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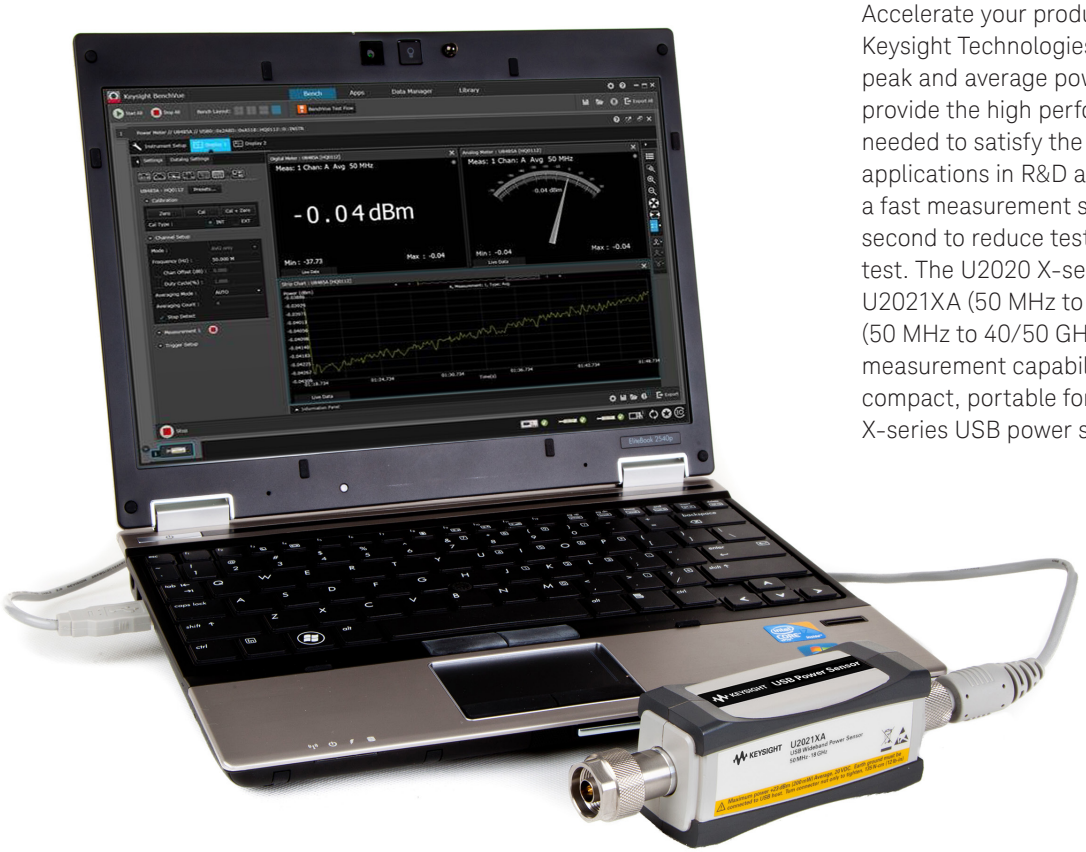
DATA SHEET

U2020 X-Series USB Peak and Average Power Sensors



KEYSIGHT TECHNOLOGIES

Accelerate Your Production Throughput



Accelerate your production throughput with Keysight Technologies, Inc. U2020 X-series USB peak and average power sensors. These sensors provide the high performance and features needed to satisfy the requirements of many power applications in R&D and manufacturing, offering a fast measurement speed of > 25,000 readings/second to reduce testing time and cut cost of test. The U2020 X-series comes with two models: U2021XA (50 MHz to 18 GHz), and U2022XA (50 MHz to 40/50 GHz). Get the peak power measurement capability of a power meter in a compact, portable form with the Keysight U2020 X-series USB power sensors.

Accurate RMS power measurements

The U2020 X-Series have a wide 30 MHz video bandwidth and a 80 M-sample/s continuous sampling rate for fast, accurate and repeatable RMS power measurements. With its high frequency coverage of 50 GHz, wide dynamic range and extensive measurement capability, the X-Series is optimized for aerospace/defense, wireless communication (LTE, WCDMA, GSM) and wireless networking applications (WLAN).

A wide peak power dynamic range

The U2020 X-series sensors' dynamic range of –30 to +20 dBm for peak power measurements enables more accurate analysis of very small signals, across a broader range of peak power applications in the aerospace, defense and wireless industries.

Internal zero and calibration

Save time and reduce measurement uncertainty with the internal zero and calibration function. Each U2020 X-series sensor comes with technology that integrates a DC reference source and switching circuits into the body of the sensor so you can zero and calibrate the sensor while it is connected to a device under test. This feature removes the need for connection and disconnection from an external calibration source, speeding up testing and reducing connector wear and tear.

The internal zero and calibration function is especially important in manufacturing and automated test environments where each second and each connection counts.

Built-in trigger in/trigger out

An external trigger enables accurate triggering of small signals close to the signal noise floor. The U2020 X-series USB power sensors come with built-in trigger in/out connection, allowing you to connect an external trigger signal from a signal source or the device-under-test directly to the USB sensor through a standard BNC to SMB cable. The sensors also come with recorder/video-output features.

Compact and portable form factor

The U2020 X-Series are standalone sensors that operate without the need of a power meter or an external power supply. The sensors draw power from a USB port and do not need additional triggering modules to operate, making them portable and lightweight solutions for field applications such as base station testing. Simply plug the sensor to the USB port of your PC or laptop, and start your power measurements.

The U2020 X-Series is supported by the Keysight BenchVue software and BV0007B Power Meter/Sensor Control and Analysis app. Once you plug the USB power sensor into a PC and run the software you can see measurement results in a wide array of display formats and log data without any programming.

