QUANTIFI PHOTONICS®
A Teradyne Company

IQABC

Automatic BIAS Control

MATRIQ User Manual

quantifiphotonics.com

Trademarks

Quantifi Photonics' trademarks have been identified as such. However, the presence or absence of such identification does not affect the legal status of any trademark. All third party product and company names are trademarks™ or registered® trademarks of their respective holders. Neither Quantifi Photonics nor any software programs or other goods or services offered by Quantifi Photonics are affiliated with, endorsed by, or sponsored by the third parties listed below.

LabVIEW™ is a trademark of National Instruments. MATLAB® is a trademark of The MathWorks Inc. Python® is a trademark of the Python Software Foundation. Microsoft Edge®, and Microsoft Windows® are trademarks of the Microsoft Corporation. Google Chrome™ is a trademark of Google LLC.

Units of Measurement

Units of measurement in this publication conform to SI standards and practices.

CE mark related enquiries

EU Authorized Representative
Certification Company
Veluwezoom 42
1327 AH ALMERE
The Netherlands
+31 (0)36 202 40 37
info@certification-company.com

Manufacturer information

Quantifi Photonics Limited
12-14 Parkway Drive
Rosedale, Auckland 0632
New Zealand

User manual version: 2.02

Table of contents

1 What's in this user manual?

You can find the following information in this document:

Before you begin	Conventions Safety information Working with optical fibers System requirements
Getting started	Introducing the IQABC Series Setting up hardware Installing software Instrument IP address
Working with your device	**CohesionUI GUI:** CohesionUI - Overview Controlling your IQABC with CohesionUI **SCPI commands:** Controlling your IQABC with SCPI commands Programming examples and applications
Maintenance	Upgrade firmware Restore factory settings

2 Conventions

Please make yourself familiar with these conventions; we use them throughout this user manual:

WARNING

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

Do not proceed unless the required conditions are met and understood.

CAUTION

Indicates a potentially hazardous situation which, if not avoided, may result in **minor or moderate injury** or **component damage**.

Do not proceed unless the required conditions are met and understood.

NOTE

Indicates relevant information that requires your attention.

3 Safety information

Carefully read all safety information before using your Quantifi Photonics product.

3.1 Optical laser radiation precautions

WARNING

To protect yourself from harm caused by optical radiation:

- Do not install or terminate fibers while the light source is active.
- Turn the Quantifi Photonics product OFF before inspecting the end face(s) of the product, or any optical patch cords connected to it.
- Never look directly into a live fiber; ensure that your eyes are protected at all times.

CAUTION

The use of controls, adjustments, and procedures other than those specified in this document may result in exposure to hazardous situations involving optical radiation.

3.2 Electromagnetic compatibility

CAUTION

For electromagnetic compatibility, this product is a Class A product. It is intended for use in an industrial environment. There may be potential difficulties in ensuring electromagnetic compatibility in other environments, due to conducted as well as radiated disturbances.

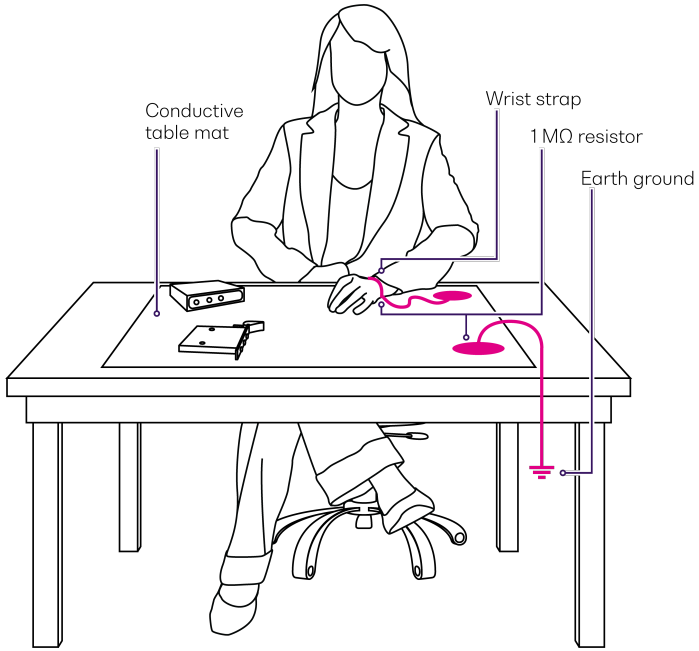

This symbol on the unit refers to documentation provided with the product for related safety information. Ensure that the required conditions are met and understood before using the product.

3.3 Electrostatic discharge precautions

CAUTION

The product is sensitive to electrostatic discharge (ESD). To ensure that you do not cause ESD damage to the product:

- Always follow proper grounding and ESD management practices.
- Store the unused product in the original protective electrostatic packaging that it was shipped in.
- Use a wrist strap and grounding table mat when unpacking or handling the product.



4 Introducing the IQABC Series

The IQABC Series has an advanced Automatic Bias Control (ABC) algorithm to accurately and reliably control and optimize all of the modulator bias points, regardless of the modulation format or pattern.

The external modulator adaptor board provides simple and quick connectivity to any IQ modulator with OIF compatibility. Each of I, Q or phase DC biases can be controlled independently in either automatic or manual mode.

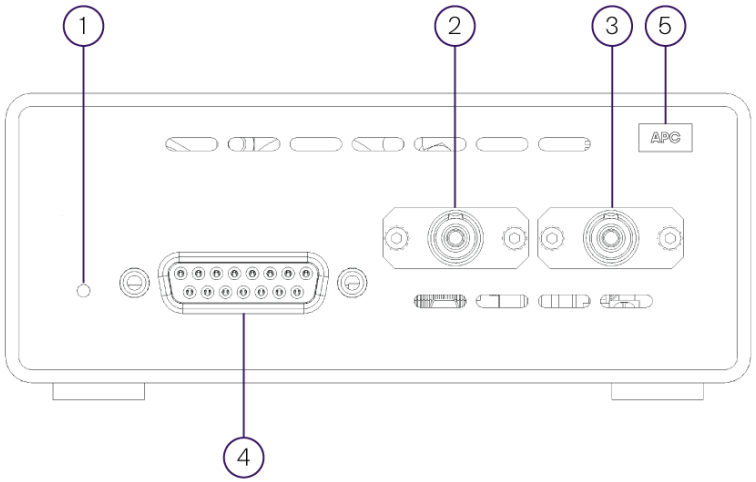
Programming interfaces

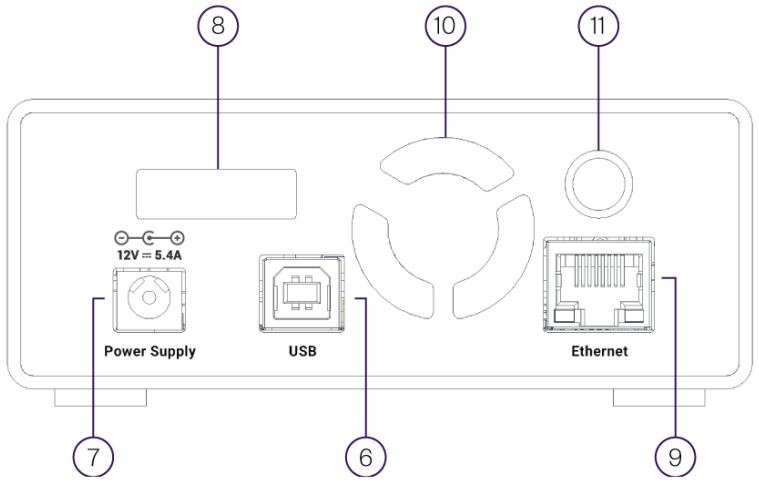
Through its programming interfaces you can take advantage of the SCPI-compliant command language and choose from programming tools such as LabView, C++, Python, or any of the other popular programming languages used to control automatic test equipment (ATE).

CohesionUI™

Quantifi Photonics' web-based graphical user interface CohesionUI is hosted on Microsoft Windows® and enables you to control your device from any supported web browser.

4.1 Hardware description





1	Status LED	6	USB type B port
2	Modulated signal in port	7	Power supply port
3	Signal out port	8	IP address LCD screen
4	Modulator connection	9	Ethernet port
5	Optical connector type	10	Ventilation fan (DO NOT OBSTRUCT)
		11	On / Off push button

NOTE

- You must use the external power supply that has been supplied by Quantifi Photonics with the unit. Any attempt to use a different external power supply may cause product damage and will void your warranty.
- The external power supply that has been used with the unit can only be used with that unit. Do not use it with any other product.

4.2 Status LEDs

The LED shows the operation state of the IQABC instrument:

LED	Meaning
OFF	Product is DISABLED.
solid RED	Indicates that an error was registered.
flashing RED/GREEN	Indicates initialization of the instrument during startup. If blinking persists for more than a few seconds, it indicates an error was registered..
flashing ORANGE	Indicates that the ABC optimizer is searching for optimal points.
solid GREEN	Indicates that the ABC is locked, and the bias points reached the optimal points.

5 Setting up hardware

Follow the instructions in this section when setting up your instrument.

CAUTION

The product is sensitive to electrostatic discharge (ESD). To prevent damage from ESD:

- Do not remove the product from the antistatic packaging until required to do so.
- Wear a grounded wrist strap at all times when handling the product.

CAUTION

Skin contact may leave corrosive residue and damage a connector:

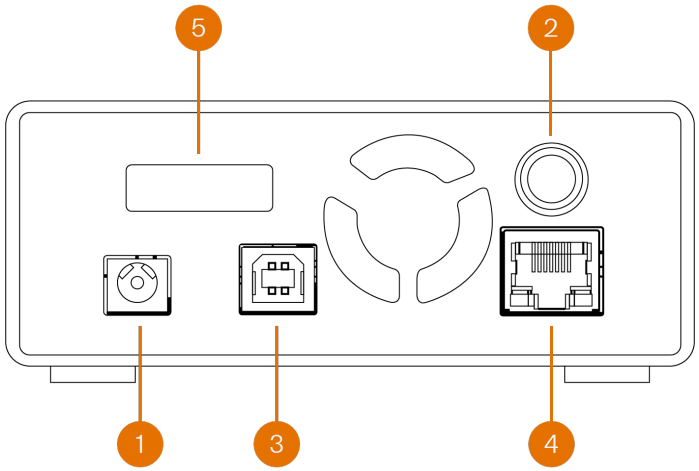
- Always clean optical end faces before mating.

NOTE

- You must use the external power supply that has been supplied by Quantifi Photonics with the unit. Any attempt to use a different external power supply may cause product damage and will void your warranty.
- The external power supply that has been supplied with the unit can only be used with that unit. Do not use it with any other product.
- DO NOT attempt to remove or adjust any component of the product while the power is on. Ensure the product is powered OFF, and that the correct handling procedure detailed herein is followed when you remove or install any products.
- Please check for the fiber end-face type of the optical ports, such as PC or APC, and only use the same type optical connector to avoid damaging the end-face.

For advice on connector and fiber care, please refer to Working with optical fibers.

5.1 Set up your IQABC instrument and power ON



▶ To set up your instrument and power ON:

To allow for optimal air flow and avoid thermal issues, do not block the ventilation fans in the front and back of the instrument and set up your instrument with a minimum clearance of 2 inches (50.8mm) around it.

1. Insert the power cord - you must use the IEC cable supplied with the unit.
2. Power the instrument ON by pushing the ON button.
3. Connect to a client computer using a USB cable,

   OR
4. Connect to your network or client computer using an Ethernet cable.
5. The instrument IP address will appear on the LCD screen. When the unit is connected via both Ethernet and USB cable, both the Ethernet and USB IP addresses are displayed.

After powering ON, please wait at least **1 minute** before attempting to communicate with the unit. This gives the unit time to finish boot procedures and initialize the communication server.

5.2 Instrument IP address

To access your Quantifi Photonics instrument from a client computer, you need the IP address of the instrument.

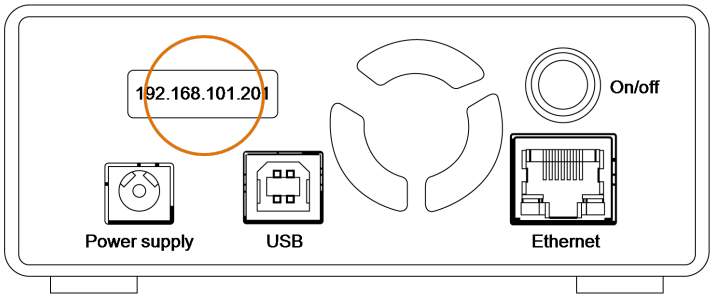
Your instrument can have two different IP addresses depending on your chosen connection method (USB or Ethernet):

- The default **USB IP address** is **192.168.101.201**. This is a static address set during instrument calibration.
- The default **Ethernet IP address** is dynamically assigned by the DHCP.

▶ To view an instrument's IP address:

With your instrument powered ON, you can view the current IP address on the LCD display.

If your instrument is connected with both, Ethernet and USB cables, both the USB and Ethernet IP address are displayed.



▶ To change an instrument's IP address:

You can change the instrument's static USB IP address and you can assign a static Ethernet IP address using CohesionUI.

Multi-instrument control

If you have several Quantifi Photonics instruments with static IP addresses on your network, make sure to assign a unique IP address to each instrument before connecting.

For details, refer to Change the instrument IP address.

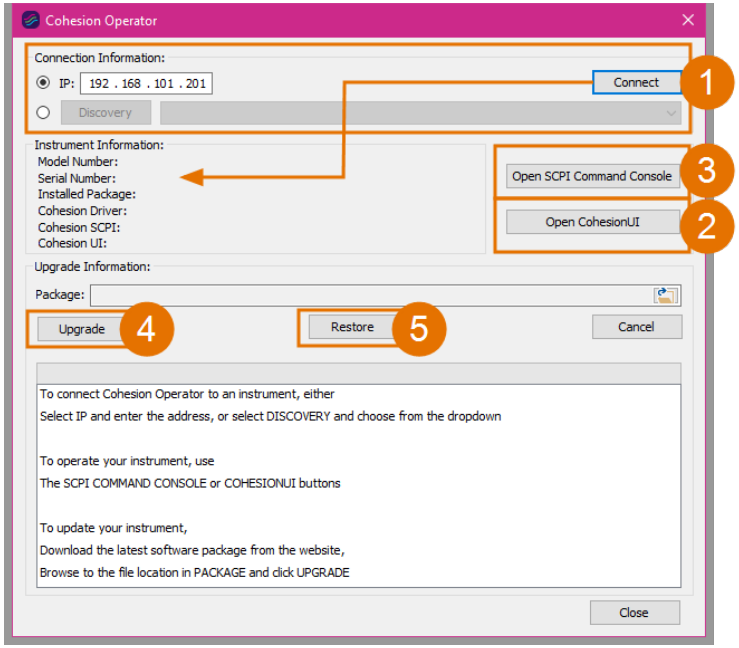
6 Installing software

To work with Quantifi Photonics instruments, you need to install the latest version of the **Cohesion Operator** software package on any computer that you use to connect with your instrument (client computer).

The software package is included on the USB media device that we provide with your instrument, or you can download it from quantifiphotonics.com (go to Resources > Drivers, software and manuals > MATRIQ Series).

Cohesion Operator enables you to:

1. **Connect** with instruments that are available on your network to retrieve instrument information and validate the instrument's IP address.
2. Access an instrument using **CohesionUI**, a web-based graphical user interface.
3. Work with an instrument using the **SCPI Command Console**.
4. Upgrade instrument **firmware**.
5. Restore an instrument to **factory settings**.



6.1 Install the Cohesion Operator software package

▶ To install the software package on a client computer:

1. (recommended) Save your work and close all programs.
2. If using the **USB media device**, insert it in the computer.
3. Double-click **CohesionOperator-<version>.exe** and follow the prompts.

   A Windows Security Alert may prompt you to allow network access. We recommend that you allow access to both, private and public networks, to enable any network configuration.

   The installation wizard will install required drivers, applications, and desktop icons on the computer.

Multi-instrument control

If another Quantifi Photonics instrument is already connected to the client computer via USB, make sure each instrument has a unique USB IP address to avoid any addressing conflicts.

▶ To open the Cohesion Operator application:

- Double-click the **Cohesion Operator** desktop icon or open **Cohesion Operator** from the Start menu.

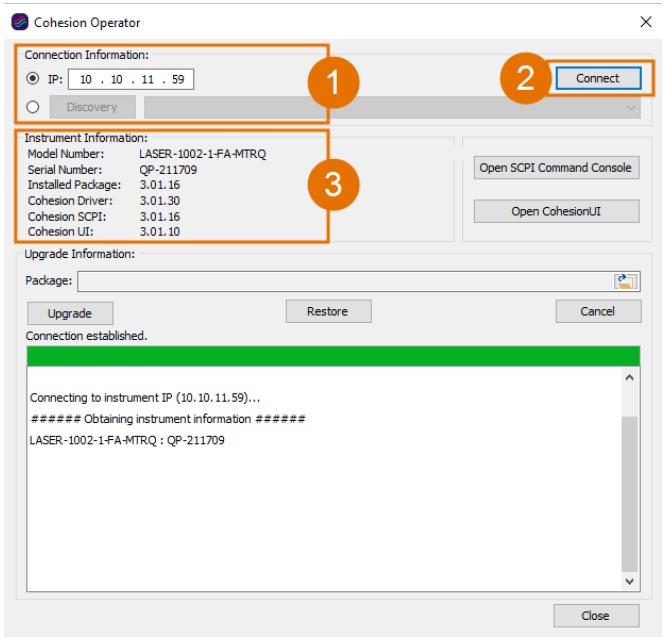
6.2 Check firmware version and other information

Using Cohesion Operator, you can check the firmware version and other details of Quantifi Photonics instruments that are available on your network.

