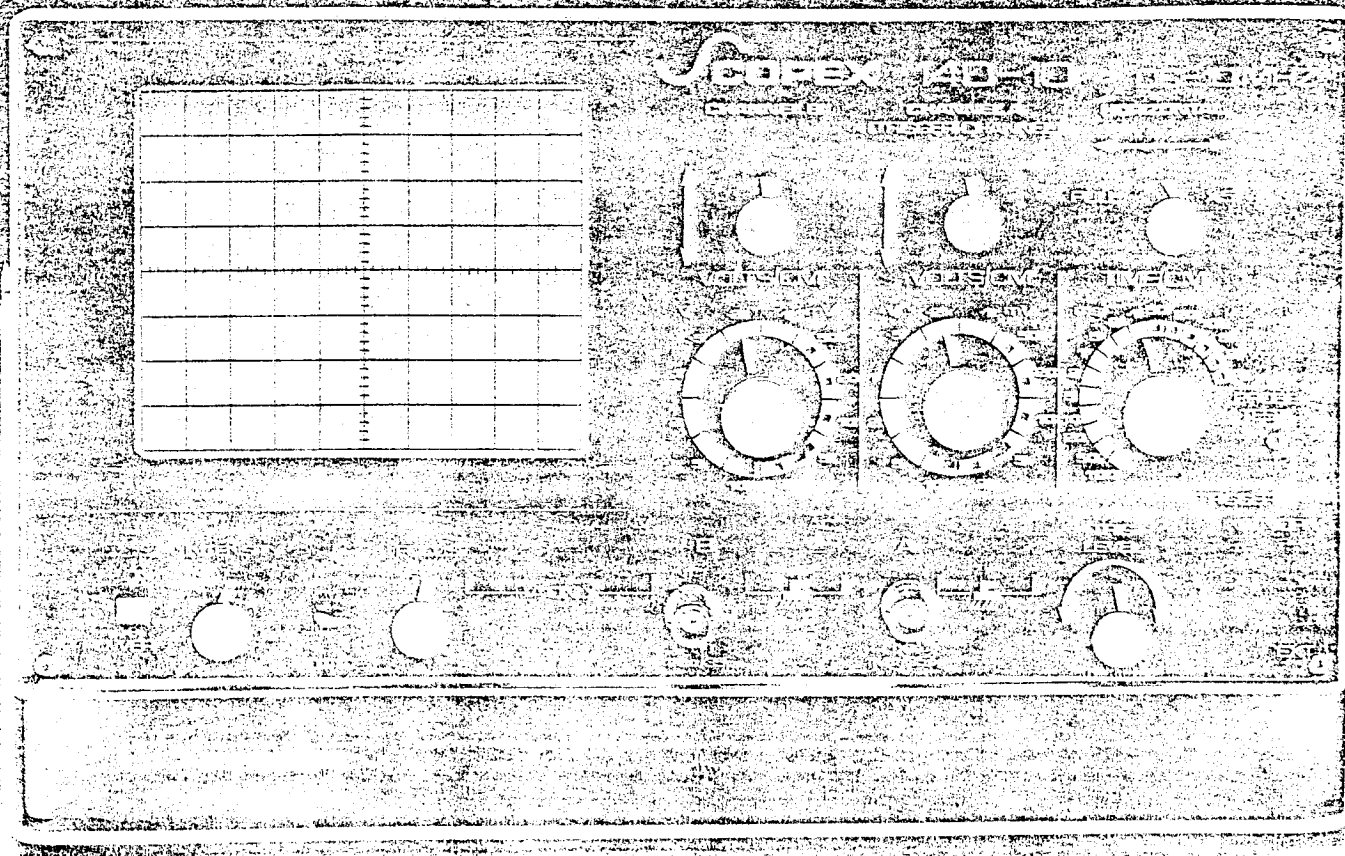


SCOPEX 14D-10

Dual Trace Solid
State Oscilloscope



For Service Manuals Contact
MAURITRON TECHNICAL SERVICES
3 Cherry Tree Rd, Chinnor
Oxon OX9 4QY
Tel: 01844-351694 Fax: 01844-352554
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MAURITRON

The 14D-10 is a completely new style of instrument employing a number of features not normally associated with low cost, high quality Oscilloscopes: switch mode power supply, 2mV sensitivity over the full bandwidth of 10MHz, add and invert facility, and X - Y operation.

These features plus the extra bonus of a 10 x 8cm display gives this instrument a specification without parallel.

DC-10 MHz Bandwidth

Sensitivity 2mV-10V/Div

Large Screen (10x8Cm)

Add Facility

Invert Facility

Switched Mode Power Supply

± 3% Accuracy

X-Y Operation

Probe Compensation

14D-10 Specification

Vertical System

CHANNELS A and B

Sensitivity:	2mV/Div to 10V/Div (12 calibrated ranges) in 1, 2, 5, Sequences
Accuracy:	±3%
Bandwidth(-3dB):	DC coupled — 10MHz AC coupled — 3Hz — 10MHz
Risetime:	35 ns (approx)
Max Input Voltage:	400V (DC + peak AC to 10kHz)
Input Impedance:	1MΩ ± 3% and 33 pf (approx)
Operating Modes:	Dual Trace, alternate or chop (110 kHz), channel A only, X - Y, Add, invert channel B
X - Y Operation:	Channel A is switched to the (X) horizontal deflection system, channel B remains the (Y) vertical amplifier Bandwidth DC — 1MHz Phase shift. <3° at 50kHz
Input Socket:	BNC

Horizontal System

TIME BASE

Sweep Speeds:	1μs/Div to 100ms/Div (16 calibrated ranges) in 1, 2, 5, sequence
Accuracy:	± 3%
Magnifier:	x5 (increases fastest sweep to 200ns/Div)

Trigger Circuit

Source:	Internal — Channel A External
Modes:	Normal — TV Field (TV line in normal mode).
Sensitivity:	Internal — 0.3 Div DC to 10MHz External — 250 mV (peak to peak nominal)
Bright Line Auto:	Trace free runs in absence of trigger signal at all sweep speeds. (Facility to disable).
Level Control:	Selects trigger level point.

Display

Graticule:	10 x 8 Div (1 Div = 1cm)
CRT:	P31 phosphor, standard, P7 optional
Trace Locate:	Returns overscanned trace to display area

Probe Compensation

Output Voltage	80mV peak to peak approximately
Wave Shape	Square wave
Frequency	At sweep repetition rate

General Information

Power Requirements:	210 — 250V AC, 105 — 125V AC, 48 — 60 Hz, 25VA (approx)
Dimensions: (mm)	H:153, W:312, D:435
Weight:	5kg.
Sweep Output:	+1.5V — 10V (approx)
Optional Accessories:	High Impedance Probes Protectormuff Light Hood



Super Precision Oscilloscopes

More Power

Probe Amplifier

Our policy is one of continuous development and we reserve the right to amend this specification without

OPERATING INSTRUCTIONS

Single Trace Operation

Plug into mains supply.

