Keysight U2020 X-Series USB Peak and Average Power Sensors

KEYSIGHT TECHNOLOGIES

User's Guide

Notices

Copyright Notice

Manual Part Number

U2021-90002

Edition

Edition 6, September 1, 2018

Printed in:

Printed in Malaysia

Published by:

Keysight Technologies
Bayan Lepas Free Industrial Zone,
11900 Penang, Malaysia

Technology Licenses

The hardware and/or software described in this document are furnished under a license and may be used or copied only in accordance with the terms of such license.

Declaration of Conformity

Declarations of Conformity for this product and for other Keysight products may be downloaded from the Web. Go to http://www.keysight.com/go/conformity. You can then search by product number to find the latest Declaration of Conformity.

U.S. Government Rights

The Software is “commercial computer software,” as defined by Federal Acquisition Regulation (“FAR”) 2.101. Pursuant to FAR 12.212 and 27.405-3 and Department of Defense FAR Supplement (“DFARS”) 227.7202, the U.S. government acquires commercial computer software under the same terms by which the software is customarily provided to the public. Accordingly, Keysight provides the Software to U.S. government customers under its standard commercial license, which is embodied in its End User License Agreement (EULA), a copy of which can be found at http://www.keysight.com/find/sweula. The license set forth in the EULA represents the exclusive authority by which the U.S. government may use, modify, distribute, or disclose the Software. The EULA and the license set forth therein, does not require or permit, among other things, that Keysight: (1) Furnish technical information related to commercial computer software or commercial computer software documentation that is not customarily provided to the public; or (2) Relinquish to, or otherwise provide, the government rights in excess of these rights customarily provided to the public to use, modify, reproduce, release, perform, display, or disclose commercial computer software or commercial computer software documentation. No additional government requirements beyond those set forth in the EULA shall apply, except to the extent that those terms, rights, or licenses are explicitly required from all providers of commercial computer software pursuant to the FAR and the DFARS and are set forth specifically in writing elsewhere in the EULA. Keysight shall be under no obligation to update, revise or otherwise modify the Software. With respect to any technical data as defined by FAR 2.101, pursuant to FAR 12.211 and 27.404.2 and DFARS 227.7102, the U.S. government acquires no greater than Limited Rights as defined in FAR 27.401 or DFAR 227.7103-5 (c), as applicable in any technical data.

Warranty

THE MATERIAL CONTAINED IN THIS DOCUMENT IS PROVIDED “AS IS,” AND IS SUBJECT TO BEING CHANGED, WITHOUT NOTICE, IN FUTURE EDITIONS. FURTHER, TO THE MAXIMUM EXTENT PERMITTED BY APPLICABLE LAW, KEYSIGHT DISCLAIMS ALL WARRANTIES, EITHER EXPRESS OR IMPLIED, WITH REGARD TO THIS MANUAL AND ANY INFORMATION CONTAINED HEREIN, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. KEYSIGHT SHALL NOT BE LIABLE FOR ERRORS OR FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES IN CONNECTION WITH THE FURNISHING, USE, OR PERFORMANCE OF THIS DOCUMENT OR OF ANY INFORMATION CONTAINED HEREIN. SHOULD KEYSIGHT AND THE USER HAVE A SEPARATE WRITTEN AGREEMENT WITH WARRANTY TERMS COVERING THE MATERIAL IN THIS DOCUMENT THAT CONFLICT WITH THESE TERMS, THE WARRANTY TERMS IN THE SEPARATE AGREEMENT SHALL CONTROL.

Safety Information

CAUTION

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

WARNING

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

Environmental Conditions

The U2020 X-Series is designed for indoor use and in an area with low condensation. The table below shows the general environmental requirements for this instrument.

Environmental condition	Requirement
Temperature	Operating condition – 0 °C to 55 °C Storage condition – –40 °C to 70 °C
Humidity	Operating condition – Up to 95% RH at 4 0°C (non-condensing) Storage condition – Up to 90% RH at 65 °C (non-condensing)
Altitude	Operating condition – Up to 3,000 m (9,840 ft.) Storage condition – Up to 15,420 m (50,000 ft.)

Regulatory Information

The U2020 X-Series complies with the following Electromagnetic Compatibility (EMC) compliances:

EMC compliance

- IEC 61326-1:2005/EN 61326-1:2006
- Canada: ICES/NMB-001:Issue 4, June 2006
- Australia/New Zealand: AS/NZS CISPR11:2004

Regulatory Markings

	The RCM mark is a registered trademark of the Australian Communications and Media Authority.		This instrument complies with the WEEE Directive (2002/96/EC) marking requirement. This affixed product label indicates that you must not discard this electrical or electronic product in domestic household waste.
	This symbol indicates the time period during which no hazardous or toxic substance elements are expected to leak or deteriorate during normal use. Forty years is the expected useful life of the product.		The CE mark is a registered trademark of the European Community. This CE mark shows that the product complies with all the relevant European Legal Directives. ICES/NMB-001 indicates that this ISM device complies with the Canadian ICES-001. Cet appareil ISM est conforme a la norme NMB-001 du Canada. ISM GRP.1 Class A indicates that this is an Industrial Scientific and Medical Group 1 Class A product.

Waste Electrical and Electronic Equipment (WEEE) Directive

This instrument complies with the WEEE Directive marking requirement. This affixed product label indicates that you must not discard this electrical or electronic product in domestic household waste.

Product category:

With reference to the equipment types in the WEEE directive Annex 1, this instrument is classified as a “Monitoring and Control Instrument” product.

The affixed product label is as shown below.

Do not dispose in domestic household waste.

To return this unwanted instrument, contact your nearest Keysight Service Center, or visit http://about.keysight.com/en/companyinfo/environment/takeback.shtml for more information.

Sales and Technical Support

To contact Keysight for sales and technical support, refer to the support links on the following Keysight websites:

- www.keysight.com/find/usbsensor
  (product-specific information and support, software and documentation updates)
- www.keysight.com/find/assist
  (worldwide contact information for repair and service)

Table of Contents

List of Figures

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK.

List of Tables

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK.

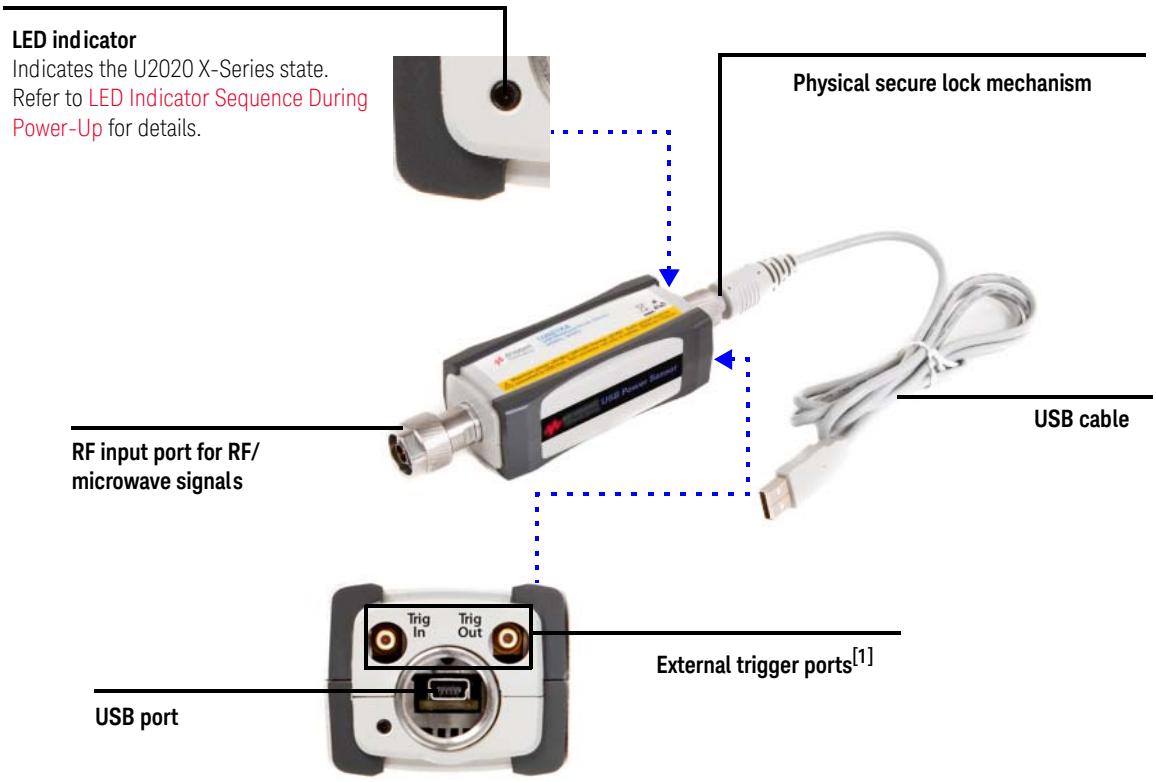
1 Getting Started

This chapter gets you started with the U2020 X-Series USB peak and average power sensors.

Overview

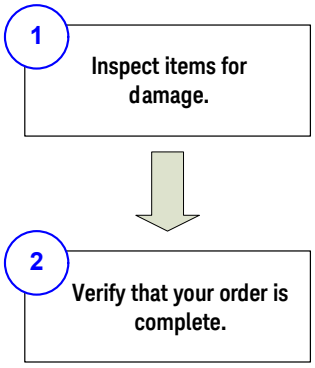
The U2020 X-Series is a USB-based standalone peak and average power sensor and meter. The U2020 X-Series consists of two models; U2021XA (50 MHz to 18 GHz) and U2022XA (50 MHz to 40 GHz).

The U2020 X-Series is capable of measuring the average and peak power of modulated, pulsed, and continuous wave (CW) signals in 50 MHz to 40 GHz frequency range and –45 dBm to 20 dBm power range.



[1] The recorder and video output share the same port as the trigger output.

Initial Inspection



- If there is mechanical damage or any missing item, notify the nearest Keysight Sales and Service office.
- Keep the damaged shipping material.
- Refer to "Sales and Technical Support" on page 6 for the contact list of Keysight Sales and Service offices.