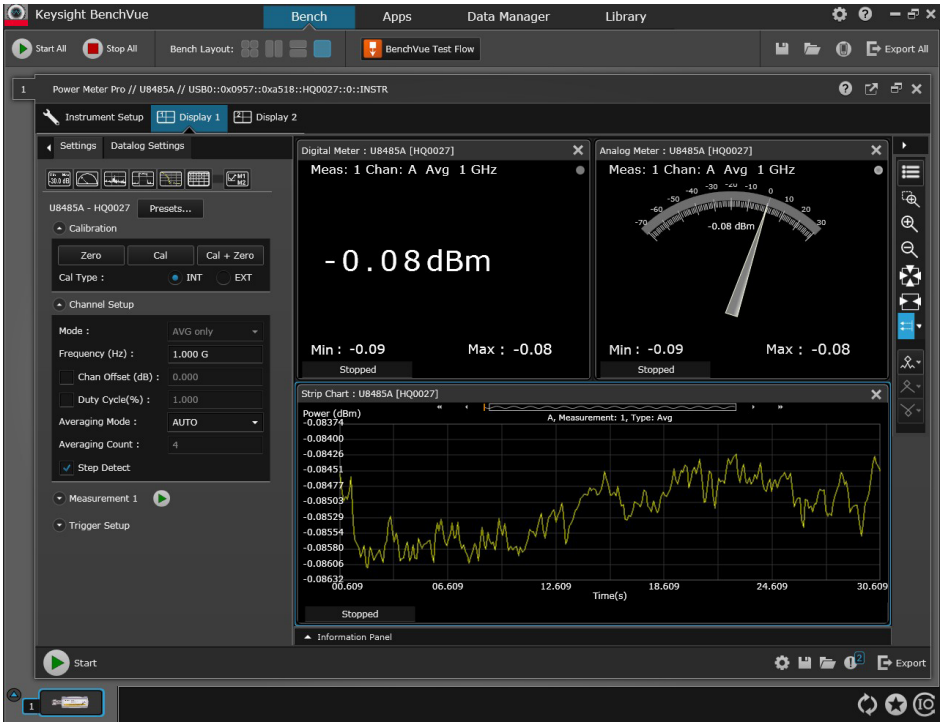
For more information, **www.keysight.com/find/BenchVue**

Fast rise and fall time; wide video bandwidth

Accurately measure the output power and timing parameters of pulses when designing or manufacturing components and subcomponents for radar systems. The U2020 X-series USB power sensors come with a 30 MHz bandwidth and ≤ 13 ns rise and fall time, providing a high performance peak and average power solution that covers most high frequency test applications up to 50 GHz.

Built-in radar and wireless presets

Begin testing faster; the U2020 X-series USB power sensors come with built-in radar and wireless presets for DME, GSM, EDGE, CDMA, WCDMA, WLAN, WiMAX™, and LTE.



Complementary cumulative distribution function (CCDF) curves

CCDF characterizes the high power statistics of a digitally modulated signal, and is defined by how much time the waveform spends at or above a given power level. The U2020 X-series supports two types of CCDF curves. Normal CCDF displays the power statistics of the whole waveform under free run, internal or external trigger modes. Gated CCDF can be coupled with a measurement gate and only the waveform within the gated region is analyzed statistically. Gated CCDF is only applicable in internal trigger and external trigger modes.

Designers of components, such as power amplifiers, will compare the CCDF curves of a signal at the amplifier's input and output. A well designed component will produce curves that overlap each other. If the amplifier compresses the signal, then the peak-to-average ratio of the signal will be lower at the output of the amplifier. The designer will need to improve the range of the amplifier to handle high peak power.

Additional 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.

List mode enables users to setup the number of measurements, the number and duration of timeslots, the start and stop frequency for sweeping and the exclusion interval. This is especially useful for speeding up measurements for eight time-slotted GSM/EDGE bursts, LTE-TDD or WLAN frames and sub-frames.

For more information, please refer to the programming examples in the U2020 X-Series Programming Guide.

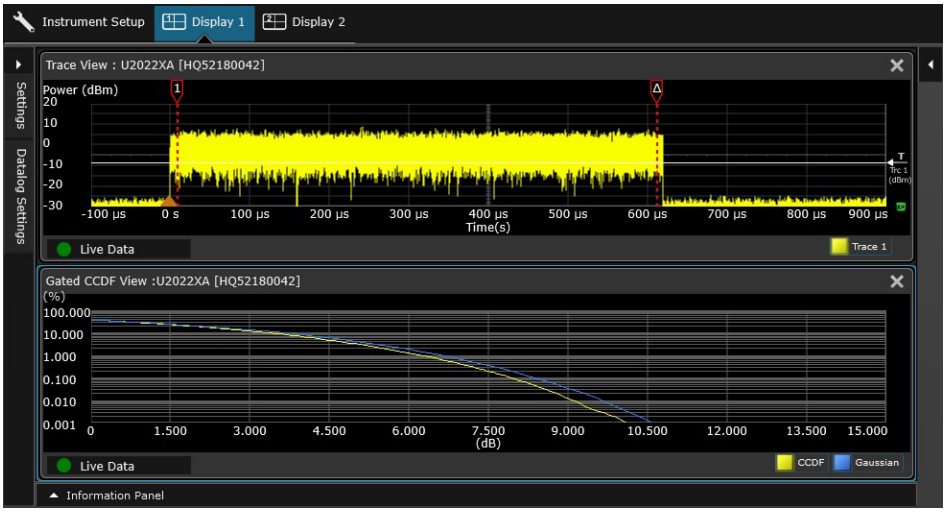
Variable aperture size

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 LTE-FDD 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 1. 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 external trigger in average only mode. The external trigger can be used to synchronize the measurement capture with signal burst timing. By adjusting the aperture size and trigger delay, users have greater control on which portion of the waveform is being measured. This function complements the time-gated function in normal mode (peak mode) by offering a wider power range and faster measurement speed, although it comes without trace display.

