RIGOL

SPQ Array Measurement and Control Solution

Quick Guide

Jun. 2025

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1 Document Overview

This document is intended to provide a quick overview of the front and rear panels, user interface, and basic operation of the device related to the SPQ array measurement and control system solution.

NOTE

For the latest version of this manual, download it from the official website of **RIGOL** (*www.rigol.com*).

Publication Number

QGK02100-1110

Format Conventions in this Manual

1. **Key**

   The front panel key is denoted by the menu key icon. For example,  indicates the Power key.

2. **Menu**

   The menu of the sofware interface is denoted by the format of "Menu Name (Bold) + Character Shading". For example, **Data acquisition** denotes the "Data acquisition" menu.

3. **Operation Procedures**

   The next step of the operation is denoted by an arrow ">" in the manual. For example, **Quick start** > **Data acquisition** indicates that first clicking **Quick start**, then clicking **Data acquisition**.

Content Conventions in this Manual

The SPQ series array measurement and control system consists of the following M-series modules. Unless otherwise specified, this manual takes M1103B chassis that supports 16 business modules as an example to illustrate the functions and basic operation methods of the SPQ system. For M1210 that supports two business modules, the slight difference lies in its power supply mode and slot setting.

Model	Description
M1103B	PQ-C16, digital measurement and control chassis supporting 16 business modules
M1210	PQ-C02, digital measurement and control chassis supporting 2 business modules

Model	Description
M2302(-I4)	PQ-M02, 2-slot embedded master module AMD V2000 CPU, 32 GB, 512G SSD
M2601(-I6)	PQ-R01, single slot remote controller module, fiber, QSFP X2, supporting PCIe Gen3 X8
M6301(-C8)	PQ-XY, 8-CH XY microwave control module
M6311(-C8)	PQ-ZC, 8-CH high-bandwidth Z-bias control module
M4910(-C44)	PQ-RD, 4-CH microwave readout module
M4911(-C17)	PQ-MC, 6-CH XY microwave control module, 1-CH microwave readout module
M8401B	PQ-S10, single-chassis synchronization module, supporting up to 16 modules in a single chassis
M8402B(-CT12)	PQ-S10 Pro, multi-chassis synchronization module, supporting up to 192 modules

2 Safety Requirement

2.1 General Safety Summary

Please review the following safety precautions carefully before putting the instrument into operation so as to avoid any personal injury or damage to the instrument and any product connected to it. To prevent potential hazards, please follow the instructions specified in this manual to use the instrument properly.

1. Only the exclusive power cord designed for the instrument and authorized for use within the destination country could be used.
2. Ensure that the instrument is safely grounded.
3. Observe all terminal ratings.
4. Use proper overvoltage protection.
5. Do not operate without covers.
6. Do not insert objects into the air outlet.
7. Use the proper fuse.
8. Avoid circuit or wire exposure.
9. Do not operate the instrument with suspected failures.
10. Provide adequate ventilation.
11. Do not operate in wet conditions.
12. Do not operate in an explosive atmosphere.
13. Keep instrument surfaces clean and dry.
14. Prevent electrostatic impact.
15. Handle with caution.

WARNING

Equipment meeting Class A requirements may not offer adequate protection to broadcast services within residential environment.

2.2 Safety Notices and Symbols

Safety Notices in this Manual:

WARNING

Indicates a potentially hazardous situation or practice which, if not avoided, will result in serious injury or death.

CAUTION

Indicates a potentially hazardous situation or practice which, if not avoided, could result in damage to the product or loss of important data.

Safety Notices on the Product:

- **DANGER**

  It calls attention to an operation, if not correctly performed, could result in injury or hazard immediately.

- **WARNING**

  It calls attention to an operation, if not correctly performed, could result in potential injury or hazard.

- **CAUTION**

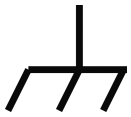
  It calls attention to an operation, if not correctly performed, could result in damage to the product or other devices connected to the product.

Safety Symbols on the Product:

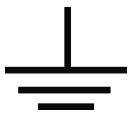
Hazardous Voltage

Safety Warning

Protective Earth Terminal



Chassis Ground



Test Ground

2.3 Care and Cleaning

Care

Do not store or leave the instrument where it may be exposed to direct sunlight for long periods of time.

Cleaning

Clean the instrument regularly according to its operating conditions.

1. Disconnect the instrument from all power sources.
2. Clean the external surfaces of the instrument with a soft cloth dampened with mild detergent or water. Avoid having any water or other objects into the chassis via the heat dissipation hole. When cleaning the LCD, take care to avoid scarifying it.

CAUTION

To avoid damage to the instrument, do not expose it to caustic liquids.

WARNING

To avoid short-circuit resulting from moisture or personal injuries, ensure that the instrument is completely dry before connecting it to the power supply.

3 General Inspection

1. **Inspect the packaging**

   If the packaging has been damaged, do not dispose the damaged packaging or cushioning materials until the shipment has been checked for completeness and has passed both electrical and mechanical tests.