▶ To check details in Cohesion Operator:

1. Select the instrument.
2. Click **Connect**.
3. Current instrument information will be displayed.

   Installed Package refers to the currently loaded firmware version.

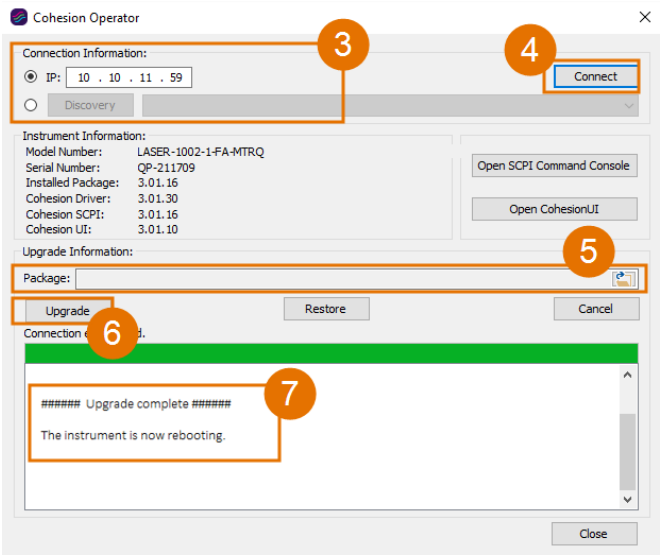


6.3 Upgrade firmware

We recommend that you upgrade firmware via a USB connection to prevent possible connection loss when using an Ethernet connection.

▶ To upgrade an instrument with the latest firmware:

1. Get the latest MATRIQ firmware package **CohesionMATRIQ-<version>.qfw**, for example by downloading it from quantifiphotonics.com (go to **Resources > Drivers, software and manuals > MATRIQ Series**), and save it to your network.
2. Open the Cohesion Operator, for example by double-clicking the **Cohesion Operator** desktop icon.



3. Select the instrument by entering its **IP address** or by selecting it from the **Discovery** drop down list.
4. To confirm that you have selected the correct instrument, click **Connect**.
   This will retrieve instrument information, with **Installed Package** showing the current firmware version.
5. In **Package**, click the Browse button, navigate to the previously downloaded firmware package and select it.
6. Click **Upgrade**. The instrument will be upgraded to the selected firmware package. This can take a few minutes and the instrument might reboot several times in the process.
7. A message shows when the upgrade is complete.

   To verify the new firmware version, click **Connect** (4) to retrieve the latest instrument information.

NOTE

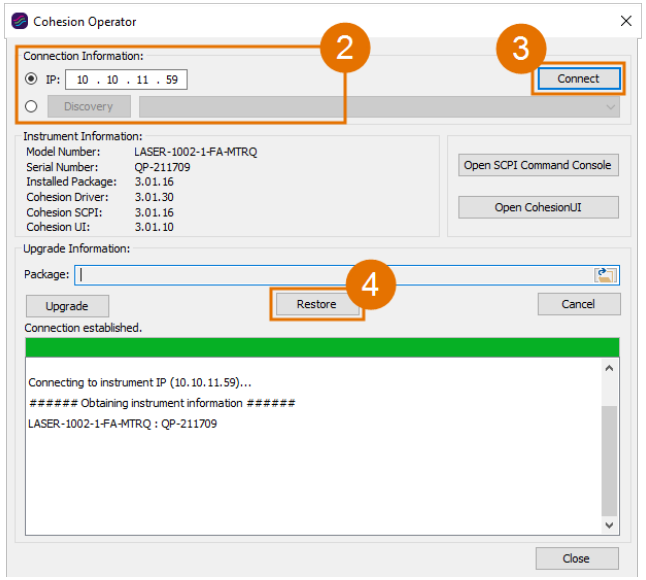
If an upgrade attempt is unsuccessful, the Cohesion Operator will stop the upgrade process and restore the instrument to its previous firmware version. Messages will be displayed accordingly.

6.4 Restore factory settings

We recommend that you restore factory settings via a USB connection to prevent possible connection loss when using an Ethernet connection.

▶ To restore factory settings:

1. Open the Cohesion Operator, for example by double-clicking the **Cohesion Operator** desktop icon.



2. Select the instrument by entering its **IP address** or by selecting it from the **Discovery** drop down list.
3. To confirm that you have selected the correct instrument, click **Connect**.
   This will retrieve instrument information, with **Installed Package** showing the current firmware version.
4. Click **Restore**.
   The instrument will be returned to factory settings, including IP address settings.

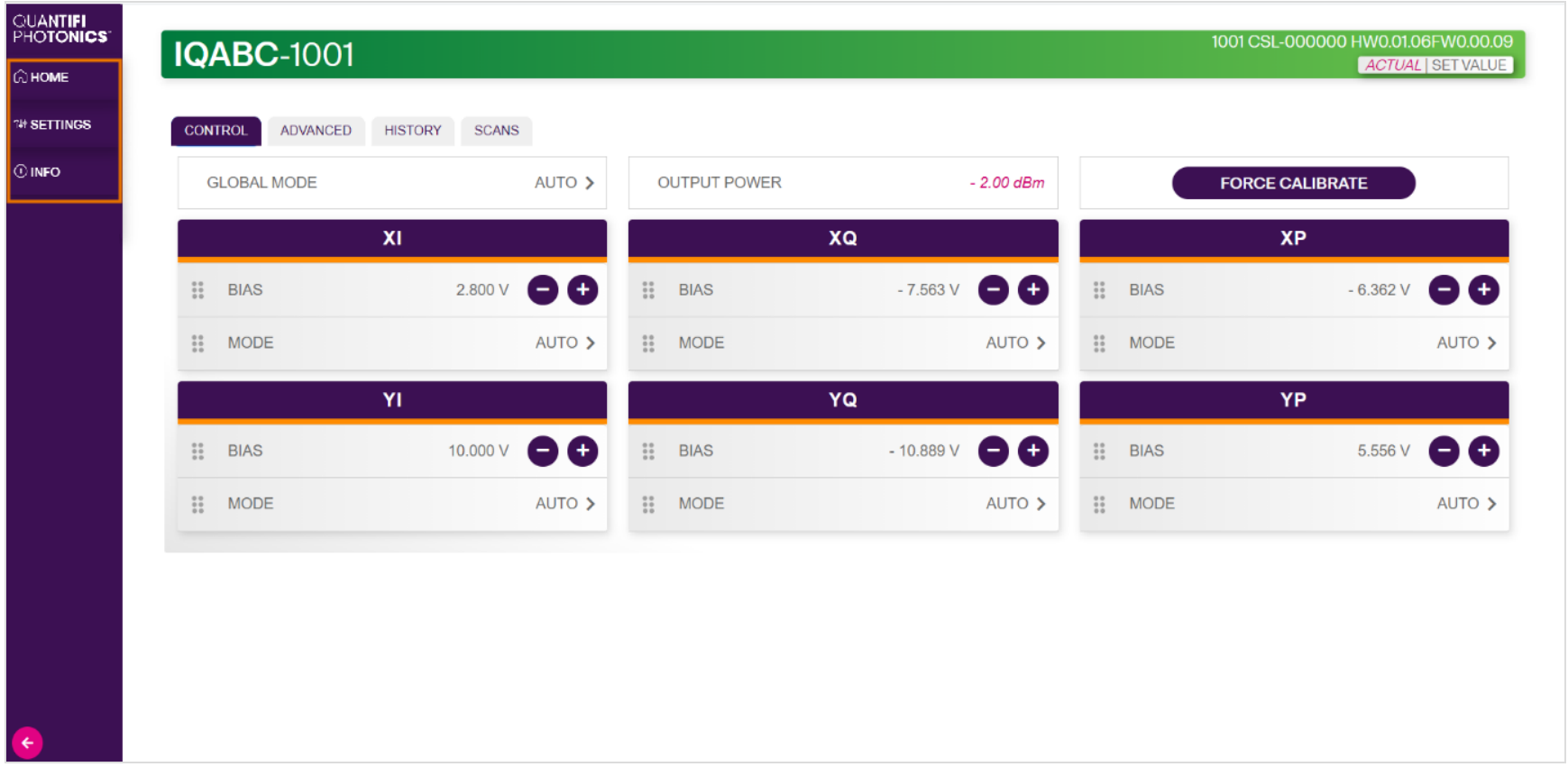
7 CohesionUI - Overview

CohesionUI is a web-based graphical interface that you can use to work with your Quantifi Photonics product.

> CohesionUI is part of the MATRIQ firmware package running on your Quantifi Photonics instrument.

From the menu on the left you can navigate to the following pages:

1. **HOME**: This is your main page. From here you can access all controls for your instrument
2. **SETTINGS**: Here you can change CohesionUI settings and/or instrument IP address
3. **INFO**: Here you can display instrument information, e.g. model number and firmware version



7.1 Access instruments with CohesionUI

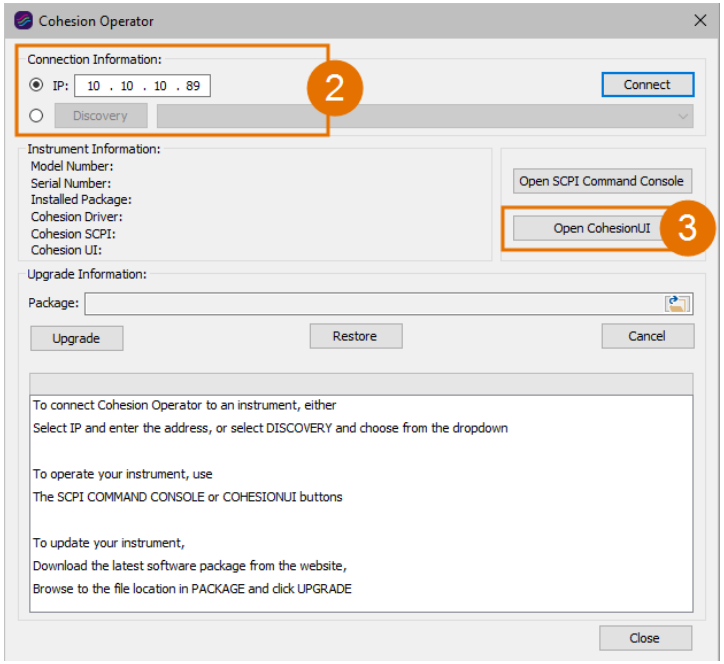
You can open CohesionUI for Quantifi Photonics MATRIQ and EPIQ instruments:

- from Cohesion Operator, or
- in a supported browser by entering the instrument IP in the address bar.

To open CohesionUI, you need the IP address of the instrument. For details, refer to the Instrument IP address section.

▶ To open CohesionUI from Cohesion Operator:

1. Open **Cohesion Operator** on a client computer, for example by double-clicking the Cohesion Operator desktop icon
2. Select the instrument by entering its **IP address** or by selecting it from the **Discovery** dropdown.
3. Click **Open CohesionUI**.
   CohesionUI will open in your standard browser.



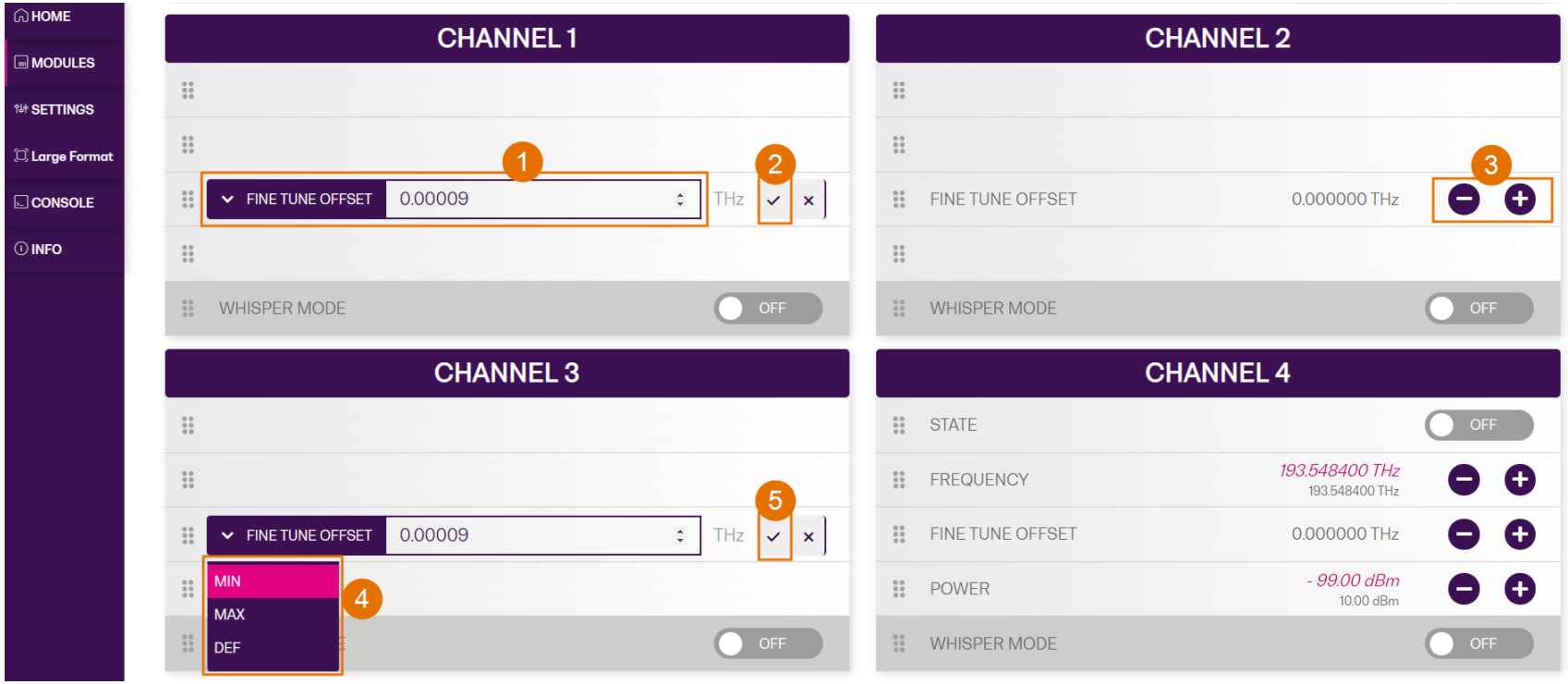
To open CohesionUI in a browser:

1. Launch a supported **browser**.
2. Enter the instrument **IP address** in the address bar.
   CohesionUI will launch in the browser.

7.2 Set values

In CohesionUI you can set values for parameters where applicable.

- To set a value:
  1. Click on a parameter and enter a value.
  2. Confirm the value.
  3. Alternatively, you can use + and - to increase or decrease the value. You can edit the step size in the **SETTINGS** menu.
- To set a pre-defined value, for example **MIN**, **MAX** or **DEF**:
  4. Click on a parameter and select a value from the dropdown menu.
  5. Confirm the value.

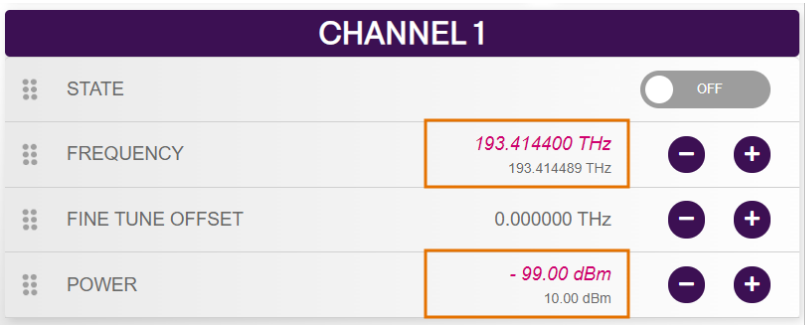


For details on how to change the step size, refer to Manage CohesionUI settings.

7.3 SET values and ACTUAL values

In some cases you can manually set a value that will be displayed alongside the actual value as follows:

- ***ACTUAL***: The actual value of the parameter as queried by the product.
- **SET**: The intended value of a given parameter as set by the user.



