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WAYNE KERR

AUTOMATIC COMPONENT BRIDGE B605 AND COMPONENT ADAPTOR JU4

OPERATION & MAINTENANCE

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Automatic Component Bridge B605
Wayne Kerr
4.818 nF
L
C
R
Series
Parallel
100 Hz
1KHz
10KHz
D - Q
Power on
Bias +ve

1.0 INTRODUCTION

Automatic Component Bridge B605 gives fast, straightforward and accurate measurements of resistors, capacitors and inductors. Readout is on a transflective liquid crystal display, suitable for viewing under all ambient lighting conditions. Values are available in equivalent series or parallel terms, and are presented as four or five digits followed by the units of measurement. In addition to the very wide range of R, C and L measurements, the B605 will read the dissipation factor of capacitors and the Q of inductors. All these measurements can be made at any of three test frequencies. Self-ranging and automatic trim functions ensure error-free readout with the best available resolution.

Optional Adaptor JU4 enhances the capability of the Bridge for making a fast series of measurements such as those required in batch testing prior to assembly. It provides single-handed connection to components with radial, axial or pre-formed leads.

2.0 SPECIFICATIONS

2.1 BRIDGE B605

DISPLAY

Rear illuminated liquid crystal display (LCD) giving five digit readout with correct decimal point, units of measurement and user instructions.

FUNCTIONS

All push-button operation for :

Selection of L, C or R measurement.

Selection from 3 available test frequencies.

Readout of values in equivalent series or parallel terms.

Readout of capacitor dissipation (D) or inductor Q.

Automatic trim.

Automatic range selection/range hold.

ACCURACY

Basically 0.1% (100Hz and 1kHz measurements).
0.25% (10kHz measurements).
See table for details.

MEASUREMENT FREQUENCIES

(B605 available in two versions).
50Hz Bridges: 100Hz, 1kHz, 10kHz $\pm$0.01%
60Hz Bridges: 120Hz, 1.02kHz, 10.2kHz $\pm$0.01%

SPEED

Measurement period approx. 0.65 second

AMBIENT TEMPERATURE

Storage: -20°C to $+60^{\circ}$C
Operation: 0°C to $+50^{\circ}$C
For full accuracy: 20°C $\pm 10^{\circ}$C

POLARISATION

2V internal
Up to 50V external

For capacitors $> 2\mu$F only, rear terminal connections.

CONNECTIONS

Two tri-axial sockets on B605, with binding-post adaptors, provide for 2, 3 and 4 terminal connections. Socket for remote selection of D or Q. (See next section for JU4 details).

PROTECTION

Input circuit protected against connection of charged capacitors:

to 500V up to 2μF,
to 50V above 2μF.

a) R, C and L (Series or parallel readout)

TERM	FREQ	MIN	MAX *	ACCURACY	DISPLAY Min	DISPLAY Max
R (Q<0.1)	100Hz, 1kHz	0 10MΩ	10MΩ 100MΩ	±0.1% ±1mΩ ±1%	0.1mΩ	9900MΩ
	10kHz	0	1MΩ	±0.25% ±1mΩ		
C (D<0.1)	10kHz	0	16μF	±0.25% ±0.001pF	0.0001pF	99mF
	1kHz	0 160μF	160μF 1600μF	±0.1 % ±0.01 pF ±1%	0.001 pF	990mF
	100Hz	0 1600μF 100mF	1600μF 100mF 1F	±0.1 % ±0.1 pF ±1% ±10%	0.01 pF	9.9F
L (Q>10)	10kHz 1kHz 100Hz	0 0 0	16H 1600H 16kH	±0.25% ±0.1μH ±0.1 % ±0.1μH ±0.1 % ±1 μH	0.0001μH 0.001 μH 0.01 μH	99kH 990kH 9900kH

* For stated accuracy; above these values, accuracy is proportionally derated.

For loss resistance of a capacitor, multiply R Accuracy by $(1 + {}^{1}/_{D})$
" " " " an inductor, " " " " $(1 + Q)$

If D>0.1, multiply C Accuracy by $(1 + D)$
" Q<10, " L " " $(1 + {}^{1}/_{Q})$

b) D & Q

TERM	FREQ	DISPLAY Min	DISPLAY Max	ACCURACY †	RANGE
D	10kHz	0.0001	9900	$\pm 0.002\ (1+D^2)$	16pF - 160nF
	1kHz	0.0001	9900	$\pm 0.001\ (1+D^2)$ $\pm 0.01\ (1+D^2)$	16pF - 160μF 160μF - 1600μF
	100Hz	0.0001	9900	$\pm 0.001\ (1+D^2)$ $\pm 0.006\ (1+D^2)$ $\pm 0.06\ (1+D^2)$	160pF - 1.6mF 1.6mF - 100mF 100mF - 1F
Q	10kHz 1kHz 100Hz	0.0001	9900	±0.2 (Q + 1/Q)% ±0.1 (Q + 1/Q)% ±0.1 (Q + 1/Q)%	16μH - 1.6mH 160μH - 160H 1.6mH - 1600H

† For C/L Ranges quoted. Accuracy is derated in proportion to measured value above upper figure, and in inverse proportion to it below lower figure quoted.

AUTO-TRIM CAPABILITY	Parallel.	10kHz : Up to 5pF max. 1kHz : Up to 50pF max. 100Hz : Up to 500pF max. Lead capacitance typically removed to within 0.0002pF at 10kHz*.
	Series.	10kHz, 1kHz, 100Hz : Up to 0.3Ω max. 10kHz : Up to 5μH max. 1kHz : Up to 50μH max. 100Hz : Up to 500μH max. Lead resistance typically removed to within 0.1mΩ. Lead inductance typically removed to within 0.001μH at 10kHz*.

Additional inductance reading errors may occur at the rate of ±0.5μH for every 0.1Ω trimmed out.

Additional resistance reading errors may occur at the rate of ±0.2mΩ for every 10μH trimmed out at 1kHz.

POWER REQUIREMENT	Two models : 50Hz and 60Hz. Both are dual voltage (115/230V ±10%). Fuse rating 300mA-T (230V); 600mA-T (115V).
DIMENSIONS	Width 405mm (Approx. 16in.) Height 134mm (" 5¼in.) Depth 315mm (" 12½in.) Weight 7.4kg (Approx. 16¼ lb)

2.2 ADAPTOR JU4

FUNCTION	Fast, single-handed connection of components with radial, axial or pre-formed leads for repetitive testing. Spring-loaded jaws provide 4-terminal connections for axial-lead components.
CONNECTORS	Twin tri-axial measurement leads for connection to B605 (compatible with other Wayne Kerr equipment). Miniature jack plug lead for D-Q selection (Push button on JU4).
DIMENSIONS	Width 125mm (Approx. 5in.) Height 70mm (" 2¾in.) Depth 130mm (" 5in.) Weight 450g. (Approx. 1 lb)

*Stated trim accuracies assume stable connecting leads/jigs.

3.0 OPERATING INSTRUCTIONS

3.1 POWER CONNECTION

Check that the rear switch with reversible locking plate is set correctly (115 or 230V) and that the appropriate fuse is fitted :

230 V	300mA-T	(20mm to B.S.4265 or I.E.C.127)
115 V	600mA-T	(" " " " " " ")

B605 instruments are supplied either for 50Hz or for 60Hz operation, the two models generating different measurement frequencies, although both versions are dual-voltage. Operation from supplies of the wrong frequency may cause reading variations. Wire the free end of the power lead as follows :-

Yellow/Green	to	Earth (Ground)
Brown	to	Live
Blue	to	Neutral

If the plug is fused, a 3-amp fuse should be fitted. The B605 is not suitable for battery operation.

3.2 MEASUREMENT CONNECTIONS

3.2.1 The B605 is supplied with one pair of screened clip leads (D10065A) and one pair of binding post adaptors. The latter convert the tri-axial panel sockets into two-terminal connections for direct screw-terminal attachment of component wires or the use of 4-mm plugs. Optional alternative connections available are :-

Component Adaptor JU4 (described later)

Low Capacity Clip Leads D10642B (for precise measurements of small-value capacitors)

Low Impedance Clip Leads D15466 (similar to D10065A) but for 4-terminal measurements.

Kelvin Clip Leads (as illustrated) D15122/D15123 (for 4-terminal connections)

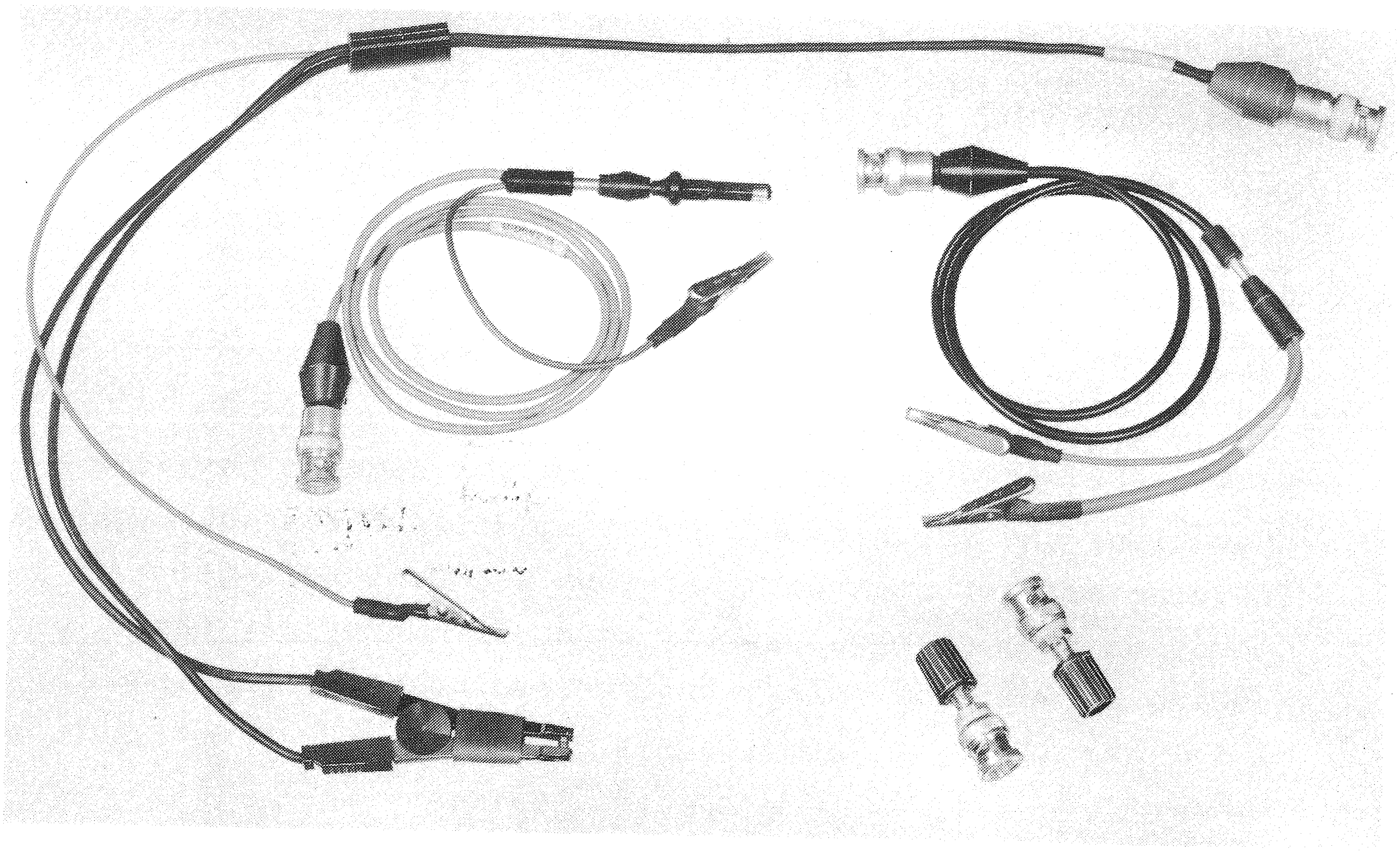

FIG. 1 MEASUREMENT LEADS

TOP : (1 OF 2) KELVIN CLIP LEADS D15122/D15123
LEFT : (1 OF 2) LOW CAPACITY CLIP LEADS D10642B
RIGHT : (1 OF 2) SCREENED CLIP LEADS D10065A
BOTTOM RIGHT : BINDING POST ADAPTORS

3.2.2 The specialised uses of these alternative leads will become clear at various stages in the operating instructions. However, for the vast majority of measurements for which the B605 is intended, simple two-terminal connections are entirely satisfactory since the Bridge automatically corrects for unwanted series or shunt impedances, as appropriate.

3.2.3. Connect the chosen leads (or binding posts, or Adaptor JU4) to the tri-axial measurement sockets.

3.3 TRIMMING

3.3.1 During operation of the Bridge, if no trimming operation has been completed since switch-on, the display may show 'Trim open circuit' or 'Trim short circuit'. Which one appears is dependent on the value of the component connected, <u>not</u> on the selection of Series or Parallel readout. If only one (open <u>or</u> short circuit) trimming operation is to be performed, the settings of all buttons is of no consequence. For O/C apply 3.3.2a, for S/C apply 3.3.2b. However, if various values are to be measured, and both trimming operations are to be performed, first release Range Hold* and then apply 3.3.2a and 3.3.2b.

3.3.2a With the leads disposed as they will be used for a measurement, but with no component connected, press TRIM. Wait for 'Trim open circuit' to be extinguished before proceeding.

3.3.2b If leads D10065A are used, clip the two red leads together. With other leads, clip the measurement connectors on to a solid conductor (e.g. a metal plate) leaving the green (guard) leads unconnected. For four-terminal measurements using leads D15466, connect the two red and two black clips to the plate. If JU4 is in use, use a heavy-gauge wire. Press TRIM and wait for 'Trim short circuit' to be extinguished before removing the short circuit.

3.3.3 In each of the foregoing operations the Bridge makes a series of twelve measurements and, from these, stores information to provide automatic correction for stray capacitance and/or for series resistance and inductance. The display during trimming will depend on the readout selected for

*On early instruments, this button is engraved simply 'Range'.

measurement. For example, Series R will go to 000 on short-circuit trim whereas Parallel R will not. There is no need to change the type of readout for trimming unless it is desired to see the process.

3.3.4 Should either trim instruction persist, this indicates that the value of 'strays' exceeds the trim capability of the Bridge. In this instance no value is stored and no correction applied.

3.3.5 The Bridge is now ready for making measurements and the stored value(s) for trim correction will remain valid until either the leads are moved or the instrument is switched off.

3.3.6 Omission of the Trimming operation will not cause serious errors, particularly for components between 100Ω and 10 kΩ. The B605 will not produce a Trim instruction in this band, although any previously stored trim corrections will be applied.

3.4 BASIC COMPONENT MEASUREMENTS

3.4.1 Select L, C or R to suit the component to be tested.

3.4.2 Select the required measurement frequency (100 Hz, 1 kHz or 10 kHz on 50 Hz instruments; 120 Hz, 1.02 kHz or 10.2 kHz on 60 Hz instruments). Normally, 100/120 Hz will be used for electrolytic and large-value inductors, 1 kHz for general-purpose measurements and 10 kHz for small-value capacitors and inductors.

3.4.3 Select Series or Parallel. At a given frequency, any complex impedance can be represented in equivalent series or parallel combinations of resistance and reactance: the B605 will compute either of these and produce the appropriate values for display. As a general guide, it is usual to evaluate impedances below about 1 kΩ in series terms and values above this in parallel terms. At 1 kHz, the rough guide figures and normal readout terms for all three types of component can be taken as:

R	Series up to 1 kΩ, parallel above this
C	Parallel up to 0.1 μF, series above this
L	Series up to 0.1 H, parallel above this.

3.4.4 Check that the Range Hold button* is "out".

3.4.5 Connect the component to be tested. If the clip leads (D10065A) are used, connect the component between the two red leads, leaving the green leads disconnected.

3.4.6 At this stage the Bridge display should show the component value with the best resolution available. Except near the extreme limits of the Bridge's overall coverage, the display will be four or five digits, with the units of measurement.

3.4.7 If the word "Error" appears on the display, check the lead connections and make sure that the L/C/R button pressed is appropriate for the type of component connected.

3.4.8 If a Trim instruction appears, refer back to section 3.3.

3.4.9 Before the component is removed, three further options are available.
Firstly, the quality of a capacitor or coil can be checked, as described in section 3.5 (D & Q measurements).
Secondly, loss resistance can be measured, as described in section 3.6.
Thirdly, the Range Hold* button can be pressed to latch in, keeping the B605 locked to this particular range. Further information on this facility is in section 3.9.

*On early instruments, this button is engraved simply 'Range'.

3.5 D & Q MEASUREMENTS

3.5.1 D, or tan δ , the dissipation factor of a capacitor, can be obtained directly by pressing the D-Q button while a C value is displayed.

3.5.2 The Q factor of a coil can be obtained directly by pressing the D-Q button while an L value is displayed.

3.5.3 Pressing the D-Q button during R measurements has no effect.

3.5.4 The D-Q button is duplicated on JU4. When using the Adaptor, either this button or the one on the Bridge can be used.

3.5.5 Q is computed by the Bridge from 1/tanδ . Therefore with low-loss coils, as tanδ becomes very small, the high Q reading is likely to fluctuate. It follows that in these circumstances the accuracy and resolution are limited. (See Specification).

3.5.6 Because both the inductance and the effective loss resistance of iron-cored coils vary with the frequency and level of the test signal, and with any d.c. passed (see section 3.14), the measured Q value will be subject to variations and these can be substantial.

3.5.7 Readout of D or Q is unaffected by the selection of Series or Parallel display for the major term.

3.6 LOSS RESISTANCE MEASUREMENTS

3.6.1 Unless Range Hold is latched in, the Bridge always changes to the range providing the best resolution for the major term of the component under test. This particular range can be used to obtain an indication of the loss term of a capacitor or coil.

3.6.2 Select Series or Parallel (see also section 3.4.3) according to the readout required for the minor term. With electrolytic capacitors it is usual to express the loss term as series resistance. For small capacitors, parallel resistance may be required. With small value inductors, series resistance is the usual loss measurement but, for large audio components, parallel resistance can be obtained.

3.6.3 Measure C or L at the required frequency. Do not change frequency or change from Series to Parallel (or vice versa) between measurement of C/L and measurement of the loss term, since the value of the major term also depends on these two factors.

3.6.4 Press R. Low-loss capacitors or inductors, with Series readout selected, will produce a very small R reading. With parallel readout the Bridge computes the R value from a fraction whose denominator may approach zero. Consequently the large reading is likely to show considerable fluctuation. In all instances, the resolution available exceeds the specified accuracy by an adequate amount.

3.6.5 It is not possible to use the Range Hold facility to increase the resolution for loss term measurements. Measurement of the R value of capacitors or coils on a range other than that selected by the Bridge for the major (C/L) term will cause overloading, and Range Error will be displayed.

3.6.6 The B605 is not suitable for measuring the very small reactive term associated with most types of resistor. In particular, when measuring resistors, disconnect any bias. If C is selected while a resistor is connected, the resultant direct current into the Bridge would cause measurement errors.

3.7 ON CHANGING FREQUENCY

If the frequency of the test signal is changed, re-trimming is not necessary. However, with C and L measurements, for best resolution or to prevent overloading, a change of range will usually be required. Provided that the Range Hold button is 'out', the B605 will make the necessary change automatically. Should the button be latched in, a change of frequency will probably cause Range Error to be displayed and the Range Hold button should be released.

3.8 2, 3 AND 4-TERMINAL CONNECTIONS

3.8.1 Most component measurements made on the B605 will use 2-terminal connections. Whatever leads or adaptors are used, the component is effectively connected between the inners of the two tri-axial panel sockets (1 and 2 in Fig. 2). If unscreened leads are used, their length should not exceed about 15 cm. Longer leads should be separately screened, with both braids connected to one or other of the outers of the panel sockets (5 or 6 in the illustration). If the component has a large area of metal not connected to either of its measured terminals (e.g. a screen or core), this should be separately connected to guard (5 or 6 - the green clip lead).

3.8.2 If the component has a relatively large, unscreened metal surface which is connected to one of its measured terminals (e.g. an air-spaced tuning capacitor), this should be connected to the right-hand (bias +ve) socket (2 in Fig. 2). Always keep inductors (air-cored or iron-cored) clear of metal objects during measurement.

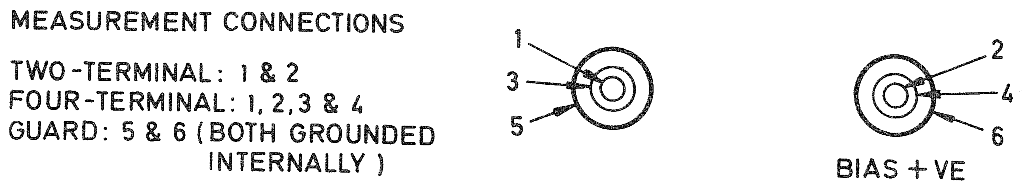

FIG. 2 TRIAXIAL CONNECTIONS

3.8.3 A component can be measured in the presence of shunt elements even when the impedance of these is much smaller than the value of the component under test. This is possible by connecting one side of all such elements to the third terminal of the Bridge, so neutralising their effect. In Fig. 3, Zu can be measured in the presence of Zd and Zs simply by connecting their common line to the guard line of the Bridge (5 or 6 in Fig. 2; the green wire on clip leads D10065A). Not only does this remove the effect of lead capacitance, it allows the measurement of components whilst they remain connected in a circuit.

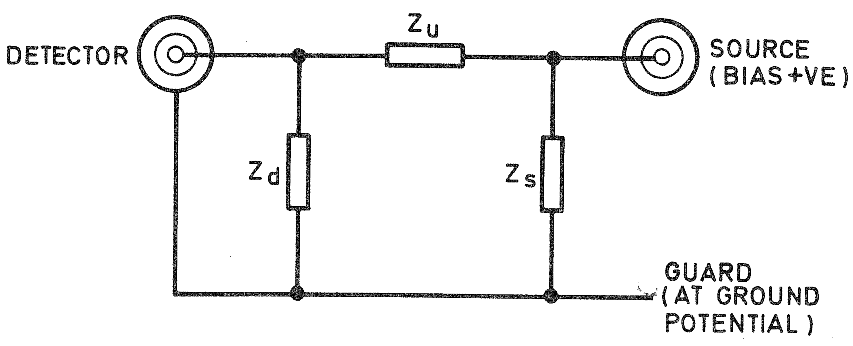

FIG. 3 IN-CIRCUIT MEASUREMENTS

The value of Zd (i.e. R, ωL or $1/\omega C$) can be as low as

2Ω at 100 Hz 20Ω at 1 kHz 200Ω at 10 kHz

without accuracy being affected by more than 1%. The minimum value of Zs depends on the value of Zu and is shown in the graph - Fig. 4.

When Zd and Zs are connected simultaneously, an additional error term occurs due to the resistance of the guard lead(Rg). This error becomes significant when Zu is large compared to Zd and Zs, and is given by

$$\text{Error } (\%) = 100\text{x} \frac{Zu}{Zs \times Zd} \times Rg$$

Rg may be minimised by connecting both guard wires simultaneously, in which case typical values are 0.015Ω for a pair of screened leads D10065A or 0.0085Ω for a pair of low impedance leads D15466.

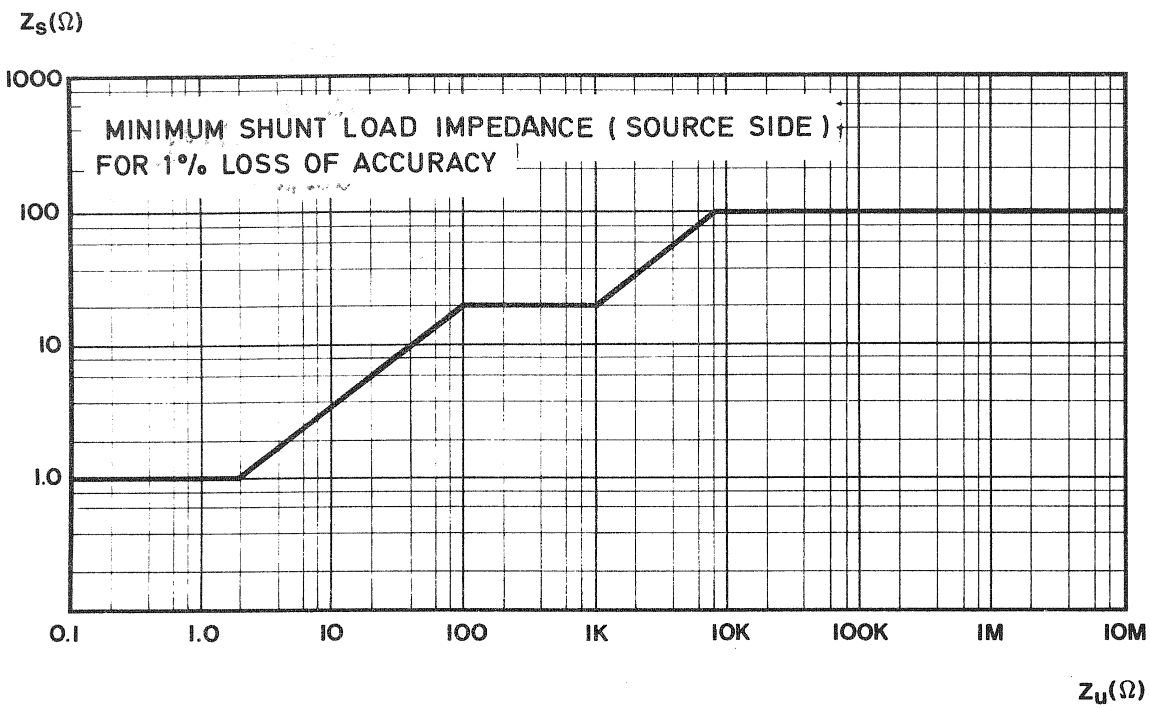

FIG. 4 PERMISSIBLE SOURCE LOADING

3.8.4 Use of four-terminal connections allows the bridge to compensate automatically for small variations in lead and contact resistance. The Kelvin Clip Leads (D15122/D15123) provide four-terminal connections to one pair of measurement points: separate connections are available from the Low Impedance Clip Leads D15466. Their use is illustrated in Fig. 5 (the red and black leads can be regarded as interchangeable but no connection should be made to the green leads). The Bridge measures the impedance (Z) between the two inner clips: for trimming, the Unknown is replaced by a heavy conductor and these two clips should be moved in very close to one another.

