DIGITAL VOLTMETERS

A210 A211 A212
A213 A215 A230
A233 & A235
FANOUT UNIT A214

Schlumberger

TECHNICAL DATA

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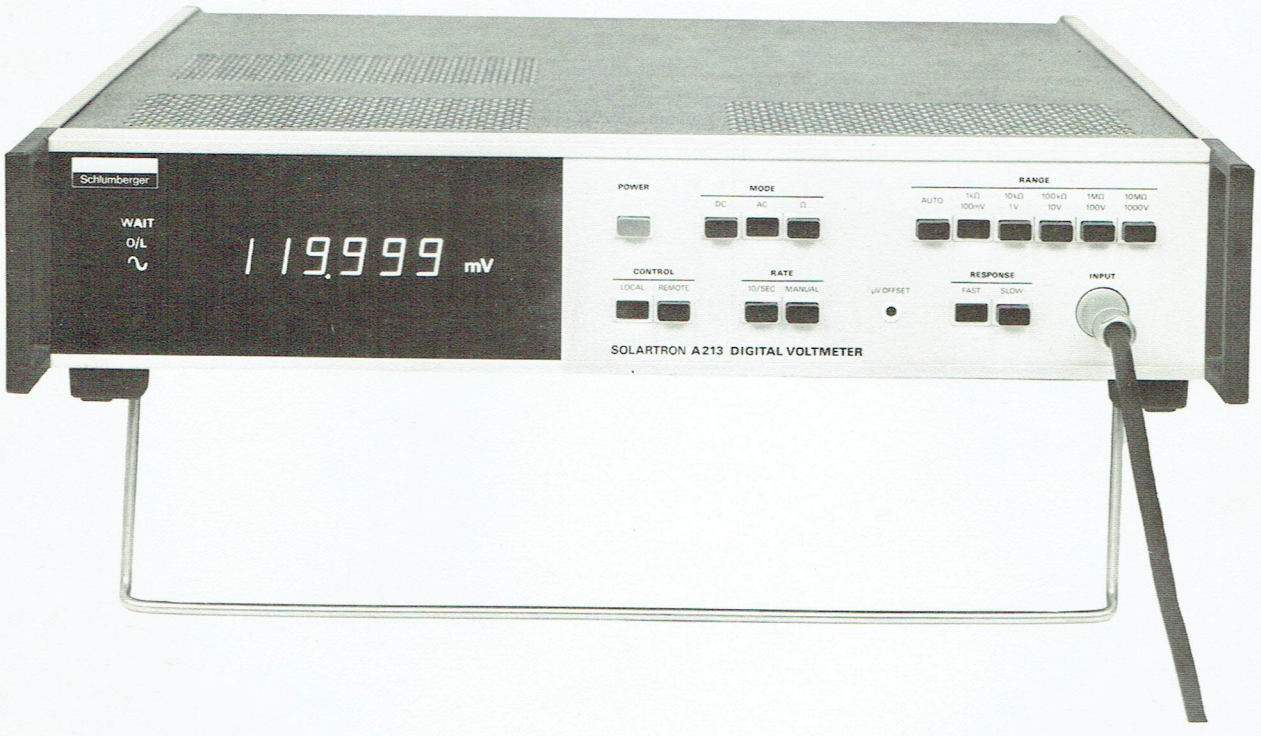

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TECHNICAL MANUAL

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INTRODUCTION

Your new digital voltmeter (dvm) is the latest in a series of sophisticated and advanced instruments. Solartron design experience has made available an accurate and sensitive range of voltmeters which, when fitted with a fan out unit, are fully programmable by remote commands.

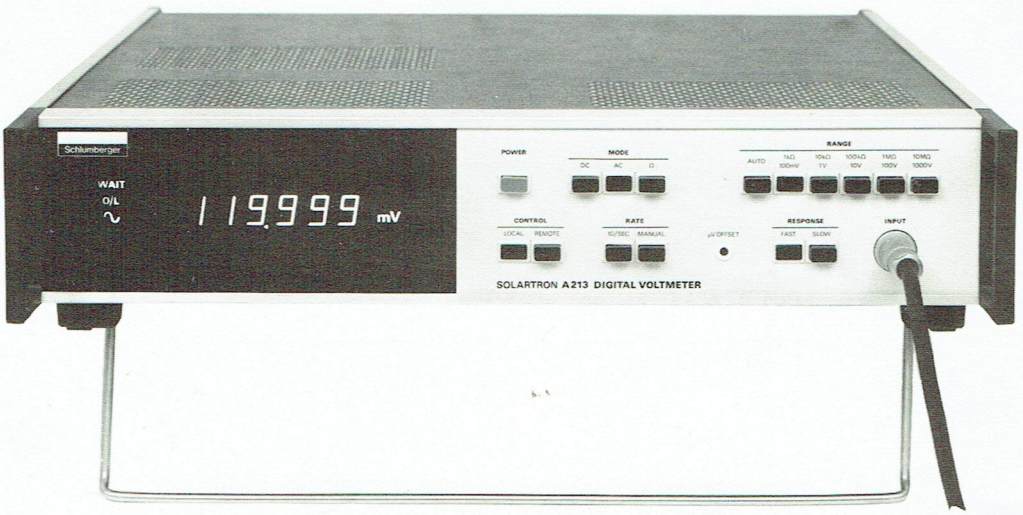
The functional control layout and clear, unambiguous display make this a simple to use dvm whilst the AC and Ohms options make the basic instrument even more versatile.

This manual contains all the necessary information on how to operate your dvm; read it carefully so that you can use the dvm to its full capability.

The Display

Some instruments use a type of display different from those illustrated in this manual. An example of an instrument with the alternative display is shown overleaf.

All information given in this manual applies to instruments with either display.



A Type A213 using a 7 Bar Neon type of display.

As well as the shape of the numerals, the appearance and positioning of the annunciators have also changed.

The following are in column to the extreme left of the display.

WAIT	Indicates an invalid display. A measurement is true when this indicator is extinguished.
O/L	Overload, in conjunction with a display of 119999.
~	AC value displayed.
REMOTE	The instrument is under remote control.

The polarity signs, + and −, lie between the annunciator column and the numerals. The units annunciators are to the right of the numerals.

CONTENTS

INTRODUCTION

SECTION 1 CONTROLS

A210 A213
A211 A230
A212 A233

SECTION 2 TECHNICAL SPECIFICATION

SECTION 3 OPERATING INSTRUCTIONS

- DC VOLTAGE MEASUREMENT
- AC VOLTAGE MEASUREMENT
- RESISTANCE MEASUREMENT
- RATIO MEASUREMENT

SECTION 4 MEASUREMENT TECHNIQUES

SECTION 5 DATA SYSTEMS USE

SECTION 6 PRINCIPLE OF OPERATION

SECTION 7 CIRCUIT DESCRIPTION AND SERVICING INFORMATION

- INTRODUCTION TO SECTION
- CIRCUIT DESCRIPTION
- FUNCTIONAL CIRCUIT DIAGRAMS
- PRINTED CIRCUIT BOARD REFERENCES AND COMPONENT LAYOUTS
- SERVICING INFORMATION
- SPATIAL DESCRIPTION

SECTION 8 TEST AND CALIBRATION PROCEDURES

SECTION 9 COMPONENT PARTS LIST

SECTION 1 Controls

A210

Indicator

Displays units (mV or V), WAIT and REMOTE.

WAIT is displayed to indicate that the display has not been updated with the result of the latest measurement, under the following conditions:-

1) When a MANUAL sample has been initiated whilst the voltmeter is in the SLOW RESPONSE mode.

2) When the voltmeter is AUTO ranging with SLOW RESPONSE.

WAIT is extinguished when the new result is displayed.

REMOTE is displayed when the voltmeter is under remote control.

Power

A push for ON - push for OFF switch for applying mains power to the voltmeter.

RANGE

Six mutually exclusive push-button switches for selecting:-

1) **AUTO:** For automatic selection of the optimum range.

2) **100mV, 1V, 10V, 100V or 1000V** dc range.

As a safety precaution, if two or more buttons are pressed simultaneously the least sensitive of the requested ranges is selected. If no buttons are pressed the voltmeter automatically selects the 1000V range.

RESPONSE

Two mutually exclusive push-button switches for selecting:-

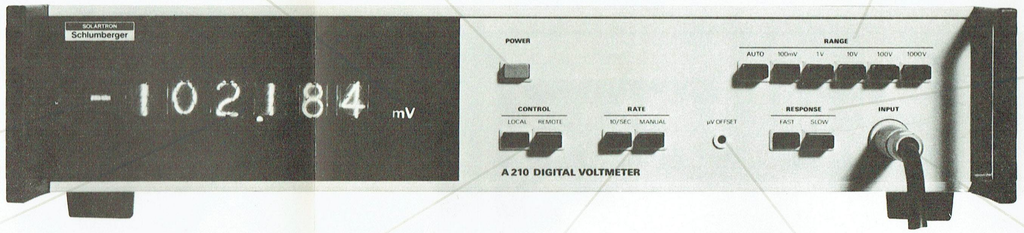
FAST: For unfiltered dc signal measurement.

SLOW: For filtered dc signal measurement. A low pass active filter provides an additional 30dB series mode rejection at 50Hz increasing at 6dB/Octave (20dB/Decade).

Polarity and Overload Display

± Indicated polarity is that of the red lead with respect to the black.

Overload symbol flashes and display shows 119999 for inputs which exceed 119999.



Display

Numerals displayed by cold cathode tubes with integral decimal points. Decimal point positioning is automatic.

CONTROL

Two mutually exclusive push-buttons for selecting:-

LOCAL: For control of the voltmeter from the front panel buttons. When a Fan Out Unit is fitted and REMOTE is electrically commanded LOCAL is overridden, REMOTE is illuminated on the display and the only effective front panel control is POWER.

REMOTE: For control of the voltmeter by remote electrical commands via the Fan Out Unit. When REMOTE is selected, REMOTE is illuminated on the display.

If no Fan Out Unit is fitted the instrument reverts to the 1000V dc range.

RATE

Two push-button switches for selecting:-

10/SEC: For automatic updating of the display every 100ms. This control is still effective when REMOTE is selected by the front panel control.

MANUAL: Initial depression of this button releases the 10/SEC button and initiates the display of a measurement. Each subsequent depression commands the display of a new measurement.

Alternatively, and only if Fan Out Unit A214 is fitted, new measurements can be remotely commanded through the Fan Out by either external contact closure or pulse application.

μV OFFSET

A potentiometer for 'backing-off' external offsets (e.g. thermal emf's from relay contacts), when making measurements on the 100mV range. Provides not less than ± 10μV offset capability.

INPUT

Connector to which the input signal is connected via a screened input lead.

To remove the input lead, pull the 'skirt' of the connector and not the cable.

A211

Indicator

Displays units (mV or V), WAIT and REMOTE.

WAIT is displayed to indicate that the display has not been updated with the result of the latest measurement, under the following conditions:-

1) When a MANUAL sample is initiated when the voltmeter is in the SLOW RESPONSE mode.

2) When a MANUAL sample is initiated when the voltmeter is in the AC MODE.

3) When the voltmeter is AUTO ranging with SLOW RESPONSE or in the AC MODE.

WAIT is extinguished when the new result is displayed.

REMOTE is displayed when the voltmeter is under remote control.

Power

A push for ON - push for OFF switch for applying mains power to the voltmeter.

MODE

Two mutually exclusive push-button switches for selecting either DC or AC measurement.

As a safety precaution, if both or neither of the buttons are pressed the DC MODE is selected.

RANGE

Six mutually exclusive push-button switches for selecting:-

1) **AUTO:** For automatic selection of the optimum range.

2) **100mV, 1V, 10V, 100V or 1000V** dc ranges.

3) **100mV, 1V, 10V, 100V or 1000V** ac ranges.

As a safety precaution, if two or more buttons are pressed simultaneously the least sensitive of the requested ranges is selected. If no buttons are pressed the voltmeter automatically selects the 1000V range.

RESPONSE

Two mutually exclusive push-button switches for selecting:-

FAST for:-

1) unfiltered dc signal measurement.

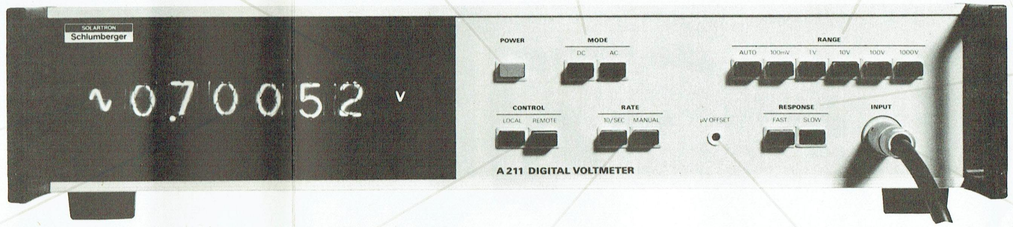
2) measurement of ac signals with frequency components ⩾ 100Hz. With 10/SEC rate selected wait 1 second after application of signal before reading the display. With MANUAL rate selected the display will be updated 1 second after pressing the MANUAL button (WAIT is displayed for this period).

SLOW for:-

1) filtered dc signal measurement. An active low pass filter provides an additional 30dB series mode rejection at 50Hz, increasing at 6dB/Octave (20dB/Decade).

2) extended ac low frequency performance (down to 40Hz). With 10/SEC rate selected wait 4 seconds after the application of signal before reading the display. The signal must be present for at least 3 seconds before pressing the MANUAL button.

With AC and AUTO range selected, SLOW RESPONSE is inhibited and the voltmeter reverts to FAST RESPONSE.



Polarity and Overload Display

± Indicated polarity is that of the red lead with respect to the black.

∿ Sine wave symbol displayed in the AC mode.

Overload symbol flashes and display shows 119999 for inputs which exceed 119999.

Display

Numerals displayed by cold cathode tubes with integral decimal points. Decimal point positioning is automatic.

CONTROL

Two mutually exclusive push-buttons for selecting:-

LOCAL: For control of the voltmeter from the front panel buttons. When a Fan Out Unit is fitted and REMOTE is electrically commanded LOCAL is overridden, REMOTE is illuminated on the display and the only effective front panel control is POWER.

REMOTE: For control of the voltmeter by remote electrical commands via the Fan Out Unit. When REMOTE is selected, REMOTE is illuminated on the display.

If no Fan Out Unit is fitted the instrument reverts to the 1000V dc range.

RATE

Two push-button switches for selecting:-

10/SEC: For automatic updating of the display every 100ms. This control is still effective when REMOTE is selected by the front panel control.

MANUAL: Initial depression of this button releases the 10/SEC button and initiates the display of a measurement. Each subsequent depression commands the display of a new measurement.

Alternatively, and only if Fan Out Unit A214 is fitted, new measurements can be remotely commanded through the Fan Out by either external contact closure or pulse application.

μV OFFSET

A potentiometer for 'backing-off' external offsets (e.g. thermal emf's from relay contacts), when making measurements on the 100mV range. Provides not less than ± 10μV offset capability.

INPUT

Connector to which the input signal is connected via a screened input lead.

To remove the input lead, pull the 'skirt' of the connector and not the cable.

A212

Indicator

Displays units (mV, V or kΩ), WAIT and REMOTE.

WAIT is displayed to indicate that the display has not been updated with the result of the latest measurement, under the following conditions:-

1) When a MANUAL sample is initiated when the voltmeter is in the SLOW RESPONSE mode.

2) When the voltmeter is AUTO ranging with SLOW RESPONSE.

WAIT is extinguished when the new result is displayed.

REMOTE is displayed when the voltmeter is under remote control.

Power

A push for ON - push for OFF switch for applying mains power to the voltmeter.

MODE

Two mutually exclusive push-button switches for selecting either DC or Ω (ohms) measurement.

As a safety precaution, if both or neither of the buttons are pressed the DC MODE is selected.

RANGE

Six mutually exclusive push-button switches for selecting:-

1) **AUTO:** For automatic selection of the optimum range.

2) **100mV, 1V, 10V, 100V or 1000V** dc ranges.

3) **1kΩ, 10kΩ, 100kΩ, 1MΩ or 10MΩ** resistance ranges.

As a safety precaution, if two or more buttons are pressed simultaneously the least sensitive of the requested ranges is selected. If no buttons are pressed the voltmeter automatically selects the 1000V or 10MΩ range (depending on MODE).

RESPONSE

Two mutually exclusive push-button switches for selecting:-

FAST for:-

1) unfiltered dc signal measurement.

2) unfiltered resistance measurement.

SLOW for:-

1) filtered dc signal measurement. An active low pass filter provides an additional 30dB series mode rejection at 50Hz increasing at 6dB/Octave (20dB/Decade).

2) filtered resistance measurement. Uses the same filter as for dc measurement.

Polarity and Overload Display

± Indicated polarity is that of the red lead with respect to the black.

Overload symbol flashes and display shows 119999 for inputs which exceed 119999.

Display

Numerals displayed by cold cathode tubes with integral decimal points. Decimal point positioning is automatic.

CONTROL

Two mutually exclusive push-buttons for selecting:-

LOCAL: For control of the voltmeter from the front panel buttons. When a Fan Out Unit is fitted and REMOTE is electrically commanded LOCAL is overridden, REMOTE is illuminated on the display and the only effective front panel control is POWER.

REMOTE: For control of the voltmeter by remote electrical commands via the Fan Out Unit. When REMOTE is selected, REMOTE is illuminated on the display.

If no Fan Out Unit is fitted the instrument reverts to the 1000V dc range.

RATE

Two push-button switches for selecting:-

10/SEC: For automatic updating of the display every 100ms. This control is still effective when REMOTE is selected by the front panel control.

MANUAL: Initial depression of this button releases the 10/SEC button and initiates the display of a measurement. Each subsequent depression commands the display of a new measurement.

Alternatively, and only if Fan Out Unit A214 is fitted, new measurements can be remotely commanded through the Fan Out by either external contact closure or pulse application.

μV OFFSET

A potentiometer for 'backing-off' external offsets (e.g. thermal emf's from relay contacts), when making measurements on the 100mV range. Provides not less than ± 10μV offset capability.

INPUT

Connector to which the input signal is connected via a screened input lead.

To remove the input lead, pull the 'skirt' of the connector and not the cable.

Indicator

Displays units (mV, V or kΩ), WAIT and REMOTE.

WAIT is displayed to indicate that the display has not been updated with the result of the latest measurement, under the following conditions:-

1) When a MANUAL sample is initiated when the voltmeter is in the SLOW RESPONSE mode.

2) When a MANUAL sample is initiated when the voltmeter is in the AC MODE.

3) When the voltmeter is AUTO ranging, with SLOW RESPONSE or in the AC MODE.

WAIT is extinguished when the new result is displayed.

REMOTE is displayed when the voltmeter is under remote control.

Polarity and Overload Display

± Indicated polarity is that of the red lead with respect to the black.

∿ Sine wave symbol displayed in the AC mode.

Overload symbol flashes and display shows 119999 for inputs which exceed 119999.

Display

Numerals displayed by cold cathode tubes with integral decimal points. Decimal point positioning is automatic.

Power

A push for ON - push for OFF switch for applying mains power to the voltmeter.

CONTROL

Two mutually exclusive push-buttons for selecting:-

LOCAL: For control of the voltmeter from the front panel buttons. When a Fan Out Unit is fitted and REMOTE is electrically commanded LOCAL is overridden, REMOTE is illuminated on the display and the only effective front panel control is POWER.

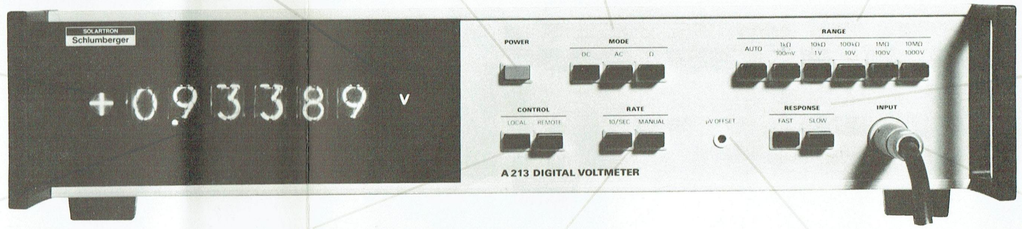
REMOTE: For control of the voltmeter by remote electrical commands via the Fan Out Unit. When REMOTE is selected, REMOTE is illuminated on the display.

If no Fan Out Unit is fitted the instrument reverts to the 1000V dc range.

MODE

Three mutually exclusive push-button switches for selecting either DC, AC or Ω (ohms) measurement.

As a safety precaution, if two, all or none of the buttons are pressed DC MODE is selected.



RATE

Two push-button switches for selecting:-

10/SEC: For automatic updating of the display every 100ms. This control is still effective when REMOTE is selected by the front panel control.

MANUAL: Initial depression of this button releases the 10/SEC button and initiates the display of a measurement. Each subsequent depression commands the display of a new measurement.

Alternatively, and only if Fan Out Unit A214 is fitted, new measurements can be remotely commanded through the Fan Out by either external contact closure or pulse application.

RANGE

Six mutually exclusive push-button switches for selecting:-

1) **AUTO:** For automatic selection of the optimum range.

2) **100mV, 1V, 10V, 100V or 1000V** dc ranges.

3) **100mV, 1V, 10V, 100V or 1000V** ac ranges.

4) **1kΩ, 10kΩ, 100kΩ, 1MΩ or 10MΩ** resistance ranges.

As a safety precaution, if two or more buttons are simultaneously depressed, the least sensitive range of those requested is selected. If no buttons are pressed the voltmeter automatically selects the 1000V or 10MΩ range (depending on MODE).

μV OFFSET

A potentiometer for 'backing-off' external offsets (e.g. thermal emf's from relay contacts), when making measurements on the 100mV range. Provides not less than ± 10μV offset capability.

RESPONSE

Two mutually exclusive push button switches for selecting:-

FAST for:-

1) unfiltered dc signal measurement.

2) unfiltered resistance measurement.

3) measurement of ac signals with frequency components ⩾ 100Hz. With 10/SEC rate selected wait 1 second after application of signal before reading the display. With MANUAL rate selected the display will be updated 1 second after pressing the MANUAL button, (WAIT is displayed for this time).

SLOW for:-

1) filtered dc signal measurement. An active low pass filter provides an additional 30dB series mode rejection at 50Hz increasing at 6dB/Octave (20dB/Decade).

2) filtered resistance measurement. Uses the same filter as for dc measurement.

3) extended ac low frequency performance (down to 40Hz). With 10/SEC rate selected wait 4 seconds after the application of signal before reading the display. The signal must be present for at least 3 seconds before pressing the MANUAL button.

With AC and AUTO range selected, SLOW RESPONSE is inhibited and the voltmeter reverts to FAST RESPONSE.

INPUT

Connector to which the input signal is connected via a screened input lead.

To remove the input lead, pull the 'skirt' of the connector and not the cable.

A213

(mean sensing ac)

A215

as shown except that AC legend is RMS (true rms measurement).

A230

Indicator

Displays units (mV or V), WAIT and REMOTE.

WAIT is displayed to indicate that the display has not been updated with the result of the latest measurement, under the following conditions:-

1) When a MANUAL sample has been initiated whilst the voltmeter is in the SLOW RESPONSE mode.

2) When the voltmeter is AUTO ranging with SLOW RESPONSE.

WAIT is extinguished when the new result is displayed.

REMOTE is displayed when the voltmeter is under remote control.

Power

A push for ON - push for OFF switch for applying mains power to the voltmeter.

RATIO

A push-to-select-push-to-cancel switch for selecting ratiometer operation.

With the switch pressed, the internal reference is disconnected and an external reference must be applied to the rear panel terminals.

RANGE

Six mutually exclusive push-button switches for selecting:-

1) **AUTO:** for automatic selection of the optimum range.

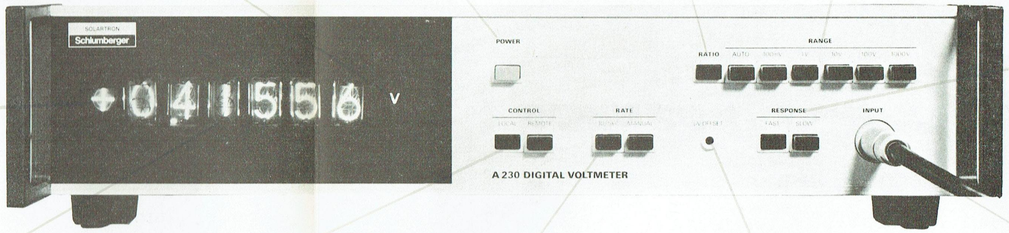
2) **100mV, 1V, 10V, 100V or 1000V** dc ranges.

As a safety precaution, if two or more buttons are pressed simultaneously the least sensitive of the requested ranges is selected. If no buttons are pressed the voltmeter automatically selects the 1000V range.

Polarity and Overload Display

± Indicated polarity is that of the red lead with respect to the black.

Overload symbol flashes and display shows 119999 for inputs which exceed 119999.



RESPONSE

Two mutually exclusive push-button switches for selecting:-

FAST: For unfiltered dc signal measurement.

SLOW: For filtered dc signal measurement. A low pass active filter provides an additional 30dB series mode rejection at 50Hz increasing at 6dB/Octave (20dB/Decade).

Not available on RATIO

Display

Numerals displayed by cold cathode tubes with integral decimal points. Decimal point positioning is automatic.

CONTROL

Two mutually exclusive push-buttons for selecting:-

LOCAL: For control of the voltmeter from the front panel buttons. When a Fan Out Unit is fitted and REMOTE is electrically commanded LOCAL is overridden, REMOTE is illuminated on the display and the only effective front panel control is POWER.

REMOTE: For control of the voltmeter by remote electrical commands via the Fan Out Unit. When REMOTE is selected, REMOTE is illuminated on the display.

If no Fan Out Unit is fitted the instrument reverts to the 1000V dc range.

RATE

Two push-button switches for selecting:-

10/SEC: for automatic updating of the display every 100ms. This control is still effective when REMOTE is selected by the front panel control.

MANUAL: Initial depression of this button releases the 10/SEC button and initiates the display of a measurement. Each subsequent depression commands the display of a new measurement.

Alternatively, and only if Fan Out Unit A214 is fitted, new measurements can be remotely commanded through the Fan Out by either external contact closure or pulse application.

μV OFFSET

A potentiometer for 'backing-off' external offsets (e.g. thermal emf's from relay contacts), when making measurements on the 100mV range. Provides not less than ± 10μV offset capability.

INPUT

Connector to which the input signal is connected via a screened input lead.

To remove the input lead, pull the 'skirt' of the connector and not the cable.

Indicator

Displays units (mV, V or kΩ), WAIT and REMOTE.

WAIT is displayed to indicate that the display has not been updated with the result of the latest measurement, under the following conditions:-

1) When a MANUAL sample is initiated when the voltmeter is in the SLOW RESPONSE mode.

2) When a MANUAL sample is initiated when the voltmeter is in the AC MODE.

3) When the voltmeter is AUTO ranging, with SLOW response or in the AC MODE.

WAIT is extinguished when the new result is displayed.

REMOTE is displayed when the voltmeter is under remote control.

Polarity and Overload Display

± Indicated polarity is that of the red lead with respect to the black.

∿ Sine wave symbol displayed in the AC mode.

Ⓢ Overload symbol flashes and display shows 119999 for inputs which exceed 119999.

Display

Numerals displayed by cold cathode tubes with integral decimal points. Decimal point positioning is automatic.

MODE

Three mutually exclusive push-button switches for selecting either DC, AC or Ω (ohms) measurement.

As a safety precaution, if two, all or none of the buttons are pressed DC MODE is selected.

Power

A push for ON - push for OFF switch for applying mains power to the voltmeter.

CONTROL

Two mutually exclusive push-buttons for selecting:-

LOCAL: For control of the voltmeter from the front panel buttons. When a Fan Out Unit is fitted and REMOTE is electrically commanded LOCAL is overridden, REMOTE is illuminated on the display and the only effective front panel control is POWER.

REMOTE: For control of the voltmeter by remote electrical commands via the Fan Out Unit. When REMOTE is selected, REMOTE is illuminated on the display.

If no Fan Out Unit is fitted the instrument reverts to the 1000V dc range.

RATIO

A push-to-select-push-to-cancel switch for selecting ratiometer operation. Can be selected in conjunction with any of the range switches in any MODE.

With the switch pressed, the internal reference is disconnected and an external reference must be applied to the rear panel terminals.

RATE

Two push-button switches for selecting:-

10/SEC: for automatic updating of the display every 100ms. This control is still effective when REMOTE is selected by the front panel control.

MANUAL: Initial depression of this button releases the 10/SEC button and initiates the display of a measurement. Each subsequent depression commands the display of a new measurement.

Alternatively, and only if Fan Out Unit A214 is fitted, new measurements can be remotely commanded through the Fan Out by either external contact closure or pulse application.

RANGE

Six mutually exclusive push-button switches for selecting:-

1) **AUTO:** for automatic selection of the optimum range.

2) **100mV, 1V, 10V, 100V or 1000V** dc ranges.

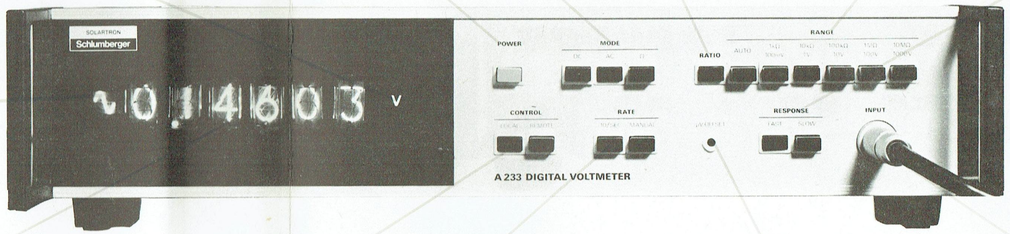
3) **100mV, 1V, 10V, 100V or 1000V** ac ranges.

4) **1kΩ, 10kΩ, 100kΩ, 1MΩ or 10MΩ** resistance ranges.

As a safety precaution, if two or more buttons are simultaneously depressed, the least sensitive range of those requested is selected. If no buttons are pressed the voltmeter automatically selects the 1000V or 10MΩ range (depending on MODE).

μV OFFSET

A potentiometer for 'backing-off' external offsets (e.g. thermal emf's from relay contacts), when making measurements on the 100mV range. Provides not less than ± 10μV offset capability.



RESPONSE

Two mutually exclusive push-button switches for selecting:-

FAST for:-

1) unfiltered dc signal measurement.

2) unfiltered resistance measurement.

3) measurement of ac signals with frequency components ⩾ 100Hz. With 10/SEC rate selected wait 1 second after application of signal before reading the display. With MANUAL rate selected the display will be updated 1 second after pressing the MANUAL button, (WAIT is displayed for this time).

SLOW for:- Not available on RATIO

1) filtered dc signal measurement. An active low pass filter provides an additional 30dB series mode rejection at 50Hz increasing at 6dB/Octave (20dB/Decade).

2) filtered resistance measurement. Uses the same filter as for dc measurement.

3) extended ac low frequency performance (down to 40Hz). With 10/SEC rate selected wait 4 seconds after the application of signal before reading the display. The signal must be present for at least 3 seconds before pressing the MANUAL button.

With AC and AUTO range selected, SLOW RESPONSE is inhibited and the voltmeter reverts to FAST RESPONSE.

INPUT

Connector to which the input signal is connected via a screened input lead.

To remove the input lead, pull the 'skirt' of the connector and not the cable.

A233

(mean sensing ac)

A235

as shown except that AC legend is RMS (true rms measurement).

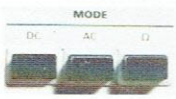
CONTROLS

The push-button controls of this series of voltmeters are arranged in six groups in accordance with the six decisions which have to be made for any measurement.

1. POWER

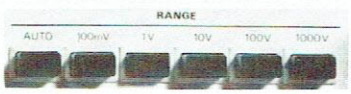
This heavy duty mains switch operates with a push on-push off action. The numerical display is always illuminated whenever the instrument is switched on and no separate warning is required. This is the only button which cannot be remotely controlled; however, the voltmeter can of course be remotely switched on and off by interruption of the mains supply.

2. MODE



The second group of controls select either DC, AC or Ω (ohms). These buttons are mutually exclusive (pressing one releases that previously selected). In the event of a user forcing in more than one of these buttons at the same time (misuse), the voltmeter automatically reverts to the DC mode as a safety precaution. Each instrument has only those buttons applicable to the options incorporated, hence dc only instruments have no MODE controls.

3. RANGE

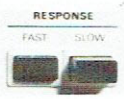


This row of buttons select the sensitivity setting. Again, pressing one button releases any previously selected in the group. There is one button for each range and an AUTO range button. If more than one range button is pressed the least sensitive range will be selected. Pressing the AUTO button causes the voltmeter to automatically select the correct range for any input from 1μV to 1.2kV or 10mΩ to 1.2MΩ.

Unless there is a particular reason for pre-selecting a fixed range the use of AUTO range is recommended: there is no reduction in accuracy, noise rejection or input resistance and in the event of accidental overload the appropriate range is quickly and automatically selected.

As it is normal to think in decimal terms, the legend which identifies each range follows a 1, 10, 100 sequence. However, there is a 20% overrange capability on all ranges. For example, the full scale value on the 1V range is, in fact, 1.19999V. There is no degradation of the performance in this upper region of the scale.

4. RESPONSE

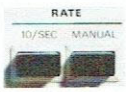


As far as dc and ohms measurements are concerned, these controls should be regarded as a luxury and not required in all but the most exceptional circumstances. In general the FAST mode should be selected. For dc and resistance the SLOW button selects an active low pass filter to reduce the effects of any noise interference. However, because the voltmeter is a mains locked integrating type, it inherently rejects mains frequency interference and its harmonics without the filter. SLOW is therefore seldom required. In doubtful cases take measurements using FAST and then SLOW; if the readings are different the filter is required, since the change must be the result of increased noise rejection.

The use of the filter introduces long time constants into an otherwise fast acting instrument; the user should therefore exploit the inherent noise rejecting properties of the instrument and avoid unnecessary use of the filter.

For ac measurement this control has a different purpose. Inherent in the design of this type of measuring system is the compromise between response time and low frequency performance. Therefore, to cater for a wide variety of applications this choice is left to the user. With AC FAST the response time to 0.1% of reading is 1 second. If the input signal contains frequency components below 100Hz the reading will fluctuate under the influence of the low frequency. With AC SLOW selected, the response time is increased to 4 seconds and accurate readings can be taken of signals which include frequency components down to 40Hz. The upper frequency limit of measurement is unaffected by FAST/SLOW selection.

5. RATE



A feature of these voltmeters is that they operate on a continuous basis, always responding to the applied signal. Whenever they are switched on they are making 10 measurements a second, although the result of every measurement will be displayed only when the 10/SEC button is pressed. When MANUAL is selected the voltmeter still makes 10 measurements each second, but the display is only updated when the button is pressed.

As an added precaution, the auto range circuitry continues to protect the instrument when MANUAL and AUTO ranges have been selected. Then, even though the display shows the reading and range applicable when the last sample was called, the instrument automatically switches to the range appropriate to the present input.

6. CONTROL

When LOCAL is selected any remote command inputs (except REMOTE and RATIO commands) are ignored.

When **REMOTE is selected (and the Fan Out Unit A214 is fitted)** and REMOTE is *not* externally commanded :–

i) Mode (DC, AC, Ω), Range (including AUTO and RATIO) and Response (FAST or SLOW) are controlled by remote commands.

ii) The reading rate (10/SEC, 25/SEC or 100/SEC) is controlled by remote commands.

iii) A single sample can be initiated externally or by pressing MANUAL.

iv) Continuous sampling at 10/SEC or 25/SEC is selected by pressing 10/SEC with the appropriate rate externally commanded.

v) Continuous sampling at 100/SEC cannot be selected.

vi) REMOTE is displayed.

Front Panel Lock-Out

An external REMOTE command inhibits the action of *all* the front panel buttons except power. The operator is reminded of this condition by REMOTE being displayed. This feature prevents unauthorised use when the voltmeter is committed within a system or, with suitable programming of the REMOTE command, enables a test sequence to include both automatic and operator control.

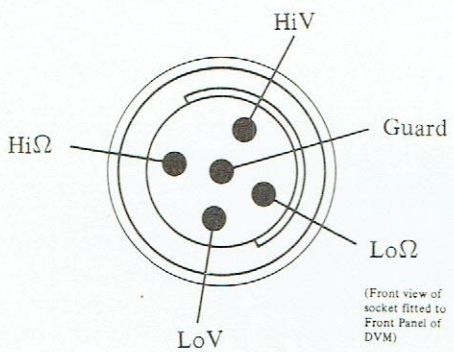
RATIO

RATIO is selected with a push on - push off action. This is conveniently located next to AUTO range selector.

Before using ratio, a suitable External Reference between 2V and 11V dc, must be connected to the reference terminals on the back panel; red to reference positive, black to reference negative.

Selecting RATIO disconnects the + and – reference rails from the internal zener reference. The voltage on the reference terminals, mounted on the ratio sub-unit and located on the dvm back panel, is applied as an external reference to the dvm.

INPUT CONNECTOR



(Front view of socket fitted to Front Panel of DVM)

The input connector simply pushes into the front panel socket with a 'snap-in' action. This cannot be released by pulling on the cable, but separation occurs only when the skirt of the connector is pulled away from the panel.

The skirt of the connector acts as an isothermal chamber preventing temperature differentials and the errors caused by the resulting thermal emf's.

The standard input lead provides connection for signal high (red) and signal low (black). It will be seen that the connector contains 5 pins and users wishing to use a three terminal driven guard input configuration should use input lead EX3183, which is available as an optional extra. (A guide to three terminal measurement in 'noisy' conditions can be obtained from the Solartron publication "Digital Voltmeters and Interference" which is free on request.) This same lead is also used for 4 terminal ohms measurement which is described later in this manual. The input to the voltmeter is completely isolated from earth and from all of the programming inputs and digital outputs.

Rear Input

This is fitted only on request and is wired in parallel with the normal front input. The input capacitance is increased by 80pF. The back panel includes a cut-out for the later addition of a rear input, and users installing their own rear connector are reminded that the use of ptfe coated wire is necessary to maintain the isolation characteristics.

μV OFFSET

The *MASTER SERIES* of voltmeters include a sophisticated chopper stabilised input amplifier to maintain very high integrity μV measurement. The stability of the input stage is so good that, provided 30 minutes initial warm-up is allowed, the drift with time is less than 1μV per week. However, external connectors may introduce thermal errors and the μV OFFSET control can be used to offset such effects. An offset range of at least ± 10μV is available.

DISPLAY

The display area is covered by a tinted screen laminated with a circularly polarised membrane to inhibit stray light or reflected light from the indicator tubes. The front surface is lightly frosted to eliminate surface reflection from overhead lights or light coloured garments worn by the user. Very slight de-focussing results from this frosting.

The display information is updated either 10 times per second (or possibly 25 or 100 times per second when A214 is fitted) or manually as described earlier.

The displayed information is:-

a) ± **Automatic polarity indicator**: The polarity is that of the red lead with respect to the black.

b) ∿ : This sign is displayed when AC MODE is selected.

c) Overload indication is given by a symbol when the input exceeds 119999. The user is not required to remember the full scale of the instrument.

d) **Numerical Indication**: Presents the result of the measurement.

e) **Decimal Point**: This is positioned automatically in conjunction with the units display.

f) **Units: mV, V and kΩ**: Display of the units is automatic and appropriate to the sensitivity and mode. Units, decimal point and numerical information are updated only as a result of a SAMPLE command as directed by the RATE control or the fan-out unit commands.

g) **Wait**: When the user selects a slow mode of operation, e.g. SLOW and AUTO range, an appreciable period of time may elapse before the new measurement is complete. During this time the result of the previous measurement is retained by the display. As a precaution against the wrong value being noted, the legend WAIT is displayed and is extinguished only when the new result is displayed.

h) **Remote**: Indication that the instrument is under remote control.

SECTION 2 Technical Specification

Note: Unless otherwise indicated, the information given in this section applies to 10/SEC operation. Variations of the specification applicable to 25/SEC and 100/SEC operation are given at the end of this section.

DC RANGES

Range	Sensitivity	Full Scale	Input Resistance	Maximum Input Voltage
100mV	1μV	119.999mV	>1000MΩ	300V pk (212V rms, sine wave)
1V	10μV	1.19999V	>10000MΩ	300V pk (212V rms, sine wave)
10V	100μV	11.9999V	>10000MΩ	300V pk (212V rms, sine wave)
100V	1mV	119.999V	10MΩ	1.2kV pk (850V rms, sine wave)
1000V	10mV	1199.99V	10MΩ	1.2kV pk (850V rms, sine wave)

AC RANGES

Range	Sensitivity	Full Scale	Input Impedance*	Maximum Input Voltage
100mV	1uV	119.999	10MΩ/< 150pF	300Vpk (212V rms, sine wave)
1V	10μV	1.19999V	10MΩ/< 150pF	300V pk (212V rms, sine wave)
10V	100μV	11.9999V	1MΩ/< 100pF	1.2kV pk (850V rms, sine wave)
100V	1mV	119.999V	1MΩ/< 100pF	1.2kV pk (850V rms, sine wave)
1000V	10mV	1199.99V	1MΩ/< 100pF	1.2kV pk (850V rms, sine wave)

*Input capacitance measured between Hi and Lo at input socket excluding input cable. Capacitance is increased by 80pF if rear input socket is fitted.

A215 and A235 only:-

The maximum input voltage/frequency product on the ac ranges must not exceed 6×10^6.

i.e. $V_{in}\, f_{in} = < 6 \times 10^6 VHz$

OHMS RANGES

Range	Sensitivity	Full Scale	Test Current	Maximum Input Voltage
1kΩ	10mΩ	1.19999kΩ	100μA	300V pk (212V rms, sine wave)
10kΩ	100mΩ	11.9999kΩ	100μA	300V pk (212V rms, sine wave)
100kΩ	1Ω	119.999kΩ	100μA	300V pk (212V rms, sine wave)
1MΩ	10Ω	1199.99kΩ	1μA	300V pk (212V rms, sine wave)
10MΩ	100Ω	11999.9kΩ	1μA	300V pk (212V rms, sine wave)

REMOTE RANGE: All ranges may be commanded externally via the optional Fan-Out unit A214.

OVERLOAD: The overload symbol illuminates and the display shows 119999 for inputs which exceed 119999.

AUTO RANGE: Operates for all ranges and all measurements except 100/SEC operation.

AC SCALING:
(A211, A213, A233) The instrument senses the mean value of the ac component and displays the rms value - assuming a sine wave input.

(A215, A235) The instrument senses and displays the rms value.

SHORT TERM ACCURACY

For 24 hours and within ± 1°C temperature stability. Resolution and linearity errors are included.

DC RANGES

Range	% of Reading	% of Full Scale
100mV	0.002	0.001
1V	0.002	0.001
10V	0.002	0.001
100V	0.003	0.001
1000V	0.003	0.001

LONG TERM ACCURACY

For 90 days ± 5°C. Assumes occasional adjustment of the μV OFFSET control

DC RANGES

Range	% of Reading	% of Full Scale
100mV	0.004	0.001
1V	0.004	0.001
10V	0.003	0.001
100V	0.004	0.001
1000V	0.004	0.001

AC RANGES 40Hz to 20kHz (A211, A213, A233)

Range	% of Reading	% of Full Scale
100mV	0.1	0.0016
1V	0.1	0.005
10V	0.1	0.005
100V	0.1	0.005
1000V	0.1	0.005

AC RANGES 20Hz to 40Hz and 20kHz to 100kHz (Typically) (A211, A213, A233)

Range	% of Reading	% of Full Scale
100mV	1.0	0.0016
1V	1.0	0.005
10V	1.0	0.005
100V	1.0	0.005
1000V	1.0	0.005

AC RANGES 100Hz to 5kHz (A215, A235)

Range	% of Reading	% of Full Scale
100mV	.05	.05
1V	.05	.05
10V	.05	.05
100V	.05	.05
1000V	.05	.05

AC RANGES 10Hz to 100Hz and 5kHz to 100kHz (A215, A235)

Range	% of Reading	% of Full Scale
100mV	0.1	1.0
1V	0.1	1.0
10V	0.1	1.0
100V	0.1	1.0
1000V	0.1	1.0

The ac accuracies are for a sine wave input of not less than 1% of Full Scale.

OHMS RANGES

Range	% of Reading	% of Full Scale
1kΩ	0.01	0.002
10kΩ	0.01	0.002
100kΩ	0.01	0.002
1MΩ	0.03	0.002
10MΩ	0.03	0.002

TEMPERATURE EFFECTS

DC RANGES

Zero drift 0 - 50°C ± 0.2μV per °C.

Coefficient of Reading 0 - 50°C.

Range	% of Reading per °C
10mV+	< 0.001
100mV	< 0.001
1V	< 0.001
10V	< 0.001
100V	< 0.0015
1000V	< 0.0015

OHMS RANGES

Coefficient of Reading 0 - 50°C

Range	% of Reading per °C
1kΩ	< 0.002
10kΩ	< 0.002
100kΩ	< 0.002
1MΩ	< 0.002
10MΩ	< 0.003

AC RANGES (A211, A213, A233)

Coefficient of Reading 0 - 50°C

Range	% of Reading per °C
100mV	< 0.005
1V	< 0.005
10V	< 0.015
100V	< 0.015
1000V	< 0.015

AC RANGES (A215, A235)

Coefficient of Reading 0 - 50°C

Range	% of Reading per °C	% of Full Scale per °C
100mV	.01	.002
1V	.01	.002
10V	.015	.002
100V	.015	.002
1000V	.015	.002

+ This range is only available for 25/SEC and 100/SEC operation under remote control.

INPUT CHARACTERISTICS

DC RANGES

Input Current: $< 10^{-10}$ A

Maximum permitted Input Voltage:

Range	Continuous Input	Input for < 200ms
10mV +	300V	1.2kV
100mV	300V	1.2kV
1V	300V	1.2kV
10V	300V	1.2kV
100V	1.2kV	1.2kV
1000V	1.2kV	1.2kV

+ This range is only available for 25/SEC and 100/SEC operation under remote control.

AC RANGES

Maximum permitted Input Voltage:

Range	Continuous Input (peak)	Input for < 200ms (peak)
100mV	300V	1.2kV
1V	300V	1.2kV
10V	1.2kV	1.2kV
100V	1.2kV	1.2kV
1000V	1.2kV	1.2kV

CREST FACTOR

(A215 and A235 only) 4 : 1 up to 20kHz.

OHMS RANGES

Maximum permitted Input Voltage:

Range	Continuous Input (peak)	Input for < 200ms (peak)
1kΩ	200V	600V
10kΩ	200V	600V
100kΩ	200V	600V
1MΩ	200V	600V
10MΩ	200V	600V

ISOLATION IMPEDANCE

Guard to Chassis: $> 10^{10}\Omega$ and < 500pF.

WARNING: HIGH POTENTIAL STEP FUNCTIONS

[> 1000V DC or > 800V AC]

If a high voltage step function is applied to the instrument, a current surge occurs as the capacitance of the input lead is changed.

The resultant transient voltage could exceed the overload rating of the instrument with resulting component failure.

RESPONSE TIMES

FIXED RANGE SETTLE PERIOD

Time that the input must be present before conversion begins:

DC FAST:	5ms (2ms at 100/SEC rate)
DC SLOW:	1s to 0.01% of Final Reading
AC FAST:	1s to 0.1% of Final Reading
AC SLOW:	4s to 0.1% of Final Reading (A211, A213, A233) 5s to 0.1% of Final Reading (A215, A235)
Ω FAST:	5ms Add 10μs/pF capacitance of input lead/MΩ input for the 1MΩ and 10MΩ ranges to give time to 0.01% of Final Reading, e.g. for the standard input lead add 3.5ms/MΩ.
Ω SLOW:	As DC SLOW for values < 10kΩ. As Fig. 2.1 for values > 10kΩ.

