Measurements International

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VOLTAGE DIVIDER
Model 1340A
Operator Manual

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VOLTAGE DIVIDER

MODEL 1340A

OPERATOR MANUAL

1340A.OM Rev. 2

2022-10-19

Approved by: AP

QA:

S/N:

Form MI 65, Rev. 3, Dated 21-03-02 (QAP 19, App."M")

This equipment may be sensitive to Electrostatic Sensitive Discharge (ESD). Failure to observe standard anti-static practices may result in degradation of performance or improper measurement results, even when an actual functional failure does not occur.

Do not touch the terminals during measurement and avoid any electro-static discharge, namely when the measurement is running.

To ensure powerline pulse rejection compliance, this equipment must be operated using the power cord supplied by the manufacturer (MIL).

Contents

Table of Figures

Table of Tables

1 Notices, Safety Warnings & Cautions

1.1 Copyright Notice

1.2 Sales and Technical Support

To contact Measurements International for sales enquiries or for technical support, refer to the support links on the following Measurements International web pages:

www.mintl.com
(Product-specific information and support, software, and documentation updates)

sales@mintl.com
(Worldwide contact information for repair and service)

1.3 Results

Typical results and uncertainties will be shown but these can and will vary. Your results will be different. However, the results that we show are achievable and, in some cases, can easily be improved upon. We have attempted to include all reasonable considerations for our uncertainty budgets, but your uncertainty budgets should be re-assessed considering your environment, operating conditions, and metrological needs.

1.4 Safety Information

CAUTION

A CAUTION notice signifies an operating procedure or practice which denotes a potential hazard and if not correctly performed, could result in damage to the product or loss of important data. Ensure that the conditions are fully understood. If not, consult with Measurements International prior to proceeding.

WARNING

A WARNING notice signifies an operating procedure or practice which denotes a potential hazard and if not correctly performed, could result in personal injury or even death. Ensure that the conditions are fully understood. If not, consult with Measurements International prior to proceeding.

SAFETY

A SAFETY notice signifies matters related to first aid or personal safety. Ensure that the conditions are fully understood. If not, consult with Measurements International prior to proceeding.

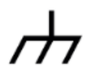
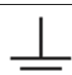
NOTE

A NOTE signifies matters that the user must pay particular attention to. Do not proceed beyond a NOTE notice until the indicated conditions are fully understood and met.

1.4.1 Electrical Safety Symbols

The following symbols on the instrument and in the operating manuals indicate precautions which must be taken to maintain safe operation of the instrument.

Table 1-1. Electrical Safety Symbols

	Direct Current (dc)		Alternating Current (ac)
	WARNING – Risk of Electric Shock		WARNING or CAUTION information to avoid personal injury or damage to the product.
	Protective Earth Ground. Indicates the wiring terminal must be connected to 'earth ground' before operating the equipment – for protection against electrical shock in case of a fault.		Frame (or chassis) ground terminal – typically connects to the equipment's metalwork frame.
	Digital Signal Ground. The reference point from which a digital logic signal is measured.		Analogue Signal Ground. The reference point from which an analogue signal is measured.

1.4.2 Safety Considerations

Read the information below before using this instrument.

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards for design, manufacture, and intended use of the instrument.

Measurements International assumes no liability for the customer's failure to comply with these requirements.

WARNING

Read all the safety information in this manual prior to using the product. Use this product indoors only and with an approved 3-conductor line cord.

Grounding the Instrument: Provided through the 3-conductor approved line cord having a protective earth terminal and an uninterruptible safety earth ground from the mains power source through the (third pin).

DO NOT operate the product in an explosive atmosphere.

Replace the line fuses with fuse(s) of the same voltage and current rating and type. DO NOT use repaired fuses or short-circuited fuse holders.

Dangerous voltages may exist even with the equipment is switched off. Only service trained personal should remove the covers or shields. DO NOT perform procedures involving cover or shield removal unless you are qualified to do so to avoid dangerous electrical shock.

Whenever it is possible that the safety protection features built into this product have been impaired, either through physical damage, excessive moisture, or any other reason, DO NOT PLUG THE 3-CONDUCTOR POWER CORD FROM THE BACK OF THE INSTRUMENT into the mains power source until safe operation can be verified by service-trained personnel. If necessary, contact Measurements International for advice prior to returning the product to Measurements International for service and repair.

Ensure that a trained person capable of rendering first-aid and resuscitation is present prior to servicing the instrument.

Do not install substitute parts or perform any unauthorized modification to the product due to the danger of introducing additional hazards. Contact Measurements International for advice for service and repair guidelines to ensure that safety features are maintained prior to returning the instrument to Measurements Instruments.

ALL input and output terminals must be considered hazardous whenever inputs greater than 100 Vdc are connected to ANY input terminal. For voltages above 100 Vdc the terminal input cover should be kept on and only removed when the voltages are off.

2 Overview

2.1 Scope

This manual contains the calibration & operating information for the MI model 1340A Voltage Divider.

2.2 General Description

The MI model 1340A is a user-friendly, cost-efficient reference voltage divider, designed and developed by metrologists, that allows for accurate voltage scaling up to a ratio of 10 000:1. The 1340A uses four separate 10:1 voltage-divider stages, constructed from specially designed networks of high-precision resistors, enclosed in a shielded, temperature stabilized chamber. The divider stages are cascaded together in different combinations to provide ever larger ratio. The internal temperature of the inner shield can be monitored from the front panel by making a four-wire resistance measurement of an internally mounted PT100.

Each 10:1 ratio stage requires a calibration to establish an accurate ratio value. The ratio drift of each stage is sub-ppm for 30 days (see specifications). The calibration can be performed in multiple ways, an example is provided in section 9.4.

The operational versatility of the 1340A offers users an uncomplicated method to scale up or down from the typical SI traceable values (10.0 Vdc, 1.018 Vdc & 1.0 Vdc) of laboratory voltage. Common uses for such a divider include the calibration and verification of a multitude of Digital Voltmeters (DVMs), nano-Voltmeters, the dc voltage outputs of multifunction calibrators, as well any number of measurements requiring the scaling-up or -down from an accurate SI traceable dc voltage source.

3 Diagram

3.1 1340A Front Panel

A diagram of the 1340A front panel is illustrated below (see Figure 3-1). Note the maximum input voltages on the Input Terminals. Exceeding the maximum voltages will result in damage to the divider.