7.4 Manage CohesionUI settings

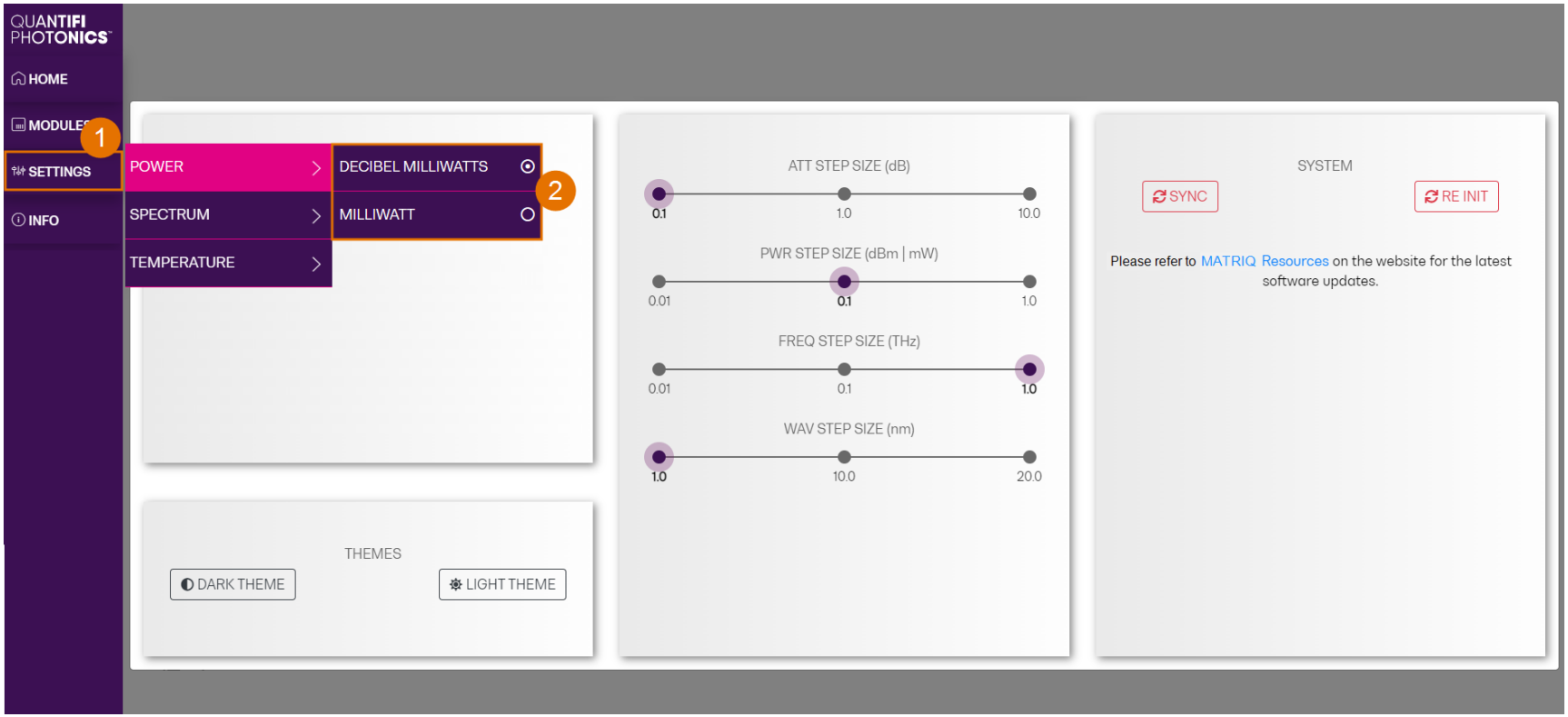
On the **SETTINGS** page you can configure CohesionUI settings and unit preferences.

▶ To view all settings and unit preferences and adjust as required:

1. Click **SETTINGS**.
2. Change settings or unit preferences as required, for example temperature units.
   Please note that the units displayed on this page are not always relevant for each product.
3. **Step size** refers to the amount by which a value is increased or decreased when clicking the **+** or **-** button.

To adjust unit preferences one at a time:

1. Hover over **SETTINGS**.
2. Select a unit from the dropdown, for example the power unit.



7.5 Change the instrument IP address

Your instrument can have two different IP addresses depending on your chosen connection method (USB or Ethernet):

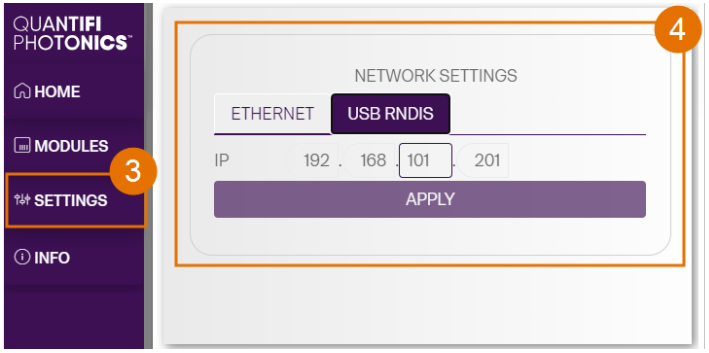
- The default **USB IP address** is **192.168.101.201**. This is a static address set during instrument calibration.
- The default **Ethernet IP address** is dynamically assigned by the DHCP.

You can change the instrument's static USB IP address, and assign a static Ethernet IP address if required.

> **Multi-instrument control**
>
> If you have several Quantifi Photonics instruments with static IP addresses on your network, make sure to assign a unique IP address to each instrument before connecting.

▶ To change the **USB IP address**:

1. Connect with the instrument from a client computer via USB. Ensure that this is the only Quantifi Photonics instrument currently connected via USB.
2. Open CohesionUI using the currently assigned USB IP address.
3. Go to **SETTINGS**.
4. In **NETWORK SETTINGS > USB RNDIS** tab:
   - The currently assigned IP address is displayed. Enter the new IP address by changing the **3rd octet** of the IP address.
     To avoid any addressing conflicts, make sure that this is a unique IP address that is not shared with any other instrument on the network.
   - Click **APPLY**. The new IP address will show in CohesionUI and on the display.



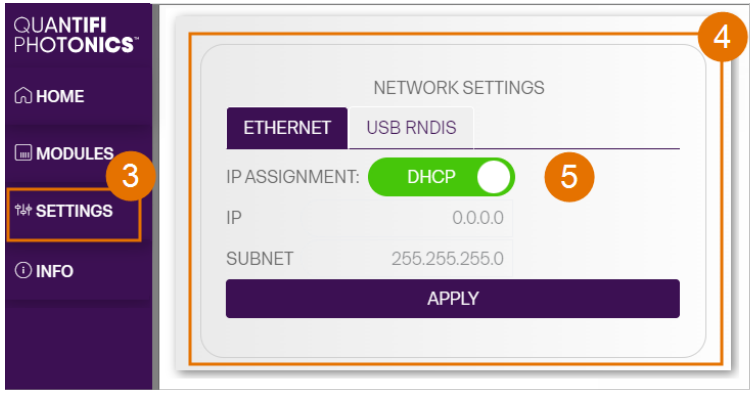
To change the **Ethernet IP address**:

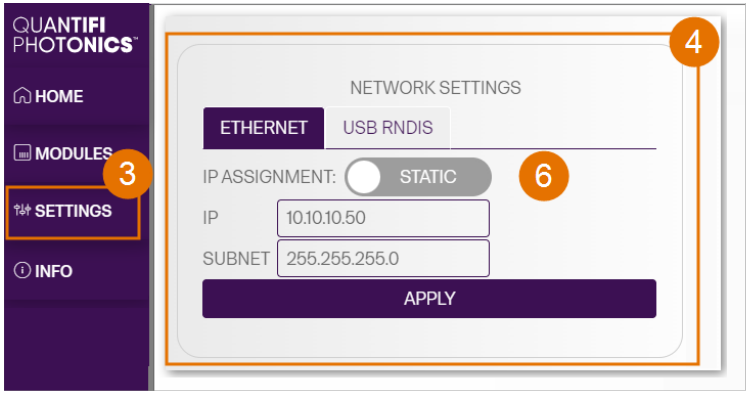
1. Connect with the instrument from a client computer via USB. Ensure that this the only Quantifi Photonics instrument currently connected via USB.
2. Open CohesionUI using the currently assigned USB IP address.
3. Go to **SETTINGS**.
4. In **NETWORK SETTINGS > ETHERNET** tab:
5. Toggle **IP ASSIGNMENT** to **DHCP** to enable the DHCP to automatically assign the Ethernet IP address (this is the default setting) and click **APPLY**.

   OR

6. Toggle **IP ASSIGNMENT** to **STATIC** to assign a static Ethernet IP address.
   Enter the new **IP address** and **SUBNET mask** and click **APPLY**.
   To avoid any addressing conflicts, make sure that this is a unique IP address that is not shared with any other instruments on the network.

   The new IP address will show in CohesionUI and on the display.



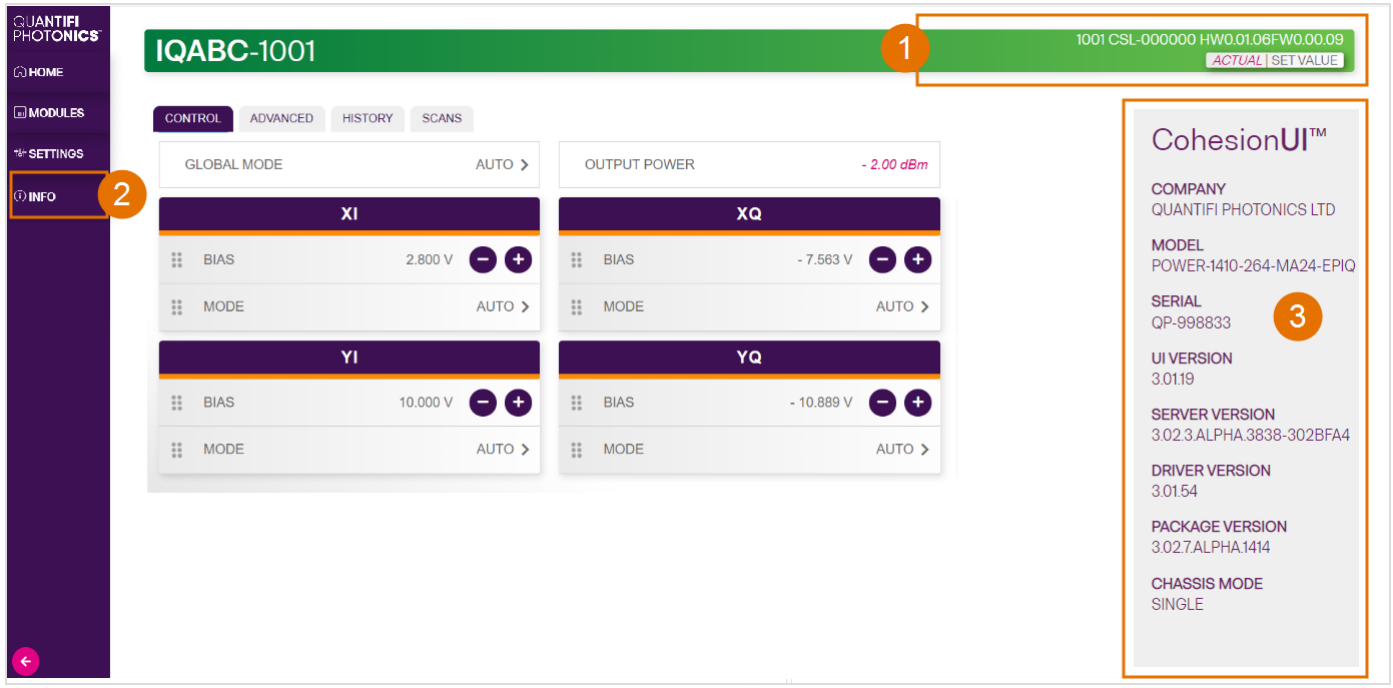


7.6 View system information

You can easily access instrument information, for example the model number and firmware version.

- To display instrument information in CohesionUI:

1. Refer to the top right corner in CohesionUI.
2. For more details, click **INFO** to display the information panel.
3. The information panel lists the instrument's serial number, and software and firmware versions.

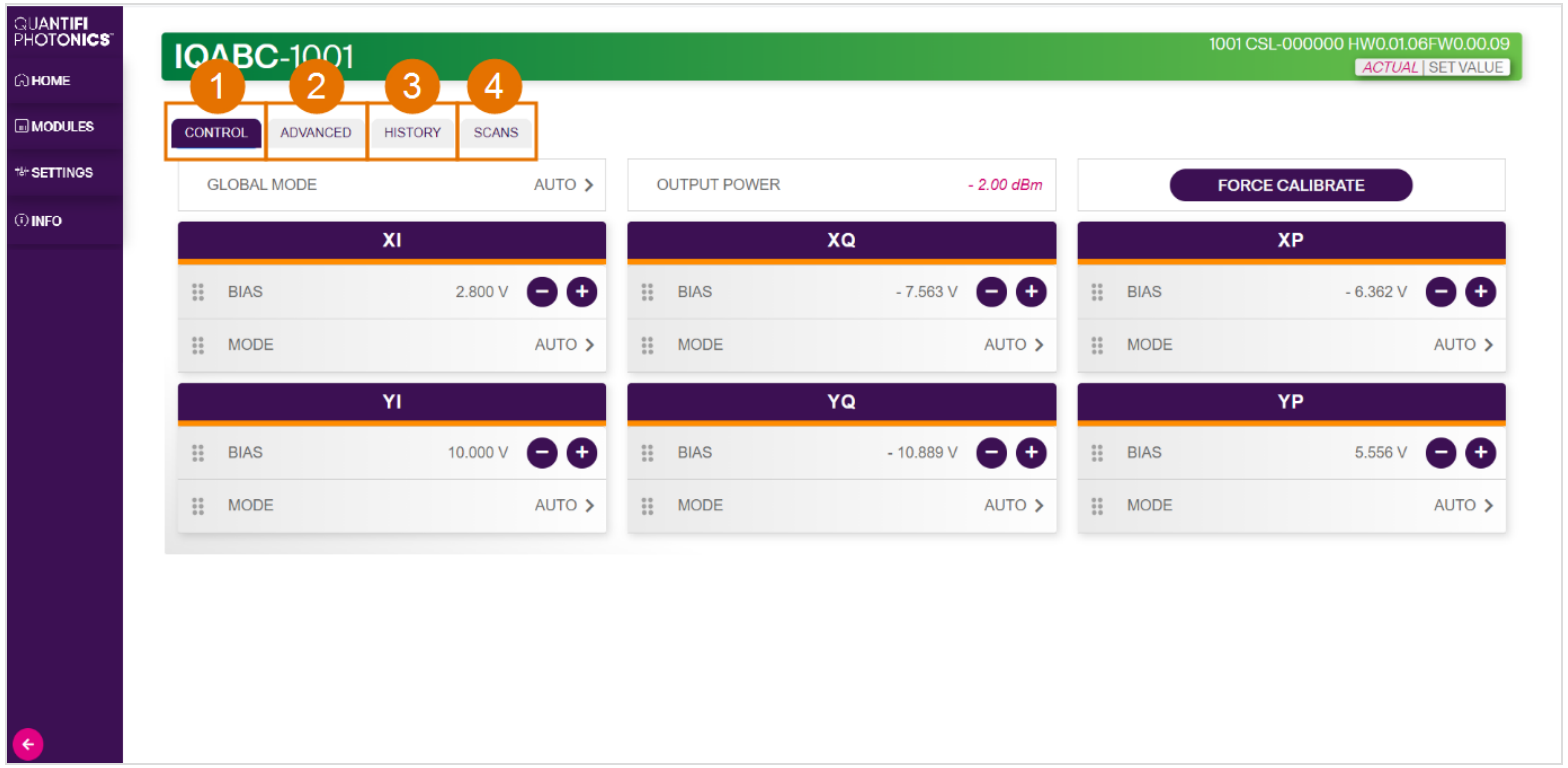


8 Controlling your IQABC with CohesionUI

You can use Quantifi Photonics' graphical user interface CohesionUI to work with your product. For details on how to get started with CohesionUI, refer to CohesionUI - Overview.

The CohesionUI IQABC HOME screen displays the modulation channels including the following tabs:

1. **CONTROL**: Control mode and bias values of the modulation channels.
2. **ADVANCED**: Control modulator dither size values and interval.
3. **HISTORY**: Review modulator bias values vs time error history plots.
4. **SCANS**: Review modulator biases power vs biases voltage plots



8.1 Instrument control tab

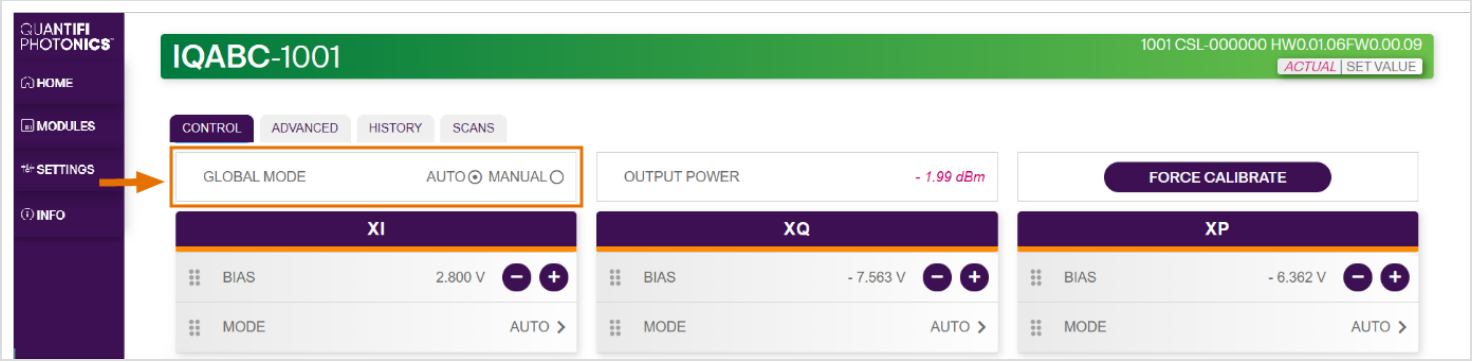
To control the IQABC instrument operation mode and bias values, click the **CONTROL** tab.

8.1.1 Setting the modulation channels mode

The modulator biases can operate in AUTO mode (default) or MANUAL mode.