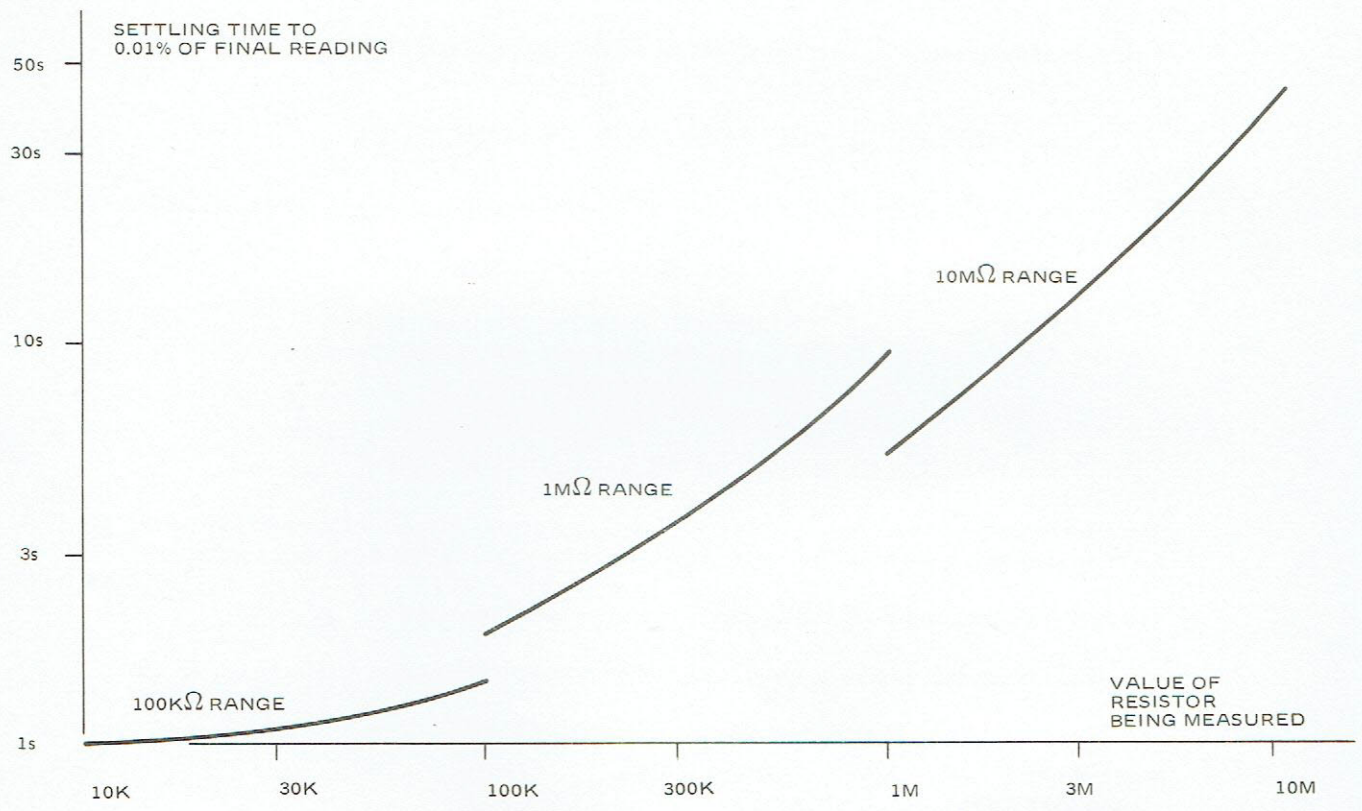


Fig. 2.1 *Fixed range settling period for SLOW response resistance measurements.*

AUTO RANGE TIMES

DC FAST, 10/SEC:	100ms per range change *	
DC FAST, 25/SEC:	80ms per range change *	
DC SLOW, 10/SEC:	1s approx. per range change +	
DC SLOW, 25/SEC:	1s approx. per range change +	
DC. 100/SEC:	Not available	
AC FAST, 10/SEC:	1s approx. per range change +	A211, A213, A233
AC FAST, 25/SEC:	1s approx. per range change +	
AC (All ranges)	7s to final range. (A215,A235)	
AC SLOW:	Not available. AC FAST automatically selected.	
AC, 100/SEC:	Not available.	
Ω FAST, 10/SEC:	100ms per range change *	
Ω FAST, 25/SEC:	80ms per range change **	
Ω SLOW:	As DC SLOW for values < 10kΩ Not recommended for values > 10kΩ	
Ω, 100/SEC	Not available.	

* Plus 0 to 100ms depending on when the SAMPLE command occurs.

** Plus 0 to 40ms depending on when the SAMPLE command occurs.

\+ Plus 1s approximately if single sample (manual or remote command) is used.

INTERFERENCE REJECTION - SERIES MODE

The ratio of the peak interference at the input terminals to one digit reading error. These figures apply providing that the applied signal plus the noise does not exceed 120% of full scale, on each range (but note the maximum permissible input on the 1000V range).

DC FAST:	> 70dB at 50 or 60Hz ± 2% (mains frequency)
DC SLOW:	A low pass filter increases the DC FAST figure by 30dB at 50Hz, increasing at 6dB per octave.

INTERFERENCE REJECTION - COMMON MODE

The ratio of the peak interference, applied between signal source and instrument ground (chassis), to the peak reading error, when there is 1kΩ unbalance between the high and low signal paths.

The maximum common mode voltage must not exceed 500V dc or peak ac.

With Guard connected to Low in the standard input cable (2 terminal measurements):

	DC RANGES	AC RANGES
DC:	> 140dB	> 140dB
50Hz FAST:	> 145dB	> 40dB
50Hz SLOW:	> 174dB	> 40dB

With Guard connected to the source of common mode interference (3 terminal measurement):

	DC RANGES	AC RANGES
DC:	> 150dB	> 150dB
50Hz FAST:	> 160dB	> 60dB
50Hz SLOW:	> 174dB	> 60dB

Note: 174dB is the greatest measurable ratio, since it is the ratio of the maximum permitted interference (500V) to the smallest digit (1μV).

Note: The following is additional information applicable to 25/SEC and 100/SEC operation. These rates are only available under remote control.

DC RANGES

	Sensitivity		Full Scale		
Range	25/SEC	100/SEC	25/SEC	100/SEC	Input Resistance
10mV	1μV	10μV	11.999mV	11.99mV	> 100MΩ
100mV	10μV	100μV	119.99mV	119.9mV	> 1000MΩ
1V	100μV	1mV	1.1999V	1.199V	> 10 000MΩ
10V	1mV	10mV	11.999V	11.99V	> 10 000MΩ
100V	10mV	100mV	119.99V	119.9V	10MΩ
1000V	100mV	1V	1199.9V	1199V	10MΩ

AC RANGES

	Sensitivity		Full Scale		
Range	25/SEC	100/SEC	25/SEC	100/SEC	Input Impedance*
100mV	10μV	100μV	119.99mV	119.9mV	10MΩ/< 150pF
1V	100μV	1mV	1.1999V	1.199V	10MΩ/< 150pF
10V	1mV	10mV	11.999V	11.99V	1MΩ/< 100pF
100V	10mV	100mV	119.99V	119.9V	1MΩ/< 100pF
1000V	100mV	1V	1199.9V	1199V	1MΩ/< 100pF

*Input capacitance measured between Hi and Lo at input socket excluding input cable. Capacitance is increased by 80pF if rear input socket is fitted.

OHMS RANGES

	Sensitivity		Full Scale		
Range	25/SEC	100/SEC	25/SEC	100/SEC	Test Current
1kΩ	100mΩ	1Ω	1.1999kΩ	1.199kΩ	100μA
10kΩ	1Ω	10Ω	11.999kΩ	11.99kΩ	100μA
100kΩ	10Ω	100Ω	119.99kΩ	119.9kΩ	100μA
1MΩ	100Ω	1kΩ	1199.9kΩ	1199kΩ	1μA
10MΩ	1kΩ	10kΩ	11999kΩ	11990kΩ	1μA

SHORT TERM ACCURACY

for high speed measurements

For 24 hours and within ± 1°C temperature stability. Resolution and linearity errors are included.

DC RANGES

	% of Reading		% of Full Scale †	
Range	25/SEC	100/SEC	25/SEC	100/SEC
10mV	0.01	0.1	0.01	0.1
100mV	0.01	0.1	0.01	0.1
1V	0.01	0.1	0.01	0.1
10V	0.01	0.1	0.01	0.1
100V	0.01	0.1	0.01	0.1
1000V	0.01	0.1	0.01	0.1

†Limited by resolution

LONG TERM ACCURACY
for high speed measurements

For 90 days ± 5°C. Assumes occasional adjustment of the μV OFFSET Control.

DC RANGES

Range	% of Reading 25/SEC	% of Reading 100/SEC	% of Full Scale † 25/SEC	% of Full Scale † 100/SEC
10mV	0.01	0.1	0.01	0.1
100mV	0.01	0.1	0.01	0.1
1V	0.01	0.1	0.01	0.1
10V	0.01	0.1	0.01	0.1
100V	0.01	0.1	0.01	0.1
1000V	0.01	0.1	0.01	0.1

AC RANGES 40Hz to 20kHz

Range	% of Reading 25/SEC	% of Reading 100/SEC†	% of Full Scale 25/SEC	% of Full Scale 100/SEC
100mV	0.1	0.1	0.01	0.1
1V	0.1	0.1	0.01	0.1
10V	0.1	0.1	0.01	0.1
100V	0.1	0.1	0.01	0.1
1000V	0.1	0.1	0.01	0.1

AC RANGES 20Hz to 40Hz and 20kHz to 100kHz (Typically)

Range	% of Reading 25/SEC.	% of Reading 100/SEC	% of Full Scale 25/SEC	% of Full Scale 100/SEC
100mV	1.0	1.0	0.01	0.1
1V	1.0	1.0	0.01	0.1
10V	1.0	1.0	0.01	0.1
100V	1.0	1.0	0.01	0.1
1000V	1.0	1.0	0.01	0.1

OHMS RANGES

Range	% of Reading 25/SEC	% of Reading 100/SEC	% of Full Scale 25/SEC	% of Full Scale 100/SEC
1kΩ	0.025	0.1†	0.01	0.1
10kΩ	0.025	0.1†	0.01	0.1
100kΩ	0.025	0.1†	0.01	0.1
1MΩ	0.025	0.1†	0.01	0.1
10MΩ	0.25	0.25	0.01	0.1

†Limited by resolution

RATIO

(A230, A233 and A235)

DVM INPUT

Sensitivity and Full Scale must be within the limits for normal dvm measurements.

REFERENCE INPUT

2V to 11V unipolar
maximum overload, ± 100V dc or peak

OPERATING POSITION

The horizontal plane of the dvm must lie within 30° of a level operation position.

SETTLING TIME OF REFERENCE

< 10 seconds

RATIO RANGES

(10V Reference)

Ratio Mode	Ratio Range
dc/dc (A230, A233 and A235)	0.000 000 1 : 1 to 100 : 1
ac/dc Mean Sensing (A233)	0.000 001 : 1 to 100 : 1
True rms (A235)	
Ω/dc (1V : 1Ω) (A233 and A235)	0.001 : 1 to 1,000 000 : 1

READ OUT

1V to 1000V Range

$$\text{Ratio} = \frac{\text{dvm reading}}{10}$$

100mV Range

$$\text{Ratio} = \frac{\text{dvm reading}}{10^4}$$

ACCURACY

$$\text{ratio uncertainty} = \frac{(\text{dvm accuracy} + 0.002\% \text{ of full scale}) \times 10}{\text{V Reference}}$$

For example, if V Reference is 5V and the dvm is reading full scale:

$$\text{ratio uncertainty} = \frac{(\pm\ 0.004\% + 0.002\%) \times 10}{5}$$

$$= \pm\ 0.012\%$$

NOISE

$$\pm\ 1.5 \text{ digits} \times \frac{10}{\text{V Reference}}$$

TEMPERATURE EFFECTS

Coefficient of Reading: ± 0.001% per °C

REFERENCE INPUT CHARACTERISTICS

Input Resistance: 1MΩ ± 10%

INTERFERENCE REJECTION (DC/DC Ratio Measurements)

REFERENCE INPUT

Reference Series Mode Rejection (Ref SMR)

The ratio of peak sinusoidal interference in series with V reference, at the reference terminals, to the dvm error.

Ref. SMR > 40dB at 50Hz

This applies for (interference + V reference) ⩽ 11V

Note: The rejection figures for dvm signal input remain unaltered.

Reference Common Mode Rejection (Ref CMR)

The ratio of the voltage between reference input and dvm signal Lo, to the error reading converted to volts.

Ref. dc Common Mode (at ± 200V dc common mode)

Range (dc)	Rejection for 10V Reference
100mV	100dB
1V	80dB
10V	70dB
100V	46dB
1000V	40dB

Ref. ac Common Mode	Rejection for 10V Reference
	> 60dB at 50Hz

For reference voltages less than 10V the dB rejection is reduced by the factor $\frac{\text{V Ref}}{10}$

ISOLATION

200V peak between reference input and dvm input.

500V peak between reference input and dvm chassis.

ENVIRONMENT

Maximum working Relative Humidity:	70%
Storage Temperature Range:	-30 to +70°C
Working Temperature Range:	0 to +50°C

MAINS SUPPLY

With the appropriate settings of the Mains Selection switches, the instrument can be powered from 98V to 128V and 195V to 255V ac at 50 or 60Hz.

Modification is necessary to achieve full interference rejection at 60Hz.

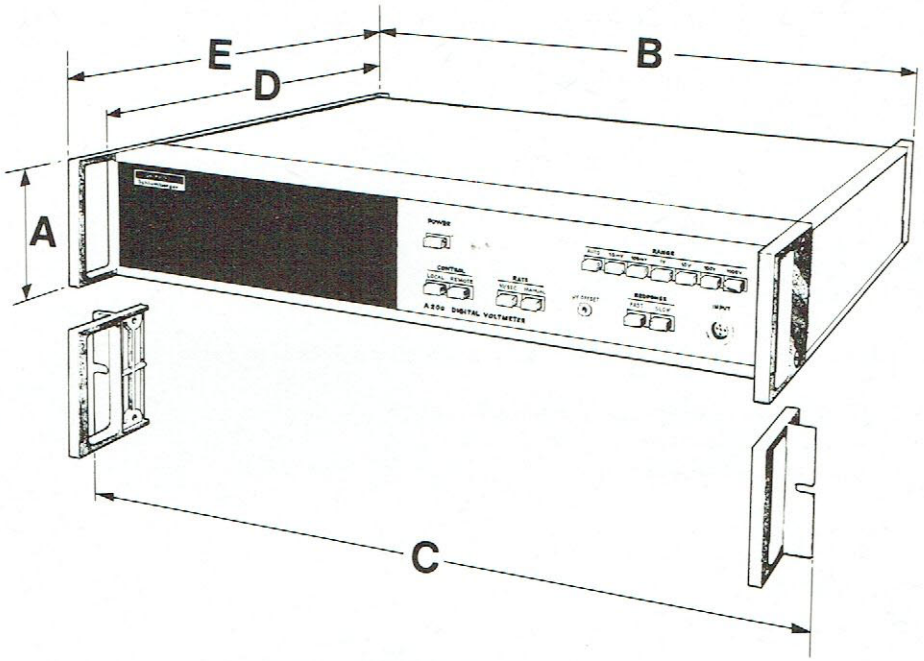
Maximum mains frequency variation giving optimum mains frequency interference rejection:	± 3%
Consumption:	45VA
Mains Fuses:	98V to 128V : 750mA SLO-BLO 195V to 255V : 300mA SLO-BLO

FAN OUT UNIT A214

Outputs:	TTL Compatible High (Logical 1) +2.4V to +6V from a 6kΩ source Low (Logical 0) -0.5V to +0.5V at 10mA sink
Inputs:	TTL Compatible High (Logical 1) +2.4V to +6V at 100μA or open circuit Low (Logical 0) -0.5V to +0.5V at 5mA sink

Details of signals are given in Section 5. (Data Systems Use).

DIMENSIONS



A	=	89mm (3.5in)
B	=	445mm (17.5in)
C	=	483mm (19.0in)
D	=	440mm (17.3in)
E	=	484mm (19.1in)

WEIGHT

Instrument:	10.5kg (23 lbs)
Instrument and Packing:	11.8kg (26lbs)

ACCESSORIES

Each voltmeter is supplied with the following accessories:

Input lead with 4mm Plug Terminations

		Solartron Part No.
Test Prod	(Red)	351901010
Test Prod	(Black)	351901020
Croc. Clip	(Red)	355900670
Croc. Clip	(Black)	355900660
750mA SLO-BLO Fuse (2 off)		360103070
300mA SLO-BLO Fuse (2 off)		360103170
Rack Mounting Handle (2 off)		429700101

Each A214 Fan-out is supplied with the following accessories:

50 WAY PLUG (BICC MS50 RN-BR118) (1 off)	354002340
Pins (BICC RM20M-12-D29) (50 off)	354001610

SECTION 3 Operating Instructions

PRELIMINARY ADJUSTMENTS

Fit the mains selector plate to suit the local mains supply voltage.

Check that the correct fuse is fitted:-

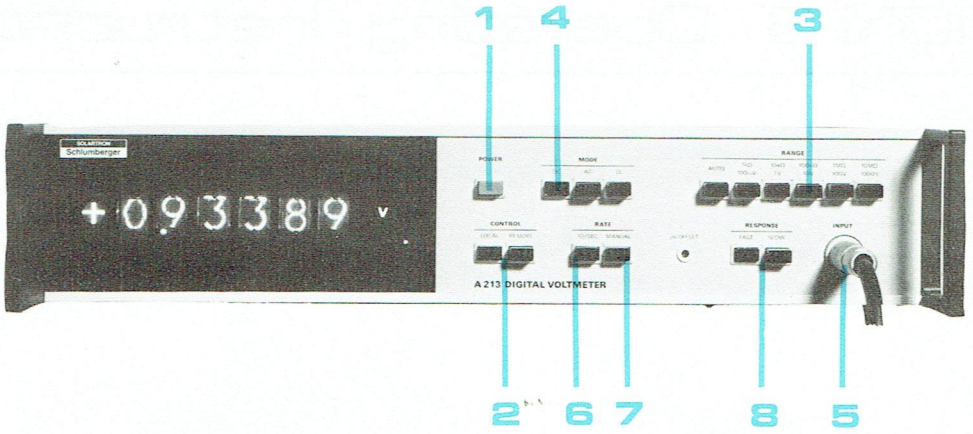
500mA SLO-BLO for mains voltages between 195V and 255V.

1A SLO-BLO for mains voltages between 98V and 128V.

Connect a suitable plug to the mains lead:-

BROWN	–	LINE
BLUE	–	NEUTRAL
GREEN/YELLOW	–	EARTH

DC VOLTAGE MEASUREMENT



Although the maximum dc input voltages that may safely be applied to the instrument are:-

i) 1200V on the 1000V and 100V ranges

ii) 300V on the 10V, 1V and 100mV ranges

the 10V, 1V and 100mV ranges will withstand 1200V for up to 200ms. Thus, for AUTO range. purposes the range of input voltage can be from 0V to 1200V.

1 Switch POWER on.

2 Select LOCAL or REMOTE. If the instrument is fitted with a Fan Out Unit and remote control is required see section 5 of this manual for a list and description of the remote control facilities. If LOCAL is selected continue from step 3.

3 Choose an appropriate range or AUTO.

4 If the instrument is anything other than an A210 or A230, press the DC MODE button

5 Connect the input lead to the unknown voltage source; red to signal high and black to signal low.

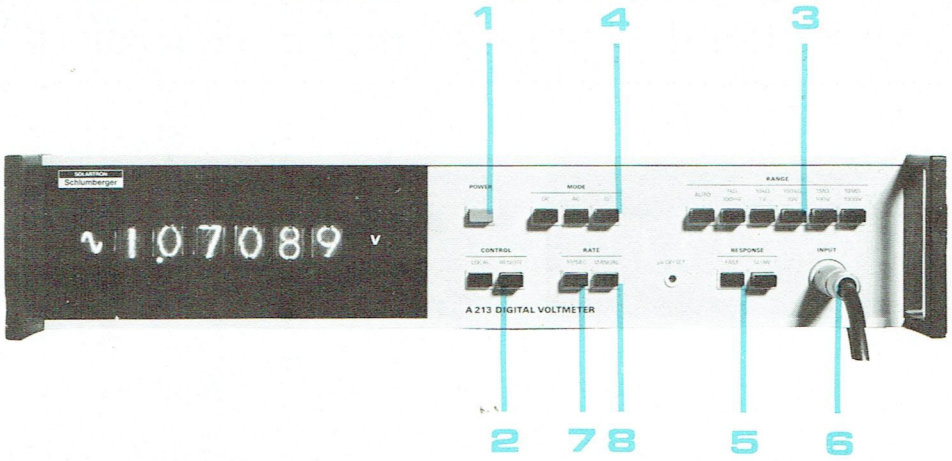
6 Press the 10/SEC button for repetitive measurement or alternatively,

7 Press the MANUAL button for 'single-shot' measurement.

8 Select SLOW or FAST RESPONSE for filtered or unfiltered measurement. In doubtful cases take measurements using FAST and then SLOW; if the readings are different the filter is required, since the change must be the result of increased noise rejection.

9 Read the voltage from the display. The indicated polarity is that of the red lead with respect to the black.

AC VOLTAGE MEASUREMENT (A211, A213, A215, A233 and A235)



Maximum applied voltages are:-

(i) 1.2kV pk* (≡ 850V rms, sine wave) on the 1000V, 100V and 10V ranges and

(ii) 212V rms on the 1V range.

(iii) **A215 and A235 only**:- The maximum input voltage/frequency product must not exceed 6×10^6 . i.e. $V_{in}\, f_{in} = < 6 \times 10^6$ VHz

The 1V range will withstand 1.2kV pk* for up to 200ms. Thus, for AUTO range operation the range of input voltage can be from OV to 1.2k V pk* without risk of damage to the lower range. When fixed range operations is employed, care should be taken not to exceed the 212V rms limit on the 1V range.

1 Switch POWER on.

2 Select LOCAL or REMOTE. If the instrument is fitted with a Fan Out Unit and remote control is required see section 5 of this manual for a list and description of the remote control facilities. If LOCAL is selected continue from step 3.

3 Choose an appropriate range or AUTO.

4 Press the AC MODE button.

5 Select SLOW or FAST RESPONSE depending on the low frequency limit required. SLOW for frequencies down to 40Hz and FAST for frequencies down to 100Hz. SLOW is not available in conjunction with AC AUTO. As soon as the voltmeter detects that AC, AUTO and SLOW have been selected it automatically goes to AC–AUTO–FAST.

6 Connect the input lead to the unknown voltage source, red to signal high and black to signal low.

7 Press the 10/SEC button for repetitive measurement or, alternatively,

8 Press the MANUAL button for 'single-shot' measurement.

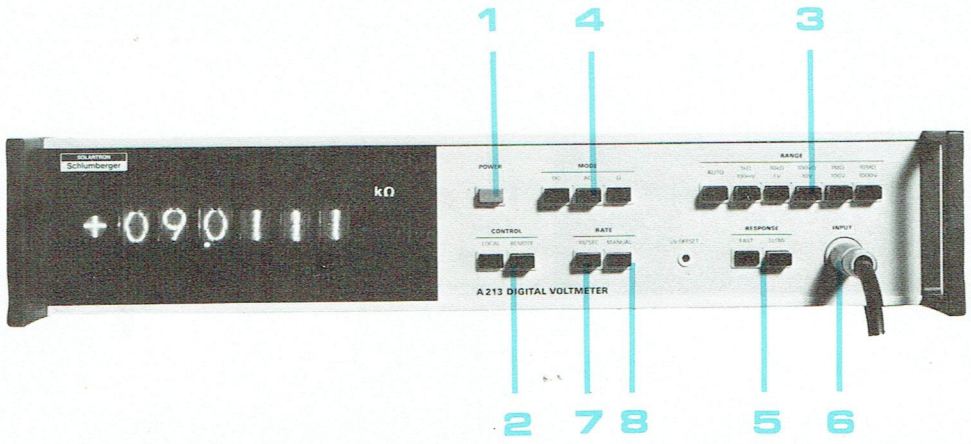
Note: If 10/SEC is selected the voltmeter displays the result of measurement ten times a second and it will be necessary to wait 1 second (FAST) or 4 seconds (SLOW), after connecting the signal to the input for an accurate result (correct to 0.1% of final reading).

If MANUAL sample is used there is an automatic delay of 1s before the display is updated. If SLOW response is used, to obtain an accurate result (to 0.1% of final reading) the input signal must be present for at least 3s before pressing the MANUAL button.

9 Read the voltage from the display.

* Including dc component.

RESISTANCE MEASUREMENT (A212, A213, A215, A233 and A235)



1 Switch POWER on.

2 Select LOCAL or REMOTE. If the instrument is fitted with a Fan Out Unit and remote control is required see section 5 of this manual for a list and description of the remote control facilities. If LOCAL is selected continue from step 3.

3 Choose an appropriate range or AUTO.

4 Press the Ω MODE button.

5 Press the FAST RESPONSE button. Although SLOW can be used in conjunction with the Ω mode, if resistances above 50kΩ are being measured the time constant of the filter is increased with a corresponding increase in the time taken for measurement.

6 Connect the input lead to the unknown resistance.

7 Press the 10/SEC button for repetitive measurement or, alternatively,

8 Press the MANUAL button for 'single-shot' measurement.

9 Read the resistance from the display.

CURRENT MEASUREMENT

Although current measurement is not a facility provided by these voltmeters, it is easily effected by measuring the potential difference developed across a known precision resistor. The type of resistor used is important: for dc use either a precision wire-wound component or, if available, a Standard resistor: for ac use a metal film precision resistor.

Alternatively, the Solartron Current Adaptor EX3180, converts any of the voltmeters in this series into an ac/dc digital ammeter capable of measuring currents in the range 100pA to 1.19999A. Full connecting details and operating instructions are contained in the manual of the EX3180.

RATIO MEASUREMENT

A230	A233	A235
DC/DC	DC/DC	DC/DC
	AC/DC (Mean Sensing)	AC/DC (True RMS)
	Ω/DC	Ω/DC

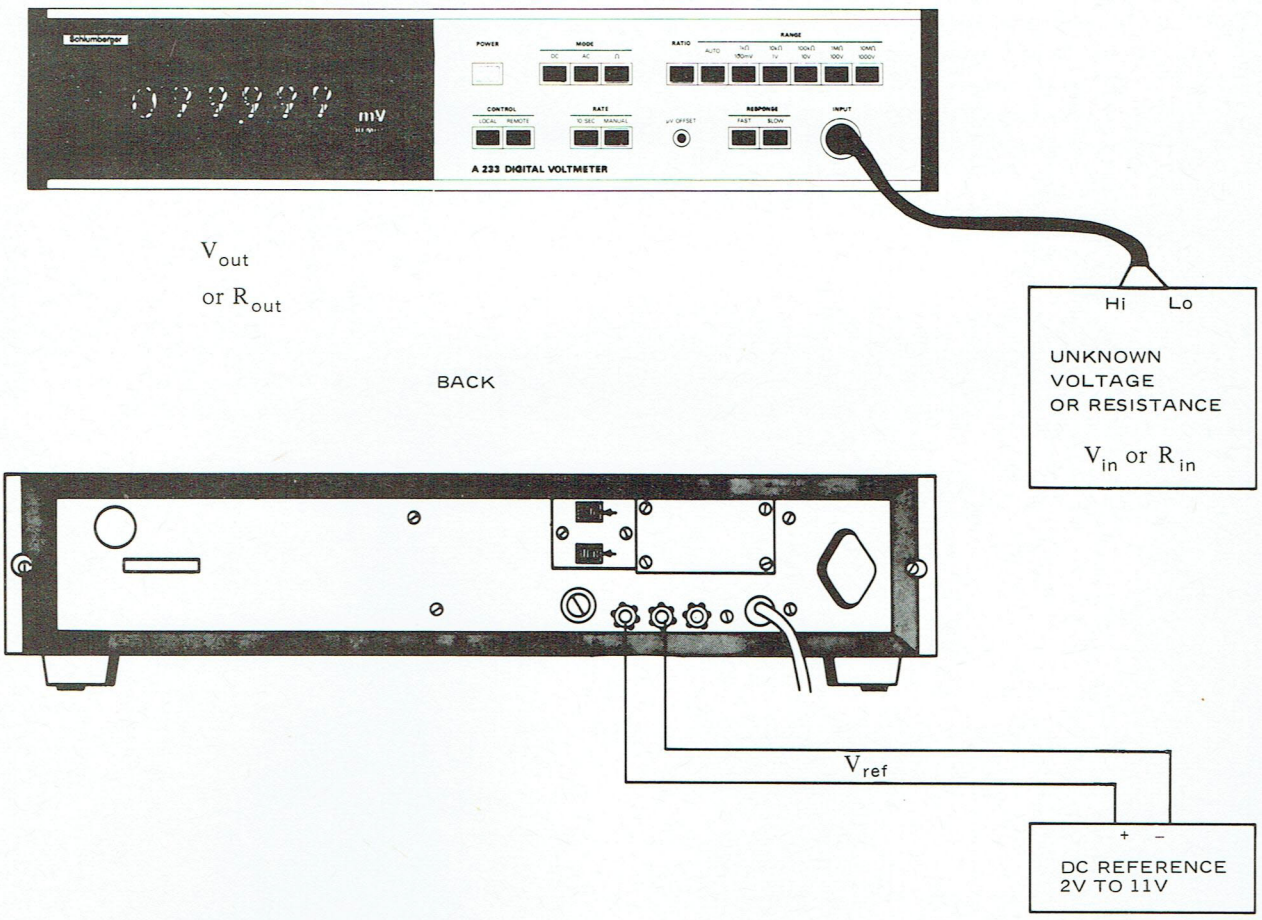
Ratio Interconnection

The following diagrams illustrate typical interconnection schemes for ratio modes available. On DC/DC Ratio, reference and signal may be linked.

Without RATIO selected, all instrument measurements are made with reference to an internal standard.

With RATIO selected, the internal standard is substituted with an external standard (between 2V and 11V DC) which must be connected; all instrument measurements are now with reference to this external standard. The relationship between the input and the display becomes,

$$V_{out} = \frac{10V_{in}}{2<V_{ref}<11}$$



The dvm is operated as for normal measurement, with the following changes:

1) Apply a DC Reference, between 2V and 11V to the BACK panel terminals; positive to RED and negative to BLACK. **Note.** The GREEN terminal is directly connected to the GUARD terminal of the front panel input connector, and hence to the black lead of the 2 core input cable.

2) Press the RATIO button. In RATIO, the instrument reverts to FAST RESPONSE; SLOW is not available.

3) Allow 10 secs after the reference is applied or changed, and read the value displayed.

The ratio (dc/dc or ac/dc mode)

$$= \frac{\text{displayed reading}}{10} \qquad \text{(when V indicator is 'lit')}$$

$$= \frac{\text{displayed reading}}{10^4} \qquad \text{(when mV indicator is 'lit')}$$

NOTE Ω/dc

Since the displayed reading indicates a ratio of two different quantities i.e. voltage and resistance, suitable scaling should be applied to relate the displayed reading to the desired ratio or deviation measurement. The relationship between the display and the input becomes.

$$R_{out} = \frac{10R_{in}}{2<V_{ref}<11}$$

The dvm is operated as for normal measurement, with the following changes:

1) Apply a DC Reference, between 2V and 11V to the BACK panel terminals; positive to RED and negative to BLACK. **Note Caution** when using GREEN (guard) terminal.

2) Press the RATIO button. In RATIO, the instrument reverts to FAST RESPONSE; SLOW is not available.

3) Allow 10 secs after the reference is applied or changed, and read the value displayed.

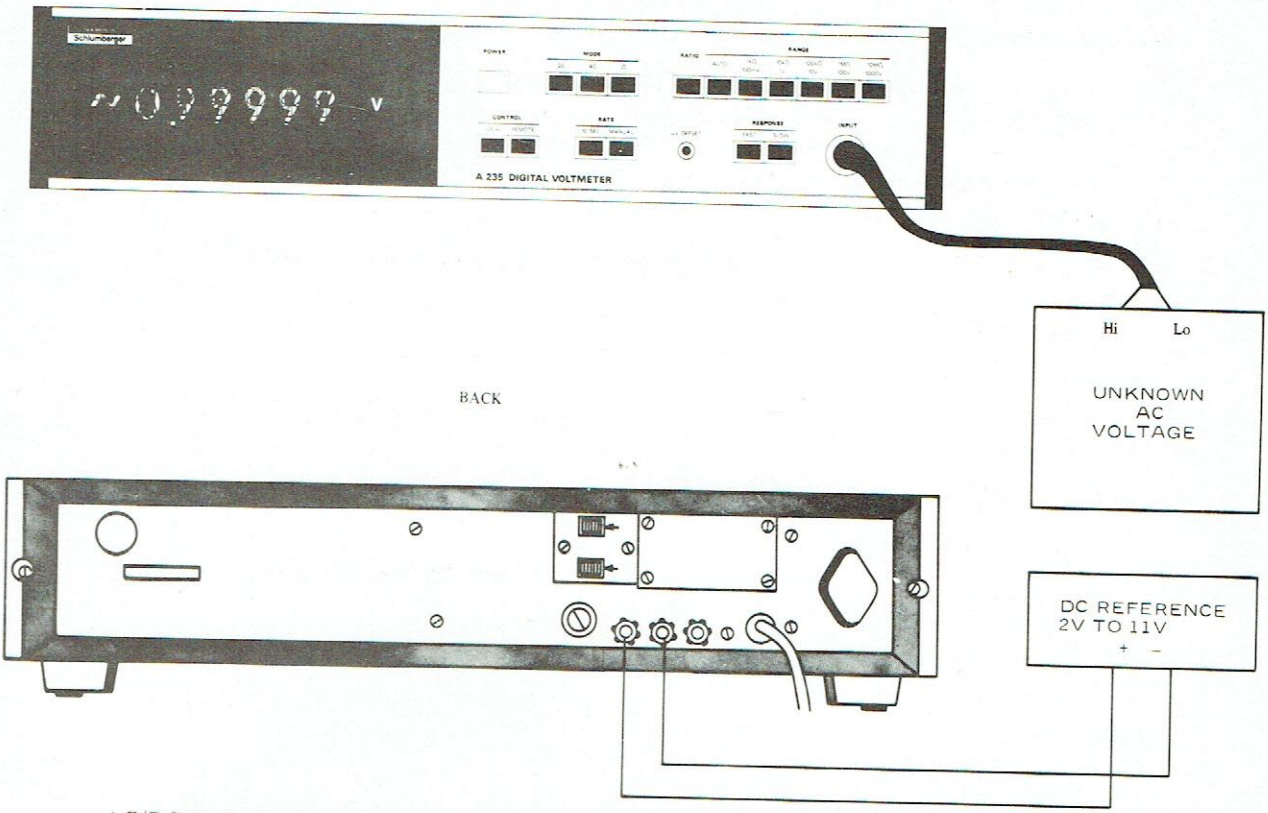
The ratio (dc/dc or ac/dc mode)

$$= \frac{\text{displayed reading}}{10} \qquad \text{(when } \mathbf{V} \text{ indicator is 'lit')}$$

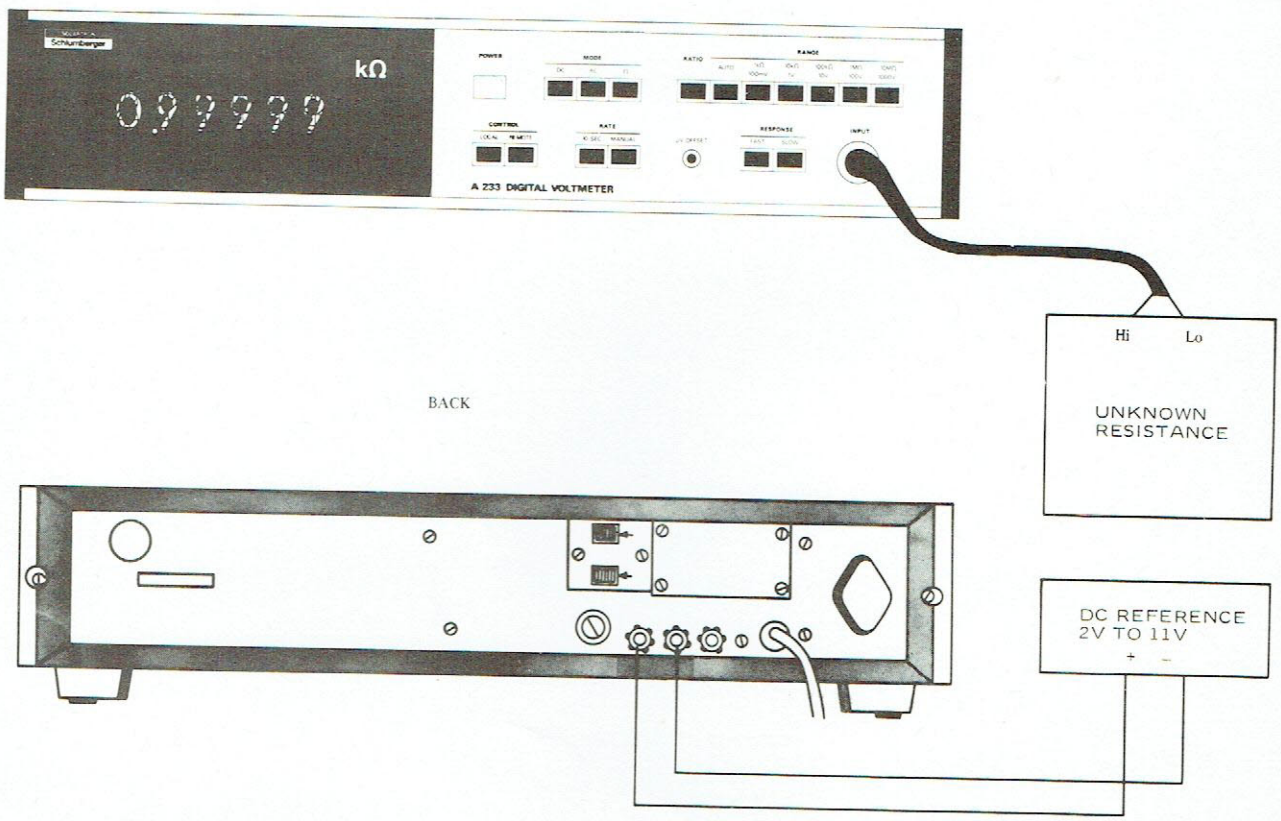
$$= \frac{\text{displayed reading}}{10^4} \qquad \text{(when } \mathbf{mV} \text{ indicator is 'lit')}$$

NOTE Ω/dc

Since the displayed reading indicates a ratio of two different quantities i.e. voltage and resistance, suitable scaling should be applied to relate the displayed reading to the desired ratio or deviation measurement.



AC/DC Ratio Interconnections



DC/Ω Ratio Interconnections

SECTION 4 Measurement Techniques

The user who is only slightly familiar with the practice of precision measurement will find the *MASTER SERIES* of voltmeters very easy to use. The layout and logical operation of the controls, the information presented by the display and the connection of the unknown signal incorporate several new features not provided in other digital voltmeters. This results in an instrument which is so simple to use that even the totally inexperienced can make measurements with confidence.

The following notes are for those who wish to know more about the techniques of precision measurement. They also provide a guide as to the best way of employing the voltmeter in more unusual measurement situations.

INPUT RESISTANCE

In making a measurement of voltage virtually all instruments take a current from the source whose voltage is being assessed. The one exception is the true potentiometer in which, at balance, no current is taken from the source. The current taken by the measuring device gives a voltage drop across the internal resistance of the source so that the measured voltage is less than the true emf of the source (Fig. 4.1).

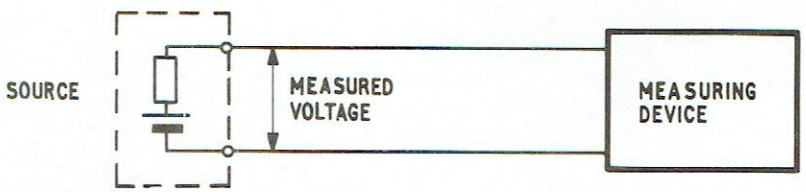


Fig. 4.1 *Current taken by a measuring instrument can cause a voltage drop across source resistance.*

A good moving coil meter will take a current of 10μA (100kΩ/V) so that if the source resistance were 1kΩ the voltage drop would be 10mV. This would be pretty hopeless for 'precision work' since a voltmeter with such a low input resistance would read 1.4900V instead of 1.500V.

Fortunately, electronic feedback techniques can give a digital voltmeter such a high input resistance that in most practical work the effect can be ignored. Thus the *MASTER SERIES* when measuring dc on the more sensitive ranges, has an input in excess of 1GΩ. This means that the source resistance will have to exceed 10kΩ before an error of 1 digit is obtained. This may sound a little vague, however, it is not possible to define the input resistance more closely because a group of voltmeters will have differing gains in their input amplifier; although this has no effect whatever on the accuracy, the input resistance may be 2GΩ or 5GΩ but will never be as small as 1GΩ.

On the 100V and 1000V dc ranges it is not possible to apply the unknown input directly to the input amplifier; it must be first attenuated. The attenuator must be very accurate and stable and must withstand high input voltages, so wirewound resistors are employed. It is difficult and expensive to make the attenuator of very high value resistors, so a 10MΩ network is used. Hence, on 100V and 1000V ranges the input resistance is 10MΩ ± 0.1% and errors arising from source resistance can be calculated with reasonable accuracy. For example, on the two highest voltage ranges, a source resistance of 1kΩ will cause the result to be 0.01% low, i.e. 10 digits in 100 000.

INPUT CURRENT

All solid state devices are current operated hence the amplifiers of these voltmeters have a current flowing at the input terminals even when the input signal is zero. By careful design this current can be reduced to almost insignificant proportions and in these voltmeters it is less than 100pA (10^{-10} A). During warm-up (for about 30 minutes after switch-on) the current will vary by about 2pA/^{o}C and then stabilise. Taking the Hi terminal as a reference, the current may flow into or out of this terminal and must therefore be regarded as lying between +100pA and -100pA.

It should be realised that the effects of input current are additional to those of input resistance. If we take an extreme example such as the measurement of a 10mV source with a resistance of 1MΩ on the 100mV range, the input resistance alone (1000MΩ) would give a reading that is up to 100μV low. Likewise an input current of 100pA will introduce an additional error of 100μV which can add to or subtract from the error caused by the input resistance. Thus, in this extreme example, ther is an uncertainty (rather than a defined error) which may be up to 100μV. (fig. 4.2).

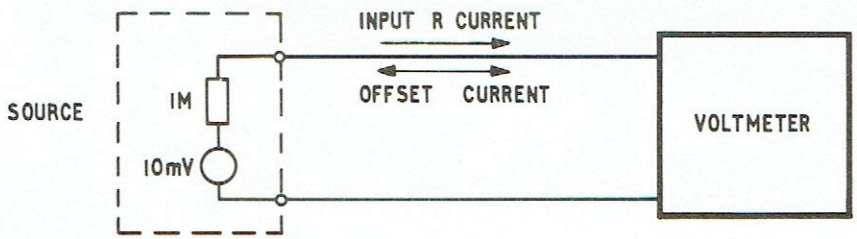


Fig. 4.2 *Current taken by input resistance flows into the voltmeter; offset current may flow either way. Both effects are present together.*

The condition given in the above example will probably never be met by the average user because low level signals nearly always have a source resistance of less than 10kΩ, in which case the errors are insignificant. If in a rare situation a low level measurement must be made on a high resistance source, the offset current can be monitored and reduced to a very low value in the following way (Fig. 4.3).

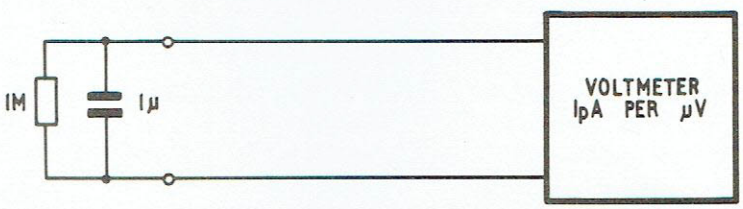
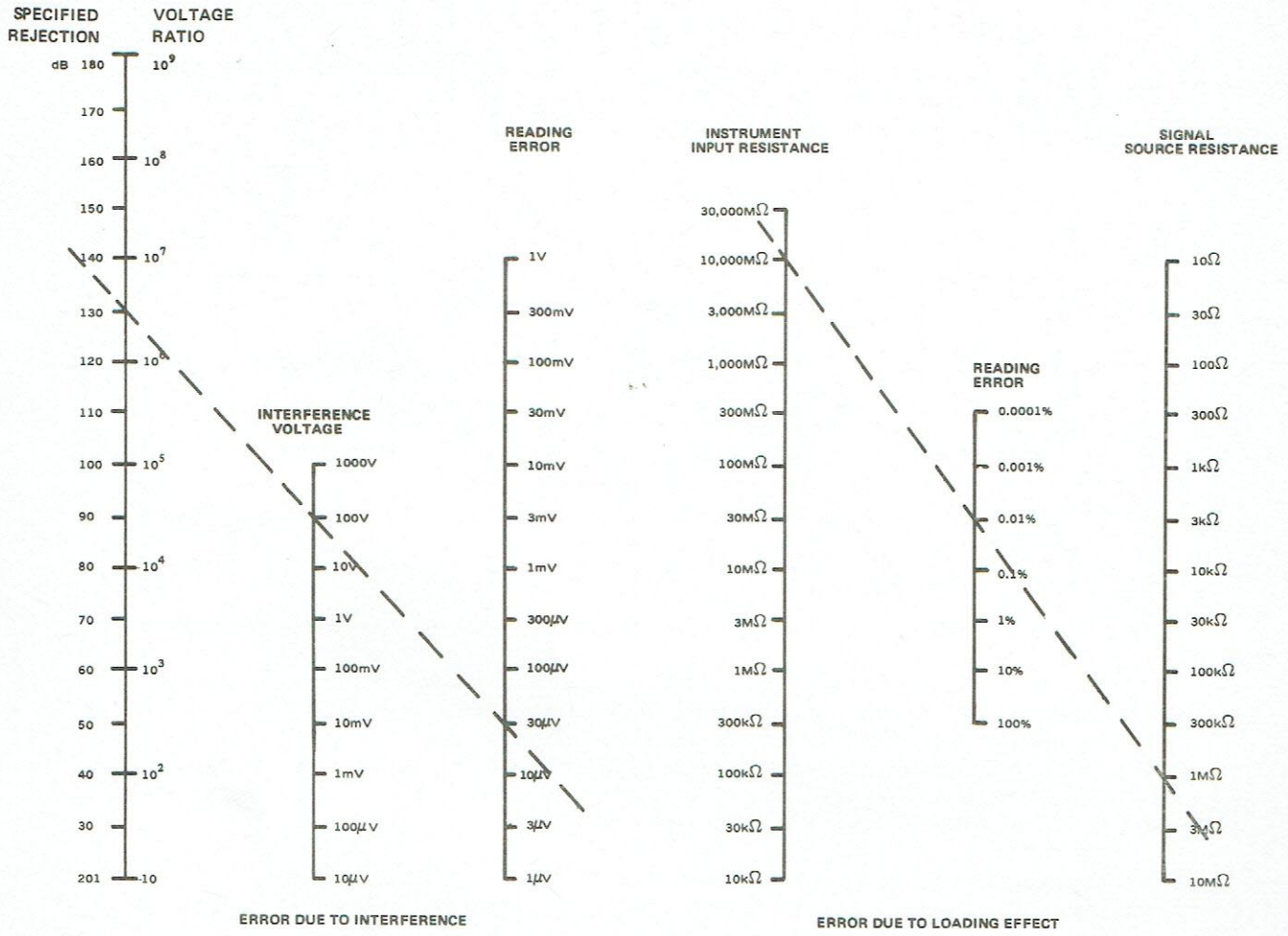


Fig. 4.3 *Using a known resistor the voltmeter can measure its own offset current.*



Remove the top outer cover, switch on and allow the instrument to warm-up for 30 minutes. Connect across the input cable a 1MΩ resistor in parallel with a low voltage 1μF capacitor - keep the connections short to minimise 50Hz pick-up. Allow a minute or two for thermal effects to disappear, with a short across the capacitor to dissipate any small dielectric storage; then remove the short circuit.

With the 100mV range selected each digit of the display represents 1pA. Through the top of the screened compartment is a pre-set control called INPUT CURRENT which can be adjusted to bring the reading to almost zero. It will probably not stay at zero for long because very small drifts of a few pA are inevitable, but it will enable a measurement of a high resistance source with less uncertainty in the short term. Over periods greater than a few hours and with changed in ambient temperature, the current will drift by tens of pA. Hence, the formal instrument specification claims only ± 100pA for long term use.

ASSESSING INPUT RESISTANCE

From the foregoing it will be realised that it is not possible to check the extremely high input resistance by using an instrument as though it were a physical resistor. Further, the measurement is complicated by the presence of the offset current.

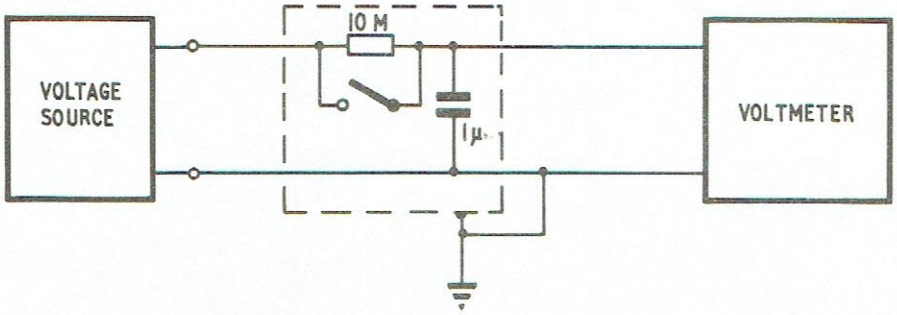


Fig. 4.4 *An assessment of input resistance will include an effect caused by offset current.*

With the arrangement shown in Fig. 4.4 the components are mounted in a screening box which is bonded to earth in order to minimise 50Hz pick-up. The voltmeter is set to the 10V dc range and the voltage source to approximately 10V. The switch is first closed and the reading noted (say 10.0570). Upon opening the switch the reading will fall, over a short period of time, to say 10.0520. Ignoring the offset current this is a fall of 5mV in 10V - a factor of 2×10^3. Thus, the input resistance is $2 \times 10^3 \times 10M\Omega = 20G\Omega$.

A proportion of the change will be due to offset current and this will become a greater proportion on the lower voltage ranges. So if any reasonable assessment of the input resistance is to be attempted, the current should first be reduced to a few pA as described earlier. As a check the measurement can be made using each polarity of input voltage in turn. A difference in the readings taken with the $10M\Omega$ in circuit will then give a measure of the offset current.

The difficulty of an accurate assessment of input resistance on more sensitive ranges is the only reason why $1G\Omega$ is specified for the 100mV range. The value is probably in excess of $1G\Omega$, but it is impossible to measure it with any reasonable degree of certainty.

SPURIOUS VOLTAGES

Although small emf's occur in the voltmeter input circuit, they are compensated for during calibration. Thereafter, when the instrument has warmed-up for about 30 minutes, they are so stable as to be quite insignificant to the user. The drift in the input amplifier is equivalent to an input voltage change of approximately $1\mu V$ per week. The user therefore need not make any compensation or adjustment in order to achieve accurate results.