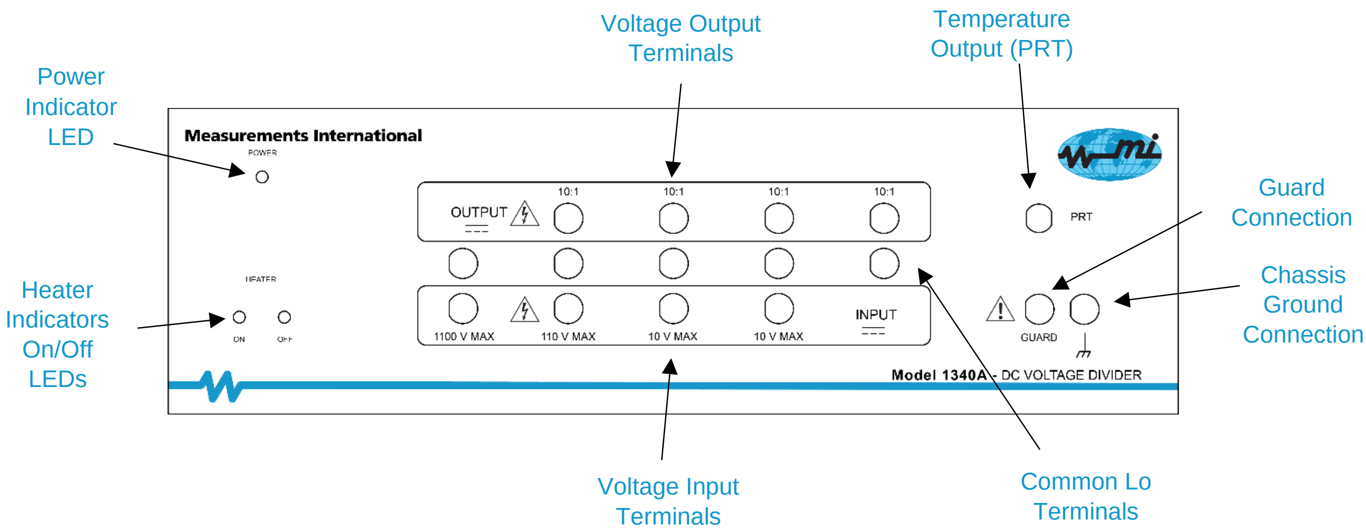


Figure 3-1. 1340A Front Panel.

3.2 1340A Rear Panel

A diagram of the 1340A rear panel is illustrated below (see Figure 3-2).

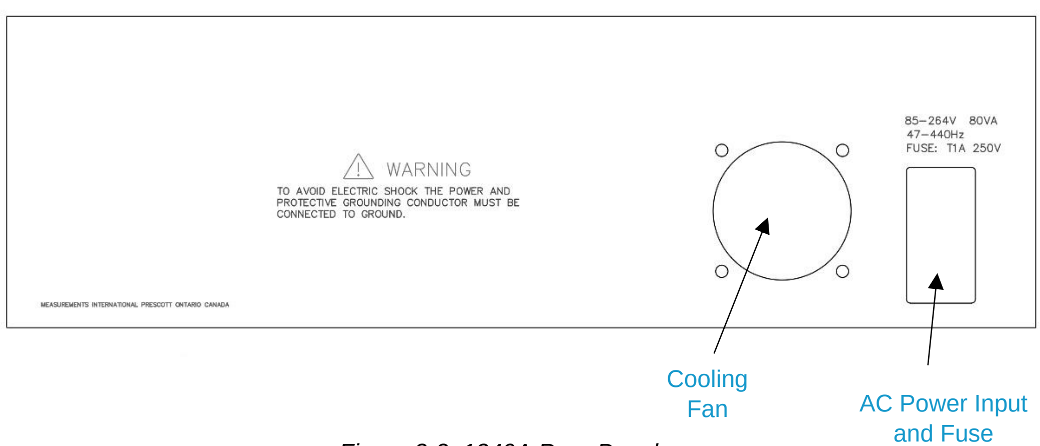


Figure 3-2. 1340A Rear Panel

1340A HIGH PRECISION VOLTAGE DIVIDER

Specifications: Rev 3

Ratio Range	Ratio Uncertainty	Input Voltage Max
10:1	± 0.2 μV/V (0.2 ppm) (30-Day)	200 V
100:1	± 0.4 μV/V (0.4 ppm) (30-Day)	1100 V
1000:1	± 0.5 μV/V (0.5 ppm) (30-Day)	10 V
Internal Temperature Stability		± 0.1 °C Over a 1 Year Period
Ambient Temperature Range		23 °C ± 5 °C
Initial Warm-up Time		24 Hours
Ambient Humidity Range		20 to 90 % Non-condensing
Storage		-50 °C to +50 °C
Self-Alignment		Not Required
Isolation to Earth		> 10^{12} Ω
Direct Cable to 57XX		Provided
Warranty		Standard 2 Year Parts & Labour

Options:
PN: 1340-O Output cable to bare ends
PN: 1340-C Output cable to custom

Other: Contact MI

Dimensions (L × W × H):
436 x 449 x 133 (mm)

Weight:
9 kg

Shipping Weight:
13 kg

Mains Power:
85 to 264 V_{ac}, 47 to 440 Hz

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5 Controls & Indicators

5.1 Power Switch

The ON/OFF rocker switch on the rear panel applies/removes AC Power to the 1340A.

5.2 Power Indicator LED

The Power Indicator LED on the front panel will be illuminated following power-up and non-illuminated when the instrument is switched 'OFF'.

5.3 Heater Indicator LEDs

On the 1340A front panel, the 'Heater ON' LED will be illuminated to indicate when the temperature-stabilized chamber's heater is 'ON'.

Conversely, the 'Heater OFF' LED will be illuminated to indicate when the temperature-stabilized chamber's heater is 'OFF'.

6 Inspection

6.1 Physical

The model 1340A is thoroughly inspected and tested before shipment. However, damage can occasionally result from excessively rough handling during shipping. It is advisable to perform a visual check of the equipment and packaging materials; both should be free of marks or dents. The shipping case should be kept until the instrument can be thoroughly checked for mechanical and electrical damage. An approved three-conductor ac power cable is supplied inside the shipping case along with the operating manual.

CAUTION

Exercise caution when handling or transporting the instrument.

Do not abuse the instrument with excessive mechanical shock.

Avoid temperature extremes during transit and storage. See specifications in Section 4.

6.2 Electrical

With the power cord disconnected, perform a visual check on the ac power entry module, located of the rear panel of the instrument. The internal power supply of the 1340A is fully auto-ranging and does not require any manual setting for the line voltage.

6.3 Fuse Inspection/Replacement

The power entry module (Figure 6-1) is integral with the power ON/OFF switch and line fuse. As a default, the instrument will have a 1 A slow-blow fuse installed.