   The consigner or carrier shall be liable for the damage to the instrument resulting from shipment. RIGOL would not be responsible for free maintenance/rework or replacement of the instrument.

2. **Inspect the instrument**

   In case of any mechanical damage, missing parts, or failure in passing the electrical and mechanical tests, contact your RIGOL sales representative.

3. **Check the accessories**

   Please check the accessories according to the packing lists. If the accessories are damaged or incomplete, please contact your RIGOL sales representative.

4 Product Overview

The SPQ series array measurement and control system is a microwave playback and acquisition array system designed for array computing and complex physical experiments. The system adopts a modular architecture, consisting of device platform, business module and synchronous trigger module. You can flexibly configure business module according to experimental requirements, to adapt to different types of complex experimental system. Such modular architecture also facilitates subsequent gradual upgrade and expansion. With industry-leading high integration capability, SPQ supports microwave control and measurement of channels ranging from 100 to 1,000, providing a solid foundation for large-scale array measurement and control.

For a brief description of the front panel, refer to *Figure 4.1* and *Table 4.1 Front Panel Description* . For a brief description of the rear panel, refer to *Figure 4.2* and *Table 4.2 Rear Panel Description* .

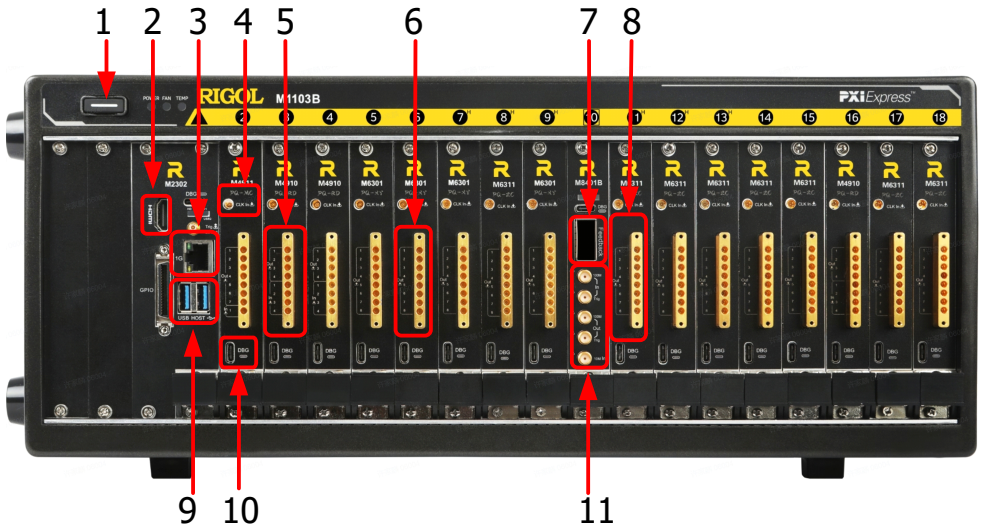


Figure 4.1 Front Panel

Table 4.1 Front Panel Description

No.	Description	No.	Description
1	Power Key	7	Feedback Communication Optical Interface
2	Master HDMI Interface	8	Offset Output Interface (M6311)
3	Master RJ45 Gigabit Network Interface	9	Master USB Interfaces
4	External Sampling Clock Debug Interface	10	Module Debug Monitoring Interface
5	RF I/O (M4910)	11	Connectors from the top to bottom: Clock input, trigger input, clock output, trigger output, 10MHz reference clock input
6	RF Output Interface (M6301)		

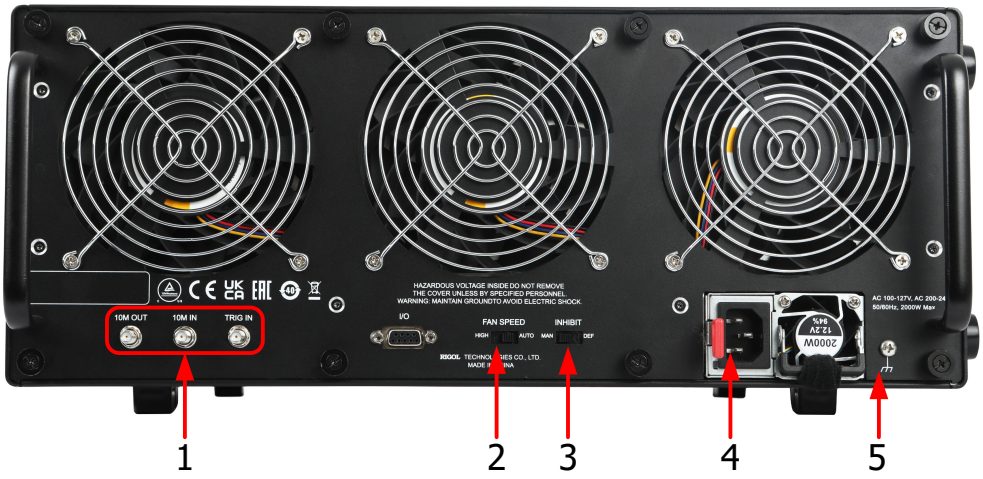


Figure 4.2 Rear Panel

Table 4.2 Rear Panel Description

No.	Description
1	Backplane Clock Trigger Connector (Reserved)
2	Fan Speed Control
3	BIOS Mode Switch
4	AC Power Cord Connector
5	Ground Terminal

5 To Prepare for Use

5.1 Open Package Inspection

After opening the package, remove the protective materials and take out the mainframe and accessories. Inspect the mainframe, the number of modules and accessories to ensure that they match your purchase list. The number of integrated RF cables should be the same as that of your purchased business modules (M6X and M4X series). The number of filters is generally the same as that of microwave control channels and that of the microwave readout channels.

