LR2000
Milliohmmeter
Instruction Manual

Form 150713/A3

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CAUTION

Voltage may be present on front and rear panel terminals. Follow all warnings in this manual when operating or servicing this instrument. Substantial levels of energy may be stored in capacitive devices tested by this unit.

Product will be marked with this symbol (ISO#3864) when it is necessary for the user to refer to the instruction manual in order to prevent injury or equipment damage.

Product marked with this symbol (IEC417) indicates presence of direct current.

Product will be marked with this symbol (ISO#3864) when voltages in excess of 1000V are present.

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Warranty

QuadTech warrants that Products are free from defects in material and workmanship and, when properly used, will perform in accordance with QuadTech's applicable published specifications. If within one (1) year after original shipment it is found not to meet this standard, it will be repaired, or at the option of QuadTech, replaced at no charge when returned to a QuadTech service facility.

Changes in the Product not approved by QuadTech shall void this warranty.

QuadTech shall not be liable for any indirect, special or consequential damages, even if notice has been given of the possibility of such damages.

This warranty is in lieu of all other warranties, expressed or implied, including, but not limited to any implied warranty or merchantability of fitness for a particular purpose.

SERVICE POLICY

QuadTech's service policy is to maintain product repair capability for a period of at least five (5) years after original shipment and to make this capability available at the then prevailing schedule of charges.

Specifications

Resistance Range:

Range F.S.	Resolution	Accuracy	Test I (typical)
20mΩ	1μΩ	± (0.1% of rdg + .006mΩ)	1A
200mΩ	10μΩ	± (0.05% of rdg + .06mΩ)	100mA
2Ω	100μΩ	± (0.05% of rdg + .6mΩ)	10mA
20Ω	1mΩ	± (0.05% of rdg + 6mΩ)	1mA
200Ω	10mΩ	± (0.05% of rdg + 40mΩ)	1mA
2kΩ	100mΩ	± (0.05 % of rdg + .2Ω)	1mA
20kΩ	1Ω	± (0.1% of rdg + 2Ω)	100μA
200kΩ	10Ω	± (0.2% of rdg + 20Ω)	10μA
2MΩ	100Ω	± (0.4% of rdg + 200Ω)	1μA

Test Signal: Modes: DC+, DC-, Pulse+, Pulse-, Pulse +/-, Standby
Dry Circuit*: Open Circuit Voltage <20mV for 200mΩ, 2Ω & 20Ω

Measurement Rate:
Fast: 65ms/measurement = 15 measurements/second
Medium: 150ms/measurement = 6 measurements/second
Slow: 650ms/measurement = 1.5 measurements/second

Trigger: Manual, Internal or External

Delay Times: Trigger Delay: 5ms – 1000ms, 5ms increments (falling or rising edge)
Measurement Delay: 0 – 100s

Ranging: Automatic or Hold Range

Zeroing: Short circuit compensation

Averaging: 1 – 10 measurements

Comparator: Nominal: Hi/Lo Limits (Value or %)

Bin Sorting: Nominal: Hi/Lo Limits (8 Bins in %)

Front Panel Lockout: Key Lock, Back Lit Display: LOCK

Display: 240 x 64 dot matrix LCD display

Indication: Audible alarm programmable High, Low or OFF for Pass or Fail

* Accuracy degraded to 1.5% with Dry Circuit ON.

Specifications (Continued)

Standard Interfaces:
- RS232

Optional Interfaces:
- IEEE-488/Handler

Connectors:
Front Connection: 4 Sheathed Banana Terminals
1 Ground Terminal

Mechanical:
Bench Mount
Dimensions:(w x h x d): 12.50 x 4.00 x 13.50 inches
312.5 x 100.0 x 337.5 mm

Weight:
10.85 lbs (5 kg) net, 15.2 lbs (7 kg) shipping

Environmental:
Specifications: 15°C to + 35°C, 75% RH
Operating: 10°C to + 40°C, 10-90% RH
Storage: 0°C to + 50°C, 10-90% RH
Pollution Degree 2
Installation Category II

Power:
- 90-125VAC: 50Hz/60Hz, Consumption 80W Max
- 190-250VAC: 50Hz/60Hz, Consumption 80W Max

Supplied:
- Instruction Manual
- AC Power Cable
- LR2000-50 Kelvin Clip Lead Set
- Calibration Certificate
- Power Line Fuses

Ordering Information:

Description	Catalog No.
Milliohmmeter	LR2000

Accessories

Accessories Included

Item	Quantity	QuadTech P/N
AC Power Cord	1	4200-0300
Power Line Fuse 1.0A 250V SB, 5x20mm	1	520026
Power Line Fuse 0.5A 250V SB, 5x20mm	1	520138
Lead Set: 4 Banana Connectors to 2 Kelvin Clips	1	LR2000-50
Instruction Manual	1	150713
Calibration Certificate	1	N/A

Accessories/Options Available

Item	Quantity	QuadTech P/N
Lead Set: 4 Banana Connectors to 2 Kelvin Clips	1	LR2000-50
IEEE-488 24-Pin Interface & Handler 24-Pin Interface	1	700171

Safety Precautions

CAUTION

The LR2000 Milliohmmeter is a low voltage instrument and provides no more than 1A AC output to the device under test (DUT). Some devices tested (especially capacitors) can store charge and may cause a hazard if not discharged properly. Follow these safety instructions.

1. Operate the LR2000 unit with its chassis connected to earth ground. The instrument is shipped with a three-prong power cord to provide this connection to ground. This power cord should only be plugged in to a receptacle that provides earth ground.
2. Plug the Kelvin Clip Lead Set into the red/black output terminals: DRIVE-, SENSE-, SENSE+, and DRIVE+ for proper connection.
3. Before turning on the LR2000 unit, make sure there is no device (DUT) or fixture connected to the test leads.
4. Before touching the test lead wires or output terminals make sure any capacitive device has been fully discharged.
5. In the case of an emergency, turn OFF the POWER switch using a “hot stick” and disconnect the AC power cord from the wall. Do not touch the LR2000 instrument.

Condensed Operating Instructions

General Information

The LR2000 Milliohmmeter is an instrument for measuring resistance (R) over the range of 1μΩ to 2MΩ. Ideal for measuring contact resistance of switches, relays, connectors and cables or for measuring winding resistance of motors, transformers, and solenoids. The LR2000 performs precision low resistance measurements in any environment: production testing, component evaluation, materials testing and incoming inspection. The resistance value can be displayed simultaneously with the comparator function or binning function. Four-Terminal Kelvin connection to device under test is provided through the four sheathed banana terminals on the front panel.

Start-Up

The LR2000 Milliohmmeter can be operated from a power source between 90-125V or 190-250V AC at a power line frequency between 48 and 62Hz. Maximum power consumption is 80W. The standard LR2000 unit is shipped from QuadTech with a 1.0A fuse in place for AC 90-125V operation. (A 0.5A fuse is included for AC 190-250V operation). The LR2000 unit is shipped with the line voltage selector set for 115V. Refer to paragraph 1.4.3 for instructions on changing the fuse or line voltage selector.

Connect the LR2000 Milliohmmeter AC power cord to the source of proper voltage. Operate the LR2000 instrument with its chassis connected to earth ground. The LR2000 instrument is shipped with a three-prong power cord to provide this connection to ground. This power cord should only be plugged into a receptacle that provides earth ground. Serious injury may result if the LR2000 instrument is not connected to earth ground.

To turn the LR2000 instrument ON, press the power button on the front panel. To switch the power OFF, press the button again or if measurements are to be made proceed with the Test Parameter Setup in Table COI-1. The LR2000 instrument should warm up for 15 minutes prior to use.

NOTE

Please read this instruction manual in its entirety before operating this instrument. These condensed operating instructions are not a substitute for all the information provided in the remainder of this manual.

NOTE

Refer to paragraphs 2.3 through 2.4 for a full description of programming test parameters and instruction on how to store the test setup. Test parameters must be set before the LR2000 instrument can be zeroed.

Condensed Operating Instructions (Continued)

There are three main menus within the LR2000 Milliohmmeter instrument software. Familiarize yourself with these menus prior to programming a test. Figure COI-1 illustrates the MEAS DISPLAY screen and lists the functions that can be accessed by pressing the [MAIN INDEX] and [SYSTEM SETUP] keys.

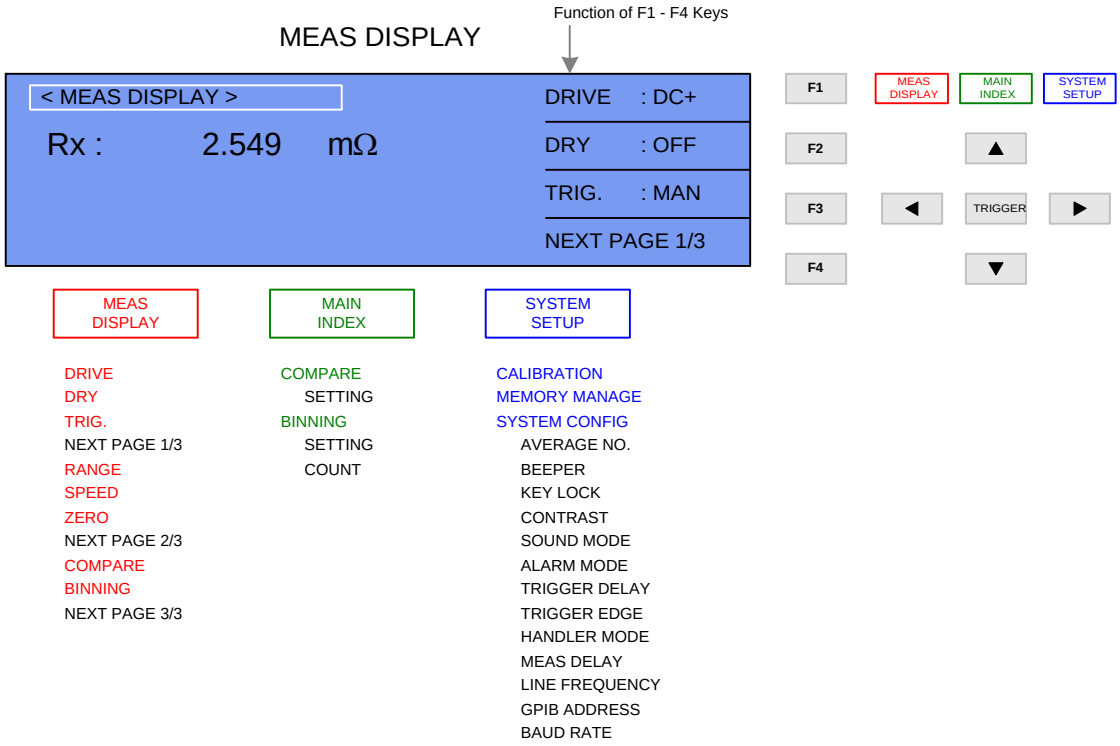


Figure COI-1: LR2000 Instrument Menus

NOTE:
To store setups as 'power-on' conditions (default), the [SYSTEM SETUP] key must be pressed following any changes.

NOTE:
The function keys [F1 – F4] are used to select the parameter to change and in some menus to change the value of that selected parameter.
The function of UP/DOWN depends on the menu. In some menus, the LEFT/RIGHT keys are used to select a digit by moving the underscored cursor left or right.

Condensed Operating Instructions (Continued)

1. Set Test Parameters

- Press [POWER] ON.
- Allow the instrument to warm up for 15 minutes.
- Press [MEAS DISPLAY]
- Set test parameters (drive, range, etc) using the function & arrow keys.

2. Correction (Zero)

After setting your test parameters, use the correction function of the LR2000 Milliohmmeter to zero the test leads. With no device connected, connect the appropriate cable to the front panel connectors. Short the test leads of the cable together. Refer to paragraph 2.6 for cable connections.

With the instrument in MEAS DISPLAY status:

1. Press [F4] = NEXT PAGE
2. Press [↓] = until ZERO: OFF is highlighted
3. Press [F3] = to change OFF to ON
4. Short Test Leads
5. Press [TRIGGER] button.
6. Wait while instrument gets CORRECTION value.
7. Press [ANY KEY] to return to MEAS DISPLAY status.

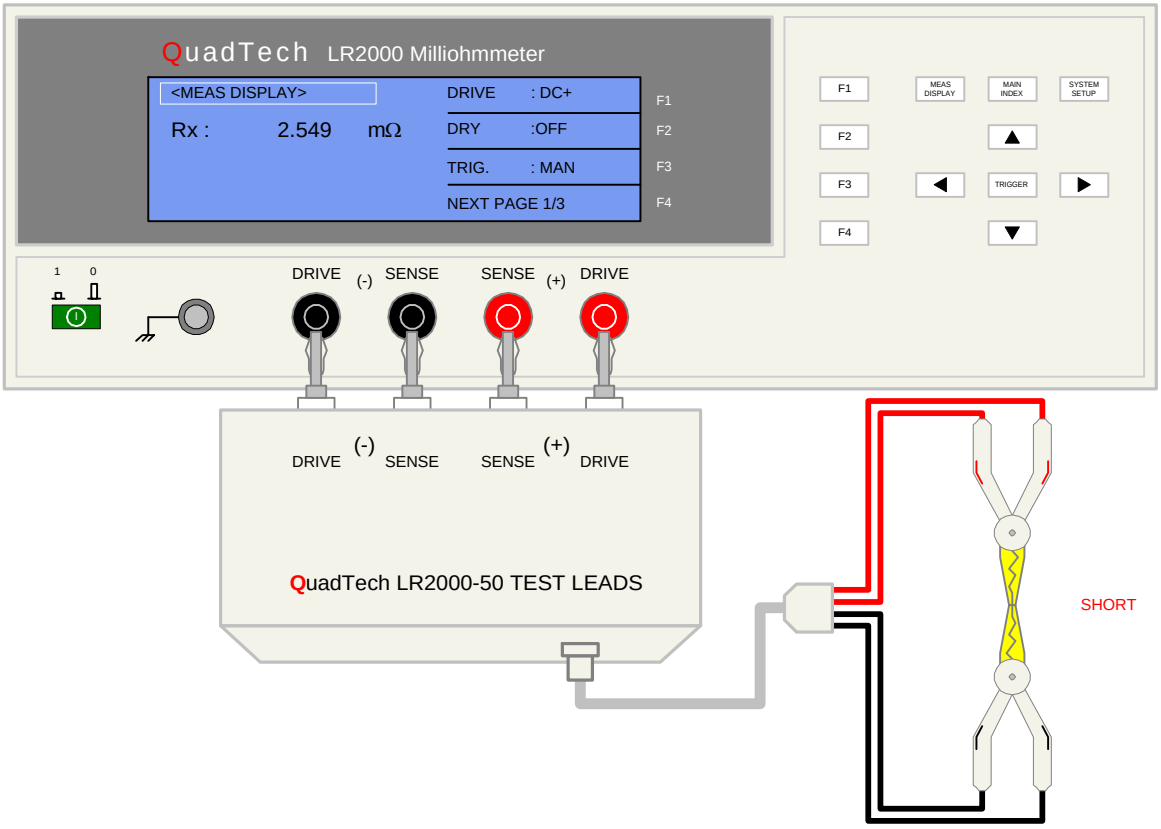
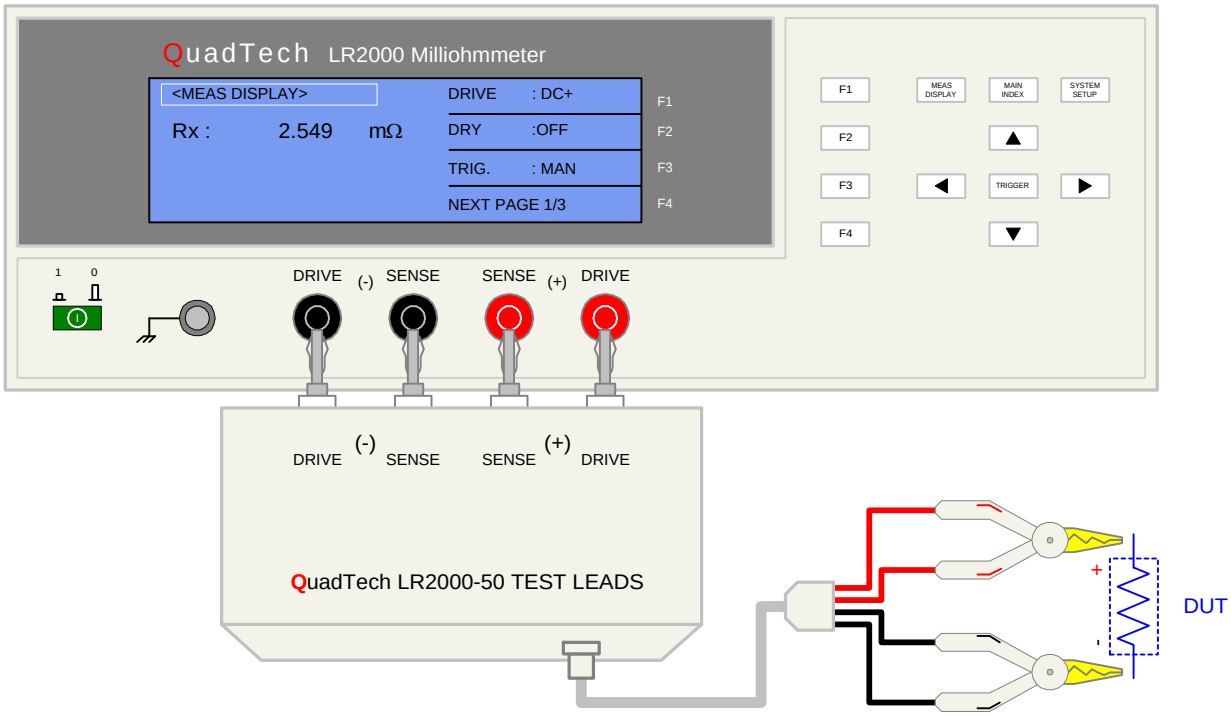


Figure COI-2: SHORT Correction Configuration

Condensed Operating Instructions (Continued)

3. Connection to Device under Test (DUT)

Figure COI-3 illustrates the connection of the LR2000 Milliohmmeter to a single DUT using the LR2000-50 4-Banana to 2-Kelvin Clips test lead set. As labeled on the LR2000-50 Test leads: the DRIVE-, SENSE-, SENSE+ and DRIVE+ connectors are connected to the corresponding front panel terminals on the LR2000 unit: red to (+) and black to (-). The red Kelvin clip is connected to the high side of the DUT and the black Kelvin clip to the low side of the DUT.



