Keysight M8121A Arbitrary Waveform Generator

User Guide

KEYSIGHT TECHNOLOGIES

Notices

Manual Part Number

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CAUTION

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

WARNING

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

Safety Summary

The following general safety precautions must be observed during all phases of operation of this instrument. Failure to comply with these precautions or with specific warnings or operating instructions in the product manuals violates safety standards of design, manufacture, and intended use of the instrument. Keysight Technologies assumes no liability for the customer's failure to comply with these requirements. Product manuals are provided with your instrument on CD-ROM and/or in printed form. Printed manuals are an option for many products. Manuals may also be available on the Web. Go to www.keysight.com and type in your product number in the Search field at the top of the page. Safe operation and the general safety precautions for the M9502A and M9505A AXIe chassis, must be followed. See: http://www.keysight.com/find/M9505A.

WARNING **To ensure mandatory safety requirements are being met, the module must be installed in a chassis which has been certified and marked by a Nationally Recognized Testing Lab (such as CSA, UL, TUV, ETL etc.) in which all the means of protection are properly implemented.**
NOTE: CE marking alone is not adequate.

NOTE This product has been designed and tested in accordance with accepted industry standards, and has been supplied in a safe condition. The documentation contains information and warnings that must be followed by the user to ensure safe operation and to maintain the product in a safe condition.

Initial Inspection

Inspect the shipping container for damage. If there is damage to the container or cushioning, keep them until you have checked the contents of the shipment for completeness and verified the instrument both mechanically and electrically. The Performance Tests give procedures for checking the operation of the instrument. If the contents are incomplete, mechanical damage or defect is apparent, or if an instrument does not pass the operator's checks, notify the nearest Keysight Technologies Sales/Service Office.

WARNING To avoid hazardous electrical shock, do not perform electrical tests when there are signs of shipping damage to any portion of the outer enclosure (covers, panels, etc.).

General

The protective features of this product may be impaired if it is used in a manner not specified in the operation instructions.

Laser Safety Information

Class 1 Laser product according IEC60825-1 (2007).

ESD Sensitive Device

All front-panel connectors of the M8121A are sensitive to Electrostatic discharge (ESD). There are also several exposed components on the PCAs, on both sides of M8121A, which can be touched accidentally while handling the unit and can risk damage to the instrument, due to ESD. It is recommended to operate the instrument in an electrostatic safe environment. There is a risk of instrument malfunction when touching a connector or side components. Please follow this instruction described in the "ESD Protection" section under "M8121A Maintenance".

Environment Conditions

This instrument is intended for indoor use in an installation category II, pollution degree 2 environment. It is designed to operate within a temperature range of 0 °C – 40 °C (32 °F – 105 °F) at a maximum relative humidity (non-condensing) of 95% up to 40 °C and at altitudes of up to 2000 meters.

This module can be stored or shipped at temperatures between -40 °C and +70 °C. Protect the module from temperature extremes that may cause condensation within it.

Before Applying Power

Verify that all safety precautions are taken. The power cable inlet of the instrument serves as a device to disconnect from the mains in case of hazard. The instrument must be positioned so that the operator can easily access the power cable inlet. When the instrument is rack mounted the rack must be provided with an easily accessible mains switch.

Line Power Requirements

The Keysight M8121A operates when installed in a Keysight AXIe mainframe.

Do Not Operate in an Explosive Atmosphere

Do not operate the instrument in the presence of flammable gases or fumes.

Do Not Remove the Instrument Cover

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made only by qualified personnel.

Instruments that appear damaged or defective should be made inoperative and secured against unintended operation until they can be repaired by qualified service personnel.

Ground the Instrument

To minimize shock hazard, the instrument chassis and cover must be connected to an electrical protective earth ground. The instrument must be connected to the ac power mains through a grounded power cable, with the ground wire firmly connected to an electrical ground (safety ground) at the power outlet. Any interruption of the protective (grounding) conductor or disconnection of the protective earth terminal will cause a potential shock hazard that could result in personal injury.

Instrument Markings

The table below lists the definitions of markings that may be on or with the product.

Table 1 Instrument Markings

Symbol	Description
	The instruction documentation symbol. The product is marked with this symbol when it is necessary for the user to refer to the instruction in the documentation.
	Frame or chassis ground terminal. Typically connects to the equipment's metal frame.
	South Korean Certification (KC) mark; includes the marking's identifier code which follows this format: R-R-Kst-ZZZZZZZZZZZZZ
	Indicates that anti-static precautions should be taken.
	China Restricted Substance Product Label. The EPUP (environmental protection use period) number in the center indicates the time period during which no hazardous or toxic substances or elements are expected to leak or deteriorate during normal use and generally reflects the expected useful life of the product.
	The RCM mark is a registered trademark of the Australian Communications and Media Authority.
	Hazardous laser radiation.
	Caution, hot surface. In case the system is running for a longer time, the surface (cover and bottom) of the module can heat up to 60 degree. Therefore, the user should carefully remove the module from the AXIe chassis.

Symbol	Description
	The CSA mark is a registered trademark of the CSA International.
	The CE mark is a registered trademark of the European Community (if accompanied by a year, it is the year when the design was proven). This product complies with all relevant directives.
	Universal recycling symbol. This symbol indicates compliance with the China standard GB 18455-2001 as required by the China RoHS regulations for paper/fiberboard packaging.
IP x y	The instrument has been designed to meet the requirements of "IP x y", where "x" is the solid particle protection and "y" is the liquid ingress protection.
ISM 1-A	This is a symbol of an Industrial Scientific and Medical Group 1 Class A product. (CISPR 11, Clause 5)
ICES / NMB-001	This is a marking to indicate product compliance with the Canadian Interference-Causing Equipment Standard (ICES-001)
ccr.keysight@keysight.com	The Keysight email address is required by EU directives applicable to our product.
	This symbol indicates separate collection for electrical and electronic equipment, mandated under EU law as of August 13, 2005. All electric and electronic equipment are required to be separated from normal waste for disposal (Reference WEEE Directive, 2002/96/EC). Do not dispose in domestic household waste. To return unwanted products, contact your local Keysight office, or see http://about.keysight.com/en/companyinfo/environment/takeback.shtml for more information.

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3 Soft Front Panel

4 Markers

5 Digital Up-Conversion (Requires option DUC)

6 Remote Programming

1 Introduction

This chapter provides an overview of M8121A Arbitrary Waveform Generator.

M8121A Overview

The Keysight M8121A is a 12 GSa/s AWG (Arbitrary Waveform Generator) with full bandwidth streaming capability. It combines excellent signal fidelity with high sampling rates, and with its ability to stream data over a full bandwidth interface, can generate signals of indefinite length.

Conventional AWGs have a certain amount of built-in waveform memory that allows the user to generate pre-calculated waveform segment(s) under the control of a sequencer. But no matter how large the memory of an instrument is, it is a finite resource and eventually a loop will occur. Even the most complex sequencing engine does not eliminate this basic limitation.

The M8121A uses a different approach: Instead of a built-in memory, it offers a full rate Optical Data Interface (ODI) to supply the samples to the DAC at up to 12 GSa/s, which enables infinitely long scenarios to be generated with up to approx. 5 GHz of modulation bandwidth.

Key Features

The M8121A is a 12 GSa/s Arbitrary Waveform Generator with the following key features:

- 1 or 2 channel AWG module with
  - 14-bit resolution up to 8 GSa/s
  - 12-bit resolution up to 12 GSa/s
- Variable sample rate from 1 GSa/s to 12 GSa/s
- Internal broadband clock synthesizer
- Optional low-phase-noise clock input
- Optional real-time digital signal processing in Keysight Technologies, Inc. proprietary ASIC for Digital up-conversion to IF
- Form-factor: 2 slot AXIe module, controlled via external PC or AXIe system controller

Optical Data Interface (ODI)

- 160 Gb/s optical streaming interfaces
- Supports full rate, gapless streaming of samples into the M8121A from compatible storage, DSP or digitizer devices or custom hardware

Two Output Paths for Different Applications

- Direct DAC – optimized for best SFDR & HD
  - Amplitude 350 mV_{pp} ... 700 mV_{pp}, offset –20 mV ... +20 mV
  - Differential output
- Optional DC coupled amplifier
  - Amplitude 500 mV_{pp} ... 1.0 V_{pp}
  - Output voltage window: –1.0 V ... +3.3 V
  - Differential output

Feature Options

The following feature options are available for the current release of M8121A:

Table 2 M8121A feature options

Option	Functionality
001	1 channel
002	2 channel
08G	8 GSa/s, 12 or 14 bit
12G	12 GSa/s, 12 or 14 bit to < 8 GSa/s, 12 bit >= 8 GSa/s
AMP	DC amplifier
DUC	Digital Up-Conversion
LPN	Low Phase Noise

DAC Format Modes

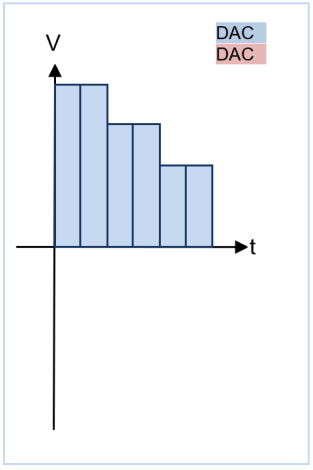
Each channel internally uses two DACs (A & B). Each DAC usually contributes to the signal 50% of a sample period.

The following three DAC format modes are available:

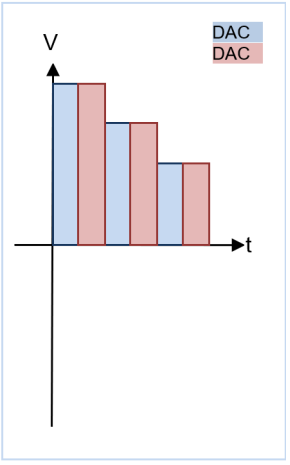
- NRZ (Non Return to Zero)
- DNRZ, (Double NRZ)
- Doublet

For more details on the DAC format modes, refer to the section “Dual-Core DAC Architectures” in the Fundamentals of Arbitrary Waveform Generation Reference Guide (Manual Part No. M8190-91050).

NRZ: DAC A sends value for whole sample period



DNRZ: DAC A and B send same value



Doublet: DAC A sends +Value, DAC-B sends –Value

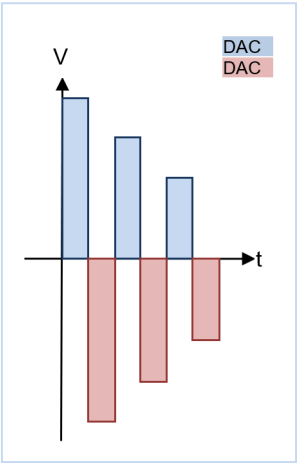


Figure 1 DAC Format Modes

The three modes have different amplitude vs. frequency responses, which are shown in the following figure:

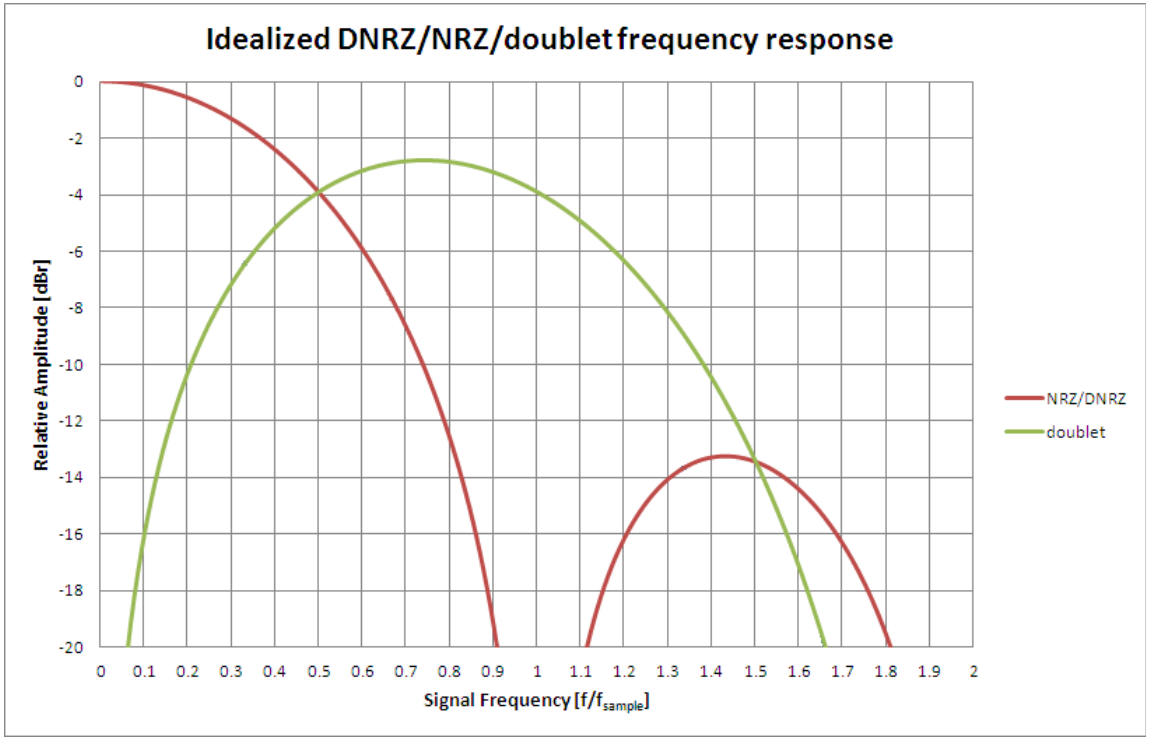


Figure 2 DNRZ/NRZ/Doublet Frequency Response

NOTE This is only comparing the idealized response of the modes, and ignores the roll off due to finite switching rise times, output RC time constant and other losses.

DNRZ Best signal performance in 1st Nyquist region

$$ideal\ frequency\ response = \frac{Sin\ (x)}{x}$$

NRZ For time domain applications, less ripple at 2 f_{sample}, more distortions than DNRZ

$$ideal\ frequency\ response = \frac{Sin\ (x)}{x}$$

Doublet More output power and flatter frequency response in 2nd Nyquist region

$$ideal\ frequency\ response = Sin\ \frac{(\frac{x}{2})^2}{(\frac{x}{2})}$$

Front Panel

Figure 3 on page 17 illustrates the front panel of the M8121A instrument.

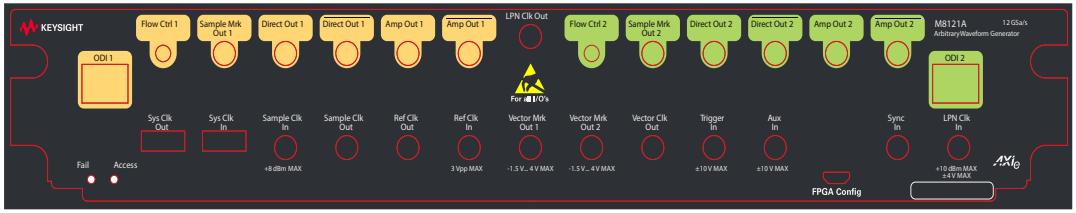


Figure 3 M8121A front panel

The M8121A front panel includes the following input/output ports:

Inputs/Outputs

- **Flow Ctrl** - This port is reserved for future use.
- **Sample Mrk Out** - The two Sample Marker Out ports (Sample Mrk Out 1/2) can be used to mark the beginning of a certain position in the analog signal. It has timing resolution of one sample clock cycle. The Marker signal can be used to trigger external equipment.
- **Direct Out** - The two Direct Out ports (Direct Out 1/2) are the differential outputs of the two digital to analog converters. The outputs can be switched ON or OFF.
- **Amp Out** - The two Amplifier Out ports (Amp Out 1/2) are the amplified output signals of the DAC. Amp Out is available if option -AMP is installed. Option -AMP is SW upgradeable.
- **LPN Clk Out** - The LPN (Low Phase Noise) Clock Output can be used to output the clock signal from the LPN clock input. For convenience, a semi-rigid cable that connects between LPN Clk Out and Sample Clk In is provided to allow users to programmatically switch between LPN clock and Sample Clk In without re-cabling. The LPN ports are only available if option -LPN is installed. Option -LPN is SW upgradeable.
- **ODI** - The two Optical Data Interface ports (ODI 1/2) can be used to connect to other ODI ports that provide streaming waveform data.
- **Sys Clk Out** - This port is reserved for the future use.
- **Sys Clk In** - This port is reserved for the future use.
- **Sample Clk In** - The Sample Clock Input can be used if an external clock source shall be used to clock the analog to digital to converters. Clock to data delay control is available when using Sample Clk In.

- **Sample Clk Out** - The Sample Clock Output provides the clock selected for use in the M8121A.
- **Ref Clk In** - The Reference Clock Input can be used to synchronize to an external clock.
- **Ref Clk Out** - The Reference Clock Output can be used to synchronize a DUT to the M8121A.
- **Vector Mrk Out** - This port has a similar functionality as the sample Marker Output. It has timing resolution of 64 sample clock periods for direct 14- and 12-bit modes, and 32 I/Q sample pairs for DUC modes.
- **Vector Clk Out** - The Vector Clock Output can be used to synchronize with external customer DUT.
- **Trigger In** - This port is reserved for future use.
- **Aux In** - This port is reserved for future use.
- **Sync In** - This port is reserved for future use.
- **LPN Clk In** - This port is used when the "Low Phase Noise External" is selected as the Sample Clock source. Low phase noise (LPN) is used with an externally connected high quality clock. Clock to data delay control is not available when using LPN Clk In. LPN is available if Option -LPN is installed. Option -LPN is software upgradeable.
- **FPGA Config** - This port is reserved for future use.

LEDs

The M8121A front panel includes the following LEDs:

- **Status LEDs**

  The "Fail" and "Access" LEDs are available at the front panel to indicate the status of the M8121A module:

  - The green 'Access' LED indicates that the controlling PC exchanges data with the M8121A module. This LED blinks after power on, and remains solid after the module's PCIe endpoint has enumerated on the bus and is ready for communication.
  - The red 'Fail' LED is 'ON' for about 2 seconds after powering the AXIe chassis. After about 2 seconds the red LED is switched 'OFF'. During normal operation of the module this LED is 'OFF'. In case of an error condition such as e.g. a self-test error, the LED is switch 'ON'.

Related Documents

To access documentation related to the Keysight M8121A AWG, use one of the following methods:

- **CD** - Browse the product CD for M8121A documentation.
- **Start** > **All Programs** > **Keysight M8121** > **Keysight M8121 Documentation** - Provides links to all product documentation.
- **Start** > **All Programs** > **Keysight M8121** > **Keysight M8121 Examples** - Provides example waveform files.
- Go to the product web site (www.keysight.com/find/M8121A) and browse the manuals under **Document Library** tab.

Additional Documents

Additional documentation can be found at:

- http://www.keysight.com/find/M9502A for 2-slot chassis related documentation.
- http://www.keysight.com/find/M9505A for 5-slot chassis related documentation.
- http://www.keysight.com/find/M9514A for 14-slot chassis related documentation.
- http://www.keysight.com/find/M9537A for embedded AXIe controller related documentation

2 Installation and Maintenance

This chapter explains the steps required to install M8121A software package.

Pre-Requisites

The following are the pre-requisites for installing Keysight M8121A software:

The supported operating systems are:

- Windows 10 (64 bit)
- Windows 8.1 (64 bit)
- Windows 7 (64 bit)

Ensure that you have **Keysight IO Libraries Suite** version 18.0 or higher installed on your system. The **Keysight IO Libraries Suite** can be found on the CD that is part of shipment content or at http://www.keysight.com/find/iosuite

NOTE Even if a non-Keysight I/O library is already installed on your PC, it is still necessary to install the Keysight I/O library. The Keysight I/O library will install as “secondary” I/O library in this case.

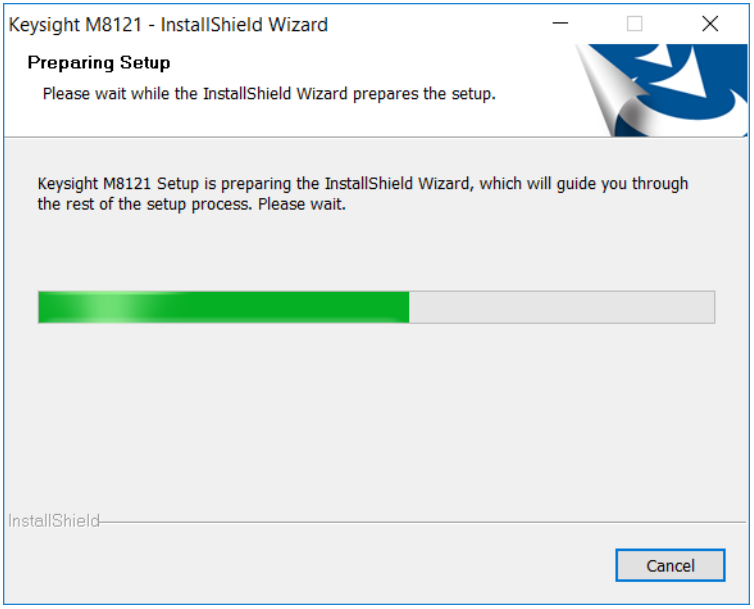
Installation Process

Follow the given steps to install Keysight M8121A software on your system:

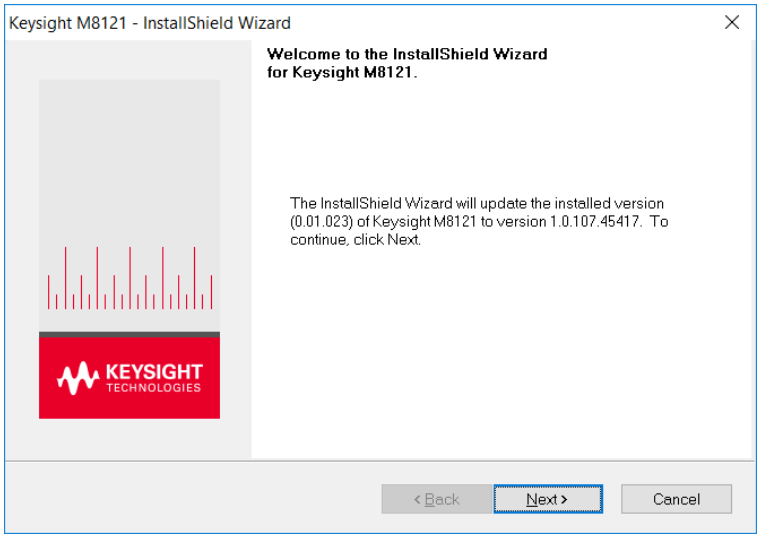
1 Double-click the executable (*M8121A_Setup.exe*). This executable file is available either on CD or Web.

