



Model 100 Series Picoammeter



User's Manual

100 Series

Picoammeter

User Manual

This document applies to the Model 100, 101, and 102 instruments.

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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.

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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 a manner not 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.

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 60664. 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 1000V, 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 in close proximity to the equipment and within easy reach of the operator.

Safety Precautions (continued)

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.

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.

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.

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1. Safety

Notices





CAUTION - A CAUTION notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in damage to the product or loss of important data. Do not proceed beyond a CAUTION notice until the indicated conditions are fully understood and met.

WARNING - A WARNING notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in personal injury or death. Do not proceed beyond a WARNING notice until the indicated conditions are fully understood and met.

Safety Information

This instrument is safety-certified in compliance with EN/IEC 61010-1:2001, UL 61010-1 Second Edition and CAN/CSA 22.2 61010-1 Second Edition, CAT III 1000 V/CAT IV 600 V Overvoltage Protection, Pollution Degree II. Use with standard or compatible test probes.

Safety Symbols

	Earth (ground) terminal
	Equipment protected throughout by double or reinforced insulation.
	Caution, risk of electric shock
	Caution, risk of danger (refer to the instrument manual for specific Warning or Caution information)
CAT III 1000 V	Category III 1000 V overvoltage protection
CAT IV 600 V	Category IV 600 V overvoltage protection

2. Introduction

The Models 100, 101, and 102 are 6-1/2 digit picoammeters designed for bench-top, laboratory, and system applications. The models differ by the biasing voltage supplies installed. These have a large, bright, reconfigurable display; your computer's monitor.

Features and functions:

- Remote operation via your computer's USB port
- Virtual Front Panel control and display
- Full featured API for user written applications, with IVI like command structure
- Trigger in and measurement-complete out (SyncBus)
- Closed-case calibration (no internal calibration adjustments)
- 1U high half-rack width enclosure that is easy to carry and is stackable on the bench
- Optional half and full rack mounting kit
- 2nA to 20mA DC full scale (2fA resolution on 2nA range)
- **Model 101** 500Ω to 5GΩ full scale
- **Model 102** 500Ω to 125GΩ full scale
- **Model 101** includes one ±10V programmable bias voltage with 20mA current limit
- **Model 102** includes two programmable bias voltages, ±10V with 20mA current limit and ±250V with 200μA current limit
- Models 101 and 102 have bias voltage read-back capability
- Internal temperature monitor
- Eight Digital I/O lines, user programmable or level triggered
- Floating measurement circuit that can run up to 300V from chassis or mains ground
- Operates from 7V to 36V DC or supplied mains power supply

3. Technical Features

Auto-Zero Function. The unit is equipped with an auto-zero 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, which eliminates some of the challenges relays present, as they age. The Model 102 can float up to ± 300 V from earth ground allowing users to make accurate high side current measurements even in high voltage environments.

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

Bias Supply. 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 the actual voltages and the included interlock connector can be used to disable the supplies when the device is under test is being installed in a fixture. This bias supply can be used for biasing silicon photodiodes, biasing avalanche photodiodes, characterizing the low current regions of semiconductors, and high-megohm resistance measurements.

Data Display. The Model 101 Picoammeter leverages 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, data logging, and statistical analysis.

SyncBus. FOR THE MODEL 101 AND 102 ONLY, the unit's proprietary SyncBus allows multiple instruments and the associated communications to be synchronized thus reducing operating system latencies. The SyncBus is compatible with industry standard Voltmeter Trigger and Voltmeter Complete interfaces.

Digital I/O. FOR THE 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.

Details: FOR THE MODEL 101 AND 102 ONLY, the Model 102 Picoammeter provides arming and triggering options compatible with most mainstream products in the industry, such as switching systems, DMMs, and component handlers.

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.

The Model 100 family of instruments ship with an external power supply or user supplied power and can be operated via a 12V vehicle system. It does not draw power from the USB port.

4. Connections to the Instrument

Power and Ground

The Model 100 family of picoammeters operate from DC voltages from 7V to 36V and draws no more than 10 watts. A universal mains power supply is provided.

CAUTION Reasonable power input protection is provided against overvoltage and reverse connections but the user is responsible for ensuring proper power application if the provided power supply is not used.

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.

USB

The Model 100 family instruments communicate via USB 2.0, using full speed mode. A standard USB cable with one type A and one type B connector is provided.

Low Voltage Bias

Presents a 0 V to ± 10 V 0 to ± 22 mA.

