User's Manual

Measure Ready®

155 Precision Current Voltage Source

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LAKE SHORE LIMITED WARRANTY

WARRANTY PERIOD: THREE (3) YEARS for all products except system products. System products are TWO (2) YEARS. System products include but are not limited to; modular characterization systems, vibrating sample magnetometer systems, cryogenic probe stations, Hall effect systems, electromagnets, electromagnet power supplies, superconducting magnet systems, superconducting magnet power supplies, liquid nitrogen cooled cryostats, liquid helium-cooled cryostats, cryogen-free cryostats, and associated options and accessories.

Manufacturer Limited Warranty. The following is the limited warranty that Manufacturer offers on its Products. Distributor agrees that it shall not extend, expand or otherwise modify this limited warranty in any manner.

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2. If Lake Shore receives notice of any such defects during the Warranty Period and the defective Product is shipped freight prepaid back to Lake Shore, Lake Shore will, at its option, either repair or replace the Product (if it is so defective) without charge for parts, service labor or associated customary return shipping cost to the Purchaser. Replacement for the Product may be by either new or equivalent in performance to new. Replacement or repaired parts, or a replaced Product, will be warranted for only the unexpired portion of the original warranty or 90 days (whichever is greater).If Lake Shore receives notice of any such defects during the Warranty Period and the defective Product is shipped freight prepaid back to Lake Shore, Lake Shore will, at its option, either repair or replace the Product (if it is so defective) without charge for parts, service labor or associated customary return shipping cost to the Purchaser. Replacement for the Product may be by either new or equivalent in performance to new. Replacement or repaired parts, or a replaced Product, will be warranted for only the unexpired portion of the original warranty or 90 days (whichever is greater).
3. Lake Shore warrants the Product only if the Product has been sold by an authorized Lake Shore employee, sales representative, distributor or an authorized Lake Shore original equipment manufacturer (OEM).
4. The Product may contain remanufactured parts equivalent to new in performance or may have been subject to incidental use when it is originally sold to the Purchaser.
5. The Warranty Period begins on the date the Product ships from Lake Shore's plant.
6. This limited warranty does not apply to problems with the Product resulting from (a) improper or inadequate installation (unless OT&V services are performed by Lake Shore), maintenance, repair or calibration, (b) fuses, software, power surges, lightning and non-rechargeable batteries, (c) software, interfacing, parts or other supplies not furnished by Lake Shore, (d) unauthorized modification or misuse, (e) operation outside of the published specifications, (f) improper site preparation or site maintenance (g) natural disasters such as flood, fire, wind, or earthquake, or (h) damage during shipment other than original shipment to you if shipped through a Lake Shore carrier.
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CERTIFICATION

Lake Shore certifies that this product has been inspected and tested in accordance with its published specifications and that this product met its published specifications at the time of shipment. The accuracy and calibration of this product at the time of shipment are traceable to the United States National Institute of Standards and Technology (NIST); formerly known as the National Bureau of Standards (NBS).

FIRMWARE LIMITATIONS

Lake Shore has worked to ensure that the firmware is as free of errors as possible, and that the results you obtain from the instrument are accurate and reliable. However, as with any computer-based software, the possibility of errors exists.

In any important research, as when using any laboratory equipment, results should be carefully examined and rechecked before final conclusions are drawn. Neither Lake Shore nor anyone else involved in the creation or production of this firmware can pay for loss of time, inconvenience, loss of use of the product, or property damage caused by this product or its failure to work, or any other incidental or consequential damages. Use of our product implies that you understand the Lake Shore license agreement and statement of limited warranty.

FIRMWARE LICENSE AGREEMENT

The firmware in this instrument is protected by United States copyright law and international treaty provisions. To maintain the warranty, the code contained in the firmware must not be modified. Any changes made to the code is at the user's risk. Lake Shore will assume no responsibility for damage or errors incurred as result of any changes made to the firmware.

FIRMWARE LICENSE AGREEMENT (continued)

Under the terms of this agreement you may only use the firmware as physically installed in the instrument. Archival copies are strictly forbidden. You may not decompile, disassemble, or reverse engineer the firmware. If you suspect there are problems with the firmware, return the instrument to Lake Shore for repair under the terms of the Limited Warranty specified above. Any unauthorized duplication or use of the firmware in whole or in part, in print, or in any other storage and retrieval system is forbidden.

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EU DECLARATION OF CONFORMITY

CE

This declaration of conformity is issued under the sole responsibility of the manufacturer.

Manufacturer:
Lake Shore Cryotronics, Inc.
575 McCorkle Boulevard
Westerville, OH 43082
USA

Object of the declaration:

Model(s): 155-DC, 155-AC
Description: Precision DC/AC I/V Source

The object of the declaration described above is in conformity with the relevant Union harmonization legislation:

2014/53/EU Radio Equipment Directive

References to the relevant harmonized standards used to the specification in relation to which conformity is declared, full or in part:

EN 62368-1:2014
Overvoltage Category II
Pollution Degree 2

EN 301 489-17 V3.2.0:2017

EN 301 489-1 V2.1.1:2017

EN 55032: 2015

EN 61000-3-2:2014

EN 61000-3-3:2013

Signed for and on behalf of:
Place, Date:
Westerville, OH USA
14-FEB-2018

Scott Ayer
Director of Quality & Compliance

Electromagnetic Compatibility (EMC) for the MeasureReady® 155 Precision Current Voltage Source

Electromagnetic Compatibility (EMC) of electronic equipment is a growing concern worldwide. Emissions of and immunity to electromagnetic interference is now part of the design and manufacture of most electronics. To qualify for the CE Mark, the MeasureReady® 155 meets or exceeds the requirements of the European Radio Equipment Directive 2014/53/EU.

The instrument was tested under normal operating conditions with sensor and interface cables attached. If the installation and operating instructions in this user's manual are followed, there should be no degradation in EMC performance.

Exposure to RF interference greater than that found in a typical laboratory environment may disturb the sensitive measurement circuitry of the instrument.

Pay special attention to instrument cabling. Improperly installed cabling may defeat even the best EMC protection. For the best performance from any precision instrument, follow the grounding and shielding instructions in the user's manual. In addition, the installer of the instrument should consider the following:

- Shield measurement and computer interface cables.
- Leave no unused or unterminated cables attached to the instrument.
- Make cable runs as short and direct as possible. Higher radiated emissions are possible with long cables.
- Do not tightly bundle cables that carry different types of signals.

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Chapter 1: Introduction

1.1 Overview

The MeasureReady® 155 precision current voltage source is a precision instrument suitable for benchtop use or panel-mounted operation in labs, test facilities, and manufacturing environments. It provides a low noise, highly-stable source of voltage or current up to 100 V or 100 mA.

Programmable operation is also possible via the instrument's USB computer interface, through which the 155 source can be commanded to output any desired current or voltage at any time. Thus, application-specific test currents and voltages can be driven from an external PC.

The 155 operates on any AC line voltage, ranging from 100 VAC to 240 VAC, 50 or 60 Hz.

1.2 Features

The MeasureReady® 155 precision current voltage source includes features such as:

- Low RMS noise: from 200 nV (10 mV)/7 pA (1 µA)
- Bipolar, 4-quadrant power source
- DC and AC modes supported up to 100 kHz (MeasureReady® 155-AC)
- Full scale ranges: Voltage: 10 mV to 100 V, Current: 1 µA to 100 mA
- 0.001% programming resolution (from 100 nV/10 pA)
- Manual and autorange function
- Front and rear input connectors
- Touchscreen user interface
- Remote connectivity via USB and GPIB adapter
- 3-year standard warranty
- Free app for Android devices available on Google Play (search for Lake Shore 155)
- For AC excitation, in-phase reference signal (see below)

The 155 provides an in-phase reference signal (useful for better lock-in amplifier performance). If a reference is not used, the user must use the primary AC excitation as a reference signal for the lock-in amplifier to use. As the signal levels decrease, the lock-in amp has in an increasingly difficult time acquiring the reference.

1.3 Applications

The MeasureReady® 155 is ideally suited for testing, measuring, and operating resistive and semiconductor devices, such as:

- Lake Shore Cernox® temperature sensors
- Diode temperature sensors, including Lake Shore DT-670
- LED devices
- Hall sensors used for magnetic field measurement

An accurate, stable source of current is key to ensuring consistent operation of these devices, where the voltage drop across the device can be dependent upon temperature, magnetic field, and other parameters. The instrument's wide output range is of great value when used with RTD-type sensors; resistance can vary with temperature by as much as 6 orders of magnitude. The AC excitation feature enables compensation for thermal EMF, important for accurately measuring resistors at very low excitation levels.

The 155 is designed for demanding scientific and engineering applications, where a high-quality, low-noise source of current or voltage is required, such as:

- Precision DC I-V and C-V curve measurements of novel materials and early stage devices
- AC impedance measurements
- Accurate resistance, magnetoresistance, and resistivity measurements
- Low-noise bias voltages/currents for characterizing new heterostructures
- High-accuracy device testing
- Very low power excitation of sensitive materials like organics
- Controlled characterization of low resistance and superconducting materials
- Low-noise excitation of sensors for improved measurement accuracy
- Hall effect measurements to determine carrier concentrations/mobilities
- Variable temperature device/material characterization using a cryogenic probe station
- Sensitive electrochemical experiments

Whether operating over a wide range of environmental conditions, establishing precise sensor calibrations or simply testing devices for conformance, the 155 source provides a convenient and reliable alternative to simple voltage-based circuits, and a very affordable alternative to more expensive multi-function current and voltage sources. It can be readily integrated into automated test systems using its built-in USB computer interface and offers a highly readable, simple-to-use operator display.

1.3.1 AC Measurement Signals

The AC excitation levels can be set to as low as 10 pA, while still maintaining accuracy of better than 1% over quite a wide range of resistances. Low level, precision excitation is key to many experimental setups where power dissipation is a concern.

1.3.2 Overcoming Cable Length

With such small resultant voltages needing to be measured, it can be very helpful to have these signals amplified slightly as close as possible to the source of these signals. Cable lengths of up to 10 m are supported, allowing the 155 to be located away from the experiment area if needed.

1.3.3 No External Filters Required

Characterization of sensitive new electronic materials often requires both AC and DC excitation signals, with source noise directly impacting measurement sensitivity. To ensure high performance and functionality in an AC source, typically DC noise performance is compromised (and vice versa) because the filtering most often used to quiet DC noise also dampens AC signals and affects stepping and pulse width modulation. The 155 achieves low-noise levels without additional filtering, enabling exceptional output performance in both DC and AC modes. In side-by-side tests, the 155 demonstrated a cleaner output signal with a lower noise floor than other commercial sources costing far more. That is a key reason why the 155 provides a solid foundation for researchers performing I/V curve, Hall effect, resistance, resistivity, and other fundamental measurements of novel materials and early-stage devices.

1.3.4 Easy to Use

The MeasureReady® 155 source features an uncluttered touch display with a unique TiltView™ screen, presenting a natural and engaging user interface. With no confusing buttons or long learning curves, the 155 is simple and intuitive to operate. The 155 features icons, gestures, and menu styles that follow familiar smart phone technology standards.

1.3.5 Remote Operation

Installing the free app on your Android device allows you to operate the 155 source remotely, whether in the same room or farther away. The app mirrors the 155's front panel interface. The app is available on Google Play (search for Lake Shore 155).

1.3.6 Portrait Mode

Turn the 155 vertically and the display adjusts automatically.

1.3.7 Output Low Earth Connection

Source output low (source common) is electrically isolated from the earth ground. The connection between the output low and the earth ground should be made near the DUT (device under test).

To prevent hazardous voltages on the connector shells, the user must connect the output low to the earth ground.

1.4 Connectivity and Usability—Communication Options

1.4.1 Physical Connectivity

USB and Ethernet connectivity provide convenient integration with systems using LabVIEW™, IVI.NET, and other software. Interfacing is straightforward using IVIclass drivers and industry-standard SCPI commands.

- *USB computer interface:* provides direct serial communication by emulating a standard RS-232 connection
- *Ethernet:* allows full control and reporting throughout an IP network
- *GPIB adapter:* available for use with MeasureReady® instruments, this adapter provides GPIB communication to instruments that don't have built-in GPIB. For more information, see: https://www.lakeshore.com/products/product-detail/measureready/gpib-adapter/

NOTE

MeasureReady® 155 sources sold prior to August 2020 also included Wi-Fi capability. Please see: https://www.lakeshore.com/instruments-wi-fi-addendum.pdf/.

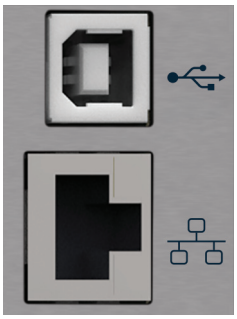


FIGURE 1-1 ***Communications connections on the MeasureReady® 155***

1.4.2 Available Functions

Multiple actions can be performed when connected to the 155 source through one of its various remote access options:

- Send any command to the instrument that could be entered via the front panel
- Upload new firmware if required

1.5 Specifications

For full specifications, see: http://www.lakeshore.com/products/MeasureReady/Model-155/pages/Specifications.aspx/.

Feature	Description
Safety interlock	Safety interlock, 2-pin, 5.0 mm detachable terminal block, maximum 10 Ω external circuit impedance
Ambient temperature	10 °C to 35 °C at rated accuracy; 5 °C to 40 °C at reduced accuracy
Power requirement	100 V to 240 V (universal input), 50 Hz or 60 Hz, 30 VA
Size	217 mm wide × 87 mm high × 369 mm deep (8.5 in × 3.4 in × 14.5 in), half rack
Weight	3.2 kg (7 lb)
Approval	CE mark

TABLE 1-1 ***Key specifications***

1.6 Safety Summary and Symbols

Observe these general safety precautions during all phases of instrument operation, service, and repair. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended instrument use. Lake Shore Cryotronics, Inc. assumes no liability for Customer failure to comply with these requirements.

The MeasureReady® 155 protects the operator and surrounding area from electric shock or burn, mechanical hazards, excessive temperature, and spread of fire from the instrument. Environmental conditions outside of the conditions below may pose a hazard to the operator and surrounding area.

- Indoor use
- Altitude to 2000 m
- Temperature for safe operation: 5 °C to 40 °C
- Maximum relative humidity: 80% for temperature up to 31 °C decreasing linearly to 50% at 40 °C
- Power supply voltage fluctuations not to exceed ±10% of the nominal voltage*
- Overvoltage category II
- Pollution degree 2
- Mains fluctuations up to ± 10%

Ground the Instrument
To minimize shock hazard, the instrument is equipped with a 3-conductor AC power cable. Plug the power cable into an approved 3-contact electrical outlet or use a 3-contact adapter with the grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet. The power jack and mating plug of the power cable meet Underwriters Laboratories (UL) and International Electrotechnical Commission (IEC) safety standards.

Ventilation
The instrument has ventilation holes in its side covers. Do not block these holes when the instrument is operating.

Do Not Operate in an Explosive Atmosphere
Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

Keep Away from Live Circuits
Operating personnel must not remove instrument covers. Refer component replacement and internal adjustments to qualified maintenance personnel. Do not replace components with power cable connected. To avoid injuries, always disconnect power and discharge circuits before touching them. Do not position the instrument so that it is difficult to disconnect the power cord.

Child Safety
This equipment is not suitable for use in locations where children are likely to be present.

Do Not Substitute Parts or Modify Instrument
Do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to an authorized Lake Shore Cryotronics, Inc. representative for service and repair to ensure that safety features are maintained. If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

Cleaning
Do not submerge instrument. Clean only with a damp cloth and mild detergent. Exterior only.

Desktop Installation
When installing the instrument in a desktop environment, ensure it is mounted on a flat, level surface.

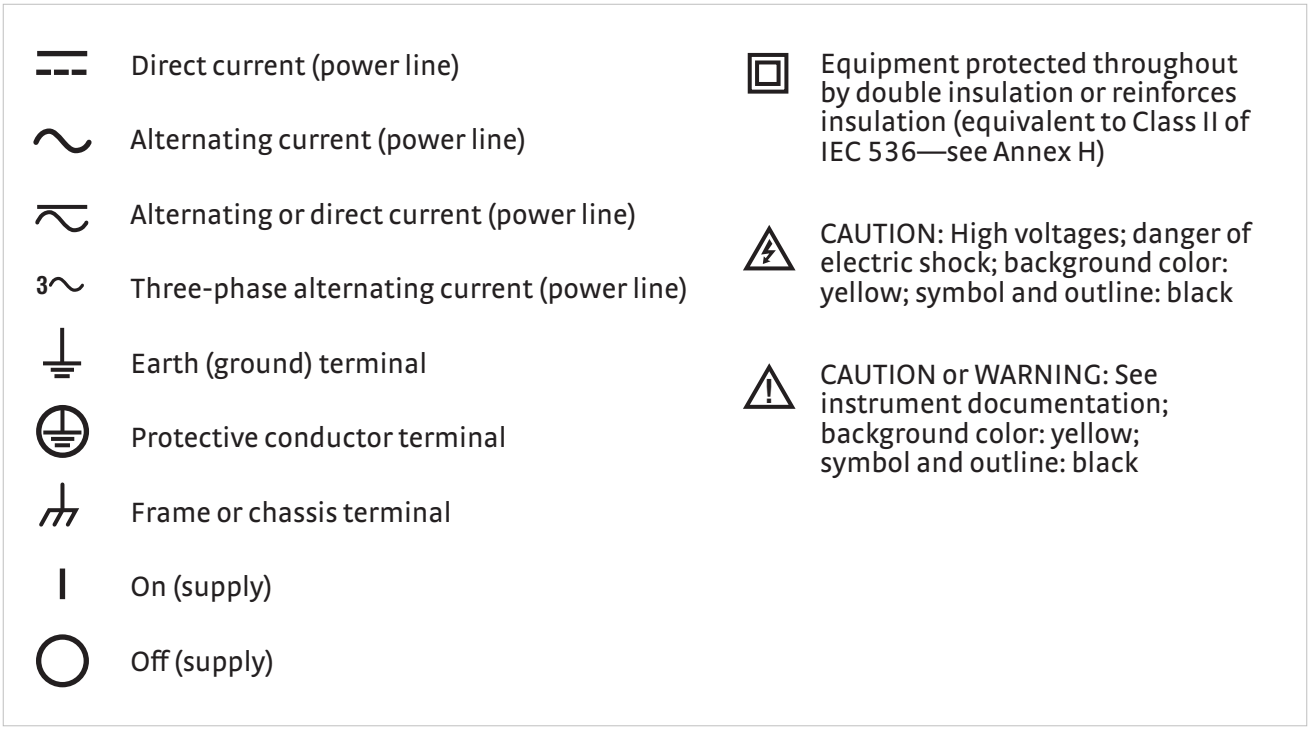


FIGURE 1-2 ***Safety symbols***

Chapter 2: Installation

2.1 General

This chapter provides general installation instructions for the MeasureReady® 155 precision current voltage source. Please read this entire chapter before installing the instrument and powering it on to ensure the best possible performance and maintain operator safety. For instrument operating instructions, refer to Chapter 3. For computer interface installation and operation, refer to Chapter 4. Refer to section 6.6 for rear panel connector pin-out details.

2.2 Inspection and Unpacking

Inspect shipping containers for external damage before opening them. Photograph any container that has significant damage before opening it. Inspect all items for both visible and hidden damage that occurred during shipment. If there is visible damage to the contents of the container, contact the shipping company and Lake Shore immediately, preferably within five days of receipt of goods, for instructions on how to file a proper insurance claim. Lake Shore products are insured against damage during shipment, but a timely claim must be filed before Lake Shore will take further action. Procedures vary slightly with shipping companies. Keep all damaged shipping materials and contents until instructed to either return or discard them.

Open the shipping container and keep the container and shipping materials until all contents have been accounted for. Check off each item on the packing list as it is unpacked. Instruments themselves may be shipped as several parts. The items included with the 155 source are listed below. Contact Lake Shore immediately if there is a shortage of parts or accessories. Lake Shore is not responsible for any missing items if not notified within 60 days of shipment.

If the instrument must be returned for recalibration, replacement or repair, a Return Authorization (RMA) number must be obtained from a factory representative before it is returned. Refer to section 6.8.3 for the Lake Shore RMA procedure.

Items Included with the MeasureReady® 155 precision current voltage source:

- 155 source
- Accessory kit:
  - USB-A to USB-C adapter
  - 2 terminal block mating connectors (6-pin), used for digital I/O and grounding connections
- 2-pin interlock connector
- MeasureReady® 155 Precision Current Voltage Source Quick Start Guide
- Line power cord

2.3 Front Panel

The MeasureReady® 155 has a 5 in capacitive touch, color TFT display with LED backlight, which is used to control the instrument and display relevant output settings and the instrument state.

FIGURE 2-1 ***MeasureReady® 155 front panel***

	Connector	Description
1	Power button	The power button turns the instrument power on and off.
2	TiltView™ touchscreen	The screen adjusts from a 0° to a 37° viewing angle, whether mounted in a rack or on a bench top.
Four safety banana connectors:		
3	Guard	Voltage that is at the same potential as output high. Typically used to reduce leakage current and mitigate effects of cable capacitance.
4	Output High	Attach to circuit to source/sink voltage or current. Output Low is electrically isolated from the chassis ground, and must be connected to the earth ground.
5	Output Low	
6	Chassis ground	Direct connection to the chassis. Typically a good place to attach any cable shielding.

TABLE 2-1 ***Front panel connections***

2.3.1 Front Panel Output Connectors

The 155 source is equipped with output terminals to suit any environment in which it is used. For simple, benchtop applications, the front panel banana jacks are easiest to use. For higher performance, it is recommended to use the BNC or triaxial connectors located on the rear panel (section 2.4.1).

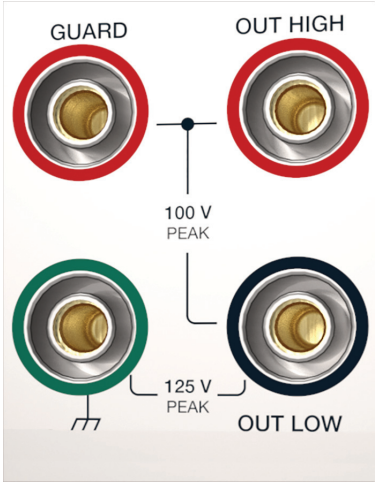


FIGURE 2-2 ***Front panel output connectors***

2.3.2 TiltView™ Touchscreen

The TiltView™ feature makes seeing the screen and operating the touch interface comfortable from any angle, even when mounted in a rack. The screen adjusts from a 0° to a 47° viewing angle, whether mounted in a rack or on a bench top.

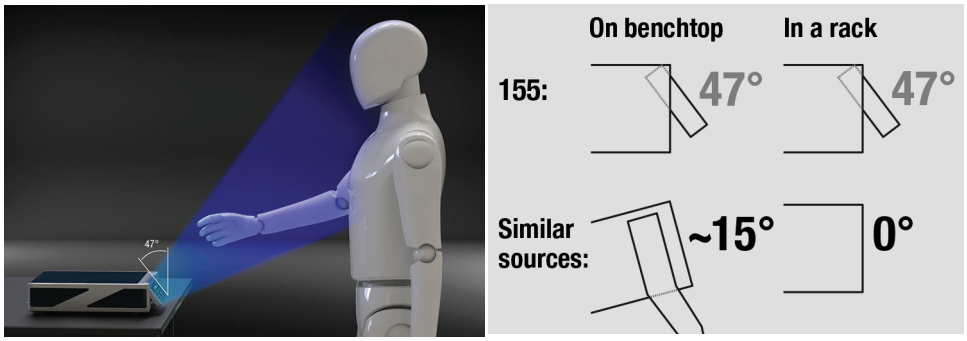


FIGURE 2-3 ***TiltView™ angle comparison***

2.4 Rear Panel

This section provides a description of the MeasureReady® 155 rear panel connections.