COI-3: Connection to Device under Test

4. Make a Measurement

1. Press [MEAS DISPLAY]
2. Connect device under test (DUT) to test leads.
3. Press [TRIGGER].
4. Record measurement.

Section 1: Introduction

1.1 Unpacking and Inspection

Inspect the shipping carton before opening. If damaged, contact the carrier agent immediately. Inspect the LR2000 Milliohmmeter instrument for any damage. If the instrument appears damaged or fails to meet specifications notify QuadTech (refer to instruction manual front cover) or its local representative. Retain the original shipping carton and packing material for future use such as returning the instrument for recalibration or service.

1.2 Product Overview

The LR2000 Milliohmmeter is a precision low resistance meter for production or laboratory testing of individual components, materials, printed circuit boards and other resistive items. The LR2000 instrument provides nine measurement ranges from 20μΩ to 2MΩ over seven current ranges from 1μA to 1A. The basic measurement accuracy is ±0.05%. Measurement rate is selectable (Slow, Medium or Fast) with rates up to 15 measurements per second. Automatic or Hold Range can also be selected. Measurements can be made continuously or triggered with a programmable delay time to 100 seconds. The RS232 interface is standard and the IEEE-488/ Handler interface is optional equipment on the LR2000 instrument. The effects of series resistance in the test leads can be zeroed with the short correction function. The LR2000 instrument is equipped with 8 Pass/Fail bins. High and low limits set in the Comparator function display the measured result as a value or percent. Bin number and count can be displayed as well. Four-terminal Kelvin connection to the device under test is obtained through the 4 sheathed banana terminals on the front panel.

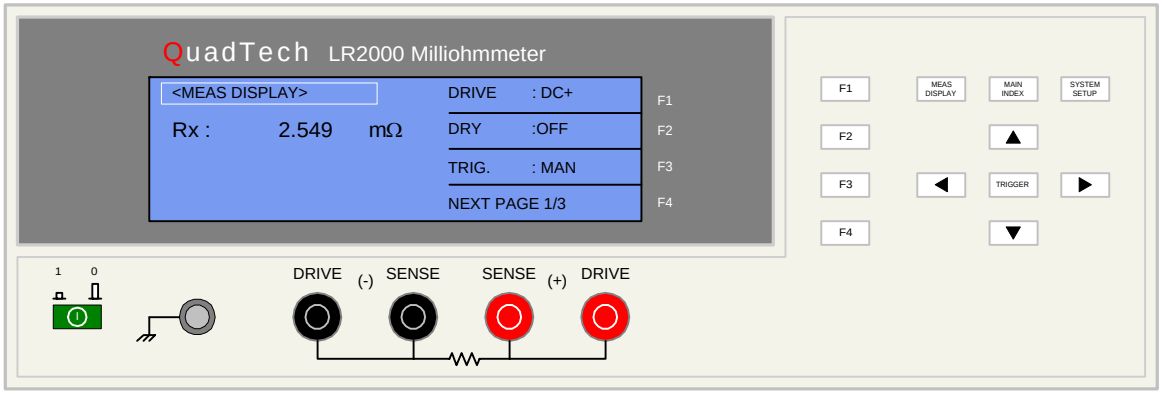


Figure 1-1: LR2000 Milliohmmeter

1.3 Controls and Indicators

1.3.1 Front Panel Controls and Indicators

Figure 1-2 illustrates the controls and indicators on the front panel of the LR2000 Milliohmmeter instrument. Table 1-1 identifies them with description and function.

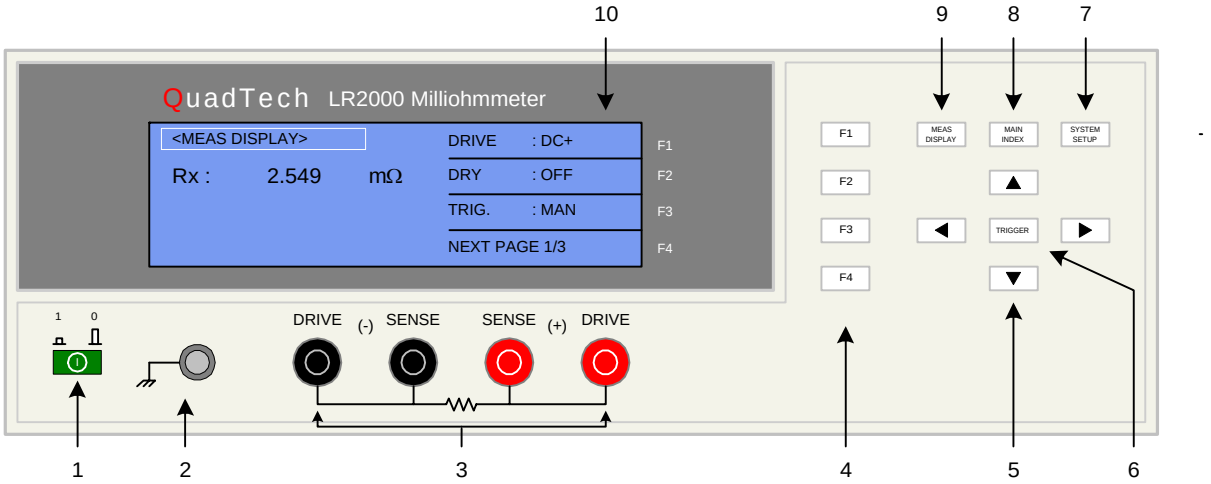


Figure 1-2: LR2000 Front Panel Controls & Indicators

Table 1-1: LR2000 Front Panel Controls & Indicators

Reference # Figure 1-2	Name	Type	Function
1		Green Push Button	Apply AC POWER: 1=ON, 0=OFF
2		Silver Banana Jack	Chassis ground connection
3	DRIVE- SENSE- SENSE+ DRIVE+	2 Black & 2 Red Sheathed Banana Terminals	Current Drive Terminal, Low (-) Voltage Sense Terminal, Low (-) Voltage Sense Terminal, High (+) Current Drive Terminal, High (+)
4	F1, F2, F3 and F4	4 gray push buttons	Select Instrument Functions Keys perform different functions under different menus. Right side of display shows corresponding key function.
5	←, ↓, →, ↑	4 gray push buttons	Move backlit box around display to choose parameter Change parameter value (increase/decrease)
6	TRIGGER	Gray push button	Initiate measurement
7	SYSTEM SETUP	Gray push button	View, Select or Change System Parameters: Calibration, Memory Manage & System Config (Average Time, Beeper, Key Lock, Contrast, Sound Mode, Alarm Mode, Trigger Delay, Trigger Edge, Handler Mode, Meas. Delay, Line Frequency, GPIB Address & Baud Rate)
8	MAIN INDEX	Gray push button	View, Select or Change Setup & Result Parameters: Compare, & Binning
9	MEAS DISPLAY	Gray push button	View, Select or Change Measurement Parameters: Drive, Dry, Trigger, Range, Speed, Zero, Compare and Binning
10		240 x 64 dot matrix Graphic LCD display	Show measurement results as value, % or bin number. Show programming instructions

1.3.2 Rear Panel Controls and Connectors

Figure 1-3 illustrates the controls and connectors on the rear panel of the LR2000 Milliohmmeter instrument. Table 1-2 identifies them with description and function.

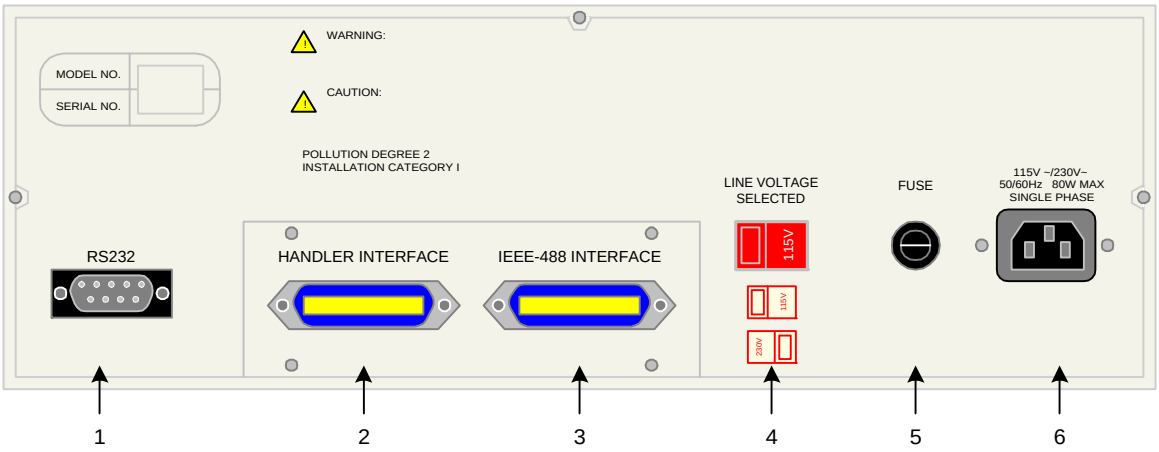


Figure 1-3: Rear Panel LR2000 Instrument

Table 1-2: LR2000 Rear Panel Controls & Connectors

Reference # Figure 1-3	Name	Type	Function
1	RS 232 INTERFACE	Silver /Black 9-pin connector	RS 232 interface for remote operation
2	HANDLER INTERFACE*	Blue 24-pin connector	Handler Interface connector for remote operation
3	IEEE-488 INTERFACE*	Blue 24-pin connector	IEEE-488 Interface connector for data transfer
4	LINE VOLTAGE SELECTED	2 Red 2-position Slide Switches	Select Voltage Level corresponding to AC Source 90V – 125V: T1.0A 250V fuse 190V – 250V: T 0.5A 250V fuse
5	FUSE	Black Screw cap fuse holder	Short circuit protection T 1.0A 250V fuse for 115V operation T 0.5A 250V fuse for 230V operation
6	AC Line Input	Black 3-wire inlet module	Connection to AC power source

* Note: The Handler and IEEE Interface are two separate interfaces packaged as a set.

1.4 Installation

1.4.1 Dimensions

The LR2000 Milliohmmeter is supplied in a bench configuration, i.e., in a cabinet with resilient feet for placement on a table. The LR2000 instrument can be tilted up for convenient operator viewing by extending the front feet out.

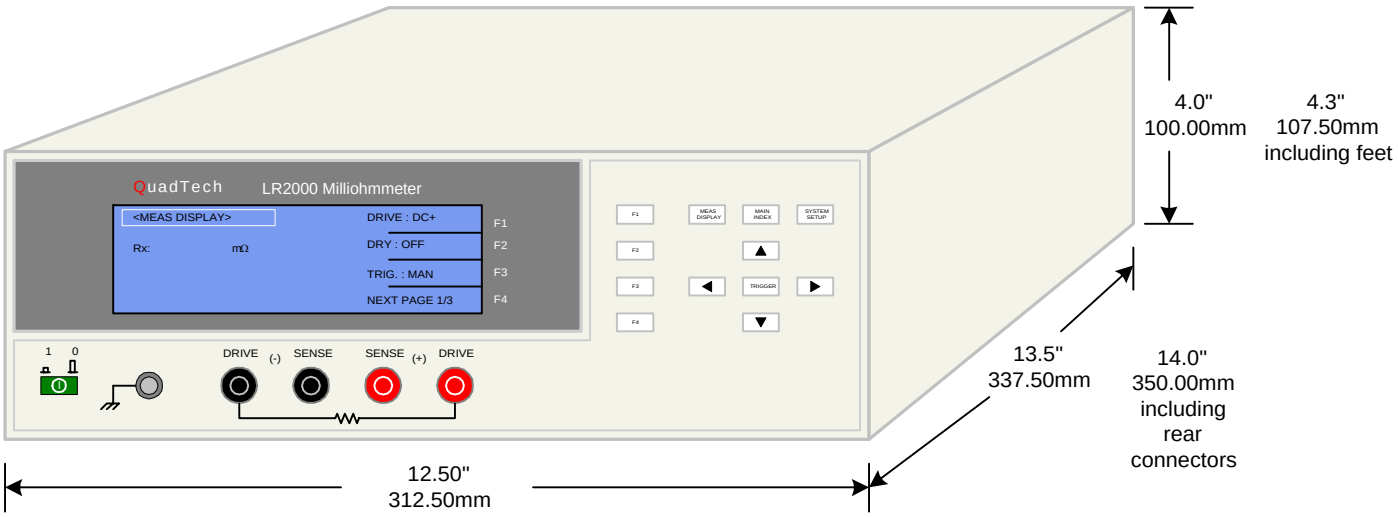


Figure 1-4: LR2000 Instrument Dimensions

1.4.2 Instrument Positioning

The LR2000 instrument contains one (1) graphic display for direct readout of measured parameters. The optimum angle for viewing is slightly down and about 10 degrees either side of center. For bench operation the front flip feet should always be used to angle the instrument up. In bench or rack mount applications the instrument should be positioned with consideration for ample air flow around the rear panel fan ventilation hole. An open space of at least 3 inches (75mm) is recommended behind the rear panel. Testing should be performed on a non-conductive surface. An ESD mat is not a recommended test platform.

1.4.3 Power Requirements

The LR2000 can be operated from a power source of 90 to 125V AC or 190 to 250V AC. Power connection is via the rear panel through a standard receptacle. Before connecting the 3-wire power cord between the unit and AC power source, make sure the voltage selection switches on the rear panel (Figure 1-5) are in accordance with the power source being used. For a 90-125V source, use a 1.0A 250V fuse. For a 190-250V source, use a 0.5A 250V fuse. Always use an outlet that has a properly connected protection ground.

CAUTION

Make sure the unit has been disconnected from its AC power source for at least five minutes before proceeding.

Procedure for Changing an LR2000 Instrument Fuse

Unscrew the fuse cap on the rear panel of the LR2000 and pull fuse holder outward.

Once the fuse holder has been removed from the instrument snap the fuse from the holder and replace. Make sure the new fuse is of the proper rating.

Install the fuse back into the cap holder by pushing in until it locks securely in place.

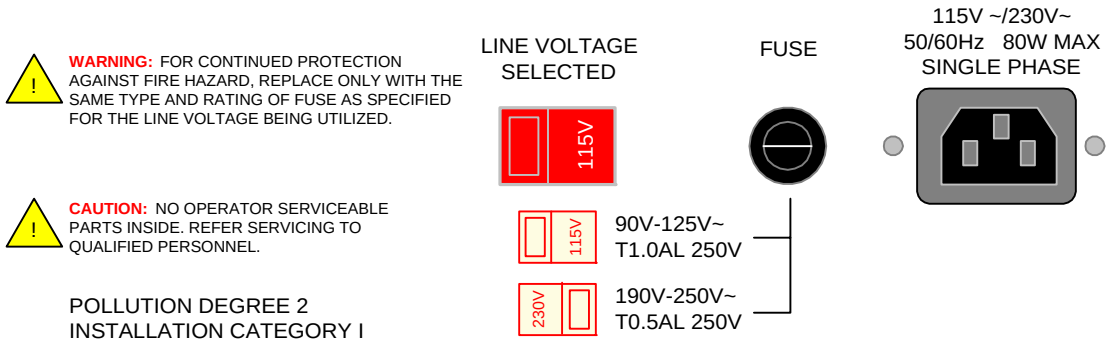


Figure 1-5: Close-Up of LR2000 Rear Panel

1.4.4 Safety Inspection

Before operating the instrument inspect the fuse holder on the rear of the LR2000 instrument to ensure that the properly rated fuse is in place, otherwise damage to the unit is possible. Make sure that the voltage selector switches are set in accordance with the power source in use. Refer to paragraph 1.4.3 and Figure 1-5.

The LR2000 instrument is shipped with a standard U.S. power cord, QuadTech P/N 4200-0300 (with Belden SPH-386 socket or equivalent, and a 3-wire plug conforming to IEC 320). Make sure the instrument is only used with these cables (or other approved international cord set) to ensure that the instrument is provided with connection to protective earth ground.

The surrounding environment should be free from excessive dust to prevent contamination of electronic circuits. The surrounding environment should also be free from excessive vibration. Do not expose the LR2000 instrument to direct sunlight, extreme temperature or humidity variations, or corrosive chemicals.

Section 2: Operation

2.1 Terms and Conventions

Table 2-1: Measurement Unit Prefixes

Multiple	Scientific	Engineering	Symbol
1000000000000000	10^{15}	Peta	P
1000000000000	10^{12}	Tera	T
1000000000	10^{9}	Giga	G
1000000	10^{6}	Mega	M
1000	10^{3}	Kilo	k
.001	10^{-3}	milli	m
.000001	10^{-6}	micro	μ
.000000001	10^{-9}	nano	n
.000000000001	10^{-12}	pico	p
.000000000000001	10^{-15}	femto	f

Accuracy: The difference between the measured value or reading and the true or accepted value. The accuracy of an ohmmeter is typically given as a ± percentage of the measured value for primary parameters and ± an absolute value for secondary value.

Basic Accuracy: Basic accuracy is specified at optimum test signal, frequencies, highest accuracy setting or slowest measurement speed and impedance of the DUT.

Binning: Procedure for sorting components into bins using sequential limits or nested limits.

Capacitor: Abbreviated C (as in LCR). A capacitor is passive component comprised of two conductors separated by a dielectric. A capacitor stores charge blocks DC flow and allows AC flow based on frequency and capacitor design.

Capacitance: The measure of the ratio of charge on either plate of a capacitor to the potential difference (voltage) across the plates. Unit of measure is the Farad (F).

Capacitive Reactance: A measurement of the actual AC resistance of a capacitor. How effective a capacitor allows AC to flow depends upon its capacitance and the frequency used. $X_C = 1 / 2\pi fC$.

Compare: Procedure for sorting components by comparing the measured value against a known standard.

Current:

AC: Alternating Current. AC is an electrical current that has one polarity during part of the cycle and the opposing polarity during the other part of the cycle. Residential electricity is AC.

DC: Direct Current. Non-reversing polarity. The movement of charge is in one direction. Used to describe both current and voltage. Batteries supply direct current (DC).

Dielectric: A material which is an electrical insulator or in which an electric field can be sustained with a minimum dissipation of power.

Dielectric Constant: Abbreviated K, relative dielectric constant. The dielectric constant of a material is the ratio of the capacitance of a capacitor filled with a given dielectric to that same capacitor having only a vacuum as a dielectric.

Discharge: The act of draining off an electrical charge to ground. Devices that retain charge should be discharged after an IR test or DC hipot test.