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 U2020 X-Series also supports automatic pulse tilt (or droop) measurements via SCPI command.

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

In an ideal measurement scenario, the reference impedance of the power sensor and DUT impedance should equal the reference impedance (Zo); however, this is rarely the case in practice. The mismatch in impedance values results in a portion of the signal voltage being reflected, and this reflection is quantified by the reflection coefficient or gamma.

Using gamma correction function, users can simply input the DUT's gamma into the sensor via SCPI commands for mismatch correction. This yields more accurate measurements.

S-parameter correction

Additional errors are often caused by components that are inserted between the DUT and power sensor, such as in base station testing where a high power attenuator is connected between the sensor and base station to reduce the output power to the measurable power range of the sensor.

The S-parameters of these components can be obtained with a vector network analyzer in the touchstone format, and inputted into the sensor using SCPI commands. This error can be corrected with the S-parameter correction so that the sensor will measure as though it is connected directly to the DUT, giving users highly accurate power measurements.

Performance Specifications

Specification definitions

There are two types of product specifications:

- Warranted specifications are specifications which are covered by the product warranty and apply over a range of 0 to 55 °C unless otherwise noted. Warranted specifications include measurement uncertainty calculated with a 95% confidence.
- *Characteristic specifications are specifications that are not warranted. They describe product performance that is useful in the application of the product.*

Characteristic information is representative of the product. In many cases, it may also be supplemental to a warranted specification. Characteristics specifications are not verified on all units. There are several types of characteristic specifications. They can be divided into two groups:

One group of characteristic types describes 'attributes' common to all products of a given model or option. Examples of characteristics that describe 'attributes' are the product weight and '50-Ω input Type-N connector'. In these examples, product weight is an 'approximate' value and a 50-Ω input is 'nominal'. These two terms are most widely used when describing a product's 'attributes.'

The second group describes 'statistically' the aggregate performance of the population of products. These characteristics d escribe the expected behavior of the population of products. They do not guarantee the performance of any individual product. No measurement uncertainty value is accounted for in the specification. These specifications are referred to as 'typical.'

Conditions

The power sensor will meet its specifications when:

- Stored for a minimum of two hours at a stable temperature within the operating temperature range, and turned on for at least 30 minutes
- The power sensor is within its recommended calibration period, and
- Used in accordance to the information provided in the User's Guide.

U2020 X-Series USB Power Sensors Specifications

Key specifications		
Frequency range	U2021XA	50 MHz to 18 GHz
	U2022XA	50 MHz to 40 GHz
		50 MHz to 50 GHz (with Option H50)
Power range	Normal mode	*–30 dBm to 20 dBm (50 MHz to <500 MHz)*
		–35 dBm to 20 dBm (500 MHz to 40 GHz)
		–35 dBm to 8 dBm (> 40 GHz to 50 GHz)
	Average only mode [1, 2]	*–45 dBm to 20 dBm (50 MHz to 40 GHz)*
		–45 dBm to 8 dBm (> 40 GHz to 50 GHz)
Damage level	23 dBm (average power)	
	30 dBm (< 1 µs duration) (peak power)	
Rise/fall time	≤ 13 ns [3]	
Maximum sampling rate	*80 Msamples/sec, continuous sampling*	
Video bandwidth	*≥ 30 MHz*	
Single-shot bandwidth	*≥ 30 MHz*	
Minimum pulse width	*50 ns* [4]	
Basic accuracy of average power measurement [5]	U2021XA	≤ ± 0.2 dB or ± 4.5%
	U2022XA	≤ ± 0.3 dB or ± 6.7%
Maximum capture length	*1 s (decimated)*	
	1.2 ms (at full sampling rate)	
Maximum pulse repetition rate	*10 MHz (based on 8 samples/period)*	
Connector type	U2021XA	N-type (m)
	U2022XA	2.4 mm (m)

1. Internal zeroing, trigger output, and video output are disabled in average only mode.
2. It is advisable to perform zeroing when using the average path for the first time after power on, significant temperature changes, or long periods since the last zeroing. Ensure that the power sensor is isolated from the RF source when performing external zeroing in average only mode.
3. For frequencies ≥ 500 MHz. Only applicable when the Off video bandwidth is selected. Add 5 ns to rise/fall time specifications for acquisitions smaller than 137.5 µs.
4. The Minimum Pulse Width is the recommended minimum pulse width viewable, where power measurements are meaningful and accurate, but not warranted.
5. This basic accuracy is valid over a range of –15 to +20 dBm, and a frequency range of 0.5 to 10 GHz, DUT Max. SWR < 1.27 for the U2021XA, and a frequency range of 0.5 to 40 GHz, DUT Max. SWR < 1.2 for the U2022XA. Averaging set to 32, in Free Run mode. The accuracy under the other conditions can be obtained with the measurement uncertainty calculator available on **www.keysight.com/find/u2022xa**.

