AMETRIX
INSTRUMENTS

Model 100 Series Picoammeter

USER'S MANUAL

Reduce Uncertainty

AMETRIX
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USER'S MANUAL

For The Model 100 Series Instruments

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1. WARRANTY & SAFETY

⚠ WARRANTY

AMETRIX Instruments warrants that the product will be free from defects in materials and workmanship for a period of three (3) years from the date of original purchase from an authorized AMETRIX Instruments distributor. If the product proves defective during this warranty period, AMETRIX Instruments, at its option, either will repair the defective product without charge for parts and labor, or will provide a replacement in exchange for the defective product.

Batteries are excluded from this warranty. Parts, modules, and replacement products used by AMETRIX Instruments for warranty work may be new or reconditioned to like new performance. All replaced parts, modules, and products become the property of AMETRIX Instruments.

In order to obtain service under this warranty, Customer must notify AMETRIX Instruments of the defect before the expiration of the warranty period and make suitable arrangements for the performance of service. Customer shall be responsible for packaging and shipping the defective product to the service center designated by AMETRIX Instruments, shipping charges prepaid, and with a copy of customer proof of purchase. AMETRIX Instruments shall pay for the return of the product to Customer if the shipment is to a location within the country in which the AMETRIX Instruments service center is located.

Customer shall be responsible for paying all shipping charges, duties, taxes, and any other charges for products returned to any other locations. This warranty shall not apply to any defect, failure, or damage caused by improper use, or improper or inadequate maintenance and care. AMETRIX Instruments shall not be obligated to furnish service under this warranty:

a) to repair damage resulting from attempts by personnel other than AMETRIX representatives to install, repair or service the product;

b) to repair damage resulting from improper use or connection to incompatible equipment;

c) to repair any damage or malfunction caused by the use of non-AMETRIX Instruments supplies; or

d) to service a product that has been modified or integrated with other products when the effect of such modification or integration increases the time or difficulty of servicing the product.

THIS WARRANTY IS GIVEN BY AMETRIX Instruments WITH RESPECT TO THE PRODUCT IN LIEU OF ANY OTHER WARRANTIES, EXPRESS OR IMPLIED. AMETRIX Instruments AND ITS VENDORS DISCLAIM ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. AMETRIX Instruments' RESPONSIBILITY TO REPAIR OR REPLACE DEFECTIVE PRODUCTS IS THE SOLE AND EXCLUSIVE REMEDY PROVIDED TO THE CUSTOMER FOR BREACH OF THIS WARRANTY. AMETRIX Instruments AND ITS VENDORS WILL NOT BE LIABLE FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES IRRESPECTIVE OF WHETHER AMETRIX Instruments OR THE VENDOR HAS ADVANCE NOTICE OF THE POSSIBILITY OF SUCH DAMAGES.

⚠ SAFETY PRECAUTIONS

The following safety precautions should be observed before using this product and any associated instrumentation. Although some instruments and accessories would normally be used with nonhazardous voltages, there are situations where hazardous conditions may be present.

This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read and follow all installation, operation, and maintenance information carefully before using the product. Refer to the user documentation for complete product specifications.

If the product is used in an unspecified manner specified, the protection provided by the product warranty may be impaired.

The types of product users are:

Responsible body is the individual or group responsible for the use and maintenance of equipment, for ensuring that the equipment is operated within its specifications and operating limits, and for ensuring that operators are adequately trained.

Operators use the product for its intended function. They must be trained in electrical safety procedures and proper use of the instrument. They must be protected from electric shock and contact with hazardous live circuits.

⚠ SAFETY PRECAUTIONS CONT.

Maintenance personnel perform routine procedures on the product to keep it operating properly, for example, setting the line voltage or replacing consumable materials. Maintenance procedures are described in the user documentation. The procedures explicitly state if the operator may perform them. Otherwise, they should be performed only by service personnel.

Service personnel are trained to work on live circuits, perform safe installations, and repair products. Only properly trained service personnel may perform installation and service procedures.

AMETRIX Instruments products are designed for use with electrical signals that are rated Measurement Category I and Measurement Category II, as described in the International Electrotechnical Commission (IEC) Standard IEC/EN 61010-1:2010. Most measurement, control, and data I/O signals are Measurement Category I and must not be directly connected to Mains voltage or to voltage sources with high transient over-voltages. Measurement Category II connections require protection for high-transient over-voltages often associated with local AC Mains connections. Assume all measurement, control, and data I/O connections are for connection to Category I sources unless otherwise marked or described in the user documentation.

Exercise extreme caution when a shock hazard is present. Lethal voltage may be present on cable connector jacks or test fixtures. The American National Standards Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30 V RMS, 42.4 V peak, or 60 VDC are present. A good safety practice is to expect that hazardous voltage is present in any unknown circuit before measuring.

Operators of this product must be protected from electric shock at all times. The responsible body must ensure that operators are prevented access and/or insulated from every connection point. In some cases, connections must be exposed to potential human contact. Product operators in these circumstances must be trained to protect themselves from the risk of electric shock. If the circuit is capable of operating at or above 1000 V, no conductive part of the circuit may be exposed.

