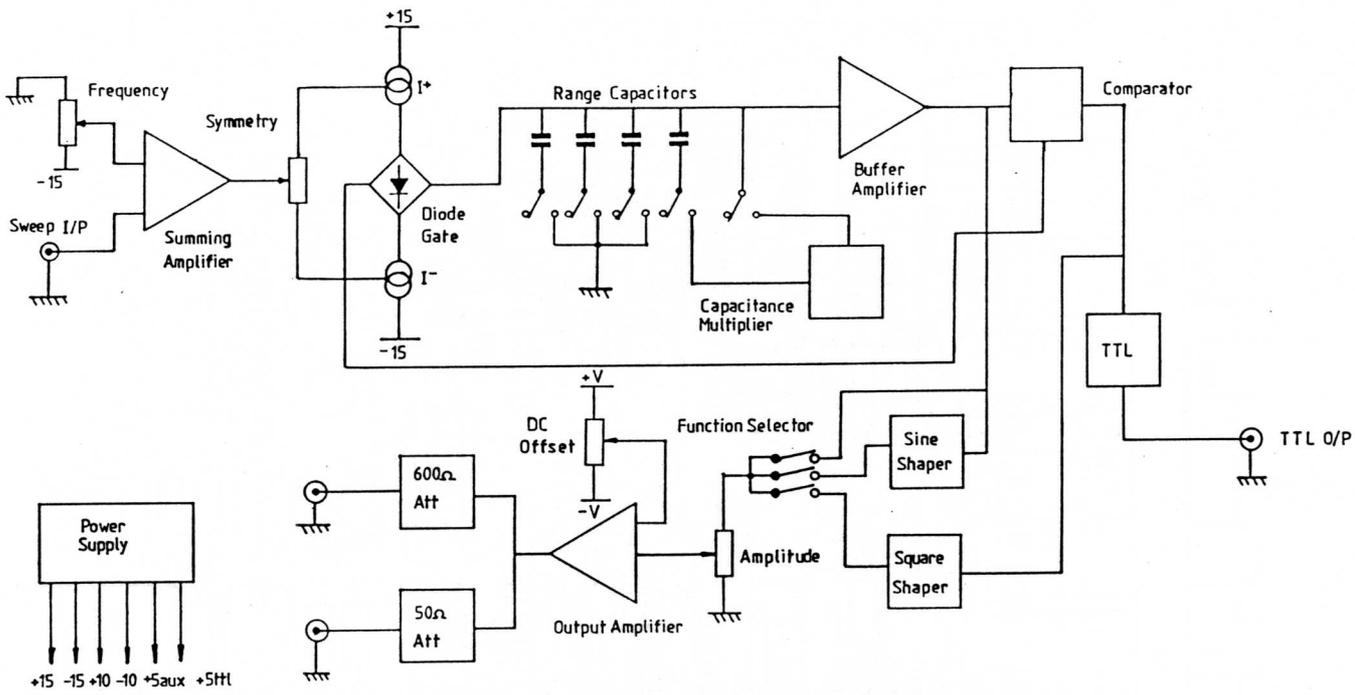
CIRCUIT POSITION	PART No.	CIRCUIT POSITION	PART No.	
R80	1k MFR25 1%	18-046	Sk5 IC socket 14-way	14-056
R81	1k MFR25 1%	18-046	Sk7 IEC mains socket	14-017
R82	120R MFR5 1%	18-140	P1-10 Terminal pin	14-005
R83	120R MFR5 1%	18-140	TP1-8 Header 8-way	14-061
R84	1k MFR25 1%	18-046	TP8-10 Header 2-way	14-069
R85	820R MFR25 1%	18-132		
R86	56R MFR25 1%	18-122		
R87	6k8 MFR25 1%	18-052	IC1 TL071CP	24-073
R88	150R MFR25 1%	18-133	IC2 TL071CP	24-073
R89	1k2 MFR25 1%	18-047	IC3 TL071CP	24-073
R90	150R MFR25 1%	18-133	IC4 TL071CP	24-073
R91	1k2 MFR25 1%	18-047	IC5 TL072CP	24-074
R92	150R MFR25 1%	18-133	IC6 CA3086	24-075
R93	390R MFR25 1%	18-134	IC7 NE527N	24-076
R94	75R MFR25 1%	18-135	IC8 CA3086	24-075
R95	4k7 CFR25 5%	18-027	IC9 74LS37N	24-011
R96	8k2 MFR25 1%	18-136	IC10 TL072CP	24-074
R97	1k6 MFR25 1%	18-137		
R98	15k MFR25 1%	18-055		
R99	15k MFR25 1%	18-055	TR1 BC184B	22-024
R100	4k7 CFR25 5%	18-027	TR2 BC214B	22-025
R101	4k7 CFR25 5%	18-027	TR3 BC214B	22-025
R102	33k CFR25 5%	18-084	TR4 BC184B	22-024
R103	15k CFR25 5%	18-036	TR5 2N3958	22-010
R104	1k CFR25 5%	18-020	TR6 2N3904	22-011
R105	1k CFR25 5%	18-020	TR7 2N3904	22-011
R106	820R CFR25 5%	18-019	TR8 2N3906	22-006
R107	1k5 CFR25 5%	18-022	TR9 2N3904	22-011
R108	22R CFR25 5%	18-074	TR10 2N3904	22-011