CAUTION

Always turn off the instrument before making any rear panel connections.

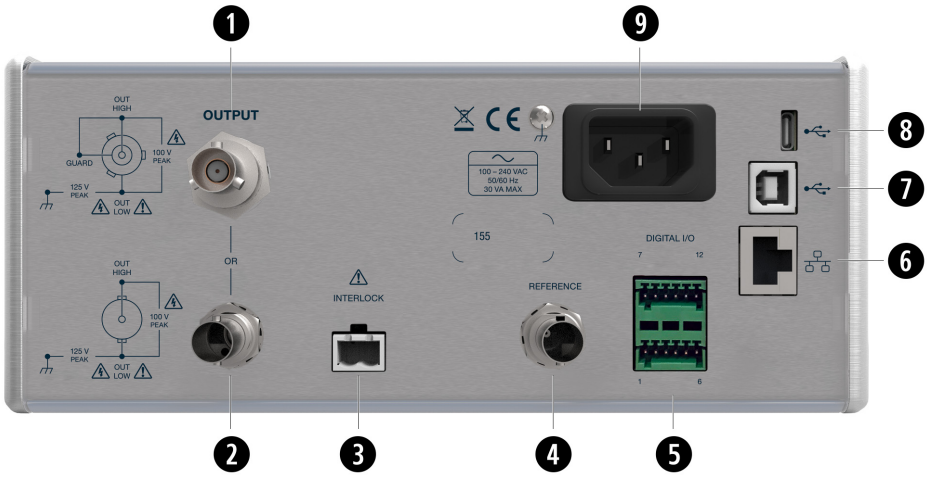


FIGURE 2-4 ***MeasureReady® 155 rear panel***

	Connector	Description
1	Triaxial output connector	Provides output high and low (HIGH, LOW) signals, plus driven guard.
2	BNC output connector	Provides output high and low (HIGH, LOW) signals.
3	Safety interlock terminal block connector	Must be connected with pins shorted for 155 source for output voltages greater than 10 V.
4	In-phase reference output connector	TTL level digital square-wave voltage synchronized to the output signal.
5	TTL digital IO port	For general purpose input/output connection or trigger output functionality. Also provides a convenient way to tie the isolated output low (source common) signal to chassis ground.
67	RJ-45 Ethernet interface	The Ethernet interface is provided to allow connection to a computer network.
7	USB communications interface	The USB interface is provided for serial communication and connects to most modern computers.
8	USB Type-C™ interface	Used for firmware updates, and to attach the MR-GPIB-USB adapter.
9	Line input assembly	Power is provided to the 155 through the line input assembly.

TABLE 2-2 ***Rear panel connections***

2.4.1 Rear Panel Output Connectors

Both BNC and triaxial connectors are provided to accommodate various test setups while still maintaining output signal integrity. In most cases, a BNC connector will be sufficient to interface the MeasureReady® 155 to the DUT. However, if a driven guard is required (as is the case when sourcing AC current to reduce the effects of cable capacitance), then the triaxial connector is a better solution.

If the rear terminals are selected in the output settings, both the BNC and triaxial are active outputs. It is recommended to select one, and not both, connectors to interface to the DUT. The 155 source will still function with both outputs attached to a circuit, however the user must be aware of the effects of paralleling the output into different branches of a circuit.

FIGURE 2-5 ***Rear panel output connectors***

2.4.1.1 Triaxial Connector

- *Center conductor:* attached to source output high.
- *Inner shield:* attached to the driven guard voltage output.
- *Outer shield:* attached to source output low (source common), which is electrically isolated from chassis ground, and must be connected to the earth ground, preferably near the DUT.

WARNING

Source output low (source common) is electrically isolated from the earth ground. To prevent hazardous voltages on the connector shells, the user must connect the output low to the earth ground.

NOTE

For best performance, it is recommended to leave the guard signal unattached at the DUT end of the triaxial cable.

WARNING

Never connect the guard to any other output, including output low. Doing so may cause damage to the MeasureReady® 155.

2.4.1.2 BNC Connector

- *Center conductor:* attached to source output high.
- *Outer shield:* attached to source output low (source common), which is electrically isolated from the chassis ground, and must be connected to the earth ground, preferably near the DUT.

2.4.1.3 Cabling Considerations

The 155 was designed to use commercially-available BNC and triaxial cabling to connect the instrument to the DUT. If the user wants to make their own cabling, the following items should be kept in mind in order to maintain signal quality and keep noise to a minimum:

- The 155 has two "grounds". The first and most obvious is the chassis which is power line ground for safety to the user. The second is output low, which is also referred to as "source common." It is isolated from the chassis ground. However, a 1 MΩ resistor and 22 nF connect the two together, loosely.
- Source output low (source common) must be connected to the earth ground, preferably near the DUT. The 155 isolation allows for a grounding scheme that avoids ground loops from multiple connections with other equipment such as the single point ground method for elimination of ground loops. The single point ground is typically the best location to connect output low to the earth ground.
- When using the output for either voltage or current, the current return path for the signal must always be to output low and never to the chassis itself, regardless of the grounding scheme, to reduce noise to the lowest level.

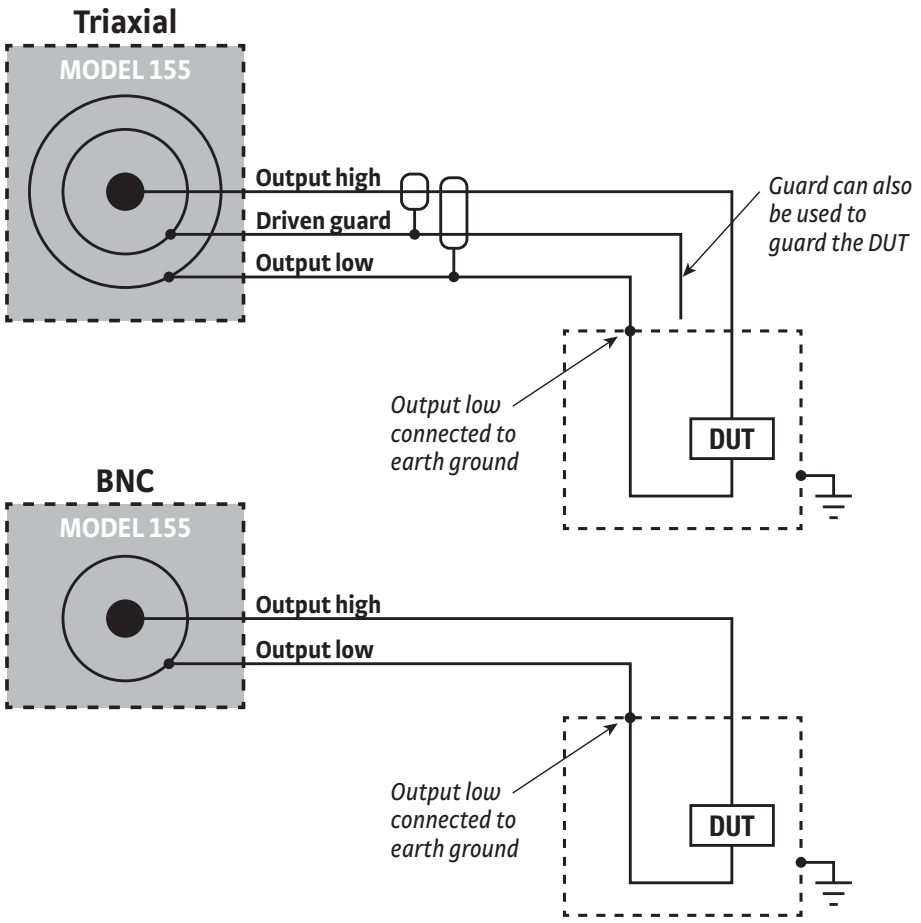


FIGURE 2-6 ***Example of instrument grounding***

2.4.2 Safety Interlock Connector

The MeasureReady® 155 includes a 2-pin interlock that must be closed in order to output voltages greater than 10 V. If the interlock is open, the instrument will still operate, but will not generate voltage outputs greater than 10 V or current outputs that require a programming voltage greater than 10 V. If the instrument is outputting a voltage greater than 10 V and the interlock is open, the output will automatically be disabled.

One mating connector (2-pin terminal block mate) is included in the connector kit shipped with the instrument. These are common 5.08 mm pitch connectors, so additional mating connectors can be purchased from local electronics suppliers. They can also be ordered from Lake Shore, part number G-106-735. The following diagram illustrates the interlock being interfaced to a switch. This allows for automatic disabling of the high voltage output, should a user require this in their test setup.

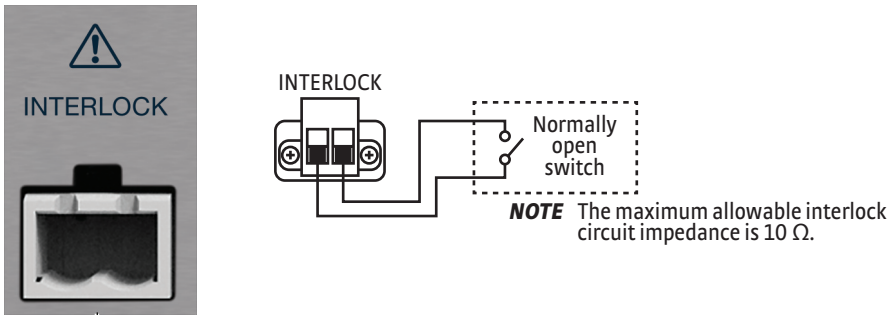


FIGURE 2-7 ***Terminal block connector***

2.4.3 Reference Output Connector

Specific to the MeasureReady® 155-AC, the reference output provides an in-phase, TTL level digital square wave voltage that is synchronized to the output signal. This signal is commonly used for synchronous (lock-in) detection of the AC voltage or current output signal.

A BNC receptacle provides the connection for the reference output. The signal is carried on the center conductor and chassis ground is on the outer conductor. The mating connector is not included.

FIGURE 2-8 ***Reference output connector***

2.4.4 Line Input Assembly

This section describes how to properly connect the 155 source to line power. Please follow these instructions carefully to ensure proper operation of the instrument and the safety of operators.

FIGURE 2-9 ***Line input assembly***

2.4.4.1 Power Cord

The 155 includes a 3-conductor power cord that mates with the IEC 320-C14 line cord receptacle. Line voltage is present on the two outside conductors and the center conductor is a safety ground. The safety ground attaches to the instrument chassis and protects the user in case of a component failure. A CE approved power cord is included with instruments shipped to Europe; a domestic power cord is included with all other instruments (unless otherwise specified when ordered).

WARNING **Always plug the power cord into an easily accessible, properly grounded receptacle to ensure safe instrument operation.**

WARNING **Position the 155 source in such a way to enable easy access to the disconnecting device. Failure to comply could result in death or injury to personnel.**

NOTE **If the power supply cord is damaged or lost, it must be replaced. Contact Lake Shore for a replacement to ensure proper voltage, current and type of cord. The power supply cord must not exceed 3 m (10 ft) in length.**

The delicate nature of the measurements being taken with this instrument may necessitate additional grounding including ground strapping of the instrument chassis. In these cases the operator's safety should remain the highest priority and low impedance from the instrument chassis to safety ground should always be maintained.

2.4.5 TTL Digital I/O Port

The MeasureReady® 155 comes with a digital I/O port that can be used for:

- Digital signal output
- Digital signal input
- Trigger output

The pin assignments can be found in the table below. The inputs only function as general purpose input pins. However, the output pins can also be configured for trigger output functionality using the `DIGital:OUTput#:FUNCtion` SCPI command.

In addition, source common and chassis ground are conveniently brought out to these connectors, allowing you to tie the grounds together, should your test setup require this.

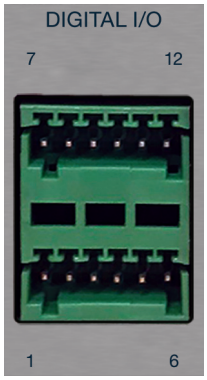


FIGURE 2-10 ***Digital I/O port***

	Description
1	Source common
2	Chassis ground
3	Input 1 high
4	Input 1 low (chassis ground)
5	Output 1 high
6	Output 1 low (chassis ground)
7	Source common
8	Chassis ground
9	Input 2 high
10	Input 2 low (chassis ground)
11	Output 2 high
12	Output 2 low (chassis ground)

TABLE 2-3 ***Digital I/O pinouts***

Chapter 3: Operation

3.1 General

This chapter provides instructions for the general operating features of the MeasureReady® 155 precision current voltage source.

3.2 Instrument Power

The 155 is powered on by plugging in the power supply. The instrument powers up in the power up state with the output disabled. When the instrument is powered on, parameters are set to the defaults. The instrument should be powered on for thirty minutes before using for rated specifications.

3.3 Display Overview

This section describes the various displays of your 155 source.

3.3.1 Default Screen

When the MeasureReady 155 is turned on, the default screen is displayed.

FIGURE 3-1 ***Default screen***

The following quick access settings are available on the main screen of the MeasureReady 155:

- Output enable
- Terminals
- Range

They can also be accessed from the Output settings screen. Tap the Settings menu (top left corner of the screen) to go to the navigation drawer, then tap Output settings. For more information on these features, see section 3.4.1.

3.3.2 Standard Displays

The 155 has four basic navigation displays, depending on what mode you are using.

3.3.2.1 Voltage DC Display

The Voltage DC screen is displayed when a voltage DC operation is configured.

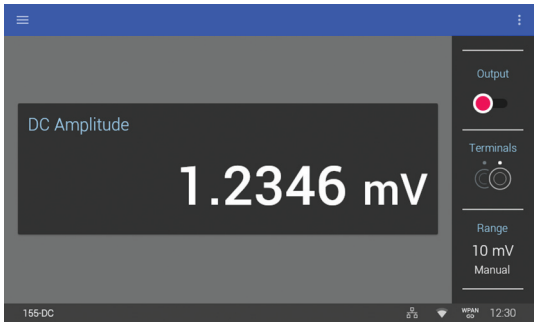


FIGURE 3-2 ***Voltage DC display***

The display shows the DC amplitude setting in mV units. Touch the DC Amplitude box on the screen to change settings.

3.3.2.2 Current DC Display

The Current DC screen is displayed when a current DC operation is configured.

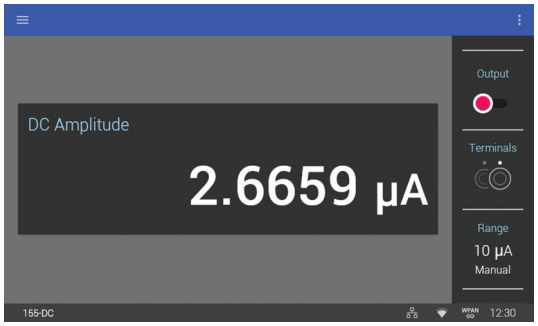


FIGURE 3-3 ***Current DC display***

The display shows the DC amplitude setting in µA units. Touch the DC Amplitude box on the screen to change settings.

3.3.2.3 Voltage AC Display (MeasureReady® 155-AC Only)

The Voltage AC screen is displayed when a voltage AC operation is configured.

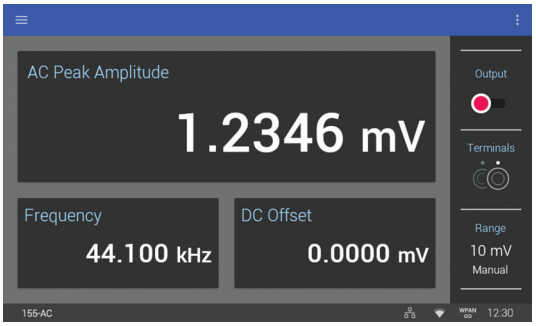


FIGURE 3-4 ***Voltage AC display***

The top half of the display shows the AC peak amplitude that is selected. AC peak amplitude is show in mV units. Touch the AC Peak Amplitude box on the screen to change settings.

The lower left quadrant displays the currently-selected frequency. Touch the Frequency box on the screen to change settings.

The lower right quadrant lists the DC offset, also shown in mV units. Touch the DC Offset box on the screen to change settings.

3.3.2.4 Current AC Display (MeasureReady® 155-AC Only)

The Current AC screen is displayed when a current AC operation is configured.

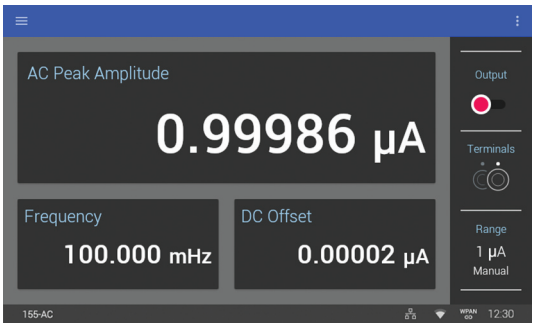


FIGURE 3-5 ***Current AC display***

The top half of the display shows the AC peak amplitude that is selected. AC peak amplitude is show in µA units. Touch the AC Peak Amplitude box on the screen to change settings.

The lower left quadrant displays the currently-selected frequency. Touch the Frequency box on the screen to change settings.

The lower right quadrant lists the DC offset, also shown in µA units. Touch the DC Offset box on the screen to change settings.

3.3.3 Display Tilt

The 155 can be placed on its side, and the screen will auto-rotate for a portrait view.

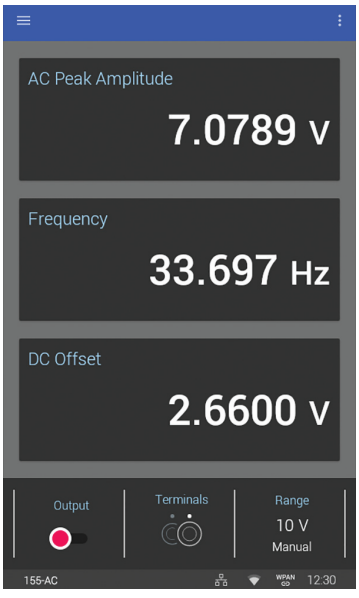


FIGURE 3-6 ***Display in portrait mode***

3.3.4 Locking and Unlocking the Screen

The screen lock feature prevents accidental changes to parameter values. When the screen is locked, some parameter values may be viewed, but most cannot be changed from the front panel.

To lock the screen:

1. Tap the Action icon (three dots in the top right corner of the screen). A drop-down menu will appear.
2. Tap **Lock**. A message indicating that the screen is locked will appear in the status bar.

To unlock the screen:

1. Tap the UNLOCK link in the status bar. The drop-down menu will appear.
2. Tap unlock again.

Interface Command: **`SYSTem:KLOCk`**

3.4 Output Setup

This section explains how to configure the output through the keypad. Each setting will have its corresponding remote interface command listed with it. Refer to Chapter 5 for more detailed information on the computer interface commands.

3.4.1 Common Voltage and Current Output Settings

The following settings are common for voltage output and current output settings.

3.4.1.1 Output Enable/Disable

The 155 source allows the user to turn on or turn off the output current by touching the **Output** enable switch. When the switch is red, the output terminals are disabled, meaning they are at maximum isolation from the signal (floating). When the switch is green, output is enabled, meaning the terminals are connected to the signal source.

Interface command: **`OUTPut[:STATe]`**

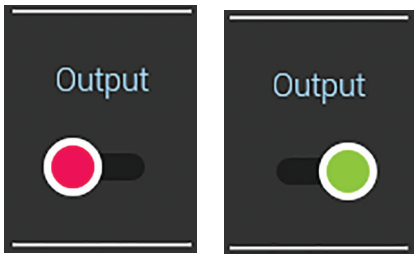


FIGURE 3-7 ***Output enable switch***
Left: disabled; Right: enabled

3.4.1.2 Terminal Selection

The rear terminals or the front terminals can be selected, but only one at a time (never at the same time). The terminals that are not presently selected are at maximum isolation from the signal source.

Interface Command: **`ROUTe:TERMinals`**

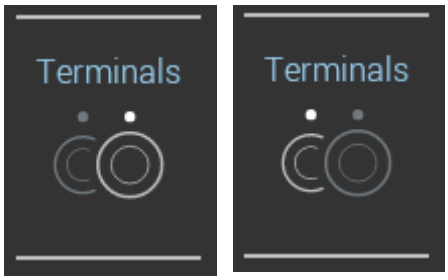


FIGURE 3-8 ***Left: Front terminals enabled.***
Right: Rear terminals enabled.

3.4.1.3 Excitation Mode

Excitation mode sets the 155 source to output a constant voltage or constant current.

Interface Command: **`SOURce:FUNCtion:MODE`**

NOTE

When changing excitation mode with the output enabled, the output will become disabled as a result of the mode change.

3.4.1.4 Shape (MeasureReady® 155-AC Only)

This setting determines whether the output is a DC signal, or an AC sinusoid signal.

Interface Command: **SOURce:FUNCtion[:SHAPE]**

3.4.1.5 Frequency (MeasureReady® 155-AC Only)

The frequency setting for the MeasureReady 155-AC output ranges from 100 mHz to 100 kHz.

Interface Command: **SOURce:FREQuency**

3.4.1.6 Reference Out Phase Compensation (MeasureReady® 155-AC Only)

The 155 is designed to minimize phase error between the output waveform and the reference out waveform. However, there are many cases where cabling and loads in experimental setups may cause further phase error.

This setting allows the user to compensate for phase error between the reference out and output waveforms. The compensation is settable between -180° and +180°. The more negative the value, the more the output signal will *lag* the reference. The more positive the value, the more the output signal will *lead* the reference.

Interface Command: **SOURce:PHASe[:ADJUst]**

This feature is not available on Embedded Hardware Version 0.0.

3.4.2 Voltage Output

The following settings are used for voltage output.

3.4.2.1 Output Levels

Depending on the type and shape setting selected on the 155 source, output level can consist of just an amplitude (MeasureReady 155-DC) or an amplitude and offset (MeasureReady 155-AC).

3.4.2.1.1 Amplitude

When the source shape setting is selected as DC, amplitude is the unvarying voltage output, settable between -100 V and 100 V. When AC (sinusoid) shape is selected, this is the peak voltage of the output sinusoidal waveform, settable between 0 V and 100 V. The peak amplitude setting + offset setting cannot exceed the selected full scale voltage range.

Interface Command: **SOURce:VOLTage[:LEVel][:IMMediate][:AMPLitude]**

3.4.2.1.2 Offset (MeasureReady® 155-AC Only)

When in AC mode, this is the steady state DC value of the output waveform, settable between -100 V and 100 V. The offset setting + peak amplitude setting cannot exceed the selected full scale voltage range.

Interface Command: **SOURce:VOLTage[:LEVel][:IMMediate]:OFFSet**

3.4.2.2 Voltage Ranges

The MeasureReady 155 has five full-scale voltage ranges, as shown in the table below.

Interface Command: **SOURce:VOLTage:RANGe**

Voltage range	Max peak current
10 mV	100 mA
100 mV	
1 V	
10 V	
100 V	10 mA

TABLE 3-1 ***Voltage ranges***

The maximum peak output power of the 155 source is 1 W. This is why the 100 V range is limited to 10 mA of current.

Range can be selected in two ways:

1. Press **Range** from the Home screen.
2. Tap the Settings menu (top left corner of the screen) to go to the navigation drawer, then tap Output settings. Scroll down to Range selection (see image below).