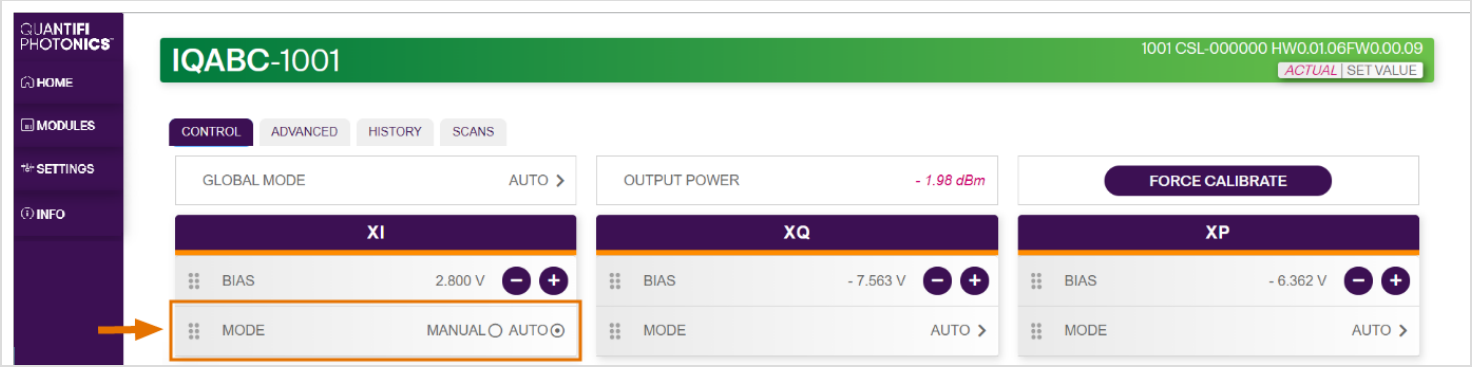
- To set the mode for **all** modulation channels:

1. In the **CONTROL** tab, click **GLOBAL MODE** and select a mode.



- To set the mode for a **selected** modulation channel:

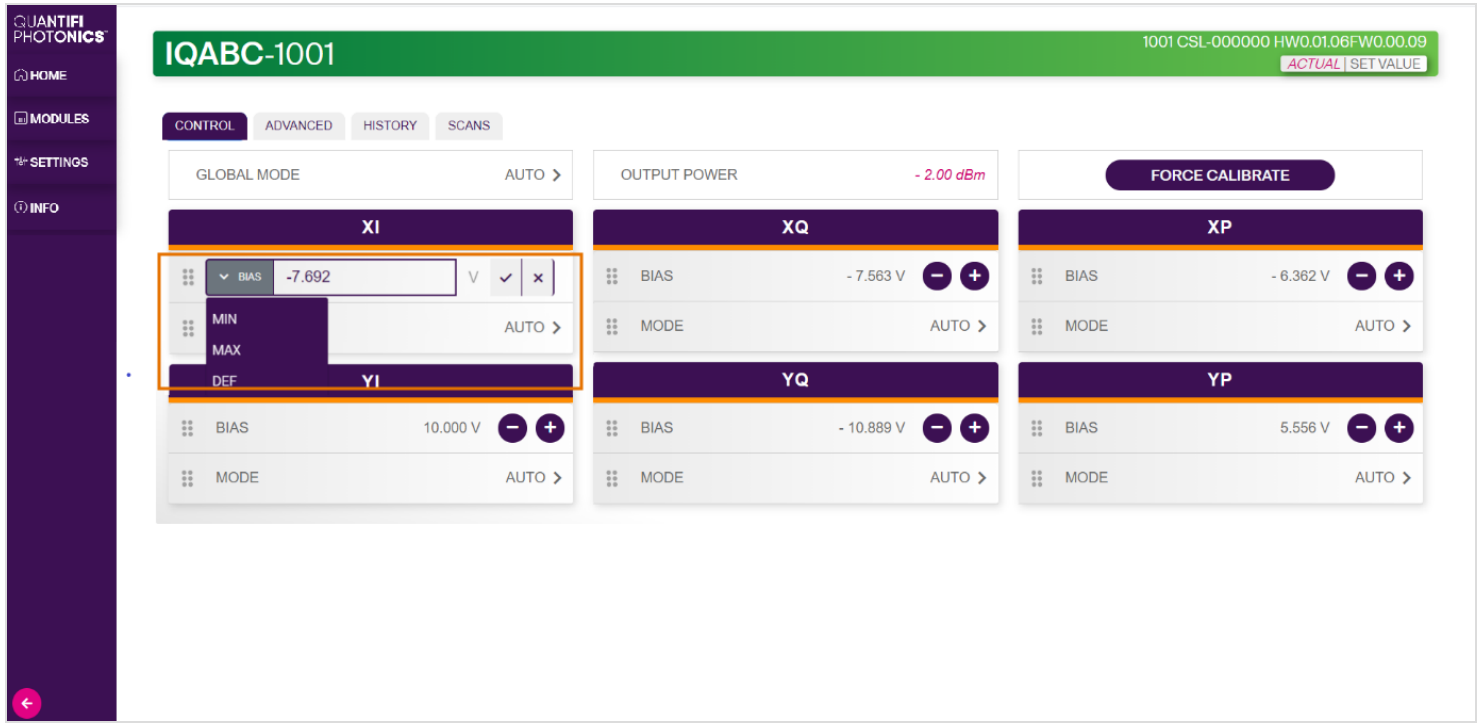
2. In the **CONTROL** tab, click **MODE** for a modulation channel and select a mode.
3. **GLOBAL MODE** will change to **CUSTOM**.



8.1.2 Setting the modulator bias values

In the **CONTROL** tab, you can set the BIAS value for each modulation channel by clicking the parameter field, or by using the **+** and **–** control buttons to increase or decrease the value by a set amount. You can set this step size in the **SETTINGS** menu.

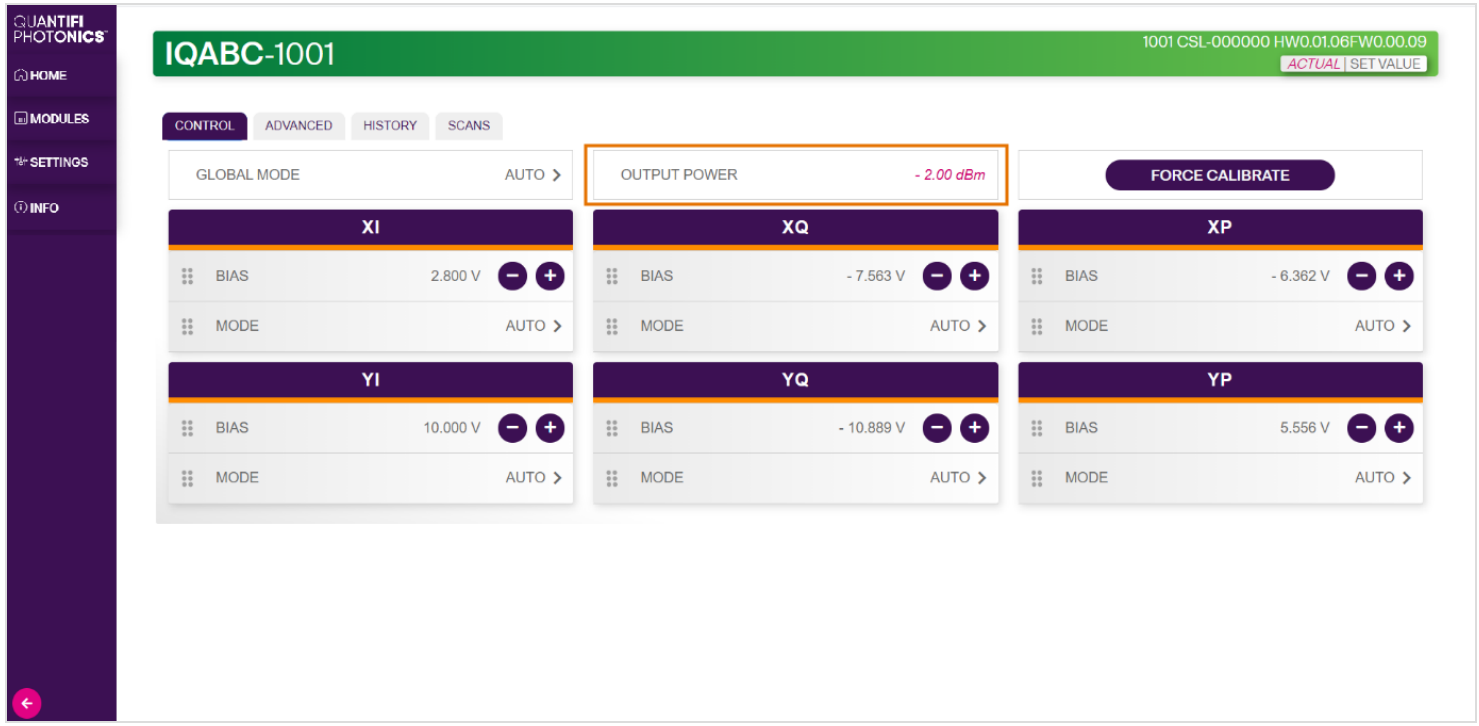
Alternatively, you can set the BIAS voltage to the **MIN** or **MAX** value by clicking the dropdown in the parameter field.



For details on how to set a value, refer to SET values and ACTUAL values

8.1.3 Output power value

The global **OUTPUT POWER** of the IQABC instrument is displayed in the **CONTROL** tab on the top-middle ribbon of the screen.

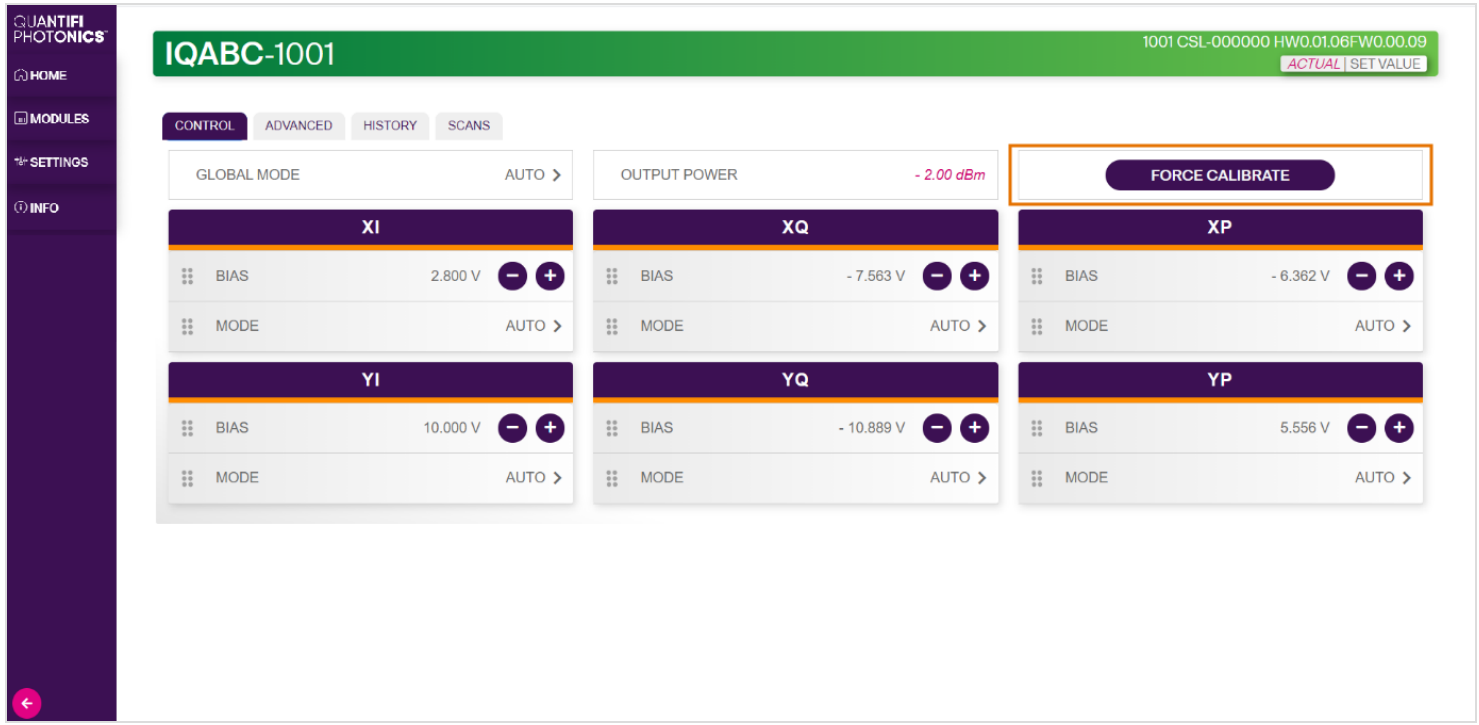


8.1.4 Force calibration button

You can initiate a new DC-bias scan after the initial power-up of the unit and when you require a new scan of the current Min-Min-Quad bias points.

▶ To initiate the scan:

1. Click **FORCE CALIBRATE** in the **CONTROL** tab or in the **HISTORY** tab.
2. During the re-calibration process, the color strip under the bias label will turn orange. Once the unit has found the correct bias point, the color strip will turn green.



8.2 Advanced configuration tab

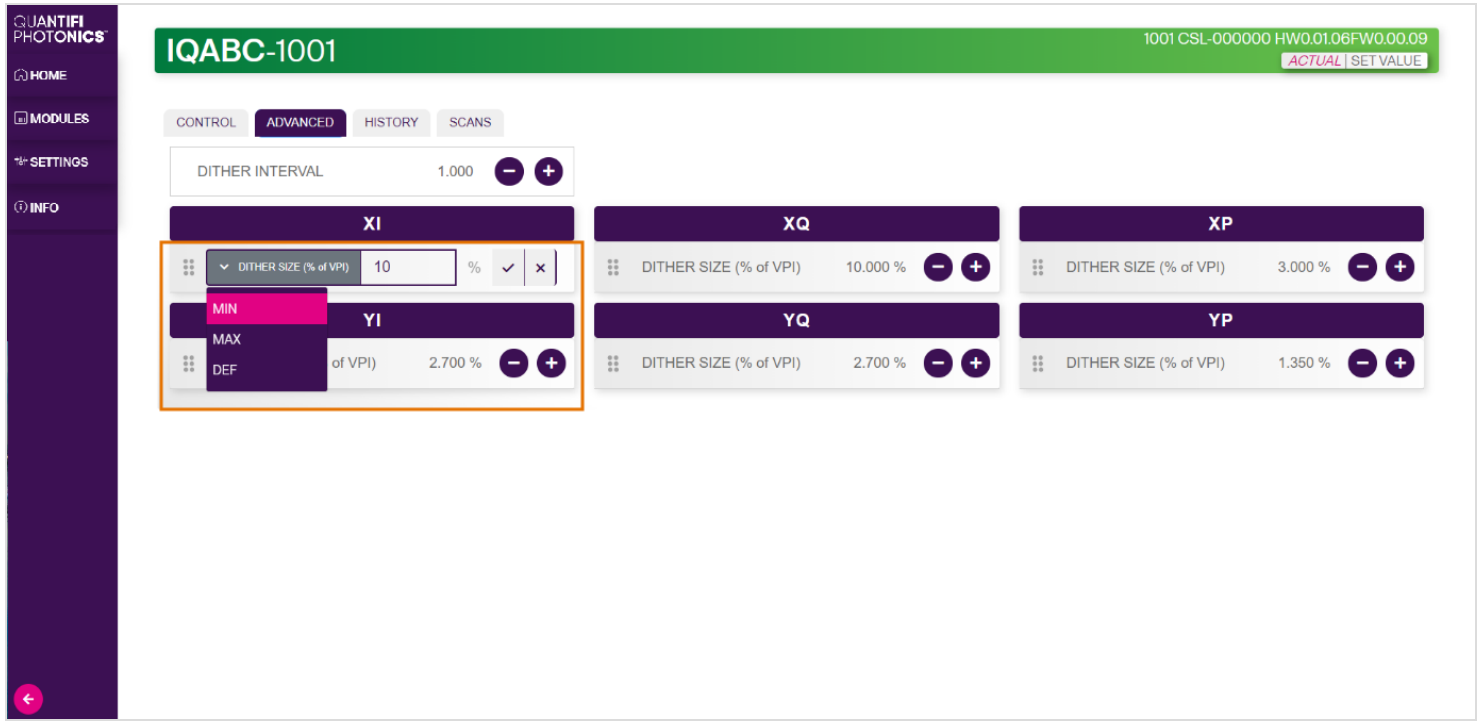
To control the IQABC modulator dither size values and interval, click the **ADVANCED** tab.

8.2.1 Setting the dither size

The **DITHER SIZE** value (percentage of VPI) for each modulator bias can be set in the **ADVANCED** tab by clicking the parameter field, or by using the + and – control buttons to increase or decrease the value by a set amount. The step size is set to 2%. Alternatively, the **DITHER SIZE** can also be set to the MIN and MAX value by clicking the dropdown in the name of the parameter.

Increasing the dither size will lead to a more accurate bias optimization, but a larger dither will show up as an occasional perturbation to the bias voltage.