Standard Purchase Items

2 × Trigger cable, BNC male to SMB female, 50 Ω, 1.5 m

Sensor cable, 1.5 m

Certificate of Calibration

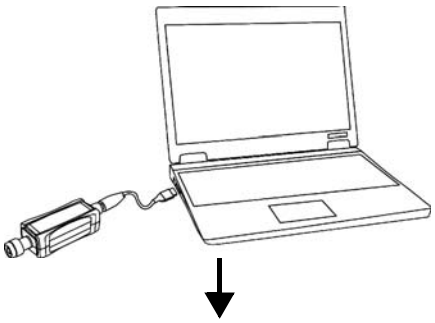
Hardware Installation and Configuration

Prior to using the U2020 X- Series, ensure that the following minimum requirements are met:

- PC with a USB host capability
- Keysight IO Libraries Suite 15.5 or higher installed

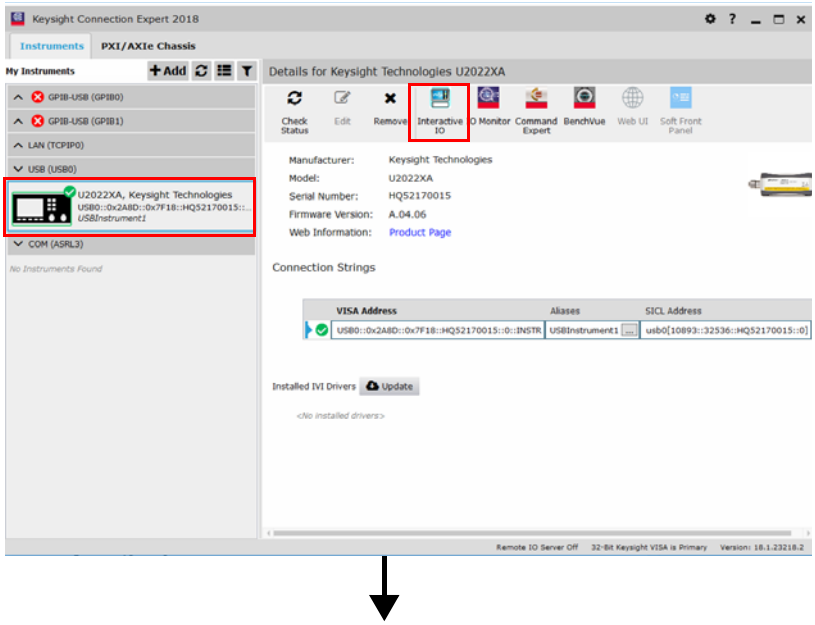
Install and verify the U2020 X-Series

1 Connect the U2020 X-Series to the PC. The U2020 X-Series driver is detected and installed automatically.

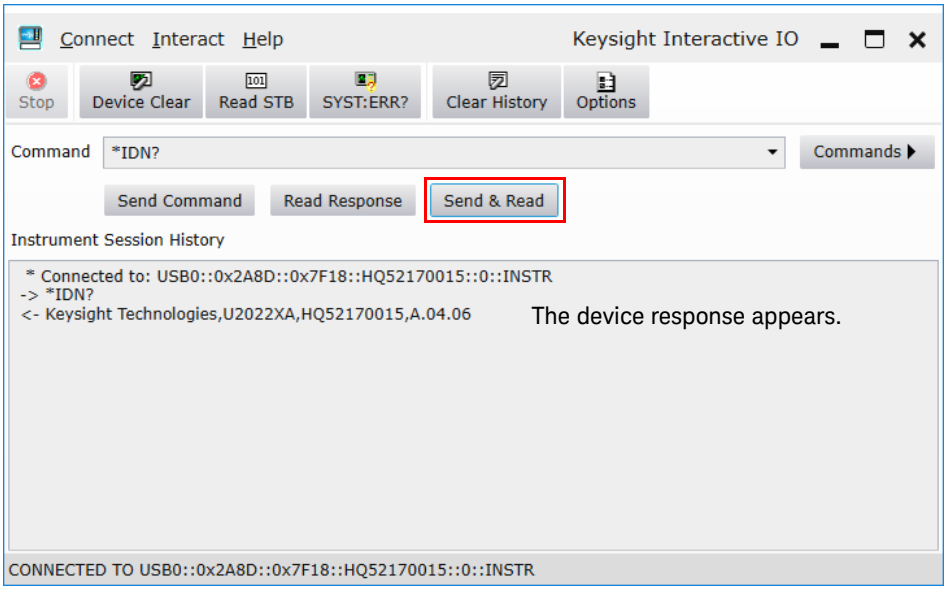


2 Go to **Start** > **All Programs** > **Keysight IO Libraries Suite** > **Keysight Connection Expert.**

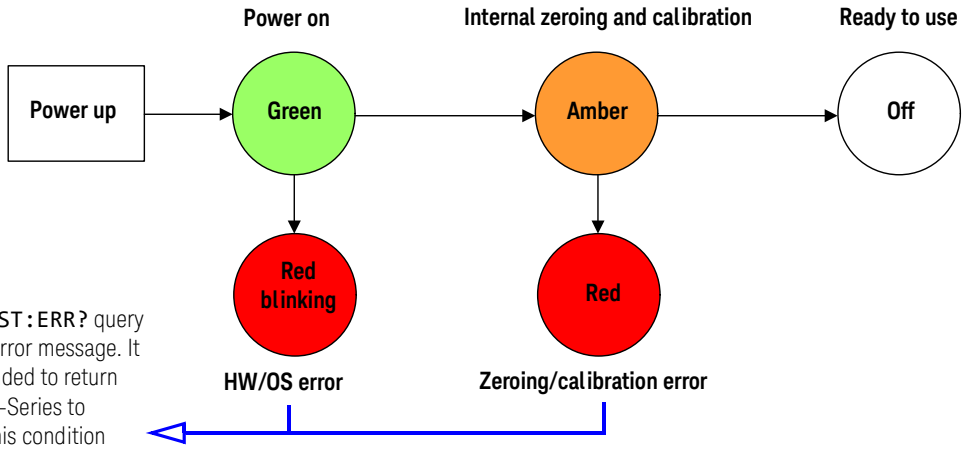
The U2020 X-series is detected



3 This verifies that the U2020 X-Series has been connected and properly installed on the PC.



LED Indicator Sequence During Power-Up



Send the `SYST:ERR?` query to read the error message. It is recommended to return the U2020 X-Series to Keysight if this condition persists after power cycle.

Other LED indicators

Amber blinking	Secure erase, flash formatting, or firmware update in progress.
Red	An error is present in the SCPI error queue including input overload. If the error queue is cleared (via the `*CLS` command) or the last error is read from the queue (via the `SYST:ERR?` query), the indicator will turn off.
Green blinking	USB activity in progress.

Firmware Upgrade

To download the latest firmware version for the U2020 X-Series, go to www.keysight.com/find/pm_firmware. The latest firmware includes the executable file and help file for installing the Firmware Upgrade Utility application in order to upgrade the U2020 X-Series.

2 General Operating Information

This chapter describes the general operating information of the U2020 X-Series.

Using the 2020 X-Series with the Keysight BenchVue

The BenchVue Power Meter application provides a virtual operating interface for the U2020 X-Series. This chapter describes the U2020 X-Series functions in the BenchVue Power Meter application in general.

NOTE For more information on how to configure each U2020 X-Series function or use each BenchVue Power Meter feature, refer to the Keysight BenchVue Power Meter help documentation.

Go to **Start > All Programs > Keysight > Keysight BenchVue > Keysight BenchVue** to launch the BenchVue Power Meter application.

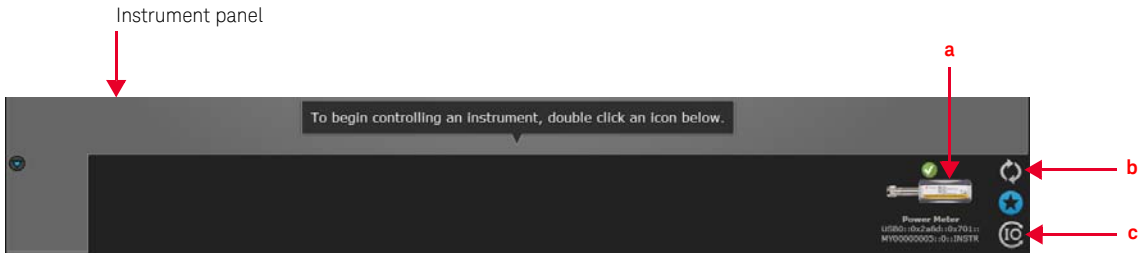


Figure 2-1 Launch the Keysight BenchVue

a Double-click the connected sensor () at the Instrument panel to start controlling the power sensor.

b If the sensor is found in the Keysight Connection Expert but is not shown in the BenchVue Instrument panel, select the refresh icon () to refresh the instrument list.

c If the sensor is not found, select the IO icon () to launch the Keysight Connection Expert to verify that the power sensor is connected properly.

When you launch the BenchVue Power Meter application, the Digital Meter is displayed by default.

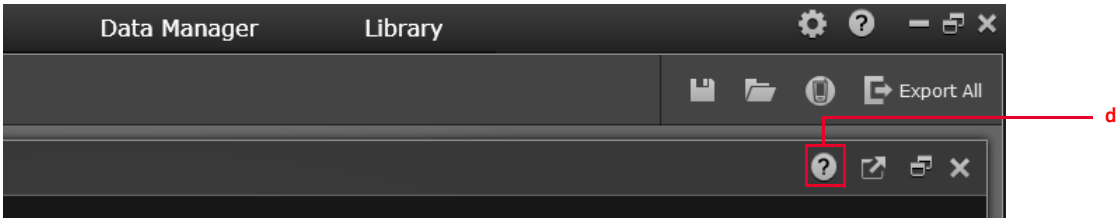


Figure 2-2 Accessing the BenchVue Power Meter help documentation

d Click (?) to access the BenchVue Power Meter help documentation.

Quick start example to perform an average power measurement

The following example guides you on how to quickly measure average power via BenchVue.

It is assumed that the U2020 X-Series is already connected to a signal generator.

1 Set up the signal generator as follows:

- Amplitude: 0 dBm
- Frequency: 1 GHz
- Modulation: Disabled

2 Turn on the RF output of the signal generator. Launch the BenchVue Power Meter application (refer to page 24). By default the power meter mode is already set to Average only.

3 Perform calibration and zeroing for an accurate measurement result.

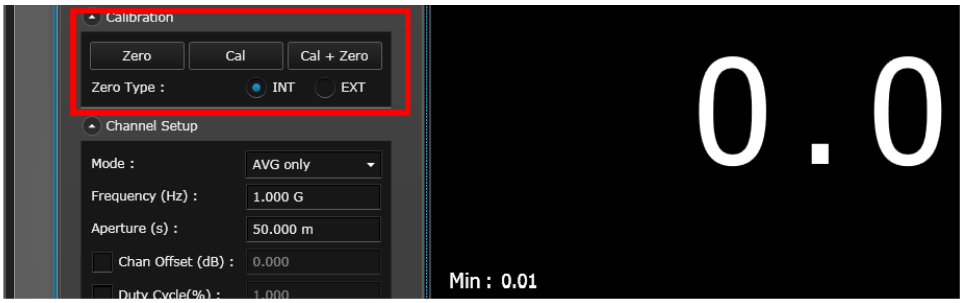


Figure 2-3 Performing calibration and zeroing

NOTE For power measurements below –50 dBm, it is recommended to perform external zeroing and turn off the RF output for better accuracy and repeatability.

4 Set the frequency of the U2020 X-Series to 1 GHz.

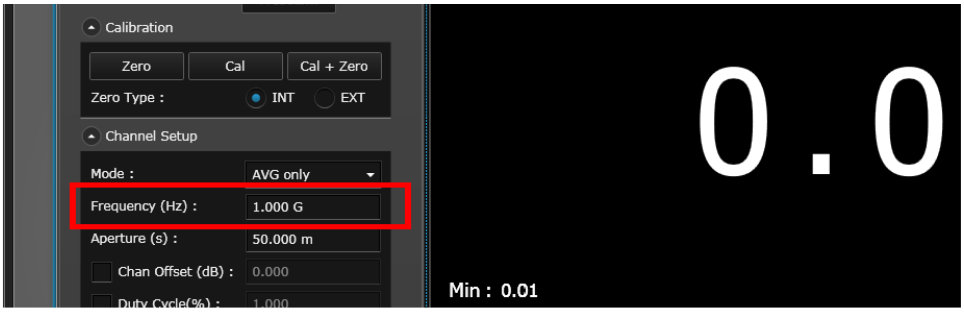


Figure 2-4 Setting the frequency

5 You should be able to view the average power measurement results in the Digital Meter display view.

Figure 2-5 Average power meter measurement results

a Indicates acquisition of measurements in the Run mode

b Indicates the measurement status

c  Change the title at the top of the display view

 Reset the displayed Minimum/Maximum measured values

d Summary of alert limit conditions for the current measurement

6 To monitor the average power over a period of time, create a Datalog display view by clicking  .

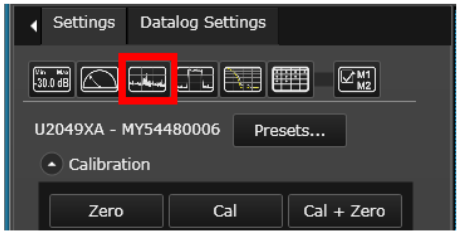


Figure 2-6 Creating Datalog display view

Select one of the available measurements from the list and click **Ok**.

