



# Voltage Maintenance Program

## Software to Maintain your Laboratory Volt

VoltRef provides the power of automation for maintaining statistical control of the volt in your laboratory. This program controls a low thermal scanner and voltmeter to compare voltage standards using the process recommended by NIST and other national laboratories.

Fully automate voltage measurements with VoltRef to improve your results and reduce labor. Improvements can be achieved by reducing the errors caused by the handling of leads and by increasing the quality and quantity of voltage comparisons. Data Proof provides the ideal solution for laboratories who have three or more voltage references and require sub parts per million accuracy.

### Friendly interactive operations include:

- ◆ For both standard cells and solid state references
- ◆ Ten-to-one scaling with 0.2 ppm typical accuracy
- ◆ Prints out complete analysis reports
- ◆ Stores results of measurements
- ◆ Plots graphs of historical data for analysis
- ◆ Delay start and auto repeat for tests
- ◆ Tracks and corrects for voltage drift

### DATA PROOF

2562 Lafayette Street, Santa Clara, CA 95050  
phone: (408) 919-1799; fax: (408) 907-3710  
info@dataproof.com, [www.DataProof.com](http://www.DataProof.com)

The screenshot displays the DATA PROOF - VoltRef software interface. At the top, a menu bar includes File, Setup, Data Files, Last Readings, and Help. Below the menu is a table with columns: Group Code, Name, Serial Number, Nominal Temp, Nominal EMF, Scanner Position, Ref. Unit?, and Level. The table contains three rows of data for groups A1, A2, and A3. Below the table are 'Prev.' and 'Next' buttons and a text input field for group codes. A 'START' button is also present. The middle section shows a hardware connection diagram for a '160A Opt. 2 or 320A Opt.2 Low Thermal Scanner' with 'INPUT LINES' and 'OUTPUT LINES'. Below the diagram is a 'SCANNER SETUP SCREEN' table. The bottom section shows a 'GROUP MEAN EMF FOR 10REF' graph with 'MICROVOLTS' on the y-axis and months from Jan 1993 to Dec on the x-axis. The graph shows a red line with data points and green trend lines. Below the graph, statistics are provided: MEAN OF DATA = 18 000 031.17 Microvolts, STANDARD DEVIATION = 1.51 uVolts (1.927 from Slope), and SLOPE = 5.83 Microvolts Per Year.

GROUP CODE	NOMINAL	SERIAL NUMBER	NOMINAL TEMP	NOMINAL EMF	SCANNER POSITION	REF. UNIT?	LEVEL
A1	10REF	DP-9812122	10.000	1.018	1 2 3	YES	A
A2	1uSTD	DP-9812123	1.018	1.018	5 6 7 8	YES	
A3	1uREF	DP-9812125	30.0	1.018	9 10 11 12	NO	

GROUP	NOMINAL	NOMINAL TEMP	EMF UNIT?	ANY REFERENCE
A1	10REF	10.00	2	YES
A2	1uREF	1.018	3	NO
A3	1uSTD	1.018	3	YES

GROUP	NOMINAL	NOMINAL TEMP	EMF UNIT?	ANY REFERENCE									
1	10REF	1	10STD	1	-31.06	0.08	9	10STD	2	10REF	1	-19.28	0.06
2	10REF	1	10STD	3	-47.47	0.09	10	10STD	4	10REF	1	*	
3	10REF	3	10STD	3	-16.59	0.10	11	10STD	4	10REF	3		
4	10REF	3	10STD	1	31.02	0.03	12	10STD	2	10REF	3		
5	10REF	2	10STD	2	47.38	0.08	13	10STD	1	10REF	2		
6	10REF	2	10STD	4	16.52	0.08	14	10STD	3	10REF	2		
7	10REF	4	10STD	4	-21.16	0.08	15	10STD	3	10REF	4		
8	10REF	4	10STD	2	-23.17	0.12	16	10STD	1	10REF	4		

GROUP MEAN EMF FOR 10REF

MEAN OF DATA = 18 000 031.17 Microvolts  
STANDARD DEVIATION = 1.51 uVolts (1.927 from Slope)  
SLOPE = 5.83 Microvolts Per Year

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## VoltRef Overview

Data Proof software is the industry standard for making precision voltage measurements. Data Proof equipment is maintaining the volt in hundreds of commercial and national laboratories around the world. To make voltage measurements with VoltRef, simply select your groups to test. VoltRef will then create a test design for up to 32 devices, and then take the measurements controlling your voltmeter and low thermal scanner. When the test design is complete you can print a complete analysis, save the results and create graphs of your saved files.