No.	Description	Qty.
1	M1103B Measurement and Control Chassis	1
2	M2302 Control Module	1
3	M8401B/M8402B Synchronization Module	1
4	M6301 (PQ-XY) Business Module	Based on the purchase quantity
5	M6311 (PQ-ZC) Business Module	Based on the purchase quantity
6	M4910 (PQ-RD) Business Module	Based on the purchase quantity
7	M4911 (PQ-MC) Business Module	Based on the purchase quantity
8	Integrated RF Cable	Based on the total quantity of the business modules
9	Power Cable	1
10	Gigabit Network Interface	1
11	Band Pass Filter 4.2 GHz-7.8 GHz	Based on the solution requirement
12	Band Pass Filter 3.2 GHz-5.8 GHz	Based on the solution requirement
13	Band Pass Filter 6.0 GHz-7.0 GHz	Based on the solution requirement
14	Band Pass Filter 6.5 GHz-7.5 GHz	Based on the solution requirement

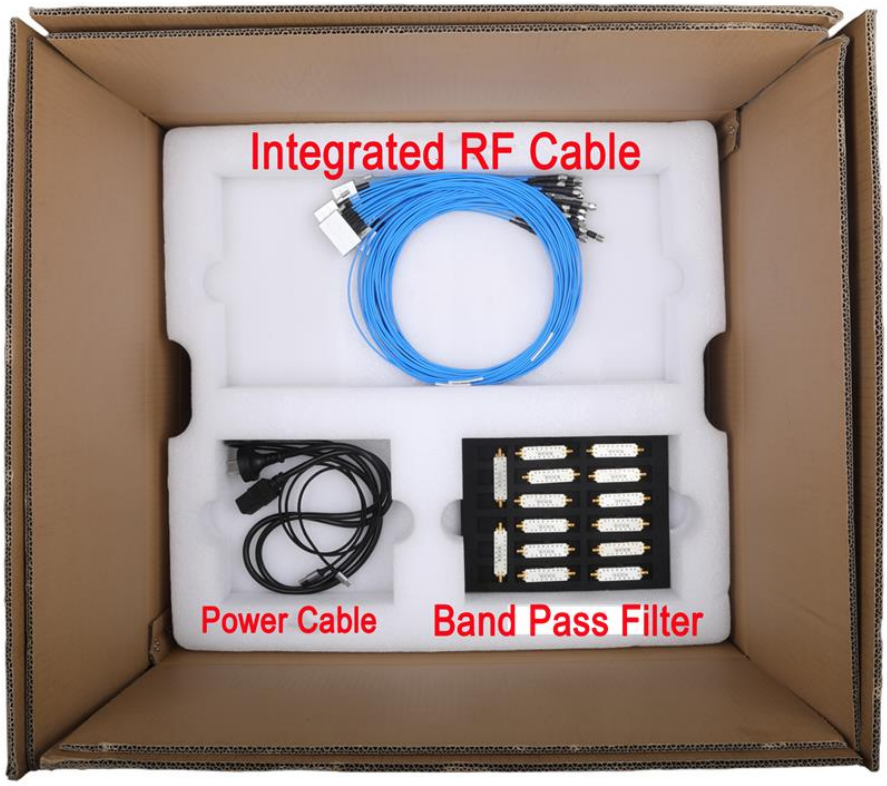
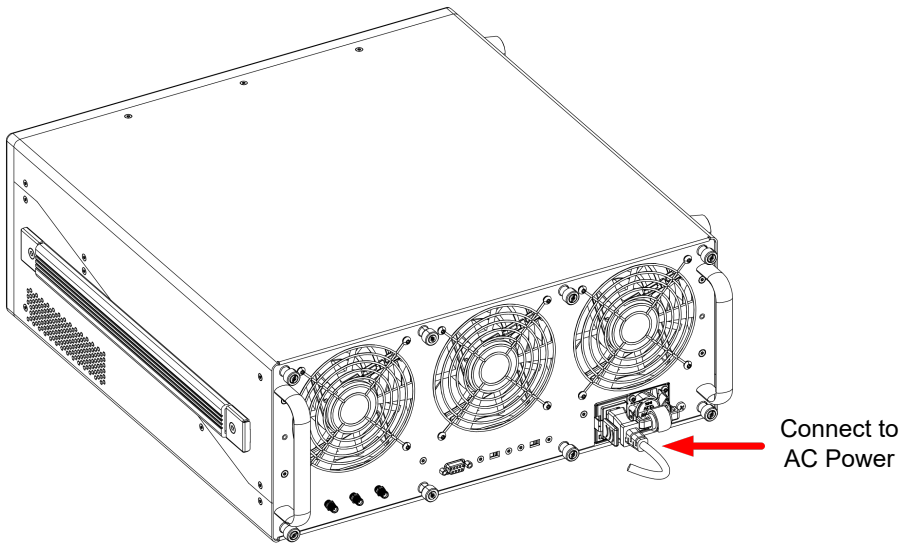