High Voltage Bias

Presents a 0 V to ± 250 V 0 to ± 2.2 mA.

WARNING This supply can source up to 250 V. The Model 102 does have an interlock connector as well as a high voltage on-off switch; these are not safety rated switches and interlocks; they are to protect the device under test from accidental over voltage; not to protect the user. If the user is exposed to potential risk, it is the user's responsibility to provide safety rated switches and interlocks, and the user must ensure that they are properly installed and wired.

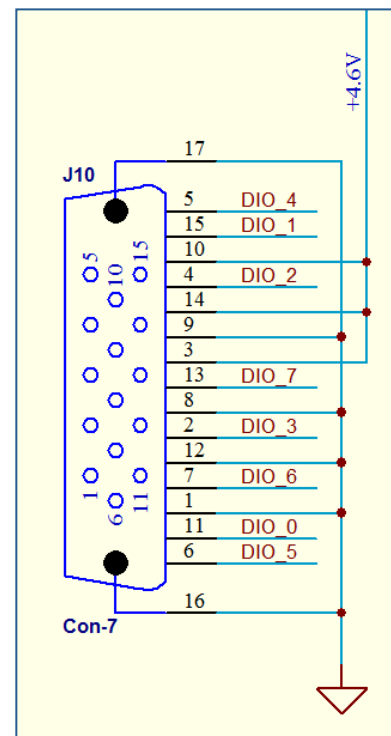
Digital IO

FOR THE MODEL 101 AND 102 ONLY, the Digital I/O may serve as general purpose I/O or may be programmed to operate in conjunction with measurements and preset limits.

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 +5V but an external load of up to 200 mA may be powered by an external power supply of up to +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.

+4.6 V is an auxiliary power supply that is current limited to 50 mA. The user may connect light loads between these pins and digital outputs, or use these pins to power other external device.

The I/O hardware is illustrated to the right.

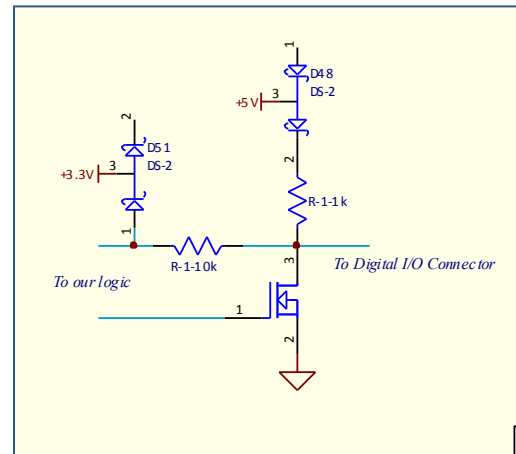
Outputs

When an output is set to ON the output is pulled to +5 V through the 1 k Ω resistor.

When the output is OFF the output is low, the MOSFET is on, and the I/O pin appears to be a $2\ \Omega$ resistor to ground.

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

The MOSFET 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. The diode in the MOSFET drain protects the MOSFET from reverse voltages and from forward voltages that exceed 26 V. The diode to +3.3V protects the system from voltages up to 26 V applied to the I/O pin.



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.

SyncBus

FOR THE MODEL 101 AND 102 ONLY, the unit offers a programmable digital bus that interfaces to industry standard trigger in/out synchronization schemes.

Connector

The SyncBus connectors are on the rear chassis and are two standard female DB-9s.

It is a handshaking system whereby units in the system pass control to one another; sort of an “I’m done, now it is your turn” system.

Hardware

The system can be connected as a Wired And in which multiple unit’s Wired And pins are connected in parallel. When all instruments involved in a function are started, each pulls to ground the same Wired And pin. As each completes its task the pin is released; the signal at the pin rises only when the last unit releases the pin.