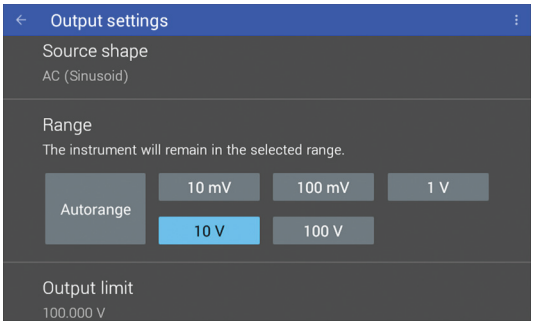


FIGURE 3-9 ***Output settings screen (voltage range)***

3.4.2.2.1 Autorange

The 155 source is equipped with an autoranging feature that will automatically select the appropriate voltage range based on output amplitude and offset (if applicable). Autorange is the default setting.

If a voltage range is explicitly selected while autorange is enabled, the voltage range will be selected and autorange will automatically be disabled.

Interface Command: **SOURce:VOLTage:RANGe:AUTO**

3.4.2.3 Output Limit

This feature prevents the user from entering a voltage output value too high, either from the front panel or by remote interface, thus potentially preventing damage to a load. This setting does not apply any limits in hardware. The output limit can be set between 0 V and 100 V. In AC mode, the combined amplitude and offset cannot exceed this value. The output limit is an absolute value, applicable to both positive and negative output levels.

Interface Command: **SOURce:VOLTage:LIMit**

3.4.2.4 Current Limit

This section will describe the current limiting behavior when the 155 is operating as a voltage source. By definition, a voltage source will adjust the current it provides in order to maintain a constant voltage across a load. When the current limit is reached, the 155 source acts as a constant current source. The 155 will remain in this state until the output voltage is reduced, or the load resistance is increased.

3.4.2.4.1 DC Current Limit

When operating as a DC voltage source, the MeasureReady® 155 can be configured to limit the amount of current its voltage source will provide, with the intent of protecting a given device under test. The minimum DC current limit setting is 0.100 µA. The maximum DC current limit setting is 100 mA for the 10 mV to 10 V ranges, and 10 mA for the 100 V range.

Interface Command:
`SOURce:VOLTage[:SENSe][:CURRent][:DC]:PROTection[:LEVel]`

3.4.2.4.2 AC Current Limit

The MeasureReady 155 does not have the capability to set the current limit when operating as an AC voltage source. In this case, the maximum current the voltage source can provide is fixed at 100 mA for the 10 mV to 10 V ranges and 10 mA for the 100 V range.

3.4.2.4.3 Current Limit Annunciator

When the 155 voltage source is in current limit, independent of the source shape, the output level text will turn red (see below). The text will remain red until the voltage source is out of current limit.

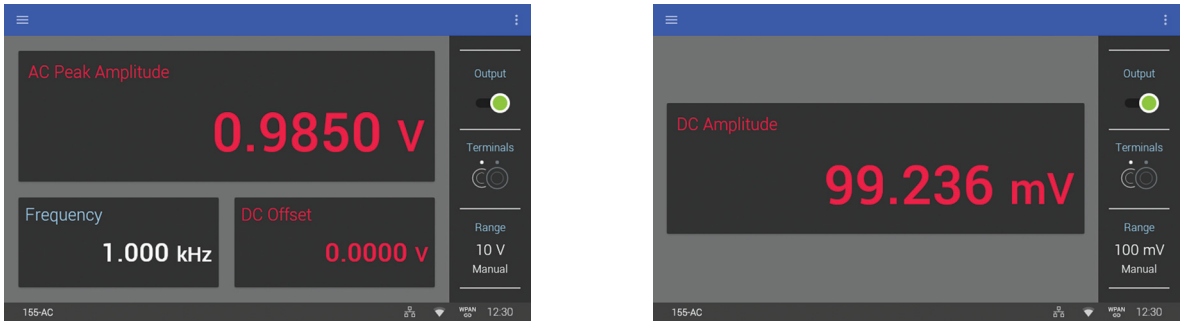


FIGURE 3-10 ***Current Limit***

When the 155 voltage output enters into current limit, the front panel screen will indicate this within 10s of milliseconds. However, a debouncing algorithm is implemented to wait 1 s before indicating that the voltage source is out of current limit. This is done to prevent the screen from flashing in the case where the peak of an AC voltage waveform hits the limit, but the remainder of the waveform is not in limit.

Interface Command:
`SOURce:VOLTage[:SENSe][:CURRent][:DC]:PROTection:TRIPped?`

3.4.3 Current Output

The following settings are used for current output.

3.4.3.1 Output Levels

Depending on the type and shape setting selected on the 155 source, output level can consist of just an amplitude (MeasureReady® 155-DC) or an amplitude and offset (MeasureReady® 155-AC).

3.4.3.1.1 Amplitude

When the source shape setting is selected as DC, amplitude is the unvarying current output, settable between -100 mA and 100 mA. When AC (sinusoid) shape is selected, this is the peak current of the output sinusoidal waveform, settable between 0 mA and 100 mA. The peak amplitude setting plus the offset setting cannot exceed the selected full scale current range.

Interface Command:
`SOURce:CURRent[:LEVel][:IMMediate][:AMPLitude]`

3.4.3.1.2 Offset (MeasureReady® 155-AC Only)

When in AC mode, the offset is the steady state DC value of the output waveform, settable between -100 mA and 100 mA. The offset setting plus the peak amplitude setting cannot exceed the selected full scale current range.

Interface Command: **`SOURce:CURRent[:LEVel][:IMMediate]:OFFSet`**

3.4.3.2 Current Ranges

The 155 source has six full-scale current ranges, as shown in the table below.

Interface Command: **`SOURce:CURRent:RANGe`**

Current range	Max compliance voltage
1 µA	100 V
10 µA	
100 µA	
1 mA	
10 mA	
100 mA	10 V

TABLE 3-2 ***Current ranges***

NOTE **The maximum peak output power of the 155 is 1 W. This is why the 100 mA range is limited to 10 V of compliance.**

Range is can be selected in two ways:

1. Press **Range** from the Home screen.
2. Tap the Settings menu (top left corner of the screen) to go to the navigation drawer, then tap Output settings. Scroll down to Range selection (see image below).

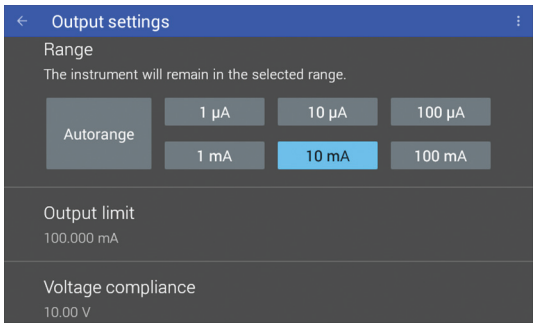


FIGURE 3-11 ***Output settings screen (current)***

3.4.3.2.1 Autorange

The 155 source is equipped with an autoranging feature that will automatically select the appropriate current range based on output amplitude and offset (if applicable). Autorange is the default setting.

If a current range is explicitly selected while autorange is enabled, the voltage range will be selected and autorange will automatically be disabled.

Interface Command: **`SOURce:CURRent:RANGe: AUTO`**

3.4.3.3 Output Limit

Output limit prevents the user from entering a current output value too high, either from the front panel or by remote interface, thus potentially preventing damage to a load. This setting does not apply any limits in hardware. The output limit can be set between 0 mA and 100 mA. In AC mode, the combined amplitude and offset cannot exceed this value. The output limit is an absolute value, applicable to both positive and negative output levels.

Interface Command: **`SOURce:CURRent:LIMit`**

3.4.3.4 Voltage Compliance

By definition, a current source will adjust the voltage it provides in order to maintain a constant current through a load. When voltage compliance is reached, the MeasureReady 155 acts as a constant voltage source. The 155 will remain in this state until the output current is reduced, or the load resistance is decreased.

3.4.3.4.1 DC Voltage Compliance

When operating as a DC current source, the 155 source can be configured to limit the amount of voltage its current source will provide, with the intent of protecting a given device under test. The minimum DC compliance voltage is 1.0 V. The maximum DC compliance voltage is 100 V for the 1 µA to 10 mA ranges, and 10 V for the 100 mA range.

Interface Command:
`SOURce:CURRent:SENSe[:VOLTage][:DC]:PROTection[:LEVel]`

NOTE **As stated in the specifications, there are different performance specifications for the current source, depending on the compliance voltage setting, as different output stages are used to generate 10 V compliance vs 100 V compliance. If DC compliance voltage of 10 V or less is desired, the low voltage stage will be used. For DC compliance voltages greater than 10 V, the high voltage stage is used.**

3.4.3.4.2 AC Voltage Compliance

As mentioned in section 3.4.3.4.1, two separate output stages are used to generate 10 V compliance versus 100 V compliance voltages when the 155 source is configured as a current source. The DC settable voltage compliance feature is not available when in AC current mode, so explicitly selecting a 10 V vs 100 V compliance voltage stage is necessary. This is done from the front panel using the AC high voltage setting, visible in the output settings menu when the 155 is configured as an AC current source.

The maximum compliance voltage the AC current source can provide is fixed at either 10 V or 100 V for the 1 µA to 10 mA ranges and 10 V only for the 100 mA range.

Interface Command: **`SOURce:CURRent[:SENSe][:VOLTage]:AC:VRANGE`**

3.4.3.4.3 Compliance Voltage Annunciator

When the 155 current source is in voltage compliance, independent of the source shape, the output level text will turn red (see below). The text will remain red until the current source is out of voltage compliance.

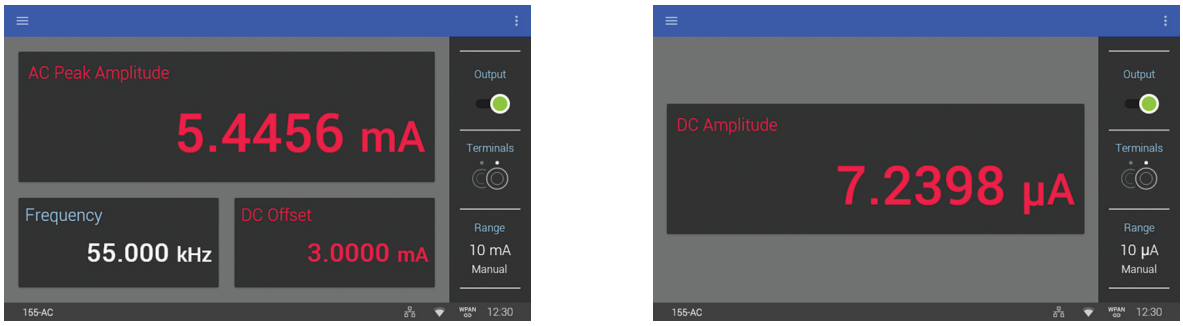


FIGURE 3-12 ***Compliance voltage***

When the 155 current output enters into voltage compliance, the front panel screen will indicate this within 10s of milliseconds. However, a debouncing algorithm is implemented to wait 1 s before indicating that the current source is out of voltage compliance. This is done to prevent the screen from flashing in the cases where the peak of an AC current waveform hits the limit but the remainder of the waveform is not in limit.

Interface Command:
`SOURce:CURRent[:SENSe][:VOLTage][:DC]:PROTection:TRIPped?`

3.5 Advanced Operation

The following sections explain the more advanced features of the MeasureReady® precision current voltage source.

3.5.1 Digital I/O

The 155 comes equipped with a digital I/O connector for general purpose input/output (GPIO) use, allowing for integration of hardware control or monitoring into any experiment. There are two dedicated 3.3 V logic-compatible inputs, and two dedicated 3.3 V logic-compatible outputs, all referenced to chassis ground. Control and monitoring of the digital I/O pins can only be performed over the remote interface.

3.5.1.1 Manual Inputs

The 155 can presently only configure its inputs for manual use. However, a SCPI command has been created to set the function of a given input, allowing for future growth. The state of the input pins can be read using the **`DIGital:IDATa?`** query. The result is a bitwise representation of the logic level presented at the respective inputs (i.e., bit 0 = state of input 1, bit 1 = state of input 2).

Interface Commands: **`DIGital:INPut#:FUNCtion, DIGital:IDATa?`**

3.5.1.2 Manual Output

Each 155 output can be configured to perform trigger out functions in addition to manual use. For more information regarding output triggering, see section 3.5.1.3. The **`DIGital:OUTput#:FUNCtion`** command is used to configure a specific output to manual mode. The **`DIGital:OSETting`** command is used to configure the state of an output pin that is configured for manual mode.

The setting is not applied for a given output if that output is configured for a function other than manual.

Interface Commands: **`DIGital:OUTput#:FUNCtion, DIGital:OSETting`**

3.5.1.3 Trigger Output

The MeasureReady 155 trigger out feature design is based on the trigger model described in Standard Commands for Programmable Instruments (SCPI, v 1999.0). Output triggering control is only available over the remote interface. The 155 trigger model has been implemented with the intent of interfacing to a meter that will allow periodic automatic sampling of a DUT upon a 155 source setting change. An example of this is changing the current output level on the 155 and having a voltmeter automatically take a reading.

3.5.1.3.1 Trigger Model Overview

The following diagram illustrates the flow of the 155 trigger model. Relevant SCPI commands are presented with each decision and event block to aid in understanding of the model.

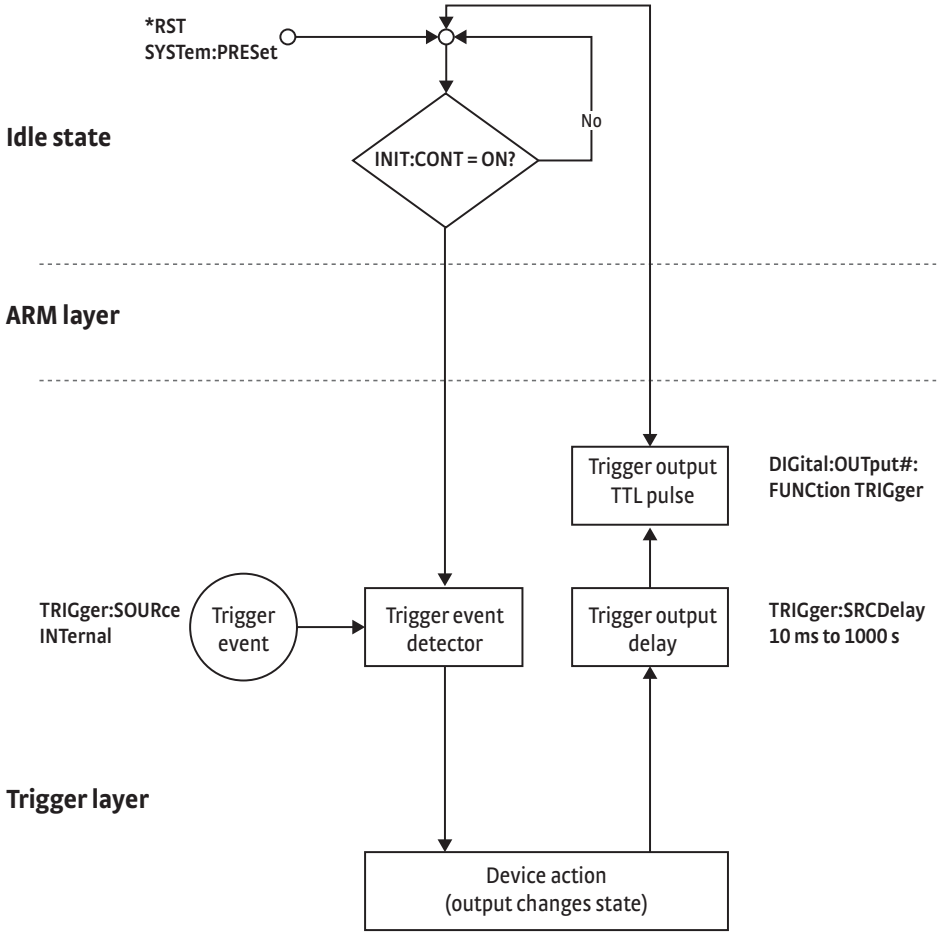


FIGURE 3-13 ***Trigger model***

Idle

On power up, the MeasureReady 155 is in the idle state. When in the idle state, the 155 will not output a trigger signal until it is brought out of the idle state. The 155 is brought out of the idle state by issuing the **`INITiate:CONTinous ON`** command. At that point, the 155 will continuously trigger on output setting changes until it is brought back into the idle state by issuing the **`INITiate:CONTinuous OFF`** command.

The trigger idle state is reported in bit 10 of the operation status register.

ARM

The SCPI 1999 standard specifies an optional ARM event detection layer. The 155 does not implement an ARM layer, however it is specified here for future growth.

Bit 6 of the operation status register is allocated to report the ARM state.

Trigger
Once the MeasureReady 155 is taken out of trigger idle state, it immediately moves to the trigger event detector. It will remain here until a trigger event is detected. The 155 implements the SCPI defined *INTernal* event detector, meaning a change in output setting, either from the front panel or remote interface, acts as a trigger event. The section below outlines the specific settings that can act as trigger events.

After the trigger event has been detected, the 155 then makes the adjustment to the source output state, known as a device action.

Once the device action occurs (i.e., the setting change is reflected at the output terminal), the 155 moves to the trigger output delay. This is a delay that is typically used to allow a change in excitation to the DUT to settle before the output trigger is sent out.

Once the user settable trigger output delay has elapsed, the 155 outputs an active low 5 µS duration, TTL pulse to another instrument. A common use case example is that a meter can accept the 155 output trigger as its input trigger.

Bit 5 of the Operation Status register reports when the 155 is waiting for a trigger event.

Internal Trigger Events
The following is a list of the 155 settings that are valid trigger detection events:

Output State changed to Enable
Shape Setting (DC versus Sine)
Frequency
Voltage Range
Voltage Amplitude
Voltage Offset
Current Amplitude
Current Offset
Current Range
Current AC Voltage Range
Terminals (Front / Rear)
DC Voltage Compliance
DC Current Limit

Modifying any of these settings while the output is disabled will not cause the trigger to fire.

3.5.1.3.2 Timing Diagram

The following diagram illustrates the timing relationship between the device action and the trigger output signal. In this example, a change in DC current is used to illustrate the device action. In addition, the trigger source delay is set to 20 ms.

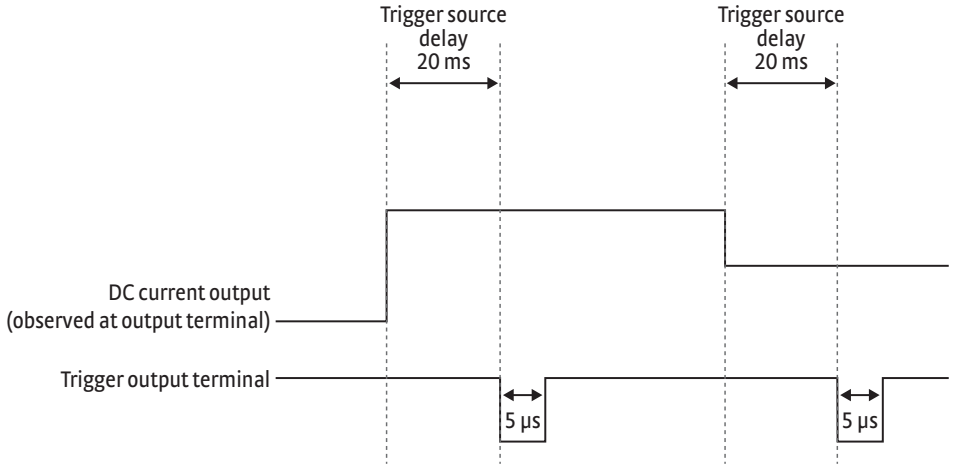


FIGURE 3-14 ***Timing diagram***

3.5.1.3.3 Programming Example

The following command sequence provides an example of how to setup and initiate the 155 source to provide a trigger output:

1. Restore the 155 to its power on state: *RST
2. Configure output 1 as trigger out: DIGITAL:OUTPUT1:FUNCTION TRIGGER
3. Setup the trigger output delay for 200 mS: TRIGGER:SEQUENCE:SRCDELAY 200
4. Configure the 155 output accordingly. In this example, the 155 will act as a DC current source operating using the rear terminal, 10 mA range with an initial output value of 1 mA, using a 10 V compliance limit.
   SOURCE:FUNCTION:MODE CURRENT
   SOURCE:FUNCTION:SHAPE DC
   ROUTE:TERMINALS REAR
   SOURCE:CURRENT:PROTECTION 10
   SOURCE:CURRENT:RANGE.010
   SOURCE:CURRENT.001
   OUTPUT ON
5. Initiate continuous triggering: INITIATE:CONTINUOUS ON
6. Continue to update the output current value, allowing the meter to add new readings to its reading buffer as a result of the trigger.

3.5.2 System Settings

The System settings menu is provided to view and set/reset general instrument settings, update firmware, and view legal information. To find these settings, tap the Settings menu (top left corner of the screen) to go to the navigation drawer, then tap System settings.

3.5.2.1 About

The following fields are displayed in the About tab:

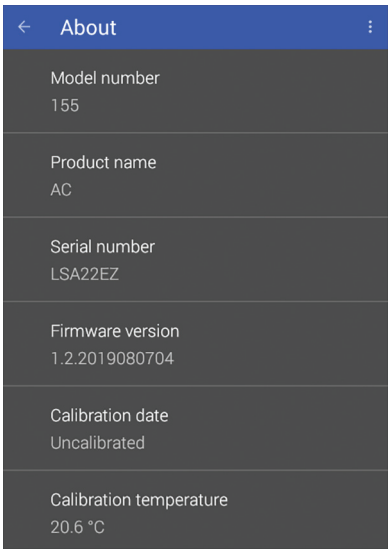


FIGURE 3-15 ***About tab***

Connector	Description
Model number	This field will always display 155.
Product name	This field will display DC or AC, depending on the model.
Serial number	The unique identifier for this specific 155, assigned during manufacturing.
Firmware version	The semantic version number assigned to the Lake Shore Firmware (LSFW) package presently running.
Calibration date	The date and time the 155 was last calibrated successfully at Lake Shore.
Calibration temperature	The ambient temperature the 155 was calibrated in at Lake Shore. This temperature is relevant when consuming the 1 year DC accuracy specifications for the 155.

TABLE 3-3 ***About fields***

3.5.2.2 Connectivity

The following fields are displayed on the Connectivity tab. Touch the enable switch next to each option to change settings

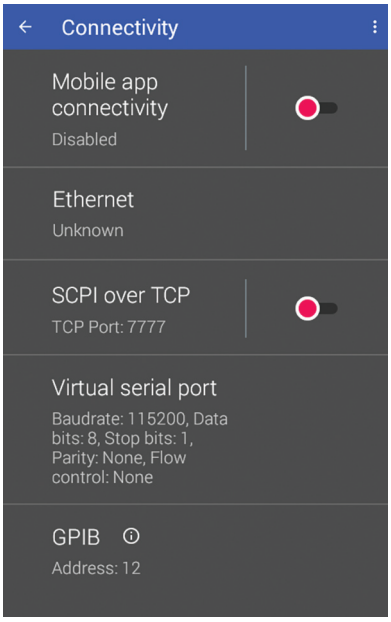


FIGURE 3-16 ***Connectivity tab***

Field	Description
Mobile app connectivity	Enables mobile app connectivity,
Ethernet	Touch the Ethernet box to see IP settings.
SCPI over TCP	Determines whether the 155 will respond to SCPI commands from the Ethernet connection.
Virtual serial port	Reports the non-settable configuration of the serial port. See section 4.4.1.2 for more information.
GPIB	Allows setting the GPIB address if the MR-GPIB-USB adapter is attached. For more information, see : https://www.lakeshore.com/products/product-detail/measureready/gpib-adapter/.