Do not connect switching cards directly to unlimited power circuits. They are intended to be used with impedance-limited sources. NEVER connect switching cards directly to AC mains. When connecting sources to switching cards, install protective devices to limit fault current and voltage to the card.

Before operating an instrument, ensure that the line cord is connected to a properly-grounded power receptacle. Inspect the connecting cables, test leads, and jumpers for possible wear, cracks, or breaks before each use.

When installing equipment where access to the main power cord is restricted, such as rack mounting, a separate main input power disconnect device must be provided within the proximity of the equipment and within easy reach of the operator.

For maximum safety, do not touch the product, test cables, or any other instruments while power is applied to the circuit under test. ALWAYS remove power from the entire test system and discharge any capacitors before: connecting or disconnecting cables or jumpers, installing or removing switching cards, or making internal changes, such as installing or removing jumpers.

Do not touch any object that could provide a current path to the common side of the circuit under test or power line (earth) ground. Always make measurements with dry hands while standing on a dry, insulated surface capable of withstanding the voltage being measured.

The instrument and accessories must be used in accordance with its specifications and operating instructions, or the safety of the equipment may be impaired.

Do not exceed the maximum signal levels of the instruments and accessories, as defined in the specifications and operating information, and as shown on the instrument or test fixture panels, or switching card.

When fuses are used in a product, replace with the same type and rating for continued protection against fire hazard.

Chassis connections must only be used as shield connections for measuring circuits, NOT as safety earth ground connections.

If you are using a test fixture, keep the lid closed while power is applied to the device under test. Safe operation requires the use of a lid interlock.

If a screw is present, connect it to safety earth ground using the wire recommended in the user documentation.

SAFETY PRECAUTIONS CONT.

The symbol on an instrument means caution, risk of danger. The user should refer to the operating instructions located in the user documentation in all cases where the symbol is marked on the instrument.

The symbol on an instrument means caution, risk of electric shock. Use standard safety precautions to avoid personal contact with these voltages.

The symbol on an instrument shows that the surface may be hot. Avoid personal contact to prevent burns.

The symbol indicates a connection terminal to the equipment frame.

If this **Hg** symbol is on a product, it indicates that mercury is present in the display lamp. Please note that the lamp must be properly disposed of according to federal, state, and local laws.

The WARNING heading in the user documentation explains dangers that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The CAUTION heading in the user documentation explains hazards that could damage the instrument. Such damage may invalidate the warranty.

The **CAT II 300 V** symbol denotes Category II 300 V overvoltage protection.

The symbol is the Earth (ground) terminal.

The symbol indicates the equipment is protected throughout by double or reinforced insulation.

Instrumentation and accessories shall not be connected to humans.

Before performing any maintenance, disconnect the line cord and all test cables.

To maintain protection from electric shock and fire, replacement components in mains circuits—including the power transformer, test leads, and input jacks—must be purchased from AMETRIX Instruments. Standard fuses with applicable national safety approvals may be used if the rating and type are the same. Other components that are not safety-related may be purchased from other suppliers as long as they are equivalent to the original component (note that selected parts should be purchased only through AMETRIX Instruments to maintain accuracy and functionality of the product). If you are unsure about the applicability of a replacement component, call a AMETRIX Instruments office for information.

To clean an instrument, use a damp cloth or mild, water-based cleaner. Clean the exterior of the instrument only. Do not apply cleaner directly to the instrument or allow liquids to enter or spill on the instrument. Products that consist of a circuit board with no case or chassis (e.g., a data acquisition board for installation into a computer) should never require cleaning if handled according to instructions. If the board becomes contaminated and operation is affected, the board should be returned to the factory for proper cleaning/servicing.

This instrument is safety-certified in compliance with IEC/EN 61010-1:2010, CAT II 300 V Over-voltage Protection, Pollution Degree II. Use with standard or compatible test probes.

2. Introduction

The Model 100 Series are 6½-digit picoammeters designed for bench-top, laboratory, and system applications. The Model 100 Series have high- and low-biasing voltage supplies installed. Each has a large, bright display—your computer's monitor.

Features and Functions:

- Remote operation via your computer's USB port—*means no bothersome cards or expensive cables*
- Virtual Front Panel control and display—*means no greasy, scratched displays*
- Feature-rich API for user-written applications with IVI like command structure
- Closed-case calibration—*no internal calibration adjustments*
- 1 U high, half-rack wide enclosure that is easy to carry and stackable on the bench
- Optional half- and full-rack mounting kit
- 2 nA to 20 mA DC full scale (1 fA resolution on 2 nA range)
- Model 100 Series can measure resistances from 500 Ω to 1 TΩ full scale*
- Model 101 and 102 include one ±10 V programmable bias voltage with 20 mA current limit
- Model 102 includes one ±250 V programmable bias voltage with 1 mA current limit
- Model 101 and 102 has bias voltage readback capability
- One-touch push-button "input offset-voltage null" reduces loading errors
- Internal temperature monitor
- Eight digital I/O lines, user programmable or level triggered
- Floating measurement circuit that can operate up to ±300 V from chassis or Mains ground
- Operates from 7 V to 36 VDC or the AMETRIX-supplied Mains power supply

3. Technical Features

AutoZero Function

Each unit is equipped with a one-touch push-button "input offset-voltage null" (AutoZero) function that ensures that the input burden voltage remains as close to zero as possible, thus compensating for time and temperature induced drifts.