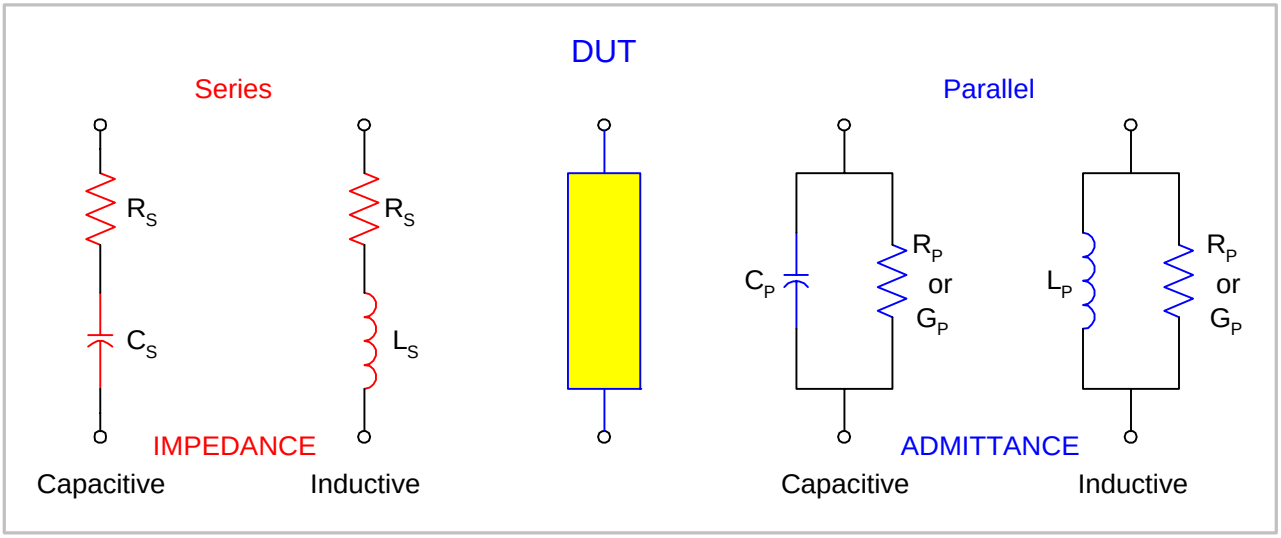
Drive Voltage: Voltage applied to DUT.

PULSE +/-:	Positive/negative square wave: +2V to 0V to –2V to 0V
PULSE +:	Positive square wave: +2V to 0V
PULSE -:	Negative square wave: –2V to 0V
DC +:	Source signal: +2V
DC -:	Source signal: -2V

Dry Circuit: The open circuit test voltage across the test leads is clamped at 20mV to avoid puncturing oxide or film resist on the contacts of devices with film/oxide contacts (switches, relays).

DUT: Device Under Test. (i.e. the product being tested).

Equivalent Circuit: The configuration of the device under test. Is it a series or parallel equivalent circuit?



Frequency: The rate at which current or voltage reverses polarity and then back again completing a full cycle, measured in Hertz (Hz) or cycles/second. AC Line Frequency = 50/60 Hz.

Ground: The base reference from which voltages are measured, nominally the same potential as the earth. Ground is also the side of a circuit that is at the same potential as the base reference.

Impedance: The AC resistance of the DUT. Impedance (Z) is a vector summation of resistance R and reactance X.
For capacitors reactance is defined as XC = 1/jωC
For inductors reactance is defined as XL = jωL
For resistors resistance is defined as R
Impedance is defined as Z = √(X2 + R2)

Inductor: Abbreviated L (as in LCR). An inductor is a coil of wire. It is used to create electromagnetic induction in a circuit.

Inductance: The property of a coil to oppose any change in current through it. If the turns (coils) of the wire are stretched out, the field intensity will be less and the inductance will be less. Unit of measure is the Henry (H).

Inductive Reactance: A measure of how much the counter electro-magnetic force (emf) of the coil will oppose current variation through the coil. The amount of reactance is directly proportional to the current variation: $X_L = 2\pi fL$.

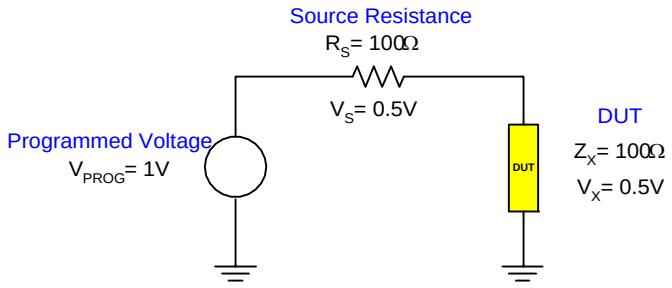
Interface:

Handler:	Device for remote control of test instrument in component handling operations.
IEEE-488:	General Purpose Interface Bus (GPIB). GPIB is an industry standard definition of a Parallel bus connection for the purpose of communicating data between devices.
RS232:	An industry standard definition for a Serial line communication link or port.
Scanner:	An electronic device designed to switch or matrix signals.

Limits:

Upper:	The high limit is the upper value for a test to be considered a pass. If the measured value is higher than the high limit the test is considered a fail.
Lower:	The low limit is the lower value for a test to be considered a pass. If the measured value is lower than the low limit the test is considered a fail.
Range:	The resistance ranges the instrument uses for reference in making the measurement.
Repeatability:	The difference between successive measurements with no changes in the test setup or test conditions.
Reproducibility:	Similar to repeatability but adds the element of what could be expected under real life conditions. Reproducibility would take into account the variability in thing like fixturing where the DUT being tested is removed from the fixture and then inserted again.
Resolution:	The smallest value that can be shown on the display in a digital instrument. LCR meters typically specify a measurement range that is the largest and smallest value that can be shown on the display.

Source Impedance: A constant source resistance of the measuring instrument used to level the voltage across the DUT to a constant voltage.



Speed: The rate at which the instrument makes a measurement in measurements per second. Speed is inversely proportional to accuracy.

Trigger: The device for initiating the test (applying the voltage or current).

External: The test is initiated via an external source such as a computer with an IEEE-488 or Handler interface. One measurement is made each time the external trigger is asserted on the handler.

Internal: The instrument continuously makes measurements.

Manual: The operator initiates the test by pressing the [TRIGGER] button. One measurement is made each time the trigger is pressed.

2.2 Startup

Check to make sure the red Line Voltage Selector switch on the rear panel agrees with the power source available. Depending on the power source the switch position should be in the up or down position as shown in Figure 1-5 (Close-Up of LR2000 Rear Panel).

Connect the instrument power cord to the source of proper voltage. **The instrument is to be used only with three-wire grounded outlets.**

Power is applied to the LR2000 instrument by pressing the green power switch on the front panel to the ON (1 position). The LR2000 unit should warm up for a period of at least 15 minutes prior to measurements being made.

2.3 SYSTEM SETUP

The SYSTEM SETUP menu contains three functions: Calibration, Memory Management and System Configuration. Press the [SYSTEM SETUP] button to access these functions.

NOTE:
To store setups as 'power-on' conditions (default), the [SYSTEM SETUP] key must be pressed following any changes.

2.3.1 Calibration

Calibration is for qualified service personnel only. Factory calibration of the LR2000 instrument to verify resistance ranges is recommended on an annual basis.

2.3.2 Memory Management

Memory Management is for qualified service personnel only. Warning: The Memory Manage function will clear the instrument memory default conditions.

2.3.3 System Configuration

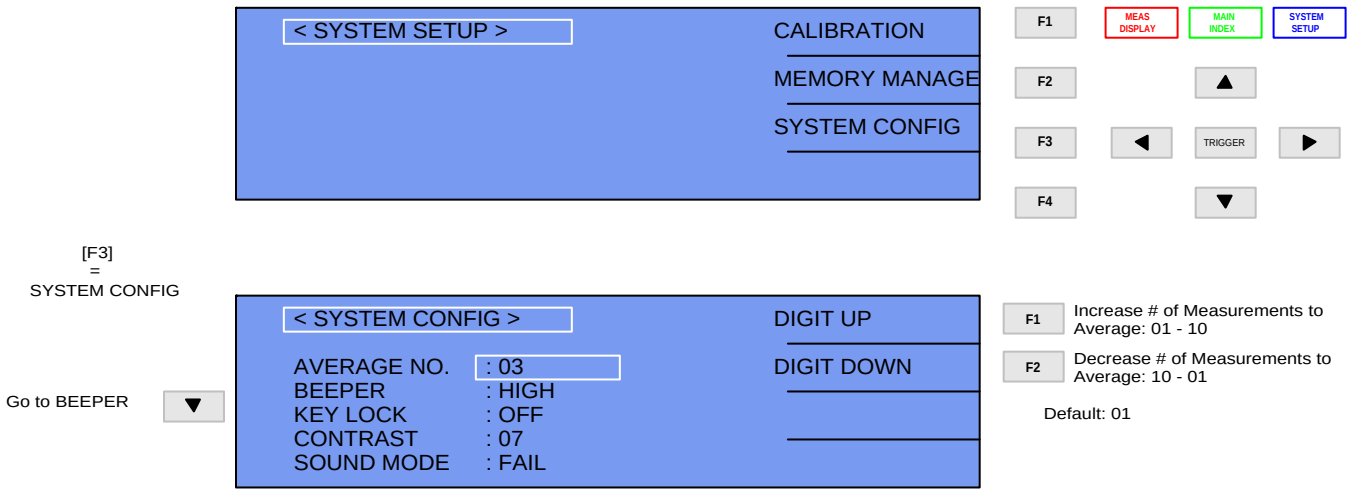
Prior to programming a test or measuring a device, set up the system controls of the LR2000 instrument. To access the system controls, press [SYSTEM SETUP] then press [SYSTEM CONFIG]. Table 2-2 lists the contents of SYSTEM CONFIG.

Table 2-2: SYSTEM CONFIG

Parameter	Function	Range	Default
AVERAGE NO.	Set # of Measurements to Average	01 - 10	01
BEEPER	Set beeper loudness	OFF, HIGH or LOW	HIGH
KEY LOCK	Lock out front panel programming	OFF/ON	OFF
CONTRAST	Set brightness of display	00 - 15	07
SOUND MODE	Set when the buzzer will sound	PASS/FAIL	FAIL
ALARM MODE	Set type of alarm signal	PULSE/CONTINUOUS	PULSE
TRIGGER DELAY	Set external trigger time	0005 – 1000 ms	0005ms
TRIGGER MODE	Set edge for trigger to activate	FALLING/RISING	FALLING
HANDLER MODE	Set handler interface mode	CLEAR/HOLD	CLEAR
MEAS DELAY	Set measurement delay time	0000 – 100 seconds	0.000s
LINE FREQUENCY	Set power line frequency	50Hz/60Hz	60Hz
GPIB ADDRESS	Set interface address	01 – 30	17
BAUD RATE	Set baud rate	1200/2400/4800/9600/19200/38400	19200

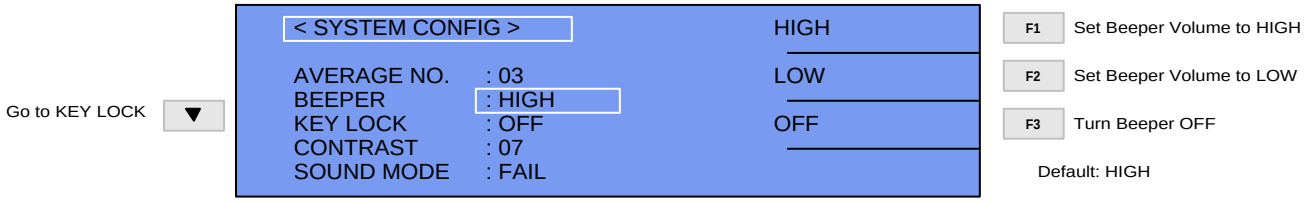
2.3.3.1 AVERAGE NO. (Number)

The number of measurements to take then average can be set from 01 to 10. The instrument default setting is 01. To change the average time press [SYSTEM SETUP], [SYSTEM CONFIG] and the down arrow [⇓] until the box next to AVERAGE NO is highlighted, then press [F1] = DIGIT UP or [F2] = DIGIT DOWN to select the number of measurements to be taken before the average is calculated.



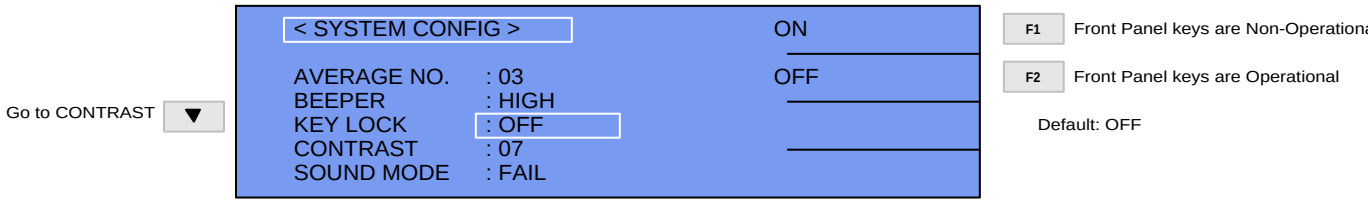
2.3.3.2 BEEPER

The loudness of the beeper or audible alarm can be set to OFF, HIGH or LOW. The instrument default setting is HIGH. To change the beeper loudness press [SYSTEM SETUP], [SYSTEM CONFIG] and the down arrow [⇓] until the box next to BEEPER is highlighted, then press [F1] = HIGH, [F2] = LOW or [F3] = OFF.



2.3.3.3 KEY LOCK

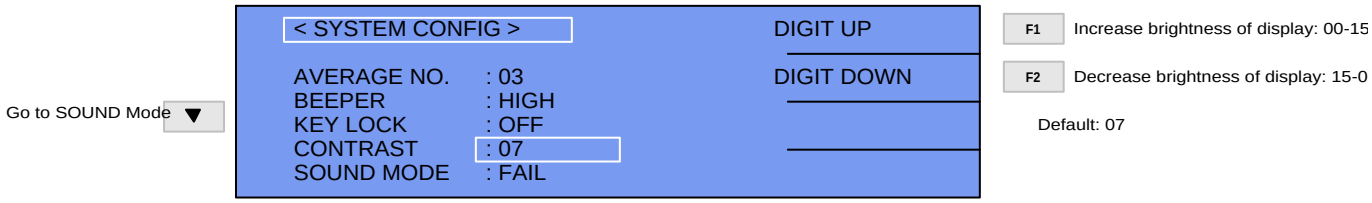
To lock out the front panel operations with the exception of the [TRIGGER] key, set the key lock function to ON. Press [SYSTEM SETUP], [SYSTEM CONFIG], [⇓] until OFF is highlighted next to KEY LOCK, then press [F1] = ON. The backlit LOCK block will appear on the measure display.



To turn the key lock function OFF: press [F1], [F4] and then [SYSTEM SETUP]. Key lock can be set ON or OFF. The instrument default setting is OFF.

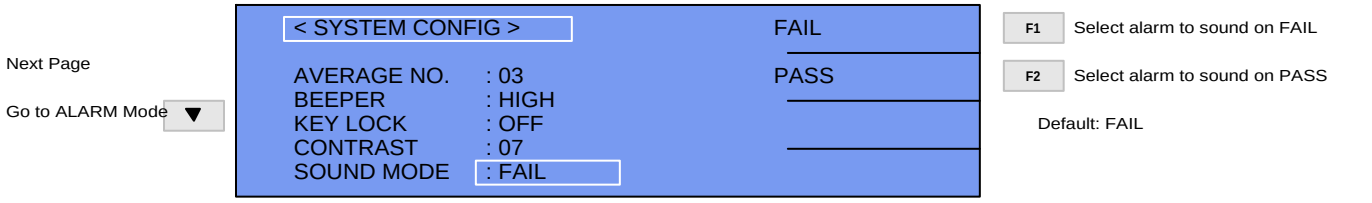
2.3.3.4 CONTRAST

The display contrast can be set for optimal viewing from 00 – 15 with 15 as the brightest. The instrument default is 07. To change the contrast of the display, press [SYSTEM SETUP], [SYSTEM CONFIG], [⇓] until 07 is highlighted next to CONTRAST, then press [F1] = DIGIT UP or [F2] = DIGIT DOWN to lighten or darken the contrast.



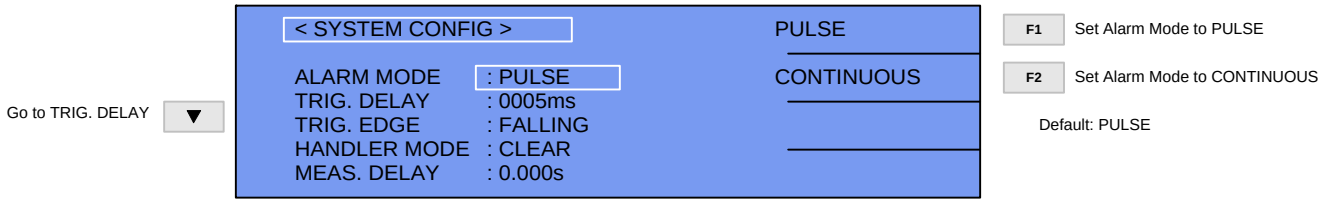
2.3.3.5 SOUND MODE

The audible alarm can be set to sound on PASS or to sound on FAIL under high or low limit judgment in the measure display. The instrument default setting is FAIL. To change the sound mode press [SYSTEM SETUP], [SYSTEM CONFIG] and the down arrow [⇓] until the box next to SOUND MODE is highlighted, then press [F1] = FAIL for the alarm to sound on a fail result or [F2] = PASS for the alarm to sound on a pass result.



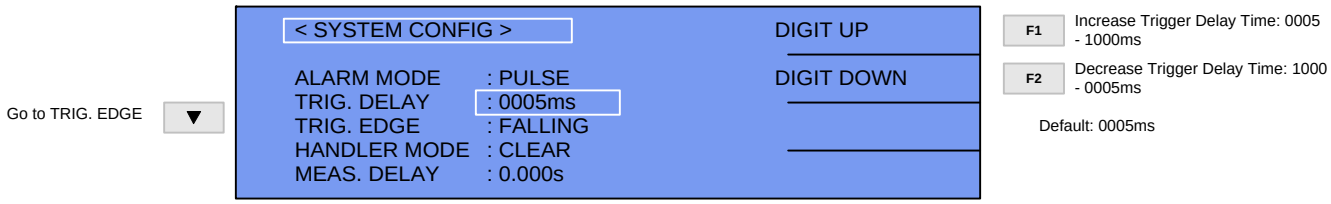
2.3.3.6 ALARM MODE

The type of audible alarm can be set to PULSE or CONTINUOUS during judgment in the measure display. The instrument default setting is PULSE. To change the alarm mode press [SYSTEM SETUP], [SYSTEM CONFIG] and the down arrow [⇓] until the box next to ALARM MODE is highlighted, then press [F1] = PULSE for the alarm to sound in a pulse tone or [F2] = CONTINUOUS for the alarm to sound continuously.