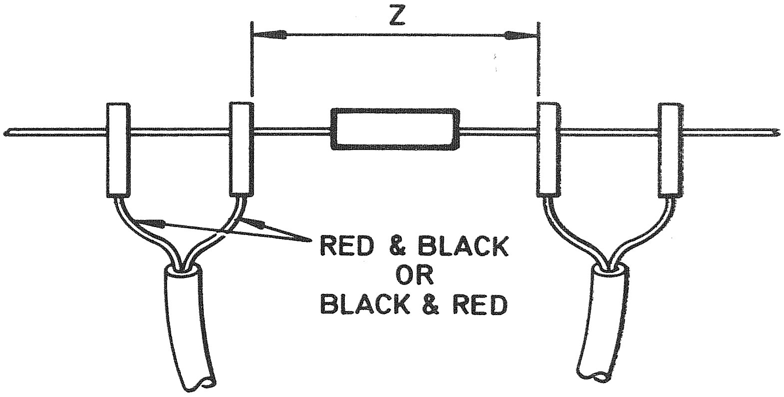

FIG. 5 FOUR-TERMINAL CONNECTIONS

3.9 RANGE HOLD

3.9.1 Pressing the latching Range Hold button while measuring any component will lock the Bridge to that particular range. This allows faster repetitive measurements to be made on batches of components, such as in Goods Inwards departments. In this situation it is normal for Range Error to show during the change-over of connections from one component to the next.

3.9.2 The Range Hold facility can also be used to make measurements at a different signal level from normal, by operating on an alternative range. This procedure is described in section 3.12 (Semiconductor Junction Capacitance).

3.10 MEASURING ELECTROLYTIC CAPACITORS

3.10.1 A low-impedance bias injection circuit provides for the rapid charging of electrolytic capacitors under test. A fixed 2V is available from an internal source, or up to 50V can be used from an external supply. In either case the polarisation appears at the measurement terminals (+ve on the right).

3.10.2 To obtain 2V polarisation, link the red central and right-hand terminals at the rear (see Fig. 6).

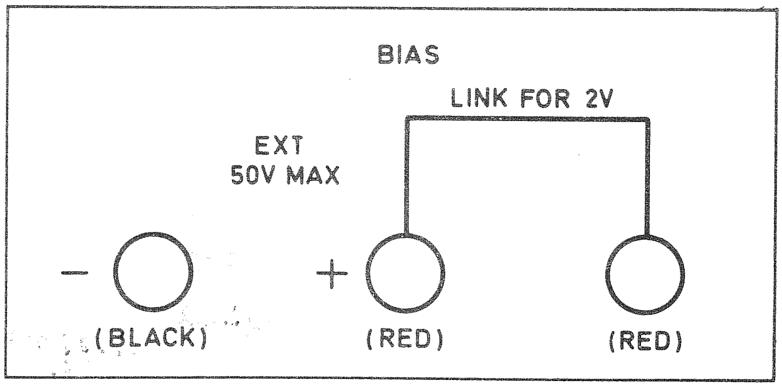

FIG. 6 POLARISATION TERMINALS

3.10.3 To obtain 0-50V polarisation, remove any link from the red terminals and apply up to 50V (as required) with the +ve connection to the central (red) rear terminal and the -ve to the left-hand (black) rear terminal. IMPORTANT: This black terminal is connected internally to supply earth.

3.10.4 The polarising bias appears only when C is selected and the Bridge is operating on ranges 1 to 4 (this corresponds to capacitors exceeding 1.6μF, measured at 100 Hz). On these C ranges, any bias connected will still appear at the measurement terminals when D-Q is selected, but will NOT appear if R is selected (for loss term measurement).

3.10.5 It must be borne in mind that the value of an electrolytic capacitor can change appreciably during charging, as the electrolyte re-forms. The charging current from the bridge is internally limited to 100 mA and the measurement circuits will not operate until the leakage current falls below about 2 mA. Total charging time can normally be taken as approximately 20 m.sec. per mF-volt (product of unknown C and bias voltage). For capacitors up to some 10-20 mF it is usually sufficient to pause before taking a reading.

3.10.6 With capacitors above 10-20 mF it may take several minutes for the leakage to fall below 2 mA (this current is outside the specification of most capacitors above 10 mF when operated at full rated voltage). For these larger values the bias voltage must be kept well below the maximum rating to avoid excessive leakage and precharging should be used to minimise the measurement delay. If leakage current measurements are required, these should be made during the pre-charging operation.

3.10.7 If capacitors are polarised before measurement, observe these limits:

500V max. up to 2μF.
50V max. above 2μF.

These voltage figures refer to charged capacitors. DO NOT make any d.c. supply connections to the measurement terminals except via a resistor, as described in 3.12.

3.10.8 Note that when pre-charging of larger capacitors has been used, it is not absolutely necessary to apply bias during measurement. If the charged capacitor is connected directly to the bridge terminals it will discharge quite slowly through the bridge circuits, and this method of operation is to be preferred for capacitors of 100 mF and above.

3.10.9 If capacitors smaller than 1.6μF are to be measured and polarisation is required, this must be applied in the same way as for semiconductors (see section 3.12).

3.11 MEASURING SMALL-VALUE CAPACITORS

For the most accurate results when measuring small-value capacitors, avoid movement of the test leads between a Trim operation and subsequent measurements. The JU4 provides a stable connection system. Also, special low-capacity clip leads (D10642B) are available as an optional extra for use with the B605.

3.12 SEMICONDUCTOR JUNCTION CAPACITANCE

3.12.1 Care is needed in making measurements of semiconductor junction capacitance. Values tend to lie at some tens or hundreds of pF which would cause the Bridge to auto-range to a setting giving an unacceptably high level of test signal. This can be overcome as follows:

3.12.2
a) Connect a resistor of any value between 15 kΩ and 80 kΩ.
b) Select R.
c) Release Range Hold (out).
d) Select 10 kHz.
e) Press Range Hold.
f) Remove the resistor.
g) Select C.

3.12.3 The Bridge is now held on range 6, generating only about 50 mV. On this range, any bias connected at the rear panel does not appear at the measurement terminals. To bias the semiconductor, use the arrangement shown in Fig. 7.

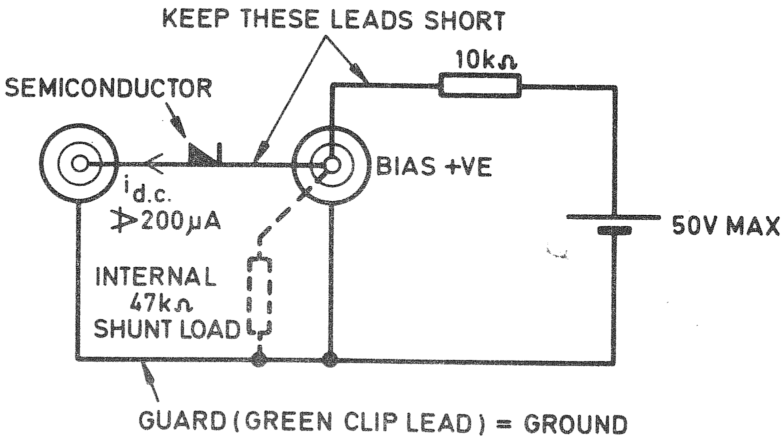

FIG. 7 BIASING SEMICONDUCTORS

3.12.4 Note that the voltage appearing across the semiconductor (or electrolytic capacitor) is approximately 80% of the supply voltage, due to the presence of a 47 kΩ shunt path within the Bridge.

3.12.5 Whilst using the Bridge in this non-standard mode (held on range 6), Range Error may be displayed and can be regarded as an indication of reduced accuracy and resolution.

3.13 MEASURING SMALL-VALUE INDUCTORS

3.13.1 To obtain the best accuracy, particular care must be taken when measuring small-value inductors. During trimming, a substantial conductor - such as a metal plate, should be used as the short circuit. Leads should not be moved between trimming and measurement. The Adaptor JU4 (see section 3.18) provides a stable connection system.

3.13.2 Small-value inductors will normally be measured at 10 kHz with a series readout. It must be appreciated that if an inductor is measured at a frequency much lower than that for which it is designed (e.g. an h.f. choke tested at a.f.) it will tend to behave as an inductive resistor. In these circumstances the measurement accuracy is widened by the factor (1 + 1/Q). The value of this factor can be determined by using the D-Q facility.

3.13.3 Air-cored coils are particularly susceptible to hum pick-up. For this reason, keep them well clear of mains transformers and, wherever possible, measure at 10 kHz or 1 kHz. Tests at 100 Hz may be marred by noise.

3.14 MEASURING IRON-CORED INDUCTORS

3.14.1 Ferrite-cored coils would usually be measured at 1 kHz, using Series or Parallel readout. Larger audio inductors, with laminated cores, are normally checked at 100 Hz with Parallel readout. Where core materials can be damaged by excessive magnetisation (some tape heads and microphone transformers) check before connection that the test signal level is acceptable (see Measurement Conditions, para. 3.15).

3.14.2 The effective value of all iron-cored inductors can vary widely with the magnetisation. Ideally, they should be measured at the frequency of use, with the same a.c. and d.c. levels as apply in use. However, valuable results - especially comparative values - can usually be obtained by passing a direct current through the inductor whilst under test. The essential requirements are to prevent this current entering the Bridge measurement circuits and to minimise the effect of the d.c. supply components on the measured value. Various arrangements are possible: the simplest is shown in Fig. 8.

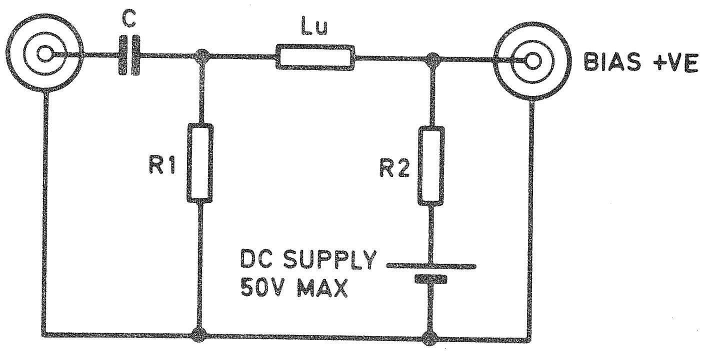

FIG. 8 INDUCTORS PASSING D.C.

3.14.3 The direct current through the inductor is also passed by resistors R1 and R2, which must have an adequate wattage rating. On the other hand, measurement errors will arise if the resistor values are made too low. For 1% accuracy the minimum values for C and R1, dependent on the frequency in use, are as follows:

100 Hz	C = 16000μF	R1 = 10Ω
1 kHz	C = 1000μF	R1 = 10Ω
10 kHz	C = 100μF	R1 = 200Ω

The minimum value for R2 can be found from Fig. 4 (section 3.8) where $Zu = \sqrt{\{Ru^2 + (2\pi fLu)^2\}}$ if Lu has significant resistance

where R_u = resistance of unknown (ohms)

f = frequency of test signal (Hz)

and L_u = inductance of unknown (Henrys)

3.14.4 The capacitor must have $D<0.5$ at the measurement frequency. This demands a high-grade aluminium electrolytic at 1 kHz and a high-grade tantalum or plastic film capacitor at 10 kHz. There is no advantage in increasing the value of C at 1 kHz, but at 100 Hz it may be increased to 100,000µF with R1 = 1Ω if suitable components are available.

3.14.5 The Bridge should be trimmed prior to measurement with all components connected and Lu replaced by a short-circuit. The shunting effect of R1 and R2 in a given measurement can easily be assessed by measuring with zero d.c. current and then noting the change when R1 and R2 are disconnected.

3.15 MEASUREMENT CONDITIONS

The nominal value of the test current or voltage depends on the impedance range selected by the Bridge. This value is shown in the table, for each range, together with the corresponding R, C and L coverage applicable at each of the three measurement frequencies. It must be stressed that the current and voltage values are given only as a guide. Considerable variations are to be expected, especially noticeable on Ranges 4 and 5. The source impedance is 1000 ohms resistive: thus the reduction in test signal level will be less for C and L measurements than for R measurements.

RANGE	NOMINAL LEVEL	RESISTANCE (100Hz, 1kHz & 10kHz)	CAPACITANCE			INDUCTANCE		
			100Hz	1kHz	10kHz	100Hz	1kHz	10kHz
1	5mA	<1Ω	>1600μF	>160μF	>16μF	<1.6mH	<160μH	<16μH
2	500μA	1-10Ω	160-1600μF	16-160μF	1.6-16μF	1.6-16mH	160-1600μH	16-160μH
3	50μA	10-100Ω	16-160μF	1.6-16μF	0.16-1.6μF	16.160mH	1.6-16mH	160-1600μH
4	50μA*	100-1000Ω	1.6-16μF	0.16-1.6μF	16-160nF	160-1600mH	16-160mH	1.6-16mH
5	50mV*	1-10kΩ	0.16-1.6μF	16-160nF	1.6-16nF	1.6-16H	160-1600mH	16-160mH
6	50mV	10-100kΩ	16-160nF	1.6-16nF	160-1600pF	16-160H	1.6-16H	160-1600mH
7	500mV	100k-1MΩ	1.6-16nF	160-1600pF	16-160pF	160-1600H	16-160H	1.6-16H
8	5V	>1MΩ	<1.6nF	<160pF	<16pF	>1600H	>160H	>16H

* See text (3.15)

3.16 DISPLAY CHARACTERISTICS

3.16.1 All values displayed by the B605 are derived by internal computation. Some of these computations may involve denominators whose value approaches zero, giving rise to large, unstable results. Also, only certain combinations of push-buttons will produce useful and meaningful results for a given component. It is not practicable to arrange for the display to be blanked for all invalid situations, but Range Error indications are supplemented by total or partial blanking in some circumstances. A minor term, for example, may be shown as only 1, 2, 3 or 4 significant figures, sometimes followed by zeros to make the magnitude correct. Such restriction of the readout is a design feature and, in normal circumstances, not a fault condition.

3.16.2 The B605 has an inductance measurement capability extending to the uncommon value of 9,900 kH. Full accuracy is maintained up to 16 kH. However, it should be noted that above 9,999 H the units of the display appear as Hk.

3.16.3 The transflective liquid crystal display embodies rear illumination, giving a clear readout under all conditions of ambient lighting.

3.17 RENEWING DISPLAY LAMPS

3.17.1 To obtain access to the interior of the instrument remove four screws from the underside and slide the cover off to the rear.

WARNING: The front of the display is polaroid. It is normally protected and care must be taken not to scratch the face while the assembly is handled.

3.17.2 Free the display bracket by removing two screws from the underside of the case. Disconnect PL.L from the Switch Board. Take care not to disturb the adhesion of the escutcheon. Disengage the Display Board from its four corner nylon pillars by compressing these and remove the board. Renew the failed lamps (12 volt, 2 watt, Vitality MES 987).

3.17.3 Re-fit the board on its four pillars and replace the assembly, making sure the Power On LED comes through the panel. Before tightening the bracket screws, ensure that the liquid crystal display clears the perspex panel by 1/16 inch. Re-fit PL.L, pivot down its plug retainer and check that SK.K is correctly fitted.

3.17.4 Replace the instrument cover, from the rear, and re-fit the four screws.

3.18 ADAPTOR JU4

3.18.1 Connect the two screened leads from JU4 to the triaxial measurement sockets of the Bridge, with the lead marked red to Bias +VE. If D or Q readings are to be taken, also connect the miniature jack plug lead.

3.18.2 Components with radial or pre-formed leads are connected by pressing one lead into each of the in-line troughs on top of the JU4. These provide two-terminal connections.

3.18.3 Axial-wired components are connected by depressing the platform to open the spring-loaded jaws (a single-handed operation). These provide four-terminal connections.

3.18.4 Any bias called up on the B605 rear panel will appear (on the appropriate C ranges) at the right-hand trough connections and on the right-hand jaws of JU4.

3.18.5 D or Q measurements are made either by pressing the D-Q button on the Bridge, or by pressing the button on the top of the Adaptor.

3.18.6 Use of JU4 is particularly valuable when measuring numbers of small-value inductors or capacitors. The consistent geometry of the measurement connections eliminates the errors that can arise with flying leads.

4.1 MICROPROCESSOR CONTROL

All functions of the bridge are under the direct control of a microprocessor (IC 101, Figs. 23/25). Each automatic cycle of operations includes an interrogation of the push-button settings - the buttons do not operate directly on the measurement circuits. The MPU then controls these circuits to obtain comparative voltages for the Unknown and Standard impedances at the selected frequency. By resolving these voltages into orthogonal components, and subsequent computation, the selected type of readout information is used to update the liquid crystal display. The computation can derive the L, C or R value of equivalent series or parallel circuits, or the ratios tan δ or Q. Trim and ranging are branches from the normal measure cycle. The full sequence of operations controlled by the microprocessor is:

1. Read front-panel controls
2. Select stimulus level and frequency
3. Select signal to be measured (Es or Eu - see 4.2)
4. Select measure gain
5. Synchronise PSD reference generator (IC 108, l.h.)
6. Select appropriate PSD reference phase (IC 107)
7. Control (by IC 107) dual slope A - D converter and store results
8. Repeat steps 3 - 7 and average 2 readings
9. Calculate required parameter (IC 100)
10. Update display (IC 201 - 211)

4.2 BASIC MEASUREMENT

Refer to Fig. 9. The guard amplifier (IC 316, Figs.19/21*) produces a feedback current through the Standard resistor,

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*Fig 19 for instruments up to Ser. No. 275. Fig. 21 for Ser. No. 276 onwards

Rs (R337) exactly matching the current through the component under test, Zu. A single measurement channel

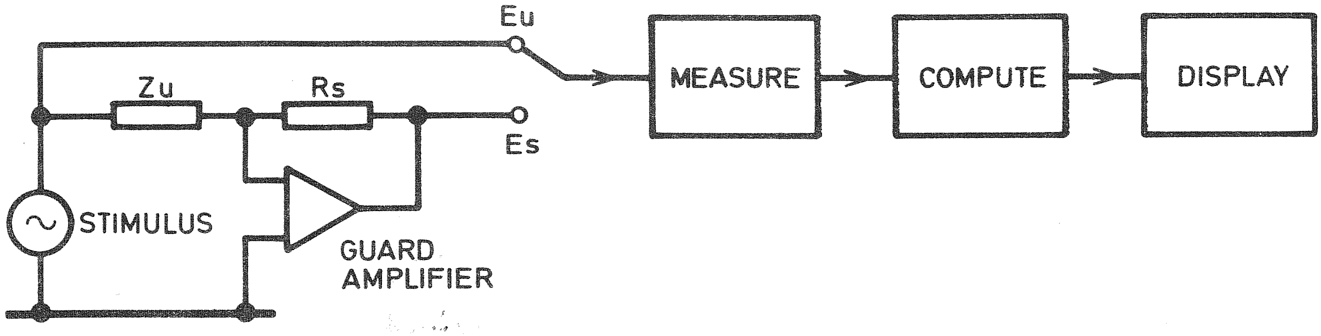


FIG. 9 BASIC MEASUREMENT

is switched electronically to measure the corresponding two voltages produced, Es and Eu. Resolution of these into in-phase and quadrature components, and subsequent computations, provides the required information for the display.

4.3 OVERALL SYSTEM

A block diagram of the complete system (excluding power supplies) is shown in Fig. 10, the Analogue circuit diagram in Figs. 19/21*, and the digital circuit diagram in Figs. 23/25. The microprocessor is shown as the right-hand end of the 8-bit data bus. Near to it is the 32.64 MHz crystal oscillator XL 100, from which all clock and measure frequencies are derived. Analogue and digital circuits are on physically separate pcb's in the instrument and are shown, respectively, in the upper and lower portions of Fig. 10.

*Fig. 19 for instruments up to Ser. No. 275, Fig. 21 for Ser. No. 276 onwards.

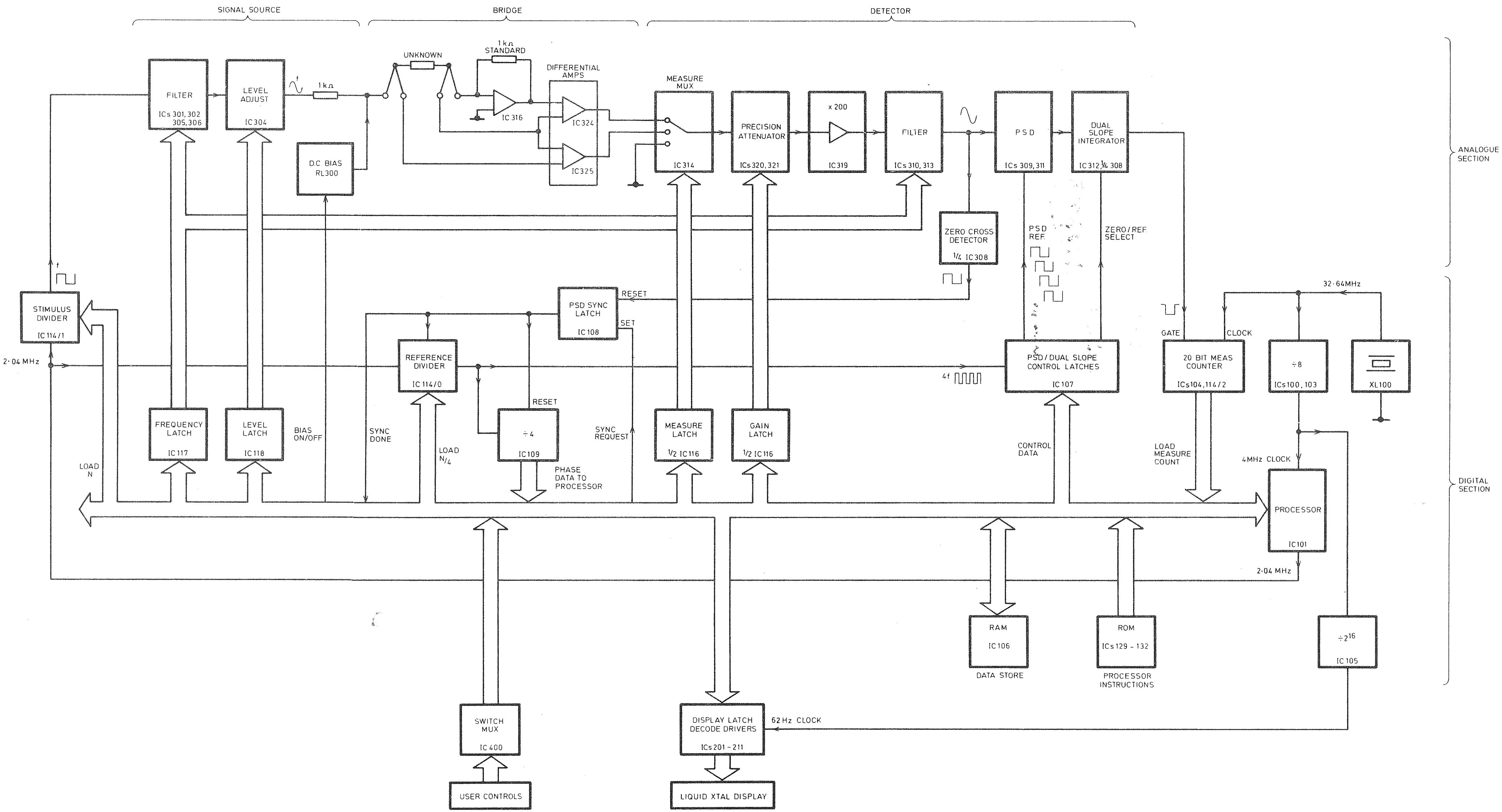


FIG. 10 BLOCK DIAGRAM

4.4 SIGNAL SOURCE

The 2.04 MHz microprocesser clock is also applied to the programmable stimulus divider, IC 114/1, whose output will be at 100 Hz, 1 kHz or 10 kHz (120 Hz, 1.02 kHz or 10.2 kHz on 60 Hz instruments). This square-wave is applied to the programmable low-pass filter (IC 305/306) with the appropriate cut-off frequency selected via IC 301/302. The sinusoidal output from the filter is set at the appropriate level (according to the range selection determined in the microprocessor) by IC 304. The signal is applied, via a 1k resistor, to the right hand triaxial measurement connector. This arrangement feeds the unknown from an approximate current source on low impedance ranges and an approximate voltage source on high impedance ranges.

4.5 BRIDGE

4.5.1 The basic Es/Eu comparison has been described in section 4.2. The separate connections for E/I and E'/I' (see Figs. 19/21) allow lead impedance errors to be eliminated. IC 317, together with IC 324/325, form a pair of differential amplifiers which sense the true voltage across the Standard and Unknown respectively.

4.5.2 The measure multiplexer, IC 314, selects Es and Eu. It also measures the inherent offset, Eo, under zero-signal conditions. The timing of these operations, relative to other parts of the operation, are shown on Fig. 18.

The Es/Eu/Eo signals, buffered by IC 315, are attenuated as necessary for the range selected (by the microprocessor) via IC 320/321, before being applied to the x200 measure amplifier, IC 319.

4.5.3 The presence of harmonics could cause errors in the phase-sensitive detectors. The programmable low-pass filter associated with IC 313/310 reduces this distortion.

4.5.4 The signal from the bridge is resolved into two orthogonal components by the phase-sensitive detector (IC 311/309, Figs. 19/21). This requires a reference signal which is derived from a separate programmable divider, IC 114/0 (Figs. 23/25), feeding the PSD control latches, IC 107.

4.5.5 To simplify the arithmetic involved in applying corrections for the automatic trim facility, this reference signal is synchronised with either Es (range 1) or Eu (range 8). Series trim is applied on low impedance ranges (1 - 4) and parallel trim on high impedance ranges (5 - 8). This requires a sequence with Es first on ranges 1 - 4 and Eu first on ranges 5 - 8. These conditions are met by the zero crossing detector IC 308 (Figs. 19/21) and PSD sync latch IC 108 (Figs. 23/25), which reset the programmable divider at the beginning of each measure cycle.

4.5.6 The dual-slope integrator, IC 312/C322/¼IC 308, (Figs. 19/21), operates with a measure reference provided by a zener diode (D 316). The integrator output is used to gate the clock signal to 20-bit measure counter, IC 104 (Figs. 23/25) with IC 114/2, whose output provides, in sequence, a measure of the in-phase and quadrature components of Es, Eu and Eo. These values are held in the RAM data store, IC 106.

4.6 COMPUTATION AND DISPLAY

4.6.1 Instructions for computing L, C and R, in equivalent series or parallel terms, for computing D and Q, and for initiating all sequences for measurement and for trimming, are held in EPROM, IC's 129-132.

4.6.2 Values are computed by the microprocessor in floating point binary form. They are converted to BCD for outputting to the display latch decode drivers, IC's 201 - 211. These provide information for the seven-segment numerical readouts, the units of measurement and the operator instructions.