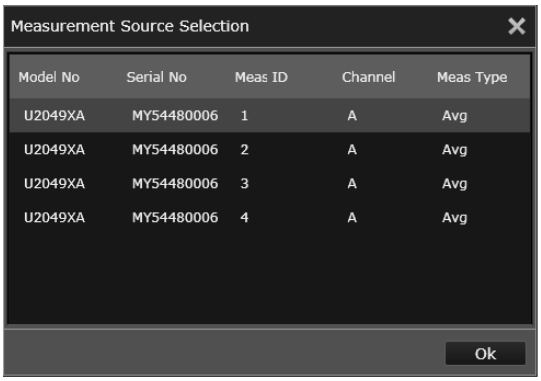


Figure 2-7 Selecting one of the measurements

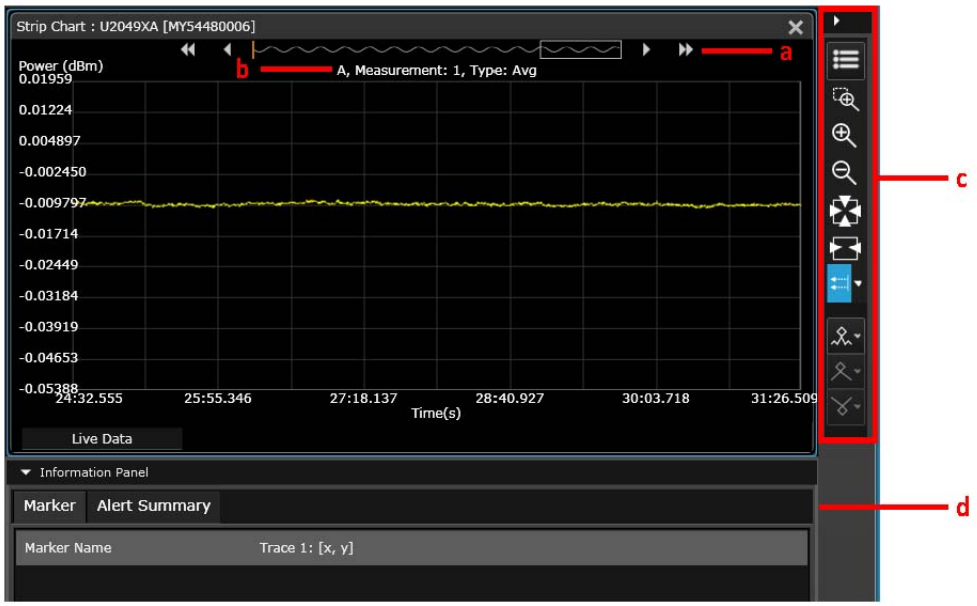


Figure 2-8 Data preview bar

a Data preview bar

b Indicates the channel name, measurement number, measurement type

c Tools palette to provide control for the datalog chart (refer to the BenchVue Power Meter help documentation for details)

d Summary of marker measurements and alert limit conditions for the current measurement.

7 Place a marker (or up to five markers) on the chart by clicking  to obtain the reading.

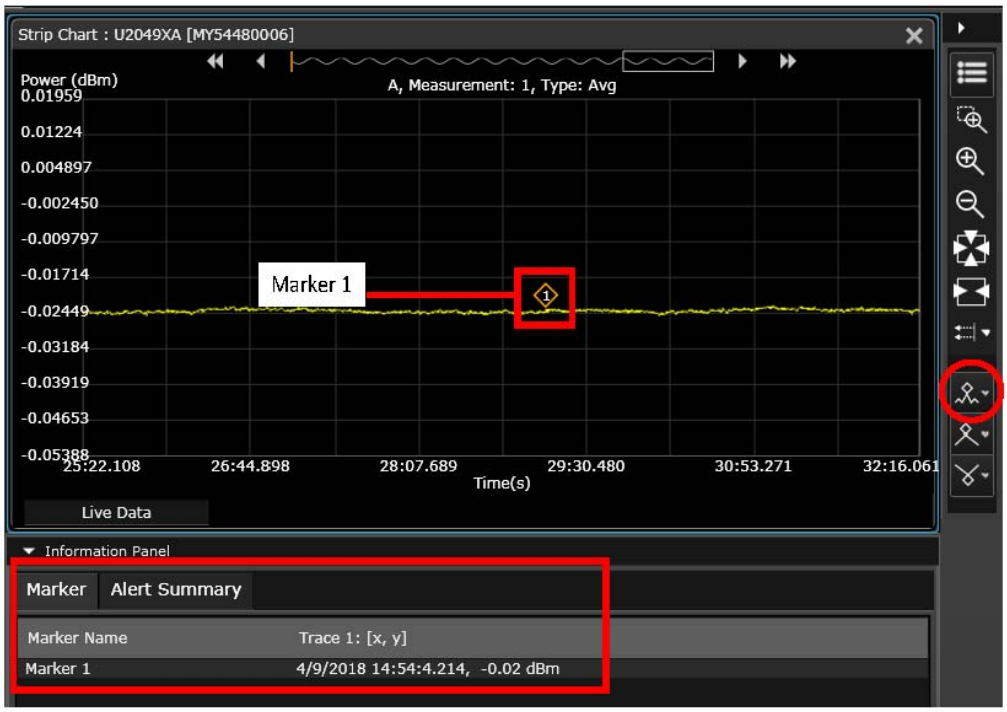


Figure 2-9 Placing a marker on the chart

Quick start example to set up a measurement in the Trace view

The following example guides you on how to set up a basic peak power measurement for RF pulses via BenchVue.

NOTE

The default power meter mode is Average only. It will change to the Normal mode when the Trace view is selected. As the Normal mode provides a lower dynamic range, the measurable power range will automatically narrow down.

To obtain a wider dynamic range for low power measurements (< –40 dBm), you will need to set to the Average only mode. If the measurement is in the Trace view, a warning message will appear as the Trace view is only applicable for the sensor's Normal mode.

It is assumed that the U2020 X-Series is already connected to a signal generator.

1 Set up the signal generator as follows:
   - Pulse period: 500 µs
   - Pulse width: 100 µs
   - Amplitude: 5 dBm
   - Frequency: 1 GHz
   - Pulse: Enabled

2 Turn on the RF output of the signal generator. Launch the BenchVue Power Meter application (refer to page 24).

3 Create a Trace display view by clicking  .

Figure 2-10 Creating a trace

4 Perform calibration and zeroing for an accurate measurement result.

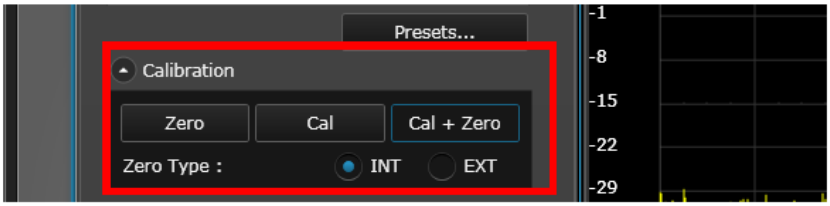


Figure 2-11 Performing calibration and zeroing

NOTE

- For power measurements below –50 dBm, it is recommended to perform external zeroing and turn off the RF output for better accuracy and repeatability.
- Ensure that modulation is enabled.

5 Set the frequency of the U2020 X-Series to 1 GHz.

Figure 2-12 Setting the frequency

6 You can set the trace scales to configure the pulse on the trace display.

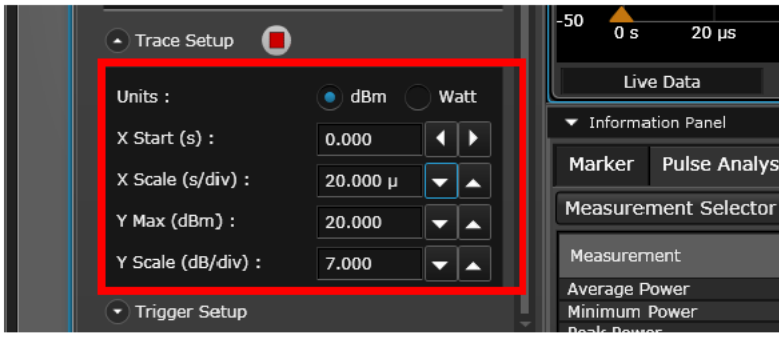


Figure 2-13 Setting the trace scales

7 To enable gates on the trace, click  at the Tools Palette.

Figure 2-14 Adding marker or configuring the trace using Tools Palette controls

NOTE You can add markers or configure the trace using the Tools Palette controls. Refer to the **BenchVue Power Meter help** documentation for details on each control.

For more precise control of your gate parameters, you can set up the gates via the **Instrument Setup** tab and enter a starting point and length (in seconds) for each of the four gate controls.

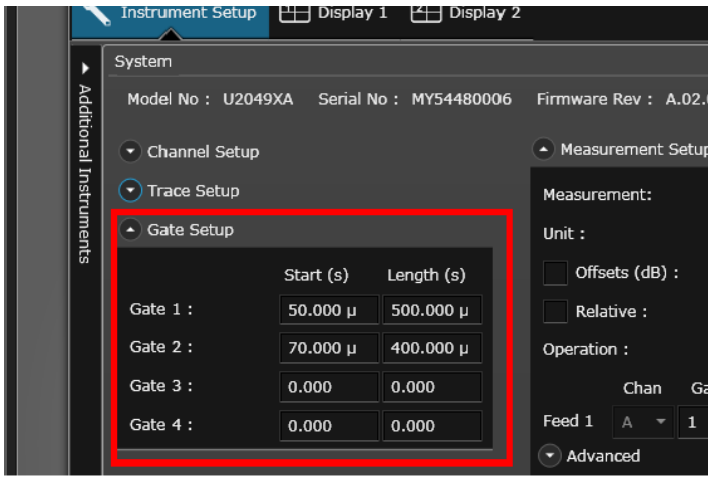


Figure 2-15 Setting the gates through Instrument Setup tab

8 View the power measurement results of the pulse at the **Pulse Analysis** tab under **Information Panel**.

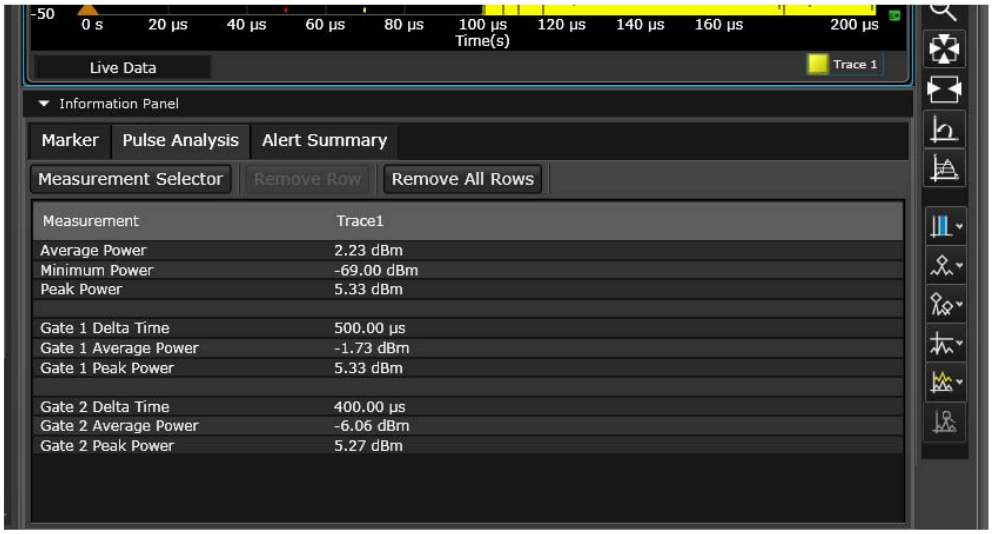


Figure 2-16 Viewing the power measurement results of the pulse

You can select additional pulse and gate measurements to display by clicking the **Measurement Selector** tab.