## Statistical Analysis

VoltRef creates a test design where your voltage standards are compared in pairs. The small difference between the two units is measured, ten times first in the forward direction and then ten times with the leads reversed. When the design is complete VoltRef computes a least-squares-fit to determine the value for each device. This value is based on the average value of your reference units included in the test. A standard deviation of the measurement is also computed.

## Choice of Designs

VoltRef provides a choice of three test designs: 1) *statistically balance* design recommended by NIST and used by the majority of western national laboratories, 2) *favored cell* used by some European national labs, and 3) *ring* design popular in a few Asian countries. (Available only with VoltRef for Windows.)

## Flexibility

VoltRef provides convenient to simplify setting up a measurement. Scanner connections and traceable values are all stored so you simply select the groups to test. It only takes a few seconds to accommodate new reference devices that come into your laboratory for calibration. Information for up to 48 groups with six units per group can be stored. VoltRef can measure any voltage up to 50 volts, and is recommended for comparing both standard cells and solid state devices. VoltRef has built in drivers to accommodate most nanovoltmeters.

## Ten-To-One Scaling

Special ten-to-one and one-to-ten routines are included to allow comparisons between 1, 1.08 and 10-volt standards. Accuracy of 0.2 ppm can be realized using suitable 8 1/2 digit meters.

## Delayed Start

A delayed start routine is included to let you make measurements at a later time without being present. This allows you to run tests at night when your lab is quiet. Up to four different designs can be printed out with choices of repeat intervals, print outs and files to store results. Repeat intervals allow you to automatically take measurements every day, week or any period of your choosing.

## Reports and Graphs

A complete analysis of the test can be printed. Historical data can be edited or deleted. Graphs can be created for individual devices or groups. Control limits can be added to graphs for statistical control. Data can also be imported or exported to commercial spread sheets.

## Voltage Drift

VoltRef computes the least-squares-straight-line slope of your devices. This aids you in predicting the emf drift for solid state standards. Also the predicted slope and calibration date can be stored for each traceable unit. This information can be used to calculate the predicted emf values for your reference standards each time a test is run.

## System Requirements

Computer, 486 or higher, with 8 Mbytes of RAM (12 Mbytes recommended) Windows® 3.1, '95 or NT, and a IEEE-488 (GPIB) bus interface card (not included) (VoltRef runs in TransEra's HWIN with Basic PLUS - runtime versions are included. HWIN Development version is also available to edit VoltRef program code.) **Recommended:** Data Proof Low Thermal Scanner and a suitable nanovoltmeter.

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## Ordering Information:

VoltRef	For Windows 3.1, Windows 95, Windows NT or higher
Also Available:	
HM900	TransEra GPIB Interface Board
HWIN	TransEra HTBasic for Windows (Development version)