MAINS LINE VOLTAGE	FUSE RATING
85 – 264 Vac	1 A – SLOW BLOW

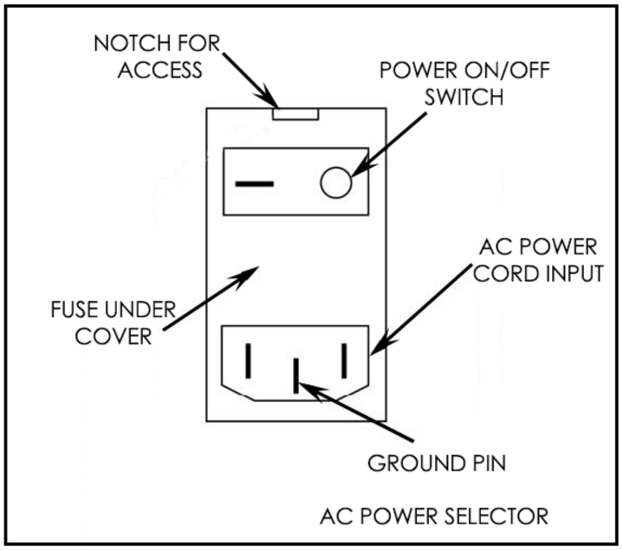

Figure 6-1. Power Entry Module.

WARNING

Remove the power cord from the 1340A before attempting to change the fuse.

The fuse is located inside the power entry module. To replace the fuse, remove the power cord and locate the small square notch in the fuse cover (Figure 6-1). Use a small, flat-bladed screwdriver to gently pry open the fuse cover.

6.4 Initial Power-up

The 1340A is supplied with a North American three conductor ac cord that plugs into the ac power entry module on the rear panel of the instrument. Insert the ac power cord into the ac power entry module on the rear panel (Figure 6-1).

WARNING

To reduce the potential of electrical shock hazard, always ensure that the power cord cable is plugged into an approved 3-contact grounded electrical power outlet.

Connect the power cord to an appropriate ac power source and turn the instrument 'ON'. The 'ON' condition is indicated by the illumination of the POWER LED on the front panel of the 1340A.

The 'HEATER ON' LED should also be illuminated. The 'HEATER OFF' lamp should illuminate after approximately twenty minutes after power-on, when the internal temperature-stabilized chamber has warmed-up to near-operating temperature. The 1340A will require 5 days with the power on for the internal temperature stabilize to the level required for the most accurate measurements

This completes the initial inspection and power-up.

7 Installation

The model 1340A is supplied in a standard 19" case allowing the unit to be either bench-mounted or rack-mounted. The 1340A is provided with an approved 3-conductor ac power cable (length ~6 ft), two connection cables for voltage input and output, and a connection cable for the PRT output.

7.1 Connections – Front Panel

Voltage Divider Input: The 1340A voltage divider consists of four separate 10:1 dividers that can be cascaded together to increase the division ratio. The voltage input is always from the bottom red input connectors. For ease of use, a double banana connector can be used. Each voltage input has a maximum input voltage clearly marked below the input Hi connector. Each input consists of two terminals, the Hi (red) and Lo (black), directly above each input connector (Figure 7-1).

Voltage Divider Output: There are four red output connectors. Each Hi terminal (red) has a matching Lo terminal (black) directly below (Figure 7-1). The output connector selected depends on the desired ratio required by the user.

PRT Output: There is a 4-pin LEMO-type connector (PRT) on the front panel used to monitor the internal temperature of the temperature-stabilized chamber. This is a four-wire resistance measurement. The temperature corresponding to the measured resistance can be found using the PT100 chart (see Table 9-2).

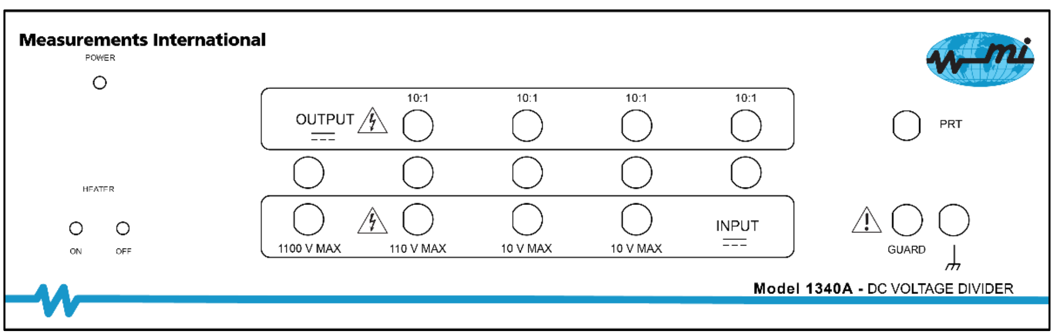

Figure 7-1. 1340A Front Panel Output Terminals.

Chassis Ground: On the front panel of the 1340A (Figure 7-1), there is a "CHASSIS GROUND" terminal. Internally this terminal is connected directly to the POWER GROUND of the ac Power Entry Module.

CAUTION

Guard: A "GUARD" terminal is provided. The shields of the input and output cables along with an inner guarded enclosure, housing the resistance networks, are connected to this terminal (Figure 7-1). If required, a potential of up to 100 Vdc can be applied to this terminal. NOTE: when applying a potential to the guard terminal, the guard cannot be connected to ground anywhere in the circuit**.**

7.2 Connections – Rear Panel

AC Mains Power: The ac power connection is made via the ac power entry module, located on the rear panel (Figure 7-2). Please refer to Section 6.3 and 6.4.

Figure 7-2. 1340A Rear Panel Connection Terminals.

8 Theory

The 1340A uses a precision resistance network that divides the voltage in a cascading network of four 10:1 dividers. Figure 8-1 explains the theory of operation. On the left are the input connectors, labeled "1in" to "4in", and on the right of the drawing are the four output connectors, labelled "1out" to "4out". When an input voltage is applied to any left-side input connector, the corresponding right-side connector, which is always one range lower in the divider network, provides a 10:1 voltage ratio.

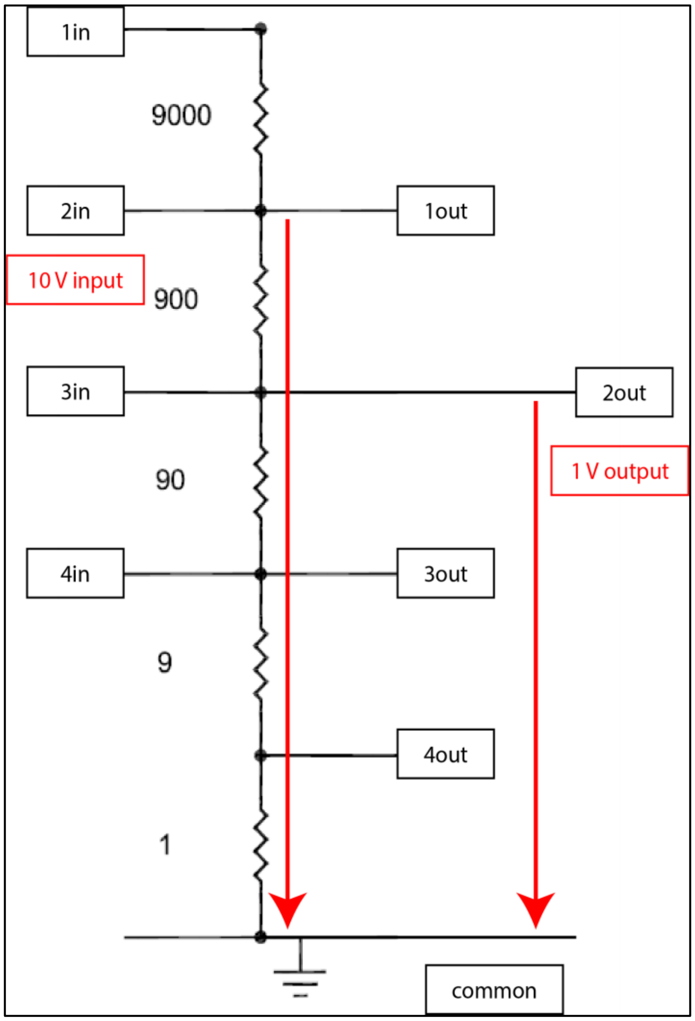

Figure 8-1. Theory of Operation.