NOTE **The installer will first check and list some pre-requisites. Click Install to install them. It is possible that your PC requests a reboot during this step. Reboot your PC, if requested.**

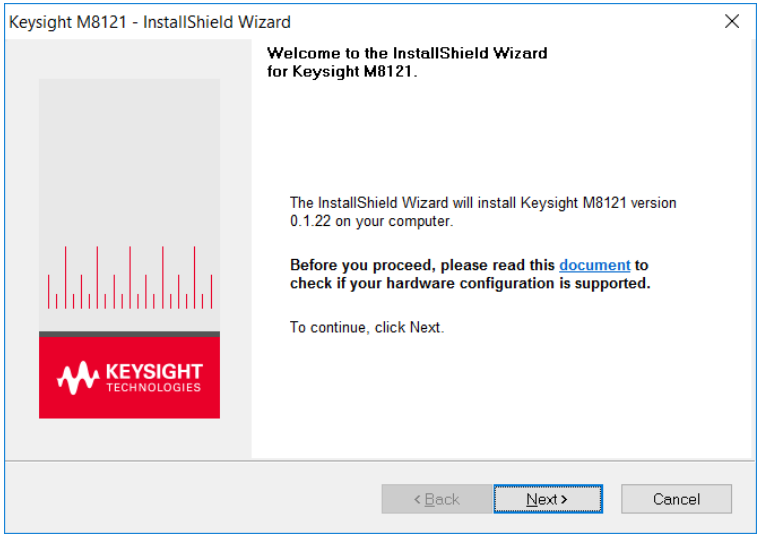
2 The Keysight **M8121A Setup** will prepare the **InstallShield Wizard** for the installation process. The following window will appear.



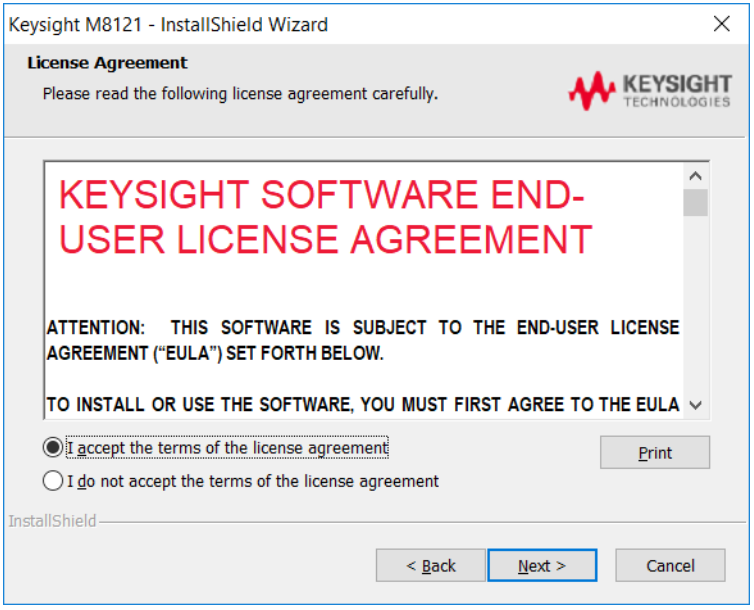
3 Follow the on-screen instructions to begin the installation process. Click **Next**.



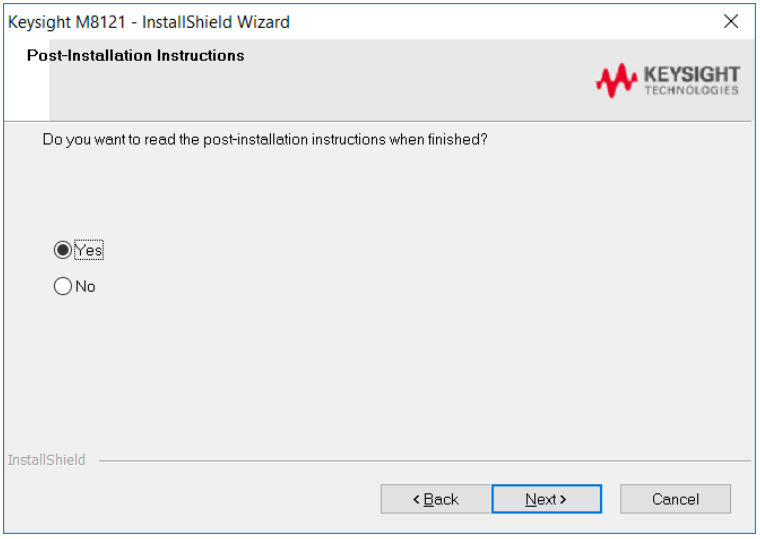
4 We recommend you to read the document to check if your hardware configuration is supported. Click **Next** to proceed to the license agreements.



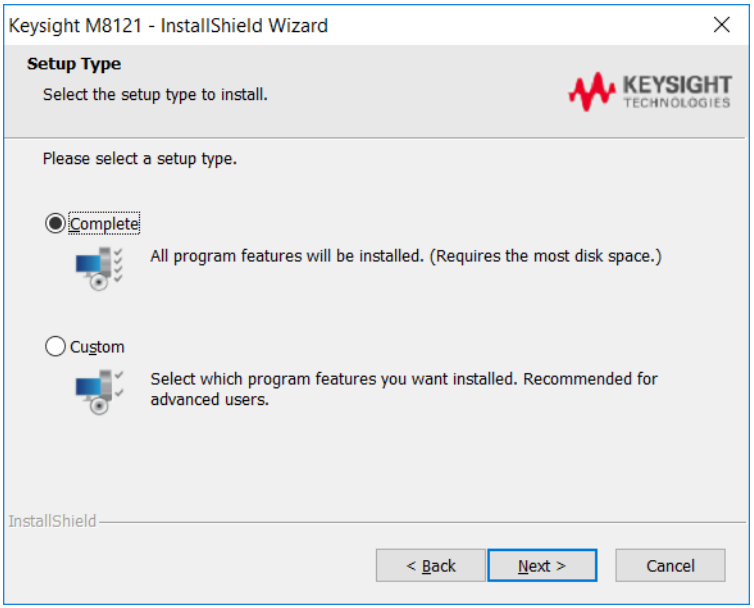
5 Accept the terms of Keysight software end-user license agreement and click **Next**.



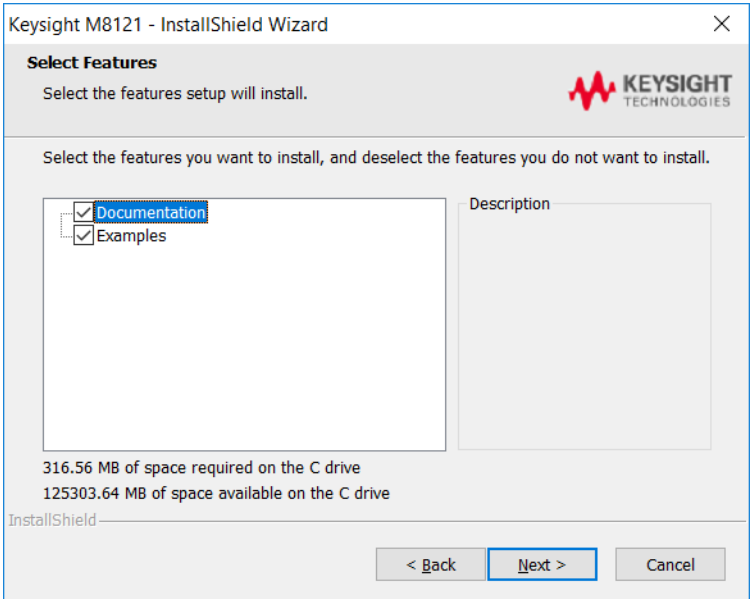
6 Select **Yes** if you want to read the post-installation instructions when finished. Click **Next** to select setup type.



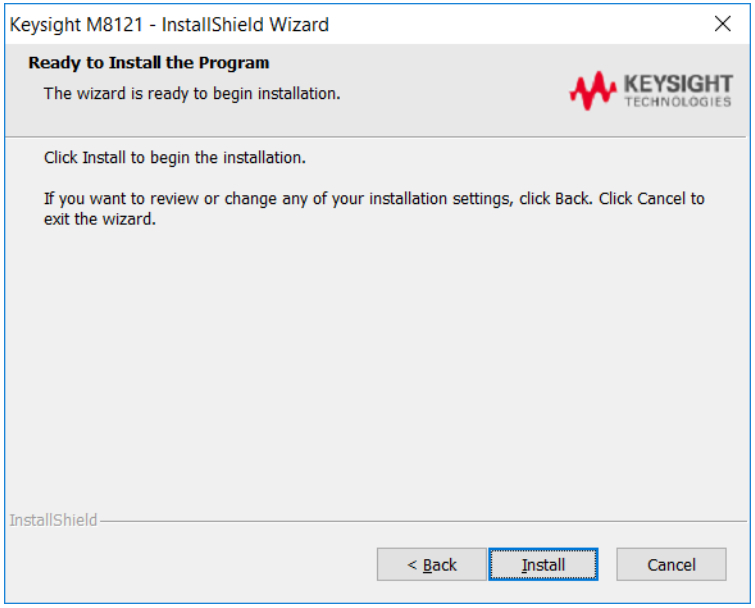
7 Select a setup type either **Complete** or **Custom**. Click **Next**.



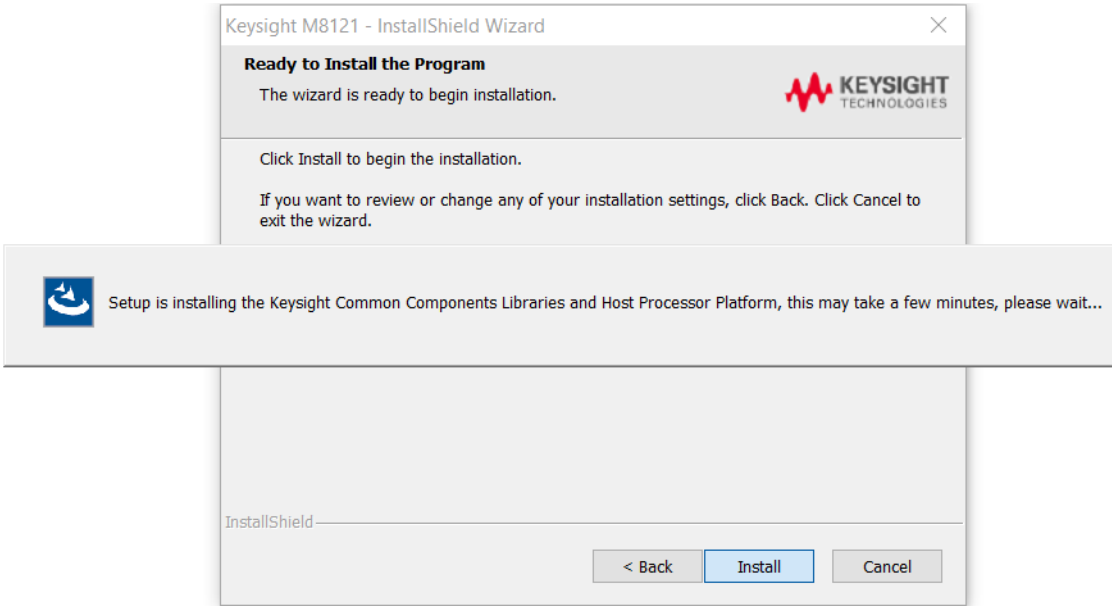
8 If you select **Custom** and click **Next**, you can specify which optional features will be installed:



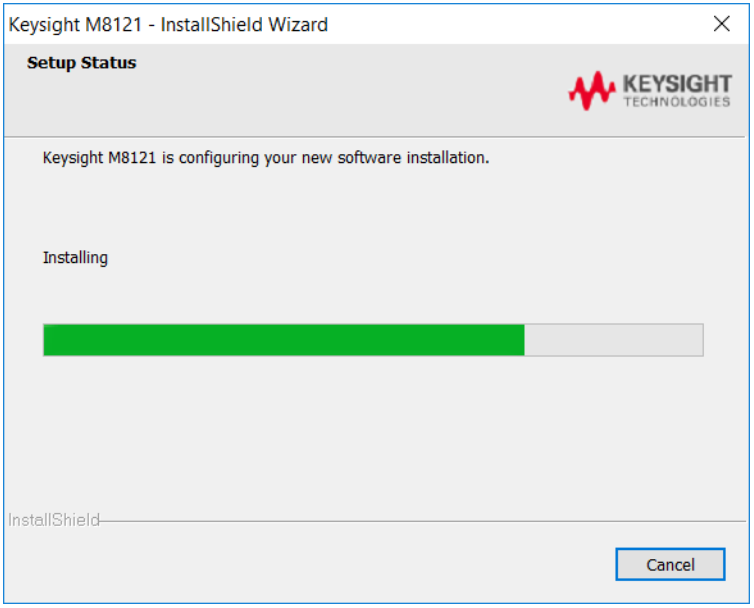
9 Click **Next** to begin installation.



10 The **Setup Wizard** will now install M8121A.

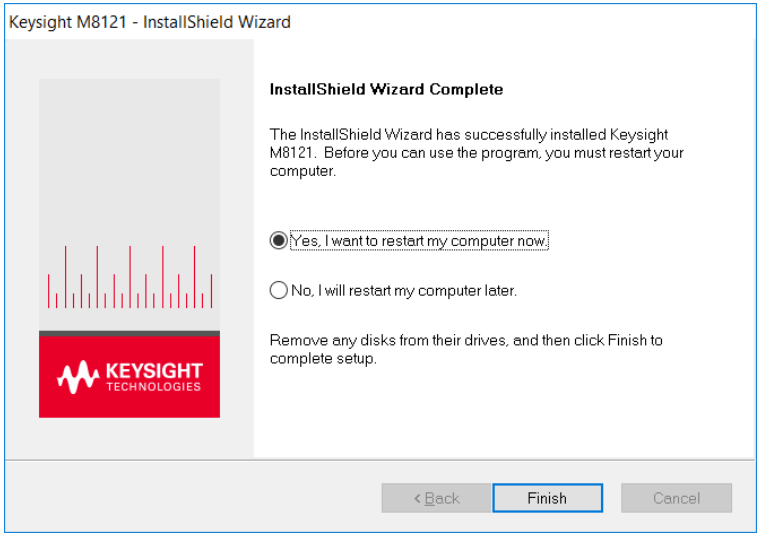


11 The Keysight M8121A will configure the new software installation.



The following screen will appear once the Keysight M8121A software is successfully installed on your system.

Click **Finish** to restart your system. Do not connect the AXIe chassis to your system using the PCIe cable during this reboot.



12 This completes the Keysight M8121A software installation.

Post Installation Steps

Follow the post installation steps as shown below:

1 Shut down PC and instrument.

2 Connect the instrument to the PC using the PCIe cable.

3 Switch on the instrument. Wait until the 'Access' LED is solid green (no longer flashing). Red indicates an error condition.

4 Switch on the PC.

5 The PC should automatically recognize the instrument.

Check this in the device manager; e.g. via **Start** > **Control Panel** > **Device Manager**, or right-click **Computer** > **Manage** > **Device Manager**.

The instrument should be visible in the device tree as **Keysight Technologies Modular Devices** > **M8121A**

NOTE Post installation steps must be followed strictly in the same order as mentioned for successful connection of the PC with M8121A.

NOTE Your PC might request a reboot. Reboot your PC, if requested.

6 Check if the M8121A is also visible in the Keysight Connection Expert application.

7 If something went wrong and the instrument is not showing in the Instruments tab in Keysight Connection Expert, it may be necessary to reboot the PC once more.

How to use the M8121A Instrument

In order to use the instrument:

1 When using the PCIe link to control the M8121A, the AXIe chassis must be switched on before you start the PC. The green status LED on the M8121A front panel must change from blinking to solid before switching on the external PC.

2 Start the M8121A application (**Start** > **All Programs** > **Keysight M8121** > **Keysight M8121**). The user interface will display the VISA resource strings for different kinds of connections (there may be more than one, depending on what the PC is connected to, and what other AXIe modules are in the chassis). Select the **M8121A**. For more details, see the section Launching the M8121A Soft Front Panel on page 40.

NOTE You must start the M8121A application in order to send SCPI commands to the instrument. The connection string can be found in the “About” Box.

M8121A Maintenance

This system should be serviced only by authorized personnel.

WARNING Using controls or adjustments or performing procedures other than those specified in the documentation supplied with your equipment can result in hazardous radiation exposure.

ESD Protection

CAUTION All the connectors are very sensitive to electrostatic discharge (ESD). There are also several exposed components on the PCAs, on both sides of the M8121A, which can be touched accidentally while handling the unit and can risk damage to the instrument, due to ESD. When you connect a device or cable that is not fully discharged to these connectors, you risk damage to the instrument and expensive instrument repairs.

CAUTION Electrostatic discharge (ESD) can damage the circuits of the M8121A. Avoid applying static discharges to the front-panel connectors. Avoid touching the front-panel connectors without first touching the frame of the instrument. Be sure the instrument and all connected devices (DUT, etc.) are properly earth-grounded (to a common ground) to prevent buildup of static charge and electrical over-stress.

Electrostatic discharge (ESD) can damage or destroy electronic components. All work on electronic assemblies should be performed at a static-safe work station. The following list and figure shows an example of a static-safe work station using two types of ESD protection. Purchase acceptable ESD accessories from your local supplier.

- Conductive table-mat and wrist-strap combination.
- Conductive floor-mat and heel-strap combination.

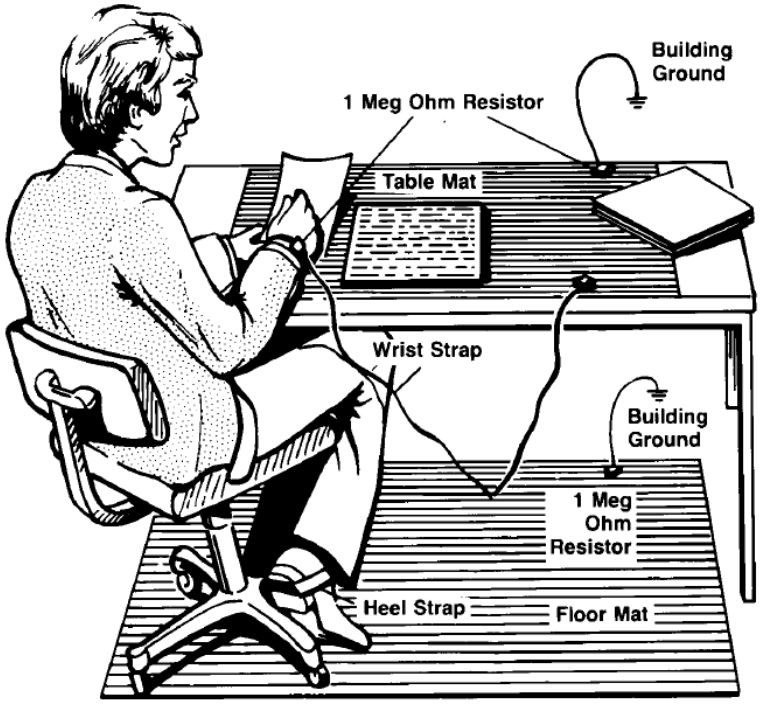


Figure 4 ESD protection

Both types, when used together, provide a significant level of ESD protection. Of the two, only the table-mat and wrist-strap combination provides adequate ESD protection when used alone. To ensure user safety, the static-safe accessories must provide at least 1 MW of isolation from ground.

WARNING These techniques for a static-safe work station should not be used when working on circuitry with a voltage potential greater than 500 volts.

Power and Ventilation Requirements

For power and ventilation requirements, refer to:

- http://www.keysight.com/find/M9514A for 14-slot chassis related documentation.
- http://www.keysight.com/find/M9505A for 5-slot chassis related documentation.
- http://www.keysight.com/find/M9502A for 2-slot chassis related documentation.

