DATA SHEET

U2049XA (Option TVA) and U/L2050/60 X-Series USB/LAN Wide Dynamic Range Peak and Average Power

Accurately measure most modulated signal with Keysight U2049XA (Option TVA) and U/L2050/60 X-Series USB/LAN wide dynamic range peak and average power sensors. The X-Series power sensors come with widest dynamic range covering a range of -70 to +26 dBm. The U2049XA (Option TVA) and L2065/66/67XT TVAC LAN power sensors are thermal vacuum qualified, you can get the same accuracy and performance even in thermal vacuum chambers.

X-Series Power Sensors Comparison Table

USB model	LAN model	Description	Frequency range	Power range	Connector type
U2051XA	L2051XA	Wide dynamic range average power sensor	10 MHz to 6 GHz	−70 to +26 dBm	N-type (male)
U2061XA	L2061XA	Wide dynamic range peak and average power sensor			
U2052XA	L2052XA	Wide dynamic range average power sensor	10 MHz to 18 GHz	−70 to +26 dBm	
U2062XA	L2062XA	Wide dynamic range peak and average power sensor			
U2053XA	L2053XA	Wide dynamic range average power sensor	10 MHz to 33 GHz	−70 to +26 dBm	3.5 mm (male)
U2063XA	L2063XA	Wide dynamic range peak and average power sensor			
-	U2049XA	Wide dynamic range peak and average power sensor	10 MHz to 33 GHz	−70 to +20 dBm	
U2054XA	L2054XA	Wide dynamic range average power sensor	10 MHz to 40 GHz	−70 to +20 dBm	2.92 mm (male)
U2064XA	L2064XA	Wide dynamic range peak and average power sensor			
U2055XA	L2055XA	Wide dynamic range average power sensor	10 MHz to 50 GHz 10 MHz to 53 GHz (Option 053)	−70 to +20 dBm (10 MHz to 50 GHz) −70 to 0 dBm (> 50 GHz to 53 GHz)[1]	2.4 mm (male)
U2065XA	L2065XA	Wide dynamic range peak and average power sensor			
U2056XA	L2056XA	Wide dynamic range average power sensor	10 MHz to 54 GHz	−70 to +20 dBm (10 MHz to 50 GHz) −70 to +15 dBm (> 50 GHz to 54 GHz)	1.85 mm (male)
U2066XA	L2066XA	Wide dynamic range peak and average power sensor			
U2057XA	L2057XA	Wide dynamic range average power sensor	10 MHz to 67 GHz	−70 to +20 dBm (10 MHz to 50 GHz) −70 to +15 dBm (> 50 GHz to 54 GHz) −70 to +10 dBm (> 54 GHz to 67 GHz	
U2067XA	L2067XA	Wide dynamic range peak and average power sensor			
Thermal Vacuum Compliance Power Sensor					
-	U2049XA (Option TVA)	Wide dynamic range peak and average power sensor with thermal vacuum option	10 MHz to 33 GHz	−70 to +20 dBm	3.5 mm (male)
-	L2065XT	Wide dynamic range peak and average power sensor with thermal vacuum compliance	10 MHz to 53 GHz	−70 to +20 dBm (10 MHz to 50 GHz) −70 to 0 dBm (> 50 GHz to 53 GHz)	2.4 mm (male)
-	L2066XT	Wide dynamic range peak and average power sensor with thermal vacuum compliance	10 MHz to 54 GHz	−70 to +20 dBm (10 MHz to 50 GHz) −70 to +15 dBm (> 50 GHz to 54 GHz)	1.85 mm (male)
-	L2067XT	Wide dynamic range peak and average power sensor with thermal vacuum compliance	10 MHz to 67 GHz	−70 to +20 dBm (10 MHz to 50 GHz) −70 to +15 dBm (> 50 GHz to 54 GHz) −70 to +10 dBm (> 54 GHz to 67 GHz)	

1. Applicable for Option 053 only.

X-Series Power Sensors Selection Guide

Measurement types	X-Series USB/LAN Wide Dynamic Range Average Power Sensors	X-Series USB/LAN Wide Dynamic Range Peak and Average Power Sensors (With 5MHz Video Bandwidth, VBW)
	U/L2051/52/53/54/55/56/57XA	U2049XA (Option TVA), U/L2061/62/63/64/65/66/67XA and L2065/66/67XT
CW power	Yes	
Wideband average power (Example: 100 MHz bandwidth)		
Time selectivity in average mode		
Time gated average power	No	Yes
Pulse profiling (Power vs time display)		
Peak power or peak-to-average power < 5 MHz bandwidth		
Pulse parameter analysis ≥ 100 ns rise time (Example: rise/fall time, duty cycle, pulse width, etc.)		

X-Series Power Sensors Key Features

Widest dynamic range power sensors

The X-Series power sensors are power sensors with the widest dynamic range of 96 dB (–70 dBm to +26 dBm). The 96 dB dynamic range enables accurate power measurements of very low signal levels for a broad range of applications such as wireless chipset, power amplifier and module manufacturing, satellite payload testing, test system or instrument calibration, and radar pulse parameter measurements. The X-Series power sensors are available with average only and peak and average feature sets, supporting frequency ranges to 67GHz. The average only versions have extensive features to help optimize the average power measurements, while the peak and average models add gated power measurements and pulse analysis.

Super-fast measurement speed

The X-Series power sensors takes up to 50,000 super-fast readings per second (in fast/buffer mode/ average mode), a ten times improvement over Keysight's previous sensor offerings, allowing test engineers to increase test throughput capacity and reduce cost of test especially in high volume manufacturing environments such as mobile chipset manufacturing.

This measurement speed is fast enough to measure every continuous pulse without leaving time gaps in between measurement acquisitions. While conventional sensors only provide a snapshot of continuous pulses, leaving dead time where a glitch could slip by unnoticed, the X-Series power sensors measures continuously in real time and keeps pace with very fast pulses, up to 10 kHz PRF. Users are also able to fully control which portion of the signal is measured and what throughput they can expect because the aperture duration precisely defines the maximum measurement speed as 1/aperture duration. For example, setting the aperture duration to 20 μs offers 20 μs of measurement time per reading, equaling a measurement speed of 50,000 readings per second.

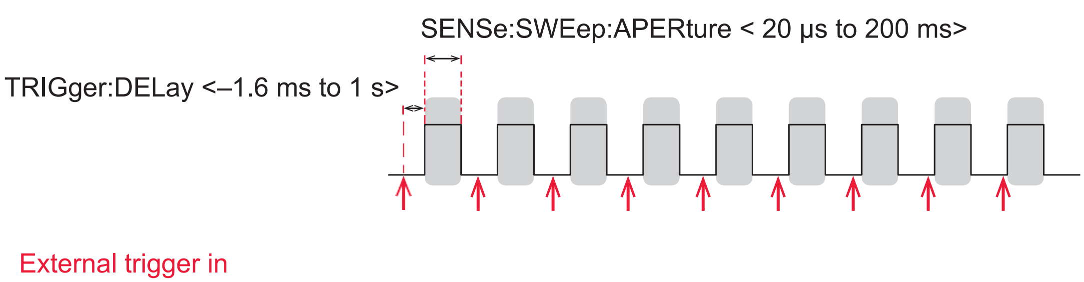


Figure 1. The X-Series power sensors offer real time measurement by measuring every consecutive pulse without dead time.