4.7 TRUTH TABLES

4.7.1 Filter frequency selection, ICs 301, 302.

FB, pins 9. FA, pins 10 (see Figs. 19/21)

Frequency	FB	FA
100Hz	0	0
120Hz	0	1
1kHz	1	0
10kHz	1	1

4.7.2 Level Selection, IC 304. LB pin 10, LA pin 11 (see Figs. 19/21)

Output Level	LB	LA
50mV	0	1
500mV	1	0
5V	1	1

4.7.3 Bridge Es/Eu/Eo selection, Measure Multiplexer IC 314. INB, pins 10, 11. INA, pin 9 (see Figs. 19/21)

Input	INB	INA
Eo	0	0
Eu	0	1
Es	1	0

4.7.4 Switched Precision Range Attenuator, IC 320, 321. GB, IC 320 pin 11 & IC 321 pin 9. GA, IC 321 pin 10 (see Figs. 19/21)

Relative Gain	GB	GA
1	0	0
÷10	0	1
÷100	1	0
÷1000	1	1

4.7.5 Data lines to PSD Multiplexer, IC 309.
PHA, pin 10, PHB, pin 9 (See Figs. 19/21)

Condition	PH.A	PH.B
+ve signal	1	0
-ve "	1	1
reference	0	1
zero	0	0

5.0 PERFORMANCE CHECKS

5.1 TEST EQUIPMENT REQUIRED

To provide verification of the measurement accuracy of the B605, precisely-known Standards such as those listed below must be available. In the absence of such components, this section can only provide a rough check on performance which may assist in fault diagnosis. In either instance, ALL tests must be performed, exactly in the sequence they are given.

D.C. Voltmeter — To measure 0-2.5V. Accuracy 50mV.

Counter — To measure 10kHz 5V r.m.s. Accuracy 0.001%.

Oscilloscope — General purpose.

Standards — The types and value of the Standards listed below are not mandatory. However, when contemplating alternative components the following considerations must be taken into account.

A Polystyrene capacitors are temperature-dependent to the extent that they must be measured and used for checking at closely matched ambient conditions.

B The $\tan\delta$ of silvered-mica capacitors is frequency-dependent. The reference value of this parameter must be established at the same frequency as that used for any given Bridge check.

C The resistor values are chosen with regard to the fact that for low impedance ranges the B605 auto-ranges downwards from range 5. The '95' values ensure that the required range is reached, and it is checked near the upper limit of its coverage.

D The capacitor values are used for checking ranges reached in upward auto-ranging. The '150' values provide initial checks at the lower impedance end of a given range and the next smaller capacitance standard (e.g. '15') can provide a second check on the high impedance end of the same range.

1.5nF		1% sealed polystyrene. $\tan\delta < 0.0001$ at 10kHz.
15pF*	1%	Silvered mica capacitors. Values known to +/- 0.01% at 100/120Hz, 1kHz & 10kHz+. $\tan\delta$ known to +/- 0.01% at 100/120Hz & 1kHz; to +/- 0.04% at 10kHz.
150pF*	1%	
1.5nF*	1%	
15nF	1%	
10.5kΩ		Bulk film resistor, value known to +/- 0.01% at 100/120Hz.

* These capacitors must be 3-terminal (i.e. in screened boxes, case connected to Guard, with screened connectors).

+ For 60Hz instruments, all references to 1kHz and 10kHz should be read as 1.02kHz and 10.2kHz, respectively.

0.95Ω	1%	) Low inductance bulk film
9.5Ω	1%	) resistors. Values known
95Ω	1%	) to +/- 0.01% at 1kHz.
950Ω	1%	) Value of 0.95Ω at 10kHz
		) known to +/- 0.02%.

160Ω 1% Metal film resistor.

5.2 INITIAL CHECKS

5.2.1 Remove any measurement leads. Press RANGE HOLD, C, 10kHz and Parallel. Connect the supply and switch on. Display should show Range Error and a 2-digit reading (X.XpF) not exceeding 3.0pF.

5.2.2 Link the two red 2V BIAS terminals on the rear panel. With the D.C. Voltmeter, check that the d.c. voltage between the inners of the two measurement sockets does not exceed 10mV.

5.2.3 Select R and release RANGE HOLD. Using the binding post adaptors, connect the 950-ohm resistor. Wait for Range Error to be extinguished and then press RANGE HOLD. Disconnect the resistor and check with the D.C. Voltmeter that the voltage across the terminals is less than 10mV.

5.2.4 Select C. The D.C. Voltmeter should now read between 1.8V and 2.45V.

5.2.5 Re-select R and check that the voltage falls to less than 10mV. Remove the binding post adaptors and disconnect the link from the 2V BIAS terminals.

5.3 AUTORANGE & SOURCE OUTPUT

5.3.1 Observe the display while releasing RANGE HOLD. It should blank for 2 seconds, then show 'trim open circuit' and a 4-digit reading (.XXXXpF) not exceeding 0.5pF.

5.3.2 With the Counter, measure the frequency at the inner of the right-hand (Bias + ve) measurement socket. It should be 10kHz +/- 0.01%. Press 1kHz and measure; also 100/120Hz. All should be within +/- 0.01%.

5.3.3 With the oscilloscope connected to the inner of the right-hand measurement socket, examine the waveform at all three measurement frequencies. In all cases it should be sinusoidal, with no visible distortion, and between 11 and 17V p-p in amplitude.

5.4 AUTO-TRIM

With no connection to the measurement sockets, select 10kHz. Press and release TRIM. The digits should be blanked for about 5 seconds and then show a nominal reading of .0000pF, +/- .0010pF. No words should show.

5.5 PHASE ADJUST

5.5.1 Connect the 1.5nF polystyrene Capacitor (as specified in 5.1) between the inners of the two measurement sockets. The displayed value should be within +/- 1% of the known value.

5.5.2 Press and hold D-Q. The reading should be .0000 +/- 1 digit. If necessary adjust SET PHASE (C316 on the Analogue Board - see Fig. 11). To obtain access, see 3.17.

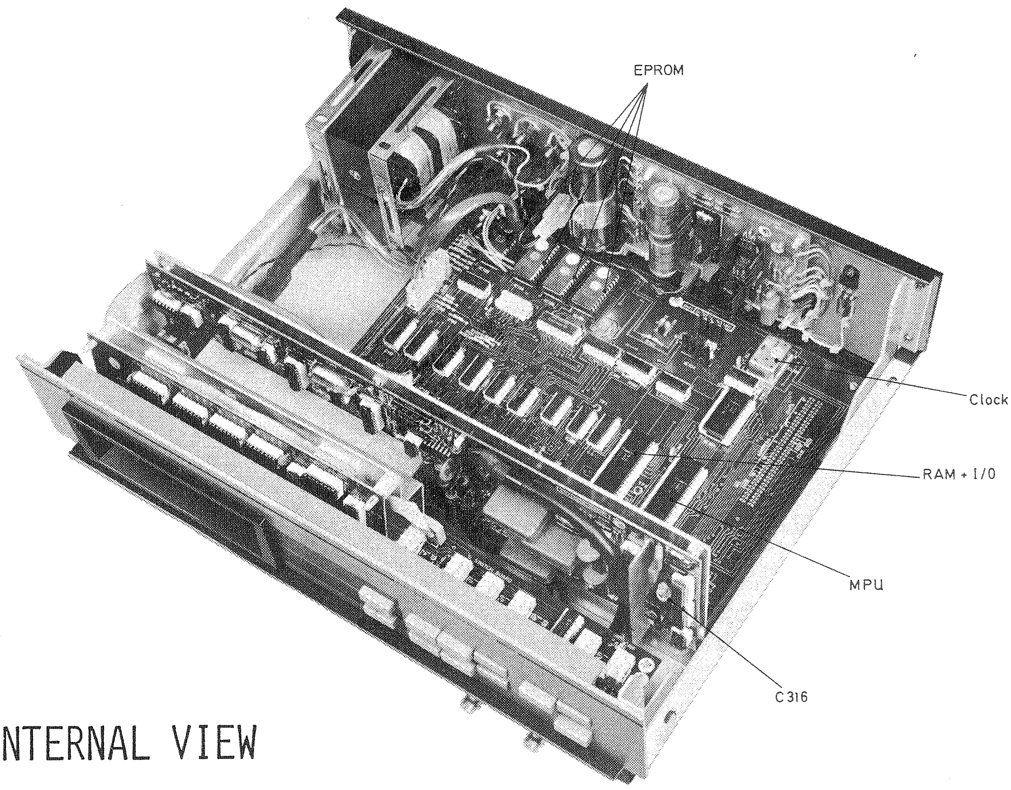


FIG. 11 INTERNAL VIEW

5.6 TRIM OPEN CIRCUIT

5.6.1 Select R, 10kHz, Parallel. Wait for Range Error to be extinguished. Press and release TRIM and wait 5 seconds. The display should show Error with blanked digits, or any reading exceeding +/- 1000MΩ.

5.6.2 Select 1kHz. The display should show Error or reading > +/- 10,000MΩ.

5.6.3 Select 100/120Hz. Display to show Error or reading > +/- 10,000MΩ.

5.6.4 Select C (100/120Hz). Display to show 0.00pF, average reading not to exceed +/- 0.1pF, noise peaks may be up to +/- 0.2pF.

5.6.5 Select 1kHz. Display to show 0.000pF, max. variation +/- .01pF.

5.6.6 Select 10kHz. Display to show .0000pF, max. variation +/- .001pF.

5.7 HIGH IMPEDANCE ACCURACY 10kHz

5.7.1 Select C, 10kHz, Parallel. Connect the 15nF capacitor (see 5.1). When Range Error is extinguished, press RANGE HOLD. The 5-digit display should show the known value, +/- 35 digits. (The instrument now on range 5).

5.7.2 Press D-Q. The display should show the known D value, +/- 20 digits.

5.7.3 Substitute the 1.5nF silvered mica capacitor (see 5.1). The 5-digit display should show the known value, +/- 35 digits. (The instrument still on range 5).

5.7.4 Press D-Q. The display should show the known D value, +/- 20 digits.

5.7.5 Release RANGE HOLD, disconnect the 1.5nF capacitor, wait for Range Error to be extinguished and then re-connect the capacitor. Press RANGE HOLD. The 5-digit display should show the known value, +/- 35 digits. (The instrument now on range 6).

5.7.6 Press D-Q. The display should show the known D value, +/- 20 digits.

5.7.7 Select L. The displayed negative inductance should lie within +/- 4 digits of the calculated value: $\frac{253.3}{C}$ (C in nF, L in mH).

5.7.8 Press D-Q. The display should show Error or a reading > +/- 500.

5.7.9 Select C. Substitute the 150pF capacitor (see 5.1). The display should show the known value, +/- 35 digits.

5.7.10 Press D-Q. The display should show the known D value, +/- 20 digits.

5.7.11 Release RANGE HOLD, disconnect the 150pF capacitor, wait for Range Error to be extinguished and then re-connect the capacitor. Press RANGE HOLD. The 5-digit display should show the known value, +/- 35 digits. (The instrument now on range 7).

5.7.12 Press D-Q. The display should show the known D value, +/- 20 digits.

5.7.13 Substitute the 15pF capacitor (see 5.1). The 5-digit display should show the known value, +/- 35 digits.

5.7.14 Press D-Q. The display should show the known D value, +/- 20 digits.

5.7.15 Release RANGE HOLD, disconnect the 15pF capacitor, wait for Range Error to be extinguished and then re-connect the capacitor. The 5-digit display should show the known value, +/- 35 digits. (The instrument now on range 8).

5.7.16 Press D-Q. The display should show the known D value, +/- 20 digits.

5.8 HIGH IMPEDANCE ACCURACY 1kHz

5.8.1 Select C, 1kHz, Parallel. Connect the 15nF capacitor (see 5.1). When Range Error is extinguished, press RANGE HOLD. The 5-digit display should show the known value, +/- 15 digits. (The instrument now on range 6).

5.8.2 Press D-Q. The display should show the known D value, +/- 10 digits.

5.8.3 Substitute the 1.5nF capacitor. The 5-digit display should show the known value, +/- 15 digits.

5.8.4 Press D-Q. The display should show the known D value, +/- 10 digits.

5.8.5 Release RANGE HOLD, disconnect the 1.5nF capacitor, wait for Range Error to be extinguished and then re-connect the capacitor. Press RANGE HOLD. The 5-digit display should show the known value, +/- 15 digits. (The instrument now on range 7).

5.8.6 Press D-Q. The display should show the known D value, +/- 10 digits.

5.8.7 Substitute the 150pF capacitor. The 5-digit display should show the known value, +/- 15 digits.

5.8.8 Press D-Q. The display should show the known D value, +/- 10 digits.

5.8.9 Release RANGE HOLD, disconnect the 150pF capacitor, wait for Range Error to be extinguished and then re-connect the capacitor. Press RANGE HOLD. The 5-digit display should show the known value, +/- 15 digits. (The instrument now on range 8).

5.8.10 Press D-Q. The display should show the known D value, +/- 10 digits.

5.9 HIGH IMPEDANCE ACCURACY 100/120Hz

Note: References to occasional noise peaks can be taken as meaning one reading in five reaching the peak limit. More frequent, or excessively high peaking may indicate a fault condition.

5.9.1 Select R, 100/120Hz, parallel. Connect the 10.5k resistor (see 5.1). When Range Error is extinguished, press RANGE HOLD. The 5-digit display should show the known value, +/- 10 digits. (The instrument now on range 6).

5.9.2 Select C. The reading should not exceed 150pF.

5.9.3 Connect the 15nF capacitor. The 5-digit display should show the known value, +/- 15 digits. (Occasional noise peaks may be up to +/- 25 digits).

5.9.4 Press D-Q. The average reading should be within +/- 10 digits of the known D value. (Occasional noise peaks may be up to +/- 15 digits).

For 50Hz instruments, carry out 5.9.5a; for 60Hz instruments, 5.9.5b

5.9.5a Release RANGE HOLD, disconnect the 15nF capacitor, wait for Range Error to be extinguished and then re-connect the capacitor. Press RANGE HOLD. The 5-digit display should show the known value +/- 15 digits. (The instrument now on range 7).

5.9.5b Release RANGE HOLD, disconnect the 15nF capacitor, wait for Range Error to be extinguished and then connect the 1.5nF capacitor. Press RANGE HOLD. Now substitute the 15nF capacitor. The 5-digit display should show the known value +/- 15 digits. Ignore display of Range Error. (The instrument now on range 7).

5.9.6 Press D-Q. The display should show the known D value, +/- 10 digits.

5.9.7 Substitute the 1.5nF capacitor. The 5-digit display should show the known value, +/- 15 digits. (Occasional noise peaks may be up to +/- 25 digits).

5.9.8 Press D-Q. The display should show the known D value, +/- 10. (Occasional noise peaks may be up to +/- 15 digits).

5.9.9 Release RANGE HOLD, disconnect the 1.5nF capacitor, wait for Range Error to be extinguished and then press RANGE HOLD. Re-connect the capacitor (60Hz machines will show Range Error : ignore this). The 5-digit display should show the known value, +/- 15 digits. (The instrument now on range 8).

5.9.10 Press D-Q. The display should show the known D value, +/- 10.

5.10 TRIM SHORT CIRCUIT & RANGE 1 ACCURACY

5.10.1 Select L, 10kHz, Series. For these tests, the connecting leads must not be moved between the trim operation and all subsequent checks up to and including 5.12.12. The JU4, which must be placed well clear of supply transformers, provides a stable connection system and the spring-loaded jaws (not the troughs) should be used, giving 4-terminal connections. Provide a heavy-gauge wire as a short-circuit at the measurement connection point (e.g. JU4 jaws). Ignore 'Trim short circuit' display. The reading should not exceed +/- 0.6μH.

5.10.2 Select R. The reading should not exceed +/- .02Ω.

5.10.3 Press and release TRIM. After 5 seconds, the display should show .0000Ω +/- 8 digits.

5.10.4 Select 1kHz. The display should show .0000Ω +/- 1 digit.

5.10.5 Select 100/120Hz. The display should show .0000Ω +/- 1 digit.

5.10.6 Select L (100/120Hz). Readings should not exceed +/- 0.1μH. (Occasional noise peaks may be up to +/- 0.15).

5.10.7 Select C (100/120Hz). Display should show F, 'error' and no digits.

5.10.8 Select L, 1kHz. Readings should not exceed +/- .01μH.

5.10.9 Select 10kHz. Readings should not exceed +/- .01μH.

5.10.10 Select R (10kHz). Replace the short-circuit by the 0.95-ohm resistor (see 5.1). The display should show the known value, +/- 35 digits.

5.10.11 Select 1kHz. The display should show the known value, +/- 20 digits.

5.10.12 Select 100/120Hz. The display should show the known value, +/- 20 digits.

5.11 RANGE 2 ACCURACY

5.11.1 Taking care not to disturb the measurement leads, replace the 0.95-ohm resistor by 9.5 ohms. Wait for Range Error to be extinguished and then press RANGE HOLD. Replace the 9.5-ohm resistor by the short-circuit. Ignore Range Error display. The average reading should not exceed +/- .001Ω. (Occasional noise peaks may be up to +/- .0015Ω).

5.11.2 Select 1kHz. Readings should not exceed +/- .001Ω.

5.11.3 Select 10kHz. Readings should not exceed +/- .002Ω.

5.11.4 Select L (10kHz). Readings should not exceed +/- 0.1μH.

5.11.5 Select 1kHz. Readings should not exceed +/- 0.26μH.

5.11.6 Select 100/120Hz. The average reading should not exceed +/- 1.6μH. (Occasional noise peaks may be up to +/- 3.0μH).

5.11.7 Replace the short-circuit by the 9.5-ohm resistor. Readings should not exceed 16μH.

5.11.8 Select 1kHz. Readings should not exceed 1.6μH.

5.11.9 Select 10kHz. Readings should not exceed 0.32μH.

5.11.10 Select R (10kHz). The display should show known value, +/- 26 digits.

5.11.11 Select 1kHz. The display should show the known value +/- 11 digits.

5.11.12 Select 100/120Hz. The display should show the known value, +/- 11 digits.

5.12 RANGE 3 ACCURACY

5.12.1 Taking care not to disturb the measurement leads, replace the 9.5-ohm resistor by 95 ohms. Wait for Range Error to be extinguished and then press RANGE HOLD. Replace the 95-ohm resistor by the short-circuit. Ignore Range Error display. The average reading should not exceed +/- .01Ω. (Occasional noise peaks may be up to .015Ω).

5.12.2 Select 1kHz. Readings should not exceed +/- .01Ω.

5.12.3 Select 10kHz. Readings should not exceed +/- .02Ω.

5.12.4 Select L (10kHz). Readings should not exceed +/- 0.4μH.

5.12.5 Select 1kHz. Readings should not exceed +/- 1.6μH.

5.12.6 Select 100/120Hz. The average reading should not exceed 16μH. (Occasional peaks may be up to 30μH).

5.12.7 Replace the short-circuit by the 95-ohm resistor. Readings should not exceed 160μH.

5.12.8 Select 1kHz. Readings should not exceed 16μH.

5.12.9 Select 10kHz. Readings should not exceed 3.2μH.

5.12.10 Select R (10kHz). The display should show the known value, +/- 25 digits.

5.12.11 Select 1kHz. The display should show the known value, +/- 10 digits.

5.12.12 Select 100/120Hz. The display should show the known value, +/- 10 digits.

5.13 TRIM OVERLOAD

5.13.1 Leaving the Bridge in the conditions reached in 5.12.12, connect the 160-ohm resistor (see 5.1). The display should show the value, +/- 1%, and Range Error.

5.13.2 Select 1kHz and check the display as in 5.13.1.

5.13.3 Select 10kHz and check the display as in 5.13.1.

Note: In 5.13.1, 5.13.2 and 5.13.3 no digits should be blanked.

5.14 RANGE 4 ACCURACY

5.14.1 Release RANGE HOLD. Connect the 950-ohm resistor. Wait for Range Error to be extinguished and then press RANGE HOLD. Select 100/120Hz. Replace the 950-ohm resistor by the short-circuit. Ignore Range Error display. The average reading should not exceed +/- 0.1Ω. (Occasional noise peaks may be up to +/- 0.15Ω).

5.14.2 Select 1kHz. Readings should not exceed +/- 0.1Ω.

5.14.3 Select 10kHz. Readings should not exceed +/- 0.2Ω.

5.14.4 Select L (10kHz). Readings should not exceed +/- 4μH.

5.14.5 Select 1kHz. Readings should not exceed +/- 16μH.

5.14.6 Select 100/120Hz. The average reading should not exceed +/- 0.16mH. (Occasional noise peaks may be up to +/- 0.3mH).

5.14.7 Replace the short-circuit by the 950-ohm resistor. Readings should not exceed 1.6mH.

5.14.8 Select 1kHz. Readings should not exceed 160μH.

5.14.9 Select 10kHz. Readings should not exceed 32μH.

5.14.10 Select R (10kHz). The display should show the known value, +/- 25 digits.

5.14.11 Select 1kHz. The display should show the known value, +/- 10 digits.

5.14.12 Select 100Hz. The display should show the known value, +/- 10 digits.

6.0 LIST OF COMPONENTS (B605)

Resistors

Ref	Value	Tol	Rating	Type	Supplier & Type No.
R5	22R	5		Carbon Film	Mullard CR37
R6	270R	5		Carbon Film	Mullard CR25
R7	680R	5		Carbon Film	Mullard CR25
R8	1k	5		Carbon Film	Mullard CR25
R9	330R	1	100ppm	Metal Film	Allen Bradley FC65
R10	120R	1	100ppm	Metal Film	Allen Bradley FC65
R11	10k	5		Carbon Film	Mullard CR37
R12	5R6	5		Carbon Film	Mullard CR25
R13	220k	5		Carbon Film	Mullard CR25
R14	22k	5		Carbon Film	Mullard CR25
*R15					
R17	100R	5		Carbon Film	Mullard CR25
R100-R103	1k0	5		Carbon Film	Mullard CR25
R104-R106	4k7	5		Carbon Film	Mullard CR25
R107-R115	1k0	5		Carbon Film	Mullard CR25
R116-R119	4k7	5		Carbon Film	Mullard CR25
R120-R125	1k0	5		Carbon Film	Mullard CR25
*R142	47R	5		Carbon Film	Mullard CR25
R143	4k7	5		Carbon Film	Mullard CR25
R150-R152	4k7	5		Carbon Film	Mullard CR25
R153-R162	1k0	5		Carbon Film	Mullard CR25
R201	270R	5		Carbon Film	Mullard CR25
R300	51k	1	100ppm	Metal Film	Allen Bradley FC65
R301	7k68	1	100ppm	Metal Film	Allen Bradley FC65
*R302	110k	2		Metal Oxide	Electrosil TR5

Resistors continued

Ref	Value	Tol	Rating	Type	Supplier & Type No.
R303	549k	1	100ppm	Metal Film	Allen Bradley FC65
R304	60k4	1	100ppm	Metal Film	Allen Bradley FC65
R305	6k65	1	100ppm	Metal Film	Allen Bradley FC65
*R306	110k	2		Metal Oxide	Electrosil TR5
R307	560k	1	100ppm	Metal Film	Allen Bradley FC65
R308	66k5	1	100ppm	Metal Film	Allen Bradley FC65
*R309	110k	2		Metal Oxide	Electrosil TR5
*R310	560k	1	100ppm	Metal Film	Allen Bradley FC65
R311	60k4	1	100ppm	Metal Film	Allen Bradley FC65
R313	6k65	1	100ppm	Metal Film	Allen Bradley FC65
*R314	110k	2		Metal Oxide	Electrosil TR5
R315	560k	1	100ppm	Metal Film	Allen Bradley FC65
R316	66k5	1	100ppm	Metal Film	Allen Bradley FC65
*R317	100k	1	100ppm	Metal Film	Allen Bradley FC65
R318	10k	1	100ppm	Metal Film	Allen Bradley FC65
R319	1k1	1	100ppm	Metal Film	Allen Bradley FC65
R323	39k	1	100ppm	Metal Film	Allen Bradley FC65
R324	10k	1	100ppm	Metal Film	Allen Bradley FC65
R325	1k0	2		Metal Oxide	Electrosil TR5
*R326	47k	5		Carbon Film	Mullard CR25
R327	47R	5		Wire Wound	Welwyn W22
R328	10R	5		Carbon Film	Mullard CR25
R329	150k	1	100ppm	Metal Film	Allen Bradley FC65
R333	150k	5		Carbon Film	Mullard CR25
R334	47R	5		Carbon Film	Mullard CR25
R335	10R	5		Carbon Film	Mullard CR25
R336	47R	5		Wire Wound	Welwyn W22
R337	1k0	0.01		Vishay	Welwyn 4802
R338	47R	5		Carbon Film	Mullard CR25
R339	150k	1	100ppm	Metal Film	Allen Bradley FC65
R344	11k	1	100ppm	Metal Film	Allen Bradley FC65
R345	50R/450R/4k5/45k			Vishay N/W	Welwyn 499203
R346	1k2	1	100ppm	Metal Film	Allen Bradley FC65

Resistors continued

Ref	Value	Tol	Rating	Type	Supplier & Type No.
*R347	240k	1	100ppm	Metal Film	Allen Bradley FC65
R348	3M0	1	100ppm	Metal Film	Allen Bradley FC70
*R349	27k	1	100ppm	Metal Film	Allen Bradley FC65
*R350	270k	1	100ppm	Metal Film	Allen Bradley FC65
*R351	100k	1	100ppm	Metal Film	Allen Bradley FC65
*R352	11k	1	100ppm	Metal Film	Allen Bradley FC65
*R353	6k8	1	100ppm	Metal Film	Allen Bradley FC65
R354	169k	1	100ppm	Metal Film	Allen Bradley FC65
*R355	75k	1	100ppm	Metal Film	Allen Bradley FC65
*R356	2k7	1	100ppm	Metal Film	Allen Bradley FC65
*R357	"	"	"	" "	" " "
*R358	62k	1	100ppm	Metal Film	Allen Bradley FC65
R359	10k	1	100ppm	Metal Film	Allen Bradley FC65
*R360	"	"	"	" "	" " "
*R361	62k	1	100ppm	Metal Film	Allen Bradley FC65
R362	3k3	5		Carbon Film	Mullard CR25
R363	4k7	5		Carbon Film	Mullard CR25
R364	2M0	5		Metal Glaze or C/F	Piher PR50
R365	3k3	5		Carbon Film	Mullard CR25
R366	4M7	5		Metal Glaze or C/F	Piher PR50
R367	47k	5		Carbon Film	Mullard CR25
*R368	27k	5		Carbon Film	Mullard CR25
R369	3k3	5		Carbon Film	Mullard CR25
R370	1M0	5		Carbon Film	Mullard CR25
R371	4k7	5		Carbon Film	Mullard CR25
*R372	24k	1	100ppm	Metal Film	Allen Bradley FC65
R373	200k	1	100ppm	Metal Film	Welwyn 4033Z
R374	680R	5		Carbon Film	Mullard CR25
R375- *R377 *R378	3k3	5		Carbon Film	Mullard CR25
R381	1k0	5		Carbon Film	Mullard CR25
R382	68R	5		Carbon Film	Mullard CR25
R383	1k0	1	100ppm	Metal Film	Allen Bradley FC65
R384	2k0	1	100ppm	Metal Film	Allen Bradley FC65
R385	68R	5		Carbon Film	Mullard CR25
R386	51k	1	100ppm	Metal Film	Allen Bradley FC65
R387	7k68	1	100ppm	Metal Film	Allen Bradley FC65
R388	4k7	5		Carbon Film	Mullard CR25