Quick overview of the BenchVue Power Meter

NOTE For details on each of the BenchVue Power Meter features, refer to the Keysight BenchVue Power Meter help documentation.

a Access the common measurement settings for the current measurement display view.

-- Click  to create a new Digital Meter display view.

-- Click  to create a new Analog Meter display view.

-- Click  to create a new Data Log display view.

-- Click  to create a new Trace display view.

-- Click  to create a new MultiList display view.

-- Click  to assign a measurement to the selected display view.

-- Click  to start or stop all assigned measurements on all display views simultaneously.

For more information, refer to "" on page 38 and "Power meter settings in the Normal mode" on page 42.

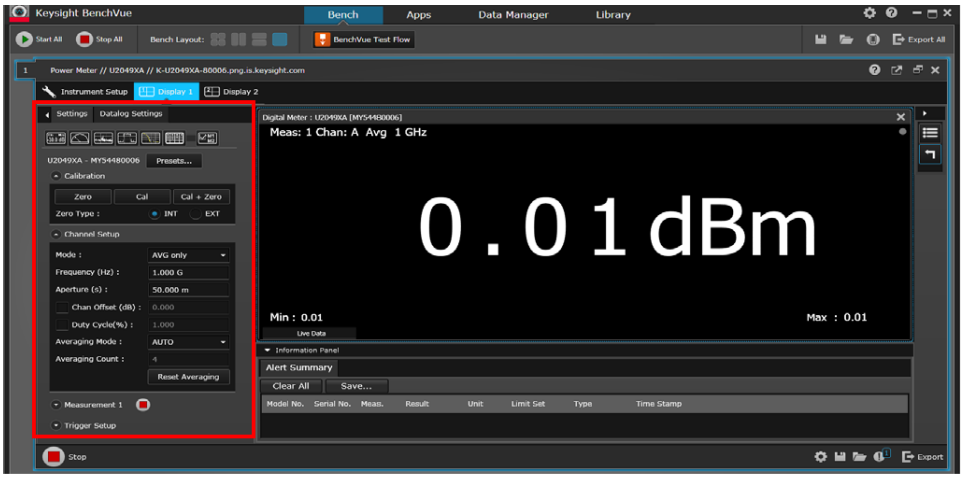


Figure 2-17 Common measurement settings pane

To access the data logger settings, click the **Datalog Settings** tab. To enable data logging, you need to stop the measurement acquisition.

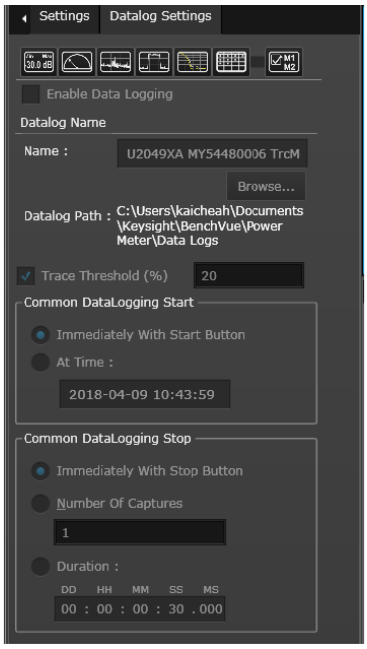


Figure 2-18 Datalog settings pane

Figure 2-19 Export the data log file

b Save or load the instrument state of the current bench application in a proprietary format with a **.state* file extension.

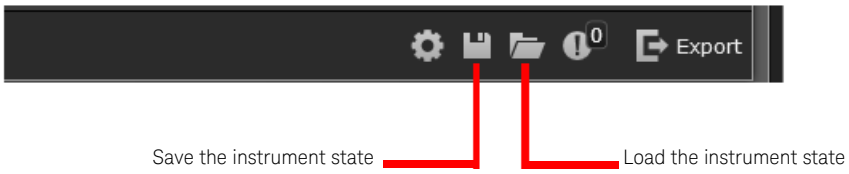


Figure 2-20 Save/load the instrument state

c Access advanced settings such as corrections (frequency-dependent offset, gamma, and S-parameter), alert limits, recorder output, trace/pulse duration reference levels, input impedance, and trigger output.

For more information, refer to "Instrument Setup tab" on page 45.

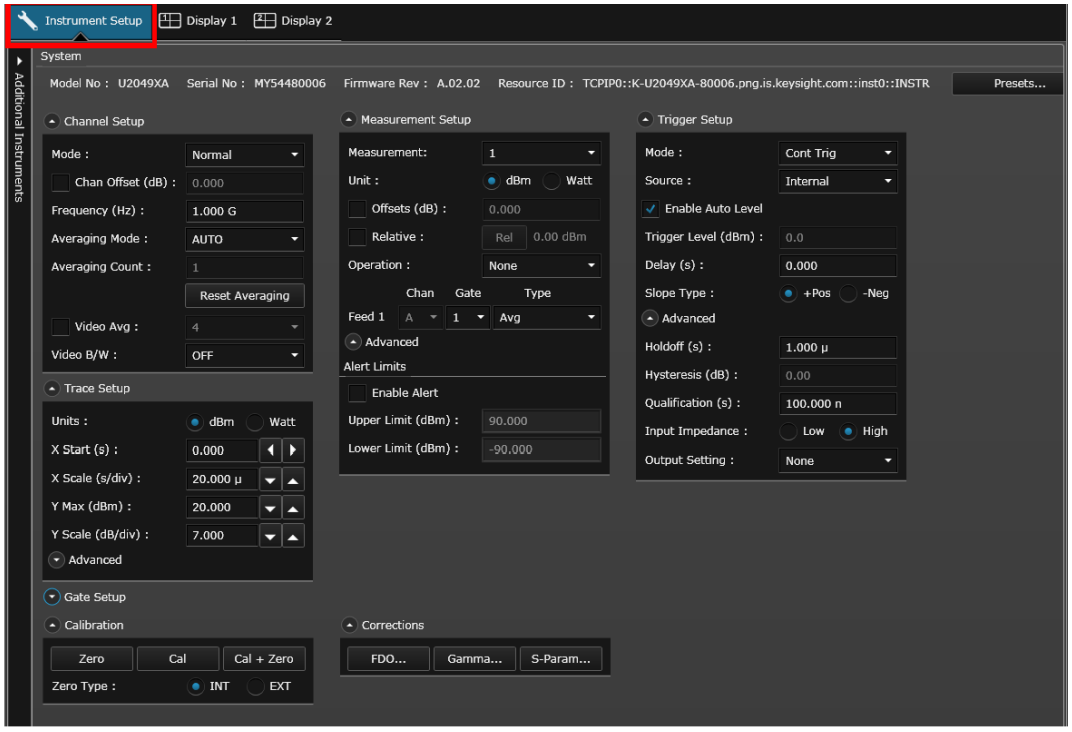


Figure 2-21 Instrument setup (advanced settings) pane

Power meter settings in the Average only mode

Common Average only mode power measurement settings

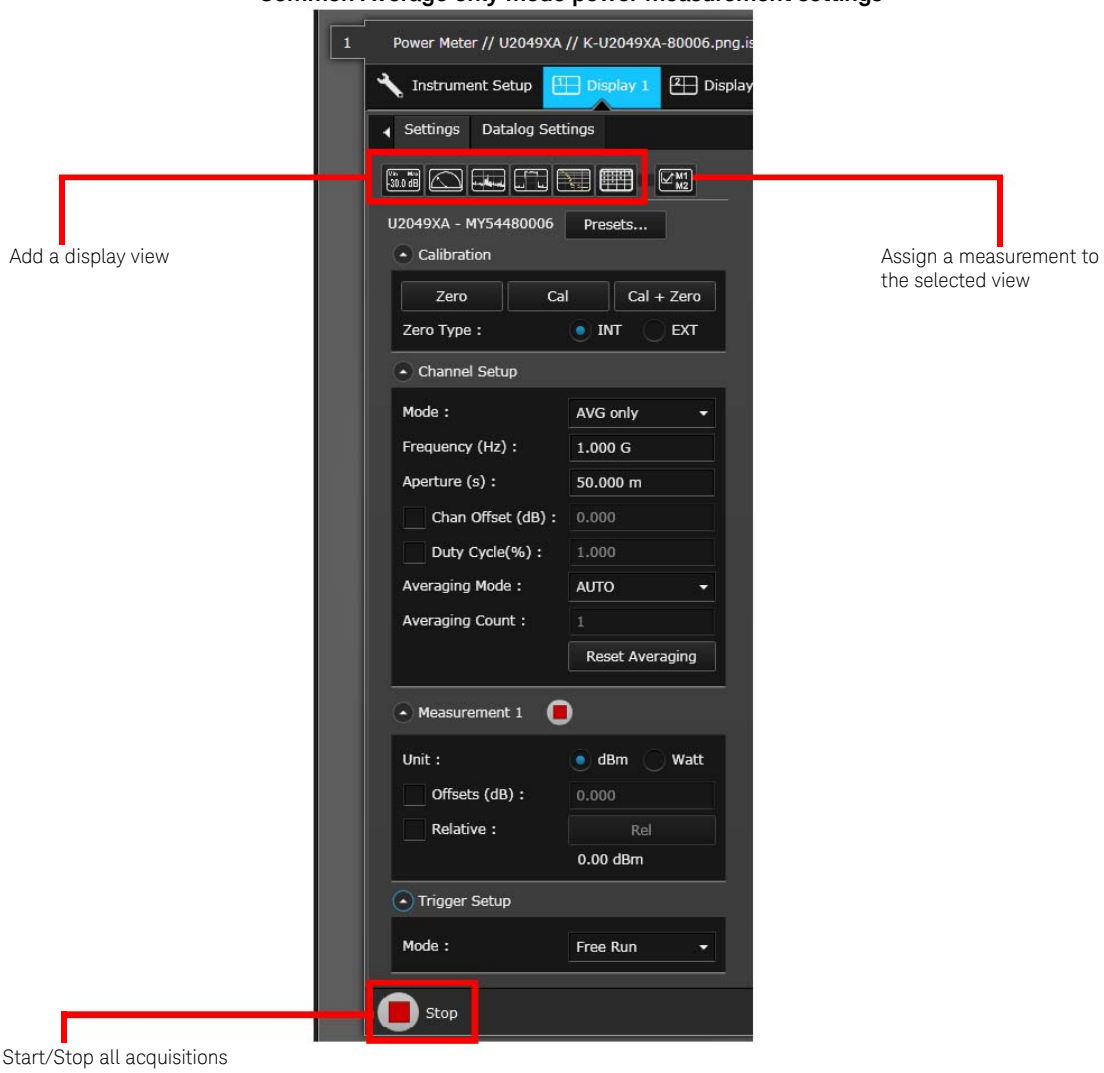


Figure 2-22 Power meter settings in the Average only mode

Table 2-1 Power meter settings in the Average only mode description

Item	Description
Presets	– Preset the instrument to its default values or values appropriate for measuring the communications format. The data stored in the correction (FDO, gamma, and S-parameter) tables, the selected correction table, and the zeroing and calibration data are not affected by a preset. – Perform a system reset.
Channel Setup	– Set the channel mode to the Normal or Average Only mode. – Set the measurement frequency. – Set the aperture size. – Set the channel offset which is applied to the measured power prior to any mathematical functions. Refer to "Simplified Measurement Path" on page 74. – Set the duty cycle. – Set the automatic or manual measurement average mode. The number of readings averaged can range from 1 to 1024. Increasing the value of the measurement average reduces measurement noise, but increases measurement time. The measurement average filter can also be reset. Refer to "Typical Averaged Readings" on page 75.
Calibration	Auto-calibrate the U2020 X-Series without having to connect it to a power reference, or auto-zero the U2020 X-Series internally or externally. Internal zeroing can be performed with or without the RF/microwave signal present, while external zeroing must be performed without any RF/microwave signal present.