Broadband coverage for any modulated signal formats

The X-Series power sensors makes accurate average or time-selective average power measurements of any modulated signal, and covers all common wireless signals such as 5G, LTE, LTE-Advanced with 100 MHz bandwidth, and WLAN 802.11ac with 80/160 MHz bandwidth. A 4-path diode stack design with parallel data acquisition paths offers seamless range transition with high accuracy and repeatability. This design enables all the diodes to operate in their square law region, allowing the X-Series power sensors to function like thermocouple power sensors to provide accurate average power for broadband modulated signals.

Time selectivity in average mode with variable aperture duration

The X-Series power sensors offer a new feature called average mode time selectivity, whereby users can configure the aperture duration of measurement capture with reference to immediate trigger, external trigger, and internal trigger. The aperture duration can be set from 20 μs to 200 ms with a resolution of 100 ns, a resolution low enough to cover any radio format.

This new feature enables precise control of what portion of the signal waveform is measured in a similar manner to time-gated measurements in peak power sensors. The key benefit of this feature is that it enables the sensor to measure average power with time selectivity across the full dynamic range and provides real time measurements up to 50000 readings per second. This is a significant improvement when compared to conventional power sensors; a conventional sensor's time gated power dynamic ranges are typically clipped at around 50 dB with maximum speed of 1000 readings per second.

Internal zero and calibration

Save time and reduce measurement uncertainty with the internal zero and calibration function. Each X-Series power sensors comes with technology that integrates a DC reference source and switching circuits into the body of the sensor so you can 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.

This internal zero and calibration function allows continuous long distance and remote measurements by maintaining the accuracy of the sensor and is useful in manufacturing and automated test environments where each second and each connection counts.

Built-in trigger in and out

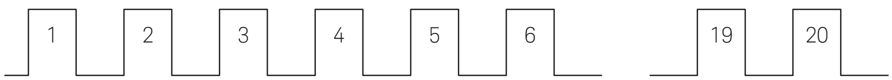
An external trigger enables accurate triggering of low-level signals close to the sensor's noise floor. The X-Series power sensors come with built-in trigger in/out connection, allowing you to connect an external trigger signal from a signal source or the device-under-test to achieve precise triggering timing. Once the trigger output is enabled, a TTL trigger output signal will be generated on every triggered measurement. The built-in trigger in and out is particularly useful when users need to synchronize the measurement acquisition of a series of daisy-chain power sensors.

Figure 2. The external trigger input and output ports on the X-Series power sensors.

20 automatic pulse parameter measurements

The U2049XA (Option TVA), U/L2060 X-Series and L2065/66/67XT peak and average power sensors offer simultaneous pulse parameter characterization of up to 20 pulses within a single capture. Individual pulse duration, period, duty cycle, rise time, fall time and other pulse parameters can be queried through the following SCPI codes: TRACe:MEASurement:PULSe[1-20], and TRACe:MEASurement:TRANsition[1-20].

Together with a system's rise time and fall time of 100 ns and video bandwidth of 5 MHz, the X-Series peak and average power sensors enable a minimum measurable pulse width of 250 ns with its sampling interval of 50 ns. Users can quickly and accurately measure the output power and pulse parameters of pulses for radar pulse component design or manufacturing.



Pulse parameter	SCPI command
Duty cycle	TRAC:MEAS:PULS[1-20]:DCYC?
Pulse duration	TRAC:MEAS:PULS[1-20]:DUR?
Pulse period	TRAC:MEAS:PULS[1-20]:PER?
Pulse separation	TRAC:MEAS:PULS[1-20]:SEP?
Negative transition duration (fall time)	TRAC:MEAS:TRAN[1-20]:NEG:DUR?
Occurrence of a negative transition relative to trigger instant	TRAC:MEAS:TRAN[1-20]:NEG:OCC?
Positive transition duration (rise time)	TRAC:MEAS:TRAN[1-20]:POS:DUR?
Occurrence of a positive transition relative to trigger instant	TRAC:MEAS:TRAN[1-20]:POS:OCC?

Figure 3. The X-Series peak and average power sensors offer simultaneous analysis of up to 20 pulses within a single capture.

Auto burst detection

Auto burst detection helps the measurement setup of the trace of gate positions and sizes. This feature also helps set up 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 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.

Built-in radar and wireless presets

Begin testing faster; the X-Series power sensors come with built-in radar and wireless presets for common signals such as DME, GSM, EDGE, WCDMA, WLAN and LTE.

Gamma correction

In an ideal measurement scenario, the reference impedance of the power sensor and device-under-test (DUT) impedance should equal the reference impedance (Z0); 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, gamma.

Using the gamma correction function, users can simply input the DUT's gamma into the X-Series power sensors using SCPI commands or the Keysight BenchVue Power Meters/Sensors App. This will remove the mismatch error, yielding more accurate measurements.

S-parameter correction

Additional errors are often caused by components that are inserted between the DUT and the 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 or through the Keysight BenchVue Power Meters/Sensors App. This error can now be corrected using the X-Series power sensor's S-parameter correction function. The sensors will behave as though it is connected directly to the DUT, giving users highly accurate power measurements.

Compact and portable form factor

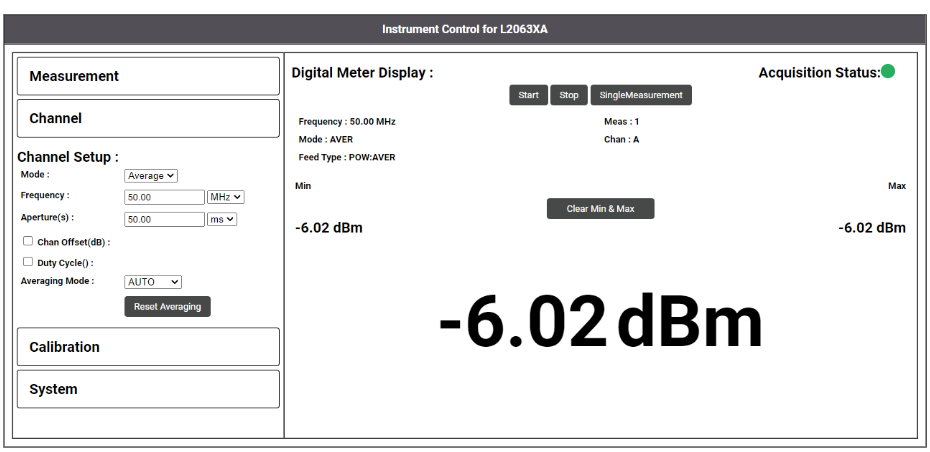
The X-Series power sensors are standalone sensors that operate without the need of a power meter or an external power supply. The sensors draw power from a USB/LAN port and do not need additional triggering modules to operate, making them portable and lightweight solutions for field applications such as base station testing. Simply plug the sensor to the USB port or LAN port (using Power over Ethernet, POE connectivity) of your PC or laptop with Keysight BenchVue Power Meters/Sensors (BV0007B) to start your power measurements.