Solid State Switching

Solid state range switching ensures years of reliable operation it employs a solid-state switching scheme, which eliminates the challenges relays present, as they age.

Data Interface

The unit is equipped with an USB interface that is easier and more cost effective than GPIB or RS-232 and eliminates non-native operating system support, expensive GPIB cards, and cables.

Bias Supply (Model 101 and 102 only)

The quiet programmable voltage bias supplies ensure stable current measurements. These supplies have fine resolution to allow precise adjustment. The voltages can be monitored by the measurement system to verify that the actual voltages are the commanded voltages. This bias supply can be used for biasing silicon photo-diodes, characterizing the low current regions of semiconductors, and high-megohm resistance measurements.

* Presently the Soft Front Panel does not display resistance, user must calculate the resistance based upon the Low Voltage Bias voltage setting and the measured current

Data Display

The Model 100 Series Picoammeters leverage the user's computer for data display since typically users use their PC for storage, analysis, or reporting, rendering an additional display redundant.

Software. The unit's included software provides a comprehensive and intuitive user interface called the Soft Front Panel, the software provides everything needed for control, display, and data logging.

Digital I/O (Model 101 and 102 only)

The digital I/O, which can be configured to set and reset selected pins based on measurement levels, is ideal for alarms and part binning. Users can control the Digital I/O via scripted commands or buttons within the user interface. The Digital I/O is compatible with traditional TTL signal levels but, as an input, can be driven to +24 V and as an output can sink 24 V loads up to 200 mA.

The unit can be controlled by user-written software in Visual Studio® or other languages by using the supplied IVI compliant driver. There is also an included LabVIEW® driver.

4. Connections to the Instrument

Power and Ground

The Model 100 Series operate from DC voltages from 7 V to 36 V and draw no more than six watts. A universal Mains power supply is provided.

⚠ ***CAUTION***: *Reasonable power input protection is provided against over-voltage and reverse connections but the user is responsible for ensuring proper power application if the provided power supply is not used.*

⧈ *If you are supplying your own power, and if it derived from Mains power, your power supply MUST have either double or reinforced insulation.*

⚠ ***WARNING***: *The unit is not grounded through the Mains power supply; it is recommended that the user ground the chassis to earth ground using best local practices.*

Digital IO (Model 101 and 102 only)

The Digital I/O on the Model 101 and 102 may serve as general purpose I/O or may be programmed to operate in conjunction with measurements and preset limits (not supported in Soft Front Panel).

Each of the eight I/O pins on the connector may be independently programmed as an input or an output. For convenience, I/O pins have an internal pull-up resistor to +5 V but may be driven as high as +24 V.

Connector. The digital I/O connector is on the rear chassis and is a standard female Mini DB-15 (VGA).

Gnd is chassis ground, which is the same as the ground of the USB connector.

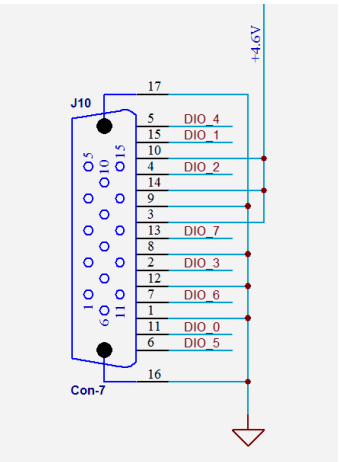
The +4.6 V is an auxiliary power supply that is current limited to 32 mA. The user may connect light loads between these pins and digital outputs, or use these pins to power other external devices.

The I/O hardware is illustrated to the right.

Outputs. When in output mode MOSFET M1 is either off or on. When off its output is pulled to +5 V through the 1 kΩ resistor R1.

When on the MOSFET appears as a 2 Ω resistor to ground.

Mini DB-15 Connector (rear)



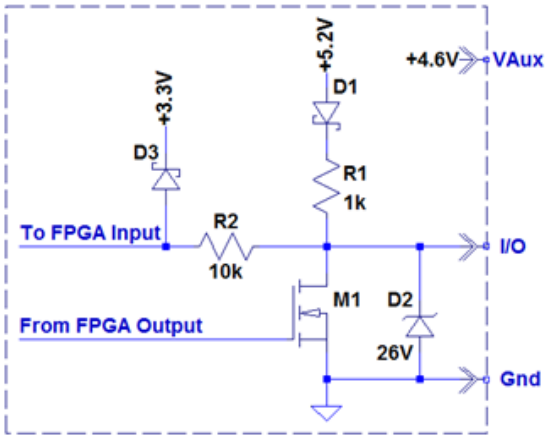
The 1 kΩ pull-up resistor provides enough current to light an LED or pull up an I/O line on a typical programmable controller, for example.