Figure 5.1 First Layer of Package Inspection

Figure 5.2 Second Layer of Package Inspection

5.2 To Connect to AC Power

The AC power specification for the SPQ array measurement and control system is 100 V ~ 240 V. Connect SPQ to the AC power by using the power cable supplied in the accessory, as shown in the figure below.



5.3 Turn-on Checkout

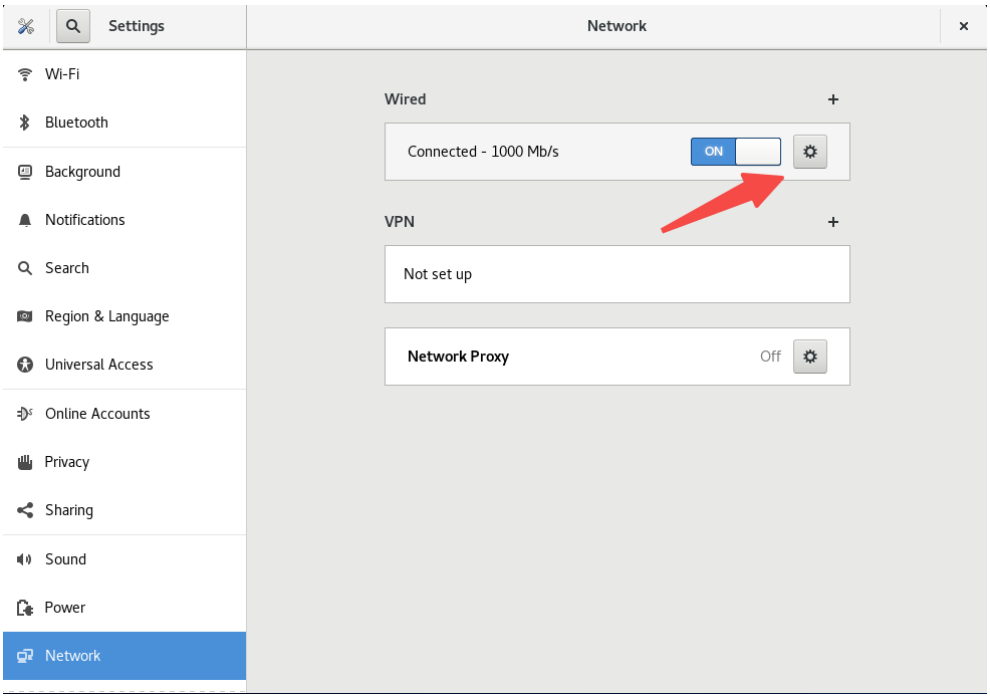
The SPQ array measurement and control system can be accessed in the following two methods: local control with mouse operation via HDMI interface; remote control via LAN interface. It is recommended to use the externally connected mouse for local control operation. First connect the monitor to the master HDMI interface of the device, and connect the mouse keyboard to the master USB interface of the device for local access control. When SPQ is connected to power source, press the Power key at the the upper-left corner of the front panel to launch it. During the power-up process, an audible beep will be heard. Then about 1 minutes later, the login screen will be displayed.

Input the default user account and password to enter the system interface. The user account is guest, and the password is rigol1234.

For the remote control operation via the LAN interface, refer to "Remote Control" section.

5.4 To Modify the IP Address

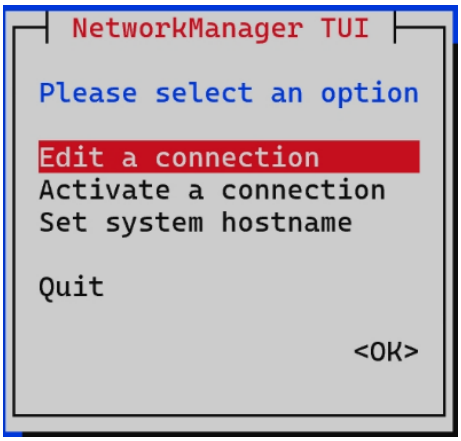
The default IP address of the device is 192.168.110.35. You are allowed to modify the IP address according to your system requirements. The device runs on the Linux-based operating system and can be modified locally in the IP configuration interface.



If you access the device via SSH remote mode, use the following command instructions in the terminal to modify the IP address.

First input the command line ssh guest@192.168.110.35 to access the device, then input the password rigol1234.

Input the command line sudo nmtui, and then select "Edit a connection" to modify the IP address.