The voltmeter will faithfully measure any input that is applied to its terminals; it is the responsibility of the user to ensure that the input contains only the voltage that he wishes to measure. In low level work - with perhaps a few tens of microvolts - this may require some care and thought in the arrangement of the circuit.

As an example, consider measuring the voltage produced by passing a very small current through a wirewound resistor. On the 100mV range the reading is recorded as $126\mu V$. But the resistor is placed - in the sun or near a power transistor - so that one end is a little warmer than the other.

Because of the dissimilar materials used in the wire of the resistor and the copper connections, a net thermal emf of possibly 40μV/^{o}C will exist. Thus a differential of 0.5^{o}C across the resistor could mean that the true result should be either 106μV or 146μV. The voltmeter cannot possibly distinguish between the wanted and unwanted parts of the signal that is applied to it. In this example, without altering the conditions of the resistor in any way, a measurement should be made with the small current flowing first in one direction and then in the other. In one case the thermal emf will add and in the other it will subtract. So the mean of the two results will eliminate the error.

Metal oxide resistors and reed relays are two other examples in which thermal emf's can bring about similar errors. In the reed relay the heating of an operating coil may contribute to this and it may be desirable to employ two reed switches in the same coil so that, when they are connected in series, the thermal emf's are self cancelling.

When the unwanted emf can be identified and is steady, it can be 'backed-off' by using the μV OFFSET control. This has a range $> \pm$ 10μV.

In attempting precision measurement of low level signals, effects other than thermal emf's can cause problems. Leakage across an insulating material when degraded by high humidity, or an industrial atmosphere may produce an unsuspected voltage across a source resistance. Coaxial cables, when flexing under vibration, can generate quite high transient voltages caused by the screen 'scrubbing' the polythene insulant; use low noise cables.

SERIES MODE INTERFERENCE

The examples of thermal emf's given above can be regarded as forms of interference because they interfere with the accurate assessment of the unknown signal. They are in series with the signal and voltmeter input and represent a special case of series mode interference because there is nothing that the voltmeter can do about rejecting dc interference while measuring a dc signal.

Series mode ac interference is a different matter. Because of their basic design principles these voltmeters will ignore all the usual forms of ac and noise that may be intermingled with the dc signal. Hence in all normal measurement work the user will be unaware of ac interference and it will not cause errors. Nevertheless, it would be possible to introduce such a degree of interference that the voltmeter would be unable to cope, so the keen user may be interested in the mechanism that brings about rejection.

The most common form of ac interference is simple 'hum' - i.e. 50Hz superimposed on the dc signal. This can be visualised either as pick-up on the connecting leads, as shown in Fig. 4.5(a), or as a generator that is a part of the source, as in Fig. 4.5(b). In both the result is the same and is shown graphically in Fig. 4.6.

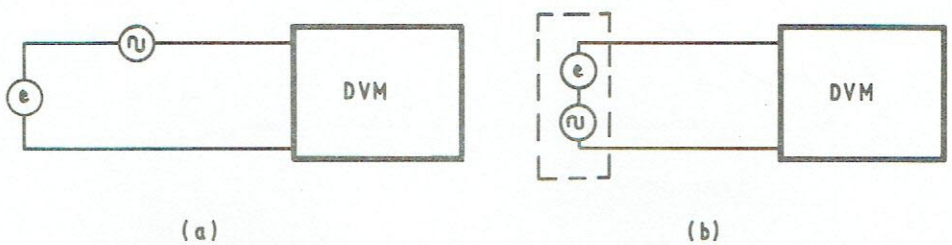


Fig. 4.5 *Interference at 50Hz can arise from pick-up on the leads (a) or may be inherent in the source (b).*

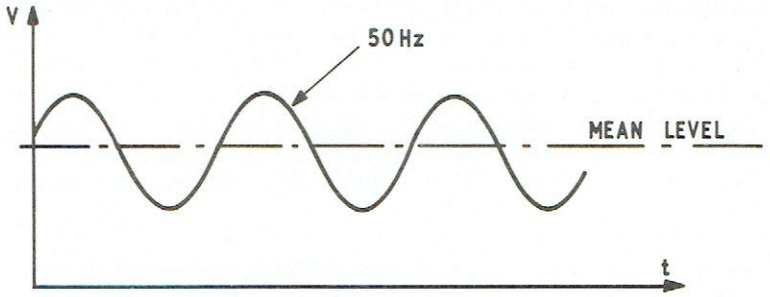


Fig. 4.6 *50Hz superimposed on the dc level that the voltmeter is trying to measure.*

Users of oscilloscopes will be familiar with this sort of picture and will know that the ac component is typically a few milli-volts peak-to-peak. This may be superimposed on a wanted dc signal of a mere 100μV.

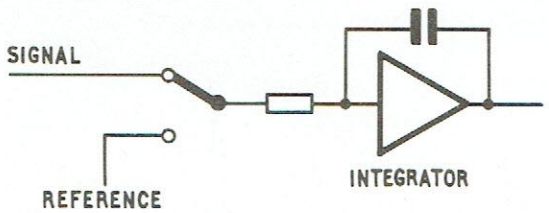


Fig. 4.7 *In the dual-ramp system the integrator is switched first to the signal (ramp-up) and then to the reference (ramp-down).*

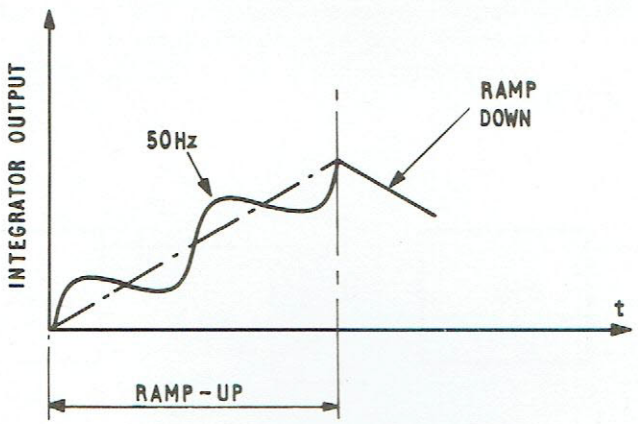


Fig. 4.8 *At the end of ramp-up the integral of any 50Hz component is zero.*

The integrator is connected to the input signal (actually to the output of the input amplifier) to start the initial phase of the measurement. This phase (ramp-up) lasts for a time that is defined by the frequency of the clock and the capacity of the counter. During ramp-up the output of the integrator is proportional to the integral of its input. If ramp-up lasts for T seconds then it is the

integral of the input over T seconds that finally remains on the capacitor when the switch opens. It is this voltage that is assessed during ramp-down. When T is made equal to the period of the ac interference (or to any whole number of periods) the integral of the ac at end of ramp-up will be zero. Thus ramp-down starts from a voltage that is proportional only to the dc component, (actually to the mean level) of the input. Fig. 4.8 illustrates the situation for a particular case of 50Hz interference.

In this series of voltmeters the ramp-up time (T) can be 40ms, 20ms or 4ms. With 40ms they inherently have rejection of 25Hz, 50Hz, 75Hz, 100Hz.....etc.; with 20ms, 50Hz, 100Hz, 150Hz.....etc. This is shown by the curves of Fig. 4.9, where rejection notches occur every 25Hz or 50Hz (depending on ramp-up time) and in which the rejection ratio is given in dB.

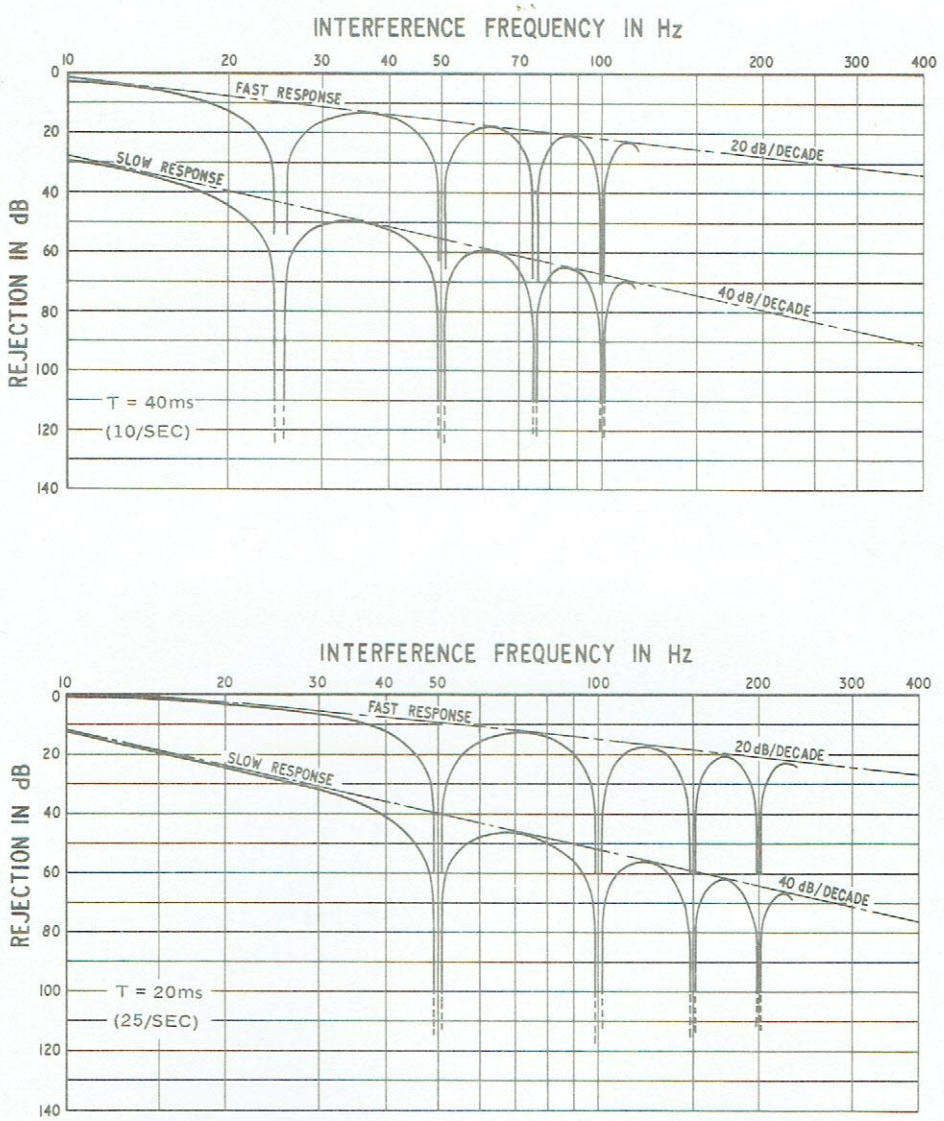


Fig. 4.9 *SERIES MODE REJECTION: These curves show the rejection that is attained at the frequencies given whilst measuring dc. The ramp-up times (40ms or 20ms nominal) are locked to the mains period so that the curves shift along the frequency axis in step with the changes of mains supply frequency.*

If the ramp-up times were precisely 40ms (10/SEC) and 20ms (25/SEC) there would be virtually infinite rejection of interference at multiples of 25Hz (40ms ramp-up) and 50Hz (20ms ramp-up) respectively. However, the clock frequency cannot be absolutely constant, and although this has no effect on the measurement accuracy (see Principle of Operation), the specified rejection must be less than infinite. Hence, with this series of voltmeters the rejection at 50Hz is better than 70dB; this means that any error will be, at worst, 3162 times smaller than the interference.

To digress for one moment - the decibel (dB) may be unfamiliar to some. It is used here to specify a voltage ratio. The relationship is:-

Number of decibels = $20 \log_{10}$ (Voltage Ratio)

Example: Voltage Ratio = 1000

Number of dB = 20 x 3 = 60dB

dB	Ratio	dB	Ratio
1	1.1	9	2.0
2	1.3	10	3.2
3	1.4	20	10
4	1.6	40	10^2
5	1.8	60	10^3
6	2.0	80	10^4
7	2.2	100	10^5
8	2.5	120	10^6

Decibels add; but ratios must be multiplied. Thus:-

36dB = 20 + 10 + 6dB

= 10 x 3.2 x 2 = 64 ratio

COMMON MODE INTERFERENCE

Interference can also arise from unwanted voltages which are common to both input leads. Consider Fig. 4.10 - here the signal source is earthed locally and the voltmeter input has also been earthed.

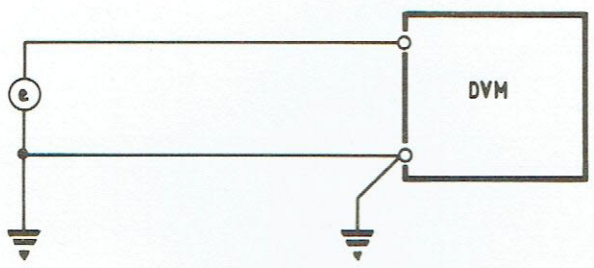


Fig. 4.10 *An 'earth' at both source and voltmeter input may introduce common mode interference. For this reason the voltmeter input is fully isolated.*

There is a distinct possibility that the two 'earths' are not at a common 'zero' potential; in industrial plants widely separated 'earths' can have as much as 10V between them. This situation is equivalent to that of Fig. 4.11 where the source is known to be at a finite potential with respect to earth.

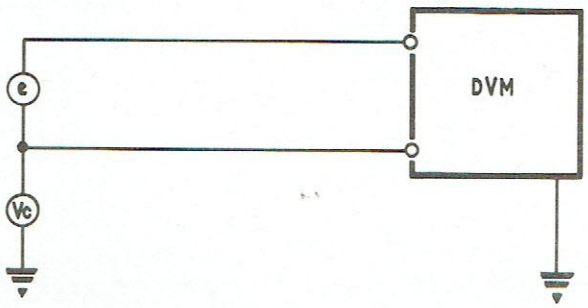


Fig. 4.11 *The source can be at high potential above earth without causing errors.*

For example, a thermocouple used to measure the temperature of a furnace element might be generating 1mV of dc signal while kept at 240V ac with respect to earth. Obviously it would be ludicrous to earth the voltmeter input, although the chassis and most of the circuits are earthed via the mains supply lead.

All the voltmeters in this series have been engineered so that the input circuits are extremely well isolated from the chassis which is connected to mains earth. In all normal measurement work the small current, which is driven down the leads to earth by a large common mode voltage, will not cause any error. This voltage should be restricted to 500V purely to ensure safety for equipment and personnel.

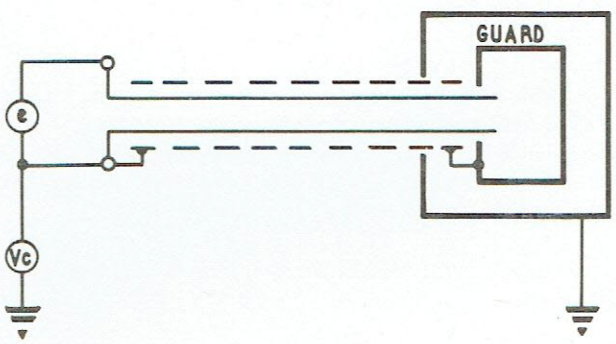


Fig. 4.12 *In the lead provided with the voltmeter, guard is strapped to Lo (Black) within the free end of the cable.*

The lead supplied with each voltmeter is shown in Fig. 4.12. Within the instrument the cable screen is wired to the guard box (a screening compartment which encloses the input circuits) and at the free end the screen is strapped to the black lead. Hence, the guard is effectively preserved right up to the signal source and common mode current flowing in the screen and via leakage to earth cannot affect the measurement in any way.

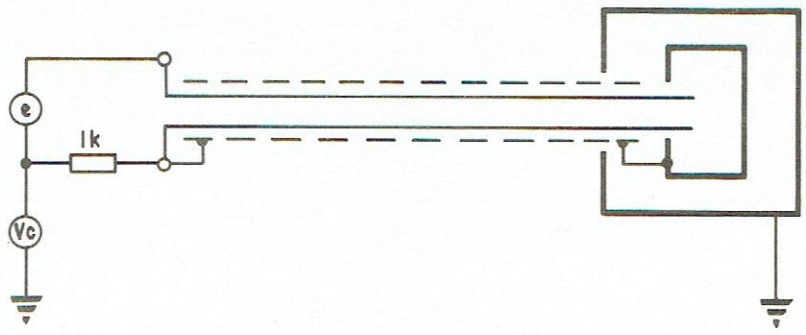


Fig. 4.13 *A rare, but more difficult, situation is where common mode current flows through lead resistance. This is entirely overcome by the arrangement of Fig. 4.14.*

In some measurement situations common mode voltage can have an affect on the reading. Most users will never meet the problem, but those who do can still eliminate error by using the voltmeter correctly. When there is resistance associated with the source - perhaps inherent in the source, or in connecting leads - the common mode current can flow through this resistance. Examples are: the resistance of strain gauges, long compensating leads from a thermocouple. This is illustrated by Fig. 4.13 where it will be seen that current flowing from V_C to earth down through the screen will pass through the resistance. If the guard-earth leakage is assumed to be the specified minimum of $10^{10}\Omega$ and V_C 100V dc the common mode current will be 10^{-8} A. Taking a lead resistance of 1kΩ, 10^{-8} A will develop a voltage drop of 10μV. Since the voltmeter cannot reject dc interference the worst error will be 10μV.

If the source of common mode is ac the stray capacitance from guard to earth is more important. The figure specified is 500pF which exhibits a reactance of about 6MΩ at 50Hz. With V_C now 100V rms the drop across 1kΩ is approximately 17mV rms or 24mV peak. This appears at the input terminals and the inherent rejection of series mode will be effective in reducing reading error to much less than 24mV. At worst the final reading error will not exceed 1μV (1 digit in the 100mV range).

In these examples a 1kΩ resistance has been assumed in one lead. Obviously the magnitude of the errors is proportional to this resistance and it is accepted practice to specify common mode rejection with 1kΩ unbalance in the leads using the configuration of Fig. 4.13. Even in these exceptionally adverse circumstances the error can be overcome by using a different input arrangement as in Fig. 4.14.

Here use has been made of a special lead EX3183* from which 4 cores and a screen are brought out as separate terminations.

* A special input lead assembly EX3193 comprising 2 cores and a screen brought out as a separate connection is available as an alternative.

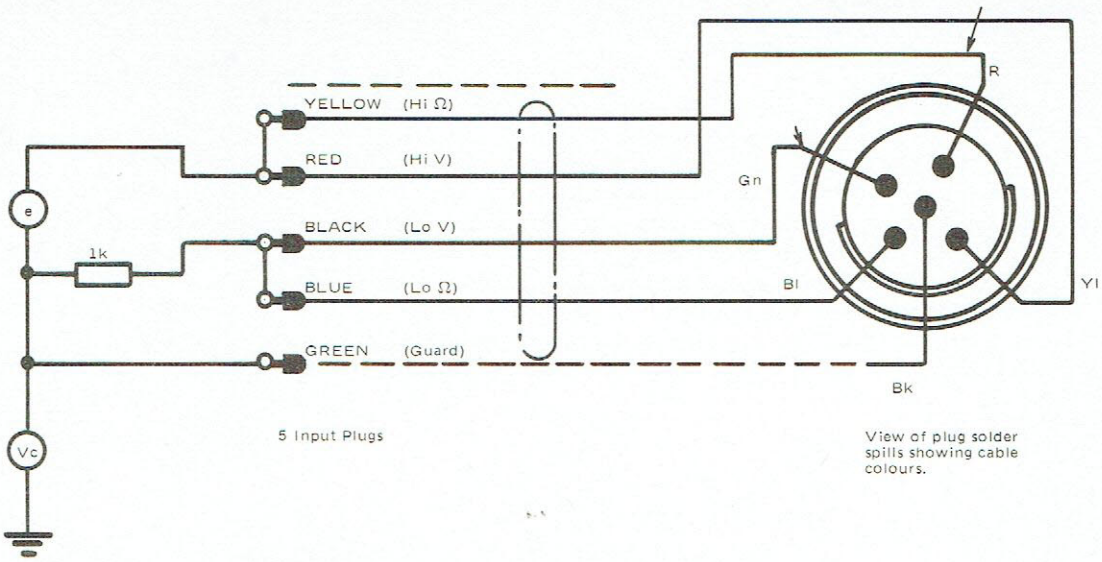


Fig. 4.14 *A special lead (EX3183) is obtainable from Solartron which enables the Guard to be driven directly by the common mode voltage.*

The 4 cores are required for 4 terminal resistance measurement as described later. For fully guarded voltage measurement, however, only 3 terminals are necessary - signal high, signal low, and guard (screen). When on voltage ranges the YELLOW and BLUE cores are connected to RED and BLACK within the voltmeter. To prevent these plugs accidentally making contact with earth, or with other circuits, the YELLOW should be plugged into RED and the BLUE plugged into the BLACK. GREEN is connected directly to the source of interference thus driving the guard at the common mode voltage and preventing common mode current flowing through the lead resistance. Using this arrangement, even though the interference were the permitted maximum (500V dc or peak ac), it is most unlikely that there would be any discernable error - even on the most sensitive range.

For a more complete treatment of interference in digital voltmeter measurement the reader is referred to:-

1) Digital Voltmeters and Interference
2) Principles of Interference Rejection

both of which are available free on request to Solartron.

NOISE

The foregoing explanation of interference rejection has dealt specifically with 50Hz because by far the most common source of interference is the mains supply, or fields radiated from mains wiring and mains energised equipment. The curves of Fig. 4.9 show that at higher harmonics of 25Hz rejection is improved so that 100Hz ripple from power supplies or 400Hz aircraft and ship supplies, are unlikely to cause difficulty. When considering 'noise' of no specific frequency (e.g. white noise) the integration process, inherent in the dual-ramp technique, still applies. The resultant noise component over 40ms integration will tend to zero.

FILTERS

For all normal dc measurement the use of the filter, which is built into the voltmeter (SLOW), is unnecessary. Although the increase in response time would be of little consequence during laboratory work, the delay may be of significance in data logging or automatic test systems. In these cases the use of FAST will give adequate interference rejection. In rare situations the interference may be so excessive that SLOW produces some benefit on dc measurement. This can be established by changing from FAST to SLOW and observing if there is a difference in reading. If there is a difference, SLOW gives the correct answer.

AC VOLTAGE

The 'unadorned' dvm is able to measure dc voltage only. It can be adapted to measure ac by including an ac-dc converter ahead of the dc input circuits. This has been done in the *MASTER SERIES*, A211, A213 and A223 include a converter which may be regarded as a sophisticated full-wave rectifier. By including semi-conductor rectifiers in an operational amplifier loop, non-linearities in the transfer characteristics of the rectifiers are eliminated. The smoothed output of such a rectifier system is a dc level which is proportional to the mean value of the ac; it is this which is passed to the dc voltmeter for measurement. Fig. 4.15 shows this action.

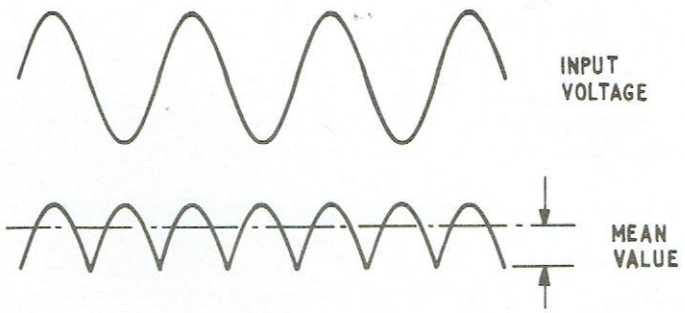


Fig. 4.15 *An ac input voltage is rectified in the ac-dc converter and the smoothed mean value is passed to the dc circuits for measurement. Although the mean value is sensed the rms value is indicated.*

There are three ways of specifying the amplitude of an ac voltage: the mean, the peak or the root-mean-square (rms) value. For any periodic function there is a precise relationship between these which can be calculated. In the case of a sine wave:-

$$\text{Mean} = \frac{2}{\pi} \text{ peak}$$

$$\text{rms} = \frac{1}{\sqrt{2}} \text{ peak}$$

When speaking of ac voltage (e.g. 240V) it is accepted convention that the rms value is understood unless mean or peak value is stated. It has therefore become accepted that a measuring instrument will read rms, although the vast majority actually measure the mean. For these reasons A211, A213 and A233 are scaled to give a reading of the rms of the input on the assumption that the input is a perfect sine wave.

Distortion is a factor which can occasionally introduce errors as a result of this assumption. The reader will be familiar with the analysis of a complex waveform which breaks down a periodic function into a fundamental sine wave plus a series of harmonics. It is the harmonics which represent the distortion content, the degree of distortion being dependent upon the order, the amplitude and phase of the harmonics. It will be extremely rare that the detailed harmonic content is known, but what may be known is the total distortion which is, in effect, the sum of the total harmonic content.

Measurement errors would be greatest for a mean sensing rms indicating instrument if the total distortion was all third harmonic. This assumption would enable an estimate of the worst possible errors to be made. In this case:

Max. percentage error = 1/3 total percentage distortion.

Thus, a total distortion of 0.3%, if all third harmonic could give a worst error of 0.1%.

The voltmeter input impedance on ac is either 1MΩ or 10MΩ (depending on range) in parallel with a capacitance. At frequencies above a few tens of Hz the capacitive term will be dominant. The values are given in the formal specification and may be used to calculate the voltage drop across a source impedance at a particular frequency.

Consideration of Fig. 4.15 will show that the lower the signal frequency the more smoothing is required before the mean level can be applied to the dc measuring circuit. Therefore, below about 100Hz a longer time constant filter (SLOW) is required in order to preserve measurement accuracy. AC measurement with a digital voltmeter gives easily the best compromise between speed and accuracy over all other forms of ac measurement. But with low frequencies, using any measurement technique, the reading must have time to settle.

On a true rms sensing instrument such as A215 or A235 the possibility of errors, because of severe waveform distortion, are virtually eliminated. However, when these instruments are used on pulse waveforms, care may be necessary to ensure that they operate within the specified limits.

It has been pointed out that when measuring dc voltages the voltmeter cannot reject thermal or other dc interference. In exactly the same way there cannot possibly be rejection of series mode ac interference when measuring ac voltages. Common mode rejection is, however, still preserved, and the inputs circuits on ac are still fully isolated from chassis and earth.

For those who are interested in pursuing the subject in greater depth, a paper on AC Voltage Measurement, with particular reference to waveform errors, is available free on request to Solartron.

RESISTANCE

Voltmeters A212, A213, A215, A233 and A235 measure the value of a resistor by passing a defined current through it an measuring the resulting potential difference. The current is small (100μA on the 1kΩ, 10kΩ and 100kΩ ranges) so that the power dissipated in the resistor is negligible. When measuring low values of resistance the voltage dropped along the leads can sometimes introduce errors. In these instruments, when using the lead provided, the effect is entirely eliminated by the use of a 4 wire technique - two wires supply the current to the resistor while two sense the potential developed across it.

The most sensitive range of 1kΩ with its 10mΩ sensitivity is satisfying for most low value measurements. Should there be a requirement for increased sensitivity on low values the voltmeter can be used on a dc voltage range to measure the potential difference across the resistor with the current provided from an external source (Fig. 4.16).

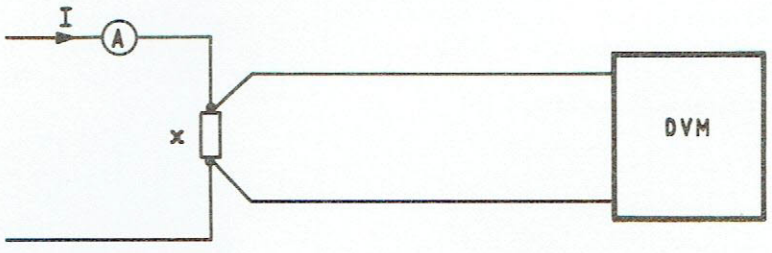


Fig. 4.16 *A very low value resistance may be measured by measuring the voltage developed across it. The voltage leads should be connected close to the ends of the resistor.*

If I is 1mA and the voltmeter is on the 100mV dc range, a reading of 101.245mV means that x is 101.245Ω. Obviously other appropriate currents and voltage ranges could be used. The first point to observe is that, in this example, the sensitivity is 1mΩ per digit. Hence the voltmeter connections must be made right at the ends of the resistor and must not embrace any significant length of the current carrying leads (10cm of 22swg copper wire is approximately 4mΩ).

A second point is that the accuracy is affected directly by the precision of the current setting. There would be little point in using a moving coil multimeter to set the current and then record a reading of 12.631Ω.

An improved technique is shown in Fig. 4.17.

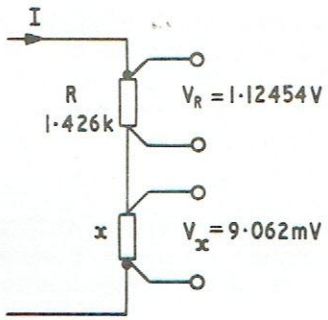


Fig. 4.17 *A ratio measurement avoids having to set a precise value of current.*

Here a resistor R, whose value is known, is connected in series with the low value unknown x. R can be a much higher value than x. If R is not already known it can be measured on one of the ohms ranges. The voltmeter, on dc auto-range, is connected across R and the current supply adjusted to give a reading greater than half full scale. The precise value of V_R is not important; neither is the value of the current I. In this example I could be simply provided by a 1.5V dry cell. The reading V_R is recorded. The voltmeter is transferred to x and the reading V_x is noted. The value of x is then given by:-

$$x = R \frac{V_x}{V_R} \text{ ohms}$$

Using the values shown in Fig. 4.17:-

$$x = \frac{1.426 \times 10^3 \times 9.062 \times 10^{-3}}{1.1245} = 11.491\Omega$$

If x is being set to different values it may be necessary to measure V_R each time because, unless I comes from a constant current supply, changes of x may significantly alter I.

Should it be necessary to measure resistance at a distance from the voltmeter which is beyond the reach of the standard lead, a special lead EX3183 may be obtained from Solartron. In this the four cores and screen are terminated separately as shown in Fig. 4.18. This cable should be extended to reach the point of measurement by means of a similar 4 core screened cable and connected to the remote resistor as shown (Fig. 4.18).

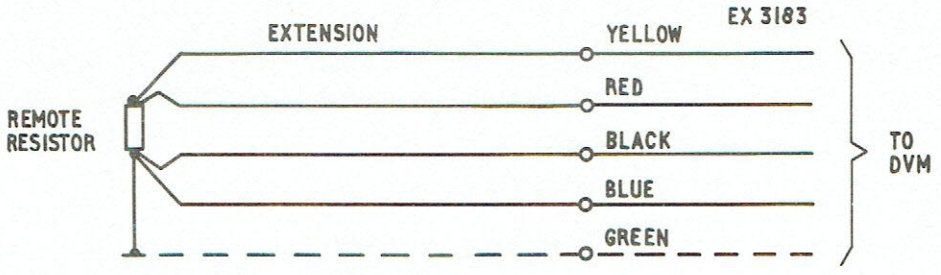


Fig. 4.18 *In measuring a remote resistor, lead compensation can be preserved by using the special input cable (EX3183, obtainable from Solartron) and extending it by a 4 core screened cable.*

This arrangement will preserve the compensation for lead resistance, up to a maximum of 1Ω per wire, on any ohms range. Using an extension of 7/.0076 wires a length of 100m can be safely used.

CURRENT

For determining current (dc or ac) the voltmeter can be used to measure the voltage drop when the current is passed through a known resistor and the value of the current thereby calculated.

If currents of the same order are to be measured frequently, the provision of a resistor of suitable value can save the chore of calculation. For example with a 1Ω resistor and the voltmeter on the 1V range currents of up to 1.19999A can be determined by direct reading amps instead of volts. If the results are to be consistent with the accuracy of which the voltmeter is capable the resistor must be known precisely. This can be achieved by taking a value that is slightly high and wiring others in parallel while measuring the total value as described earlier. The main resistor should be a precision type capable of good stability; a wirewound type is suggested for dc work, but for ac measurement metal film resistors should be used to avoid inductance effects.

In applications where a wide range of currents are to be measured, Current Adaptor EX3180 should be considered. This has precision resistors built-in. When used with a voltmeter in the *MASTER SERIES* current ranges of 1A down to 10μA can be selected by push buttons giving a maximum sensitivity of 100pA.

LONG TERM INTEGRATION

In measuring a steady dc input the number of pulses gated to the counter during ramp down is the measure of the input voltage. If this number of pulses is p:

$$p \propto \text{input voltage}$$

actually $$p \propto \frac{1}{T}\int_0^T v(t)dt$$ where $v(t)$ is a varying input, T is ramp-up time

or $$p \propto V \text{ where } V = \frac{1}{T}\int_0^T v(t)dt$$

On a given range each single pulse results in 1 digit in the display, and the value of 1 digit depends upon the range. Thus if 1 digit represents S volts (Sensitivity), p digits (i.e. p pulses) represents pS volts.

But the display at nominal range is 100 000 for 10 samples/SEC operation.

Then $S = R \times 10^{-5}$ where R is nominal range value in volts.

(e.g. on 100mV range, $S = 100 \times 10^{-3} \times 10^{-5} = 1\mu V$).

Then $V = pR \times 10^{-5}$ for each individual reading.

If N readings are taken: $V = \frac{Np}{N} R \times 10^{-5}$

But Np is the total pulses accumulated during N measurements.

Put $Np = P$

Then $V = \frac{P}{N} R \times 10^{-5}$

In a time t secs there are $10t$ readings, so $N = 10t$:

$$V = \frac{P}{10t} R \times 10^{-5}$$

$$V = P \frac{R \times 10^{-6}}{t} \text{ volts}$$

At 25/SEC $S = R \times 10^{-4}$

and $N = 25t$

then $V = P \frac{R \times 4 \times 10^{-6}}{t}$ volts

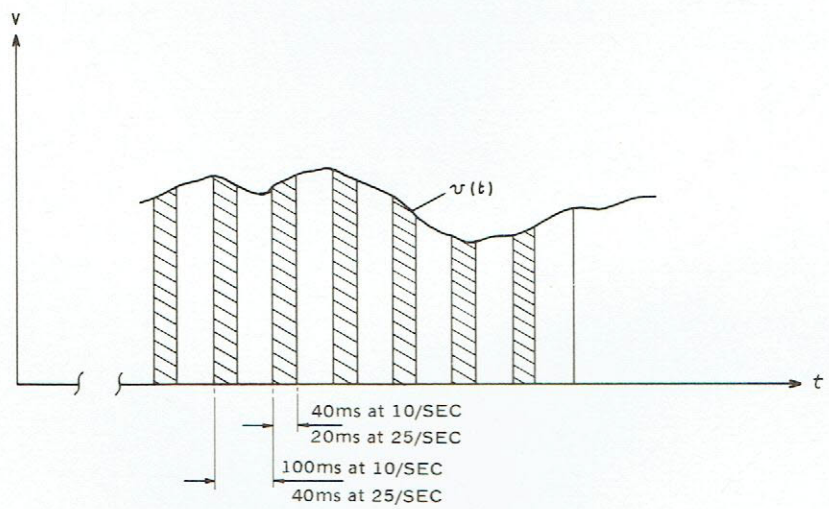


Fig. 4.19

Each group of pulses from each sample represents the average of $v(t)$ during ramp up, which at 10/SEC is for 40ms (20ms at 25/SEC) and, since samples are taken every 100ms for 10/SEC operation (40ms for 25/SEC), the final average of the long term measurement, V, will only be correct if variations of $v(t)$ are slow relative to 100ms (40ms for 25/SEC). This is exactly the situation in which long term averaging is required – for example, gradual variations in a chemical plant. Obviously it is valid only when the input is continuously of one polarity, since the gated pulses do not contain polarity information.

Thus a long term average of a slowly changing input may be obtained by taking the output from pin k on the fan-out unit to an external counter.

$$\text{Average} = \frac{\text{total count x nom. range in volts}}{\text{count time in seconds}} \times 10^{-6} \text{ volts for 10/SEC operation.}$$

$$\text{Average} = \frac{\text{total count x nom. range in volts}}{\text{count time in seconds}} \times 4 \times 10^{-6} \text{ volts for 25/SEC operation.}$$

RATIO

Ratio is the measure of one quantity relative to another, usually a reference or standard quantity.

The stability and accuracy of a precision dvm is such that users may forget to allow for errors in associated equipment.

The use of ratio is very adaptable as unknown effects can be eliminated. For example, in dc/dc ratio the reference and signal inputs can be derived from the same voltage source; any variation in the source, provided this is within both input limits, will not affect the readings.

DC/DC RATIO (A230, A233 and A235)

1. The linearity and accuracy of each step of a voltage divider may be checked to an uncertainty of ± 0.004% + 0.002% of reading at full scale to ± 0.013% + 0.02% of reading at one tenth of full scale, using a 1% grade power supply unit.

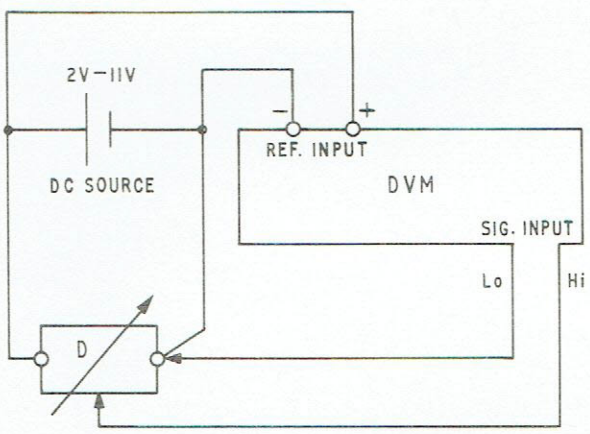


Fig. 4.20

In Fig. 4.20, the reference voltage source is a P.S.U. set for a value between 10V and 11V for minimum uncertainty of ratio. The same voltage is applied to the divider, D, the tap being taken to signal Hi. Now any change in the reference voltage is also applied to the device being measured and will not affect the ratio measurement.

For each setting of the divider,

$$\text{Ratio} = \frac{\text{dvm reading}}{10} \quad \text{or} \quad \frac{\text{dvm reading}}{10^4} \quad (100\text{mV range only})$$

Thus, if the dvm reading for the first step on the premier decade

$$= 1.00021\text{V}$$

$$\text{Ratio} = 0.100021 : 1$$

and the divider error = +0.021% at that step.

If D represents a potentiometer, Ratio can determine the linearity of a potentiometer when read out is related to wiper position.

Fan Out facility enables the readings to be printed and form part of a permanent calibration record.

2. Comparing the performance of transducers. Two transducers A and B are in the same enclosure (Fig. 4.21).

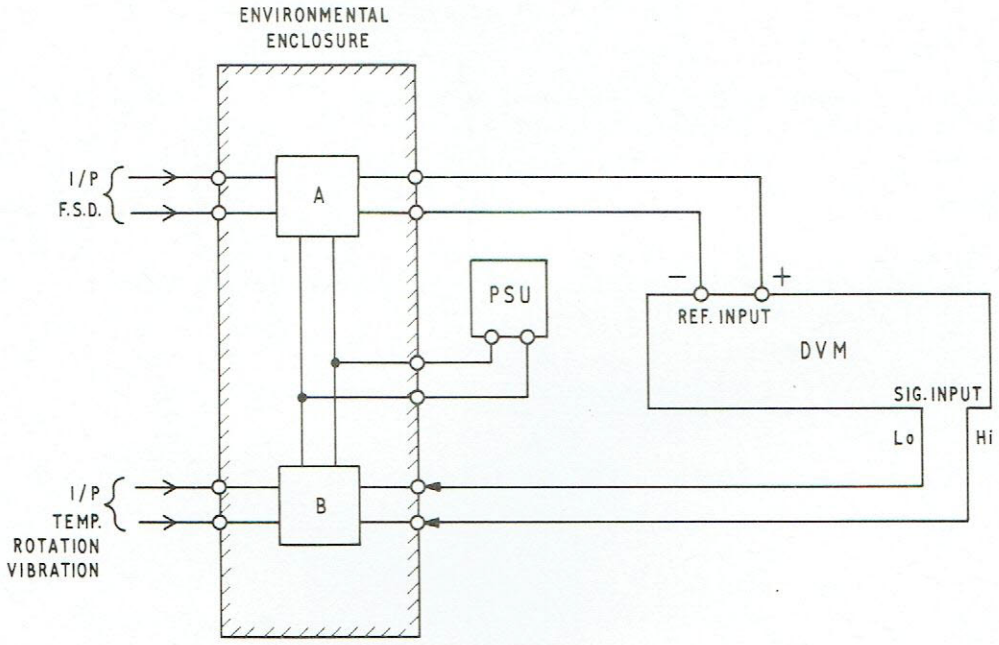


Fig. 4.21

The output of the standard transducer, A, is taken to dvm reference and the output of B - the transducer under test - is taken to dvm signal input.

Now $\frac{\text{dvm reading}}{10}$ is the ratio of B to A under identical conditions, any changes in the P.S.U., temperature or vibration affecting both devices equally.

3. Measurement of low value resistors, using a nominal 1A current source.

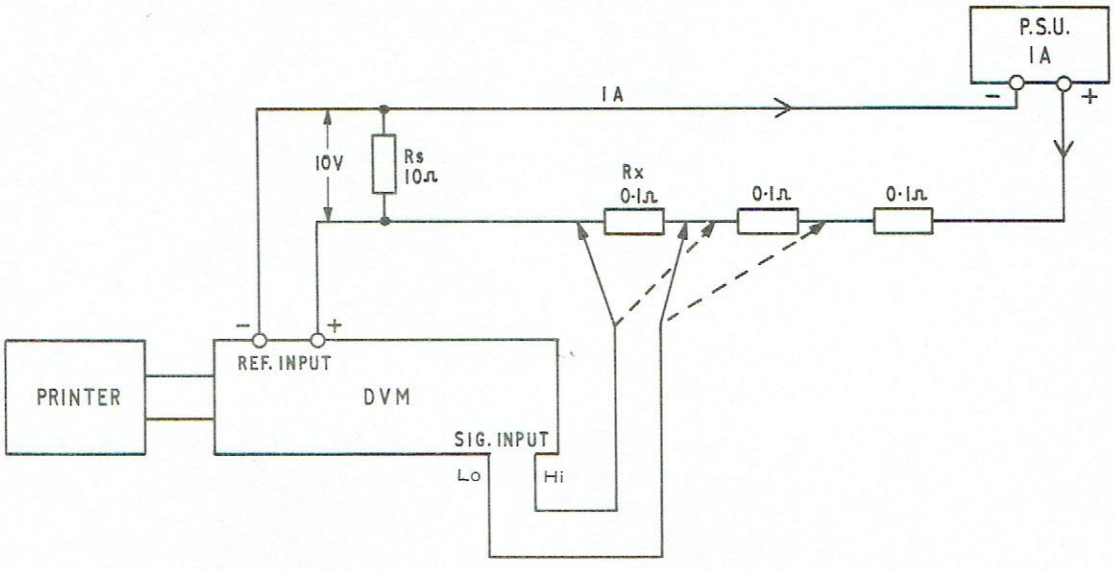


Fig. 4.22

Suppose we require to determine the value of a number of 0.1Ω precision resistors, given a 10Ω, 1A rated, standard resistor of known value 10.0002Ω (± 0.005%).

In this case, the source operates in the constant current mode set to 1A nominal, and the reference voltage will be 10V nominal.

$$\text{Now } \frac{Rx}{Rs} = \text{Ratio} = \frac{\text{dvm reading}}{10^4} \qquad \text{(on 100mV Range)}$$

$$Rx = \frac{\text{dvm reading}}{10^4} \times Rs$$

If the dvm reading is 100.050mV

$$\text{then } Rx = \frac{100.050}{10^4} \times 10.0002$$

$$= 0.100053\Omega$$

Note the resolution of the result is 1μΩ and the total uncertainty is (± 0.004 + 0.002)% ± 0.005%, (± 0.005% being the uncertainty of the standard resistor). Note also the similarity of this technique with that shown in Fig. 4.17 and the two important differences:-

(i) voltage across the known resistor does not have to be measured,

(ii) provided V reference does not fall below 10V (for minimum uncertainty) the source current need not be stable.

Another variant of this technique is shown in Fig. 4.23 and described in 4 below.

4. Calibration of resistance thermometers in the range 500Ω to 1kΩ using a nominal 10V source and a known 9kΩ resistor, R1 in Fig. 4.23.

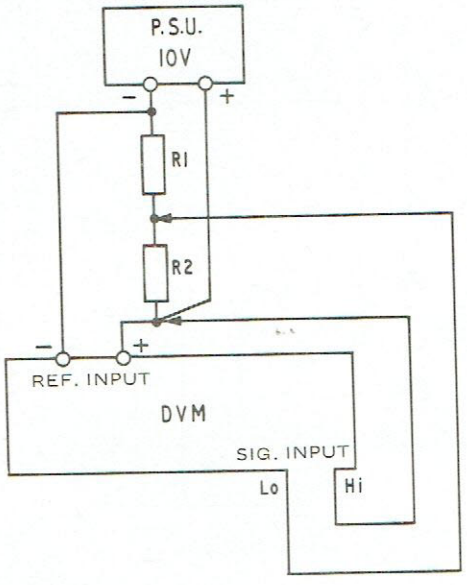


Fig. 4.23

In this case, V reference is across the known resistance R1, and the unknown resistance, R2.

Again, variations in source voltage between 10V and 11V (for minimum uncertainty) will not affect the readings, and although two readings have to be taken at each temperature setting, the uncertainty of the results are minimised.

The closer to full scale of each ratio reading, ratio uncertainties will tend to cancel, and in this example can be better than 0.05Ω.

$$\frac{R2}{R1} = \frac{\text{Ratio of R2}}{\text{Ratio of R1}}$$

$$R2 = \frac{\text{R1 x R2 reading}}{\text{R1 Reading}}$$

5. Efficiency of an engine and vehicle. If V reference is made directly proportional to fuel consumption, say gallons or litres per hour, and signal input is directly proportional to vehicle speed in miles or kilometres per hour,

$$\text{efficiency} = \frac{\text{miles}}{\text{hour}} \div \frac{\text{gallons}}{\text{hour}}$$

$$= \frac{\text{miles}}{\text{gallons}}$$

$$= \frac{\text{V input}}{\text{V reference}}$$

$$= \frac{\text{dvm readout}}{\text{V reference x 10}}$$

AC/DC RATIO (A233 and A235)

1. Checking the linearity of a demodulator at a given frequency.

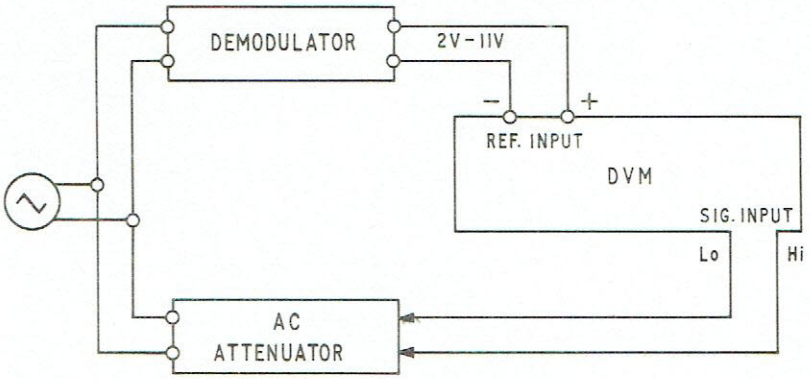


Fig. 4.24

The attenuator represents a non-inductive voltage divider and is set for an ac reading of 100 000 on a suitable range. The ac input is increased (Fig. 4.25) for a demodulated reference voltage between 2V and 11V and the dvm readings recorded. (Fig. 4.26).

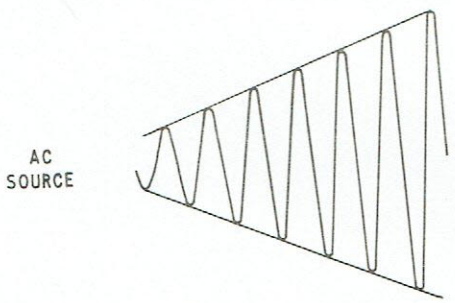


Fig. 4.25

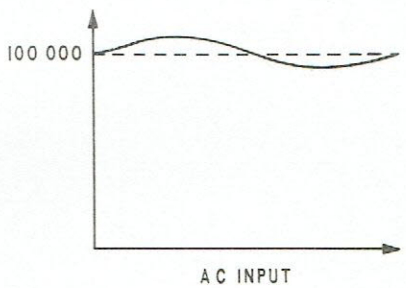


Fig. 4.26

2. Checking the frequency response of an unknown thermal converter.

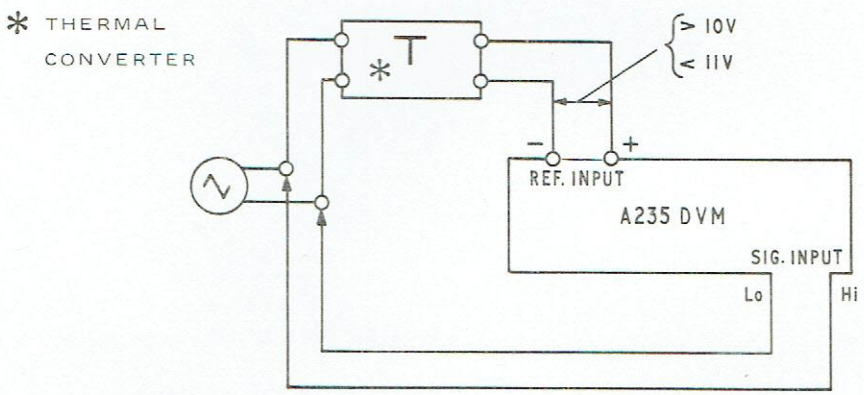


Fig. 4.27

The A235 (true rms reading voltmeter) in fig. 4.27 is being used as a true rms ac transfer standard of known frequency response.