Thermal Protection

Overheating Detection

The instrument monitors its internal temperature. If the temperature exceeds what the instrument can tolerate, the power supply is switched off. The instrument will not turn on automatically if the temperature is decreasing again.

Fan Failure

If a fan is broken or prevented from operating by a blockage the temperature will increase. When the temperature exceeds what the instrument can tolerate, the overheating detection switches off the instrument for safety reasons. For reliability it is recommended to send instruments with broken or defective fans immediately to Keysight Service for repair.

Battery

The M8121A module does not have a battery.

Operating Environment

For details on the operating environment for the M8121A module, refer to the section Operating Environment on page 139.

Fiber Optic Connector Care for Optical Data Interface (ODI)

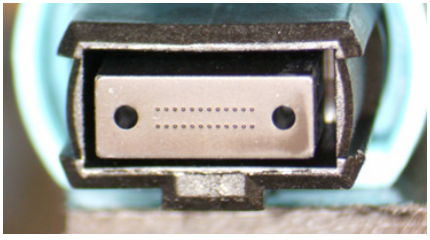
The fiber optic connector care is vital to maintain good measurements and avoid costly repairs caused by damage to fiber optic connectors on optical test equipment.

Improper connector care, cleaning, or use of mismatched cable connectors can invalidate the published specifications and damage connectors. Clean all cables before applying to any connector. Repair of damaged connectors due to improper use is not covered under warranty.

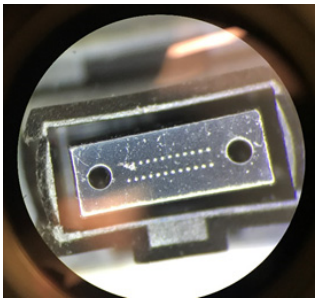
Treat all fiber-optic connectors like the high-quality lens of an expensive camera. Damage to the connectors on calibration and verification devices, test ports, cables, and other devices can:

- Degrade measurement accuracy and repeatability and
- Cause expensive damage to instruments.

Because fiber-optic connectors are susceptible to damage that is not immediately obvious to the naked eye, it is very easy to make bad measurements without being aware of a connector problem. Learning about proper handling and cleaning techniques will help you to avoid any degradation in connector performance. With glass-to-glass interfaces, any damage of the ferrule or end of the fiber, any stray particles, or finger oil can have a significant effect on fiber-optic connectors.



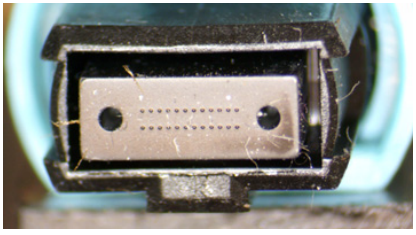
This picture shows the end of a clean, problem-free fiber-optic connector.



This picture shows physical damage to the glass fiber end of the optical cable caused by either repeated connections made without removing loose particles from the fiber end or by using improper cleaning processes.

This damage can be severe enough to transfer the damage from the connector end to a good connector with which it comes in contact.

The cure for these problems is disciplined connector care. Visual inspection of fiber ends can be helpful. Contamination or imperfections on the cable end face can be detected as well as cracks or chips in the fiber itself. Use a microscope to inspect the entire end face for contamination, scratches on the fiber core, raised metal or dents, and any other imperfections.



Visible imperfections not touching the fiber core may not affect performance unless the imperfections keep the fibers from contacting.

Guidelines

- Use a fiber-optic inspection scope to visually inspect the fiber-optic end.
- Always remove both ends of fiber-optic cables from any instrument, system, or device before visually inspecting the fiber ends. Disable all optical sources before disconnecting fiber-optic cables. Failure to do so may result in permanent injury to your eyes.
- Keep all fiber-optic connectors clean using professional fiber-optic cleaning products. Many products are available and are easily located via an Internet search on "fiber optic cleaning products". You can purchase tools designed specifically for the type of fiber-optic connector that you are using. For the 24-fiber MPO interface, purchase one for MPO II – MTP® Brand Connectors.
- Never use metal or sharp objects to clean a connector and never scrape the connector.

- When inserting a fiber-optic cable into a connector:
  - Gently insert it in as straight a line as possible. Tipping and inserting at an angle can scrape material off the inside of the connector or even break the inside sleeve of connectors made with ceramic material.
  - Ensure that the fiber end does not touch the outside of the mating connector or adapter.

Cleaning

WARNING **If flammable fluids are used to clean connectors, the fluid shall not be placed on the instrument during use or when connected to mains voltage. Cleaning the connectors shall take place in ventilated area to allow fluid vapors to dissipate and reduce the risk of fire.**

Keep all fiber-optic connectors clean using professional fiber-optic cleaning products. Many products are available and are easily located via an Internet search on "fiber optic cleaning products". You can purchase tools designed specifically for the type of fiber-optic connector that you are using. For the 24-fiber MPO interface, purchase one for an MTP connector.

Fiber Optic inspection scopes are available which can give a very clean view of the fiber end and even provide some analysis capability.

WARNING **Always remove both ends of fiber-optic cables from any instrument, system, or device before visually inspecting the fiber ends. Disable all optical sources before disconnecting fiber-optic cables. Failure to do so may result in permanent injury to your eyes.**

3 Soft Front Panel

This chapter describes the M8121A Soft Front Panel.

Launching the M8121A Soft Front Panel

Select **Start** > **All Programs** > **Keysight M8121** > **Keysight M8121** from the **Start** menu.

The following **Connect to Instrument** dialog will appear:

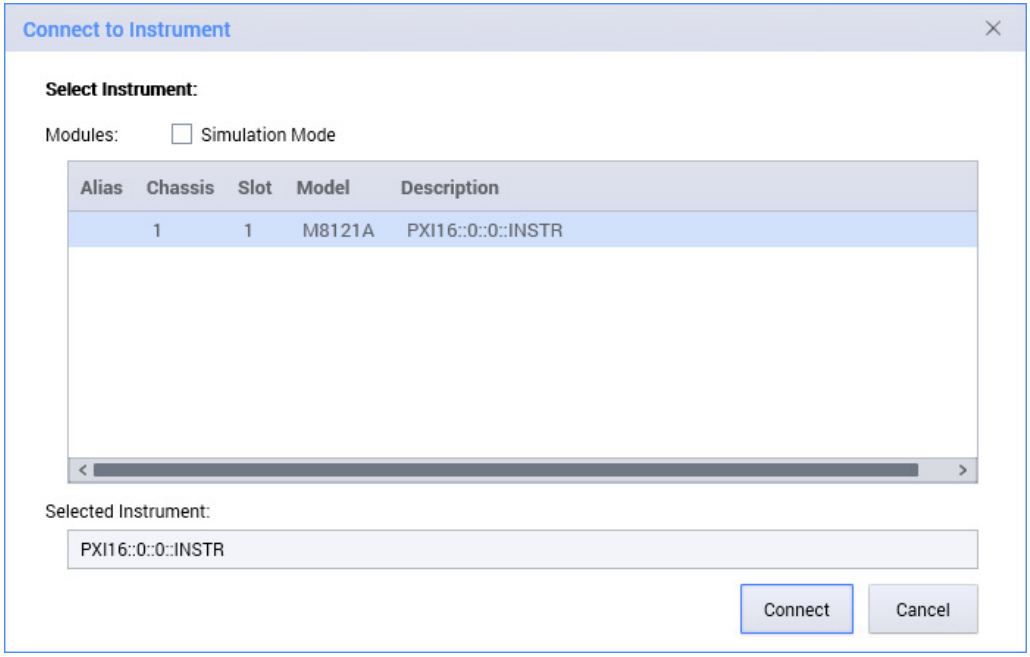


Figure 5 M8121A connected to PC

This dialog shows the addresses of the discovered M8121A modules. Select a module from the list and click "**Connect**".

If no M8121A module is connected to your PC, you can select "**Simulation Mode**" to simulate an M8121A module.

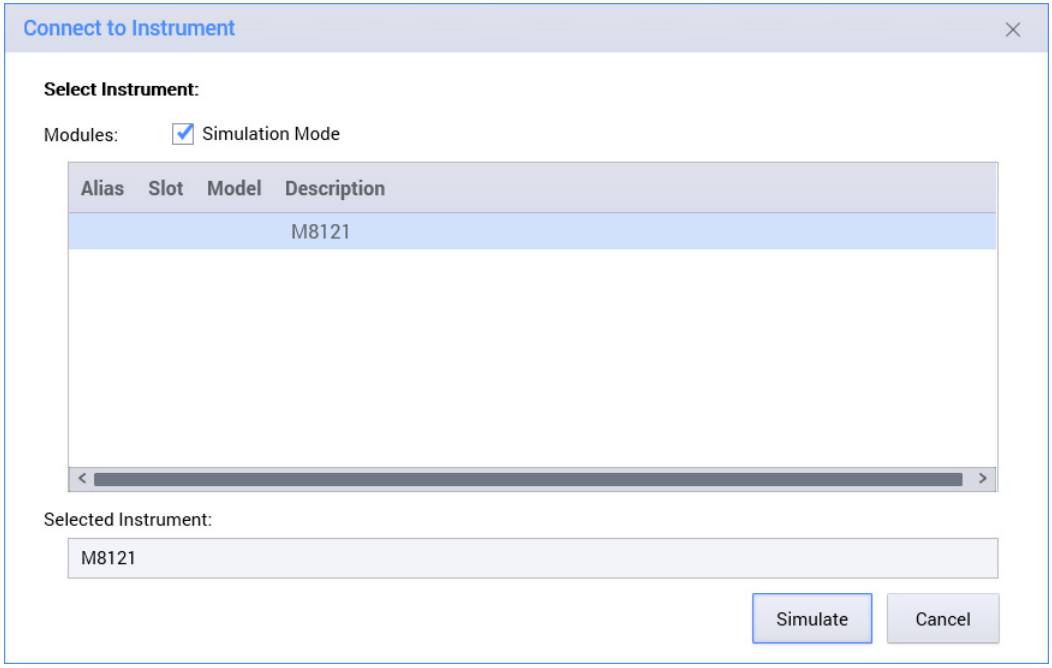


Figure 6 M8121A connected in simulation mode

Next, a M8121A software startup screen will be displayed as shown in Figure 7 on page 42.

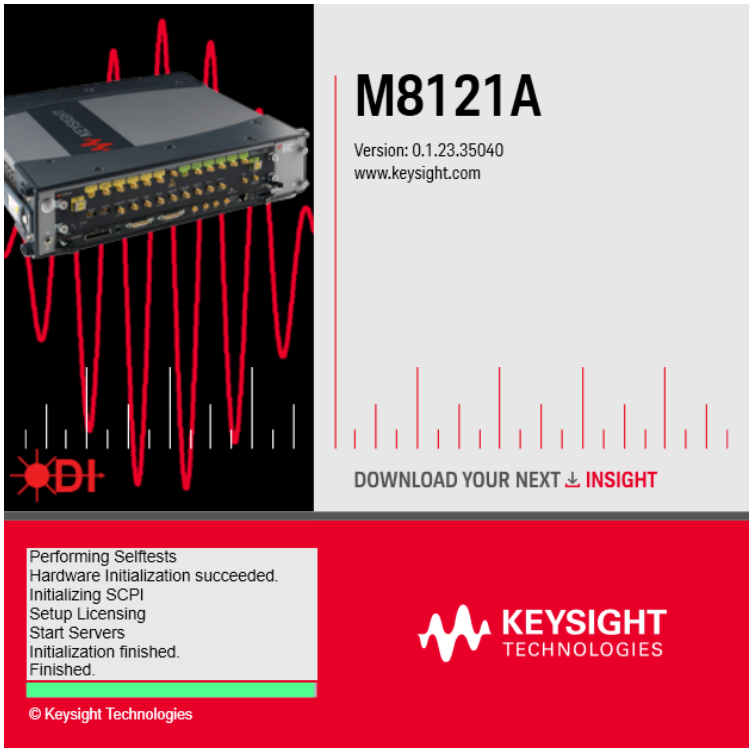


Figure 7 M8121A startup screen

M8121A Soft Front Panel

The **M8121A Soft Front Panel** and its GUI elements are illustrated in Figure 8 on page 43.

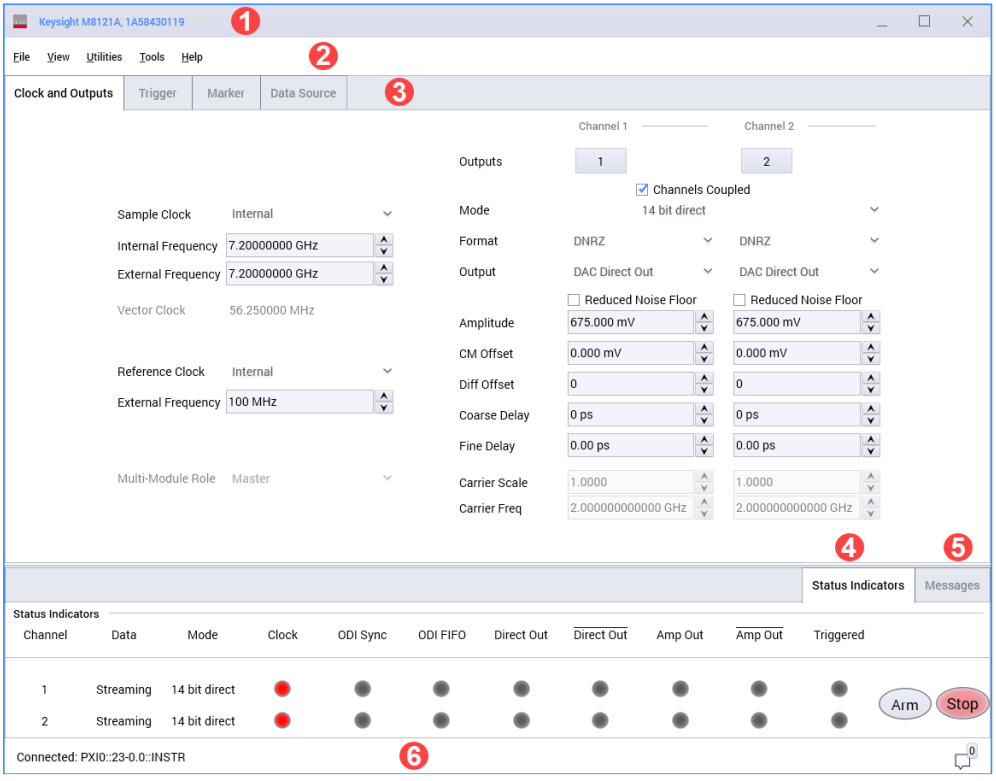


Figure 8 M8121A user interface

The M8121A Soft Front Panel includes the following GUI elements:

1 Title Bar
2 Menu Bar
3 Tabs
4 Status Indicator
5 Messages
6 Lower Pane

Title Bar

The title bar contains the standard Microsoft Window elements such as the window title and the icons for minimizing, maximizing, or closing the window.

Menu Bar

The menu bar consists of various pull down menus that provide access to the different functions and launch interactive GUI tools.

The menu bar includes the following pull down menu:

- File
- View
- Utilities
- Tools
- Help

Each menu and its options are described in the following sections.

File Menu

The **File** menu includes the following selections:

File > Save Configuration...	Saves configuration as a text file.
File > Save Configuration As...	Saves configuration as a text file. Not functional in the current software release.
File > Load Configuration...	To be implemented. Loads the previously saved configuration file. Not functional in the current software release.
File > Exit	Exits the M8121A application.

View Menu

The **View** menu includes the following selections:

View > Preferences...	Opens the Display Setting dialog which allows you to set the display settings. For more details, refer to Display Settings Dialog on page 46.

Utilities Menu

The **Utility** menu includes the following selections:

Utility > Reset	Resets the instrument, reads the state and updates all fields.

Tools Menu

The **Tools** menu includes the following selections:

Tools > SCPI Editor...	Opens SCPI Editor that lists all SCPIs that can be used to program M8121A and also provides a platform to execute them. For details, see SCPI Editor on page 47.

Help Menu

The **Help** menu includes the following selections:

Help > Contents	Opens the M8121A User Guide.
Help > Online Support	Opens the instrument's product support web page.
Help > About	Displays product information including version number, build date, build info, installed licenses, available options and web links for M8121A information and support.

Display Settings Dialog

The **Display Settings** dialog allows you to set the display the GUI.

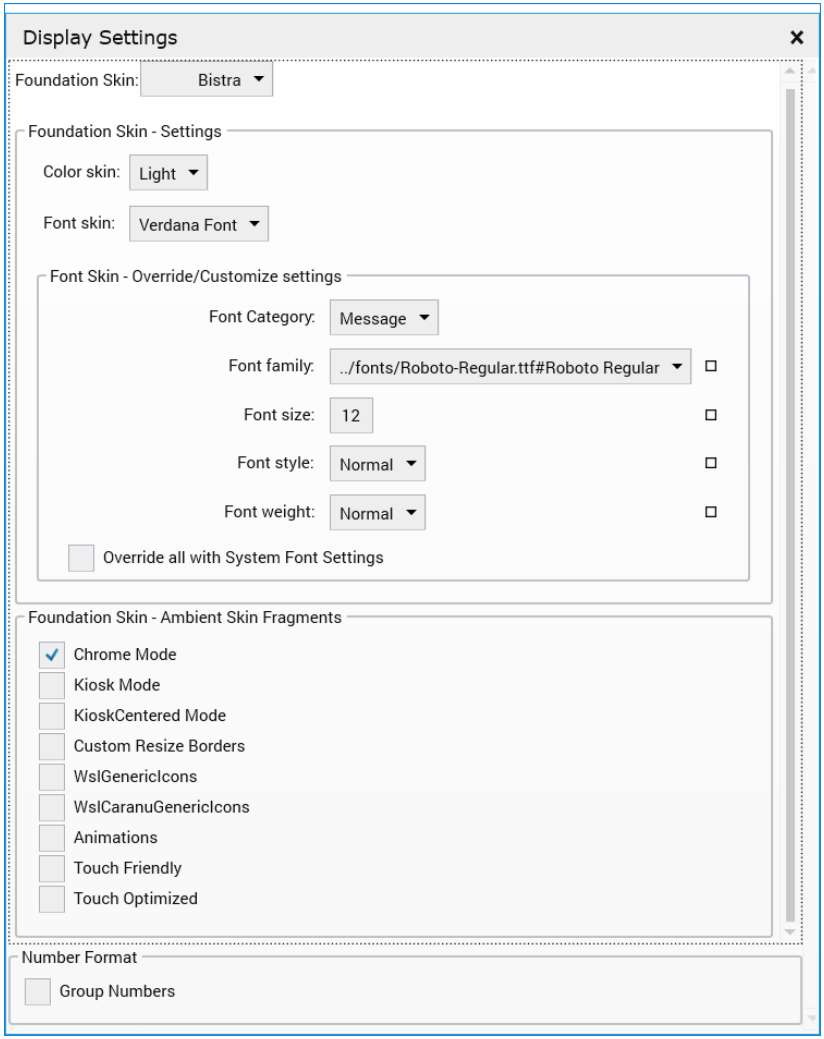


Figure 9 Display Settings dialog

Using this dialog, you can apply the provided setting to the interface skin, color, font, font skin, message icons, and number format.

SCPI Editor

The **SCPI Editor** lists all SCPI that can be used to program M8121A and also provides a platform to execute them.

The following figure depicts the elements of the **SCPI Editor**:

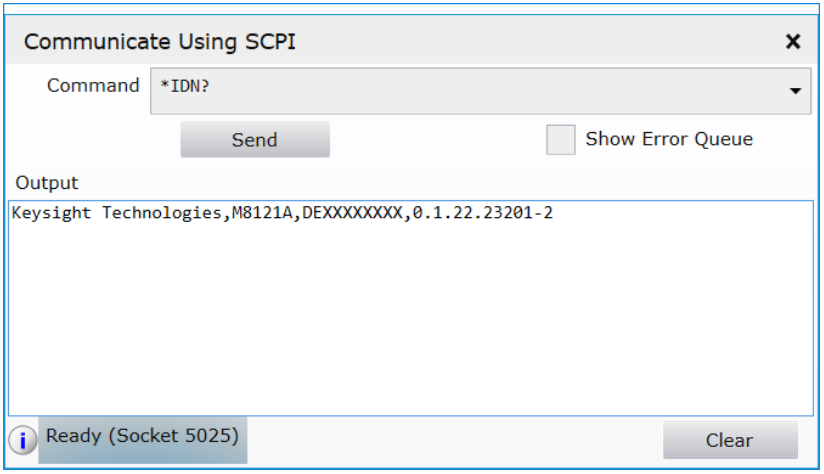


Figure 10 SCPI Editor

It has the following elements:

- **Command list** - Shows the list of default commands.
- **Output Area** - Allows you to enter a command. Also the output of the executed command is displayed in this area.
- **Send Button** - Press this button once you select the command from the command list or enter a SCPI.
- **Show Error Queue** - Select this check-box to show the errors which are generated when a command is executed.
- **Clear** - Clears the **Output** area.

Status Indicator

The **Status Indicator** window displays the status of the analog outputs of each channel of the M8121A module.