R109	270R CFR25 5%	18-014	TR11 2N3904	22-011
R110	390R CFR25 5%	18-039	TR12 2N3904	22-011
R111	750R MFR25 1%	18-138	TR13 2N3906	22-006
R114	47R CFR25 5%	18-093	TR14 2N3904	22-011
RProt	51R MFR5 1% 0.75W	18-083	TR15 2N3906	22-006
			TR16 2N3906	22-006
VR3	100k horiz preset	19-025	TR17 2N3904	22-011
VR5	100k horiz preset	19-025	TR18 2N3906	22-006
VR7	100k horiz preset	19-025	TR19 2N3904	22-011
VR8	100k horiz preset	19-025	TR20 2N2219A	22-012
VR9	220R horiz preset	19-005	TR21 2N2905A	22-013
VR10	4k7 horiz preset	19-023	TR22 2N3904	22-011
VR11	4k7 horiz preset	19-023	TR23 2N3906	22-006
VR12	1k horiz preset	19-007	TR24 BD140	22-015
VR13	2k2 horiz preset cermet	19-024	TR25 BD139	22-014
VR14	2k2 horiz preset	19-008	TR26 2N3906	22-006
VR15	100R horiz preset	19-004		
VR16	22k horiz preset	19-009	D1 1N916	23-004
VR18	470k horiz preset	19-016	D2 1N916	23-004
			D3 1N916	23-004
S1-S7	4P/2W Frequency	16-019	D4 1N916	23-004
S8	2P/2W Symmetry	16-020	D5 1N916	23-004
S9-S11	2P/2W Function		D6 1N916	23-004
S12-13	2P/2W Attenuator		D7 1N916	23-004
S14	4P/2W Attenuator		D8 1N916	23-004
S15	Mains Switch	16-011	D9 1N4148	23-005
			D10 1N4148	23-005
			D11 Not used	
Sk1	50 Ohm BNC	14-002	D12 1N916	23-004
Sk2	50 Ohm BNC	14-002	D13 1N916	23-004
Sk3	50 Ohm BNC	14-002	D14 1N916	23-004
Sk4	50 Ohm BNC	14-002	D15 1N916	23-004