Set controls as shown on front cover photograph (all push buttons out, HORIZONTAL position controls pushed in and all pointer knobs as near vertical as possible).

Switch on and check green power light on.

Allow a one minute warm up period, when a trace should appear. If not, press LOCATE switch, adjust INTENSITY control until a line appears. Use HORIZONTAL POSITION and 'A' VERTICAL POSITION controls to place the line on the centre line of the graticule. Connect a signal between input 'A' and ground.

Depress AC button on 'A' channel AC-G-DC switch.

N.B. This type of switch has three positions - either of the buttons depressed or both buttons out.

Adjust 'A' VOLTS/cm switch to obtain a display of convenient amplitude, say 4 cms.

Rotate TRIG LEVEL control until picture 'locks' (i.e. gives a stationary picture). Adjust TIME/cm switch to display as much detail as required. Adjust FOCUS and INTENSITY for optimum definition.

Dual Trace Operation

Carry out instructions for single trace operation. Then depress the DUAL button. Find and position the second trace (if necessary using LOCATE switch), using the 'B' VERTICAL POSITION control. Connect the second input signal between 'B' INPUT and ground. Switch 'B' channel AC-G-DC switch to AC.

Adjust VOLTS/cm switch of both channels to give convenient display amplitudes.

X/Y Operation

Selecting X/Y causes the signal at 'A' input to become the 'X' axis deflection leaving the signal at 'B' input to provide the 'Y' axis deflection. This function can be useful for comparing the phase of two signals and for use with a sweep frequency oscillator.

Add

The ADD function does just as its name implies in that it adds the signal at input 'A' to the signal at input 'B' and displays the result. This is probably best understood by demonstration. Connect an audio oscillator set at approximately 2KHz to both inputs simultaneously. Select 'A' channel input to DC and 'B' channel input to ground. Adjust 'A' VOLTS/cm and the oscillator output to give a display of exactly 4 cms and set 'B' channel VOLTS/cm to the same sensitivity as 'A' channel. Selecting 'B' channel input to DC will cause the display to increase to 8 cms showing the addition of the two in phase signals. Pressing the INVERT 'B' button causes 'B' channel to operate such that positive voltages cause the display to move down as though the signal had been phase shifted 180° . In the present case this will cause the display to become a straight line for as 'A' channel tries to deflect the display in one direction, 'B' channel will deflect it an equal amount in the opposite direction the result being zero deflection. This 'differential' mode can be useful for examining small signals superimposed on a large signal, or adjusting two signals to be exactly equal in amplitude.

AC-G-DC Switch

In the ground position 'G', the amplifier (but not the input signal) is grounded, giving a true ZERO voltage reference. On the AC position, a capacitor is placed in series with the input signal, so as to exclude its DC component will be seen on the screen as a positive or negative shift of the zero baseline. Too large a DC component may displace the trace right off the screen.

Horizontal Position Control

This control simultaneously positions both traces in the horizontal axis. When pulled out it increases the horizontal gain by a factor of 5, and in effect provides a trace 50 cms long. When measuring time, this gain of 5 must be corrected by dividing the time by the same amount. (E.g. with TIME/cm SWITCH at 1u second and horizontal X5 switch out, the true time calibration is $\frac{1}{5} = .2\mu \text{ sec/cm.}$)

Normal - T.V. Field

For all applications other than examining T.V. video signals at frame rate use the NORMAL mode. This includes triggering from T.V. line sync pulses.

When the button is depressed a passive integrator circuit is introduced which enables the timebase to be triggered from the frame sync block in the video waveform. The TRIGGER SLOPE SWITCH should be on + for positive sync and on - for negative sync.

Probe Test

This socket provides a fast rise negative going step at sweep rate to facilitate setting of X10 probe compensation.

To set up a probe set TIME/cm switch to 0.1ms/cm, VOLTS/cm to .1V/cm and turn TRIG level control fully anti-clockwise so that sweep free runs. Connect probe to 'A' input and connect probe tip to the PROBE outlet. Adjust the probe compensation trimmer on the body of the probe to give a square corner at the start of the sweep without overshoot or undershoot. In the case of a X1/X10 switchable probe, ensure that it is set to the X10 position before setting up. To minimise pickup in the probe it may be necessary to touch an earth point with one hand while carrying out this operation.

Trace Rotate

This control is used to align the trace with the horizontal graticule lines with the input switches in the GROUND position. **

Sweep Output (on rear of instrument)

This socket provides a positive going sawtooth waveform of approx +7 volts starting from ground and of the same duration as the timebase sweep.

Auto Trigger Disable

Linking the two pins by the side of M404 disables the auto trigger. This may prove useful on application involving sweep repetition of less than 2 per second.

** If the trace cannot be adjusted to the horizontal graticule lines then reversing the two wires from the trace rotate coil on the main board will allow correct adjustment.

Vertical Amplifiers

The following description applies to both amplifiers, simply add 100 to the circuit references for 'B' channel. The signal input passes to the attenuator which comprises five frequency compensated dividers which can be bypassed, used singly or in cascade thus enabling the signal to be adjusted to a level suitable for application to the input source followers.

The output of the source followers drive the inputs of a monolithic video amplifier M151. The overall gain of the channel is adjusted by RV151. The output from the monolithic amplifier is at low impedance and provides a suitable point for taking the trigger signal from channel 'A' and inserting the inverting switch in channel 'B'. The output of each monolithic amplifier is fed to a long tailed pair amplifier, these two long tailed pair amplifiers share a single virtual earth amplifier and channel switching is accomplished by turning their emitter current on and off as required by the emitter coupled pair TR153 and TR154. The current for the stage is determined by the constant current stage TR155. When the ADD mode is selected both long tailed pair amplifiers must be on simultaneously, the current for channel 'B' is provided by the extra constant current stage TR255. Resistors R168 and R169 are returned to the +15V rail to provide the extra current required at the input to the virtual earth amplifier. The output of the virtual earth mixing amplifier is fed to a balanced cascode output amplifier. The current in the output amplifier is determined by R189 and R191. When the LOCATE button is depressed R192 is inserted in series and reduces the output stage current such that the beam cannot be driven off the screen.