## Order Contact:

**Data Proof**  
2562 Lafayette Street  
Santa Clara, CA 95050  
Phone (048) 919-1799  
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email: [info@dataproof.com](mailto:info@dataproof.com)  
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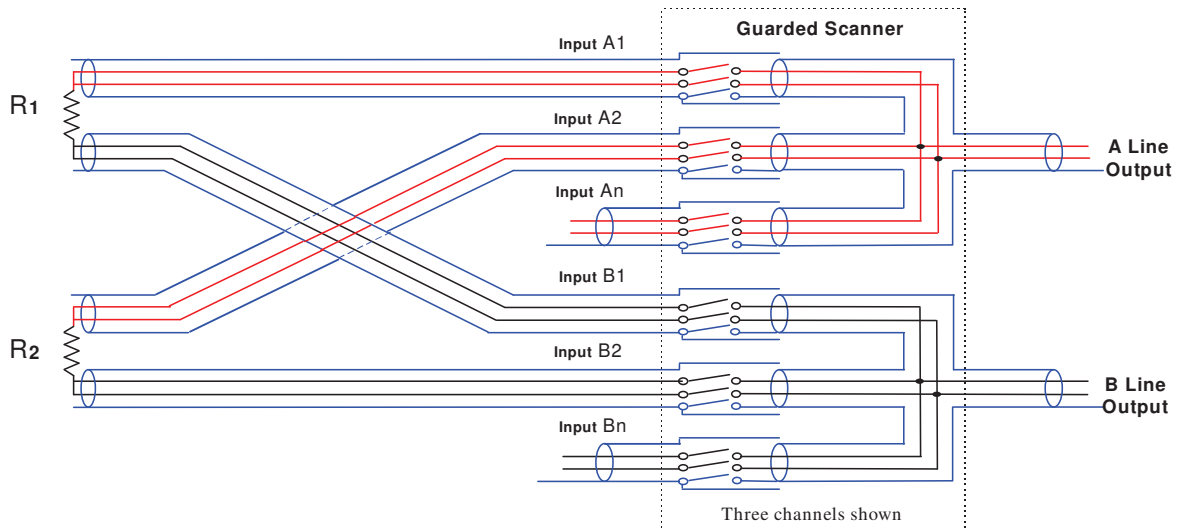
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# LOW THERMAL GUARDED SCANNER

Models: 160B Opt. 3 & 320B Opt. 3



Data Proof's Low Thermal Guarded Scanners are designed to improve accuracy in high resistance measurements. Unguarded, the Data Proof scanners have leakages of about  $10^{12} \Omega$  which can cause errors of a few tenths of a ppm when measuring 1 M $\Omega$ . Guarding greatly reduces the errors allowing excellent accuracy up to the 1 G $\Omega$  level.

The high guard surrounds the potential and current leads to the high end of each resistor, and a separate low guard surrounds the leads to the low end of the resistor. The guard shields are switched along with the current and potential lines. The guard is carried through shielded cables from the resistor, through the scanner and to the output cables.

The latching relays are modified so that the armatures are included in the guard circuit to prevent leakages through the relay coil circuitry. These are the same relays used to provide the low thermal performance that Data Proof is famous for.

The Option 3 Scanners are clearly a superior choice for automating precision resistance measurements. They offer advantages for making resistance measurements even if the guard system is not used. The high side and the low side of each resistor are switched by separate relays which reduces leakage current even when the guard is not used. Also 16 four-terminal devices can be connected to the 160B Opt. 3 and 32 four-terminal devices to the 320B Opt.3.

## SPECIFICATIONS

### Thermoelectric Potentials:

- Less than 20 nanovolts typical
- 50 nanovolts maximum

### Relay Contact Ratings:

- Life: >10,000,000 cycles at low levels
- Initial contact resistance: 0.05 $\Omega$  maximum
- Current: 100 mA maximum at 10 volts
- Voltage switched: 100 volts max. at 1 mA
- Voltage non-switched: 600 volts maximum

**Leakage Resistance (guarded):**  $10^{14} \Omega$

**Leakage Resistance (not guarded):**  $10^{12} \Omega$

## REAR PANEL CONNECTIONS

### Inputs:

**160B Opt. 3:** 16 pairs of six-foot guarded cables

**320B Opt. 3:** 32 pairs of six-foot guarded cables

**Outputs:** Two pairs of six-foot guarded cables

**Cables:** Stranded Silver Plated Copper with Teflon Insulation  
Braided Silver Plated Copper Shield with Teflon Wrap

**Bus Inputs:** 24 pin IEEE-488 connector

**Size:** 420mm (16.5in) length, 451mm (17.7in) width,  
133mm (5.2in) height

### Scanner Control:

Local - using front panel push buttons

Remote - via IEEE-488 bus (includes)

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## GUARDED HIGH-OHM RESISTANCE SYSTEM

By using a guarded scanner and two sources to form a guarded resistance bridge, measurements from 100K $\Omega$  to 10G $\Omega$  can be made with excellent accuracy. This system provides a simple yet effective way to activate both the high and low guard circuits. Adjusting the source outputs to set the high impedance side of the bridge circuit to zero volts reduces errors caused by meter circuit loading. The system described here is similar to one to the one used by NIST for measuring resistors in the G $\Omega$  range.

### HIGH-OHM DESCRIPTION

This circuit is a wheatstone bridge where two legs of the bridge are voltage sources. A DVM measures the voltage across the bridge and a low thermal scanner is used to switch the resistors in the test.