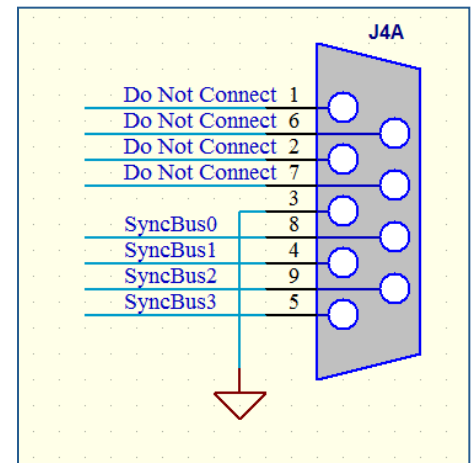
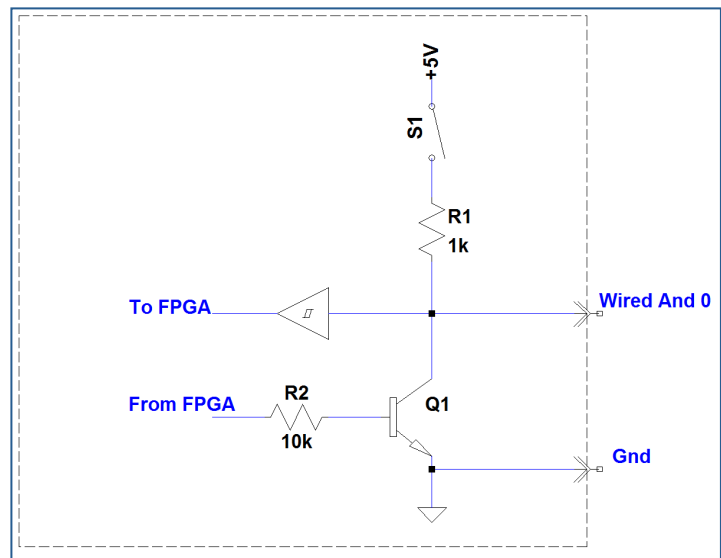
One must still declare a master unit because only the master unit closes the switch that provides the pull-up resistor. If each unit had a permanent pull-up resistor, the Wired And load would change as the number of units changed.

Multiple instruments can also use the Wired And pins as Voltmeter Complete/Trigger Input pairs. One unit’s Wired And pin is programmed as an output and connects to a Wired And pin on another unit that is programmed an input.

Units can be programmed to monitor the Wired And lines and respond with pre-programmed actions.

The two SyncBus connectors are connected in parallel so that it is easy to daisy chain the connections to other units. The two connectors are identical and it doesn't matter whether one connects to the top one or the bottom.

Users who wish to connect to other manufacturer’s products are free to do so but risk damaging their products if they connect to incompatible devices.



5. The Soft Panel Display

Display panel

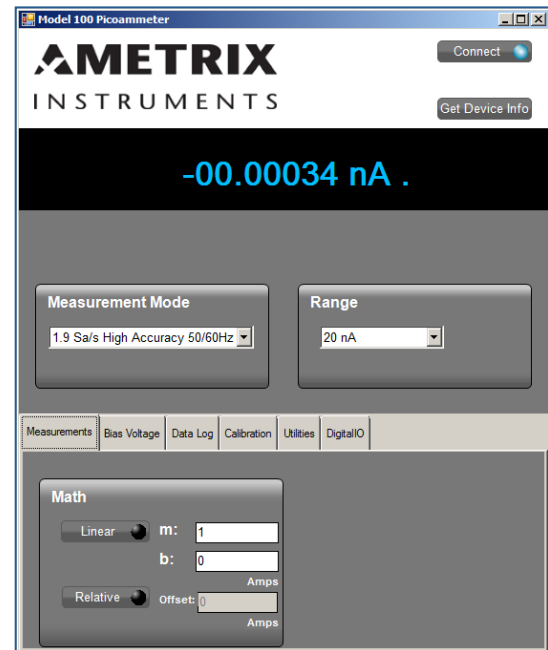
The Connect button. Press this button to connect and disconnect from the Model 10x

Get Device Info button. Pressing this button displays the various Model 10x's 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) couldn't keep up with the measurements.

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.

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 10x 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

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

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

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.

For $t=1$, D_1 is the displayed value and is M_1 (the first measurement) for $t>1$ display

$$D_t = \alpha * D_{t-1} + (1 - \alpha) * M_t$$

Where α 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.

Bias Voltage tab.

WARNING The Model 102 has output voltages that can be lethal. AMETRIX Instruments LLC provides reasonable warnings and interlocks but the interlocks are NOT safety interlocks. These interlocks are designed to protect the device under test, not the user. If SAFETY interlocks are deemed necessary, it is the responsibility of the owner of the Model 102 to provide such.

In the case of the Model 102, the bias supplies share a common low (black) output.

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.

The Low Voltage Bias has a resolution of 2.5 mV, so the actual value sent to the supply may be slightly different than that requested. The Present Value display indicates the value that was sent to the supply.