Table 2-1 Power meter settings in the Average only mode description (continued)

Item	Description
Measurement	– Run/stop the measurement. – Set the logarithmic (dBm) or linear (Watt) measurement unit. – Set the measurement offset factor. The U2020 X-Series corrects every measurement by this factor to compensate for the gain/loss. – Enable the relative mode, which computes the measurement result relative (as a ratio) to a reference value. When enabled, the reference value can be set using the <**Rel**> control. The relative reading is displayed in either dB or %. – Measurement feed operation is not available in the Average only mode.
Trigger Setup	– Set the single, free run, or continuous trigger mode. The free run mode does not allow any trigger setup. – Set the trigger source to an external source in the single or continuous trigger mode. – Set the delay time to be applied between the trigger event and all the gate start times. This allows you to time-shift all the gates by the same amount with one setting change. – Select the positive or negative slope type to determine if the trigger event is recognized on the rising or falling edge of a signal respectively. – Set the holdoff time to disable the trigger mechanism after a trigger event occurs. – Set the qualification value.

Power meter settings in the Normal mode

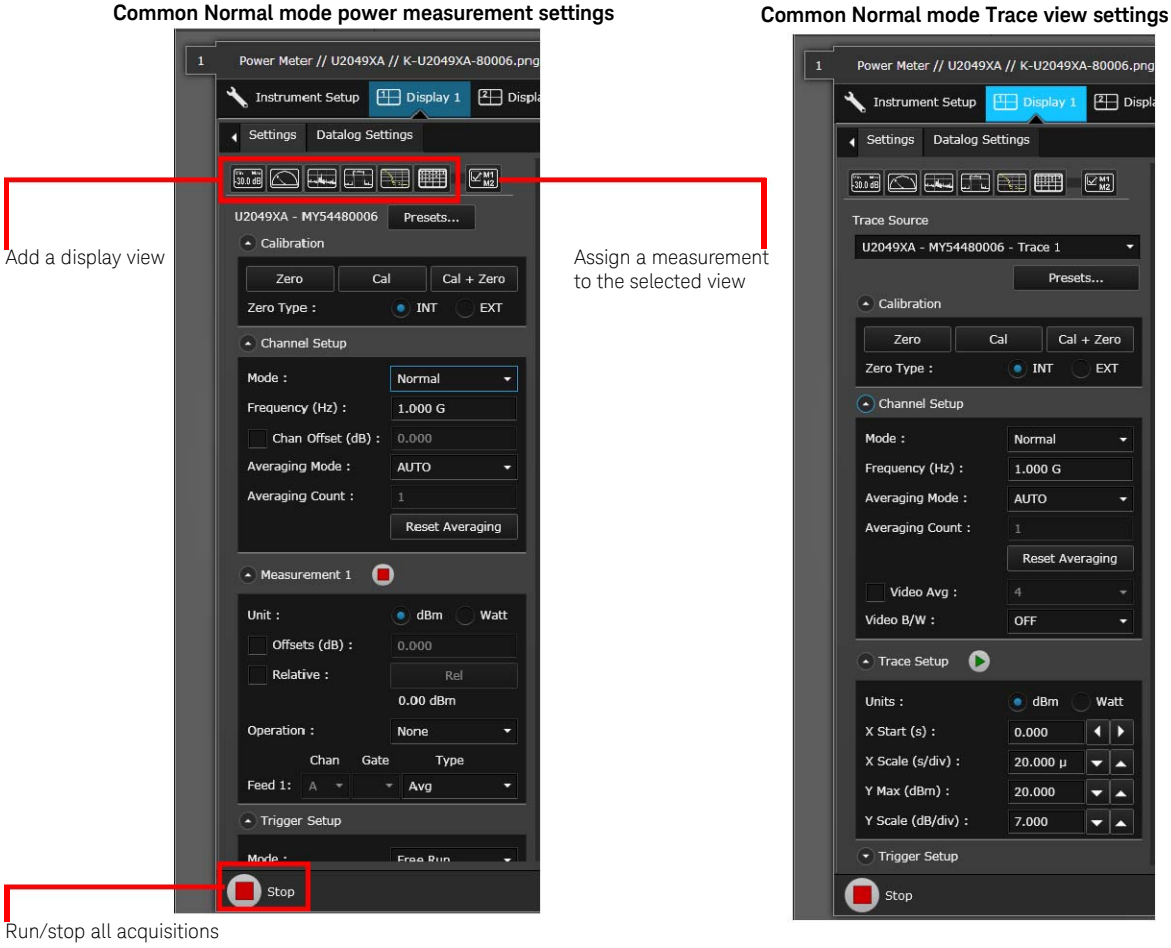


Figure 2-23 Power meter settings in the Normal mode

Table 2-2 Power meter settings in the Normal mode description

Item	Description
Presets	– Preset the instrument to its default values or values appropriate for measuring the communications format. The data stored in the correction (FDO, gamma, and S-parameter) tables, the selected correction table, and the zeroing and calibration data are not affected by a preset. – Perform a system reset.
Channel Setup	– Set the channel mode to the Normal or Average Only mode. – Set the measurement frequency. – Set the channel offset which is applied to the measured power prior to any mathematical functions. Refer to "Simplified Measurement Path" on page 74. – Set the automatic or manual measurement average mode. The number of readings averaged can range from 1 to 1024. Increasing the value of the measurement average reduces measurement noise, but increases measurement time. The measurement average filter can also be reset. Refer to "Typical Averaged Readings" on page 75.
Calibration	Auto-calibrate the U2020 X-Series without having to connect it to a power reference, or auto-zero the U2020 X-Series internally or externally. Internal zeroing can be performed with or without the RF/microwave signal present, while external zeroing must be performed without any RF/microwave signal present.
Measurement	– Run/stop the measurement. – Set the logarithmic (dBm) or linear (Watt) measurement unit. – Set the measurement offset factor. The U2020 X-Series corrects every measurement by this factor to compensate for the gain/loss. – Enable the relative mode, which computes the measurement result relative (as a ratio) to a reference value. When enabled, the reference value can be set using the <**Rel**> control. The relative reading is displayed in either dB or %. – Enable the difference or ratio measurement, or disable all operations between feed 1 and feed 2. – Configure the gate and acquired measurement type for the feed.

Table 2-2 Power meter settings in the Normal mode description (continued)

Item	Description
Trigger Setup	– Set the single, free run, or continuous trigger mode. The free run mode does not allow any trigger setup. – Set the trigger source to an internal or external source. – Enable auto level or manually set the trigger level for the internal trigger source. – Set the delay time to be applied between the trigger event and all the gate start times. This allows you to time-shift all the gates by the same amount with one setting change. – Select the positive or negative slope type to determine if the trigger event is recognized on the rising or falling edge of a signal respectively. – Set the holdoff time to disable the trigger mechanism after a trigger event occurs. – Set the hysteresis to help generate a more stable trigger by preventing triggering unless the RF power level achieves the trigger level and the additional hysteresis value. It can be applied to both rising and falling edge trigger generation. Hysteresis is only available for the internal trigger source and manual trigger level. – Set the qualification value.
Channel Setup (in the Trace view)	– Set the video averaging to average repetitions of a triggered signal, with a count of 1 to 256 in multiples of 2^n. With video averaging, the average of a number of acquisitions is calculated to smooth the displayed trace and reduce apparent noise. The measurement requires a continuously repeating signal. – Set the video bandwidth. The Low, Medium, and High pass band shapes achieved by the video bandwidth settings provide flat filter responses with very sharp cut-off points by applying digital signal processing techniques to ensure accurate power measurement within the specified band. When the video bandwidth is set to Off, it removes all digital signal conditioning. This provides less than 3 dB roll-off[a] and is best suited for capturing an accurate trace, minimizing overshoot, and removing any ringing effects caused by the sharp cut-off filters used in the Low, Med, and High settings. Refer to "**Bandwidth Filter Shapes**" on page 77.
Trace Setup	Set the trace unit, start time, X-axis scale, Y-axis maximum value, and Y-axis scale.
Trigger Setup (in the Trace view)	Select to enable trace for the single and continuous trigger modes.

[a] When the U2020 X-Series frequency is set to ≥300 MHz.

Instrument Setup tab

This tab provides you an option to configure additional instrument settings for your measurements as described in Table 2-3.

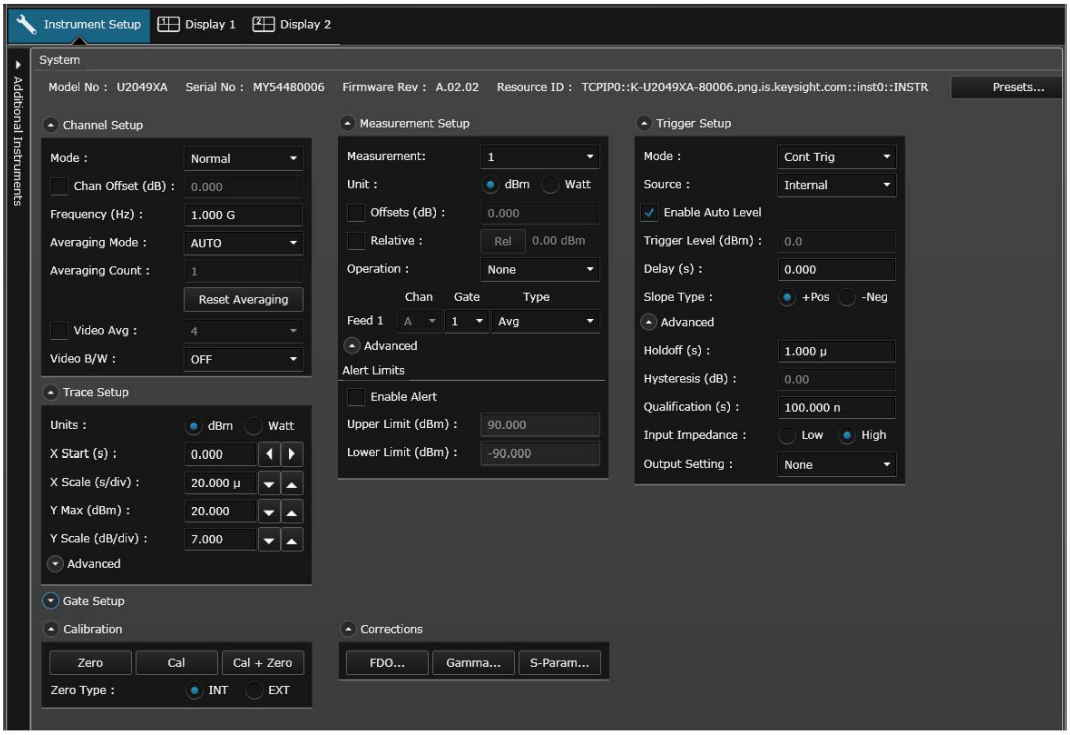


Figure 2-24 Instrument Setup tab

Table 2-3 Additional Instrument Setup tab settings description

Item	Available settings
Trace Setup	**Advanced:** – Set the trace reference levels to be used in the calculation of transition durations and occurrences. This allows transition measurements between non-standard reference levels. – Set the trace reference level to be used in the calculation of pulse durations. This allows pulse duration measurements between non-standard reference levels.
Gate Setup	Set the gate start time and length. The gate start time is relative to the trigger event. Positive values set a measurement gate to a maximum time of 1 second after the trigger. Negative values set a measurement gate to a maximum time of 1 second before the trigger. Refer to "Measurement Gates" on page 78 for more information.
Corrections	– Set the frequency-dependent offset (FDO) which compensates for frequency-related changes in the response of your test system. The BenchVue Power Meter application can store 10 FDO tables with 512 frequency points each. – Set the gamma and S-parameter corrections. The BenchVue Power Meter application can store 10 gamma/S-parameter tables with 1024 magnitude-phase pairs each. Also refer to "Simplified Measurement Path" on page 74 for the above corrections.
Measurement Setup	**Advanced:** Enable alerts to detect when a measurement has crossed over a predefined upper and/or lower limit value. Refer to "Limit Checking Application Example" on page 79 for more information.
Trigger Setup	**Advanced:** – Set the input impedance for the external TTL trigger to Low (50 Ω) or High (100 kΩ). – Enable the trigger output where a TTL level high is produced at the Trig Out connector when the U2020 X-Series is triggered. – Enable the 10 MHz timebase.
Additional Instruments	View all connected instruments and select any instrument to use on the BenchVue Power Meter application. You can connect up to 15 instruments per BenchVue Power Meter application.