The standard low thermal scanner has leakages of about  $10^{12}\Omega$ . In a normal arrangement the leakage currents would cause errors of about 1 ppm at the 1 M $\Omega$  and 100 ppm at 100 M $\Omega$ . By using a fully guarded scanner, leakages can be significantly reduced.

Because the sources have low impedances, the high guards can be connected directly to the source outputs. The low guard can be connected directly to ground because the sources are always adjusted so that the DMV reads zero.

Keeping both sides of the bridge at zero volts reduces leakage errors. This is done by using two voltage sources for two arms of the bridge as shown in the diagram below. Voltage source #1 is adjusted so that the DVM always reads zero, which sets the center point of the two resistors being compared to zero volts. The tare standard is always in the circuit, and the low thermal scanner is used to switch the standard and test resistors into the circuit one at a time.

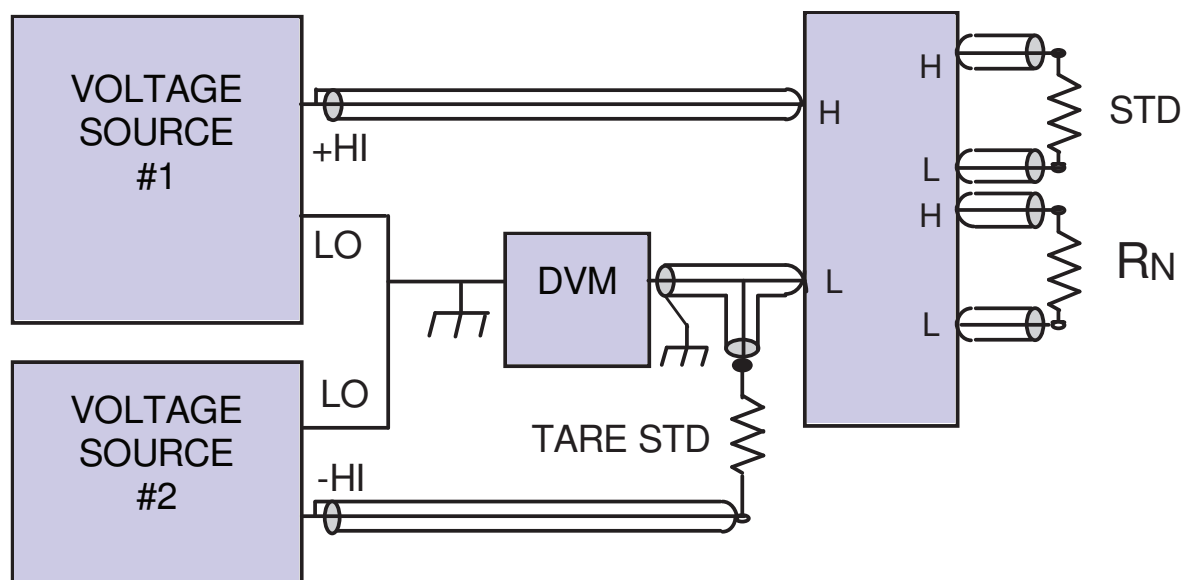
### OhmRef SOFTWARE

The High-Ohm Resistance method is now included in the Data Proof OhmRef software. This provides a convenient means to set up an make high resistance measurements. OhmRef will allow up to 8 resistors to be compared at a time.

### HIGH-OHM RESULTS

A non-guarded scanner can be used to compare resistors to 10M $\Omega$  with an uncertainty of about 1ppm. With a guarded scanner good results can be obtained comparing 1G $\Omega$  resistors with an uncertainty of about 10 ppm.

Different values of resistors can be compared over a wide range with the uncertainty is primarily dependant upon the scaling accuracy of the voltage source being used.



**Guarded High-Ohm Resistance System**

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# Resistance Software Program

## Resistance Software for Standards Laboratories

OhmRef provides the power of automation for maintaining statistical control of resistance values in your laboratory. This program controls a Low Thermal Scanner along with other equipment commonly available in Standards Laboratories to compare resistance standards over the range of  $100\mu\Omega$  to  $10G\Omega$ . Comparison accuracies are better than 1 ppm in the midranges.