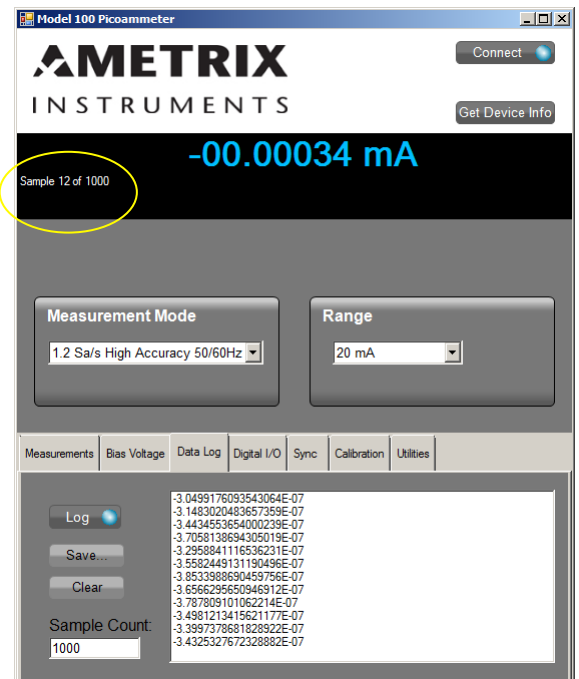


Data Log tab. Enter the number of measurements to be logged in the Sample Count text box

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

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.

Digital IO tab. This feature is not yet implemented in the SFP but is available in the API

Sync tab. This feature is not yet implemented in the SFP but is available in the API

Calibration tab. Presently the only function available on Calibration tab is Auto Zero. Auto Zero 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 $\pm 5^{\circ}\text{C}$ since the last Auto Zero.

Utilities tab. This feature is not yet implemented in the SFP but is available in the API. This feature will allow the user to update the firmware in their Model 10x.

Making Current Measurements With the Soft Front Panel:

Connections.

Apply power to the Model 10x. The Model 10x is supplied with a mains power supply but the Model 10x 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.

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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.

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 Auto Zero button. It is best to do this any time the temperature changes more than $\pm 5^{\circ}\text{C}$ since the last Auto Zero. Auto Zero temporarily shorts the input, disconnects the current measurement circuitry from the BNC, and adjusts the input offset voltage to zero.

Next select the desired Measurement Mode.

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

5. Measurement Modes

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

The modes are:

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 60Hz	Slower	Quieter
39 Sa/s High Accuracy 50Hz	Slower	Quieter
7.7 Sa/s 50/60Hz	Slower	Quieter
1.9 Sa/s High Accuracy 50/60Hz	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.

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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 that 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.

Specifications

Model 100 Picoammeter Specifications

Range	Resolution	Accuracy ^{1,2} 1 yr. 23°C ±5°C ±(% rdg + offset)	RMS Noise 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 3. Specifications subject to change without notice. 4. Specifications shown on our website supersede all others			

Measurements

- **Input Voltage Burden:** <100 µV on all ranges except 20 mA range <1 mV with auto-zero enabled
- **Maximum Common Mode Voltage:** 300 V to chassis
- **Maximum Voltage Between Inputs High & Low Without Damage:** 250V
- **Meter Low to Chassis Isolation:** greater than $10^{11}\Omega$ || 4 nF
- **NMRR:** >100dB at 50/60Hz at integer line cycle sample rates
- **Temperature Coefficient Outside of 23°C ±5 °C:** include an additional 0.05 x % rdg 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

General Specifications

- **Environmental**
- **Operating Temperature:** 0 to 50 °C
- **Storage Temperature:** -40 to 70 °C

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- **Humidity:** non-condensing
- **Protection:** IP41
- **Altitude:** <2000meters
- **Pollution Degree:** 2
- **Communications:** USB 2.0 full-speed mode
- **Vibration:** MIL STD 810E Category 1 and 10
- **Safety:** IEC 61010-1:2001
- **EMC Compliance:** IEC61326-1:2005
- **External Power:** Connector XLR
- **Voltage Range:** 7 V to 36 VDC
- **Power Consumption:** <6 W
- **Dimensions:** H43.7 x W216 x D254 mm (1.72" x 8.5" x 10.0")
- **Weight:** 430 g (0.95 lb)
- **Calibration cycle:** 1 year
- **Warm-up Time:** 15 minutes to within 2 °C of final operating temperature