5.5 RF Cable Installation

RIGOL provides one integrated RF cable for each SPQ business module. If the cable is damaged in the future use, you can purchase it (CB8-L100) separately. The integrated RF cable has excellent isolation in the full-frequency band, converting 8 RF channels into 8 SMA interfaces. When installing, no tools are required. Just insert the cable with the connector at one side into the business module, irrespective of its front and rear side, then tighten the two screws to install the connector in place.

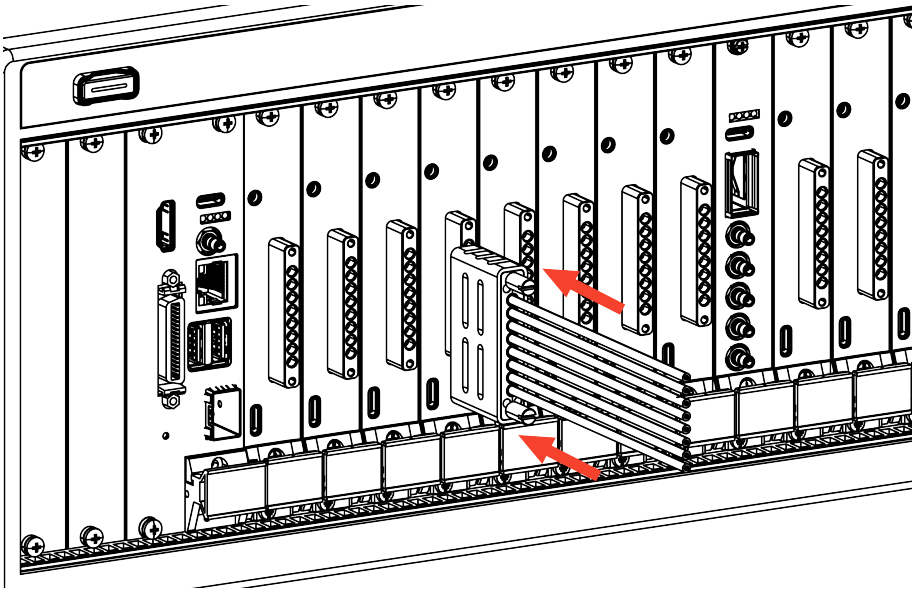


Figure 5.3 Insert the RF Cable

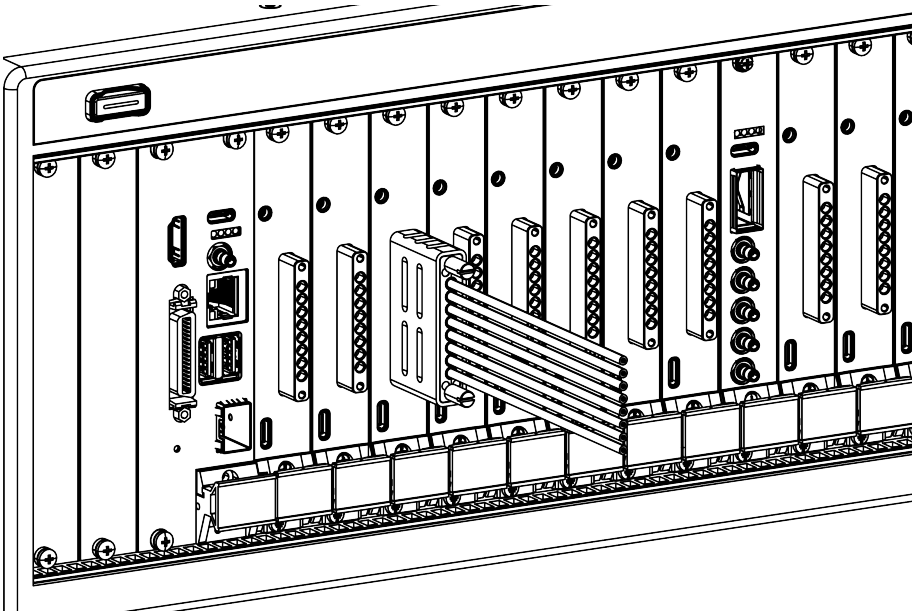
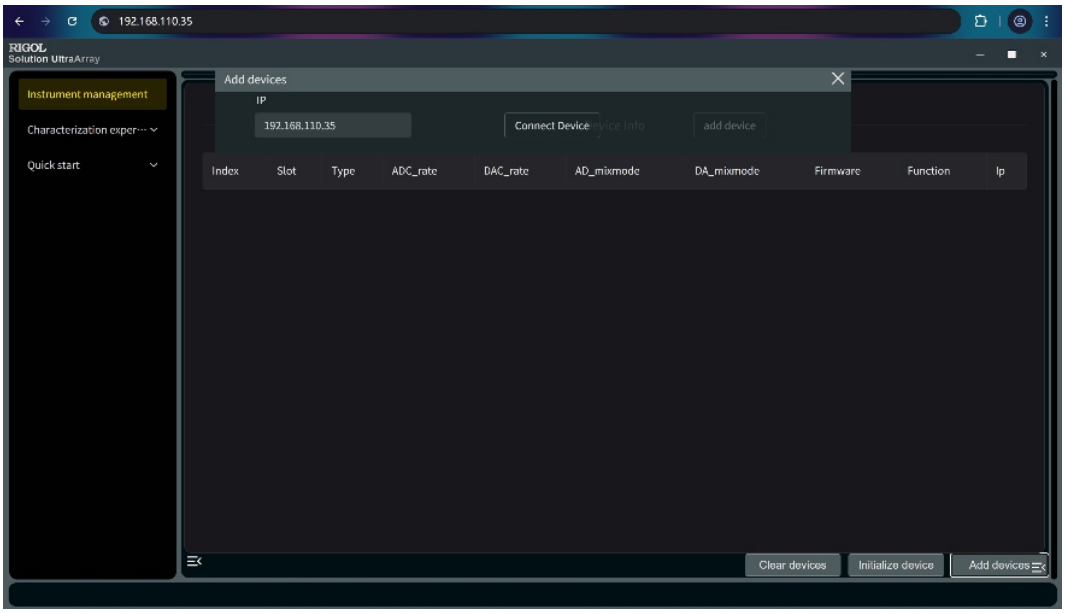