This include:

- **Data** indicates the data source: either “Streaming” data over the ODI port, or from internal “Waveform” memory.
- **Mode** reports the selected data format.
- **Clock** reports status of the sample clock; green means ready and red means there is no detection of correct clock signal of the selected sample clock.
- The **ODI Sync** LED is lit when the ODI port is activated and synchronized with the data source.
- The **ODI FIFO** LED is lit when there are brief gaps in the ODI data stream during otherwise continuous operations. It also indicates when ODI data starts / flows / stops (for example, when the Rapids play a recording).
  - Gray when inactive (output off, or Data source internal).
  - Yellow when ODI is waiting for sync.
  - Gray when ODI is synced and there is no ODI data (ODI data rate == 0 during previous 1s).
  - Green when ODI is synced and ODI data is flowing (rate > 0 over 1s period) without FIFO underflowing.
  - Red when ODI is synced and FIFO underflow detected. Remains red until ODI stops being transmitted (rate == 0 for at least 1 sec).
- **Direct Out** and **Amp Out** ports for each channel (indicated by green LED).
- The **Triggered** LED is lit when the trigger event is initiated or when the continuous mode of trigger is selected.
  - **Continuous mode** – Always green when the continuous trigger mode is selected.
  - **Triggered mode** – Green when trigger action is performed and grayed out when the trigger is stopped.
- **Start** button to start the waveform.
- **Stop** button to stop the waveform.
- Press the **ARM** button to set to an armed state. Signal generation is started after a trigger is received. This option is applicable only when **Triggered** option is selected under the **Trigger Mode** drop-down list.

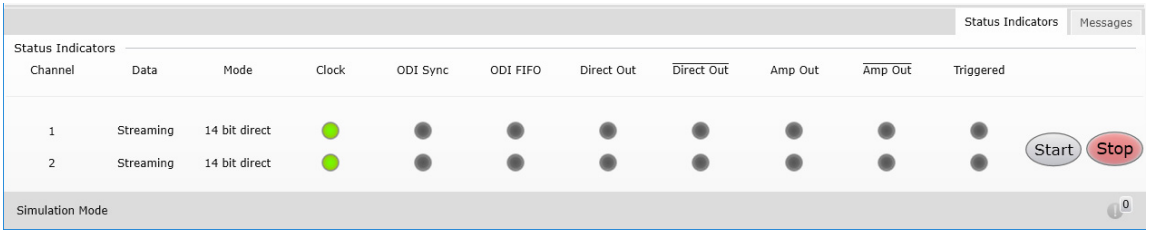


Figure 11 Status Indicators

Messages

The **Messages** window displays the messages, warnings, and errors. You can also filter the messages, warnings and errors so that they get displayed on the Messages window. For each messages, warnings, and errors, it also shows the details i.e. notification type, message log, details and time.

Figure 12 Messages window

It has the following controls, signs, and columns:

ⓘ	Messages	Click this button to show/hide messages.
⚠	Warnings	Click this button to show/hide warning messages.
⊗	Errors	Click this button to show/hide the error messages.

	Save...	Click this button to save the selected messages, warnings or errors, inside the list, to a specified location.
	Copy	Click this button to copy the selected messages, warnings or errors. Once you perform the copy operation, you can later paste them in any text editor.
	Clear	Click this button to clear all the messages, warnings or errors from the Messages window.

Status Bar

The status bar contains the following fields from left to right:

- **Connection state "Not Connected"** – No instrument is connected. "Connected: <Instrument resource string>" – An instrument is connected. The resource string, for example PXI36::0::0::INSTR is displayed. "Simulation Mode" – No real instrument is connected. The user interface is in simulation mode. Click this field to open the Instrument Selection Dialog.
- **Instrument status** - Displays the instrument status, for example "Reset complete" after issuing a reset command.
- **Show messages/warning/errors** - Click the "Error Count"  button to view the window to view messages, warnings, and errors on the Message window.

Working with M8121A Front Panel

Numeric Control Usage

The numeric control is used to adjust the value and units. Whenever you bring the mouse pointer over the numeric control, a tool tip appears which shows the possible values in that range.

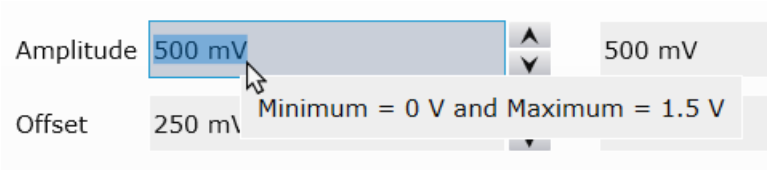


Figure 13 Tool tip showing possible values in the range

The numeric controls can be used in the following ways:

Use the up/down arrows to change the value. The control automatically stops at the maximum/minimum allowed value.

You can increase or decrease the value starting at a specific portion of the value. To do this, place the cursor to the right of the targeted digit and use the up/down arrows. This is especially useful when changing a signal characteristic that is immediately implemented and observing the result in another instrument. For example, you can change the signal generator's frequency by increments of 10 MHz and observe the measured result in a signal analyzer:

Figure 14 Typing directly into the field

Type directly into the field and press the Enter key. If you enter a value outside the allowed range, the control automatically limits the entered value to the maximum or minimum allowed value.

When you type the value, you can type the first letter of the allowed unit of measure to set the units. For example, in the Frequency control you can use "H", "K", "M", or "G" to specify Hz, kHz, MHz or GHz, respectively. (The control is not case sensitive.)

The controls allow scientific notation if it is appropriate to the allowed range. Type the first decimal number, enter an "E", and omit any trailing zeroes. For example, in the Frequency control you can type 2.5e+9 and press [Enter] to set the frequency to 2.5 GHz. (The plus sign is automatically inserted if it is omitted.)

Tooltip

The tooltip is a small pop-up window that concisely describes the object being pointed to, such as descriptions of toolbar controls, icons, graphics, links, menu items and taskbar buttons.

The following example shows the tooltip providing a description of toolbar buttons.

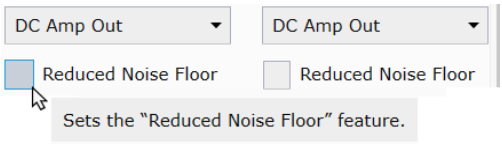


Figure 15 Tooltip example 1

Here is another example where the tooltip provides information to the user on the minimum and maximum values the parameter can hold.

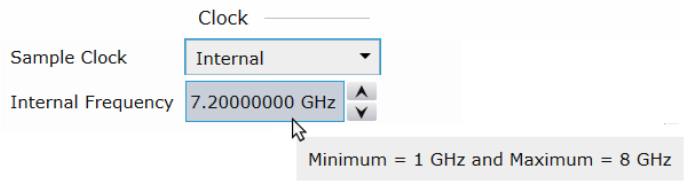


Figure 16 Tooltip example 2

Clock and Output Tab

The **Clock and Output** tab is used to configure the clock and outputs of the M8121A module. It includes input fields for the clocks (Internal/External/LPN) to configure the relevant frequencies and also includes the outputs of the channel of M8121A Module.

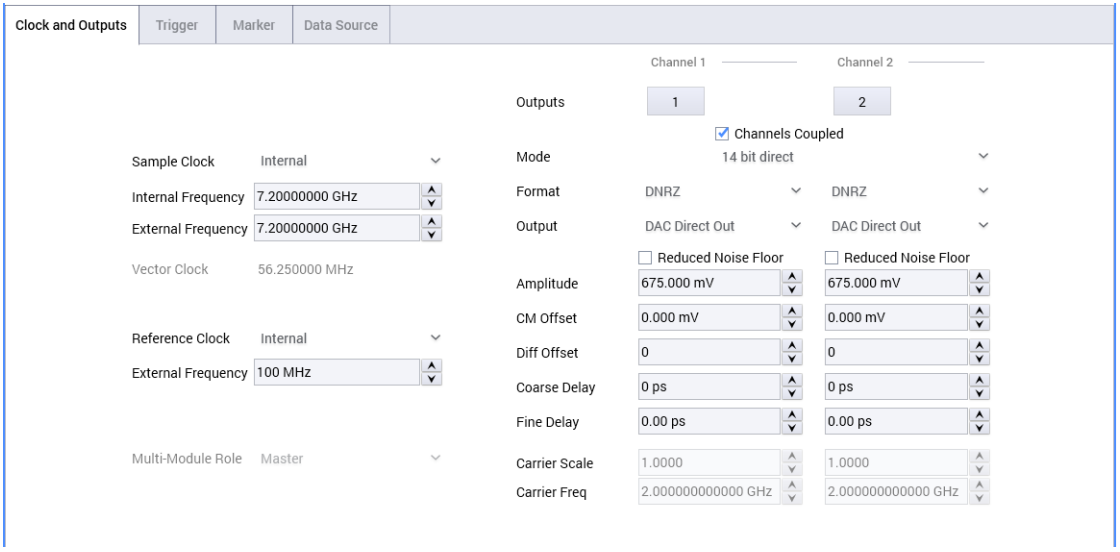


Figure 17 Clock and Outputs tab

This tab has the following options:

Clock

- **Sample Clock** - Use this drop-down list to select the sample clock among Internal, External or Low Phase Noise (LPN) External.
  - The clock power to the LPN input should be removed when using the Internal clock.
  - Use the semi-rigid cable to connect the LPN Clock Out to the Sample Clock In when switching between the External and LPN clock sources. This eliminates the need to re-cable.

- **Internal Frequency** - Use this option to set the frequency of the internally generated sample clock.
- **External Frequency** - Use this option to specify the frequency of the selected external clock source.
- **Vector Clock** - This is read-only and reports the vector clock frequency that is available from the Vector Clk Out port.
- **Reference Clock** - Use this drop-down list to select the reference clock source from:
  - **Internal** - Reference generated by an internal oscillator inside M8121A module.
  - **External** - Reference from Ref Clock In.
  - **AXI** - Reference from AXI Backplane of the AXIe chassis.
  - **Default** - For Default option, the AXI value is applicable.
- **External Frequency** - Use this option to set the frequency of the used external reference clock.
- **Multi-Module Role** - This is a read-only field. Depending upon the M8192A module connection, it displays one of the following:
  - **Normal** - When the M8121A module is not configured in the M8192A module.
  - **Master** - When the M8121A module is configured as **Master** in the M8192A module.
  - **Slave** - When the M8121A module is configured as **Slave** in the M8192A module.

Channel 1/ Channel 2

- **Outputs** - Click on the button to enable/disable the output port (normal and complement for Direct DAC Out) for channels 1 and 2.
- **Mode** - Selects the waveform output modes. Available selections are:
  - 12 bit Direct
  - 14 bit Direct
  - Interpolated mode: x3/x12/x24/x48
- **Channels Coupled** - Use this check box to select the coupling mode of the two channels. The channels can operate in coupled or uncoupled mode.
- **Format** - Selects among the DAC format modes.
  - DNRZ: DAC A and B send same value.
  - NRZ: DAC A sends value for whole sample period.
  - Doublet: DAC A sends +Value, DAC B sends –Value

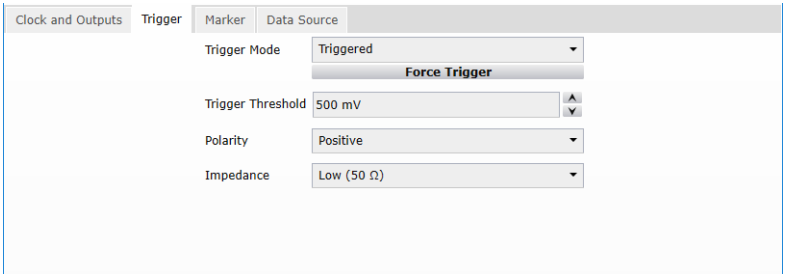
- **Output** - Select the output path.
  - DAC Direct Out
  - DC Amp Out
- **Reduced Noise Floor**- Select this option to enable the "Reduced Noise Floor" feature. When the reduced noise floor feature is enabled, there is less phase noise in the generated output signal.

  The M8121A has a delay adjustment in the module that allows a delay to be added to a channel's output signal. Using the delay adjustment, a user can delay the signal on one channel compared to the signal on the other channel. One reason for this might be to compensate for differences in delay caused by different cable lengths. It is also possible to use the delay adjustment to set an arbitrary delay offset between the channels.

  The delay line used for the delay adjustment adds phase noise to the output signal. When the reduced noise floor feature is enabled, this delay line is by-passed so that phase noise is reduced. When reduced noise floor is enabled, the delay adjustment is not available.
- **Amplitude** - Sets the amplitude of the output signal.
- **CM Offset** - Sets the CM (common mode) offset of the output signal
- **Diff. Offset** - Sets an offset adjustment to compensate for small offset differences between the normal and complement output.
- **Coarse Delay** - Specifies the coarse delay portion of the variable delay.
- **Fine Delay** - Provides a small range of delay that may be added to the output signal on either channel.The fine delay is not available when using the Low Phase Noise clock source or when the Reduced Noise Floor box is checked. The range is dependent on the sample frequency as follows:
  - Sample freq >= 6.25 GSa/s: 0-30 ps
  - 2.5 GSa/s <= Sample freq < 6.25 GSa/s: 0-60 ps
  - Sample freq < 2.5 GSa/s: 0-150 ps
- **Carrier Scale** - Sets the carrier amplitude scale for interpolated modes. The Carrier Scale refers to the amplitude of the carrier signal in Up-Conversion Mode (Interpolated Mode). IQ data is used to modulate the carrier signal. An interpolation filter is applied which may result (depending on the IQ data values) in final DAC values that are outside the valid range of the DAC. In that case the signal is clipped, and a warning message is displayed in the Error List Window. When clipping is not acceptable, the user can set a smaller carrier scale. The default value for carrier scale guarantees in all cases a signal without clipping.
- **Carrier Frequency** - Set the carrier frequency for interpolated modes.

Trigger tab

The **Trigger** tab is used to configure the trigger inputs of the M8121A module.



This tab has the following options:

- **Trigger Mode** - Use this drop-down list to select the trigger mode value.

  The following options are available:

  - **Continuous** – Signal generation starts immediately after pressing the Run button. No trigger needed.
  - **Triggered** – Signal generation starts after a trigger is received.
- **Force Trigger** - Use this button to force a trigger when waiting for front panel trigger. This option is enabled only when **Triggered** option is selected under the **Trigger Mode** drop-down list.
- **Trigger Threshold** - Sets the threshold for trigger and event input.
- **Polarity** - Sets the polarity for the input.

  The following options are available:

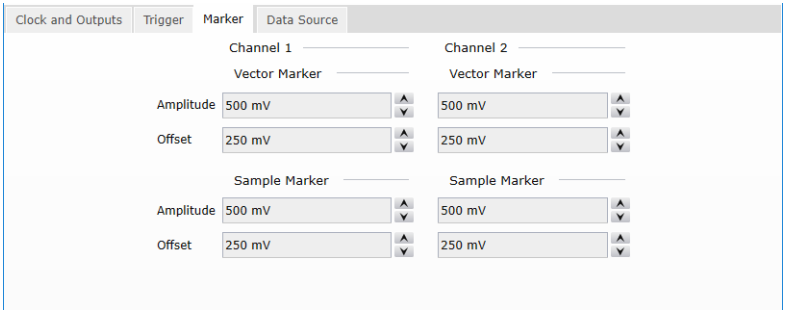
  - **Positive** – Rising edge
  - **Negative** – Falling edge
  - **Either** - Both
- **Impedance** - Sets the impedance of the input.

  The following options are available:

  - Low (50 Ohm)
  - High (1k Ohm)

Marker tab

The **Marker** tab is used to configure the marker outputs of the M8121A module.



This tab has the following options for Channel 1 and Channel 2.

Vector Marker

- **Amplitude** - Specifies the amplitude of the marker output signal.
- **Offset** - Specifies the offset of the marker output signal.

Sample Marker

- **Amplitude** - Specifies the amplitude of the marker output signal.
- **Offset** - Specifies the offset of the marker output signal.

For more information on markers, refer to Markers on page 63.

Data Source Tab

The **Data Source** tab is used to configure the data source (internal/optical) of the M8121A module.

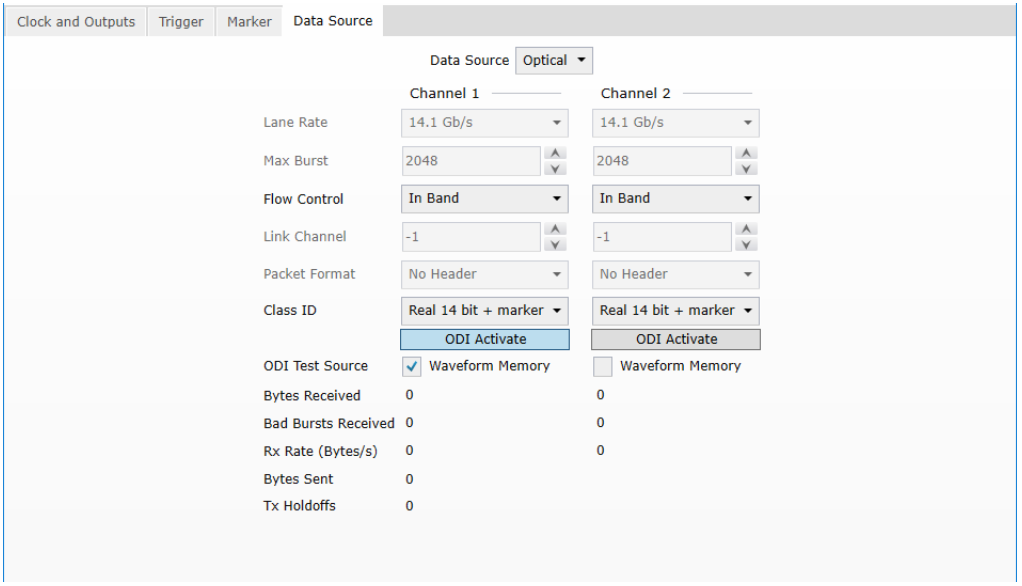


Figure 18 Data Source tab

This tab has the following options:

- **Data Source** - This drop-down list allows the selection of the data source for the waveform. The available options are; Internal (waveform memory) and Optical (ODI optical streaming interface). When selecting Optical, the following controls are available.
  - **Optical Data Source** - For the optical data source, the following options are available for channel 1 and 2:
    - **Lane Rate** - Currently 14.1 Gb/s is the only supported lane rate.
    - **Max Burst** - This is the maximum burst size and is 2048 (not adjustable).

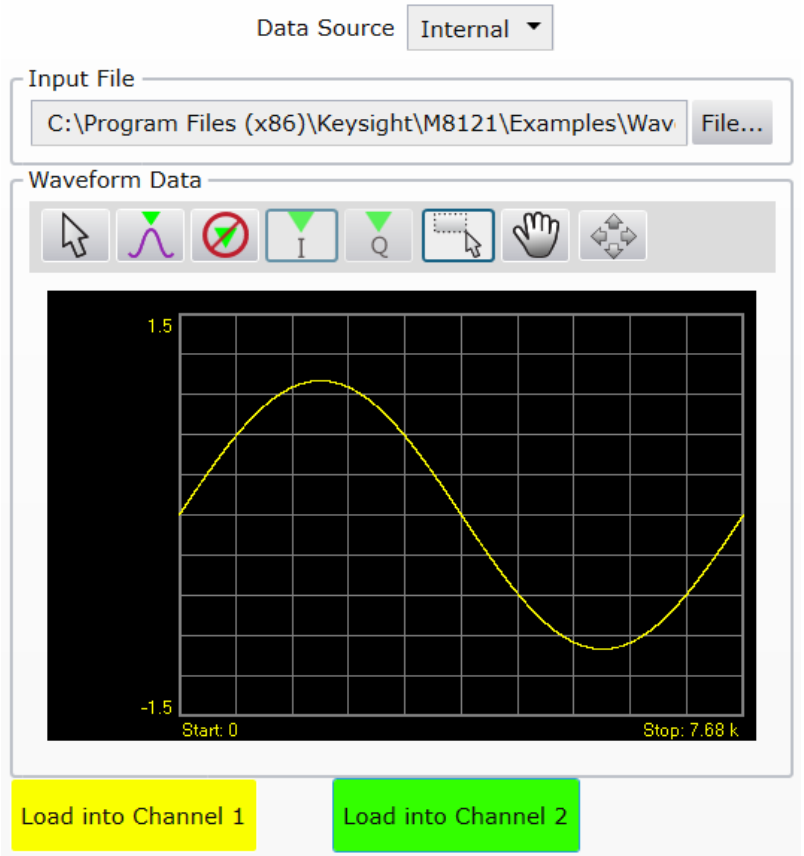
- **Flow Control** - Flow control is sometimes needed to control the flow of data over the ODI link. Select “In Band” when streaming data from a source that is not digitizing data real-time, such as a RAID or DSP module. Select “None” when streaming data from a digitizer that is digitizing data real-time. If the sample clock is shared with the real-time data source, “In Band” or “None” can be used.
- **Link Channel** - Currently, the setting of -1 is supported.
- **Packet Format** - The M8121A accepts data without any header information, so only “None” is available. Other options are reserved for future use.
- **Class ID** - The Class Id should match the format on the Clock and Output tab. The incoming data format defined by the Class ID should adhere to the ODI standard.
  - **Packed 12 bit**: This can be used when the Mode on the Clock and Outputs tab is “12 bit direct”. The data should be streamed from the data source in packed 12 bit samples.
  - **Real 12 bit** + marker: This can be used when the Mode on the Clock and Outputs tab is “12 bit direct”. The data should be streamed from the data source in 16 bit samples of which the 12 most significant bits is the sample, and the 2 least significant bits are the markers.
  - **Real 14 bit + marker**: This should be used when the Mode on the Clock and Outputs tab is “14 bit direct”. The data should be streamed from the data source in 16 bit samples of which the 14 most significant bits is the sample, and the 2 least significant bits are the markers.
  - **I/Q 15 bit + marker**: This should be used when the Mode on the Clock and Outputs tab is any of the Interpolated modes. The data should be streamed from the data source in interleaved (alternating I and Q) 16 bit samples of which the 15 most significant bits is the sample, and the 1 least significant bit is the marker.
- **ODI Activate** – This button will reactivate the ODI port. This can be used to attempt to resynchronize the M8121A ODI port with that of a ODI data producer. ODI statistics are reset whenever the ODI port is activated.