Measured Rise Time Percentage Error Versus Signal-Under-Test Rise Time

Although the rise time specification is ≤ 13 ns, this does not mean that the U2021XA/22XA can accurately measure a signal with a known rise time of 13 ns. The measured rise time is the root sum of the squares (RSS) of the signal-under-test (SUT) rise time and the system rise time (13 ns):

Measured rise time = $\sqrt{((\text{SUT rise time})^2 + (\text{system rise time})^2)}$ and the % error is:
% Error = ((measured rise time – SUT rise time)/SUT rise time) × 100

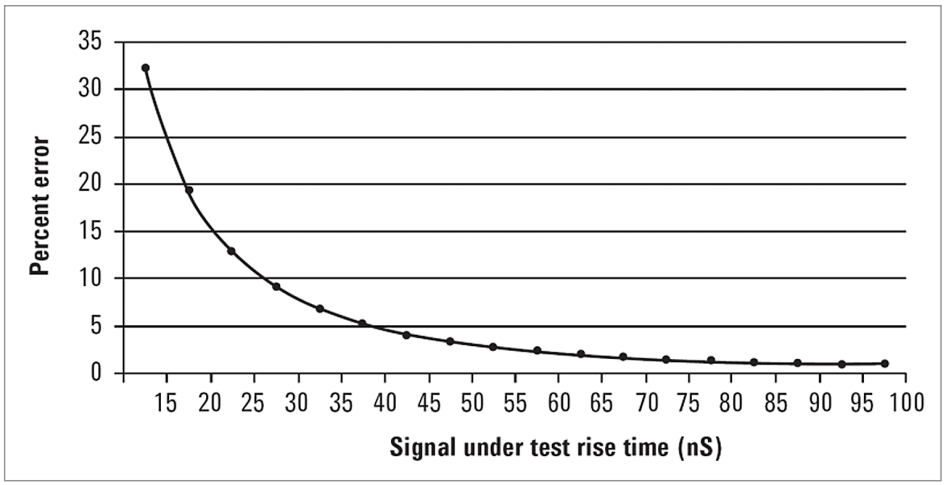


Figure 1. Measured rise time percentage error versus signal under test rise time.

Power Linearity

Power range	Linearity at 5 dB step (%)	
	25 °C	0 to 55 °C
–20 dBm to –10 dBm	*1.2*	*1.8*
–10 dBm to 15 dBm	*1.2*	*1.2*
15 dBm to 20 dBm	*1.4*	*2.1*

Video Bandwidth

The video bandwidth in the U2021XA/22XA can be set to High, Medium, Low, and Off. The video bandwidths stated below are not the 3 dB bandwidths, as the video bandwidths are corrected for optimal flatness (except the Off filter). Refer to Figure 2, "Characteristic peak flatness," for information on the flatness response. The Off video bandwidth setting provides the warranted rise time and fall time specifications and is the recommended setting for minimizing overshoot on pulse signals.

Video bandwidth setting		Low: 5 MHz	Medium: 15 MHz	High: 30 MHz	Off
Rise time/fall time [1]	*< 500 MHz*	*< 93 ns*	*< 75 ns*	*< 72 ns*	*< 73 ns*
	≥ 500 MHz	*< 82 ns*	*< 27 ns*	*< 17 ns*	*< 13 ns* [3]
Overshoot [2]					*< 5%*

1. Specified as 10% to 90% for rise time and 90% to 10% for fall time on a 0 dBm pulse.
2. Specified as the overshoot relative to the settled pulse top power. Applicable to signal with rise time ≥ 15 ns.
3. Add 5 ns to rise/fall time specifications for acquisitions smaller than 137.5 µs.

Recorder Output and Video Output

The recorder output produces a voltage proportional to the selected power measurement and is updated at the measurement rate. Scaling can be selected with an output range of 0 to 1 V and impedance of 1 kΩ.

The video output is the direct signal output detected by the sensor diode, with no correction applied. The video output provides a DC voltage proportional to the measured input power. The DC voltage can be displayed on an oscilloscope for time measurement. The video output impedance is 50 Ω and the level is approximately 500 mV at 20 dBm CW. The trigger out and recorder/video out share the same port, and the level is approximately 250 mV at 20 dBm.

Characteristic Peak Flatness

The peak flatness is the flatness of a peak-to-average ratio measurement for various tone separations for an equal magnitude two- tone RF input. The figure below refers to the relative error in peak-to-average ratio measurements as the tone separation is varied. The measurements were performed at –10 dBm.

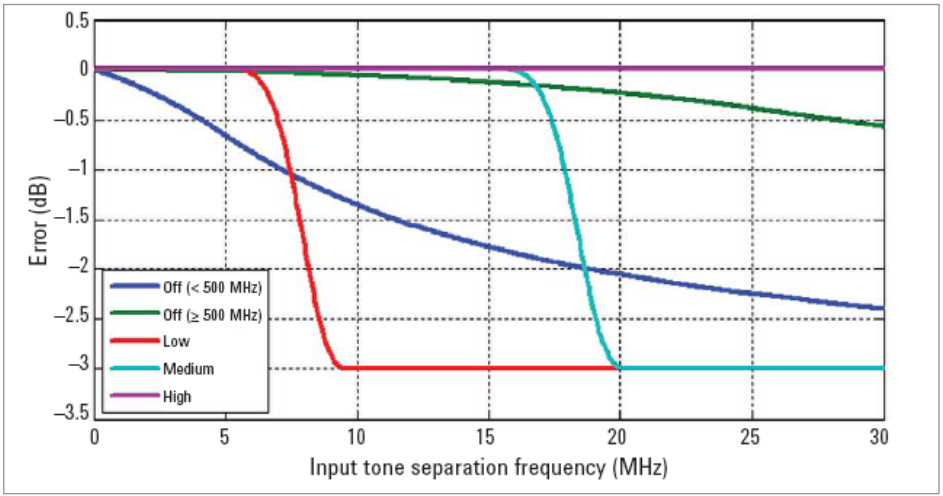


Figure 2. U2021XA/22XA error in peak-to-average measurements for a two-tone input (High, Medium, Low and Off Filters).