The channel switching is controlled by the flip-flop M402b. In the 'A' only mode, Q is held high by the RESET which ensures channel 'A' is connected to the vertical output amplifier. When DUAL trace is selected the RESET signal is removed allowing the flip-flop to toggle. At sweep speeds faster than 1mS/cm the output from M201/12 is held high and the negative going pulse from M402a is inverted by M201c to switch M403b. At sweep speeds slower than 1mS/cm the oscillator formed by M201a and M201b is allowed to run, the output passing through M201c during the sweep period and blocked during flyback.

The X/Y mode places a SET on M403b which ensures that 'B' channel is connected to the vertical output amplifier, at the same time the output of the trigger amplifier is applied to the horizontal output amplifier.

The trigger signal from the monolithic amplifier is further amplified by a balanced feedback amplifier TR501 to TR504. The output of this amplifier is fed to the trigger source switch and can also be fed via the analogue switches M406 directly to the 'X' output stage. The gain control RV501 enables the gain of the amplifier to be adjusted such that the oscilloscope has equal 'X' and 'Y' sensitivities in the X/Y mode.

The input to the trigger stage can be selected from either the internal trigger amplifier or the EXT trigger socket by the TRIG SOURCE switch S401, S402 either bypasses or inserts a low pass filter R402, C402 which enables the instrument to lock to the frame block of a television waveform. The TRIGGER SLOPE switch determines to which of the trigger stage inputs the signal is applied. The long tailed pair amplifier TR401, TR402 drives a Schmitt input NAND gate M401a. In its quiescent state, i.e. ready to be triggered, the \bar{Q} output of M403a is high (+5V) and TR403 is bottomed. When the clock input of M403a goes positive, \bar{Q} changes state to low and TR403 is turned off, the diode D402 is included to prevent hole storage in TR403 which would slow the speed at which it turns off. With TR403 turned off, the timing capacitors C411-C416 can charge positively to the voltage at the top end of the timing resistors R424-R428. The potential at the junction of the timing capacitors and resistor is fed to the super beta pair TR404, TR405 and the zener diode D403 ensures that the potential across the charging resistor is always constant (i.e. V_{be} drop of TR404 + V_{be} drop of TR406 + V_{br} of D403). This constant voltage across the resistors produces a constant current charge to the capacitors and hence generates a linear ramp. The charging of the timing capacitors continues until D404 conducts and raises the input of M401b causing it to produce at 0 at the output. The length of time that the output remains at 0 is determined by the discharge of the hold off capacitors C417 and C412-C416 by R431, R423. The circuit is designed such that the required hold off capacitor is always $\frac{1}{10}$ of the value of the charging capacitor, thus one series of capacitors can provide both the requirements. The output of M401b is applied to the reset input of M403a causing its \bar{Q} output to go high which in turn bottoms TR403 discharging the timing capacitors. During the time that the reset input is held low the clock input of M403a is overridden and any trigger pulses occurring during the flyback period cannot retrigger the timebase. The hold off period ensures sufficient time for the whole sweep circuit to reset and settle.

The trigger pulses from M401a are also fed to the retriggerable multivibrator M402. When there are no pulses the \bar{Q} output remains high and the timebase free runs, however, immediately trigger pulses are produced the \bar{Q} output goes low and remains low for 1 second after the cessation of trigger pulses. This low causes the timebase to run only when triggered. The gate M404a ensures that when the 'auto disable' pins are shorted together the timebase will not free run in the absence of a trigger signal. When the LOCATE button is pressed the inputs to M404b go low and the timebase free runs. The output of M404b is fed to an input of M404c whose main purpose is to ensure that the set and reset inputs to M405a cannot both be low at the same time. The third input to M404c is also a convenient point to provide an inhibit pulse to prevent the timebase from running when the X/Y mode has been selected.

In all modes except X/Y the linear ramp appearing at the emitter of TR405 is fed via the bilateral switch M406a to the horizontal output amplifier. At the same time the bilateral switch M406b selects the potential from the HORIZONTAL SHIFT controls RV406. When the X/Y mode is selected the bilateral switches connect the output of the trigger amplifier to the horizontal output amplifier. The horizontal output amplifier is a long tailed pair TR408/TR411 driven by a pair of emitter followers TR407 and TR412. The current in the output stage is determined by the constant current source TR409. The gain of the stage is set by the emitter coupling resistors RV403 and R461. The amount of coupling can be increased by switching in a parallel set of resistors RV404/R457 which increases the gain by a factor of 5. When the LOCATE button is depressed, R459 is inserted in the emitter circuit of TR409 reducing the output stage current such that the display cannot be driven off the screen.

All the various voltages required to operate the instrument are produced by a switched mode power supply. The incoming AC supply is rectified by the rectifiers D701 to D704. For 230V operation the diodes form a conventional bridge, connecting a link across pins Z-Z for 110V operation the circuit becomes a voltage doubler. The resulting 360V DC is applied to a relaxation oscillator formed by T701 and TR703. The control circuit adjusts the mark/space ratio so that the rectified outputs remain constant against both load and mains input variations. The output from T701 drives TR703 into conduction via R717 until TR702 fires to short the drive current to earth turning off TR703. The firing of TR702 is determined by the speed at which C708 charges. If the output voltage tries to rise the charging current supplied by TR701 increases, speeding the rate of charge of C708 which in turn shortens the

conduction time of TR703 thereby tending to reduce the output voltages. The emitter current of TR703 passes through R714 and provides a degree of overload protection. Excessive emitter current in TR703 will produce a voltage which will charge C708 thus shortening the conduction time which acts to reduce the effect of the overload.

Calibration

The advanced circuit design coupled with solid state reliability will make frequent recalibration unnecessary. Before assuming that a fault condition exists, always set up the oscilloscope as outlined in the first time operation; this will eliminate any apparent faults caused by incorrect setting of the controls.

Should recalibration become desirable, all the necessary highly accurate signals are provided by the Scopex oscilloscope calibrator.

Before recalibration allow approx 20 minutes after switch on for the instrument to stabilise. The bottom cover, which gives access to all the calibration controls can be removed by sliding it backwards after removing the lower two screws located on the rear of the two wide side trims. The two top screws release the top cover. High voltages exist inside the instrument and great care must be exercised when operating the instrument with the covers removed.

Power Supplies

With the mains input at nominal i.e. 230V on the 230V tap adjust RV701 on the power supply board for +15.00 on the main printed circuit board using a digital voltmeter of $\pm 0.5\%$ or better. The other supplies should fall within $\pm 5\%$ of their nominal value.

Astigmatism

Before recalibrating the instrument the ASTIG should be correctly adjusted as this has a considerable effect on the calibration of the oscilloscope.

Apply a 2KHz approx sine wave signal to 'A' channel and adjust the amplitude to give 8 cm display height. Select 500 uS/cm and lock the display, now select DUAL with 'B' channel centred and grounded. The display will consist of almost vertical lines and a horizontal line. Adjust the FOCUS and ASTIG controls to make the horizontal and verticals equally sharp.