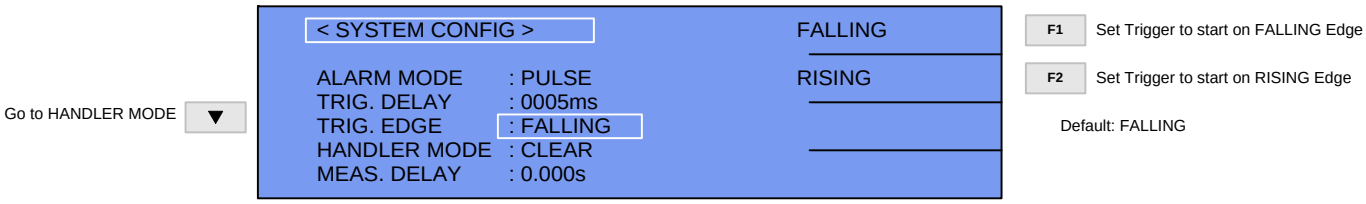
2.3.3.7 TRIG. DELAY

The trigger delay is the amount of time between the activation of a trigger (via IEEE, Handler or front panel) and the LR2000 making the measurement. The delay time can be programmed from 0005 to 1000 milliseconds. The instrument default value is 0005 milliseconds. To change the TRIGGER DELAY press [SYSTEM SETUP], [SYSTEM CONFIG] and the down arrow [⇓] until the box next to TRIGGER DELAY is highlighted, then press [F1] = DIGIT UP to increase the delay time or [F2] = DIGIT DOWN to decrease the delay time.



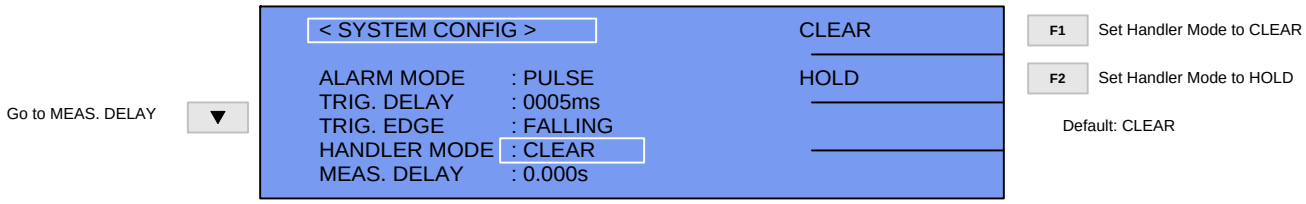
2.3.3.8 TRIG. EDGE

Select on which edge the measurement is triggered: FALLING or RISING. The instrument default setting is FALLING. To change the TRIGGER EDGE press [SYSTEM SETUP], [SYSTEM CONFIG] and the down arrow [⇓] until the box next to TRIGGER EDGE is highlighted, then press [F1] = FALLING or [F2] = RISING.



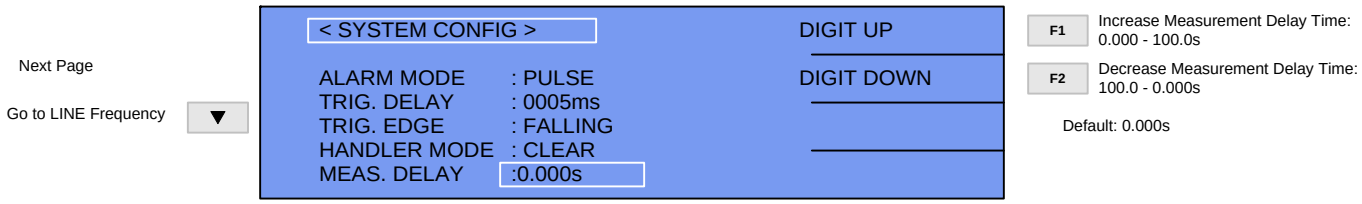
2.3.3.9 HANDLER MODE

The handler interface mode can be set to CLEAR or HOLD. The instrument default setting is CLEAR. When set to CLEAR, the handler interface will clear the last test result prior to each subsequent measurement. When set to HOLD, the handler interface will hold the last test result until the next measurement is made and displayed. To change the handler mode press [SYSTEM SETUP], [SYSTEM CONFIG] and the down arrow [⇓] until the box next to HANDLER MODE is highlighted, then press [F1] = CLEAR or [F2] = HOLD.



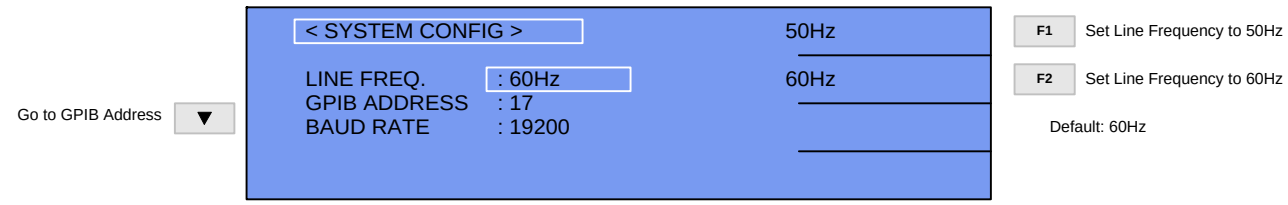
2.3.3.10 MEAS. DELAY

The measurement delay time can be programmed from 0000 to 100.0 seconds. The instrument default value is 0000 seconds. To change the MEAS DELAY press [SYSTEM SETUP], [SYSTEM CONFIG] and the down arrow [⇓] until the box next to MEAS DELAY is highlighted, then press [F1] = DIGIT UP to increase the delay time or [F2] = DIGIT DOWN to decrease the delay time.



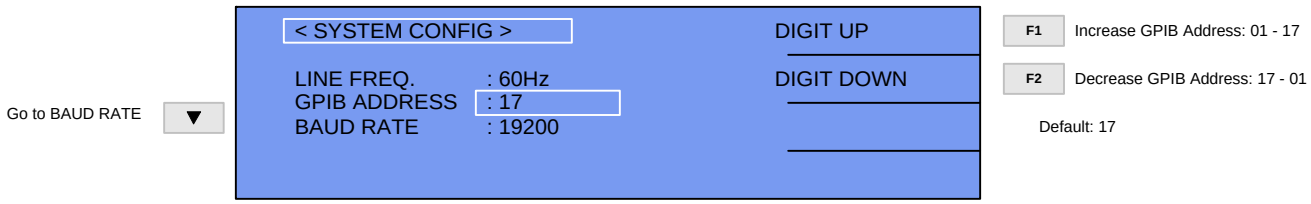
2.3.3.11 LINE FREQUENCY

Select the power line frequency: 50Hz or 60Hz. The instrument default setting is 60Hz. To change the LINE FREQUENCY press [SYSTEM SETUP], [SYSTEM CONFIG] and the down arrow [⇓] until the box next to LINE FREQUENCY is highlighted, then press [F1] = 50Hz or [F2] = 60Hz.



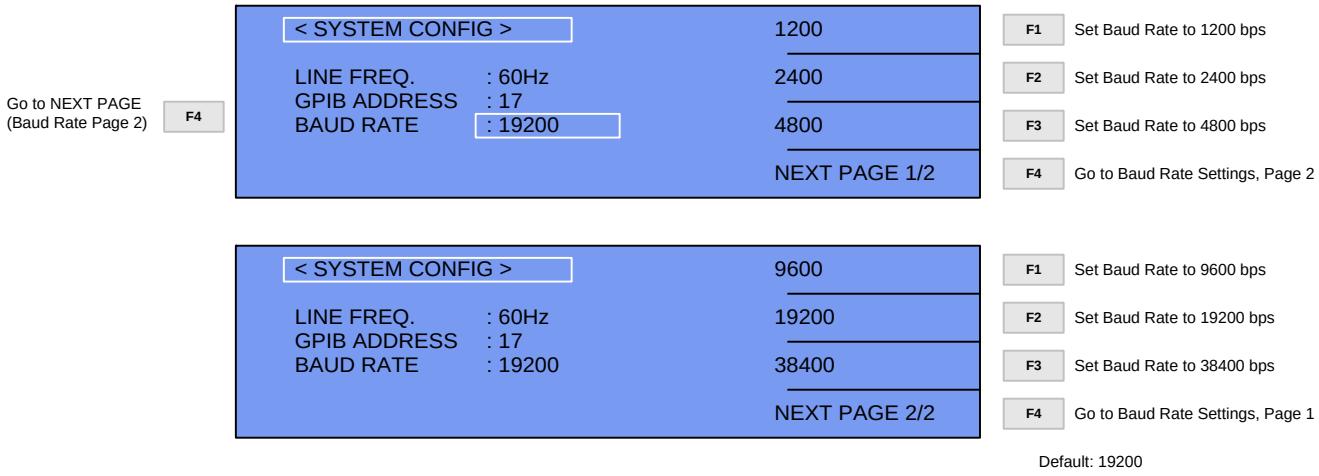
2.3.3.12 GPIB ADDRESS CODE

The IEEE-488 interface address can be programmed from 01 to 30. The instrument default setting is 17. To change the GPIB ADDRESS press [SYSTEM SETUP], [SYSTEM CONFIG] and the down arrow [⇓] until the box next to GPIB ADDRESS is highlighted, then press [F1] = DIGIT UP to increase the address, or [F2] = DIGIT DOWN to decrease the address.



2.3.3.13 BAUD RATE

The baud rate is the amount of bits per second transferred via the RS232 interface. The baud rate can be programmed as: 1200, 2400, 4800, 9600, 19200 or 38400 bps. The instrument default value is 19200 bps. To change the BAUD RATE press [SYSTEM SETUP], [SYSTEM CONFIG] and the down arrow [⇓] until the box next to BAUD RATE is highlighted, then press [F1] = 1200, [F2] = 2400, [F3] = 4800 or [F4] = NEXT PAGE 1/2 to page 2 of baud rate settings. On Page 2/2 choose [F1] = 9600, [F2] = 19200, [F3] = 38400 or [F4] = NEXT PAGE 2/2 to return to page 1 of baud rate settings.



Recall that when any system parameters are changed:

NOTE:
To store setups as 'power-on' conditions (default), the [SYSTEM SETUP] key must be pressed following any changes.

2.4 MEAS DISPLAY

The LR2000 instrument's stand-by display is the MEAS DISPLAY. After power has been applied to the instrument and it cycles quickly through the information screen, the instrument reverts to the MEAS DISPLAY. To view the instrument information screen as illustrated in Figure 2.1, press [SYSTEM SETUP] then [⇐].

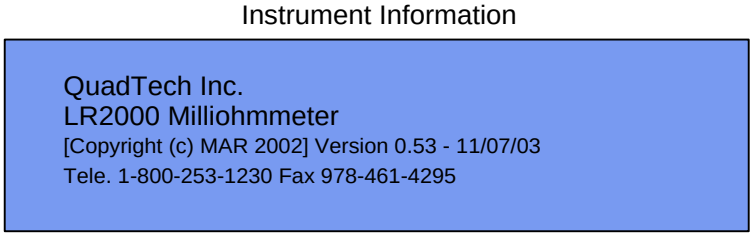


Figure 2.1: Instrument Information Screen

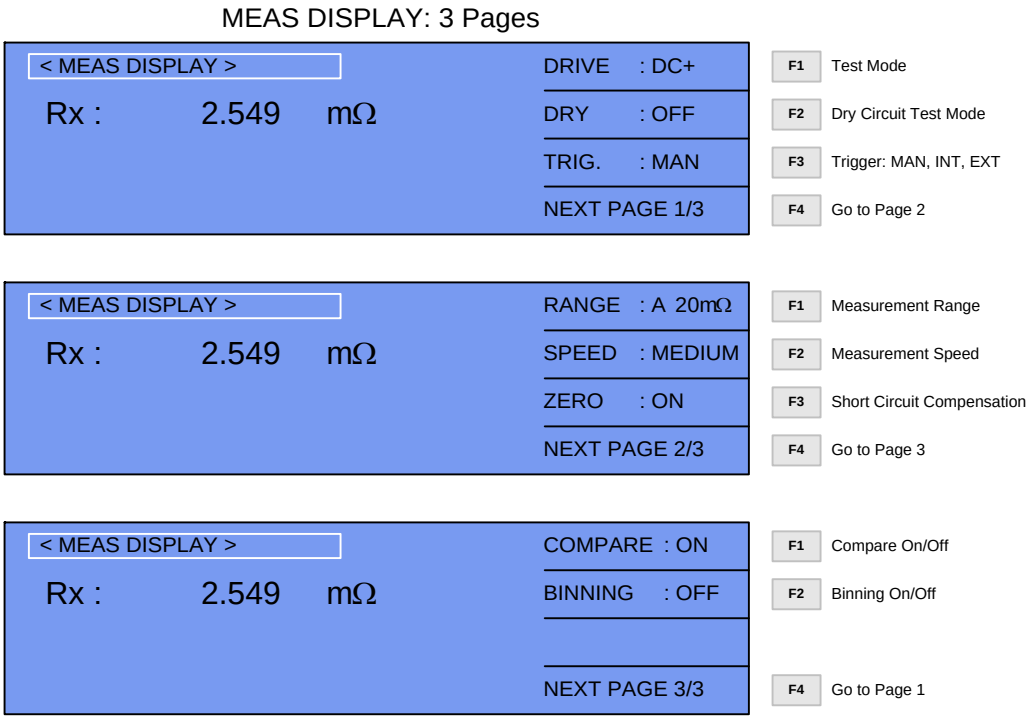
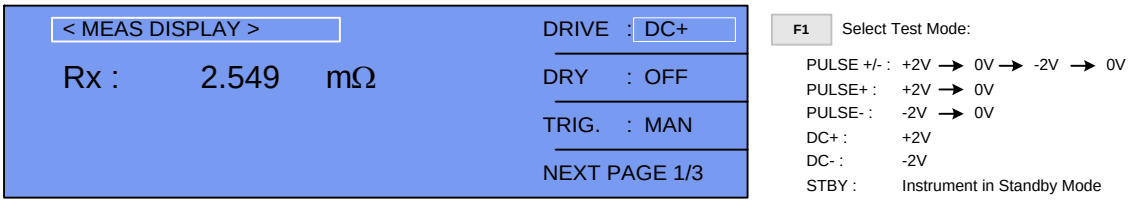


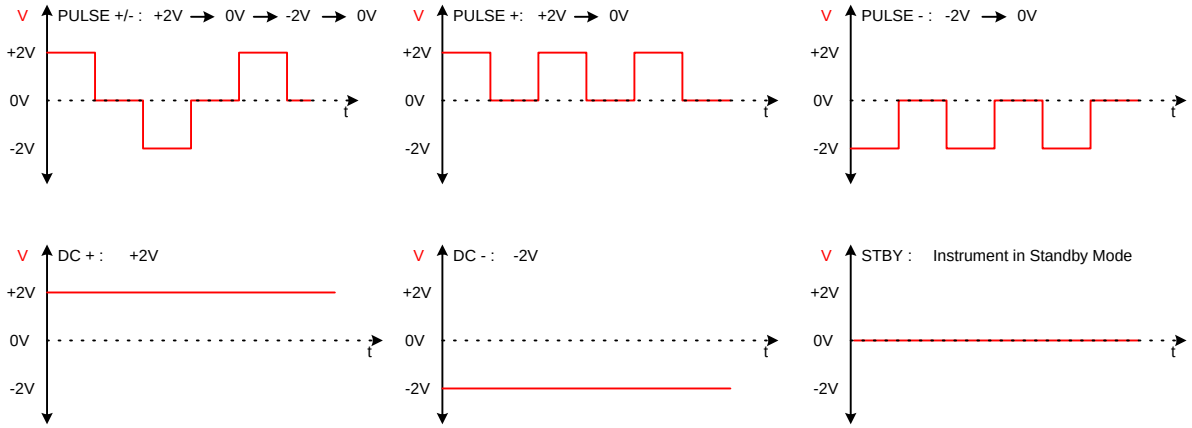
Figure 2.2: MEAS DISPLAY

Figure 2.2 illustrates the three pages of parameters that can be programmed within the MEAS DISPLAY. The binning and comparison functions are enabled/disabled in MEAS DISPLAY and programmed in MAIN INDEX Paragraphs 2.4.1 through 2.4.9 explain each parameter in detail.

2.4.1 DRIVE

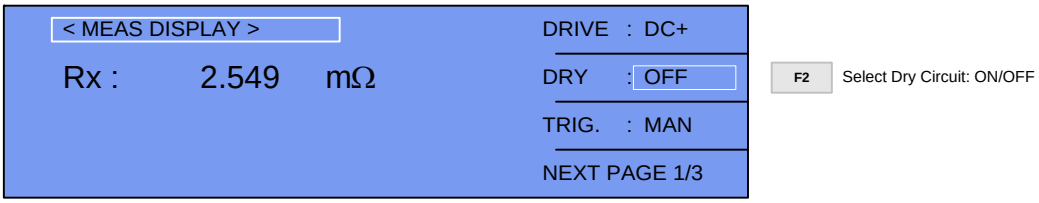
The LR2000 instrument provides six test modes: PULSE+/-, PULSE+, PULSE-, DC+, DC- and STBY. In MEAS DISPLAY, press [F1] so that the highlighted cursor is to the right of DRIVE. Press [F1] to toggle through and select test mode. The instrument default setting is PULSE+/-. The PULSE+/- mode is a positive/negative square wave that switches the source signal from +2V to 0V to –2V to 0V. The PULSE+ mode is a positive square wave that switches the source signal for +2V to 0V. The PULSE- mode is a negative square wave that switches the source signal for -2V to 0V. The DC+ mode provides the source signal equal to +2V. The DC- mode provides the source signal equal to -2V. The STBY mode puts the instrument in stand-by status.





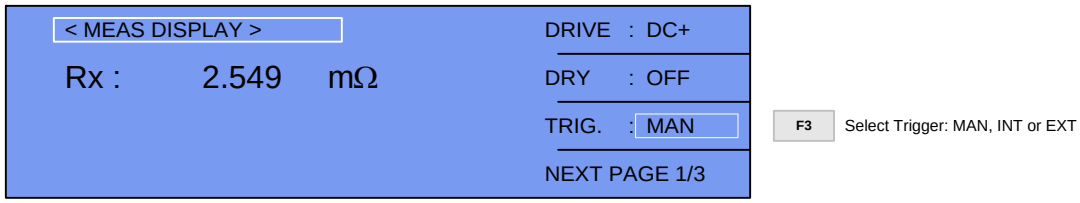
2.4.2 DRY Circuit

For low resistance measurements made on devices with film or oxide contacts (switches, relays), select DRY circuit = ON to hold the open circuit voltage across the instrument's test leads clamped at 20mV. This will avoid puncturing the oxidation or film resist on the contacts. Press [F1] to enable the dry circuit function. Press [F2] to disable the dry circuit function. The instrument default setting is OFF.