The MOSFET M1 is capable of sinking up to 200 mA and withstanding 24 V, so if one wished to drive the coil of a 24 V relay, an external +24 V supply could be used to power the relay coil and the MOSFET would act as a switch energizing and de-energizing the coil.

⚠ ***NOTE**: Diode D2 protects the MOSFET M1 and the 5.2 V supply from over-voltages and reverse voltages, but the current must be limited to 10 mA. A stiff voltage source will damage D2 and probably M1 as well.*

Resistor R2 and diode D3 limit the current and protect the input of the FPGA when the I/O pin is driven to voltages higher than 3.3 V.

Digital I/O Functional Schematic

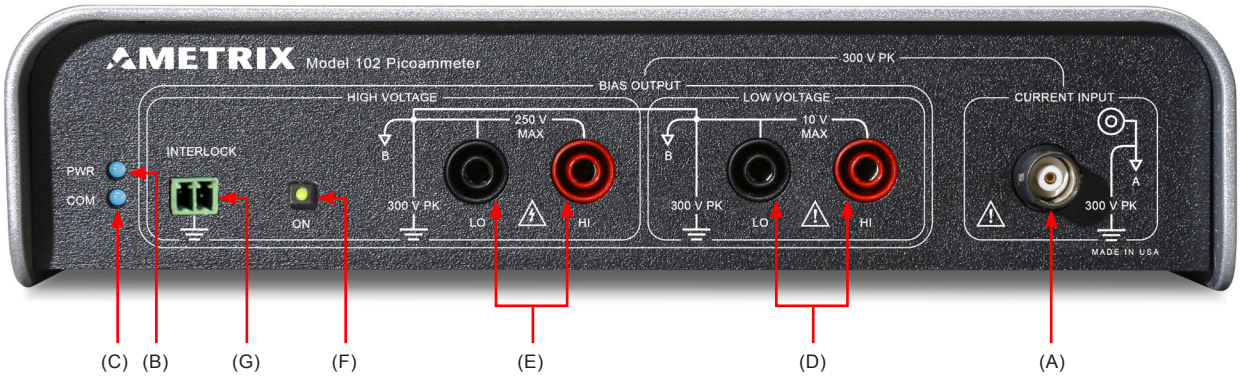


Inputs. When programmed as an input, the user may query the level or program events to occur when a level is changed or set. When programmed as an input the MOSFET is automatically turned off.

Inputs are considered low when the voltage is less than 0.75 V and high when the voltage exceeds 2.4 V; voltages that are in between these two voltages are in an indeterminate state.

The inputs may be connected to external switches to ground; when the switch is open the input is pulled up through R1.

The inputs may be connected to external voltages up to +24 V.



Current Measurement

The safety BNC (A) is the current measurement input. The BNC shield is measurement low, and the BNC center pin is measurement high. Measurement low is electrically isolated from the chassis and the low of the voltage biases.

LEDs

PWR (B) is illuminated any time power is applied to the instrument.

COM (C) is illuminated any time the instrument and the computer are communicating.

Low-Voltage Bias (Model 101 and 102 only)

The banana jacks (D) provides a programmable 0 V to ±10 V, 0 to ±22 mA with 2.5 mV resolution.

High-Voltage Bias (Model 102 only)

The banana jacks (E) provides a programmable 0 V to ±250 V, 0 to ±1 mA with 62 mV resolution.

⚠ ***CAUTION**: The low-voltage bias and the high-voltage bias share a common low connection which is isolated from the chassis and the current measurement by as much as ±300 VDC.*

High-Voltage Bias ON (Model 102 only)

The push button (F) enables and disables the high voltage output. When depressed, and the interlock is closed, and the Enable High Voltage bit is set via software command, the high voltage is enabled and the LED in the button is illuminated red. If the interlock is not closed, or the Enable High Voltage bit is not set, or the button is not depressed, the LED will be green and the high voltage will be disconnected from the banana jacks (E).

High-Voltage Bias INTERLOCK (Model 102 only)

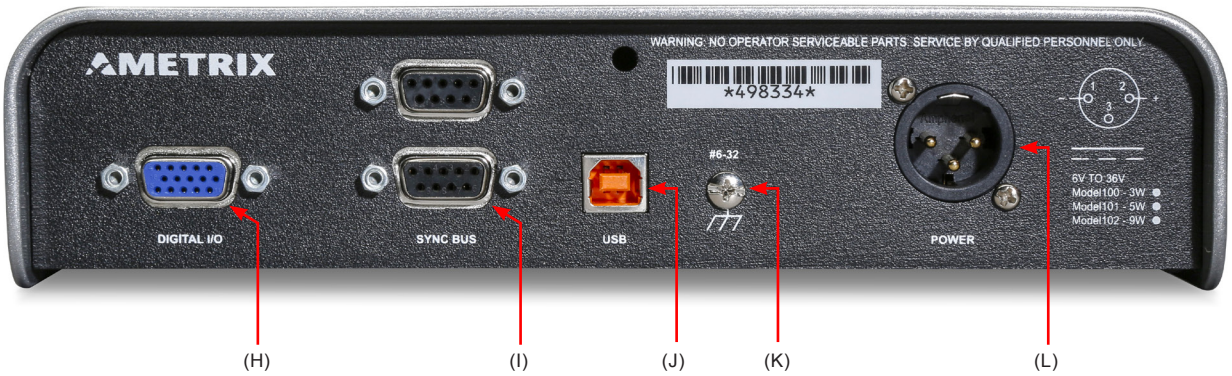
A wired short between the pins of the INTERLOCK connector (G) enables the high voltage output. As with the high-voltage ON switch (E), the Enable High Voltage bit must be set via software command and the high voltage ON button must be depressed to enable high-voltage output.