Noise and drift											
Mode	**Zeroing**	**Zero set**		**Zero drift 1**	**Noise per sample**		**Measurement noise**				
		< 500 MHz	≥ 500 MHz		< 500 MHz	≥ 500 MHz					
Normal	No RF on input	± 200 nW		*± 100 nW*	*± 3 µW*	*± 2.5 µW*	*± 100 nW [2] (Free run)*				
	RF present	*± 200 nW*	± 200 nW								
Average only	No RF on input	± 10 nW		*± 6 nW*	*± 3 µW*	*± 2.5 µW*	*± 4 nW [3]*				

Measurement average setting		**1**	**2**	**4**	**8**	**16**	**32**	**64**	**128**	**256**	**512**	**1024**
Normal mode	Free run noise multiplier	*1.00*	*0.9*	*0.8*	*0.7*	*0.6*	*0.5*	*0.45*	*0.4*	*0.3*	*0.25*	*0.2*
Average only	NORMal speed noise multiplier	*4.25*	*2.84*	*2.15*	*1.52*	*1.00*	*0.78*	*0.71*	*0.52*	*0.5*	*0.47*	*0.42*
	DOUBle speed noise multiplier	*5.88*	*4.00*	*2.93*	*1.89*	*1.56*	*1.00*	*0.73*	*0.55*	*0.52*	*0.48*	*0.44*

Video bandwidth setting			**Low: 5 MHz**	**Medium: 15 MHz**	**High: 30 MHz**	**Off**
	Noise per sample multiplier	< 500 MHz	*0.6*	*1.3*	*2.7*	*1.00*
		≥ 500 MHz	*0.55*	*0.65*	*0.8*	*1.00*

For average only mode with aperture size of ≥ 12 ms and averaging set to 1, the measurement noise is calculated as follows:

- Measurement noise = 120/√(aperture size in ms) nW.
- For average only mode with aperture size of < 12 ms and averaging set to 1, the measurement noise is equal to 50 nW.
- For example, if the aperture size is 50 ms and averaging set to 1, Measurement noise = 120/√(50) nW = 17 n.

1. Within 1 hour after zeroing, at a constant temperature, after a 24-hour warm-up of the U2020 X-Series. This component can be disregarded with the auto-zeroing mode set to ON.
2. Measured over a 1-minute interval, at NORMal speed, at a constant temperature, two standard deviations, with averaging set to 1.
3. Tested with averaging set to 16 at NORMal speed and 32 at DOUBLE speed.

Effect of Video Bandwidth Setting

The noise per sample is reduced by applying the video bandwidth filter setting (High, Medium, or Low). If averaging is implemented, this will dominate any effect of changing the video bandwidth.

Effect of Time-Gating on Measurement Noise

The measurement noise for a gated average measurement is calculated from the noise per sample specification. The noise for any particular gate is equal to $N_{sample}/\sqrt{}$(gate length/12.5 ns). The improvement in noise limits at the measurement noise specification of 100 nW.

Maximum SWR

Frequency band	U2021XA	U2022XA
50 MHz to 10 GHz	1.2	1.2
> 10 GHz to 18 GHz	1.26	1.26
> 18 GHz to 26.5 GHz		1.3
> 26.5 GHz to 40 GHz		1.5
> 40 GHz to 50 GHz		1.7

Calibration Uncertainty

Definition: Uncertainty resulting from non-linearity in the U2021XA/22XA detection and correction process. This can be considered as a combination of traditional linearity, calibration factor and temperature specifications and the uncertainty associated with the internal calibration process.

Frequency band	U2021XA	U2022XA
50 MHz to 500 MHz	4.2%	4.3%
> 500 MHz to 1 GHz	4.0%	4.2%
> 1 GHz to 10 GHz	4.0%	4.5%
> 10 GHz to 18 GHz	4.5%	4.5%
> 18 GHz to 26.5 GHz		5.3%
> 26.5 GHz to 40 GHz		5.8%
> 40 GHz to 47 GHz (up to +8 dBm only)		7%
> 47 GHz to 50 GHz (up to +8 dBm only)		8%

Note. For power range +8 dBm to +20 dBm within the frequency range of > 40 GHz to 50 GHz, the typical power measurement error is up to 10% at room temperature (23 °C ± 3 °C).

Timebase and Trigger Specifications

Timebase	
Range	*2 ns to 100 ms/div*
Accuracy	*± 25 ppm*
Jitter	*≤ 1 ns*
Trigger	
Internal trigger	
Range	*–20 to 20 dBm*
Resolution	*0.1 dB*
Level accuracy	*± 0.5 dB*
Latency [1]	*300 ns ± 12.5 ns*
Jitter	*≤ 5 ns RMS*
External TTL trigger input	
High	*> 2.4 V*
Low	*< 0.7 V*
Latency [2]	*212.5 ns ± 12.5 ns*
Minimum trigger pulse width	*15 ns*
Minimum trigger repetition period	*50 ns*
Maximum trigger voltage input	*5 V EMF from 50 Ω DC (current < 100 mA), or*
	5 V EMF from 50 Ω (pulse width < 1 s, current < 100 mA)
Impedance	*50 Ω, 100 kΩ (default)*
Jitter	*≤ 0.5 ns RMS*
External TTL trigger output	**Low to high transition on trigger event**
High	*> 2.4 V*
Low	*< 0.7 V*
Latency [3]	*50 ns ± 12.5 ns*
Impedance	*50 Ω*
Jitter	*≤ 5 ns RMS*
Trigger delay	
Range	*± 1.0 s, maximum*
Resolution	*1% of delay setting, 12.5 ns minimum*
Trigger holdoff	
Range	*1 µs to 400 ms*
Resolution	*1% of selected value (to a minimum of 12.5 ns)*
Trigger level threshold hysteresis	
Range	*± 3 dB*
Resolution	*0.05 dB*

1. Internal trigger latency is defined as the delay between the applied RF crossing the trigger level and the U2021XA/22XA switching into the triggered state.
2. External trigger latency is defined as the delay between the applied trigger crossing the trigger level and the U2021XA/22XA switching into the triggered state.
3. External trigger output latency is defined as the delay between the U2021XA/22XA entering the triggered state and the output signal switching.