- **ODI Test Source** - Select the **Waveform Memory** check box to enable the ODI Test Source to play out Waveform Memory over ODI, and to view more statistics about the ODI port including Bytes Sent and Tx Holdoffs.

  Bytes Received, Bad Bursts Received, and Rx Rate (Bytes/s) are always displayed.

- **ODI Statistics** - Display the ODI statistics in terms of Bytes Received, Bad Bursts Received, Rx Rate (Bytes/s), Bytes Sent and Tx Holdoffs.

- **Internal Data Source** - For internal data source, the following options are available:



- **Input File** - Allows you to add the waveform data file. For details on the waveform data file, refer :TRACe Commands on page 117. Click **File...** button to provide the waveform data file location. The waveform must meet certain length rules that are dependent upon the Mode that is selected in the Clock and Outputs tab.
  - 12 bit direct: multiple of 192 samples
  - 14 bit direct: multiple of 320 samples
  - Interpolated mode: multiple of 64 samples
  - A 12 bit packed waveform may be loaded and used when doing a self-test of the ODI. In this case, the waveform must be a multiple of 768 samples.
  - The waveform memory size is 1,048,576 bytes, or 524,288 16-bit samples.

- **Waveform Data** - Displays the waveform and allows to set the markers to the waveform data using the waveform toolbar. The waveform toolbar provides the following buttons:

	Uses the mouse to control the marker. The respective position of marker at X and Y axis are displayed on the top of waveform.
	Takes the marker to the peak position
	Turns off the marker
	Sets the marker on the I data part of the waveform
	Sets the marker on the Q data part of the waveform
	Provides zoom functionality. Use the mouse pointer to select the area on waveform that you want to zoom. Once done, you can click Auto scale icon to zoom out the waveform.
	Uses the mouse pointer to move the waveform around. You can also use the pan tool when the waveform is zoomed in.
	Auto scale the waveform

- **Load into Channel 1/2** - Click these buttons to load the waveform data to the respective channels (Channel 1and/or Channel 2).

4 Markers

This chapter describes the markers supported by M8121A.

Introduction

The instrument provides output signals with a defined timing relationship to the output sample stream. These signals are called markers.

There are two different types of markers:

- Sample Markers
- Vector Markers

The details of these markers are explained in the sections that follow.

Sample Markers

Sample markers can be used to mark individual samples.

The following table shows the marker granularity:

Table 3 Marker granularity

Mode	Granularity in DAC Samples
High Speed (Option -12G)	48
High Precision (Option -14B)	40
INT_x3 (Option -DUC)	24
INT_x12 (Option -DUC)	24
INT_x24 (Option -DUC)	24
INT_x48 (Option -DUC)	48

The marker width of one marked sample is fixed to the marker granularity. Multiple consecutive marked samples generate one output marker, which is expanded to cover all marked bits. The length of this marker is quantized to the marker granularity.

The sample marker is always aligned to the sample data. This alignment varies depending on the mode. Delay adjustments also change the delay of the sample marker.

The following drawing shows an example. The dots represent the marked samples.

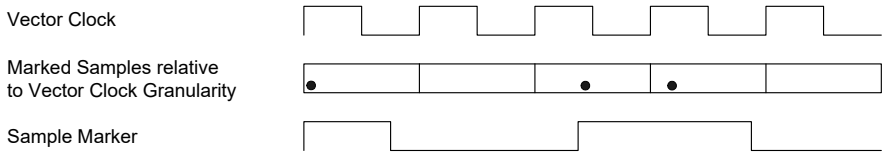


Figure 19 Samples marked by sample marker

Pause Between Multiple Marked Samples

Due to the quantization of markers, a minimum pause between blocks of marked samples is required to see the gap at the sample marker output.

Table 4 Pause between multiple marked samples

Mode	Minimum Gap Size
12-bit direct	128 Samples
14-bit direct	128 samples
INT_x3 (Option -DUC)	8 IQ Sample Pairs
INT_x12 (Option -DUC)	2 IQ Sample Pairs
INT_x24 (Option -DUC)	1 IQ Sample Pairs
INT_x48 (Option -DUC)	1 IQ Sample Pairs

The table above shows the minimum gap size between blocks of multiple marked samples/IQ sample pairs. If this condition is violated, it might be possible to get one “combined marker” instead two individual markers.

Vector Markers

In addition to the high-speed marker, each channel provides a second marker called vector marker. This vector marker can only be set in vector clock granularity.

The vector marker is an output of the pattern generation. Delay adjustments do not change the delay of the vector marker.

The following drawing shows an example. The dots represent the marked clock vectors.

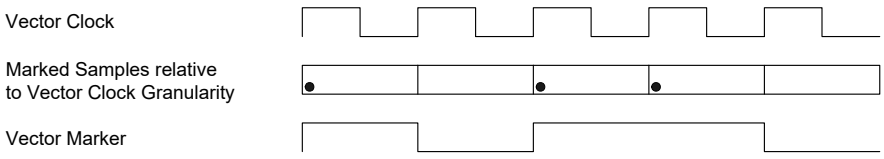


Figure 20 Marked clock vectors

5 Digital Up-Conversion (Requires option DUC)

This chapter describes the Digital Up-Conversion for the M8121A.

Introduction

The following diagram shows the hardware structure of features for Digital Up-Conversion.

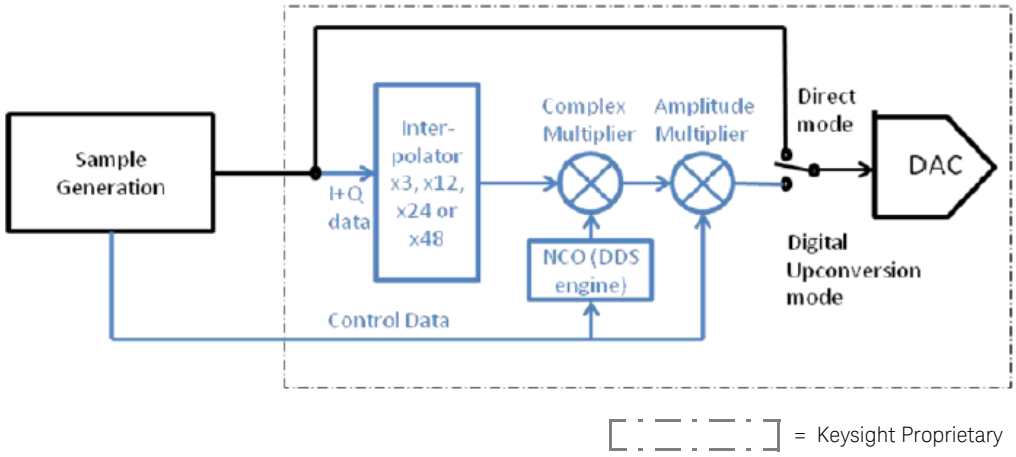


Figure 21 Hardware Structure of Features for Digital Up-Conversion

The M8121A provides a direct mode, which allows sending sample data directly to the output of the instrument. Additionally, it provides mechanisms to do IQ modulation internally (highlighted in blue in Figure 21 on page 68). This includes the interpolation of IQ sample pairs from a low input data rate to the sampling rate of the instrument, the generation of a carrier frequency by a Numerically Controlled Oscillator (NCO) and the IQ modulation itself.

Direct Mode

In direct mode, the samples are sent directly to the DAC. IQ modulation can be implemented by:

- Using two channels providing I and Q data separately to an external analog IQ modulator. This setup is expensive and causes analog distortions.
- IQ modulation can be done by software to generate the samples for an IQ modulated signal.

Digital Up-Conversion Modes

In these modes (see Option -DUC), IQ sample pairs provided by the sample data source are interpolated to the selected sample rate and are fed to the IQ modulator. The result is sent to the DAC. The benefit is that there are no distortions caused by an external analog IQ modulator.

IQ Modulation

The instrument is able to provide an IQ modulated signal at its output, which is based on the IQ data provided by the customer, the selected interpolation mode, the carrier frequency and amplitude multiplication factor.

Interpolated Modes

The instrument provides interpolation filters that allow an interpolation by x3, x12, x24 and x48.

The available signal bandwidth of each interpolation filter is 0.8 x F_S where F_S is the input I/Q sample rate. F_S multiplied with the interpolation factor leads to the DAC sampling rate.

The following table shows examples for the maximum DAC sample rate of 7200 MSa/s:

Table 5 Mode dependent modulation bandwidth

Interpolation Mode	Max. Input Sample Rate	Max. Modulation Bandwidth
INT_x3	2400 MSa/s	1920 MHz
INT_x12	600 MSa/s	480 MHz
INT_x24	300 MSa/s	240 MHz
INT_x48	150 MSa/s	120 MHz

Markers in Interpolated Modes

Markers can be provided for each incoming IQ sample pair. It is not possible to perform marking of interpolated sample values.

For more details about markers, refer to chapter Markers on page 63.

NOTE **The marker to sample output delay is different in the digital up-conversion mode compared to the corresponding value in direct modes (For details, refer to the M8121A datasheet).**

Amplitude Scaling

The amplitude multiplier allows to scale the amplitude of the DAC output signal (see Figure 21 on page 68).

The chain of interpolation filters and the IQ modulator could increase the signal value, which then exceeds the valid DAC range. This leads to a clipping of samples. This effect depends on the input data and therefore cannot be handled automatically.

The instrument is able to detect clipping and signals it to the user by the status register or a dialog box in the soft front panel. Clipping could be prevented by using scale factor values of 1.0 or smaller. This scale factor value reduces the output amplitude relative to the direct mode to approx. 37.6%.

It is possible to increase the scale factor up to 2.828, but depending on the input IQ sample sequence this can result in signal clipping. The value can be separated into two multiplication factors:

- Factor 2.0 is related to the interpolation filters and is dependent from the input sample sequence.
- Factor 1.414 is related to the IQ modulators. The maximum I value (1.0) and the maximum Q value (1.0) causes a resulting vector with a length of sqrt (2)≈1.414.

So whenever the user can guarantee that the sum of I and Q doesn't exceed the unit circle, it is safe to set the scale value to 1.414 and increase the overall amplitude.

A scale factor of 1.0, which is a "safe" value in terms of clipping, reduces the overall possible output amplitude to approx. 37.6 %. Clipping is highly depending on IQ input data provided by the user. Therefore, this allows scale factor values in the range from 0.0 to 2.828 and allows using as much as possible from the available DAC range. The user is responsible to select a proper scale value depending on his input data.

Doublet Mode and Digital Up-Conversion

The doublet mode is also available for the digital up-conversion modes.

The frequency band is mirrored at the half of the sample frequency (7.2 GHz max). The content of the first Nyquist band (0 – 3.6 GHz max.) is transferred to the second Nyquist band (3.6 GHz to 7.2 GHz max.).

6 Remote Programming

Remote Programming Overview

Introduction

SCPI programming, optionally using a LAN connection is the way to control the M8121A automatically.

Three LAN protocols are supported:

- **VXI-11**: The Visa Resource String is e.g., “TCPIP0::localhost::inst0::INSTR”.
- **HiSLIP**: This protocol is recommended. It offers the functionality of VXI-11 protocol with better performance that is near socket performance. Visa Resource Strings look like “TCPIP0::localhost::hislip0::INSTR”. The correct resource string is shown in the M8121A About Box.
- **Socket**: This protocol can be used with any I/O library or using standard operating system socket functionality connecting to port 5025. Visa Resource string looks like “TCPIP0::localhost::5025::SOCKET”.

Command Line Arguments

Before sending SCPI commands to the instrument, the firmware (M8121Firmware.exe) must be started. This can be done in the Windows Start menu (All Programs >Keysight M8121 > Keysight M8121).

(See Communication for details about /s, /t, /i, /AutoID, /NoAutoID, /FallBack).

Option	Decsription
/Minimized	Start minimized.
/Hide	Start without application window; only show notify icon.
/s socketPort	Set the socket port at which the firmware waits for SCPI commands
/t telnetPort	Set the telnet port at which the firmware waits for SCPI commands
/i instrumentNumber	Set the instrument number (instN, hislipN) at which the firmware waits for SCPI commands
/AutoID	Automatically select ports and number for the connections (default behavior).

Option	Decsription
/NoAutoID	Disable the default behavior; i.e. do not automatically select ports and number for the connections.
/FallBack	Try to find unused ports and number if starting a server fails.
/r resourceName	Visa PXI resource string of the module to connect to, e.g. PXI12::0::0::INSTR

Communication

Depending on the command line arguments /s, /t, /i, /AutoID, /NoAutoID, /FallBack, the firmware starts several servers to handle SCPI commands. (Refer the table above.)

/s, /t, /i: If -1, don't start the respective servers

- Defaults:
  - Socket port: 5025 (e.g. TCPIP0::localhost::5025::SOCKET)
  - Telnet port: 5024
  - HiSLIP, VXI-11.3: 0 (e.g. TCPIP0::localhost::hislip0::INSTR, TCPIP0::localhost::inst0::INSTR)

/FallBack: If starting a server fails because of a conflict, try using another port or number

- HiSLIP, VXI-11.3: increase the index until a server can be started successfully
- Socket, Telnet: start with port 60000, then increase it until the servers can be started successfully. If neither socket nor telnet is disabled the firmware tries to start the servers on two consecutive ports (socket port = telnet port + 1)

/AutoID: Automatically select ports and number for the connections, which are unique per instrument.

- This is the default behavior; it is not necessary to specify this argument on the command line.
- If only one AXIe module is connected to this PC and it is an M8121A module, first try to use the command line arguments /s, /t, /i or their respective default values if they are not specified. If starting the servers fails, proceed with the steps below.
- /s, /t, /i are ignored (unless they are -1 and a server is disabled)
- If the firmware detects more than one AXIe module, use a special mechanism to obtain a number for the HiSLIP and VXI-11.3 servers, which makes sure that the firmware uses always the same VISA resource string per module

- The socket and telnet port are then calculated from the HiSLIP index:
  - telnet port = 60000 + 2 * <HiSLIP index>
  - socket port = 60000 + 2 * <HiSLIP index> + 1

NOTE **Ports may already be in use by Windows or other applications, so they are not available for M8121A. The first port not assigned by IANA is 49152 (IANA, Internet Assigned Numbers Authority, http://www.iana.org).**

/NoAutoID: Do not automatically select ports and number for the connections, use the values specified with /s, /t, /i, /r or their respective default values instead. In Win7, /NoAutoID must be used before /s, /t, /i, or /r. In Win10, /NoAutoID does not need to be specified before /s, /t, /i, or /r.

If both /NoAutoID and /AutoID are specified, /AutoID overrides /NoAutoID.

Instructions

Instructions, both commands and queries, normally appear as strings embedded in a statement of your host language, such as Visual Basic for Applications (VBA), Visual Basic .NET, C#, C, etc.

The only time a parameter is not meant to be expressed as a string is when the instruction's syntax definition specifies <binary_block _data>, such as with the `:SYSTem:SET` command. There are only a few instructions that use block data.

Instructions are composed of two main parts:

- The header, which specifies the command or query to be sent.
- The program data, which provides additional information to clarify the meaning of the instruction.

Instruction Header

The instruction header is one or more command mnemonics separated by colons (:). They represent the operation to be performed by the oscilloscope. Queries are formed by adding a question mark (?) to the end of the header. Many instructions can be used as either commands or queries, depending on whether or not you include the question mark. The command and query forms of an instruction usually have different program data. Many queries do not use any program data.

White Space (Separator)

White space is used to separate the instruction header from the program data. If the instruction does not require any program data parameters, you do not need to include any white space. In this manual, white space is defined as one or more spaces. ASCII defines a space to be character 32 in decimal.

Braces

When several items are enclosed by braces, { }, only one of these elements may be selected. Vertical line (|) indicates "or". For example, {ON | OFF} indicates that only ON or OFF may be selected, not both.

Ellipsis

... An ellipsis (trailing dots) indicates that the preceding element may be repeated one or more times.

Square Brackets

Items enclosed in square brackets, [ ], are optional.

Program Data

Program data is used to clarify the meaning of the command or query. It provides necessary information, such as whether a function should be on or off, or which waveform is to be displayed. Each instruction's syntax definition shows the program data and the values they accept.

When there is more than one data parameter, they are separated by commas (,). You can add spaces around the commas to improve readability.

Common Commands

***IDN?**

Read the instrument's identification string which contains four fields separated by commas. The first field is the manufacturer's name, the second field is the model number, the third field is the serial number, and the fourth field is a revision code which contains four numbers separated by dots and a fifth number separated by a dash:

`Keysight Technologies, M8121A,<serial number>, x.x.x.x-h`

`x.x.x.x`= Soft Front Panel revision number, e.g. 2.0.0.0

`h`= Hardware revision number

***CLS**

Clear the event register in all register groups. This command also clears the error queue and cancels a `*OPC` operation. It doesn't clear the enable register.

***ESE**

Enable bits in the Standard Event Status Register to be reported in the Status Byte. The selected bits are summarized in the "Standard Event" bit (bit 5) of the Status Byte Register. The `*ESE?` query returns a value which corresponds to the binary-weighted sum of all bits enabled decimal by the `*ESE` command. These bits are not cleared by a `*CLS` command. Value Range: 0–255.

ESR?

Query the Standard Event Status Register. Once a bit is set, it remains set until cleared by a `*CLS` (clear status) command or queried by this command. A query of this register returns a decimal value which corresponds to the binary-weighted sum of all bits set in the register.

***OPC**

Set the "Operation Complete" bit (bit 0) in the Standard Event register after the previous commands have been completed.

*OPC?

Return “1” to the output buffer after the previous commands have been completed. Other commands cannot be executed until this command completes.

*OPT?

Read the installed options. The response consists of any number of fields separated by commas.

*RST

Reset instrument to its factory default state.

*SRE[?]

Enable bits in the Status Byte to generate a Service Request. To enable specific bits, you must write a decimal value which corresponds to the binary-weighted sum of the bits in the register. The selected bits are summarized in the “Master Summary” bit (bit 6) of the Status Byte Register. If any of the selected bits change from “0” to “1”, a Service Request signal is generated. The `*SRE?` query returns a decimal value which corresponds to the binary-weighted sum of all bits enabled by the `*SRE` command.

*STB?

Query the summary (status byte condition) register in this register group. This command is similar to a Serial Poll but it is processed like any other instrument command. This command returns the same result as a Serial Poll but the “Master Summary” bit (bit 6) is not cleared by the `*STB?` command.

*TST?

Execute Self Tests. If self-tests pass, a 0 is returned. A number lager than 0 indicates the number of failed tests.

To get actual messages, use `:TEST:TST?`

*LRN?

Query the instrument and return a binary block of data containing the current settings (learn string). You can then send the string back to the instrument to restore this state later. For proper operation, do not modify the returned string before sending it to the instrument. Use `:SYST:SET` to send the learn string. See :SYSTem:SET[?] on page 115.

*WAI?

Prevents the instrument from executing any further commands until the current command has finished executing.

:ABOrt Commands

:ABORt[1|2]

Command	`:ABORt[1|2]`
Parameters	None
Parameter Suffix	None
Description	This command stops signal generation on channel. If channels are coupled, signal generation on both channels will be stopped.
Examples	Command `:ABOR1`

:ARM Commands

:ARM[:SEQuence][:STARt][:LAYer]:DELay[1|2][?]

Command `:ARM[:SEQuence]|[STARt][:LAYer]:DELay[1|2][?] <delay> | MINimum | MAXimum`

Query `:ARM[:SEQuence]|[STARt][:LAYer]:DELay[1|2]?`

Parameters {<delay> | MINimum | MAXimum}

Parameter Suffix HZ

Description This command sets or queries the fine delay settings. The unit is in seconds.

Examples Command

```
:ARM:DEL1 2e-12
```

Query

```
:ARM:DEL1? -> 2e-12
```

Table 6 Fine Delay Settings

Sample Frequency	Fine Delay Range
$f_{Sa} \geq 6.25$ GSa/s	0 .. 30e-12
2.5 GSa/s $\leq f_{Sa} <$ 6.25 GSa/s	0 .. 60e-12
$f_{Sa} <$ 2.5 GSa/s	0 .. 150e-12

:ARM[:SEQuence][:STARt][:LAYer]:CDELay[1|2][?] <coarse_delay>|MINimum|MAXimum

Command `:ARM:CDEL[?]`

Long `:ARM[:SEQuence][:STARt][:LAYer]:CDELay[1|2][?]`

Parameters <coarse_delay> | MINimum | MAXimum

Parameter Suffix None

Description Set or query the coarse delay settings. The unit is in seconds.