Resistors continued

Ref	Value	Tol	Rating	Type	Supplier & Type No.
R390	47R	5		Carbon Film	Mullard CR25
R391	3k9	0.1	50ppm	Metal Film	Allen Bradley FC65
R392	100R	0.1	50ppm	Metal Film	Allen Bradley FC65
R393	3k9	0.1	50ppm	Metal Film	Allen Bradley FC65
R394	100R	0.1	50ppm	Metal Film	Allen Bradley FC65
R395	3k9	0.1	50ppm	Metal Film	Allen Bradley FC65
R396	100R	0.1	50ppm	Metal Film	Allen Bradley FC65
R397	470R	5		Carbon Film	Mullard CR25
R400	1k0	5		Carbon Film	Mullard CR25
R401	"	"		" "	" "

Capacitors

Ref	Value	Tol	Rating	Type	Supplier & Type No.
C1	6800µ		16V	Electrolytic	Mullard 071-15682
C2	1µ0	20	35V	Tantalum Bead	ITT TAG 1.0/35V
C3	1µ0	20	100V	Polyester	Wima MKS
C4	680µ		40V	Electrolytic	Mullard 017-17681
C5	1µ0	20	35V	Tantalum Bead	ITT TAG 1.0/35V
C6	680µ		40V	Electrolytic	Mullard 017-17681
C7	1µ0	20	35V	Tantalum Bead	ITT TAG 1.0/35V
*C8					
C11	47µ		10V	Electrolytic	Mullard 015-14479
C12	4µ7	20	35V	Tantalum Bead	ITT TAG 4.7/35V
C100-C110	10n		40V	Disc Ceramic	Erie 831T40V
*C111	1µ0	20	35V	Tantalum Bead	ITT TAG 1.0/35V
*C112	2µ2	20	35V	Tantalum Bead	ITT TAG 2.2/35V
C113	47µ	20	16V	Tantalum Bead	ITT TAG 47/16V
C114	"	"	"	" "	" " "
*C115					
C201-C204	10n		40V	Disc Ceramic	Erie 831T40V
C300	2µ2		63V	Electrolytic	Mullard 015-18228
C301	22n	2.5	160V	Polystyrene	LCR FSC

Capacitors continued

Ref	Value	Tol	Rating	Type	Supplier & Type No.
C302	220p	2.5	160V	Polystyrene	Suflex HS
C303	22n	2.5	160V	Polystyrene	LCR FSC
C304	220p	2.5	160V	Polystyrene	Suflex HS
C305	2µ2	20	35V	Tantalum Bead	ITT TAG 2.2/35V
C306	10µ		63V	Electrolytic	Mullard 016-18109
C307	"		"	"	" "
C308	4µ7	5	100V	Polyester	Wima MKS
C311	4µ7	5	100V	Polyester	Wima MKS
C312	"	"	"	"	" "
C313	100p	2.5	160V	Polystyrene	Suflex HS
C316	2-10p	8mm	Tetfer	Preset	Jackson Bros. 5750/HPC
C317	4n7	20	500V	Disc Ceramic	ITT Erie Hi-K/811/4700
C318	1µ5	5	100V	Polyester	Wima MKS
*C319	68n	5	250V	Polyester	Wima MKS
C320	560p	2.5	160V	Polystyrene	Suflex HS
C321	8n2	2.5	160V	Polystyrene	LCR FSC
C322	100n	2.5	160V	Polystyrene	LCR FSC
C324	470µ		10V	Electrolytic	Mullard 017-14471
C325	10µ		25V	Electrolytic	Mullard 015-16109
C326	"		"	"	" "
C327	47µ		25V		Mullard 016-16479
C328	"		"		" "
C329	470µ		10V	Electrolytic	Mullard 017-14471
C330	10µ	20	10V	Tantalum Bead	ITT TAG 10/10V
C331-C333	22p	1p	160V	Polystyrene	Suflex HS
C334	220n	5	100V	Polyester	Wima MKS
C335	10n	20	250V	Polyester	Wima MKS
C336	33p	1p	160V	Polystyrene	Suflex HS
C337	100µ		25V	Electrolytic	Mullard 016-16101
C338	"		"	"	" "
C339	47n		40V	Disc Ceramic	Erie 811T40V
C340	"		"	" "	" "
C341	470p	2.5	160V	Polystyrene	Suflex HS
C342	1n	2.5	160V	Polystyrene	Suflex HS

Capacitors continued

Ref	Value	Tol	Rating	Type	Supplier & Type No.
*C343					
C344	47n		40V	Disc Ceramic	Erie 811T40V
C345	"		"	" "	" "
C346	1n	2.5	160V	Polystyrene	Suflex HS
C400	10n		40V	Disc Ceramic	Erie 831T40V

Diodes

Ref	Type	Supplier & Type No.
D1-D4	30S1	IR
D5-D7	1N 4002	IR (ITT) (Mullard)
D8	1N 4006	IR (ITT) (Mullard)
D9	1N 4148	IR (ITT) (Mullard)
D10-D12	1N 4002	IR (ITT) (Mullard)
D201	LED (Power on)	Monsanto MV5053
D301-D304	1N 4148	IR (ITT) (Mullard)
D305-D309	1N 4006	IR (ITT) (Mullard)
D312, D313	1N 4006	IR (ITT) (Mullard)
*D314, D315	1N 4148	IR (ITT) (Mullard)
D316	4.7V Zener	Mullard BZY88C4V7

Transistors

TR1		
TR2	BFX86	Mullard
TR3	BC213	Texas
TR4	BC183	Texas
TR5	BC182	Texas
TR6	TIP30A	Texas

Integrated Circuits

IC1	+ 5V Regulator	Fairchild μA 7805UC
IC2	+12V Regulator	Fairchild μA 78M12UC
*IC3	-12V Regulator	Fairchild μA 79M12UC

Integrated Circuits continued

Ref	Type	Supplier & Type No.
IC100	Dual JK Flip-flop	Texas 74S112N
IC101	Microprocessor	Intel P8085
IC102	Hex Inverter	Texas 74LS04N
IC103, IC104	4-bit Binary Counter	Texas 74LS93N
IC105	14-stage Ripple Counter	RCA CD4020BE
IC106	I/O Chip	Intel P8155
IC107-IC109	Dual D Flip-flop	Texas 74LS74N
IC110	Quad 2-input NAND	Texas 74LS26N
IC111	Hex Inverter	Texas 74LS04N
IC112	Quad 2-input NOR	Texas 74LS02N
IC114	Triple Counter	Intel P8253
IC115	Tri-state Octal Latch	Texas 74LS373N
IC116-IC118	Quad Latch	RCA CD4042BE
IC119	3 to 8 Line Decoder	Texas 74LS138N
IC120	Quad 2-input OR	Texas 74LS32N
IC121	Triple 3-input NOR	Texas 74LS27N
IC122	Dual 4-input NAND	Texas 74LS20N
IC123	Quad 2-input NAND	Texas 74LS26N
IC124	4 to 10 Line Decoder	Texas 74LS145N
IC125	Hex Inverter	Texas 74LS04N
IC126	Hex Converter	RCA CD4049UBE
IC127	3 to 8 Line Decoder	Texas 74LS138N
IC128	Quad 2-input AND	Texas 74LS08N
*IC129	1k x 8 EPROM	PROM kit to WBE Drawing
*IC130	" "	DP3/23916 (for 50Hz)
*IC131	" "	
*IC132	" "	DP3/23918 (for 60Hz)
*IC134	-5V Regulator	Fairchild µA 79M05UC
IC201-IC203	4-segment LCD Driver	RCA CD4054BE
IC204-IC208	BCD to 7-segment Decoder	RCA CD4056BE
IC209-IC211	4-segment LCD Driver	RCA CD4054BE
IC212	BCD to Decimal Decoder	RCA CD4028BE
IC301, IC302	Multiplexer 2 x 4	RCA CD4052BE
*IC303	Op. Amp.	National LF356N

Integrated Circuits continued

Ref	Type	Supplier & Type No.
IC304	Multiplexer 1 x 8	RCA CD4051BE
IC305, IC306	Op. Amp.	National LF356N
IC307	Op. Amp.	National LF357N
IC308	Quad Op. Amp.	National LM339AN
IC309	Multiplexer 2 x 4	RCA CD4052BE
*IC310-IC312	Op. Amp.	National LF356N
IC313	Multiplexer 2 x 4	RCA CD4052BE
IC314	Multiplexer 3 x 2	RCA CD4053BE
IC315	Op. Amp.	SIGNETICS 5534AN †
IC316	Op. Amp.	National LF356N
IC317	Op. Amp.	SIGNETICS 5534AN †
*IC318		
IC319	Op. Amp.	SIGNETICS 5534AN †
IC320	Multiplexer 3 x 2	RCA CD4053BE
IC321	Multiplexer 2 x 4	RCA CD4052BE
IC322	Quad 2-input NOR	RCA CD4001BE
IC323	+8V Regulator	Fairchild μA 7808UC
IC324, IC325	Op. Amp.	SIGNETICS 5534AN †
IC400	4 to 10 Line Decoder	Texas SN74LS145N

† Or equivalent

Miscellaneous

*XL100	32.64MHz Crystal	ITT SPXO 10
T1	Power Transformer	W.B.E. DL/2/24046
SA, SB, SC	L/C/R	W.B.E. DP3/23869
SD (D-Q)	2 pole momentary (without bracket)	Lipa & Isostat
SE, SF, SG	100Hz/1kHz/10kHz	W.B.E. DP3/23869
SH, SJ	Series/Parallel	W.B.E. DP3/23868
SK (Trim)	2 pole momentary (without bracket)	Lipa & Isostat
SL (Range Hold)	2 pole latching (without bracket)	Lipa & Isostat
ST (Power on)	Switch (with bracket)	Lipa & Isostat MS
SU	115/230V	Rendar R530, 040, 00

Miscellaneous continued

Ref	Type	Supplier & Type No.
Switch buttons (11)	Light grey	Lipa & Isostat 4094/SN10604
Switch button	Black	Lipa & Isostat 4094/SN10607
RL300	DIL Reed Relay	Astralux 121A-4
FS1 (230V)	Fuse, slow blow, 300mA-T	20 x 5mm
" (115V)	" " " 600mA-T	20 x 5mm
Display illum'n	Lamp, 12V 2W	Vitality MES 987
PLA	Filtered Power Connector	Rendar R470-503-00
SKP	Measure Connector Ass'y (RH)	W.B.E. DP3/23913/A
SKQ	" " " (LH)	W.B.E. DP3/23913/B
SKR	Jack socket 3.5mm	Rendar R322,100,00
	Liquid Crystal Display	W.B.E. DL3/24045

LIST OF COMPONENTS (JU4)

	Description	Part No.
SA	Push-button switch	C & K 8121J812122
SKA	Jack socket	Rendar R322,108,00
Trough	Radial clamp (4 required)	DC4/24782
-	Connecting cable	DC2/24677
-	Jack lead assembly	D70509

* The preceding List of Components applies to earlier B605 instruments. Some changes and/or re-numbering of components occurred from Ser. No. 276 onwards, on the Power Supply and Analogue circuits; from Ser. No. 376 onwards on the Digital circuits. The later details are shown on the next page.

LATER INSTRUMENT CHANGES (see footnote on page 58)

R15	1K3	R309	665K	R351	21K5	R358	27K4
R16	150R	R314	665K	R352	147K	R360	22K
R302	665K	R347	220K	R353	26K1	R361	60K4
R306	665K	R350	49K9	R356	2K4	R372	51K

All the above are 1%, 100ppm, Metal Film, Allen Bradley FC65

R377	47K	5% Carbon Film, Mullard CR25
R378	2K7	" " " " "

Deleted: R107, R108, R125, R142, R156-162, R310, R317, R326, R349, R355, R357, R368.

C8	10μ	25V	Mullard
C115	10n	40V	Disc Ceramic, Transcap 831T 40V
C319	33n	5%	250V Polyester, Wima MKS
C343	100p	2.5%	160V Polystyrene, LCR FSC

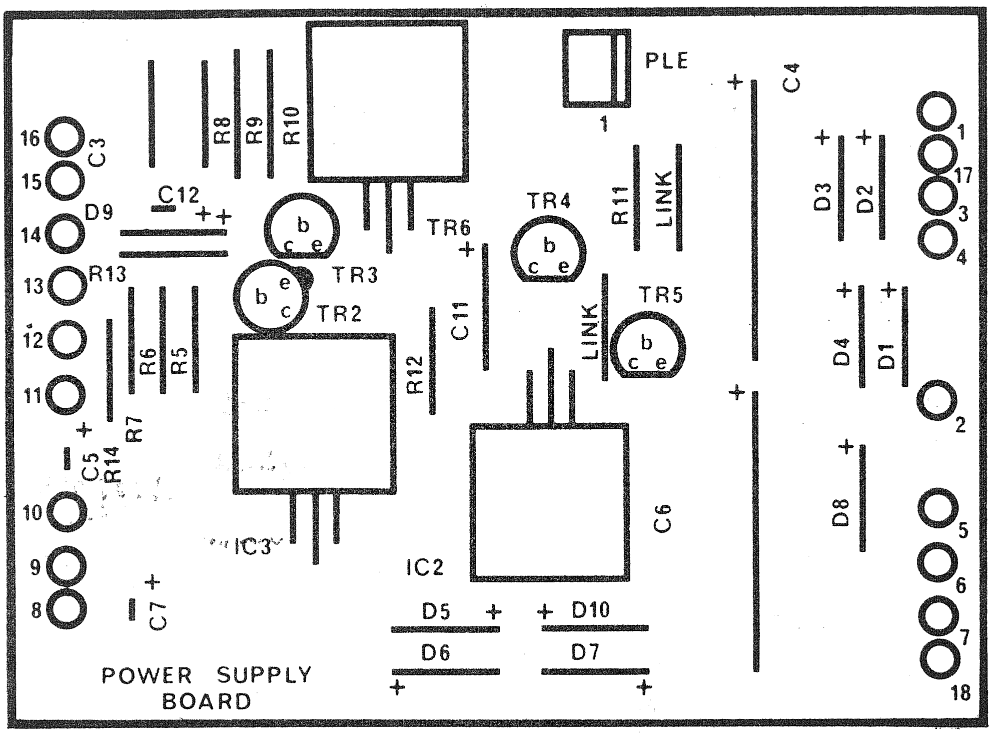
Deleted: C111, C112

Deleted: D315

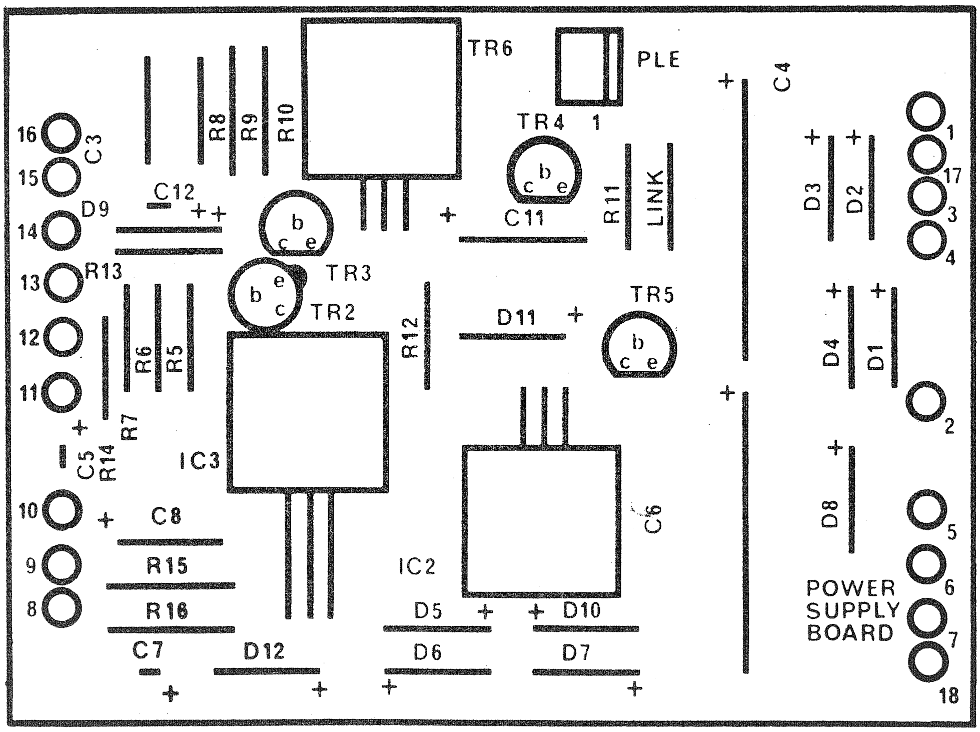
IC3		-12V Regulator LM337MP
IC129	1k x 8 EPROM	PROM kit to WBE Drawing
IC130	1k x 8 EPROM	DP3/23920 (50Hz)
		DP3/23921 (60Hz)
IC133 & IC134		Tri-state Hex Buffer 74LS365
IC311		Op. Amp. National LF35901-1A

Deleted: IC131, IC132, IC303

XL100 32.64MHz Crystal, Cathodeon FS5901-1A or
Hytek Microsystems HY4550 or
MF Electronics Corp M1100 or
ITT DIL 1100C