Variable Sampling Rate 1M samples/sec and Long Memory 1M Samples Data Storage

The U/L206x X-series power sensors were specifically designed to meet the European Telecommunications Standard Institute (ETSI) power measurement requirement capturing 1 MHz sampling waveforms from the power sensor and requires at least 1 MB memory per second. The new U/L206x X-series power sensors come with a feature of adjustable sampling rate up to 1 Msa/s and long internal memory up to 1 MB. The variable sampling rate function allows you to slow down the measurement from the default 20 Ms/s to 1M Sa/s, and the internally can hold data up to 1 M data samples. Multi-channel synchronous power measurement can be extended and set up easily with multiple U/L206x X-Series power sensors and using external triggering time synchronization. The output data samples are stored and kept for offline power measurement analysis as specified by the standard.

LAN Power Sensors Web Interface

The L205x/6x X-Series LAN power sensors include a built-in Web Interface for monitoring and controlling the instrument via a Web browser. The LAN power sensors should be operated remotely from a PC using the web browser interface with the virtual front panel interface that looks and acts as the real front panel on the L205x/6x X-Series LAN power sensors.



U2049XA (Option TVA), L2050/60XA and L2065/66/67XT X-Series LAN Power Sensors

LAN/Power over ethernet connectivity

Overcome the cable length limitations associated with USB connectivity. With Power over Ethernet (PoE)/LAN connectivity, the LAN power sensors can perform remote monitoring over a single span of up to 100 meters. The PoE connectivity is also compliant to the IEEE 802.3af or 802.3at Type 1 standards.

Note that the typical LAN port found on a PC or Keysight instruments will not be able to power up the LAN power sensor. A typical LAN port is only used for data transfer and communication. The LAN power sensors must connect to a PoE port, which can be used to supply the DC power required to power up the sensor and to transfer data.

The Ideal Solution for Remote Monitoring of Satellite Systems

Get the same accuracy and performance in thermal vacuum (TVAC) chambers with the world's first TVAC qualified power sensor. With best-in-class long term drift performance, the LAN power sensors is ideal for fault detection and monitoring of satellite systems. And with LAN/power over Ethernet (PoE) connectivity, a first in the industry, you can perform long distance, remote monitoring of satellite systems with ease and confidence.

Thermal vacuum compliance

The U2049XA Option TVA (thermal vacuum option) and L2065/66/67XT are LAN TVAC compliant power sensors that can be used within a thermal vacuum chamber. These sensors have been meticulously designed by selecting components with minimum outgassing properties. Each of these sensors are also subject to temperature cycling in a vacuum chamber to stabilize the materials and to remove outgassing particles.

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. These characteristics are shown in italics.

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. These 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-ohm input Type-N connector’. In these examples, product weight is an ‘approximate’ value, and a 50-ohm input is ‘nominal’. These two terms are most widely used when describing a product’s ‘attribute’.

The second group describes ‘statistically’ the aggregate performance of the population of products. These characteristics describe 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’.

The power sensors 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 sensors are within its recommended calibration period, and
- Used in accordance with the information provided in the User’s Guide
- For power measurements below –60 dBm, it is recommended to turn on the power sensor for 1.5 hours (with the X-Series power sensors connected to the device-under-test)

Specifications

U/L2050 X-Series wide dynamic range average power sensors

	U/L2051/52XA	U/L2053XA	U/L2054XA	U/L2055XA	
Frequency range	U/L2051XA: 10 MHz to 6 GHz U/L2052XA: 10 MHz to 18 GHz	10 MHz to 33 GHz	10 MHz to 40 GHz	10 MHz to 50 GHz	10 MHz to 53 GHz (Option 053)
Average mode power range (Average only mode)	−70 to +26 dBm		−70 to +20 dBm	−70 to +20 dBm −70 to 0 dBm (> 50 GHz to 53 GHz) [3]	
Maximum power (Damage level)	Average: +29 dBm		Average: +26 dBm		
	Peak: +32 dBm for < 10 µs duration		Peak: +29 dBm for < 10 µs duration		
	Voltage: ≤ 10 VDC				
Zero and calibration	Internal zero and calibration supported				
Maximum sampling rate	*20 Msamples/second continuous sampling*				
Power linearity at 5 dB step [1]	*Average mode: < 1.0%*				
Basic accuracy of average power measurement [2]	*≤ ± 0.20 dB or ± 4.5% for < 30 MHz*	*≤ ± 0.20 dB or ± 4.6% for < 30 MHz*	*≤ ± 0.24 dB or ± 5.8% for < 30 MHz*	*≤ ± 0.23 dB or ± 5.5% for < 30 MHz*	*≤ ± 0.24 dB or ± 5.8% for < 30 MHz*
	≤ ± 0.18 dB or ± 4.0% for ≥ 30 MHz to ≤ 10 GHz	*≤ ± 0.22 dB or ± 5.0% for ≥ 30 MHz to ≤ 26.5 GHz*	*≤ ± 0.19 dB or ± 4.5% for ≥ 30 MHz to ≤ 26.5 GHz*	*≤ ± 0.20 dB or ± 4.6% for ≥ 30 MHz to ≤ 26.5 GHz*	*≤ ± 0.20 dB or ± 4.7% for ≥ 30 MHz to ≤ 26.5 GHz*
	≤ ± 0.18 dB or ± 4.1% for > 10 GHz to 18 GHz	*≤ ± 0.26 dB or ± 5.8% for > 26.5 GHz to ≤ 33 GHz*	*≤ ± 0.24 dB or ± 5.8% for > 26.5 GHz to ≤ 40 GHz*	*≤ ± 0.23 dB or ± 5.5% for > 26.5 GHz to ≤ 50 GHz*	*≤ ± 0.28 dB or ± 6.6% for > 26.5 GHz to ≤ 53 GHz*