For example, if 10 V were applied to connector "2in," the resistance to ground is equal to 900+90+9+1=1000. On the output connector "2out," the resistance to ground is 90+9+1=100, hence a division of 10:1 (1000/100)

If the voltage output at connector "3out" is measured, an extra 10:1 division occurs. The original 10 V appears at connector "2out" as 1 V. This becomes the input voltage for connector "3in". The path to ground for this second voltage (1 V) is through resistors 90+9+1=100, and for connector "3out" it is 9+1=10 resulting in another 10:1 division (100/10). The original input voltage at connector "2in" is divided by 10x10:1 at connector "3out". This cascading feature can be used four times, resulting in a maximum voltage division of 10 000:1. Ensuring the maximum input voltage is not exceeded, many ratio combinations are possible.

The same cascading principle applies to the uncertainties for the voltage divider. If only using one stage of the divider, the uncertainty is the ratio uncertainty for that stage. When using multiple divider stages, the k = 1 ratio uncertainties are root sum squared together, for however many stages of the divider are being used.

9 Operation

9.1 Warm-up

After the 1340A instrument has been installed and been switched 'ON', the recommended warm-up time is approximately 24 hours, but for the most accurate measurements, a warm-up time of 2-3 days is recommended. This allows the precision resistor networks (housed inside the temperature-controlled chamber) to overcome thermal inertia and reach stable temperature equilibrium.

9.2 Connections

The 1340A consists of four 10:1 dividers. The 10:1 ratio furthest to the right will be referred to as stage 1, and the furthest left ratio is stage 4. The ratio between each input and adjacent output pair is 10:1. Increasing the spacing between the output and input pairs increases the ratio by a factor of 10 for each empty output pair between the two measurement points. This can be achieved by moving the input pair further to the left of the unit or by moving the output pair further to the right.

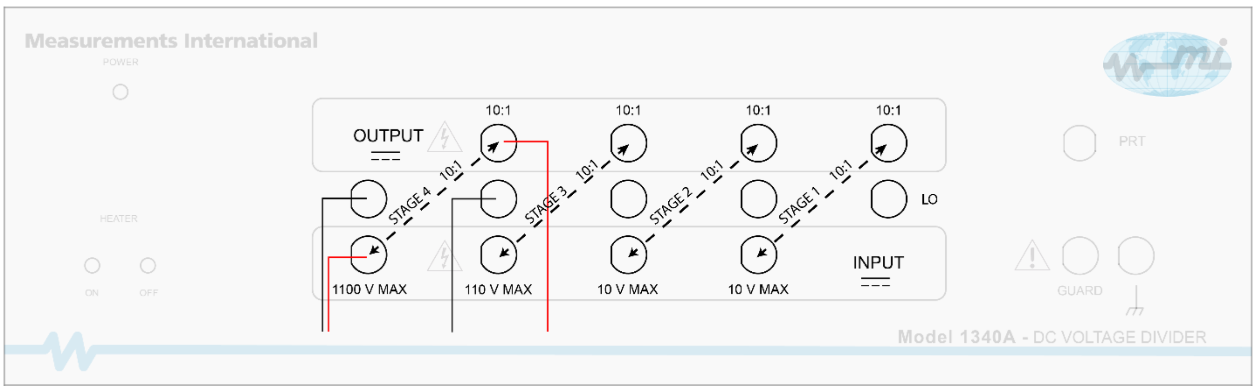

Figure 9-1. Connecting the Divider 10:1 ratio.

Figure 9-1 demonstrates the connection for a 10:1 ratio obtained between the input voltage to stage 4, and the output voltage to stage 4.

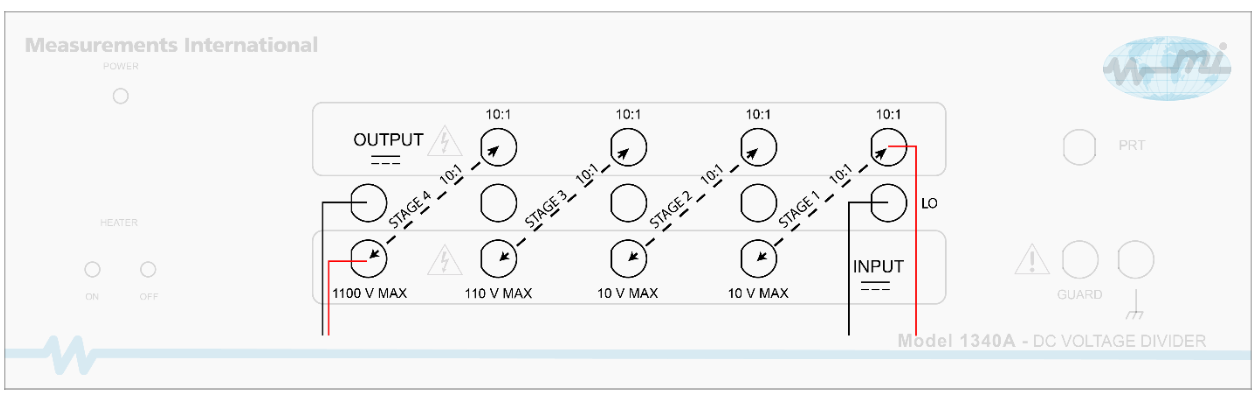

Figure 9-2. Connecting the Divider 10 000:1 ratio.

In the example of Figure 9-2, the input voltage is connected to stage 4 and the output voltage is taken from the output of stage 1 for a ratio of 10 000:1 or 10 x 10 x 10 x 10. By moving the input connection towards the right, the ratio is reduced by a factor of 10 for each stage the input voltage connection is moved closer to the output connection. The same reduction in the ratio is achieved by moving the output connection further to the left.

CAUTION

Take note of the maximum allowable input voltage on the front panel. Exceeding these input voltages can permanently damage the unit.

9.2.1 Grounding and Guarding

The best metrological practices should always be followed when making accurate electrical measurements. All the guard terminals are connected together. At the same time, the ground and Lo are connected to the guard at a single point.