TABLE 3-4 ***Connectivity fields***

3.5.2.3 Display and Sound

The front panel display brightness can be adjusted for optimal viewing. The default value should work well in most standard room temperature environments, but deviations in room temperature and extreme viewing angles can cause the display brightness to require adjustment for optimal viewing.

As with many touchscreen LED backlit displays, keeping the brightness to a minimum will help to maximize the life of the display. The half-life of the MeasureReady display is rated with a typical value of 30,000 hours. In addition, to help further maximize the life of the display, the 155 source implements an auto dimming function when the display has not been touched for a prolonged period of time.

The brightness setting can be accessed from the front panel by tapping the Settings menu (top left corner of the screen) to go to the navigation drawer. Then tap System settings. Adjust brightness on the Display and Sound tab (see image below).

The MeasureReady 155 will produce sounds on various presses of the screen as a means to provide feedback to the user that a key press has occurred. The volume setting can be set to 100%, 75%, 50%, 25%, or off.

Interface Command: **`SYSTem:BEEPer:VOLume`**

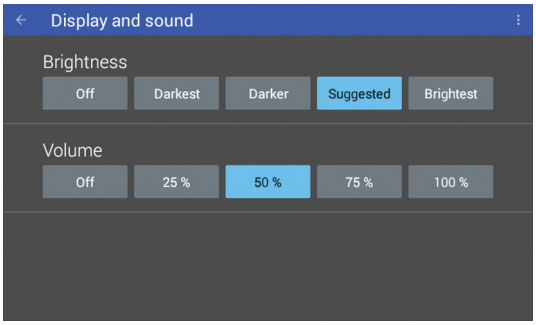


FIGURE 3-17 ***Display and Sound***

3.5.2.4 Legal

This screen is available for the user to see the various open source software used.

3.5.2.5 Update

See section 6.4 for information on firmware updates.

3.5.2.6 Privacy

If enabled and an internet connection is present, the instrument will periodically send usage statistics and crash reports to identify problems that could be addressed. No personally identifiable information or measurement data will be collected or sent with this service.

3.5.2.7 Date/Time

The 155 contains a real-time clock, allowing the current date, time, and time zone to be stored. The time, date and time zone can be set and viewed via the front panel or over the remote interface.

In addition, the 155 has a feature to automatically set its date and time with a network connection.

Interface Commands:
SYSTem:DATE
SYSTem:AUTODATETIME
SYSTem:TIME
SYSTem:TZONE

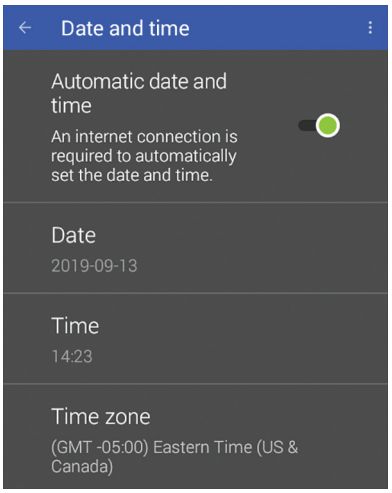


FIGURE 3-18 ***Date and time***

3.5.2.8 Reset

The MeasureReady® 155 precision current voltage source has two types of settings: instrumentation and system. Instrumentation settings includes settings that are unique to the instrument, such as shape, frequency, amplitude and full scale range. System settings are settings common to most instruments, such as volume, brightness and TCP/IP settings.

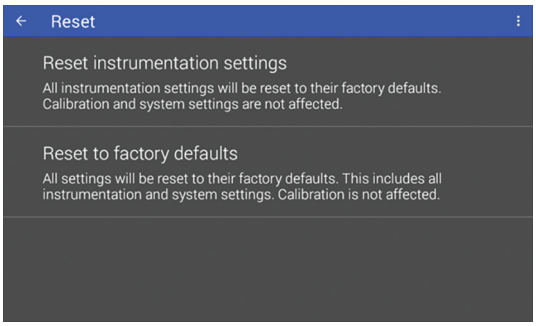


FIGURE 3-19 ***Reset***

3.5.2.8.1 Reset instrumentation settings

155 instrumentation settings are not stored in non-volatile memory. Therefore, the table below can be considered a listing of both the power-on and the default settings. This will not affect calibration. When Reset instrumentation settings is initiated, the following settings are reset:

Output setup – general	Power-on default
State	Disabled
Mode	Voltage
Shape	DC
Frequency*	1 kHz
Terminals	Rear
Output setup – voltage	**Power-on default**
Range	10 V
Autorange	Enabled
Amplitude	0
Offset*	0
DC current limit	100 mA
Output limit	100 V

** Setting only available in MeasureReady® 155-AC only.*

Output setup – current	Power-on default
Range	100 mA
Autorange	Enabled
Amplitude	0
Offset*	0
DC voltage compliance	10 V
AC voltage range	10 V
Output limit	100 mA
Digital I/O and triggering	**Power-on default**
Digital input function	Manual
Digital output function	Manual
Digital output setting	0
Trigger source	Internal
Continuous trigger	Disabled
Trigger out delay	10 ms

TABLE 3-5 ***Reset instrumentation settings values***

Interface Commands:
`SYSTem:PRESET` or **`*RST`**

3.5.2.8.1 Reset to factory defaults

If necessary, the 155 instrument settings can be restored to factory defaults. System settings are stored in non-volatile memory. A factory default reset will reset both instrumentation settings and system settings. As with the reset instrumentation settings function, a factory default will not affect calibration.

When a factory reset in initiated, diagnostic logs and user added firmware repositories are cleared (the default firmware.lakeshore.com/production remains). In addition, the following system settings are reset back to their default state:

Connectivity – general	Default
Mobile app connectivity	Disabled
SCPI over TCP	Disabled
TCP socket port number	7777
Connectivity – Ethernet	**Default**
IP Configuration	DHCP
Static IP	192.168.0.12
Static Gateway	192.168.0.1
Static Subnet mask	255.255.255.0
DNS 1	8.8.8.8
DNS 2	8.8.4.4
Connectivity – GPIB	**Default**
Address	12

Display and sound	Default
Brightness	50
Volume	50
Date and time	**Default**
Automatic date and time	Disabled
Time zone	GMT
Privacy	**Default**
Send usage statistics	Disabled
Keypad	**Default**
Lock	Disabled

TABLE 3-6 ***Reset to factory defaults values***

Interface Commands:
`SYSTem:FACTORYRESET`

3.6 Interlock Functionality

As introduced in section 2.4.2, the MeasureReady® 155 includes a 2-pin interlock connector that must be closed in order to output voltages greater than 10 V.

If the instrument outputs a voltage greater than 10 V and the interlock is open, the output will automatically be disabled and a message will appear, "*interlock is protecting the output*." The protection symbol will appear in the upper right corner. Subsequently, closing the interlock will allow the source to resume high voltage operation. The user must manually re-enable the output.

If the interlock is open, the 155 will still operate, but is limited in the following ways:

- *Voltage source:* maximum output of 10 V
- *Current source:* will generate up to 100 mA, however the voltage compliance setting is limited to 10 V.

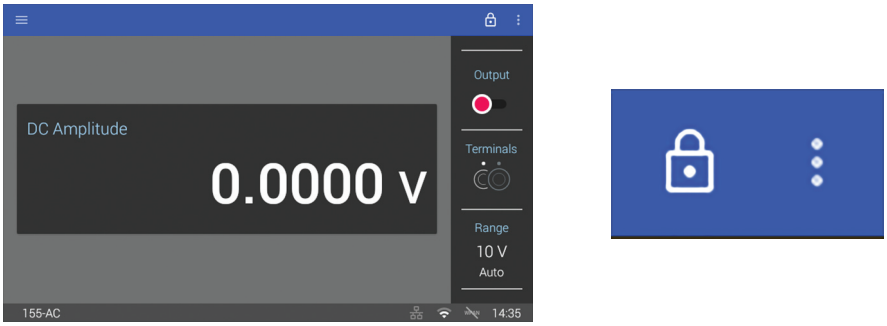


FIGURE 3-20 ***Left: Interlock screen. Right: Protection symbol***

Chapter 4: Computer Interface Operation

4.1 General

This chapter provides operational instructions for the remote interface for the Lake Shore MeasureReady® 155 precision current voltage source. The 155 supports the following remote interfaces for direct user control:

- USB (emulating a serial communications port)
- Ethernet
- GPIB

NOTE

MeasureReady 155 sources sold prior to August 2020 also included Wi-Fi capability. Please see: https://www.lakeshore.com/instruments-wi-fi-addendum.pdf/.

The MeasureReady 155 adheres to the Standard Commands for Programmable Instruments (SCPI) standard, as discussed in section 4.2, regardless of the remote interface selected for user control.

In addition, the Ethernet interface allows for connectivity between the 155 and the mobile application. This is further explained in section 4.4.

4.2 Standard Commands for Programmable Instruments (SCPI)

The MeasureReady 155 adheres to the SCPI command language. SCPI is a standardized command language, presently maintained by the Interchangeable Virtual Instruments (IVI) Foundation, used for controlling test and measurement instruments. SCPI provides instrument control with a standardized command syntax and style.

The following sections provide a brief overview of the SCPI language, syntax, and behavior, that will allow a new instrument user to get up and running quickly. The complete SCPI specification can be found on the IVI website: http://www.ivifoundation.org/docs/scpi-99.pdf.

4.2.1 Command Types

There are two different types of SCPI commands that the 155 responds to: common and subsystem.

4.2.1.1 Common

SCPI builds upon the IEEE 488.2 standard. Because of this, several of the commands found in IEEE 488.2 are required by the 155 to be considered SCPI compliant. These commands include, but are not limited to, functionality to reset (*RST), clear the status registers (*CLS), or identify the instrument (*IDN?).

These commands are identifiable by the fact that they:

1. Always consist of three letters and
2. Are always preceded by an asterisk

4.2.1.2 Subsystem

In addition to the common commands, SCPI defines subsystem commands. If the 155 is considered a "system", then the logical grouping of its various functions can be considered different "subsystems", forming a hierarchical "tree". Each subsystem is comprised of program headers. Together, these comprise the individual SCPI command. The following is an example of several 155 SCPI commands and how they fit into the hierarchical tree:

:DISPlay
:BRIGhtness <brightness>
:ENABle <bool>
:SOURce
:FUNCtion
:MODE <mode>
[:SHAPe] <shape>
:CURRent
:LIMit <limit>
:RANGe <range>
:AUTO <Bool>

4.2.2 Queries

Many times, a command will have a corresponding query. Queries require a question mark at the end of the command header. If a query requires a parameter, place the question mark at the end of the header and before the query parameters.

4.2.3 Optional Commands

If a command header is enclosed in brackets ([]), then it is optional. Do not include the brackets if you send the optional command to the instrument. For example, the following command messages are both valid, since the STATe header is optional:

```
OUTPut:STATe ON
OUTPut ON
```

4.2.4 Short and Long Form

SCPI specifies a short and long form for its command headers. The command header is completely spelled out in the long form while it is abbreviated to the first three or four letters for short form. The following is an example of the same command in both short and long form:

```
SOURce:FUNCtion:MODE VOLTage
SOUR:FUNC:MODE VOLT
```

4.2.5 Number Suffix

When a command header is used to represent multiple instances of a given function of the instrument, the selection of which to use is designated by a numeric suffix attached to the command header. This suffix is applicable for both short and long forms.
Examples:

```
DIGital:OUTput1:FUNCtion MANual
DIG:OUT2:FUNC TRIG
```

4.2.6 Multiple Commands in a Single Message

Many times, it is desirable to chain multiple commands and queries together into one message transmission. To do this, separate each command/query with a semicolon and be sure to include a colon before the next command, unless it is a common command which uses the "*" prefix.

If multiple commands are provided in a given message, the 155 will process the commands in the order in which they were received. Subsequently, if multiple queries are included in chained message, the 155 will respond to the queries in the order in which they were received.

As an example, the following command message will set the voltage amplitude to 7 V, turn the output on, query the 155 for the voltage setting that was just sent down, and request a response of "1" once all the commands are processed.

Sent: `SOURCE:VOLTAGE 7;:OUTPUT:STATE 1;:SOURCE:VOLTAGE?;*OPC?`
Received: `7;1`

4.2.6.1 Commands Within the Same Subsystem

Referring to the subsystem tree shown in section 4.2.1.2, if multiple commands within the same level of the SCPI tree are sent in the same chained message, the colon does not need to be included in order to reset the SCPI header path. An example of this is the MODE and SHAPe headers within the SOURCE:FUNCTION subsystem.

The following example sets the mode to CURRent and the shape to SINusoid. Note how "`:SOURce:FUNCtion`" is allowed to be omitted in the second part of the message, since SHAPe is on the same hierarchal level as MODE.

```
SOURCE:FUNCTION:MODE CURRENT;SHAPE SINUSOID
```

4.2.7 Terminators

All data in a given SCPI message is encoded in the American Standard Code for Information Interchange (ASCII) format. A special ASCII character, the line feed (hex 0A, decimal 10), is required by the instrument to know where the SCPI message ends. The instrument also allows an optional carriage return (hex 0D, decimal 13) to precede the line feed.

4.2.8 Message Flow Control

It is important to remember that the user program is in charge of SCPI communication at all times, independent of the communications bus used to control the instrument. The instrument cannot initiate communication, determine which device should be transmitting at a given time, or guarantee timing between messages. All of this is the responsibility of the user program.

Most commands sent to the MeasureReady® 155 will execute within 100 ms of the last character being transmitted. However, the SCPI command protocol does not specify that an instrument return an acknowledge message when a given command is finished executing. Because of this, a user program could potentially flood and overload the instruments SCPI buffer.

Therefore, it is highly recommended to append the Operation Complete Query (*OPC?) to the end of any given command string. The operation complete query is a SCPI mandated IEEE 488.2 query that will cause the instrument to send a "1" back to the user program when all commands have been processed. This scheme closes the timing loop and provides the proper balance for a user program to maximize command throughput yet not risk overrunning the instrument SCPI buffer. *OPC? can be appended onto a single command or a chained SCPI message.

The following example sets the instrument to voltage mode, sets the terminals to the rear, sets the amplitude to 5 V, turns the output on, and waits for "1" to be returned when the commands have been processed:

```
SOURCE:FUNCTION:MODE VOLTAGE;:ROUTE:TERMINALS
REAR;:SOURCE:VOLTAGE 5;:OUTPUT:STATE ON;*OPC? 1
```

4.3 Status and Error Reporting

4.3.1 Status System Overview

The MeasureReady® 155 implements a status system compliant to the SCPI-99 standard. The SCPI status system is derived from the status system called out in chapter 11 of the IEEE 488.2 standard. The status system provides a method of recording and reporting instrument information. At the center of the status system is the status byte register. This register contains summary bits from other status registers, providing the user one register to periodically query to determine if further interrogation of the instrument is required.

In addition to the status byte and its complementary service request enable register, the status system is made up of standard, questionable, and operation status register sets. Each one of those register sets comprises three types of registers: condition, event, and enable. In addition, the status system contains an output buffer and error queue. A diagram of the status system is shown below.

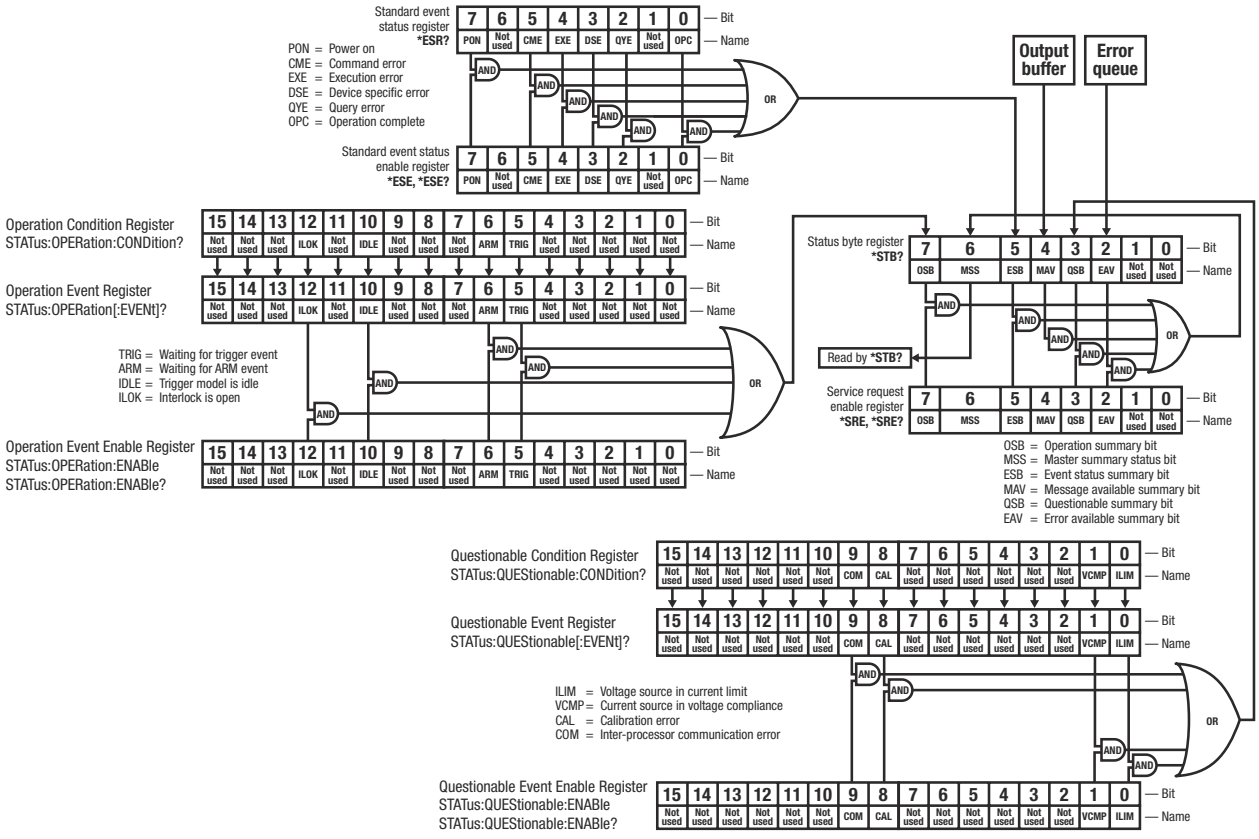


FIGURE 4-1 ***MeasureReady® 155 status system***

4.3.1.1 Status Byte Register

The status byte register, typically referred to as the status byte, is a non-latching, read-only register that contains all of the summary bits from the register sets. The status of the summary bits are controlled from the register sets as explained in section 4.3.2.1 to section 4.3.2.5. The status byte also contains the Master Summary Status (MSS) bit. This bit is used to report if any of the summary bits are set via the *STB? command. The status of the MSS bit is controlled by the summary bits and the service request enable register.

4.3.1.2 Service Request Enable Register

The service request enable register determines which summary bits in the status byte will set the MSS bit of the status byte. The user may write to or read from the service request enable register. Each status byte summary bit is logically ANDed to the corresponding enable bit of the service request enable register. When a service request enable register bit is set by the user, and the corresponding summary bit is set in the status byte, the MSS bit of the status byte will be set.

4.3.1.3 Conditional Registers

Each register set (except the standard event register set) includes a condition register as shown in FIGURE 4-1. The condition register constantly monitors the instrument status. The data bits are real-time and are not latched or buffered. The register is read-only.

4.3.1.4 Event Registers

Each register set includes an event register as shown in FIGURE 4-1. Bits in the event register correspond to various system events and latch when the event occurs. Once an event bit is set, subsequent events corresponding to that bit are ignored. Set bits remain latched until the register is cleared by a query command (such as *ESR?) or a *CLS command. The register is read-only.

4.3.1.5 Enable Registers

Each register set includes an enable register as shown in FIGURE 4-1. An enable register determines which bits in the corresponding event register will set the summary bit for the register set in the status byte. The user may write to or read from an enable register. Each event register bit is logically ANDed to the corresponding enable bit of the enable register. When an enable register bit is set by the user, and the corresponding bit is set in the event register, the output (summary) of the register will be set, which in turn sets the master summary status bit of the status byte register.

4.3.1.6 Register Read/Write Behavior

4.3.1.6.1 Reading Registers

Any register in the status system may be read using the appropriate query command. Some registers clear when read, others do not (section 4.3.1.6.3). The response to a query will be a decimal value that corresponds to the binary-weighted sum of all bits in the register (TABLE 4-1). The actual query commands are described later throughout section 4.6.

Position	B7	B6	B5	B4	B3	B2	B1	B0
Decimal	128	64	32	16	8	4	2	1
Weighting	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

Example: If bits 0, 2, and 4 are set, a query of the register will return a decimal value of 21 (1+4+16)

TABLE 4-1 ***Binary weighting of an 8-bit register***

4.3.1.6.2 Programming Registers

The only registers that may be programmed by the user are the enable registers. All other registers in the status system are read-only registers. To program an enable register, send a decimal value that corresponds to the desired binary-weighted sum of all bits in the register (TABLE 4-1). The actual commands are described throughout section 4.6.

4.3.1.6.3 Clearing Registers

The methods to clear each register are detailed in the table below.

Register	Method	Example
Condition registers	None: registers are not latched	—
Event registers: **Standard event status register** **Operation event register**	Query the event register	*ESR? (clears standard event status register)
	Send *CLS	*CLS (clears both registers)
	Power on instrument	—
Enable registers: **Standard event status enable register** **Operation event enable register** **Service request enable register** **Questionable event enable register**	Write 0 to the enable register	*ESE 0 (clears standard event status enable register)
	Power on instrument	—
Status byte	There are no commands that directly clear the status byte as the bits are non-latching; to clear individual summary bits clear the event register that corresponds to the summary bit—sending *CLS will clear all event registers which in turn clears the status byte	If bit 5 (ESB) of the status byte is set, send *ESR? to read the standard event status register and bit 5 will clear
	Power on instrument	—

TABLE 4-2 ***Register clear methods***

4.3.2 Register Details

4.3.2.1 Status Byte Register

The summary messages from the event registers and the output buffer set or clear the summary bits of the status byte register (FIGURE 4-2). These summary bits are not latched. Clearing an event register will clear the corresponding summary bit in the status byte register. Reading all messages in the output buffer, including any pending queries, will clear the message available bit. Reading all errors out of the queue will clear the error available bit. The bits of the status byte register are described as follows:

- *Operation Summary (OSB), Bit (7):* this bit is set when an enabled operation event has occurred.
- *Master Summary Status (MSS), Bit (6):* this bit is set when a summary bit and the summary bit's corresponding enable bit in the service request enable register are set. A *STB? will read the status of the MSS bit (along with all of the summary bits), but also will not clear it. To clear the MSS bit, either clear the event register that set the summary bit or disable the summary bit in the service request Enable register.

  In addition, with a GPIB interface, this bit is also defined as the Request Service (RQS) bit. In this case, when the RQS/MSS bit would be set, the service request hardware line would go high, indicating to the controller on the bus to query the status byte.
- *Summary (ESB), Bit (5):* this bit is set when an enabled standard event has occurred.
- *Message Available (MAV), Bit (4):* this bit is set when a message is available in the output buffer.
- *Questionable Summary (QSB), Bit (3):* this bit is set when an enabled questionable event has occurred.

4.3.2.2 Service Request Enable Register

The service request enable register is programmed by the user and determines which summary bits of the status byte may set bit 6 (MSS). Enable bits are logically ANDed with the corresponding summary bits (FIGURE 4-2). Whenever a summary bit is set by an event register and its corresponding enable bit is set by the user, bit 6 will be set. The Service Request Enable command (*SRE) programs the Service Request Enable Register and the query command (*SRE?) reads it.

