Quick Start Guide

MeasureReady™

M81 Synchronous Source Measure System

Safety Precautions

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™ M81 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
- -20 °C to 70 °C, <90% relative humidity non-condensing
- Overvoltage category II
- Pollution degree 2
- Mains fluctuations up to ±10%

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

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

Ground the Instrument
To minimize shock hazard, the instrument is equipped with a 3-conductor AC power cable that mates with the IEC320-C14 line power receptacle on the back of the instrument. 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.

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.

Improper Use
If the instrument is used in a manner that is not specified by Lake Shore, the safety protections provided by the instrument are no longer guaranteed, and may be impaired.

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


Alternating current (power line)


Protective conductor terminal


Frame or chassis terminal


CAUTION or WARNING: See instrument documentation; background color: yellow; symbol and outline: black

Key specifications

Ambient temperature
Rated accuracy is ±5 °C of calibration temperature; 5 °C to 40 °C at reduced accuracy

Power requirement
100, 120, 220, 240 VAC, ±10%, 50 Hz or 60 Hz, 140 VA

MeasureReady™ M81-SSM size
216 mm wide × 87 mm high × 369 mm deep
(8.5 in × 3.4 in × 14.5 in)

MeasureReady™ M81-SSM weight
5.7 kg (12.6 lb)

Approvals
See https://www.lakeshore.com/compliance/.
NRTL listed to UL 61010-1 and CSA C22.2 No. 61010-1
M81 calibration is compliant with 17025 calibration standards. Calibration data is optionally available.
https://www.lakeshore.com/about-us/iso-certifications.

NOTE: Not all specifications are listed. Sizes and weights of the modules differ. For full specifications, see https://www.lakeshore.com/M81/.

Introduction

This guide provides basic information for getting started with your MeasureReady™ M81 synchronous source measure system (SSM™). For further documentation and information, see our website.

Items included with the MeasureReady™ M81-SSM:

- Lake Shore M81-SSM
- Line power cord
- USB-Type A to USB-Type C™ adapter
- USB-Type A to USB-Type B cable
- Remote source and measure modules (sold separately)

Unpacking

Inspect all items for both visible and hidden damage that occurred during shipment. If there is visible damage to the contents, contact the shipping company and Lake Shore immediately.

NOTE: Procedures vary with shipping companies. Keep all damaged shipping materials and contents until instructed to either return or discard them.

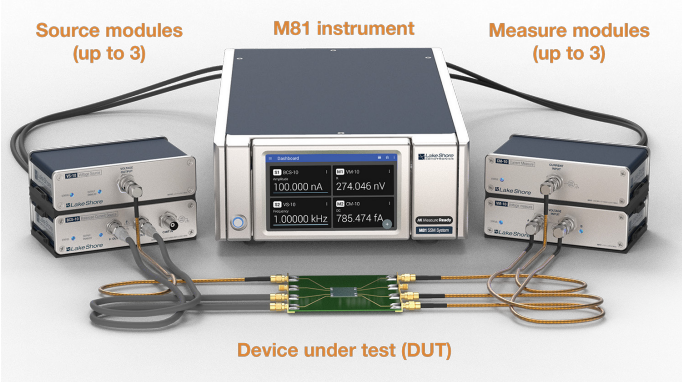
Features

- Unique real-time sampling architecture for synchronous sourcing and measuring
  - MeasureSync™ technology for simultaneous source module excitation and measure module timing across all channels
  - User-selectable measurements of AC, DC, and lock-in functions on all measure channels
  - Common DAC/ADC sampling clock ensures highly precise and consistent source/measure timing coordination between 3 sources and 3 measures
- Designed for scientific-grade low-level measurement applications
  - Linear power supply architecture for lowest possible source/measure noise
  - Fully analog signal paths between data converters, modules, and the device under test (DUT)
  - Remote modules for the shortest possible signal path to the DUT, which separates sensitive analog circuits from digital circuits and unwanted sources of interference typical of traditional single-enclosure instrument designs