The dc output of the thermal converter is the reference voltage input; the actual reference voltage applied will be directly proportional to the converter frequency response.

The ac source should be stable over its frequency coverage but need not be accurate. It is ideally set for a thermal converter output of 10V, with the dvm reading 100 000 at, say, 400 Hz.

Now for any frequency, within dvm and converter range:

$$\text{Converter response for } \pm 10\% \text{ deviation from 10V} = \frac{10^3}{\text{dvm reading}} \%$$

e.g. for a dvm reading of 10.2040 at 15 kHz

$$\text{converter response} = \frac{10^3}{10.204} = 98\%$$

DC/Ω RATIO (A233 and A235)

Checking the percentage deviation of a batch of resistors, RX from a known standard, RS, of the same nominal value.

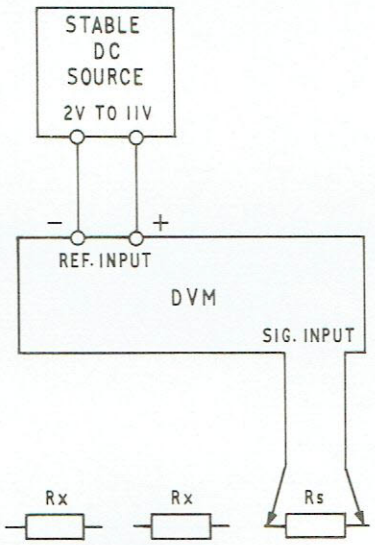


Fig. 4.28

This is an example of scaling.

The reference voltage is set by an operator for a dvm reading of 100 000 with Rs connected to signal input. Rs is then removed.

Each of unknown resistors is connected to signal input in turn and the dvm reading is recorded. The results will be percentage deviations from Rs and in this way the batch is checked for tolerance.

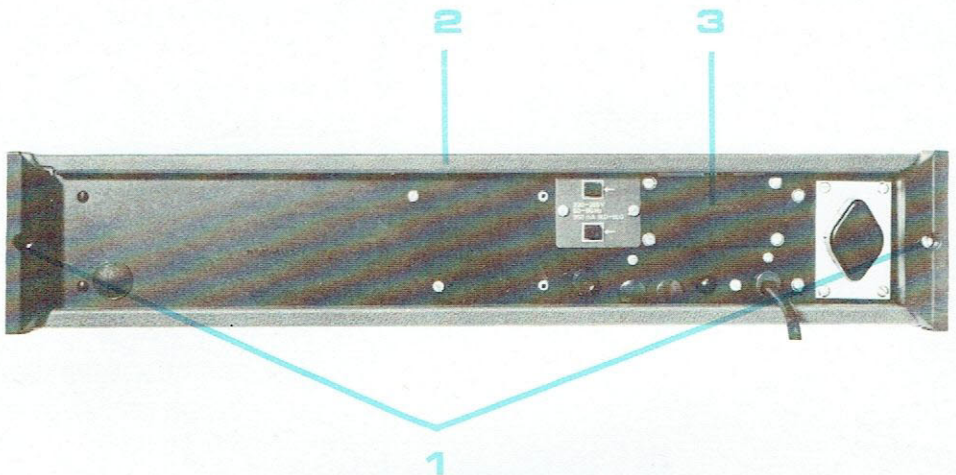
SECTION 5 Data Systems Use

SYSTEMS USE

The addition of a fan-out unit makes this voltmeter eminently suitable for use in a data logging or automatic test system. It enables full remote control of all the front panel functions (except POWER) and provides display information and the various control signals necessary in such systems.

In addition, the Fan-Out Unit permits the selection of a further two operating speeds, namely 25 readings per second and 100 readings per second.

INSTALLATION OF FAN-OUT UNIT A214



1. Release the two side panel captive screws and withdraw the side panels.
2. Remove the top cover.
3. Remove the blanking plate.
4. Insert the fan-out unit into the vacant connectors and, using the blanking plate screws, secure the fan-out socket to the rear panel.
5. Replace the top and side covers and secure.

RACK MOUNTING

Included in the accessories is a pair of combination handles/rack-mounting ears for substitution with the standard handles. This is effected by removing the four handle retaining screws and the handles, and replacing with the rack-ear/handles using the same screws.

In addition, if space is required between instruments within the rack for rack runners, it is necessary to remove the lower side panel retaining strips and the bottom cover, as follows:-

1. Release the rear feet.
2. Slide out the side panels.
3. Remove the lower retaining strips.
4. Remove the bottom cover.

The side panels may be replaced.

FAN-OUT FACILITIES (at rear socket)

PIN	FUNCTION	PIN	FUNCTION
A	1×10^0 — All at 0 when 25/SEC RATE and 100/SEC RATE commanded.	d	Polarity (+)
B	2×10^0	e	Polarity (–)
C	4×10^0	f	1 — Range Information (See Output Information)
D	8×10^0	h	2
E	1×10^1	j	4
F	2×10^1 — All at 0 when 100/SEC RATE commanded.	k	Gated Clock
H	4×10^1	m	1 BCD
J	8×10^1	n	2 Range Command
K	1×10^2	p	4 (See Remote Command)
L	2×10^2 — Staticised Display Information BCD	r	Command CONTROL
M	4×10^2	s	Contact Sample
N	8×10^2	t	Pulse Sample
P	1×10^3	u	Print Command (Pulse)
R	2×10^3	v	Print Command (Level)
S	4×10^3	w	Data is Changed
T	8×10^3	x	Data can Change
U	1×10^4	y	Command AUTO range
V	2×10^4	z	Command RESPONSE (FAST/SLOW)
W	4×10^4	AA	Command MODE (DC, AC or Ω)
X	8×10^4	BB	(See Remote Commands)
Y	1×10^5	CC	Mode Information
Z		DD	
a		EE	Command RATE
b		FF	(See Remote Commands)
c	Command RATIO	HH	0V

Commands à distance.

REMOTE COMMANDS

Remote control of the instrument is possible only when Fan-Out Unit A214 is fitted. Remote commands are effective only when REMOTE operation has been commanded either electrically (at pin r of rear socket) or by the front panel switch.

Input Levels:

Level '1' is $+2.4V < '1' < +6V$ at $100\mu A$ or open circuit

Level '0' is $-0.5V < '0' < +0.5V$ at 5mA sink.

CONTROL

Control Command

REMOTE Commanded	Pin r
Yes	0
No	1

Note: If REMOTE is not commanded whilst the REMOTE switch is in, then the only functions under front panel control are POWER and RATE.

RANGE

Ranges are selected by addressing pins m, n and p with 1, 2, 4 BCD. If the decimal value of the code is 'N' then the full scale (nominal) commanded is:-

1×10^{-N} kV or $1 \times 10^{(1-N)}$ MΩ

depending upon the MODE selection.

Range Commands when 10/SEC rate commanded.

Range Code p(4)	n(2)	m(1)	N	DC Voltage Range	AC Voltage Range	Resistance Range
0	0	0	0	1000V	1000V	10MΩ
0	0	1	1	100V	100V	1MΩ
0	1	0	2	10V	10V	100kΩ
0	1	1	3	1V	1V	10kΩ
1	0	0	4	100mV	100mV	1kΩ
1	0	1	5	1000V *	1000V *	10MΩ *

* These are non-standard commands which disobey the formula.

Range Commands when 25/SEC rate commanded.

Range Code p(4)	n(2)	m(1)	N	DC Voltage Range	AC Voltage Range	Resistance Range
0	0	0	0	1000V	1000V	10MΩ
0	0	1	1	100V	100V	1MΩ
0	1	0	2	10V	10V	100kΩ
0	1	1	3	1V	1V	10kΩ
1	0	0	4	100mV	100mV	1kΩ
1	0	1	5	10mV	1000V *	10MΩ *

Range Commands when 100/SEC rate commanded.

Range Code p(4)	n(2)	m(1)	N	DC Voltage Range	AC Voltage Range	Resistance Range
0	0	0	0	1000V	1000V	10MΩ
0	0	1	1	100V	100V	1MΩ
0	1	0	2	10V	10V	100kΩ
0	1	1	3	1V	1V	10kΩ
1	0	0	4	100mV	100mV	1kΩ
1	0	1	5	10mV	1000V *	10MΩ *

* These are non-standard commands which disobey the formula.

AUTO RANGE

Auto range is commanded by a Level '0' at pin y.

RATE

Repetitive: There are two rates available for repetitive operation: 10/SEC and 25/SEC. In both cases the conversion cycle is locked to the mains supply frequency. Repetitive operation is selected by pressing the 10/SEC button on the front panel and commanding the rate (10/SEC or 25/SEC), the mode, the range and NOT REMOTE at the fan-out socket.

Rate Commands (Repetitive)

RATE	Pin EE	Pin FF	Full Scale
10/SEC	1	1	119999
25/SEC	0	1	11999X
Non-standard			
10/SEC	0	0	119999

Each digit shown as X is coded at the Fan-Out socket as zero and is blank on the display.

Single Sample: There are three rates available for single sample operation: 10/SEC, 25/SEC and 100/SEC. At 10/SEC and 25/SEC the conversion cycle is locked to the mains supply frequency.

Rate Commands (Single Sample)

RATE	Pin EE	Pin FF	Full Scale *	DC Resolution
10/SEC	1	1	117000	1μV
25/SEC	0	1	11999X	1μV
100/SEC	1	0	1199XX	10μV
Non-standard				
10/SEC	0	0	117000	1μV

Each digit shown as X is coded at the Fan-Out socket as zero and is blank on the display.

* Further information is given under Sample Commands.

Rate Changes

When the RATE command is changed, the next SAMPLE command must not be given until at least 50ms after the change.

Changes of RATE should only occur after PRINT COMMAND goes to '1'.

SAMPLE Commands

Each Single Sample is initiated by:

either CONTACT SAMPLE: Contact closure between pin s and 0V, (pin HH) with less than 2ms contact bounce,

or PULSE SAMPLE: A positive pulse applied to pin t of amplitude between +3V and +8V and duration greater than 10μs.

SAMPLE Command must occur after PRINT COMMAND.

In order to achieve the maximum reading rate at 10/SEC and 25/SEC (i.e. staticisation of the result of every conversion cycle) SAMPLE command must occur during the following periods:-

10/SEC: After PRINT COMMAND and not later than approximately 40ms after DATA CAN CHANGE goes to '0'.

(The exact period depends upon the clock frequency which is determined by the supply frequency).

25/SEC: After PRINT COMMAND and not later than approximately 10ms after DATA CAN CHANGE goes to '0'.

(The exact period depends upon the clock frequency which is determined by the supply frequency).

If SAMPLE command is applied after these times it is stored and used to initiate staticisation of the result of the next but one conversion cycle.

Note: If AC mode or SLOW response is commanded, staticisation is delayed until approximately 1s after SAMPLE command to allow extra settling time for these measurements.

In order to achieve the maximum reading rate at 10/SEC the full scale reading must be reduced to allow time for the sample command to be given. A fsd of 117000 will allow a period of approximately 1ms after PRINT COMMAND.

At 25/SEC a fsd of 11999 (i.e. the maximum fsd) also allows a period of approximately 1ms.

At 100/SEC the measurement cycle is initiated by SAMPLE command. To achieve maximum reading rate SAMPLE command must occur as soon as possible after PRINT COMMAND.

Input Signal

1) DC and Ω mode, FAST response measurements.

For an accurate result from the next conversion cycle the input signal must have been connected and have settled at the following times:

10/SEC:	⩾ 55ms after DATA CAN CHANGE
25/SEC:	⩾ 15ms after DATA CAN CHANGE
100/SEC:	⩽ 1ms before SAMPLE COMMAND *

This allows sufficient time before the start of ramp up in the conversion cycle for the input amplifier to settle.

* On the 10mV dc range this time must be increased to 10ms unless the instrument is modified by connecting a 1kΩ 2 watt metal film resistor in parallel with R6 on board 19 in the floating section. However, this reduces the maximum permitted overload input on the 10mV, 100mV, 1V and 10V ranges to 20V. If AUTO ranging is used and the instrument has been modified, inputs should still be restricted to 20V peak.

At 100/SEC, if DATA is changed (see below) a 15ms delay is introduced, and the settle period is not required.

2) AC FAST response and DC SLOW response measurements at 10/SEC and 25/SEC.

The 1s staticisation delay after SAMPLE command allows sufficient settling time provided the input signal was connected when SAMPLE command was given.

3) AC SLOW response measurements at 10/SEC and 25/SEC.

If AC mode and SLOW response are commanded the input signal must be connected at least 3s before SAMPLE command is given.

4) AC measurements at 100/SEC.

The input signal must be connected at least 1s before SAMPLE command is given.

Note: If AC SLOW is commanded at 100/SEC, the dvm reverts to AC FAST measurements.

DATA IS CHANGED

DATA IS CHANGED is used at the 25/SEC and 100/SEC rates to inform the dvm that extra settling time is required because the commanded data (range, mode and response) is changed.

If the data is changed apply a '1' at pin w.

If the data is not changed apply a '0' at pin w.

DATA IS CHANGED must be applied after DATA CAN CHANGE occurs (goes to '0'), and before the SAMPLE command, and must be maintained until at least 10μs after the SAMPLE command.

When DATA IS CHANGED is applied with the 25/SEC rate commanded, the SAMPLE command is stored and is used to initiate staticisation of the result of the next but one conversion cycle.

When DATA IS CHANGED is applied with the 100/SEC rate commanded, the start of the conversion cycle is delayed until 15ms after SAMPLE command.

At 10/SEC DATA IS CHANGED has no effect.

Any changes in the range, mode and response commands must occur after DATA CAN CHANGE goes to '0' and before the following times if AUTO is not commanded:-

10/SEC: 39ms after DATA CAN CHANGE goes to '0'

25/SEC: 9ms after DATA CAN CHANGE GOES TO '0'

100/SEC: Before SAMPLE command.

Note: If DC SLOW response or AC is commanded, staticisation is delayed to approximately 1s after SAMPLE command if the 10/SEC or 25/SEC rates are commanded.

MODE

Mode Commands

MODE	Pin AA	Pin BB
DC	1	1
AC	0	1
Ω	1	0
Non-standard		
DC	0	0

RESPONSE

Response Command

RESPONSE	Pin z
FAST	1
SLOW	0

If SLOW and 100/SEC RATE are commanded the dvm automatically reverts to FAST response.

RATIO

Ratio Command

RATIO Commanded	Pin c
Yes	0
No	1

The RATIO command is inhibited if the 100/SEC RATE is commanded.

OUTPUT INFORMATION

Output Levels:

Level '1' is +2.4V < '1' < +6V from 6kΩ source

Level '0' is -0.5V < '0' < +0.5V at 10mA sink.

RANGE

There are two possible range output codes; code 1 is identical to the range command code whilst code 2 simplifies the interpretation of the output data by the use of the simple equation:-

Value = Reading (as an integer*) x 10^{-N} Volts or kilohms

N = range output code.

*i.e. the decimal point is ignored but the digits which are coded out as zeroes at the 25/SEC and 100/SEC rates, are included.

Code 1 Range Output (as Range Commands)

Voltage Range	Range Output Code j(4)	h(2)	f(1)	N	Resistance Range
1000V	0	0	0	0	10 000kΩ
100V	0	0	1	1	1000kΩ
10V	0	1	0	2	100kΩ
1V	0	1	1	3	10kΩ
100mV	1	0	0	4	1kΩ
10mV	1	0	1	5	

Formula: Value in BCD = Reading (as an integer) x $10^{-(N+2)}$V or x $10^{-(N+1)}$kΩ.

Code 2 Voltage Range Output

Voltage Range	Output Code j(4)	h(2)	f(1)	N
1000V	0	1	0	2
100V	0	1	1	3
10V	1	0	0	4
1V	1	0	1	5
100mV	1	1	0	6
10mV	1	1	1	7

Formula: Value in BCD = Reading (as an integer) x 10^{-N}V.

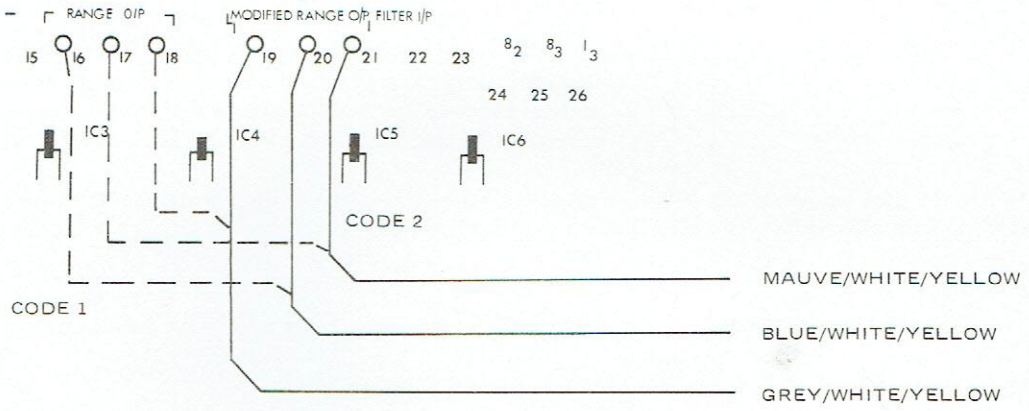
Code 2 Ohms Range Output

Ohms Range	Output Code j(4)	h(2)	f(1)	N
10 000kΩ	0	0	1	1
1000kΩ	0	1	0	2
100kΩ	0	1	1	3
10kΩ	1	0	0	4
1kΩ	1	0	1	5

Formula: Value in BCD = Reading (as an integer) x 10^{-N}kΩ.

The range output information is staticised, and is updated when DATA CAN CHANGE goes to '0'.

Except when supplied to special order or as a part of a Compact-33 Logging System the Fan Out Unit is connected for Code 2 range output data. To change to Code 1 locate pcb No. 27 by removing the top cover of the dvm. Three wires are connected to terminals 19 20 and 21 by pull-off disconnects. Transfer the wires on these terminals to terminals 18, 16 and 17 respectively. The alternative positions are illustrated below.



MODE

Mode Output Information

MODE	Pin CC	Pin DD
DC	0	0
AC	1	0
Ω	0	1

The Mode output information is staticised and is updated when DATA CAN CHANGE goes to '0'.

DISPLAY DATA

The pin connections are given at the front of this section.

The Display Data is staticised, and is updated just before PRINT COMMAND goes to '1'. If the RATE is changed, the staticised output is valid until DATA CAN CHANGE next goes to '0'.

DATA CAN CHANGE

Data Can Change Information

Data Can Change	Pin x
Yes	0
No	1

The DATA CAN CHANGE output is set to '1' by SAMPLE COMMAND and goes to '0' at the end of ramp up for fixed range operation, and at the end of ramp down for AUTO range operation. This indicates that the commanded data (Range, Mode and Response) may be changed.

PRINT COMMAND

PRINT COMMAND (LEVEL): During repetitive measurements pin v is held at '0'. During single sample measurements pin v is set to '0' by the SAMPLE command, and goes to '1' at the end of ramp down, indicating that the Display Data has been updated.

PRINT COMMAND (PULSE): During repetitive measurements pin u is held at '0'. During single sample measurements pin u goes to '1' for between 10μs and 30μs at the end of ramp down, indicating that the Display Data has been updated.

When the dvm requires extra settling time after SAMPLE command (e.g. for ac measurements) PRINT COMMAND only occurs after the required settle time.

GATED CLOCK

Pin k presents the clock pulses which are counted during ramp down to give the displayed value.

POLARITY

Polarity Information

Polarity	Pin d	Pin e
Positive	1	0
Negative	0	1

For ac measurements both Pins d and e are logical 0.

For 2 terminal resistance measurements positive is coded.

For 4 terminal resistance measurements the polarity indicated depends on the connection of the test current and sensing leads. Positive will be coded if ΩHi (Yellow) is connected to VHi (Red), and ΩLo (Blue) is connected to V Lo (Black).

The Polarity information is staticised, and is updated just before PRINT COMMAND goes to '1'.

OPERATING SPEED

The more important factors which determine the reading rate of a data system using a dvm are:-

1. The time required to select the input signal.

2. The conversion time of the dvm.

3. The time required to record or use the result of each measurement.

Selection of Input Signal

Normally this is carried out by means of a scanner using relays to select the required channel. The selection time will be determined by:

i) the 'break before make' gap, which is the time between the release of one channel and the connection of the next;

ii) the 'sample delay', which is the delay before SAMPLE command is issued, which may be introduced to ensure that the new input signal has settled before the conversion cycle begins.

Conversion Time

This is the time between SAMPLE command and when the result of the measurement is available. This time will depend on:-

i) The RATE selected.

ii) Whether AUTO ranging or fixed ranging is used.

iii) Whether the commanded data (Range and Mode) is changed.

iv) Which mode (DC, AC or Ω) is used.

v) Whether FAST or SLOW RESPONSE is used.

Recording Time

The speed of the recording device will affect the operating speed if it is too slow to register and record the Display Data and any other information during the period between successive PRINT COMMAND signals from the dvm (assuming maximum reading rate). If this is the case, SAMPLE command must be inhibited until PRINT COMPLETE is received from the recording device, thereby reducing the reading rate. The nominal recording times of devices used by Solartron are:-

Addo X Printer	55ms per character +350ms
Clary 35 Printer	60ms per character +150ms
IBM 'B' Typewriter	100ms per character +500ms approx. per new line

cont.

ASR 33 Teleprinter	100ms per character
Addo 5 Punch	55ms per character
Facit 4070 Punch	13.3ms per character
DD110 Punch	9ms per character +9ms
RDL 10000 Tape Recorder	1ms to 2.5ms per character (depending on packing density).

These values should be used in conjunction with the information given under High Speed Remote Control to determine the organisation of the dvm and Recorder signals.

NOTES

Auto Range

This is not available for 100/SEC operation.

10/SEC and 25/SEC Operation

The dvm takes continuous measurements, but only staticise the results when a SAMPLE COMMAND is given. Therefore, if SAMPLE COMMAND is not synchronised to DATA CAN CHANGE and PRINT COMMAND, then the time when the reading is staticised will depend on:-

i) Value of the reading, relative to f.s.d.
ii) Position in the conversion cycle that SAMPLE COMMAND is given.

100/SEC OPERATION

Following PRINT COMMAND of a previous reading, the dvm is clamped in the drift correct phase and held in readiness for instant start on receiving SAMPLE COMMAND.

119999 f.s.d. at 10/SEC

If a f.s.d. of 119000 is required, the reading rate for 10/SEC operation will be reduced to 5/SEC, provided SAMPLE COMMAND is given after PRINT COMMAND and not later than approximately 140ms (determined by supply frequency) after DATA CAN CHANGE goes to '0'.

HIGH SPEED REMOTE CONTROL

1. USING THE 10/SEC and 25/SEC RATES

Figure 5.1 shows a typical basic logger and its associated timing diagram. This arrangement is designed to scan at the maximum rate compatible with the speed of the recording device and scanner.

i) DATA CAN CHANGE is used to initiate channel changing and selection of the Range and Mode commands for the next channel.

ii) DATA IS CHANGED is only required for 25/SEC operation, and if it is applied staticisation of the measurement of the new channel will be delayed until the end of the next but one conversion cycle.

iii) The SAMPLE DELAY is only required if the input signal does not settle by the times given below.

Note: If AC mode and SLOW response are commanded a SAMPLE DELAY of at least 3s is required.

iv) The PRINT COMPLETE signal is only required if the recording device cannot record the Display and Range Mode Information and the Channel identity in the times given below.

v) The effect of the SAMPLE DELAY and PRINT COMPLETE signals is that the PULSE SAMPLE signal does not initiate staticisation of the result of the next conversion cycle. This means that the reading rate will be slower. In addition, if AC mode or SLOW response is commanded, staticisation will be internally delayed by approximately 1s after SAMPLE command.

Logging Rules for Maximum Reading Rate at 10/SEC and 25/SEC

Description	Time	RATE 10/SEC	RATE 25/SEC
Time after DATA CAN CHANGE goes to '0' within which the new input signal must be connected and have settled.	a	55ms	15ms
Time after DATA CAN CHANGE goes to '0' within which SAMPLE command must be issued to initiate staticisation of the result of the next conversion cycle.	b	40ms approx.	10ms approx.
Time after PRINT COMMAND goes to '1' within which SAMPLE command must be issued to initiate staticisation of the result of the next conversion cycle.	c	1ms approx. for 117000 fsd	1ms approx. for 11999 fsd
Time that the DISPLAY DATA is available at the Fan-Out socket after PRINT COMMAND	d	⩽60ms	⩽30ms
Time that the RANGE and MODE DATA is available at the Fan-Out socket after PRINT COMMAND	e	⩽60ms	⩽30ms

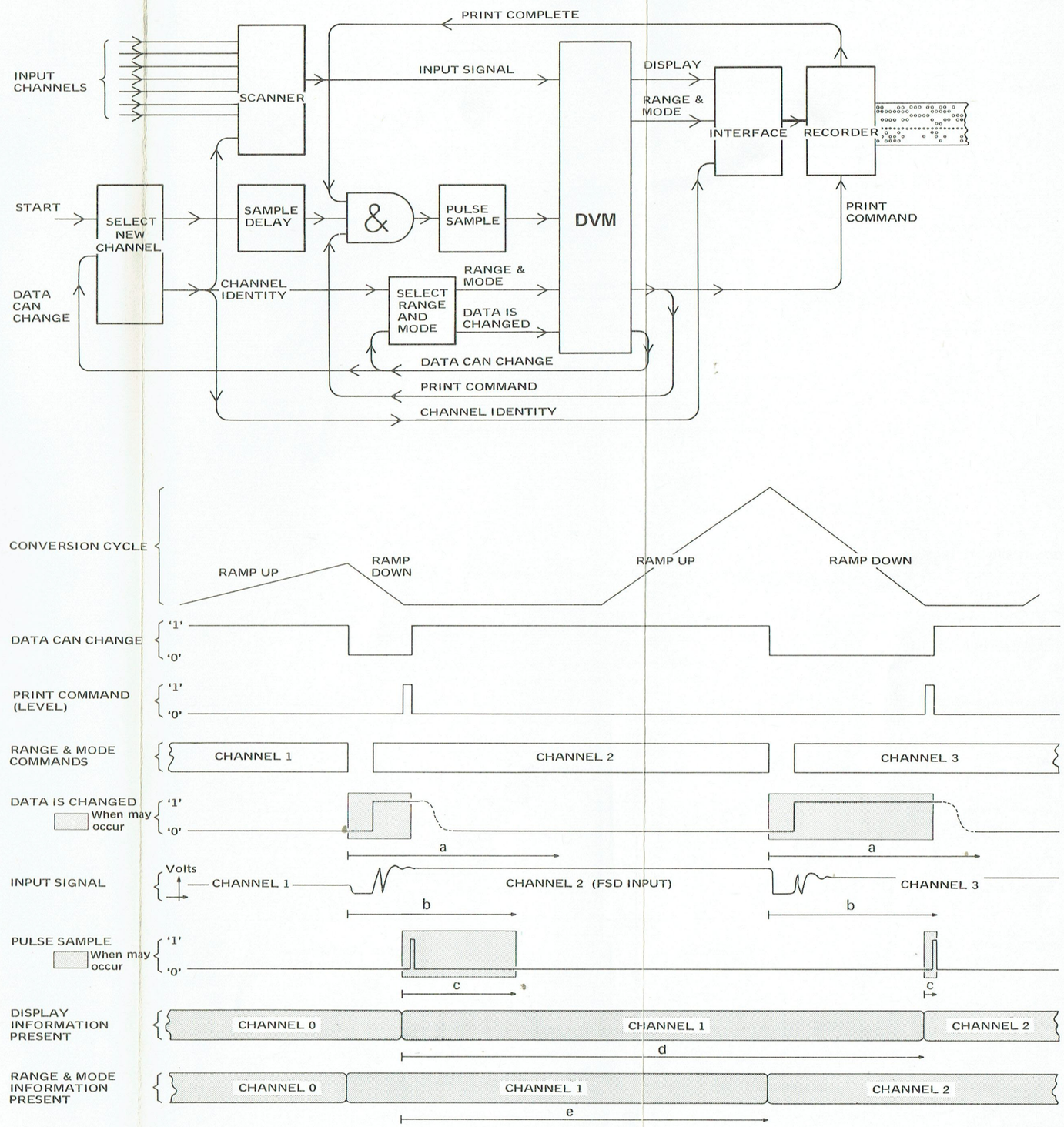
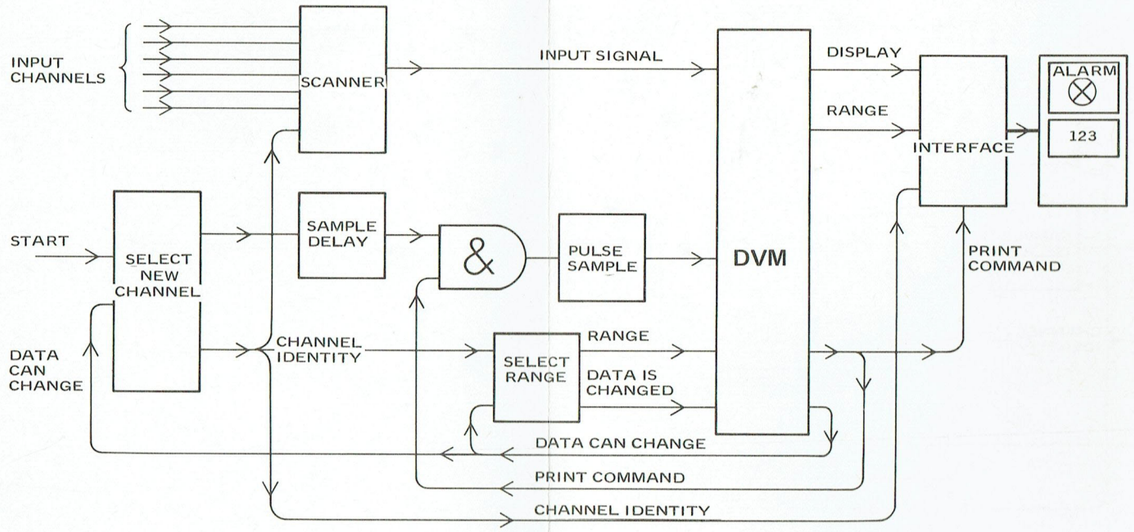
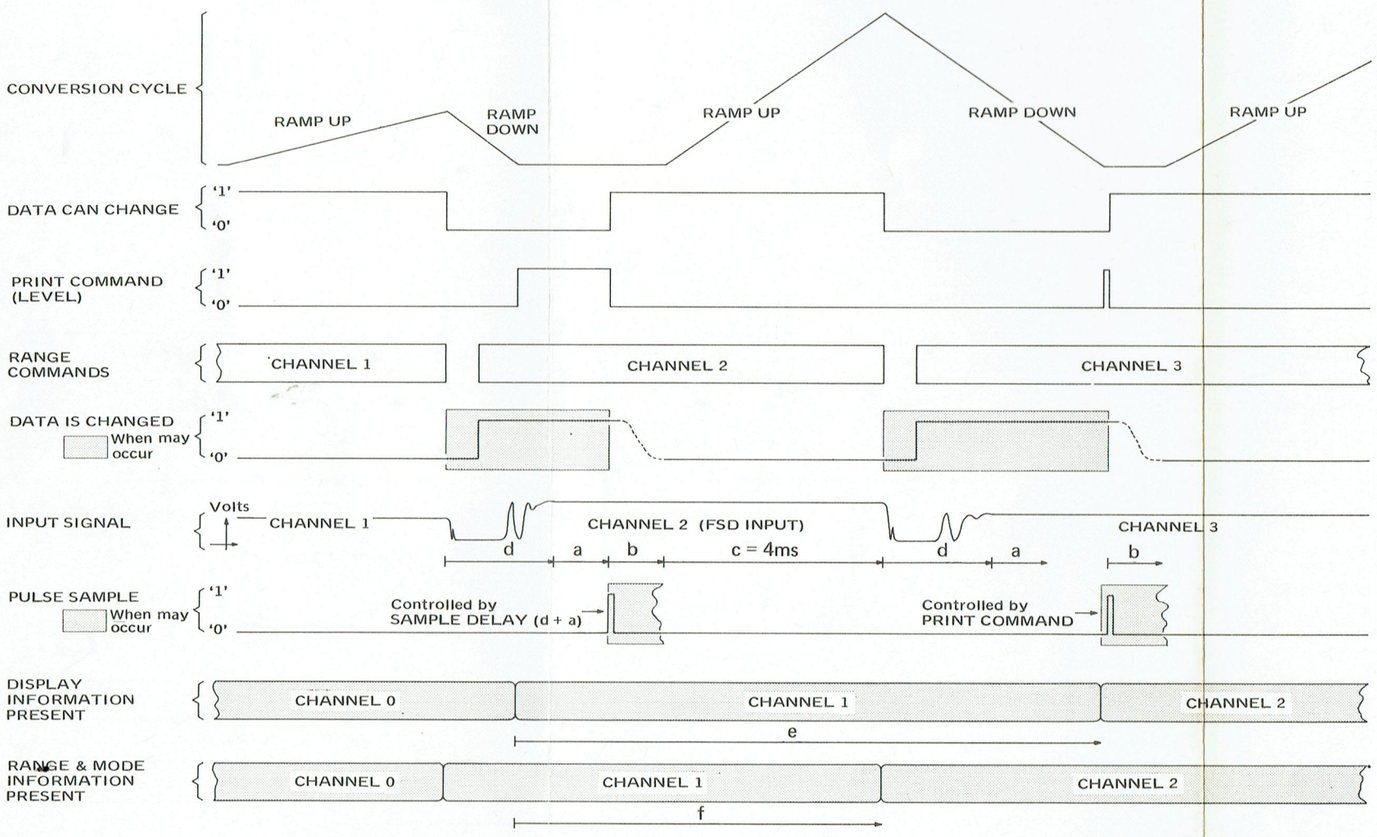


Fig. 5.1 *Data logging at 10/SEC and 25/SEC.*





2. USING THE 100/SEC RATE

Figure 5.2 shows a typical alarm logger and its associated timing diagram. This arrangement is designed to scan at the maximum reading rate compatible with the speed of the scanner, and assumes that the interface and off-limit detector are sufficiently fast to allow operation at the maximum reading rate. Only the DC mode is used.

i) DATA CAN CHANGE is used to initiate channel changing and selection of the Range commands for the next channel.

ii) If DATA IS CHANGED is applied, the time b is increased from 1ms to 15ms.

iii) The SAMPLE DELAY (a + d) is required to ensure that the scanner output will settle by at least 1ms before PULSE SAMPLE is issued.

Logging Rules for Maximum Reading Rate at 100/SEC

Description	Time	Value
Time after the new input signal has settled before SAMPLE command may be issued.	a	⩽1ms *
Time after PRINT COMMAND when SAMPLE command must be issued.		As soon as possible, compatible with a.
Delay between SAMPLE command and start of ramp up.	b	DATA is not changed: 1ms DATA is changed: 15ms
Ramp up time.	c	4ms
Time after DATA CAN CHANGE when the new input signal has settled.	d	Determined by Scanner
SAMPLE DELAY	a + d	⩾5ms for 100 samples/SEC
Time that the DISPLAY DATA is available at the Fan-Out socket after PRINT COMMAND.	e	⩽(a + d) + b
Time that the RANGE and MODE DATA is available at the Fan-Out socket after PRINT COMMAND.	f	⩽(a + d) + b

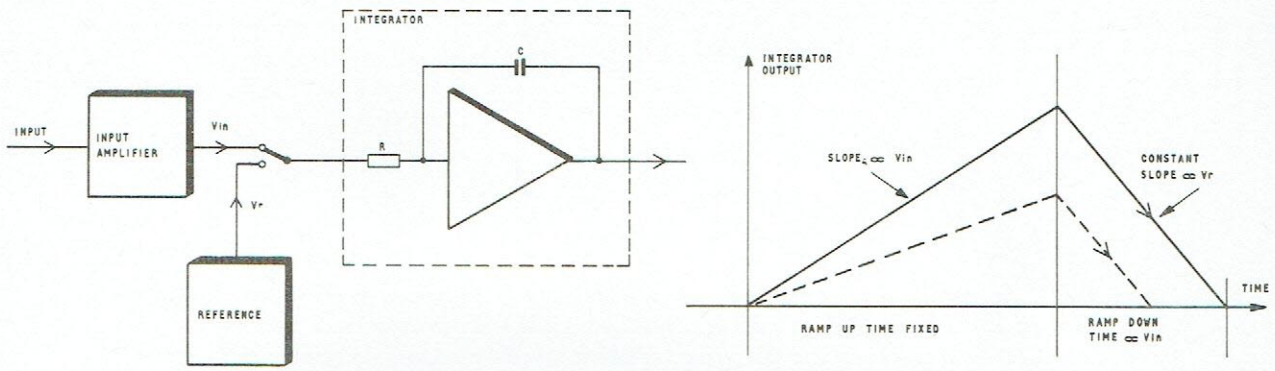
* Increases to 10ms on the 10mV range unless the instrument is modified as described in REMOTE COMMANDS above.

◄Fig. 5.2 *Data logging at 100/SEC.*

SECTION 6 Principles of Operation

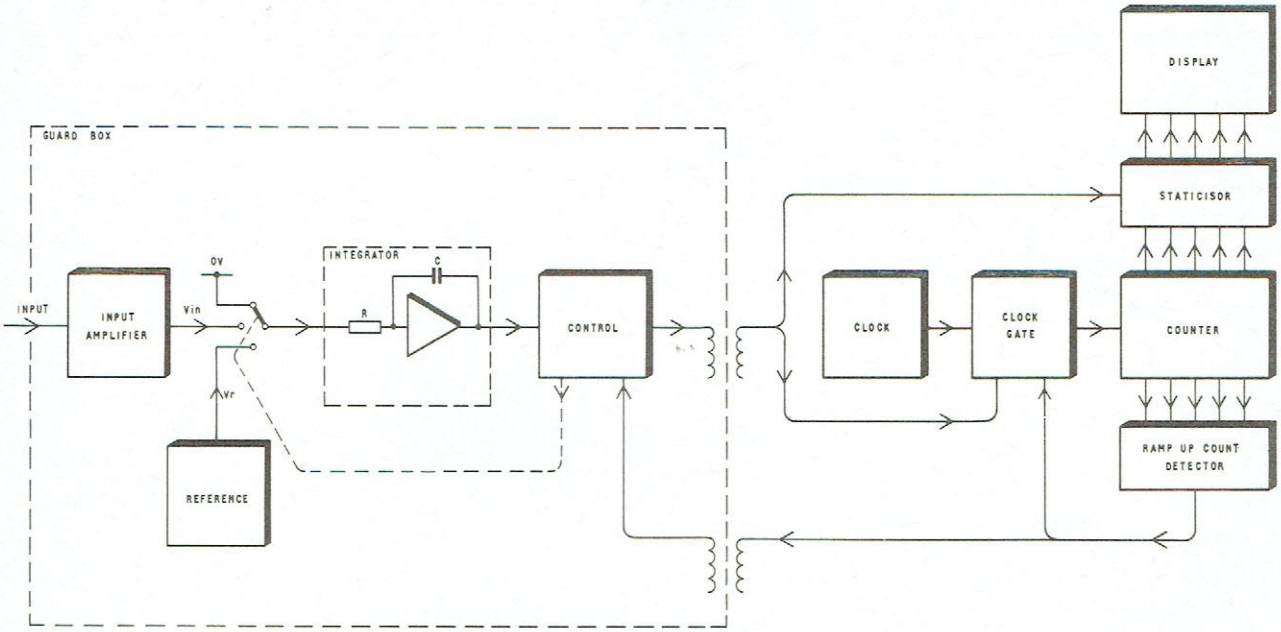
DUAL RAMP

The basic measuring circuit is a bipolar analogue to digital converter operating on the dual ramp principle.



The unknown input (buffered and scaled by the Input Amplifier) is connected to the Integrator for a fixed time ('ramp up'). The output of the Integrator will then be proportional to *Vin*.

Then a reference voltage *Vr* of opposite polarity is connected to the Integrator, ('ramp down') and the time taken for the output of the Integrator to be restored to zero is measured. This time will be proportional to *Vin*, and is displayed as the voltage reading.



Initially the Integrator input is connected to 0V and the Counter is reset. At the start of the conversion cycle the Integrator input is connected to *Vin* and the Clock Gate is opened. The Integrator output ramps up and the clock pulses are accumulated in the Counter. When the Counter reaches a pre-set count *Vin* is disconnected from the Integrator, the Clock Gate is closed and the Counter is reset. After a short delay the appropriate polarity of *Vr* is connected to the Integrator and the Clock Gate is opened. When the Integrator output has ramped down to zero the Clock Gate is closed, *Vr* is disconnected from the Integrator input, and the number of clock pulses in the Counter is transferred to the Display.

The time (T_1) for the Counter to reach the preset count (N_1) at the end of ramp up is fixed, and the number of pulses accumulated in the Counter during ramp down (N_2) is proportional to the ramp down time T_2.

The output of the Integrator at the end of ramp up, V_1, will be:

$$V_1 \frac{1}{RC} \int_0^{T_1} Vin\, dt$$

If *Vin* is a steady voltage, then

$$V_1 = \frac{1}{RC} \cdot Vin.T_2$$

The output of the Integrator at the end of ramp down is zero. Therefore, the ramp down time T_2 is given by

$$0 = V_1 - \frac{1}{RC}\int_0^{T_2} Vr.\,dt$$

$$= \frac{1}{RC}\,(Vin\,T_1 - Vr\,T_2)$$

Let the Clock frequency be f Hz.

$$\therefore \quad T_1 = \frac{N_1}{f} \text{ and } T_2 = \frac{N_2}{f}$$

$$\therefore \quad Vin\,\frac{N_1}{f} = Vr\,\frac{N_2}{f}$$

$\therefore$ N_2, the count at the end of ramp down, is given by

$$N_2 = \frac{Vin}{Vr}\,N_1$$

Vr and N_1 are constants

$\therefore$ $N_2 \propto Vin$, and is independent of the Clock frequency f.

The *MASTER SERIES* has certain refinements to this basic operation which improve the performance of the instruments.

i) The Clock frequency f is locked to the mains supply frequency, and is chosen so that the ramp up time is equal to a whole number of mains periods. This means that any mains frequency series mode interference on the input signal is averaged out by the Integrator.

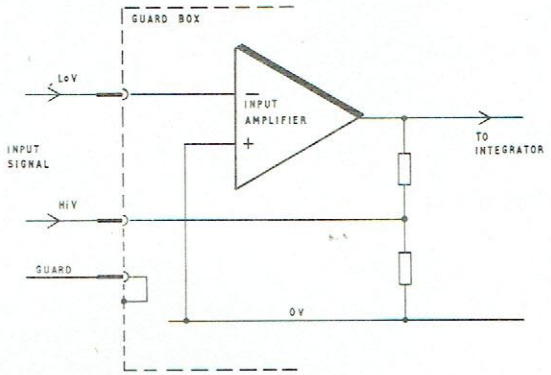
ii) When the Integrator input is connected to 0V and the Counter is reset (during the reset period) a drift correcting voltage is applied to the Integrator, giving improved accuracy.

iii) The input circuitry is contained within a Guard Box and is fully isolated. This gives excellent common mode rejection and enables inputs with a high common mode voltage input to be measured.

The A210, A211, A212, A213, A215, A230, A233 and A235 instruments offer a choice of reading rates: 10/SEC, 25/SEC and 100/SEC. The conversion cycles at 10/SEC and 25/SEC are locked to the mains period. The timing of events at the three rates is as follows:-

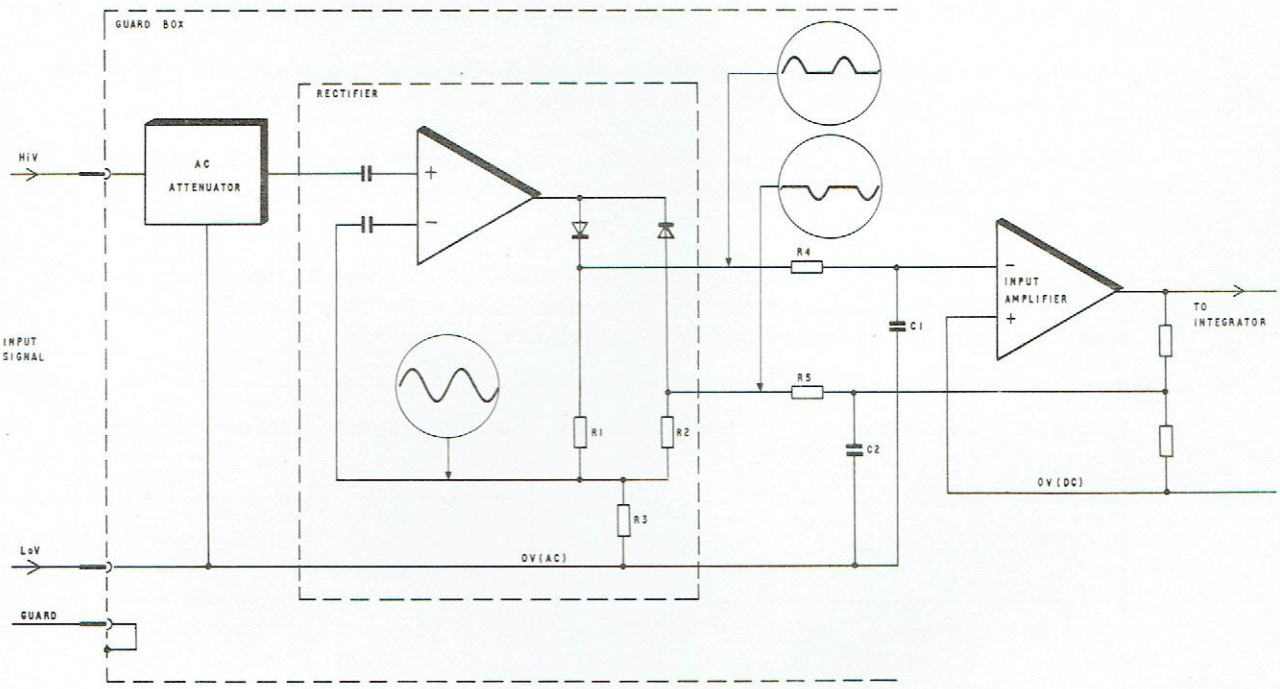
RATE	Clock Freq. f	Ramp Up Count N_1	Ramp Up Time T_1	Ramp Down Time T_2	FSD
10/SEC	3MHz	119999	40ms (2 mains periods)	0 to 40ms	119999
25/SEC	Ramp up: 600kHz Ramp down: 1.5MHz	11999	20ms (1 mains period)	0 to 8ms	11999
100/SEC	300kHz	11999	4ms	0 to 4ms	1199

DC MEASUREMENT



This arrangement gives a very high input impedance (>1GΩ) on the 10V, 1V and 100mV ranges. Then the range is set by the potential divider at the amplifier output. Additional attenuation to the input signal on the 100V and 1000V ranges reduces the input impedance to 10MΩ on these ranges.

AC MEASUREMENT

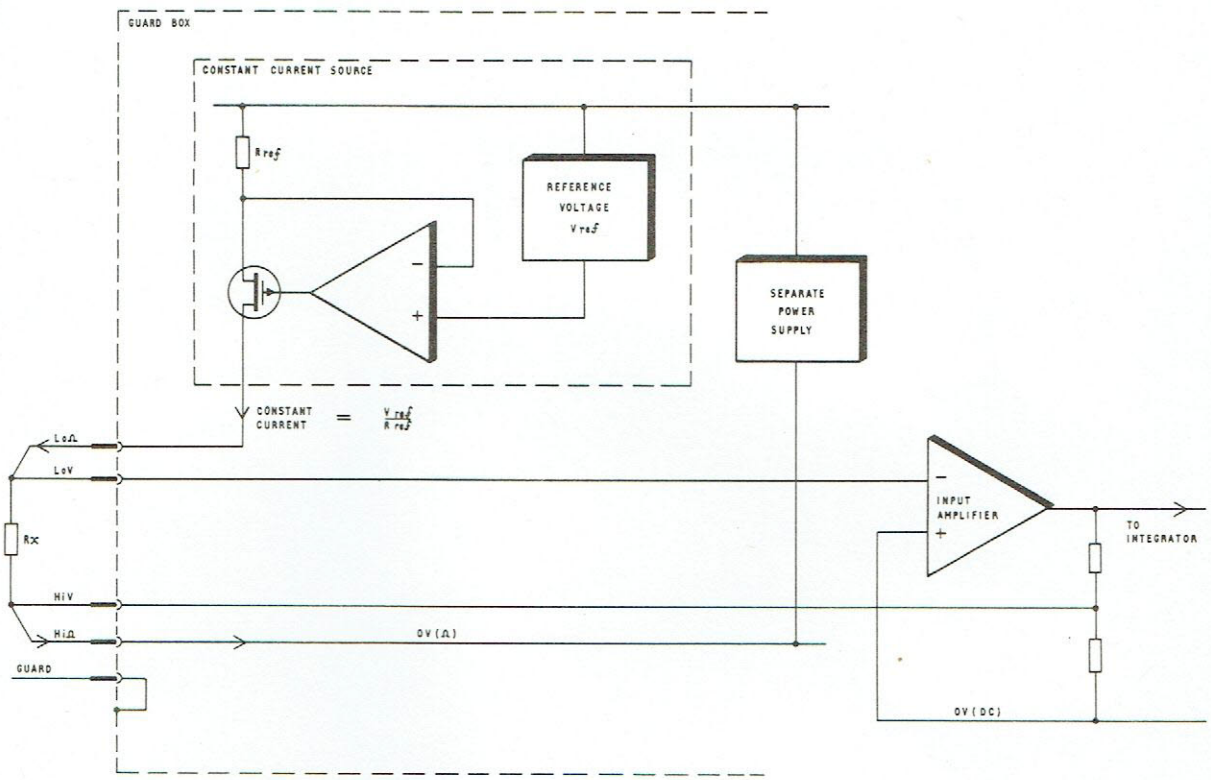


The positive and negative half cycle outputs of the Rectifier are summed by potential divider R1/R2/R3. This sets the rectifier gain and, in conjunction with the AC Attenuator, determines the ac ranges.