CIRCUIT POSITION	PART No.
IC204 74HC4094	24-103
SK202 40 Pin DIL Socket	14-013
J200 1" 5 Way Jumper	14-136
DS200 7 Segment LED Display	26-002
DS201 7 Segment LED Display	26-002
DS202 7 Segment LED Display	26-002
DS203 7 Segment LED Display	26-002
DS204 3mm LED	26-001
DS205 3mm LED	26-001
DS206 3mm LED	26-001
DS207 3mm LED	26-001
LED Support x8	13-030
PCB DISPLAY	30-048

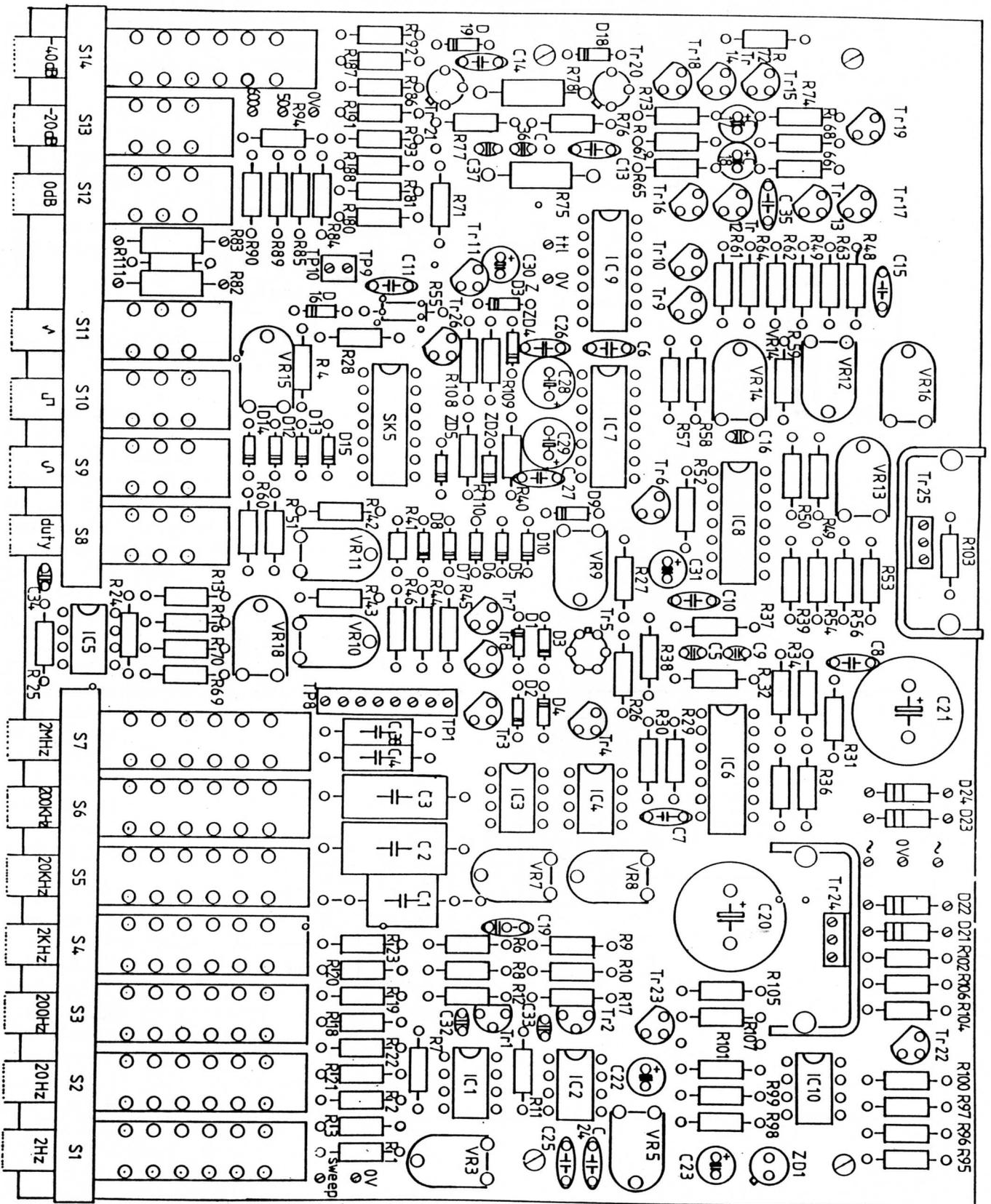
MECHANICAL

DESCRIPTION(QTY)	PART NO.
Spacer (2)	13-039
Ferrite Bead	17-007
Screen	15-031
8 way IDT socket	14-033
Sleeving H15 (8)	15-004
Shroud Mains skt	15-005
Rear panel printed	28-040
Tamperproof screw M3x12	13-055
Solder tag 5BA	14-035
Nut full M3 (11)	13-019
Screw M3x70 pozi (4)	13-003
Screw M3x10 pozi c/sk (2)	13-023
Screw M2.5 x 0.45 x 5 (2)	13-026
Washer shakeproof M3 (10)	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	28-039
Leg	27-008
Knob black+white line (4)	29-016
Knob cap grey+white line (4)	29-018
Button grey (14)	29-014
Screw self tap No.4 x 1/4 (4)	13-044
Heatsink TV15-05 (2)	38-001
Mica washer (4)	13-004
Fibre washer (12)	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 (5)	13-032
Instruction manual	31-105
Polystyrene packing piece (2)	31-077
Carton	31-078
Fuse 250mA antisurge (2)	33-002