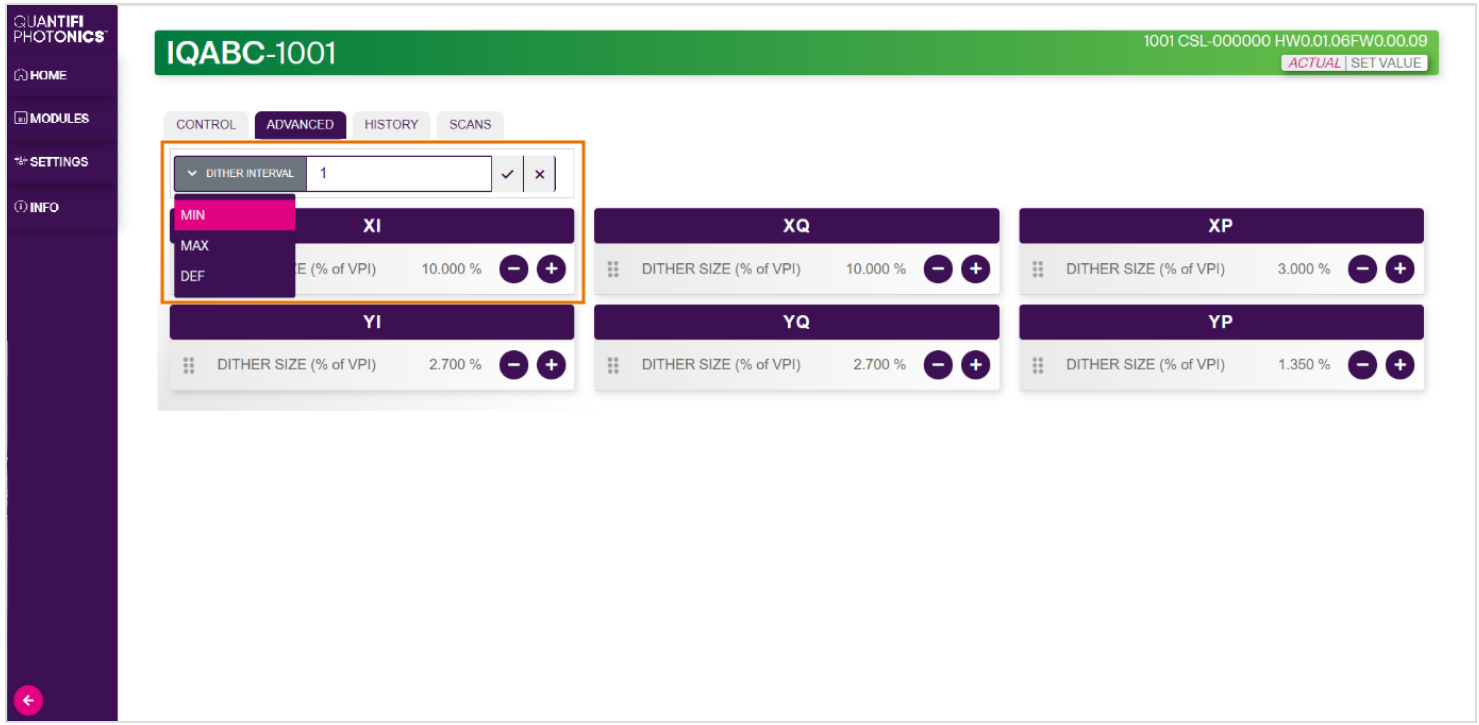
It is recommended to use the default dither size unless a residual bias error is constantly observed. In such cases, increasing the step size can improve the bias convergence accuracy.



8.2.2 Setting the dither interval

The **DITHER INTERVAL** value for each modulator can be set in the **ADVANCED** tab by clicking the parameter field, or by using the + and – control buttons to increase or decrease the value by a set amount. Alternatively, the **DITHER INTERVAL** can also be set to the MIN and MAX value by clicking the dropdown in the name of the parameter.

The dither interval determines how frequently the bias control dither is applied. Lower dither interval will result in a faster convergence, while a higher dither interval will result in a more stable bias control.

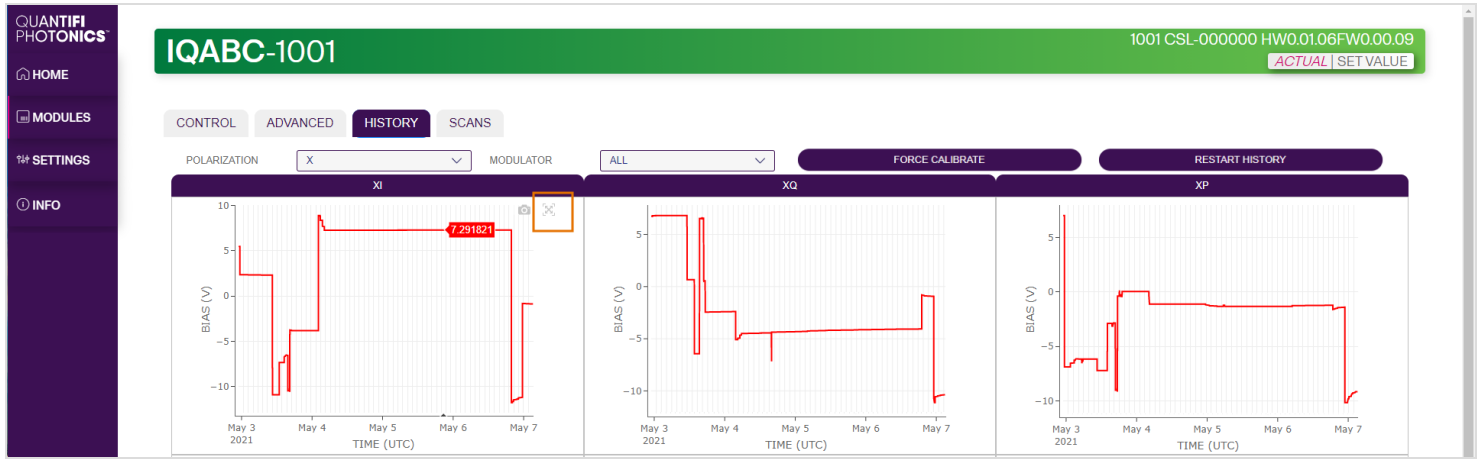


8.3 Error history tab

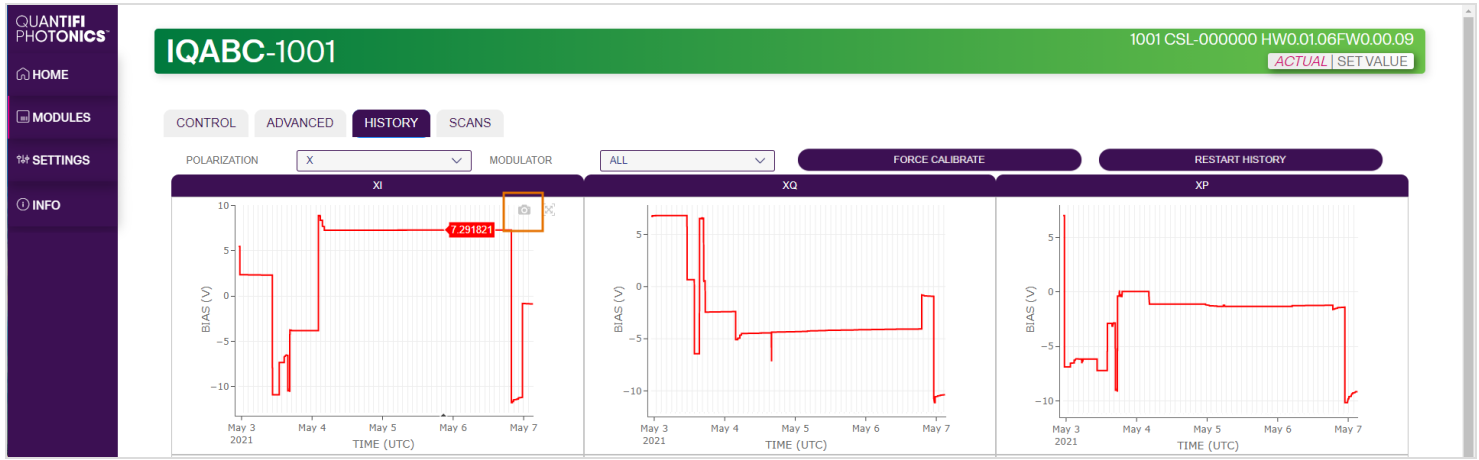
To review the IQABC modulator bias value vs. time error history plots, click the **HISTORY** tab.

The polarization (X or Y) and the modulator biases (All, I, Q, P) can be selected and filtered by clicking the drop down lists above the plots area.

The plots can be zoomed to show a specific section of the analysis by clicking and dragging the desired area with the cursor. To reset the zoom, click the Autoscale button or double-click on the plot area.

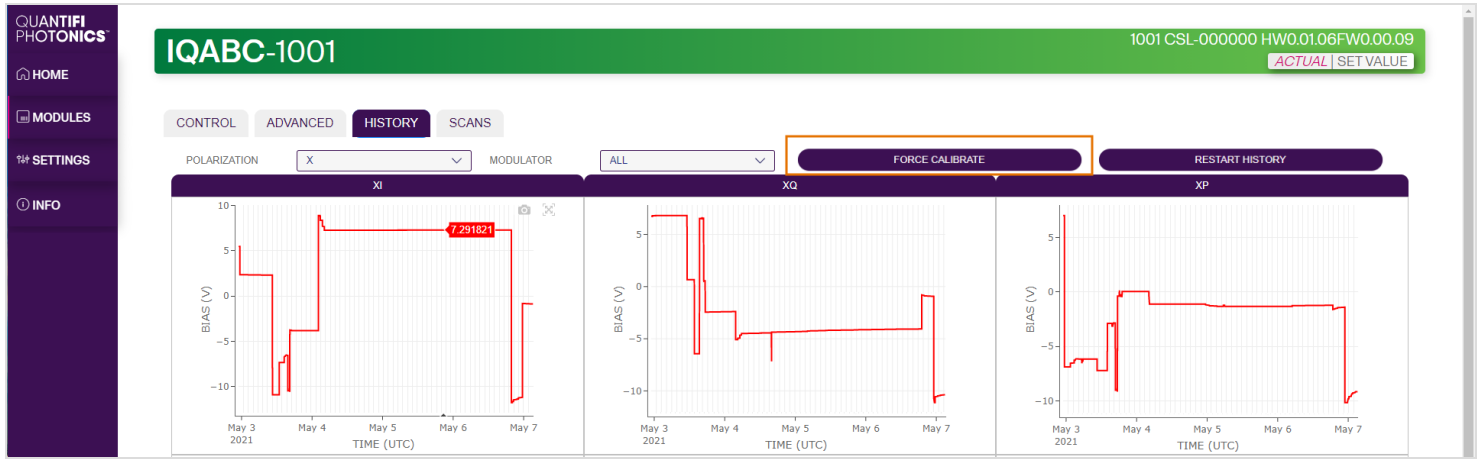


To download a plot as a PNG file, click the 'Download plot as a png' button.



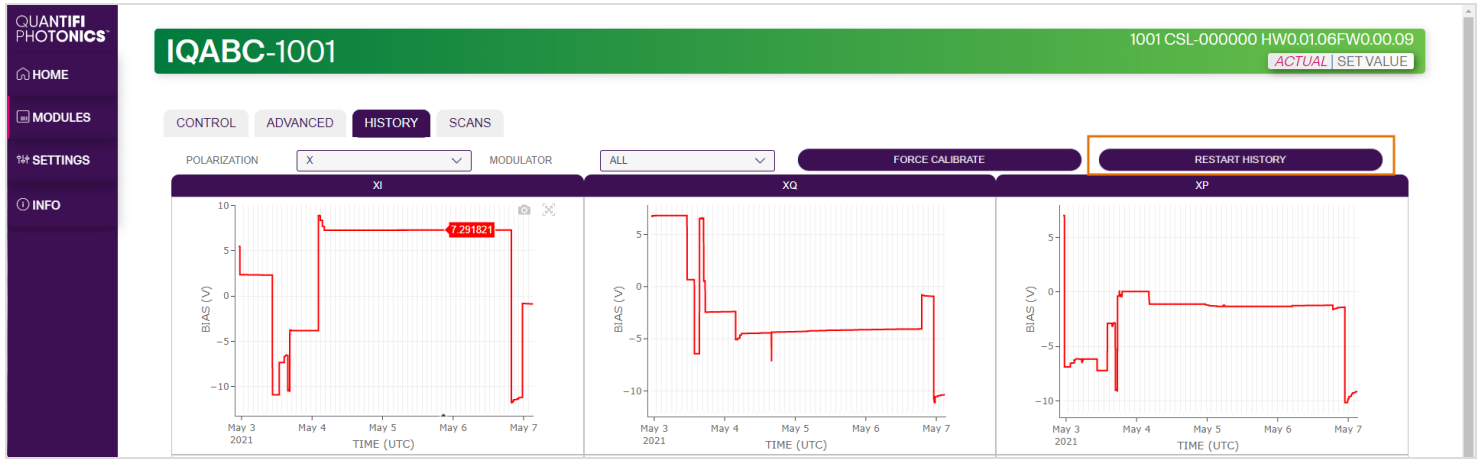
8.3.1 Force calibration button

The **FORCE CALIBRATE** button is also found within the **HISTORY** page for convenience. Clicking the button will initiate a new DC bias scan.



8.3.2 Restart history button

To clear the modulator's error plots history, click the **RESTART HISTORY** button.

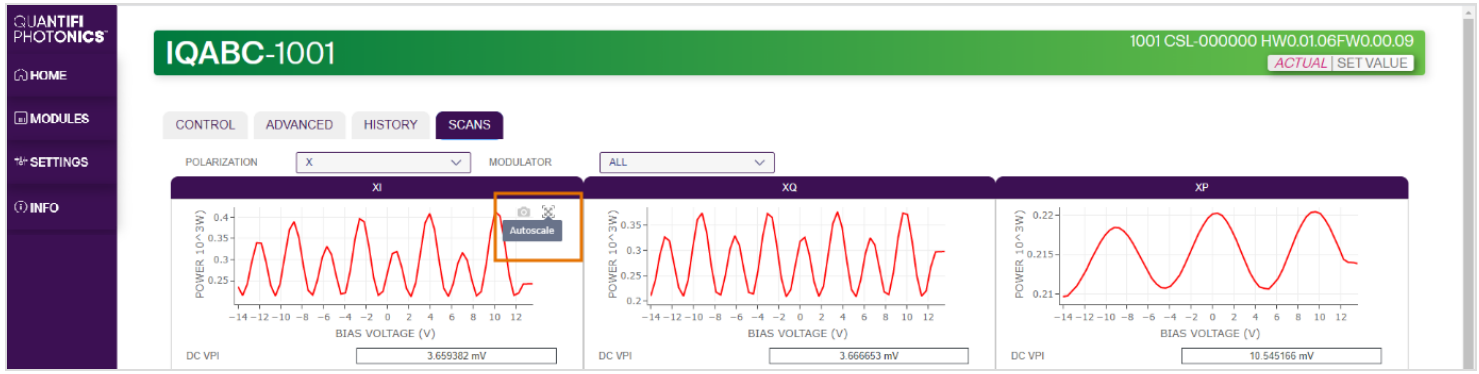


8.4 Scans tab

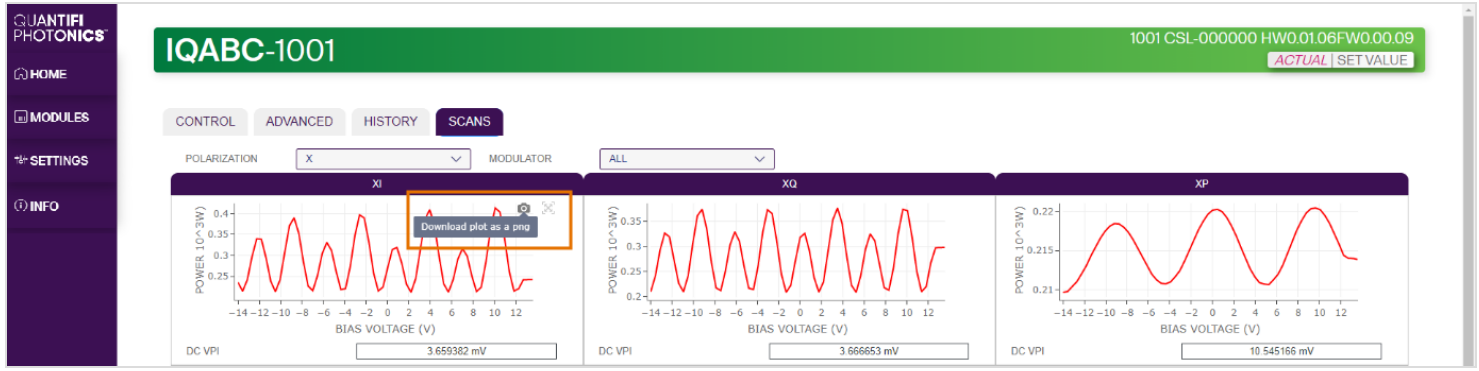
To review the IQABC modulator biases power vs. biases voltage plots, click the **SCANS** tab.

The polarization (X or Y) and the modulator biases (All, I, Q, P) can be selected and filtered by clicking the drop down lists above the plots area.

The plots can be zoomed to show a specific section of the analysis by clicking and dragging the desired area with the cursor. To reset the zoom, click the **Autoscale** button or double-click on the plot area.



To download a plot as a PNG file, click the 'Download plot as a png' button.



9 Controlling your IQABC with SCPI commands

Remote communication with the CohesionSCPI service is achieved through the Standard Commands for Programmable Instruments (SCPI).

Support for VISA I/O API over TCP/IP is provided by the VXI-11 compliant CohesionSCPI service. With VISA communication drivers installed on the client, the implementation of VISA programming within environments such as MATLAB becomes available.

This section details the programming and measurement conventions to follow while executing the commands for the CohesionSCPI service.

NOTE

In NI-MAX a RIO interface will show up, however there are no communication methods available or implemented on this interface. Quantifi Photonics products are **ONLY** accessible through the **VISA TCPIP INSTR** interface provided by the CohesionSCPI service installed on the system.

9.1 Overview

You can operate your Quantifi Photonics instrument using SCPI commands.

For details on available SCPI commands, refer to:

- Command summary
- Command descriptions

9.2 Programming conventions

This section details the programming and measurement conventions to follow while executing the commands for the CohesionSCPI service.

Parameter	Default Unit	Alternative Units
Power	MW	MW, W
Frequency	HZ	THZ, GHZ, MHZ, KHZ
Frequency Fine	HZ	THZ, GHZ, MHZ, KHZ
Wavelength	NM	NM, PM
Voltage	V	MV

Argument	Data Format
`<wsp>`	Specifies whitespace character (01_{16} – 09_{16}, $0B_{16}$ – 20_{16}).
`<value>`	Is numerical data, an integer, a decimal, exponential (10e-9 or 5.8e6) or string.
`[VALUE1|VALUE2]`	A parameter choice. The '|' separates the unique parameters available, only one of the choices can be used. In the example, either the input parameter `[VALUE1]` or `[VALUE2]` can be used, but not both. Some commands may have more than two choices available. This parameter can be omitted where the command has a default defined in the command description.