⚠ ***CAUTION**: For safety reasons, the INTERLOCK connections utilize the chassis ground, not the bias voltage ground.*

⚠ ***CAUTION**: While there is some protection provided against electronic damage to these connections, do not apply voltages to these pins, only an open or closed switch or wire connection.*

⚠ ***WARNING**: The purpose of the INTERLOCK, High-Voltage On, and the Enable High Voltage bit are to protect the devices being sourced and measured, these are not safety interlocks. If users are at risk of harmful shocks, it is up to the user to provide an external, approved safety interlock.*

Power and Ground



Power is applied to the XLR connector (L) on the rear of the Model 100 Series Picoammeter. Connections are indicated on the rear of the instrument. The instrument operates from DC voltages from 7 V to 36 V and draw no more than six watts. A universal Mains power supply is provided.

⚠ ***CAUTION**: Reasonable power input protection is provided against over-voltage and reverse connections but the user is responsible for ensuring proper power application if the AMETRIX Instruments provided power supply is not used. If you are supplying your own power, and if it derived from Mains power, your power supply MUST have either double or reinforced insulation.*

⚠ ***WARNING**: The unit is not grounded through the Mains power supply; it is recommended that the user ground the chassis to earth ground screw (K) using best local practices.*

USB

The Model 100 Series communicates via USB 2.1 connector (J), using full-speed mode. A standard USB cable with one type A and one type B connector is provided.

NOTE: The Model 100 Series is not powered by the USB connection; only external power.

Digital I/O (Model 101 and 102 only)

The DIGITAL I/O connector (H) can be configured to set and reset selected pins based on measurement levels is ideal for alarms and part binning. Users can control the Digital I/O via scripted commands or buttons within the user interface. The Digital I/O is compatible with traditional TTL signal levels but, as an input, can be driven to +24 V and as an output can sink 24 V loads up to 200 mA. The unit can be controlled by user-written software in Visual Studio® or other languages by using the supplied IVI compliant driver. There is also an included LabVIEW™ driver.

SYNC BUS

While the SYNC BUS connector (I) exists, is not yet supported.

5. The Soft Front Panel (SFP) Display

Display Panel

The Connect button. Press this button to connect and disconnect from the Model 100 Series.

When the connect button is active (blue "LED" within the button is lit) the Model 100 Series is in communication with the SFP.

Get Device Info button. Pressing this button displays the various Model 100 Series firmware revisions.

Display. Displays the measured current. The number of displayed digits is a function of the Measurement Mode. Also, at measurement rates greater than 7.7 samples per second, all the measurements are acquired for logging but only periodic values are sent to the display because the display (and the human eye) cannot keep up with the measurements.

NOTE: *When using faster Measurement Modes, fewer digits are displayed; this is because at higher rates, more noise is present, and so displaying the noisy data is only a distraction. Note too that the data sent to the Data Log window is always written as a floating point number with all digits included (even the noisy ones).*

Measurement Mode. This selects the speed at which measurements are taken. The various modes trade off speed for noise and some offer mains frequency noise rejection. Basically, the higher the sample rate the higher the noise. For more information, please refer to the AMETRIX *Technote 7: Differences Among Different Model 100 Series Measurements.*

The easy to use Soft Front Panel helps reduce the uncertainty of taking highly accurate voltage measurements

Range. One can manually select a range or use AutoRange. Note that if the current being measured is noisy due to the nature of the source or inadequately shielded wires and device under test, one can experience AutoRange issues where The Model 100 Series spends so much time AutoRanging that a measurement is never acquired. The best solution is to improve the shielding, but if that isn't possible please use the manual ranging.