Improve your results while reducing labor with OhmRef resistance software. Improvements can be achieved by reducing errors caused by handling test leads and by increasing the quality and quantity of resistance comparisons. Data Proof provides the ideal solution for laboratories who desire a lower cost solution to improve ease and accuracy of maintaining resistance standards.

### Friendly interactive operations include:

- ◆ Range:  $100\mu\Omega$  to  $10G\Omega$
- ◆ Low cost - using commonly available equipment
- ◆ Quickly start tests with a few clicks of a mouse
- ◆ Scaling over a range of ten-to-one
- ◆ Prints out complete analysis reports
- ◆ Plots graphs of historical data
- ◆ Tracks and corrects for resistor drift rates

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info@dataproof.com, www.DataProof.com

The screenshot displays the OhmRef software interface. At the top, a table lists test units with columns for Number, Unit Name, Ohms, Channels, Max Amps, and Reference?. Below the table are buttons for 'Start Scanner', 'Enter Keyboard', and 'Graph Data'. The middle section shows a 'Scanner Setup Screen' with a diagram of the scanner's input and output lines. Below the diagram is a table of scanner setup parameters. The bottom section shows a list of test results with columns for Unit No., Name, Nominal Value, Channel, Max Amps, Nominal Dev., and Reference Value. At the bottom, a plot shows 'DEVIATION FROM NOMINAL OHM FOR: 1 ohm#2' with 'Parts Per Million' on the y-axis and 'Per' on the x-axis. The plot shows a mean value of 1.9263 PPM and a standard deviation of 0.061 PPM.

## OhmRef Overview

Making resistance measurements with OhmRef is as simple as clicking on resistors from your list and selecting your choice of test methods. OhmRef will create a test design for up to eight resistance devices and control your multimeter, Low Thermal Scanner and source to take the measurements. When all the readings have been taken you can print a complete analysis, save the results and create graphs of the data. OhmRef accommodates any resistance value between  $100\mu\Omega$  and  $10G\Omega$  with comparison accuracy better than 1 ppm for resistor values between  $1\Omega$  and  $10M\Omega$ .

## Choice of Methods

OhmRef allows you to select between four test methods depending upon the resistance level, required accuracy, and equipment available in your laboratory. The first and most basic method requires only the Low Thermal Scanner and ohmmeter. All methods take advantage of equipment that's commonly available in standards laboratories, providing very good accuracy at a low cost.

## Statistical Analysis

OhmRef creates a test design to compare resistors in pairs. Each resistor in the pair is measured, one at a time, and the difference between the two units is saved. When all the measurements are complete OhmRef computes a least-squares-fit to determine the value for each device. This value is based on the average value of the reference units included in the test. A standard deviation of the measurement is also computed. The designs and computations used are similar to those recommended by NIST developed for voltage calibrations.

## Flexibility

OhmRef provides a convenient means to set up a measurement. Scanner connections and traceable values can be saved, so you simply select the resistors to test. It only takes a few seconds to add new resistors that come into your laboratory for calibration. Information for up to 100 resistors can be stored. OhmRef has built in drivers to accommodate suitable multimeters and sources.

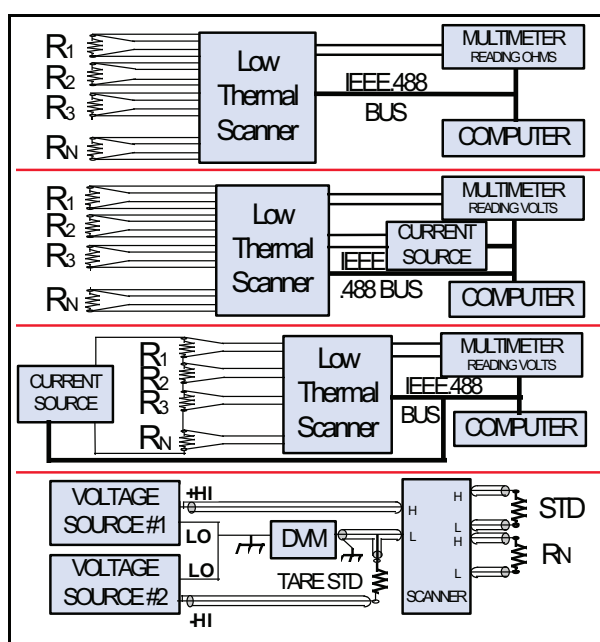
## Reports and Graphs

A complete analysis of the test can be printed. Various graphs can be made to monitor your resistors. Add control

limits to your graphs for statistical control with the click of a mouse. Historical data can be edited in OhmRef or exported to popular spreadsheet programs.