The outputs of the Rectifier are averaged by R4/C1 and R5/C2 and then applied as a dc differential input to the Input Amplifier proportional to the mean modulus of the ac input signal. The scaling is adjusted so that the Display reads rms values, assuming a sine-wave input.

The power for the ac section is derived from a separate isolated supply.

RESISTANCE MEASUREMENT



The test current from an accurate constant current source flows through the unknown resistor Rx. The voltage appearing across Rx is measured as a differential input to the Input Amplifier. Errors due to lead resistance are eliminated since the test current does not flow through the sensing leads.

SUB-SECTION 7.1 Introduction to Section

GENERAL

This section provides information to enable fault-finding and servicing to be carried out on the DVM's.

CIRCUIT DIAGRAMS

The functional circuit diagrams given in Sub-section 7.3 are based upon functional blocks that are not restricted by the physical boundaries of printed circuit boards and other sub-units, the various parts of each board circuit diagram being incorporated into the functional circuit diagrams.

Index tables in Sub-section 7.4 list each board with reference to the functional diagrams containing part of the board circuit diagram, and the major functions on the edge pins of each board can be identified by referring to mother board pin connection diagrams. Component location and the associated copper track illustrations for every board are also shown in Sub-section 7.4.

Fig. 7.1.1 is a cross-reference chart which may be used to identify the association between the printed circuit boards (pcb's) and the functional circuit diagrams.

FAULT FINDING AND SERVICING

A simplified circuit description and a functional description (Sub-section 7.2) provide a working knowledge of the instrument to help diagnose the faulty area of the instrument. A functional key diagram shows the relationship between the functional diagrams (Sub-section 7.3) and by referring to the appropriate functional diagram, detailed circuit information on the faulty area can be examined.

A description of the use of the functional diagrams in fault-finding is given in Sub-section 7.3 and fault-finding waveforms are shown in Sub-section 7.5.

Sub-section 7.5 also gives instructions on the dismantling of the instrument to gain access to the boards and other sub-units and the replacement of these items.

The spatial description (Sub-section 7.6) illustrates the location of the boards and other sub-units in the instrument.

MODEL VARIATIONS

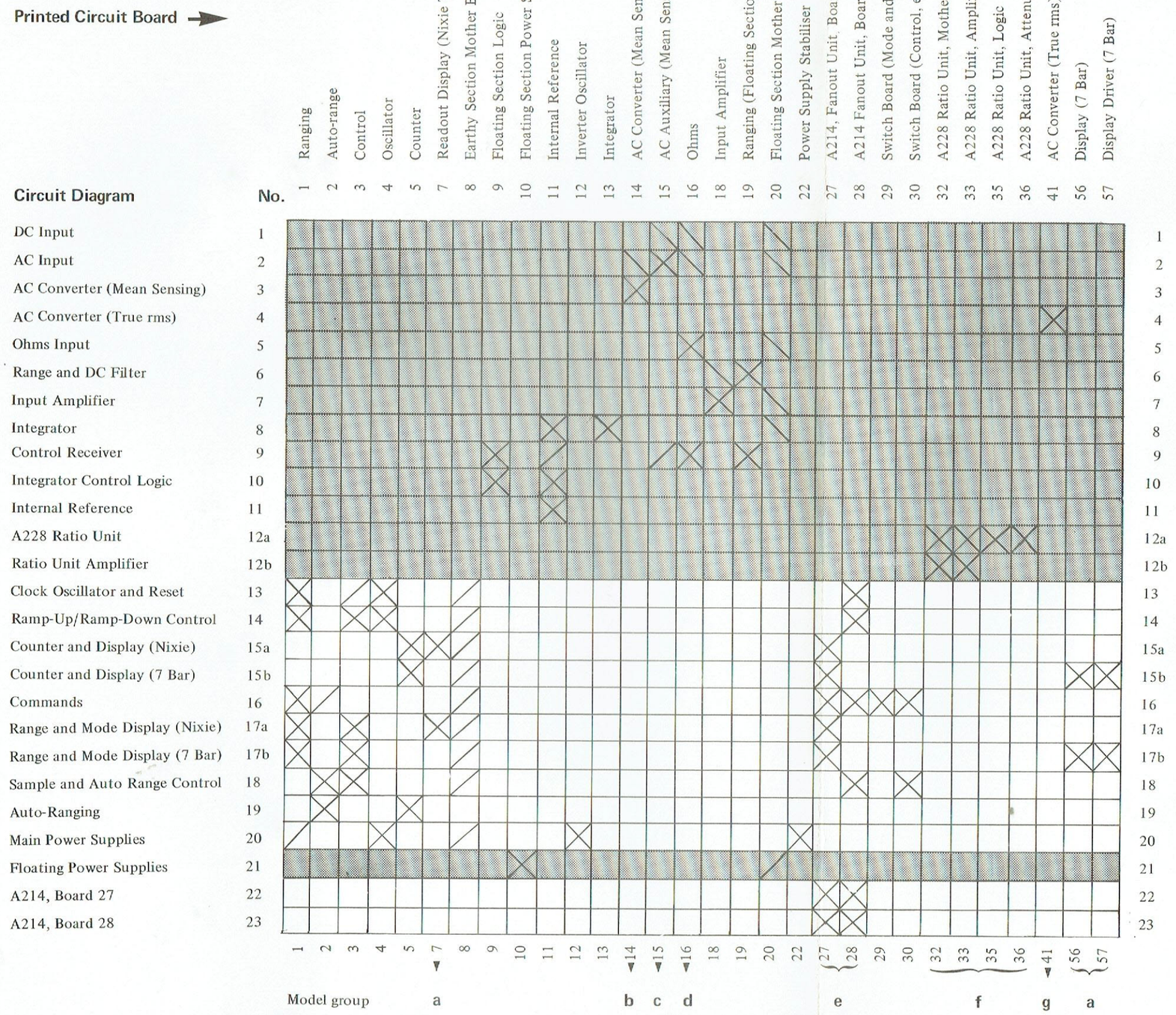
All the models described in this Manual are either the type A210 or the A210 plus various extra plug-in pcb's and modules. Table 7.1.1 is a list of the variations.

It may be noted that the true rms models result from a direct substitution of pcb 41 for pcb 14.

The 7 bar display is a result of the substitution of pcb's 56 and 57 for pcb 7.

Model	Assembly
A211	A210 + pcb's 14, 15
A212	A210 + pcb 16
A213	A210 + pcb's 14, 15, 16
A215	A210 + pcb's 15, 16, 41
A230	A210 + Ratio module
A233	A210 + Ratio module + pcb's 14, 15, 16
A235	A210 + Ratio module + pcb's 15, 16, 41

Table 7.1.1 Model variations.



Circuit Diagram/Printed Circuit Board Cross-reference Chart

If a circuit diagram, listed vertically, contains a significant amount of detail relating to a particular pcb, listed horizontally, a cross is shown at the intersection. If the relationship is of a minor nature, such as a through connection, it is indicated by a stroke. The floating section is shown shaded.

Model Groups

Reference letters below the columns refer to the model variations. Unmarked columns refer to all models. The variations are as follows:-

a) pcb 7 (Nixie) alternative to 56 and 57 (7 Bar).

b) pcb 14 - A211, A213, A233 only.

c) pcb 15 - A211, A213, A215, A233, A235 only.

d) pcb 16 - A212, A213, A215, A233, A235 only.

e) pcb 27, 28 - Optional on all models.

f) Ratio Unit - A230, A233, A235 only.

g) pcb 41 - A215, A235 only.

Fig. 7.1.1 PCB Reference Chart

SIMPLIFIED CIRCUIT DESCRIPTION

GENERAL

The operation of a digital voltmeter (DVM) depends upon the following three basic functions.

(a) Analogue-to-digital conversion (ADC) of the input signal.

(b) Decimal display of each ADC.

(c) Control circuits to operate and synchronise the two above functions.

DUAL-RAMP PRINCIPLE

The analogue-to-digital conversion technique used in this series of DVM is based upon the dual-ramp principle. A description of this principle, with mathematical content, and an explanation of mains integration is given in Section 6. The following description is purely functional.

Refer to Fig. 7.2.1. The input signal voltage is applied to the semiconductor switch S1, via the input amplifier. Initially S1 is switched on and S2 is switched off, so connecting the input voltage to the integrator (amplifier B, C1 and R1). Capacitor C1 will now charge up (ramp-up) for a fixed time predetermined by the clock frequency and the full scale count of the display counter. At the end of the fixed time the voltage developed across capacitor C1 is proportioned to the input voltage.

Switch S1 is now switched off and S2 is switched on to connect a fixed reference supply to the integrator. This reference supply is arranged to be of opposite polarity to that of the input voltage, i.e. the voltage now developed across C1. At the same time the gate is opened and pulses from the clock are accumulated in the counter, which has been previously reset to zero at the end of the fixed time.

The capacitor C1 now discharges (ramps down) at a rate dependent upon the reference voltage. The time taken for the voltage across C1 to reach zero volts is dependent upon the initial charge held on the capacitor, this charge being proportional to the DVM input voltage as previously stated. Amplifier C detects the zero volt condition and the decision logic circuit simultaneously closes the gate, thus inhibiting pulses from the clock being accumulated in the counter. The counter now contains a number, in digital form, that is directly related to the input voltage applied to the DVM.

DECIMAL DISPLAY

The binary code decimal (BCD) from the counter is held in a staticiser (store).

The outputs from the staticiser are connected into the decimal display circuits where the BCD is converted into decimal and displayed on the readout display. If a system interface (fanout) unit is fitted, the outputs from the staticiser are also connected out to the system print-out device.

CONTROL CIRCUITS

The control circuits have to cope with a wide range of DVM functions and also provide for external control of some of the functions when the DVM is interfaced with a system.

The sampling circuits determine how many analogue-to-digital conversions are made in one second. These circuits reset all the counters and logic circuits before each new conversion is made. Low speed sampling rates are derived from the mains supply frequency. High speed sampling rates can be used when interfacing the DVM with a system, the sampling rate is usually dependent on factors external to the DVM.

A basic clock of 6MHz, which is locked to the mains supply frequency, is divided down to 3MHz and connected to the counter and logic circuits.

The setting of the front panel controls which determines the mode and range of operation of the DVM are interpreted by relay control circuits to energise the appropriate relays for the mode and range selected. Provision is also made for remote selection of mode and range of operation.

FLOATING AND EARTHY SECTIONS

This series of DVM has a high factor of Common Mode Interference Rejection (CMR), refer to Section 4 for a description of CMR. To achieve this feature the analogue-to-digital conversion circuits must be highly insulated from the main DVM chassis which is connected to mains earth. This isolated section is referred to as the Floating Section and is mounted on a sub-assembly, termed the Guard Box.

The main DVM chassis is referred to as the Earthy Section. It contains the digital control circuits, the display circuits and the main power supply.

To maintain the high insulation between the Floating and Earthy Sections, electrical communication between them is made by transmitting and receiving pulses via toroid transformers. Also the Floating Section has a separate power supply which is energised by an isolated high frequency ac from the main power supply.

FUNCTIONAL CIRCUIT DESCRIPTION

GENERAL

The following circuit description is based on Fig. 7.2.2, the functional key diagram, which shows the relationship between the functional diagrams given in Sub-section 3.

As previously explained in Sub-section 1 the functional diagrams consist of functional blocks that are not limited by the physical boundaries of printed circuit boards or other sub-units.

FLOATING SECTION

INPUT CIRCUITS (Drg. 1, 2, 3, 4 and 5)

The arrangment of the signal input circuits, depends on the Type No. of the DVM. The basic dc mode of operation is common to all types of DVM and the dc input signal is routed via range relay switching into the Input Amplifier (Drg. 6 and 7).

In the mean sensing ac mode of operation the ac input signal is passed through an ac range attenuator (Drg. 2) into an ac to dc converter (Drg. 3). The dc output from the converter is filtered (Drg. 2) and routed to the Input Amplifier (Drg. 6 and 7).

In the true rms ac mode of operation the ac input signal is passed through an ac range attenuator (Drg. 2) into an ac to dc converter (Drg. 4). The dc output from the converter is filtered (Drg. 2) and routed to the Input Amplifier (Drg. 6 and 7).

In the ohms mode of operation a reference current source is connected out to the front panel connector from the ohms board (Drg. 5). The resistance to be measured is connected in series with this reference current source and the resultant voltage drop is measured and shown as a direct ohms reading on the DVM display. Two of the leads in the signal input cable carry the reference current.

INPUT AMPLIFIER (Drg. 7)

The input amplifier is a chopper drift corrected dc amplifier with a very high gain used in a potentiometer feedback circuit.

RANGE AND DC FILTER (Drg. 6)

The Range and DC Filter circuits provide,

(a) DC attenuation and range selection.

(b) Fast and slow response.

(c) Gain and scaling networks for the Input Amplifier (Drg. 7).

INTEGRATOR (Drg. 8)

The signal voltage from the Input Amplifier is applied to the Integrator which converts the applied voltage to a time interval proportional to the applied voltage.

The timing of the integrator functions is controlled by the Integrator Control Logic (Drg. 10). With the exception of the end of ramp-down command all of the timing commands originate in the Earthy Section and these are transmitted to the Control Logic circuit via toroid transformers and the Control Receiver circuits (Drg. 9).

Ten analogue-to-digital conversions in one second is the basic sampling rate. The sampling rate includes the timing of the integrator functions, the display of the conversion and resetting time to allow the circuits to be reset before commencing another analogue-to-digital conversion.

The approximate integrator timings for the 10/SEC sampling rate are as follows:-

Ramp-up	40ms
Wait period between the end of ramp-up and the start of ramp-down.	40μs
Ramp-down (full scale)	40ms
Reset	20ms

The integrator is drift corrected during the period between the end of ramp-down and the start of the next ramp-up. The polarity of the input signal is detected during the wait period at the end of ramp-up.

End of ramp-down is detected when the integrator output passes through zero volts.

INTEGRATOR CONTROL (Drg. 10)

The Integrator Control Logic circuits synchronise the timing command pulses to the integrator. The wait delay and ramp-down delay are generated by these circuits. Also information on the polarity of the input signal and the end of ramp-down is passed to the Earthy Section via a toroid transformer.

CONTROL RECEIVER; RANGE AND MODE DECODE (Drg. 9)

The Control Receiver circuits receive ramp-up and ramp-down command pulses from the Earthy Section via a toroid transformer. Range and mode of operation pulses are received in serial form, via the same toroid during the reset period. All of the pulses received are shaped to logic levels and converted from serial to parallel form before being passed to the appropriate circuits in the Floating Section.

Range and mode information is decoded and the appropriate relays are energised to give the selected mode and range of operation.

INTERNAL REFERENCE SOURCE (Drg. 11)

The Internal Reference Source is a special type of 6.2V zener diode which is mounted in a temperature controlled oven. A negative reference is obtained by connecting an inverting amplifier with unity gain to the +6.2V reference.

RATIO UNIT A228 (Drg. 12A AND 12B)

When the ratio mode of operation is selected (DVM types A230 and A233) the external reference source is substituted for the internal reference source by relay switching.

POWER SUPPLIES (Drg. 21)

The power supply is energised by an isolated 24kHz supply from the Earthy Section. The +16V, -16V supply and the +5V supply are fixed stabilised supplies.

EARTHY SECTION

CLOCK OSCILLATOR AND RESET (Drg. 13)

The basic clock is a transformer coupled 6MHz oscillator which is locked to the mains frequency on the 10/sec and 25/sec sampling rates.

Reset pulses for the 10/sec, 25/sec and 100/sec sampling rates are generated at the correct time sequence, and passed to the Floating Section via a toroid transformer.

RAMP-UP/RAMP-DOWN CONTROL (Drg. 14)

The Ramp Up/Ramp Down Control circuits control the operation of the integrator timing commands in conjunction with the display counter. The timing commands are passed to the Floating Section via a toroid transformer.

During the reset period, mode and range of operation information is also sent to the floating section via the same transformer. This information consists of serial pulses.

On receipt of a reset pulse the display counter is reset to zero and a start of ramp-up command is issued to the Floating Section. The display counter accumulates counts from a gated 3MHz clock (derived from the 6MHz basic clock) until the counter is full. When a full counter is detected, an end of ramp-up command is sent to the Floating Section to cease ramp-up. The display counter is set to zero and a start of ramp-down command is issued to the Floating Section. When the Integrator Control Logic Circuits (Drg. 10) issue an end of ramp-down command the output from the 3MHz clock is inhibited and the number held in the counter is transfered to the staticiser. A reset pulse then resets all of the instrument circuits to await the start of another DVM reading.

COUNTER AND DISPLAY (Drg. 15)

The counter in conjunction with the ramp-up/ramp-down control circuits determines the fixed time for ramp-up. The end of ramp-up is detected when the counter is full, i.e. it holds 119999. The counter is then reset and at the end of ramp-down it holds the value of the signal input voltage in BCD form.

A full count obtained during ramp-down indicates an input signal over-load for the range selected.

The BCD count accumulated in the counter is transferred to the main staticiser (store) on receipt of a staticise command and is connected directly from the staticiser into a BCD-to-decimal decoder in the display circuits to operate the decimal display. The instrument can be fitted with one of two types of display, either the Nixie tube display or the seven-bar neon display.

RANGE, MODE, RESPONSE AND RATE COMMANDS (Drg. 16)

The Range, Mode, Response and Rate Commands circuits interpret the settings on the front panel controls and set-up the appropriate logic states in the Range and Mode Serialiser (Drg. 17) circuits and in the Sample and Auto Range (Drg. 18) circuits to the mode and range of operation selected. Similarly when the instrument is interfaced with a system the remote control commands are interpretated by these circuits.

RANGE AND MODE SERIALISER, STORE AND DISPLAY (Drg. 17)

The range and mode data is stored in a serialiser and during the reset period this information is passed to the Floating Section via the Ramp-Up/Ramp-Down Control (Drg. 14) circuits and a toroid transformer. Range and mode data are also held in a staticiser (store) and subsequently displayed.

During the wait period, at the end of ramp-up, the polarity information from the Floating Section received via the Ramp-Up/Ramp-Down Control (Drg. 14) circuits is stored and subsequently displayed.

Should a full count of 119999 be received from the counter during ramp-down time, indicating a signal input overload for the range selected, the overload condition will be detected and displayed.

SAMPLE AND AUTO RANGE CONTROL (Drg. 18)

The sampling circuits automatically issue a sampling pulse when the sample rates of 10/SEC or 25/SEC are used. When the instrument is interfaced with a system a sampling rate of 100/SEC can also be used, the sampling rate is usually dependent on factors external to the instrument (e.g. the speed of the print-out device).

The Auto-Range circuits set the logic states of the Auto-Ranging (Drg. 19) circuits when command by the auto range command (Drg. 16).

AUTO RANGING (Drg. 19)

The Auto Ranging circuits automatically select the correct range of operation to suit the signal input voltage. These circuits continuously monitor the output of the main counter (at the end of ramp-down) when the auto-ranging facility is selected. Should a high count reading be detected (greater than 109999) a command is issued to the range logic in the Range Command (Drg. 16) circuits to select a higher range, which in turn effects a higher range to be inserted in the range serialiser (Drg. 17). Information about the new range selected is transmitted to the Floating Section as described in Range and Mode Serialiser (Drg. 17).

Similarly when a low reading is detected (less than 10000) a lower range is selected.

FANOUT UNIT (SYSTEMS INTERFACE UNIT) TYPE A214 (Drg. 22 AND 23)

The Fanout Unit is an optional unit that interfaces the instrument with a system, e.g. a data logging system. The unit comprises two printed circuit boards and a connector that are fitted to the Earthy Section of the instrument.

Sampling rates of 25/sec and 100/sec are available in addition to the basic sampling rate of 10/sec. Factors external to the DVM can determine the sampling rate and the timing functions of the integrator circuits.

The selection of mode and range of operation is made by the system and resultant readings are buffered from the output of the staticiser to be recorded by the system print-out device.

POWER SUPPLY (Drg. 20)

The dc outputs from the power supply are derived from an isolated, stabilised 24kHz supply. This isolated high frequency supply also energises the power supply in the Floating Section.

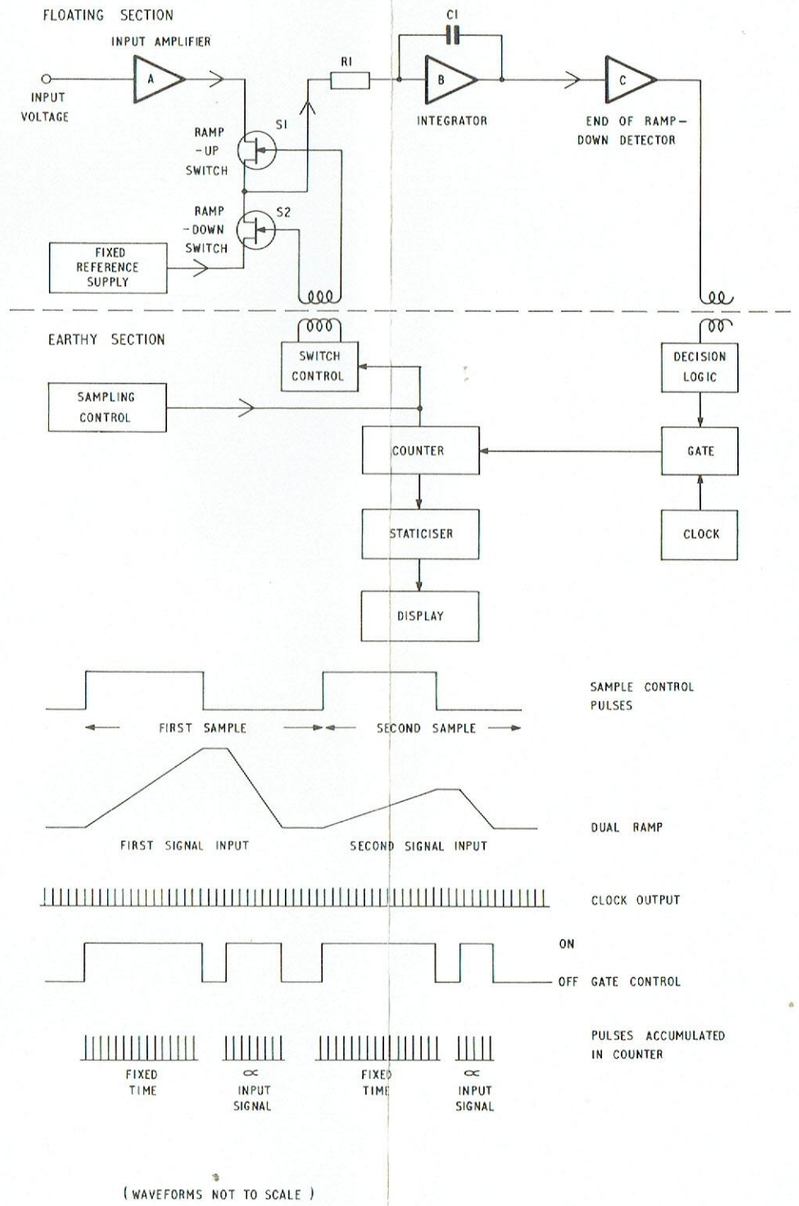


Fig. 7.2.1 Simplified Block Diagram

FLOATING SECTION (ANALOGUE TO DIGITAL CONVERSION)

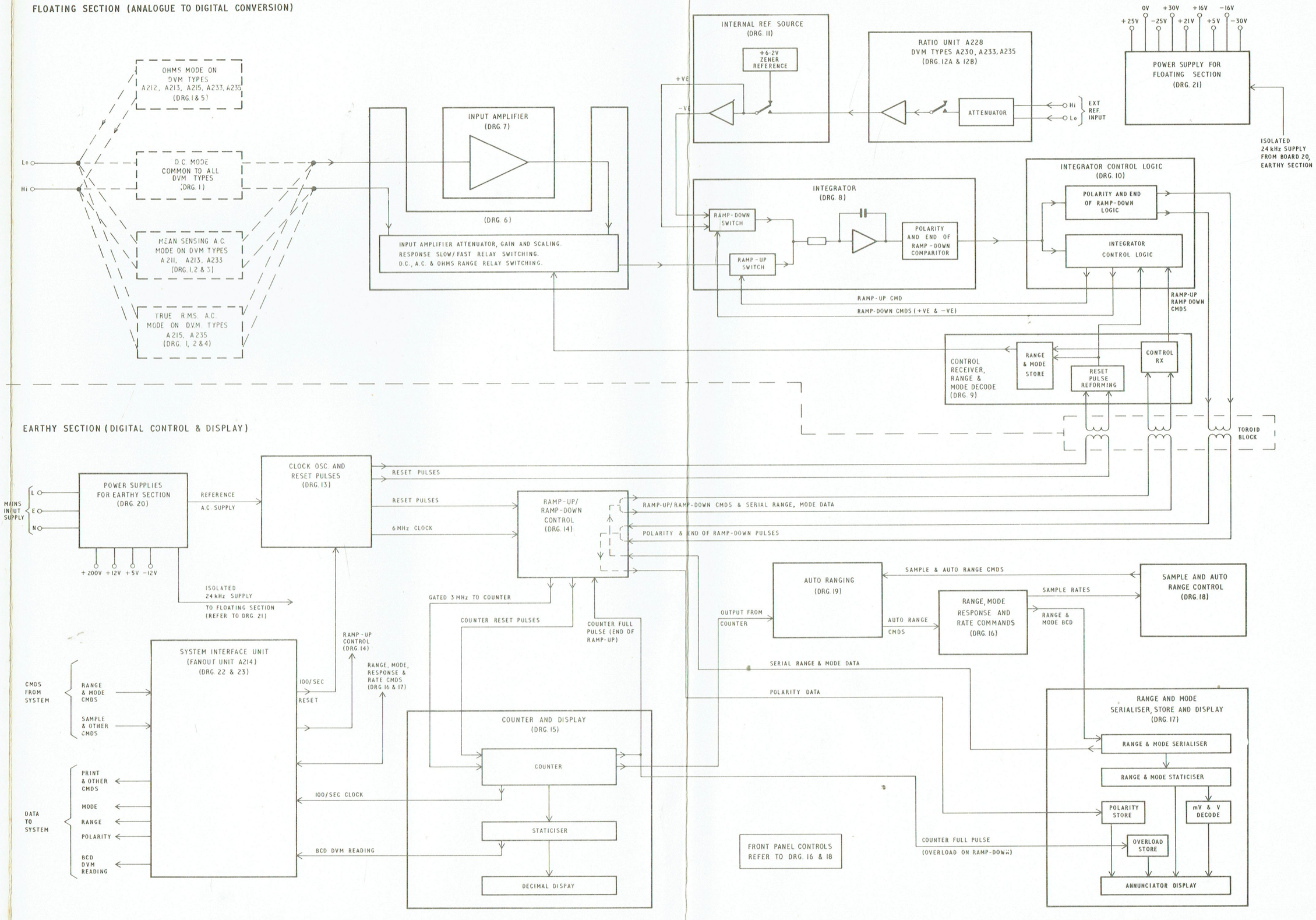


Fig. 7.2.2 Functional Key Diagram

SUB-SECTION 7.3 Functional Circuit Diagrams

GENERAL

These functional diagrams are based upon functional blocks that show the circuit diagrams of DVM operational functions without the restrictions of physical boundaries of printed circuit boards and other sub-units.

The functional circuit diagrams are shown on right hand pages, each of which is identified with a drawing number, and the corresponding text appears opposite on the left hand page.

FAULT FINDING

A functional key diagram which shows the relationship between the functional drawings is given in Sub-section 7.2, Circuit Description.

The left-hand page of a functional drawing can be considered as a block diagram, the main signal paths being shown, where possible in thick lines. All inputs and outputs between diagrams are fully cross-referenced in detail to give easy continuity of reference when following signal paths between drawings.

Each block is presented with a left to right signal path with inputs on the left of the blocks and outputs on the right. Input and output conditions for each block are given and by referring to these conditions a faulty block can be detected and investigated to component level and the faulty component then isolated.

LOGIC LEVELS

Most of the logic circuits are constructed from DTL or TTL digital integrated circuits of international type which operate from a supply of +5V.

Positive convention is used to define the logic levels as follows.

High level Logic 1 (referred to as Hi) +2.4V to +5V

Low level Logic 0 (referred to as Lo) 0V to +0.5V

All major functional lines are identified by name and also by the logic level applicable to their active function as shown in the following two examples.

Refer to Drawing 13, Blocks 13D, 13E and 13H. The common output from these blocks is the $\overline{\text{RESET}}$ (note the negation bar) line. During a Reset period this line is Lo (active state) at all other times (Ramp-up, Wait, Ramp-down) it is Hi.

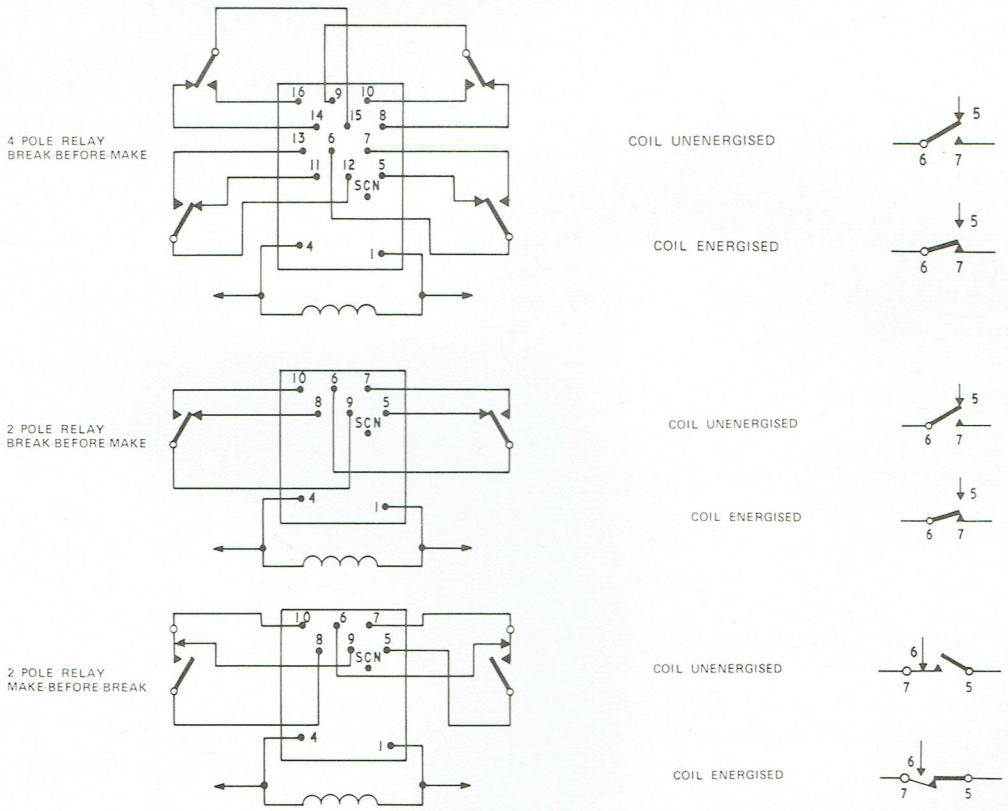
Refer to Drawing 16, Block 16B. When the DVM is operating at the 10/SEC sampling rate, the 10/SEC line is Hi and the $\overline{\text{10/SEC}}$ line is Lo. The level of these lines will change, when operating in the 25/SEC and 100/SEC sampling rates, to that given in functional block 16B text.

RELAYS

The base connections and circuit symbols for the conventional miniature relays as shown in the functional diagrams are as follows. Note that all relays are directly wired into circuit, relay holders are not used.

Relays F and N are encapsulated reed relays, the contacts on this type of relay are not identified by numbering.

A special type of relay is used in the Ratio Unit (when fitted). Refer to Drawing 12A.



RELAY TABLE

The on (energised) or off (unenergised) state for each relay, in conjunction with the mode and range of DVM operation is given in the relay table. The board onto which each relay is fitted is also given.

This table will be of assistance when referring to functional diagrams that contain relay circuits.

BOARD IDENTIFICATION

Printed circuit board numbers on the functional diagrams are abbreviated to the least one or two, significant numbers e.g. board A21009013 is abbreviated to board 13. Refer to Sub-section 7.4 for information on the relationship between the board circuit diagrams and the functional diagrams.

OPTIONAL VARIATIONS

The functional diagrams show all the optional units along with the basic DC mode of operation. Optional units consist of one or more boards that are plugged into vacant connectors that have been provisioned on the Mother Boards. Disregard information on an optional unit (e.g. Fanout Unit) that is not fitted to the instrument under examination.

Optional facilities available with reference to the DVM Type No. are listed as follows. Refer to Section 1 for information on the facilities available for all versions of the DVM series.

Facility	DVM Type No.
DC Mode	Common to all instruments
AC (Mean Sensing)	A211, A213, A233
AC (RMS)	A215, A235
Ohms	A212, A213, A233
Ratio	A230, A233
Fanout Unit	Can be fitted to all types

LIST OF FUNCTIONAL CIRCUIT DIAGRAMS

Drawing No.	Title
1	DC Input
2	AC Input
3	AC Converter (Mean Sensing)
4	AC Converter (True RMS)
5	Ohms Input
6	Range and DC Filter
7	Input Amplifier
8	Integrator
9	Control Receiver, Range and Mode Decode
10	Integrator Control Logic
11	Internal Reference
12A	A228 Ratio Unit
12B	Ratio Unit Amplifier
13	Clock Oscillator and Reset
14	Ramp-Up/Ramp-Down Control
15A	Counter and Readout Display (Nixie Type)
15B	Counter and Readout Display (7 Bar Type).
16	Range, Mode, Response and Rate Commands
17A	Range and Mode Serialiser, Store and Display (Nixie Type)
17B	Range and Mode Serialiser, Store and Display (7 Bar Neon Type)
18	Sample and Auto Range Control
19	Auto-Ranging
20	Main Power Supplies
21	Floating Power Supplies
22	A214, Board 27
23	A214, Board 28

		RANGE								MODE		DC RESPONSE				AC RESPONSE		SAMP-LING		RATIO
	Relays	A	B	C	G	H	R	J	N	L	M	P	F		Q		K		D	E	S^+
	Board	19	19	19	15	15	15	14	16	15	15	16	19		19		15		19	11	
	DC												FAST	SLOW	FAST	SLOW	FAST	SLOW			
1000V		OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF	ON	OFF	ON	OFF	OFF			
100V		OFF	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF			
10V		ON	OFF	OFF	OFF	OFF	ON	OFF	ON	OFF	ON	OFF	OFF	ON	OFF	ON	OFF	OFF			
1V		ON	OFF	ON	OFF	OFF	ON	OFF	ON	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF			
100mV		ON	ON	OFF	OFF	OFF	OFF	OFF	ON	OFF	ON	OFF	OFF	ON	OFF	ON	OFF	OFF			
10mV		ON	ON	ON	OFF	OFF	OFF	OFF	ON	OFF	ON	OFF	OFF	ON	OFF	OFF	OFF	OFF			
	AC																				
1000V		ON	OFF	ON	OFF	OFF	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON			
100V		ON	OFF	ON	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON			
10V		ON	OFF	ON	OFF	ON	ON	ON	ON	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON			
1V		ON	OFF	ON	ON	ON	ON	OFF	ON	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON			
100mV		ON	OFF	ON	ON	OFF	OFF	ON	ON	ON	OFF	OFF	OFF	ON	OFF	OFF	OFF	ON			
	Ω																				
10M		ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	OFF	ON	OFF	ON	OFF	OFF			
1M		ON	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	ON	ON	OFF	ON	OFF	OFF	OFF	OFF			
100k		ON	OFF	OFF	OFF	OFF	ON	OFF	ON	OFF	ON	ON	OFF	ON	OFF	ON	OFF	OFF			
10k		ON	OFF	ON	OFF	OFF	ON	OFF	ON	OFF	ON	ON	OFF	ON	OFF	OFF	OFF	OFF			
1k		ON	ON	OFF	OFF	OFF	OFF	OFF	ON	OFF	ON	ON	OFF	ON	OFF	ON	OFF	OFF			

RATE
10 & 100/SEC
25/SEC

RATIO*
RATIO
RATIO

*Not on 100/SEC

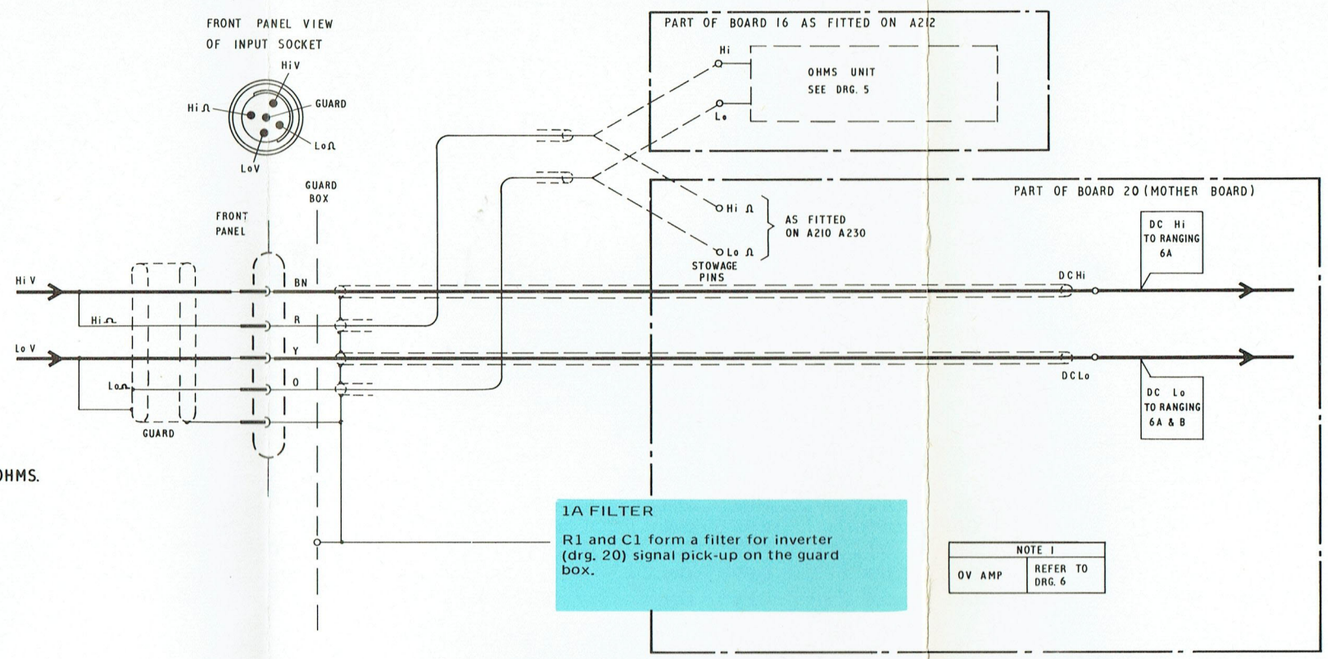
OFF
ON

ON
OFF

+See Drg. 12 (RATIO as fitted on A230, A233)

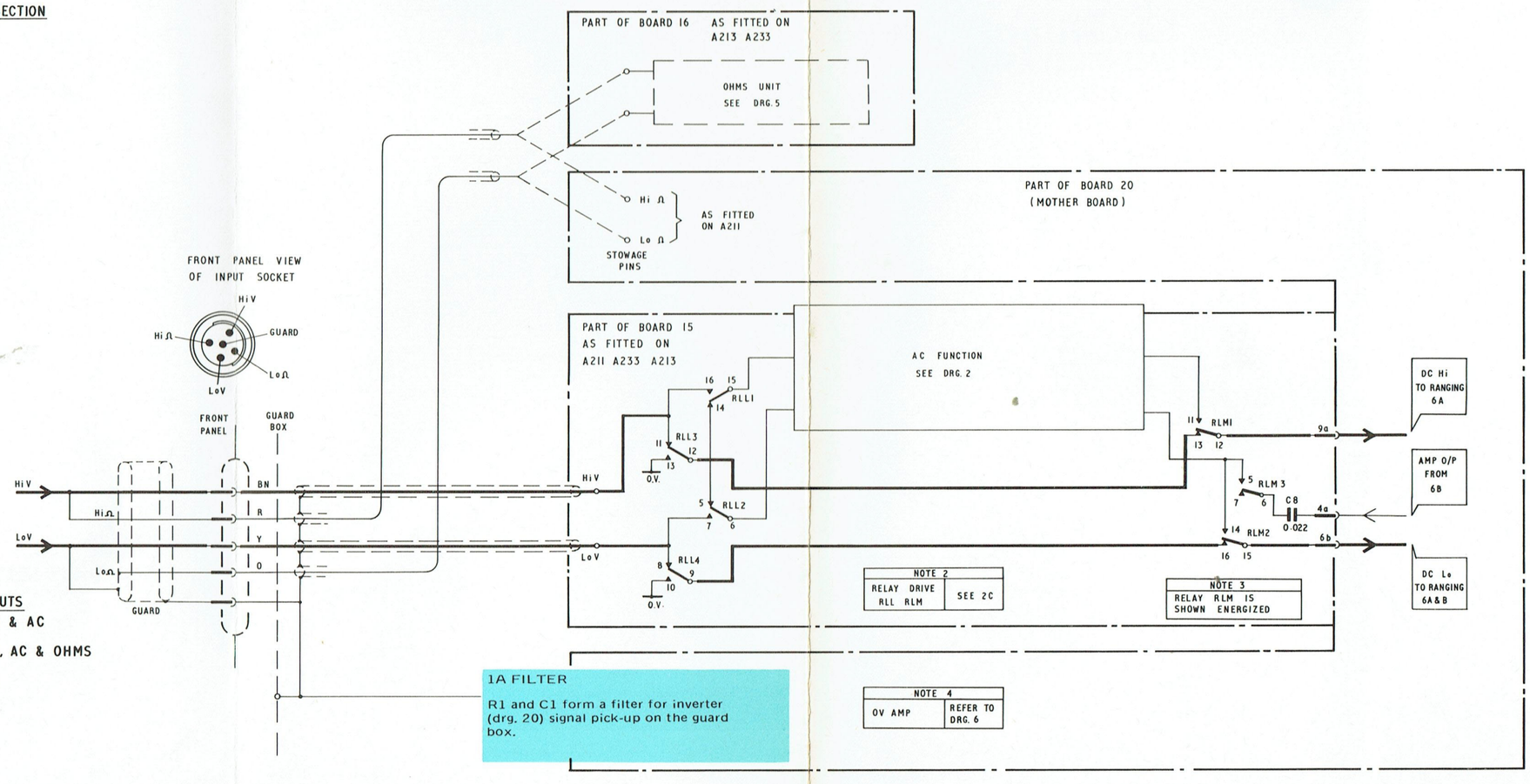
Relay Table

PART OF FLOATING SECTION



DVM TYPE	INPUTS
A 210, A 230	DC
A 212	DC & OHMS.

PART OF FLOATING SECTION



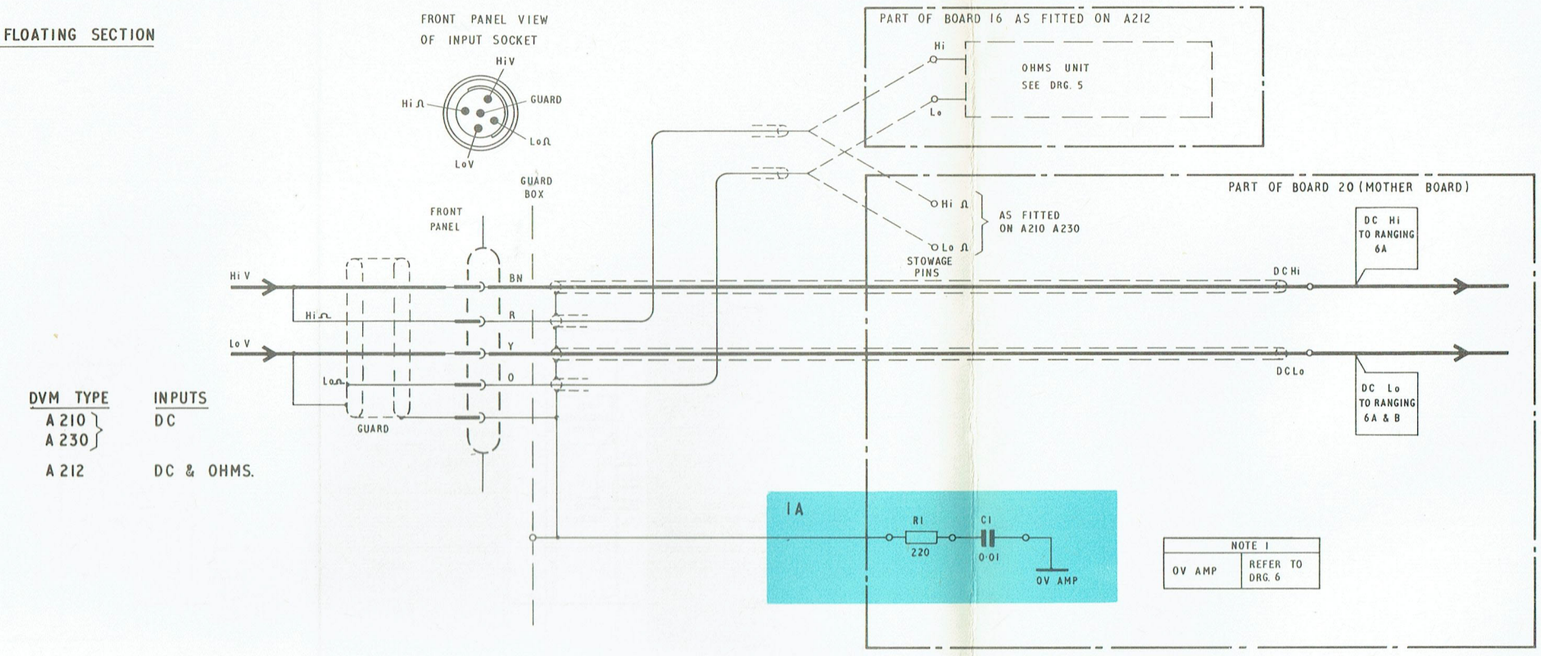
DVM TYPE	INPUTS
A 211	DC & AC
A 213, A 233	DC, AC & OHMS

The relays are shown for the DC mode and Ω mode of operation. *

MODE SWITCHING

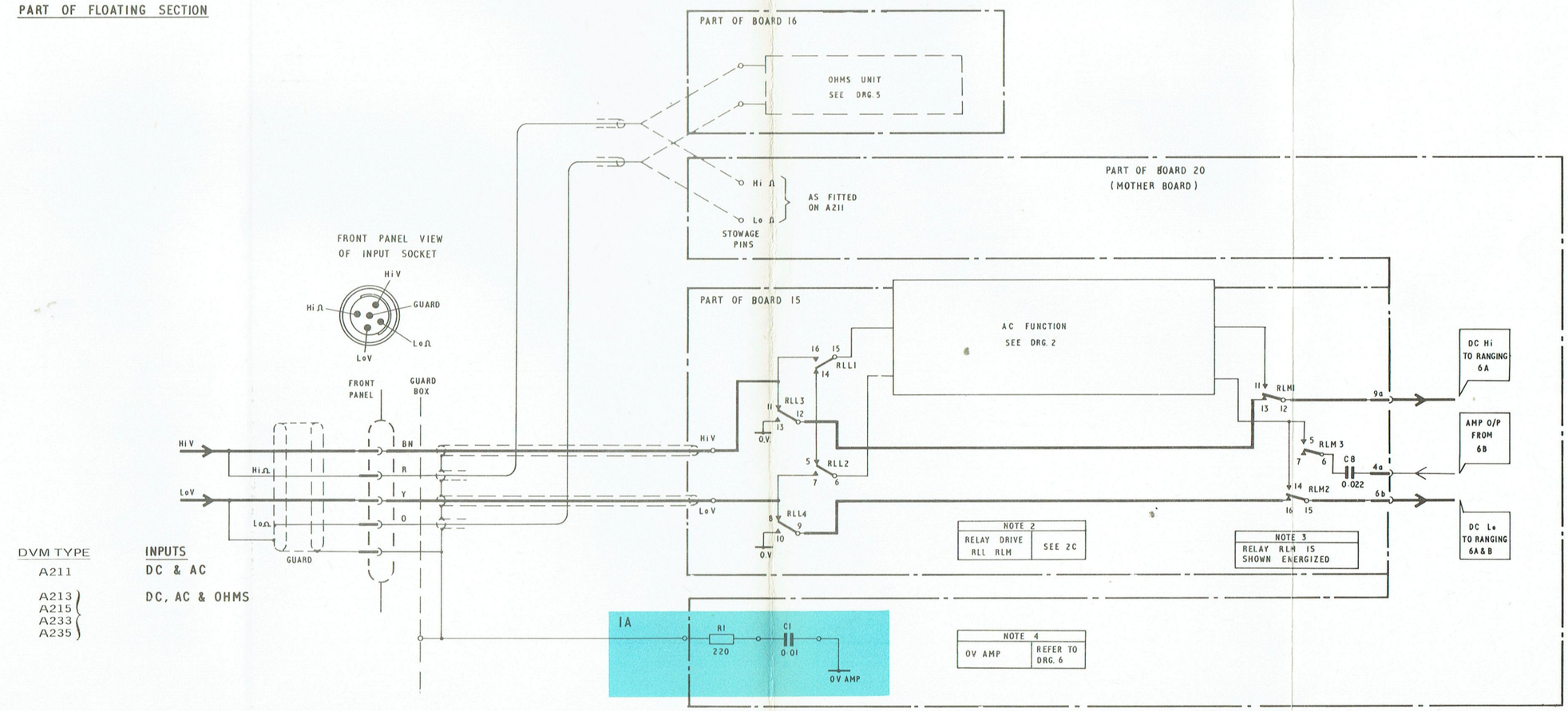
Relay	Mode	
	AC	DC & Ω
RLL	on	off
RLM	off	on

PART OF FLOATING SECTION



DVM TYPE	INPUTS
A 210, A 230	DC
A 212	DC & OHMS.