	U/L2056XA	U/L2057XA
Frequency range	10 MHz to 54 GHz	10 MHz to 67 GHz
Average mode power range (Average only mode)	−70 to +20 dBm (10 MHz to 50 GHz) −70 to +15 dBm (> 50 GHz to 54 GHz)	−70 to +20 dBm (10 MHz to 50 GHz) −70 to +15 dBm (> 50 GHz to 54 GHz) −70 to +10 dBm (> 54 GHz to 67 GHz)
Maximum power (Damage level)	Average: +26 dBm	
	Peak: +29 dBm for < 10 µs duration	
	Voltage: ≤ 10 VDC	
Zero and calibration	Internal zero and calibration supported	
Maximum sampling rate	*20 Msamples/second continuous sampling*	
Power linearity at 5 dB step [1]	*Average mode: < 1.0%*	
Basic accuracy of average power measurement [2]	*≤ ±0.29 dB or ±6.9% for < 30 MHz*	*≤ ±0.29 dB or ±6.9% for < 30 MHz*
	≤ ±0.19 dB or ±4.4% for ≥ 30 MHz to ≤ 26.5 GHz	*≤ ±0.19 dB or ±4.4% for ≥ 30 MHz to ≤ 26.5 GHz*
	≤ ±0.21 dB or ±4.9% for > 26.5 GHz to ≤ 33 GHz	*≤ ±0.23 dB or ±5.4% for > 26.5 GHz to ≤ 40 GHz*
	≤ ±0.22 dB or ±5.1% for > 33 GHz to ≤ 40 GHz	*≤ ±0.23 dB or ±5.5% for > 40 GHz to ≤ 50 GHz*
	≤ ±0.24 dB or ±5.6% for > 40 GHz to ≤ 54 GHz	*≤ ±0.25 dB or ±5.9% for > 50 GHz to ≤ 67 GHz*

1. Any relative power measurement of up to 5 dB will have < 1% error, excluding zero set, zero drift and noise effects. With default aperture and averaging, for power levels above –50 dBm, zero set, zero drift and noise effects can be disregarded.
2. Valid across power range -45dBm to +26dBm for all power sensors with up to 33GHz frequency range (where the DUT max SWR is <1.2. For all other sensor's specification is valid over a power range of -45dBm to +20dBm where the DUT SWR is <1.2. For all models it is assumed the sensor operates with free run acquisition and averaging set to 32. Attention is drawn to Appendix A for the calculations required to understand the measurement uncertainty for conditions not covered in this definition.
3. Applicable for option 053.

U2049XA (Option TVA), U/L2060 X-Series and L2065/66/67XT wide dynamic range peak and average power sensors

	U2049XA (Option TVA)	U/L2061/62XA	U/L2063XA	U/L2064XA	U/L2065XA	U/L2065XA and L2065XT
Frequency range	10 MHz to 33 GHz	U/L2061XA: 10 MHz to 6 GHz U/L2062XA: 10 MHz to 18 GHz	10 MHz to 33 GHz	10 MHz to 40 GHz	10 MHz to 50 GHz	10 MHz to 53 GHz (Option 053)
Average mode power range (Average only mode)	–70 to +20 dBm	–70 to +26 dBm	–70 to +26 dBm	–70 to +20 dBm	−70 to +20 dBm −70 to 0 dBm (> 50 GHz to 53 GHz) [5]	
Maximum power (Damage level)	Average: +29 dBm			Average: +26 dBm		
	Peak: +32 dBm for < 10 μs duration			Peak: +29 dBm for < 10 μs duration		
	Voltage: ≤ 20 VDC	Voltage: ≤ 10 VDC				
Zero and calibration	Internal zero and calibration supported					
Maximum sampling rate	*20 Msamples/second continuous sampling*					
Power linearity at 5 dB step [1]	*Average mode: < 1.0%*					
	Normal mode: < 1.0%	*Normal mode: < 1.3%*				
Basic accuracy of average power measurement [2]	*≤ ± 0.30 dB or ± 6.6% for < 30 MHz*	*≤ ± 0.20 dB or ± 4.5% for < 30 MHz*	*≤ ± 0.20 dB or ± 4.6% for < 30 MHz*	*≤ ± 0.24 dB or ± 5.8% for < 30 MHz*	*≤ ± 0.23 dB or ± 5.5% for < 30 MHz*	*≤ ± 0.24 dB or ± 5.8% for < 30 MHz*
	≤ ± 0.23 dB or ± 5.2% for ≥ 30 MHz to ≤ 26.5 GHz	*≤ ± 0.18 or ± 4.0% for ≥ 30 MHz to ≤ 10 GHz*	*≤ ± 0.22 dB or ± 5.0% for ≥ 30 MHz to ≤ 26.5 GHz*	*≤ ± 0.19 dB or ± 4.5% for ≥ 30 MHz to ≤ 26.5 GHz*	*≤ ± 0.20 dB or ± 4.6% for ≥ 30 MHz to ≤ 26.5 GHz*	*≤ ± 0.20 dB or ± 4.7% for ≥ 30 MHz to ≤ 26.5 GHz*
	≤ ± 0.27 dB or ± 5.9% for > 26.5 GHz to ≤ 33 GHz	*≤ ± 0.18 dB or ± 4.1% for > 10 GHz to 18 GHz*	*≤ ± 0.26 dB or ± 5.8% for > 26.5 GHz to ≤ 33 GHz*	*≤ ± 0.24 dB or ± 5.6% for > 26.5 GHz to ≤ 40 GHz*	*≤ ± 0.23 dB or ± 5.5% for > 26.5 GHz to ≤ 50 GHz*	*≤ ± 0.28 dB or ± 6.6% for > 26.5 GHz to ≤ 53 GHz*
Normal mode power range (Peak mode)	*Off: –40 to +20 dBm*	*Off: –40 to +26 dBm*	*Off: –40 to +26 dBm*	*Off: –40 to +20 dBm*	*Off: –40 to +20 dBm*	*Off: –40 to +20 dBm* [6]
	High/5 MHz: –40 to +20 dBm	*High/5 MHz: –40 to +26 dBm*	*High/5 MHz: –40 to +26 dBm*	*High/5 MHz: –40 to +20 dBm*	*High/5 MHz: –40 to +20 dBm*	*High/5MHz: –40 to +20 dBm* [6]
	Medium/1.5 MHz: –45 to +20 dBm	*Medium/1.5 MHz: –45 to +26 dBm*	*Medium/1.5 MHz: –45 to +26 dBm*	*Medium/1.5 MHz: –45 to +20 dBm*	*Medium/1.5 MHz: –45 to +20 dBm*	*Medium/1.5 MHz: –45 to +20 dBm* [7]
	Low/300 kHz: –45 to +20 dBm	*Low/300 kHz: –45 to +26 dBm*	*Low/300 kHz: –45 to +26 dBm*	*Low/300 kHz: –45 to +20 dBm*	*Low/300 kHz: –45 to +20 dBm*	*Low/300 kHz: –45 to +20 dBm* [7]
Signal bandwidth	*VBW for peak power: ≤ 5 MHz* [4]					
	Wideband average power					
Single shot bandwidth	*5 MHz*					
Minimum pulse width	*250 ns*					
Rise/fall time [3]	≤ 100 ns					
Maximum capture length	*1 s (decimated)*					
	6.5 ms (at full sampling rate)					
Maximum pulse repetition rate	*2 MHz (based on 10 samples/period)*					