## Drift Rates

OhmRef computes the least-squares, straight-line slope of your resistors. This aids you in predicting the drift for your standards. Also the predicted slope and calibration date can be stored for each traceable unit. This information can be used to calculate the predicted values for your traceable resistors each time a test is run.



## System Requirements

Computer, 486 or higher, with 16 Mbytes of RAM, Windows® 3.1/ 95 / NT or higher, and a IEEE-488 (GPIB) bus interface card (not included), a Data Proof Low Thermal Scanner and suitable multimeter. (OhmRef runs in TransEra's HWIN with Basic PLUS - runtime versions are included. HWIN Development version is also available to edit OhmRef program code.) **Recommended:** Suitable source(s) (for methods 2, 3 & 4).

## Ordering Information:

OhmRef For Windows 3.1, Windows 95, Windows NT or higher

Also Available:

HM900 TransEra GPIB Interface Board

HWIN TransEra HTBasic for Windows (Development version)

## Order Contact:

### Data Proof

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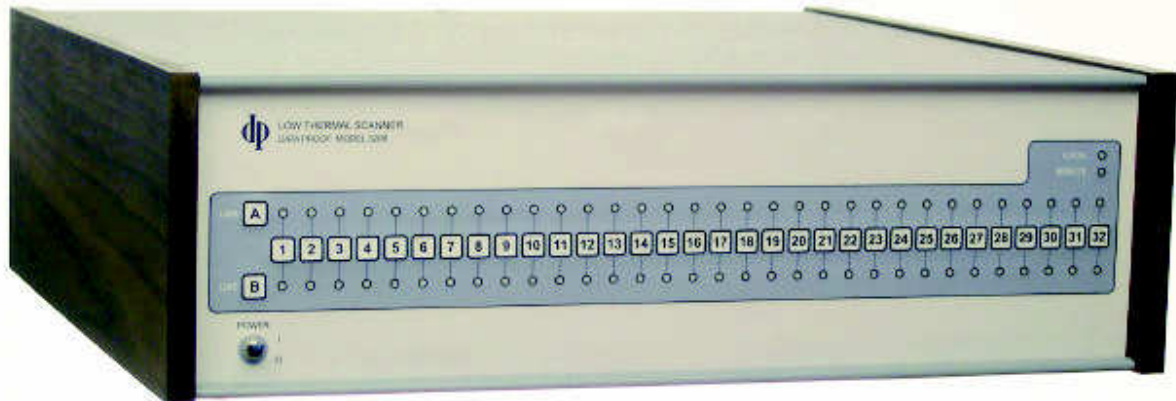
email: [info@dataproof.com](mailto:info@dataproof.com)

[www.DataProof.com](http://www.DataProof.com)



# LOW THERMAL SCANNER

Models: 160B  
and 320B



## FEATURES

- \* Thermals typically < 15 or 20 nanovolts
- \* Front Panel or bus operation
- \* Dual output configuration with 16 or 32 inputs
- \* Four terminal measurements
- \* Standard cell protection
- \* Simple operation

## USES

Data Proof Low Thermal Scanners with extremely low thermal offsets are ideal for automating precision measurements to sub-ppm accuracy. This versatile dual scanner has two pairs of output lines that make it suitable for a wide variety of uses. It can be used to make difference measurements for comparing voltage reference standards, as well as four-terminal measurements on resistance devices.

## LOW THERMAL DESIGN

Special care has been taken to minimize thermal offsets. The switches used are latching relays requiring only a short pulse to actuate, and thus no self-heating occurs. Two types of low thermal relays are used depending upon the model. Scanners will contain a customized sealed relay or a Printact® relay manufactured by Data Proof.

Input leads are attached directly to the relay boards reducing the number of connections. Relays make connection by shorting together adjacent pads with pairs of contacts. Thus any thermal emf caused by a contact is canceled out by the nearly equal thermal emf generated by the other half of the pair. Relays are mounted in a heavy machined aluminum box to maintain thermal equilibrium in the switching area.