- The absolute accuracy of DC plus the detection sensitivity of lock-in instrumentation
  - All source and measure channels are capable of DC to 100 kHz signals
  - Optimized for fundamental, harmonic, and phase measurements of AC combined with DC biased signals
  - Modularity allows for flexible, user-configured modules to suit a specific application
- Unique, flexible instrument with distributed module architecture
  - Remote-mountable modules are interchangeable between instruments
  - Modules are dynamically recognized when the system is reconfigured
  - Uses a clean, simple UI and a common programming API for fast setup and a shorter learning curve

Components of the M81-SSM

- Connect up to three source modules and up to three measure modules
- Exchange modules and adapt the configuration for each measurement
- All modules are capable of measuring with DC and AC to 100 kHz
- All modules are optimized for highest precision with common amplitude and frequency references

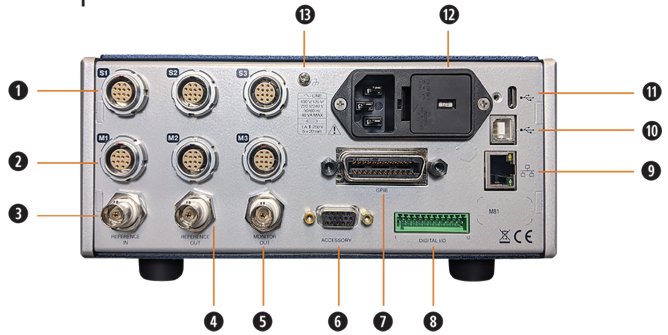


Front panel

The front panel consists of:

1. Power button
2. TiltView™ touchscreen

Rear panel

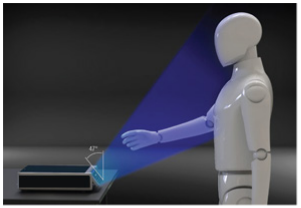


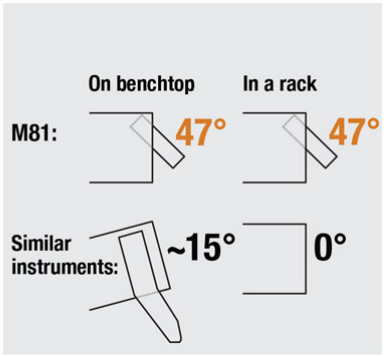
The rear panel consists of:

1. LEMO source module connectors
2. LEMO measure module connectors
3. BNC reference input
4. BNC reference output
5. BNC monitor output
6. DB15 accessory connector
7. GPIB interface connector
8. 12-pin digital I/O connector
9. RJ-45 Ethernet interface
10. USB Type- B serial communications interface
11. USB Type-C™ data transfer interface for file upload/ download
12. AC mains input connector & voltage selector/fuse module
13. Chassis ground connection

Placement

The MeasureReady™ M81 synchronous source measure system is an out-of-the-box benchtop instrument with an adjustable TiltView™ screen for an improved viewing angle. The screen adjusts from a 0° to a 47° viewing angle, whether mounted in a rack or on a bench top.





Rack mounting

The M81-SSM 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.
See http://www.lakeshore.com/rack-kit/ for full details.

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

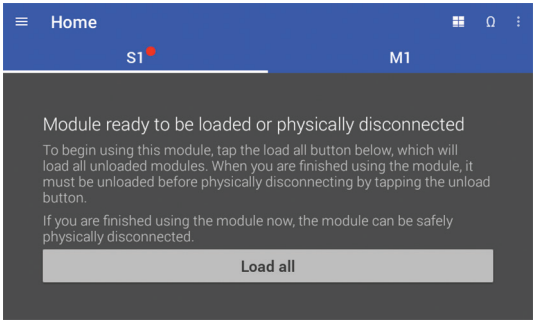
Startup

Module connection

- The source/measure modules should be connected to the instrument rear panel LEMO connectors designated as S1, S2 or S3 for source modules, or to connectors M1, M2 or M3 for measure modules.
  NOTE: M81-SSM-2 instruments only have S1 and M1 connectors; M81-SSM-4 have S1, S2, M1, and M2 connectors.