Model 101 Picoammeter Specifications

Range	Resolution	Accuracy ^{1,2} 1 yr. 23°C ±5°C ±(% rdg + offset)	RMS Noise 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
5. at 1.9 measurements per second 6. All specifications assume that the temperature is ±5 °C of last AutoZero and within one year of last factory calibration 7. Specifications subject to change without notice. 8. Specifications shown on our website supersede all others			

Measurements

- **Input Voltage Burden:** < 100 µV on all ranges except 20 mA range
< 1 mV with auto-zero 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 $10^{11} \Omega$ || 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

- **Output Range:** 0 to ± 10 V, with 0 to ± 20 mA load
- **Output Accuracy:** ± (0.1 % of setting + 6.0 mV)

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- **Output Resolution:** 2.5 mV
- **Output Measurement Accuracy:** \pm (0.025 % of setting + 100 μ V)
- **Output Noise:** 1 mV P-P 0-10 Hz
- Bias supply common to measurement common \pm 250 V maximum

Digital I/O

- **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 \leq + 24 V
 - High:** 1 k Ω 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 meters
 - Pollution Degree:** 2

General Specifications

- **Communications:** USB 2.0 full-speed mode
- **Vibration:** MIL STD 810E Category 1 and 10
- **Safety:** IEC 61010-1:2001
- **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 \pm 2 °C of final operating temperature

Model 102 Picoammeter Specifications

Range	Resolution	Accuracy ^{1,2} 1 yr. 23°C ±5°C ±(% rdg + offset)	RMS Noise 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 3. Specifications subject to change without notice. 4. Specifications shown on our website supersede all others			

Measurements

- **Input Voltage Burden:** <100 µV on all ranges except 20 mA range <1 mV with auto-zero 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 $10^{11} \Omega$ || 4 nF
- **NMRR:** >100dB 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 to the accuracy specification
- **Measurement Rates:** 1.9, 7.7, 39, 45 measurements p/second with line cycle noise rejection, 150, 300, 900, 1800, 3500 measurements p/second for higher speed
- **Maximum Input Capacitance:** Stability guaranteed up to 100 nF.
- **Input Connector:** Safety BNC

Low Voltage Bias Supply

- **Output Range:** 0 to ±10 V, 0 to with 0 to ±20 mA load

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- **Output Accuracy:** $\pm(0.1\%$ of setting +6.0 mV)
- **Output Resolution:** 2.5 mV
- **Output Measurement Accuracy:** $\pm(0.025\%$ of setting +100 μ V)
- **Output Noise:** 1 mV P-P 0-10 Hz
- Bias supply common to measurement common ± 250 V max.

High Voltage Bias Supply

- **Output Range:** 0 to ± 250 V, 0 to with 0 to ± 2 mA load
- **Output Accuracy:** $\pm(0.1\%$ of setting +200 mV)
- **Output Resolution:** 63 mV
- **Output Measurement Accuracy:** $\pm(0.025\%$ of setting +5 mV)
- **Output Noise:** 52 mV P-P 0-10 Hz
- **Safety Interlock:** connect to user-provided normally open circuit
- High and Low Voltage Bias Supplies share the same common but measurement common may float ± 250 V max.

Digital I/O

- **Channels:** 8 individually programmable as input or output
- **Input Logic Levels:** Low: $< +0.75$ V, High: 2.4 V to +24 V
- **Output:** Low: $< 10\Omega$ to chassis ground, High: 1k Ω pull up to +5 V. Low can sink 0.2 A with load connected to external power $\leq +24$ V

General Specifications

- **Environmental**
- **Operating Temperature:** 0 to 50 °C
- **Storage Temperature:** -40 to 70 °C
- **Humidity:** non-condensing
- **Protection:** IP41
- **Altitude:** <2000meters
- **Pollution Degree:** 2
- **Communications:** USB 2.0 full-speed mode
- **Vibration:** MIL STD 810E Category 1 and 10
- **Safety:** IEC 61010-1:2001
- **EMC Compliance:** IEC61326-1:2005
- **External Power:** Connector XLR
- **Voltage Range:** 7 VDC to 36 VDC
- **Power Consumption:** <9 W
- **Dimensions:** H43.7 x W216 x D254 mm (1.72" x 8.5" x 10.0")
- **Weight:** 430 g (0.95 lb)

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- **Calibration cycle:** 1 year
- **Warm-up Time:** 15 minutes \pm 2 °C of final operating temperature