2.4.3 TRIGGER

The LR2000 instrument can be triggered manually, internally or externally. In MEAS DISPLAY (Pg 1/3), press [F3] so that the highlighted cursor is to the right of TRIG. Use the [F3] key to change the trigger. The instrument default setting is INT (internal trigger). When MANUAL trigger is selected, one measurement will be made each time the trigger is pressed. When EXTERNAL trigger is selected, one measurement will be made each time the external trigger is asserted by the handler. When INTERNAL trigger is selected, measurements are performed continuously when in [MEAS DISPLAY].



2.4.4 RANGE

The LR2000 instrument's measurement range can be selected as AUTO or HOLD. The instrument measurement ranges are 20mΩ, 200mΩ, 2Ω, 20Ω, 200Ω, 2kΩ, 20kΩ, 200kΩ and 2MΩ. In MEAS DISPLAY (Pg 2/3) press [F1] so that the A box is highlighted. Use the right arrow [⇒] to toggle between A (Auto) and H (Hold). Press [F1] to increase or decrease the range value. The instrument default setting is A (Auto Range). When Dry Circuit is ON, only the 200mΩ, 2Ω and 20Ω ranges are available.

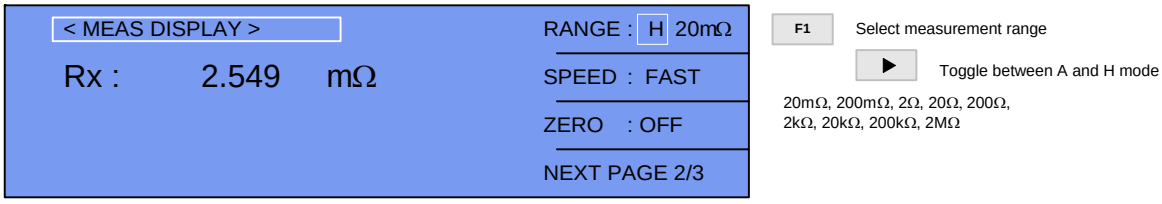
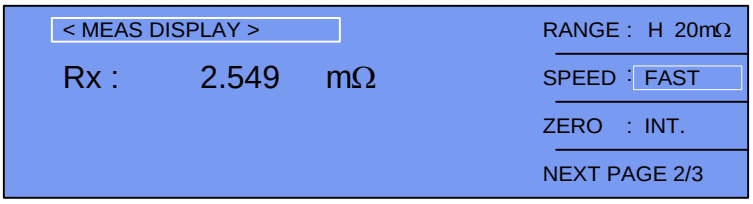


Table: 2-3: Full Scale Measurement Ranges

Full-Scale Range	20mΩ	200mΩ	2Ω	20Ω	200Ω	2kΩ	20kΩ	200kΩ	2MΩ
Resolution	1μΩ	10μΩ	100μΩ	1mΩ	10mΩ	100mΩ	1Ω	10Ω	100Ω

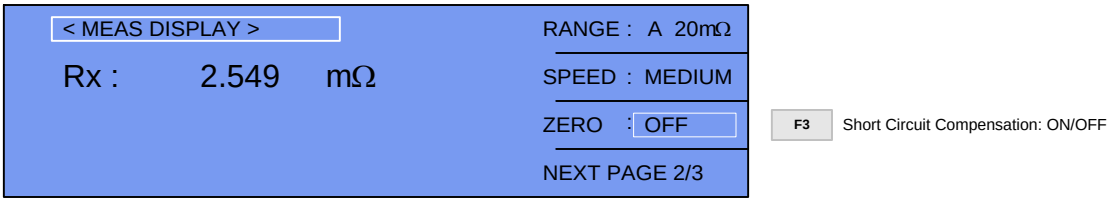
2.4.5 SPEED

The LR2000 instrument can be programmed for Slow (1.5measurements/second), Medium (6 measurements/second) or Fast (15 measurements/second) test times. The basic accuracy (0.05%) is specified for the slow measurement speed. In MEAS DISPLAY (Pg 2/3) press [F2] so that FAST is highlighted. Press [F2] to increase/decrease the speed. The instrument default setting is FAST (15 measurements/second).



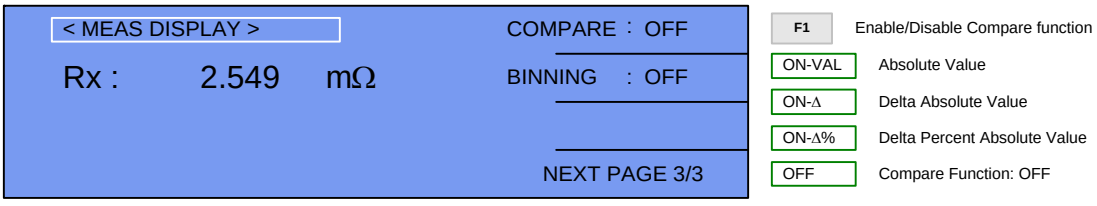
2.4.6 ZERO

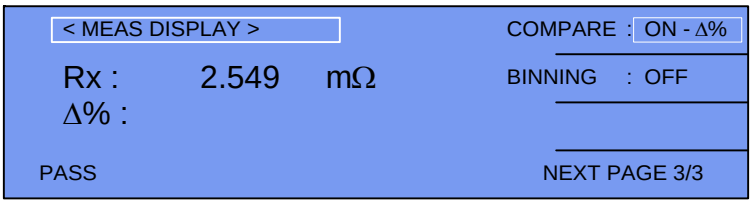
Short circuit compensation can be performed on the test leads/fixture by selecting the ZERO function = ON. In MEAS DISPLAY (Pg 2/3), press [F3] so that the box next to ZERO is highlighted. Press [F3] to select ZERO ON or OFF. The instrument default setting is OFF.



2.4.7 COMPARE

To enable/disable the compare function, in MEAS DISPLAY (Pg 3/3), press [F1] so that the box next to COMPARE is highlighted. Press [F1] to switch the compare function ON/OFF*. The instrument default setting is OFF. Setting the comparison values is done within the MAIN INDEX menu. Refer to paragraph 2.5.1 for instructions on setup of Compare.





*** Notes on Compare Settings:**

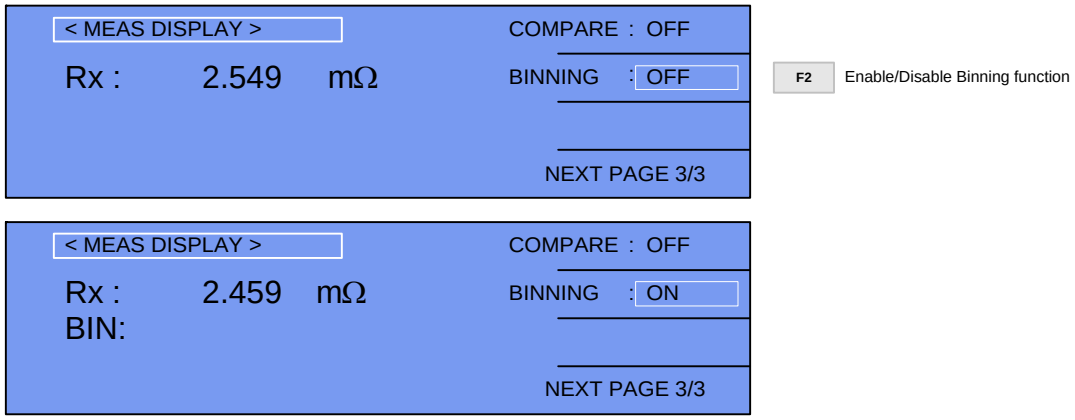
Setting COMPARE = ON will display the measured reading in addition to a PASS. A LO reading is lower than the set nominal value and a HI reading is higher than the set nominal value.

Setting COMPARE = ON-Δ will display the measured value and the difference between the measured value and the set nominal value. A PASS, LO, or HI judgment is also displayed.

Setting COMPARE = ON-Δ% will display the measured value and the percent difference between the measured value and the set nominal value. A PASS, LO, or HI judgment is also displayed.

2.4.8 BINNING

The LR2000 instrument has 8 pass/fail bins for sorting components by test result. To enable/disable the binning function, in MEAS DISPLAY (Pg 3/3) press [F2] so that the box next to BINNING is highlighted. Press the [F2] key to switch the binning function ON/OFF. The instrument default setting is OFF. Setting the bin values is done within the MAIN INDEX menu. Refer to paragraph 2.5.2 for instructions on setup of Binning.



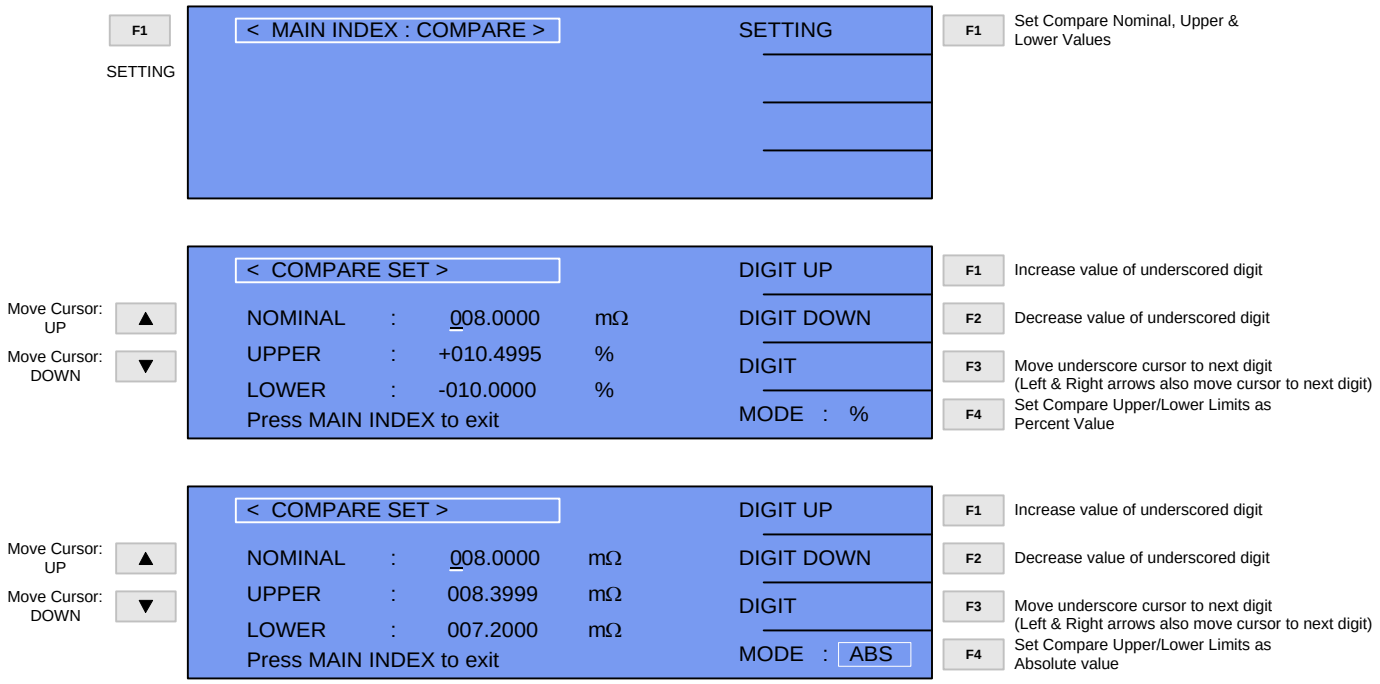
2.5 MAIN INDEX

Within the LR2000 instrument's MAIN INDEX are the Binning and Compare Setting Functions. To access these functions press [MAIN INDEX] and the display should look as shown in Figure 2-4.

Figure 2-4: MAIN INDEX

2.5.1 COMPARE

To set up a comparison test, use the COMPARE function. To access the COMPARE function, press [MAIN INDEX] then press [F1] = COMPARE. Press [F1] = SETTING to set the nominal, upper and lower judgment limits. Press [F1] = DIGIT UP and [F2] = DIGIT DOWN to increase and decrease the limits. Press [F4] to select the mode equal to percent or absolute value.



*** Notes on Compare Settings:**

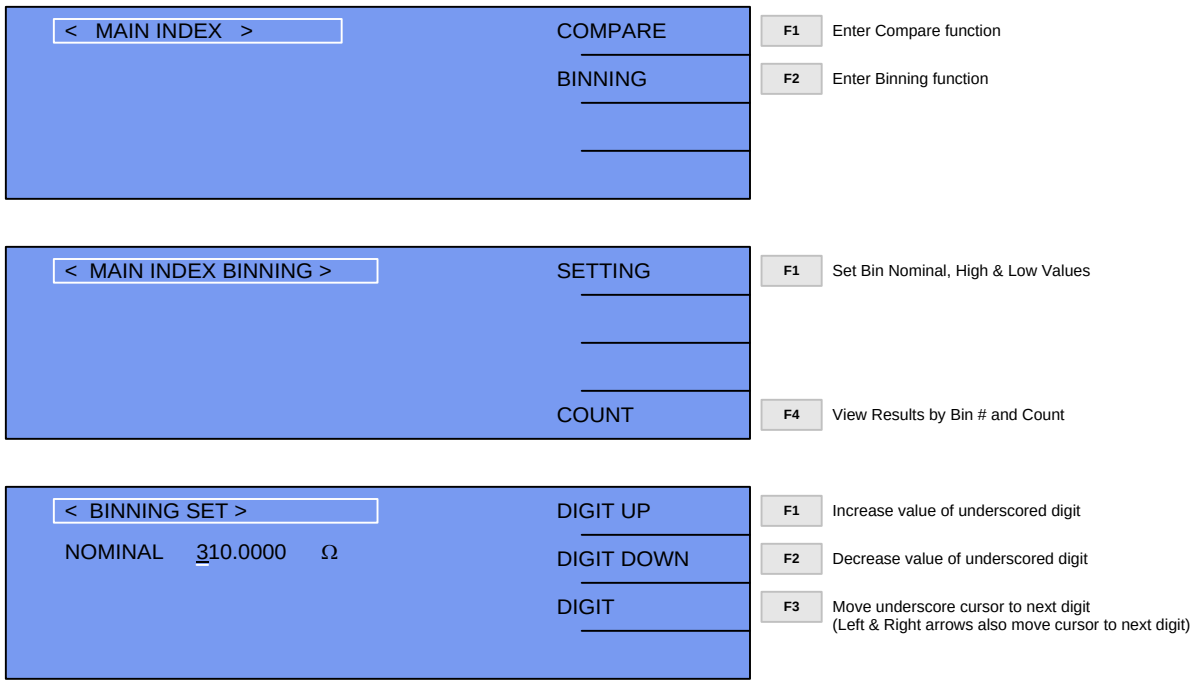
Setting COMPARE = ON will display the measured reading in addition to a PASS. A LO reading is lower than the set nominal value and a HI reading is higher than the set nominal value.

Setting COMPARE = ON-Δ will display the measured value and the difference between the measured value and the set nominal value. A PASS, LO, or HI judgment is also displayed.

Setting COMPARE = ON-Δ% will display the measured value and the percent difference between the measured value and the set nominal value. A PASS, LO, or HI judgment is also displayed.

2.5.2 BINNING

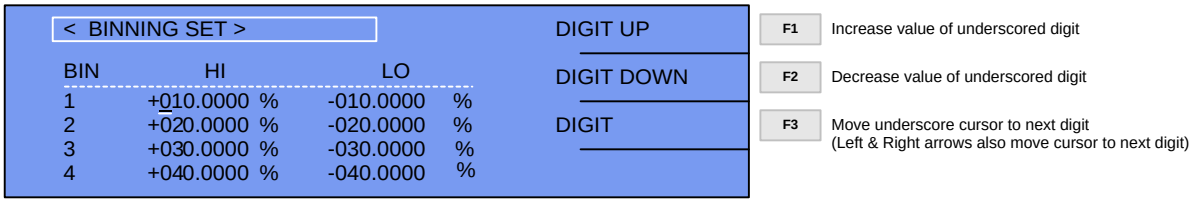
To enter the Bin Setting functions for the LR2000 instrument, press [MAIN INDEX] then [F2] = BINNING.



- Press [F1] = SETTING to enter the BINNING SET Display.
- To set the nominal value, press [F1] = DIGIT UP to increase the value of the underscored digit.
- Press [F2] = DIGIT DOWN to decrease the value of the underscored digit.
- Press [F3] = DIGIT to move the underscored digit right. The left [⇐] and right [⇒] arrow keys also move the underscored digit left or right on a single line.
- Once the nominal value is set, press the [⇓] down arrow key to set the bin limits.

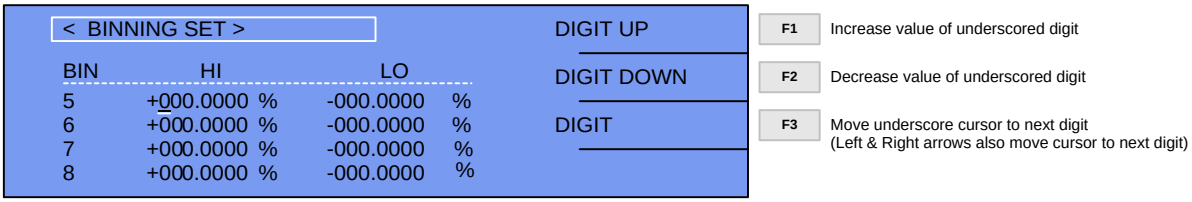
BINNING SET Display:

Set Bin 1 High Limit.



Press the right arrow [⇒] key to move from Bin 1 HI to Bin 1 LO. Set Bin 1 Low Limit.
Press the left arrow [⇐] key and the down arrow [⇓] key to go to Bin 2. Set Bin 2 High Limit.
Press the right arrow [⇒] key to move from Bin 2 HI to Bin 2 LO. Set Bin 2 Low Limit.
Press the left arrow [⇐] key and the down arrow [⇓] key to go to Bin 3. Set Bin 3 High Limit.
Press the right arrow [⇒] key to move from Bin 3 HI to Bin 3 LO. Set Bin 3 Low Limit.

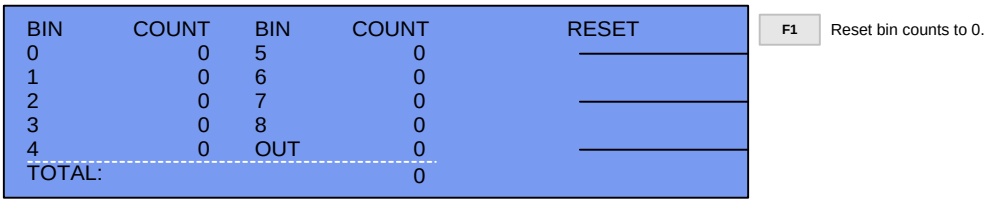
Continue this setting process until all bin HI and LO limits are set.



When the nominal, and all the bin values are set, press the [F4] key to view bin setup. To exit the Binning menu, press the [MAIN INDEX] key.