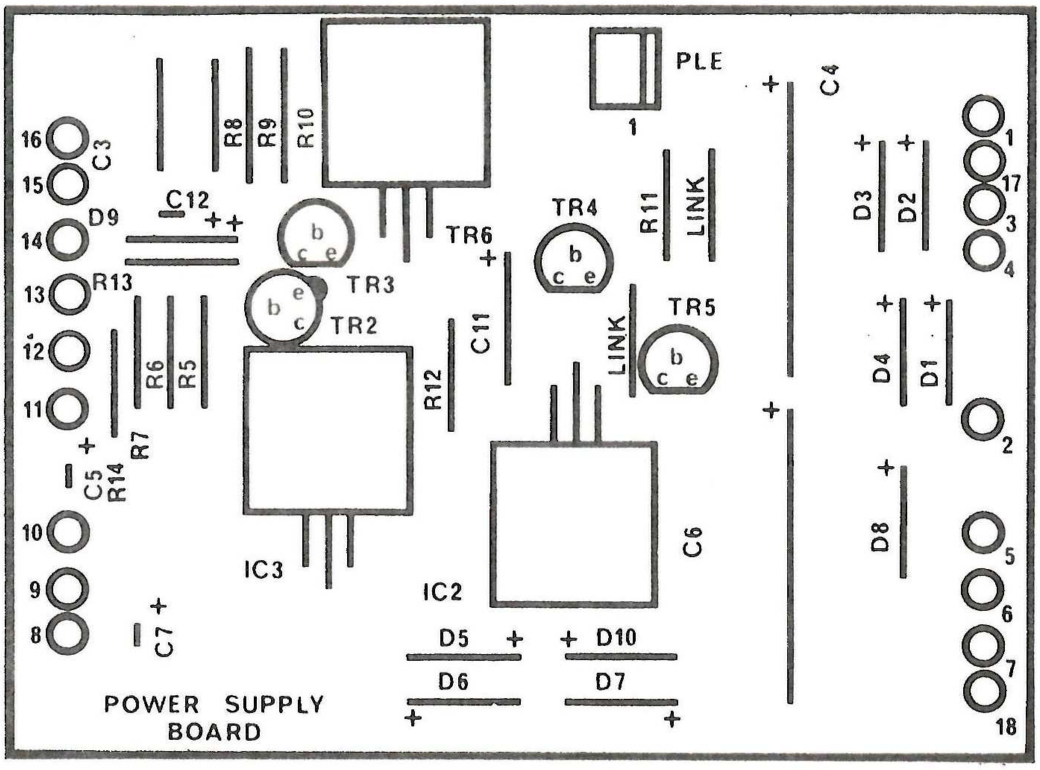


Up to Ser. No. 275

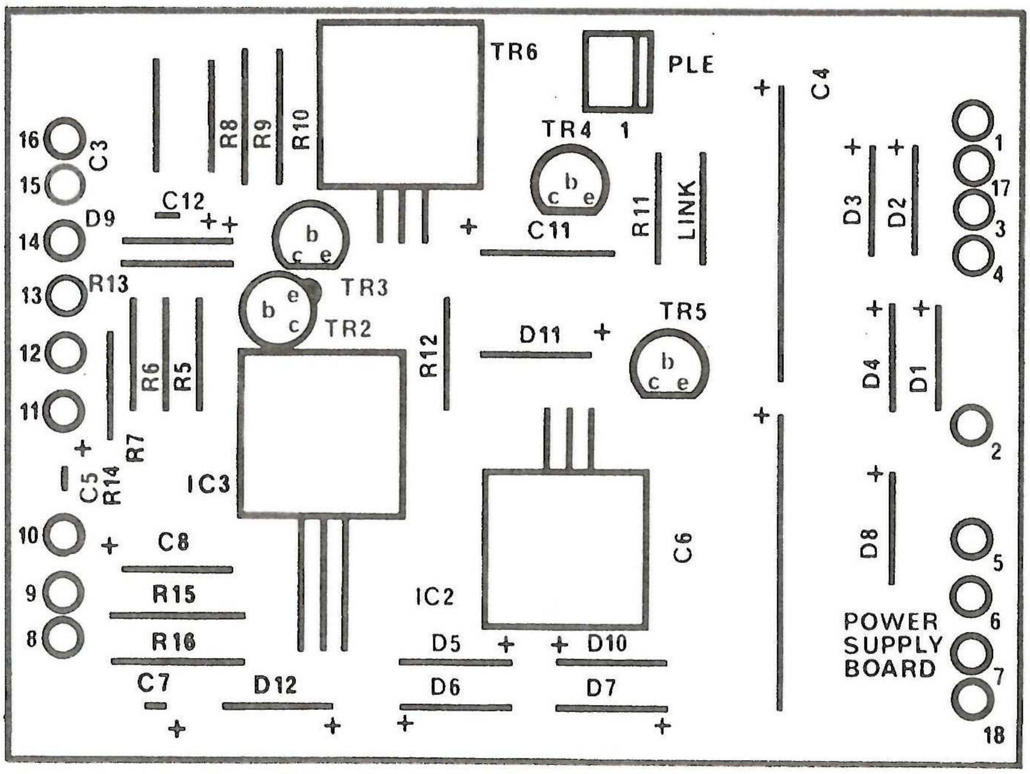


Ser. No. 276 onwards

FIG. 12 POWER SUPPLY P.C.B. LAYOUTS



Up to Ser. No. 275



Ser. No. 276 onwards

FIG. 12 POWER SUPPLY P.C.B. LAYOUTS

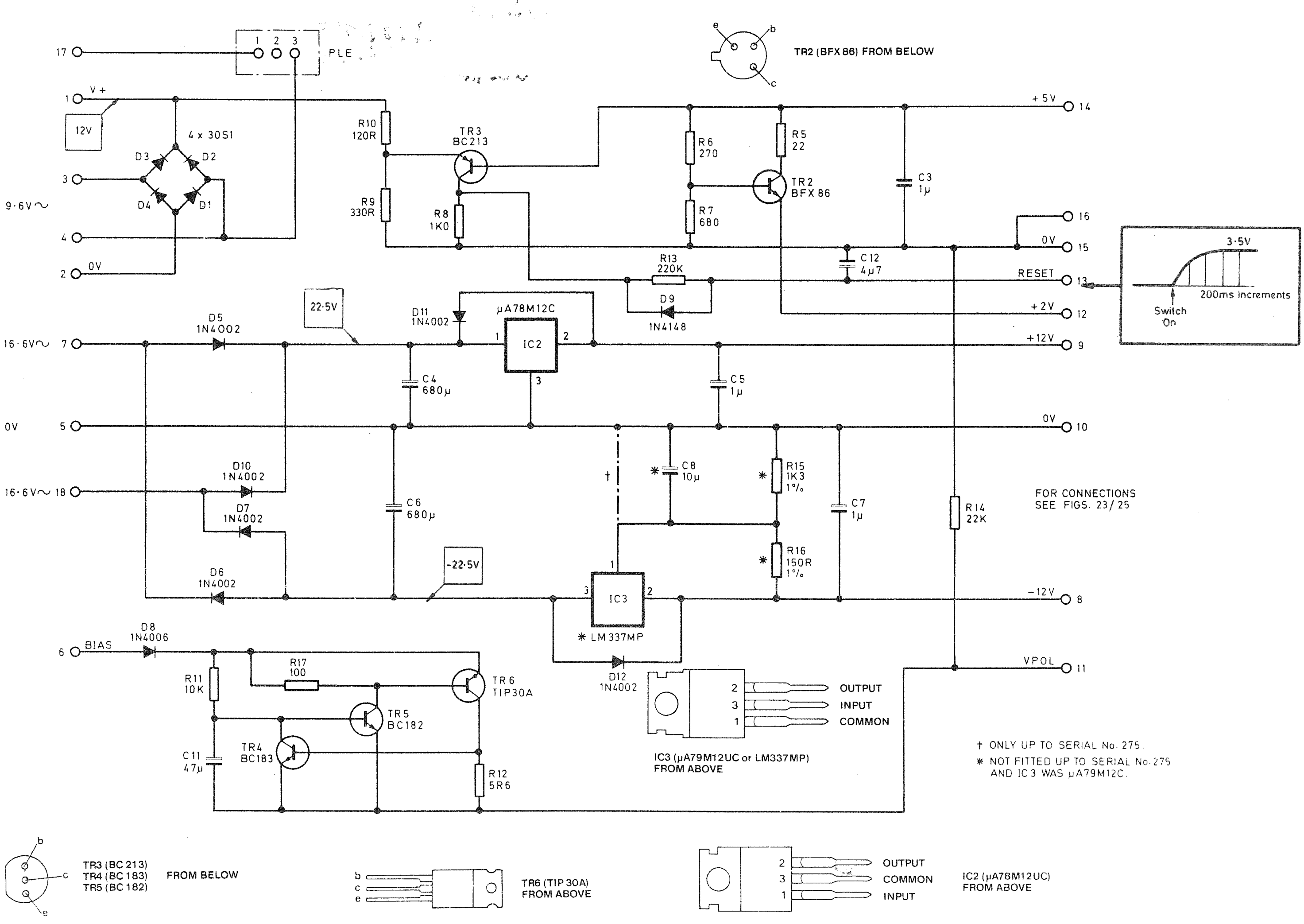


FIG. 13 POWER SUPPLY CIRCUIT DIAGRAM

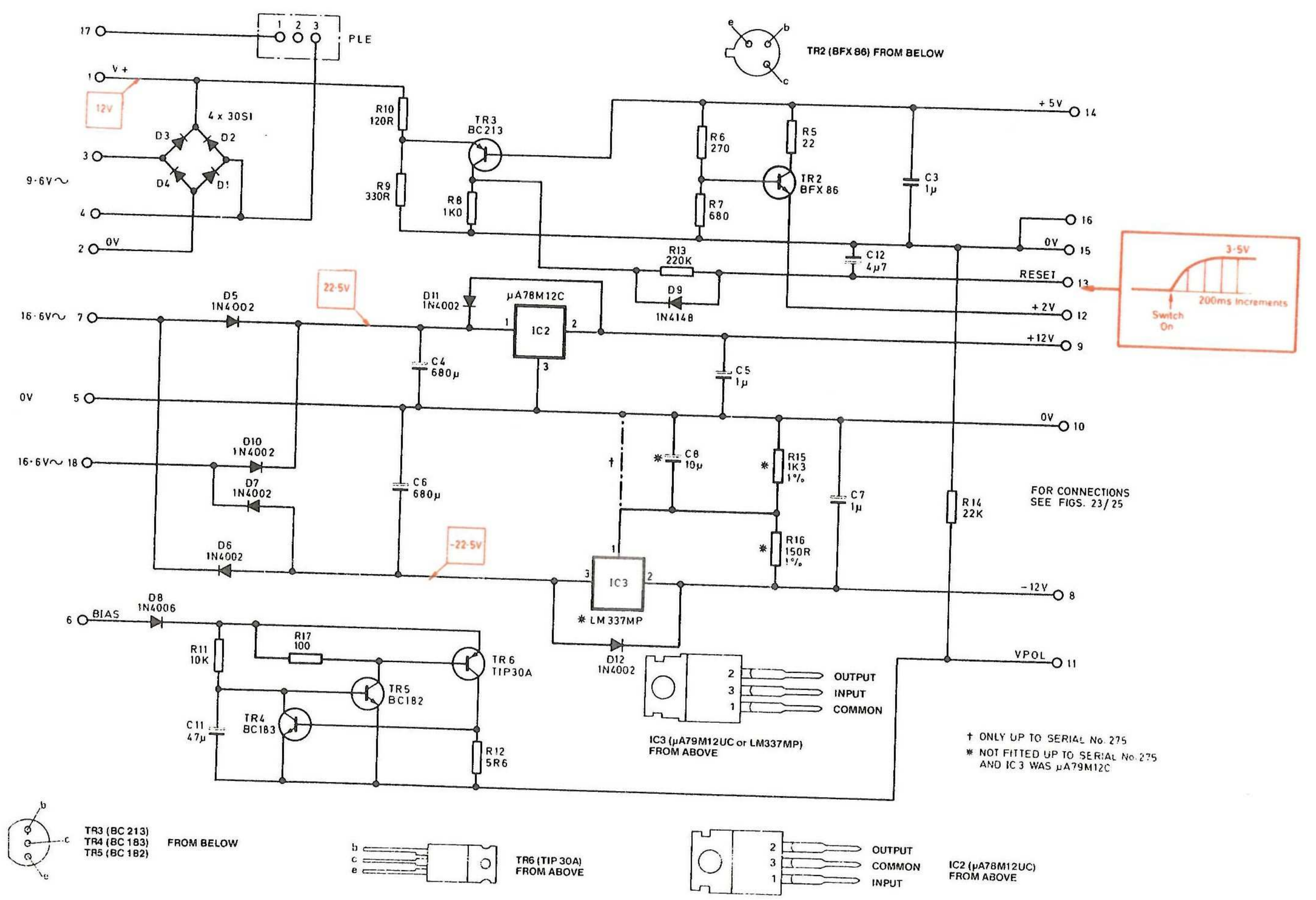


FIG. 13 POWER SUPPLY CIRCUIT DIAGRAM

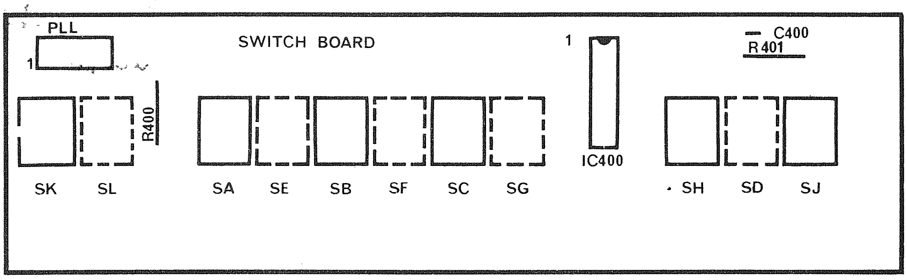


FIG. 14 SWITCH BOARD P.C.B. LAYOUT

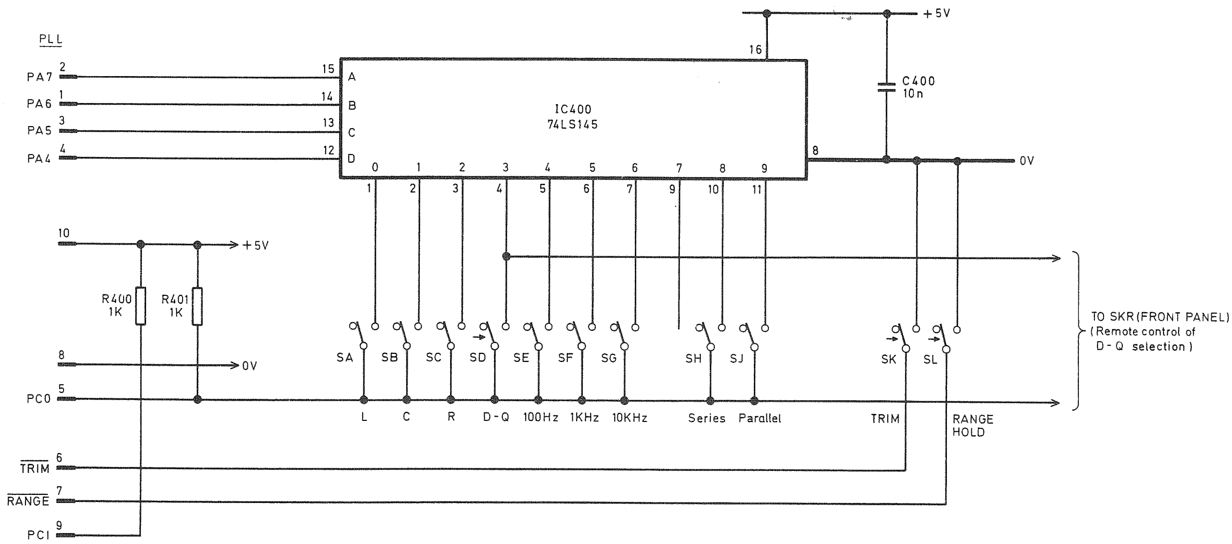


FIG. 15 SWITCH BOARD CIRCUIT DIAGRAM

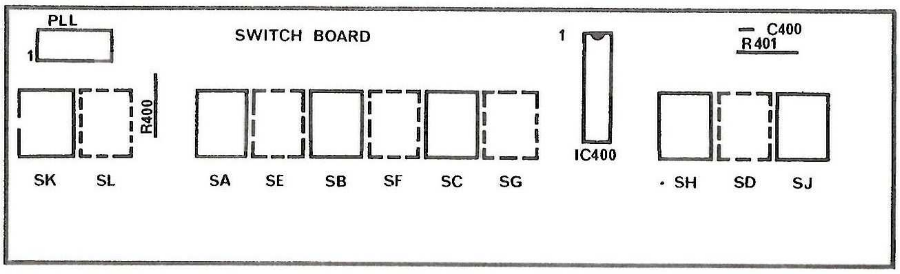


FIG. 14   SWITCH BOARD P.C.B. LAYOUT

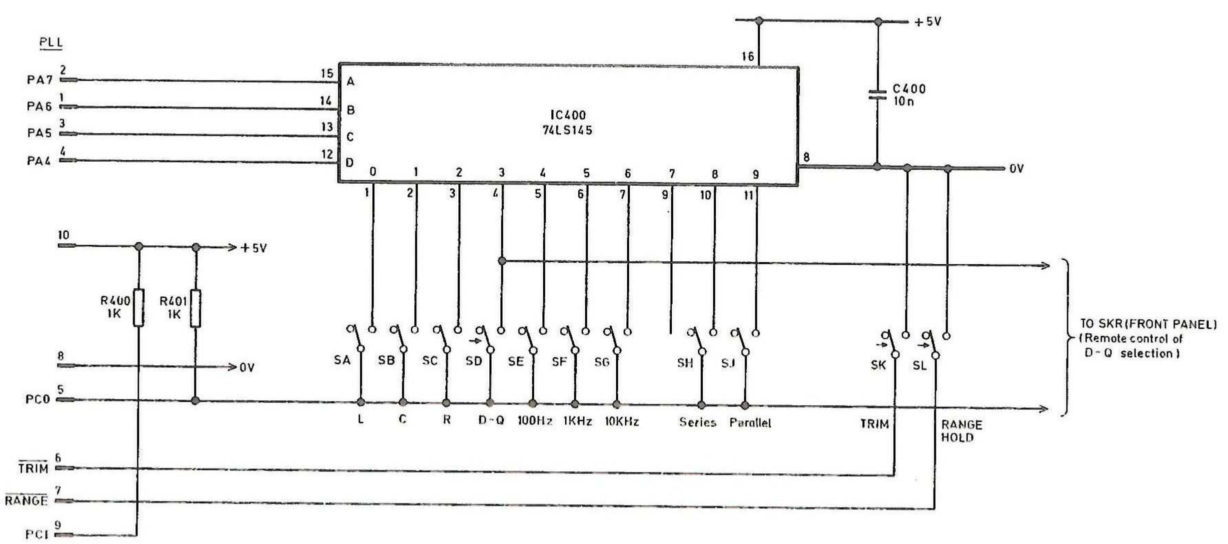


FIG. 15   SWITCH BOARD CIRCUIT DIAGRAM

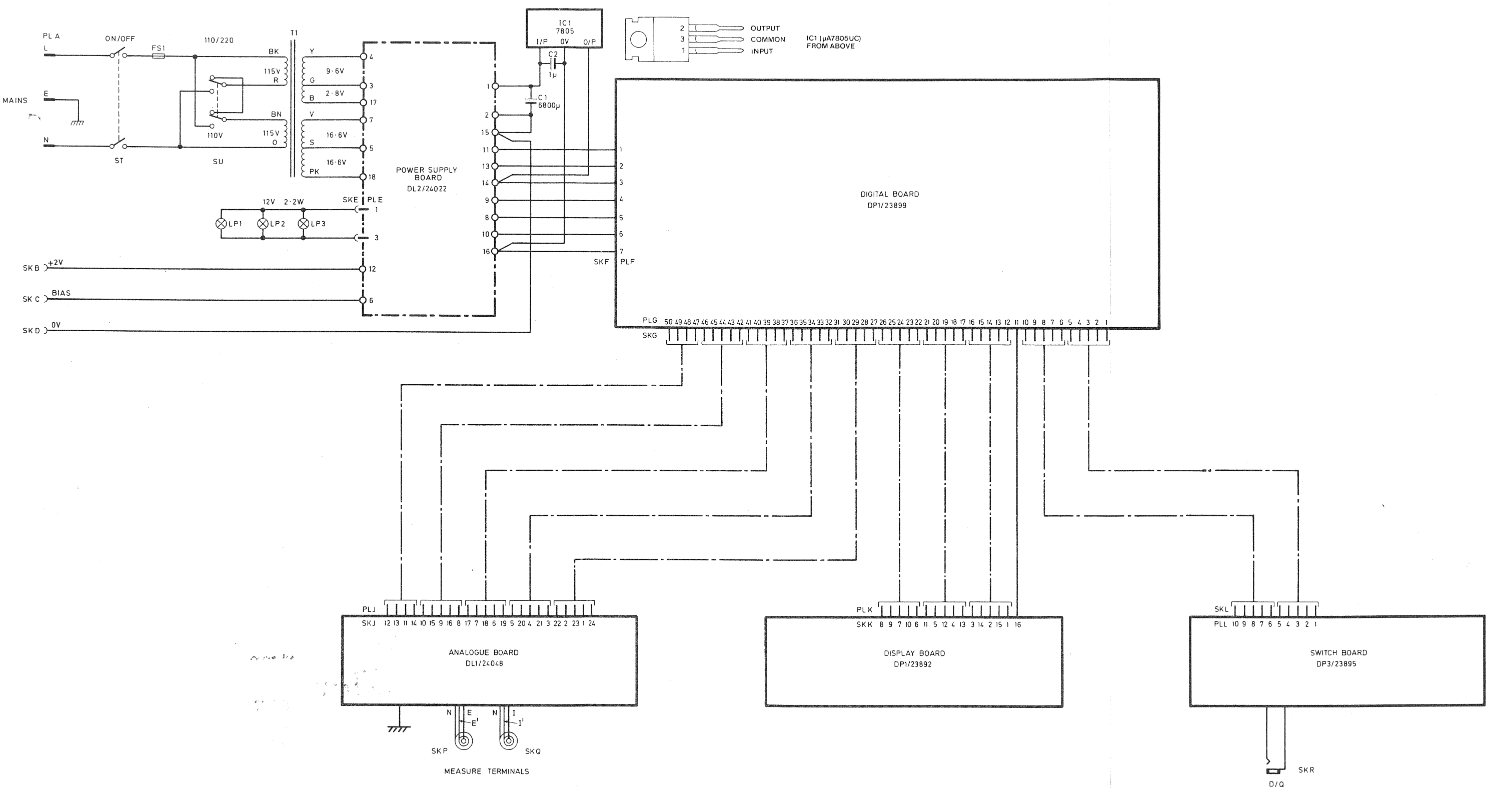


FIG. 16 INTERCONNECTION DIAGRAM

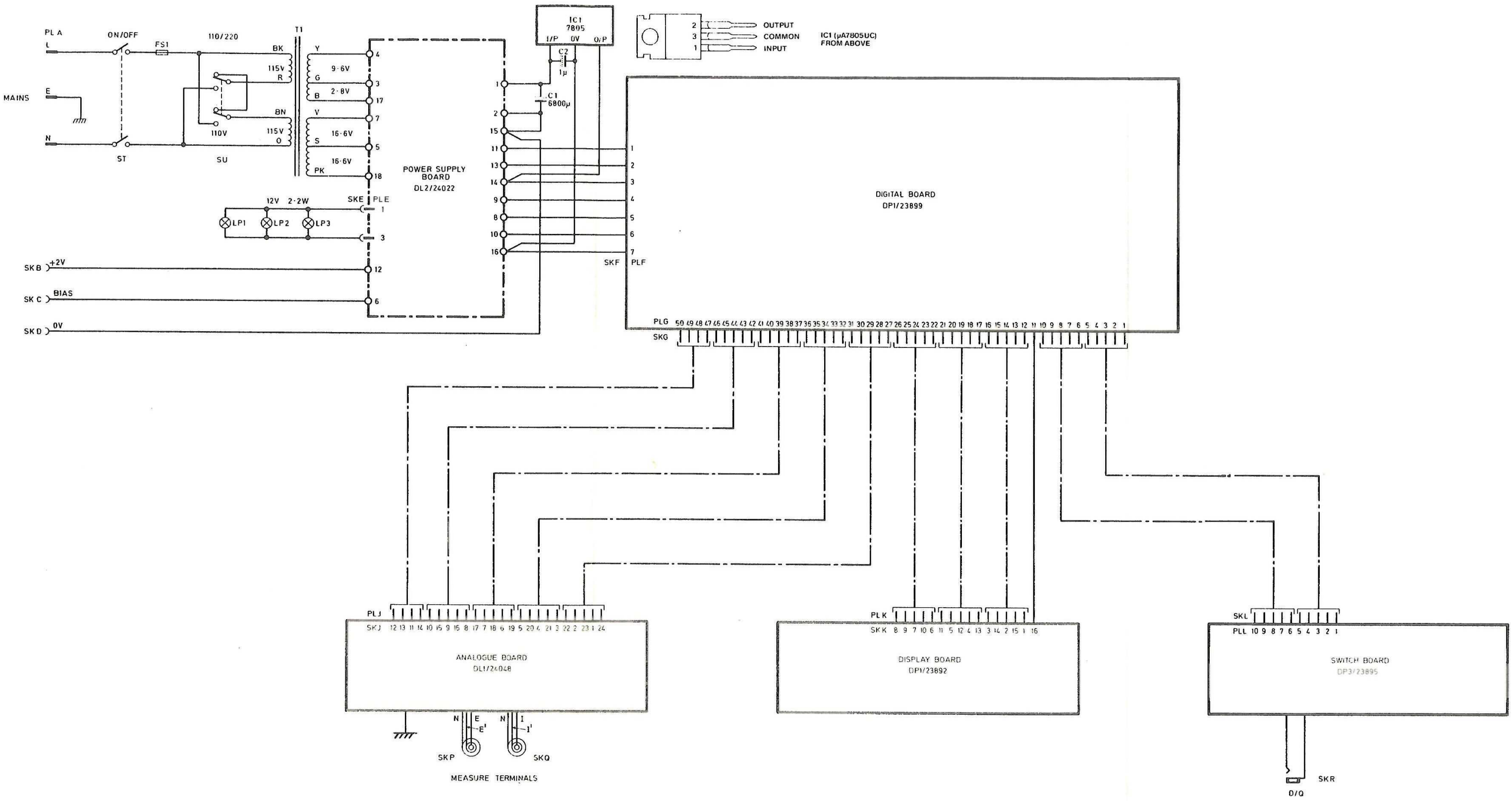


FIG. 16 INTERCONNECTION DIAGRAM

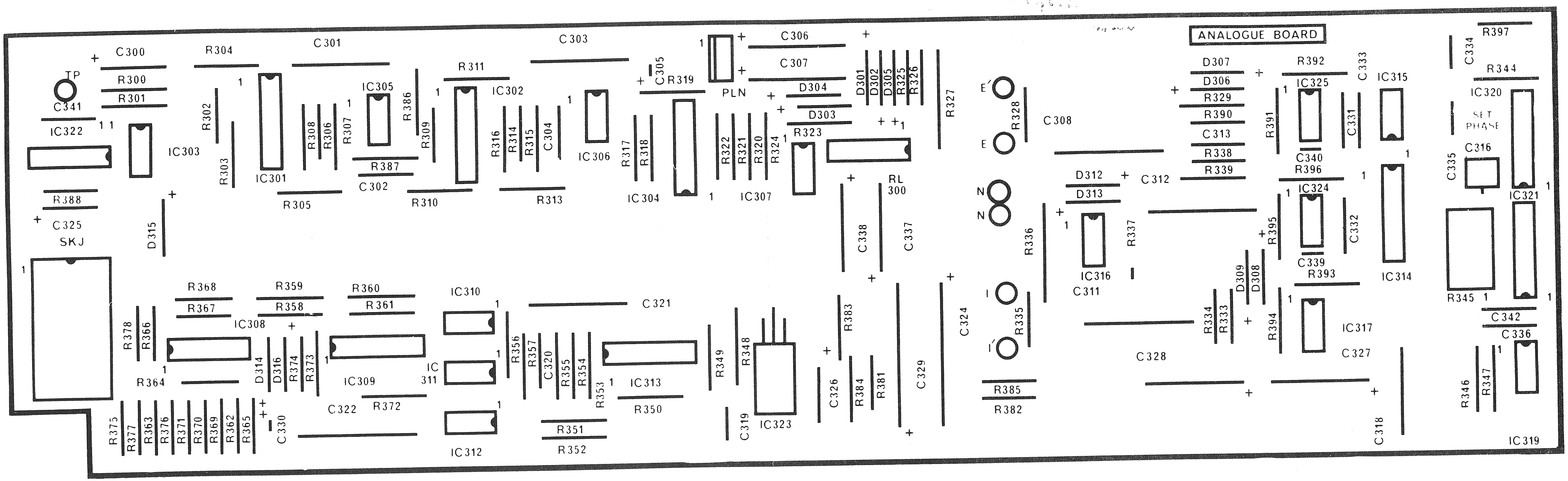


FIG. 17 ANALOGUE P.C.B. LAYOUT (UP TO SER. NO. 275)

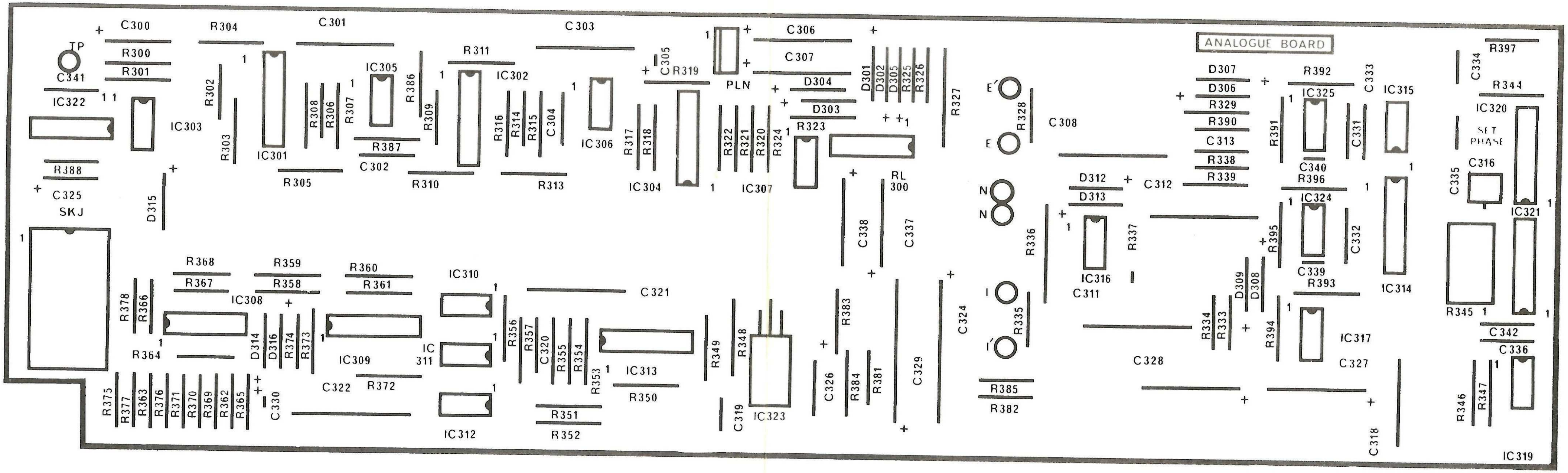
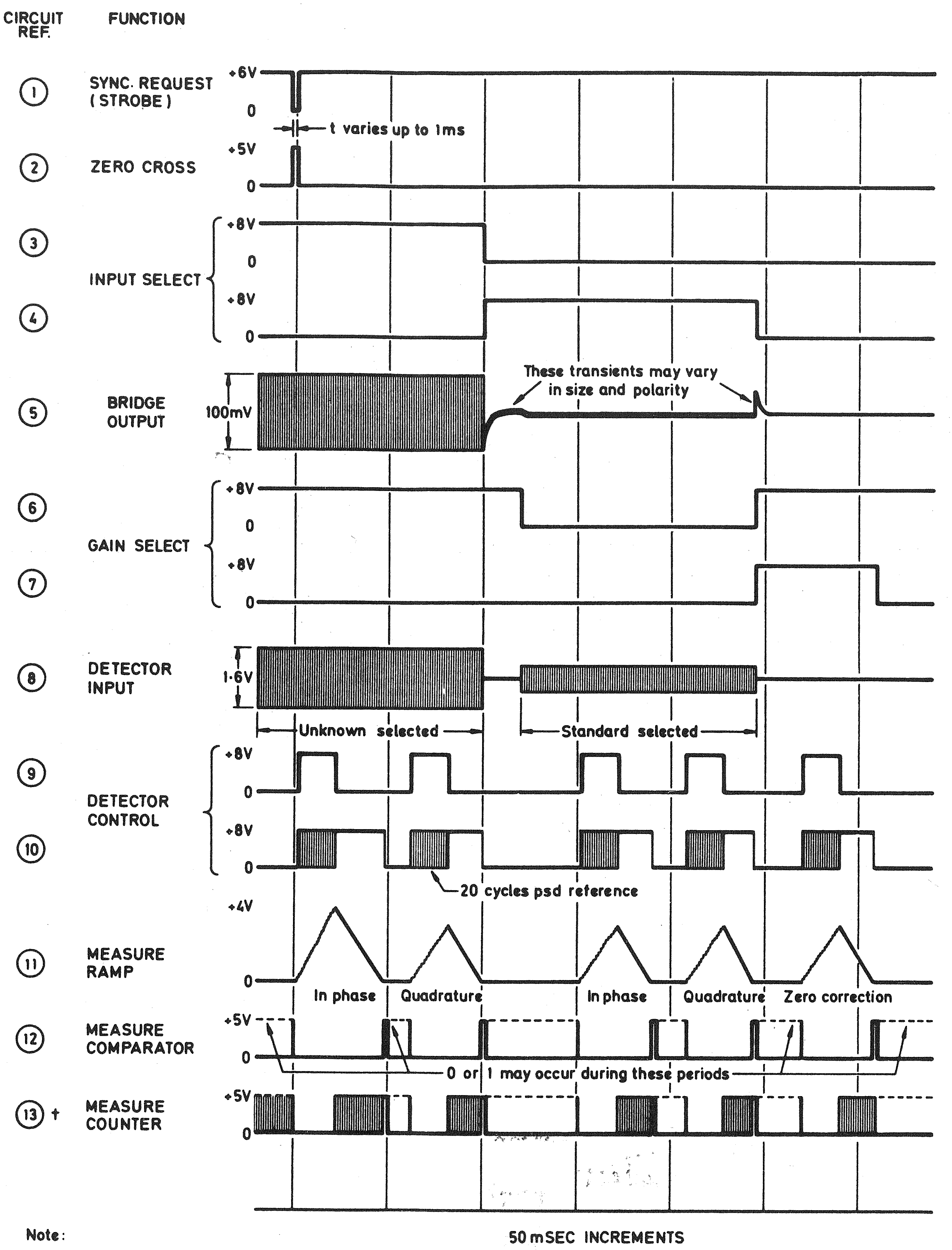


FIG. 17 ANALOGUE P.C.B. LAYOUT (UP TO SER. NO. 275)



Note:

† This waveform only appears on Digital pcb.
Voltages are not drawn to scale.