Measurements Tab

Math

The Math section on the Measurement tab allows the user to linearly scale the displayed measurements:

- **None**. Displayed measurements reflect the application of factory calibration only
- **Linear**. Allows the user to manually set an offset and/or gain to linearly scale the measured value
- **Set Relative**. Stores subtracts the present measured value from all future measurements until Set Relative is pressed again or the Math pull-down is set to None
- **Natural Logarithm**. Displays the natural log (log base e) of the measured value
- **Log Base 10**. Displays the log base 10 of the measured value
- **Log**. Displays the log base n of the measured value, where n is a value entered by the user

Filtering

The filtering section on the Measurement tab allows the user to select one of six digital filters:

- **None**. Measurements are not filtered.
- **Running average.** The user selects how many measurements to include in the calculation of the mean. A table of the most recent measurements, the size of which is equal to the number of measurements to be averaged, is maintained. Each new measurement is added to the top of the table and the oldest is removed and the mean is calculated.
- **Block average.** The user selects how many measurements to include in the calculation of the mean. In this mode there is a table as described above but the entire table is flushed and re-filled; once refilled the mean is calculated and displayed, and the table flushed and refilled.
- **Median running.** The user selects how many measurements to include in the calculation of the median. A table of the most recent measurements, the size of which is equal to the number of measurements to be filtered, is maintained. Each new measurement is added to the top of the table and the oldest is removed and the median is calculated.
- **Block median.** The user selects how many measurements to include in the calculation of the median. In this mode there is a table as described above but the entire table is flushed and re-filled; once refilled the median is calculated and displayed, and the table flushed and refilled.
- **Exponential.** This filter includes many past measurements but weights the newest one the heaviest and the oldest the weakest.

Once a filter type is configured, the LED on the Submit Button will turn yellow. To make the filter active, press the Submit Button.

For t=1, $D1$ is the displayed value and is $M1$ (the first measurement) for $t > 1$ display:

$$D_t = \alpha * D_t - 1 + (1 - \alpha) * M_t$$
$$\text{Where } \alpha \text{ is } 0.8647$$

Filtering comments. The displayed averaging filter output includes all measurements in the set; no information is wasted. Unfortunately averaging filters are subject to outliers; one noisy measurement can have a drastic effect on the displayed measurement.

The displayed median filter output is a single measurement no matter how large the filter size. This one measurement is deemed to be most representative of the group. This seems rather wasteful, taking a large group of measurements and only using one, but it is more robust in the presence of large noise spikes.

The exponential helps reduce noise yet is least affected by older measurements and so tracks changes well.

***NOTE**: Filtering affects both the displayed and logged data.*

For more information, please refer to the AMETRIX *Technote 4: An In-Depth Discussion of Digital Filter Options in the AMETRIX Model 100 Series Picoammeters.*

Bias Voltage Tab (Model 101 and 102 only)

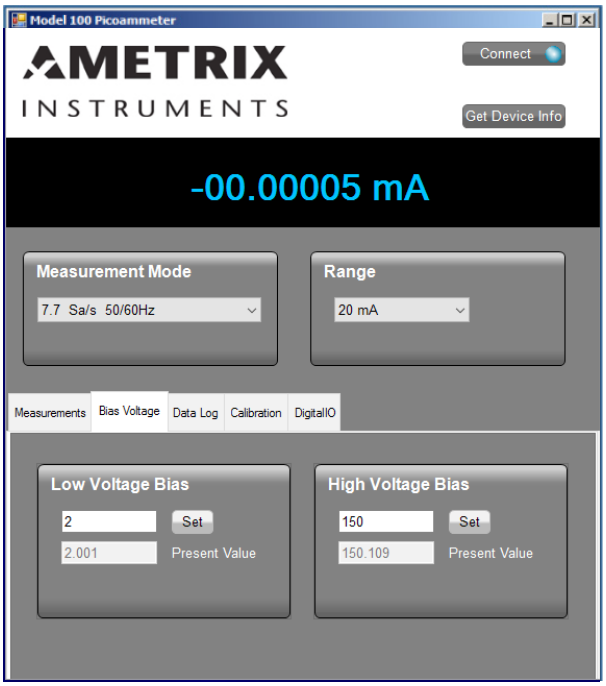
For the Model 101 and 102, the bias supply's outputs float with respect to both chassis and measurement. This allows the user to connect the ammeter in either the bias high or bias low lead.

Click on the Bias Voltage tab of the SFP.

Enter the desired voltage in the text box at the top of The Low Voltage Bias group and press the Set button.

Because the bias generator uses a 13-bit digital to analog converter, the voltage entered into the SET window is usually not exactly what is created, but is as close as possible to the desired voltage. The voltage displayed in the Present Value window is the value measured value by the 16-bit analog to digital converter and is about four times more accurate than the SET value.

The Present Value window is updated only when a new voltage is SET, it is not continuously updated; to re-measure a given setting, simply re-SET the same voltage value and the Present Value window will display the new measurement.



Data Log Tab

Enter the number of measurements to be logged in the Sample Count text box.

Press the Log button. The Log button's LED will light and the sample totalizer will indicate how many samples have been taken (*see the yellow oval at right)*.