Vertical Amplifier Sensitivity and Position Centre

Using an accurate $50\ \Omega \div 5$ attenuator connected immediately before the $50\ \Omega$ through termination connect the 40mV square wave output from the SC1 calibrator to 'A' channel input socket. Connect the 'time mark' output to the 'ext trig' socket. Select 1mS on the SC1 and 2mV/cm, DC coupling, 'ext trig' on the 14D10, now adjust RV153 to give exactly 4 cms between the top and bottom flat portions of the waveform.

Return the vertical position control to precisely mid range and with the AC-G-DC switch at G, adjust RV101 such that the trace lies along the centre line of the graticule.

Now repeat the above procedure for 'B' channel, adjusting RV253 and RV101. Return the terminated lead to 'A' channel, select 10uS in the SC1, 1uS/cm on the 14D10 TIME/cm switch and trigger on the -ve edge. Adjust CV151 to give the squarest corner to the displayed waveform.

X/Y Adjustment

Using the attenuator and terminated lead as previously, connect the 40mV square wave output of the SC1 calibrator to 'A' channel input, select AC coupling and 2mV/cm and X/Y. Select 1mS on the SC1. Now adjust RV501 to give exactly 4 cms between the horizontal dots on the display.

Sweep Timing

Using an unterminated $50\ \Omega$ lead, connect the 500mV time marks from the SC1 calibrator to 'A' channel input socket. Select 1mS on the SC1 and set the 14D10 controls as follows: DC coupling, 200mV/cm, 1mS/cm and trig level adjusted to give a locked display. Adjust RV403 to give one mark every cm. Now pull the X5 magnifier and adjust RV404 to give one mark every 5 cms. Select 1uS/cm and apply 1uS time marks and adjust C401 located behind the large hole on the main board to give one mark per cm. Return through all the ranges to check that they remain within specification.

Attenuator Compensation

When adjusting the trimmers listed in this section, they should be set to give a flat top and square corner to the displayed waveform.

Connect the H2 head directly to the 'input sockets' of the 14D10. DO NOT USE ANY LEADS. Connect the trigger signal from the SC1 directly to the EXT TRIG socket of the 14D10. Set the 14D10 controls as follows:

'A' channel DC coupled, 2mV/cm, 1mS/cm, EXT TRIG and on the H2 head, 2mV/cm and 'set ratio'.

Now obtain a locked display.

The following table gives the correct sequence and appropriate control settings. The VOLTS/cm switch on the 14D10 and the VOLTS/cm range switch on the H2 should always be set to the same position. The 'set ratio' should be adjusted first followed by 'set input'.

<u>VOLTS/CM SWITCH</u>	<u>HEIGHT OF WAVEFORM</u>	<u>SET RATIO</u>	<u>SET INPUT</u>
2mV	4 divisions	CV10A	CV9A
5mV	4 divisions	CV8A	CV7A
10mV	4 divisions	CV6A	CV5A
20mV	4 divisions	CV4A	CV3A
200mV	4 divisions	CV2A	CV1A

All other ranges should now be checked to see that they are correct.

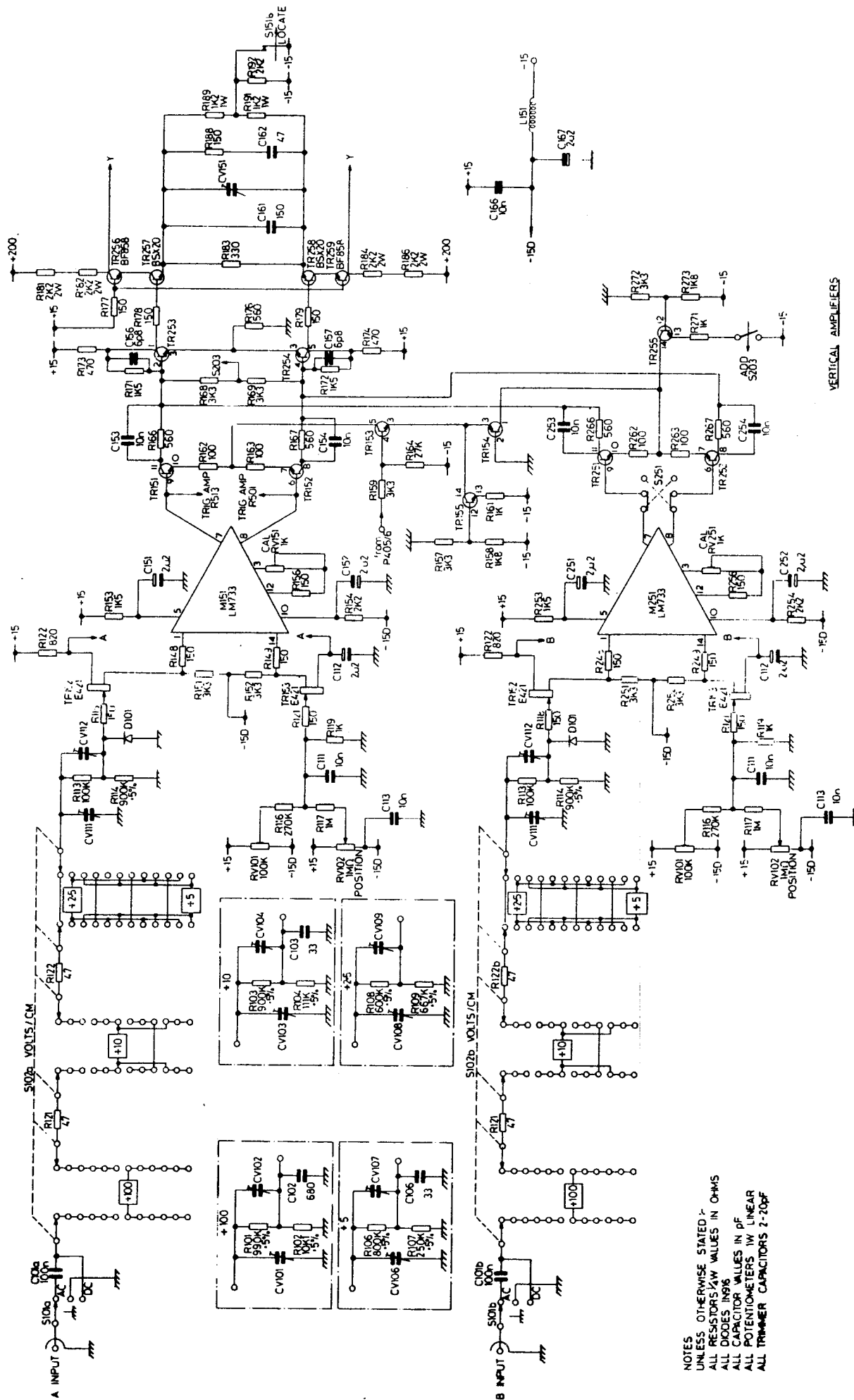
Transfer the H2 head to 'B' channel input, select DUAL and repeat the above procedure for 'B' channel attenuator.