General Specifications

Inputs/Outputs	
Current requirement	450 mA max (approximately)
Recorder output	Analog 0 to 1 V, 1 kΩ output impedance, SMB connector
Video output	0 to 1 V, 50 Ω output impedance, SMB connector
Trigger input	Input has TTL compatible logic levels and uses a SMB connector
Trigger output	Output provides TTL compatible logic levels and uses a SMB connector
Remote programming	
Interface	USB 2.0 interface USB-TMC compliance
Command language	SCPI standard interface commands, IVI-COM, IVI-C driver and LabVIEW drivers
Maximum measurement speed	
Free run trigger measurement	*25,000 readings per second* [1]
External trigger time-gated measurement	*20,000 readings per second* [2]

1. Tested under normal mode and fast mode, with buffer mode trigger count of 100, output in binary format, unit in watt, auto-zeroing, auto-calibration, and step detect disabled.
2. Tested under normal mode and fast mode, with buffer mode trigger count of 100, pulsed signal with PRF of 20 kHz, and pulse width at 15 µs.

General Characteristics

Environmental compliance	
Temperature	Operating condition: –0 to 55 °C
	Storage condition:–40 to 70 °C
Humidity	Operating condition: Maximum: 95% at 40 °C (non-condensing)
	Storage condition: Up to 90% at 65°C (non-condensing)
Altitude	Operating condition: Up to 3000 m (9840 ft)
	Storage condition: Up to 15420 m (50000 ft)
Regulatory compliance	
The U2021XA/22XA USB peak power sensor complies with the following safety and EMC requirements:	IEC 61010-1:2001/EN 61010-1:2001 (2nd edition)
	IEC 61326:2002/EN 61326:1997 +A1:1998 +A2:2001 +A3:2003
	Canada: ICES-001:2004
	Australia/New Zealand: AS/NZS CISPR11:2004
	South Korea EMC (KC Mark) certification: RRA 2011-17
Dimensions (Length × Width × Height)	140 mm × 45 mm × 35 mm
Weight	Net weight: ≤ *0.25 kg*
	Shipping weight: *1.4 kg*
Connectivity	
USB 2.0, with the following cable lengths: (Selectable during sensor purchase)	Option 301: 1.5 m
	Option 302: 3 m
	Option 303: 5 m
Recommended calibration interval	1 year

Mechanical Characteristic

Mechanical characteristics such as center conductor protrusion and pin depth are not performance specifications. They are, however, important supplemental characteristics related to electrical performance. At no time should the pin depth of the connector be protruding.

Using the U2020 X-Series with the BenchVue Software

The U2020 X-Series is supported by Keysight BenchVue software's BV0007B Power Meter/Sensor Control and Analysis App. Keysight BenchVue software for the PC accelerates testing by providing intuitive, multiple instrument measurement visibility and data capture with no programming necessary. You can derive answers faster than ever by easily viewing, capturing and exporting measurement data and screen shots. Keysight BenchVue software license (BV0007B) is now included with your instrument.

For more information,
www.keysight.com/find/BenchVue

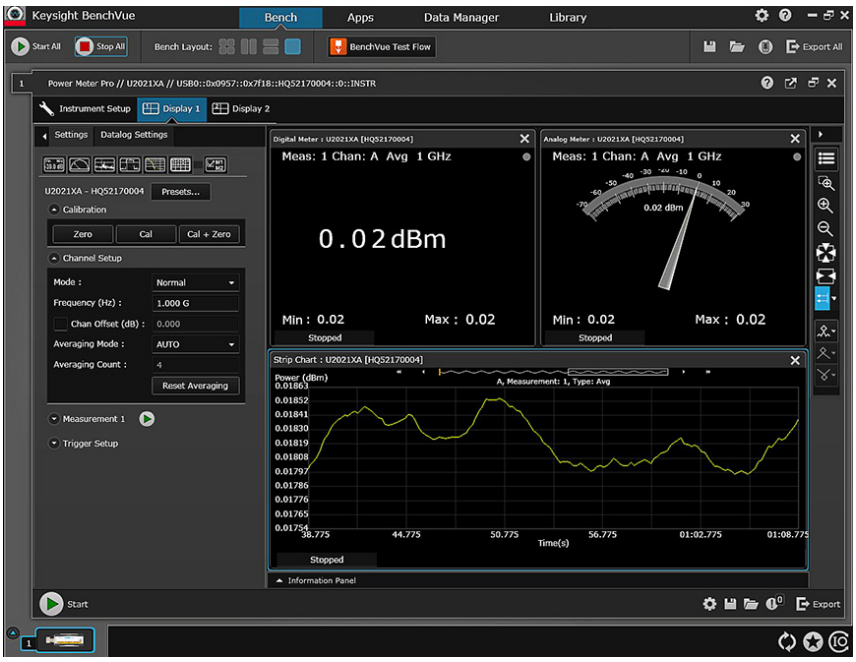


Figure 3. Digital meter, analog meter and datalog view.