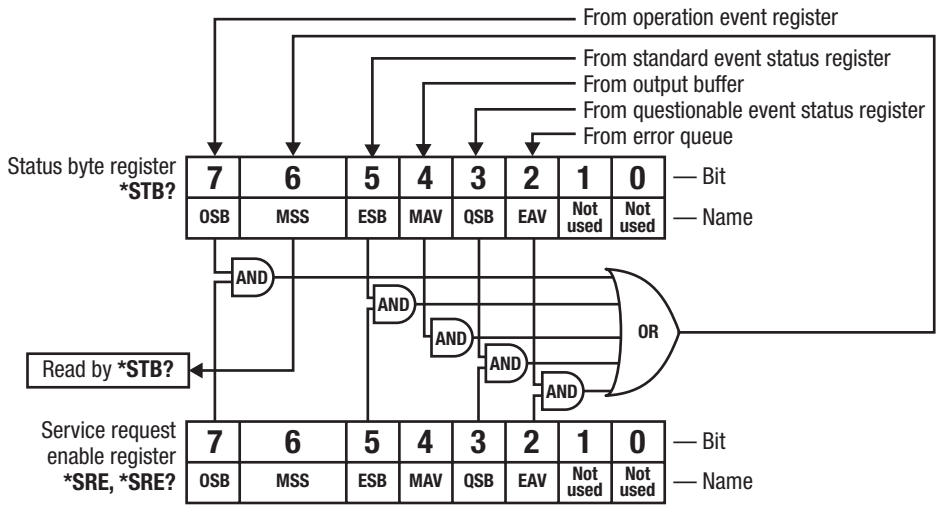


FIGURE 4-2 ***Status byte register and service request enable register***

4.3.2.3 Standard Event Status Register Set

The standard event status register reports the following interface-elated instrument events: power on detected, command syntax errors, command execution errors, query errors, and operation complete. Any or all of these events may be reported in the standard event summary bit through the enable register (FIGURE 4-3). The standard event status enable command (*ESE) programs the enable register and the query command (*ESE?) reads it. *ESR? reads and clears the standard event status register.

The used bits of the standard event register are described as follows:

- *Power On (PON), Bit (7):* this bit is set to indicate an instrument off-on transition.
- *Command Error (CME), Bit (5):* this bit is set if a command error has been detected since the last reading. This means that the instrument could not interpret the command due to a syntax error, an unrecognized header, unrecognized terminators, or an unsupported command.
- *Execution Error (EXE), Bit (4):* this bit is set if an execution error has been detected. This occurs when the instrument is instructed to do something not within its capabilities. A typical example of this are command parameters that are outside the instrument's acceptable bounds.
- *Device Specific Error (DSE), Bit (3):* this bit is set if an error occurs that does not fall into another category defined as a standard event. Examples include if the 155 is unable to set its date/time or time zone.
- *Query Error (QYE), Bit (2):* this bit indicates a query error. It occurs rarely and involves loss of data because the output queue is full.
- *Operation Complete (OPC), Bit (0):* when *OPC is sent, this bit will be set when the instrument has completed all pending operations. The operation of this bit is not related to the *OPC? command, which is a separate interface feature (section 4.2.8).

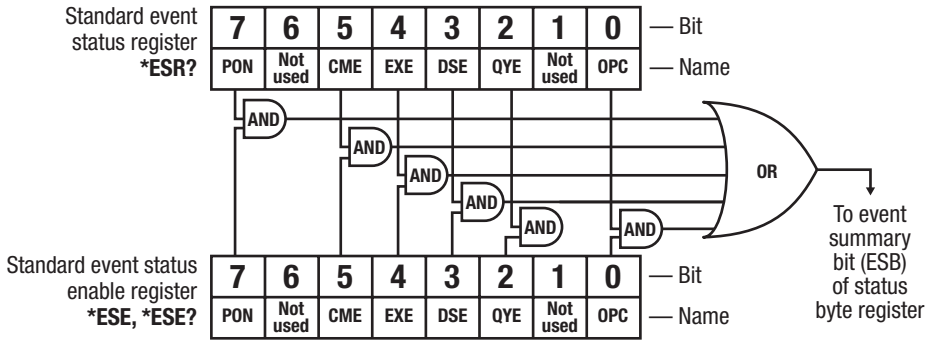


FIGURE 4-3 ***Standard event status register***

4.3.2.4 Operation Event Register Set

The operation event register reports the instrument events that are considered part of normal operation. Any or all of these events may be reported in the operation event summary bit through the enable register (FIGURE 4-4.) The operation event enable command (**`STATus:OPERation:ENABle`**) programs the enable register and the query command (**`STATus:OPERation:ENABle?`**) reads it.
`STATus:OPERation[:EVENt]?` reads and clears the operation event register.
`STATus:OPERation:CONDition?` reads the operation condition register.

The used bits of the operation event register are described as follows:

- *Interlock is Open (ILOK), Bit (12):* this bit is set when the safety interlock switch is open. The interlock is required to be closed to source voltages over 10 V or source currents that require a programming voltage over 10 V.
- *Trigger Model Idle (IDLE), Bit (10):* Indicates that the 155 trigger model is in the idle state.
- *Waiting for ARM event (ARM), Bit (6):* Indicates that the 155 is in the ARM layer waiting for an ARM event to occur. Presently, the 155 does not implement the ARM layer, however the bit is left here for future growth.
- *Waiting for Trigger event (TRIG), Bit (5):* indicates that the 155 is in the trigger layer waiting for a trigger event to occur.

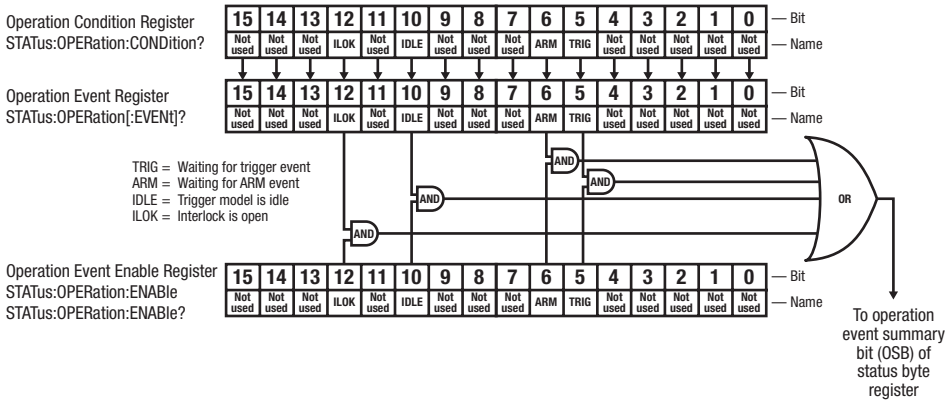


FIGURE 4-4 ***Operation event status register***

4.3.2.5 Questionable Status Register Set

The questionable status register reports various states of the instrument that could indicate the quality of the output signal may be compromised. Any or all of these events may be reported in the questionable event summary bit through the enable register (FIGURE 4-5). The questionable event enable command (**STATus:QUEStionable:ENABle**) programs the enable register and the query command (**STATus:QUEStionable:ENABle?**) reads it.
STATus:QUEStionable[:EVENt]? reads and clears the operation event register.
STATus:QUEStionable:CONDition? reads the operation condition register.

The used bits of the operation event register are described as follows:

- *Inter-Processor Communication error (COM), Bit (9):* this bit is set if communications are lost between the main microprocessor and the analog board microprocessor.
- *Calibration Error (CAL), Bit (8):* indicates that the instrument did not pass calibration, contains corrupt calibration constants, contains default calibration constants, or has uninitialized calibration memory.
- *Voltage Compliance (VCMP), Bit (1):* when the 155 is configured as a current source and the compliance limit voltage has been reached, this bit will be set.
- *Current Limit (ILIM), Bit (0):* when the 155 is configured as a voltage source and the current limit has been reached, this bit will be set.

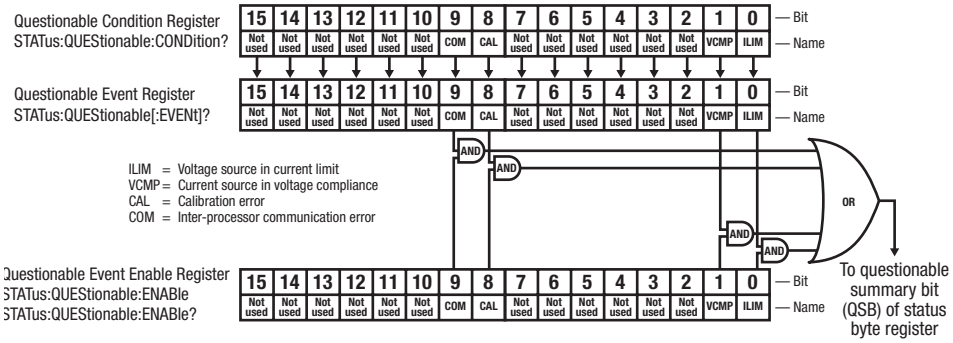


FIGURE 4-5 ***Questionable event status register***

4.3.3 Error Messages

As called out in the SCPI-99 specification, the MeasureReady 155 implements an error queue that contains coded error and status messages thrown during operation. SCPI 99 defines error messages with a negative (-) prefix as standard errors, common to all SCPI compliant instruments. Error messages with a positive prefix (+) are allocated to instrument manufacturers for instrument specific messages. Presently, the 155 source does not implement any instrument specific messages. All 155 specific errors and status are captured in the status register system.

Coded error and status messages can be retrieved and cleared over the remote interface using the following commands:

`SYSTem:ERRor:ALL?`
`SYSTem:ERRor:CLEar`
`SYSTem:ERRor:COUNt?`
`SYSTem:ERRor[:NEXT]?`

The queue is implemented with a “First In, First Out” (FIFO) approach. This means, if the 155 adds multiple messages to the queue in a given period of time, issuing the **`SYSTem:ERRor[:NEXT]?`** query will return the message that was added to the queue first, and, subsequently remove it from the queue. For further details on these error query commands, see section 4.6.

SCPI 99 categorizes its standard errors into logical groups that match bit definitions in the standard event status register. When the 155 adds an error message to the queue, a bit in the standard event status register will be set as well. The error code range table shown below lists the error code ranges, title, and the corresponding bit in the standard event status register that gets set when the error or status is added to the queue.

Error code range	Description	Standard event register bit
-100 to -184	Command errors	5
-200 to -294	Execution errors	4
-300 to -365	Device specific errors	3
-400 to -440	Query errors	2

TABLE 4-3 ***Error code ranges***

A comprehensive list of standard SCPI error codes descriptions can be found in chapters 21.8.9 through 21.8.16 of the official SCPI 99 standard, located on the IVI foundation website: http://www.ivifoundation.org/docs/scpi-99.pdf.

The MeasureReady® 155 does not implement every error code listed in the standard.

4.4 Remote Interfaces

This section provides operational instructions for the three remote interfaces for the Lake Shore MeasureReady® 155 precision current voltage source. Each of the three interfaces provided with the 155 source permits remote operation.

4.4.1 USB

The USB interface provides a convenient way to connect to most modern computers. The USB interface is implemented as a virtual serial com port connection. This implementation provides a simple migration path for modifying existing RS-232 based remote interface software. It also provides a simpler means of communicating than a standard USB implementation.

4.4.1.1 Physical Connection

The 155 has a B-type USB connector on the rear panel. This is the standard connector used on USB peripheral devices, and it allows the common USB A-type to B-type cable to be used to connect the 155 to a host PC. The pin assignments for A-type and B-type connectors are shown in section 6.6. The maximum length of a USB cable, as defined by the USB 2.0 standard, is 5 m (16.4 ft). This length can be extended using USB hubs every 5 m (16.4 ft) up to five times, for a maximum total length of 30 m (98.4 ft).

4.4.1.2 Hardware Support

The USB interface emulates an RS-232 serial port at a fixed 115,200 baud rate, but with the physical connections of a USB. This programming interface requires a certain configuration to communicate properly with the 155. The proper configuration parameters are listed in the table below.

Baud rate	115,200
Data bits	8
Parity	None
Stop bits	1
Flow control	None

TABLE 4-4 ***Host com port configuration***

The USB hardware connection uses the full speed (12,000,000 bit/s) profile of the USB 2.0 standard; however, since the interface uses a virtual serial com port at a fixed data rate, the data throughput is still limited to a baud rate of 115,200 bit/s.

4.4.1.3 Installing the USB Driver

The USB driver is available through Windows® Update. This is the recommended method for installing the driver, as it will ensure that you always have the latest version of the driver installed. If you are unable to install the driver from Windows® Update, refer to section 4.4.1.3.2 to install the driver from the web. These procedures assume that you are logged into a user account that has administrator privileges.

4.4.1.3.1 Installing the Driver from Windows® Update

1. Connect the USB cable from the 155 to the computer.
2. Turn on the 155 source.
3. When the Found New Hardware wizard appears, select **Locate and install driver software (recommended)**.
4. The Found New Hardware wizard should automatically connect to Windows® Update and install the drivers.

5. When the Found New Hardware wizard finishes installing the driver, a confirmation message stating "the software for this device has been successfully installed" will appear. Click **Close** to complete the installation.

4.4.1.3.2 Installing the Driver from the Web

The USB driver is available on the Lake Shore website. To install the driver, it must be downloaded from the website and extracted. Use the procedures below to download, extract, and install the driver using Windows®.

Download the driver:

1. Locate the USB driver on https://www.lakeshore.com/software.
2. Right-click on the USB driver download link, and select **Save as**.
3. Save the driver to a convenient place, and take note where the driver was downloaded.

Extract the driver:

The downloaded driver is in a ZIP compressed archive. The driver must be extracted from this file. Windows® provides built-in support for ZIP archives. If this support is disabled, a third-party application, such as WinZip™ or 7-Zip, must be used.

1. Right-click on the file and click **extract all.**
2. An Extract Compressed (Zipped) Folders dialog box will appear. It is recommended the default folder is not changed. Take note of this folder location.
3. Click to clear the **Show extracted files when complete** checkbox, and click **Extract**.

Manually install the driver:

The following section describes how to manually install the driver using Windows. To install the driver, you must be logged into a user account that has administrator privileges.

1. Connect the USB cable from the 155 to the computer.
2. Turn on the 155 source.
3. If the Found New Hardware wizard appears, click **Ask me again later**.
4. Open Device Manager. Use this procedure to open Device Manager.
   a. Type Device Manager in the **Start Search** box.
   b. Click the Device Manager link in the Search Results dialog box.
   c. If User Account Control is enabled click **Continue** on the User Account Control prompt.
5. Click **View** and ensure the **Devices by Type** check box is selected.
6. In the main window of Device Manager, locate **Ports (COM & LPT)** in the list of device types. If the **Ports (COM & LPT)** item is not already expanded, click the + icon. In many instances, it will be listed after Network adapters.
   Lake Shore MeasureReady 155 should appear indented in the list. If it is not displayed as **Lake Shore MeasureReady 155**, it might be displayed as USB Device. If neither are displayed, click **Action** and then **Scan for hardware changes**, which may open the Found New Hardware wizard automatically. If the Found New Hardware wizard opens, click **Cancel**.
7. Right-click on **Lake Shore MeasureReady 155** and click **Update Driver Software**.
8. Click **Browse my computer for driver software**.
9. Click **Browse** and select the location of the extracted driver.
10. Ensure the **Include subfolders** checkbox is selected and click **Next**.
11. When the driver finishes installing a confirmation message stating "Windows has successfully updated your driver software" should appear. Click **Close** to complete the installation.

4.4.2 Ethernet

The Ethernet interface provides a means of connecting the MeasureReady 155 to a network. These networks provide the ability to communicate across large distances, often using existing equipment (the internet, pre-existing local networks). The Ethernet interface of the 155 provides the ability to use TCP socket connections (section 4.4.2.4) to send commands and queries to the instrument using the common command set detailed in section 4.6.1.

4.4.2.1 Ethernet Configuration

Configuration and status for the Ethernet connection can be found from the front panel by tapping the Settings menu (top left corner of the screen) to go to the navigation drawer. Then tap System settings. Ethernet settings can be found under the Connectivity tab.

A screen is displayed showing network status and IP settings. In the example below, the network is disconnected..

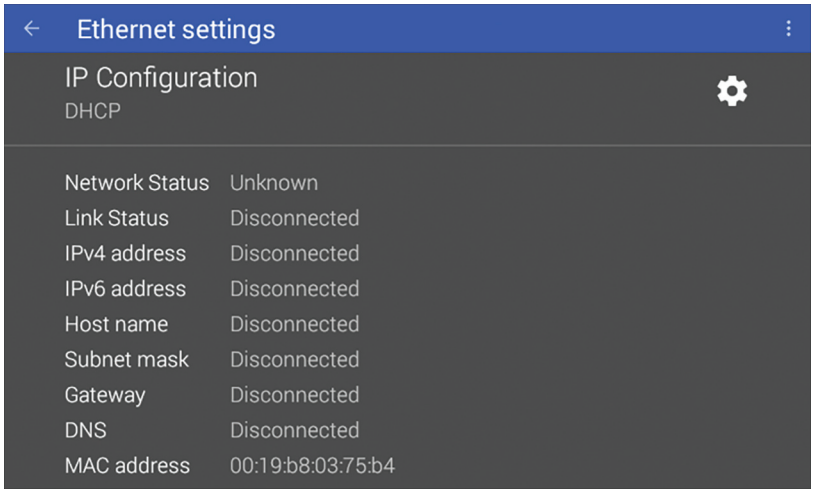


FIGURE 4-6 ***Ethernet settings***

4.4.2.2 Network Address Parameters

Network address parameters include the IP address, the subnet mask, gateway address, and DNS address. The network address parameters of the 155 can be configured using one of two methods: DHCP or Static-IP.

- *IP Address:* an IP address is required for a device to communicate using TCP/IP, which is the protocol generally used for Ethernet devices and the 155 source. The 155 supports both IPv4 and IPv6. However, for simplicity, references to the IP protocol from this point forward will be referring to IPv4.

  An IP address is a 32-bit logical address used to differentiate devices on a network. It is most often given in dotted decimal notation, such as nnn.nnn.nnn.nnn where nnn is a decimal number from 0 to 255.

- *Subnet Mask:* a sub network, or subnet, is a group of devices within a network that have a common, designated IP address routing prefix. A subnet mask is a 32-bit "bit mask" that signifies which part of the IP address represents the subnet routing prefix, and which part represents the device's address on the subnet. A subnet mask is most often given in dotted decimal notation, such as nnn.nnn.nnn.nnn where nnn is a decimal number from 0 to 255. When converted to a binary notation, the 32-bit subnet mask should consist of a contiguous group of ones, followed by a contiguous group of zeros. The ones represent which bits in the IP address refer to the subnet, and the zeros represent which bits refer to the device

address. For example, the default Static-IP Address of the 155 source is 192.168.0.128, and the default static subnet mask is 255.255.255.0. Converting this subnet mask to binary shows that the first 24 bits are ones, and the last 8 bits are zeros. This means that the first 24 bits of the Static-IP Address (192.168.0) represent the subnet, and the last 8 bits (12) represent the device.

- *Gateway Address:* a gateway is a network traffic routing device that is used to route communication between networks. If a gateway is not used, then devices on a network can only communicate with other devices on that same network. A gateway address is the IP address of the gateway on a network. Contact the network administrator for the gateway address for your network.

- *DNS Address:* a Domain Name System (DNS) is a service that translates names into IP addresses. This service allows for using human readable names for devices on a network. As an example, when a web browser attempts to retrieve the web page at www.lakeshore.com, the browser first performs a forward-lookup on the assigned DNS server to attempt to retrieve the IP address that is represented by the name www.lakeshore.com. If successful, the web browser then uses the retrieved IP address to communicate with the web server that hosts the website at www.lakeshore.com.

4.4.2.3 Network Address Configuration Methods

The network address parameters of the 155 can be configured using one of two methods: DHCP or Static-IP. DHCP is an automatic configuration method while Static-IP requires manual configuration. If supported by the server, DHCP can also be used to automatically configure DNS server addresses, as well as IP address parameters.

Dynamic Host Configuration Protocol (DHCP): DHCP is a method of automatically configuring the IP address, subnet mask, and gateway of Ethernet devices on a network. This method provides simple automatic configuration for users connecting to a network that provides a DHCP server. The network DHCP server will provide an IP address, subnet mask, and gateway address. Depending on the DHCP server configuration, it may also provide primary DNS and secondary DNS addresses as well. DHCP is the simplest method of IP configuration. DHCP does have the disadvantage of not necessarily preserving the IP address through a device reconfiguration, as well as the possibility of being automatically reconfigured when the DHCP "lease" expires. Contact your network administrator to find out the DHCP lease policy on your network.

Static-IP: Static-IP is a method of manually configuring the IP address, subnet mask, and gateway of network enabled devices. When using the Static-IP method, the IP address, subnet mask, and gateway must be configured appropriately for the connected network, or for the connected PC, in order to establish connection to the network. A major advantage to the Static-IP method is that the IP address will not change during device reconfiguration (power cycle). Disadvantages of using the Static-IP method include the requirement of knowing how your network is configured in order to choose the correct configuration parameters.

Domain Name: A domain is a collection of network devices that are managed according to some common characteristic of its members. Domains can contain subdomains, which are subsets within the domain. The hierarchy can contain several dot-separated levels which flow from right to left. For example, lakeshore.com contains the top-level-domain "com" and the subdomain "lakeshore". When using the Domain Name System (DNS) to connect to a specific host device on a network, the device's hostname is tacked onto the left of the domain name. For example, the "www"" in www.lakeshore.com refers to the Lake Shore web server, located within the internet domain "lakeshore.com."

4.4.2.4 TCP Socket Communication

A TCP socket connection interface is provided as the communication medium for the network interface of the MeasureReady 155. A TCP socket connection, or simply "socket connection", is a common connection protocol used by Ethernet devices. The Transmission Control Protocol (TCP) is commonly used for creating a communication channel between one program on one computer and one program on another computer, for example a web browser on a PC and a web server on the Internet. In the case of the 155, the protocol is used to create a communication channel between one program on one computer and the command line interface of the 155. TCP uses error correction and collision avoidance schemes that make it a very reliable form of network communication, but has drawbacks of having nondeterministic timing, and can encounter relatively large delays depending on network conditions. These delays can be on the order of seconds. Sockets use port numbers to identify sending and receiving endpoints on network devices. This allows for multiple separate communication links to exist on each device.

The port number used for TCP socket connections is 7777 by default. The port number can be configured from the Connectivity screen in System settings.

4.4.3 SCPI over TCP

There may be scenarios where the user desires to have the 155 source connected to the internet but does not want anyone to be able to connect to the 155 and start controlling it. The SCPI over TCP setting allows for this. If the setting is disabled then network connections are still allowed, allowing firmware or autodate time to still function. For example, remote control of the 155 will not be allowed even if another user knows the IP address and socket of the 155.

In order to issue SCPI commands over TCP and remotely control the instrument, this setting needs to be enabled. This can be done by touching the switch, as shown below.

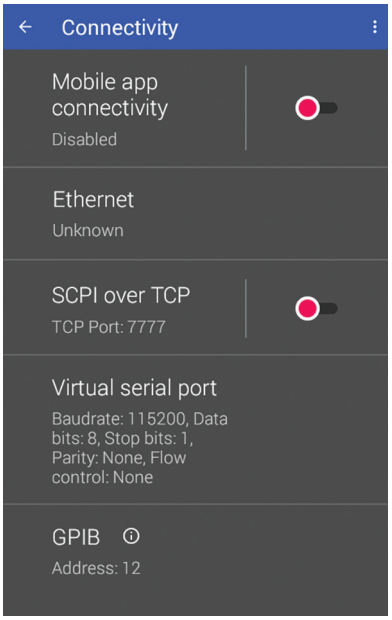


FIGURE 4-7 ***SCPI over TCP***

4.4.4 GPIB

A GPIB adapter is available for use with MeasureReady® instruments. This adapter provides GPIB communication to instruments that don't have built-in GPIB. For more information, see:
https://www.lakeshore.com/products/product-detail/measureready/gpib-adapter/

4.5 Mobile App

Besides traditional remote control using a computer, the MeasureReady 155 is equipped to be controlled by an Android device using the free app that is downloadable from the Google Play store (iOS is not supported at this time). The mobile app mirrors the 155 front panel interface, allowing the user to get started quickly when controlling via a mobile device.