TEST CONDITIONS: FREQUENCY = 1KHz
FUNCTION = R
TEST COMPONENT = 22KΩ RESISTOR
SCOPE SYNC. FROM TP1 (DIGITAL BOARD)
SCOPE RETURN TO 0V (CHASSIS)

FIG. 18 WAVEFORM TIMING DIAGRAM

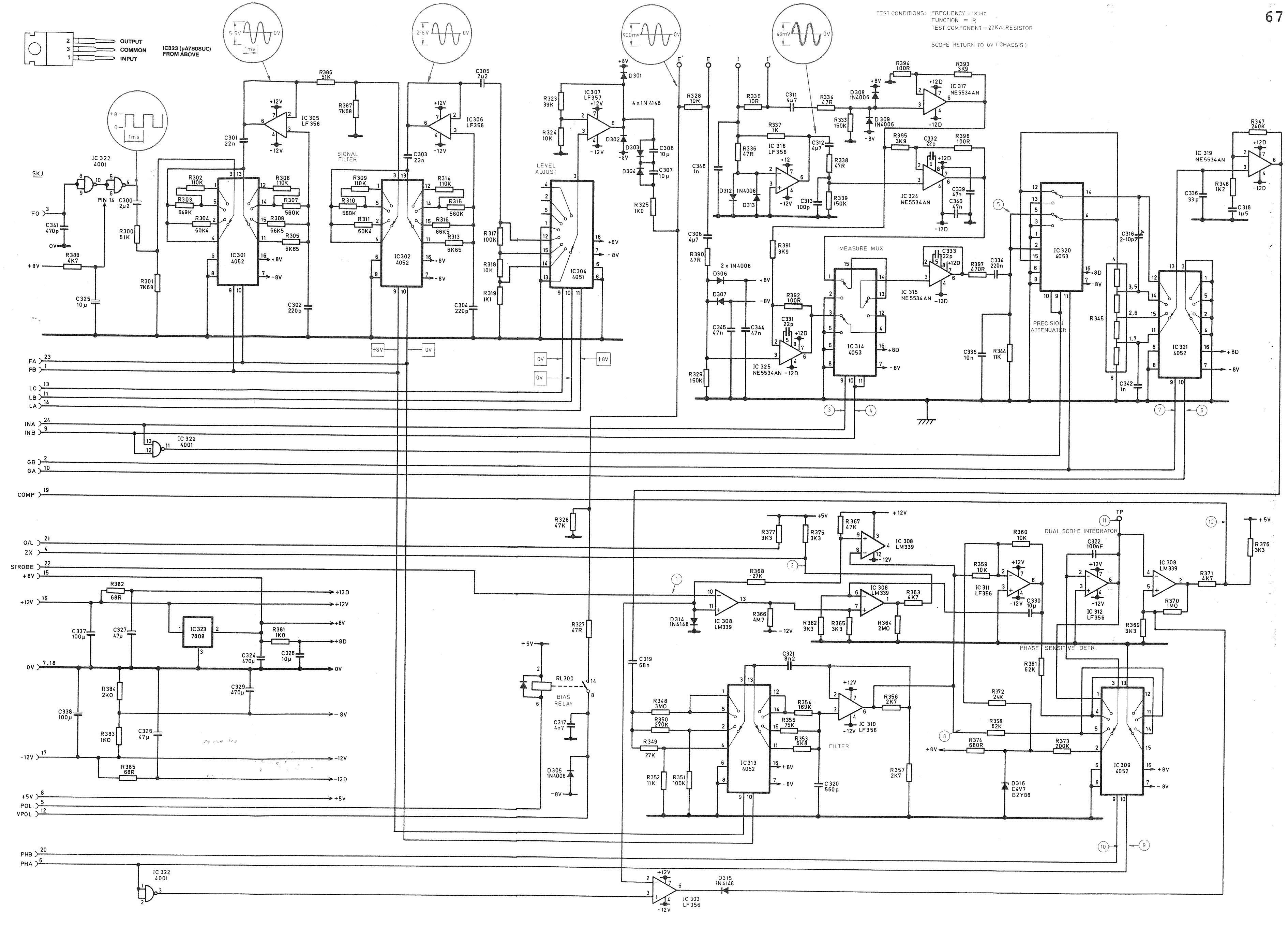


FIG. 19 ANALOGUE CIRCUIT DIAGRAM (UP TO SER. NO. 275)

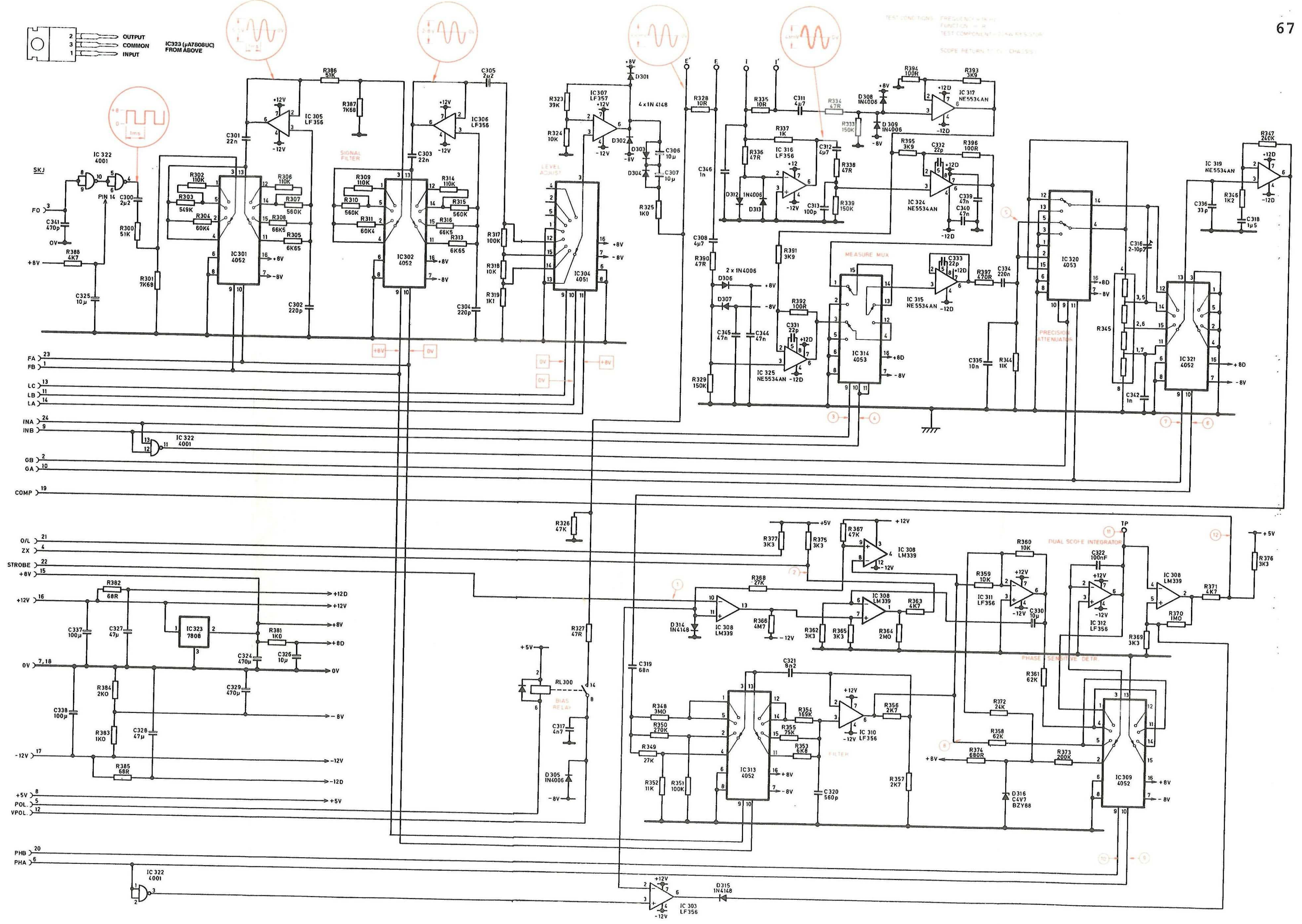


FIG. 19 ANALOGUE CIRCUIT DIAGRAM (UP TO SER. NO. 275)

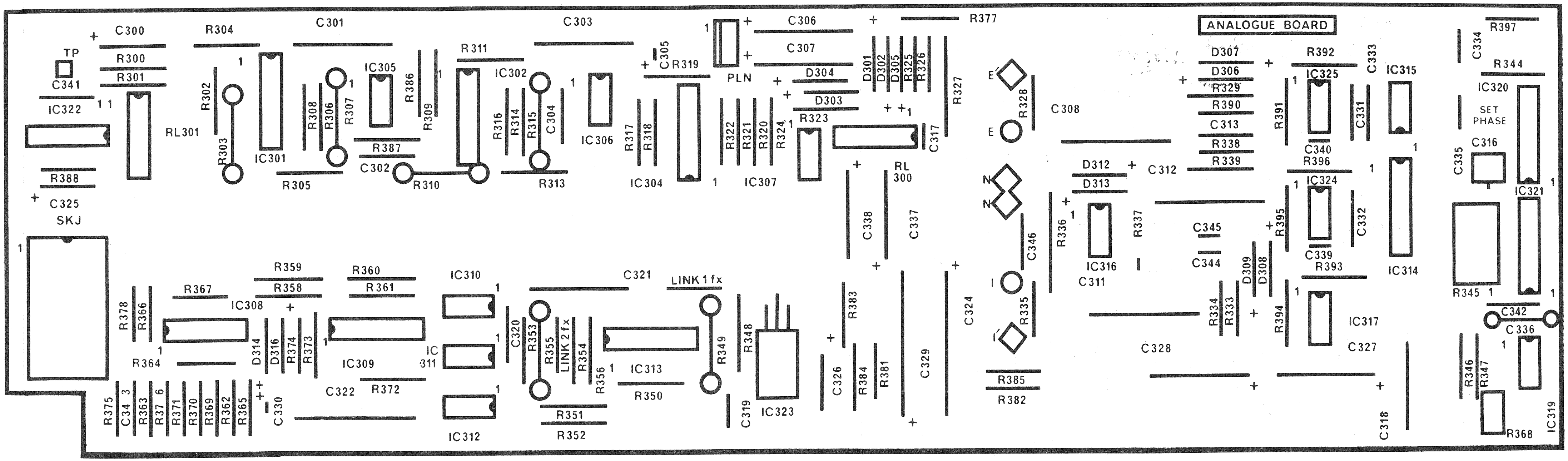


FIG. 20 ANALOGUE P.C.B. LAYOUT (SER. NO. 276 ONWARDS)

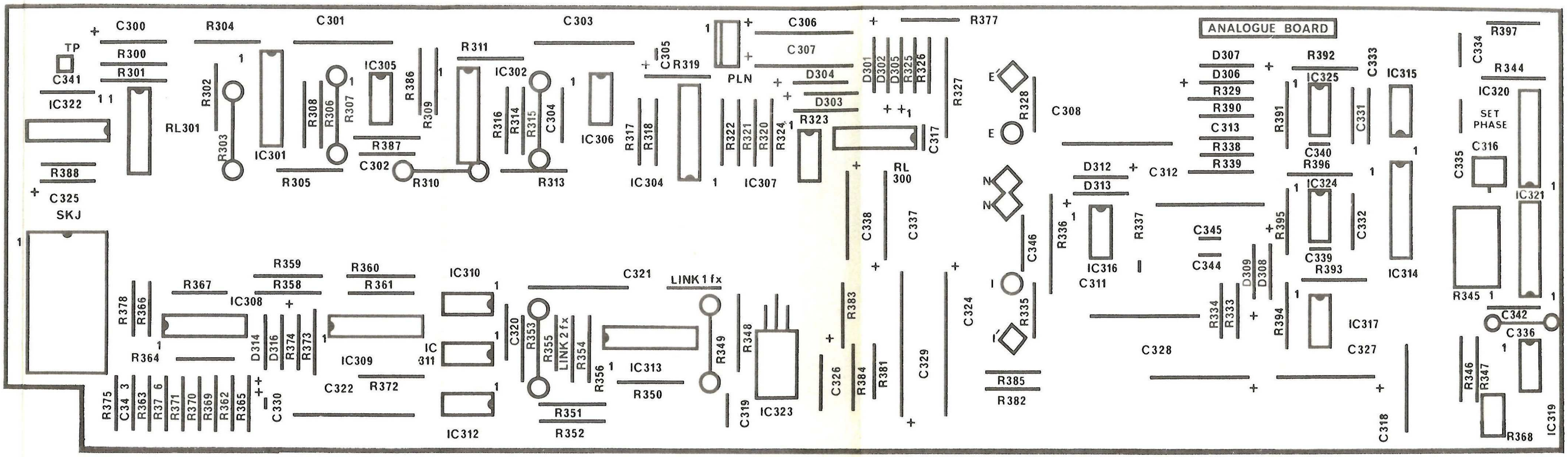
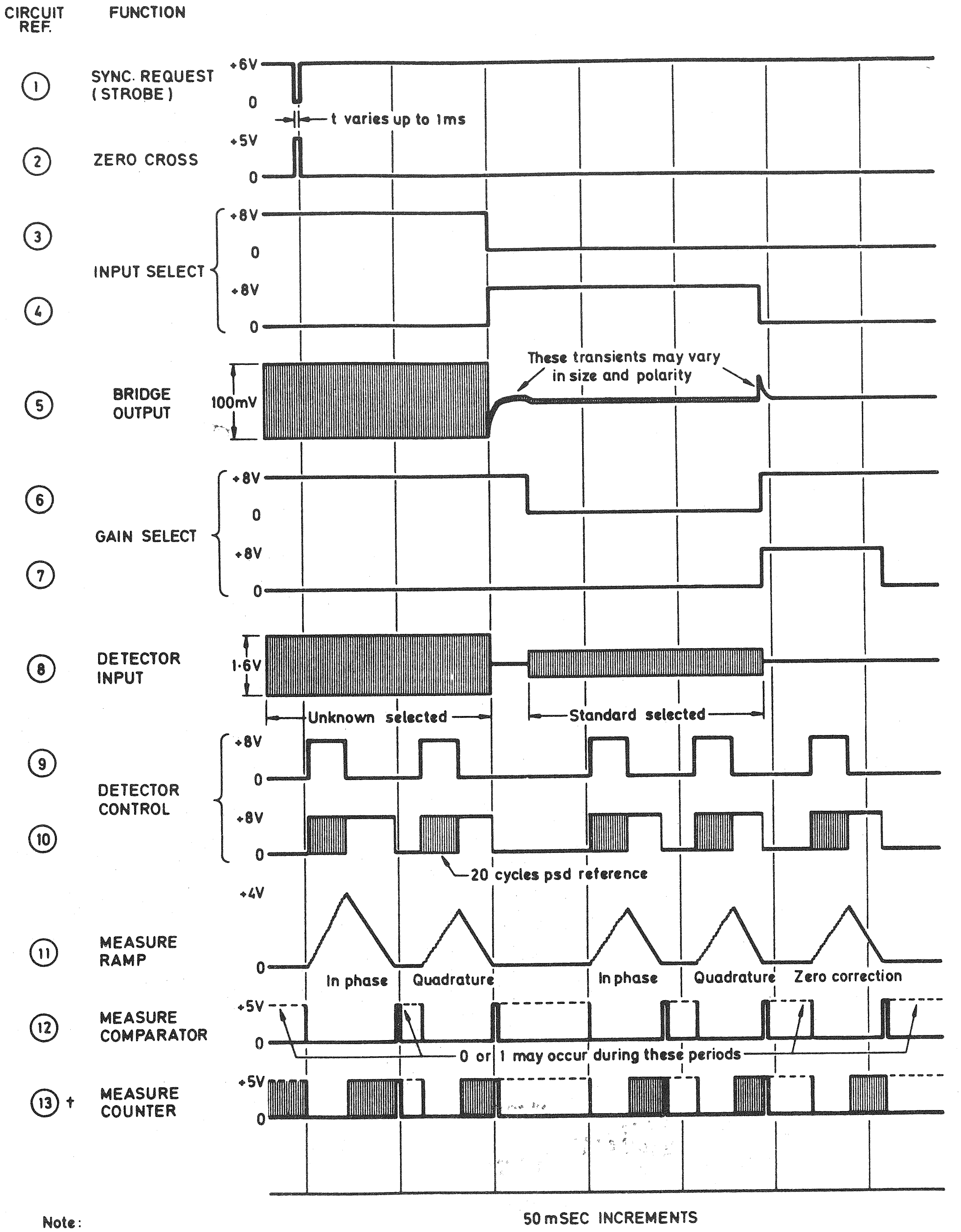


FIG. 20 ANALOGUE P.C.B. LAYOUT (SER. NO. 276 ONWARDS)



Note:

†This waveform only appears on Digital pcb.
Voltages are not drawn to scale.

TEST CONDITIONS: FREQUENCY = 1KHz
FUNCTION = R
TEST COMPONENT = 22KΩ RESISTOR
SCOPE SYNC. FROM TP1 (DIGITAL BOARD)
SCOPE RETURN TO 0V (CHASSIS)

FIG. 18 WAVEFORM TIMING DIAGRAM

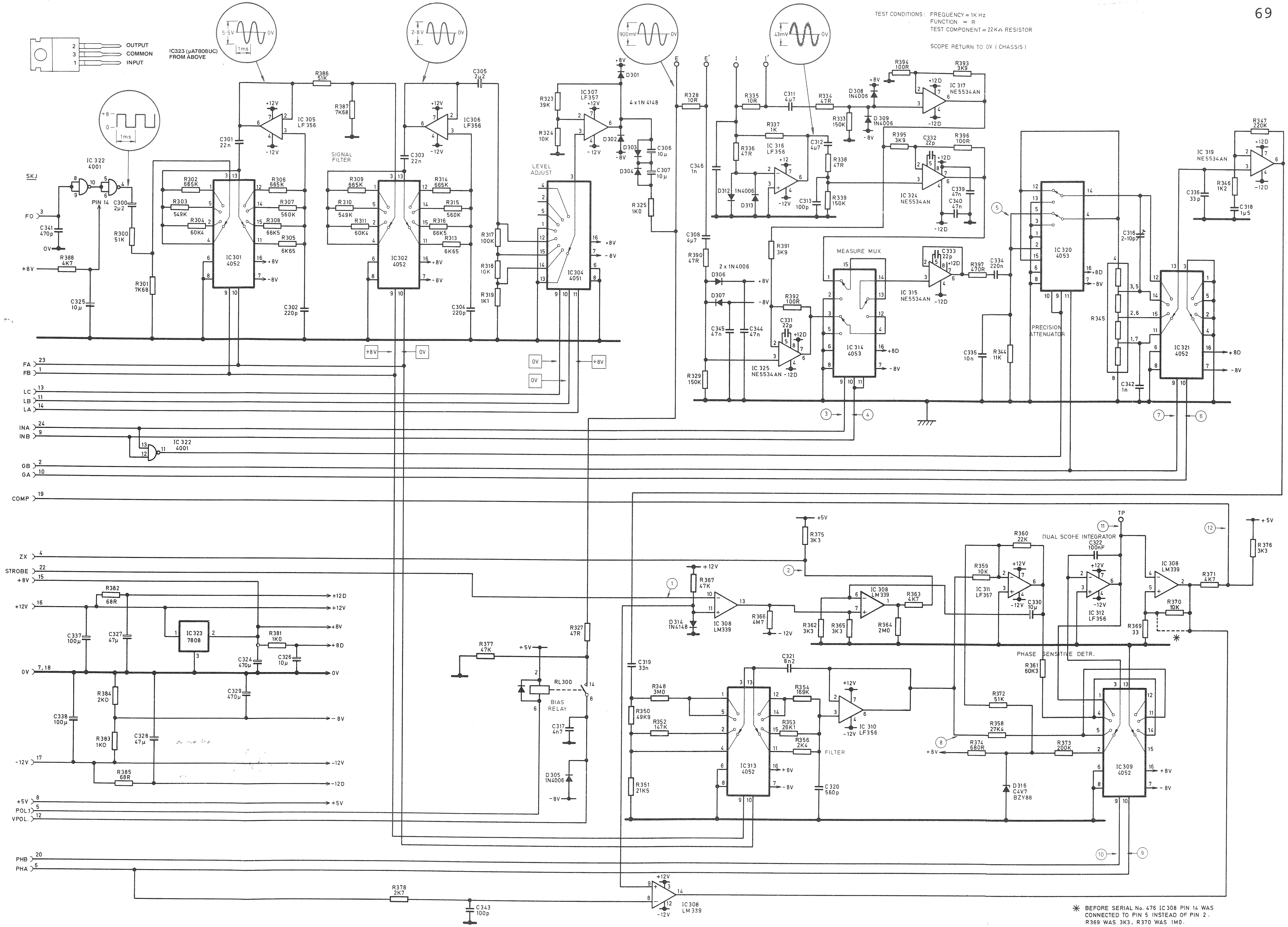
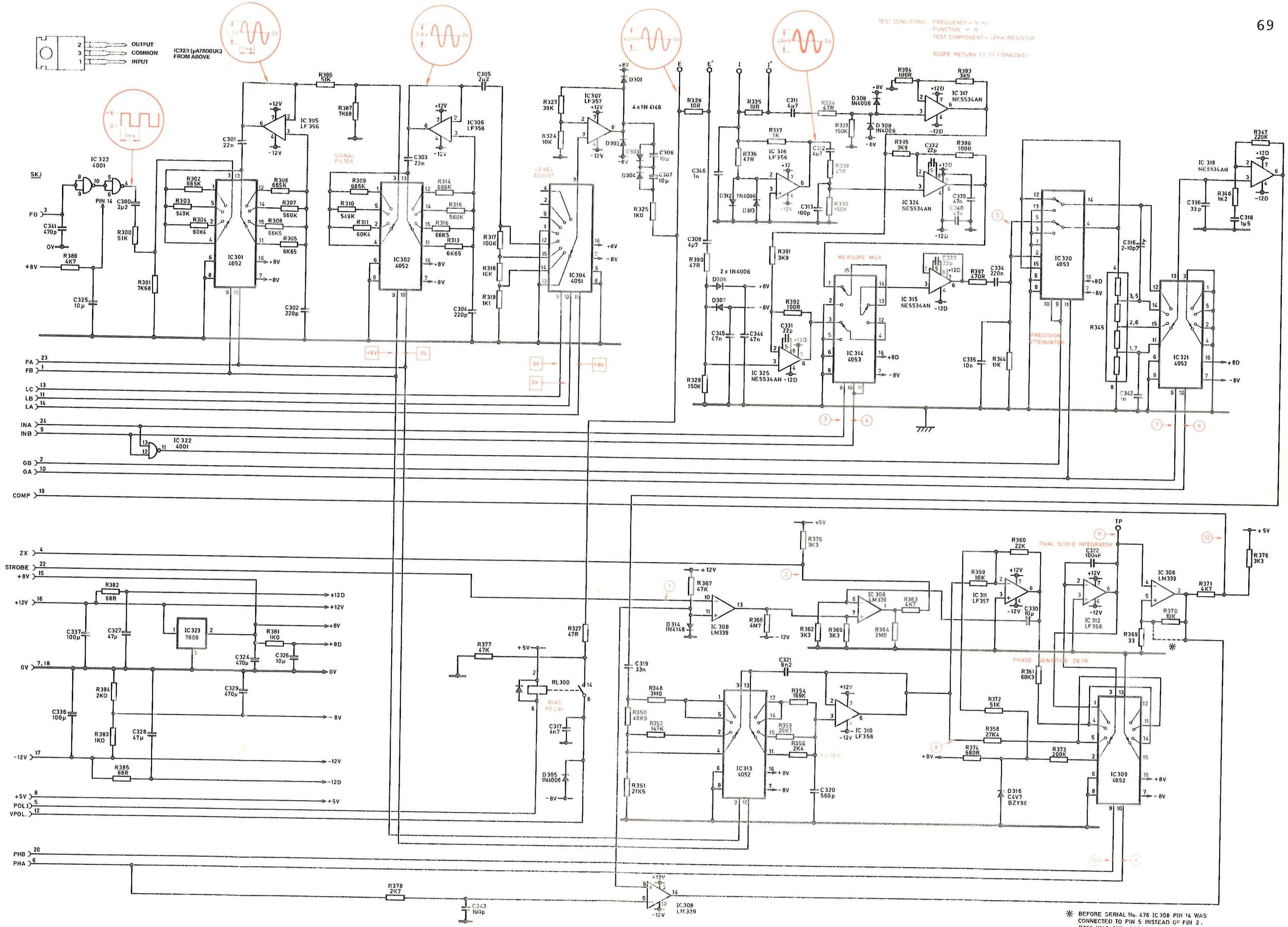


FIG. 21 ANALOGUE CIRCUIT DIAGRAM (SER. NO. 276 ONWARDS)



✱ BEFORE SERIAL No. 476 IC308 PIN 14 WAS CONNECTED TO PIN 5 INSTEAD OF PIN 2. R369 WAS 3K3. R370 WAS 1M0.