Main Toolbar Functions

Icon	Function
	Connect to the U2020 X-Series.
	Disconnect the U2020 X-Series.
	Open any CSV-supported files.
	Save measurement data as a CSV-supported file.
	Preview a screenshot of the application prior to printing.
	Print a screenshot of the application.
	Save a screenshot of the application as an image file.
	Start the acquisition of all measurements on created tabs/views.
	Stop the acquisition of all measurements on created tabs/views.
	Record and save measurement data in a CSV-supported file.
	Create a new soft panel display view[a].
	Create a new gauge display view[a].
	Create a new strip chart display view[a].
	Create a new trace graph display view[a].

Icon	Function
	Create a new Complementary Cumulative Distribution Function (CCDF) graph display view or a new gated CCDF graph display view[a]. CCDF curves characterize the higher level power statistics of a digitally modulated signal, and are defined by how much time the waveform spends at or above a given power level. CCDF is applicable in the free-run, internal trigger, and external trigger modes. Gated CCDF is applicable in the internal trigger and external trigger modes only. You can view traces for Channel A, Gaussian, and Reference.
	Create a new overlay graph display view[a].
	Create a multilist display view[a].
	Remove the currently selected view from the application.
	Remove the currently selected tab (including the views in the tab).
	Provide application options and settings configuration.
	Display the alert summary dialog.
	Switch between compact mode and full mode display.
	Provide quick access to the help documentation.

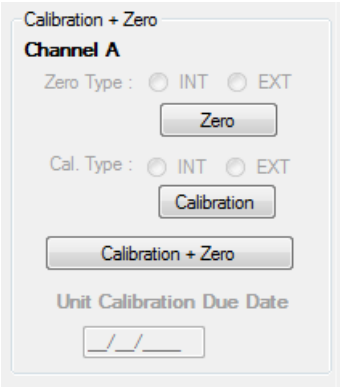
[a] When this icon is selected, corresponding function icons will appear on the toolbar. Refer to the *Power Analyzer help documentation* for details.

Instrument Properties Toolbar Functions

Icon	Function
	Offer a list of preset options for the U2020 X-Series properties settings. The data stored in the FDO tables, the selected FDO table, and the zeroing and calibration data are not affected by a preset.
	Save the U2020 X-Series states.
	Recall any saved U2020 X-Series states.
	Display the error list.
	Reset the U2020 X-Series to its default settings.
	Set the frequency-dependent offset (FDO) (refer to Simplified measurement path) which compensates for frequency-related changes in the response of your test system. The U2020 X-Series can store 10 FDO tables with 512 frequency points each.

Function Settings

Auto-calibration and auto-zeroing



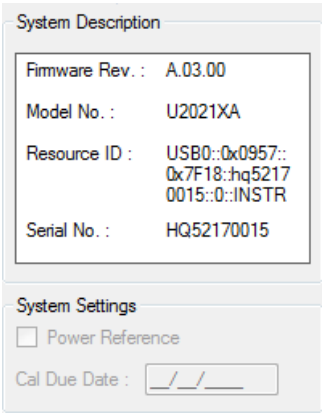
Auto-calibrate the U2020 X-Series without having to connect it to a power reference, or auto-zero the U2020 X-Series with or without the RF/microwave signal present.

Zeroing is recommended:

- when connection to the U2020 X-Series is established.
- every 24 hours.
- prior to measuring low-level signals.

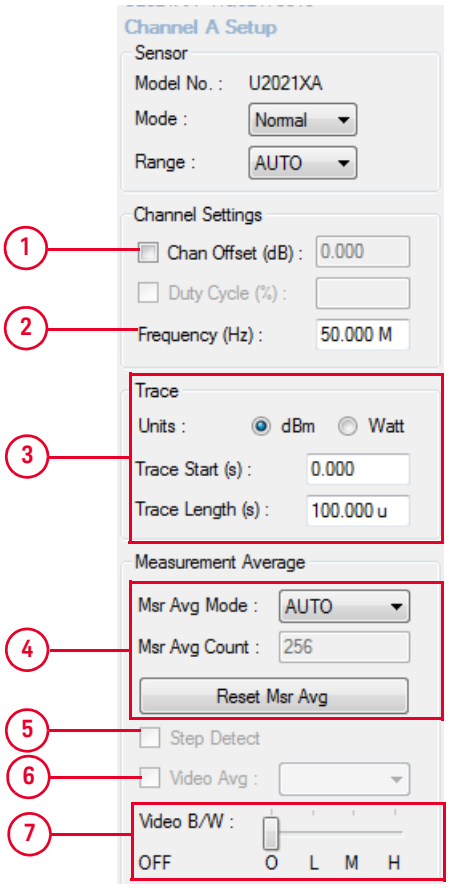
The U2020 X-Series will perform auto-zeroing and auto-calibration every time it is powered up.

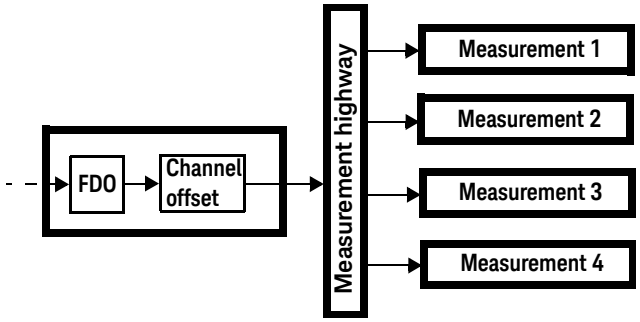
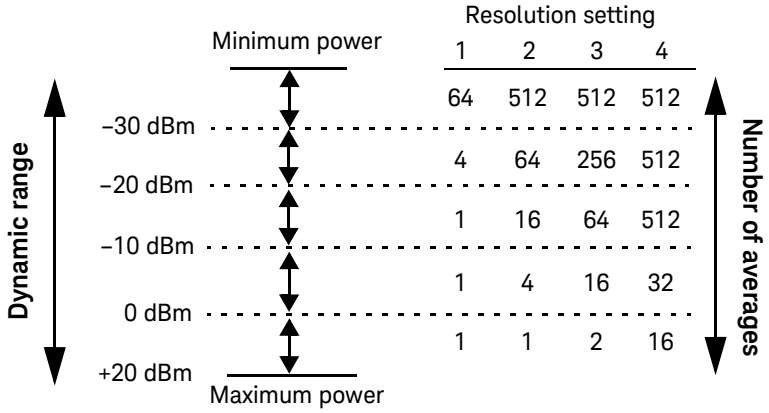
System-related function

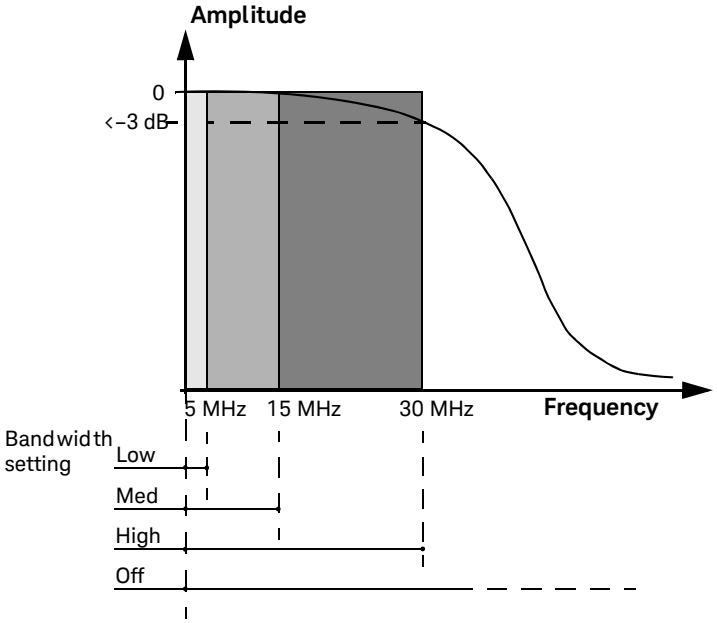


Display the system information (firmware revision, model number, instrument identity, and serial number) of the U2020 X-Series.

Channel setup functions



No.	Function
1	Set the channel offset which is applied to the measured power prior to any mathematical functions. **Simplified measurement path** 
2	Set the measurement frequency.
3	Set the trace unit, start time, and length.
4	Set the automatic or manual measurement average mode. The number of readings averaged can range from 1 to 1024. Increasing the value of the measurement average reduces measurement noise, but increases measurement time. The measurement average filter can also be reset. Below shows the typical number of averages for each range and resolution when the U2020 X-Series is in the auto-average mode and set to the normal speed mode.  The four resolution levels represent: – 1, 0.1, 0.01, 0.001 dB respectively if the measurement suffix is dBm or dB. – 1, 2, 3, or 4 significant digits respectively if the measurement suffix is W or %.

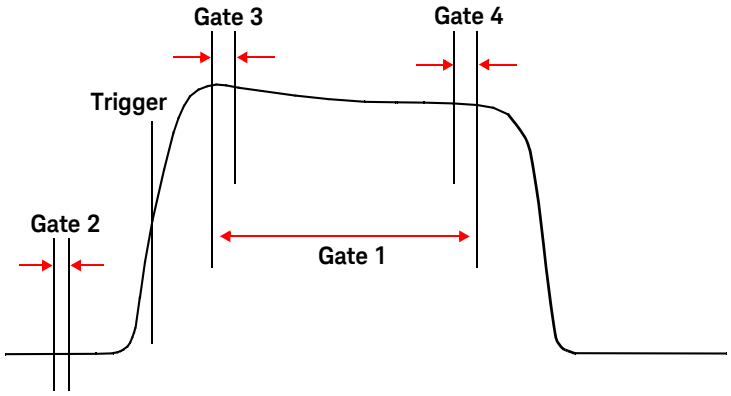
No.	Function
5	Enable step detection in both manual and automatic average modes. The filter can be set to re-initialize upon detection of a step increase or decrease in the measured power to reduce the filter settling time after a significant step in the measured power.
6	Set the video averaging to average repetitions of a triggered signal, with a count of 1 to 256 in multiples of 2^n. With video averaging, the average of a number of acquisitions is calculated to smooth the displayed trace and reduce apparent noise. The measurement requires a continuously repeating signal.
7	Set the video bandwidth. The Low, Medium, and High pass band shapes achieved by the video bandwidth settings provide flat filter responses with very sharp cut-off points by applying digital signal processing techniques to ensure accurate power measurement within the specified band. When the video bandwidth is set to Off, it removes all digital signal conditioning. This provides less than 3 dB roll-off at ≥500 MHz, and is best suited for capturing an accurate trace, minimizing overshoot, and removing any ringing effects caused by the sharp cut-off filters used in the Low, Med, and High settings. **Bandwidth filter shapes (for ≥500 MHz)** 

Measurement gates

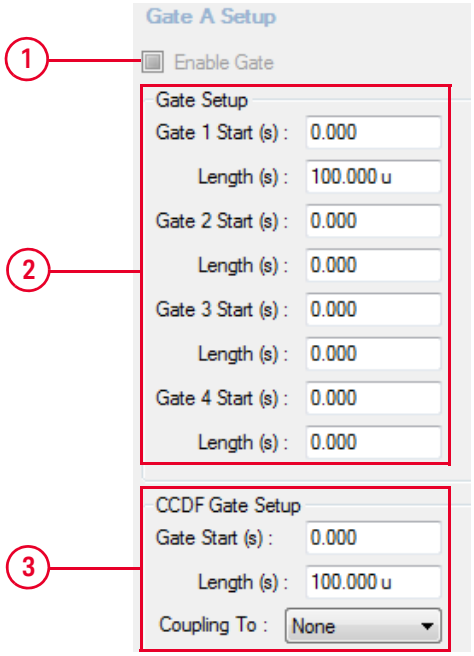
A measurement gate allows measurements to be performed on particular sections of the input signal. The gate is defined by a start time relative to the trigger instant and a duration. Signal samples acquired during the time interval specified by the gate are used for the measurements in that gate. A system of up to four independent gates is provided.