1. Any relative power measurement of up to 5 dB will have <1% error, excluding zero set, zero drift and noise effects. With default aperture and averaging, for power levels above –50 dBm, zero set, zero drift and noise effects can be disregarded.
2. Valid across power range -45dBm to +26dBm for all power sensors with up to 33GHz frequency range (except U2049XA Option TVA) where the DUT max SWR is <1.2. For all other sensor's specification is valid over a power range of -45dBm to +20dBm where the DUT SWR is <1.2. For all models it is assumed the sensor operates in average only mode, with free run acquisition and averaging set to 32. Attention is drawn to Appendix A for the calculations required to understand the measurement uncertainty for conditions not covered in this definition.
3. With video bandwidth OFF setting and carrier frequency ≥ 300 MHz.
4. 5 MHz video bandwidth is applicable for carrier frequency ≥ 300 MHz. For carrier frequency < 300 MHz, video bandwidth of LOW/MED is 90 kHz, video bandwidth of HIGH/OFF is 240 kHz. Refer to Characteristic peak flatness section for details.
5. Applicable for option 053.
6. Applicable for frequency ≤ 50 GHz only. –40 dBm to 0 dBm for frequency > 50 GHz.
7. Applicable for frequency ≤ 50 GHz only. –45 dBm to 0 dBm for frequency > 50 GHz.

	U/L2066XA and L2066XT	U/L2067XA and L2067XT
Frequency range	10 MHz to 54 GHz	10 MHz to 67 GHz
Average mode power range (Average only mode)	−70 to +20 dBm (10 MHz to 50 GHz) −70 to +15 dBm (> 50 GHz to 54 GHz)	−70 to +20 dBm (10 MHz to 50 GHz) −70 to +15 dBm (> 50 GHz to 54 GHz) −70 to +10 dBm (> 54 GHz to 67 GHz)
Maximum power (Damage level)	Average: +26 dBm	
	Peak: +29 dBm for < 10 μs duration	
	Voltage: ≤ 10 VDC	
Zero and calibration	Internal zero and calibration supported	
Maximum sampling rate	*20 Msamples/second continuous sampling*	
Power linearity at 5 dB step [1]	*Average mode: < 1.0%*	
	Normal mode: < 1.3%	
Basic accuracy of average power measurement [2]	*≤ ±0.29 dB or ±6.9% for < 30 MHz*	*≤ ±0.29 dB or ±6.9% for < 30 MHz*
	≤ ±0.19 dB or ±4.4% for ≥ 30 MHz to ≤ 26.5 GHz	*≤ ±0.19 dB or ±4.4% for ≥ 30 MHz to ≤ 26.5 GHz*
	≤ ±0.21 dB or ±4.9% for > 26.5 GHz to ≤ 33 GHz	*≤ ±0.23 dB or ±5.4% for > 26.5 GHz to ≤ 40 GHz*
	≤ ±0.22 dB or ±5.1% for > 33 GHz to ≤ 40 GHz	*≤ ±0.23 dB or ±5.5% for > 40 GHz to ≤ 50 GHz*
	≤ ±0.24 dB or ±5.6% for > 40 GHz to ≤ 54 GHz	*≤ ±0.25 dB or ±5.9% for > 50 GHz to ≤ 67 GHz*
Normal mode power range (Peak mode)	*Off: –40 to +20 dBm*	*Off: –40 to +20 dBm*
	High/5 MHz: –40 to +20 dBm	*High/5 MHz: –40 to +20 dBm*
	Medium/1.5 MHz: –45 to +20 dBm	*Medium/1.5 MHz: –45 to +20 dBm*
	Low/300 kHz: –45 to +20 dBm	*Low/300 kHz: –45 to +20 dBm*
Signal bandwidth	*VBW for peak power: ≤ 5 MHz [4]*	
	Wideband average power	
Single shot bandwidth	*5 MHz*	
Minimum pulse width	*250 ns*	
Rise/fall time [3]	*≤ 100 ns*	
Maximum capture length	*1 s (decimated)*	
	6.5 ms (at full sampling rate)	
Maximum pulse repetition rate	*2 MHz (based on 10 samples/period)*	

1. Any relative power measurement of up to 5 dB will have <1% error, excluding zero set, zero drift and noise effects. With default aperture and averaging, for power levels above –50 dBm, zero set, zero drift and noise effects can be disregarded.
2. Valid across power range -45dBm to +26dBm for all power sensors with up to 33GHz frequency range (except U2049XA Option TVA) where the DUT max SWR is <1.2. For all other sensor's specification is valid over a power range of -45dBm to +20dBm where the DUT SWR is <1.2. For all models it is assumed the sensor operates in average only mode, with free run acquisition and averaging set to 32. Attention is drawn to Appendix A for the calculations required to understand the measurement uncertainty for conditions not covered in this definition.
3. With video bandwidth OFF setting and carrier frequency ≥ 300 MHz.
4. 5 MHz video bandwidth is applicable for carrier frequency ≥ 300 MHz. For carrier frequency < 300 MHz, video bandwidth of LOW/MED is 90 kHz, video bandwidth of HIGH/OFF is 240 kHz. Refer to Characteristic peak flatness section for details.
5. Applicable for option 053.
6. Applicable for frequency ≤ 50 GHz only. –40 dBm to 0 dBm for frequency > 50 GHz.
7. Applicable for frequency ≤ 50 GHz only. –45 dBm to 0 dBm for frequency > 50 GHz.

Noise and drift

U2049XA (Option TVA) and L2065/66/67XT

Mode	VBW setting	Zero set [1]		Zero drift [2]	Measurement noise	Noise per sample
		External zero	Internal zero			
Normal	LOW/MED	± 16 nW	± 23 nW	*± 10 nW*	*± 10 nW* [3]	*± 0.15 μW*
	HIGH/OFF	± 50 nW	± 60 nW	*± 15 nW*	*± 32 nW* [3]	*± 0.8 μW*
Average	–	± 100 pW for < 300 MHz	± 1 nW	*± 25 pW*	*± 80 pW* [4]	—
		± 70 pW for >= 300 MHz				

1. After 1 hour of warm up and at a constant temperature.
2. After 1 hour of warm up and at a constant temperature, measurements taken over a period of 4 hours after zeroing. Drift is calculated based on the average difference of any two measurements 1 hour apart.
3. Noise defined for 1 average in free run mode.
4. Noise defined for 16 averages with 50 ms aperture.