9.2.1 Index addressing of modules (slot, source) and units (channel)

When executing commands, it is almost always necessary to provide the index of a specific module or an index of a specific installed unit.

For the commands that require index values:

Index	Description	Value
`<n>`		integer `1`
`<m>`	the index of a specific channel in the module	integer `1`

Message queues

Information is exchanged in the form of messages. These messages are held in input and output queues.

The output queue stores responses to query commands. The CohesionSCPI service transmits any data in the output queue when a read request is received. Unless specified, all output response data is transmitted in ASCII format.

9.3 Status and event registers

9.3.1 Standard Event Status Register

The Standard Event Status Register (SESR) is modified by the Quantifi Photonics product with the results of the command operations.

Bit	Description
7 (MSB), 6	Not used
5	Is set when a Command Error event has been detected
4	Is set when a command Execution Error has been detected
3	Is set when a Device Dependent Error event has been detected
2	Is set when there a Query Error event has been detected
1	Not used
0 (LSB)	Is set when an Operation Complete event has been generated

9.3.2 Standard Event Status Enable Register (Mask)

The Standard Event Status Enable Register (SESR Mask) is used to build the Event Status Bit (ESB) within the Status Byte Register (STB). To ignore any of the events detected and set in the SESR, set the corresponding bit within the SESR Mask to 0. The STB can then be queried and the value of the ESB can be used to determine service request requirements based on the SESR Mask applied.

NOTE

The 0 (LSB) value within the SESR Mask is 0.

9.3.3 Status Byte Register

The Status Byte Register (STB) is built from all other status registers and masks. This register can be used in queries to determine if an event has been detected and where that event has been detected.

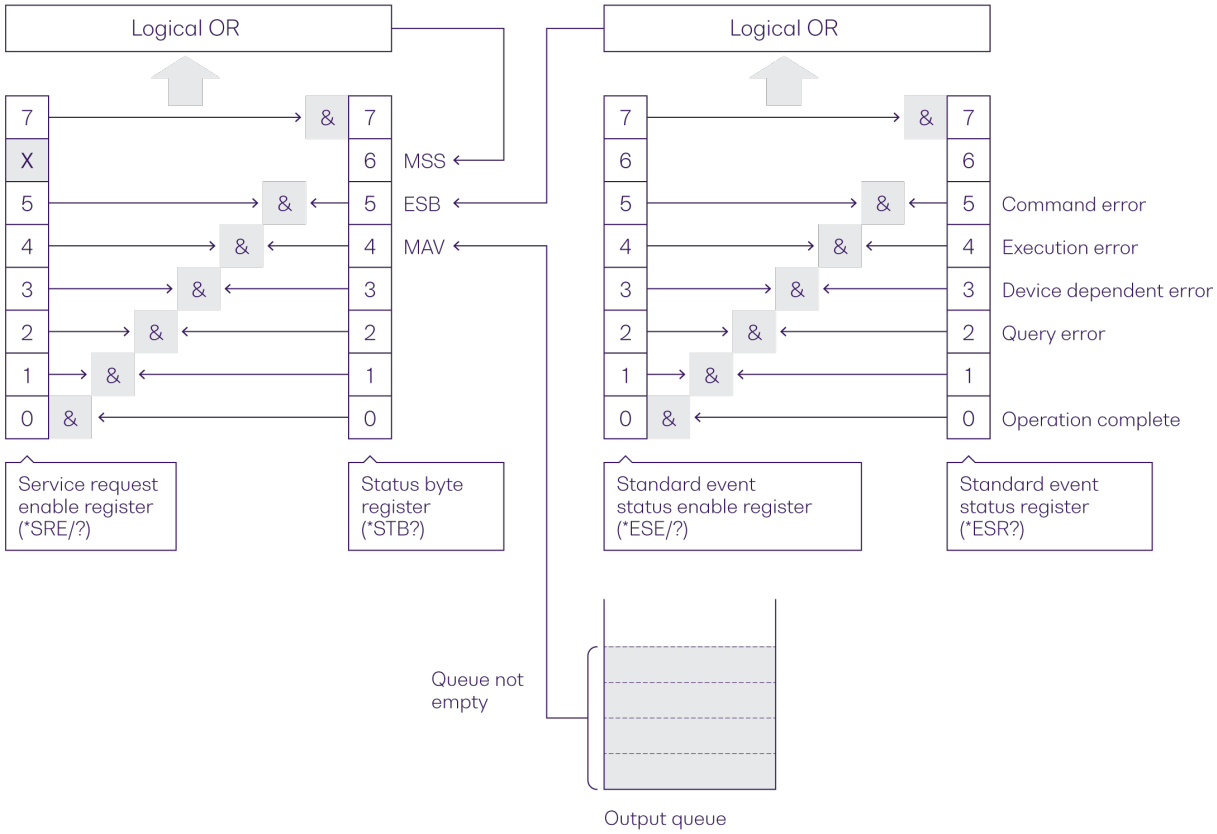
Bit	Description
7 (MSB)	Not used
6	The Master Summary Status (MSS) bit is set from the STB and SRE Mask
5	The Event Status Bit (ESB) is set from the SESR and the SESR Mask
4	Message Available (MAV) is set when there is data in the output queue
3, 2, 1, 0 (LSB)	Not used

9.3.4 Service Request Enable Register (Mask)

The Standard Request Enable Register (SRE Mask) is used to build the Master Summary Status Bit (MSS) within the Status Byte Register (STB). To ignore any of the events detected and set in the STB register itself, set the corresponding bit within the SRE Mask to 0. The STB can then be queried and the value of the MSS can be used to determine the type of service request required based on the SRE Mask applied.

Bit	Description
7 (MSB)	Not used
6	The Master Summary Status (MSS) bit is set from the STB and SRE Mask
5	The Event Status Bit (ESB) is set from the SESR and the SESR Mask
4	Message Available (MAV) is set when there is data in the output queue
3, 2, 1, 0 (LSB)	Not used

9.3.5 Status and event registers diagram



9.4 Command summary

9.4.1 Common commands

Command	Description
*CLS	Clear session message queues >>
*IDN?	Query the instrument identification >>
*OPT?	Query the modules installed in the instrument >>
*OPC?	Query the Operation Complete Status >>
*ESR?	Query the Standard Event Status Register >>

9.4.2 System commands

Command	Description
:SYSTEM	
:INFO?	Query the version of services >>
:SLOTS?	Query the number of modules installed in the instrument >>

9.4.3 Slot commands

Command	Description
:SLOT<n>	
:IDN?	Query the module identification >>
:OPC?	Query the Operation Complete Status of the module >>
:OPTions?	Query the modules installed on the slot >>

9.4.4 Configuration commands

Command	Description
:ABC<n>	
:<XI|XQ|XP|YI|YQ|YP>	
:PILOT?	Query the modulator channel auto-bias state >>
:PILOT	Set the modulator channel auto-bias state >>
:BIAS?	Query the modulator channel bias voltage >>
:BIAS	Set the modulator channel bias voltage >>
:LOCK?	Query whether the bias is locked to its optimal position >>
:HISTory?	Query the error history timeframe and reason >>
:SCAN?	Query the ABC modulator scan results >>
:GAIN?	Query the gain VPi percentage (dither size) >>
:GAIN	Set the gain VPi percentage (dither size) >>
:PDPower?	Query the output power of the unit in mW >>
:TIMEnulling?	Query the dark nulling time remained to complete >>
:NULLing	Perform dark current nulling on the specified channel >>
:CALibrate?	Queries the recalibration status of the auto-bias control system >>
:CALibrate	Forces recalibration of the auto-bias control system >>
:HISTory	
:STARt	Set a reset of the error history >>
:VPI?	Query the DC scan VPi >>
:SLOWfactor?	Query the optimizer timing factor >>
:SLOWfactor	Set the optimizer timing factor >>

NOTE

The modulator biases :<XI|XQ|XP|YI|YQ|YP> can be replaced with :MODulator<1|2|3|4|5|6>.

9.5 Command descriptions

9.5.1 Common commands

Command	***CLS**	Summary >>
Syntax	`*CLS`	
Description		
Parameters	N/A	
Response	N/A	
Example	`*CLS`	

Command	***IDN?**	Summary >>
Syntax	`*IDN?`	
Description	Query the instrument identification	
Parameters	N/A	
Response	Comma separated string with the <manufacturer>,<server name>,<chassis controller name>,<server version>	
Example	`*IDN? -> Quantifi Photonics Ltd, IQABC-1001-1-FA-MTRQ,QP-210001,HW0.01.00FW3.01.04`	

Command	***OPT?**	Summary >>
Syntax	`*OPT?`	
Description	Query the modules installed in the instrument	
Parameters	N/A	
Response	Comma separated string of the installed modules in the chassis	
Example	`*OPT? -> IQABC-1001-1-FA-MTRQ`	

Command	***OPC?**	Summary >>
Syntax	`*OPC?`	
Description	Query the Operation Complete Status	
Parameters		
Response	**1**: all modules installed in the chassis are ready to execute commands	
	0: modules installed in the chassis still have commands to execute in the input queue	
	NOTE: Any commands sent to the module when `:SLOT<n>:OPC?` is NOT equal `1`, may not execute or return an error.	
Example	`*OPC? -> 1`	

Command	***ESR?**		Summary >>
Syntax	`*ESR?`		
Description	Query the Standard Event Status Register		
Parameters	N/A		
Response	Unsigned integer 8 bit value for the register <0 to 255>, as a string.		
	Bit	Description	Decimal Value
	7 (MSB)	Not used	0
	6	Not used	0
	5	Command error	32
	4	Command Execution Error	16
	3	Device Dependent Error	8
	2	Not used	0
	1	Not used	0
	0 (LSB)	Operation Complete	1
Example	`*ESR? -> 8` `*ESR? -> 32`		

NOTE

It is recommended to use the `*ESR?` command query after every command that is sent to the device. The `*ESR?` query will be able to catch:

- **Device dependent Error** – the device is reporting an error in operation.
- **Execution Error** – SCPI was unable to execute the given command.
- **Command Error** – SCPI was unable to parse the given command, likely due to an incorrect command.

9.5.2 System commands

Command	**:SYSTEM:INFO?** Summary >>
Syntax	`:SYSTEM:INFO?<wsp>[ALL|SERVER|DRIVER]`
Description	Query the version of services
Parameters	**SERVER**: Returns CohesionSCPI version
	DRIVER: Returns CohesionDriver version
	ALL: Returns all of the above
Response	Comma separated string containing the `<parameter>,<version number>`
Example	`:SYSTEM:INFO? ALL -> DRIVER,3.01.04 SERVER,3.00.02`

Command	**:SYSTEM:SLOTS?** Summary >>
Syntax	`:SYSTEM:SLOTS?`
Description	Query the number of modules installed in the instrument
Parameters	N/A
Response	Returns the number of modules installed in the IQABC
Example	`:SYSTEM:SLOTS? -> 1`

9.5.3 Slot commands

Command	**:SLOT<n>:IDN?** Summary >>
Syntax	:SLOT<n>:IDN?
Description	Query the module identification
Parameters	N/A
Response	A comma-separated string containing "<manufacturer>,<model name>,<serial number>,<hardware version><firmware version>". Note that the hardware and firmware versions are not comma separated.
Example	:SLOT1:IDN? -> Quantifi Photonics Ltd, IQABC-1001-FA, CSL-000000, HW0.01.06FW0.00.05

Command	**:SLOT<n>:OPC?** Summary >>
Syntax	:SLOT<n>:OPC?
Description	Query the Operation Complete Status of the module
Parameters	N/A
Response	**1**: the module is ready to accept a new command
	0: the module is busy performing a previous operation
	NOTE: Any commands sent to the module when :SLOT<n>:OPC? is NOT 1, may not execute or return an error.
Syntax	:SLOT1:OPC? -> 1

Command	**:SLOT<n>:OPTions?** Summary >>
Syntax	:SLOT<n>:OPTions?
Description	Query the modules installed on the slot
Parameters	N/A
Response	Comma separated string of detectors installed in the IQABC. If a module is not installed in a channel, it will not return any identification string
Example	:SLOT1:OPT? -> 1,1,1,1,1,1

9.5.4 Configuration commands

Command	**:ABC<n>:[XI|XQ|XP|YI|YQ|YP]:PILOT?** Summary >>
Syntax	:ABC<n>:[XI|XQ|XP|YI|YQ|YP]:PILOT?<wsp>[DEF|ALL|SET|INFO]
Description	Query the modulator channel auto-bias state
Parameters	**DEF**: Query the default programmable modulator channel auto-bias state
	SET: Query the set programmable modulator channel auto-bias state
	ALL: Returns all the modulator channel auto-bias states in a comma separated string
	INFO: Returns the string for the specified channel auto-bias state
Response	**1** is returned if the modulator channel auto-bias state is AUTO
	0 is returned if the modulator channel auto-bias state is MANUAL
Example	:ABC1:XI:PILOT? ALL -> 1,1

Command	**:ABC<n>:[XI|XQ|XP|YI|YQ|YP]:PILOT** Summary >>
Syntax	:ABC<n>:[XI|XQ|XP|YI|YQ|YP]:PILOT<wsp>[1|ON|0|OFF|DEF]
Description	Set the modulator channel auto-bias state
Parameters	**1|ON**: Set to the modulation auto-bias state to on **0|OFF**: Set to the modulation auto-bias state to off **DEF**: Set the default programmable modulator channel auto-bias state
Response	No response
Example	:ABC1:XI:PILOT ON

Command	**:ABC<n>:[XI|XQ|XP|YI|YQ|YP]:BIAS?**	Summary >>
Syntax	:ABC<n>:[XI|XQ|XP|YI|YQ|YP]:BIAS?<wsp>[MIN|MAX|DEF|SET|ALL|STEP| UNIT]	
Description	Query the modulator channel bias voltage	
Parameters	**MIN**: Get the minimum programmable value	
	MAX: Get the maximum programmable value	
	DEF: Get the default programmable value	
	SET: Get the desired set value	
	ALL: Returns all of the above parameters in a comma separated string	
	STEP: Returns the step size value	
	UNIT: Returns the BIAS measurement unit	
Response	Returns the string for the modulator DC bias voltage for the specified channel	
Example	:ABC1:XI:BIAS? ALL -> -14.0000,14.0000,6.0000,-3.932	

Command	**:ABC<n>:[XI|XQ|XP|YI|YQ|YP]:BIAS**	Summary >>
Syntax	:ABC<n>:[XI|XQ|XP|YI|YQ|YP]:BIAS<wsp><MIN|MAX|DEF|value>	
Description	Set the modulator channel bias voltage	
Parameters	**MIN**: Set to the minimum programmable value	
	MAX: Set to the maximum programmable value	
	DEF: Set to the default programmable value	
	<value>: Sets to the user value (V is default). The valid range is <-14.0 to 24.0>	
Response	No response	
Example	:ABC1:XI:BIAS 1	

Command	**:ABC<n>:<XI|XQ|XP|YI|YQ|YP>:LOCK?**	Summary >>
Syntax	:ABC<n>:<XI|XQ|XP|YI|YQ|YP>:LOCK?<wsp>[INFO]	
Description	Query whether the bias is locked to its optimal position	
Parameters	**INFO**: Returns the string for the specified channel LOCK states	
Response	**1** is returned if the modulator channel is LOCKED	
	0 is returned if the modulator channel is UNLOCKED	
Example	:ABC1:XI:LOCK? INFO -> 0:FALSE 1:TRUE	

Command	**:ABC<n>:<XI|XQ|XP|YI|YQ|YP>:HISTory?** Summary >>
Syntax	:ABC<n>:<XI|XQ|XP|YI|YQ|YP>:HISTory?<wsp>[<start_time>,<end_time> <BIAS|ERROR|FULL]
Description	Query the error history timeframe and reason
Parameters	**<wsp>**: The start and end time of the error history
	BIAS: The bias voltage value and time when the error occurred
	ERROR: The error number and time when the error occurred
	FULL: Returns all of the above parameters in a comma separated string
Response	**<wsp>**: <starttime>,<endtime>
	BIAS: <timestamp[1]+startTime>:<vbias[1]>
	ERROR: <timestamp[1]+startTime>:<error[1]>
	FULL: <timestamp[1]+startTime>:<vbias[1]>,<error[1]>
Example	:ABC1:XI:HISTory? FULL -> 41000203.456:2.54,4.55

Command	**:ABC<n>:<XI|XQ|XP|YI|YQ|YP>:SCAN?** Summary >>
Syntax	:ABC<n>:<XI|XQ|XP|YI|YQ|YP>:SCAN?<wsp>[POWER|ERROR|PHASE|FULL| UNIT]
Description	Query the ABC modulator scan results
Parameters	**POWER**: The measured power values at the time of the scan for the current bias value
	ERROR: The error numbers at the time of the scan for the current bias value
	PHASE: The phase values at the time of the scan for the current bias value
	FULL: Returns all of the above parameters in a comma separated string
	UNIT: Get the scan measurement unit
Response	**POWER**: <number of points N>:<dcbias x-axis for all>:<power1,...,powerN>
	ERROR: <number of points N>:<dcbias x-axis for all>:<error1,...,errorN>
	PHASE: <number of points N>:<dcbias x-axis for all>:<phase1,...,phaseN>
	FULL: <number of points N>:<dcbias x-axis for all>:<power1,...,powerN>:<error1,...,errorN>:<phase1,...,phaseN>
	UNIT: The scan measurement unit
Example	:ABC1:XI:SCAN? POWER -> 32:-14.000000,-13.125000,-12.250000,-11.375000,-10.500000,-9.625000,-8.750000,-7.875000,-7.000000,-6.125000,-5.250000,-4.375000,-3.500000,-2.625000,-1.750000,-0.875000,0.000000,0.875000,1.750000,2.625000,3.500000,4.375000,5.250000,6.125000,7.000000,7.875000,8.750000,9.625000,10.500000,11.375000,12.250000,13.125000:0.000987,0.000926,0.000987,0.001094,0.000865,0.001048,0.000865,0.000926,0.000835,0.000987,0.000774,0.001018,0.000850,0.001109,0.000896,0.000896,0.000957,0.000926,0.000822,0.001021,0.143313,0.143236,0.143236,0.143236,0.143267,0.143145,0.143221,0.143236,0.143175,0.143099,0.143221,0.143130