Trigger Balance

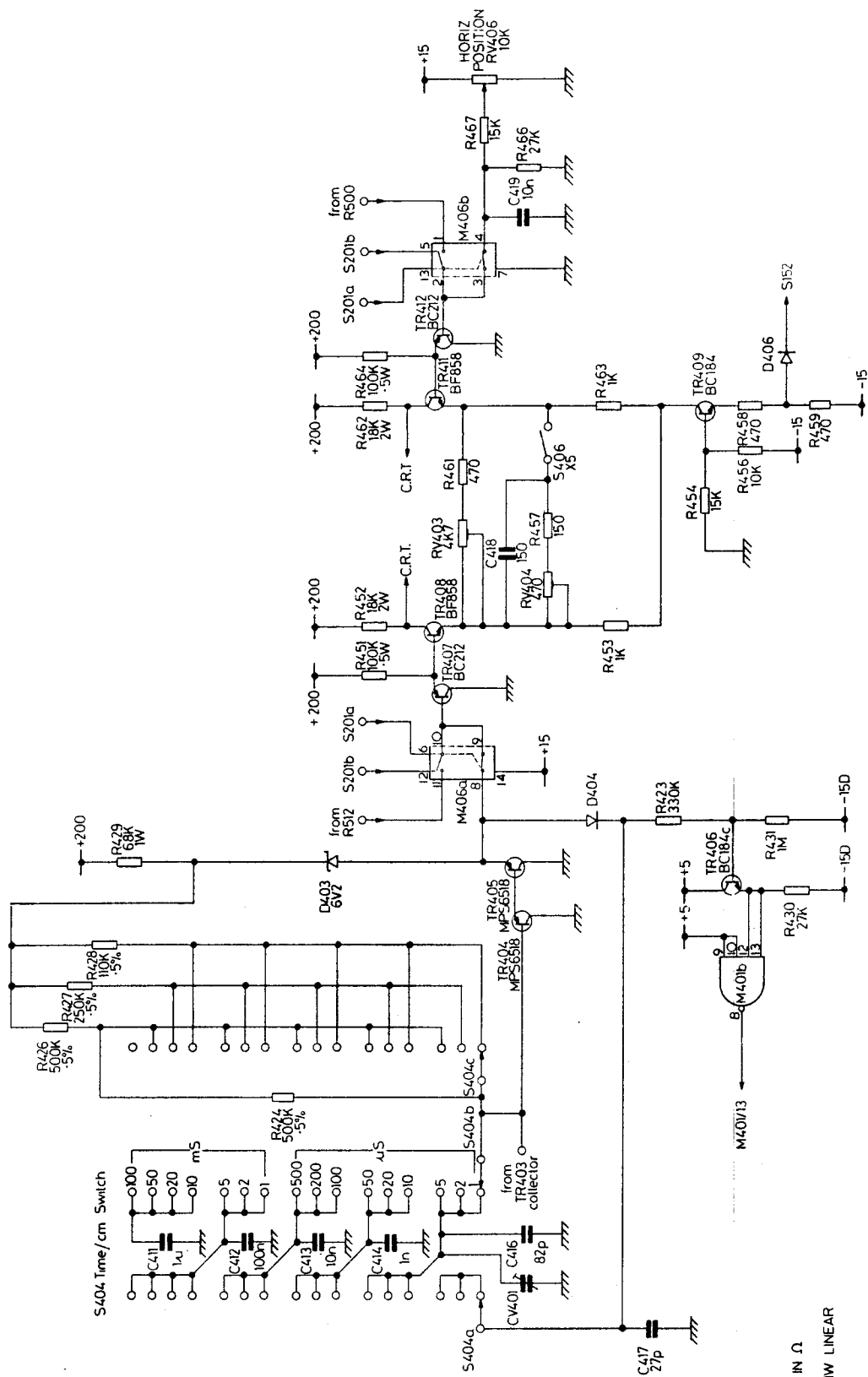
Apply approx 3KHz sine wave to 'A' channel to give a display height of 4cms, select 100 μ S/cm and adjust the TRIG LEVEL for a locked display. Switching repeatedly between + and - edge triggering, adjust RV401 so that the traces start at exactly the same level.

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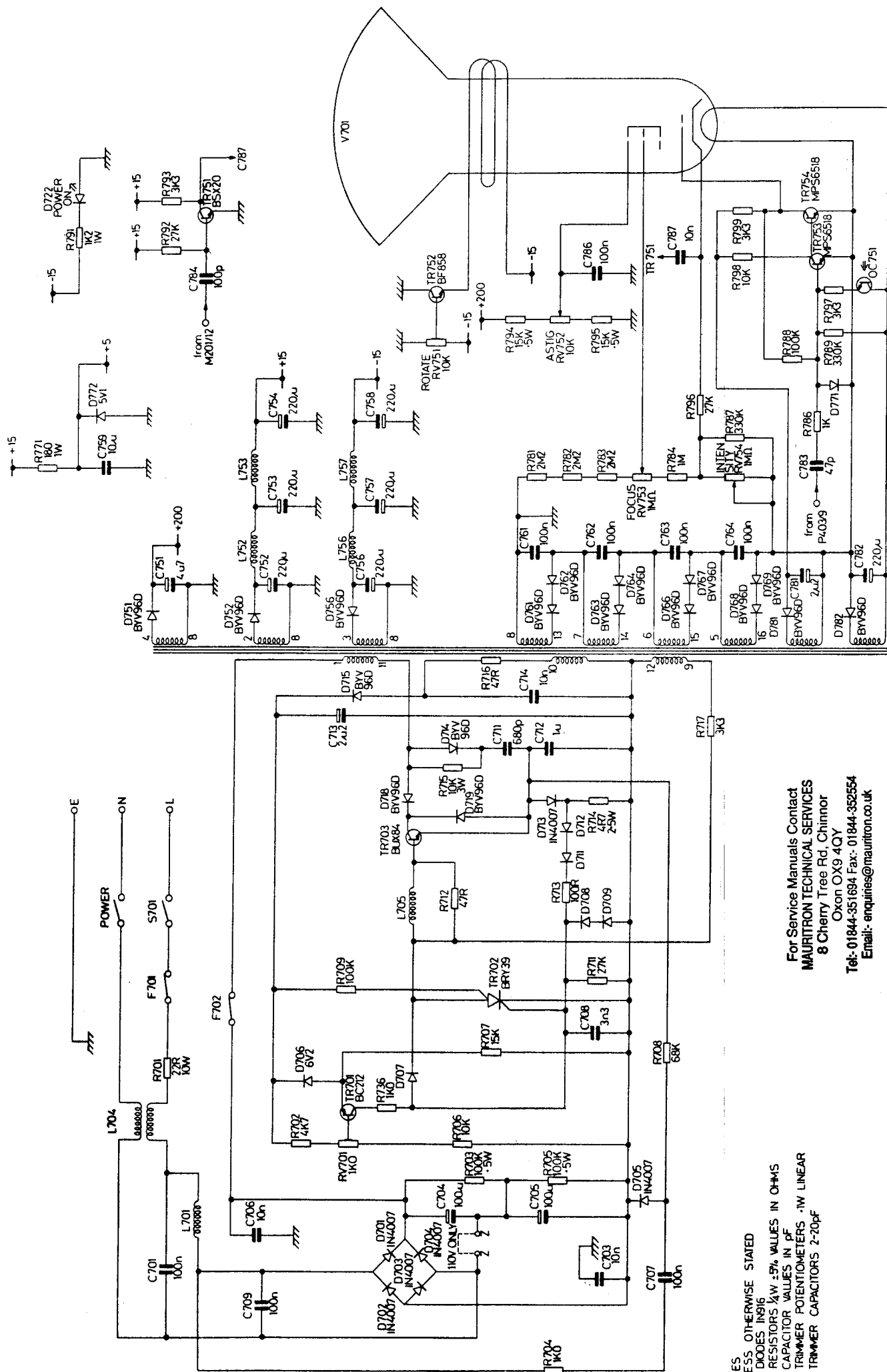
Should you have to return the instrument for service PLEASE DO NOT RETURN ACCESSORIES unless you believe they are faulty.