U/L2050/60 X-Series

Mode	VBW setting	Zero set [1]		Zero drift [2]	Measurement noise	Noise per sample
		External zero	Internal zero			
Normal [3]	LOW/MED	± 12 nW	± 15 nW	*± 10 nW*	*± 10 nW* [4]	*± 0.15 μW*
	HIGH/OFF	± 27 nW	± 30 nW	*± 15 nW*	*± 32 nW* [4]	*± 0.8 μW*
Average	–	± 90 pW for < 300 MHz	± 1 nW	*± 25 pW*	*± 80 pW* [5]	—
		± 70 pW for >= 300 MHz				

1. After 1 hour of warm up and at a constant temperature.
2. After 1 hour of warm up and at a constant temperature, measurements taken over a period of 4 hours after zeroing. Drift is calculated based on the average difference of any two measurements 1 hour apart.
3. Only applicable to U/L2060 X-Series.
4. Noise defined for 1 average at free run mode.
5. Noise defined for 16 averages at 50 ms aperture.

Noise multipliers

The measurement noise for the X-Series power sensors are dependent on the measurement mode and the time for the measurement. In general, average only mode is lower noise than normal mode, and the longer a measurement takes the lower the noise is. We will define three measurement modes and how the noise can be adjusted.

Average-only mode

The measurement noise due to the X-Series power sensors are dependent on the measurement time. In general, the longer a measurement takes the lower the noise is. The measurement noise specification is defined for 16 averages with an aperture of 50 ms, or a total time of 800 ms. Noise will reduce or increase with the square root ratio of the measurement time to the specification measurement time. Thus, a noise multiplier factor can be derived for any combination of averaging and aperture:

$$N_{mult} = \sqrt{\frac{0.8}{N_{ave} \times t_a}}$$

Increasing measurement time will reduce noise at this rate until around 3 seconds. As the measurement time increases beyond 3.2 seconds the noise reduction exponent changes from 0.5 to 0.2.

$$N_{mult} = 0.89 \times \left(\frac{1}{N_{ave} \times t_a} \right)^{0.5}, \text{ for } N_{ave} \times t_a \leq 3.2$$

$$N_{mult} = 0.63 \times \left(\frac{1}{N_{ave} \times t_a} \right)^{0.2}, \text{ for } N_{ave} \times t_a \leq 3.2$$

$$Noise_{actual} = N_{mult} \times Noise_{spec}$$

Where $N_{ave} \stackrel{def}{=}$ is number of averages and $t_a \stackrel{def}{=}$ aperture in seconds.

Free-run normal mode

The measurement noise specification is defined for average of 1. Although the noise will reduce with increased averaging, it will not have a significant impact on the measurement uncertainty, and the figure of 32 nW (High/Off VBW) or 10 nW (Low/Med VBW) without any multiplier should be used in the uncertainty calculations. (Refer to the measurement noise in the noise and drift table above.)

Gated-average normal mode

The measurement noise on a time-gated average power measurement in normal mode will depend on the time gate length. 20 averages are carried out every 1 μs of gate length. The noise-per-sample contribution in this mode can be reduced by approximately $\sqrt{\frac{\text{gate length}}{\text{50 ns}}}$ to a limit of 32 nW. (Refer to the noise and drift table above for the noise-per-sample.)

Maximum SWR

	U2049XA (Option TVA)	
Frequency band	**−70 to < +15 dBm**	**+15 to +20 dBm**
10 MHz to 30 MHz	2.18	2.21
> 30 MHz to 50 MHz	1.35	1.37
> 50 MHz to 100 MHz	1.22	1.24
> 100 MHz to 11.5 GHz	1.17	1.21
> 11.5 GHz to 30 GHz	1.29	1.33
> 30 GHz to 33 GHz	1.33	1.36

	U/L2051/61XA		U/L2052/62XA	
Frequency band	**−70 to +15 dBm**	**+15 to +26 dBm**	**−70 to +15 dBm**	**+15 to +26 dBm**
10 MHz to 6 GHz	1.15	1.24	1.15	1.24
> 6 GHz to 18 GHz	—	—	1.26	1.30

	U/L2053/63XA	
Frequency band	**−70 to +15 dBm**	**> +15 to +26 dBm**
10 MHz to 6 GHz	1.16	1.24
> 6 GHz to 16 GHz	1.24	1.27
> 16 GHz to 26.5 GHz	1.33	1.40
> 26.5 GHz to 33 GHz	1.41	1.53

	U/L2054/64XA		U/L2055/65XA and L2065XT	
Frequency band	**−70 to +10 dBm**	**> +10 to +20 dBm**	**−70 to +10 dBm**	**> +10 to +20 dBm**
10 MHz to 30 MHz	1.60	1.60	1.60	1.60
> 30 MHz to 50 MHz	1.15	1.22	1.15	1.22
> 50 MHz to 300 MHz	1.13	1.21	1.13	1.21
> 300 MHz to 4 GHz	1.17	1.26	1.14	1.20
> 4 GHz to 8 GHz	1.21	1.22	1.16	1.20
> 8 GHz to 14 GHz	1.19	1.25	1.20	1.21
> 14 GHz to 26.5 GHz	1.28	1.31	1.29	1.29
> 26.5 GHz to 40 GHz	1.36	1.39	1.32	1.32
> 40 GHz to 48 GHz	–	–	1.40	1.40
> 48 GHz to 50 GHz	–	–	1.40	1.47
> 50 GHz to 53 GHz [1]	–	–	1.68	–

	U/L2056/66XA and L2066XT	U/L2057/67XA and L2067XT
Frequency band	**−70 to +20dBm**	**−70 to +20 dBm**
10 MHz to 30 MHz	2.22	2.22
> 30 MHz to 75 MHz	1.24	1.24
> 75 MHz to 2 GHz	1.19	1.19
> 2 GHz to 14 GHz	1.22	1.22
>14 GHz to 26.5 GHz	1.29	1.29
> 26.5 GHz to 40 GHz	1.31	1.31
> 40 GHz to 48 GHz	1.33	1.33
> 48 GHz to 54 GHz	1.37	1.37
> 54 GHz to 60 GHz	-	1.41
> 60 GHz to 67 GHz	-	1.63
> 67 GHz to 70 GHz [2]	-	2.23

1. Applicable for option 053 and power dynamic range −70 to 0 dBm only.
2. Typical specification only.

Calibration uncertainty

Definition: Relative expanded uncertainty resulting from non-linearity in the X-Series power sensors detection and correction processes. This can be considered as a combination of traditional linearity, calibration factor and temperature specifications and the uncertainty associated with the internal calibration process. See Appendix A for how to combine all uncertainty terms to provide the combined measurement uncertainty for power.

Power Accuracy Verification to be perform during periodic service to ensure the compliance of X-Series power sensors' calibration after a period of usage. Relative expanded uncertainty in following table shall be taken as sensor's calibration uncertainty if compliance is confirmed, refer to product service guide for detail.