BenchVue software's power meter/sensor control and analysis app

Supported functionality	
Measurement displays	Digital meter
	Analog meter
	Data log view
	Trace view (up to 4 channels or traces on one graph)
	Complementary cumulative distribution function (CCDF) view
	Multilist with ratio/delta function
	Compact mode display
Graph functions	Single marker (up to 5 markers per graph)
	Dual marker (up to 2 sets of markers per graph)
	Graph autoscaling
	Graph zooming
	Gate measurement analysis (up to 4-pair of gates)
Pulse characterization functions	17-point automatic pulse parameters characterization
Instrument settings	Save and recall instrument state including graph settings
	Instrument preset settings (DME, GSM, WCDMA, WLAN, LTE, etc.)
	FDO tables
	Gamma and S-parameters tables
	Full instrumentation control include frequency/average/trigger settings, zero and calibration, etc.
Limit and alert function	Sensors Limit and alert notification
	Alert summary
Export data or screen shots	Data logging (HDF5/MATLAB/Microsoft Excel/Microsoft Word/CSV)
	Save screen capture (PNG/JPEG/BMP)

System and Installation Requirements

PC operating system	
Windows 10, 8 and 7	Windows 10 32-bit and 64-bit (Professional, Enterprise, Education, Home versions)
	Windows 8 32-bit and 64-bit (Core, Professional, Enterprise)
	Windows 7 SP1 and later 32-bit and 64-bit (Professional, Enterprise, Ultimate)
Computer hardware	Professor: 1 GHz or faster (2 GHz or greater recommended)
	RAM: 1 GB (32-bit) or 2 GB (64-bit) (3 GB or greater recommended)
Windows XP SP3 32-bit (Professional)	Processor: 600 MHz or faster (1 GHz or greater recommended)
	RAM: 1 GB (2 GB or greater recommended)
Interfaces	USB, GPIB, LAN, RS-232
Display resolution	1024 x 768 minimum for single instrument view (higher resolutions are recommended for multiple instrument view)

Additional requirements

Software: BenchVue requires a VISA (Keysight or National Instruments) when used to connect to physical instruments. Keysight IO Libraries, which contains the necessary VISA, will be installed automatically when BenchVue is installed. IO Libraries information is available at: www.keysight.com/find/iosuite

Ordering Information

Model	Description
U2021XA	X-Series USB peak and average power sensor, 50 MHz to 18 GHz
U2022XA	X-Series USB peak and average power sensor, 50 MHz to 40 GHz
U2022XA-H50	X-Series USB peak and average power sensor, 50 MHz to 50 GHz

Standard shipped Items

- Power sensor cable 5 ft (1.5 m), default cable length
- BNC male to SMB female trigger cable, 50 Ω, 1.5 m (Quantity: 2)
- Certificate of calibration

Options	Description
Accessories	
U2000A-201	Transit case
U2000A-202	Soft carrying case
U2000A-203	Holster
U2000A-204	Soft carrying pouch
Cables (selectable during sensor purchase)	
U2000A-301	Power sensor cable, 5 ft (1.5 m)
U2000A-302	Power sensor cable, 10 ft (3 m)
U2000A-303	Power sensor cable, 16.4 ft (5 m)
Cables (ordered standalone)	
U2031A	Power sensor cable, 5 ft (1.5 m)
U2031B	Power sensor cable, 10 ft (3 m)
U2031C	Power sensor cable, 16.4 ft (5 m)
U2032A	BNC male to SMB female trigger cable, 50 Ω , 1.5 m
Documentation	
Option OB1	English language operating and service guide
Option OBF	English language programming guide
Option OBN	English language service guide
Option ABJ	Japanese language operating and service guide
U2021XA-CD1	Documentation optical disk (consists of documentation CD-ROM and Keysight instruments control DVD)
Software	
BV0007B	BenchVue Power Meter/Sensor Control and Analysis app license
Calibration	
UK6	Commercial calibration with test data
A6J[1]	ANSI Z540 compliant calibration and test data
1A7[1]	ISO 17025 compliant calibration and test data

1. Not available for Option H50.

Worked Example

Uncertainty calculations for a power measurement (settled, average power)
(Specification values from this document are in ***bold italic***, values calculated on this page are underlined.)