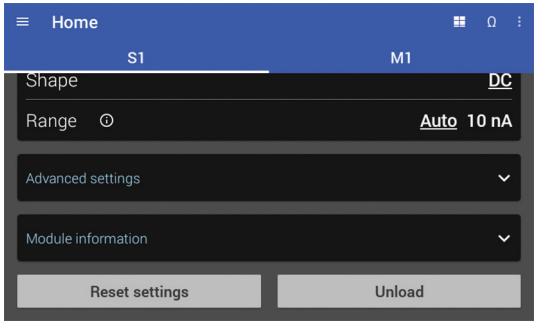
- To insert module LEMO connectors, align the rotation indicator and press firmly until the click/lock mechanism is felt or heard engaging.
- To remove module LEMO connectors, pull directly away from the instrument on the sliding barrel of the LEMO connector.

- Once a module is physically connected to its respective LEMO connector (S or M), refer to the front panel notification, requesting that the operator confirm module should be loaded.



Upon confirmation, the module control screen will appear and be available for use.

- To disconnect a source or measure module, scroll to the bottom of the module front panel control screen and click the **Unload** button. After the notification screen appears, the module LEMO can be physcially removed.



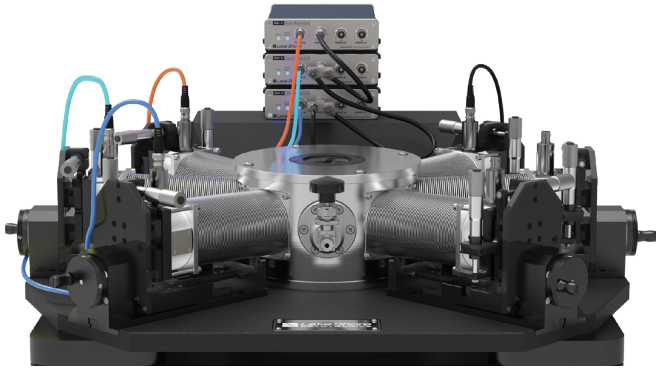
- A **Reset settings** button is also located at the bottom of each module's control screen adjacent to the **Unload** button. This can be used to reset the specific module user settings to factory default if needed.

SMU-10 source measure modules

The SMU-10 module combines the functionality of the M81's four single function V/I source and V/I measure modules into a single module that can be programmed in all four modes: Constant V or I source, V or I measure, DC and AC signals and with unique Lock-In detection like VM and CM modules.

This all in one SMU architecture can simplify wiring to samples and fixturing while avoiding changing modules and wiring when changing measurement modes. For 2-wire measurements, the SMU often reduces cabling and connection costs for many I-V characterization (such as a semiconductor device) applications.

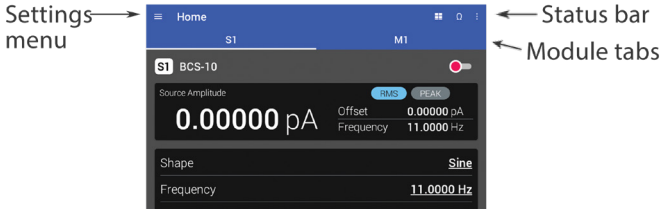
The SMU-10 is pictured below with a Lake Shore cryogenic probe station setup. Each probe arm uses a single triax connector and cable (blue/red cables) for each SMU connected to the sample device, and a single ground connection (black cables) between SMUs is all that is required for most I-V characterization setups.



Instrument connection

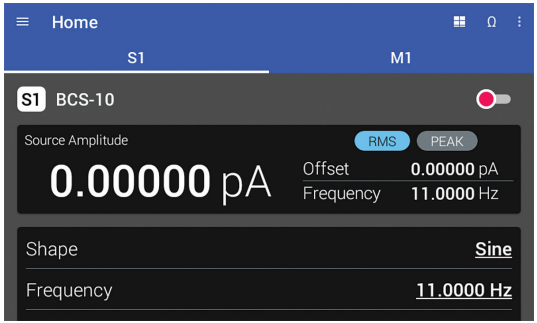
- Plug in the MeasureReady™ M81-SSM using the supplied power cord. The instrument will begin its power-up sequence. After the sequence is complete (this may take approximately 45 s during initial operation), the Home screen is displayed.
- Tap a module tab or swipe to navigate between modules.