Average mode, 0 to 55 °C (25 ± 5 °C where applicable)

Frequency band	0 to 55 °C (25 ± 5 °C)			
	U2049XA (Option TVA)	U/L2051/61XA	U/L2052/62XA	U/L2053/63XA
10 MHz to 30 MHz	4.5%	4.3% (3.2%)	4.3% (3.2%)	4.4%
> 30 MHz to 500 MHz	3.9%	3.5% (2.3%)	3.5% (2.3%)	3.9%
> 500 MHz to 1 GHz	3.8%	3.5% (2.3%)	3.5% (2.3%)	3.9%
> 1 GHz to 6 GHz	4.0%	3.5% (2.3%)	3.5% (2.3%)	3.9%
> 6 GHz to 10 GHz	4.0%	–	3.6% (2.8%)	4.0%
> 10 GHz to 18 GHz	4.2%	–	3.7% (3.0%)	4.2%
> 18 GHz to 26.5 GHz	4.9%	–	–	4.5%
> 26.5 GHz to 33 GHz	5.6%	–	–	5.1%

Frequency band	0 to 55 °C		
	U/L2054/64XA	U/L2055/65XA	U/L2055/65XA (Option 053) and L2065XT
10 MHz to 30 MHz	4.6%	4.6%	4.7%
> 30 MHz to 500 MHz	3.6%	3.6%	3.8%
> 500 MHz to 6 GHz	3.6%	3.6%	3.9%
> 6 GHz to 8 GHz	3.7%	3.7%	3.9%
> 8 GHz to 12 GHz	3.7%	3.7%	3.9%
> 12 GHz to 16 GHz	3.9%	3.9%	3.9%
> 16 GHz to 26.5 GHz	4.2%	4.2%	4.3%
> 26.5 GHz to 33 GHz	4.3%	4.3%	4.9%
> 33 GHz to 40 GHz	4.8%	4.8%	5.0%
> 40 GHz to 50 GHz	–	5.0%	5.6%
> 50 GHz to 53 GHz	–	–	5.8%

Frequency band	0 to 55 °C	
	U/L2056/66XA and L2066XT	U/L2057/67XA and L2067XT
10 MHz to 30 MHz	4.8%	4.8%
> 30 MHz to 500 MHz	3.2%	3.2%
> 500 MHz to 6 GHz	3.6%	3.6%
> 6 GHz to 12 GHz	3.6%	3.6%
> 12 GHz to 16 GHz	3.8%	3.8%
> 16 GHz to 26.5 GHz	4.0%	4.0%
> 26.5 GHz to 33 GHz	4.5%	4.5%
> 33 GHz to 40 GHz	4.7%	4.7%
> 40 GHz to 48 GHz	5.1%	5.1%
> 48 GHz to 54 GHz	5.1%	5.1%
> 54 GHz to 60 GHz	-	5.4%
> 60 GHz to 67 GHz	-	5.4%
> 67 GHz to 70 GHz [1]	-	*10.7%*

1. Typical specification only.

Normal mode, 0 to 55 °C (25 ± 5 °C where applicable)

Frequency band	0 to 55 °C (25 ± 5 °C)							
	VBW OFF/HIGH				VBW MED/LOW			
	U2049XA (Option TVA)	U/L2061XA	U/L2062XA	U/L2063XA	U2049XA (Option TVA)	U/L2061XA	U/L2062XA	U/L2063XA
10 MHz to 30 MHz	4.5%	4.3% (3.7%)	4.3% (3.7%)	4.4%	4.5%	4.5% (3.8%)	4.5% (3.8%)	4.3%
> 30 MHz to 500 MHz	4.1%	3.6% (2.8%)	3.6% (2.8%)	4.1%	3.9%	3.8% (2.8%)	3.8% (2.8%)	4.0%
> 500 MHz to 1 GHz	3.9%	3.6% (2.8%)	3.6% (2.8%)	4.1%	3.9%	3.8% (2.8%)	3.8% (2.8%)	4.0%
> 1 GHz to 6 GHz	4.0%	3.6% (2.8%)	3.6% (2.8%)	4.1%	4.0%	3.7% (2.9%)	3.7% (2.9%)	4.0%
> 6 GHz to 10 GHz	4.1%	–	3.6% (3.3%)	4.1%	4.1%	–	3.7% (3.3%)	4.1%
> 10 GHz to 18 GHz	4.3%	–	3.8% (3.4%)	4.3%	4.2%	–	3.8% (3.5%)	4.3%
> 18 GHz to 26.5 GHz	5.0%	–	–	4.6%	4.9%	–	–	4.5%
> 26.5 GHz to 33 GHz	5.7%	–	–	5.2%	5.6%	–	–	5.2%

Frequency band	0 to 55 °C					
	VBW OFF/HIGH			VBW MED/LOW		
	U/L2064XA	U/L2065XA	U/L2065XA (Option 053) and L2065XT	U/L2064XA	U/L2065XA	U/L2065XA (Option 053) and L2065XT
10 MHz to 30 MHz	4.7%	4.7%	4.6%	4.4%	4.4%	4.7%
> 30 MHz to 500 MHz	4.0%	4.0%	4.0%	3.5%	3.5%	3.9%
> 500 MHz to 6 GHz	4.0%	4.0%	4.0%	3.5%	3.5%	4.0%
> 6 GHz to 8 GHz	4.1%	4.1%	4.2%	3.7%	3.7%	4.0%
> 8 GHz to 12 GHz	4.1%	4.1%	4.2%	3.7%	3.7%	4.0%
> 12 GHz to 16 GHz	4.2%	4.2%	4.2%	3.8%	3.8%	4.4%
> 16 GHz to 26.5 GHz	4.6%	4.6%	4.5%	4.0%	4.0%	5.0%
> 26.5 GHz to 33 GHz	4.7%	4.7%	5.1%	4.2%	4.2%	5.0%
> 33 GHz to 40 GHz	5.3%	5.3%	5.1%	4.7%	4.7%	5.0%
> 40 GHz to 50 GHz	–	5.7%	5.8%	–	4.9%	5.6%
> 50 GHz to 53 GHz	–	–	5.9%	–	–	5.8%

Frequency band	0 to 55 °C			
	VBW OFF/HIGH		VBW MED/LOW	
	U/L2066XA and L2066XT	U/L2067XA and L2067XT	U/L2066XA and L2066XT	U/L2067XA and L2067XT
10 MHz to 30 MHz	5.0%	5.0%	4.5%	4.5%
> 30 MHz to 500 MHz	4.2%	4.2%	3.7%	3.7%
> 500 MHz to 6 GHz	4.2%	4.2%	3.9%	3.9%
> 6 GHz to 12 GHz	4.3%	4.3%	4.0%	4.0%
> 12 GHz to 16 GHz	4.6%	4.6%	4.4%	4.4%
> 16 GHz to 26.5 GHz	4.8%	4.8%	4.7%	4.7%
> 26.5 GHz to 33 GHz	5.1%	5.1%	4.8%	4.8%
> 33 GHz to 40 GHz	5.1%	5.1%	4.8%	4.8%
> 40 GHz to 48 GHz	5.8%	5.8%	5.2%	5.2%
> 48 GHz to 54 GHz	5.9%	5.9%	5.2%	5.2%
> 54 GHz to 60 GHz	-	6.0%	-	5.3%
> 60 GHz to 67 GHz	-	6.0%	-	5.3%
> 67 GHz to 70 GHz [1]	-	*11.2%*	-	*10.8%*