Examples Command

:ARM:CDEL 3e-9

Query

:ARM:CDEL?

Table 7 Coarse Delay Settings

Sample Frequency	Coarse Delay Range	Coarse Delay Resolution
$f_{Sa} \geq 6.25$ GSa/s	0 .. 10e-9	10e-12
2.5 GSa/s $\leq f_{Sa} <$ 6.25 GSa/s	0 .. 10e-9	20e-12
$f_{Sa} <$ 2.5 GSa/s	0 .. 10e-9	50e-12

:ARM[:SEQuence][:STARt][:LAYer]:RNOisefloor[1 | 2][?]

Command `:ARM[:SEQuence][:STARt][:LAYer]:RNOisefloor[1 | 2] OFF|ON|0|1`

Query `:ARM[:SEQuence][:STARt][:LAYer]:RNOisefloor[1 | 2]?`

Parameters `OFF|ON|0|1`

Parameter Suffix None

Description This command sets or queries the state of the “Reduced Noise Floor” feature.

- 0/OFF – Noise reduction disabled.
- 1/ON – Noise reduction enabled.

Examples Command

```
:ARM:RNO1 ON
```

Query

```
:ARM:RNO1? -> 1
```

NOTE If the noise reduction is enabled and fine delay are constant and cannot be adjusted.

:ARM[:SEQuence][:STARt][:LAYer]:TRIGger:IMPedance[?]

Command	`:ARM:TRIGger:IMPedance LOW|HIGH`
Query	`:ARM:TRIGger:IMPedance?`
Parameters	LOW|HIGH
Parameter Suffix	None
Description	Set or query the trigger input impedance. • LOW – low impedance • HIGH – high impedance
Examples	Command :ARM:TRIG:IMP HIGH Query :ARM:TRIG:IMP?

:ARM[:SEQuence][:STARt][:LAYer]:TRIGger:LEVel[?]

Command	`:ARM:TRIGger:LEVel <level>|MINimum|MAXimum`
Query	`:ARM:TRIGger:LEVel?`
Parameters	<level>|MINimum|MAXimum
Parameter Suffix	None
Description	Set or query the trigger input threshold level. <level> – Threshold level voltage.
Examples	Command :ARM:TRIG:LEV 3e-9 Query :ARM:TRIG:LEV?

:ARM[:SEQuence][:STARt][:LAYer]:TRIGger:SLOPe[?]

Command	`:ARM:TRIGger:SLOPe POSitive|NEGative|EITHer`
Query	`:ARM:TRIGger:SLOPe?`
Parameters	POSitive|NEGative|EITHer
Parameter Suffix	None
Description	Set or query the trigger input slope. • POSitive – rising edge • NEGative – falling edge • EITHer – both
Examples	Command :ARM:TRIG:SLOP POS Query :ARM:TRIG:SLOP?

:ARM[:SEQuence][:STARt][:LAYer]:TRIGger:STATus{1:2}?

Query	`:ARM[:SEQuence][:STARt][:LAYer]:TRIGger:STATus{1:2}?`
Description	This query returns “1” after the trigger event is received, either from a trigger signal received at the front panel, or via the "Force Trigger" command (:TRIGger[:SEQuence][:STARt]:BEGin{1:2}[:IMMediate]/nquery/). It returns 0 after playback is stopped (:ABOR).
Examples	Query :ARM:TRIG:STAT1?

:TRIGger Commands

:TRIGger[:SEQuence][:STARt]:BEGin[1|2][:IMMediate]

Command	`:TRIG:BEG`
Long	`:TRIGger:BEGin`
Parameters	None
Parameter Suffix	None
Description	In triggered mode send the start/begin event to a channel.
Examples	Command :TRIG:BEG

:MARKer Commands

[:SOURce]:MARKer[1|2]:SAMPle:VOLTage[:LEVel][:IMMediate]:AMPLitude[?] <level>

Command	`:MARK:SAMP:VOLT:AMPL[?]`
Long	`:MARKer:SAMPle:VOLTage:AMPLitude[?]`
Parameters	<level>
Parameter Suffix	None
Description	Set or query the output amplitude for sample marker.
Examples	Command :MARK:SAMP:VOLT:AMPL 3.0e-9 Query :MARK:SAMP:VOLT:AMPL?

[:SOURce]:MARKer[1|2]:SAMPle:VOLTage[:LEVel][:IMMediate]:HIGH[?] <level>

Command	`:MARK:SAMP:VOLT:HIGH[?]`
Long	`:MARKer:SAMPle:VOLTage:HIGH[?]`
Parameters	<level>
Parameter Suffix	None
Description	Set or query the output high level for sample marker.
Examples	Command :MARK:SAMP:VOLT:HIGH 1.5 Query :MARK:SAMP:VOLT:HIGH?

[:SOURce]:MARKer[1|2]:SAMPle:VOLTage[:LEVel][:IMMediate]:LOW[?] <level>

Command	`:MARK:SAMP:VOLT:LOW[?]`
Long	`:MARKer:SAMPle:VOLTage:LOW[?]`
Parameters	<level>
Parameter Suffix	None
Description	Set or query the output low level for sample marker.
Examples	Command :MARK:SAMP:VOLT:LOW -0.5 Query :MARK:SAMP:VOLT:LOW?

[:SOURce]:MARKer[1|2]:SAMPle:VOLTage[:LEVel][:IMMediate]:OFFSet[?] <level>

Command	`:MARK:SAMP:VOLT:OFFS[?]`
Long	`:MARKer:SAMPle:VOLTage:OFFSet[?]`
Parameters	<level>
Parameter Suffix	None
Description	Set or query the output offset for sample marker.
Examples	Command :MARK:SAMP:VOLT:OFFS 2.5e-9 Query :MARK:SAMP:VOLT:OFFS?

[:SOURce]:MARKer[1:2]:VECTor:VOLTage[:LEVel][:IMMediate]:AMPLitude <level>

Command	`:MARK:VECT:VOLT:AMPL[?]`
Long	`:MARKer:VECT:VOLTage:AMPLitude[?]`
Parameters	<level>
Parameter Suffix	None
Description	Set or query the output amplitude for vector marker.
Examples	Command :MARK:VECT:VOLT:AMPL 2.5e-9 Query :MARK:VECT:VOLT:AMPL?

[:SOURce]:MARKer[1:2]:VECTor:VOLTage[:LEVel][:IMMediate]:HIGH <level>

Command	`:MARK:VECT:VOLT:HIGH[?]`
Long	`:MARKer:VECT:VOLTage:HIGH[?]`
Parameters	<level>
Parameter Suffix	None
Description	Set or query the output high level for vector marker.
Examples	Command :MARK:VECT:VOLT:HIGH 1.5 Query :MARK:VECT:VOLT:HIGH?

[:SOURce]:MARKer[1:2]:VECTor:VOLTage[:LEVel][:IMMediate]:LOW <level>

Command	`:MARK:VECT:VOLT:LOW[?]`
Long	`:MARKer:VECT:VOLTage:LOW[?]`
Parameters	<level>
Parameter Suffix	None
Description	Set or query the output low level for vector marker.
Examples	Command :MARK:VECT:VOLT:LOW -0.5 Query :MARK:VECT:VOLT:LOW?

[:SOURce]:MARKer[1:2]:VECTor:VOLTage[:LEVel][:IMMediate]:OFFSet <level>

Command	`:MARK:VECT:VOLT:OFFS[?]`
Long	`:MARKer:VECT:VOLTage:OFFSet[?]`
Parameters	<level>
Parameter Suffix	None
Description	Set or query the output offset for vector marker.
Examples	Command :MARK:VECT:VOLT:OFFS 2.5e-9 Query :MARK:VECT:VOLT:OFFS?

:INITiate Commands

:INITiate:IMMediate[1|2]

Command	`:INITiate:IMMediate[1|2]`
Parameters	None
Parameter Suffix	None
Description	This command starts signal generation on a channel or arms the channel in triggered mode. If channels are coupled, the signal generation on both the channels will start.
Examples	Command `:INIT:IMM1`

:INITiate:CONTinous[1|2][:STATe][?] OFF|ON|0|1

Command	`:INIT:CONT[1|2]:STAT[?]`
Long	:INITiate:CONTinuous[1|2]:STATe[?]
Parameters	ON: Continuous OFF: Triggered
Parameter Suffix	None
Description	This command is used to set or query the continuous mode, or to set the triggered mode. 0/OFF – Continuous mode is off. 1/ON – Continuous mode is on. Trigger mode is “automatic”.
Examples	Command :INIT:CONT:STAT ON Query :INIT:CONT:STAT?

:INSTrument Commands

:INSTrument:COUPle:STATe[1|2][?]

Command	`:INSTrument:COUPle:STATe[1|2] OFF|ON|0|1`
Query	`:INSTrument:COUPle:STATe[1|2]?`
Parameters	`OFF|ON|0|1`
Parameter Suffix	None
Description	This command switch coupling on/off. Coupled mode means both channels are synchronized. If coupling is switched from on to off, the values of the channel where coupling is switched on are taken. The coupled values are: `:TRAC[1|2]:DWID`

Examples	Command
	`:INST:COUP:STAT1 ON`
	Query
	`:INST:COUP:STAT1?`

:INSTrument:SLOT[:NUMBer]?

Query	`:INSTrument:SLOT[:NUMBer]?`
Parameters	None
Parameter Suffix	None
Description	This query returns the instrument's slot number in its AXIe frame.
Examples	Query `:INST:SLOT?`

:MMEMory Commands

This node provides access to parts of the remote host file system, so that waveform files can be loaded from the remote host into the module.

:MMEMory:LOAD:CSTate

Command	`:MMEMory:LOAD:CSTate <file_name>`
Parameters	`<file_name>`
Parameter Suffix	None
Description	This command loads the saved configuration file to the instrument.
Examples	Command `:MMEM:LOAD:CST "C:\data.txt"`

:MMEMory:STORe:CSTate

Command	`:MMEMory:STORe:CSTate <file_name>`
Parameters	`<file_name>`
Parameter Suffix	None
Description	This command stores the current state of instrument to a file.
Examples	Command `:MMEM:STOR:CST "C:\data.txt"`

:OUTPut Commands

:OUTPut[1|2]:COMPlement[:STATe][?]

Command	`:OUTPut[1|2]:COMPlement[:STATe] OFF|ON|0|1`
Query	`:OUTPut[1|2]:COMPlement[:STATe]?`
Parameters	`OFF|ON|0|1`
Parameter Suffix	None
Description	This command switch the complement output on or off.

Examples	Command
	`:OUTP:COMP ON`
	Query
	`:OUTP:COMP? -> 1`

:OUTPut[1|2]:DIOFfset[?]

Command	`:OUTPut[1|2]:DIOFfset <value>|MINimum|MAXimum`
Query	`:OUTPut[1|2]:DIOFfset?`
Parameters	`<value>|MINimum|MAXimum`
Parameter Suffix	None
Description	This command sets the differential offset. The hardware can compensate for little offset differences between the normal and complement output. “<value>” is the offset to the calibrated optimum DAC value, so the minimum and maximum depend on the result of the calibration.

Examples	Command
	`:OUTP:DIOF MAX`
	Query
	`:OUTP:DIOF?`

:OUTPut[1|2][:NORMal][:STATe][?]

Command	`:OUTPut[1|2][:NORMal][:STATe] OFF|ON|0|1`
Query	`:OUTPut[1|2][:NORMal][:STATe]?`
Parameters	`OFF|ON|0|1`
Parameter Suffix	None
Description	This command switch (normal) output on or off.

Examples	Command
	`:OUTP:NORM ON`
	Query
	`:OUTP:NORM? -> 1`

:OUTPut[1|2]:ROUTe[:SELect][?] DAC|DC

Command	`:OUTPut[1|2]:ROUTe[:SELect] DAC|DC`
Query	`:OUTPut[1|2]:ROUTe[:SELect]?`
Parameters	`DAC|DC`
Parameter Suffix	None
Description	This command selects the output path: • DAC: Direct DAC output • DC: Amplified differential output

Examples	Command
	`:OUTP:ROUT DAC`
	Query
	`:OUTP:ROUT?`

:SOURce Commands

[:SOURce]:DAC|DC[1|2]:FORMat[?]

Command	`[:SOURce]:DAC|DC[1|2]:FORMat DNRZ|NRZ|DOUBlet`
Query	`[:SOURce]:DAC|DC[1|2]:FORMat?`
Parameters	`DNRZ|NRZ|DOUBlet`
Parameter Suffix	None
Description	This command sets or queries the DAC format mode.

Examples	Command
	`:DAC:FORM DNRZ`
	Query
	`:DAC:FORM? -> DNRZ`

[:SOURce]:DAC|DC[1|2]:VOLTage[:LEVel][:IMMediate]:AMPLitude[?]

Command Syntax	`[:SOURce]:DAC|DC[1|2]:VOLTage[:LEVel][:IMMediate]:AMPLitude <level>`
Query Syntax	`[:SOURce]:DAC|DC[1|2]:VOLTage[:LEVel][:IMMediate]:AMPLitude?`
Parameters	`<level>`
Parameter Suffix	None
Description	This command sets or queries the amplitude for the DAC or DC output path, as specified in the SCPI command. The output path can also be set using the OUTP:ROUT:SEL command (see :OUTPut[1|2]:ROUTe[:SELect][?] DAC|DC on page 95).

Examples	Command
	`:DAC:VOLT:AMPL 0.685`
	Query
	`:DAC:VOLT:AMPL?`

[:SOURce]:DAC|DC[1|2]:VOLTage[:LEVel][:IMMediate]:HIGH[?]

Command Syntax `[:SOURce]:DAC|DC[1|2]:VOLTage[:LEVel][:IMMediate]:HIGH <level>`

Query Syntax `[:SOURce]:DAC|DC[1|2]:VOLTage[:LEVel][:IMMediate]:HIGH?`

Parameters `<level>`

Parameter Suffix None

Description This command sets or queries the high level for the DAC or DC output path, as specified in the SCPI command.
The output path can also be set using the OUTP:ROUT:SEL command (see :OUTPut[1|2]:ROUTe[:SELect][?] DAC|DC on page 95).

Examples Command

```
:DAC:VOLT:HIGH 3e-1
```

Query

```
:DAC:VOLT:HIGH?
```

[:SOURce]:DAC|DC[1|2]:VOLTage[:LEVel][:IMMediate]:LOW[?]

Command `[:SOURce]:DAC|DC[1|2]:VOLTage[:LEVel][:IMMediate]:LOW <level>`

Query `[:SOURce]:DAC|DC[1|2]:VOLTage[:LEVel][:IMMediate]:LOW?`

Parameters `<level>`

Parameter Suffix None

Description This command sets or queries the low level for the DAC or DC output path, as specified in the SCPI command.
The output path can also be set using the OUTP:ROUT:SEL command (see :OUTPut[1|2]:ROUTe[:SELect][?] DAC|DC on page 95).

Examples Command

```
:DAC:VOLT:LOW -0.3
```

Query

```
:DAC:VOLT:LOW?
```

[:SOURce]:DC[1|2]:VOLTage[:LEVel][:IMMediate]:TERMination[?]

Command `[:SOURce]:DC[1|2]:VOLTage[:LEVel][:IMMediate]:TERMination <level>`

Query `[:SOURce]:DC[1|2]:VOLTage[:LEVel][:IMMediate]:TERMination?`

Parameters `<level>`

Parameter Suffix None

Description This command sets or queries the termination voltage level.

Examples Command

```
:DC:VOLT:TERM 3e-1
```

Query

```
:DC:VOLT:TERM?
```

[:SOURce]:VOLTage[:LEVel][:IMMediate]:OFFSet[?]

Command `[:SOURce]:VOLTage[:LEVel][:IMMediate]:OFFSet <level>`

Query `[:SOURce]:VOLTage[:LEVel][:IMMediate]:OFFSet?`

Parameters `<level>`

Parameter Suffix None

Description This command sets or queries the output offset.

Examples Command

```
:VOLT:OFFS 0.02
```

Query

```
:VOLT:OFFS?
```

[:SOURce]:CARRier[1|2]:FREQuency[?]

Command `[:SOURce]:CARRier[1|2]:FREQuency <frequency_integral>[,<frequency_fractional>]|DEFault`

Query `[:SOURce]:CARRier[1|2]:FREQuency?`

Parameters `<frequency_fractional>]|DEFault`

Parameter Suffix Hz

Description This command sets or queries the carrier frequency used for interpolated modes. The command form expects an integral value in the range [0 .. 12] GHz and a fractional value in the range [0,1) Hz. To query the minimum and maximum values use the following two commands. `[:SOURce]:CARRier[1|2]:FREQuency:INTegral[?] [<frequency_integral>|MIN|MAX|DEFault]` and `[:SOURce]:CARRier[1|2]:FREQuency:FRACtional[?] [<frequency_fractional>|MIN|MAX|DEFault.`

- `<frequency_integral>` – Integral part of the carrier frequency (in Hz)
- `<frequency_fractional>` – Fractional part of the carrier frequency (optional, defaults to 0.0)

Examples Command

```
:CARR1:FREQ 1e9,0.5
```

This command sets the carrier frequency to 1.0000000005GHz (1GHz + 0.5Hz).

Query

```
:CARR1:FREQ?
```

[:SOURce]:CARRier[1|2]:FREQuency:FRACtional[?]

Command `[:SOURce]:CARRier[1|2]:FREQuency:FRACtional <frequency_fractional>|MIN|MAX|DEFault`

Query `[:SOURce]:CARRier[1|2]:FREQuency:FRACtional?`

Parameters `<frequency_fractional> | MIN | MAX | DEFault`

Parameter Suffix Hz

Description This command sets or queries the fractional part of the carrier frequency used for interpolated modes.

`<frequency_fractional>` – Fractional part of the carrier frequency

Examples Command

```
:CARR1:FREQ:FRAC 1e-9
```

Query

```
:CARR1:FREQ:FRAC?
```

[:SOURce]:CARRier[1|2]:FREQuency:INTegral[?]

Command `[:SOURce]:CARRier[1|2]:FREQuency:INTegral[?] <frequency_integral>|MIN|MAX|DEFault`

Query `[:SOURce]:CARRier[1|2]:FREQuency:INTegral[?] <frequency_integral>|MIN|MAX|DEFault`

Parameters `<frequency_integral> | MIN | MAX | DEF`

Parameter Suffix None

Description This command sets or queries the integral part of the carrier frequency used for interpolated modes.

`<frequency_integral>` – Integral part of the carrier frequency (in Hz)

Examples Command

```
:CARR1:FREQ:INT 1e9
```

Query

```
:CARR1:FREQ:INT?
```

[:SOURce]:CARRier[1|2]:POFFset [?]

Command `[:SOURce]:CARRier[1|2]:POFFset <phase- offset> |MINimum|MAXimum|DEFaultency_integral>|MIN|MAX|DEFaul t`

Query `[:SOURce]:CARRier[1|2]:POFFset?`

Parameters `<phase-offset> | MIN | MAX | DEF`

Parameter Suffix None

Description This command sets or queries the carrier phase offset used for interpolated modes.

Examples Command

```
:CARR1:POFF 0.1
```

This command sets the carrier phase offset to 0.1 cycles.

Query

```
:CARR1:POFF?
```

[:SOURce]:CARRier[1|2]:SCALe[?]

Command
```
[:SOURce]:CARRier[1|2]:SCALe
<scale>|MINimum|MAXimum|DEFaultency_integral>|MIN|MAX
|DEFault
```

Query
```
[:SOURce]:CARRier[1|2]:SCALe?
```

Parameters
```
<scale> | MIN | MAX | DEF
```

Parameter Suffix None

Description This command sets or queries the amplitude scale used for interpolated modes.

Examples Command

```
:CARR1:SCAL 0.9
```

This command sets the carrier amplitude scale to 0.9.

Query

```
:CARR1:SCAL? -> 0.9
```

[:SOURce]:FREQuency:RASTer[?]

Command
```
[:SOURce]:FREQuency:RASTer
<frequency>|MINimum|MAXimumency_integral>|MIN|MAX|DEF
ault
```

Query
```
[:SOURce]:FREQuency:RASTer?
```

Parameters
```
<frequency>|MINimum|MAXimum
```

Parameter Suffix None

Description This command is used to set or query the sample clock frequency.

Examples Command

```
:FREQ:RAST 2e9
```

Query

```
:FREQ:RAST?
```

[:SOURce]:FREQuency:RASTer:EXTernal[?]

Command
```
[:SOURce]:FREQuency:RASTer:EXTernal
<frequency>|MINimum|MAXimumency_integral>|MIN|MAX|DEF
ault
```

Query
```
[:SOURce]:FREQuency:RASTer:EXTernal?
```

Parameters
```
<frequency>|MINimum|MAXimum
```

Parameter Suffix None

Description This command sets or queries the external sample frequency. The internal sample clock $f_{Sa,i}$ is derived from the sample clock provided at SCLK IN.
For $f_{Sa,i}$ = 500 MSa/s...1 GSa/s the sample clock input must be twice of $f_{Sa,i}$.
For $f_{Sa,i}$ = 250 MSa/s...500 MSa/s the sample clock input must be four times $f_{Sa,i}$.
For $f_{Sa,i}$ = 125 MSa/s...250 MSa/s the sample clock input must be eight times $f_{Sa,i}$.