To View the BINNING COUNT screen:

Press [MAIN INDEX], [F2] = BINNING and then press [F4] = COUNT. The display will list the results of the 8 bins plus the total for all bins used.



Two of the most common methods of sorting results into bins are using nested limits or sequential limits.

Nested Limits

Nested limits are a natural choice for sorting components by % tolerance around a single nominal value with the lower bins narrower than the higher numbered bins. Nested limits for three bins are illustrated in Figure 2-5. Note that the limits do not have to by symmetrical (Bin 3 is –7% and +10%).

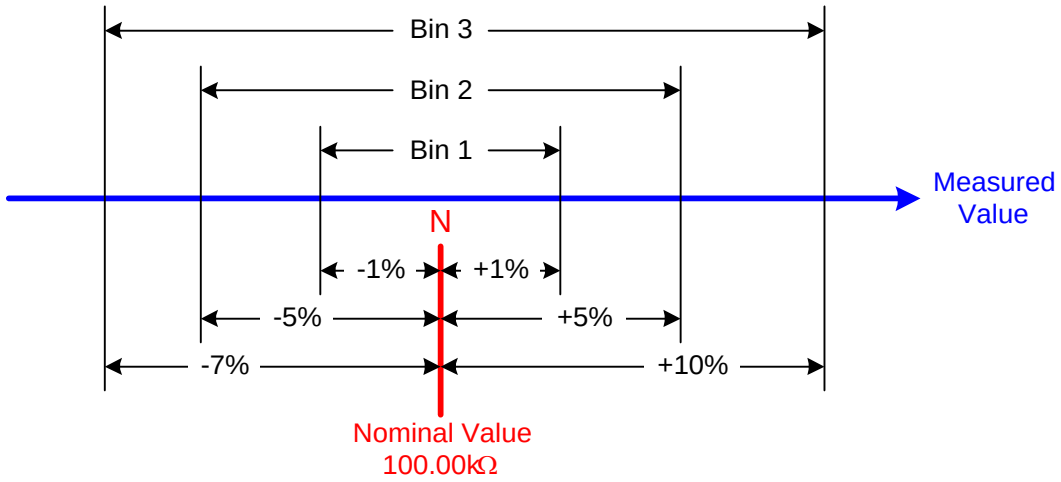


Figure 2-5: Nested Limits

Sequential Limits

Sequential limits are a natural choice when sorting components by absolute value. Figure 2-6 illustrates the use of sequential limits for a total of three bins. Sequential bins do not have to be adjacent. Their limits can overlap or have gaps depending upon the specified limit. Any component that falls into an overlap between bins would be assigned to the lower numbered bin and any component that falls into a gap between bins would be assigned to the overall fail bin.

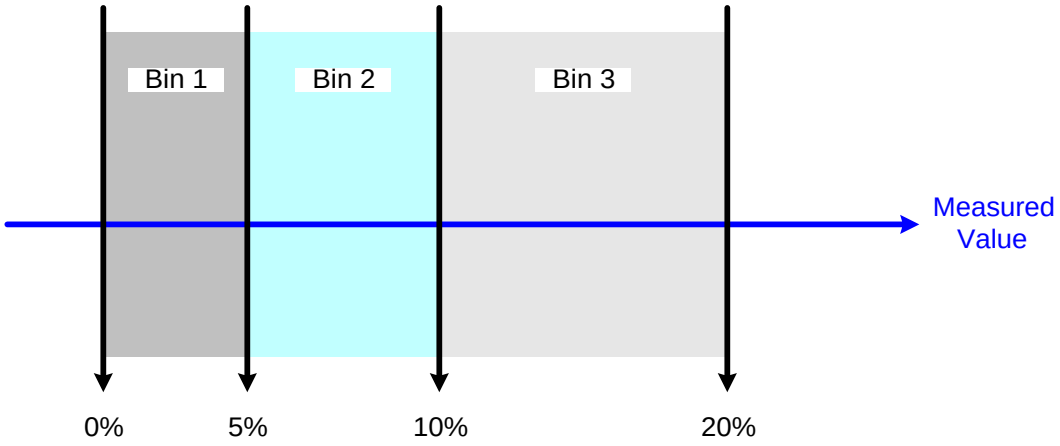


Figure 2-6: Sequential Limits

2.6 Connection to Device under Test

Figure 2-9 illustrates the connection of the LR2000 to a single DUT using the LR2000-50 Kelvin Clip Cable lead set. The red Kelvin clip is connected between the Drive (+) and Sense (+) terminals on the LR2000 unit. The black Kelvin clip is connected between the Drive (-) and Sense (-) terminals on the LR2000 unit.

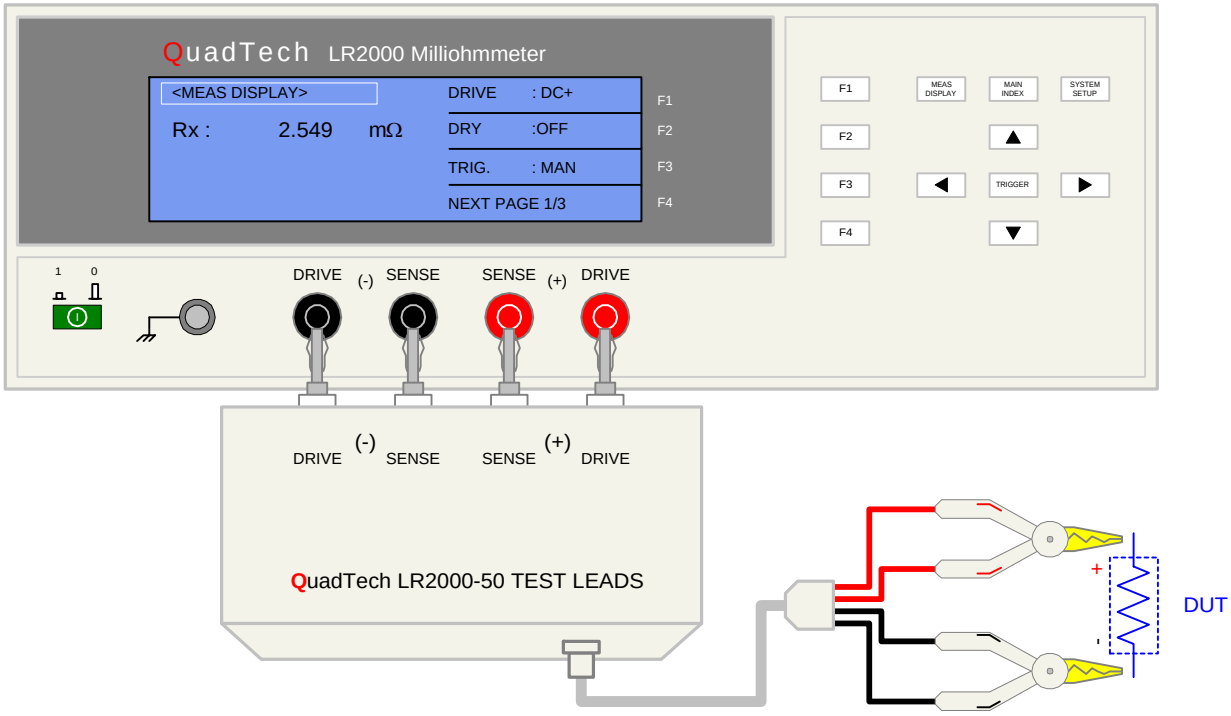


Figure 2-9: LR2000-50 Kelvin Clip Test Leads

2.7 Measurement Procedure

Before a measurement is made verify the following:

1. The rear panel voltage selector switch is set to the correct line voltage.
2. The LR2000 instrument is turned ON.
3. The LR2000 has had a 15-minute warm-up.
4. The Display is set to MEAS DISPLAY.
5. All test parameters programmed.
6. The test cables or fixture is connected.
7. A ZERO function is performed (if desired).
8. The device under test is connected.

To initiate a test:

Press [TRIGGER].

The LR2000 instrument judges the measurement value based on the COMPARE and BINNING functions set up previously. Refer to paragraphs 2.5.1 and 2.5.2 for instructions on setting these judgment parameters. Upon completion of the test the output voltage is terminated and the display shows the test result.

Section 3: Interface

3.1 RS-232 Interface

3.1.1 RS-232 Pin Configuration

The LR2000 instrument comes standard with an RS232 Interface for remote operation. Connection is through the black/silver 9-pin connector labeled 'RS232' on the rear panel of the LR2000 instrument. Figure 3-1 illustrates the designation of the pins on the RS232 connector. The connection cable must be a 'straight through' cable for the LR2000 unit to communicate.

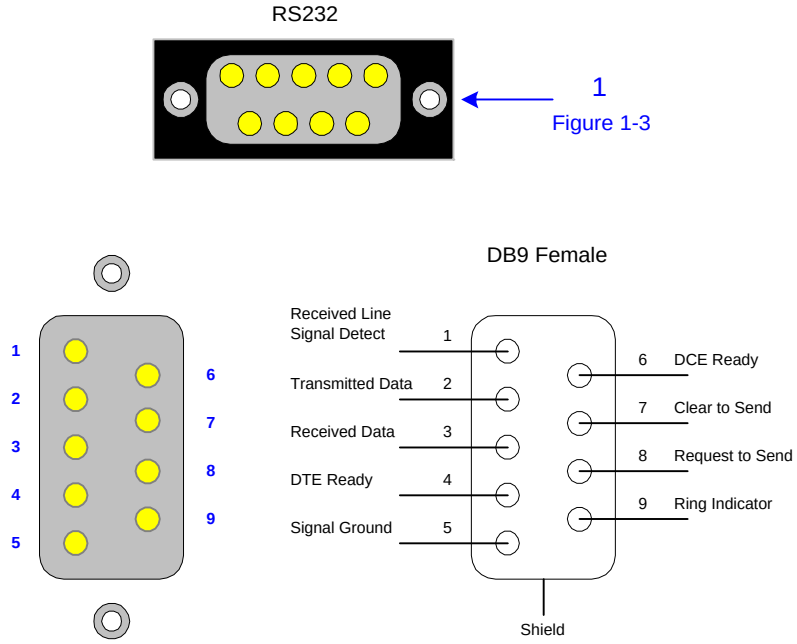


Figure 3-1: RS-232 Interface Pin Configuration

3.1.2 RS232 Specifications

Data Bits:	8
Stop Bits:	1
Parity:	None, Odd, Even
Baud Rate:	1200, 2400, 4800, 9600, 19200 or 38400bps, Software selectable
EOS:	LF or CR + LF
Echo:	Off

Refer to paragraph 2.3.3.13. Setting the Baud Rate is done in the SYSTEM CONFIGURATION function under SYSTEM SETUP settings:

- From the STAND BY display, press [SYSTEM SETUP]
- Press [F3] = SYSTEM CONFIG.
- Press [⇓] = until the box next to BAUD RATE is highlighted.
- Press [F1] = INCREASE or [F2] = DECREASE to select baud rate.
- Press [F4] to EXIT

3.1.3 RS232 Commands

The command set for the RS232 interface is the same as the IEEE-488 interface command set listed in paragraphs 3.2.3 through 3.2.5 of this instruction manual.

NOTE
CR + LF are necessary end codes for the RS232 commands.

Additional RS232 Commands

Some commands for RS232 use only are listed here. These commands follow the SCPI version 1999.0.

:SYSTem:LOCK:RELease ==> Change statue to local, as GPIB Go To Local.
:SYSTem:LOCK:REQuest? ==> Change statue to Remote, return '1' if successful.
:SYSTem:LOCK:OWNer? ==> Query the statue.
:SYSTem:LOCk <Boolean> ==> As GPIB Local Lockout.
:SYSTem:LOCk? ==> Query the Key Lock status.

3.1.4 Sample QuickBasic Program

This is a simple quick basic program for the LR2000 milliohmmeter.
This is for RS232 communication at a baud rate set to 9600
The program reads *idn from LR2000
The program asks how many measurements to make,
It then sends trigger command to the LR2000 and displays the measured results.

```
Print "Calculating Delay Loops ....."
Rem delay correction routine
q = 1
Do While Environ$(q) <> ""
   If Left$(Environ$(q), 7) = "MACHINE" Then
      qq = q
      mn = Val(Right$(Environ$(q), 1))
      mn$ = Right$(Environ$(q), 1)
    End If
   q = q + 1
Loop
error1:
t1 = Timer
s = 0
```

```
For i = 1 To 30000
Next i
t2 = Timer
k = t2 - t1
If k = 0 Then GoTo error1
k2 = 40000 / k

Open "COM1:9600,n,8,1,cs,ds" For Random As #1:

Rem Get identification string from LR2000
For j = 1 To k2: Next j
Print #1, "*cls"; Chr$(13); Chr$(10)
Print #1, "*idn?"; Chr$(13); Chr$(10)
For j = 1 To k2: Next j
GoSub cget
r45$ = Input$(x, #1)
Print "Identification String is;"
Print r45$
Print ""
Print ""
Print "Enter number of measurements to make"
INPUT nummeas

Cls
For i = 1 To nummeas
For j = 1 To k2: Next j
Print #1, "*cls"; Chr$(13); Chr$(10)

Print #1, "*TRG"; Chr$(13); Chr$(10)
GoSub cget
r45$ = Input$(x, #1)
Print ""
Print "Measurement" + Str$(i)
Print r45$
Next i

Close #1
Print ""
Print "End of Program"
End

cget:
' subroutine to get serial input loop until first character is received
Do While (Loc(1) = 0)
For j = 1 To k2: Next j
 Loop
' then get the rest of the string
y = x + Loc(1)
Do While (x <> y)
y = x
For j = 1 To k2 / 10: Next j
x = Loc(1)
Loop
'PRINT x
Return
```

3.2 IEEE-488 Interface

3.2.1 Pin Configuration

An IEEE-488 Interface (illustrated in Figure 3-2) is an available option for the LR2000 instrument. Connection is through the blue 24-pin connector labeled 'IEEE-488 INTERFACE' on the rear panel of the LR2000 instrument. This interface can be used to connect a system containing a number of instruments and a controller in which each meets IEEE Standard 488.2 (Standard Digital Interface for Programmable Instrumentation).

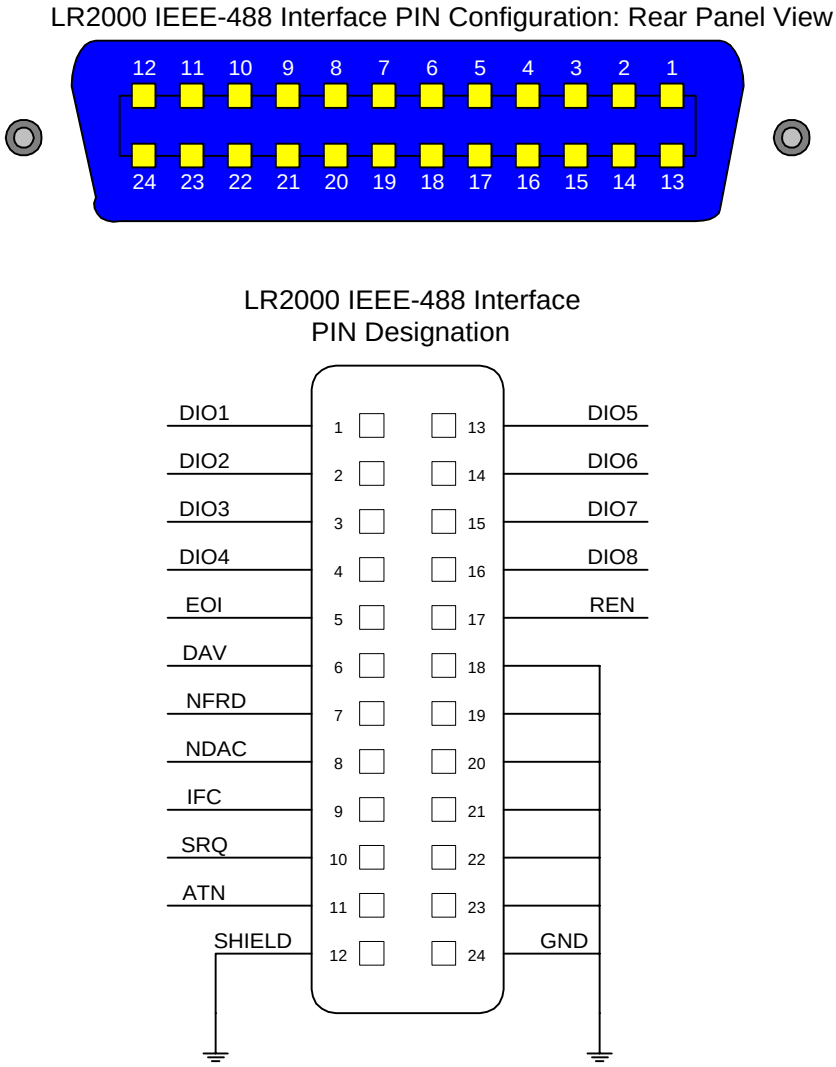


Figure 3-2: IEEE-488 Interface Pin Configuration

Table 3-1 lists the IEEE-488 Interface pin designations by pin number, signal name and pin function. Bus and driver information is also listed.

Table 3-1: IEEE-488 Interface Pin Designations

Bus	Driver	Signal Name	Pin Number	Function
Handshake	3 States	DAV	6	Low State: "Data is Available" and valid on DI01 through DI08
	Open Collector	NRFD	7	Low State: At least one Listener on the bus is "Not Ready For Data"
	Open Collector	NDAC	8	Low State: At least one Listener on the bus is "Not Accepting Data"
Control	3 States	ATN	11	"Attention" specifies 1 of 2 uses for the DI01 through DI08 lines: Low State: Controller command messages High State: Data bytes from the Talker device
	3 States	IFC	9	"Interface Clear" Low State: Returns portion of interface system to a known quiescent state
	Open Collector	SRQ	10	"Service Request" Low State: A Talker or Listener signals (to the controller) need for attention in the midst of the current sequence of events.
	3 States	REN	17	"Remote Enable" Low State: Enables each device to enter remote mode when addressed to listen. High State: All devices revert to Local control.
	3 States	EOI	5	"End of Identify" If ATN is in HIGH state, then EOI LOW state indicates the end of a multiple-byte data transfer sequence. If ATN is in LOW state, then EOI LOW state indicates a parallel poll.
Data	Open Collector	DI01	1	The 8-Line Data Bus. If ATN is in LOW state, then the bus conveys interface messages. If ATN is in HIGH state, then the bus conveys device-dependent messages. (Example: carries remote control commands from the controller or from a talker device)
		DI02	2	
		DI03	3	
		DI04	4	
		DI05	13	
		DI06	14	
		DI07	15	
		DI08	16	

3.2.2 IEEE-488 Interface Function Codes and Messages

The IEEE-488 (GPIB) address is defined under the SYSTEM SETUP in the SYSTEM CONFIG menu. Press [SYSTEM SETUP], then the numerical key [F3] to enter the SYSTEM CONFIG menu. Press down arrow [⇓] to enter the GPIB ADDRESS code. To select a new IEEE-488 address, use the function keys. Refer to paragraph 2.3.3.12 for more information. The default setting for the IEEE address is 17.