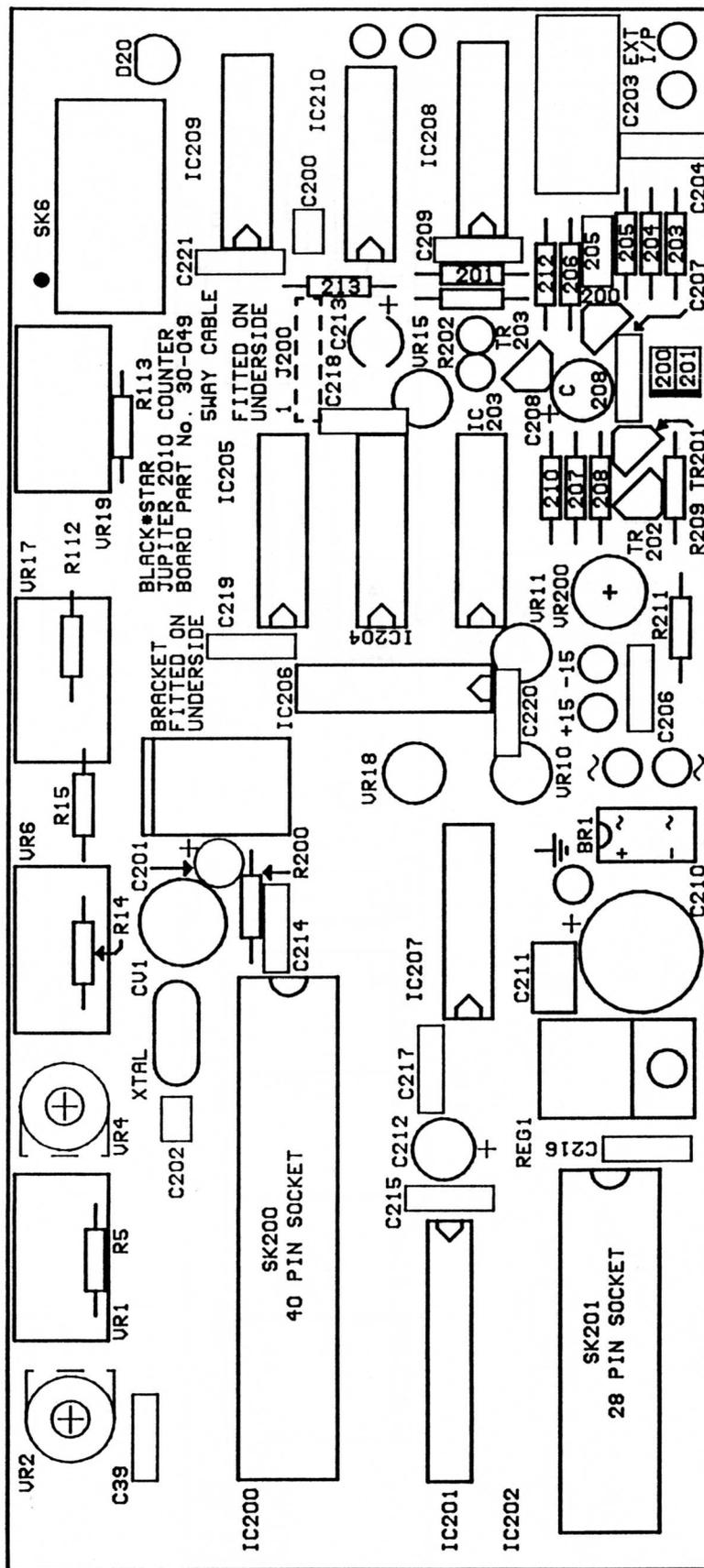
BLOCK DIAGRAM



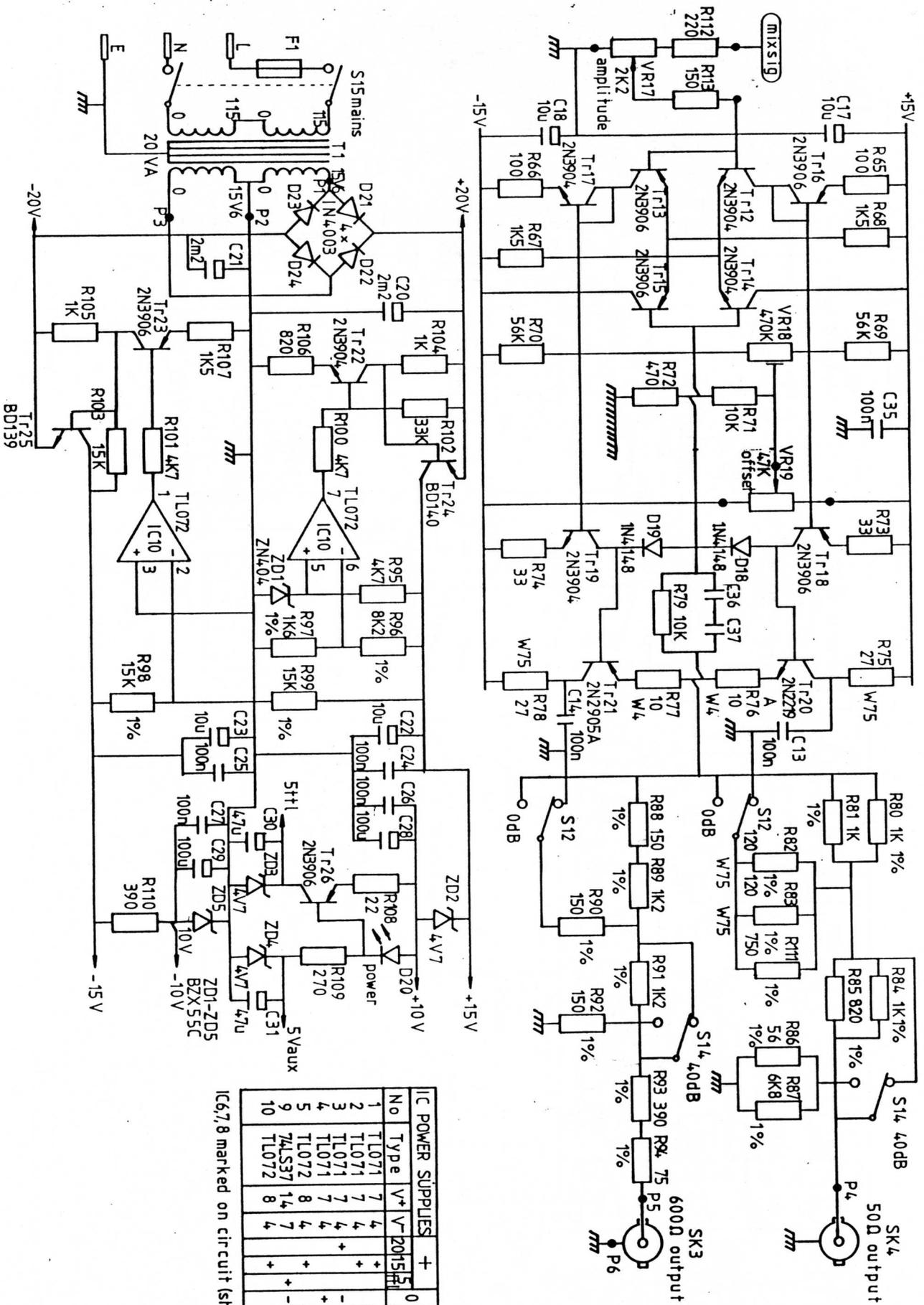