NOTES
UNLESS OTHERWISE STATED :-
ALL RESISTORS 1/4W VALUES IN OHMS
ALL DIODES IN 96
ALL CAPACITOR VALUES IN pF
ALL POTENTIOMETERS 1W LINEAR
ALL TRIMMER CAPACITORS 2-20pF



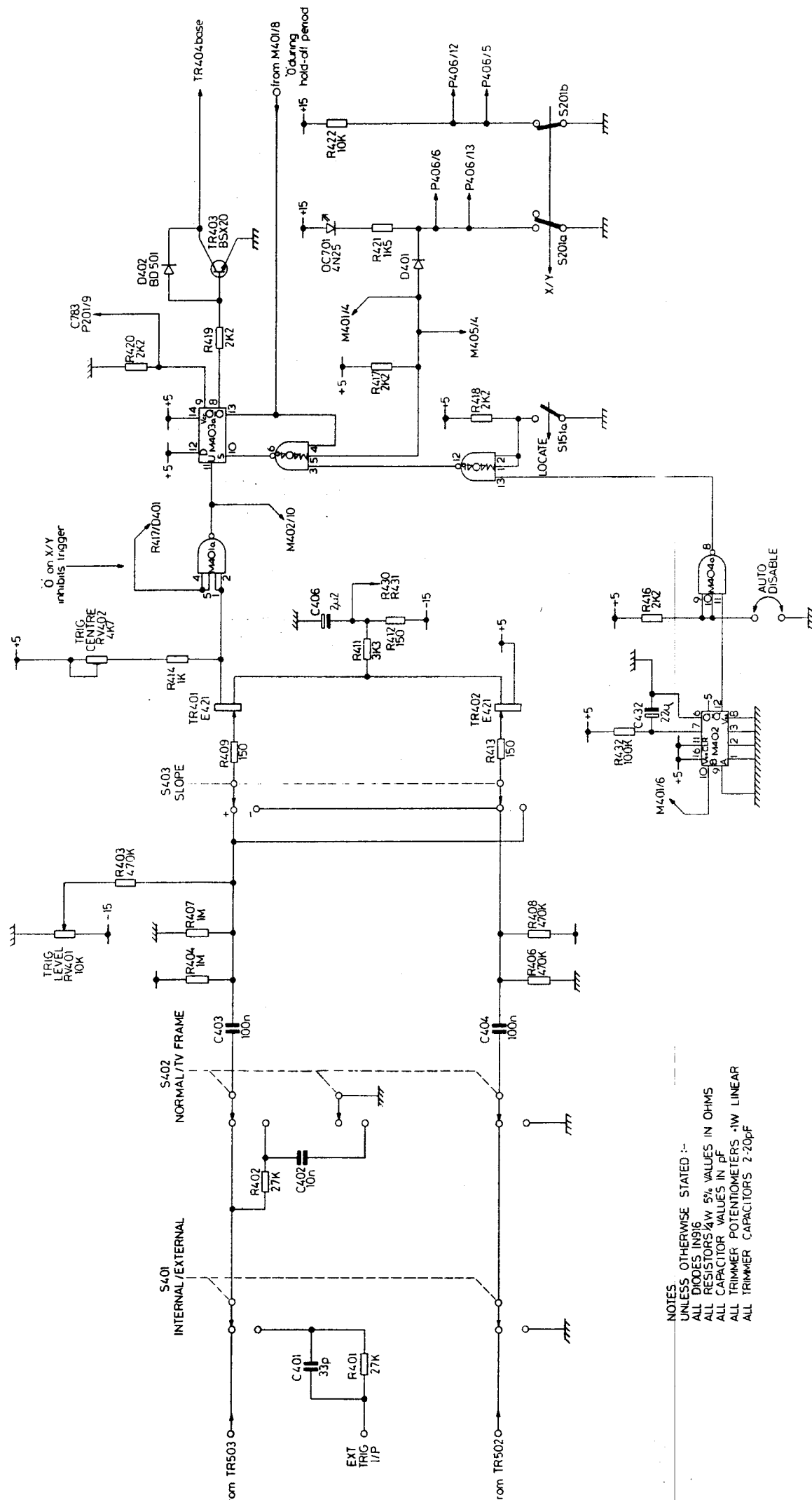
NOTES
UNLESS OTHERWISE STATED :-
ALL DIODES IN916
ALL RESISTORS 1/4W ±5% VALUES IN Ω
ALL CAPACITOR VALUES IN pF
ALL TRIMMER POTENTIOMETER .1W LINEAR
ALL TRIMMER CAPACITOR 2-20pF