Below is an example of a 4-gate setup to perform the following measurements simultaneously:

Average power level of the pulse	Gate 1, average measurement
Average “off” power level ahead of the pulse	Gate 2, average measurement
Peak-to-average ratio	Gate 1, peak-to-average measurement
Pulse droop	Gate 3, average measurement, minus Gate 4, average measurement

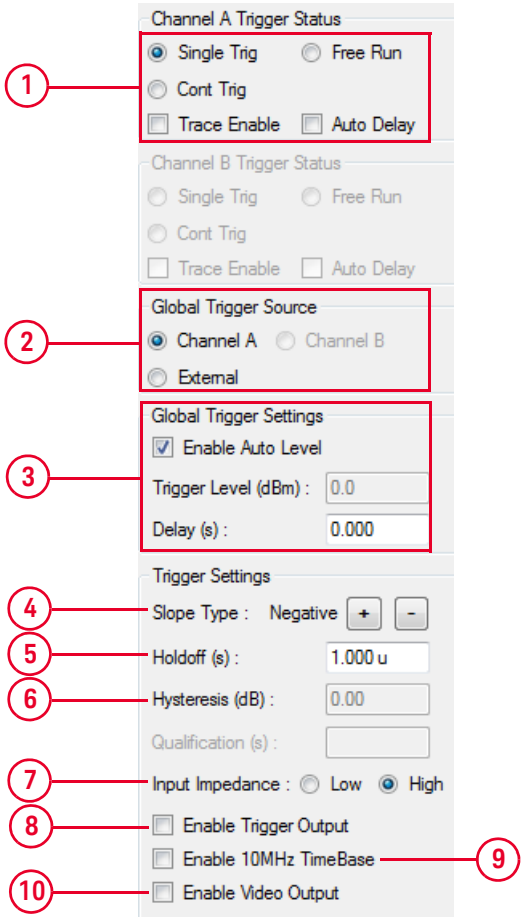


Measurement gate functions



No.	Function
1	**Enable Gate** is always checked and grayed out.
2	Set the gate start time and length. The gate start time is relative to the trigger event. Positive values set a measurement gate, to a maximum time of 1 second, after the trigger. Negative values set a measurement gate, to a maximum time of 1 second, before the trigger.
3	The CCDF gate does not allow a gate start time before the trigger event. For this reason, it has a separate definition and control section in the menu. For greater usability, any of the standard gates can be coupled to the CCDF gate (start time and length are shared).

Trigger functions

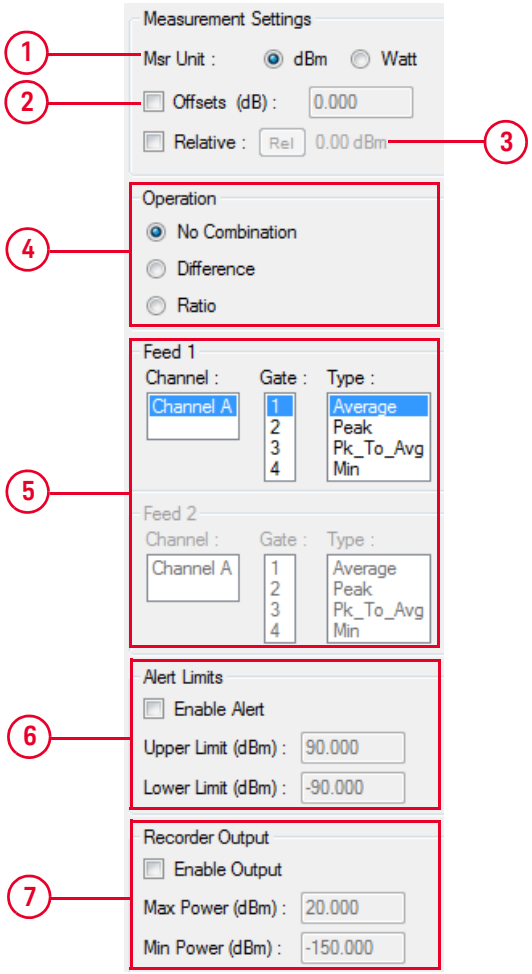


No.	Function
1	Set the single, free run, or continuous trigger mode. Select to enable trace and auto trigger delay for the single and continuous trigger modes. For the free run mode, only auto trigger delay can be enabled.
2	Set the global trigger source to channel A or an external source.

No.	Function
3	Enable auto level or manually set the trigger level if the channel A global trigger source is selected. Set the delay time to be applied between the trigger event and all the gate start times. This allows you to time-shift all the gates by the same amount with one setting change.
4	Select the positive or negative slope type to determine if the trigger event is recognized on the rising or falling edge of a signal respectively.
5	Set the holdoff time to disable the trigger mechanism after a trigger event occurs.
6	Set the hysteresis to help generate a more stable trigger by preventing triggering unless the RF power level achieves the trigger level and the additional hysteresis value. It can be applied to both rising and falling edge trigger generation. Hysteresis is only available for the channel A global trigger source and manual trigger level.
7	Set the input impedance for the external TTL trigger to Low (50 **Ω**) or High (100 k**Ω**).
8	Enable the trigger output where a TTL level high is produced at the Trig Out connector when the U2020 X-Series is triggered.[a]
9	Enable the 10 MHz timebase.[1]
10	Enable the video output which provides a DC voltage proportional to the measured input power through an SMB connector.[1]

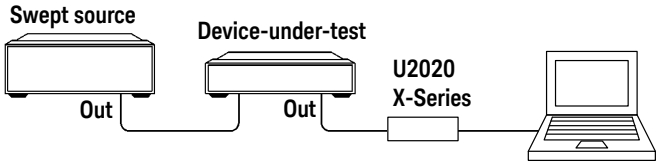
[a] You can only enable either the trigger output or the 10 MHz timebase or the video output at a time.

Measurement functions



No.	Function
1	Set the logarithmic (dBm) or linear (Watt) measurement unit for the currently selected measurement.
2	Set the measurement offset factor. The U2020 X-Series corrects every measurement by this factor to compensate for the gain/loss.
3	Enable the relative mode, which computes the measurement result relative (as a ratio) to a reference value. When enabled, the reference value can be set using the <Rel> control. The relative reading is displayed in either dB or %.
4	Enable the difference or ratio measurement, or disable all operations between feed 1 and feed 2.
5	Configure the gate and acquired measurement type for the feed.

No.	Function
6	Enable alerts to detect when a measurement has crossed over a predefined upper and/or lower limit value. Below shows an example of a limits checking application.



The limits have been set at +4 dBm and +10 dBm for the above application. A fail occurs each time the output power is outside these limits as shown below.

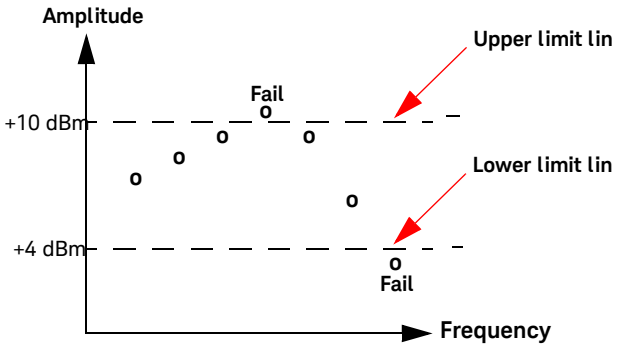


Table 2-4 Range of values for limits

Unit	Maximum	Minimum	Default maximum	Default minimum
dB	+200 dB	–180 dB	60 dB	–120 dB
dBm	+230 dBm	–150 dBm	90 dBm	–90 dBm
%	10.0 Z%	100.0 a%	100.0 M%	100.0 p%
W	100.000 EW	1.000 aW	1.000 MW	1.000 pW

7	Enable the recorder output which produces a DC voltage (0 to 1 VDC) that corresponds to the power level in Watts of the channel. The output impedance is typically 1 kΩ . Channel and display offsets have no effect on the recorder output.

U2020 X-Series Features

List mode

List mode is a mode of operation where a predefined sequence of measurement steps can be programmed into the power sensor and repeatedly executed as many times as required. This mode is suitable for power and frequency sweeps which normally require changing the parameters via the appropriate SCPI commands before performing a measurement. The hardware handshaking communication between the power sensor and the signal source provides the fastest possible execution time in performing the test sequences.

Trigger and gating parameters control which part of the waveform to be included or excluded from the measurement. The list mode helps to analyze modulated signals with regular and time-slotted or frame structure. For example, eight time-slotted GSM bursts, LTE-FDD and LTE-TDD frames and sub-frames, WCDMA frames and slots, and time-slotted measurements are supported in this mode. The desired number of slots and their duration and exclusion intervals can be easily programmed.

NOTE Refer to the *U2020 X-Series Programming Guide* for more information.

Variable aperture size

In average only mode and at normal measurement speed, the time interval length used to measure the average power of the signal can be adjusted by setting the aperture size to between 125 μs and 200 ms. This is useful for CW signals and noise-like modulated signals such as FDD-LTE and WCDMA by performing measurements over the full frames or sub-frames.

Decreasing the aperture size will improve the measurement throughput but reduce the signal-to-noise ratio of the measured signal. However, increasing the aperture size will improve the signal-to-noise ratio of the measured signal but reduce the measurement throughput.

Table 2-5 Aperture size

Measurement speed	Default aperture size	Adjustable
NORMal	50 ms	Yes
DOUBle	26 ms	No
FAST	2 ms	No

Average only mode external trigger

The U2020 X-Series also supports an external trigger in the average only mode. The external trigger can be used to synchronize noise-like modulated signals with the average measurement. By adjusting the aperture size and trigger delay, there is more control on which part of the waveform is being measured. This feature complements the time-gated function of the normal mode (peak mode) by offering a wider power range and a faster measurement speed but without the trace display.

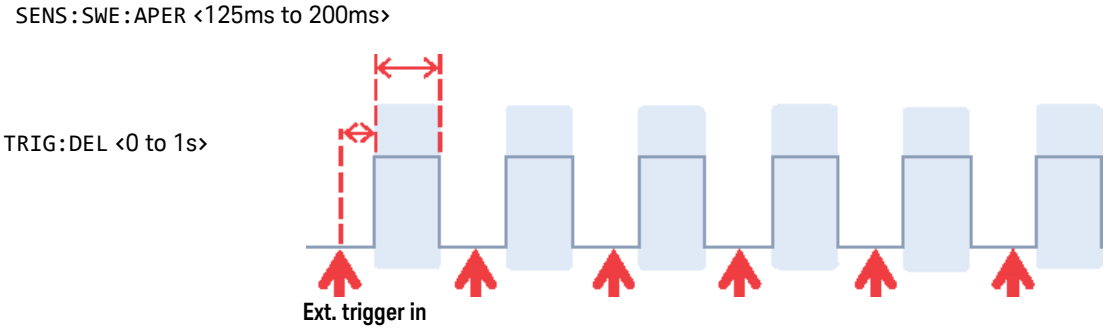


Figure 2-25 Average only mode external trigger

Auto burst detection

Auto burst detection helps the measurement setup of the trace or gate positions and sizes, and triggering parameters on a large variety of complex modulated signals by synchronizing to the RF bursts. After a successful auto-scaling, the triggering parameters such as the trigger level, delay, and hold-off are automatically adjusted for optimum operation. The trace settings are also adjusted to align the RF burst to the center of the trace display.