Command	**:ABC<n>:<XI|XQ|XP|YI|YQ|YP>:GAIN?**	Summary >>
Syntax	:ABC<n>:<XI|XQ|XP|YI|YQ|YP>:GAIN?<wsp>[MIN|MAX|DEF|SET|ALL|UNIT]	
Description	Query the gain VPi percentage (dither size)	
Parameters	**MIN**: Get the minimum gain VPi percentage value of the modulation channel	
	MAX: Get the maximum gain VPi percentage value of the modulation channel	
	DEF: Get the default gain VPi percentage value of the modulation channel	
	SET: Get the default gain VPi percentage value of the modulation channel	
	ALL: Returns all of the above parameters in a comma separated string	
	UNIT: Get the modulation channel gain VPi percentage measurement unit	
Response	Depending on the parameters the response will be a single value or a comma separated string of values.	
Example	:ABC1:XI:GAIN? SET -> 20.75	

Command	**:ABC<n>:<XI|XQ|XP|YI|YQ|YP>:GAIN**	Summary >>
Syntax	:ABC<n>:<XI|XQ|XP|YI|YQ|YP>:GAIN<wsp><value|MIN|MAX|DEF>	
Description	Set the gain VPi percentage (dither size)	
Parameters	**value**: Set the gain VPi percentage value of the modulation channel	
	MIN: Set the minimum gain VPi percentage value of the modulation channel	
	MAX: Set the maximum gain VPi percentage value of the modulation channel	
	DEF: Set the default gain VPi percentage value of the modulation channel	
Response	No response	
Example	:ABC1:XI:GAIN SET 20.75	

Command	**:ABC<n>:PDPower?**	Summary >>
Syntax	:ABC<n>:PDPower?<wsp>[MIN|MAX|ALL|UNIT]	
Description	Query the output power of the unit in mW	
Parameters	**MIN**: Get the minimum output power value of the unit	
	MAX: Get the maximum output power value of the unit	
	ALL: Returns all of the above parameters in a comma separated string	
	UNIT: Get the output power measurement unit	
Response	Returns the current output power of the unit in mW	
Example	:ABC1:PDP? ALL -> 0.000, 10.000, 0.142	

Command	**:ABC<n>:PDPower:TIMEnulling?**	Summary >>
Syntax	:ABC<n>:PDPower:TIMEnulling?<wsp>[UNIT]	
Description	Query the dark nulling time remained to complete	
Parameters	**UNIT**: Get the dark nulling time remainING to complete measurement unit	
Response	No response	
Example	:ABC1:PDP:TIME? UNIT -> s	

Command	**:ABC<n>:PDPower:NULLing**	Summary >>
Syntax	:ABC<n>:PDPower:NULLing	
Description	Perform dark current nulling on the specified channel	
Parameters	N/A	
Response	N/A	
Example	:ABC1:PDP:NULL	

Command	**:ABC<n>:CALibrate?**	Summary >>
Syntax	:ABC<n>:CALibrate<wsp>[COM|REQ|INFO]	
Description	Queries the recalibration status of the auto-bias control system	
Parameters	**COMpleted**: Get the recalibration status of the auto-bias control system	
	REQuested: Query if the recalibration of the auto-bias control system was requested	
	INFO: Returns a string of the auto-bias control system recalibration states	
Response	**1**: Returned if the recalibration status is REQUESTED	
	0: Returned if the recalibration status is COMPLETED	
	TRUE / FALSE: Returned depending on the REQ / COM state	
Example	:ABC1:CAL? REQ -> FALSE	

Command	**:ABC<n>:CALibrate**	Summary >>
Syntax	:ABC<n>:CALibrate	
Description	Forces recalibration of the auto-bias control system	
Parameters	N/A	
Response	N/A	
Example	:ABC1:CAL	

Command	**:ABC<n>:HISTory:STARt**	Summary >>
Syntax	:ABC<n>:HISTory:STARt	
Description	Set a reset of the error history	
Parameters	N/A	
Response	N/A	
Example	:ABC1:HIST:STAR	

Command	**:ABC<n>:VPI?**	Summary >>
Syntax	:ABC<n>:MODulator<m>:VPI?<wsp>[POWER|ERROR|PHASE|UNIT]	
Description	Query the DC scan VPi	
Parameters	**POWER**: Get the Vpi value as measured from the Output power vs DC Voltage scan	
	ERROR: Get the Vpi value as measured from the bias control error signal vs DC Voltage scan	
	PHASE: Get the Vpi value as measured from the Phase vs DC Voltage scan	
	UNIT: Get the unit of the Vpi value	
Response	Depending on the parameters the response will be a single value or a comma separated string of values.	
Example	:ABC1:MODulator1:VPI? POWER -> 3.073177,3.030208,3.753062,NAN,NAN,NAN	

Command	**:ABC<n>:SLOWfactor?** Summary >>
Syntax	:ABC<n>:SLOWfactor?<wsp>[MIN|MAX|DEF|SET|ALL]
Description	Query the optimizer timing factor
Parameters	**MIN**: Get the minimum optimizer timing factor value of the modulation channel
	MAX: Get the maximum optimizer timing factor value of the modulation channel
	DEF: Get the default optimizer timing factor value of the modulation channel
	SET: Get the default optimizer timing factor value of the modulation channel
	ALL: Returns all of the above parameters in a comma separated string
Response	Depending on the parameters the response will be a single value or a comma separated string of values.
Example	:ABC1:SLOW? MAX -> 250

Command	**:ABC<n>:SLOWfactor** Summary >>
Syntax	:ABC<n>:SLOWfactor<wsp><value|MIN|MAX|DEF>
Description	Set the optimizer timing factor
Parameters	**<value>**: Set the optimizer timing factor value of the modulation channel
	MIN: Set the minimum optimizer timing factor value of the modulation channel
	MAX: Set the maximum optimizer timing factor value of the modulation channel
	DEF: Set the default optimizer timing factor value of the modulation channel
Response	N/A
Example	:ABC1:SLOWfactor MAX

9.6 Programming examples

The following is a simple example of how to control the IQABC instrument by using SCPI commands. See the previous section for specific details and extra parameters that the listed commands accept.

> We recommend that you use the `*ESR?` query after every command that is sent to the device. This enables you to debug unreceived or incorrect commands sent to the product.

```
#Identify and setup the IQABC instrument
:SLOT1:IDN?                             #Query to confirm the correct IQABC setup
:SLOT1:OPT?                             #Query the number of biases available
:SLOT1:CAL                              #Force calibrate the IQABC

#Query if the setup was successful
:ABC1:CAL?                              #Query if the calibration has been completed
:ABC1:XI:LOCK?                          #Query if the XI bias is locked
:ABC1:XQ:LOCK?                          #Query if the XQ bias is locked
:ABC1:XP:LOCK?                          #Query if the XP bias is locked
:ABC1:YI:LOCK?                          #Query if the YI bias is locked
:ABC1:YQ:LOCK?                          #Query if the YQ bias is locked
:ABC1:YP:LOCK?                          #Query if the YP bias is locked

#Manually set the bias voltage
:ABC1:XI:PILOT OFF                      #Change the control state of the XI bias from AUTO (default) to MANUAL
:ABC1:XI:BIAS 2                         #Set the static bias voltage of XI to 2 V
```

9.7 SCPI Command Console

The SCPI Command Console enables you to communicate with Quantifi Photonics product via SCPI commands. You can easily test commands and verify their syntax.

For available SCPI commands, refer to the user manual of the Quantifi Photonics product you are communicating with.

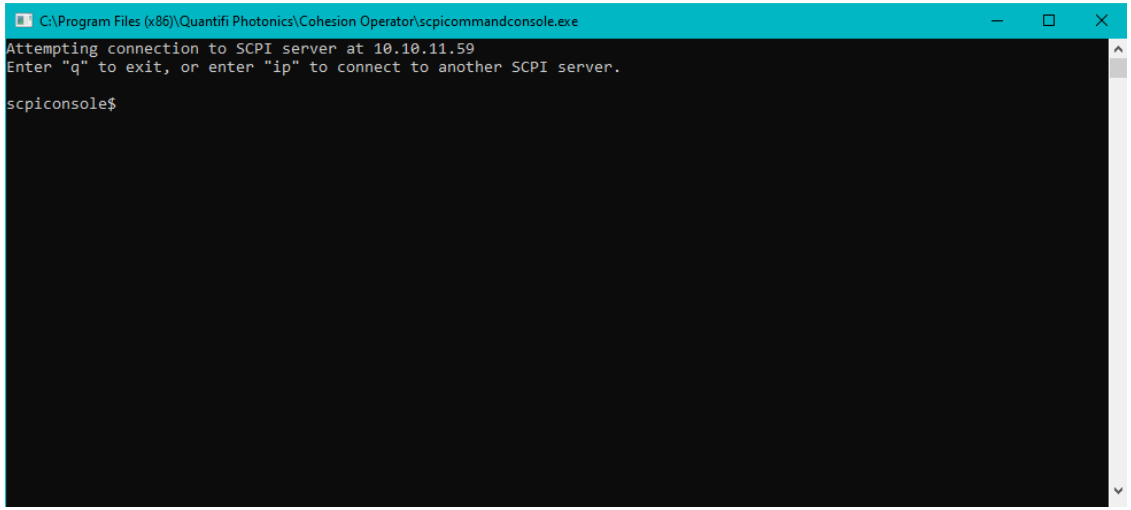
The two most common error codes are:

17: IO writer error: The command was invalid or not accepted by the instrument.

15: IO timeout: there was no response available before expiry of the reading wait time.

▶ To open the SCPI Command Console:

- Open the Cohesion Operator, for example by double-clicking the **Cohesion Operator** desktop icon.
- Select the instrument by entering its **IP address** or by selecting it from the **Discovery** drop down list.
- Click **Open SCPI Command Console**.



1. To verify that you are communicating with the right device:

- Enter `*idn?` and press **<ENTER>**.
- The device will return identification details.

2. To switch to another Quantifi Photonics device:

- Enter `ip` and press **<ENTER>**.
- Enter the IP address of the Quantifi Photonics product you would like to switch to and press **<ENTER>**.
- Confirm that you are communicating with the right product: Enter `*idn?` and press **<ENTER>**.

  The device will return identification details

3. To send a command or query to a Quantifi Photonics device:

- Enter a command and press **<ENTER>**.
- The device will execute the command and return an action response to the console if applicable.

4. To exit the SCPI Command Console:

- Enter `q` and press **<ENTER>**.

Example: Send instrument identification query *idn?

5. Enter the command: `*idn?`

   The instrument returns the requested information.

6. If you enter the command incorrectly, for example: `*ind?`

   The instrument returns **error code 32**.

   For details on error codes, please refer to the `*ESR?` command.

Example: Send a WRITE only command

7. If you enter a command correctly, for example: `*cls`

   The instrument executes the command, there will be no action response.

8. If you enter a command incorrectly, for example: `*csl`

   The instrument returns **error code 17: IO write error**.

10 Programming examples and applications

Remote communication with the CohesionSCPI service is achieved through the Standard Commands for Programmable Instruments (SCPI).

Support for VISA I/O API over TCP/IP is provided by the VXI-11 compliant CohesionSCPI service. With VISA communication drivers installed on the client, the implementation of VISA programming within environments such as MATLAB becomes available.

This section details the programming and measurement conventions to follow while executing the commands for the CohesionSCPI service.

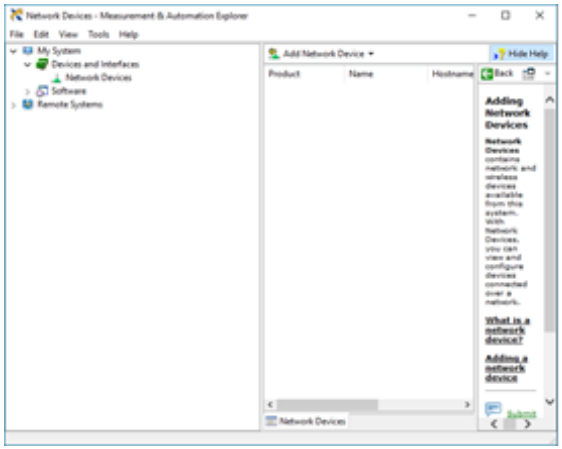
NOTE

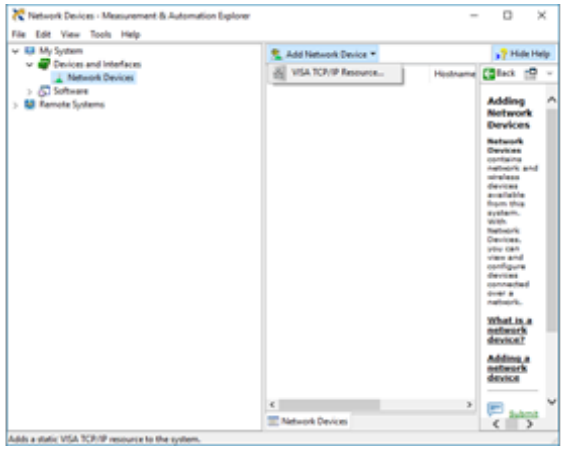
In NI-MAX a RIO interface will show up, however there are no communication methods available or implemented on this interface. Quantifi Photonics products are **ONLY** accessible through the **VISA TCPIP INSTR** interface provided by the CohesionSCPI service installed on the system.

10.1 Setting up NI-MAX application

To communicate with any Quantifi Photonics product, the chassis / benchtop product must first be setup as a TCP/IP instrument.

1. After installing NI-MAX, launch the application. In the left side panel of the window, click the **Devices and Interfaces** option. A drop down of available instruments detected will show up.
2. Click on **Network Devices**, then click **Add Network Devices** and select **VISA TCP/IP Resource**.



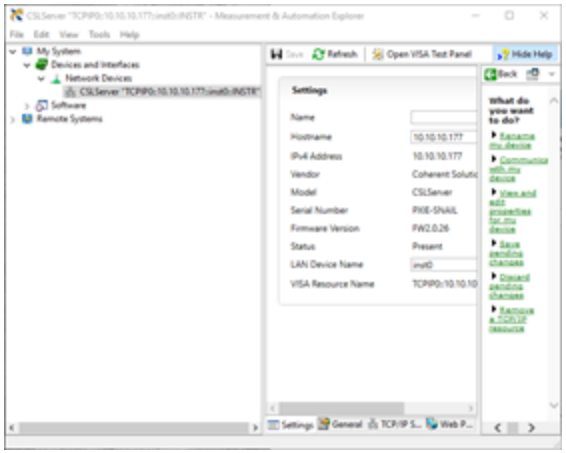


3. Select **Manual Entry of LAN Instrument**. Enter in the Hostname or IP Address.
   Note when operating locally, enter in the localhost IP address of **127.0.0.1**. Click **Finish** to end the setup process.

10.2 Setting up NI-VISA application

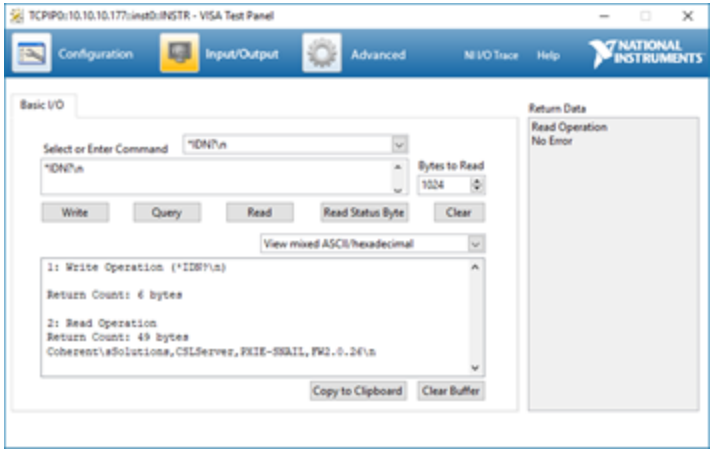
NI-VISA is used to communicate with the PXIe chassis or installed modules / instruments. The above steps must be completed before attempting to communicate using NI-VISA.

1. Launch NI-MAX. In the left-hand side menu, select an instrument from the **Network Devices** list.



2. On the right-hand side panel, select **Open VISA Test Panel**. A new window will popup. Click the **Input / Output** button from the window menu.

   Valid chassis and module commands can be entered in, and their returns queried



10.3 Python® code example

The following example shows how to communicate with the Quantifi Photonics product using Python code.

```python
# You can get VXI11 from pip:
# pip install python-vxi11==0.9
import vxi11
from vxi11.vxi11 import Vxi11Exception
# replace this with the IP of your device
ip = "127.0.0.1"
try:
    print("connecting to " + ip + " ... ")
    instrument = vxi11.Instrument(ip)
    print("connected")
    print("checking IDN...")
    command = "*IDN?"
    data = instrument.ask(command)
    print("IDN: " + data)
    print("checking OPT...")
    command = "*OPT?"
    data = instrument.ask(command)
    print("OPT: " + data)
    # replace this with a valid command for your device (read # the programming guide section for examples)
    command = ""
    print("writing a specific command")
    instrument.write(command)
    print("checking ESR")
    command = "*ESR?"
    data = instrument.ask(command)
    print("*ESR?: " + data)
except Vxi11Exception as e:
    # pass
    print("ERROR" + str(e) + ", command: " + str(command))
```

10.4 MATLAB® code example

To communicate with the Quantifi Photonics product in MATLAB® the installation of a VISA IO driver is required. These drivers enable the creation of the Interface Object for instrument communication.