## TWO MODELS AVAILABLE

A choice of two scanners is available. The Model 160B has 16 input channels and the Model 320B has 32 channels. Four different input connections are also available. The Option 1,3 and 4 has 6 foot cables to connect directly to the devices under test, and the Option 2 has low thermal binding posts. Rack mount versions are available.

## CONVENIENT OPERATION

The relay circuits are activated either by front panel push buttons or by means of an IEEE-488 bus. A bus interface is built into the scanner as standard equipment and is easy to operate. A simple three character bus command sets the interface to remote, opens any previously closed relay, and then closes the specified relay.

## DUAL SCANNER DESIGN

Each input pair is connected to separate relays, and each relay switches the input lines to two different output circuits. Both high and low input lines are switched. This dual arrangement allows difference measurements to be made between voltage devices. True four-terminal measurements can also be made on resistance devices by using two input channels. With the Option 3 scanners true four-terminal measurement can be made with each channel.

## VOLTAGE APPLICATION

The diagram below shows the connections for comparing voltage standards. Any two units can be compared by closing one A-Line relay and one B-Line relay. The small difference voltage is measured by a meter across the high A and B Lines. The negative terminals are connected together by a short-circuit on the low lines. All other devices connected to the scanner are left floating.



Diagram for Opt. 1, 2, 4 Low Thermal Scanners

## STANDARD CELL PROTECTION

These scanners were carefully designed to protect standard cells from being damaged due to scanner failure or operator error. An extra contact on each relay is used to connect the relays in series, forming a protection circuit. All relays on a line must be open before power can be applied to close any relay. This protection circuit is available at the rear panel so that multiple scanners can be cascaded and all cells in a large system will have this protection feature. Also relays are driven from a decoder so only one circuit can be activated at a time.

## MANY APPLICATIONS AVAILABLE

Data Proof Scanners are very versatile and can be used anywhere low thermal switching is needed. Please contact us for application notes with designs to automate measurements of voltage, resistance, temperature, etc. Software is also available.

## SPECIFICATIONS

### Number of Input Channels:

16 for Models 160B and 160BR\*  
32 for Models 320B and 320BR\*  
\* Rack mount versions

### Thermoelectric Potentials:

Less than 20 nanovolts typical,  
50 nanovolts maximum (Options 1, 2, 3)  
Less than 15 nanovolts typical,  
30 nanovolts max (Option 4)

### Error Contribution:

Standard deviation <20 nanovolts when NIST  
4x4 design is run with inputs shorted

### Scanner Control:

Local - using front panel push buttons  
Remote - via IEEE-488 bus (included)

### Relay Contact Ratings:

10,000,000 cycles minimum at low levels  
0.05 ohm maximum resistance (initial)  
2.0 amp maximum at 24 V. DC. (Option 1 & 2)  
0.1amp maximum at 24 V. DC. (Option 3 & 4)

### Size in inches (millimeters):

5.2 (133) high, 17.7 (451) wide, 16.5 (420) deep

**Power:** 100 – 250V ~, 50-60 Hz, (external power supply)

*Data Subject to change*

## REAR PANEL CONNECTIONS

### Inputs - Choice of:

- Opt 1: Six foot cables. Untinned solid copper wire in groups of 4 pairs.
- Opt 2: Low thermal binding posts. Tellurium copper gold flashed per Mil-G-45204.
- Opt 3: Six foot shielded/guarded Teflon wire (See Opt.3 Guarded Scanner data sheet.)
- Opt 4: Six foot cables. Shielded Teflon wire groups of 4 pairs.

### Outputs:

Four low thermal binding posts (Options 1, 2, 4)  
A and B high lines  
A and B low lines

**Bus Input:** 24 pin IEEE-488 connector CINCH No. 57-20240

**Cell Protection:** Terminals go low (0 volts) when any relay is closed, and go high (5 volts through 10 kohm) when all relays are open. These lines can be connected in parallel with other scanners to protect all standard cells in a large system. Two circuits are provided, one for A line and one for B line.

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Santa Clara, CA 95050  
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fax: 408-907-3710  
email: [info@dataproof.com](mailto:info@dataproof.com),  
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