Once the samples have been acquired the data may be saved to a file by pressing the Save button. Pressing the Save button will prompt for a file name. The file format is a simple text file holding the data, for example:

-3.04991760935431E-07

-3.14830204836574E-07

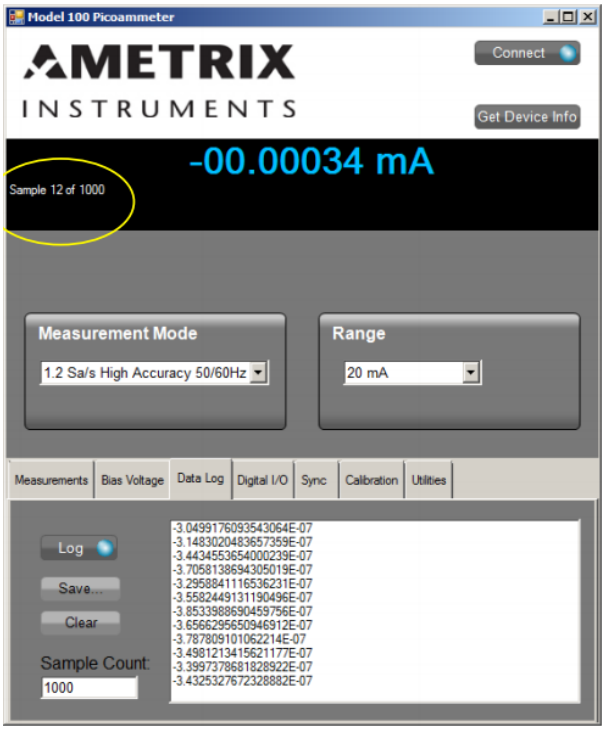
-3.44345536540002E-07

-3.7058138694305E-07

-3.29588411165362E-07

-3.55824491311905E-07

-3.85339886904598E-07



Alternatively, one can click in the Data Log text box with the measurements and type **<ctrl> A** to select all, and **<ctrl> C** to copy. Then in a spreadsheet click on a cell and type **<ctrl> V** to paste the measurements.

Clear erases the measurements in the measurement text window.

As stated earlier, all measurements are logged as floating point numbers, even though the displayed values are decimated for readability. Also, logged values are affected by filtering. If one uses a block averaging or median filter, only the one filtered result will be logged.

Digital IO Tab (Model 101 and 102 only)

In the SFP, this feature allows the user to toggle individual output bits high and low, and to read input bits. There is no facility for setting threshold levels and have bits change based on measurements.

This manual bit manipulation is included in the SFP primarily for users who write their own programs, but want to ensure that their digital IO hardware is functioning properly. This allows the user to toggle bits and see that the circuitry they have attached to the Digital IO connector is working properly.

Calibration Tab

Presently the only function available on Calibration tab is AutoZero. AutoZero temporarily shorts the input, disconnects the current measurement circuitry from the BNC, and adjusts the input offset voltage to zero.

It is best to do this on power up and any time the temperature changes more than ±5 °C since the last AutoZero.

6. Making Current Measurements With the Soft Front Panel

Connections

Apply power to the Model 100 Series

The Model 100 Series are supplied with a mains power supply but can be powered from any DC source with a voltage between 7 V and 36 V. The unit requires less than 9 watts of power.

Connect the USB port to the computer

This unit is USB 2.1 compatible.

For the highest accuracy, allow the unit's internal temperature to stabilize for at least 15 minutes.

Connect the current to be measured to the BNC, center pin is the high (positive) input, and low (negative) connects to the BNC shell.

⚠ **WARNING.** *This instrument may be floated ±300 V from the grounded chassis, but only using approved safety BNC cables and banana plugs.*

Connect to any of the bias supplies as needed.

Load the Soft Front Panel (SFP)

Press the Connect button on the upper right.

The SFP starts with the 20 mA range and 45 samples per second enabled.

For the highest accuracy, go to the Calibration tab and press the AutoZero button. It is best to do this any time the temperature changes more than ±5 °C since the last AutoZero. AutoZero temporarily shorts the input, disconnects the current measurement circuitry from the BNC, and adjusts the input offset voltage to zero.

Warm-up

To ensure meaurements meet the specified accuracy, the unit should be powered for at least 15 minutes.

Next select the desired Measurement Mode

The display will immediately begin displaying the measurements with the new setup.

7. Measurement Modes

There are nine measurement modes from which to choose, from slow but very quiet to fast but fairly noisy.

Mode	Speed	Noise
3600 Sa/s	Fastest	Noisiest
1800 Sa/s	Slower	Quieter
900 Sa/s	Slower	Quieter
300 Sa/s High Accuracy	Slower	Quieter
150 Sa/s High Accuracy	Slower	Quieter
45 Sa/s High Accuracy, 60 Hz	Slower	Quieter
39 Sa/s High Accuracy, 50 Hz	Slower	Quieter
7.7 Sa/s, 50/60 Hz	Slower	Quietest
1.9 Sa/s High Accuracy, 50/60 Hz	Slowest	Quietest

Noise is highly dependent upon the user's setup, so no noise magnitudes are given here, but the concept is, the faster the measurement rate, the higher the noise. The basic accuracy is not sacrificed by running at higher rates, the average of a large number of fast measurements will average to the same value as one very slow measurement.

The High Accuracy modes interleave offset and gain corrections between signal measurements to improve accuracy. This helps eliminate the effects of ambient temperature shifts.

Note: *Some of the slower measurement rates also provide mains frequency rejection which is useful where small signals are contaminated by power-line pickup.*

These many options allow the user to choose the rate that is most appropriate for their application.