Examples Command

```
:FREQ:RAST:EXT MIN
```

Query

```
:FREQ:RAST:EXT?
```

[:SOURce]:FREQuency:RASTer:SOURce[?]

Command	`[:SOURce]:FREQuency:RASTer:SOURce INTernal|EXTernal|LPNoise`
Query	`[:SOURce]:FREQuency:RASTer:SOURce?`
Parameters	`INTernal|EXTernal|LPNnoise`
Parameter Suffix	None
Description	This command sets or queries the selected clock source for the module. When switching to EXTernal a stable sample clock that matches the frequency set with must be supplied at SCLK IN.

NOTE External is the LPN Clk In and therefore this command replaces [:SOURce]:FREQuency:RASTer:LPNoise, [:SOURce]:FREQuency:RASTer:LPNoise:ACTive, [:SOURce]:FREQuency:RASTer:LPNoise:ENABle

Examples

Command

```
:FREQ:RAST:SOUR INT
```

Query

```
:FREQ:RAST:SOUR?
```

[:SOURce]:FREQuency:RASTer:STATus[1:2]?

Query	`[:SOURce]:FREQuency:RASTer:STATus[1:2]?`
Parameters	None
Parameter Suffix	None
Description	This queries the status of clock stability for each channel. It reflects the Clock LED status on the soft front panel.

Examples

Query

```
FREQ:RAST:STAT1?
```

[:SOURce]:FUNCtion[1|2]:MODE[?]

Command	`[:SOURce]:FUNCtion[1|2]:MODE <INTernal|OPTical>`
Parameters	`INTernal|OPTical`
Parameter Suffix	None
Description	This command sets or queries the source of the waveform data.

Examples	Command
	`:FUNC1:MODE:INT`
	Query
	`:FUNC1:MODE:INT?`

[:SOURce]:ROSCillator:FREQuency[?]

Command	`[:SOURce]:ROSCillator:FREQuency <frequency>|MINimum|MAXimum`
Query	`[:SOURce]:ROSCillator:FREQuency?`
Parameters	`<frequency>|MINimum|MAXimum`
Parameter Suffix	None
Description	This command sets or queries the expected reference clock frequency, if the external reference clock source is selected.

Examples	Command
	`:ROSC:FREQ MIN`
	Query
	`:ROSC:FREQ?`

[:SOURce]:ROSCillator:SOURce[?]

Command	`[:SOURce]:ROSCillator:SOURce EXTernal|AXI|INTernal`
Query	`[:SOURce]:ROSCillator:SOURce?`
Parameters	`EXTernal|AXI|INTernal`
Parameter Suffix	None
Description	This command sets or queries the reference clock source. EXTernal: reference is taken from REF CLK IN. AXI: reference is taken from AXI backplane. INTernal: module internal reference.

Examples	Command
	`:ROSC:SOUR AXI`
	Query
	`:ROSC:SOUR?`

[:SOURce]:VOLTage[1|2][:LEVel][:IMMediate][:AMPLitude][?]

Command	`[:SOURce]:VOLTage[1|2][:LEVel][:IMMediate][:AMPLitude] <level>`
Query	`[:SOURce]:VOLTage[1|2][:LEVel][:IMMediate][:AMPLitude]?`
Parameters	`<level>`
Parameter Suffix	None
Description	This command sets or queries the amplitude for the currently selected output path (DAC or DC, selected with the OUTP:ROUT:SEL command). See :OUTPut[1|2]:ROUTe[:SELect][?] DAC|DC on page 95.

Examples	Command
	`:VOLT 0.685`
	Query
	`:VOLT?`

[:SOURce]:VOLTage[1|2][:LEVel][:IMMediate]:HIGH[?]

Command `[:SOURce]:VOLTage[1|2][:LEVel][:IMMediate]:HIGH <level>`

Query `[:SOURce]:VOLTage[1|2][:LEVel][:IMMediate]:HIGH?`

Parameters `<level>`

Parameter Suffix None

Description This command sets or queries the high level for the currently selected output path (DAC or DC, selected with the OUTP:ROUT:SEL command). See :OUTPut[1|2]:ROUTe[:SELect][?] DAC|DC on page 95.

Examples Command

```
:VOLT:HIGH 3e-1
```

Query

```
:VOLT:HIGH?
```

[:SOURce]:VOLTage[1|2][:LEVel][:IMMediate]:LOW[?]

Command `[:SOURce]:VOLTage[1|2][:LEVel][:IMMediate]:LOW <level>`

Query `[:SOURce]:VOLTage[1|2][:LEVel][:IMMediate]:LOW?`

Parameters `<level>`

Parameter Suffix None

Description This command sets or queries the low level for the currently selected output path (DAC or DC, selected with the OUTP:ROUT:SEL command). See :OUTPut[1|2]:ROUTe[:SELect][?] DAC|DC on page 95.

Examples Command

```
:VOLT:LOW -0.3
```

Query

```
:VOLT:LOW?
```

[:SOURce]:VOLTage[1|2][:LEVel][:IMMediate]:OFFSet[?]

Command	`[:SOURce]:VOLTage[1|2][:LEVel][:IMMediate]:OFFSet <level>`
Query	`[:SOURce]:VOLTage[1|2][:LEVel][:IMMediate]:OFFSet?`
Parameters	`<level>`
Parameter Suffix	None
Description	This command sets or queries the offset for the currently selected output path (DAC or DC, selected with the OUTP:ROUT:SEL command). See :OUTPut[1|2]:ROUTe[:SELect][?] DAC|DC on page 95.

Examples	Command
	`:VOLT:OFFS 0.02`
	Query
	`:VOLT:OFFS?`

:STATus Commands

The Operation Status register contains conditions which are part of the instrument's normal operation.

The following commands access the operation status group.

:STATus:OPERation[:EVENt]?

Reads the event register in the operation status group. It's a read-only register. Once a bit is set, it remains set until cleared by this command or *CLS command. A query of the register returns a decimal value which corresponds to the binary-weighted sum of all bits set in the register.

:STATus:OPERation:CONDition?

Reads the condition register in the operation status group. It's a read-only register and bits are not cleared when you read the register. A query of the register returns a decimal value which corresponds to the binary-weighted sum of all bits set in the register.

:STATus:OPERation:ENABle[?]

Sets or queries the enable register in the operation status group. The selected bits are then reported to the Status Byte. A *CLS will not clear the enable register but it does clear all bits in the event register. To enable bits in the enable register, you must write a decimal value which corresponds to the binary-weighted sum of the bits you wish to enable in the register.

:STATus:OPERation:NTRansition[?]

Sets or queries the negative-transition register in the operation status group. A negative transition filter allows an event to be reported when a condition changes from true to false. Setting both positive/negative filters true allows an event to be reported anytime the condition changes. Clearing both filters disable event reporting. The contents of transition filters are unchanged by *CLS and *RST.

:STATus:OPERation:PTRansition[?]

Set or queries the positive-transition register in the operation status group. A positive transition filter allows an event to be reported when a condition changes from false to true. Setting both positive/negative filters true allows an event to be reported anytime the condition changes. Clearing both filters disable event reporting. The contents of transition filters are unchanged by *CLS and *RST.

:STATus:PRESet

Clears all status group event registers. Presets the status group enables PTR and NTR registers as follows:

ENABle = 0x0000, PTR = 0xffff, NTR = 0x0000

:QUEStionable Commands

The Questionable Data register group provides information about the quality or integrity of the instrument. Any or all of these conditions can be reported to the Questionable Data summary bit through the enable register.

The following commands access the questionable status group.

:STATus:QUEStionable[:EVENt]?

Reads the event register in the questionable status group. It's a read-only register. Once a bit is set, it remains set until cleared by this command or the `*CLS` command. A query of the register returns a decimal value which corresponds to the binary-weighted sum of all bits set in the register.

:STATus:QUEStionable:CONDition?

Reads the condition register in the questionable status group. It's a read-only register and bits are not cleared when you read the register. A query of the register returns a decimal value which corresponds to the binary-weighted sum of all bits set in the register.

:STATus:QUEStionable:ENABle[?]

Sets or queries the enable register in the questionable status group. The selected bits are then reported to the Status Byte. A `*CLS` will not clear the enable register but it does clear all bits in the event register. To enable bits in the enable register, you must write a decimal value which corresponds to the binary-weighted sum of the bits you wish to enable in the register.

:STATus:QUEStionable:NTRansition[?]

Sets or queries the negative-transition register in the questionable status group. A negative transition filter allows an event to be reported when a condition changes from true to false. Setting both positive/negative filters true allows an event to be reported anytime the condition changes. Clearing both filters disable event reporting. The contents of transition filters are unchanged by `*CLS` and `*RST`.

:STATus:QUEStionable:PTRansition[?]

Set or queries the positive-transition register in the questionable status group. A positive transition filter allows an event to be reported when a condition changes from false to true. Setting both positive/negative filters

true allows an event to be reported anytime the condition changes. Clearing both filters disable event reporting. The contents of transition filters are unchanged by `*CLS` and `*RST`.

:SYSTem Commands

:SYSTem:COMMunicate:INSTr[:NUMBer]?

Query	`:SYSTem:COMMunicate:INSTr[:NUMBer]?`
Parameters	None
Parameter Suffix	None
Description	This query returns the VXI-11 instrument number used by the firmware.
Examples	Query `:SYST:COMM:INST?`

:SYSTem:COMMunicate:HISLip[:NUMBer]?

Query	`:SYSTem:COMMunicate:HISLip[:NUMBer]?`
Parameters	None
Parameter Suffix	None
Description	This query returns the HiSLIP number used by the firmware.
Examples	Query `:SYST:COMM:HISL?`

:SYSTem:COMMunicate:SOCKet[:PORT]?

Query	`:SYSTem:COMMunicate:SOCKet[:PORT]?`
Parameters	None
Parameter Suffix	None
Description	This query returns the socket port used by the firmware.
Examples	Query `:SYST:COMM:SOCK?`

:SYSTem:COMMunicate:TCPip:CONTrol?

Query	`:SYSTem:COMMunicate:TCPip:CONTrol?`
Parameters	None
Parameter Suffix	None
Description	This query returns the port number of the control connection. You can use the control port to send control commands (for example “Device Clear”) to the instrument.
Examples	Query `:SYST:COMM:TCP:CONT?`

:SYSTem:COMMunicate:TELNet[:PORT]?

Query	`:SYSTem:COMMunicate:TELNet[:PORT]?`
Parameters	None
Parameter Suffix	None
Description	This query returns the telnet port used by the firmware.
Examples	Query `:SYST:COMM:TELN?`

:SYSTem:ERRor:COUNT?

Query	`:SYSTem:ERRor:COUNT?`
Parameters	None
Parameter Suffix	None
Description	This query returns the error count.
Examples	Query `:SYST:ERR:COUNT?`

:SYSTem:ERRor[:NEXT]?

Query `:SYSTem:ERRor[:NEXT]?`

Parameters None

Parameter Suffix None

Description Read and clear one error from the instrument's error queue.

A record of up to 30 command syntax or hardware errors can be stored in the error queue. Errors are retrieved in first-in-first-out (FIFO) order. The first error returned is the first error that was stored. Errors are cleared as you read them.

If more than 30 errors have occurred, the last error stored in the queue (the most recent error) is replaced with "Queue overflow". No additional errors are stored until you remove errors from the queue.

If no errors have occurred when you read the error queue, the instrument responds with 0,"No error".

The error queue is cleared by the *CLS command, when the power is cycled, or when the firmware is re-started.

The error queue is not cleared by a reset (*RST) command.

The error messages have the following format (the error string may contain up to 255 characters):

error number,"Description", e.g.

-113,"Undefined header".

Examples Query

```
:SYST:ERR?
```

:SYSTem:HELP:HEADers?

Query `:SYSTem:HELP:HEADers?`

Parameters None

Parameter Suffix None

Description The HEADers? query returns all SCPI commands and queries and IEEE 488.2 common commands and common queries implemented by the instrument. The response is a <DEFINITE LENGTH ARBITRARY BLOCK RESPONSE DATA> element. The full path for every command and query is returned separated by line feeds. The syntax of the response is defined as:

The <nonzero digit> and sequence of <digit> follow the rules in IEEE 488.2, Section 8.7.9. An <SCPI header> is defined as: It contains all the nodes from the root. The <SCPI program mnemonic> contains the node in standard SCPI format. The short form uses uppercase characters while the additional characters for the long form are in lowercase characters. Default nodes are surrounded by square brackets ([]).

Examples Query

```
:SYST:HELP:HEAD?
```

:SYSTem:LICense:EXTended:LIST?

Query `:SYSTem:LICense:EXTended:LIST?`

Parameters None

Parameter Suffix None

Description This query lists the licenses installed.

Examples Query

```
:SYST:LIC:EXT:LIST?
```

:SYSTem:SET[?]

Command `:SYSTem:SET <binary block data>`

Query `:SYSTem:SET?`

Parameters `<binary block data>`

Parameter Suffix None

Description In query form, the command reads a block of data containing the instrument's complete set-up. The set-up information includes all parameter and mode settings, but does not include the contents of the instrument setting memories or the status group registers. The data is in a binary format, not ASCII, and cannot be edited.

In set form, the block data must be a complete instrument set-up read using the query form of the command.

This command has the same functionality as the *LRN command.

Examples Command

```
:SYST:SET <binary block data>
```

Query

```
:SYST:SET?
```

:SYSTem:VERSion?

Query `:SYSTem:VERSion?`

Parameters None

Parameter Suffix None

Description This query returns a formatted numeric value corresponding to the SCPI version number for which the instrument complies.

Examples Query

```
:SYST:VERS?
```

:TRACe Commands

`:TRACe` commands should be used when working with the M8121A internal memory. With the exception of the `:TRACe[1|2]:DWIDth[?]` command, they do not apply when streaming data over the ODI port.

NOTE **:TRACe commands must follow the waveform length rules as outlined in the Data Source Tab section.**

Use the `:TRACe` subsystem to control the arbitrary waveforms and their respective parameters:

- Select the DAC width in direct mode and the interpolation factor in interpolated mode.
- Create waveform segments of arbitrary size with optional initialization.
- Download waveform data into memory.
- Delete data from the waveform memory.

Direct and Interpolated Mode

In direct mode, arbitrary waveforms are generated directly from the DAC values in the waveform data. Each DAC value has a resolution of 12 bits or 14 bits.

In interpolated mode the waveform data consists of I/Q sample pairs. They are first interpolated and then sent to the internal IQ modulator. The result is sent to the DAC. I and Q values have a size of 15 bits each.

Waveform Memory Capacity

DAC values and I/Q samples are stored in a dedicated waveform memory. The capacity of this memory in samples depends on the waveform output mode and the installed memory option. The waveform memory size is 1,048,576 bytes, but the maximum number of samples is dictated not only by the memory size but also the waveform granularity discussed in the next section.

Table 8 Waveform Memory Capacity

Waveform output mode and packing	Number of Samples
12-bit, stored in 16-bit words	524,160
14-bit, stored in 16-bit words	524,160
12-bit stored in 12-bit “packed” words	523,776
xN interpolation	262,144

Waveform Granularity and Size

The waveform memory is internally organized in fixed size memory vectors. Their size depends on the selected waveform output mode. The waveform length must be multiples of the memory vector size. The maximum segment size is only limited by the size of the available memory.

Table 9 Waveform Granularity and Size

Waveform output mode	Memory vector size in samples
12-bit, stored in 16-bit words	192
14-bit, stored in 16-bit words	320
12-bit stored in 12-bit “packed” words	768
xN interpolation	64

Waveform Data Format in Direct Mode

DAC values have 14 or 12 bit resolution. DAC values are signed. Valid range is -8192 to +8191 in 14-bit mode and -2048 to 2047 in 12-bit mode.

Marker position data consists of two bits, one bit for sample markers (SMPM) and one bit for sync markers (SYNM). The marker position data is stored together with the DAC values in a 16-bit signed integer. The DAC values occupy the most significant bits and the marker data the least significant bits. In 12-bit mode bits 2 and 3 are don’t-care. The same data format can be used for both modes. In speed mode the two least significant bits are simply ignored.

Only the sync marker bit in the first sample of each memory vector is used. Sync marker bits in the other samples are ignored.

DAC Value binary format in 14-bit mode:

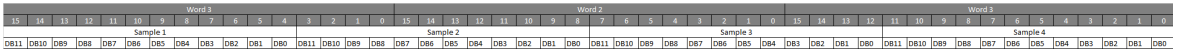
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DB13	DB12	DB11	DB10	DB9	DB8	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	SYNM	SMPM

DAC Value binary format in 12-bit mode:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DB11	DB10	DB9	DB8	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	X	X	SYNM	SMPM

The 12-bit packed format is useful to mimic the data format needed when sending data over the ODI to the M8121A in 12-bit mode. The packing is required in order to fit within the data bandwidth of the ODI. When using the 12-bit packed format, there are no marker bits.

DAC Value binary format in 12-bit packed mode:



Waveform Data Format in Interpolated Mode

I and Q values have 15 bit resolution in interpolated mode. I and Q values are signed. Valid range is -16384 to +16383.

Marker position data consists of one bit for a sample marker (SMPM) and one bit for a sync marker (SYNM) for each I/Q sample pair. The 24 I and Q samples are stored interlaced. The marker position data is stored together with I and Q values in two 16-bit signed integers.

Only the sync marker bit in the first sample of each memory vector is used. Sync marker bits in the other samples are ignored.

The same data format can be used for all four interpolated modes (x3, x12, x24 and x48).

I/Q value binary format in interpolated mode:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
I14	I13	I12	I11	I10	I9	I8	I7	I6	I5	I4	I3	I2	I1	I0	SMPM
Q14	Q13	Q12	Q11	Q10	Q9	Q8	Q7	Q6	Q5	Q4	Q3	Q2	Q1	Q0	SYNM

Arbitrary Waveform Generation

To prepare your module for arbitrary waveform generation follow these steps:

1 Select one of the direct modes (12- or 14-bit) or one of the interpolated modes ((x3, x12, x24 and x48) using `:TRACe[1|2]:DWIDth`

2 Define the waveform using the various forms of the `:TRAC[1|2]:DEF` command

3 Fill the memory with values and marker data using `:TRAC[1|2]:DATA`

4 Signal generation starts after calling `INIT:IMM`

:TRACe[1|2]:COMMent[?]

Command `:TRACe[1|2]:COMMent[?] <segment_id>,<comment>`

Query `:TRACe[1|2]:COMMent?`

Parameters `<segment_id>,<comment>`

Parameter Suffix None

Description This command associates a comment to a segment. The query gets the comment for a segment.

`<segment_id>` – id of the segment, must be 1.

`<comment>` – string of at most 256 characters

Examples Command

```
:TRAC:COMM 1, "Comment"
```

Query

```
:TRAC:COMM? 1
```

:TRACe[1|2][:DATA][?] <segment_id>,<offset>,(<length>|<block>|<numeric_values>)

Command `:TRACe[1|2][:DATA] <segment_id>,<offset>,(<length>|<block>|<numeric_values>)`

Query `:TRACe[1|2][:DATA]? <segment_id>,<offset>,<length>`

Parameters `<segment_id>,<offset>,(<length>|<block>|<numeric_values>)`

- `<segment_id>` – id of the segment, must be 1
- `<offset>` offset in samples for direct modes and I/Q sample pairs for interpolated modes to allow splitting the transfer in smaller portions. The offset parameter is necessary to overcome the SCPI restriction that only allows transferring up to 999999999 bytes at once.
- `<block>` waveform data samples and marker values in the data format described above in IEEE binary block format
- `<numeric_values>` waveform data samples and marker values in the data format described above in comma separated list format; each element is a 16-bit integer values representing DAC samples and marker data Di in direct modes or I/Q samples and marker data Ii, Qi in interpolated modes.
- Direct mode: D0, D1, D2,...
- Interpolated mode: I0, Q0, I1, Q1, I2, Q2...

Parameter Suffix None

Description Use this command to load waveform and marker data into the module memory. If <segment_id> is already filled with data, the new values overwrite the current values. If length is exceeded error -223 (too much data) is reported.

Examples Command

Load data consisting of 320 samples as comma-separated list into previously defined segment 1 starting at sample offset 0.

```
:TRAC1:DATA 1,0,0,1,2,…,319
```

Query

```
:TRAC:DATA? 1,0,48
```

:TRACe[1|2]:DEFine[?]

Command
```
:TRACe[1|2]:DEFine
<segment_id>,<length>[,<init_value1>[,<init_value2>]]
```

Query
```
:TRACe[1|2]:DEFine?
```

Parameters
```
<segment_id>,<length>[,<init_value1>[,<init_value2>]]
```

- `<segment_id>` – id of the segment, must be 1.
- `<length>` – length of the segment in samples for direct modes or in I/Q sample pairs for interpolated modes.
- `<init_value1>` – optional initialization value. For direct modes this is a DAC value. For interpolated modes this is the I-part of an I/Q sample pair.
- `<init_value2>` – optional initialization value, only applicable for interpolated modes. This is the Q-part of an I/Q sample pair.

Parameter Suffix None

Description Use this command to define the size of a waveform memory segment. If is specified (direct modes) or and (interpolated modes) are specified, all sample values in the segment are initialized. If not specified, memory is only allocated but not initialized. The segment will be flagged write-only, so it cannot be read back or stored.