NOTE: The screens you see may differ, depending on your software version. Some screens are scrollable.



Basic source operation

To configure a source module on the front panel, navigate to the tab for the module.
NOTE: Additional settings, as applicable to a specific module, will also be displayed.



Basic operations are described on the following pages. For more information, see the user's manual.

Enable/Disable

A source module's output can be enabled or disabled with the slider switch. When the switch is red, the output is disconnected and no excitation is applied. When the switch is green, the output is connected and excitation is applied.
NOTE: Make sure that other settings are configured appropriately before enabling the output.

Shape

The shape setting determines whether the output is a DC signal, or an AC signal (sine, triangle, or square).

Frequency

The source frequency can be set by tapping the frequency and entering a new frequency value.

Amplitude

When shape is DC, the amplitude directly sets the total excitation level. When shape is not DC, the amplitude sets the peak level of the excitation waveform.:

Offset

The offset is added to the excitation waveform allowing for simultaneous AC and DC excitation.
NOTE: Offset is not used if shape is DC and will be automatically configured to zero.

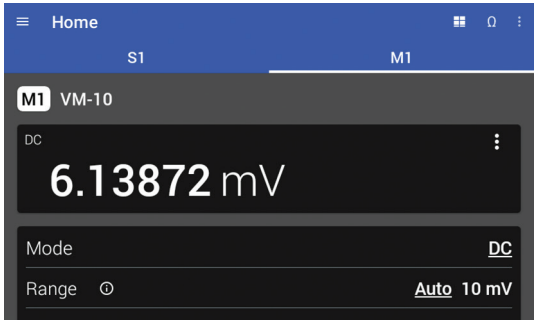
Basic measurement operation

To configure a measurement module on the front panel, navigate to the tab for the module.
NOTE: Additional measurement module settings will also be displayed.

The first setting is the Mode setting. The other settings displayed will change based on what is relevant in the selected mode.

M81 current and voltage measurement modules can be configured for DC, AC, or Lock-in detectiosn modes. To change the mode on the front panel, tap the mode and select the desired option..

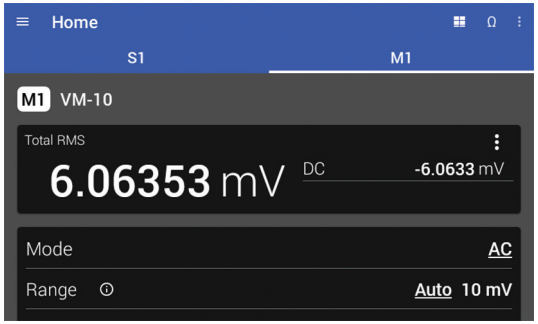
DC mode



Display
In DC mode, the display will show a single value, which is the DC indication.

Averaging time
The averaging time is specified in Number of Power Line Cycles (NPLC). Note that the M81 detects the power line frequency in your country. For example, if your power line frequency is 60 Hz, setting an averaging time of 30 NPLC would mean an averaging time of 0.5 s. For best rejection of line-related interference, an integer number of NPLC should be selected.

AC mode



Display

In AC mode, the display can be configured to show Total RMS and DC indications, or Peak to Peak and +Peak, -Peak indications. Tap the **Action** icon in the upper right hand corner of the screen to change what is displayed.