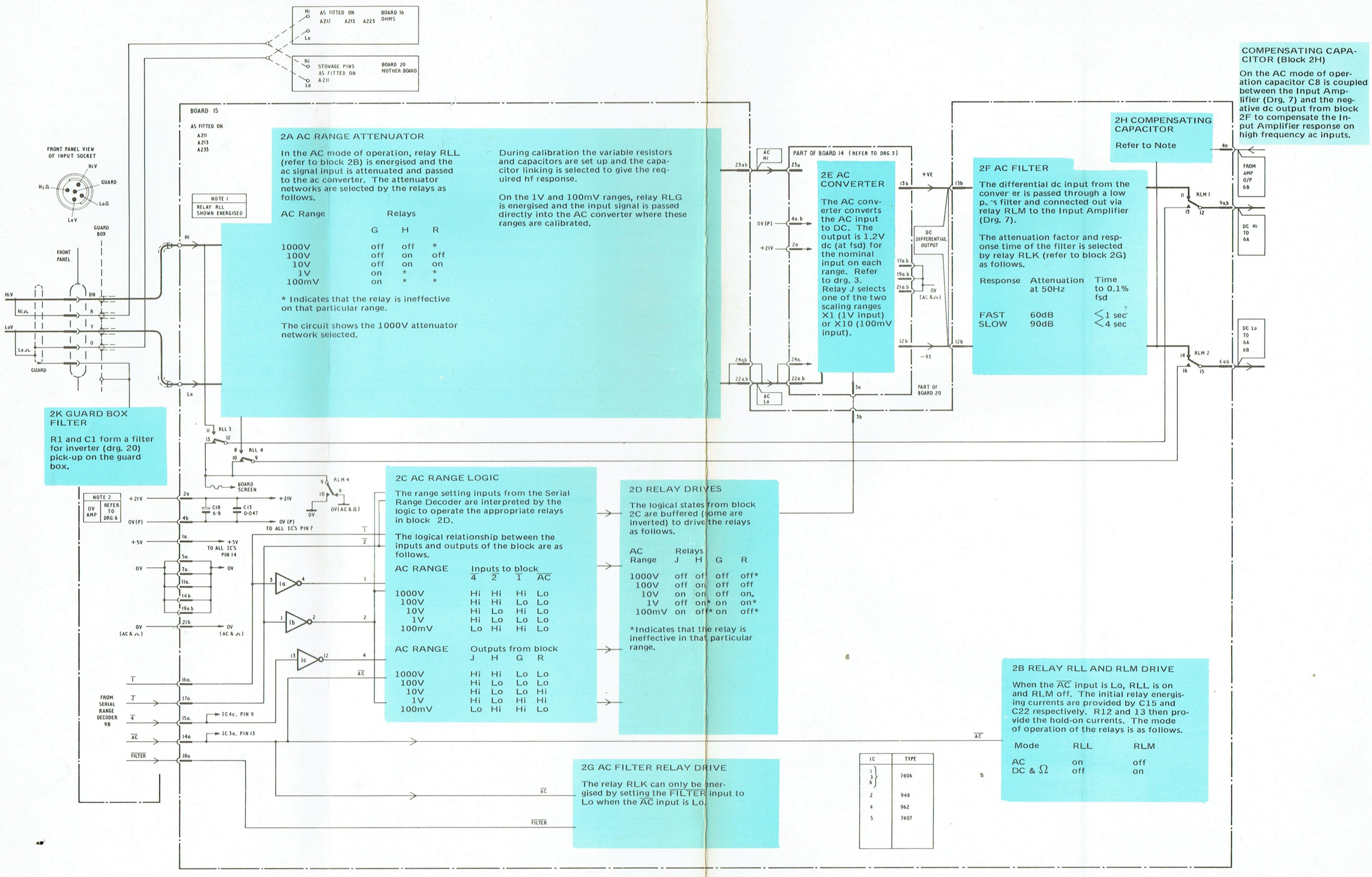
PART OF FLOATING SECTION

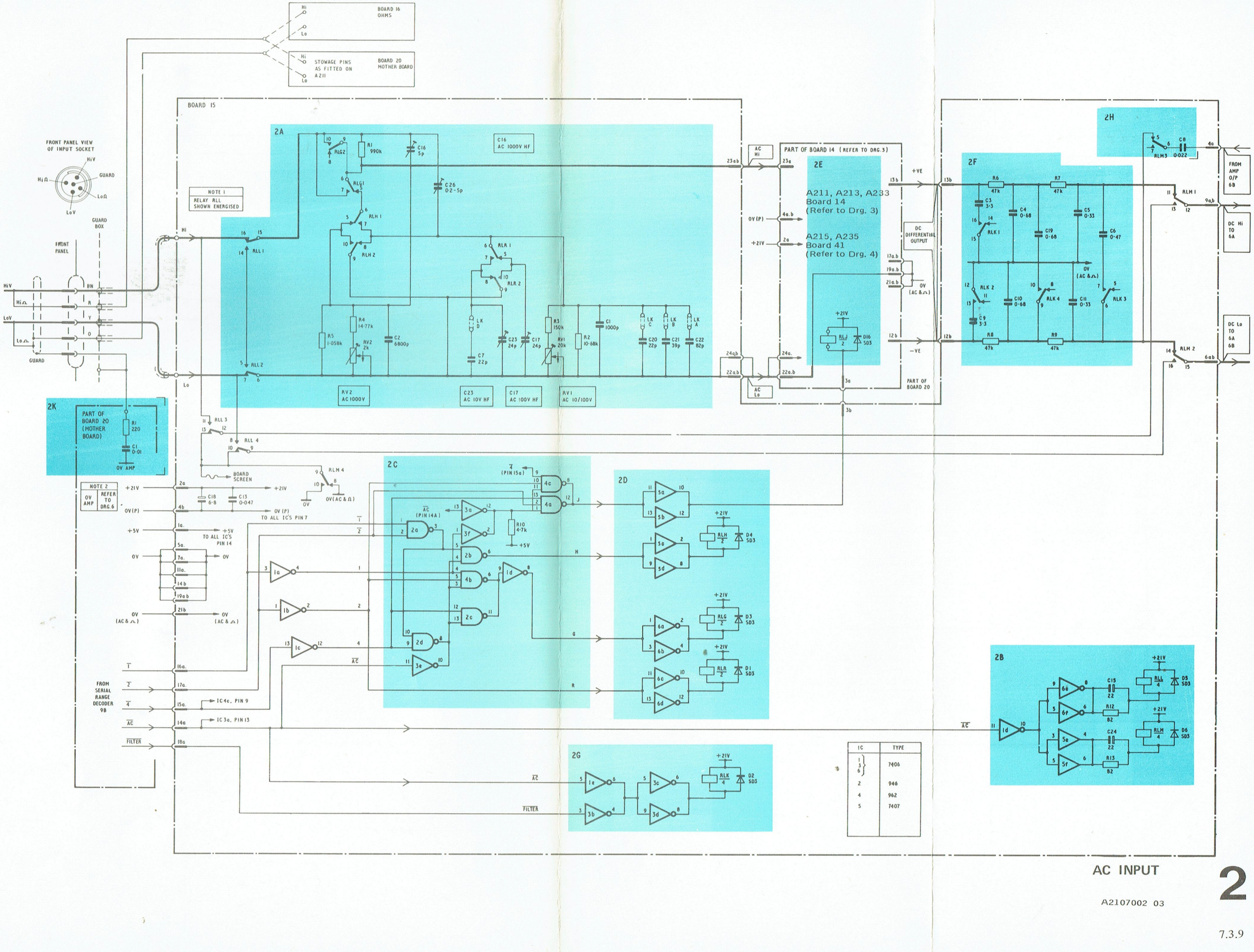


DVM TYPE	INPUTS
A211	DC & AC
A213, A215, A233, A235	DC, AC & OHMS

DC INPUT 1

A2107031 02


Hi AS FITTED ON A212 A213 A223 BOARD 16 OHMS
Lo
Hi STOWAGE PINS AS FITTED ON A211 BOARD 20 MOTHER BOARD
Lo
BOARD 15
AS FITTED ON A211 A213 A233
FRONT PANEL VIEW OF INPUT SOCKET
Hi V
Hi Ω
GUARD
Lo Ω
Lo V
GUARD BOX
FRONT PANEL
NOTE 1
RELAY RLL SHOWN ENERGISED
Hi
Lo
2A AC RANGE ATTENUATOR
In the AC mode of operation, relay RLL (refer to block 2B) is energised and the ac signal input is attenuated and passed to the ac converter. The attenuator networks are selected by the relays as follows.
AC Range Relays G H R
1000V off off *
100V off on off
10V off on on
1V on * *
100mV on * *
* Indicates that the relay is ineffective on that particular range.
The circuit shows the 1000V attenuator network selected.
During calibration the variable resistors and capacitors are set up and the capacitor linking is selected to give the required hf response.
On the 1V and 100mV ranges, relay RLG is energised and the input signal is passed directly into the AC converter where these ranges are calibrated.
2K GUARD BOX FILTER
R1 and C1 form a filter for inverter (drg. 20) pick-up on the guard box.
RLL 3
RLL 4
RLM 4
BOARD SCREEN
NOTE 2
OV AMP
REFER TO DRG 6
+21V
OV (P)
+5V
OV
OV (AC & Ω)
C18 6·8
C13 0·047
TO ALL IC'S PIN 7
TO ALL IC'S PIN 14
IC 4c, PIN 9
IC 3a, PIN 13
FROM SERIAL RANGE DECODER 9B
2C AC RANGE LOGIC
The range setting inputs from the Serial Range Decoder are interpreted by the logic to operate the appropriate relays in block 2D.
The logical relationship between the inputs and outputs of the block are as follows.
AC RANGE Inputs to block 4 2 1 AC
1000V Hi Hi Hi Lo
100V Hi Hi Lo Lo
10V Hi Lo Hi Lo
1V Hi Lo Lo Lo
100mV Lo Hi Hi Lo
AC RANGE Outputs from block J H G R
1000V Hi Hi Lo Lo
100V Hi Lo Lo Lo
10V Hi Lo Lo Hi
1V Hi Lo Hi Hi
100mV Lo Hi Hi Lo
2D RELAY DRIVES
The logical states from block 2C are buffered (some are inverted) to drive the relays as follows.
AC Range Relays J H G R
1000V off off off off*
100V off on off off
10V on on off on
1V off on* on on*
100mV on off* on off*
*Indicates that the relay is ineffective in that particular range.
2G AC FILTER RELAY DRIVE
The relay RLK can only be energised by setting the FILTER input to Lo when the AC input is Lo.
2B RELAY RLL AND RLM DRIVE
When the AC input is Lo, RLL is on and RLM off. The initial relay energising currents are provided by C15 and C22 respectively. R12 and 13 then provide the hold-on currents. The mode of operation of the relays is as follows.
Mode RLL RLM
AC on off
DC & Ω off on
IC TYPE
7406
946
962
7407
PART OF BOARD 14 (REFER TO DRG 3)
AC Hi
AC Lo
2E AC CONVERTER
The AC converter converts the AC input to DC. The output is 1.2V dc (at fsd) for the nominal input on each range. Refer to drg. 3. Relay J selects one of the two scaling ranges X1 (1V input) or X10 (100mV input).
+VE
−VE
DC DIFFERENTIAL OUTPUT
PART OF BOARD 20
2F AC FILTER
The differential dc input from the converter is passed through a low pass filter and connected out via relay RLM to the Input Amplifier (Drg. 7).
The attenuation factor and response time of the filter is selected by relay RLK (refer to block 2G) as follows.
Response Attenuation at 50Hz Time to 0.1% fsd
FAST 60dB ≤1 sec
SLOW 90dB ≤4 sec
2H COMPENSATING CAPACITOR
Refer to Note
COMPENSATING CAPACITOR (Block 2H)
On the AC mode of operation capacitor C8 is coupled between the Input Amplifier (Drg. 7) and the negative dc output from block 2F to compensate the Input Amplifier response on high frequency ac inputs.
FROM AMP O/P 6B
DC Hi TO 6A
DC Lo TO 6A 6B
RLM 1
RLM 2

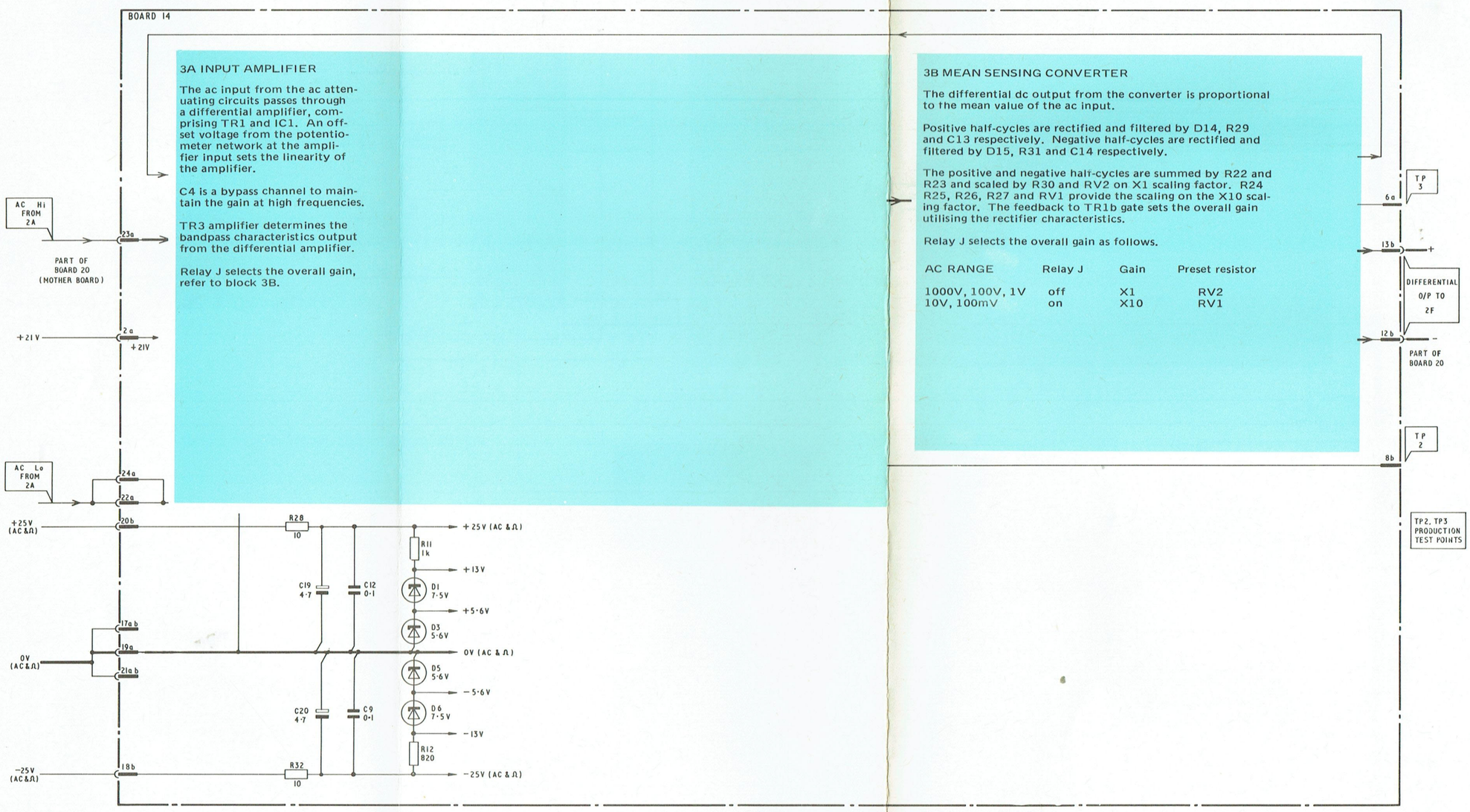


AC INPUT

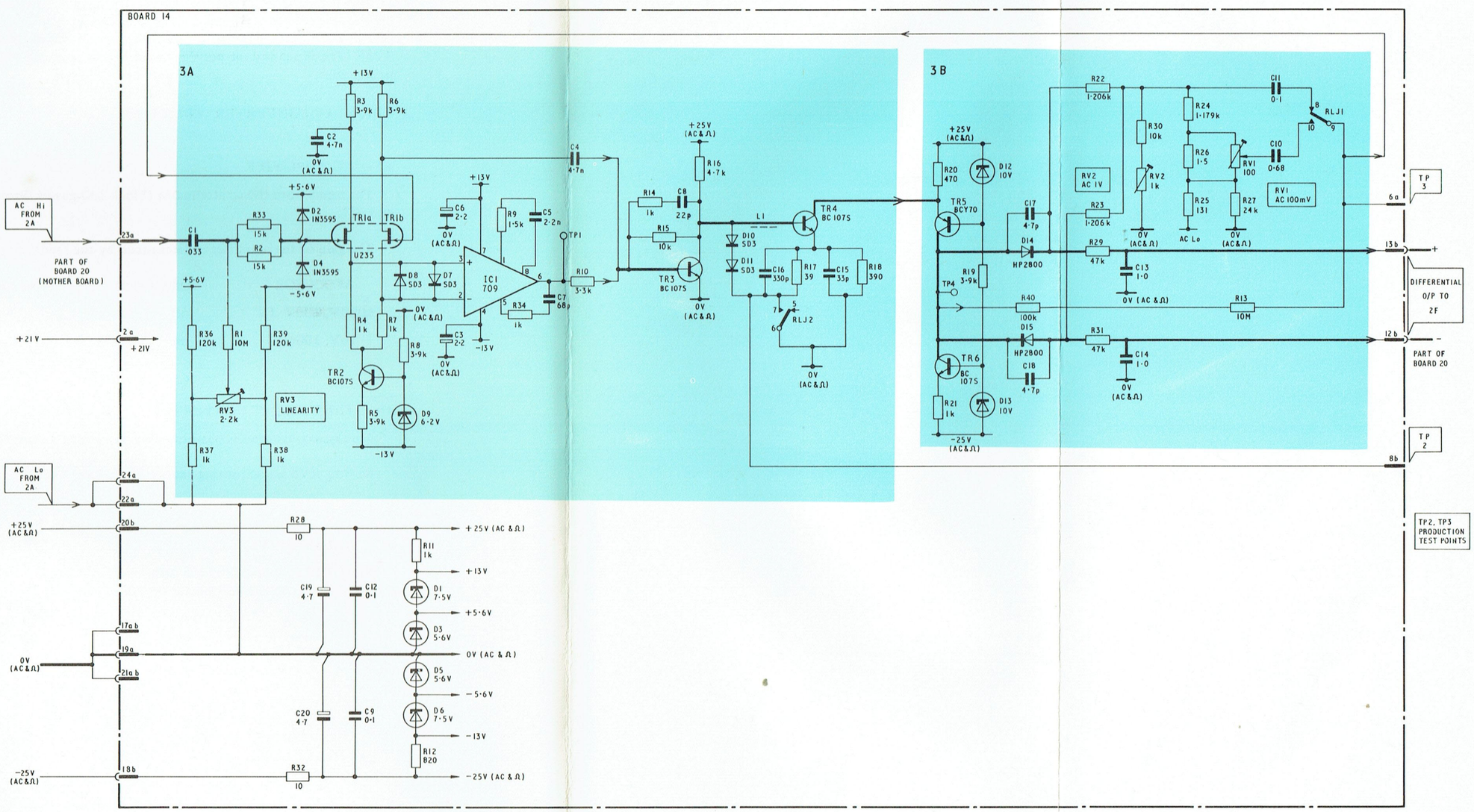
2

A2107002 03

PART OF FLOATING SECTION



PART OF FLOATING SECTION



AC CONVERTER (MEAN SENSING) **3**

A2107003 02

DRG. 4 AC CONVERTER (TRUE RMS)

Drg. 4 of this supplement shows the complete circuit diagram for Board 41, the true rms ac converter, and it complements with Drg. 2.

Drg. 2 shows the signal input circuit diagram for the mean sensing ac mode of operation. By altering the reference above block 2E to read "Part of Board 41 (Refer to Drg. 4)" Drg. 2 becomes the signal input circuit diagram for the true rms ac mode of operation applicable to DVM Types A215 and A235. The input and output signals are on the same pin numbers and the operation of Relay J is unaltered.

DRG 4 AC CONVERTER (TRUE RMS)

4A AC AMPLIFIER

The input from the ac attenuator (block 2A) passes through the differential amplifier, TR1 and IC1.

The gain of the amplifier is determined by the feedback network as follows.

AC RANGE	Relay J	Gain	Preset Calibration Resistor
1.000V, 100V, 1V	off	X1	RV2 (block 4B)
10V, 100mV	on	X10	RV1

4B TRUE RMS AC CONVERTER

True rms conversion is performed by IC2 which consists of an encapsulated module.

RV3 to RV6 are set during calibration to cancel offsets within the module.

4C RELAY DRIVE

Relay RLJ is operated by the logic circuits in Drg. 2. Refer to block 4A and the Relay Table at the front of this sub-section for the on-off states of the relay.

BOARD 41

4A

AC Hi FROM 2A

AC Lo FROM 2A

PART OF BOARD 20 (MOTHER BOARD)

23a

22a

24a

0V

C1 ·033

R1 10M

C2 ·01

R2 100k

+9·1V

D8 IN3595

D9 IN3595

-9·1V

R19 10k

TR1a

TR1b

U235

+14·7V

TR2 BC107

TR3 BC107

R3 10k

R5 10k

R4 10k

D3 3·3V

-14·7V

C16 100p

C14 1

R16 10M

C6 22p

R7 1·179k

RV1 A.C. 100mV

R9 4·7

RV1 1k

R8 131

RLJ

0V.

4B

+14·7V

IC1 LM318H

C8 330

D11 IN3595

D12 IN3595

R18 4·7

IC2 R310

-14·7V

C12 2·2

RV2 500

RV2 A.C. 1V

R13 50k

13b

OUTPUT TO 2F

12b

RV3 20k

RV4 20k

RV5 20k

RV6 20k

X = +14·7V

Y = -14·7V

RV3 - RV6 RMS OFFSET

PART OF BOARD 20 (MOTHER BOARD)

+25V (A.C. & Ω)

20b

R11 150

+14·7V

D4 5·6V

C9 0·47

C4 3300p

+9·1V

D5 9·1V

0V. (A.C. & Ω)

19a

0V.

D6 9·1V

C10 0·47

C5 3300p

-9·1V

D7 5·6V

-25V (A.C. & Ω)

18b

R12 150

-14·7V

+21V

2a

+21V

0V. (P)

4a,b

0V. (P)

4C

+21V

D10 SD5

RLJ

0V. (P)

3a

RELAY DRIVE FROM 20

LM318H

BOTTOM VIEW

U235

BOTTOM VIEW

R310

BOTTOM VIEW

AC CONVERTER (TRUE RMS) 4

PART OF FLOATING SECTION

PART OF BOARD 16

REF. TEST POINT 13a

+25V (AC & Ω) 20a — R4 10 — TP6 — +25V (AC & Ω)

0V 10b — C5 0·01 — C3 0·1 — LK (REFER K TO NOTE 1)

0V (AC & Ω) 19b — 0V (AC & Ω)

C4 0·1

−25V (AC & Ω) 18a — R5 10 — −25V (AC & Ω)

+21V 2a — TO RLN DRIVE RLP « (SEE DIAG. 9)

C2 0·047 — C1 22 — TP7

0V (P) 5a — TO IC2 PIN 7 (SEE DIAG. 9)

+5V 1a — +5V TO IC2 PIN 14 (SEE DIAG. 9)

NOTE 1
LK 'K'
LINK REMOVED :— A 213 A 233
LINK IN :- A 212

5A VOLTAGE REFERENCE

The output from this block is a reference voltage for the Constant Current Source, block 5B.

Diode D8, the reference diode is supplied with a constant current by TR3, D9, D10 and R7.

Links A to H are selected during calibration and RV1 adjusted to give the required current output from block 5B.

5B CONSTANT CURRENT SOURCE

The output from this block is a reference constant current source of either 1μA or 100μA depending on the resistance range selected.

TR6 and IC1 form a differential amplifier with a high input impedance and low input current that compares the reference voltage from block 5A with a voltage from the potential divider RV2, R24, R25 or from R26.

Amplifier TR6/IC1 compares the voltage Vref on TP1 with the current developed across R24, R25 and R26. The amplified error is applied to TR7 gate varying the current flow through TR7 so that the voltages on TP1 and TP4 are equal. As TP4 operates at constant voltage and TR7 gate draws virtually no current, all of the current through R24, R25 and R26 also passes through TR7.

The reference current output, 1μA or 100μA, is selected as follows.

Resistance Range	Effective DC Range (R = V/I)	Reference Current	Setting Resistor	Relay RLN
10MΩ	10V	1μA	RV2	off
1MΩ	1V	1μA		off
100kΩ	10V	100μA	RV1	on
10kΩ	1V	100μA		on
1kΩ	100mV	100μA		on

NOTE 3
RELAYS RLN, RLP, SHOWN ENERGISED

NOTE 2	
RELAY DRIVE	SEE DIAG. 9G
RLN RLP	

5D RELAY CONTACT PROTECTION

R1 and C6 limit relay contact arcing should a high voltage be present on the DVM input when switching to or from the OHMS mode of operation.

FRONT PANEL VIEW OF INPUT SOCKET

HiV, HiΩ, GUARD, LoΩ, LoV

FRONT PANEL — GUARD BOX

HiV, HiΩ, LoV, LoΩ, GUARD

BN, R, Y, O

TO UNKNOWN RESISTANCE

HiΩ, LoΩ

A5 DC INPUT

A210, A212, A230 } SEE DRG. 1 TOP

A211, A213, A233 } SEE DRG. 1 BOTTOM

U251 — D1, G1, S1, CAN, S2, G2, D2 — TOP VIEW

MT101B — G, S, D, SUB — TOP VIEW

D11, D14 (3-LEAD TYPE) PAD10 / BAV48 — A, CASE, C — BOTTOM VIEW

PART OF BOARD 20 (MOTHER BOARD)

5C FILTER

R1, C1 form a filter for inverter (Drg. 20) signal pick up on the guard box.

NOTE 4	
0V AMP	REFER TO DRG. 6

PART OF FLOATING SECTION

PART OF BOARD 16

REF. TEST POINT

13a

+25V (AC & Ω) — 20a — R4 10 — TP6 — +25V (AC & Ω)

0V — 10b — C5 0·01 — C3 0·1 — LK (REFER TO NOTE 1)

0V (AC & Ω) — 19b — 0V (AC & Ω)

C4 0·1

−25V (AC & Ω) — 18a — R5 10 — −25V (AC & Ω)

+21V — 2a — TO RLN DRIVE, RLP " (SEE DIAG. 9)

C2 0·047 — C1 22 — TP7

0V (P) — 2g — TO IC2 PIN 7 (SEE DIAG. 9)

+5V — 1g — +5V TO IC2 PIN 14 (SEE DIAG. 9)

NOTE 1
LK 'K'
LINK REMOVED :— A213 A233
LINK IN :— A212

5A

+25V (AC & Ω)

R3 120k — TP1

D8 9V 1N938 — RV1 100 — RV1 SET 100k Ω

TP5

R8 300

R9 86·6 — LK H

R10 169 — LK G

R11 332 — LK F

R12 649 — LK E

R13 1270 — LK D

R14 2438 — LK C — +25V (AC & Ω)

R15 4844 — LK B — R17 1·1k

R16 9624 — LK A — TR4 BCY70

R6 2·7k — TR3 BC107 — R19 2·7k

D9 SD3

R7 820 — D10 6·2V IN823

−25V (AC & Ω)

5B

+25V (AC & Ω)

RV2 SET 10MΩ

RV2 20k — R24 3·6M — R25 4·59M — R26 82·82k — RLN

R20 22k — TR6 U251 — R29 22k — TP4

0V (AC & Ω)

TP3

+25V (AC & Ω)

TP2 — IC1 741C — TR7 MT101B

R20 330k — R21 330k — C7 0·1 — R23 1·5k

+25V (AC & Ω)

D14 PADIO — D11 PADIO

+25V (AC & Ω) — R18 2·2M — TR5 BC107 — R22 100k — −25V (AC & Ω)

D12 7·5V

D13 7·5V

0V (AC & Ω)

5D

9 — 10 — RLP 1 — R1 1k — C6 0·01

RLP 3 — I6 — D15 — R2 10k

8 — 5 — RLP 2 — Lo Ω — R27 10k — Hi Ω

6 — 7

0V (AC & Ω)

NOTE 3
RELAYS RLN, RLP, SHOWN ENERGISED

NOTE 2	
RELAY DRIVE	SEE DIAG. 9G
RLN RLP	

FRONT PANEL VIEW OF INPUT SOCKET

Hi V — Hi Ω — GUARD — Lo Ω — Lo V

Hi Ω — Lo Ω

FRONT PANEL — GUARD BOX

TO UNKNOWN RESISTANCE

Hi V — BN

Hi Ω — R

Lo V — Y

Lo Ω — O

GUARD

PART OF BOARD 20 (MOTHER BOARD)

5C

R1 220 — C1 0·01 — 0V AMP

NOTE 4	
0V AMP	REFER TO DRG. 6

AS DC INPUT

A210, A212, A230 } See Drg. 1 Top

A211, A213, A215, A233, A235 } See Drg. 1 Bottom

U251 TOP VIEW — MT101B TOP VIEW — D11, D14 (3-LEAD TYPE) PADIO / BAV48 BOTTOM VIEW

Ω INPUT **5**

A2107005 02

JR/A210/2

7.3.13

PART OF FLOATING SECTION

TO BOARD 15, P4a
SEE DRGS 1 & 2

PART OF BOARD 19

6a,b

21a,b

DC LOW
SEE DRGS
1, DC INPUT
2, AC INPUT OR
5, Ω INPUT

6B INPUT AMPLIFIER

The input amplifier is a chopper stabilised inverting amplifier.

4a,b

TP1

0V

0V AMP

PART OF BOARD 20

19a,b 20a,b 22a,b

6A INPUT ATTENUATOR

On the 100V and 1000V dc ranges RLA is off. The resistor network provides a 100 : 1 attenuation for these ranges, the input amplifier having a different gain factor for each range. Refer to Block 6C.

RLA is off on all AC ranges.

PART OF BOARD 20 (MOTHER BOARD)

6E FILTER (RESPONSE)

C1 to C4 are switched to provide the response as selected on the front panel. RLF is off for FAST response and on for SLOW response RLQ and RLB set the appropriate filter capacitors. Refer to Relay Table at front of this section.

6C GAIN

The amplifier gain is set by the resistor network selected by relays RLB 2, RLC 1 and RLC 2.

Gain	RLB 2	RLC 1 and RLC 2
X1	OFF	OFF
X10	OFF	ON
X100	ON	OFF
X1000	ON	ON

6D SCALING

This resistor network sets the scaling for the 10V range on all sampling rates. Links A to J, RV5 and RV6 are set during calibration.

RLD	RATE	Fine Adjustment
Off	10 and 100/SEC	RV5
On	25/SEC	RV6

NOTE
REFER TO DRG 9 FOR DRIVE TO RELAYS RLA - RLD, RLF AND RLQ

DC Hi
SEE DRGS
1, DC INPUT
2, AC INPUT OR
5, Ω INPUT

9a,b

TO BOARD 18 4a

5a,b
17a,b
11a,b
12a,b
TO SCREENS

0V

STAR POINT

TP2

SCALED SIG O/P TO INTEGRATOR 8A

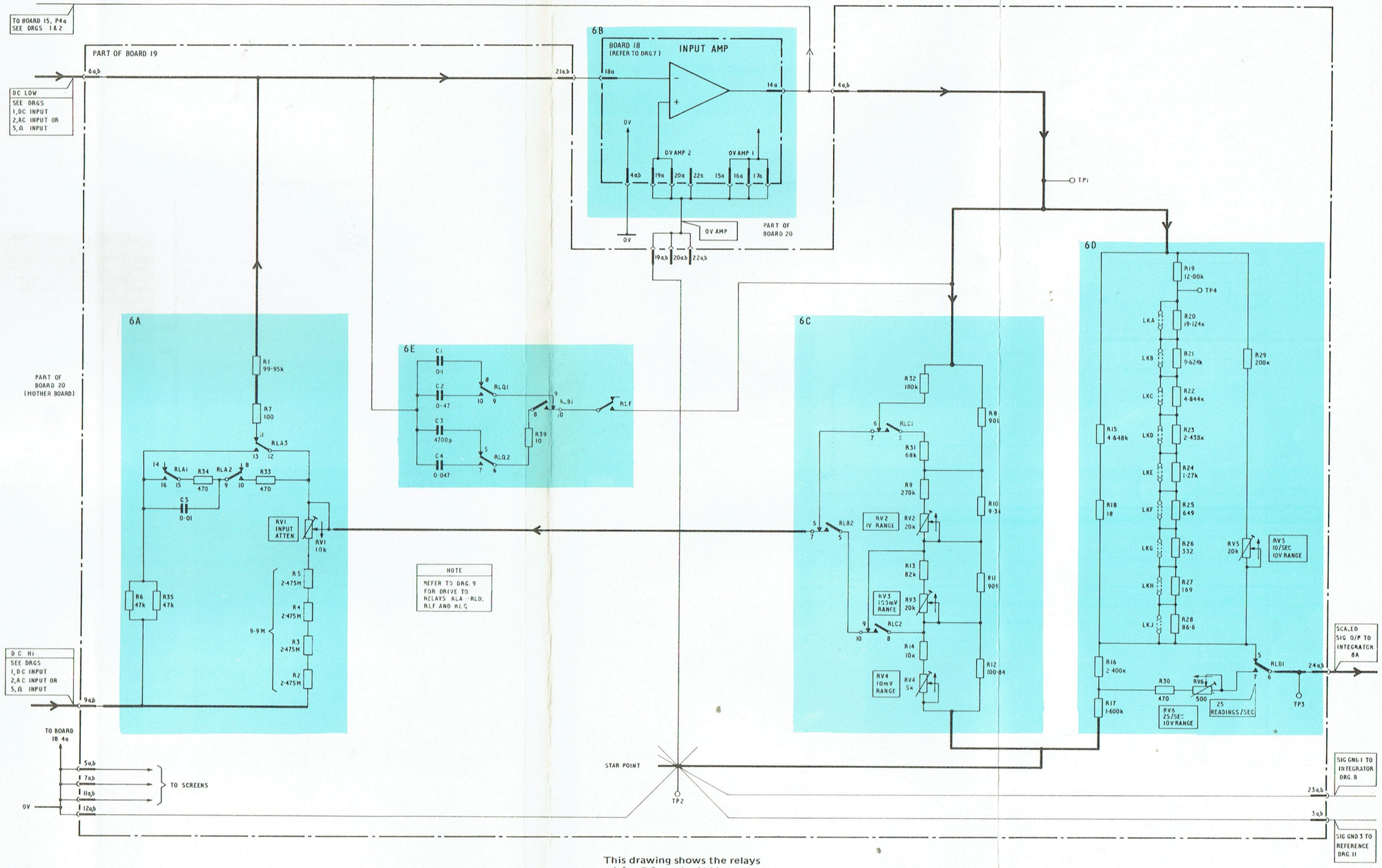
23a,b

SIG GND 1 TO INTEGRATOR DRG. 8

3a,b

SIG GND 3 TO REFERENCE DRG. 11

PART OF FLOATING SECTION

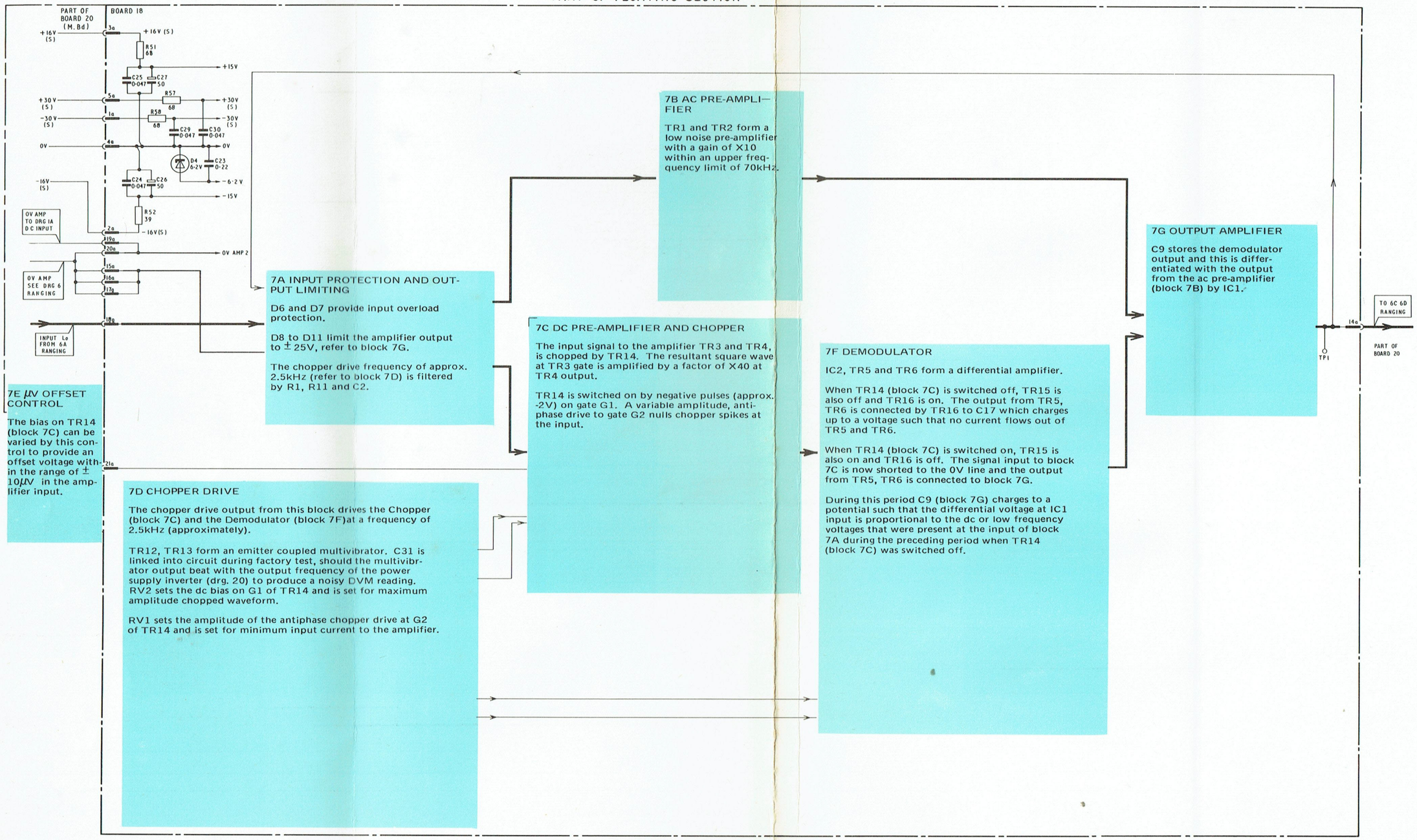


This drawing shows the relays set for DC mode, 1kV range 10/SEC sampling rate and FAST RESPONSE filter.

RANGE AND DC FILTER **6**

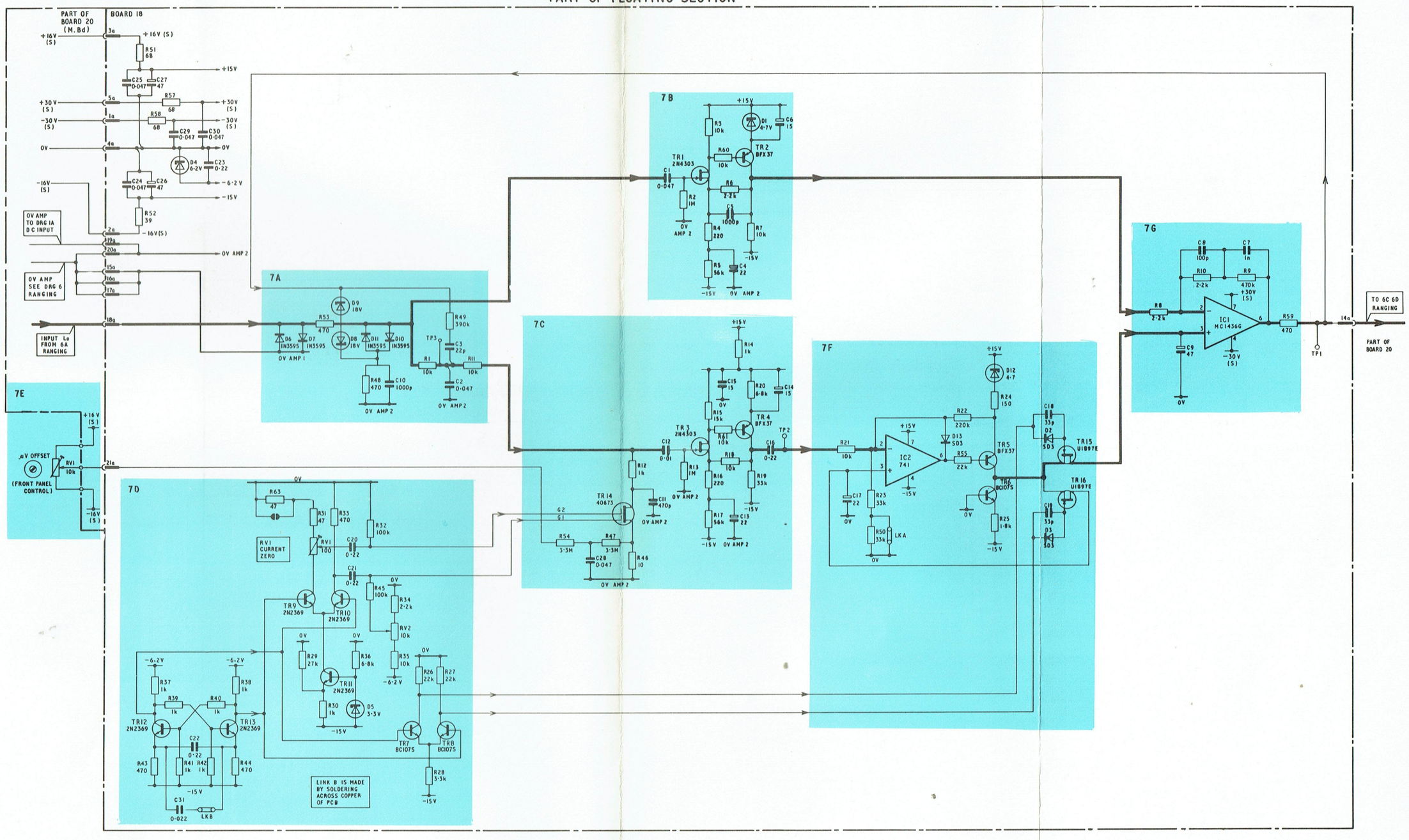
A2107006 02

PART OF FLOATING SECTION



TR14
G2 G1
D S
BASE VIEW

PART OF FLOATING SECTION



INPUT AMPLIFIER 7

A2107007 03

PART OF FLOATING SECTION

PART OF BOARD II

+ VE REF

RAMP-DOWN PERIOD (Block 8C)

The ramp-down period is proportional to the DVM input signal. For maximum DVM inputs (i.e. full-scale) the ramp-down periods are as follows.

Sampling Rate	Nominal Ramp-down Period
10/SEC	40ms
25/SEC	8ms
100/SEC	4ms

The polarity of the reference voltage is determined by the polarity of the DVM input signal as follows.

DVM Input	Reference Polarity	TR2	TR3
-ve	+ve	on	off
+ve	-ve	off	on

When the RATIO mode of operation is used an external voltage source is substituted for the internal reference source. RV9 is a calibration potentiometer for internal reference and RV8 is used for external reference (RATIO) calibration.

PUT)

20 (MOTHER BOARD)

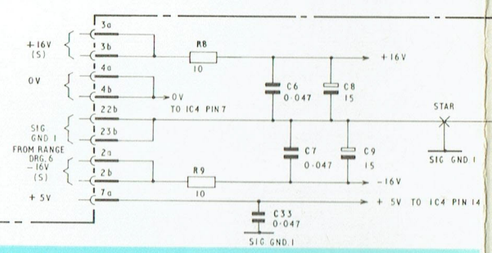
BOARD I?

8G OFFSET

As the first part of the ramp-down slope is nonlinear, the main counter (Drg. 15) in the Earthy Section does not accumulate a count during this period. To compensate for this a small offset voltage (approx. 30 bits on the DVM display) derived from the voltage reference lines and of the same polarity as the reference selected for ramp-down is connected to the non inverting input of the comparator (block 8F). The offset voltage allows the integrator output to go beyond zero before the end of ramp-down is detected.

TR16 switches the +ve reference (-ve DVM input) and TR17 the -ve reference (+ve DVM) to the offset voltage variable resistors. These variable resistors are set for the internal reference source and ratio (external reference source).

RV1 balances the initial offset voltages to the Comparator and is set, with 0V input at the DVM, to give equal +ve and -ve polarity decisions.



SIG GND 2 TO REFERENCE II

16ab

-VE DVM INPUT FROM 10L

-VE REF VOLTS FROM 11B

+VE REF VOLTS FROM 11A

8C RAMP-DOWN SWITCHES

A reference voltage of the correct polarity is connected into the input of the integrator (block 8D) by TR2 or TR3. TR2 or TR3 is switched on by applying a positive input to the appropriate diode (D2 or D3) during the ramp-down period. Refer to note.

8D INTEGRATOR

The DVM scaled signal input is integrated by TR9, TR10, TR11 and IC1 which form a high gain differential amplifier with low input current and low noise factor. R10 is the input resistor and C10 the integrating capacitor.

A drift correcting voltage is applied to the gate of TR9B after the end of ramp-down.

8E INVERTING AMPLIFIER

The output from the integrator is inverted by this amplifier with a gain of X10.

D7, D8, D9 and D10 limit the output swing from the amplifier.

8F COMPARATOR

The comparator is a high speed, high gain differential amplifier which

(a) Detects the signal Polarity in conjunction with block 8H, at the output of the inverting amplifier (block 8E).

(b) Detects the End of Ramp-down when the inverting amplifier output (block 8E) equals the offset voltage from block 8G.

DVM Input	IC3 Output
+ve	Lo
-ve	Hi

8H POLARITY DECISION

During the WAIT period t1, the POL ENABLE line is Hi.

The output from the block is as follows

DVM Input	DET	$\overline{DET}$
+ve	Lo	Hi
-ve	Hi	Lo

PART OF BOARD 20

24a DET

POL AND END OF R.D. TO 10E

23a $\overline{DET}$

RAMP-UP SWITCH (Block 8A)

TR1 is switched on by applying a positive input to diode D1 during the ramp-up period.

Sampling Rate	Ramp-up Period
10/SEC	40ms
25/SEC	20ms
100/SEC	4ms

'ART OF BOARD II

11b 11a

24b

8A RAMP-UP SWITCH

The scaled signal output from the input amplifier (drg. 6) is connected into the integrator (block 8D) when TR1 is switched on.

Refer to note for TR1 switching.

WAIT CMD (END OF R.U.) FROM 10K

15b 15a

8B WAIT SWITCH

The input to the integrator (block 8D) is grounded when TR4 is switched on. TR4 is switched on by applying a positive input to diode D4 during WAIT (the waiting time between the end of ramp-up and the start of ramp-down).

DRIFT CORRECT FROM 10H

14b 14a

8J INTEGRATOR DRIFT CORRECT

During the period between the end of ramp-down and the start of the next ramp-up the input to the integrator (block 8D) is grounded by applying a positive input to D5 to switch TR5 on. Also during this period TR6 is switched on to connect the output from the inverter (block 8F) to C16. C16 charges up to the drift error output from the integrator and the inverting amplifier. This error is applied to TR9b of the integrator as a correction factor during ramp-up and ramp-down.