Table 3-2 defines the IEEE-488 interface codes and their function. Table 3-3 defines the IEEE-488 interface messages the LR2000 instrument responds to and their function.

Table 3-2: IEEE-488 Interface Functions

Code	Function
SH1	Source Handshake (Talker)
AH1	Acceptor Handshake (Listener)
T6	Basic Talker Function
	Serial Poll Function
	Listener-specified Talker Release Function
	No TALK-ONLY Function
L4	Basic Listener Function
	Talker-specified Listener Release Function
SR1	Service Request Function
RL1	All Remote/Local Functions
PP0	No Parallel Poll Function
DC1	Device Clear Function
DT1	Device Trigger Function
C0	No Controller Functions

Table 3-3: IEEE-488 Interface Messages

Interface Message	Function	Description
GTL	Go To Local	Only addressed devices that receive this command are set to local mode. Cancels the remote control mode, making the front panel switches operative.

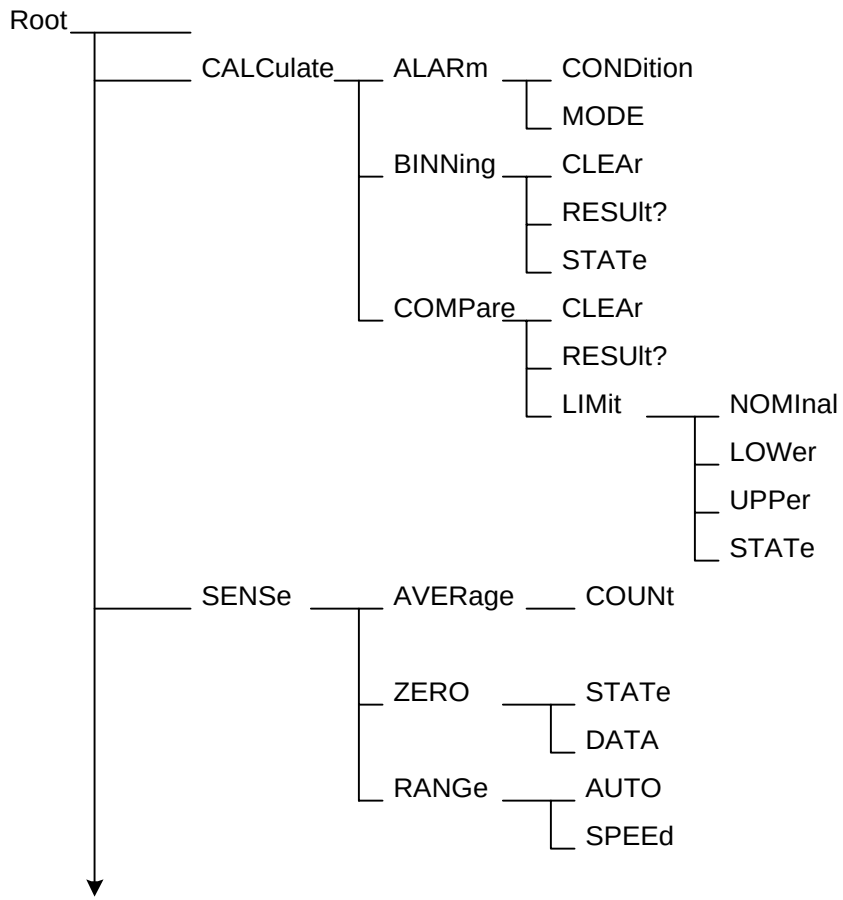
Table 3-4 lists the IEEE-488 interface commands the LR2000 instrument accepts to set or query a parameter value. Paragraphs 3.2.3 through 3.2.5 detail command function, format, return value and description.

Table 3-4: IEEE-488 Commands

Command	Name	Function	Output Format
*CLS	Clear Status	Clear standard event status register. Clear status bit group register except for bit 4 (MAV)	
*ESE	Event Status Enable	Enable standard event status register value.	0 – 255
*ESE?	Event Status Enable	Query standard event status of device enable register	0 – 255
*ESR?	Event Status Register	Query standard event register value of device. After this command, the standard register is cleared to 0.	0 – 255
*IDN?	Identification	Query/Read basic device data. (A comma separates the identification fields.)	4 ID: Manufacturer, Device Model, Serial Number, Firmware Version
*OPC	Operation Complete	Operation is complete.	0
*OPC?	Operation Complete	Query operation complete.	1
*RST	Reset	Reset Device.	
*SRE	Service Request Enable	Enable service request register value.	0 – 255
*SRE?	Service Request Enable	Query/Read service request register value.	0 – 255
*STB?	Status Byte Enable	Query status register text.	0 – 255
*TRG	Trigger Bus	Trigger the 1715 instrument	
*TST?	Self Test	Perform self test & report error	0 = no error 1 = CPLD 2 = EEPROM 3 = HANDLER 4 = Cal Data

3.2.3 IEEE-488 Commands

Figure 3-2 illustrates the programming commands accepted by the IEEE-488 interface of the LR2000 instrument. The commands are written in tabular format as a single reference to view all the commands. The command format and examples are detailed in paragraphs 3.2.4 – 3.2.5.



Continued on next page

Figure 3-2a: IEEE-488 Commands

Figure 3-2 Continued: Tabular format of IEEE-488 Commands

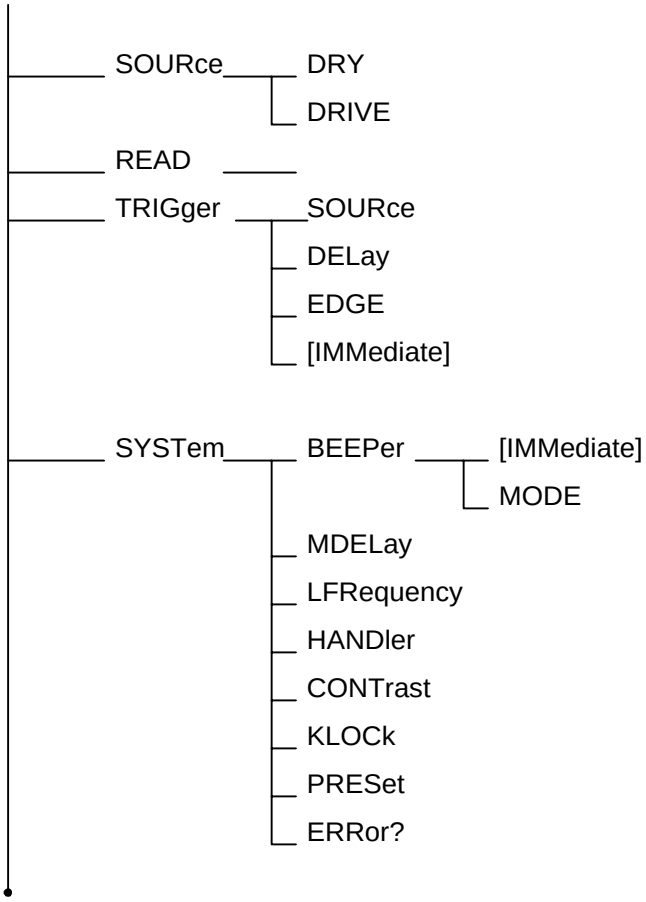


Figure 3-2b: IEEE-488 Commands

3.2.4 IEEE-488 Command Format

The IEEE-488 commands are configured in Root format. There are six levels of the instruction from top to bottom. Follow the specific path (as illustrated in Figure 3.2) to configure a specific command. The colon at the beginning of each line denotes that all line signals are root. Use a colon (:) to separate levels. Use the semicolon (;) to separate two commands on the same line.

For example, to format the command for the lower Compare, use this path:

:CALCulate:COMP:LIMIt:LOW 3.12E2

If the command is a setting, then put the parameter after the instruction. If the command is an inquiry, then put a question mark (?) after the instruction.

For example, to set the Trigger to External:

:TRIGger:SOURce:EXTernal

To inquire what the Trigger is set to:

:TRIGger:SOURce?

The lowercase letters and portion in parenthesis can be omitted so the above instruction can be rewrites as:

:TRIG:SOUR:EXT

The Ending Code can be any type in Table 3-5.

Table 3-5: IEEE-488 Interface Ending Codes

Ending Code
[CR] (0Dh)
[LF] (0Ah)
[CR] (0Dh) + [LF] (0Ah)

3.2.5 IEEE-488 Commands - Detailed

The IEEE commands listed in Figure 3-2 are detailed in paragraphs 3.2.5.1 – 3.2.5.7 including command, parameter, return value, function, and description. Note: Numerical data is transferred via one of three methods: integer format, fixed decimal format or floating point decimal format. Refer to Figure 3-3.

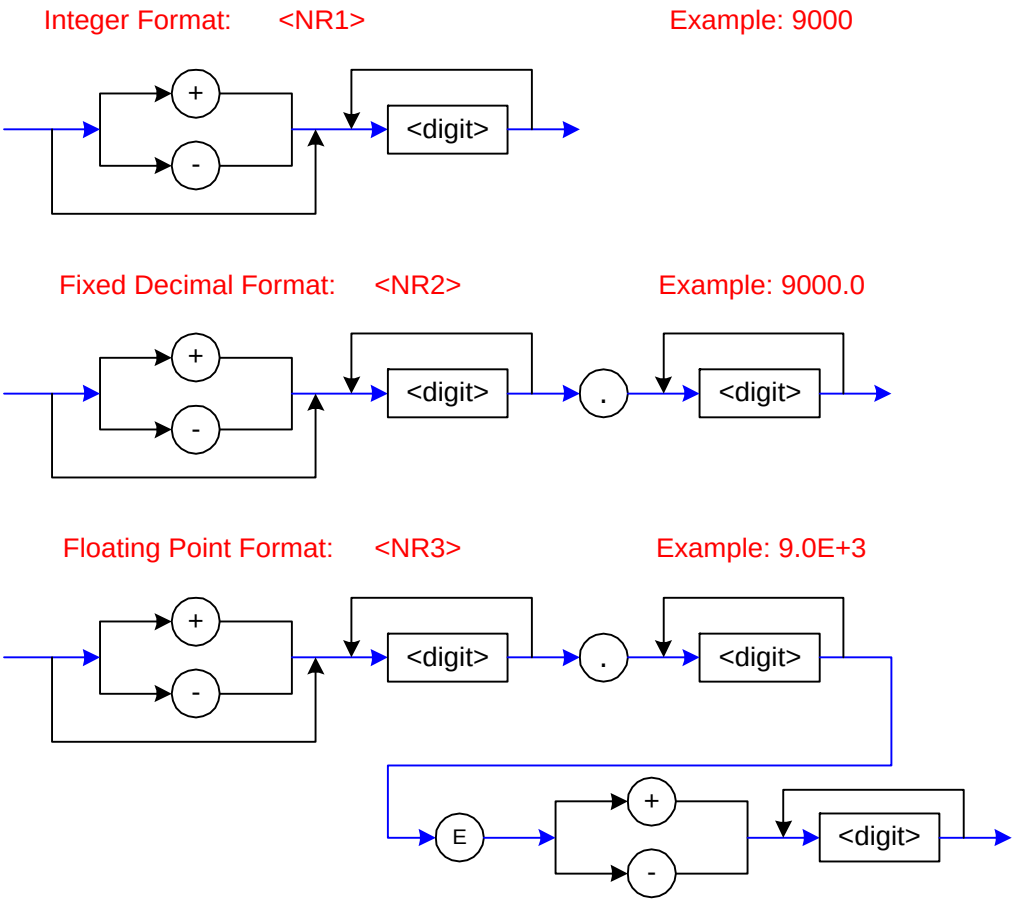


Figure 3-3: Numerical Data Transfer

3.2.5.1 Root Function:

ABOR

Instruction: ABOR
Parameter: None
Return Value: None
Function: Terminate Trigger in process. Reset Trigger.

3.2.5.2 CALCulate Function:

:CALC:ALAR:COND

Instruction:	CALC:ALAR:COND	
Parameter:	{FAIL | PASS}	
Return Value:	{FAIL | PASS}	
Function:	Set the alarm to sound on FAIL or PASS result.	
Description:	FAIL	Alarm will sound on FAIL result
	PASS	Alarm will sound on PASS result
Example:	:CALC:ALAR:COND FAIL	

:CALC:ALAR:MODE

Instruction:	CALC:ALAR:MODE	
Parameter:	{PULSe | CONTinuous}	
Return Value:	{PULSe | CONTinuous}	
Function:	Set the alarm to pulse or to sound continuously.	
Description:	PULSe	Alarm will pulse
	CONTinuous	Alarm will sound continuously
Example:	:CALC:ALAR:MODE CONT	

:CALC:BINN:CLEA

Instruction:	CALC:BINN:CLEA
Parameter:	None
Return Value:	None
Function:	Clear Bins – reset all bins to 0.
Example:	:CALC:BINN:CLEA

:CALC:BINN:STAT

Instruction:	CALC:BINN:STAT	
Parameter:	{ON (1) | OFF (0)}	
Return Value:	{1 | 0}	
Function:	Set the BINNING function ON or OFF.	
Description:	1	Enable Binning
	0	Disable Binning
Example:	:CALC:BINN:STAT ON	

:CALC:COMP:CLEA

Instruction:	CALC:COMP:CLEA
Parameter:	None
Return Value:	None
Function:	Clear Comparison Settings – reset all to 0.
Example:	:CALC:COMP:CLEA

:CALC:COMP:RESU?

Instruction:	CALC:COMP:RESU?		
Parameter:	None		
Return Value:	{LO (0)|HI (+9)|PASS (10) |STBY (11)}		
Function:	Query the COMPARE result.		
Description:	+0	LO	Result is below low limit
	+9	PASS	Result is within low and high limits
	10	HI	Result is above high limit
	11	STBY	Result is above high limit
Example:	:CALC:COMP:RESU?		
Response:	+9		

:CALC:COMP:MATH:STAT

Instruction:	CALC:COMP:MATH:STAT	
Parameter:	{ON (1)|OFF (0)}	
Return Value:	{1|0}	
Function:	Set or query if CALCulate:COMPare:MATH is ON or OFF.	
Description:	ON (1)	Turn on CALCulate:COMPare:MATH
	OFF (0)	Turn off CALCulate:COMPare:MATH
Example:	:CALC:COMP:MATH:STAT ON	

:CALC:COMP:LIM:NOM

Instruction:	CALC:COMP:LIM:NOM
Parameter:	{MAX |MIN| <numeric value> (NR3 mode)}[Suffix Unit]
Return Value:	{The nominal value}
Function:	Set the NOMINAL limit for COMPARE function.
Example:	:CALC:COMP:LIM:NOM 15.0

:CALC:COMP:LIM:LOW

Instruction: CALC:COMP:LIM:LOW
Parameter: {<numeric value>|MAXimum|MINimum}[Suffix Unit]
Return Value: The lower limit value, the format is <NR3> (Floating point)
Function: Set or query the lower limit value.
Description: MINimum 0.0000
MAXimum 999.9999
Example: :CALC:COMP:LIM:LOW 10.00

:CALC:COMP:LIM:UPP

Instruction: CALC:COMP:LIM:UPP
Parameter: {The upper limit value|MAXimum|MINimum}[Suffix Unit]
Return Value: The upper limit value, the format is <NR3> (Floating point)
Function: Set or query the upper limit value.
Description: MINimum 0.0000
MAXimum 999.9999
Example: :CALC:COMP:LIM:UPP 20.00

:CALC:COMP:LIM:STAT

Instruction: CALC{1|2}:LIM:STAT
Parameter: {ON (1)|OFF (0)}
Return Value: {1|0}
Function: Set or query if the Compare function is ON or OFF.
Description: ON (1) Turn on Compare function
OFF (0) Turn off Compare function
Example: :CALC:COMP:LIM:STAT ON

3.2.5.3 SENSe Function

:SENS:AVER:COUN

Instruction: SENS:AVER:COUN
Parameter: {<numeric value>} (1 – 10)
Return Value: {<numeric value>} (1 – 10)
Function: Set or query the number of measurements to average.
Description: Set the number of measurements for the instrument to take then average.
Example: :SENS:AVER:COUN 1

:SENS:ZERO:STAT

Instruction:	SENS:ZERO:STAT	
Parameter:	{OFF (0)|ON (1)}	
Return Value:	{0|1}	
Function:	Select SHORT compensation function ON or OFF.	
Description:	0	Short compensation OFF
	1	Short compensation ON
Example:	:SENS:ZERO:STAT ON	

:SENS:ZERO:DATA

Instruction:	SENS:ZERO:DATA?
Parameter:	None
Return Value:	{<numeric value> (NR3 mode)}
Function:	Query the numeric correction (short compensation) value.
Description:	
Example:	:SENS:ZERO:DATA?
Response:	7.309873E-06

:SENS:RANG

Instruction:	SENS:RANG	
Parameter:	{<numeric value>|MIN|MAX}	
Return Value:	{<numeric value>} in <NR3> format	
Function:	Set or query the measurement range.	
Description:	0	20mΩ range
	1	200mΩ range
	2	2Ω range
	3	20Ω range
	4	200Ω range
	5	2kΩ range
	6	20kΩ range
	7	200kΩ range
	8	2MΩ range
Example:	:SENS:RANG 1	

Note: If DRY CIRCUIT is ON and an invalid measurement range is selected, the LR2000 unit will display an error. Valid ranges are 200mΩ, 2Ω, 20Ω and Auto.