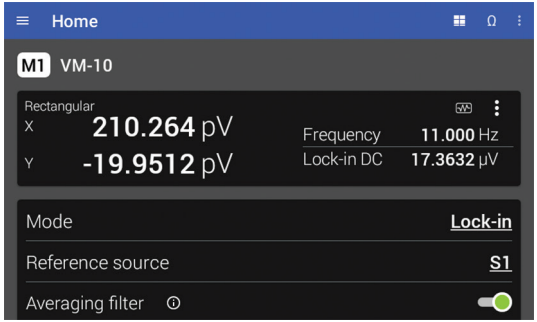
- Total RMS: the total power of the input signal, including AC and DC components within the averaging time
- DC: the DC level of the input signal
- +Peak: the highest input level detected during the averaging time
- -Peak: the lowest input level detected during the averaging time
- Peak to Peak: the span between the highest and lowest input levels detected during the averaging time

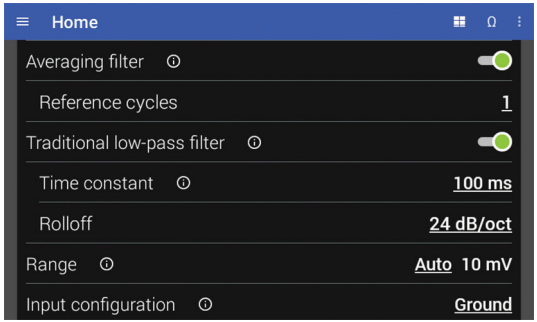
Averaging time

Averaging time is specified in Number of Power Line Cycles (NPLC). Note that the M81 detects the power line frequency in your country. For example if your power line frequency is 60 Hz, setting an averaging time of 30 NPLC would mean an averaging time of 0.5 s. For best rejection of line-related interference, an integer number of NPLC should be selected.

Lock-in mode

In Lock-in mode, the MeasureReady™ M81-SSM will detect signals which are coherent with the configured reference signal.





Display
In Lock-in mode, the display can be configured to show either rectangular coordinates (X, Y) or polar coordinates (R, θ). In addition, the % of Range and Frequency are always displayed. Tap the Action icon in the upper right hand corner of the display area to change what is displayed.

- X: the real (in phase) component of the detected signal
- Y: the imaginary (quadrature) component of the detected signal
- R: the magnitude of the detected signal
- θ: the phase of the detected signal relative to the reference signal
- % of Range: the amount of the present range being used by the total input signal, including any noise. Tap the value to switch to Lock-in DC.
- Frequency: the frequency of the reference signal
- Lock-in DC: the DC component of the detected signal. The averaging time of the DC compnonent is determined by the number of FIR cycles. Tap the value to switch to % of Range.

Reference source
The measure channel will detect frequencies which are coherent with the specified reference source. For example, if a sample is being excited with a current by S1, the reference source can be set to S1.

The reference source can also be set to Ref In. In this case, the source will track the frequency detected on the reference input.

Averaging Filter
When this filter is enabled, a separate FIR filter is applied to the PSD output in addition to the Traditional low-pass (standard IIR output) filter specified by the time constant and rolloff settings. This FIR filter is a moving average over a configurable number of cycles (periods) of the carrier frequency. This additional filter helps reject the carrier and harmonics of the carrier when making lock-in measurements.

Traditional low-pass filter
The traditional low-pass IIR filter is used to attenuate/reject signals outside of its pass band. Unlike the frequency response of the FIR filter, the IIR does not "bounce" and allow certain frequencies through. This means that if there is a large interfering signal, the IIR will remove it better than the FIR. However, because of the exponential settling behavior of the IIR filter, it can take a long time for a measurement to be acceptably settled.

Any input changes will remain in the IIR filter forever, getting smaller as time goes on but never going away completely. This means that large input disturbances can remain as errors in the lock-in measurement for a long time.

Time constant
The time constant setting determines the bandwidth of the PSD output filter. Longer time constants will result in lower Equivalent Noise Bandwidth (ENBW) at the cost of longer settle times. See the table, right.

Rolloff
The rolloff setting determines the slope of the PSD output filter in the stop band. Steeper rolloff will result in lower ENBW at the cost of longer settle times. Steeper rolloff will also provide better rejection of interfering signals that are near the frequency of interest.

For time constant T, the ENBW and time to settle to 1% are approximately:

Rolloff	Equivalent noise bandwidth (ENBW)	1% settle time
6 dB/oct	$\frac{1}{4T}$	5 T
12 dB/oct	$\frac{1}{8T}$	7 T
18 dB/oct	$\frac{3}{32T}$	9 T
24 dB/oct	$\frac{5}{64T}$	10 T

Reference harmonic
The reference harmonic can be set to detect signals at a frequency which is a harmonic of the reference. For example, if the reference frequency is 1 kHz, setting reference harmonic to 2 would result in detecting signals at 2 kHz which are coherent with the reference.