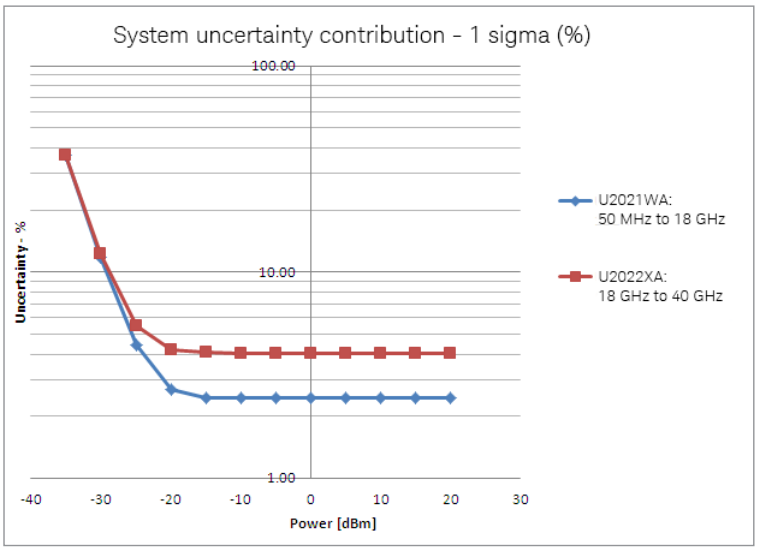
Process

1.	Power level	*1 mW*
2.	Frequency	*1 GHz*
3.	Calculate sensor uncertainty:	
	In Free Run, auto zero mode average = 16	
	Calculate noise contribution	
	– If in Free Run mode, Noise = Measurement noise x free run multiplier = 100 nW x 0.6 = 60 nW	
	– If in Trigger mode, Noise = Noise-per-sample x noise per sample multiplier	
	Convert noise contribution to a relative term 1 = Noise/Power = 60 nW/100 µW	*0.06%*
	Convert zero drift to relative term = Drift/Power = ***100 nW/1 mW***	*0.01%*
	RSS of above terms =	*0.061%*
4.	Zero uncertainty	
	(Mode and frequency dependent) = Zero set/Power = ***200 nW/1 mW***	*0.02%*
5.	Sensor calibration uncertainty	
	(Sensor, frequency, power and temperature dependent) =	*4.0%*
6.	System contribution, coverage factor of 2 ≥ sys_{rss} =	*4.0%*
	(RSS three terms from steps 3, 4 and 5)	
7.	Standard uncertainty of mismatch	
	Max SWR (frequency dependent) =	*1.20*
	Convert to reflection coefficient, $\lvert \rho_{Sensor} \rvert$ = (SWR–1)/(SWR+1) =	*0.091*
	Max DUT SWR (frequency dependent) =	*1.26*
	Convert to reflection coefficient, $\lvert \rho_{DUT} \rvert$ = (SWR–1)/(SWR+1) =	*0.115*
8.	Combined measurement uncertainty @ k=1	
	$U_C = \sqrt{\left(\frac{Max(\rho_{DUT}) \cdot Max(\rho_{Sensor})}{\sqrt{2}}\right)^2 + \left(\frac{sys_{rss}}{2}\right)^2}$	*2.13%*
	Expanded uncertainty, k = 2, = UC · 2 =	*4.27%*

1. The noise to power ratio is capped for powers > 100 µW, in these cases use: Noise/100 µW.

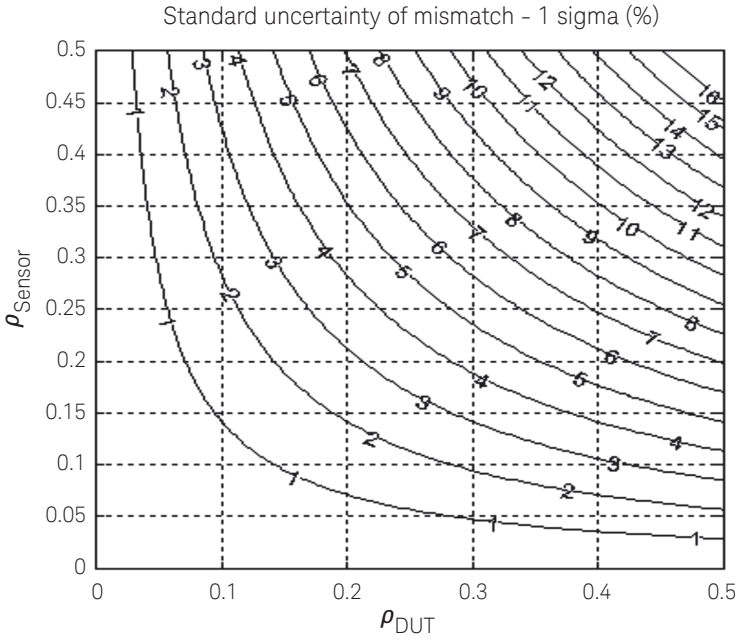
Graphical Example

A. System contribution to measurement uncertainty versus power level (equates to step 6 result/2)



Note. The above graph is valid for conditions of free-run operation, with a signal within the video bandwidth setting on the system. Humidity < 70 %.

B. Standard uncertainty of mismatch



SWR	ρ	SWR	ρ
1.0	0.00	1.8	0.29
1.05	0.02	1.90	0.31
1.10	0.05	2.00	0.33
1.15	0.07	2.10	0.35
1.20	0.09	2.20	0.38
1.25	0.11	2.30	0.39
1.30	0.13	2.40	0.41
1.35	0.15	2.50	0.43
1.40	0.17	2.60	0.44
1.45	0.18	2.70	0.46
1.5	0.20	2.80	0.47
1.6	0.23	2.90	0.49
1.7	0.26	3.00	0.50

Note. The above graph shows the Standard Uncertainty of Mismatch = $\rho_{DUT} \cdot \rho_{Sensor} / \sqrt{2}$, rather than the Mismatch Uncertainty Limits. This term assumes that both the Source and Load have uniform magnitude and uniform phase probability distributions.

C. Combine A and B

$U_C = \sqrt{(\textit{Value from Graph A})^2 + (\textit{Value from Graph B})^2}$

Expanded uncertainty, k = 2, = $U_C \cdot 2$ = ... ± %

Appendix A

Uncertainty calculations for a power measurement (settled, average power)
(Specification values from this document are in ***bold italic***, values calculated on this page are underlined.)

Process

1.	Power level	W
2.	Frequency	
3.	Calculate sensor uncertainty:	
	Calculate noise contribution	
	– If in Free Run mode, Noise = Measurement noise x free run multiplier	
	– If in Trigger mode, Noise = Noise-per-sample x noise per sample multiplier	
	Convert noise contribution to a relative term 1 = Noise/Power =	%
	Convert zero drift to relative term = Drift/Power =	%
	RSS of above terms =	%
4.	Zero uncertainty	
	(Mode and frequency dependent) = Zero set/Power =	%
5.	Sensor calibration uncertainty	
	(Sensor, frequency, power and temperature dependent) =	%
6.	System contribution, coverage factor of 2 ≥ sys_{rss} =	%
	(RSS three terms from steps 3, 4 and 5)	
7.	Standard uncertainty of mismatch	
	Max SWR (frequency dependent) =	
	Convert to reflection coefficient, $\lvert \rho_{Sensor} \rvert$ = (SWR–1)/(SWR+1) =	
	Max DUT SWR (frequency dependent) =	
	Convert to reflection coefficient, $\lvert \rho_{DUT} \rvert$ = (SWR–1)/(SWR+1) =	
8.	Combined measurement uncertainty @ k = 1	
	$U_C = \sqrt{\left(\frac{Max(\rho_{DUT}) \cdot Max(\rho_{Sensor})}{\sqrt{2}}\right)^2 + \left(\frac{sys_{rss}}{2}\right)^2}$	%
	Expanded uncertainty, k = 2, = UC · 2 =	%

1. The noise to power ratio for average only mode is capped at 0.01% for MU calculation purposes.

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