FIG. 21 ANALOGUE CIRCUIT DIAGRAM (SER. NO. 276 ONWARDS)

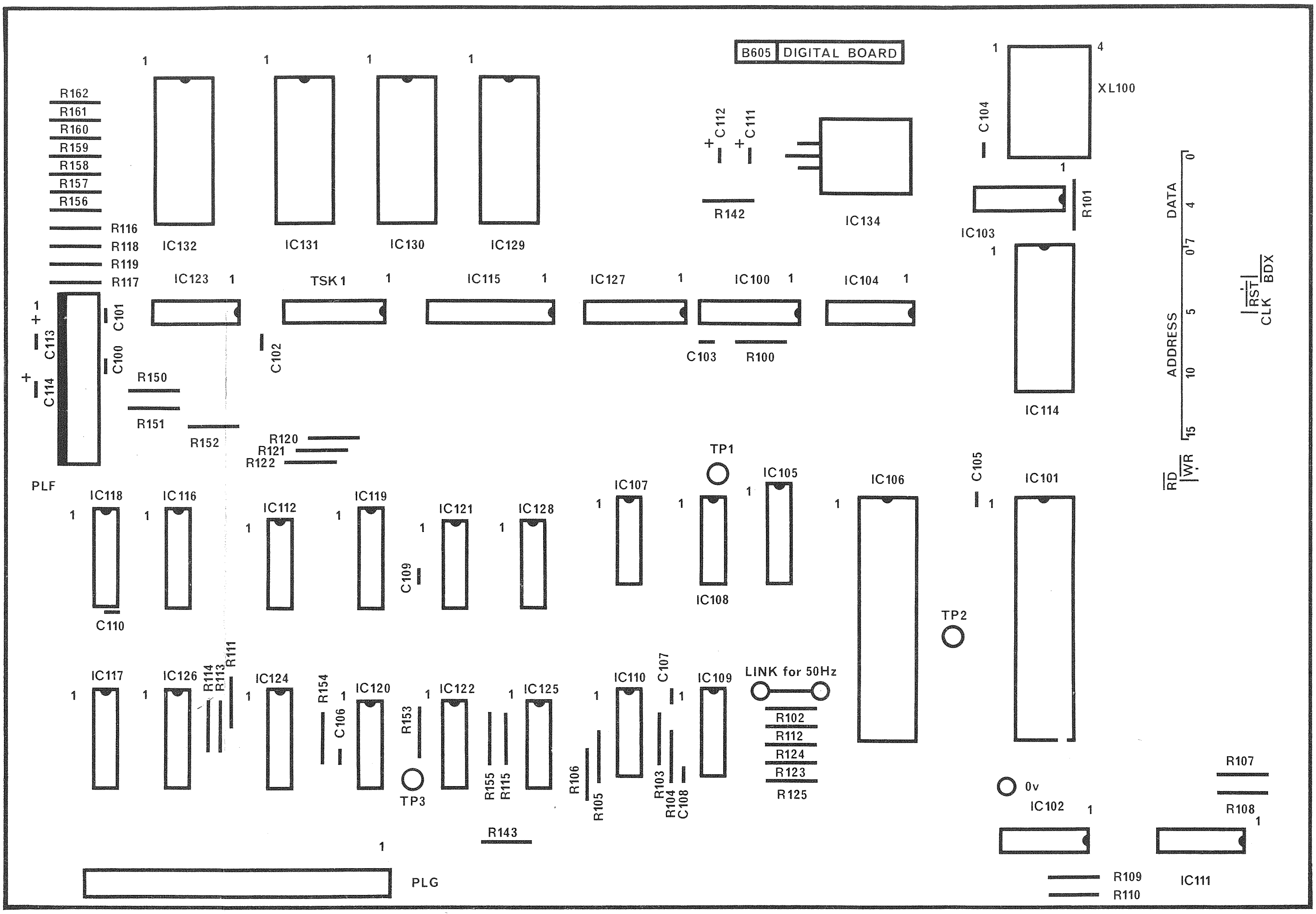


FIG. 22 DIGITAL P.C.B. LAYOUT (UP TO SER. NO. 375)

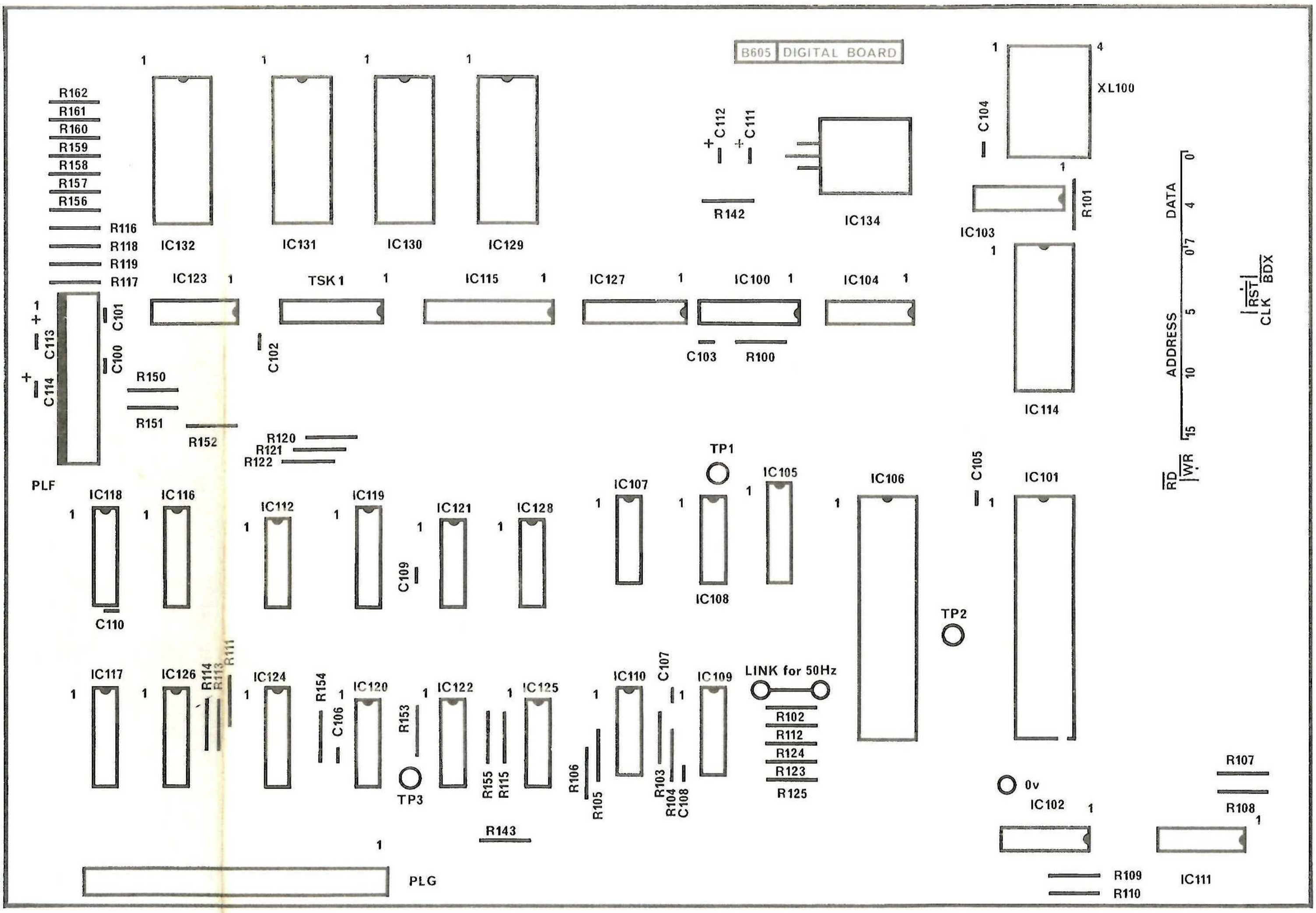
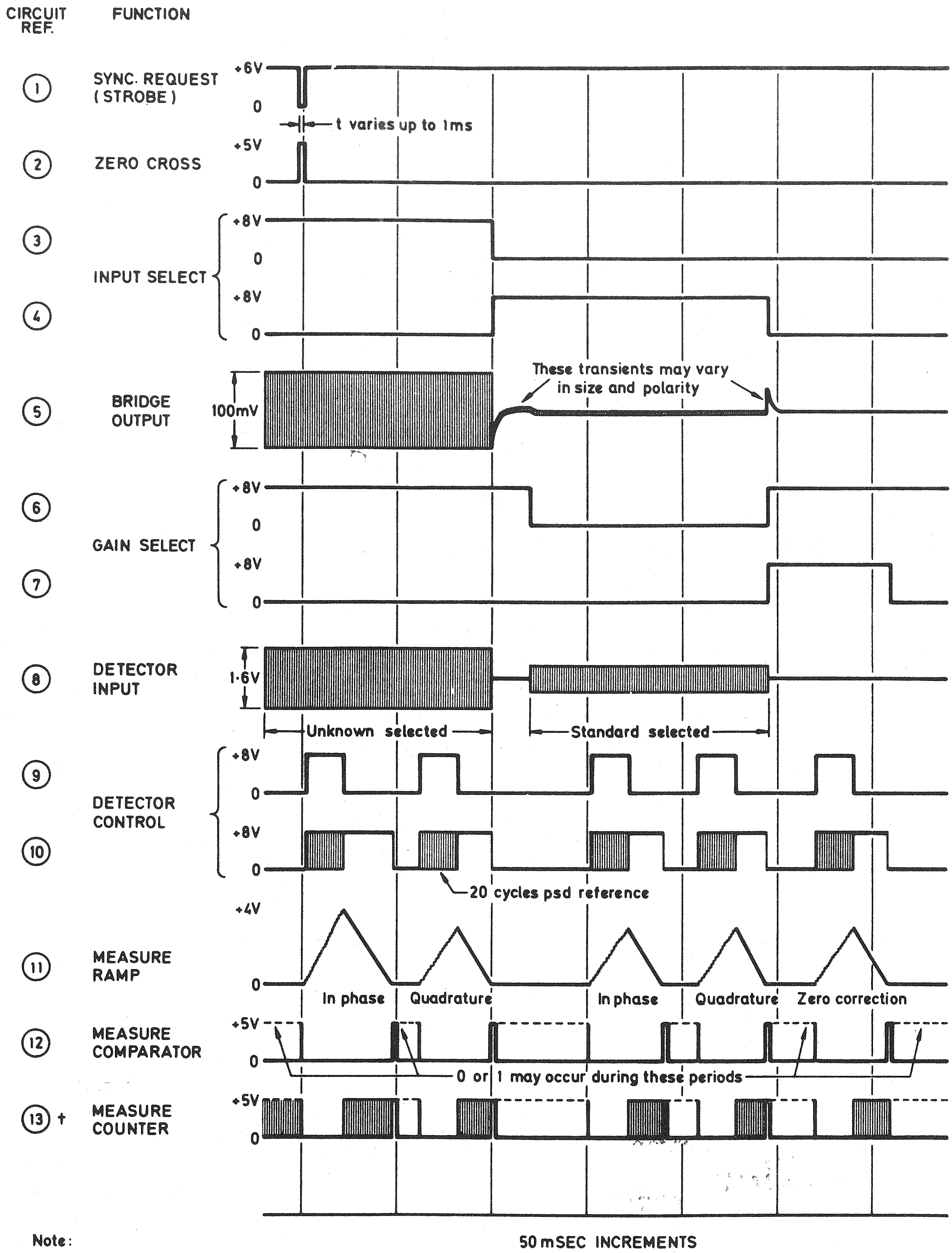


FIG. 22 DIGITAL P.C.B. LAYOUT (UP TO SER. NO. 375)



Note:

† This waveform only appears on Digital pcb.
Voltages are not drawn to scale.

TEST CONDITIONS: FREQUENCY = 1K Hz
FUNCTION = R
TEST COMPONENT = 22KΩ RESISTOR
SCOPE SYNC. FROM TP1 (DIGITAL BOARD)
SCOPE RETURN TO 0V (CHASSIS)

FIG. 18 WAVEFORM TIMING DIAGRAM

REF.	IC100	IC102 IC111 IC125	IC103 IC104	IC105	IC106	IC107 IC108 IC109	IC110 IC123	IC112	IC113	IC114	IC115	IC116 IC117 IC118	IC119 IC127	IC120	IC121	IC122	IC124	IC126	IC128	IC129 IC130 IC131 IC132
TYPE	74S112	74LS04	74LS93	4020	8155	74LS74	74LS25	74LS02	74LS244	8253	74LS373	CD4042	74LS138	74LS32	74LS27	74LS20	74LS145	CD4049	74LS08	2708
+5V	PIN 16	PIN 14	PIN 5	PIN 16	PIN 40	PIN 14	PIN 14	PIN 14	PIN 20	PIN 24	PIN 20		PIN 16	PIN 14	PIN 14	PIN 14	PIN 16	PIN 1	PIN 14	PIN 24
-5V																				PIN 21
+12V																				PIN 19
0V	PIN 8	PIN 7	PIN 10	PIN 8	PIN 20	PIN 7	PIN 7	PIN 7	PIN 10	PIN 12	PIN 10	PIN 8	PIN 8	PIN 7	PIN 7	PIN 7	PIN 8	PIN 8	PIN 7	PIN 12
+8V												PIN 16								

POWER SUPPLY CONNECTIONS

NOTE: ALL UNSPECIFIED RESISTORS 1K0

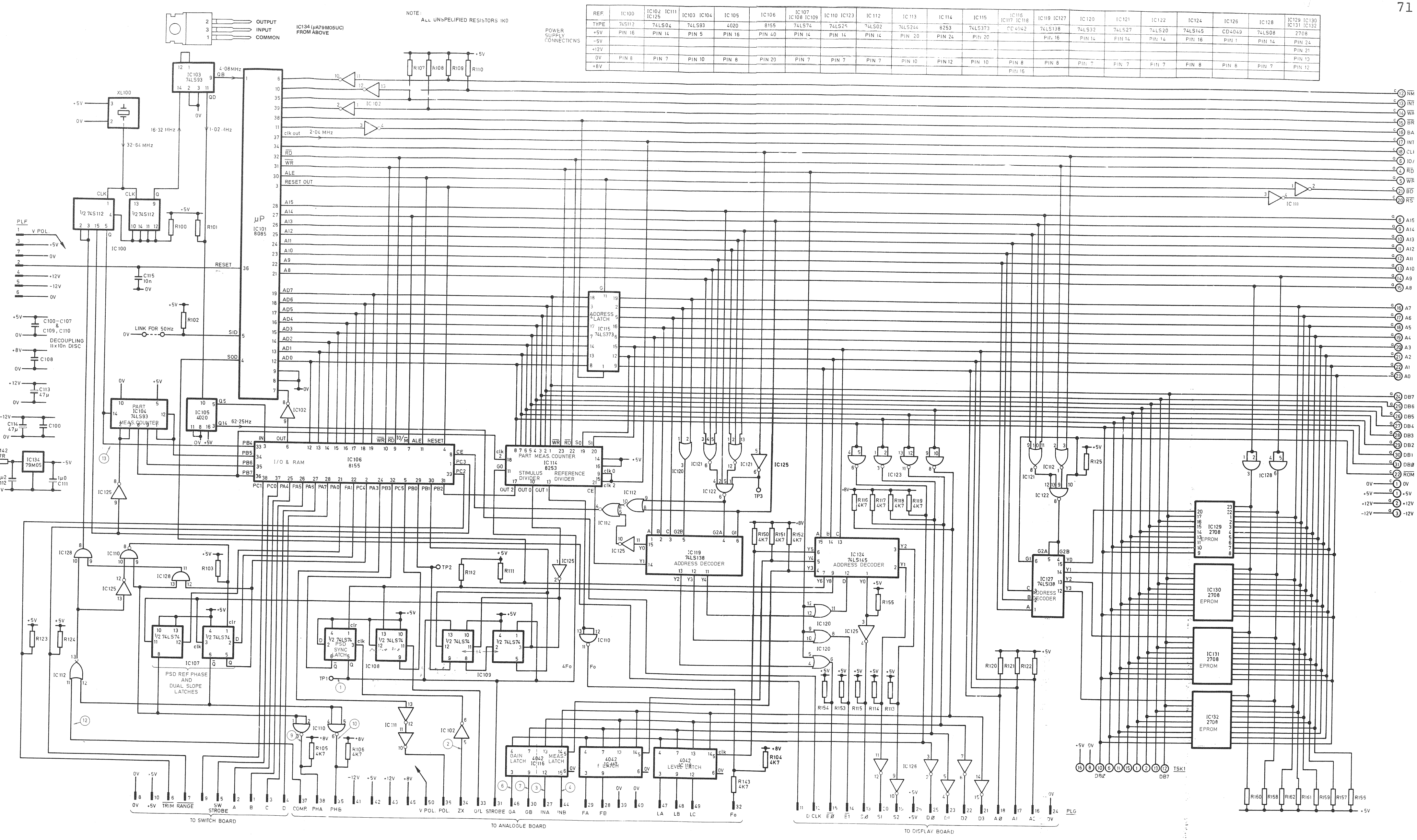


FIG. 23 DIGITAL CIRCUIT DIAGRAM (UP TO SER. NO. 375)

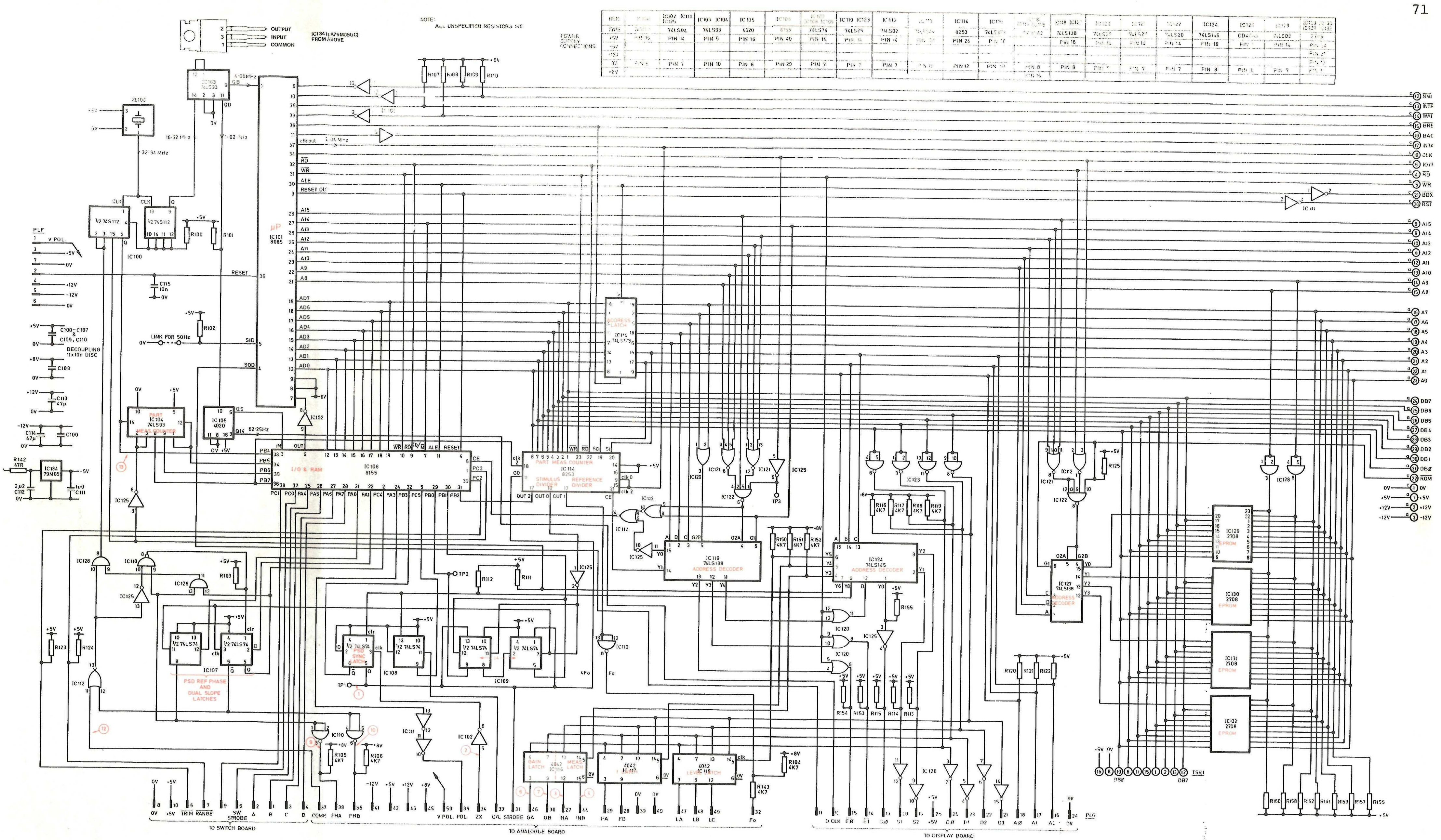


FIG. 23 DIGITAL CIRCUIT DIAGRAM (UP TO SER. NO. 375)

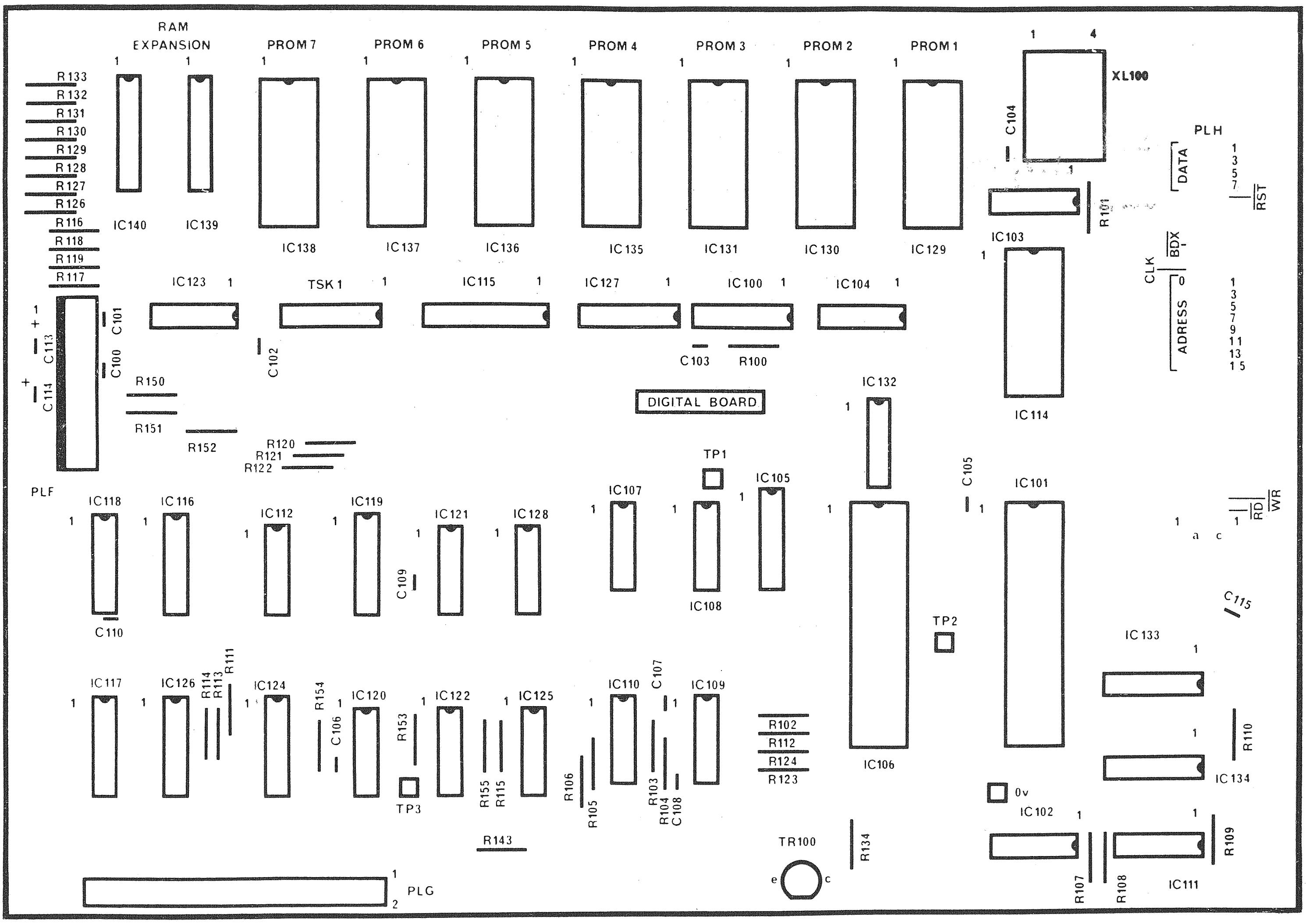


FIG. 24 DIGITAL P.C.B. LAYOUT (SER. NO. 376 ONWARDS)

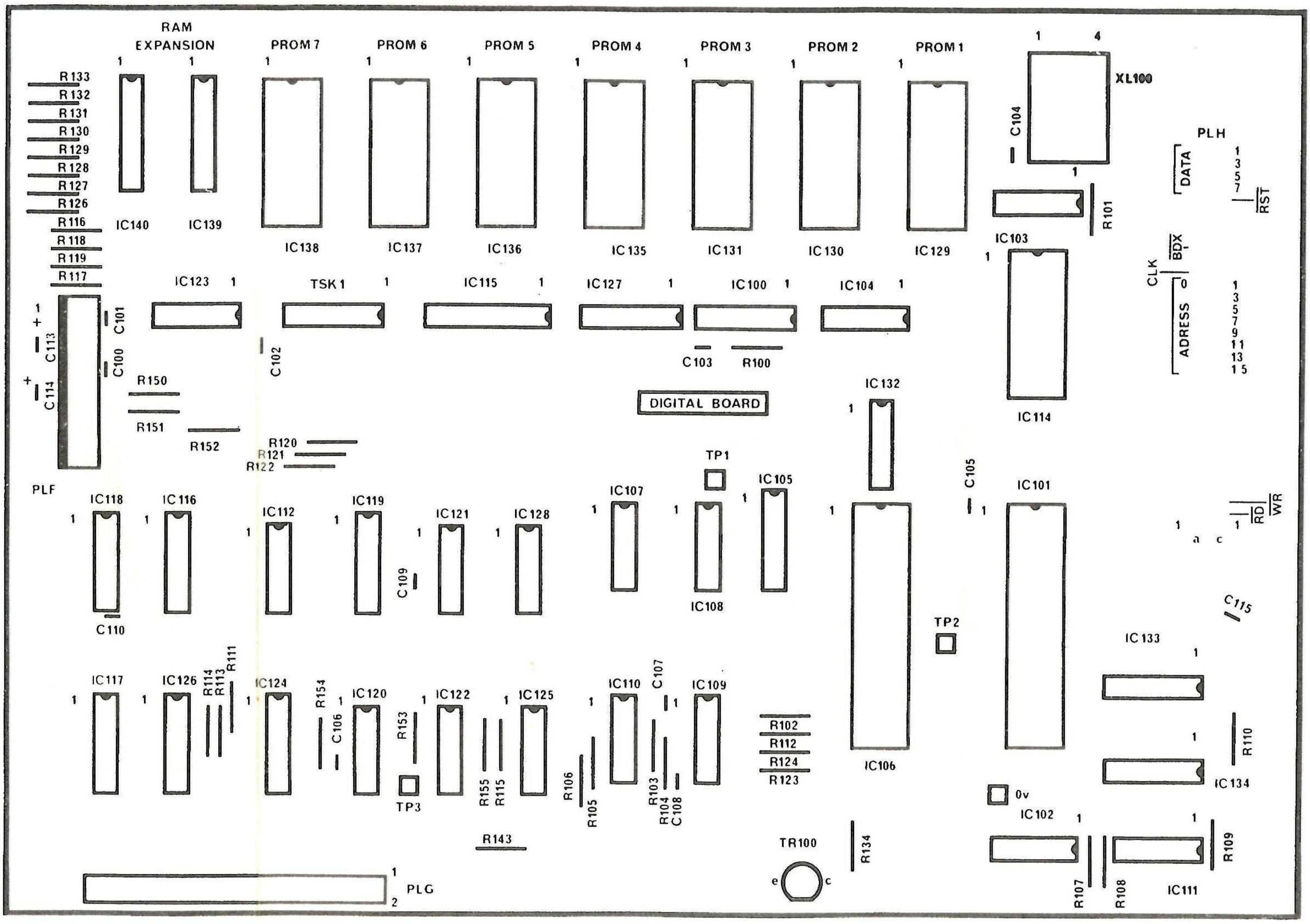
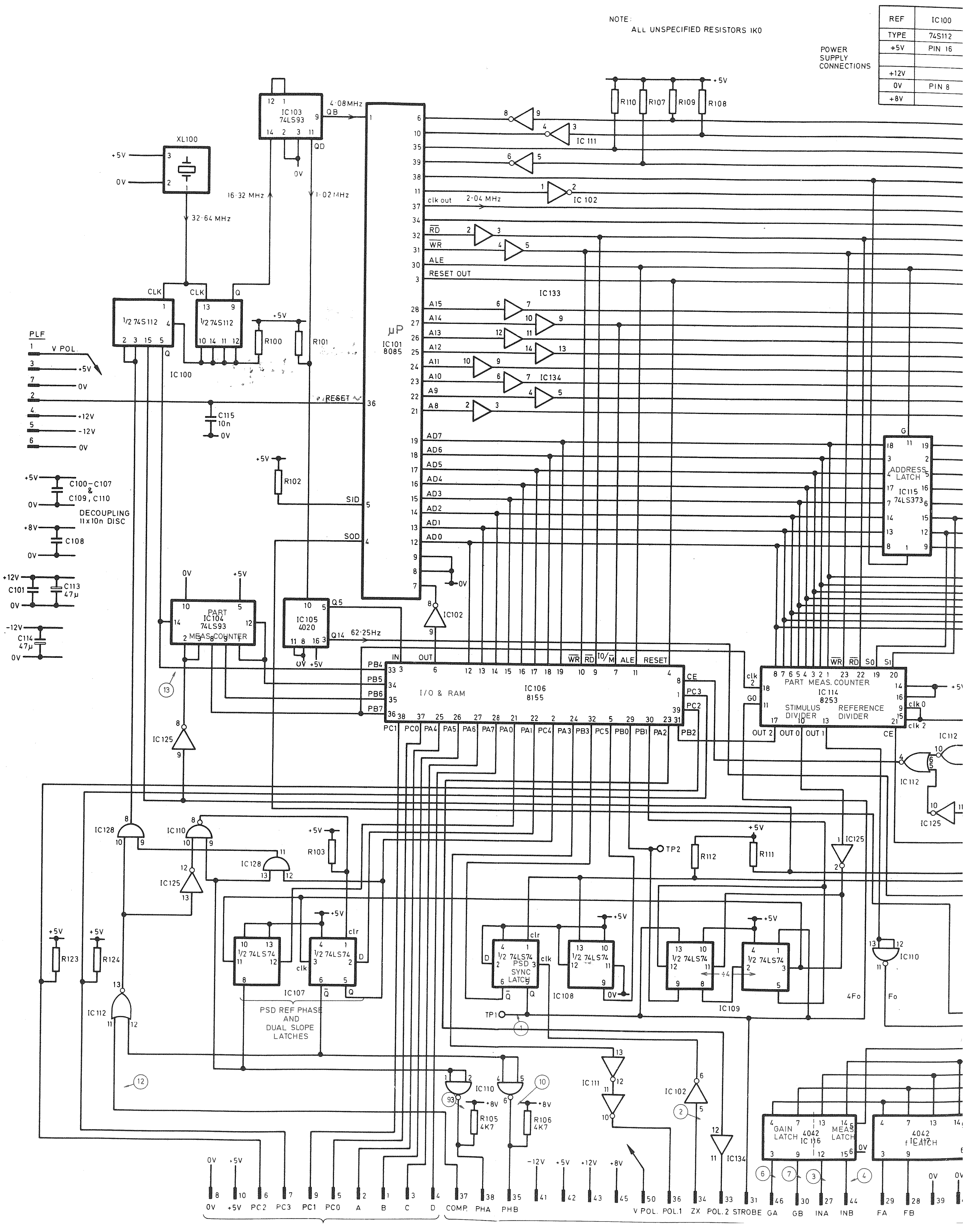