Reference phase shift
The reference phase shift is applied to the reference source before using the reference for demodulation.

Tap **auto** to set the phase shift to result in zero degrees of indicated angle. Note that the indication should be settled before tapping **auto**. Tap **clear** to set the phase shift to zero.

Remote operation

If desired, attach the the MeasureReady™ M81-SSM to your PC using Ethernet, USB-Type B, or GPIB.

- **USB-Type B:** implemented as a virtual serial com port connection. The USB driver is available through Windows® Update or from the web.

USB-Type B Serial port settings	
Baud rate	921,600
Data bits	8
Parity	None
Stop bits	1
Flow control	RTS/CTS

- **Ethernet:** provides a means of connecting the M81 to an Ethernet based computer network. The Ethernet interface provides the following capabilities:
  - Send SCPI commands via TCP socket
  - Use of the mobile app (coming soon)
  - Firmware updates

Ethernet settings	
IP address	DHCP or Manual
Port	7777

- **GPIB:** the M81 provides a GPIB interface for controlling the instrument from a computer via a GPIB controller.

GPIB settings	
Default address	12
Valid terminators	LF, CRLF, LF + EOI, CRLF + EOI, EOI

Remote access

The M81 adheres to the Standard Commands for Programmable Instruments (SCPI) standard. Once connected to your PC, the M81 can be remotely operated in the following ways:

Lake Shore Python driver

To install the Lake Shore Python driver, install python then run:

```
pip install lakeshore
```

For example, to get a DC reading from M1:

```
from lakeshore import SSMSystem

ssm = SSMSystem()
voltage_measure = ssm.get_measure_module(1)

print(voltage_measure.get_dc())
```

See full documentation for the python driver at: http://lake-shore-python-driver.readthedocs.io/

LabVIEW driver

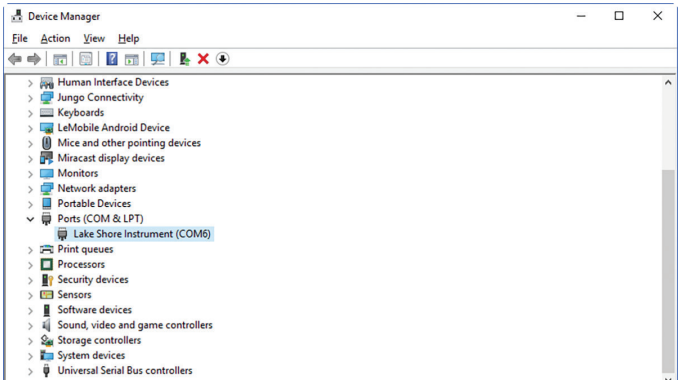
See full documentation for the LabVIEW driver at https://www.lakeshore.com/software.

MeasureLINK™-MCS software
MeasureLINK™-MCS software can be downloaded from https://www.lakeshore.com/software.

For more information, please see the MeasureLINK™-MCS Software Quick Start Guide, and the integrated Help files within MeasureLINK™-MCS software for specific scripting examples for the M81-SSM™.

Computer interface connections

The USB connection will be listed as a virtual COM port on your PC. If you are not able to connect, make sure you have the correct COM port selected. You can do this by checking Device Manager:



If you are unable to see the M81-SSM in this view, you may need to install the USB driver that can be found on the Lake Shore Software web page: http://www.lakeshore.com/software/.

Contacting Lake Shore

The Lake Shore Technical Support Department is staffed Monday through Friday between the hours of 8:00 a.m. and 5:00 p.m. EST, excluding holidays and company shut down days: https://www.lakeshore.com/support/.

The Lake Shore Forum is also a great place to look for solutions, to post issues, and to share successes: http://forums.lakeshore.com/.

For further documentation and information, please see https://www.lakeshore.com/M81/.

Lake Shore Technical Support

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