COMPONENT LAYOUT MAIN BOARD



COMPONENT LAYOUT COUNTER BOARD



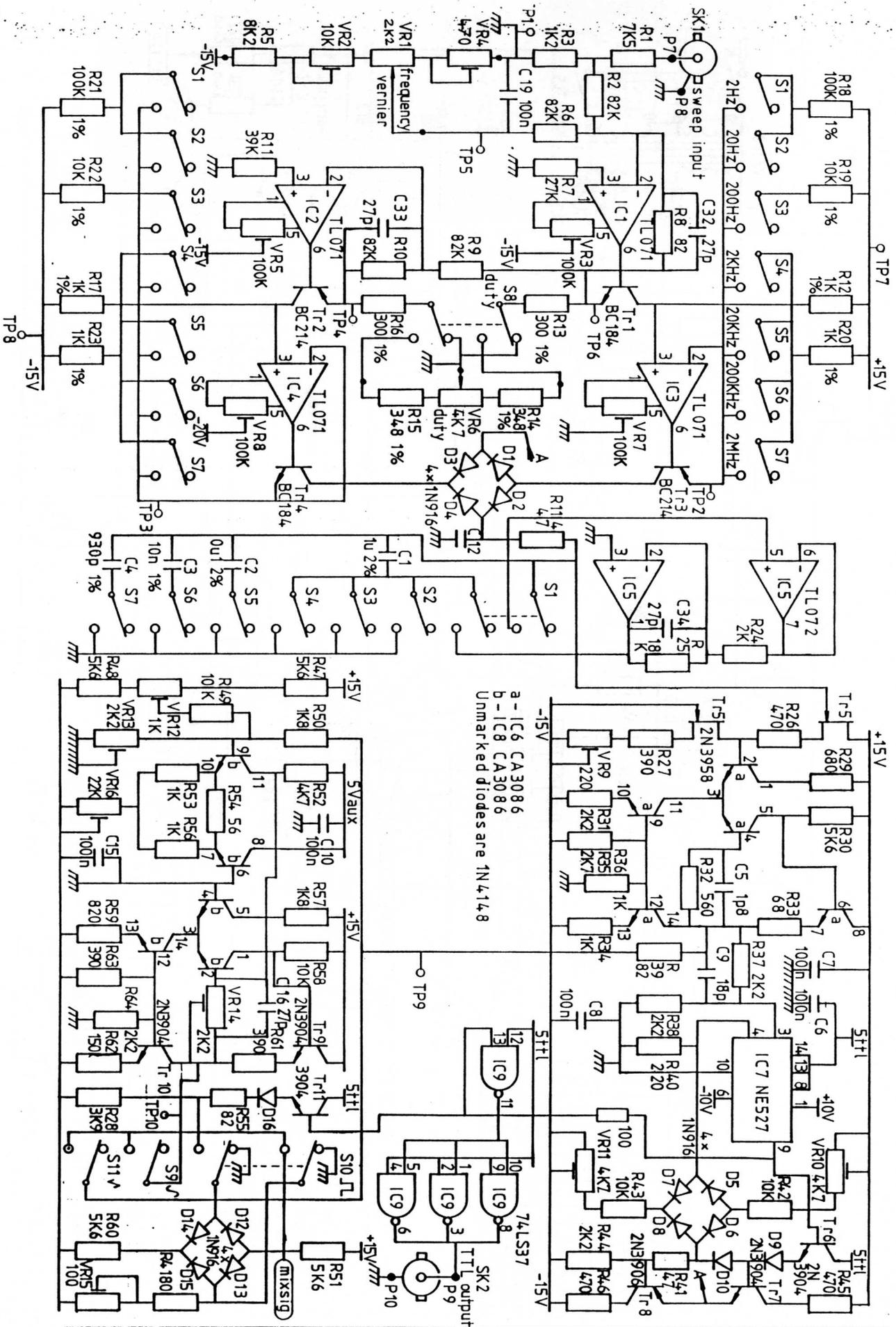
CIRCUIT DIAGRAM 1. POWER SUPPLY AND OUTPUT AMPLIFIER