As mentioned earlier, if the 155 is hooked up to a local network via Ethernet, a mobile device running the 155 app can connect to the 155 if it is connected to the same local network.

To start using the mobile connection, download the app from the Google Play store (search for Lake Shore 155), install it, and follow the simple and easy to use on-screen instructions to set up both your phone and the 155 for mobile app connectivity.

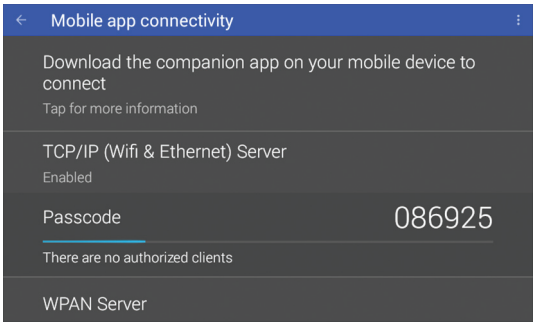


FIGURE 4-8 ***Mobile app connectivity***

4.6 Command Summary

This section lists the interface commands in alphabetical order.

bool	Boolean data type. Used to specify if a setting should be enabled or disabled. A "0" or "OFF" are valid for disable, while a "1" or "ON" are valid for enable.
NR1	Signed integer with no decimal point. Example: 77
NR2	Real number with a fixed decimal point. Examples: 56.25, 1999.0
NRf	A number that can be represented in one of three ways. Examples include an integer (77), a real number (77.325), or an exponential number (7732.5E02)
named	A finite group of strings representing valid parameters. Examples include "TRIGger," and "MANual" as valid parameters for the **`DIGital:OUTput#FUNCtion`** command.
string	Character string enclosed in double quotes.
AARD	Arbitrary un-delimited 7-bit ASCII response data.

TABLE 4-5 ***Command parameter data types***

NOTE

All command and query examples listed below are assumed to have a terminator included at the end of the string.

4.6.1 Common Commands

The following commands and queries are specified in both IEEE 488.2 and SCPI-99.

*CLS

Command Format *CLS

Remarks Clears the bits in the status byte register and the standard event status register, clears the error queue and terminates all pending operations. It does not clear the enable registers.

*ESE

Command Format *ESE <data>

Parameter

	<data>	Decimal value that is the sum of the binary-weighted values for the desired bits. Data type is *NR1*

Query Format *ESE?

Return Parameter

	<data>	(see above)

Examples

Command	*ESE 48	Enables command error and execution error flags
Query	*ESE?	
Query Response	32	Indicates that the command error flag is set

Remarks This command programs the standard event status enable register bits. Each bit is assigned a bit weighting and represents the enable/disable mask of the corresponding event flag bit in the standard event status register. To enable an event flag bit, send the command *ESE with the sum of the bit weighting for each desired bit. Refer to section 4.3.2.3 for a list of event flags.

Bit	Bit weighting	Event name
0	1	OPC
2	4	QYE
3	8	DSE
4	16	EXE
5	32	CME
7	128	PON
Total:	189	

*IDN?

Query Format *IDN?

Return Parameter <manufacturer>,<model>,<serial number>,<firmware version>
Each parameter is of type AARD

Examples

Query *IDN?

Query Response LSCI, 155-DC, 155B23C, 1.1.2

Remarks Returns the MeasureReady® 155 identification string. Each field in the return message is separated by a comma.

*OPC

Command Format *OPC

Remarks Generates an operation complete event in the event status register upon completion of all pending selected device operations. Send it as the last command in a command string. Unrelated to *OPC? See section 4.3.2.3 for more details.

*OPC?

Query Format *OPC?

Return Parameter 1 Data type is *NR1*

Examples

Query *OPC?

Query Response 1

Remarks Places a 1 in the 155 output buffer upon completion of all pending selected device operations. Send as the last command in a command string. See section 4.2.8 for more detail.

*RST

Command Format *RST

Remarks This command performs an instrument reset. This command resets the volatile memory of the instrument to the power-up settings.

*SRE

Command Format *SRE <data>

Parameter <data> Decimal value that is the sum of the binary-weighted values for the desired bits.
Data type is *NR1*

Query Format *SRE?

Return Parameter <data> (see above)

Examples

Command *SRE 4 Enables error available flag

Query *SRE?

Query Response 136 Indicates that operation and questionable event enable flags are set

Remarks This command programs the service request enable register bits. This register determines which bits from the status byte register are summed to set the Master Status Summary (MSS) bit. To enable a status flag bit, send the command *SRE with the sum of the bit weighting for each desired bit. Refer to section 4.3.2.2 for a list of status flags.

Bit	Bit weighting	Event name
2	4	EAV
3	8	QSB
4	16	MAV
5	32	ESB
7	128	OSB
Total:	188	

*STB?

Query Format *STB?

Return Parameter <data> Data type is *NR1*

Examples

Query *OPC?

Query Response 1

Remarks Reads the status byte register. Acts like a serial poll, but does not reset the register to all zeros. The integer returned represents the sum of the bit weighting of the status flag bits that are set in the Status Byte Register. Refer to section 4.3.2.1 for a list of status flags.

*TST?

Query Format *TST?

Return Parameter <status> 0 = no errors found, 1= errors found
Data type is *NR1*

Examples

Query *TST?

Query Response 0 Indicates no errors were found

Remarks The 155 report status based on test done at power up..

*WAI

Command Format *WAI

Remarks Causes the 155 interface to hold off until all pending operations have been completed. This is the same function as the *OPC command, except that it does not set the operation complete event bit in the event status register.

4.6.2 SCPI Subsystem Commands

The following commands and queries are derived from the SCPI 99 standard.

DIGital:IDATa?

Query Format DIGital:IDATa?

Return Parameter <data> Bitwise representation of the logic state of the input pins. Data type is *NR1*

Examples

Query DIG:IDAT?

Query Response 2 Indicates that pin 2 is logic high and pin 1 is logic low

Remarks Reads the state of the TTL input pin.

DIGital:INPut#:FUNCtion

Command Format DIGital:INPut#:FUNCtion <function>

Parameter <function> MANual
MANual allows the pin to be read by the user for general purpose use using the DIGital:IDATA query.
Data type is named

Query Format **DIGital:INPut#:FUNCtion?**

Return Parameter <function> (see above)

Examples

Command DIG:INP1:FUNC MANual Sets input 1 to function as MANual

Query DIG:INP2:FUNC?

Query Response MANUAL Indicates that input 2 is configured for manual

Remarks The input# field includes an enumerated suffix. If the suffix is left off, SCPI assumes input 1 is intended.

DIGital:OSETting

Command Format DIGital:OSETting <data>

Parameter <data> Bitwise representation of the desired output's logic levels. Data type is NR1

Query Format **DIGital:OSETting?**

Return Parameter <data> (see above)

Examples

Command DIG:OSET 2 Sets output 2 high and output 1 low

Query DIG:OSET?

Query Response 3 Indicates that outputs 1 and 2 are set to logic high

Remarks If an output pin is configured for trigger out mode, this command will have no effect on the state of the output pin.
NOTE: The query returns the setting, not the actual logic state of the output pin.

DIGital:OUTPut#:FUNCtion

Command Format DIGital:OUTput#:FUNCtion <function>

Parameter <function> MANual, TRIGger
MANual allows the output to be controlled by the user for general purpose use using the **`DIGital:OSETting`** command.
TRIGger configures the output to act as an active low TTL trigger out pulse, 5uS in duration, that is a result of the 155 changing its output setting.
Data type is named

Query Format **DIGital:OUTPut#:FUNCtion?**

Return Parameter	<function>	(see above)
Examples		
Command	DIG:OUTP1:FUNC Trig	Sets output 1 to function as trigger out
Query	DIG:OUTP2:FUNC?	
Query Response	MANUAL	Indicates that output2 is not configured for a specific function and can be used for general purpose use.
Remarks	The ouput# field includes an enumerated suffix. If the suffix is left off, SCPI assumes output 1 is inteded.	

DISPlay:BRIGhtness

Command Format	DISPlay:BRIGhtness <brightness>	
Parameter	<brightness>	0 (OFF), 25, 50, 75, 100 Data type is NR1
Query Format	**DISPlay:BRIGhtness?**	
Return Parameter	<brightness>	(see above)
Examples		
Command	DISP:BRIG 50	Sets the display brightness to 50
Query	DIG:BRIG?	
Query Response	100	Indicates that the display brightness is set to 100
Remarks	This command controls the intensity of the display on the device.	

DISPlay:ENABle

Command Format	DISPlay:ENABle <on/off>	
Parameter	<on/off>	0 = OFF, 1 = ON Data type is bool
Query Format	**DISPlay:ENABle?**	
Return Parameter	<on/off>	(see above)
Examples		
Command	DISP:ENAB 1	Turns on the display
Query	DISP:ENAB?	
Query Response	0	Indicates that the display is off
Remarks	This command controls whether the display is turned on or off.	

INITiate:CONTinuous

Command Format	INITiate:CONTinuous <on/off>	
Parameter	<on/off>	0 = OFF, 1 = ON Data type is bool
Query Format	**INITiate:CONTinuous?**	
Examples		
Command	INIT:CONT 1	Turns on continuous triggering
Query	INIT:CONT?	
Query Response	0	Indicates that continuous triggering is off
Remarks	If a MeasureReady® 155 output pin is setup for triggering, sending INIT:CONT 1 will bring the instrument out of the trigger idle state and ready to receive trigger events. Sending INIT:CONT 0 will turn off continuous triggering, however the output pin will remain configured for trigger out mode.	

OUTPut[:STATe]

Command Format	OUTPut[:STATe] <closed/open>	
Parameter	<closed/open>	0 = OFF, 1 = ON Data type is bool
Query Format	**OUTPut:STATe?**	

Examples

Command	OUTP:STAT 1	Enables the output
Query	OUTP:STAT?	
Query Response	0	Indicates the output is disabled

Remarks This command controls whether the output terminals are open or closed. The output is enabled when the terminals are closed, and disabled when the terminals are open. When the terminals are open, they are at maximum isolation from the signal (floating).

ROUTe:TERMinals

Command Format ROUTe:TERMinals <selection>

Parameter

<selection>	FRONt, REAR	
	FRONt selects the front terminals	
	REAR selects the rear terminals	
	Data type is named	

Query Format **ROUTe:TERMinals?**

Return Parameter <selection> (see above)

Examples

Command	ROUT:TERM REAR	Routes source signal to front terminals
Query	ROUTE:TERM?	
Query Response	REAR	

Remarks This command controls whether the front and rear terminals will provide the source signal, when the output is enabled. The front and rear terminals may not be selected simultaneously. The non-active terminals are always floating.

SOURce:CURRent[:LEVel][:IMMediate]

Remarks The group of commands below controls the output signal levels when the MeasureReady® 155 is configured to operate as a current source.

[:AMPLitude]

Command Format SOURce:CURRent[:LEVel][:IMMediate][:AMPLitude] <amplidute>

Parameter

<amplitude>	For DC signal	-100 mA to 100 mA
	For AC peak signal	0 mA to 100 mA
	Data type is NRf	

Query Format **SOURce:CURRent[:LEVel][:IMMediate][:AMPLitude]?**

Return Parameter <amplitude> (see above)

Examples

Command	SOUR:CURR 22.314e-06	Sets the current amplitude to 22.314 µA
Query	SOUR:CURR?	
Query Response	0.0018654	Indicates the current amplitude is set to 1.8654 mA

Remarks This command is used to specify the output current level for both DC and AC modes. When in AC mode, the level parameter represents the peak amplitude. If a negative amplitude is set in DC mode and the 155 source is then set to a shape that is not DC, the amplitude will be zeroed.

:OFFSet

Command Format SOURce:CURRent[:LEVel][:IMMediate]:OFFSet <offset>

Parameter

<offset>	-100 mA to 100 mA	
	Data type is NRf	

Query Format **SOURce:CURRent[:LEVel][:IMMediate]:OFFSet?**

Return Parameter <offset> (see above)

Examples

Command	SOUR:CURR:OFFS -0.005	Sets the current offset to -5 mA
Query	SOUR:CURR:OFFS?	

Query Response	5.0023e-07	Indicates the current offset is set to 500.23 nA
Remarks	This command sets the DC component of the output signal when operating in AC mode. This command is not applicable, and not accepted, when the device has its shape set to DC.	

:HIGH

Command Format	SOURce:CURRent[:LEVel][:IMMediate]:HIGH <more positive peak>	
Parameter	<more positive peak>	-100 mA to 100 mA Data type is NRf
Query Format	**SOURce:CURRent[LEVel][:IMMediate]:HIGH?**	
Return Parameter	<more positive peak>	(see above)
Examples		
Command	SOUR:CURR:HIGH 0.001	Sets the more positive peak to 1 mA
Query	SOUR:CURR:HIGH?	
Query Response	4.1234e-07	Indicates the more positive peak is set to 412.34 nA
Remarks	Sets the more positive peak of a time-varying signal. This command is not applicable, and not accepted, when the device has its shape set to DC. It is used in conjunction with LOW and can be used as an alternative to amplitude and offset.	

:LOW

Command Format	SOURce:CURRent[:LEVel][:IMMediate]:LOW <more negative peak>	
Parameter	<more negative peak>	-100 mA to 100 mA Data type is NRf
Query Format	**SOURce:CURRent[LEVel][:IMMediate]:LOW?**	
Return Parameter	<more negative peak>	(see above)
Examples		
Command	SOUR:CURR:LOW -0.012	Sets the more negative peak to -12 mA
Query	SOUR:CURR:LOW?	
Query Response	-0.0005697	Indicates the more negative peak is set to -569.7 µA
Remarks	Sets the more negative peak of a time-varying signal. This command is not applicable, and not accepted, when the device has its shape set to DC. It is used in conjunction with HIGH and can be used as an alternative to amplitude and offset.	

SOURce:CURRent:LIMit

Command Format	SOURce:CURRent:LIMit <limit>	
Parameter	<limit>	0 mA to 100 mA Data type is NRf
Query Format	**SOURce:CURRent:LIMit?**	
Return Parameter	<limit>	(see above)
Examples		
Command	SOUR:CURR:LIM .01	Limits the settable current to 10 mA
Query	SOUR:CURR:LIM?	
Query Response	0.1	Indicates the settable current limit is 100 mA
Remarks	This command sets the maximum bounds on the value of the current output setting. Attempting to set a larger value will cause the output level setting to be clamped to the limit value. The limit is an absolute value, so it is applicable for negative setting values as well, when operating in DC mode. This setting is simply an additional level of protection to prevent the user from attempting to set an output level that might, for example, damage the load. This setting should not be confused with the settable DC current limit that is available when operating in voltage mode.	

SOURce:CURRent:RANGe

Command Format	SOURce:CURRent:RANGe <range>	
Parameter	<range>	1E-6, 10E-6, 100E-6, 1E-3, 10E-3, 100E-3

Data type is NRf

Query Format **SOURce:CURRent:RANGe?**

Return Parameter <range> (see above)

Examples

Command	SOUR:CURR:RANG .001	Sets the current range to 1 mA
Query	SOUR:CURR:RANG?	
Query Response	1e-05	Indicates 10 µA range is selected

Remarks Sets the current output full scale range. The MeasureReady® 155 has six defined ranges. Any range specified between the defined ranges will be rounded up to the next higher defined range. If autorange is enabled and a manual range is received, autorange will be disabled.

SOURce:CURRent:RANGe:AUTO

Command Format SOURce:CURRent:RANGe:AUTO <on/off>

Parameter <on/off> 0 = OFF, 1 = ON
Data type is bool

Query Format **SOURce:CURRent:RANGe:AUTO?**

Return Parameter <on/off> (see above)

Examples

Command	SOUR:CURR:RANG:AUTO 0	Turns autorange off
Query	SOUR:CURR:RANG:AUTO?	
Query Response	1	Indicates autorange is turned on

Remarks Enables or disables automatic selection of the current range. When on, the 155 will select a range based on the current level setting to maximize the signal to noise ratio.

SOURce:CURRent[:SENSe][:VOLTage][:DC]:PROTection:TRIPped?

Query Format SOURce:CURRent[:SENSe][:VOLTage][:DC]:PROTection:TRIPped?

Return Parameter <in compliance> 0 = current source not in compliance
1 = current source in compliance
Data type is bool

Examples

Query	SOUR:CURR:PROT:TRIP?	
Query Response	1	Indicates the current source is in compliance

Remarks Returns the real-time compliance status of the current source. This status is applicable in both AC and DC modes.

SOURce:CURRent[:SENSe][:VOLTage][:DC]:PROTection[:LEVel]

Command Format SOURce:CURRent[:SENSe][:VOLTage][:DC]:PROTection[:LEVel] <level>

Parameter <level> 1 V to 100 V
Data type is NRf

Query Format **SOURce:CURRent[:SENSe][:VOLTage][:DC]:PROTection[:LEVel]?**

Return Parameter <level> (see above)

Examples

Command	SOUR:CURR:PROT 2.55	Sets the DC compliance voltage to 2.55 V
Query	SOUR:CURR:PROT?	
Query Response	50.5	Indicates that the DC compliance voltage is set to 50.5 V

Remarks Sets the DC compliance voltage setting of the current source. This setting will restrict the maximum DC voltage level that the 155 can output that is necessary to maintain a constant current. When the level is greater than 10 V, the high voltage stage, with its different noise and accuracy specifications, is selected. Otherwise, the low voltage output stage is selected. The settable DC compliance voltage is only applied in DC mode. In AC mode, the **SOURce:CURRent:AC:VRANGE** command setting is applied.

SOURce:CURRent[:SENSe][:VOLTage]:AC:VRANGE

Command Format SOURce:CURRent[:SENSe][:VOLTage]:AC:VRANGE <vrange>
Parameter <vrange> 10 V, 100 V
Data type is NRf
Query Format **SOURce:CURRent[:SENSe][:VOLTage]:AC:VRANGE?**
Return Parameter <vrange> (see above)
Examples
Command SOUR:CURR:SENS:VOLT:AC:VRANGE 100 Current compliance voltage is fixed at 100 V
Query SOUR:CURR:SENS:VOLT:AC:VRANGE?
Query Response 10 Indicates the AC current compliance voltage is fixed at 10 V
Remarks This command configures the MeasureReady® 155 current output stage to the low voltage state (fixed 10 V compliance) or high voltage state (fixed 100 V compliance) when in AC mode. Any range specified between the defined ranges will be rounded up to the next higher defined range. This range is only applicable in AC current mode. In DC current mode, the **`SOURce:CURRent:PROTection`** command setting will be used.

SOURce:FREQuency

Command Format SOURce:FREQuency <frequency>
Parameter <frequency> 100 mHz to 100 kHz
Data type is NRf
Query Format **SOURce:FREQUENCY?**
Return Parameter <frequency> (see above)
Examples
Command SOUR:FREQ 15.3622E3 Sets the frequency to 15.3622 kHz
Query SOUR:FREQ?
Query Response 0.988446 Indicates that the frequency is set to 988.446 mHz
Remarks Sets the frequency of the voltage or current sinusoidal waveform.

SOURce:FUNCtion[:SHAPE]

Command Format SOURce:FUNCtion[:SHAPE] <shape>
Parameter <shape> DC, SINusoid
Data type is named
Query Format **SOURce:FUNCtion:SHAPE?**
Return Parameter <shape> (see above)
Examples
Command SOUR:FUNC SIN Sets the output shape to sinusoid
Query SOUR:FUNC:
Query Response DC Indicates the output shape is set to DC
Remarks This command determines whether the voltage or current output signal shape is DC or SINusoid.

SOURce:FUNCtion:MODE

Command Format SOURce:FUNCtion:MODE <mode>
Parameter <mode> VOLTage, CURRent
Data type is named
Query Format **SOURce:FUNCtion:MODE?**
Return Parameter <mode> (see above)
Examples
Command SOUR:FUNC:MODE CURR Configures the 155 to source current
Query SOUR:FUNC:MODE?
Query Response VOLTAGE Indicates the 155 source is configured to source voltage

Remarks This command determines whether the device operates in constant current or constage voltage mode.
NOTE: If the output is enabled and the mode is then changed, the output will automatically be disabled.

SOURce:PHASe[:ADJust]

Command Format SOURce:PHASe[:ADJust] <phase>
Parameter <phase> -180° to +180°
Data type is NRf
Query Format **SOURce:PHASe[:ADJust]?**
Return Parameter <phase> (see above)
Examples
Command SOUR:PHAS +45.2 Command output signal to lead reference by +45.2°
Query SOUR:PHAS?
Query Response -120.6 Indicates the output signal is lagging reference by -120.6°
Remarks Allows compensation of any phase error between the reference out and the output waveform. The more negative the value, the more the output signal will lag the reference. The more positive the value, the more the output signal will lead the reference. This may be useful, particularly when configured for AC current source functionality, where cabling and DUT resistance can significantly impact phase error. In this case, it may be desirable to align the zero crossings of the reference out and source.

SOURce:VOLTage[:LEVel][:IMMediate]

Remarks The group of commands below controls the output signal levels when the MeasureReady® 155 is configured to operate as a voltage source.

[:AMPLitude]

Command Format SOURce:VOLTage[:LEVel][:IMMediate][:AMPLitude] <amplidute>
Parameter <amplitude> For DC signal -100 V to 100 V
For AC peak signal 0 V to 100 V
Data type is NRf
Query Format **SOURce:VOLTage[:LEVel][:IMMediate][:AMPLitude]?**
Return Parameter <amplitude> (see above)
Examples
Command SOUR:VOLT 9325 Sets the voltage amplitude to 9.325 V
Query SOUR:VOLT?
Query Response 50.23 Indicates that the voltage amplitude is set to 50.23 V
Remarks This command is used to specify the output voltage level for both DC and AC modes. When in AC mode, the level parameter represents the peak amplitude. If a negative amplitude is set in DC mode and the 155 source is then set to a shape that is not DC, the amplitude will be zeroed.

:OFFSet

Command Format SOURce:VOLTage[:LEVel][:IMMediate]:OFFSet <offset>
Parameter <offset> -100 V to 100 V
Data type is NRf
Query Format **SOURce:VOLTage[:LEVel][:IMMediate]:OFFSet?**
Return Parameter <offset> (see above)
Examples
Command SOUR:VOLT:OFFS -0.005 Sets the voltage offset to -5 mV
Query SOUR:VOLT:OFFS?
Query Response 0.20056 Indicates that the voltage offset is set to 200.56 mV

Remarks This command sets the DC component of the output signal when operating in AC mode. This command is not applicable, and not accepted, when the device has its shape set to DC.

:HIGH

Command Format SOURce:VOLTage[:LEVel][:IMMediate]:HIGH <more positive peak>

<more positive peak> -100 V to 100 V
Data type is NRf

Query Format **SOURce:VOLTage[:LEVel][:IMMediate]:HIGH?**

Return Parameter <more positive peak> (see above)

Examples

Command	SOUR:VOLT:HIGH 0.125	Sets the more positive peak to 125 mV
Query	SOUR:VOLT:HIGH?	
Query Response	50.25	Indicates that the more positive peak is set to 50.25 V

Remarks Sets the more positive peak of a time-varying signal. This command is not applicable, and not accepted, when the device has its shape set to DC. It is used in conjunction with LOW and can be used as an alternative to amplitude and offset.