:SENS:RANG:AUTO

Instruction:	SENS:RANG:AUTO	
Parameter:	{ON (1)|OFF (0)}	
Return Value:	{1|0}	
Function:	Set or query if the Auto Range is ON or OFF.	
Description:	ON (1)	Turn on Auto Range
	OFF (0)	Turn off Auto Range
Example:	:SENS:RANG:AUTO ON	

:SENS:SPEE

Instruction:	SENS:SPEE	
Parameter:	{FAST|MEDIum|SLOW}	
Return Value:	{FAST|MEDIum|SLOW}	
Function:	Set or query measurement speed.	
Description:	FAST	15 measurements per second
	MEDI	6 measurements per second
	SLOW	1.5 measurements per second
Example:	:SENS:SPEE SLOW	

3.2.5.4 SOURce Function

:SOUR:DRY

Instruction:	SOUR:DRY	
Parameter:	{ON (1)|OFF (0)}	
Return Value:	{1|0}	
Function:	Set or query if Dry Circuit mode is ON or OFF.	
Description:	ON (1)	Turn on Dry Circuit Mode
	OFF (0)	Turn off Dry Circuit Mode
Example:	:SOUR:DRY 0	

:SOUR:DRIV

Instruction:	SOUR:DRIV	
Parameter:	{PULSE+/- (0)|PULSE+ (1) |PULSE- (2)|DC+ (3)|DC- (4)|STBY (5)}	
Return Value:	{0|1|2|3|4|5}	
Function:	Set or query the Drive Signal.	
Description:	PULSE+/- (0)	Drive Signal: +2V – 0V – -2V – 0V
	PULSE+ (1)	Drive Signal: +2V – 0V
	PULSE- (2)	Drive Signal: -2V – 0V
	DC+ (3)	Drive Signal: +2V
	DC- (4)	Drive Signal: -2V
	STBY (5)	Drive Signal: Standby
Example:	:SOUR:DRIV:0	

3.2.5.5 READ Function

READ

Instruction: READ
Parameter: None
Return Value: {<numeric value>} in <NR3> format
Function: Query the present measurement result.
Description:
Example: READ?
Response: 6.698189E+03

3.2.5.6 TRIGger Function

:TRIG:SOUR

Instruction: TRIG:SOUR
Parameter: {BUS | EXTernal}
Return Value: {BUS | EXTernal}
Function: Set or query the Trigger Source to bus or external.
Description: BUS Trigger activated by bus signal
EXT Trigger activated by external signal
Example: :TRIG:SOUR BUS

:TRIG:DEL

Instruction: TRIG:DEL
Parameter: Trigger Delay Time
Unit: [MS]
Return Value: {Trigger Delay Time} in <NR3> format
Function: Set or query the trigger delay time.
Range Values: 0 ~ 9999ms
Example: :TRIG:DEL: 20

:TRIG:EDGE

Instruction: TRIG:EDGE
Parameter: {FALLing | RISIng}
Return Value: {FALL | RISI}
Function: Set or query the trigger edge.
Example: :TRIG:EDGE RISI

3.2.5.7 SYSTem Function

:SYST:BEEP:MODE

Instruction: SYST:BEEP:MODE
Parameter: {ON, LARGe (0) | ON, SMALl (1) | OFF (2)}
Return Value: {0 | 1 | 2}
Function: Set the loudness of the beeper.
Example: :SYST:BEEP:MODE SMAL

:SYST:LFR

Instruction: SYST:LFR
Parameter: {50 | 60}
Return Value: {50 | 60}
Function: Set or query if the Line Frequency.
Example: :SYST:LFR 60

:SYST:HAND

Instruction: SYST:HAND
Parameter: {CLEAr | HOLD}
Return Value: {CLEAr | HOLD}
Function: Set the Handler to clear result or hold result for each test.
Example: :SYST:HAND HOLD

:SYST:KLOC

Instruction: SYST:KLOC
Parameter: {ON (1) | OFF (0)}
Return Value: {1 | 0}
Function: Set or query if the Key Lock function is ON or OFF.
Description: ON (1) Turn on Key Lock
OFF (0) Turn off Key Lock
Example: :SYST:KLOC 1

:SYST:PRES

Instruction: SYST:PRES
Parameter: None
Return Value: None
Function: Set the instrument to initial default values.
Example: :SYST:PRES

:SYST:ERR?

Instruction: SYST:ERR?
Parameter: None
Return Value: {<numeric value>|<string>}
Function: Reads the error queue.
Example: :SYST:ERR?
Response: 0 “No Error”

Error Messages:

Table 3-6 lists the error messages for the LR2000 Milliohmmeter.

Table 3-6: Error Messages

Code	Type	Message
0	No error	None
-102	Syntax error	Invalid character exists in the command string.
-104	Data error	Parameter is not defined in the command string.
-106	Illegal parameter	Parameter is not a valid command.
-202	Conflicting Settings	Command conflicts with instrument settings. Example: Send ‘Trigger’ when mode is external.
-203	Data range	Data exceeds the valid range.
-211	Data stale	No resent measurement result. Example: Send ‘Read?’ when in Standby status.
-224	Self-Test failed	Self-test via remote interface (*TST) failed.
-225	Excess errors	The error queue is full (more than 20 errors). Queue cleared after power down or *CLS command.
-226	Query interrupted	Device status changed after query sent. Output buffer will be cleared

3.3 Handler Interface

A Handler interface (Figure 3-4) is an available option for the LR2000 instrument. Connection is made through the blue 24-pin connector labeled “HANDLER’ on the rear panel of the LR2000 instrument.

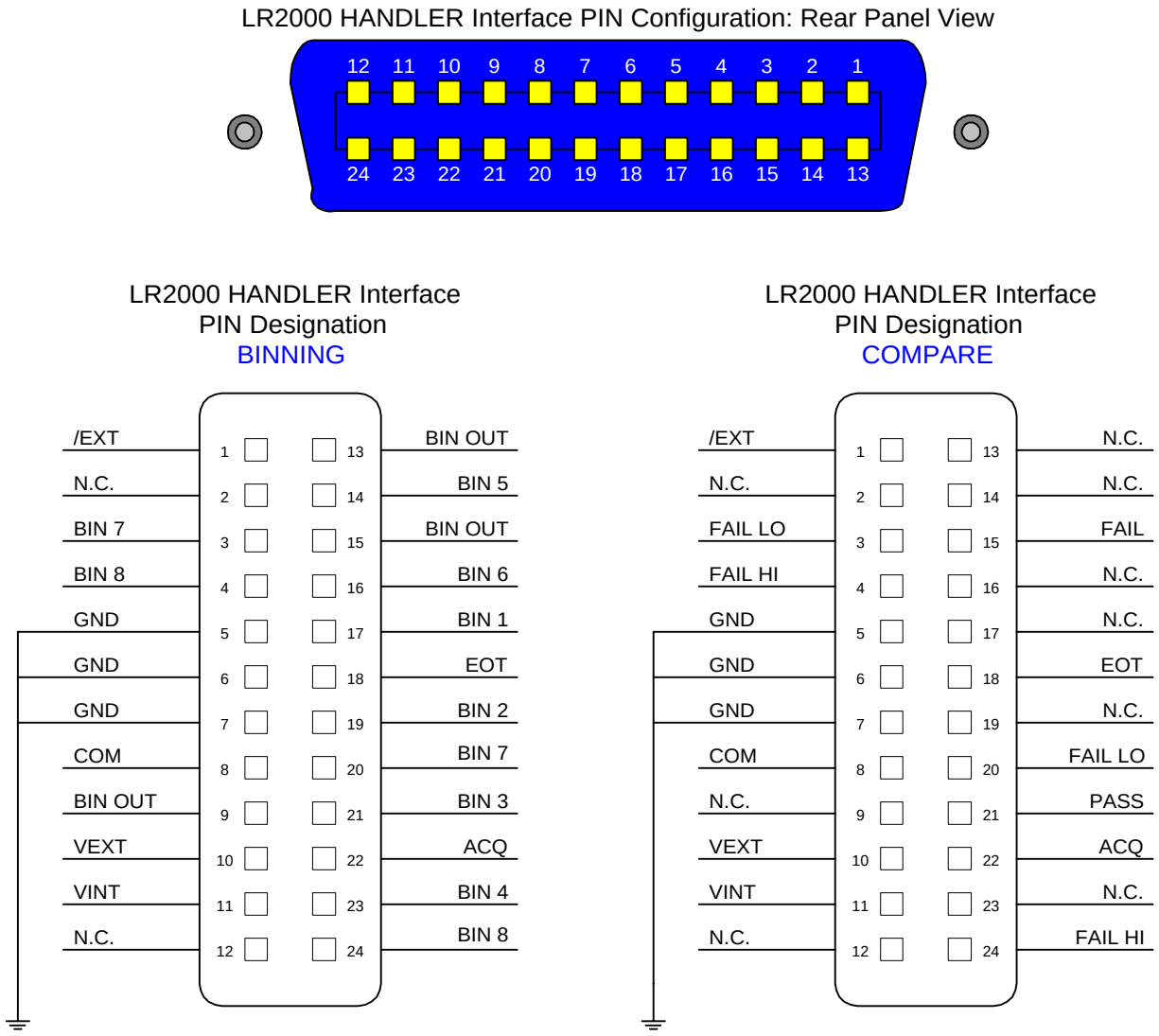


Figure 3-4: Handler Interface Pin Configuration

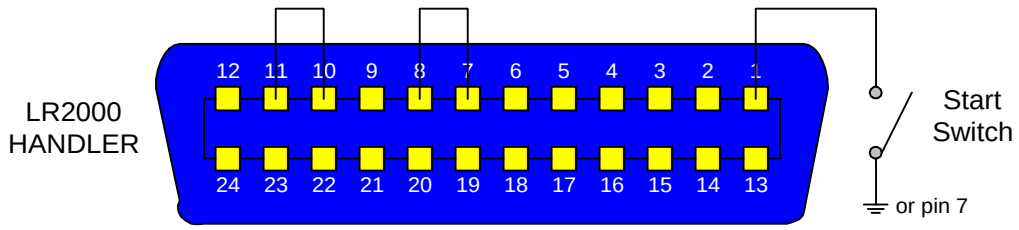


Figure 3-5: Start Switch

Paragraph 2.3.3.9 contains the instructions for changing the Handler mode. Paragraphs 2.3.3.7 and 2.3.3.8 contain instructions for setting the Trigger Delay time and selecting the Trigger Edge. Figure 3-6 illustrates the Trigger function.

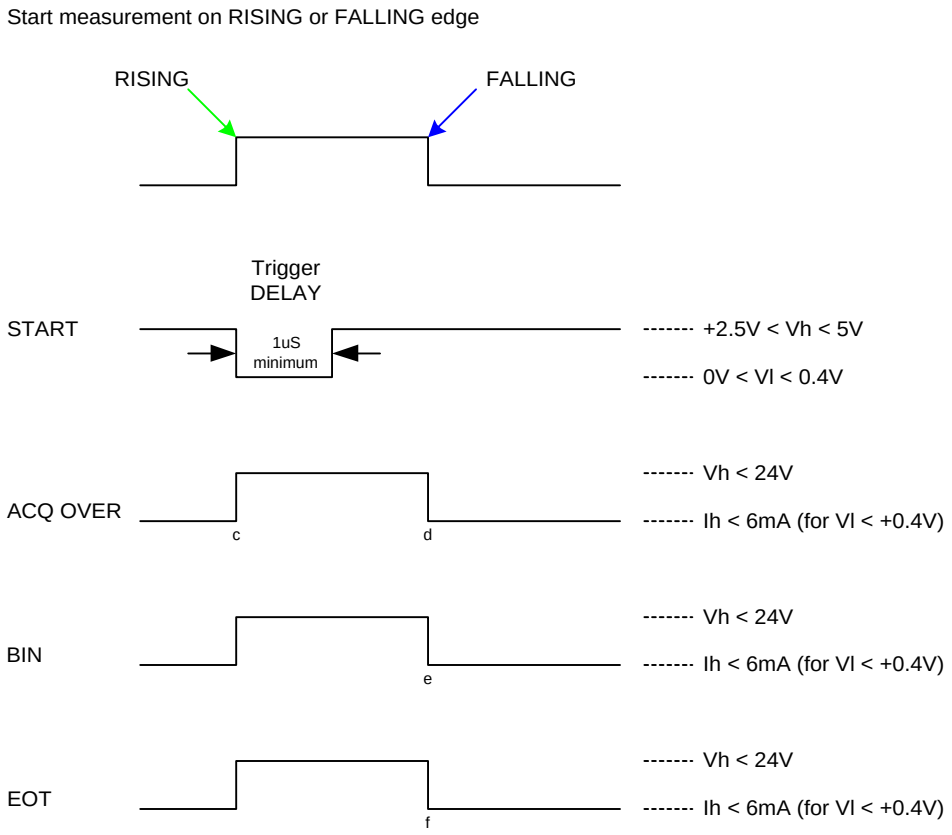


Figure 3-6: Trigger

Output Signals

The output lines of the LR2000 Handler interface are open collector drivers that pull each signal line to a low voltage, signal ground when the signal is active (true). Each external line should be pulled up (with a resistor) to a positive voltage between 5V and 24V. The pull-up resistor must limit the current to < 6mA for a signal of a comparison function and to < 5mA for a control signal (EOT).

Input Signal

The input signal to the LR2000 Handler interface is active low and requires a positive external voltage to pull the signal down below 0.4V, ground.

3.3.1 Handler Pin Assignments for Binning Operation

Table 3-7 lists the pin assignments when the handler interface on the LR2000 instrument is performing a Binning operation. The device under test is sorted by test value. The test limits can be set as absolute value or percent value.

Table 3-7: Handler Pin Assignments for Binning

Pin	Name	Description
1	/EXT	External trigger
2	X	No connection
3, 20	BIN 7	Rx pass (within Bin 7 limits)
4, 24	BIN 8	Rx pass (within Bin 8 limits)
5, 6, 7	GND	Chassis Ground
8	COM	Common Ground
9, 13, 15	BIN OUT	Rx fail
10	VEXT	External DC voltage: 5V ~ 24V
11	VINT	Internal DC voltage: +5V
12	N.C.	No Connection
14	BIN 5	Rx pass (within Bin 5 limits)
16	BIN 6	Rx pass (within Bin 6 limits)
17	BIN 1	Rx pass (within Bin 1 limits)
18	EOT	End of Test
19	BIN 2	Rx pass (within Bin 2 limits)
21	BIN 3	Rx pass (within Bin 3 limits)
22	ACQ	Received data, ready to accept next
23	BIN 4	Rx pass (within Bin 4 limits)

NOTE:
When using External DC Voltage (VEXT), Pins 5, 6, & 7 (GND) must be connected to Pin 8 (COM)

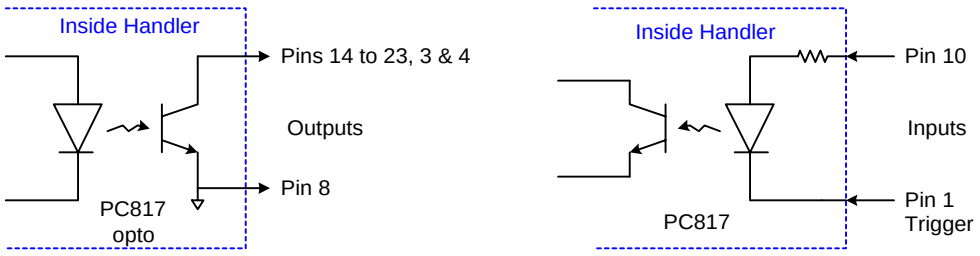


Figure 3-7: Handler I/O Pins

3.3.2 Handler Pin Assignments for Compare Operation

Table 3-8 lists the pin assignments when the handler interface on the LR2000 instrument is performing a Compare operation. The device under test is being compared against a standard of known value. High and low limits can be defined as absolute value or percent value.

Table 3-8: Handler Pin Assignments for Compare

Pin	Name	Description
1	/EXT	External Trigger
2	X	No connection
3, 20	FAIL LO	Rx fail low (test value below low limit)
4, 24	FAIL HI	Rx fail high (test value above high limit)
5, 6, 7	GND	Chassis Ground
8	COM	Common Ground
9, 13	N.C.	No connection
10	VEXT	External DC voltage: 5V ~ 24V
11	VINT	Internal DC voltage: +5V
12	X	No connection
14	X	No connection
15	FAIL	Rx fail (Not within limits)
16	X	No connection
17	X	No connection
18	EOT	End of Test
19	X	No connection
21	PASS	Rx pass (test value within limits)
22	ACQ	Received data, ready to accept next
23	X	No connection

NOTE:
When using External DC Voltage (VEXT), Pins 5, 6, & 7 (GND) must be connected to Pin 8 (COM)

Section 4: Service & Calibration

4.1 General

Our warranty (at the front of this manual) attests to the quality of materials and workmanship in out products. If malfunction should be suspected or other information desired, applications engineers are available for technical assistance. Applications assistance is available in the U.S. by calling (978) 461-2100 and asking for Applications Support. For support outside of the United States please contact your local QuadTech Distributor.

4.2 Instrument Return

Before returning an instrument to QuadTech for service, please call our **Customer Care Center (CCC)** at **800-253-1230** for Return Material Authorization (RMA). It will be necessary to include a Purchase Order Number to insure expedient processing, although units found to be in warranty will be repaired at no-charge. For any questions on repair costs or shipping instructions please contact our CCC Department at the afore-mentioned number. To safeguard an instrument during storage and shipping, please use packaging that is adequate to protect it from damage, i.e. equivalent to the original packaging, and mark the box "Delicate Electronic Instrument". Return material should be sent freight prepaid to:

QuadTech, Inc.
5 Clock Tower Place, 210 East
Maynard, Massachusetts 01754

Attention: RMA#

Shipments sent collect cannot be accepted.

4.3 Calibration

Calibration of the LR2000 Milliohmmeter instrument is completed at the factory and includes a NIST calibration certificate. Verification of instrument operation and accuracy is recommended on an annual basis. Accurate operation of the LR2000 instrument is confirmed using the LR2000-TP Verification Procedure.

4.3.1 LR2000 Verification Procedure

This section outlines the relevant information to verify performance of the LR2000 Milliohmmeter. It is recommended that performance be performed at least once a year using this outline procedure. Instrument should be warmed up for a minimum of 15 minutes prior to verification. Verification should be performed under the following conditions: Temperature equal to 23°C ± 1.2°C and Relative Humidity (RH) between 35% and 55%.

Recommended standards are listed below. All standards should be traceable to a National Laboratory such as N.I.S.T. with calibrated values for primary and secondary parameters at the required test frequencies. QuadTech's verification conforms to ANSI Z540 and QuadTech recommends that the calibrated values for the primary and secondary standards have an uncertainty 4 times better than the primary and secondary accuracy specified in the Verification Data Sheet. If the calibrated values for the standards used do not have an uncertainty of 4 times better than the specified accuracy of the LR2000 the uncertainty of the standard should be added to the specified accuracy of the LR2000.

4.3.2 LR2000 Verification Data Sheet

Range	Test Value	LR2000 Accuracy	Tool Number	Standard Value	Low limit	Measured Value	High limit
20mΩ		0.10%					
	10mΩ						
	19mΩ						
200mΩ		0.05%					
	100mΩ						
	190mΩ						
2Ω		0.05%					
	1Ω						
	1.9Ω						
20Ω		0.05%					
	10Ω						
	19Ω						
200Ω		0.05%					
	100Ω						
	190Ω						
2kΩ		0.05%					
	1kΩ						
	1.9kΩ						
20kΩ		0.10%					
	10KΩ						
	19kΩ						

LR 2000 Verification Table – continued

200kΩ		0.20%					
	100kΩ						
	190kΩ						
2MΩ		0.40%					
	1MΩ						
	1.9MΩ						

Test Value	Standard Value	Low Limit	Pulse +	Pulse -	DC +	DC -	High Limit
10mΩ							
1.9MΩ							