If developing locally on the PXIE Platform, then these will already be installed. However, if development is on a remotely connected system the VISA Libraries, e.g. National Instruments NI-VISA will have to be installed.

NOTE

MATLAB 2010x or later with the Instrument Control Toolbox is required to execute the code detailed in this section.

The following example shows how to communicate with a Quantifi Photonics product using MATLAB code.

```
% Find a VISA-TCPIP object. This is if the VISA object has already been
% created with tmtool or has been removed from the workspace without
% first being closed (cleanly disconnected).
PXIE_Chassis = instrfind('Type', 'visa-tcpip', ...
'RsrcName', 'TCPIP0::10.10.10.89::inst0::INSTR', 'Tag', '');
% Create the ‘agilent’ VISA-TCPIP object if it does not exist
% otherwise use the object that was found.
if isempty(PXIE_Chassis)
    PXIE_Chassis = visa('agilent', 'TCPIP0::10.10.10.89::inst0::INSTR');
else
    fclose(PXIE_Chassis);
    PXIE_Chassis = PXIE_Chassis (1);
end
% Open the connection to the VISA object.
fopen(PXIE_Chassis);
% Query the PXIE_Chassis.
response = query(PXIE_Chassis, '*IDN?');
disp('The *IDN query response:');
disp(response);
response = query(PXIE_Chassis, '*OPT?');
disp('The *OPT query response:');
disp(response);
% Replace this with a valid command for your device (read the programming
% guide section for examples)
command = ''
% Close the connection to the object.
```

11 Example: QPSK configuration procedures

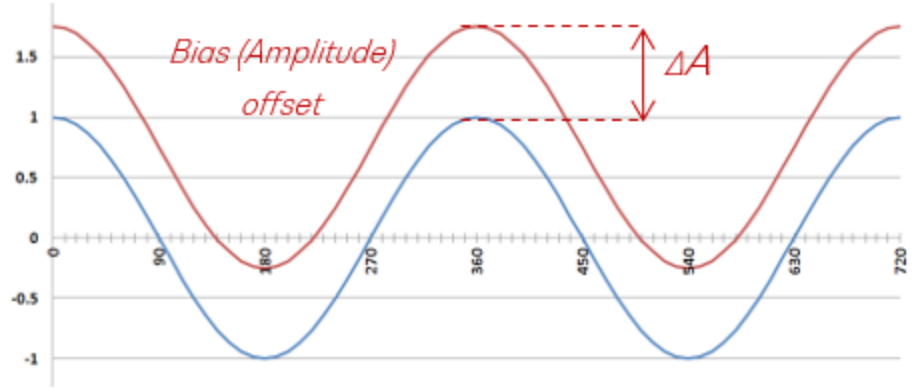
The various modulation adjustments on certain models of the IQABC are used to calibrate and configure the optical signal. This section provides detail on the calibration for the example QPSK hardware setups.

11.1 Modulator adjustments

The modulator adjustments provide manual adjustment of the In-phase (I), Quadrature (Q) and optical output signals. With the auto-bias control option, these biases will be automatically varied to compensate for the errors below and if the user wishes to manually control the bias voltages, they can do so with CohesionUI.

11.1.1 Modulator bias-I and bias-Q

The bias-I and bias-Q dials are used to set the bias offset (ΔA) for either the In-phase (I) or Quadrature (Q) components of the optical signal.



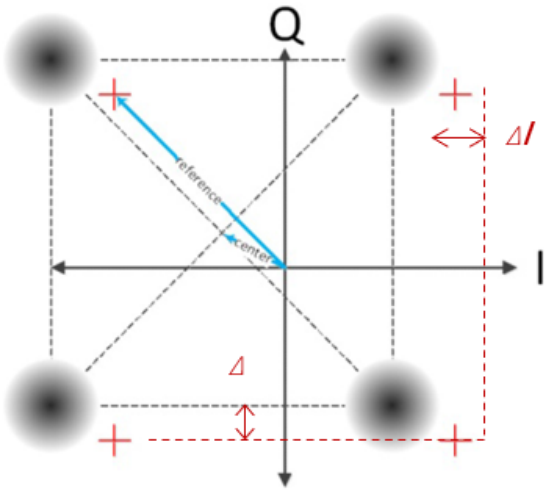
Changing the bias offset for a given component (I, Q) is related to reducing bias error within the constellation, represented by ΔI and ΔQ in section I & Q optical phase offset.

The bias offset is a measure of how far the center of the constellation is with respect to the ideal center point. For QPSK and QAM modulation formats, the ideal center point is [0, 0] (I, Q). It is more convenient to represent the bias errors in percentages to make it independent of the average optical power.

Additionally, the bias error can be separated into orthogonal components (I and Q) as shown in the equation below, to help identify the origin of the bias error. Since the electrical to optical transfer function of optical modulators is typically non-linear, a 5% bias offset as measured in the optical domain may not necessarily correspond to a 5% error in bias voltage.

$$Ibias_{Error}\% = \frac{Re(centre)}{Re(reference)} \times 100$$

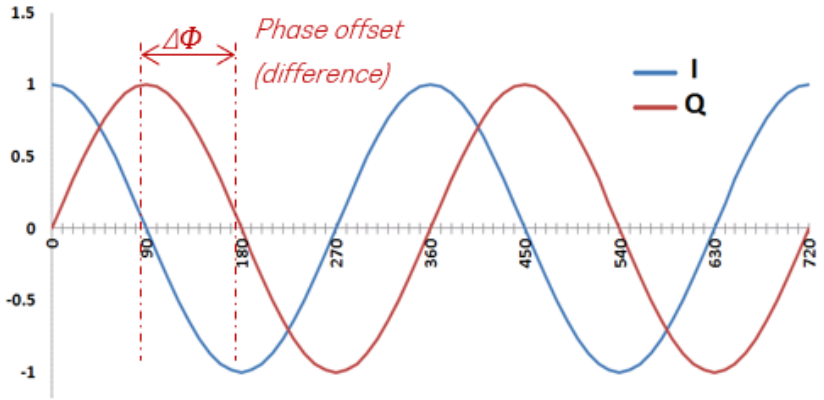
$$Qbias_{Error}\% = \frac{Im(centre)}{Im(reference)} \times 100$$



11.1.2 I & Q optical phase offset

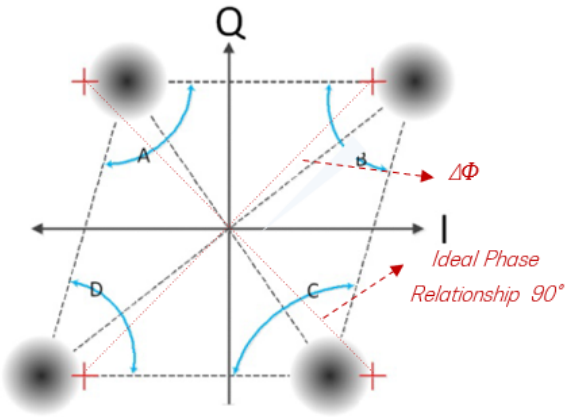
The I & Q optical phase offset dial is used to set the phase offset, or phase difference (ΔΦ as seen in the figures below), between the in-phase and quadrature phase components of the optical output signal generated by the IQABC.

The I & Q optical phase offset dial should be adjusted to align the clusters to the ideal phase relationship of 90° which is shown in this figure:



In-Phase (I) and Quadrature (Q) Phase Offset

The quadrature error is a measure of the phase error of the constellation points with respect to the ideal phase relationship between the constellation points.



For QPSK and QAM modulation formats, the ideal phase between the constellation points is 90°.

The quadrature error is an average measurement taken over all the constellation points as shown in this equation:

$$Quad_{Error} = \frac{\angle A - \angle B + \angle C - \angle D}{4}$$

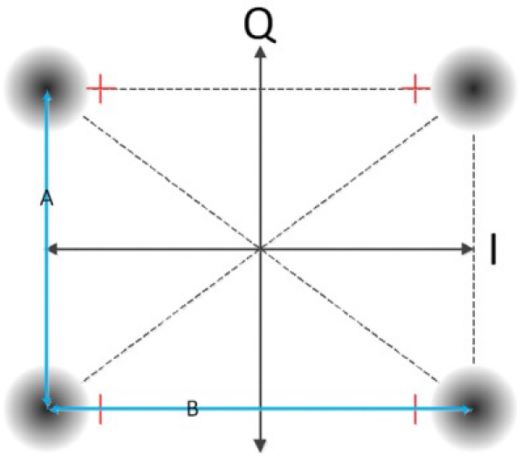
12 Measurement definitions

12.1 IQ RF imbalance

The IQ RF imbalance is the ratio of the in-phase component versus the quadrature component of the constellation points.

The ratio is represented as a percentage, so 10% IQ RF imbalance would mean that the in-phase component is 10% larger than the quadrature component.

$$IQ_{Imbalance}\% = (\frac{|B|}{|A|} - 1) \times 100$$



12.2 Error vector

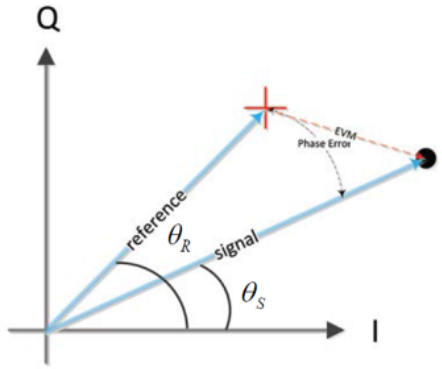
The error vector can be separated into its two primary components: Error Vector Magnitude (EVM) and Phase Error (PE).

The error vector magnitude is the magnitude of the error vector, which is the difference between the signal vector and the ideal reference vector. It is more convenient to represent the EVM as a percentage to make it independent of the average signal power, as shown in this equation:

$$EVM\% = \frac{|signal - reference|}{|reference|} \times 100$$

The phase error is the phase difference between the signal vector and the ideal reference vector, as shown here:

$$PhaseError = \theta_R - \theta_S$$



Error Vector, Single Sample Point

13 Working with optical fibers

Quantifi Photonics products are equipped with high quality optical connectors in compliance with EIA-455-21A standards.

CAUTION

Keep connectors clean and in good condition to ensure maximum power and to avoid erroneous readings. Quantifi Photonics is not responsible for damage or errors caused by bad fiber cleaning or handling.

- Always inspect fiber end faces for cleanliness using a fiber inspection probe before inserting them into a port..
- If required, clean fibers and faces as detailed below.

NOTE

- To avoid damaging ferrules or fiber faces due to mismatched connectors, always check ports and connector type information before inserting a connector. All Quantifi Photonics units are labeled with connector type information.
- Failing to align and/or connect fiber-optic cables properly will result in significant signal loss and reflection.

▶ When connecting a fiber-optic cable to a port:

1. Visually inspect the fiber end face using a fiber inspection microscope.
2. If a **connector end face** is dirty:
    - Wipe the connector end face using a reel-type cleaner and inspect again.
    - For stubborn hard to clean connectors:
        - Use lint-free fiber-cleaning wipes soaked in a fiber optic cleaning solution.
        - Wipe the connector on the soaked part.
        - Dry the connector by wiping on the dry part of the wipe, or by using a reel-type cleaner.
    - Repeat the process until connector inspection shows a clean fiber face.
3. If a **bulkhead inner connector face** is dirty:
    - Use a pen-type dry cleaner, align the cleaning tip with the port and push the cleaner until you hear the characteristic click. Inspect again.
    - For stubborn hard to clean bulkhead connectors:
        - Use a stick-type cleaner dipped in a fiber optic cleaning solution.
        - Carefully align and insert the stick into the connector and gently rotate the stick for several seconds applying light pressure.
        - Use a pen-type cleaner to dry the connector.
    - Repeat the process until connector inspection shows a clean fiber face.
4. If the fiber end face is clean:
    - Carefully align the connector and port to prevent the fiber end from touching the outside of the port or other surfaces. If the connector features a key, mate it correctly into the corresponding notch of the port bulkhead.

- Push the connector in so that the fiber-optic cable is firmly in place with adequate contact. If your connector features a screw sleeve, tighten the connector to firmly maintain the fiber in place. Do not over-tighten, as this will dam-age the fiber and the port bulkhead.

14 System requirements

Quantifi Photonics PXIe modules

Supported browsers for working with CohesionUI	Google Chrome™ Microsoft Edge®
Chassis	PXIe-compatible chassis that • supports PXIe, or • contains PXI hybrid compatible slots
Recommended PXIe controller operating system	Microsoft Windows® 10 (64-bit)

Quantifi Photonics MATRIQ / EPIQ instruments

Supported browsers for working with CohesionUI	Google Chrome™ Microsoft Edge®
Recommended client computer operating system	Microsoft Windows® 10 (64-bit)

15 Maintenance

To help ensure long, trouble-free operation:

- Always inspect fiber-optic connectors before using them and clean them if necessary.
- Keep the unit free of dust.
- Store the unit at room temperature in a clean and dry area. Keep the unit out of direct sunlight.
- Avoid high humidity or significant temperature fluctuations.
- Avoid unnecessary shocks and vibrations.
- If any liquids are spilled on or into the unit, power off the chassis immediately. Remove the unit and allow to dry completely.
- To allow for sufficient air flow and avoid thermal issues, set up your instrument with a minimum clearance of 2 inches (50.8mm) around it and do not block any ventilation fans.

WARNING

The use of controls, adjustments, and procedures other than those specified herein may result in exposure to hazardous situations or impair the protection provided by this unit.

15.1 Annual calibration schedule

To ensure that the unit is performing within specification, we recommend it is re-calibrated every 12 months.

All Quantifi Photonics products are calibrated during manufacture, and each product is shipped to the customer with a Calibration Certificate. On this certificate, the calibration date, as well as the next calibration due date are mentioned.

We recommend your product is returned for re-calibration before the listed due date, to ensure continued performance of the product. For re-calibration service information, or to send in a product for re-calibration service, email support@quantifiphotonics.com.

If the Calibration Certificate has been misplaced, or the calibration due date is not known, email support@quantifiphotonics.com.

16 Technical Support

16.1 Contacting the Technical Support Group

To obtain after-sales service or technical support for this product, contact Quantifi Photonics:

support@quantifiphotonics.com

To accelerate the process, please provide information such as the name and the serial number of the product (see the product identification label), as well as a description of your problem.

16.2 Transportation

Maintain a temperature range within specifications when transporting the unit.

Transportation damage can occur from improper handling.

The following steps are recommended to minimize the possibility of damage:

- Pack the product in its original packing material when shipping. If the original packaging is unavailable, use appropriate foam packaging to provide shock absorption and avoid displacement of the product inside the shipping box. Please keep all input connectors covered with the supplied anti-static plastic covers during transport and avoid any shipping material making contact with the sensitive connectors of the product.
- Avoid high humidity or large temperature fluctuations.
- Keep the product out of direct sunlight.
- Avoid unnecessary shocks and vibrations.

17 Warranty Information

17.1 General information

Quantifi Photonics Ltd (Quantifi Photonics) warrants from the date of the original shipment (the Warranty Period) that this product will conform to specifications and will be free from defects in material and workmanship for the applicable Warranty Period. Quantifi Photonics also warrants that the equipment will meet applicable specifications under normal use.

NOTE

The warranty can become null and void if:

- The unit has been tampered with, repaired, or worked upon by unauthorized individuals or non-Quantifi Photonics personnel.
- The warranty sticker has been removed.
- The unit has been opened, other than as explained in this guide.
- The unit serial number has been altered, erased, or removed.
- The unit has been misused, neglected, or damaged by accident.
- The unit has been used with an external power supply not supplied by Quantifi Photonics with the unit.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. IN NO EVENT SHALL QUANTIFI PHOTONICS BE LIABLE FOR SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

For full warranty terms and conditions, please visit quantifiphotonics.com.

17.2 Liability

Quantifi Photonics shall not be liable for damages resulting from the use of the product, nor shall be responsible for any failure in the performance of other items to which the product is connected or the operation of any system of which the product may be a part.

Quantifi Photonics shall not be liable for damages resulting from improper usage, transportation or unauthorized modification of the product, its accompanying accessories and software.

The external power supply that has been supplied by Quantifi Photonics with the unit can only be used with that unit, do not use it with any other product.

17.3 Exclusions

Quantifi Photonics reserves the right to make changes in the design or construction of any of its products at any time without incurring obligation to make any changes whatsoever on units purchased. Accessories, including but not limited to fuses, pilot lamps, batteries and universal interfaces (EUI) used with Quantifi Photonics products are not covered by this warranty.

This warranty excludes failure resulting from: Improper use or installation, normal wear and tear, accident, abuse, neglect, fire, water, lightning or other acts of nature, causes external to the product or other factors beyond the control of Quantifi Photonics.

17.4 Certification

Quantifi Photonics certifies that this equipment met its published specifications at the time of shipment from the factory.

17.5 Service and repairs

To send any equipment for service, repair or calibration please contact the Technical Support Group: support@quantifiphotonics.com.

QUANTIFI PHOTONICS®
A Teradyne Company

Test. Measure. Solve.™

Quantifi Photonics is transforming the world of photonics test and measurement. Our portfolio of optical and electrical test instruments is rapidly expanding to meet the needs of engineers and scientists around the globe. From enabling ground-breaking experiments to driving highly efficient production testing, you'll find us working with customers to solve complex problems with optimal solutions.

To find out more, get in touch with us today.

General Enquiries	sales@quantifiphotonics.com
Technical Support	support@quantifiphotonics.com
Phone	+64 9 478 4849
North America	+1-800-803-8872

quantifiphotonics.com