Figure 9-3 shows an example of grounding when the 1340A is used with a calibrator. The most straightforward point to connect Lo, guard, and ground is at the calibrator. When "external guard" is not selected on the calibrator, Lo is connected to the guard internally.

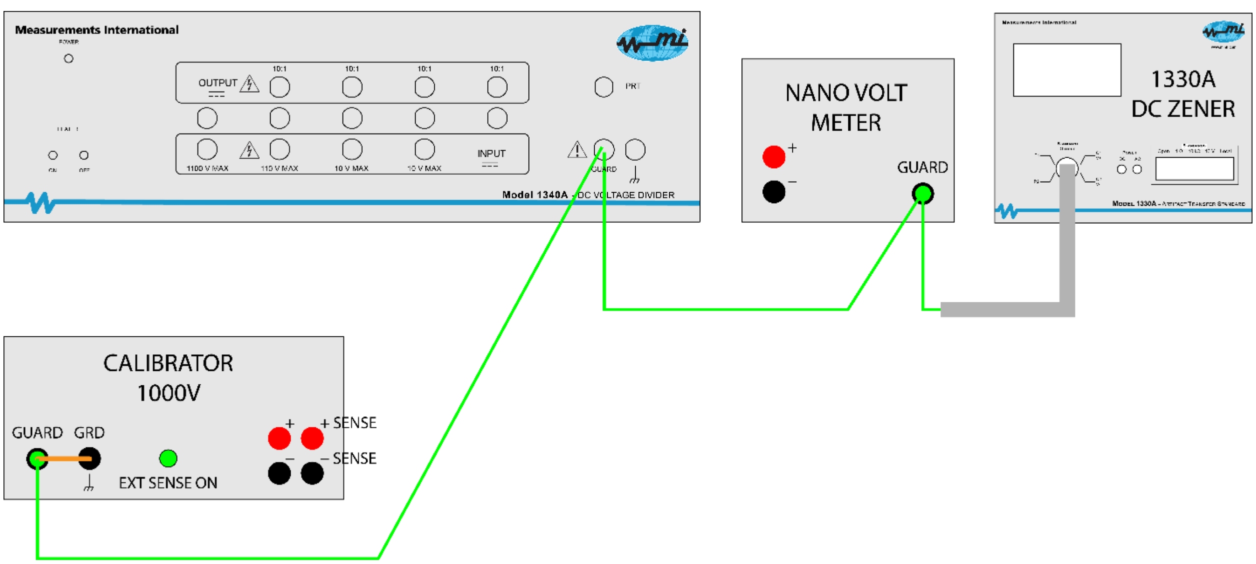

Figure 9-3. Instrument Grounding.

9.3 Input Voltage Loading

Instrument loading effects occur when the input resistance of a device connected to a source causes a change in the source voltage. When using the 1340A, it is recommended to connect all calibrators in the four-wire external sense mode.

The design of stage four of the 1340A enables using a dc Zener as a source with minimum loading effects. When using a dc Zener as a source in stage four, an added uncertainty component of 0.2 µV/V is added to the uncertainty budget to account for loading effects. To avoid the added uncertainty, transfer the value of the dc Zener to a calibrator and use the calibrator in “external sense” mode. The transfer can be performed either before using the calibrator, or both before and after the measurements are completed.

9.4 Divider Calibration

Each 1340A is constructed to provide four 10:1 ratio very close to nominal. Each ratio is made up of a resistive divider network. As with standard resistors, the resistive network will be affected by travel and environmental factors, and the resistors will drift over time. These changes are small and how much of a concern the change in value will depend upon the uncertainties required by each laboratory. The drift specification provided by Measurements International is for 30 days. Full calibration requires that all four divider stages be measured using both positive and negative voltage.

The end user can develop a calibration method that provides the required uncertainties for the laboratory. The chosen method could be as easy as the following:

1) Connect a calibrator, in external sense mode, to one divider stage and set the calibrator to 10V.
2) Measure the output voltage with a DVM.
3) Adjust the input voltage until the output voltage reads 1.000 000 V.
4) Measure the input voltage at the divider. The ratio value will be equivalent to the measured value of the input voltage.
5) Repeat this for each stage of the divider.

Perform the calibration of the divider as often as required. It is not necessary to perform a full calibration of the 1340A divider on each calibration. Suppose the laboratory uses only one or two divider stages more often than the other ones, it is appropriate to calibrate only those stages regularly. In a situation like this, the stages that have been calibrated should be clearly noted.

As with the calibration method, the ratio drift offers the user flexibility in determining the drift uncertainty to meet their requirements. The user can determine the drift over longer periods of time and expand the uncertainty as required. Or if the laboratory’s goal is to reduce uncertainties, the ratios could be calibrated both before and after using divider, for instance, on Monday morning and again on Friday afternoon. The actual drift in the ratio could then be used in the uncertainty budget.

Further still, the daily drift could be calculated, and the ratio corrected for each day of use. This is all dependent on the required measurement uncertainty.

9.4.1 Calibration using a 3458A

When using this method of calibration, a voltage source that is stable over the measurement period, generally a calibrator is used, and an 8 ½ digit voltmeter with very low linearity uncertainties.

This method's accuracy depends on the linearity specification of the 3458A and the short-term stability of the voltage source. The linearity specifications for the HP/Agilent/Keysight 3458A on the 10 V range are stated as 0.05 ppm of range +0.05 ppm of reading from full scale to 10% of full scale, measurements made within 10 minutes and temperature stability of 0.5°C. There are several papers written about the 3458A's linearity characteristics and stability. It has been shown that the 3458A meets this specification when calibrated against a Programable Josephson Voltage Source (PJVS).

The absolute value recorded with the 3458A is of no importance. It is only the difference between the 10 V value and the 1 V value that is of concern. Section 9.4.2 detailed the calibration just described, which is one of many ways that can be used to calibrate the divider.