22a

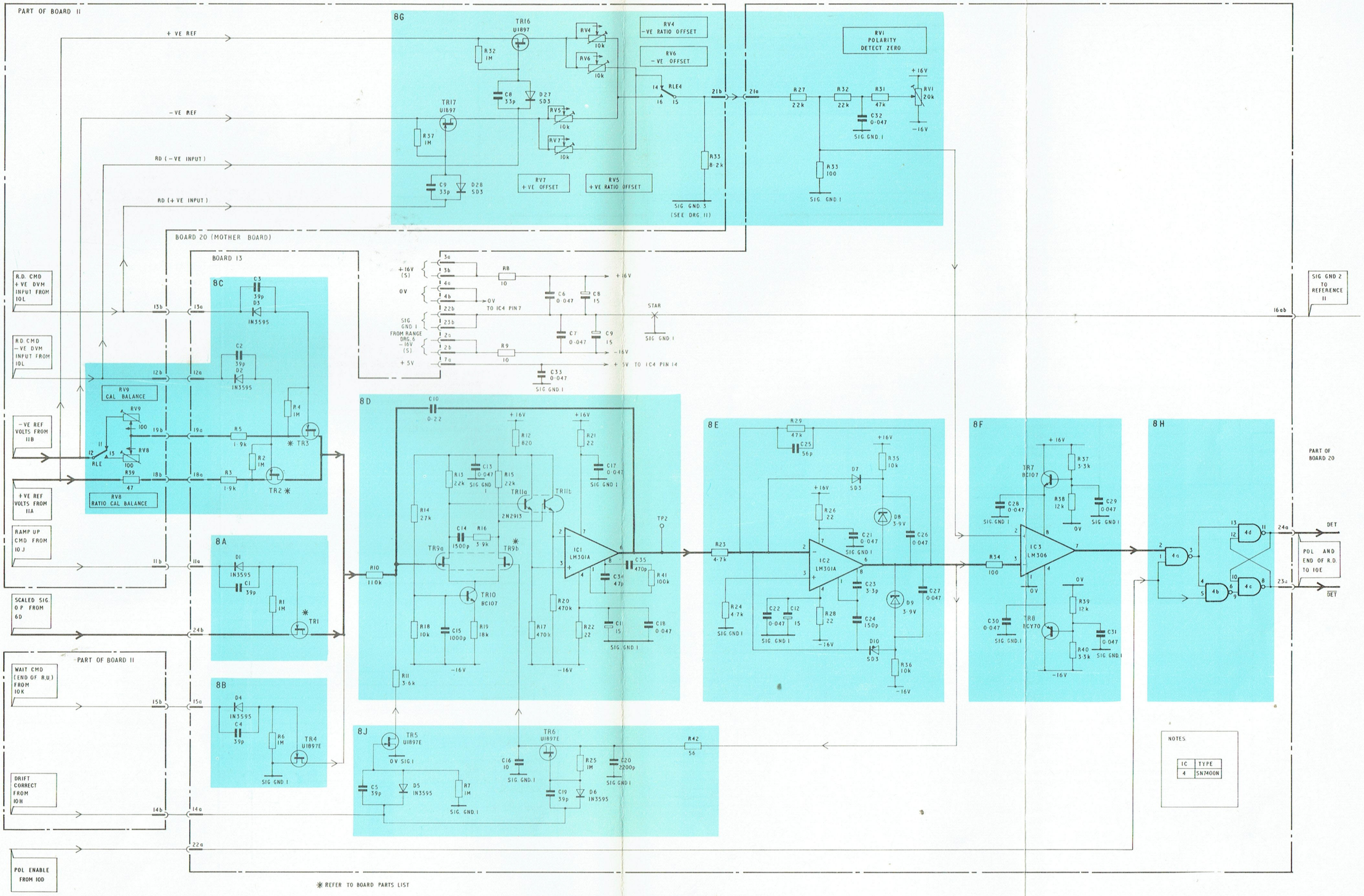
POL ENABLE FROM 10D

NOTES

IC	TYPE
4	SN7400N

✳ REFER TO BOARD PARTS LIST

PART OF FLOATING SECTION



INTEGRATOR 8

A2107008 02

WN/A210/1

7.3.19

PART OF FLOATING SECTION

PART OF BOARD 9

+5V
0V(S)
0V(P)
-16V(S)

1a,b
4a,b
5a
5b
2b

C15 0.047
C12 33
C1 0.047
C2 0.047
C11 0.047
C13 0.047
R13 82
C7 0.047

+5V TO ALL IC'S PIN 14
ALL OTHER 0V AND IC'S PIN 7
0V(S) TP8
IC1 PIN-7
-16V(S)
0V

NOTE No. 1 RELAY LOGIC FOR BLOCKS 9F TO 9K

The outputs from IC6 and IC12 (block 9B) operate the relay logic circuits that select the appropriate relay combination to give the mode and range of operation as selected on the front panel of the DVM or commanded externally. Refer to the Relay Table at the front of this Sub-section and to Drg. 16 for range and mode logic truth tables to determine the logic drive for each relay.

9C 24kHz SYNC. GATE

This gate is opened and closed by the input to pin 10 of IC15 as follows.

	IC15, pin 10
Open (during Reset)	Hi
Closed (from start Ramp-up to start Reset)	Lo

24 kHz SYNC FROM 21

19b

TP12

9B RANGE AND MODE REGISTER

This block converts the range and mode information from serial to parallel form and stores it.

During reset, the range and mode data held at IC9a is clocked into the Range and Mode register IC7 by the 24kHz Sync. clock.

The 9th clock edge transfers the Hi on IC9b from D to Q and via delay R18, C14 to IC6 and IC12, where the range and mode data is staticised as outputs to the relay drive logic (blocks 9F to 9K and 2B).

The 24kHz clock is then inhibited by the Sync. gate (block 9C) and the Hi from IC9b, pin 9 enables the control gate (block 9E).

$\overline{AC}$ AC $\overline{\Omega}$ Ω F $\overline{25}$ 25

$\overline{R}$ R $\overline{I}$ I $\overline{2}$ 2 $\overline{4}$ 4

PART OF BOARD 20 MOTHER BOARD

GUARD BOX

PART OF TOROID BLOCK 3096014

RANGE AND MODE CTL. PULSES FROM 14H

5 14 13 12 4

6a 7a 8a

9A CONTROL RECEIVER

Range, mode and control information is received, via the toroid transformer from the Earthy Section in the form of +ve and -ve (100ns) serial pulses during the reset period. The pulses are converted to logic levels.
A +ve going pulse at TR1 base results in the latch being set to Lo at IC2a. A +ve going pulse at TR2 base results in the latch being set Hi at IC2a.

Range and mode data received during the reset period is routed to the range and mode register (block 9B).

The following control commands are routed to the control gate (block 9E) at the appropriate times.

- Start ramp-up
- End ramp-up
- Wait
- Start ramp-down
- Drift correct

Refer to the waveforms in Sub-section 7.5.

9D RESET

The reset pulse from the Earthy Section is converted to logic levels.

A +ve going pulse (100ns) switches TR4 on. TR5 collector goes Hi and IC4, pin 2 is set Lo to reset the Range and Mode registers (block 9B) IC7 and IC9 to Lo.

A reset pulse always resets the logic to RESET condition, by overriding the Control input.

RESET PULSE FROM 13 J

3 11 10 9 2 1 17

11a 12a

NOTES	
IC	TYPE
BOARD 9	
1	7406
2	7400
8	7400
11	7400
13	7400
16	7400
17	7400
3	7473
4	7404
14	7404
5	7413
6	74175
12	74175
7	74164
9	7474
10	7410
11	7420
BOARD 19	
1	7407
2	7407
BOARD 16	
2	7406

RR INDICATES REED RELAY

9F RELAY A LOGIC

Refer to Note No. 1.

Relay A is switched on for all ranges and modes of operation except the 1000V and 100V DC ranges when the four inputs to the block are Hi switching off the relay.

$\overline{AC}$ $\overline{\Omega}$ $\overline{4}$ $\overline{2}$

PART OF BOARD 19 — SEE 6A

+5V 1b → +5V TO IC1 AND 2 PIN 14
0V(P) 1a → 0V (P) TO IC1 AND 2 PIN 7

PART OF BOARD 16 AS FITTED ON A 212 A 213 A 233

+5V 1a → TO IC2 PIN 14
+21V 2a → +21V
0V(P) 5a → TO IC2 PIN 7
TP7 C2 0.047 C1 22

9G RELAY N AND P LOGIC

Refer to Note No. 1.

Relay N is switched off for the 1000V and 100V, AC and DC ranges and also for the 10M ohms and 1M ohms ranges when both the $\overline{4}$ and $\overline{2}$ inputs will be Hi.

Relay P is switched on for the OHMS mode by the $\overline{\Omega}$ input going Lo.

SEE 5 B

6b

3b $\overline{\Omega}$

PART OF BD 19

9H RELAY B, C, D and Q LOGIC

Refer to Note No. 1.

$\overline{AC}$ 4 — Relays B and C are range relays that are switched according to the range selected.

Relay Q is a response (filter) relay that is switched according to the range and mode of operation.

$\overline{I}$ $\overline{AC}$ — Relay D is the RATE relay that is switched according to the sampling rate selected. The relay is off for the 10/SEC and 100/SEC sampling rates and is on for the 25/SEC rate.

F $\overline{25}$

SEE 6C 6E — SEE 6C — SEE 6E — SEE 6D

BOARD 20 (MOTHER BOARD)

9J RELAY F LOGIC

Refer to Note No. 1.

Relay F is a response (filter) relay that is switched according to the filter time selected (FAST or SLOW) for the range and mode of operation.

$\overline{F}$ — 18ab 13a

SEE 6E

17a 18a — $\overline{FILTER}$ — PART OF BD.15 AS FITTED ON A 211 A 213 A 233

$\overline{AC}$ 7b 14a $\overline{AC}$
$\overline{I}$ 9b 16a $\overline{I}$
$\overline{2}$ 16b 17a $\overline{2}$
$\overline{4}$ 8b 15a $\overline{4}$
R (GREY) TP7 — TO RATIO UNIT A230, A233

SEE 2B

9E CONTROL GATE

The control commands from block 9A are routed to the Integrator Control Logic (drg. 10) via this gate.

The gate is enabled with a Hi output from IC9b at the end of the Reset period. Control data from IC2c (block 9A) is then passed to the Integrator Control Logic (drg. 10).

9K RELAY E LOGIC

Refer to Note No. 1.

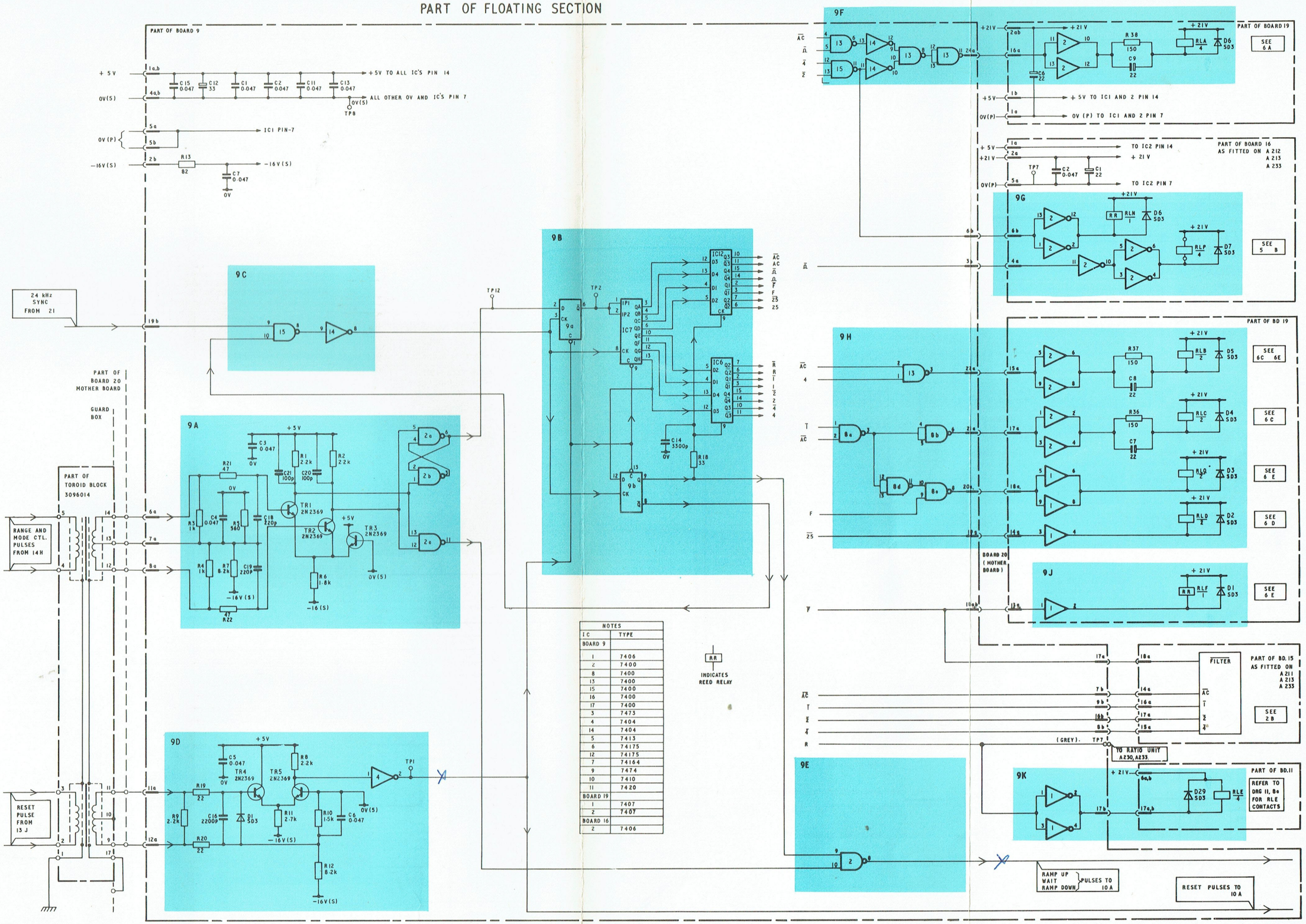
Relay E is switched on when RATIO is selected.

PART OF BD.11 — REFER TO DRG 11, 8c FOR RLE CONTACTS

RAMP UP, WAIT, RAMP DOWN } PULSES TO 10A

RESET PULSES TO 10A

PART OF FLOATING SECTION



NOTES	
IC	TYPE
BOARD 9	
1	7406
2	7400
8	7400
13	7400
15	7400
16	7400
17	7400
3	7473
4	7404
14	7404
5	7413
6	74175
12	74175
7	74164
9	7474
10	7410
11	7420
BOARD 19	
1	7407
2	7407
BOARD 16	
2	7406

RR INDICATES REED RELAY

CONTROL RECEIVER
RANGE & MODE DECODE 9

A2107009 03

PART OF FLOATING SECTION

PART OF BOARD II

CONTROL COUNTER OUTPUTS (Block 10A)

Measurement Cycle Periods	Decode circuit	Q1	Q2
Drift correct and reset	10H	0	0
Ramp-up	10J	1	0
Wait	10K	0	1
Ramp-down (+V input)	10L	1	1
Ramp-down (-V input)	10L	1	1

10A CONTROL COUNTER

The control counter receives measurement cycle pulses in serial form. The parallel outputs from the counter are decoded by logic circuits (blocks 10J, H, K and L) to issue command pulses to the integrator (Drg. 8).
The outputs from the counter are shown in block above.

10B t1 DELAY

Between the end of ramp-up and the start of ramp-down there is a Wait period of approx. 40μs. The Wait period is generated in the Earthy Section (Refer to drg. 14). At the start of the Wait period (i.e. at the end of ramp-up) a delay of approx. 16μs, termed the t1 delay is generated in this block. During this t1 delay the DVM input polarity is detected (Refer to drg. 8).
Refer to note for a description of this block.

t1 DELAY (Block 10B)

At the start of the Wait period Q2 line switches to Hi. This change of state is delayed to the input of IC5a by the time constant R15, C9. During this delay (t1) the output from IC5a is Lo.

TP4 goes Hi after t1 for the remaining part of the Wait period and also during Drift correct and Reset.

10C t2 DELAY

t2 delay inhibits the possible detection of the end of ramp-down at the beginning of ramp-down. This is effective on low DVM inputs when spurious signals could initiate a wrong decision.
Q1 line is switched to Hi at the start of Ramp-down. This change of state is delayed by the time constant R14, C8 to the input of 5b, resulting in IC5b output remaining Lo for approx. 6μs (i.e. t2). Refer to Note for the outputs from this block.

10D POLARITY ENABLE GATE

During time t1 (i.e. polarity decision time) the output from this block is Hi. The output is also Hi during Ramp-down time after t2. At all other times it is Lo.

10E POLARITY STORE

During time t1, IC16 is enabled and the data from block 8H is stored by 16c and 16d.

The outputs from this block are as follows:

DVM Input	16c($\overline{D}$)	16d(D)
+ve	Lo	Hi
-ve	Hi	Lo

BLOCK 10C OUTPUTS

The outputs from block 10C are as follows.

	IC10c	TP3	TP5
During t2	Hi	Hi	Lo
Ramp-down, after t2	Lo	Lo	Hi

10F RAMP-DOWN DECISION

Both outputs from this block are Hi until the end of Ramp-down when the outputs are as follows.

DVM Input	IC10a	IC10b
+ve	Lo	Hi
-ve	Hi	Lo

10G TRANSMISSION TO EARTHY SECTION

Polarity and end of Ramp-down are transmitted to the Earthy Section as follows.

Polarity
IC17b and c are enabled during Wait after t1 and the following outputs are obtained at TP10 and TP11.

DVM Input	TP10	TP11
+ve	Hi	Lo
-ve	Lo	Hi

Start of Ramp-down
IC17a and b are enabled during t2 and the following outputs are obtained.

DVM Input	TP10	TP11
+ve	Lo	Hi
-ve	Hi	Lo

End of Ramp-down
At the end of Ramp-down the following outputs are obtained.

DVM Input	TP10	TP11
+ve	Hi	Lo
-ve	Lo	Hi

10H DRIFT CORRECT COMMAND OUTPUT

The output is Hi only when the two inputs are Hi.

10J RAMP-UP COMMAND OUTPUT

During the Ramp-up period the two inputs to this block are Hi to give a Hi output that switches on TR1 in block 8A.

Sampling Rate	Nominal Ramp-up Period
10/SEC	40ms
25/SEC	20ms
100/SEC	4ms

10K WAIT COMMAND OUTPUT

During the WAIT period (the waiting time between the end of ramp-up and the start of ramp-down) the two inputs to this block are Hi causing the output to be Hi.

10L RAMP-DOWN COMMAND OUTPUT

-ve DVM input.

The output from TR4 is Hi only when the three inputs are Hi.

+ve DVM input

The output from TR5 is Hi only when the three inputs are Hi.

10M 12V AND 22V LINES

The voltage outputs from this block limit the voltage levels on TP1 to TP5 which are applied to FET gates, refer to drg. 8.

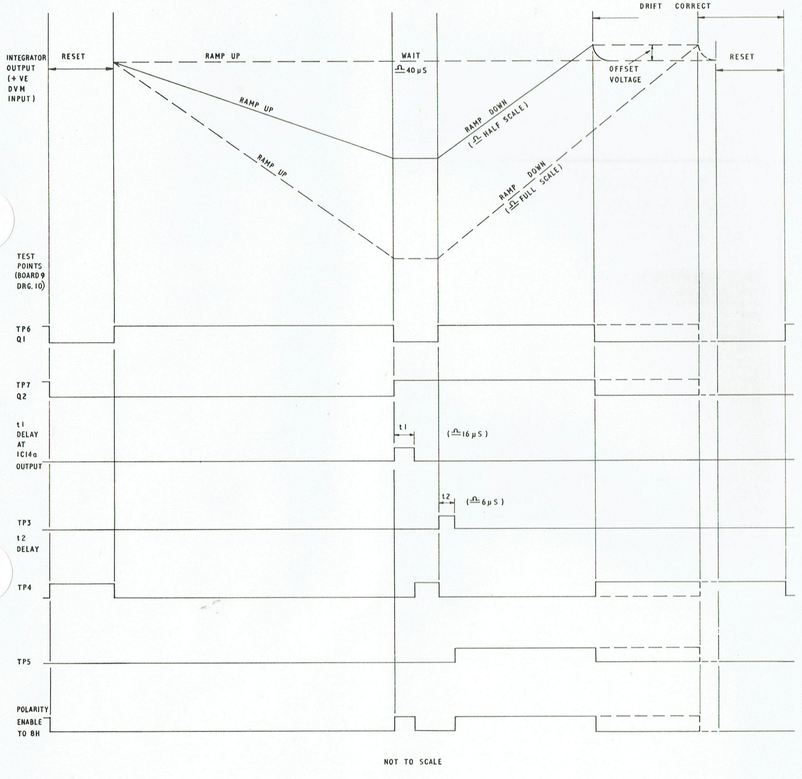
X +12v
Y -22v

NOTE

DIODE	TYPE
▷|	SD3

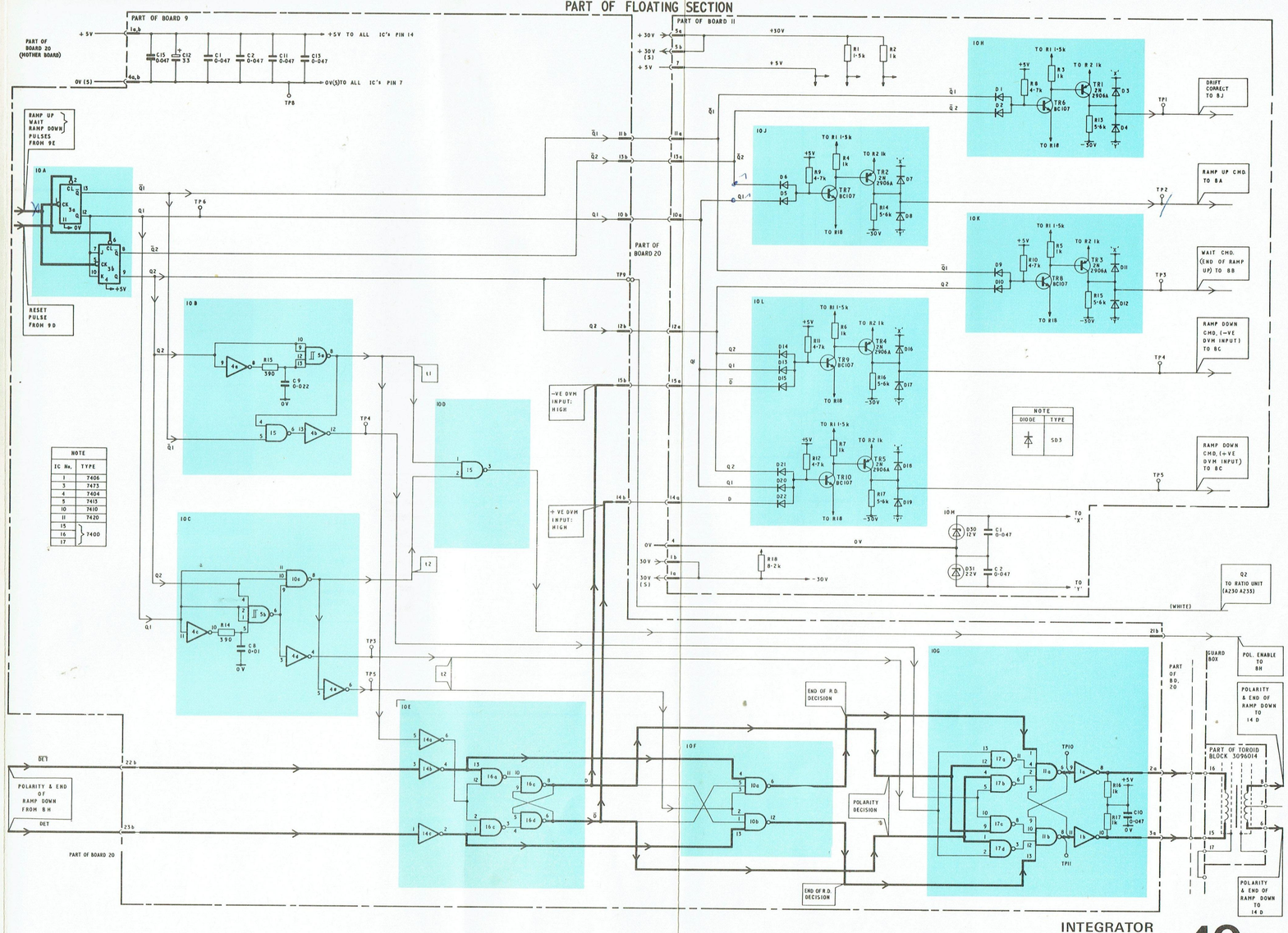
DRIFT CORRECT TO 8J
RAMP UP CMD. TO 8A
WAIT CMD. (END OF RAMP UP) TO 8B
RAMP DOWN CMD. (-VE DVM INPUT) TO 8C
RAMP DOWN CMD. (+VE DVM INPUT) TO 8C
TO 'X'
TO 'Y'
Q2 TO RATIO UNIT (A230 A233)
(WHITE)
POL. ENABLE TO 8H
POLARITY & END OF RAMP DOWN TO 14D
POLARITY & END OF RAMP DOWN TO 14D
PART OF TOROID BLOCK 3096014
GUARD BOX
PART OF BD. 20
PART OF BOARD 20
PART OF BOARD 20
POLARITY & END OF RAMP FROM 8H
-VE DVM INPUT: HIGH
+VE DVM INPUT: HIGH
END OF R.D. DECISION
END OF R.D. DECISION
POLARITY DECISION

INTEGRATOR CONTROL TIMING



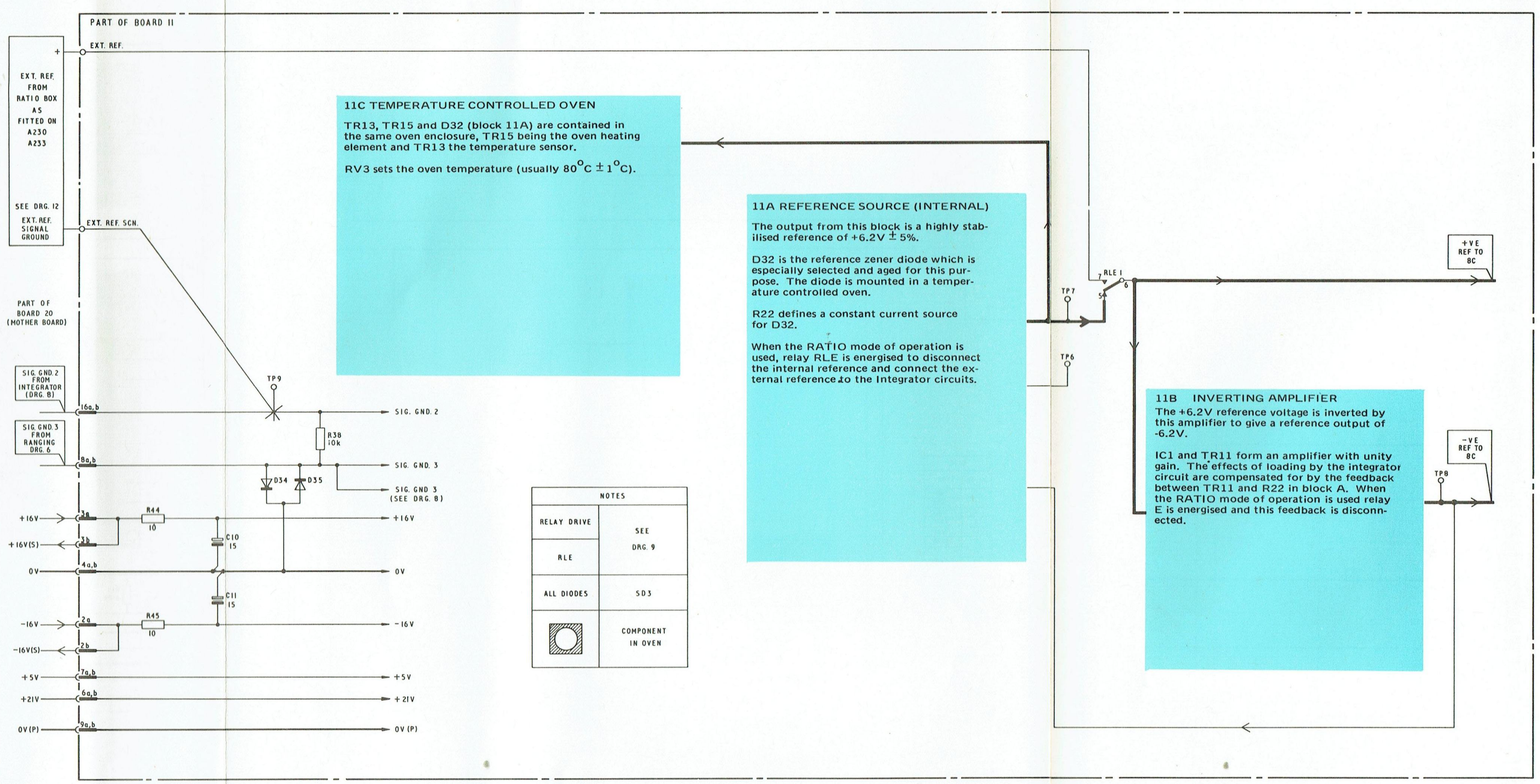
NOT TO SCALE

PART OF FLOATING SECTION

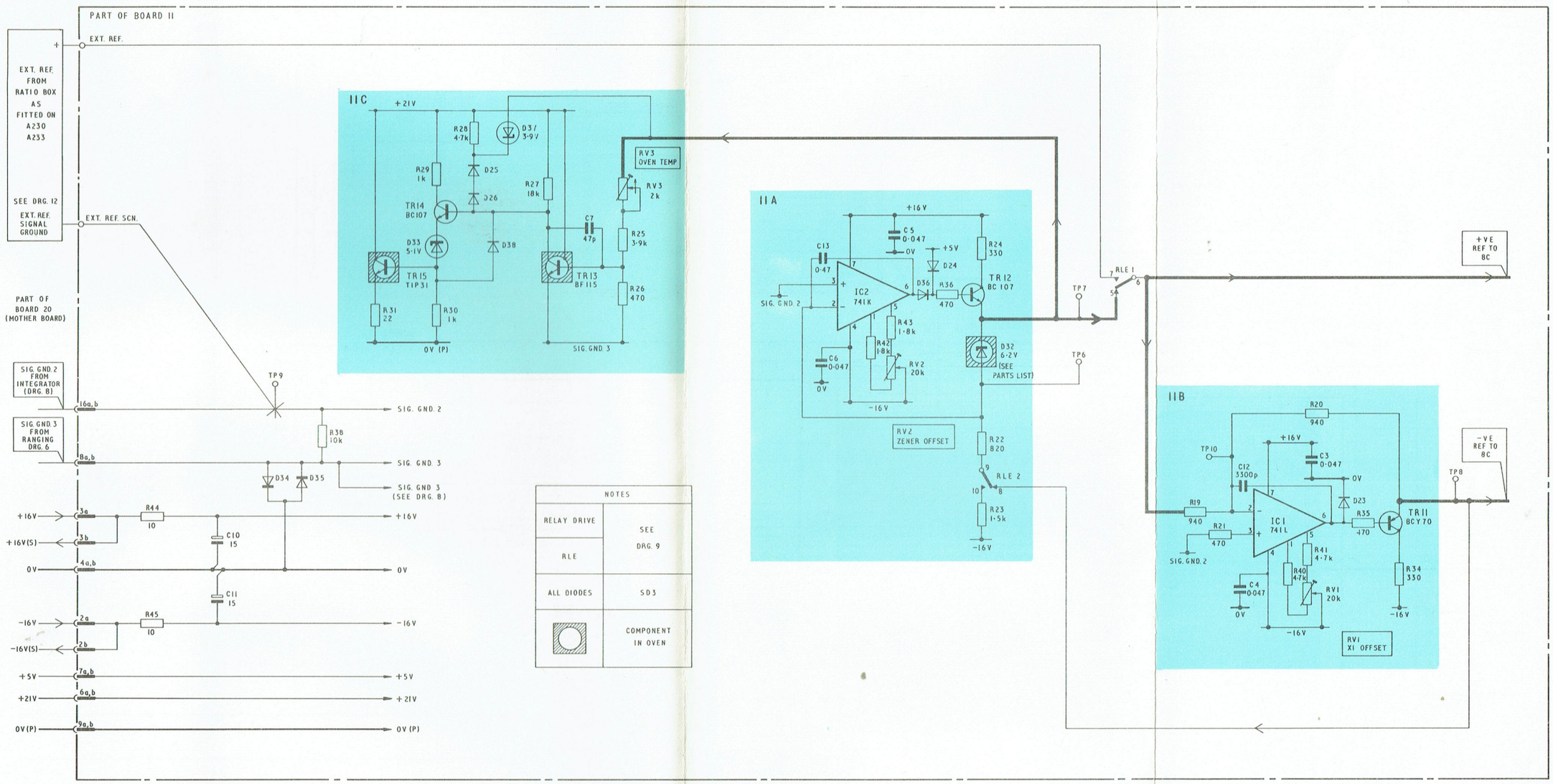


INTEGRATOR CONTROL LOGIC
A2107010 03

10


PART OF BOARD 11
EXT. REF.
EXT. REF. FROM RATIO BOX AS FITTED ON A230 A233
SEE DRG. 12
EXT. REF. SIGNAL GROUND
EXT. REF. SCN.
PART OF BOARD 20 (MOTHER BOARD)
SIG. GND 2 FROM INTEGRATOR (DRG. 8)
SIG. GND 3 FROM RANGING DRG. 6
TP9
R38 10k
D34
D35
SIG. GND. 2
SIG. GND. 3
SIG. GND 3 (SEE DRG. 8)
+16V
+16V(S)
0V
-16V
-16V(S)
+5V
+21V
0V(P)
R44 10
C10 15
C11 15
R45 10
11C TEMPERATURE CONTROLLED OVEN
TR13, TR15 and D32 (block 11A) are contained in the same oven enclosure, TR15 being the oven heating element and TR13 the temperature sensor.
RV3 sets the oven temperature (usually 80°C ± 1°C).
11A REFERENCE SOURCE (INTERNAL)
The output from this block is a highly stabilised reference of +6.2V ± 5%.
D32 is the reference zener diode which is especially selected and aged for this purpose. The diode is mounted in a temperature controlled oven.
R22 defines a constant current source for D32.
When the RATIO mode of operation is used, relay RLE is energised to disconnect the internal reference and connect the external reference to the Integrator circuits.
NOTES
RELAY DRIVE
RLE
SEE DRG. 9
ALL DIODES
SD3
COMPONENT IN OVEN
TP7
TP6
RLE 1
+VE REF TO BC
-VE REF TO BC
TP8
11B INVERTING AMPLIFIER
The +6.2V reference voltage is inverted by this amplifier to give a reference output of -6.2V.
IC1 and TR11 form an amplifier with unity gain. The effects of loading by the integrator circuit are compensated for by the feedback between TR11 and R22 in block A. When the RATIO mode of operation is used relay E is energised and this feedback is disconnected.

PART OF FLOATING SECTION



NOTES	
RELAY DRIVE	SEE DRG. 9
RLE	
ALL DIODES	SD3
	COMPONENT IN OVEN

A228 RATIO UNIT

0V
-16V
+16V
+21V
0V(P)
+5V
FROM FLOATING POWER SUPPLIES DRG 21

BOARD 32 (A228 MOTHER BOARD)

+5V 0V(P) +21V +16V -16V 0V

BOARD 35

12A2 RELAY LOGIC DRIVE

IC1 and 2 are gated monostables that are enabled when the A1 and A2 inputs are Lo. This occurs when Range is selected, the Hi on the R line is inverted by IC3b.

At the end of Ramp-down the Lo on the Q2 line is inverted by IC3a and the Hi on B of IC1 initiates a Hi output of 6 to 10ms from Q. The Hi is inverted by IC3f which switches on coil 1 of RLS. $\overline{Q}$ of IC1 will go Hi at the end of the one shot input to initiate a Hi output from IC2 for 6 to 10ms. This Hi is inverted by IC3e and coil 2 of RLS is energised. Coil 2 remains latched until the end of the next Ramp-down period when the above cycle of events is repeated.
IC3c and d act as dummy loads to stabilise the +21V line when the relay coils are switched in and out.

Q2 FROM INT.CTL. LOGIC 10 (WHITE)
R FROM RANGE AND MODE DECODE 9 (GREY)
Q2 8b
INH 10b
TO DVM FLOATING BOX STAR POINT

TO +5V AND ALL IC'S PIN 14
TO 0V (P) AND ALL IC'S PIN 7
R5 5·6
C4 33
C5 0·047
C6 0·047
14b
12b
16b
GROUND PLANE
TP3
0V(P)
+21V
+16V
-16V
0V

D1 SD3
D2 SD3
TP1
TP2

RELAY DRIVE WAVEFORMS WITH 'RATIO' SELECTED
TP9 BD9 (DRG 10) +5V 0V
TP1 +21V 0V 6/10mS
TP2 +21V 0V 6/10mS
END OF RAMP DOWN — DRIFT CORRECT

WHEN 'RATIO' IS CANCELLED TP1 AND TP2 RISE TO +21V

+21V
20b 18b 16b
RLS2 RLS1 +21V
0V (P)

BOARD 32 (A228 MOTHER BOARD)

BOARD 36

12A1 EXTERNAL REFERENCE INPUT

R1 to R11 and C1 form an external reference input scaling attenuator (40dB at 50 Hz) and filter.

Links A to H and RV1 are set during calibration.

RLS is a double-pole, latching relay with mercury wetted contacts.

At the end of the Ramp-down period coil 1 of the relay is energised for a period of 6 to 10ms. During this time C2 charges up to the scaled input reference voltage. Coil 2 is then energised for a period of 6 to 10ms, the relay contacts change-over and remain latched. The amplifier (block 12A3) now operates as a voltage follower to transfer the scaled input held on C2 to the Floating Section of the DVM. At the end of the next ramp-down period coil 1 is again energised and the sequence of operation is repeated.

DVM BACK PANEL
+VE RED I/P Hi
EXTERNAL REFERENCE INPUT
BLACK -VE I/P Lo
GUARD GREEN
CAUTION GUARD IS CONNECTED TO SIGNAL INPUT GUARD (FRONT PANEL)
RV1 REF CAL

AMP O/P
MONITOR I/P CURRENT SET BY RV1 B'D33
AMP I/P
R1 39k
C1 4700p
R3 2·2k
18a

RV1 B'D32 OFFSET (SET ON +2V REF I/P)
21a

12A4 OFF-SET CONTROL

Internal off-sets generated in the amplifier can be compensated for by RV1 which is set during calibration.

NOTES

IC No.	LOCATION	TYPE
1,2	BOARD 35	SN74121
3	BOARD 35	SN7406

PART OF BOARD 33

+16V +15V R10 330 C14 0·047 3a +16V
0V 4a 0V
-16V -15V R11 330 C15 0·047 2a -16V

12A3 AMPLIFIER

The scaled external reference voltage input is connected to the Reference circuits (Drg. 11) via this amplifier when the ratio mode of operation is selected.

+16V R2 4·7K
14a OP
SIG GND A 16a SG
17a 19a 20a SIG GND B

RELAY BASE
No No Nc Nc
S + C C +

DVM FLOATING SECTION
EXT REF+ TO REFERENCE (SEE DRG.11)
EXT REF SIG GND TO REFERENCE (SEE DRG.11)
FROM RATIO POWER RAIL OUTER SCREEN

A228 RATIO UNIT

0V
-16V
+16V
+21V
0V(P)
+5V
FROM FLOATING POWER SUPPLIES DRG 21

BOARD 32 (A228 MOTHER BOARD)

BOARD 35

12A2

Q2 FROM INT.CTL. LOGIC 10 (WHITE)

R FROM RANGE AND MODE DECODE 9 (GREY)

TO DVM FLOATING BOX STAR POINT

R1 4·7K
R2 4·7K
C2 1·0
R3 10K
IC1 74121
C11 0·047
C3 1·0
R4 10K
IC2 74121
R7 680
R6 680
3a 3b 3c 3d 3e 3f
D1 SD3
D2 SD3
TP1
TP2

RELAY DRIVE WAVEFORMS WITH 'RATIO' SELECTED

TP9 BD9 (DRG 10)
TP1
TP2
6/10mS
END OF RAMP DOWN
DRIFT CORRECT

WHEN 'RATIO' IS CANCELLED TP1 AND TP2 RISE TO +21V

TO +5V AND ALL IC'S PIN 14
TO 0V (P) AND ALL IC'S PIN 7
R5 5·6
C4 33
C5 0·047
C6 0·047
GROUND PLANE
TP3

+5V 0V(P) +21V +16V -16V 0V

14b 12b 16b

20b 18b 16b
RLS2 RLS1 +21V
0V (P)

BOARD 32 (A228 MOTHER BOARD)

BOARD 36

12A1

R1 189·3k
R2 540·4k
R3 85k
R4 42·59k
R5 21·5k
R6 11·0k
R7 5·6k
R8 2·87k
R9 1·47k
R10 750
RV1 1k
R11 189·3k

DVM BACK PANEL
+VE RED
-VE BLACK
GUARD GREEN
I/P Hi
I/P Lo
O/P Hi
O/P Lo
C1 1·5

EXTERNAL REFERENCE INPUT

CAUTION
GUARD IS CONNECTED TO SIGNAL INPUT GUARD (FRONT PANEL)

RV1 REF CAL

COIL COIL
RLS No Nc C
CONTACTS SHOWN FOR COIL 1 LAST ENERGISED
R12 22
C2 0·47

AMP O/P
MONITOR I/P CURRENT SET BY RV1 B'D33

AMP I/P
SG
C1 4700p
C2 3300p
R1 39k
R3 2·2k

RV1 B'D32 OFFSET (SET ON +2V REF I/P)

12A4 +16
RV1 20k
-16V

PART OF BOARD 33
+16v +15V R10 330 3a +16V
C14 0·047 0V 4a 0V
C15 0·047 -15V R11 330 2a -16V
-16V

12A3 AMPLIFIER (SEE DRG 12B)
SIG GND
OFFSET VOLTAGE

18a 21a 14a 16a 17a 19a 20a
+16V R2 4·7K
OP
SG
SIG GND A
SIG GND B

NOTES

IC No.	LOCATION	TYPE
1, 2	BOARD 35	SN74121
3	BOARD 35	SN7406

RELAY BASE
No No
Nc Nc
C C

DVM FLOATING SECTION
EXT REF+ TO REFERENCE (SEE DRG.11)
EXT REF SIG GND TO REFERENCE (SEE DRG.11)
FROM RATIO POWER RAIL OUTER SCREEN

A228 RATIO UNIT
A2287012/1 03

12a

JR/A210/2

7.3.27

PART OF BOARD 32
(RATIO UNIT, A228,
MOTHER BOARD)

BOARD 33

+5V
0V (P)
+21V

FROM FLOATING POWER SUPPLY SEE DRG. 21

+16V
+15V
R10 330
3a
C14 0·047
0V
4a
C12 50
C15 0·047
−15V
R11 330
2a
−16V

40673 BASE
BASE
G2 G1
D S

AMP O/P FROM RLS (SEE DRG 12A)

R1 39k
C1 4700
R3 2·2k
18a

AMP I/P FROM RLS (SEE DRG.12A)

12B1 INPUT PROTECTION AND OUTPUT LIMITING

D1 and D2 protect the amplifier during overload and D11 limits the amplifier output to the limits of -0.6V to +8.2V.

R3, R4 and C2 filter the chopper drive frequency.

12B2 CHOPPER

The input signal is chopped by TR1 which is switched on by negative going pulses from block 12B3.

12B3 CHOPPER DRIVE

The chopper drive output from this block drives the Chopper (block 12B3) and the Demodulator (12B4) at a frequency between 200Hz to 250Hz. TR3 and TR4 form an emitter coupled multivibrator. C5 is linked into circuit during factory test should the multivibrator frequency beat with the frequency of the power supply inverter (Drg. 20) to produce a noisy DVM reading.

RV1 SET INPUT CURRENT

ANTI-PHASE DRIVE

DRIVE

OFFSET

12B4 AMPLIFIER AND DEMODULATOR

The square wave input is amplified by IC2 and demodulated by TR2.

When TR1 (block 12E2) is switched on, TR2 is switched off.

12B5 OUTPUT AMPLIFIER

This amplifier sums the ac and dc signal components to complete the chopper stabilised amplifier.

PART OF BOARD 32
(RATIO MOTHER BOARD)

RV1 OFFSET
+16V
RV1 20k
−16V
21a

+16V
R2 4·7k
AMP O/P TO RLS (SEE DRG 12A)
14a
O P

EXT. REF. + TO REFERENCE (SEE DRG. 11)

PART OF BOARD 32
(RATIO MOTHER BOARD)

EXT. REF. SIG. GND. TO REFERENCE (SEE DRG. 11)

SIG. GND. (A)
16a
SG
SIG. GND. (B)
17a
19a
20a

PART OF BOARD 32
(RATIO UNIT, A228,
MOTHER BOARD)

BOARD 33

+5V
0V (P)
+21V

FROM FLOATING POWER SUPPLY SEE DRG. 21

+16V
+15V
0V
-15V
-16V

R10 330
R11 330
C14 0·047
C11 47
C12 47
C15 0·047

40673 BASE
BASE
G2 G1 D S

AMP O/P FROM RLS (SEE DRG 12A)

R1 39k
C1 4700
R3 2·2k
18a

AMP I/P FROM RLS (SEE DRG.12A)

12B1

D11 8·2V
R26 470
D2 IN 3595
D1 IN 3595
SIG. GND. (B)
D4 IN 3595
D3 IN 3595
R2 470
C13 0·001
SIG. GND (A)
R3 10k
R4 100k
C2 0·047
SIG. GND. (B)

12B2 CHOPPER

TR1 40673
R21 100k
R22 100k
R25 220k
C8 0·047
R23 10
SIG. GND. (B)

RV1 SET INPUT CURRENT
ANTI-PHASE DRIVE
DRIVE
OFFSET

12B3

+15V 0V 0V +15V 0V
R12 10k
D7 3·9V
D8 3·9V
R13 10k
C9 100p
RV1 20k
R14 22k
R15 22k
R20 33k
TR3 BC107
TR4 BC107
C10 1·0
C5 0·1
R16 3·3k
R18 10k
R19 10k
R17 3·3k
-15V

PART OF BOARD 32 (RATIO MOTHER BOARD)

RV1 OFFSET
+16V
RV1 20k
-16V
21a

2B4 CHOPPER AMPLIFIER & DEMODULATOR

+15V
C3 0·047
IC2 301A
R5 220k
SIG. GND. (B)
C16 2·2p
-15V
R8 10k
C6 0·47
R9 68k
C7 47
R7 220k
R6 39
C4 200
SIG. GND. (B)
D6 SD3
D5 SD3
SIG. GND. (B)
TR2 40673
SIG. GND. (B)

12B5

+16V
C1 0·47
IC1 741
R27 100
R1 220k
SIG. GND. (B)
-16V
14a
O P

+16V
R2 4·7k

AMP O/P TO RLS (SEE DRG.12A)

EXT. REF. + TO REFERENCE (SEE DRG. 11)

PART OF BOARD 32 (RATIO MOTHER BOARD)

EXT. REF. SIG. GND. TO REFERENCE (SEE DRG. 11)

SIG. GND. (A) 16a
SG
SIG. GND. (B) 17a
19a
20a

RATIO UNIT
AMPLIFIER
A2287012/2 03

12b

JR/A210/2

7.3.29

PART OF BOARD 4

+5V — 4b — +5V TO ALL IC's PIN 14
L2 — +5V(A)
+12V — 15a — L1 — +12V(A)
R15 470 — +9·1V(A)
C12 ·047, C13 ·047, D9 9·1V
0V — 5b — 0V TO ALL IC's PIN 7
PART OF BOARD 8 (MOTHERBOARD)
C14 ·047, D11 9·1V
R16 470 — −9·1V(A)
L3 — −12V(A)
−12V — 16a — −12V

RAMP UP FROM 14B — 11b
STAT 1 FROM 14G — 12b
100/SEC FROM 16B — 1b
10/SEC FROM 16B — 2b
MAINS FREQ. FROM 20A — 13a, 16b

25Hz, 10Hz, 50Hz

13A MAINS LOCKED INTEGRATION CONTROL

The voltage output from this block controls the frequency of the clock oscillator (block 13B).

The frequency output from the clock is locked to the mains supply frequency to make the Ramp-up time equal to a complete multiple of mains periods (Refer to Section 6). Ramp-up time is determined by the number of clock counts accumulated in the main counter, e.g. 119999 for 10/SEC sampling rate.

At the end of Ramp-Up, $\overline{\text{RAMP-UP}}$ goes high clocking IC5a and the level on the 50Hz input will be stored. If the clock frequency is high, end of Ramp-Up will occur before the 50Hz input goes low and the Q output will go high. For a low clock frequency the $\overline{Q}$ output will go high.

The $\overline{\text{STAT 1}}$ pulse at the end of Ramp-down enables IC3d and IC3c. For a high clock frequency TP4 pulses Hi, and for a low clock frequency TP3 pulses Lo. These pulses are differentiated by C2 or C3 to add or subtract a small charge to/from C6. Thus the voltage on C6, buffered by TR5 will increase for high clock frequencies and decrease for low clock frequencies.

During 100/SEC operation the clock frequency is not mains locked. TR4 is turned on, and the voltage on C6 (i.e. the clock frequency) is set by RV1.

13B CLOCK OSCILLATOR

The output from 13A controls the frequency of the 6MHz oscillator TR6 via varactor diode D8. The output is buffered by TR7 and TR8.

6 MHz CLOCK TO 14L

13C MAINS DIVIDER

The mains input is squared by TR10 and IC6a. On 400Hz operation IC8 divides the input frequency down to 50Hz. The outputs from IC1 are 25Hz and 10Hz.

13D 25/SEC RESET

The output from this block goes Lo for 10ms in every second when the 25/SEC rate is remotely commanded (block 16B) and the inputs to the block are as follows.

50Hz	Hi
25Hz	Hi
10/SEC	Lo
100/SEC	Hi

13E 10/SEC RESET

The output from this block goes Lo for 20ms only when the total time taken for the periods Ramp-up, Wait and Ramp-down does not exceed 80ms. If the total time exceeds 80ms, the 10/SEC $\overline{\text{RESET}}$ output will be inhibited (i.e. a Hi output) by IC5b (pin 9 Hi and the output of IC3a Hi) until a $\overline{\text{STAT 1}}$ pulse is generated, refer to note.