20-pulse measurements

The U2020 X-Series can measure up to 20 pulses. The measurement of radar pulse timing characteristics is greatly simplified and accelerated by performing analysis simultaneously on up to 20 pulses within a single capture. Individual pulse duration, period, duty cycle and separation, positive or negative transition duration, and time (relative to the delayed trigger point) are measured. The pulse parameters of these 20 pulses in a single capture can be queried through SCPI codes using the `TRACe:MEASurement:PULSe[1-20]` and `TRACEe:MEASurement:TRANsition[1-20]` commands. For example, `TRAC:MEAS:TRAN20:POS:DUR?` will return the 20th positive transition duration (rise time) found within the capture.

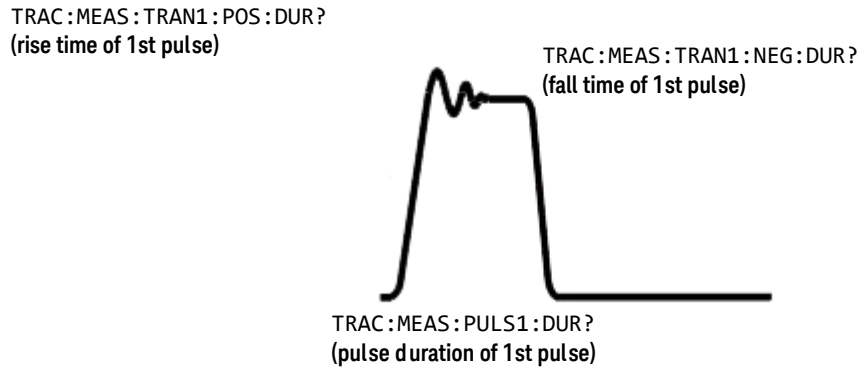


Figure 2-26 Pulsed radar analysis – 1st pulse

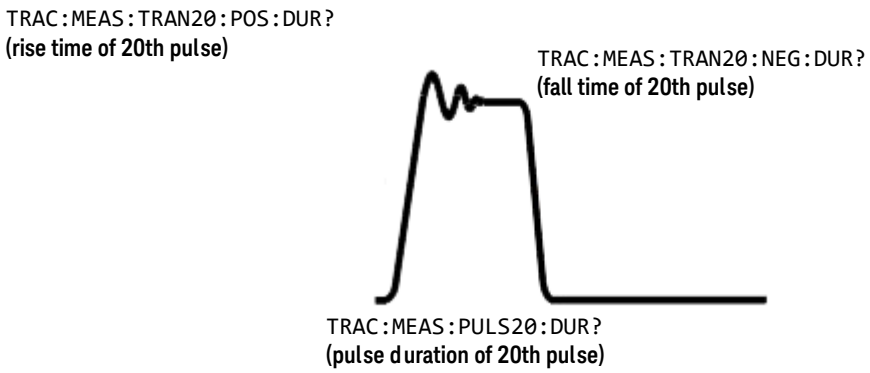


Figure 2-27 Pulsed radar analysis – 20th pulse

NOTE Refer to the *U2020 X-Series Programming Guide* for more information.

High average count reset

When high averaging factors have been set, any rapid adjustments to the amplitude of the measured signal will be delayed due to the need to allow the averaging filter to fill before a new measurement can be taken at a stable power level. The U2020 X-Series allows you to reset the long filter after the final adjustment to the signal's amplitude has been made.

Gamma correction

NOTE The Gamma correction function is only available in U2020 X-Series power sensors with firmware version A.04.04 and above.

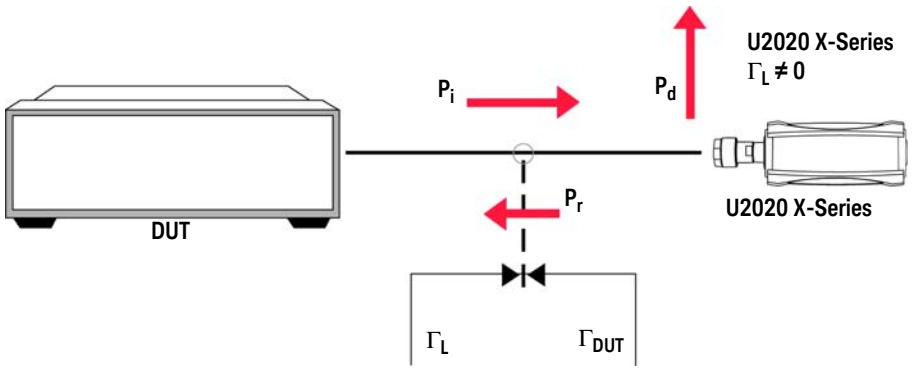


Figure 2-28 Device-Under-Test (DUT) to U2020 X-Series connection diagram

In a realistic measurement environment, the DUT impedance or the reference impedance (Z_o) is not equal to the U2020 X-Series impedance. The mismatch in impedance values causes a portion of the signal voltage to be reflected. This is quantified by the reflection coefficient, or Gamma (Γ). A portion of the incident power to the U2020 X-Series, P_i, is reflected back to the DUT as P_r. The remaining power, P_d, gets delivered to the U2020 X-Series. A generic DUT will reflect part of P_r back to the U2020 X-Series, and the reflected portion will be superimposed onto P_i. The nominal power, P_{zo} (the power generated after factoring in Z_o) may be calculated as follows:

$$P_{zo} = P_i\left|1 - \Gamma_{DUT}\Gamma_L\right|^2$$

Gamma correction compensates for impedance mismatch via two options, which are Single Point Gamma and Table-Based Gamma.

Single Point Gamma

Single Point Gamma correction is used when you have a known and constant frequency, so a single Gamma value can be used for calculation. The value for Γ_{DUT} may be entered as a Single Point Gamma which may be applied across all measurement frequencies in the U2020 X-Series operating range. You may input the value for GDUT directly into the U2020 X-Series via SCPI commands in the magnitude-phase format.

Table-Based Gamma

Table-Based Gamma is used when there are multiple known frequencies, leading to multiple Gamma values. This option supports a list of up to 1024 measurement frequency values. You may load the values in table form directly into the U2020 X-Series via SCPI commands as a Gamma table to be used for calculation.

NOTE The U2020 X-Series supports up to 10 Gamma tables that are retained across reset and power cycles.

The Γ_L values for factory calibration frequencies within the U2020 X-Series operating range are already pre-loaded in the U2020 X-Series. These Γ_L values are retained across reset and power cycles.

NOTE

- The `*OPT?` query will return the option string “GAM” for U2020 X-Series power sensors that have been pre-loaded with Γ_L values. U2020 X-Series power sensors that were shipped before the introduction of Gamma correction have no pre-loaded Γ_L values.
- For more details on SCPI commands, refer to the *U2020 X-Series Programming Guide*.

S-Parameter correction

NOTE The S-Parameter correction function is only available in U2020 X-Series power sensors with firmware version A.04.04 and above.

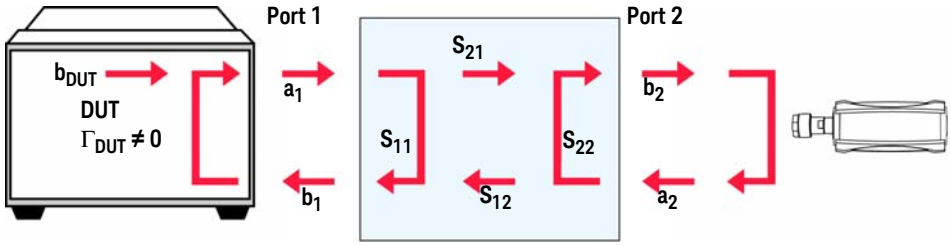


Figure 2-29 Non-ideal 2-port device

A DUT that has *n* number of ports has n^2 S-Parameters. These S-Parameters represent reflected energy which interferes with the power measurements. These errors are usually caused by additional components such as attenuators, adapters, or matching pads, which are inserted between the DUT and the U2020 X-Series. Typically, DUTs are non-ideal, as illustrated in Figure 2-29. When power is transmitted from the DUT, the U2020 X-Series will reflect a part of its incident wave back to the 2-port device. The 2-port device will reflect this wave back to the U2020 X-Series. The power from the DUT may therefore be calculated as follows:

$$b_{DUT} = b_2 \frac{(1 - S_{11}\Gamma_{DUT})(1 - S_{22}\Gamma_L)}{S_{21}} - S_{12}\Gamma_{DUT}\Gamma_L$$

This feature enables you to correct for the effect of 2-port devices in your test setup. You may load the values in table form directly into the U2020 X-Series via SCPI commands as an S-Parameter table to be used for calculation.

NOTE

- The U2020 X-Series supports up to 10 S-Parameter tables that are retained across reset and power cycles.
- For more details on SCPI commands, refer to the *U2020 X-Series Programming Guide*.

Tilt measurement

Tilt measurement is used to measure the amount of tilted droop (A_D) of the input signal as shown in Figure 2-30.

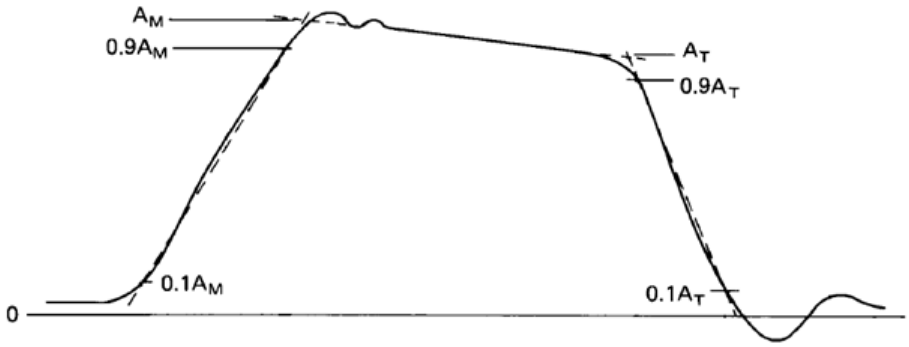


Figure 2-30 Tilt measurement graph

Pulse amplitude, A_M

The pulse amplitude quantity is determined by the intersection of a line passing through the points on the rising edge, where the instantaneous value reaches 10% and 90% of A_M and a straight line that is the best least-squares fit to the pulse in the pulse-top region.

Trailing edge (last transition) amplitude, A_T

The trailing edge amplitude quantity is determined by the intersection of a line passing through the points on the falling edge where the instantaneous value reaches 90% and 10% of A_T, and the straight-line segment fitted to the top of the pulse in determining A_M.

Tilt, A_D

Tilt is the difference between A_M and A_T. It is expressed in percentage of A_M or in dB.

$$\text{TILT}(\%) = \frac{A_M - A_T}{A_M} \times 100$$

$$\text{TILT}(\text{dB}) = 10 \times \log 10\left(\frac{A_M}{A_T}\right)$$

3 Specifications and Characteristics

For the characteristics and specifications of the U2020 X- Series USB peak and average power sensors, refer to the datasheet at
http://literature.cdn.keysight.com/litweb/pdf/5991-0310EN.pdf

THIS PAGE HAS BEEN INTENTIONALLY LEFT BLANK.

Edition 6, September 1, 2018

Printed in Malaysia

U2021-90002
www.keysight.com