Figure 5.4 Complete the Installation of the RF Cable

6 Local Operation

6.1 To Operate with the Software

The SPQ array measurement and control system provides web-based interface control software. Open the browser locally on the device and input the device IP address to enter the software interface. In the interface, click **Add devices**, then the "Add devices" window is displayed. Add the IP address of your device, and click **Connect Device**. If the device is connected properly, click **add device** to add the specified device.



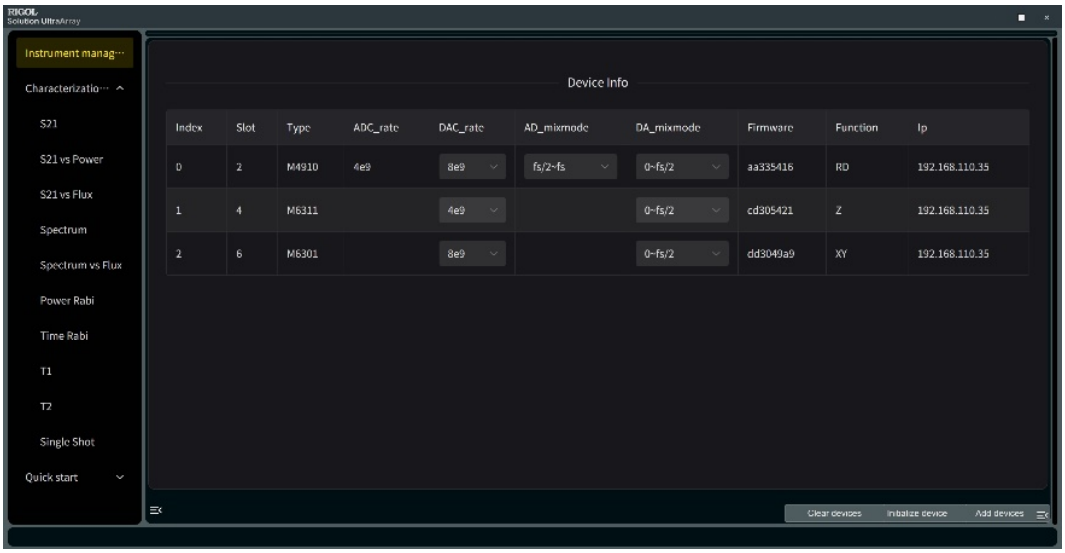
After the device has been added, all the business modules and configuration options available in the current device chassis are automatically listed below.

The sample rates of the readout and acquisition channel are not allowed to be modified. They are fixed to be 4 GSa/s. Set **AD_Mixmode** according to the frequency range of the sampled signal. Set it to **0 ~ fs/2** when the signal frequency is 0.1 GHz ~ 2 GHz or 4 GHz ~ 6 GHz. Set it to **fs/2 ~ fs** when the signal frequency is 2 GHz ~ 4 GHz or 6 GHz ~ 8 GHz.

The sample rates for the microwave control channel, readout channel, and excitation channel can be configured to be 6 GSa/s, 8 GSa/s, and 10 GSa/s, respectively. Select a proper sample rate based on the bit frequency and the filter range. In general, the bit frequency ranges from 3.2 GHz to 7 GHz. Set **DA_Mixmode** to **fs/2 ~ fs**. The sample rates on the three channels correspond to the following frequency range of the output signal: 3.2 GHz to 5.8 GHz, 4.2 GHz to 7.8 GHz, and 5.2 GHz to 9.8 GHz.

The sample rate for the bias control channel can be set to 2 GSa/s or 4 GSa/s. The parameter **DA_Mixmode** must be set to **0 ~ fs**, otherwise DC components will be lost.

After completing the configurations for each board, click **Initialize device** to complete the device initialization synchronization. Each board completes the channel-to-channel initialization synchronization, and then you can do other experiment operations on the software.