:LOW

Command Format SOURce:VOLTage[:LEVel][:IMMediate]:LOW <more negative peak>

Parameter <more negative peak> -100 V to 100 V
Data type is NRf

Query Format **SOURce:VOLTage[:LEVel][:IMMediate]:LOW?**

Return Parameter <more negative peak> (see above)

Examples

Command	SOUR:VOLT:LOW -5.5	Sets the more negative peak to -5.5 V
Query	SOUR:VOLT:LOW?	
Query Response	-0.086	Indicates that the more negative peak is set to -86 mV

Remarks Sets the more negative peak of a time-varying signal. This command is not applicable, and not accepted, when the device has its shape set to DC. It is used in conjunction with HIGH and can be used as an alternative to amplitude and offset.

SOURce:VOLTage:LIMit

Command Format SOURce:VOLTage:LIMit <limit>

Parameter <limit> 0 - 100 V
Data type is NRf

Query Format **SOURce:VOLTage:LIMit?**

Return Parameter <limit> (see above)

Examples

Command	SOUR:VOLT:LIM 50	Limits the settable voltage to 50 V
Query	SOUR:VOLT:LIM?	
Query Response	75	Indicates that the settable voltage limit is 100 V

Remarks This command sets the maximum bounds on the value of the voltage output setting. Attempting to set a larger value will cause the output level to be clamped to the limit value. The limit is an absolute value, so it is applicable for negative setting values as well, when operating in DC mode. This setting is simply an additional level of protection to prevent the user from attempting to set an output level that might, for example, damage the load. This setting should not be confused with the settable DC voltage compliance limit that's available when operating in current mode.

SOURce:VOLTage:RANGe

Command Format SOURce:VOLTage:RANGe <range>

Parameter

<range>	0.01, 0.1, 1, 10, 100
	Data type is NRf

Query Format **SOURce:VOLTage:RANGe?**

Return Parameter

<range>	(see above)

Examples

Command	SOUR:VOLT:RANG 10	Sets the voltage range to 10 V
Query	SOUR:VOLT:RANG?	
Query Response	0.01	Indicates the 10 mV range is selected

Remarks Sets the voltage output full scale range. The MeasureReady® 155 has five defined ranges. Any range specified between the defined ranges will be rounded up to the next higher defined range. If autorange is enabled and a manual range is received, autorange will be disabled.

SOURce:VOLTage:RANGe:AUTO

Command Format SOURce:VOLTage:RANGe:AUTO <on/off>

Parameter

<on/off>	0 = OFF, 1 = ON

Query Format **SOURce:VOLTage:RANGe:AUTO?**

Return Parameter

<on/off>	(see above)

Examples

Command	SOUR:VOLT:RANG:AUTO 0	Turns autorange off
Query	SOUR:VOLT:RANG:AUTO?	
Query Response	1	Indicates autorange is turned off

Remarks Enables or disables automatic selection of the voltage range. When on, the MeasureReady® 155 will select a range based on the voltage level setting to maximize the signal to noise ratio.

SOURce:VOLTage[:SENSe][:CURRent][:DC]:PROTection[:LEVel]

Command Format SOURce:VOLTage[:SENSe][:CURRent][:DC]:PROTection[:LEVel] <level>

Parameter

<level>	100 nA to 100 mA
	Data type is NRf

Query Format **SOURce:VOLTage[:SENSe][:CURRent][:DC]PROTection[:LEVel]?**

Return Parameter

<level>	(see above)

Examples

Command	SOUR:VOLT:PROT 1.01E-6	Sets the DC current limit to 1.01 µA
Query	SOUR:VOLT:PROT?	
Query Response	1.06e-05	Indicates that the DC current limit is set to 10.6 µA

Remarks Sets the DC current limit setting of the voltage source. This setting will restrict the maximum current level that the 155 can output that is necessary to maintain a constant voltage. The DC settable compliance voltage is only applied in DC mode.

SOURce:VOLTage[:SENSe][:CURRent][:DC]:PROTection:TRIPped?

Query Format SOURce:VOLTage[:SENSe][:CURRent][:DC]:PROTection:TRIPped?

Return Parameter

<in limit>	0 = voltage source not in current limit
	1 = voltage source is in current limit
	Data type is bool

Examples

Query	SOUR:VOLT:PROT:TRIP?	
Query Response	1	Indicates that the voltage source is in current limit

Remarks Returns the real-time current limit status of the voltage source. This status is applicable for both AC and DC modes.

SYSTem:AUTODATETIME

Command Format	SYSTem:AUTODATETIME <on/off>	
Parameter	<on/off>	0 = auto date/time disabled. 1 = auto date/time enabled Data type is bool
Query Format	**SYSTem:AUTODATETIME?**	
Return Parameter	<on/off>	
Examples		
Command	SYST:AUTODATETIME 1	Enables auto date/time
Query	SYST:AUTODATETIME?	
Remarks	This command will automatically set the date and time for the user. The instrument must be connected to the internet for this feature to work properly.	

SYSTem:BEEPer:VOLume

Command Format	SYSTem:BEEPer:VOLume <volume>	
Parameter	<volume>	0 to 100 Data type is NR1
Query Format	**SYSTem:BEEPer:VOLume?**	
Return Parameter	<volume>	(see above)
Examples		
Command	SYST:BEEP:VOL 100	Sets the instrument volume to max volume
Query	SYST:BEEP:VOL?	
Query Response	50	Indicates that the instrument volume is set to mid-scale
Remarks	This command sets the volume of audible tones.	

SYSTem:DATE

Command Format	SYSTem:DATE <year>,<month>,<day>	
Parameter	<year>	####
	<month>	1-12
	<day)	1-31
		All three parameters are data type is NR1
Query Format	**SYSTem:DATE?**	
Return Parameter	<year>,<month>,<day>	(see above)
Examples		
Command	SYST:DATE 2017, 5, 15	Sets the date to May 15, 2017
Query	SYST:DATE?	
Query Response	2018,2,23	Indicates that the date is set to February 23, 2018
Remarks	This command sets the date of the instrument.	

SYSTem:ERRor

Remarks The group of command and queries below are related to the reading and control of the error/event queue.

:ALL?

Query Format	SYSTem:ERRor:ALL?	
Return Parameter	<code>,<error message>	code is the error event code Data type is NR1 error message is a description of the error Data type is string
Examples		
Query	SYST:ERR:ALL?	
Query Response	-113,"Undefined header;asdf",221,"Settings conflict",-221,"Data out of range"	

Remarks Queries the error/event queue for all the unread items and removes them from the queue. If there are multiple errors queued, the response returns a comma separated list of code, error message pairs, in FIFO order. If the queue is empty, the response code is 0 and the error message is "No error".

:CLEar

Command Format SYSTem:ERRor:CLEar
Parameter None
Examples
Command SYST:ERR:CLE
Remarks This command removes all errors from the error/event queue.

:COUNt?

Query Format SYSTem:ERRor:COUNt?
Return Parameter <count> Number of errors in the queue
Data type is NR1
Examples
Query SYST:ERR:COUN?
Query Response 4 Indicates there are 4 unread errors in the queue
Remarks Returns the number of unread items in the error/event queue for the number of unread items. If the queue is empty, the response is 0.

[:NEXT]?

Query Format SYSTem:ERRor[:NEXT]?
Return Parameter <code>,<error message> code is the error event code
Data type is NR1
error message is a description of the error
Data type is string
Examples
Query SYST:ERR?
Query Response -113,"Undefined header;qwerty"
Remarks Queries error/event queue for the next item and removes it from queue.

SYSTem:FACTORYRESET

Format SYSTem:FACTORYRESET
Examples SYST:FACTORYRESET
Remarks This command resets the instrument settings to its factory defaults.

SYSTem:KLOCk

Command Format SYSTem:KLOCk <on/off>
Parameter <on/off> 0 = unlocked, 1 = locked
Data type is bool
Query Format **SYSTem:KLOCk?**
Return Parameter <on/off>
Examples
Command SYST:KLOC 1 Locks the front panel from being used
Query SYST:KLOC?
Query Response 0 Indicates that the front panel is unlocked
Remarks This command locks the front panel controls of the instrument.

SYSTem:PRESet

Command Format SYSTem:PRESet
Parameter None
Examples
Command SYST:PRES
Remarks This command sets the device to the same state as the front-panel reset instrument settings key.

SYSTem:TIME

Command Format SYSTem:TIME <hour>,<minute>,<second>
Parameter

<hour>	0 – 23
<minute>	0 – 59
<second>	0 – 59
	All three parameters are data type NR1

Query Format **SYSTem:TIME?**
Return Parameter <hour>,<minute>,<second> (see above)
Examples

Command	SYST:TIME 13,34,00	Sets the time to 1:34 PM
Query	SYST:TIME?	
Query Response	4,5,4	Indicates that the time is set to 4:05:04 AM

Remarks This command sets the clock of the instrument. If any parameter exceeds the range specified above, it shall be rippled up through the date. For example, if SYST:TIME 9,30,126 is sent, the time will be set to 9:32:06 AM.

SYSTem:TZONE

Command Format SYSTem:TZONE <hour>,<minute>
Parameter

<hour>	-12 – 12
<minute>	0, 30, 45
	Both data types are NR1

Query Format **SYSTem:TZONE?**
Return Parameter <hour>,<minute> (see above)
Examples

Command	SYST:TZONE -5,00	Sets the time zone to UTC -05:00
Query	SYST:TZONE?	
Query Response	9,0	Indicates that the time zone is set to UTC +09:00

Remarks This command sets the time zone of the instrument. When each field is subtracted from the value of the TIME command, the result is the correct universal coordinated time (also known as UCT).

SYSTem:VERSion?

Query Format SYSTem:VERSion?
Return Parameter

<version>	Version of the SCPI standard that the instrument adheres to Data type is NR2

Examples

Query	SYST:VERS?	
Query Response	1999.0	Indicates that this instrument adheres to SCPI version 1999

Remarks None

STATus:OPERation

Remarks This group of commands, known as the Operation Status Register, contains informative conditions which are part of the normal operation of the MeasureReady ™ 155. The following table provides the bit definitions for the operation status register. Further explanation can be found in section 4.3.

Bit(s)	Description
0 – 4	Unused
5	Trigger: Waiting for Trigger
6	Trigger: Waiting for ARM
7 – 9	Unused
10	Trigger: IDLE
11	Unused
12	Interlock not present
13 – 15	Unused

:CONDition?

Query Format STATus:OPERation:CONDition?

Return Parameter <value> Sum of the binary-weighted values for the set bits
Data type is NR1

Examples

Query STAT:OPER:COND?

Query Response 5120 Indicates that the interlock is not present and the trigger model is in the IDLE state (bits 10 and 12 are set)

Remarks Returns the "real-time" status of the operation status register. This information is non-latching. The register contents are not altered by issuing this query.

:ENABle

Command Format STATus:OPERation:ENABle <mask>

Parameter <mask> Sum of the binary-weighted values for the set bits
Both data types are NR1

Query Format **STATus:OPERation:ENABle?**

Return Parameter <mask> (see above)

Examples

Command STAT:OPER:ENAB 4096 Enables interlock not present

Query STAT:OPER:ENAB?

Query Response 5120 Indicates that interlock not present and IDLE are enabled

Remarks This command specifies the enable mask, allowing true conditions in the operation event register to be reported in the operation summary bit, located in the status byte register. If a bit is set in the enable register and its associated event bit transitions to true, the operation summary bit will be set.

[:EVENt]?

Query Format STATus:OPERation[:EVENt]?

Return Parameter <value> Sum of the binary-weighted values for the set bits
Data type is NR1

Examples

Query STAT:OPER:EVEN?

Query Response 1024 Indicates that instrument is in trigger idle mode

Returns the contents of the operation status register since the last time the event register was read. Reading the register will clear its contents.

STATus:PRESet

Command Format STATus:PRESet
Parameter None
Examples
Command STAT:PRES
Remarks Resets the operation and questionable event enable registers to 0.

STATus:QUEStionable

Remarks This group of commands, known as the Questionable Status Register, contain informative conditions which can indicate that the quality of the output signal of the MeasureReady ™ 155 might be compromised. The following table provides the bit definitions for the questionable status register. Further explanation can be found in section **TODO:**

Bit(s)	Description
0	Voltage source is in current limit
1	Current source is in voltage compliance
2 – 7	Unused
8	Calibration
9	Internal communications error
10 – 15	Unused

:CONDition?

Query Format STATus:QUEStionable:CONDition?
Return Parameter <value> Sum of the binary-weighted values for the set bits
Data type is NR1
Examples
Query STAT:QUES:COND?
Query Response 2 Indicates that the current source is in voltage compliance
Remarks Returns the "real-time" status of the questionable status register. This information is non-latching. The register contents are not altered by issuing this query.

:ENABle

Command Format STATus:QUEStionable:ENABle <mask>
Parameter <mask> Sum of the binary-weighted values for the set bits
Both data types are NR1
Query Format **STATus:QUEStionable:ENABle?**
Return Parameter <mask> (see above)
Examples
Command STAT:QUES:ENAB 3 Enables current limit and voltage compliance
Query STAT:QUES:ENAB?
Query Response 512 Indicates that internal communication error is enabled
Remarks This command specifies the enable mask, allowing true conditions in the questionable event register to be reported in the questionable summary bit, located in the status byte register. If a bit is set in the enable register and its associated event bit transitions to true, the questionable summary bit will be set.

[:EVENt]?

Query Format STATus:QUEStionable[:EVENt]?
Return Parameter <value> Sum of the binary-weighted values for the set bits
Data type is NR1
Examples
Query STAT:QUES:EVEN?

Query Response	256	Indicates that the instrument's calibration is questionable

Returns the contents of the questionable status register since the last time the event register was read. Reading the register will clear its contents.

TRIGger:SEQuence:SOURce

Command Format	TRIGger:SEQuence:SOURce <source>	
Parameter	<source>	INTernal An internal channel is selected as the trigger source Data type is named
Query Format	**TRIGger:SEQuence:SOURce?**	
Return Parameter	<source>	
Examples		
Command	TRIG:SEQ:SOUR INTernal	
Query	TRIG:SEQ:SOUR?	
Query Response	INTERNAL	
Remarks	In SCPI instruments that implement a trigger model, this command selects the source for the trigger event detector. The 155 presently only allows for INTERNAL (i.e. a change in state of the source hardware) trigger events.	

TRIGger:SEQuence:SRCDelay

Command Format	TRIGger:SEQuence:SRCDelay <millisecond delay>	
Parameter	<millisecond delay>	1 – 1000000 Data type is NR1
Query Format	**TRIGger:SEQuence:SRCDelay?**	
Return Parameter	<millisecond delay>	(see above)
Examples		
Command	TRIG:SEQ:SRCD 100	Delay set to 100 milliseconds
Query	TRIG:SEQ:SRCD?	
Query Response	5000	Delay set to 5 seconds
Remarks	When an output setting change is made, this is the amount of time between the setting being applied at the output terminal and the 5uS active low TTL pulse being generated on the digital IO output pin.	

Chapter 5: Options and Accessories

5.1 General

This chapter provides information on the models, options, and accessories available for the MeasureReady® 155 precision current voltage source.

5.2 Models and Kits

The list of 155 source model numbers is provided as follows:

Model	Description of models
155-DC	Standard MeasureReady® 155
155-AC	MeasureReady® 155 with AC option

TABLE 5-1 ***Model description***

5.3 Accessories

Accessories are devices that perform a secondary duty as an aid or refinement to the primary unit. Refer to https://www.lakeshore.com/ for details. A list of accessories available for the 155 source is provided in the table below.

Model	Description of accessories
MR-GPIB-USB	GPIB adapter
G-106-735	Terminal block, 2-pin
G-106-741	Terminal block, 6-pin green Phoenix
CAL-155-CERT	MeasureReady® 155 recalibration with certificate
CAl-155-DATA	MeasureReady® 155 recalibration with certificate and data
RM-1/2	Half rack mount kit
RM-2	Dual half rack mount kit

TABLE 5-2 ***Accessories***

5.4 Rack Mounting

The MeasureReady® 155 can be installed into a half rack or dual half rack mount using the optional Lake Shore rack mount kits. The kits contain the necessary parts to mount one instrument with the provided blank, or two instruments side by side in a rack mount space, 483 mm (19 in) wide by 88.9 mm (3.5 in) high.

NOTE **Ensure that there is a 25 mm (1 in) clearance on both sides of the instrument after rack mounting.**

5.4.1 Half Rack Mounting

Refer to the figure below for half rack installation details.

Item	Description	Qty
❶	Rack mount panel	1
❷	Rack mount ear	2
❸	Screw, M4 × 8 mm FHM Phillips	2
❹	Screw, M4 × 16 mm FHM Phillips (original touchscreen instrument screws)	4
	-- OR --	
	Screw, 6-32 × 0.5 in FHM Phillips	4

1. Remove instrument feet.
2. Attach the blank to the rack ear using the supplied screws.
3. *For dark blue touchscreen instruments:*

   Remove the front screws from the side panels and use these M4 screws to attach the rack ears.

   For beige keypad instruments:

   a. Remove the front screws from the sides of the instrument and retain for future use, if the rack kit is ever removed.

   b. Use the 6-32 screws ❹ to attach the rack ears.

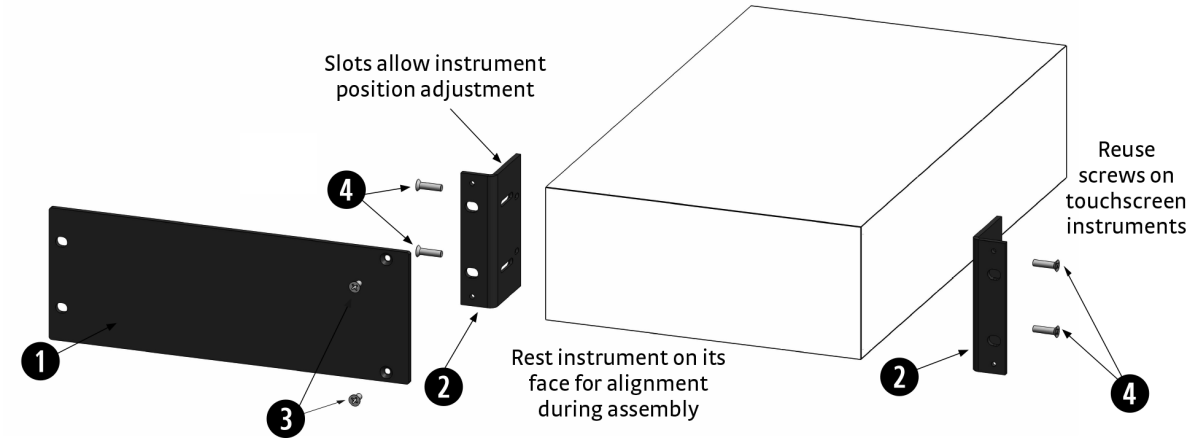
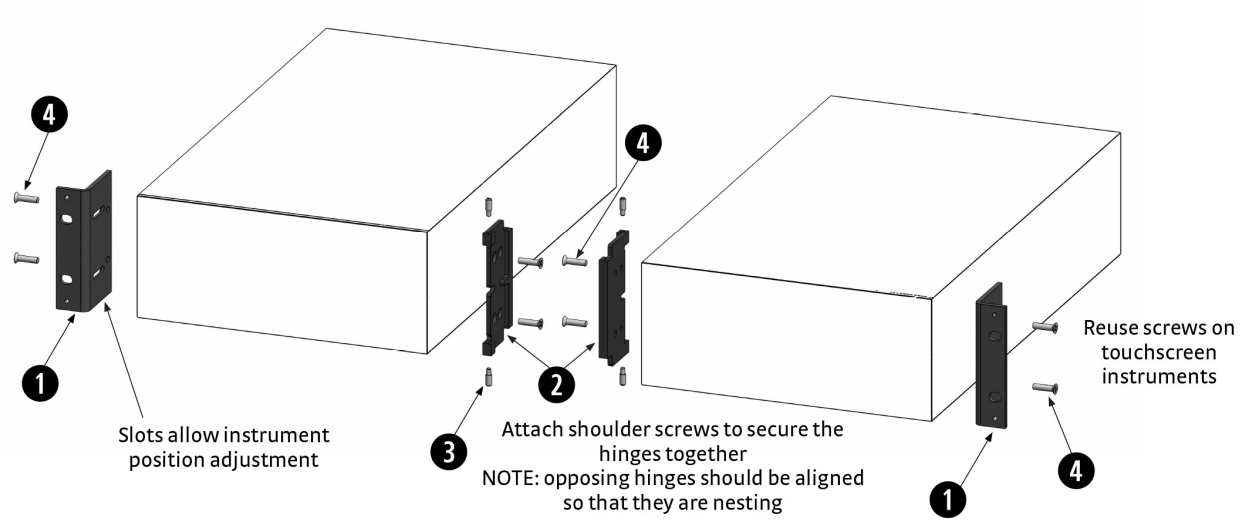


FIGURE 5-1 ***Half rack mounting***

5.4.2 Dual Half Rack Mounting

Refer to the figure below for dual half rack installation details.



Item	Description	Qty
❶	Dual rack mount ears	2
❷	Dual rack mount hinges	2
❸	Screw, headless shoulder	4
❹	Screw, M4 × 16 mm FHM Phillips (original touchscreen instrument screws	8
	-- OR --	
❹	Screw, 6-32 × 0.5 in FHM Phillips	8

1. Remove instrument feet.
2. *For dark blue touchscreen instruments:*

   Remove the front screws from the side panels and use the M4 screws to attach the rack ears and hinges to the sides of each instrument.

   For beige keypad instruments:

   a. Remove the front screws from the sides of the instrument and retain for future use, if the rack kit is ever removed.

   b. Use the supplied 6-32 screws ❹ to attach the rack ears and hinges to the sides of each instrument.
3. Nest the two hinges together and install all four ❸ screws to lock instruments together.

FIGURE 5-2 ***Dual half rack mounting***

Chapter 6: Service

6.1 Overview

This chapter provides basic service information for the MeasureReady® 155 precision current voltage source. Customer service of the product is limited to the information presented in this chapter. Lake Shore trained service personnel should be consulted if the instrument requires repair.

6.2 USB Troubleshooting

This section provides USB interface troubleshooting for issues that arise with new installations, existing installations, and intermittent lockups.

6.2.1 New Installation

1. Check that the instrument's interface is set to USB.
2. Check that the USB driver is installed properly and that the device is functioning. In Microsoft Windows®, the device status can be checked using Device Manager by right-clicking **Lake Shore Instrument** under Ports (COM & LPT) or Other Devices and then clicking Properties. Refer to Chapter 5 for details on installing the USB driver.
3. Check that the correct com port is being used. In Microsoft Windows®, the com port number can be checked using Device Manager under Ports (COM & LPT).
4. Check that the correct settings are being used for communication. Refer to Chapter 5 for details on installing the USB driver.
5. Check cable connections and length.
6. Send the message terminator.
7. Send the entire message string at one time including the terminator. (Many terminal emulation programs do not.)
8. Send only one simple command at a time until communication is established.
9. Be sure to spell commands correctly and use proper syntax.

6.2.2 Existing Installation No Longer Working

1. Power the instrument off, then on again to see if it is a soft failure.
2. Power the computer off, then on again to see if communication port is locked up.
3. Check all cable connections.
4. Check that the com port assignment has not been changed. In Microsoft Windows®, the com port number can be checked using Device Manager under Ports (COM & LPT).
5. Check that the USB driver is installed properly and that the device is functioning. In Microsoft Windows®, the device status can be checked using Device Manager by right-clicking **Lake Shore Instrument** under Ports (COM & LPT) or Other Devices and then clicking Properties.