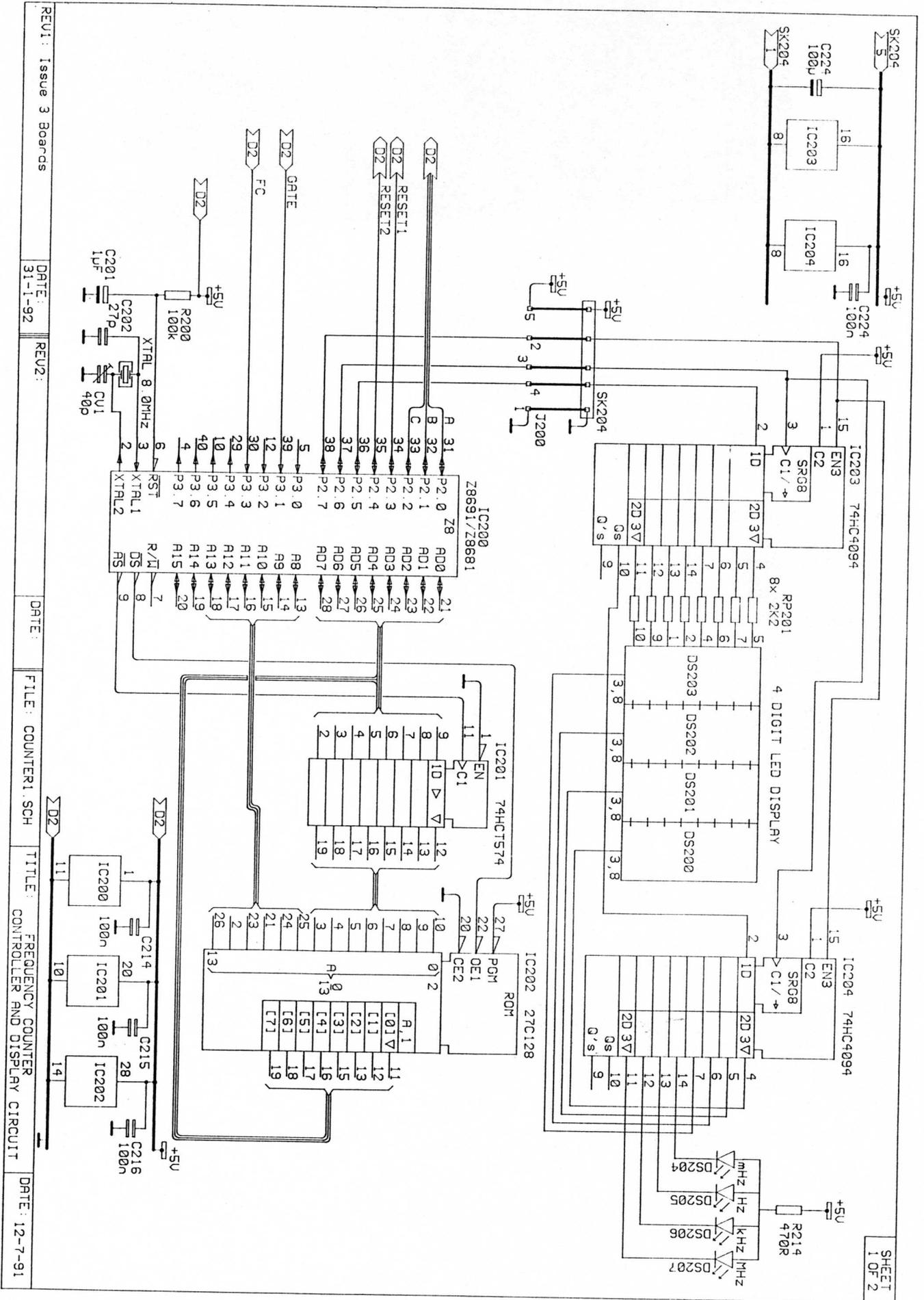
IC POWER SUPPLIES									
No	Type	V+	V-	Z	RA	RB	RC	RD	RE
1	TL071	7	7	4	+	+	+	+	+
2	TL071	7	7	4	+	+	+	+	+
3	TL071	7	7	4	+	+	+	+	+
4	TL071	7	7	4	+	+	+	+	+
5	TL072	8	8	4	+	+	+	+	+
9	74LS37	14	7	7	+	+	+	+	+
10	TL072	8	8	4	+	+	+	+	+

IC6,7,8 marked on circuit (sheet 1)

CIRCUIT DIAGRAM 2. WAVEFORM GENERATOR



CIRCUIT DIAGRAM 3. COUNTER CONTROLLER AND DISPLAY



SHEET
1 OF 2

REV1: Issue 3 Boards DATE: 31-1-92 REV2: DATE: FILE: COUNTER1.SCH TITLE: FREQUENCY COUNTER CONTROLLER AND DISPLAY CIRCUIT DATE: 12-7-91