+5V — R3 4·7k — 25/SEC $\overline{\text{RESET}}$
TP2 — 10/SEC $\overline{\text{RESET}}$
100/SEC $\overline{\text{RESET}}$

PART OF BOARD 8 (MOTHERBOARD)

10SEC/RESET (Block 13E)

As $\overline{\text{STAT 1}}$ is generated only if Ramp-Down occurs it is possible for the instrument to "lock-out" on switch on. This is prevented by the output of IC3a going Lo during the last 10ms of the nominal 20ms time allowed for Reset. IC3a going Lo produces the 10/SEC $\overline{\text{RESET}}$ output.

The 10/SEC input to the block is Hi except when the other two rates are commanded externally.

PART OF BOARD 3

6a — $\overline{\text{RESET}}$ TO 14A, 14B, 14F 14K, 17D

1a — $\overline{\text{RESET}}$ — 15b

FANOUT UNIT A214 (IF FITTED) PART OF BOARD 28

4a — +5V TO ALL IC's PIN 14
5a — 0V TO ALL IC's PIN 7

13F DATA IS CHANGED COMMAND

When a Fanout Unit is fitted and a DATA IS CHANGED command is received (a Hi on pin w) the trailing edge of the Lo $\overline{\text{SAMPLE CMD}}$ pulse clocks 13F output Hi. The output is reset Lo by the trailing edge of the POWER STAT.

13H 100/SEC RESET

When a fanout unit is fitted 100/SEC operation reset is initiated by $\overline{\text{SAMPLE CMD}}$ which triggers monostable IC6.

When DATA IS CHANGED is commanded the reset period is approximately 15ms, when not commanded it is approximately 1ms.

POWER STAT FROM 18E
DATA IS CHANGED — w — 16
13d — 9, 8
SAMPLE CMD TO/FROM 18
25/SEC FROM 16B
100/SEC FROM 16B

13G $\overline{\text{SAMPLE COMMAND}}$ INHIBIT

During 25/SEC operation if DATA IS CHANGED is commanded the $\overline{\text{SAMPLE CMD}}$ is held Lo until POWER STAT (i.e. reading display) occurs for the previous sample.

100/SEC $\overline{\text{RESET}}$

PART OF BOARD 1

24kHz SYNC FROM 20

PART OF BOARD 1

12a 3 — 6b — 4
24 kHz SYNC
2a — +5V TO ALL IC's PIN 14
3a — 0V TO ALL IC's PIN 7

13J RESET PULSE SYNCHRONISER

IC10 synchronises the start of RESET PULSE sent to the Floating Section with the 24kHz SYNC signal. The first Lo going edge of the 24kHz SYNC clocks IC11b output Hi. At the end of the Reset period IC11b output is reset Lo.

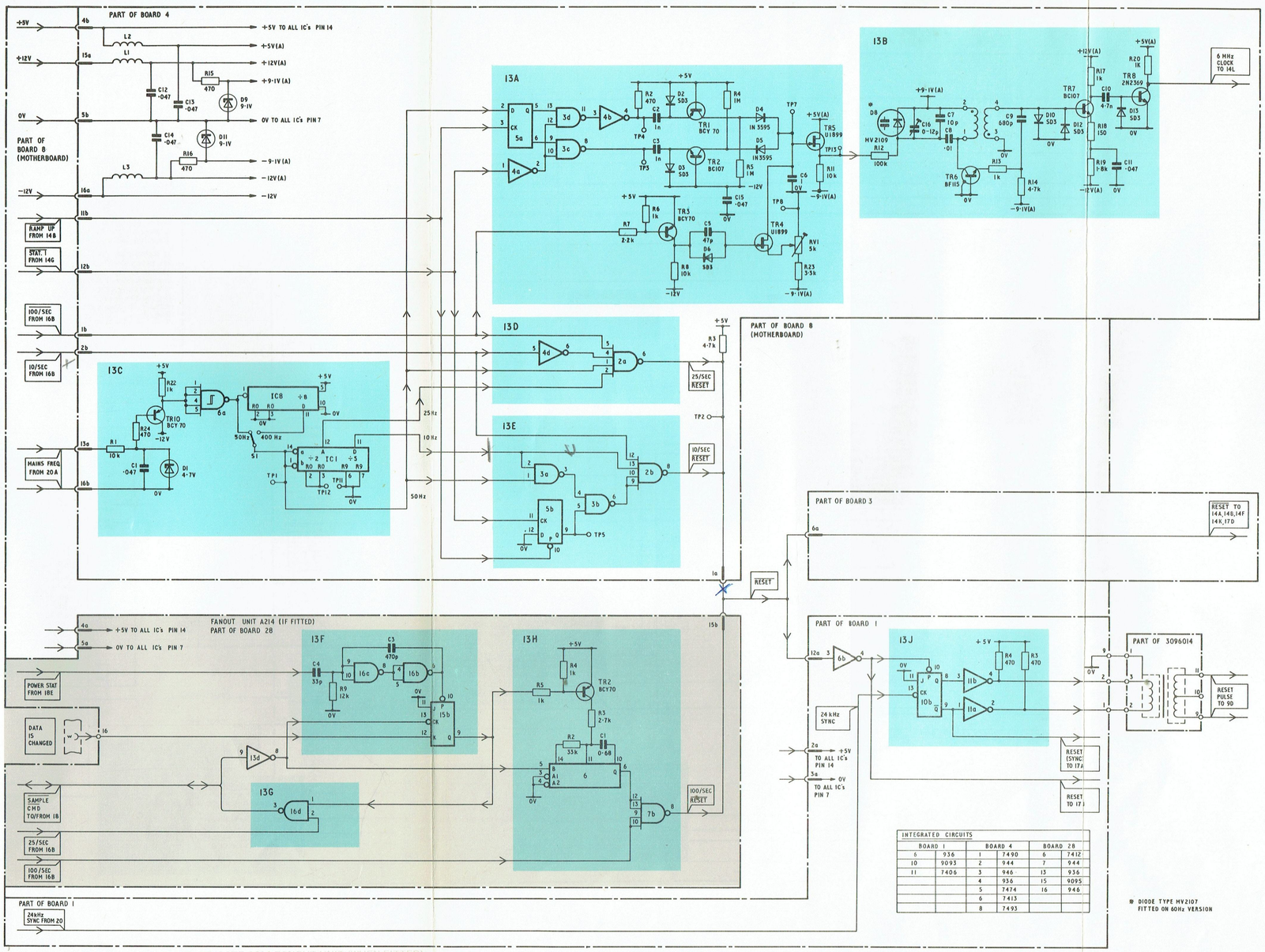
PART OF 3096014

9, 1, 0V, 2, 3, 11, 10, 9, 1, 2
RESET PULSE TO 9D
RESET (SYNC) TO 17A
RESET TO 17J

INTEGRATED CIRCUITS

BOARD 1		BOARD 4		BOARD 28	
6	936	1	7490	6	74121
10	9093	2	944	7	944
11	7406	3	946	13	936
		4	936	15	9095
		5	7474	16	946
		6	7413		
		8	7493		

* DIODE TYPE MV2107 FITTED ON 60Hz VERSION



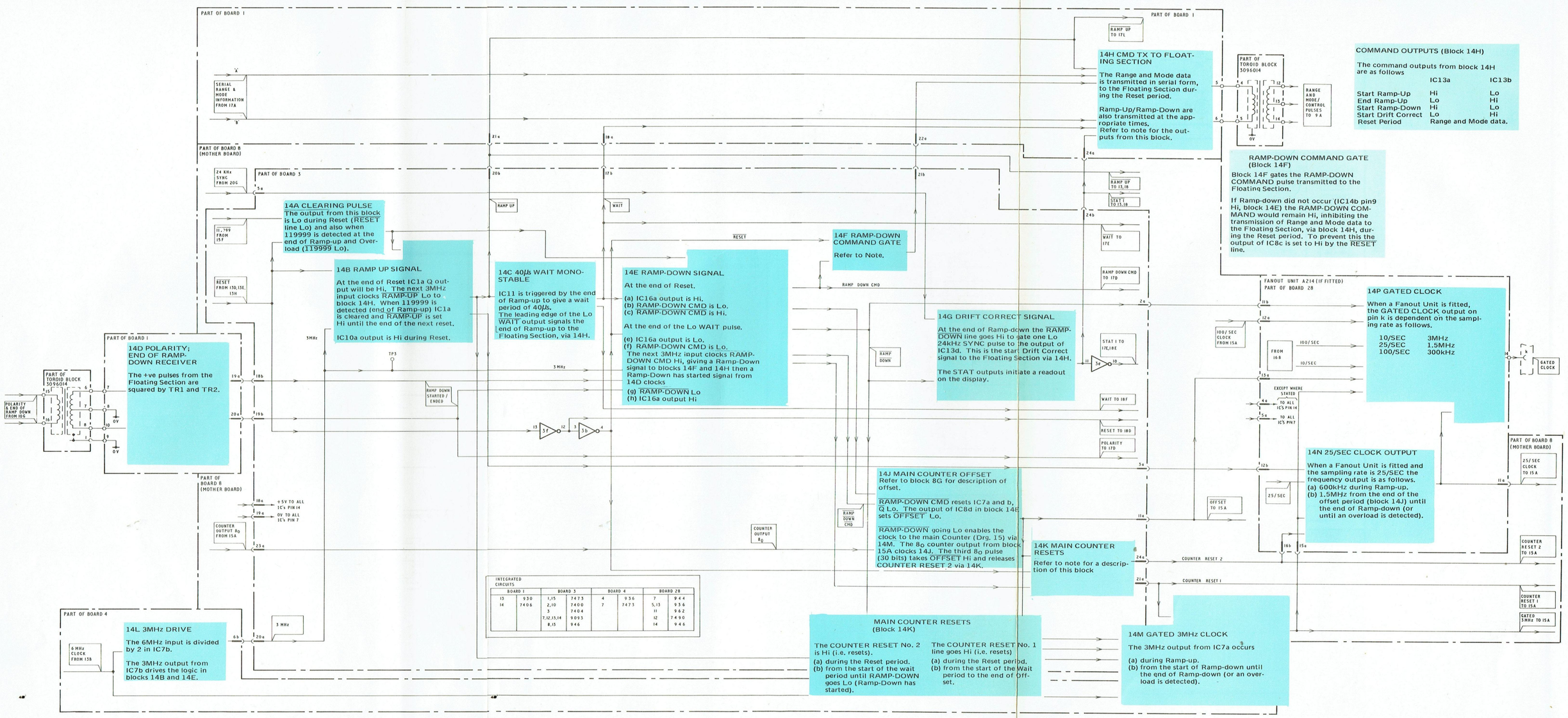
GREY AREAS INDICATE A214 FANOUT UNIT (WHEN FITTED)

JR/A210/1

CLOCK OSCILLATOR AND RESET
A2107013 03

13

7.3.31

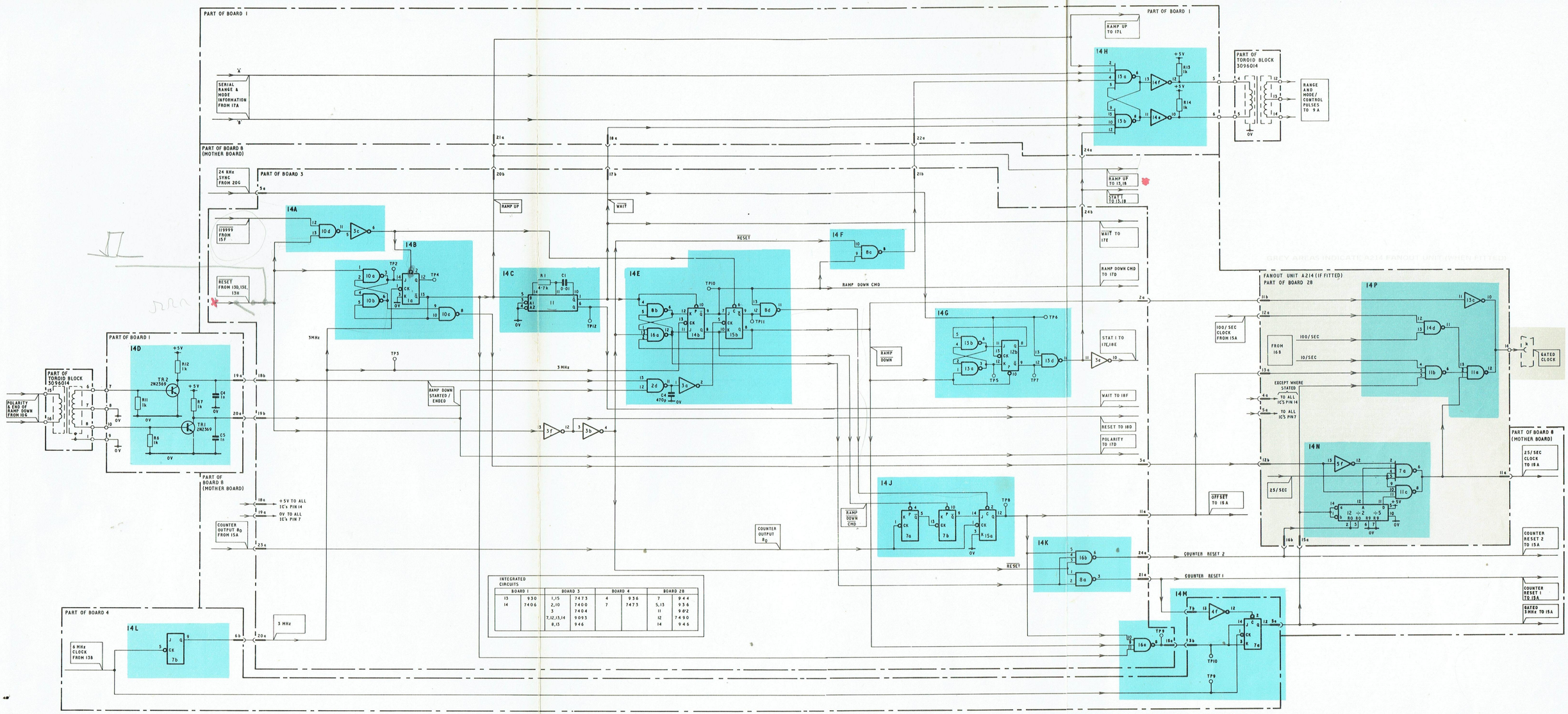

PART OF BOARD 1
SERIAL RANGE & MODE INFORMATION FROM 17A
PART OF BOARD B (MOTHER BOARD)
24 KHz SYNC FROM 20G
PART OF BOARD 3
11,799 FROM 15F
RESET FROM 13D,13E, 13H
14A CLEARING PULSE
The output from this block is Lo during Reset (RESET line Lo) and also when 119999 is detected at the end of Ramp-up and Overload (119999 Lo).
14B RAMP UP SIGNAL
At the end of Reset IC1a Q output will be Hi. The next 3MHz input clocks RAMP-UP Lo to block 14H. When 119999 is detected (end of Ramp-up) IC1a is cleared and RAMP-UP is set Hi until the end of the next reset.
IC10a output is Hi during Reset.
14C 40μs WAIT MONOSTABLE
IC11 is triggered by the end of Ramp-up to give a wait period of 40μs.
The leading edge of the Lo WAIT output signals the end of Ramp-up to the Floating Section, via 14H.
14E RAMP-DOWN SIGNAL
At the end of Reset.
(a) IC16a output is Hi.
(b) RAMP-DOWN CMD is Lo.
(c) RAMP-DOWN CMD is Hi.
At the end of the Lo WAIT pulse.
(e) IC16a output is Lo.
(f) RAMP-DOWN CMD is Lo.
The next 3MHz input clocks RAMP-DOWN CMD Hi, giving a Ramp-Down signal to blocks 14F and 14H then a Ramp-Down has started signal from 14D clocks
(g) RAMP-DOWN Lo
(h) IC16a output Hi
14F RAMP-DOWN COMMAND GATE
Refer to Note.
14G DRIFT CORRECT SIGNAL
At the end of Ramp-down the RAMP-DOWN line goes Hi to gate one Lo 24kHz SYNC pulse to the output of IC13d. This is the start Drift Correct signal to the Floating Section via 14H.
The STAT outputs initiate a readout on the display.
PART OF TOROID BLOCK 3096014
POLARITY & END OF RAMP DOWN FROM 10G
14D POLARITY; END OF RAMP-DOWN RECEIVER
The +ve pulses from the Floating Section are squared by TR1 and TR2.
PART OF BOARD 8 (MOTHER BOARD)
+5V TO ALL IC's PIN 14
0V TO ALL IC's PIN 7
COUNTER OUTPUT 8Q FROM 15A
PART OF BOARD 4
6MHz CLOCK FROM 13b
14L 3MHz DRIVE
The 6MHz input is divided by 2 in IC7b.
The 3MHz output from IC7b drives the logic in blocks 14B and 14E.
3 MHz
INTEGRATED CIRCUITS
BOARD 1: 13 930; 14 7406
BOARD 3: 1,15 7473; 2,10 7400; 3 7404; 7,12,13,14 8,15 9093; 9046
BOARD 4: 4 936; 7 7473
BOARD 28: 7 944; 5,13 936; 11 962; 12 7490; 14 946
14J MAIN COUNTER OFFSET
Refer to block 8G for description of offset.
RAMP-DOWN CMD resets IC7a and b, Q Lo. The output of IC8d in block 14E sets OFFSET Lo.
RAMP-DOWN going Lo enables the clock to the main Counter (Drg. 15) via 14M. The 8Q counter output from block 15A clocks 14J. The third 8Q pulse (30 bits) takes OFFSET Hi and releases COUNTER RESET 2 via 14K.
14K MAIN COUNTER RESETS
Refer to note for a description of this block
MAIN COUNTER RESETS (Block 14K)
The COUNTER RESET No. 2 is Hi (i.e. resets).
(a) during the Reset period.
(b) from the start of the wait period until RAMP-DOWN goes Lo (Ramp-Down has started).
The COUNTER RESET No. 1 line goes Hi (i.e. resets)
(a) during the Reset period.
(b) from the start of the Wait period to the end of Offset.
14M GATED 3MHz CLOCK
The 3MHz output from IC7a occurs
(a) during Ramp-up.
(b) from the start of Ramp-down until the end of Ramp-down (or an overload is detected).
PART OF BOARD 1
RAMP UP TO 17L
14H CMD TX TO FLOATING SECTION
The Range and Mode data is transmitted in serial form, to the Floating Section during the Reset period.
Ramp-Up/Ramp-Down are also transmitted at the appropriate times.
Refer to note for the outputs from this block.
PART OF TOROID BLOCK 3096014
RANGE AND MODE/ CONTROL PULSES TO 9A
COMMAND OUTPUTS (Block 14H)
The command outputs from block 14H are as follows

	IC13a	IC13b
Start Ramp-Up	Hi	Lo
End Ramp-Up	Lo	Hi
Start Ramp-Down	Hi	Lo
Start Drift Correct	Lo	Hi
Reset Period	Range and Mode data.	

RAMP-DOWN COMMAND GATE (Block 14F)
Block 14F gates the RAMP-DOWN COMMAND pulse transmitted to the Floating Section.
If Ramp-down did not occur (IC14b pin9 Hi, block 14E) the RAMP-DOWN COMMAND would remain Hi, inhibiting the transmission of Range and Mode data to the Floating Section, via block 14H, during the Reset period. To prevent this the output of IC8c is set to Hi by the RESET line.
RAMP UP TO 13,18
WAIT TO 13,18
WAIT TO 17E
RAMP DOWN CMD TO 17D
STAT 1 TO 17E,18E
WAIT TO 18F
RESET TO 18D
POLARITY TO 17D
FANOUT UNIT A214 (IF FITTED) PART OF BOARD 28
14P GATED CLOCK
When a Fanout Unit is fitted, the GATED CLOCK output on pin k is dependent on the sampling rate as follows.

10/SEC	3MHz
25/SEC	1.5MHz
100/SEC	300kHz

100/SEC CLOCK FROM 15A
FROM 16B
EXCEPT WHERE STATED TO ALL IC'S PIN 14
TO ALL IC'S PIN 7
GATED CLOCK
14N 25/SEC CLOCK OUTPUT
When a Fanout Unit is fitted and the sampling rate is 25/SEC the frequency output is as follows.
(a) 600kHz during Ramp-up.
(b) 1.5MHz from the end of the offset period (block 14J) until the end of Ramp-down (or until an overload is detected).
OFFSET TO 15A
25/SEC
PART OF BOARD B (MOTHER BOARD)
25/SEC CLOCK TO 15A
COUNTER RESET 2 TO 15A
COUNTER RESET 2
COUNTER RESET 1
COUNTER RESET 1 TO 15A
GATED 3MHz TO 15A



RAMP UP/RAMP DOWN CONTROL
A2107014 03

14

JR/A210/2

7.3.33

MAIN COUNTER (Block 15A)

The main counter sets the fixed time for the Ramp-up period and also (after being reset) holds the count (i.e. the DVM reading) accumulated during Ramp-down.
The fixed times for the Ramp-up period are as follows.

Nominal Ramp-up time	Rate
40ms	10/SEC
20ms	25/SEC
4ms	100/SEC

(a) 10/SEC Operation

(1) Ramp-up: 3MHz pulses are accumulated until all the counter outputs go Hi and 119999 is detected.

(2) Ramp-down: COUNTER RESET 1 resets (goes Hi) IC2 from the end of Ramp-up until Ramp-down has started.
COUNTER RESET 2 resets (goes Hi) IC3, 5, 7, 14 and 13b during the 10μs Offset period (Refer to block 14J). At the start of the Offset period the decade counter IC2 is driven by the GATED 3MHz input. When the D(80) output from IC2 goes Lo for the third time (30 pulses counted), COUNTER RESET 2 goes Lo (refer to block 14J) thus enabling the reset of the counter.

(b) 25/SEC Operation

(1) Ramp-up: IC2 is reset to 9 (BCD) output by the $\overline{\text{OFFSET}}$ going Hi. The 25/SEC, Ramp-up 600kHz CLOCK pulses are accumulated by IC3, 5, 7, 14 and 13b until all of their output lines go Hi (11999 pulses received) when block 15F will detect 119999 (end of Ramp-up).

(2) Ramp-down: COUNTER RESET 1 resets IC2 from the end of Ramp-up until Ramp-down has started.
COUNTER RESET 2 resets IC3, 5, 7, 14 and 13b during the 10μs Offset period. Refer to sub-para (2) of 10/SEC operation. At the end of the Offset period IC2 is reset to 9 (BCD) output and the rest of the counter is enabled. The counter accumulates the 25/SEC, Ramp-down, 1.5MHz CLOCK pulses.

(c) 100/SEC Operation

(1) Ramp-up: IC2 is reset to 9 (BCD) output by the $\overline{\text{OFFSET}}$ going Hi. The GATED 3MHz pulses are accumulated, via IC10b by IC3, 5, 7, 14 and 13b until all of their output lines go Hi (11999 pulses received) when block 15F will detect 119999 (end of Ramp-up).

(2) Ramp-down COUNTER RESET 1 resets IC2 from the end of Ramp-up until Ramp-down has started.
COUNTER RESET 2 resets IC3, 5, 7, 14 and 13b during the Offset period. Refer to sub-para 2) of the 10/SEC Operation.
At the end of the 10μs Offset period, IC2 is reset to 9 (BCD) output and the rest of the counter is enabled. The counter accumulates the GATED 3MHz pulses via IC10b.

INTEGRATED CIRCUITS

BOARD 1	
1	936
5	946
BOARD 5	
1	936
2,3,5,7,14	7490
4,6,11,12,15	7475
9	930
10	946
13	9093
BOARD 7	
1,2,3,4,5,6	7441A
BOARD 27	
1,2,7	7407
8,10	946
9,11	936

15D DECIMAL POINT DECODE

Range and mode information is decoded in this block to operate the appropriate decimal point on the Nixie tubes.
The DP drive lines from IC4 have a voltage level of approx. +2.5V when driving a Nixie character and approx. +60V when not.
Refer to note for information on the outputs from this block

15C READOUT DISPLAY (NIXIE TYPE)

The parallel BCD inputs from the main staticiser are decoded to decimal notation by IC1, 2, 3, 5, 6 and the resultant decimal outputs are displayed by the V3 to V7 Nixie tubes. V2 displays the most significant number (decimal 0 or 1) a Hi input to the TR5 TR6 network gives '1' display, a Lo input gives '0' display.

The least significant display figure (V7) is blanked out during the 25/SEC sampling rate and the least two significant display figures (V7 and V6) are blanked out during the 100/SEC sampling rate.

The logic levels of the 10/SEC (STAT) and $\overline{100/\text{SEC}}$ (STAT) lines are as follows.

Sampling Rate	10/SEC (STAT)	$\overline{100/\text{SEC}}$ (STAT)	BLANK NIXIE
10/SEC	Hi	Hi	None
25/SEC	Lo	Hi	V7
100/SEC	Lo	Lo	V7, V6

The Nixie character drive lines from the decoding IC's have a voltage level of approx. +1.25V when driving a character and approx. +65V when not.

15E DISPLAY DATA BUFFERS

If a Fanout unit is fitted the BCD data from the staticiser is connected out to the system print-out device via buffer amplifiers.

During 25/SEC operation a Lo input to IC10 initiates an '0' character to be printed for the least significant figure. During 100/SEC operation a Lo input to IC10 and 8 initiates an '0' character to be printed for the two least significant figures.

15B MAIN STATICISER

The parallel outputs from the main counter are stored by the IC's in this block.
The data on the IC input lines is transferred to the IC output lines when the POWER STAT line is Hi.

The data on the output lines remains unchanged when the POWER STAT line is Lo.

15F 119999 DETECTOR

Output goes Lo when 119999 is detected (i.e. main counter is full) at the end of Ramp-up period.

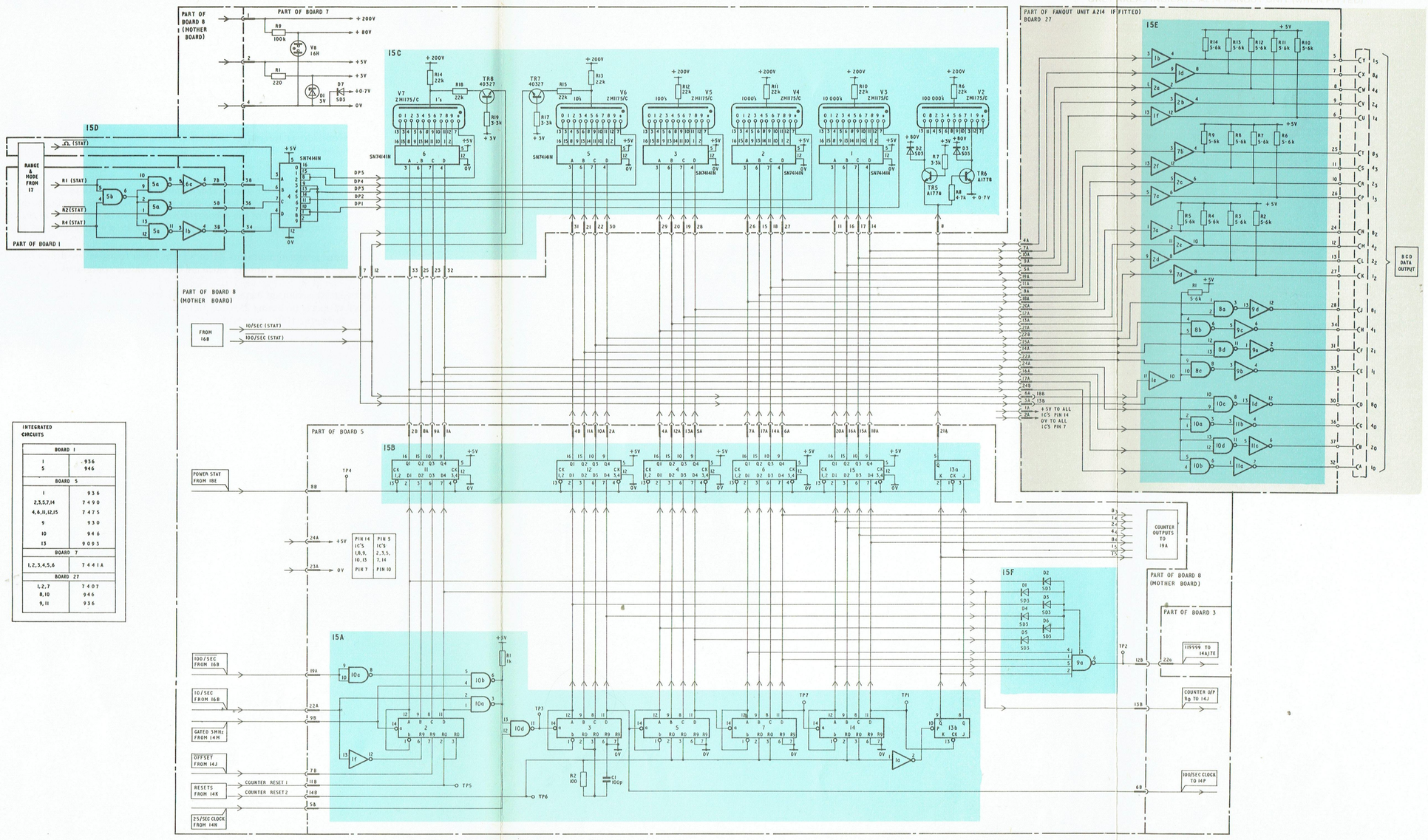
During the Ramp-down period, an overload at the DVM input is indicated by 119999 being detected.

15A MAIN COUNTER

Refer to note for a description of this block.

DECIMAL POINT DECODE OUTPUTS (block 15D)

Voltage Range AC and DC	Input Lines (Stat) Ω	R4	$\overline{\text{R2}}$	R1	DP Line Lo (Approx. 2.5V)
1000V		Hi	Lo	Hi	Lo	DP4
100V		Hi	Lo	Hi	Hi	DP3
10V		Hi	Lo	Lo	Lo	DR2
1V		Hi	Lo	Lo	Hi	DP1
100mV		Hi	Hi	Hi	Lo	DP3
10mV		Hi	Hi	Hi	Hi	DP2
Resistance Range					
10MΩ		Lo	Lo	Hi	Lo	DP5
1MΩ		Lo	Lo	Hi	Hi	DP4
100kΩ		Lo	Lo	Lo	Lo	DP3
10kΩ		Lo	Lo	Lo	Hi	DP2
1kΩ		Lo	Hi	Hi	Hi	DP1



GREY AREAS INDICATE A214 FANOUT DRIVE WHEN FITTED

INTEGRATED CIRCUITS

BOARD 1	
1	936
5	946
BOARD 5	
1	936
2,3,5,7,14	7490
4,6,11,12,15	7475
9	930
10	946
13	9093
BOARD 7	
1,2,3,4,5,6	7441A
BOARD 27	
1,2,7	7407
8,10	946
9,11	936

COUNTER AND READOUT DISPLAY (NIXIE TYPE)

15a

A2107015 03

15c READOUT DISPLAY (7 SEGMENT) FIG. 15b

The BCD output of 15b is converted to the 7 segment code, necessary for display on indicators X1 to X3, by the decoder/drivers, IC's 1 to 5.

Each decoder/driver accepts the BCD information from the data staticiser (15b) and decodes it. This data is then used to drive the seven segments of the appropriate display without the need for other circuit elements.

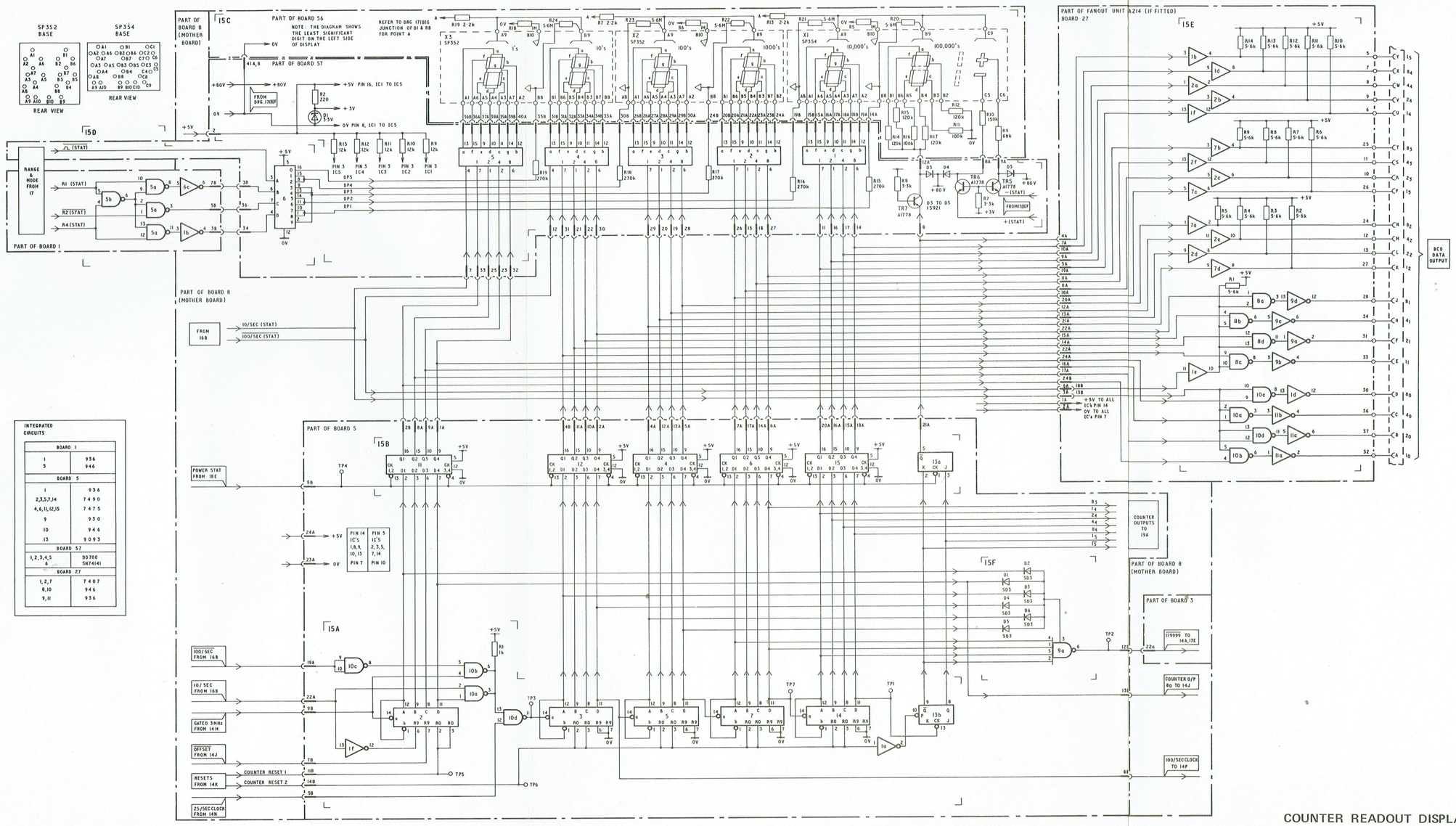
The brightness level of the display is determined by resistors R9 to R13, (Board 57), which control the programmed current level to the segments. To ensure even brightness of all segments, the output segment current of the decoder/driver is ratioed to the output of segment b. (with segment b = 1.00 then segments a, f and g = 0.93, c = 1.25, d = 1.00 and e = 1.10).

The decimal points of indicators X1 to X3 (the lower triangles) are driven from 15d. The upper triangles are "keep-alive" cathodes which are used to ensure continuous ionisation of the indicators.

The two least significant digits are blanked by terminals 4 of IC5 and/or by IC4 going Lo. The 10/sec STAT line is Lo during 25/s and 100/s rates, blanking the 1's digit; and the 100 SEC STAT line is Lo during the 100/s rate blanking the 10's digit.

Diodes D3 to D5 protect transistors TR5 to TR7 by preventing the collector voltages from exceeding +80V.

All other parts of this circuit are identical to 15a.



INTEGRATED CIRCUITS	
BOARD 1	
1	936
5	946
BOARD 5	
1	936
2,3,5,7,14	7490
4,6,11,12,15	7475
9	930
10	946
13	9093
BOARD 57	
1,2,3,4,5 6	DD700 SN74141
BOARD 27	
1,2,7	7407
8,10	946
9,11	936

COUNTER READOUT DISPLAY (7 BAR TYPE) **15b**

A2107030 03

16B RATE

When a Fanout unit is fitted the external Rate command on pins EE and FF is detected and the outputs from the block are as follows.

SAMP. RATE	CMD RATE Pin EE	CMD RATE Pin FF	BLOCK OUTPUTS 10/SEC	25/SEC	100/SEC
10/SEC	Hi	Hi	Hi	Lo	Lo
	Lo	Lo	Hi	Lo	Lo
25/SEC	Lo	Hi	Lo	Hi	Lo
100/SEC	Hi	Lo	Lo	Lo	Hi

IC4a and b staticise the rate commmand

(a) for fixed range operation at the end of Ramp-up.
(b) for auto range operation at the end of Ramp-down.

16C MODE

The mode output lines from this block are controlled by the front panel switches SB only when

(a) Remote is not selected on the front panel.
(b) An external remote is not commanded.

Under these conditions the REM line to IC2a is Hi.

During remote operation (i.e. Fanout unit fitted) the output lines are controlled by the levels on the CMD MODE input pins AA and BB as follows.

MODE	CMD MODE Pin AA	CMD MODE Pin BB	BLOCK OUTPUT LINES. DC	AC	Ω
DC	Hi	Hi	Lo	Hi	Hi
	Lo	Lo	Lo	Hi	Hi
AC	Hi	Lo	Hi	Lo	Hi
Ω	Lo	Hi	Hi	Hi	Lo

16A CONTROL

When a Fanout unit (consisting of boards 27, 28 and connector) is fitted and REMOTE CONTROL is commanded (Lo on pin r) all of the front panel switches, with the exception of mains on/off, are disabled. The outputs from the block are as follows.

CMD REMOTE	FRONT PANEL	REM	REM
Hi	Local	Lo	Hi
Hi	Remote	Hi	Lo
Lo	Disabled	Hi	Lo

16D CMD AUTO RANGE

The AUTO R output line from R4 is controlled by the front panel switch SA2a only when

(a) REMOTE is not selected on the front panel,
(b) An external remote is not connected.

Under these conditions the REM input to IC1f is Hi.

During remote operation (i.e. Fan-out unit fitted) the AUTO R line is controlled by the level on connector pin y as follows. Note that Auto-range operation is inhibited during 100/SEC sampling.

Refer to note for the outputs from this block.

BLOCK 16D OUTPUTS

CMD AUTO RANGE Pin y	REM	100/SEC	BLOCK OUTPUT AUTO R
Lo	Hi	Lo	Lo
Lo	Hi	Hi (inhibit)	Hi

16H RATIO

When LOCAL control is used the REM line is Hi and the front panel switch SA selects the Hi or Lo level on the RATIO output line which goes Lo when RATIO is selected.

When a Fanout unit is fitted RATIO can be externally commanded by pin c being made Lo and the output from this block is as follows.

CMD RATIO (Pin C)	100/SEC	REM	RATIO OUTPUT
Lo	Hi	Lo	Lo

RATIO cannot be commanded for 100/SEC sampling rate. (100/SEC line will go Lo).

16G RESPONSE (FILTER)

When LOCAL control is used the REM line is Hi and the front panel switch SE1 selects the Hi or Lo level on the FILTER output line, Hi for FAST, Lo for SLOW.

When a Fanout Unit is fitted the SLOW RESPONSE can be externally commanded by pin z being made Lo.

FILTER (i.e. SLOW RESPONSE) cannot be commanded for

(a) AUTO RANGE AC measurements. (AC line goes Lo and Ext Auto R Cmd line goes Hi).

(b) 100/SEC sampling. (100/SEC line goes Lo).

16E RANGE

Range can be selected in one of three ways as follows.

(a) By the front panel switch SA if REMOTE and AUTO RANGE have not been selected or externally commanded.

(b) By the CMD RANGE (when Fanout Unit is fitted) lines (pins m, n, p) if REMOTE has been selected or externally commanded but AUTO RANGE has not.

(c) By the Auto Ranging circuits (Drg. 9) if AUTO RANGE has been selected or externally commanded.

When Auto-range is selected or commanded the AUTO R input to IC1a, b and c (board 28) goes Lo to inhibit remote range. The REM line is Hi when an external remote is commanded.

The range inputs and outputs from the block are as follows.

VOLTAGE RANGE	RESISTANCE RANGE	(RANGE NO.)	CMD RANGE 4 (p)	CMD RANGE 2 (n)	CMD RANGE 1 (m)	BLOCK OUTPUT 4	BLOCK OUTPUT 2	BLOCK OUTPUT 1
1000V	10M	0	Lo	Lo	Lo	Hi	Hi	Hi
100V	1M	1	Lo	Lo	Hi	Hi	Hi	Lo
10V	100k	2	Lo	Hi	Lo	Hi	Lo	Hi
1V	10k	3	Lo	Hi	Hi	Hi	Lo	Lo
100mV	1k	4	Hi	Lo	Lo	Lo	Hi	Hi
10mV		5	Hi	Lo	Hi	Lo	Hi	Lo

16F RANGE CHECK

The range output lines ($\overline{4}$, $\overline{2}$, $\overline{1}$) from this block all go Hi to select the 1000V (10MΩ) range when

(a) The 10mV DC range (5) is commanded for 10/SEC operation. (The 10/SEC line to IC2a goes Hi).

(b) Range 5 is commanded for AC and Ω. (The 10/SEC line to IC2f goes Hi).

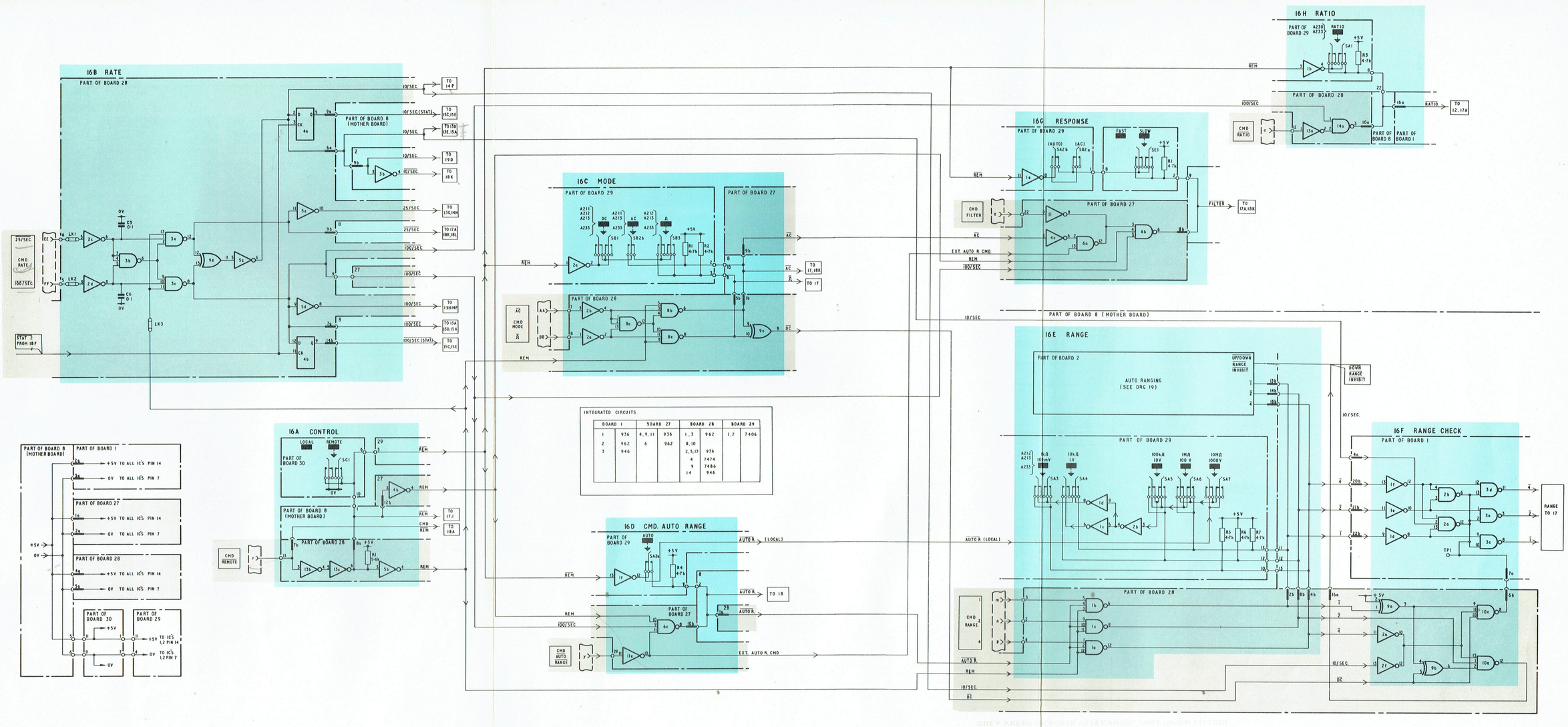
The DOWN RANGE INHIBIT line goes Lo, inhibiting the Auto Range Counter (Drg. 19) during the 25/SEC and 100/SEC sampling rates when

(a) The 10mV DC range is commanded. (The DC line to IC9b goes Lo).

(b) Range 4 is commanded for AC and resistance measurements. (The DC line to IC9b goes Hi).

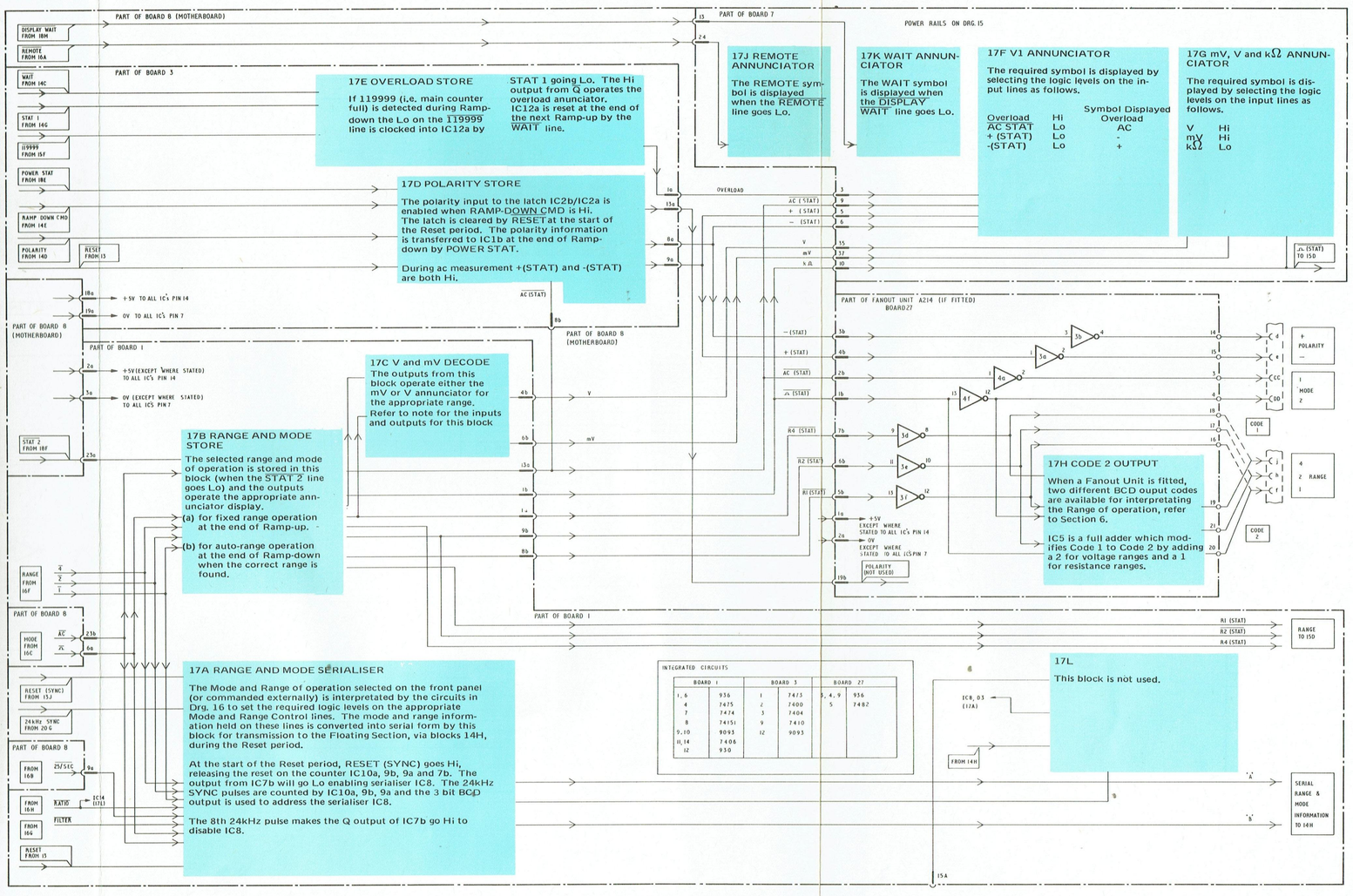
INTEGRATED CIRCUITS

	BOARD 1	BOARD 27	BOARD 28	BOARD 29
1	936	4, 9, 11 936	1, 3 962	1, 2 7406
2	962	6 962	8, 10	
3	946		2, 5, 13 936	
			4 7474	
			9 7486	
			14 946	



RANGE, MODE, RESPONSE & RATE COMMANDS
A2107016 02

16



V and mV DECODE OUTPUTS (Block 17C)

Ω (STAT)	R4 STAT	V	mV
Lo	Lo	Lo	Hi
Lo	Hi	Hi	Lo
Hi	Lo	Lo	Lo
Hi	Hi	Lo	Lo