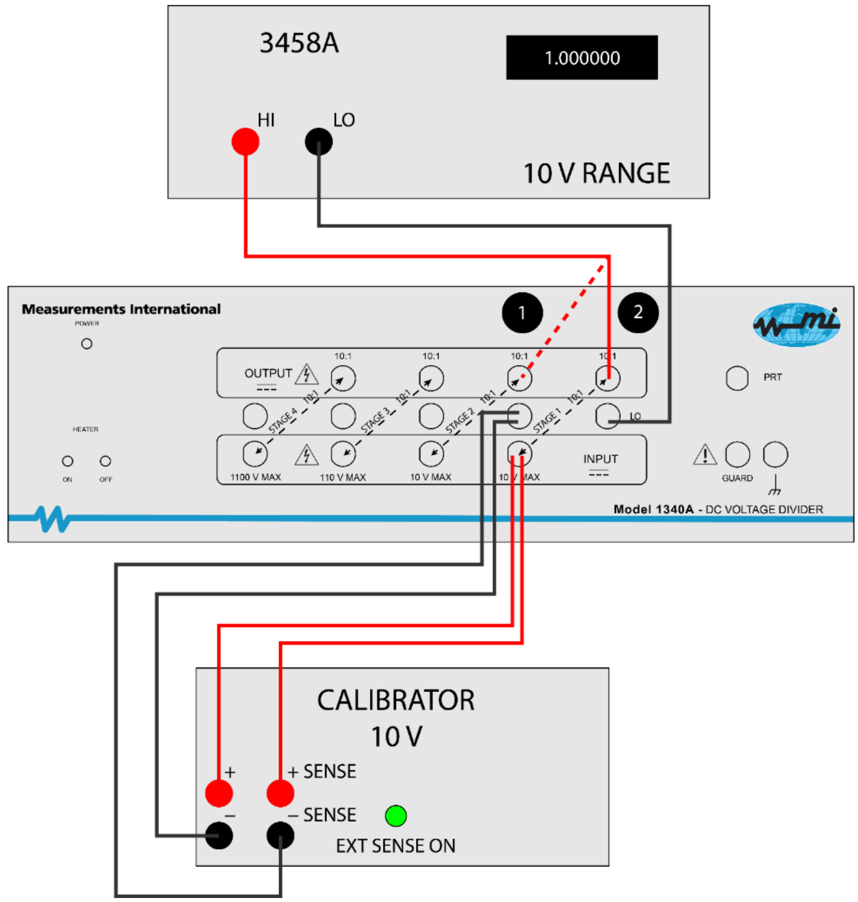

Figure 9-4. Calibration of the Divider Ratio

9.4.2 Calibration Example

In this example, there are three instruments, a dc source, the 1340A divider, and a 3458A. For each divider stage, 10 V is applied to the input terminals, the meter is used to measure the input and output voltage, as shown in the diagram below.

The settings for the instruments are listed below. NOTE: Placing the meter in the 10 V range is the most crucial step, as both the 10 V and the 1 V must be measured in the same range to use the linearity uncertainties for the meter.

3458A:
NPLC 100
Auto Zero ON
Dc Volts 10 V range
Guard External

Calibrator:
External Sense: ON
Dc volts 10.0 V

The 10 V input voltage is measured, and subsequently, the 1 V output voltage is measured with the same cable by simply moving the Hi input wire from one divider terminal to another.
Each measurement is repeated three times in a specific pattern, as shown in the graph below. Each measurement set consists of 30 measurements of the input and output voltages. These measurements provide six separate ratio calibrations. The average of these six values provides a single value for the ratio. Repeat the exact measurement, described above for each stage of the divider.

Measurement Pattern:
10 V 30 measurements
1 V 60 measurements
10 V 60 measurements
1 V 60 measurements
10 V 60 measurements
1 V 60 measurements
10 V 30 measurements

Allow for an appropriate settle time before measurements commence. This time varies from unit to unit and can be measured by analyzing the output voltage data for each divider stage. In the graph below, the output voltage of stage 4 requires a 60-second settle time for measurements of the highest accuracy.

Figure 9-5 shows the input voltage being measured on the output terminal (red) directly above the input terminal. The terminal configuration is designed to allow the use of two banana plugs simultaneously, one on the input and one on the output.

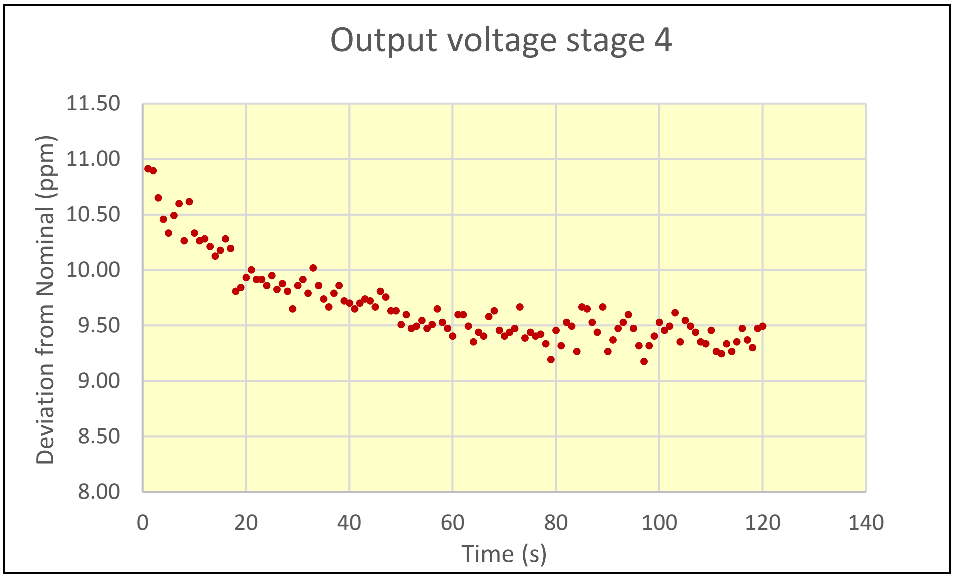

Figure 9-5. Setting Time.

It should be noted that when viewing the red terminals from top to bottom, both red terminals in a single column are electrically at the same point in the circuit. The same is true for all the common terminals (black).

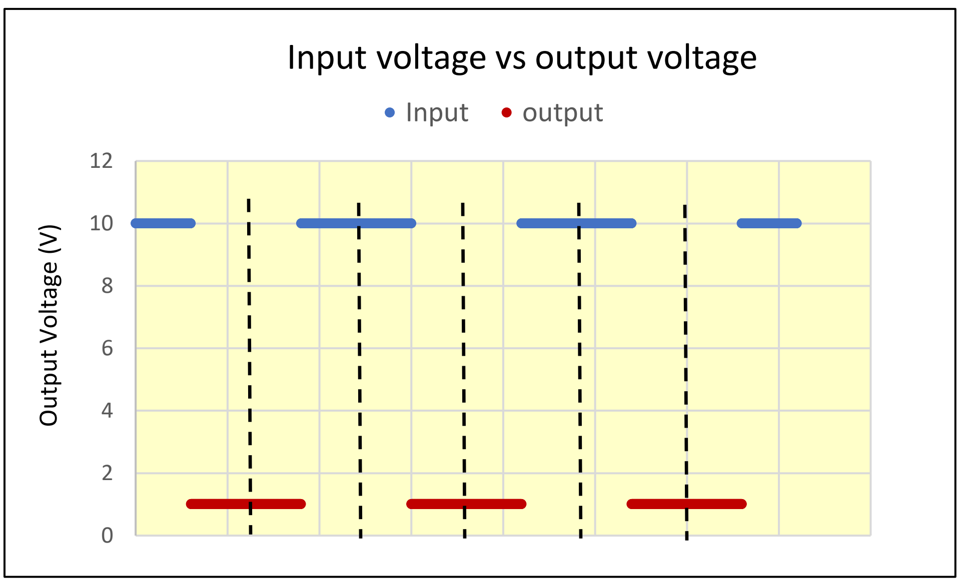

Figure 9-6. Calibration of a divider stage.