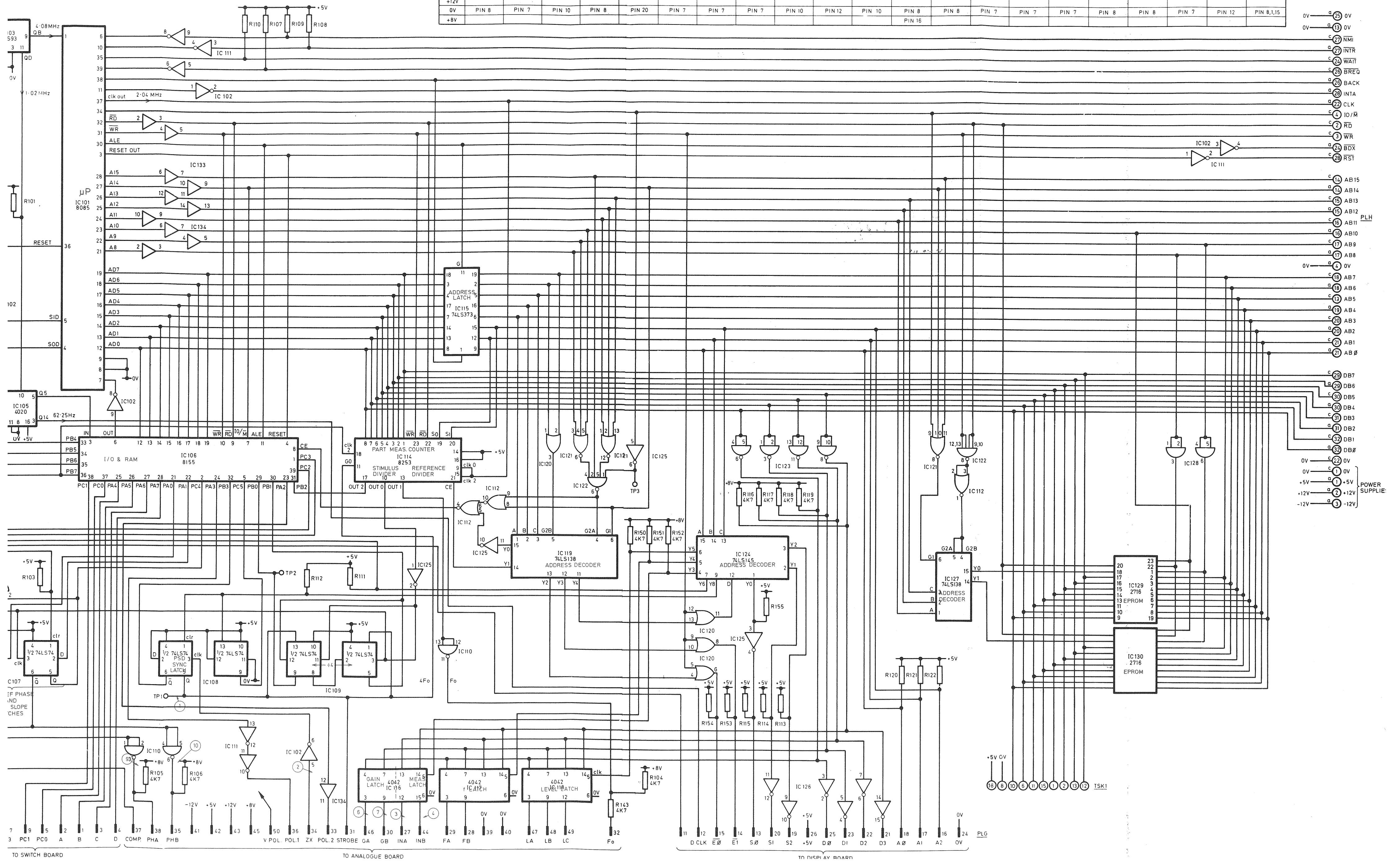
FIG. 24 DIGITAL P.C.B. LAYOUT (SER. NO. 376 ONWARDS)


NOTE:
ALL UNSPECIFIED RESISTORS 1K0
POWER SUPPLY CONNECTIONS
REF
IC100
TYPE
74S112
+5V
PIN 16
+12V
0V
PIN 8
+8V
XL100
32·64 MHz
16·32 MHz
1·02 MHz
4·08 MHz
IC103 74LS93
μP
IC101 8085
IC100
1/2 74S112
PLF
V POL.
RESET
C115 10n
C100–C107 & C109, C110
DECOUPLING 11x10n DISC
C108
C101
C113 47μ
C114 47μ
R102
SID
SOD
PART MEAS. COUNTER
IC104 74LS93
IC105 4020
62·25Hz
I/O & RAM
IC106 8155
IC111
IC102
clk out
2·04 MHz
IC133
IC134
ADDRESS LATCH
IC115 74LS373
PART MEAS. COUNTER
IC114 8253
STIMULUS DIVIDER
REFERENCE DIVIDER
IC112
IC125
IC128
IC110
IC107
PSD REF PHASE AND DUAL SLOPE LATCHES
PSD SYNC LATCH
IC108
IC109
4Fo
Fo
TP1
TP2
R105 4K7
R106 4K7
GAIN LATCH
4042 IC116
MEAS LATCH
4042 IC117
F LATCH
0V
+5V
PC2
PC3
PC1
PC0
A
B
C
D
COMP.
PHA
PHB
V POL.
POL.1
ZX
POL.2
STROBE
GA
GB
INA
INB
FA
FB

NOTE:
ALL UNSPECIFIED RESISTORS 1K0

POWER SUPPLY CONNECTIONS

REF	IC100	IC102 IC111 IC125	IC103 IC104	IC105	IC106	IC107 IC108 IC109	IC110 IC123	IC112	IC113	IC114	IC115	IC116 IC117 IC118	IC119 IC127	IC120	IC121	IC122	IC124	IC126	IC128	IC129 IC130	IC133 IC134
TYPE	74S112	74LS04	74LS93	4020	8155	74LS74	74LS26	74LS02	74LS244	8253	74LS373	CD4042	74LS138	74LS32	74LS27	74LS20	74LS145	CD4049	74LS08	2716	74LS365
+5V	PIN 16	PIN 14	PIN 5	PIN 16	PIN 40	PIN 14	PIN 14	PIN 14	PIN 20	PIN 24	PIN 20		PIN 16	PIN 14	PIN 14	PIN 14	PIN 16	PIN 1	PIN 14	PIN 21,24	PIN 16
+12V																					
0V	PIN 8	PIN 7	PIN 10	PIN 8	PIN 20	PIN 7	PIN 7	PIN 7	PIN 10	PIN 12	PIN 10	PIN 8	PIN 8	PIN 7	PIN 7	PIN 7	PIN 8	PIN 8	PIN 7	PIN 12	PIN 8,1,15
+8V												PIN 16									



POWER SUPPLY CONNECTIONS

REF	IC100	IC102 IC111 IC125	IC103 IC104	IC105	IC106	IC107 IC108 IC109	IC110 IC123	IC112	IC113	IC114	IC115	IC116 IC117 IC118	IC119 IC127	IC120	IC121	IC122	IC124	IC126	IC128	IC129 IC130	IC133 IC134
TYPE	74S112	74LS04	74LS93	4020	8155	74LS74	74LS26	74LS02	74LS244	8253	74LS373	CD4042	74LS138	74LS32	74LS27	74LS20	74LS145	CD4049	74LS08	2716	74LS365
+5V	PIN 16	PIN 14	PIN 5	PIN 16	PIN 40	PIN 14	PIN 14	PIN 14	PIN 20	PIN 24	PIN 20		PIN 16	PIN 14	PIN 14	PIN 14	PIN 16	PIN 1	PIN 14	PIN 21,24	PIN 16
+12V																					
0V	PIN 8	PIN 7	PIN 10	PIN 8	PIN 20	PIN 7	PIN 7	PIN 7	PIN 10	PIN 12	PIN 10	PIN 8	PIN 8	PIN 7	PIN 7	PIN 7	PIN 8	PIN 8	PIN 7	PIN 12	PIN 8,1,15
+8V												PIN 16									

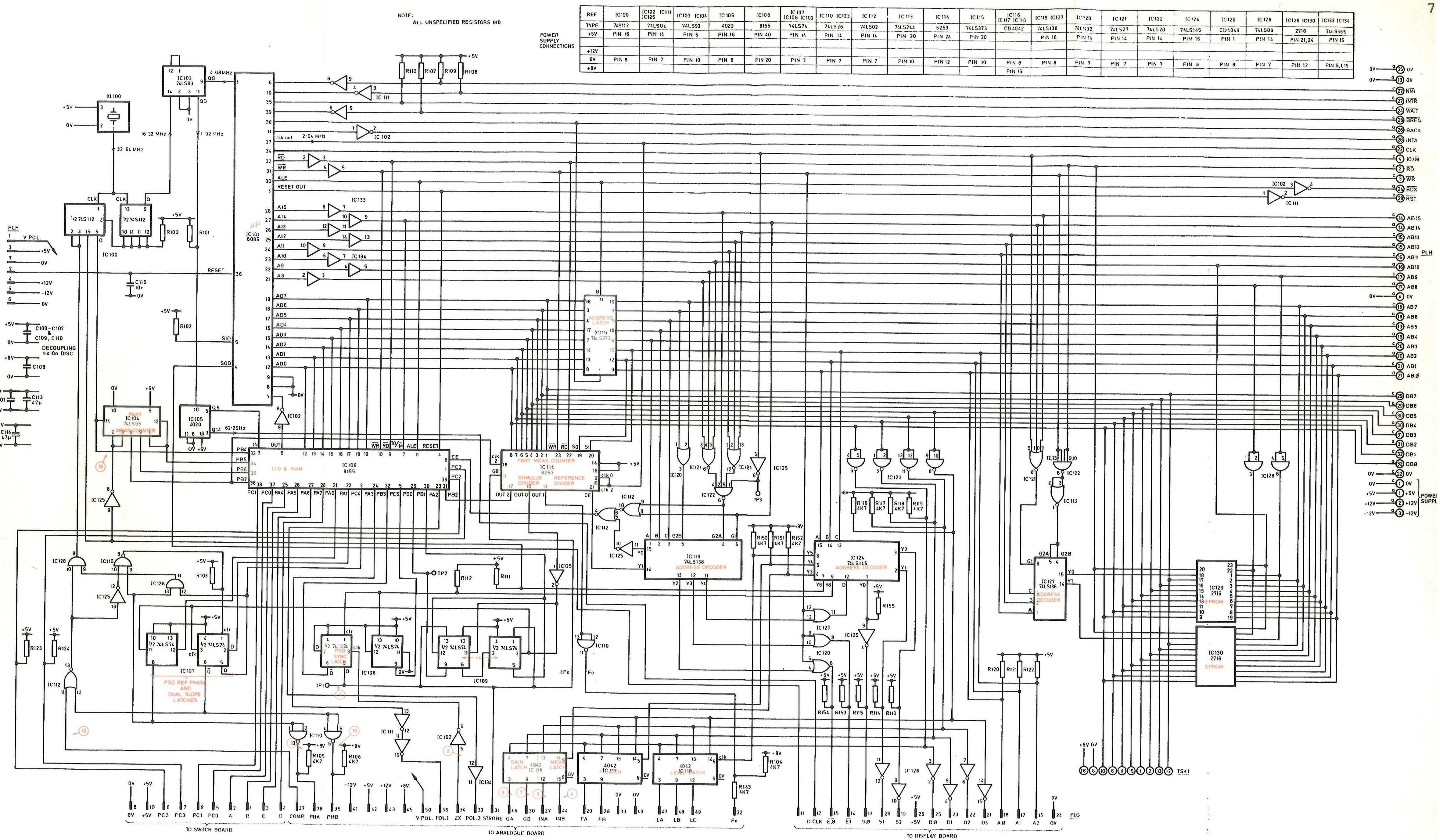


FIG. 25 DIGITAL CIRCUIT DIAGRAM (SER. NO. 376 ONWARDS

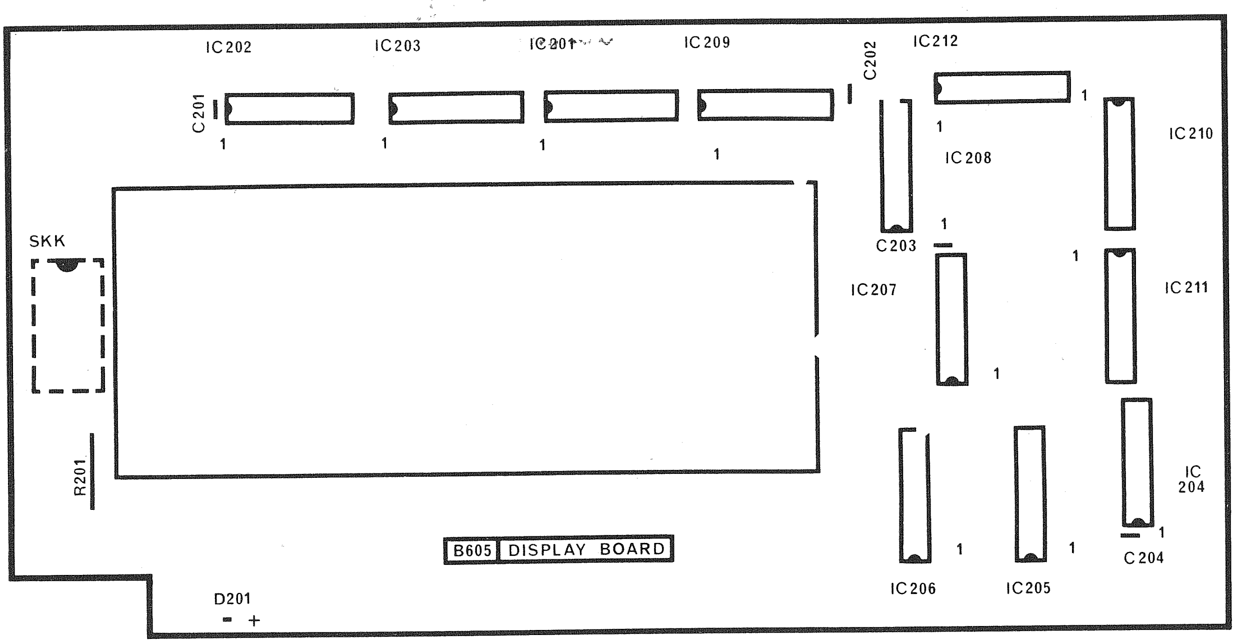


FIG. 26 DISPLAY BOARD LAYOUT

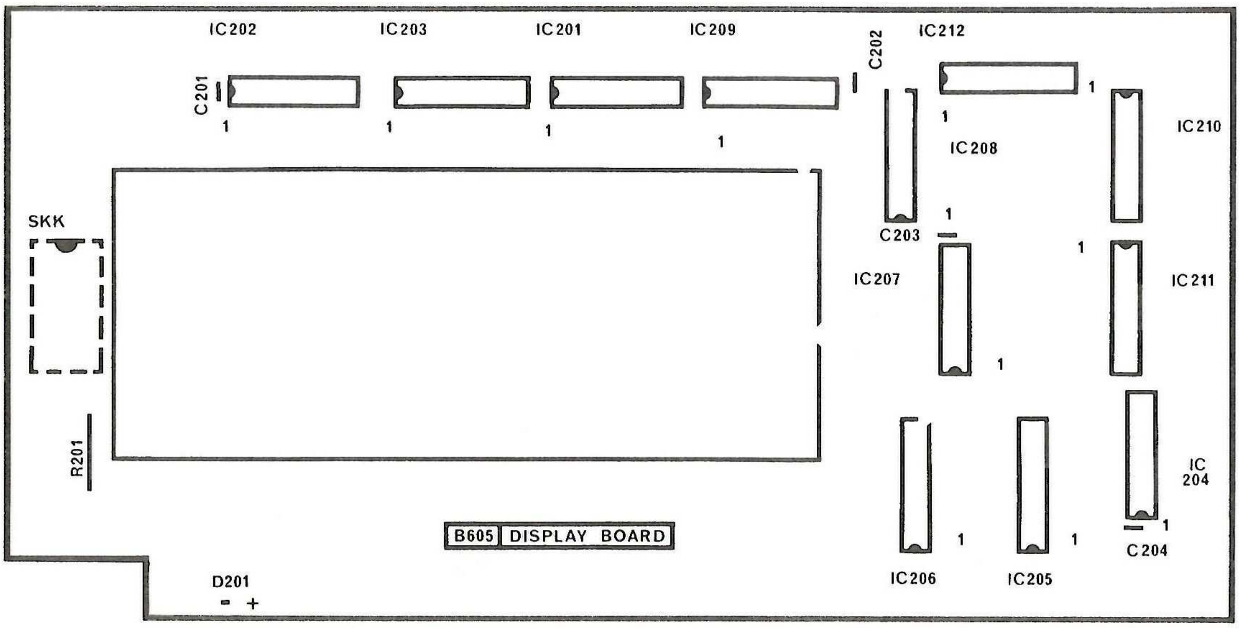


FIG. 26 DISPLAY BOARD LAYOUT

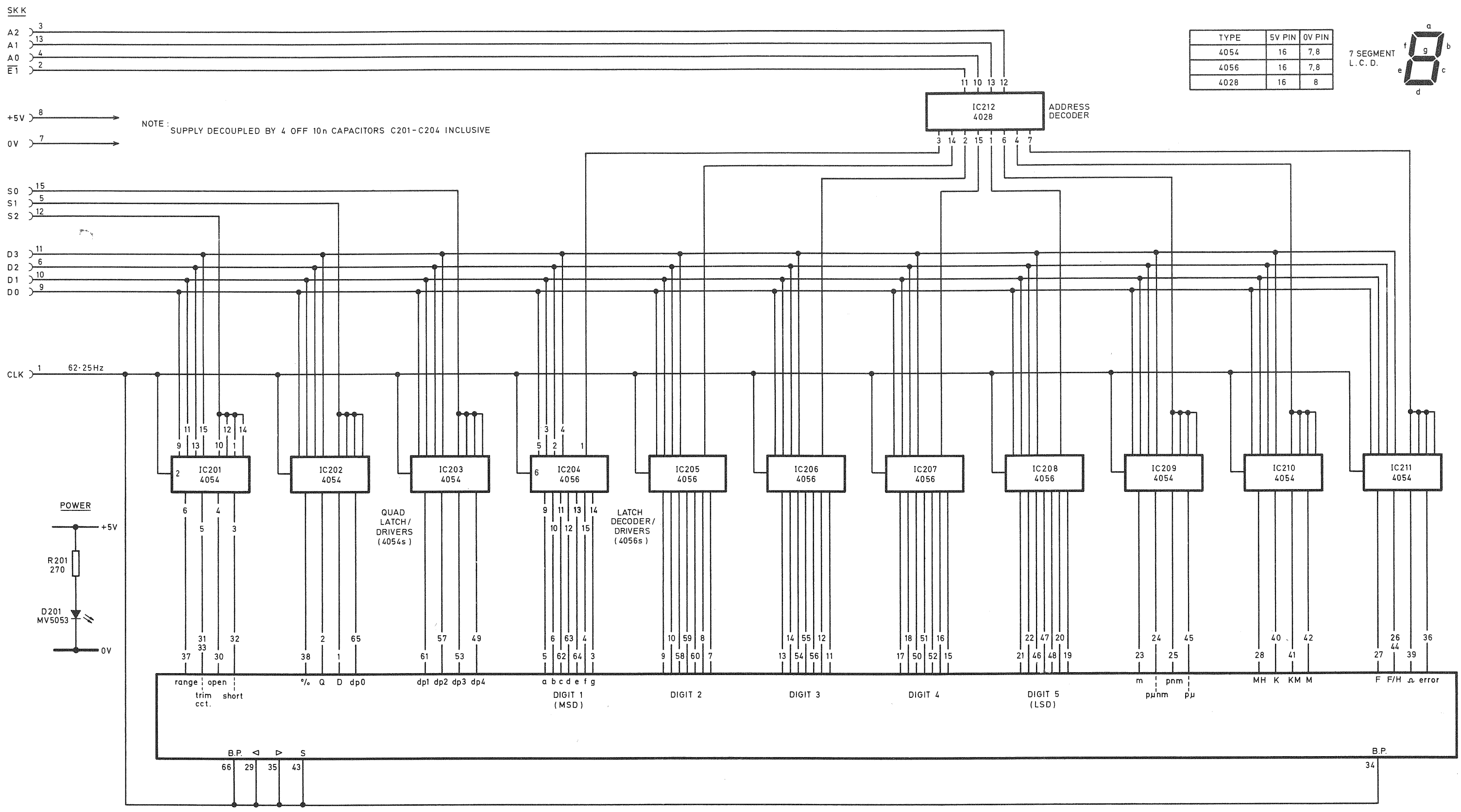


FIG. 27 DISPLAY BOARD CIRCUIT DIAGRAM

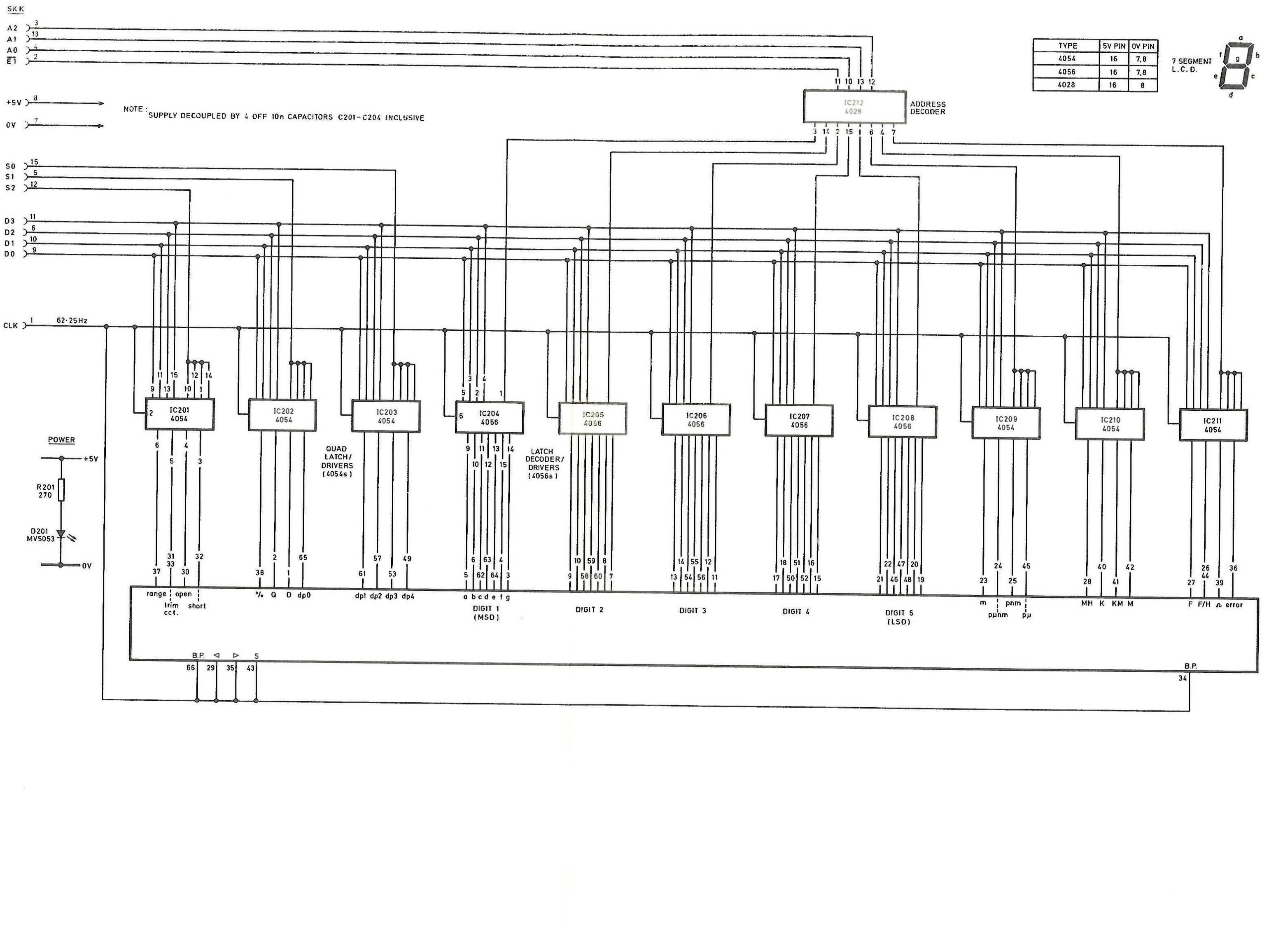


FIG. 27 DISPLAY BOARD CIRCUIT DIAGRAM

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Printed in England WIP/5.83/200