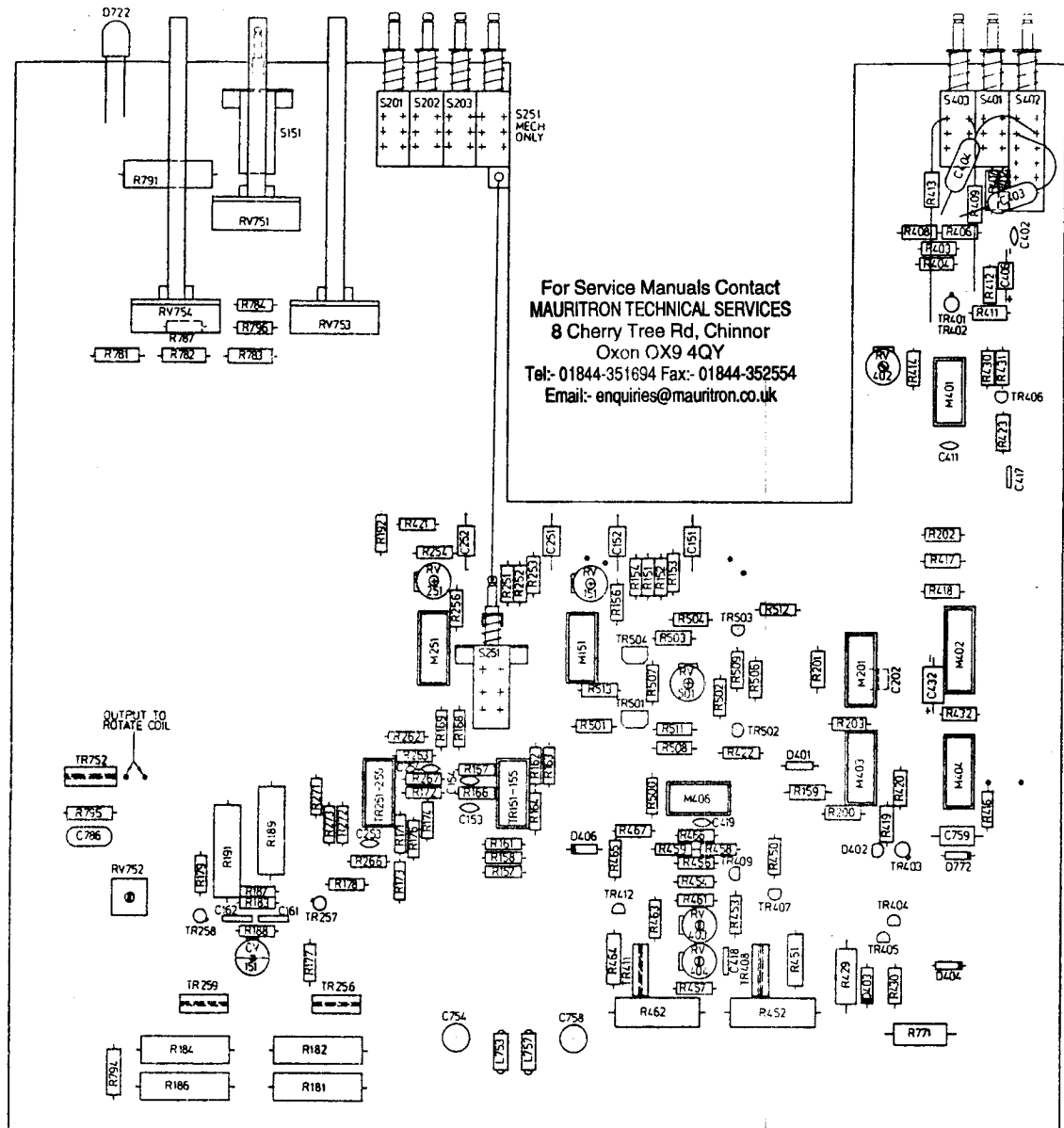
SWITCHED MODE POWER SUPPLY

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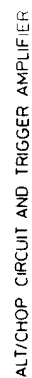
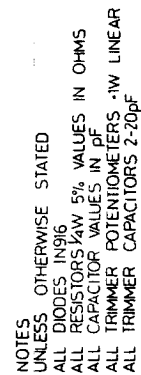