Figure 9-6 shows how the data is divided into six separate measurements. One ratio measurement consists of taking the average value of 30 input voltage measurements and dividing that by the average value of the 30 corresponding output voltages. The result is six voltage ratio measurements.

Table 9-1. Calculation of the Divider Ratio.

	10.000 024 9
	10.000 026 5
	10.000 026 6
	10.000 024 9
	10.000 024 4
	10.000 025 5
average	10.000 025 5

Table 9-1 shows the average of the six ratio values, and the result is the voltage ratio for one stage of the divider.

These measurements are repeated for all four stages of the divider. The ratios determined through the calibration of the divider are required when using the 1340A to perform calibrations. It is a good metrological practice to repeat this measurement regularly.

9.5 Voltage Divider Operation

The 1340A provides a simple method to scale both upwards and downwards from your laboratory traceable 10.0 V, 1.018 V 1.0 V, and 100 mV SI voltage (depending on the Zeners available in the laboratory). Do not forget about Input voltage loading; see Section 9.3. Always connect the calibrators to the divider in external sense mode.

9.5.1 DC Voltages Below the Reference Voltage

If using a calibrator as a transfer standard, by following the laboratory procedure, transfer the laboratory's traceable dc voltage value from the Zener to the calibrator. Ensure the calibration is in four wire sense mode. When connecting to the divider it is recommended to use the same cables that were used in the transfer.

The calibrator can be used at any voltage level, depending on how the divider is being used. But if an SI voltage value has been transferred to the calibrator, that is the voltage the calibrator should be set to provide an unbroken traceability chain to the SI.

<u>Step 1</u>: Connect the calibrator to any pair of input terminals. In this case a Zener can also be used, but due to loading, it must be connected to the Stage 4 input terminals, and the loading effect must be included in the uncertainty budget.

<u>Step 2</u>: The voltage on the output terminals directly to the right of the input terminals is divided by the calibrated ratio value for that divider stage (Section 9.4). In the example below, the used ratio is stage 3 (r_{S3}), but the same calculation is valid for all divider stages.

$$\frac{10\ \mathrm{V}}{r_{S3}} = 1.0\ \mathrm{V}$$

$$r_{S3} = 10.000\,000$$

Using a set of terminals further to the right increases the division 10-fold for each step. The calibrated ratio values are multiplied to determine the value by which the input voltage is divided.

$$\frac{10\text{ V}}{r_{S3}} = 1.0\text{ V}$$

$$\frac{1\text{ V}}{r_{S2}} = 100\text{ mV}$$

Multiple stages are the combination of the equations seen above:

$$V_{IN} \times \frac{1}{r_{S3}} \times \frac{1}{r_{S2}} = V_{OUT}$$

$$\frac{V_{IN}}{r_{S3} \times r_{S2}} = V_{OUT}$$

For a larger ratio, more ratio values are multiplied in the denominator.

<u>Step 3</u>: Use the known voltage to calibrate an artifact or instrument. Figure 9-7 illustrates the calibration of a nano voltmeter.

Note that by using a 1.0 V or 100 mV Zener, or by calibrating a dc voltage calibrator at a lower voltage, the divider can be used to calibrate voltages of less than 1 mV.

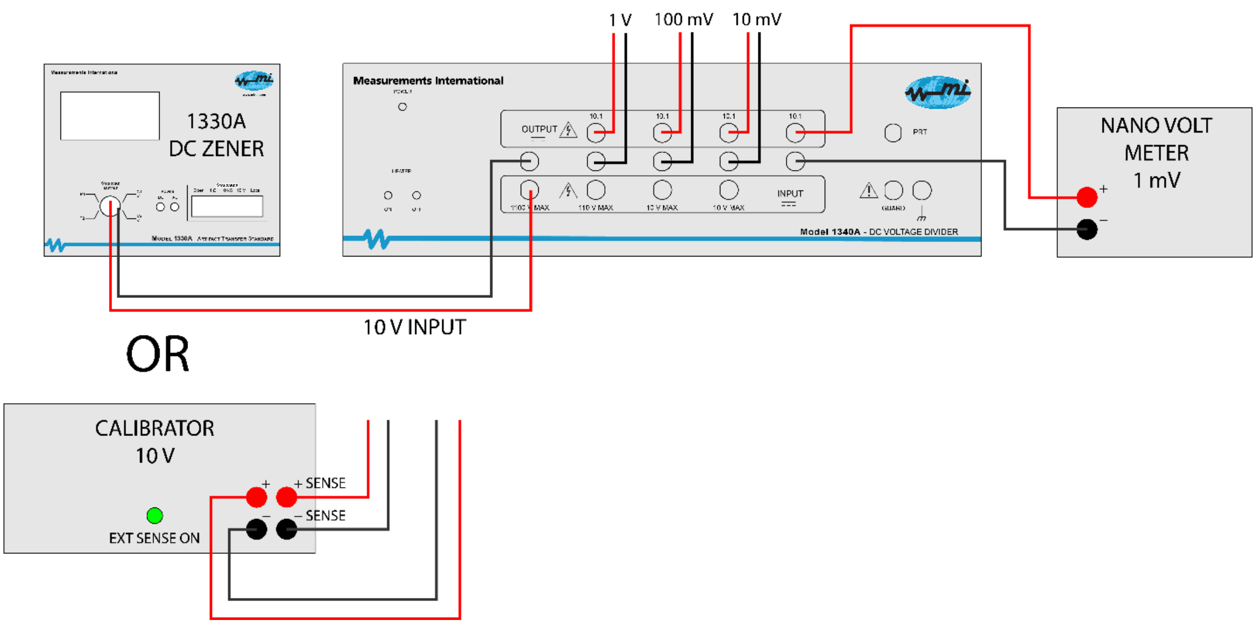

Figure 9-7. Divider Operation for Voltage Below the Reference

9.5.2 DC Voltages Above the Reference Voltage

The calibrator input can be connected to any input terminal of the 1340A voltage divider, but voltages above 10 V must be connected to Stage 3 or 4 so as not to exceed the maximum input voltage.