6.2.3 Intermittent Lockups

1. Check cable connections and length.
2. Increase the delay between all commands to 100 ms to make sure the instrument is not being overloaded.
3. Ensure that the USB cable is not unplugged and that the 155 source is not powered down while the com port is open. The USB driver creates a com port when the USB connection is detected, and removes the com port when the USB connection is no longer detected. Removing the com port while in use by software can cause the software to lock up or crash.

6.3 System Troubleshooting

6.3.1 Factory Reset

For reset functions, please see section 3.5.2.8.

6.3.2 Calibration Information

Instrument calibration can be obtained through Lake Shore Service. Refer to section 6.8 for technical inquiries and contact information. Additional information regarding calibration can be found by touching the Action icon (top right of the screen) and selecting Detailed calibration information.

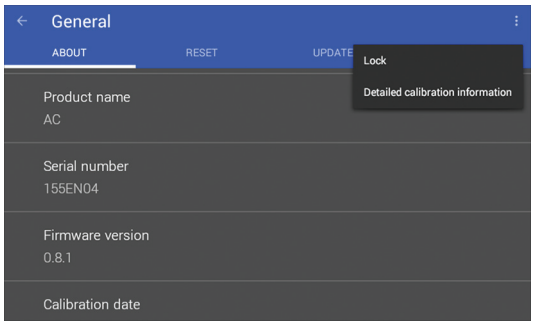


FIGURE 6-1 ***Detailed calibration information***

Information displayed on the top level About menu is present, along with other information such as the State, Passed, Count, and Checksum fields.

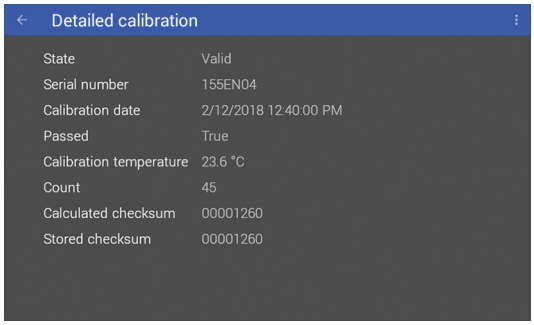


FIGURE 6-2 ***Detailed calibration information***

6.3.2.1 Calibration Errors

The MeasureReady® 155 contains calibration constants, programmed into the instrument during assembly and test, that are stored in non-volatile memory (NOVRAM). This memory is checked on power up, and if the calibration constants are determined to be invalid, they are reported on the front panel. In addition, bit 8 of the questionable event status register is set.

In these cases, the instrument cannot be guaranteed to be within published specifications and the default calibration constants are applied to guarantee the 155 will function. The user is allowed to continue operation of the 155, despite it being out of calibration.

Default

In this case, the NOVRAM contains default gain and offset calibration constants.

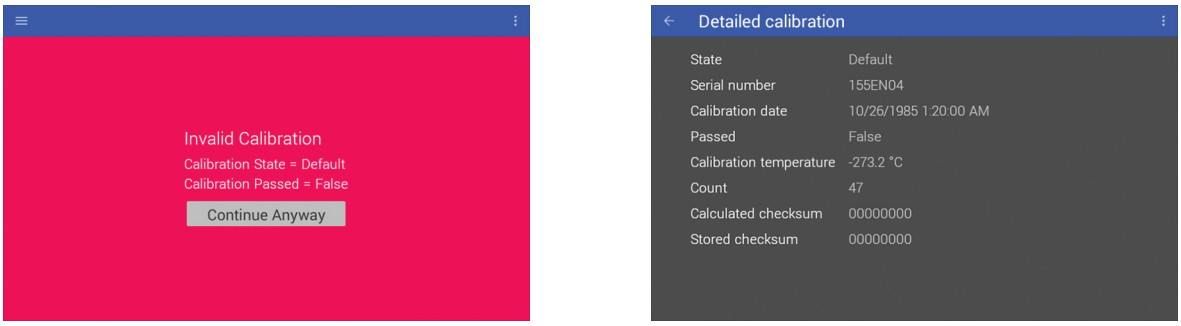


FIGURE 6-3 ***Calibration error: default***

Uninitialized

The Calibration NOVRAM is in an uninitialized/blank state.

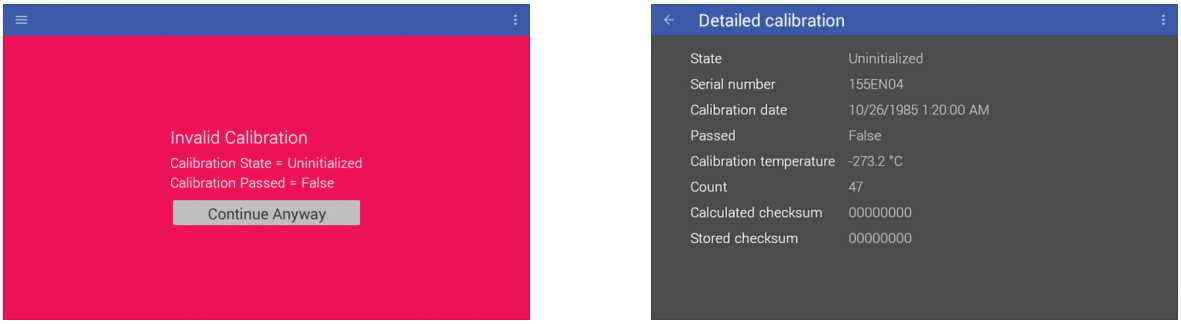


FIGURE 6-4 ***Calibration error: uninitialized***

Corrupt

In this state, one or more of the calibration constants is invalid, resulting in a mismatch of the calculated and stored checksums.

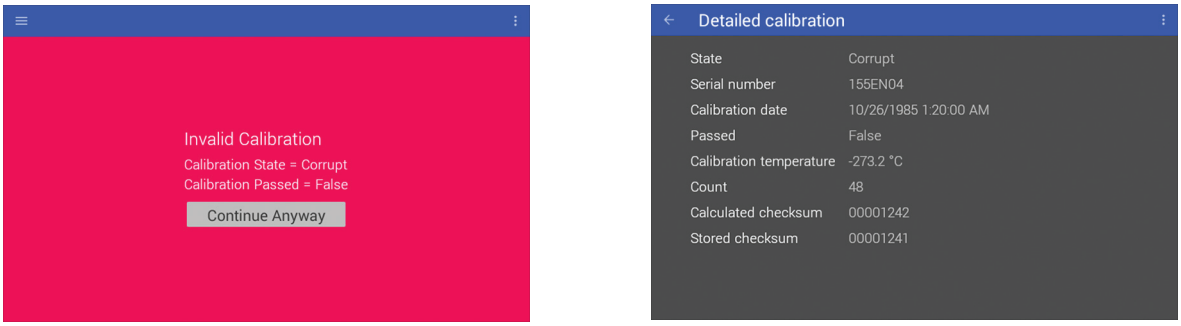


FIGURE 6-5 ***Calibration error: corrupt***

Not Passed

In this case, the calibration data is not corrupt, default or uninitialized and is therefore considered valid, from a data integrity standpoint. However, despite running through the full calibration process, the 155 did not pass calibration.

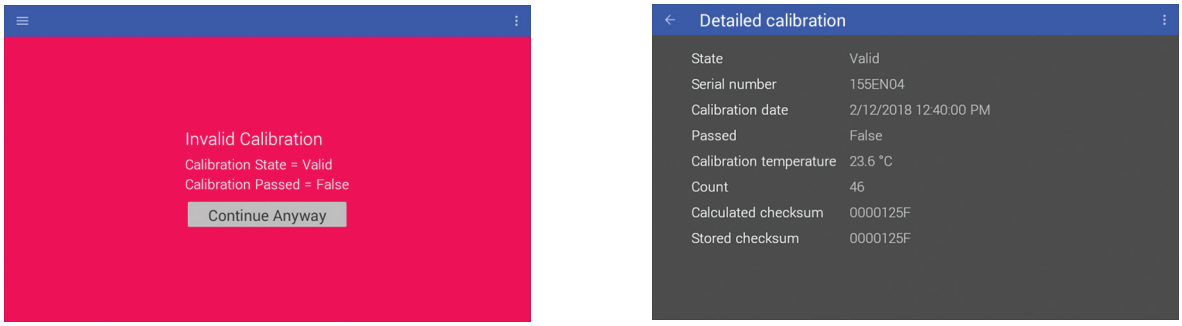


FIGURE 6-6 ***Calibration error: not passed***

6.4 Firmware Updates

6.4.1 Overview

The 155 can update its firmware manually by attaching a USB Type-C™ stick to the rear panel, or by downloading and installing updates from Lake Shore with a 155 source connected to the internet.

155 firmware comprises many files, aggregated together to form a Lake Shore Firmware (LSFW) package. The 155 stores versions of its LSFW packages in its internal memory. This local memory location is called the "local repository". This allows you to downgrade firmware should you choose, since older versions will still remain on the 155 in the local repository. In addition, Lake Shore maintains LSFW packages on a network server that allows us to deploy those packages to all 155 customers. This is called the "remote repository".

Firmware update information can be found via the 155 front panel by tapping the Settings menu (top left corner of the screen) to go to the navigation drawer. Then tap General. Select the Update tab.

Lake Shore recommends enabling the "Notify when updates are available" setting to ensure your 155 firmware is up-to-date with the latest features and updates. If used with a valid network connection, the 155 will automatically notify you via a notification on the notification bar as soon as an update is available.

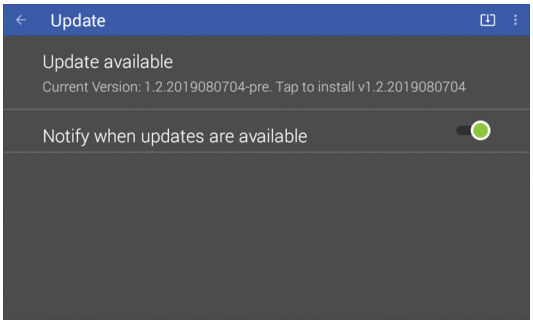


FIGURE 6-7 ***Firmware updates: notification***

If the 155 notifies you that a firmware update is available, tap "Updates are available. Click here to install". You'll then be presented with a notification, prompting you to install. Click Install and follow the on screen instructions.

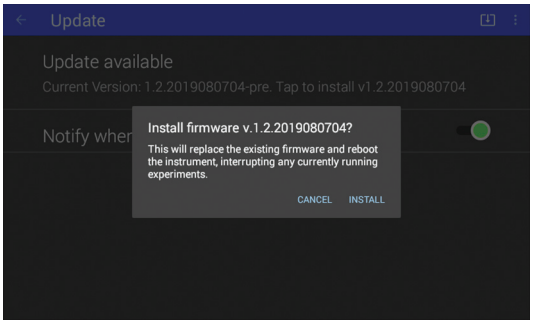


FIGURE 6-8 ***Firmware updates***

6.4.2 Manual Update Procedure Using USB Type-C™

The 155 firmware can be downloaded from the lake shore website and manually installed on the 155 using a USB Type-C™ stick:

1. To download the firmware, go to the Downloads tab at https://www.lakeshore.com/155/.
2. Enter your name and e-mail address so that we can keep you updated on any new firmware for your instrument.
3. Insert the USB stick into your computer and copy the downloaded 155 LSFW package to the root directory of the USB stick.
4. Remove the stick from the computer and insert it into the USB Type-C™ port of the 155.
5. On the 155 front panel, tap Settings menu (top left corner of the screen) to go to the navigation drawer, then tap General. Select the Update tab.
6. Click "Updates are available. Click here to install" and follow the on-screen instructions to update the firmware.

6.5 Error and Status Messages

The following are error and status messages that may be displayed by the 155 during operation.

Message	Description
Interlock is protecting	See section 3.6.
Output cannot be enabled while interlock is protecting	See section 3.6.
Voltage range of 100 V and current limit > 10 mA cannot be applied simultaneously	1. An attempt was made to set the voltage range to 100 V while the DC current limit was set to a value greater than 10 mA. Set the DC current limit to 10 mA or less first. 2. An attempt was made to set the DC current limit to a value greater than 10 mA while the voltage range was set to 100 V. Set the voltage range to 10 V or less first.
Current range of 100 mA and voltage compliance limit of > 10 V cannot be applied simultaneously	1. An attempt was made to set the DC compliance voltage setting to a value greater than 10 V while the current range is set to 100 mA. Set the current range to 10 mA or less first. 2. An attempt was made to set the current range to 100 mA while the DC compliance voltage was set to a value greater than 10 V. Set the DC compliance voltage to 10 V or less first.
Internal communication interrupted	The main microprocessor has lost communication with the analog board microprocessor. The output is automatically disabled as a result of this event.
Invalid calibration	See section 6.3.2.1.
Output current setting text is red	See section 3.4.2.4.
Output voltage setting text is red	See section 3.4.3.4.

TABLE 6-1 ***Error messages***

6.6 Rear Panel Connector Definition

The connectors on the rear panel are defined below.

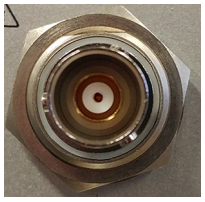


FIGURE 6-9 ***Triaxial connector***

Pin	Description
Center conductor	Output high
Inner shield	Driven guard voltage output
Outer shield	Output low (source common)

TABLE 6-2 ***Triaxial settings***

FIGURE 6-10 ***BNC connector***

Pin	Description
Center conductor	Output high
Outer shield	Output low (source common)

TABLE 6-3 ***BNC settings***

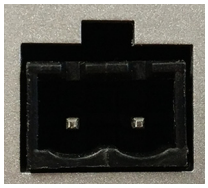


FIGURE 6-11 ***Interlock connector***

FIGURE 6-12 ***Reference output connector***

Pin	Description
Center conductor	Voltage output high
Outer shield	Reference return (chassis ground)

TABLE 6-4 ***Reference output settings***

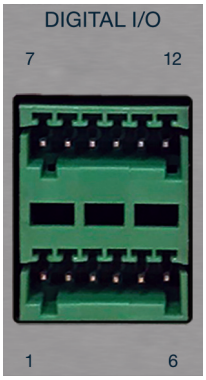


FIGURE 6-13 ***TTL digital I/O port***

Pin	Description	Pin	Description
1	Source common	7	Source common
2	Chassis ground	8	Chassis ground
3	Input 1 high	9	Input 2 high
4	Input 1 low (chassis ground)	10	Input 2 low (chassis ground)
5	Output 1 high	11	Output 2 high
6	Output 1 low (chassis ground)	12	Output 2 low (chassis ground)

TABLE 6-5 ***Digital I/O port settings***

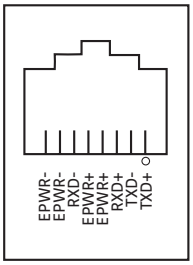


FIGURE 6-14 ***Ethernet pin and connector***

Pin	Symbol	Description
1	TXD+	Transmit data+
2	TXD-	Transmit data-
3	RXD+	Receive data+
4	EPWR+	Power from switch+ (not used)
5	EPWR+	Power from switch+ (not used)
6	RXD-	Receive data-
7	EPWR-	Power from switch- (not used)
8	EPWR-	Power from switch- (not used)

TABLE 6-6 ***Ethernet pin and connector details***

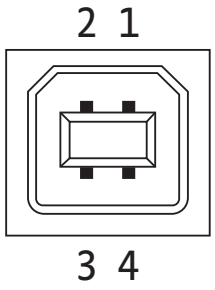


FIGURE 6-15 ***USB pin and connector***

Pin	Name	Description
1	VCC	+5 VDC
2	D-	Data –
3	D+	Data +
4	GND	Ground

TABLE 6-7 ***USB pin and connector details***

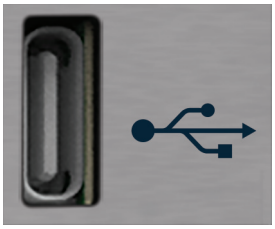


FIGURE 6-16 ***USB Type-C™ connector***

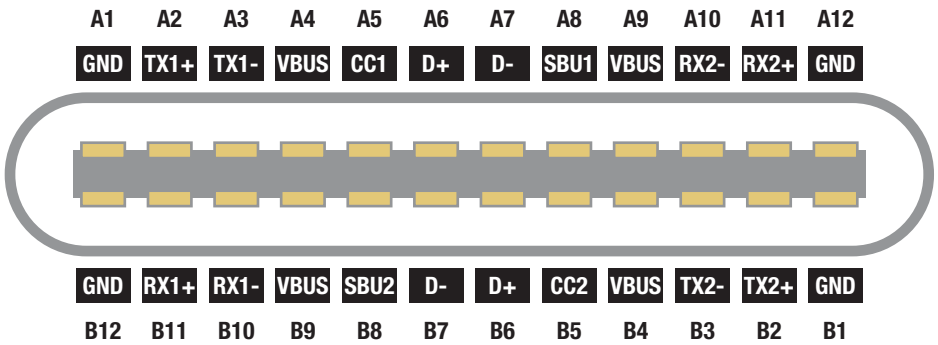


FIGURE 6-17 ***USB Type-C™ connector***

Pin	Name	Description	Pin	Name	Description
A1	GND	Ground return	**B12**	GND	Ground return
A2	SSTXp1	SuperSpeed differential pair #1, TX, positive	**B11**	SSRXp1	SuperSpeed differential pair #2, RX, positive
A3	SSTXn1	SuperSpeed differential pair #1, TX, negative	**B10**	SSRXn1	SuperSpeed differential pair #2, RX, negative
A4	V_{BUS}	Bus power	**B9**	V_{BUS}	Bus power
A5	CC1	Configuration channel	**B8**	SBU2	Sideband use (SBU)
A6	Dp1	Non-SuperSpeed differential pair, position 1, positive	**B7**	Dn2	Non-SuperSpeed differential pair, position 2, negative
A7	Dn1	Non-SuperSpeed differential pair, position 1, negative	**B6**	Dp2	Non-SuperSpeed differential pair, position 2, positive
A8	SBU1	Sideband use (SBU)	**B5**	CC2	Configuration channel
A9	V_{BUS}	Bus power	**B4**	V_{BUS}	Bus power
A10	SSRXn2	SuperSpeed differential pair #4, RX, negative	**B3**	SSTXn2	SuperSpeed differential pair #3, TX, negative
A11	SSRXp2	SuperSpeed differential pair #4, RX, positive	**B2**	SSTXp2	SuperSpeed differential pair #3, TX, positive
A12	GND	Ground return	**B1**	GND	Ground return

TABLE 6-8 ***USB Type-C™ connector details***

6.7 Summary of Internal Memory Devices

This section outlines the internal memory devices used inside the MeasureReady® 155, and provides an explanation of the types of data they contain.

Printed circuit board	Manufacturer	Part number	Description	Location	Function	Volatility	Field modifiable
Analog	Atmel/Microchip	ATSAME70Q21A	Microprocessor	U1	Microprocessor code	Non-volatile	No
Analog	Cypress	FM24V10	Microprocessor	U2	Calibration data, license files	Non-volatile	No
Digital	Kingston	EMMC04G-S100-A08U	4 GB eMMC Flash	U31	Operating system, firmware repository, app service, and instrument settings	Non-volatile	No
Digital	SK Hynix	H5TC2G83GFR--PBA	1 GB (256 MB x 4) DDR3L SRAM	U2, U3, U4, U5	Run-time data storage	Volatile	No
Digital	Microchip	SST25VF016B-50-4C	16 Mbit serial flash	U17	Bootloader	Non-volatile	No

TABLE 6-9 ***Internal memory devices***

1. The Atmel/Microchip ATSAME70Q21A is a microprocessor with 2048 KB of onboard programmable flash memory. The code is loaded by initiating a firmware update over the remote interface.
2. The Cypress FM24V10 is a 128 KB I2C FRAM. It is used to store calibration constants and feature license files. The memory is programmed at Lake Shore.
3. The Kingston EMMC04G-S100-A08U is a 4GB eMMC flash memory used to store the instrument operating system. It also contains the local firmware repository and app service, and instrument settings. Presently the instrument settings stored in this memory are not resettable in the field, but will be in a future firmware update.
4. The SK Hynix H5TC2G63GFR-PBA memories are comprised of four 256 MBDDR3L SRAM chips, totaling 1 GB of volatile memory. This memory is used by the operating system and applications during runtime as temporary data storage. Data is lost on a power cycle.
5. The Microchip SST25VF016B-50-4C is a 16 Mbit SPI flash. It is used to store bootloader firmware. The memory is programmed at Lake Shore.

6.8 Technical Inquiries

Refer to the following sections when contacting Lake Shore for application assistance or product service. Questions regarding product applications, price, availability and shipments should be directed to sales. Questions regarding instrument calibration or repair should be directed to instrument service. Do not return a product to Lake Shore without a Return Material Authorization (RMA) number (section 6.8.2).

6.8.1 Contacting Lake Shore

The Lake Shore Service Department is staffed Monday through Friday between the hours of 8:00 AM and 5:00 PM EST, excluding holidays and company shut down days.

Contact Lake Shore Service through any of the means listed below. However, the most direct and efficient means of contacting is to complete the online service request form at https://www.lakeshore.com/service/. Provide a detailed description of the problem and the required contact information. You will receive a response within 24 hours or the next business day in the event of weekends or holidays.

If you wish to contact Service or Sales by mail or telephone, use the following:

Mailing address	Lake Shore Cryotronics Instrument Service Department 575 McCorkle Blvd. Westerville, Ohio USA 43082-8888	
E-mail address	sales@lakeshore.com support@lakeshore.com	Sales Instrument Service
Telephone	614-891-2244 614-891-2243 option 6	Sales Instrument Service
Fax	614-818-1600 614-818-1609	Sales Instrument Service
Web service request	https://www.lakeshore.com/service/	Instrument Service

TABLE 6-10 ***Contact information***

6.8.2 Return of Equipment

The MeasureReady® 155 precision current voltage source is packaged to protect it during shipment.

The user should retain any shipping carton(s) in which equipment is originally received, in the event that any equipment needs to be returned.

If the original packaging is not available, a minimum of 76 mm (3 in) of shock absorbent packing material should be placed snugly on all sides of the instrument in a sturdy corrugated cardboard box. After receiving your 155 source, please use reasonable care when removing the temperature controller from its protective packaging and inspect it carefully for damage. If it shows any sign of damage, please file a claim with the carrier immediately. Do not destroy the shipping container; it will be required by the carrier as evidence to support claims. Call Lake Shore for return and repair instructions.

All equipment returns must be approved by a member of the Lake Shore Service Department. The service engineer will use the information provided in the service request form and will issue an RMA. This number is necessary for all returned equipment. It must be clearly indicated on both the shipping carton(s) and any correspondence relating to the shipment. Once the RMA has been approved, you will receive appropriate documents and instructions for shipping the equipment to Lake Shore.

6.8.3 RMA Valid Period

RMAs are valid for 60 days from issuance; however, we suggest that equipment needing repair be shipped to Lake Shore within 30 days after the RMA has been issued. You will be contacted if we do not receive the equipment within 30 days after the RMA is issued. The RMA will be canceled if we do not receive the equipment after 60 days.

6.8.4 Shipping Charges

All shipments to Lake Shore are to be made prepaid by the customer. Equipment serviced under warranty will be returned prepaid by Lake Shore. Equipment serviced out-of-warranty will be returned FOB Lake Shore.

6.8.5 Restocking Fee

Lake Shore reserves the right to charge a restocking fee for items returned for exchange or reimbursement.