6.2 To Operate with the Script Programming

The device can be controlled with the Python API functions. Jupyter Notebook is recommended. The device has been configured to boot Jupyter Notebook automatically at power-on. Open the browser, and input the IP address ("8889") of the device. If you haven't modified the IP address, its IP address is 192.168.110.35:8889. When you log in, open the available test cases to run the tests and characterization programs. For details, refer to *SPQ Programming Guide*.

7 Remote Control

The SPQ array measurement and control system allows you to build communication with the PC via the RJ45 Gigabit network interface to realize remote control. With remote control of the device, you can perform basic characterization experiments with the software. However, for the complex user-defined experimental applications, we recommend you to use the scripts to call APIs. Remote control is available for both software interface control and scripts use.

7.1 To Operate with the Software

The SPQ interface control software is web-based and supports cross-platform remote control of the instrument. Connect the LAN interface of the PC to SPQ via the network cable. Then configure the IP address segments and gateway to be consistent with that of SPQ. Ensure that the communication between your PC and SPQ works properly. If successfully connected, when you open any browser and input the device IP address, you can enter the software interface. Then operate the device with the software. The usage methods are just the same as what described in "Local Use".

7.2 To Operate with the Script Programming

SPQ provides comprehensive API for users. For details on how to use it, refer to *SPQ Programming Guide*. Jupyter Notebook is recommended. For the installation issues, refer to relevant tutorials about Github.

8 Basic Testing

The SPQ array measurement and control system software provides quick performance test for user evaluation. You can use the "Test for Pulse Signal Playback" function to check the pulse distortion; use the "Test for Continuous Signal Playback" function to check signal output frequency, power, spurious, phase noise, noise power spectral density, etc.; use the "Test for Signal Acquisition" function to check signal acquisition delay, signal-to-noise ratio (SNR), etc. With the above-mentioned basic functions, you can quickly get familiar with the device operation, conducive to being well prepared for the follow-up characterization experiments and advanced application experiments.

8.1 Test for Pulse Signal Playback

To perform this test, you need to connect the Out pin of the M6301 (or M6311) board to the oscilloscope, and connect the TrigOut connector of M8401B (or M8402B) to the oscilloscope to observe the playback signal. To better demonstrate the signal, we recommend you to acquire the low-frequency signal. Before initializing the device, set the board parameter **DA_Mixmode** to **0 ~ fs/2**. After completing the **Initialize device** operation, click the **Quick start** option from the menu displayed at the left side of the interface, then select **Pulse waveform play**. Set the test parameters, and then click **Run** at the right side of the interface to complete the experiment. The software interface also allows to test the generated waveform signal. Click the **Real time wave** tab to switch to the waveform check interface. The horizontal axis is the acquisition time, expressed in ns, and the vertical axis is the amplitude of the playback signal that has been normalized. Select the channel that receives the TrigOut signal from M8401B (or M8402B) as the trigger source, and observe the waveform signal output from the Out pin. You can attempt to modify the configuration parameters of the playback signal to get familiar with the device characteristics.

8.2 Test for Continuous Signal Playback

To perform this test, you need to connect the Out pin of the M6301 (or M6311) board to the oscilloscope/spectrum analyzer/phase noise analyzer to observe the playback signal. To better demonstrate the signal, we recommend you to acquire the low-frequency signal. Before initializing the device, set the board parameter **DA_Mixmode** to **0 ~ fs/2**. After completing the **Initialize device** operation, click the **Quick start** option from the menu displayed at the left side of the interface, then select **Cont waveform play**. Set the test parameters, and then click **Run** at the right side of the interface to complete the experiment. The software interface also allows to test the generated waveform signal. Click the **Real time wave** tab to switch to the waveform check interface. The horizontal axis is the acquisition time, expressed in ns, and the vertical axis is the amplitude of the playback signal that has been normalized. You can attempt to modify the configuration parameters of the playback signal to get familiar with the device characteristics.

When evaluating the high-frequency microwave signal output, for example, the 5.3 GHz signal quality, you should set **DA_Mixmode** to **fs/2 ~ fs**, select the sample rate of 6 GSa/s or 8 GSa/s, and connect to the specified filter, and then connect to the specified instrument for evaluation.