8. Specifications*

Range	Range Resolution	Accuracy[1, 2] (1 yr) 23 °C ±5 °C ±(% rdg + offset)	RMS Noise Typical[1]
2 nA	1 fA	0.3 + 400 fA	56 fA
20 nA	10 fA	0.2 + 1 pA	56 fA
200 nA	100 fA	0.1 + 10 pA	2.4 pA
2 µA	1 pA	0.1 + 100 pA	2.4 pA
20 µA	10 pA	0.08 + 1 nA	255 pA
200 µA	100 pA	0.08 + 10 nA	255 pA
2 mA	1 nA	0.06 + 100 nA	26 nA
20 mA	10 nA	0.06 + 1 µA	26 nA

1. At 1.9 measurements per second
2. All specifications assume that the temperature is ±5 °C of last AutoZero and within one year of last factory calibration

MEASUREMENTS

Input Voltage Burden: < 100 µV on all ranges except 20 mA range < 1 mV with AutoZero enabled
Maximum Common Mode Voltage: 300 V to chassis
Maximum Voltage Between Inputs High & Low Without Damage: 250 V
Meter Low-to-Chassis Isolation: greater than 10^{11} Ω || 4 nF
NMRR: > 100 dB at 50/60 Hz at integer line cycle sample rates
Temperature Coefficient Outside of 23 °C ±5 °C: include an additional 0.05 x % rdg / °C to the accuracy specification
Measurement Rates: 1.9, 7.7, 39, 45 measurements per second with line cycle noise rejection 150, 300, 900, 1800, 3500 measurements per second for higher speed
Maximum Input Capacitance: Stability guaranteed up to 100 nF
Input Connector: Safety BNC

LOW-VOLTAGE BIAS SUPPLY (MODEL 101 AND 102 ONLY)

Output Range: 0 to ±10 V, with 0 to ±20 mA load
Output Accuracy: ±(0.1% of setting +6.0 mV)
Output Noise: 1 mV P-P 0-10 Hz
Output Resolution: 2.5 mV
Output Measurement Accuracy: ±(0.05% of setting +2.5 mV)
Output Measurement Resolution: 300 µV

HIGH-VOLTAGE BIAS SUPPLY (MODEL 102 ONLY)

Output Range: 0 to ±250 V, with 0 to ±1 mA load
Output Accuracy: ±(0.1% of setting +500 mV)
Output Resolution: 62 mV
Output Noise: 50 mV P-P 0-10 Hz
Output Measurement Accuracy: ±(0.25% of setting +65 mV)
Output Measurement Resolution: 8 mV
Bias supply common to measurement common ±250 V maximum
High-Voltage output common is the same as Low-Voltage output common

DIGITAL I/O (MODEL 101 AND 102 ONLY)

Channels: 8 individually programmable lines
Input Logic Levels: Low: 0 to +0.75 V, High: 2.4 V to +24 V
Output
- **Low**: < 10 Ω to digital I/O common, can sink up to 200 mA with load connected to external power ≤ +24 V
- **High**: 1 kΩ pull up to +5 V

Digital I/O common is chassis ground

ENVIRONMENTAL

- **Operating Temperature:** 0 °C to 50 °C
- **Storage Temperature:** -40 °C to 70 °C
- **Humidity**: non-condensing
- **Environmental**: IP41
- **Altitude**: < 2000 m
- **Pollution Degree:** 2

GENERAL SPECIFICATIONS

Communications: USB 2.1 full-speed mode
Vibration: MIL STD 810E Category 1 and 10
Safety: IEC/EN 61010-1:2010
EMC Compliance: IEC61326-1:2005
- **External Power:** connector XLR
- **Voltage Range:** 7 VDC to 36 VDC
- **Power Consumption:** < 6 W

Dimensions: 43.7 mm high x 216 mm wide x 254 mm depth (1.72 in x 8.5 in x 10.0 in)
Weight: 430 g (0.95 lb)
Calibration cycle: 1 year
Warm-up Time: 15 minutes to 2 °C of final operating temperature

INCLUDED

- CD with software and manual
- PS1 100 V to 250 V 50/60 Hz input power supply
- USB cable 1 m

ACCESSORIES

The Model 100 Series can be expanded with a variety of accessories:

Current Calibrator: NIST traceable kit for calibrating the current ranges of a Model 100 Series; BNC cable, banana cables included**

Pwr-1: Mains to 12 V supply with power cable and output cable for Model 100 Series

Cable-2: USB Male A to Male B

Cable-3: 1-XLR-F to 3-XLR-M allows up to 3 Model 100 Series to be powered by one power supply

Cable-4-L: Safety BNC to Safety BNC, (user-specified length) of RG58U cable

Cable-5: 15-pin HD D-Sub, male-to-male, digital I/O cable, 1.5 m

* Specifications shown on **www.ametrixinst.com** supersede all others and are subject to change without notice.

** For all models, user must supply a traceable DMM, Keysight Technologies Model 34401, or Keithley Model 2000, or better. For a Model 100 an external 0 V to ±10 VDC calibrator is required; Models 101 and 102 use the internal low-voltage bias supplies.

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