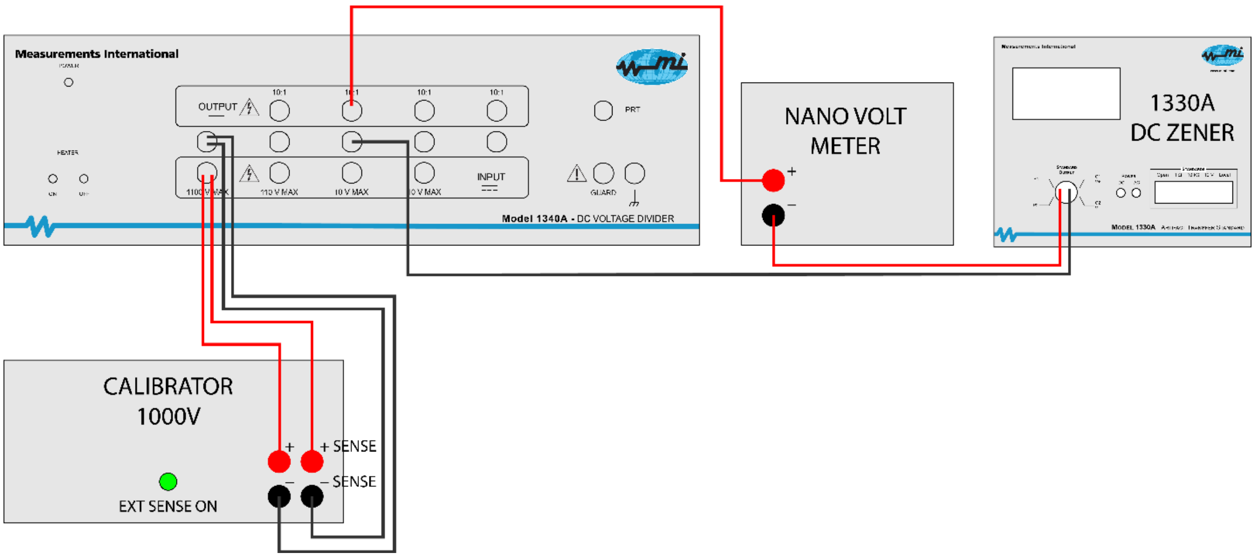

Figure 9-8. Divider Operation for Voltage Above the Reference

<u>Step 1</u>: Connect the calibrator to the selected input terminals in four-wire sense mode. A Zener, connected in opposition to the selected output terminal, allows for the direct calibration of a 100 V and 1000 V source. If lower uncertainties are acceptable, the output can also be read using a calibrated high-accuracy DVM. The output voltage measurement is used to calculate the value of the higher voltage. The equation is shown below for a 100:1 ratio measurement versus a 10 V Zener.

To calculate the value of the input voltage V_X:

$$\frac{V_X}{r_{S3} \times r_{S4}} = V_{REF}$$

$$V_X = V_{REF} \times r_{S3} \times r_{S4}$$

For larger ratios, multiply additional ratio values. For smaller ratios remove one ratio value from the equation.

NOTE

In precision metrology, connecting with high-quality shielded twisted-pair cables is good practice. The cable shield should be connected to the "GUARD" terminals of all the instruments in the measurement circuit. At a single point in the circuit, the guard should be connected to "Lo" and to the main "CHASSIS GROUND". The conductors in the connection cables should be solid bare copper or silvered copper wire.

CAUTION

Do not apply any voltages above the displayed maximum input voltage or damage to the divider will result. See section 4 for a comprehensive list of the 1340A specification details.

9.6 Temperature Deviation

The PRT connector on the 1340A front panel is used to supply a 4-wire resistance measurement to a DVM, which can be correlated against a temperature (see Table 9-2). It is recommended that a DVM with a resolution of at least 5.5 digits be used to measure the resistance of the PRT. The connection from the PRT connector to the DVM is made using cables supplied with 1340A (Figure 9-9. Hook-up of PRT to DVM for Temperature Deviation Monitoring.).

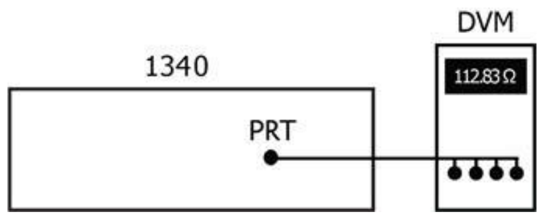

Figure 9-9. Hook-up of PRT to DVM for Temperature Deviation Monitoring.

Table 9-2. PT100 Temperature vs Resistance

°C	0	1	2	3	4	5	6	7	8	9	10	°C
	Resistance (Ω)											
-40	84.27	83.87	83.48	83.08	82.69	82.29	81.89	81.50	81.10	80.70	80.31	**-40**
-30	88.22	87.83	87.43	87.04	86.64	86.25	85.85	85.46	85.06	84.67	84.27	**-30**
-20	92.16	91.77	91.37	90.98	90.59	90.19	89.80	89.40	89.01	88.62	88.22	**-20**
-10	96.09	95.69	95.30	94.91	94.52	94.12	93.73	93.34	92.95	92.55	92.16	**-10**
0	100.00	99.61	99.22	98.83	98.44	98.04	97.65	97.26	96.87	96.48	96.09	**0**
0	100.00	100.39	100.78	101.17	101.56	101.95	102.34	102.73	103.12	103.51	103.90	**0**
10	103.90	104.29	104.68	105.07	105.46	105.85	106.24	106.63	107.02	107.40	107.79	**10**
20	107.79	108.18	108.57	108.96	109.35	109.73	110.12	110.51	110.90	111.29	111.67	**20**
30	111.67	112.06	112.45	112.83	113.22	113.61	114.00	114.38	114.77	115.15	115.54	**30**
40	115.54	115.93	116.31	116.70	117.08	117.47	117.86	118.24	118.63	119.01	119.40	**40**
50	119.40	119.78	120.17	120.55	120.94	121.32	121.71	122.09	122.47	122.86	123.24	**50**
60	123.24	123.63	124.01	124.39	124.78	125.16	125.54	125.93	126.31	126.69	127.08	**60**
70	127.08	127.46	127.84	128.22	128.61	128.99	129.37	129.75	130.13	130.52	130.90	**70**
80	130.90	131.28	131.66	132.04	132.42	132.80	133.18	133.57	133.95	134.33	134.71	**80**
90	134.71	135.09	135.47	135.85	136.23	136.61	136.99	137.37	137.75	138.13	138.51	**90**
100	138.51	138.88	139.26	139.64	140.02	140.40	140.78	141.16	141.54	141.91	142.29	**100**
110	142.29	142.67	143.05	143.43	143.80	144.18	144.56	144.94	145.31	145.69	146.07	**110**
120	146.07	146.44	146.82	147.20	147.57	147.95	148.33	148.70	149.08	149.46	149.83	**120**
130	149.83	150.21	150.58	150.96	151.33	151.71	152.08	152.46	152.83	153.21	153.58	**130**
140	153.58	153.96	154.33	154.71	155.08	155.46	155.83	156.20	156.58	156.95	157.33	**140**

[1] F. Galliana, R. Cerri and C. Davide, "Automatic DC voltage precision resistive divider with ratios between 10:1 and 107:1," *Measurement*, 2021, vol. 183, p. 109865.

[2] Keysight Technologies, “3458A Data Sheet”, 2021.

[3] M. Maruyama *et al*., "Evaluation of linearity in digital voltmeters using PJVS," *29th Conference on Precision Electromagnetic Measurements (CPEM 2014)*, 2014, pp. 262-263.

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