8.3 Test for Signal Acquisition

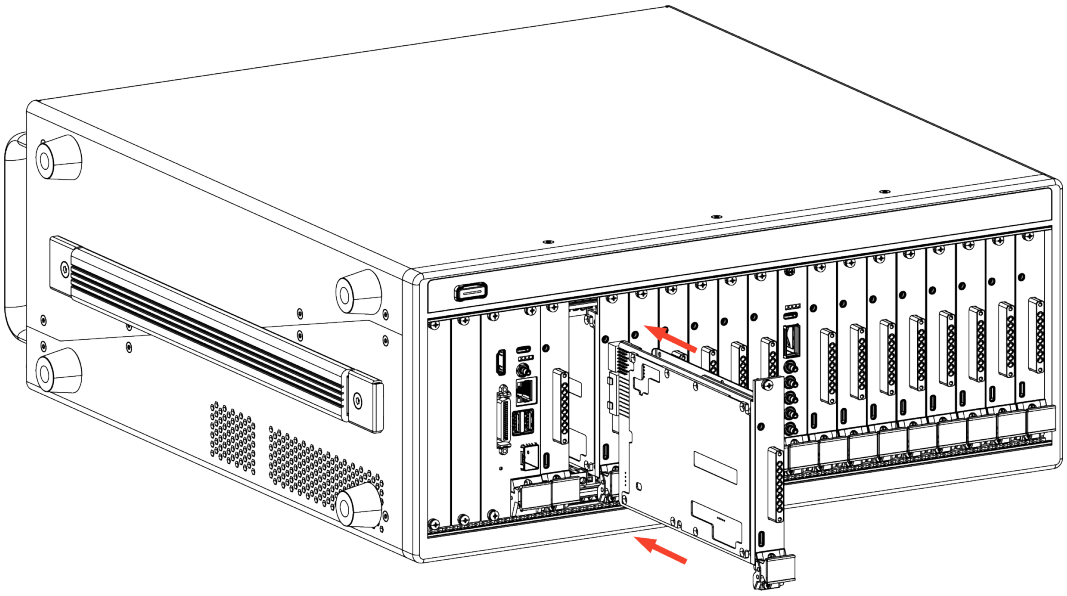
To perform this test, you are required to connect the O pin and I pin of the M4910 (or M4911) board to acquire the playback signal directly. To better demonstrate the signal, we recommend you to acquire the low-frequency signal. Before initializing the device, set the board parameter **DA_Mixmode** and **AD_Mixmode** to **0 ~ fs/2**, respectively. After completing the **Initialize device** operation, click the **Quick start** option from the menu displayed at the left side of the interface, then select **Data acquisition**. Set the test parameters, and then click **Run** at the right side of the interface to complete the experiment. The horizontal axis is the acquisition time,

expressed in ns, and the vertical axis is the amplitude of the acquired int16 original data that have not been normalized. You can attempt to modify the configuration parameters of the playback and acquisition signal to get familiar with the device characteristics.

The software also enables you to make the frequency domain analysis for the original signal. Click the **FFT res** tab above to view the FFT results for the current acquisition data. To achieve better FFT analysis, we recommend you to set the playback time to be greater than the acquisition time, adjust INDelay to increase the start delay of the acquisition to remove the noise of the front segments, ensuring that the acquired data does not contain noise.

9 Module Assembly and Disassembly

The SPQ array measurement and control system allows you to remove, add, or modify the business module. The system software automatically recognizes the slot and the module function and its version according to the type of module inserted. To replace the business module, perform the following operations:



1. Power off the device. Disconnect the device from the power, and remove the power cord.
2. Use a Phillips screwdriver to loosen the two screws that fasten the upper and lower parts of the specified module.
3. Remove the module using the module ejector.
4. Along the slide rail, insert a new module, and use the ejector to install it in place.
5. Secure the two screws that fasten the upper and lower part of the module with a Phillips screwdriver.

WARNING

To avoid the electric shock, before replacing a module, make sure that you have powered off the device and disconnected it from the power source. It is not safe enough to just press down the power key on the front panel of the chassis to turn off the device without pulling out the power cable, as this cannot disconnect the standby power.

10 More Product Information

For more information about this product, refer to the relevant manuals by logging in to the official website of **RIGOL** (*www.rigol.com*) to download them.

SPQ User Guide introduces the functions of the instrument and the operation methods, remote control methods, possible failures and solutions in using the instrument, the technical specifications, and order information.

SPQ Programming Guide provides the API command sets and programming examples.

SPQ Data Sheet provides the main features and technical specifications of the instrument.

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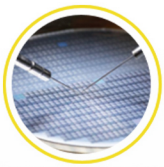

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HEADQUARTER

RIGOL TECHNOLOGIES CO., LTD.
No.8 Keling Road, New District,
Suzhou,JiangSu, P.R.China
Tel: +86-400620002
Email: info-cn@rigol.com

EUROPE

RIGOL TECHNOLOGIES EU GmbH
Carl-Benz-Str.11
82205 Gilching
Germany
Tel: +49(0)8105-27292-0
Email: info-europe@rigol.com

NORTH AMERICA

RIGOL TECHNOLOGIES, USA INC.
10220 SW Nimbus Ave.
Suite K-7
Portland, OR 97223
Tel: +1-877-4-**RIGOL**-1
Email: sales@rigol.com

JAPAN

RIGOL JAPAN CO., LTD.
5F,3-45-6,Minamiotsuka, Toshima-Ku,
Tokyo,170-0005,Japan
Tel: +81-3-6262-8932
Fax: +81-3-6262-8933
Email: info.jp@rigol.com

KOREA

RIGOL KOREA CO,. LTD.
5F, 222, Gonghang-daero,
Gangseo-gu, Seoul, Republic of Korea
Tel: +82-2-6953-4466
Fax: +82-2-6953-4422
Email: info.kr@rigol.com

For Assistance in Other Countries

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