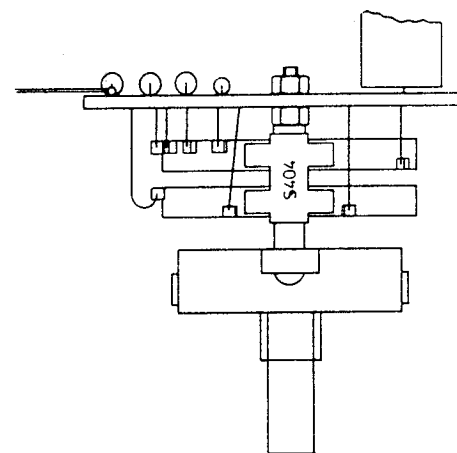
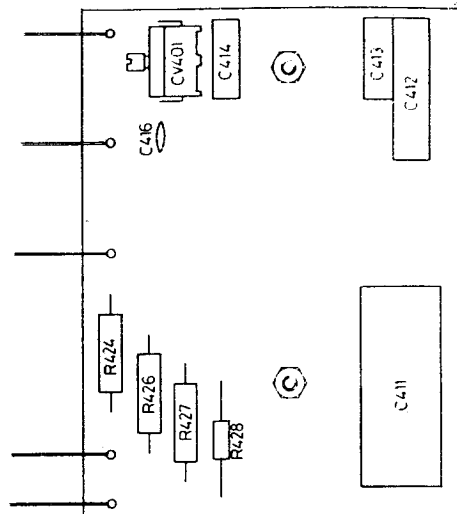
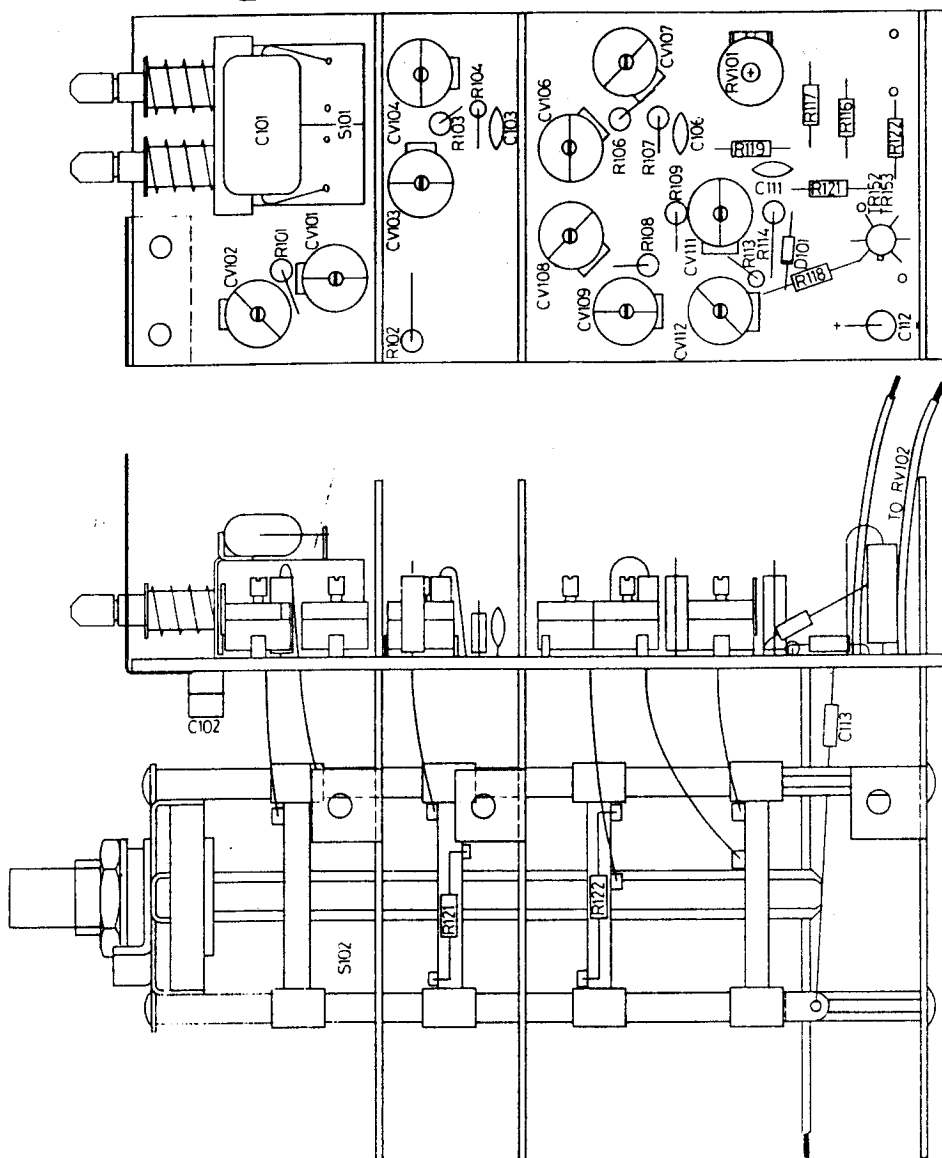
NOTES
UNLESS OTHERWISE STATED :-
ALL DIODES IN916
ALL RESISTORS 1/4W 5% VALUES IN OHMS
ALL CAPACITOR VALUES IN pF
ALL TRIMMER POTENTIOMETERS 1W LINEAR
ALL TRIMMER CAPACITORS 2-20pF



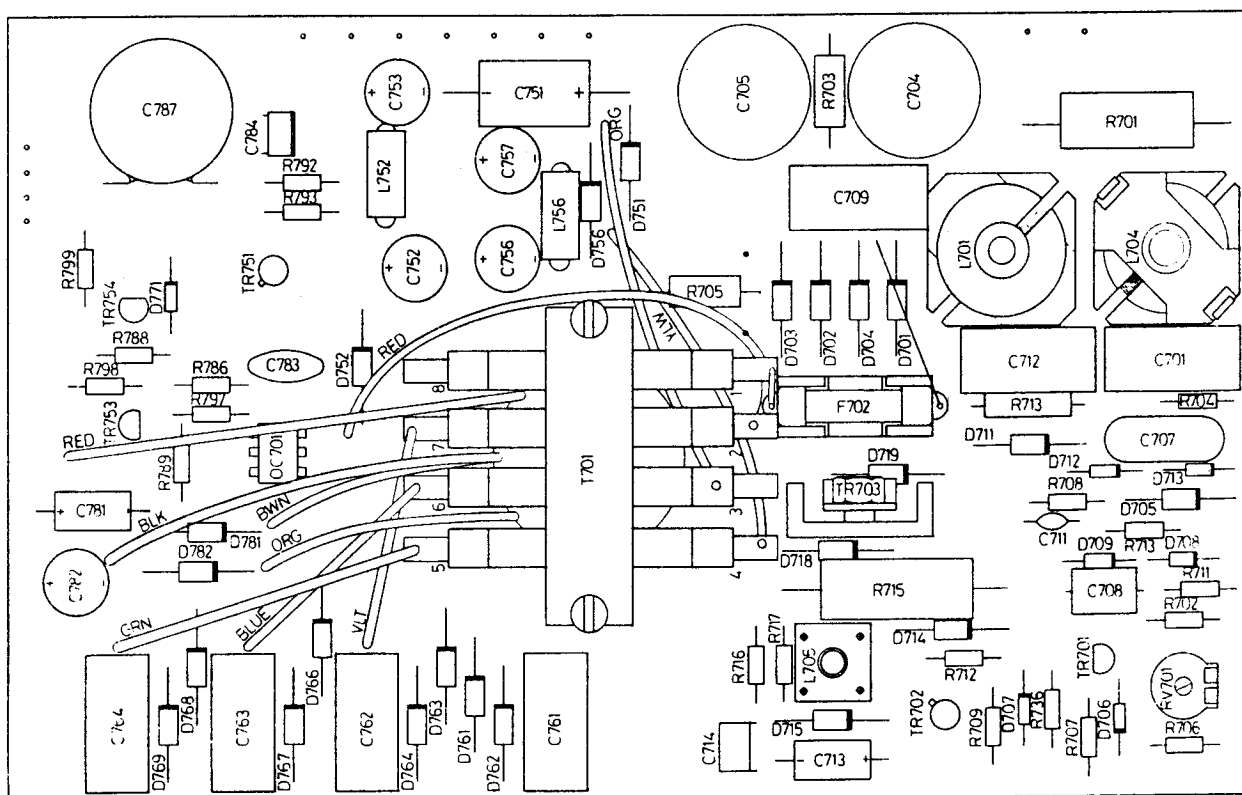
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MAIN BOARD COMPONENT LAYOUT





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PSU TIME/BASE AND ATTENUATOR COMPONENT LAYOUT

ERRATA

SCOPEX 14D10, 14D10V & 14D15

27-07-82

PLEASE NOTE THAT THE SUPPLY RAILS SHOULD BE +15v, -15v & +180v.

NOT +12 & +200 AS SHOWN ON SOME CIRCUIT DIAGRAMS.

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ERRATA

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11th May, 1983

THE SET RATIO AND SET INPUT SHOULD READ AS FOLLOWS:-

CV112A	CV111A
CV109A	CV108A
CV107A	CV106A
CV104A	CV103A
CV102A	CV101A