Examples Commands

To set precision mode

```
:TRAC1:DWID WPR
```

To define a segment with id 1 and length 320 samples. Initialize to sample value 0.

```
:TRAC1:DEF 1,320,0
```

To set interpolated mode, interpolation factor 3.

```
:TRAC1:DWID INTX3
```

To define a segment with id 1 and length 64 samples. Initialize with I/Q value pair (0,1).

```
:TRAC:DEF 1,64,0,1
```

:TRACe[1|2]:DEFine:NEW?

Command

Query `:TRACe[1|2]:DEFine:NEW? <length> [,<init_value1>[,<init_value2>]]`

Parameters `<length> [,<init_value1>[,<init_value2>]]`

- `<length>` – length of the segment in samples for direct modes or in I/Q sample pairs for interpolated modes
- `<init_value1>` – optional initialization value. For direct modes this is a DAC value. For interpolated modes this is the I-part of an I/Q sample pair.
- `<init_value2>` – optional initialization value, only applicable for interpolated modes. This is the Q-part of an I/Q sample pair.

Parameter Suffix None

Description Use this query to define the size of a waveform memory segment. If <init_value1> is specified (direct modes) or <init_value1> and <init_value2> (interpolated modes) are specified, all sample values in the segment are initialized. If not specified, memory is only allocated but not initialized. If the query was successful, a new <segment_id> will be returned.

This query returns a segment ID of 1 every time, unless the allocation fails.

It always removes the existing segment #1 and creates a new one of the specified size, returning ID=1.

Examples Query

Define a segment of length 320 samples. Returns the segment id.

```
:TRAC1:DEF:NEW? 320
```

:TRACe[1|2]:DWIDth[?]

Command `:TRACe[1|2]:DWIDth[?] WSPeed|WPRecision|INTX3|INTX12|INTX24|INTX48`

Query `:TRACe[1|2]:DWIDth?`

Parameters `WSPeed|WPRecision|INTX3|INTX12|INTX24|INTX48`

- `WSPeed` – speed mode, 12 bit DAC resolution
- `WPRecision` – precision mode, 14 bit DAC resolution
- `INTX3` – interpolation x3 mode
- `INTX12` – interpolation x12 mode

- `INTX24` – interpolation x24 mode
- `INTX48` – interpolation x48 mode

Parameter Suffix: None

Description: Use this command or query to set or get the waveform output mode. If the DAC resolution is changed in direct mode or if there is a switch from direct mode to interpolated mode or vice versa, all waveform segments for this channel are invalidated.

The interpolated modes INTX3, INTX12, INTX24 and INTX48 are only available when the DUC option is installed.

Note that although this command is channelized, the output mode must remain the same for both channels. Changing one channel will change the other to be the same.

Examples: Command

```
:TRAC:DWID INTX3
```

Query

```
:TRAC:DWID?
```

:TRACe[1|2]:DELete

Command: `:TRACe[1|2]:DELete <segment_id>`

Query:

Parameters: `<segment_id>`

Parameter Suffix: None

Description: `<segment_id>` – id of the segment, must be 1.

Delete a segment. The command can only be used in program mode.

Examples: Command

```
:TRAC:DEL 5
```

:TRACe[1|2]:DELete:ALL

Command: `:TRACe[1|2]:DELete:ALL`

Query:

Parameters: None

Parameter Suffix None

Description Delete all segments. The command can only be used in program mode.

Examples Command

```
:TRAC:DEL:ALL
```

:TRACe[1|2]:FREE[?]

Command `:TRACe[1|2]:FREE`

Query `:TRACe[1|2]:FREE?`

Parameters None

Parameter Suffix None

Description The query returns the amount of memory space available for waveform data in the following form: <bytes available>, <bytes in use>, < contiguous bytes available>.

Examples Query

```
:TRAC:FREE?
```

:TRACe[1|2]:IMPort[?]

Command `:TRACe[1|2]:IMPort <segment_id>,<file_name>,BIN[,ALENgth|FILL|[,<dac_value>]]`

Query `:TRACe[1|2]:IMPort?`

Parameters `<segment_id>,<file_name>,BIN[,ALENgth|FILL|[,<dac_value>]]`.

Parameter Suffix None

Description Use this command to import waveform data from a file.

- `<segment_id>` - Id of the segment must be 1
- `<file_name>` file name.
- `<type>` BIN. File format.
- `<padding>` ALENgth|FILL.
- `<dac_value>` a DAC value in binary format

Examples

```
:TRAC1:IMP 1, "C:\Program Files (x86)\Keysight\M8121\
Examples\WaveformDataFiles\Sin1MHzAt7p68GHz.bin", BIN
```

:TRACe[1|2]:IQIMport[?

Command
```
:TRACe[1|2]:IQIMport
<segment_id>,<file_name>BIN|IQBIN,IONLy|QONLy|BOTH,ON
|OFF|1|0,[,ALENgth|FILL|[,<init_valueI>[,<init_valueQ
> [,<ignore_header_parameters>]]
```

Query
```
:TRACe[1|2]:IQIMport?
```

Parameters
```
<segment_id>,<file_name>BIN|IQBIN,IONLy|QONLy|BOTH,ON
|OFF|1|0,[,ALENgth|FILL|[,<init_valueI>[,<init_valueQ
>[,<ignore_header_parameters>]]
```

Parameter Suffix None

Description Import segment data from a file. Different file formats are supported. This can be used to import real waveform data as well complex I/Q data.

Examples Command

```
:TRAC1:IQIM 1, "C:\Program Files (x86)\Keysight\
M8121\Examples\WaveformDataFiles\
Sin1MHzAt7p68GHz.bin", BIN, IONLY, ON, ALEN
```

:TRACe[1|2]:NAME[?]

Command
```
:TRACe[1|2]:NAME <segment_id>,<name>
```

Query
```
:TRACe[1|2]:NAME?
```

Parameters
```
<segment_id>,<name>
```

Parameter Suffix None

Description This command associates a name to a segment. The query gets the name for a segment.

`<segment_id>` – Id of the segment must be 1

`<name>` – string of at most 32 characters

Examples Command

```
:TRAC:NAME 1,”ADY”
```

Query

```
:TRAC:NAME? 1
```

:MMEMory Commands

NOTE MMEM commands requiring <directory_name> assume the current directory if a relative path or no path is provided. If an absolute path is provided, then it is ignored.

:MMEMory:CATalog?

Query `:MMEMory:CATalog?`

Parameters None

Parameter Suffix None

Description This query returns the disk usage information (drive capacity, free space available) and obtain a list of files and directories in a specified directory in the following format:

```
<numeric_value>,<numeric_value>,{<file_entry>}
```

This query returns two numeric parameters and as many strings as there are files and directories. The first parameter indicates the total amount of storage currently used in bytes. The second parameter indicates the total amount of storage available, also in bytes. The <file_entry> is a string. Each <file_entry> indicates the name, type, and size of one file in the directory list:

```
<file_name>,<file_type>,<file_size>
```

As the Windows file system has an extension that indicates file type, <file_type> is always empty. <file_size> provides the size of the file in bytes. In case of directories, <file_entry> is surrounded by square brackets and both <file_type> and <file_size> are empty.

Examples Query

```
:MMEM:CAT?
```

:MMEMory:CDIRectory[?]

Command `:MMEMory:CDIRectory [<directory_name>]`

Query `:MMEMory:CDIRectory?`

Parameters None

Parameter Suffix None

Description This command changes the default directory for a mass memory file system. The `<directory_name>` parameter is a string. If no parameter is specified, the directory is set to the `*RST` value. At `*RST`, this value is set to the default user data storage area, that is defined as System.Environment.SpecialFolder.Personal

e.g. `C:\Users\Name\Documents`

`MMEMory:CDIRectory?` – Query returns full path of the default directory.

Examples Command

```
:MMEM:CDIR "C:\Users\Name\Documents"
```

Query

```
:MMEM:CDIR?
```

:MMEMory:COPY

Command `:MMEMory:COPY <string>,<string>[,<string>,<string>] <string>,<string>`

Parameters `<string>,<string>[,<string>,<string>] <string>,<string>`

Parameter Suffix None

Description This command copies an existing file to a new file or an existing directory to a new directory. Two forms of parameters are allowed. The first form has two parameters. In this form, the first parameter specifies the source, and the second parameter specifies the destination.

The second form has four parameters. In this form, the first and third parameters specify the file names. The second and fourth parameters specify the directories. The first pair of parameters specifies the source. The second pair specifies the destination. An error is generated if the source doesn't exist or the destination file already exists.

Examples Command

```
:MMEM:COPY "C:\data.txt", "C:\data_new.txt"
```

:MMEMory:DATA?

Query `:MMEMory:DATA? <file_name>`

Parameters `<file_name>`

Parameter Suffix None

Description The query form is `MMEMory:DATA? <file_name>` with the response being the associated `<data>` in block format.

Examples Query

```
:MMEM:DATA? "C:\data.txt"
```

:MMEMory:DATA

Command `:MMEMory:DATA <file_name>, <data>`

Parameters `<file_name>, <data>`

Parameter Suffix None

Description The command form is `MMEMory:DATA <file_name>,<data>`. It loads `<data>` into the file `<file_name>`. `<data>` is in 488.2 block format. `<file_name>` is string data.

Examples Command

```
:MMEM:DATA "C:\data.txt", #14test
```

:MMEMory:DELete

Command `:MMEMory:DELete <file_name>[,<directory_name>]`

Parameters `<file_name>`

Parameter Suffix None

Description This command removes a file from the specified directory. The `<file_name>` parameter specifies the file to be removed.

Examples Command

```
:MMEM:DEL "C:\data.txt"
```

:MMEMory:MDIRectory

Command	`:MMEMory:MDIRectory <directory_name>`
Parameters	`<directory_name>`
Parameter Suffix	None
Description	This command creates a new directory. The `<directory_name>` parameter specifies the name to be created.
Examples	Command `:MMEM:MDIR "C:\data_dir"`

:MMEMory:MOVE

Command	`:MMEMory:MOVE <string>,<string>[,<string>,<string>]`
Parameters	`<string>,<string>`
Parameter Suffix	None
Description	This command moves an existing file to a new file or an existing directory to a new directory. Two forms of parameters are allowed. The first form has two parameters. In this form, the first parameter specifies the source, and the second parameter specifies the destination. The second form has four parameters. In this form, the first and third parameters specify the file names. The second and fourth parameters specify the directories. The first pair of parameters specifies the source. The second pair specifies the destination. An error is generated if the source doesn't exist or the destination file already exists.
Examples	Command `:MMEM:MOVE "C:\data_dir","C:\newdata_dir"`

:MMEMory:RDIRectory

Command	`:MMEMory:RDIRectory <directory_name>`
Parameters	`<directory_name>`
Parameter Suffix	None
Description	This command removes a directory. The `<directory_name>` parameter specifies the directory name to be removed. All files and directories under the specified directory are also removed.
Examples	Command `:MMEM:RDIR "C:\newdata_dir"`

:FORMat Subsystem

:FORMat:BORDer NORMal|SWAPped

Command	`:FORM:BORD[?]`
Long	`:FORMat:BORDer[?]`
Parameters	`NORMal|SWAPped`
Parameter Suffix	None
Description	Byte ORDer. Controls whether binary data is transferred in normal (“big endian”) or swapped (“little endian”) byte order. Affects [:SOURce]:SEQuence:DATA, [:SOURce]:STABle:DATA and TRACe:DATA.

Examples	Command
	`:FORM:BORD NORM`
	Query
	`:FORM:BORD?`

:CaLibrate Commands

The `:CALibrate` commands are used to control the latency from the M8131A digitizer to the M8121A AWG. This set of commands should be used only when controlling both instruments. The end effect is that the delay from the analog input of the digitizer to the analog output of the AWG is a fixed latency for a given setup. The calibration procedure must be run upon a change in conditions, such as a disruption to the data flow over ODI, change in cables, or a change in clock source.

:CALibrate:SYNC:INPut:LEVel

Command	:CAL:SYNC:INP:LEV <level>
Query	:CAL:SYNC:INP:LEV?
Parameters	<level>|MINimum|MAXimum|DEFault
Parameter Suffix	None
Description	Set or query the Sync input threshold in Volts. The Sync Input is used with the M8131A digitizer to calibrate a deterministic latency from analog input to analog output.
Examples	:CALibrate:SYNC:INPut:LEVel 0.4

:CALibrate:LATency:LCMP

Command	:CALibrate:LATency:LCMP <lcmp_value>
Parameters	<lcmp_value>
Parameter Suffix	None
Description	Lowest common multiplier between the internal clocks of the M8131A and M8121A. Use value of 5 when operating with a M8131A digitizer.
Examples	:CALibrate:LATency:LCMP 5

:CALibrate:LATency[:STEP] ARM | ADJust | STOP

Command	:CALibrate:LATency ARM | ADJust | STOP
Parameters	STOP: default value ARM: Arms the deterministic latency mechanism. Must be sent before the source (i.e. M8131A) sends sync pulses or ODI data ADJust: Performs deterministic latency adjustment procedure. Requires ARM to have been previously sent, and expects that the source (i.e. M8131A) is in appropriate mode before this command is sent.
Parameter Suffix	None
Description	This command executes a step in the latency calibration of the data path between M8131A digitizer (master) and M8121A AWG (slave). In a 2 channel AWG, affects both channels if enabled. If both channels can be successfully calibrated, then they will be adjusted to ensure that they use the same latency i.e. :CALibrate:LATency:VALue applies to both channels. The status of each channel can be checked using :CALibrate:LATency:STATus{1|2}?
Examples	:CAL:LAT ARM

:CALibrate:LATency:VALue

Command	:CALibrate:LATency:VALue <value> | MINimum | MAXimum
Query	:CALibrate:LATency:VALue?
Parameter	<value> | MINimum | MAXimum
Description	Use :CALibrate:LATency:VALue? to query the current value of Deterministic Latency in seconds. This value is set during the Deterministic Latency ADJustment phase, and maybe subsequently modified by the user. A value of 9.91E37 indicates that deterministic latency adjustment has either not yet been performed, has failed to complete, or has become invalid. Since :CALibrate:LATency[:STEP] ADJust acts on both channels, and sets the latency to the same value for both channels, the value returned by :CALibrate:LATency:VALue? is the same for both channels. After Deterministic Latency Calibration has been successfully run, the range can be queried using CALibrate:LATency:VALue? MINimum | MAXimum. The results from this query are only valid if CALibrate:LATency:VALue? is not 9.91E37. The MINimum value is the value determined during the Deterministic Latency ADJustment phase.

The MAXimum value is the maximum deterministic latency that can be set. The value depends on the system configuration and the internal adjustments used during deterministic latency adjustment. Note - these limits are recalculated after each Deterministic Latency ADJustment phase. If deterministic latency is invalid, the MINimum and MAXimum results are not useful and are set to 0 and 9.91E37.

After getting the latency range, the latency can be set using CALibrate:LATency:VALue <value> | MINimum | MAXimum, where <value> is in seconds. The value must be between the MIN and MAX limits, and is subject to rounding to step sizes determined by the M8121A configuration. The resolution is limited to sample clock periods (125ps @ 8GHz when operating with the M8131A) when using a reduced noise floor or LPN clock. Otherwise, the resolution is the same as the fine delay setting. After setting this value, the user may read the value as used by the M8121A using :CALibrate:LATency:VALue?. Note that there could be a difference in ~40 ns in reported minimum latency after calibration. If it is desired to have a fixed latency each time the system is calibrated, use this command to explicitly set the latency to be larger than the largest minimum reported after multiple calibrations.

Validity: This command applies after the value has been set during the Deterministic Latency ADJustment phase, and until the value is reset automatically during the next Deterministic Latency ADJustment phase, or when Deterministic Latency becomes invalid. Error -221 “Settings conflict” is generated if this command is sent while the current value is 9.91E37 (Deterministic Latency not valid).

Examples Command

:CALibrate:LATency:VALue MAX

Query

:CALibrate:LATency:VALue?

:CALibrate:LATency:STATus{1|2}?

Query	CALibrate:LATency:STATus{1|2}?
Parameter Suffix	None
Description	This query returns status of deterministic latency calibration for the specified channel. Returns 1 if deterministic latency adjustment is currently valid, and 0 if deterministic latency adjustment has either not yet been performed, has failed to complete, or has become invalid.
Examples	CALibrate:LATency:STATus?

:ODI Commands

The :ODI commands are documented in the AXIe standard document (http://www.axiestandard.org/odispecifications.html). Please refer to the AXIe standard documentation for details on these commands. The following is a listing of the `:ODI` commands supported by the M8121A:

```
:ODI:PORT[N]:ACTivate
:ODI:PORT[N]:CAPability:DIRection?
:ODI:PORT[N]:CAPability:FCONtrols?
:ODI:PORT[N]:CAPability:NAME?
:ODI:PORT[N]:CAPability:RATes?
:ODI:PORT[N]:CAPability:RBMax?
:ODI:PORT[N]:CAPability:TBMax?
:ODI:PORT[N]:CAPability:TRMatch?
:ODI:PORT[N]:CAPability:VERSion?
:ODI:PORT[N]:NAME?
:ODI:PORT[N]:DEACtivate
:ODI:PORT[N]:PSTatistics:BBURrsts?
:ODI:PORT[N]:PSTatistics:RBYTes?
:ODI:PORT[N]:PSTatistics:TBYTes?
:ODI:PORT[N]:PSTatistics:THOFfs?
:ODI:PORT[N]:CSTatus?
:ODI:PORT:COUNt?
:ODI:CONSumer[N]:ACTivate
:ODI:CONSumer[N]:CAPability:CLIDs?
:ODI:CONSumer[N]:CAPability:LFILter?
:ODI:CONSumer[N]:CAPability:NAME?
:ODI:CONSumer[N]:CAPability:PFORmats?
:ODI:CONSumer[N]:CAPability:VERSion?
:ODI:CONSumer[N]:CAPability:MAXPacket?
```

```
:ODI:CONSumer[N]:CAPability:TIMestamp:TFORmats?

:ODI:CONSumer[N]:DEACtivate

:ODI:CONSumer[N]:NAME?

:ODI:CONSumer[N]:IFSupported?

:ODI:CONSumer:ASTReam <name>, <dataDestination>,
<sourcePorts>, <options>

:ODI:CONSumer:DESTination?

:ODI:CONSumer:RSTReam

:ODI:CONSumer:COUNt?

:TEST:ODI:PORT[1:2]:TRANsmitter[:STATe] 0|OFF|1|ON
```

:TEST:ODI:PORT[1:2]:TRANsmitter[:STATe] 0|OFF|1|ON

Command	:TEST:ODI:PORT[1:2]:TRANsmitter[:STATe] 0|OFF|1|ON
Query	:TEST:ODI:PORT[1:2]:TRANsmitter[:STATe]?
Parameters	OFF|ON
Parameter Suffix	None
Description	This command turns on/off the ODI test source (from waveform memory). This is useful for debugging the ODI interface such as during interoperability testing.
Examples	:TEST:ODI:PORT:TRAN ON

7 Characteristics

Performance Specification

The performance specification can be found in the Data Sheet of the M8121A at: http://www.keysight.com/find/M8121A.

Operating Environment

Storage Temperature	–40 °C to +70 °C
Operating Temperature	0 °C to 40 °C
Maximum Relative Humidity (Non-condensing)	95% RH up to 40 °C
Operating Altitude	Up to 2000 m
Installation	Category II
Pollution	Degree 2

WARNING The instrument is not designed for outdoor use. Do not expose the instrument to rain or other excessive moisture. Protect the instrument from humidity and temperature changes, which could cause condensation within the instrument.

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

NOTE The Class 1 laser is safe to operate under reasonably foreseeable conditions. The user of this instrument is expected to have experience in safety operating products containing lasers.

Regulatory Information

EMC: Complies with the essential requirements of the European EMC Directive as well as current editions of the following standards (dates and editions are cited in the Declaration of Conformity):

- IEC/EN 61326-1
- CISPR Pub 11, Group 1, class A
- AS/NZS CISPR 11
- ICES/NMB-001

  This ISM device complies with Canadian ICES-001.

  Cet appareil ISM est conforme a la norme NMB-001 du Canada.

SAFETY: Complies with the following standard (dates and editions are cited in the Declaration of Conformity): IEC/EN 61010-1

Acoustic statement: (European Machinery Directive)

Acoustic noise emission

LpA <70 dB

Operator position

Normal operation mode per ISO 7779

To find a current Declaration of Conformity for a specific Keysight product, go to: http://www.keysight.com/go/conformity

Environmental Information

Samples of this product have been type tested in accordance with the Keysight Environmental Test Manual and verified to be robust against the environmental stresses of Storage, Transportation and End-use; those stresses include but are not limited to temperature, humidity, shock, vibration, altitude and power line conditions.

Test Methods are aligned with IEC 60068-2 and levels are similar to MIL-PRF-28800F Class 3.

General

Power consumption	190 W (nom)
Safety complies with	IEC/EN 61010-1
EMC tested to	IEC61326
Warm-up time	30 min
Calibration interval	2 years recommended
Cooling Requirements	Do NOT block vents and fan exhaust. To ensure adequate cooling and ventilation, leave a gap of at least 50 mm (2") around vent holes on both sides of the chassis.

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