1. Typical specification only.

Timebase and Trigger Specifications

Model	U2049XA (Option TVA)	U/L2060 X-Series	L2065/66/67XT	U/L2050 X-Series
Timebase				
Range [3]	2 ns to 100 ms/div			
Accuracy	± 25 ppm	± 2.0 ppm[1]	± 25 ppm	
Jitter	≤ 1 ns			
Trigger				
Minimum internal trigger level (Normal Mode)	-25 dBm			
Resolution	0.1 dB			
Level accuracy	± 0.5 dB			
Latency	1.5 μs ± 50 ns	1.95 μs ± 50 ns [4]		
Jitter	≤ 5 ns rms			
Minimum internal trigger level (Average Mode) [5]	-37 dBm	-40 dBm	-37 dBm	-40 dBm
Resolution	0.1 dB			
Level accuracy	± 0.5 dB			
Latency	< 100 us			
Jitter	≤ 2*Aperture points			
External TTL trigger input				
High	> 2.4 V			
Low	< 0.7 V			
Latency	500 ns ± 50 ns	950 ns ± 50 ns	500 ns ± 50 ns	950 ns ± 50 ns
Minimum trigger pulse width	150 ns (average mode)			
	50 ns (normal mode)			
Minimum trigger period	300 ns (average mode)			
	100 ns (normal mode)			
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	100 kΩ (default), 50 Ω			
Jitter	≤ 15 ns rms			
External TTL trigger output				
High	> 2.4 V			
Low	< 0.7 V			
Latency	500 ns ± 50 ns	950 ns ± 50 ns	500 ns ± 50 ns	950 ns ± 50 ns
Impedance	50 Ω			
Jitter	≤ 15 ns rms			
Trigger delay				
Range	Normal mode: ± 1.0 s			
	Average only mode: -1.6 ms to +1 s			
Resolution	1% of delay setting, 50 ns minimum			
Trigger hold off (Normal Mode)				
Range	1 μs to 400 ms			
Resolution	1% of selected value (to a minimum of 50 ns)			
Trigger hold off (Average Mode)				
Range	1 μs to 400 ms			
Resolution	1% of selected value (to a minimum of 50 ns)			

Model	U2049XA (Option TVA)	U/L2060 X-Series	L2065/66/67XT	U/L2050 X-Series
Trigger level threshold hysteresis				
Range	*± 3 dB*			
Resolution	*0.05 dB*			

1. ± 2.0 ppm for first year. Typically, ± 2.7 ppm after first year.
2. For frequency range > 50 GHz to 53 GHz.
3. Applicable only when use with Benchvue PM App software.
4. Except L2065/66/67XT. L2065/66/67XT refer to U2049XA (Option TVA) Latency's specification.
5. Criteria for RF input signal when using AVER mode internal trigger's measurement feature to enable proper edge detection; for Aperture size <= 200us, rising/falling edge detection must have minimum 3 measurement points above and below the edge detection whereas for Aperture size > 200us, rising or falling edge detection must have minimum 1 measurement points with 400us time buffer above and below the edge detection. Measurement point time resolution is set by aperture time setting

General Specifications

Inputs/Outputs	
Current requirement	**U2050/60 X-Series:** compatible with USB 2.0 (<500 mA)
	U2049XA (Option TVA), L2050/60 X-Series and L2065/66/67XT: compatible with 802.3af and 802.3at type 1 (≤3 W)
Trigger input	Input has TTL compatible logic levels and uses an SMB connector
Trigger output	Output provides TTL compatible logic levels and uses an SMB connector
Remote programming	
Interface	**U2050/60 X-Series:** USB 2.0 interface USB-TMC compliant
	U2049XA (Option TVA), L2050/60 X-Series and L2065/66/67XT: 10/100 Mbps RJ-45 Power Over Ethernet port, transfers data and power on one single cable, 802.3af or 802.3 at Type 1 compliant
Command language	SCPI standard interface commands, IVI-COM, IVI-C drivers
Maximum measurement speed (Applicable for USB & LAN socket connectivity)	
Free run trigger measurement	*25,000 readings per second* [1]
External trigger time-gated measurement	*20,000 readings per second* [2]
Average mode real time measurement	*50,000 readings per second* [3]

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.
3. Tested under average only mode and fast mode, with buffer mode trigger count of 200, aperture duration of 20 µs, data format set to real, external trigger or immediate trigger setting. For LAN socket connectivity, network traffic might affect the measurement speed intermediately. Direct LAN connection to computer via PoE injector would provide the fastest measurement speed.

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.

General Specifications (continued)

Environmental compliance	
Temperature	**All models except U2049XA Option TVA and L2065/66/67XT:** – Operating condition: 0 to 55 °C – Storage condition: –40 to 70 °C
	For U2049XA Option TVA and L2065/66/67XT: – Operating Condition: 0 to 55 °C. This operating condition is applicable for both standard Atmospheric environment and thermal vacuum environment. – Storage condition: –40 to 100 °C (U2049XA Option TVA and L2065/66/67XT)
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 3,000 m (9,840 ft) Storage condition: Up to 15,420 m (50,000 ft)
Regulatory compliance	
The X-Series complies with the following safety and EMC requirements	IEC 61010-1:2001/EN61010-1:2001 (2nd edition) IEC 61326:2002/EN 61326:1997 + A1:1998 +A3:2003 Canada: ICES-001:2004 Australia/New Zealand: AS/NZS CISPR11:2004 Canada: ICES-001:2004 Australia/New Zealand: AS/NZS CISPR11:2004

Model	U2049XA (Option TVA)	U2051/52/ 61/62XA	L2051/52/ 61/62XA	U2053/ 63XA	L2053/ 63XA	U2054/55/ 64/65XA	L2054/55/ 64/65XA	L2065XT
Dimensions: Length x Width x Height (mm)	197 x 40 x 24	159 x 44 x 35	180 x 48 x 36	148 x 44 x 35	169 x 48 x 36	133 x 44 x 35	155 x 48 x 36	172 x 40 x 24
Net weight (kg)	≤ 0.37	≤ 0.3				≤ 0.24	≤ 0.26	≤ 0.26
Shipping weight (kg)	≤ 1.4	≤ 1.3				≤ 1.24	≤ 1.26	≤ 1.26
Recommended calibration interval	1 year							

Model	U2056/57/66/67XA	L2056/57/66/67XA	L2066/67XT
Dimensions: Length x Width x Height (mm)	133 x 44 x 34	154 x 48 x 34	180 x 40 x 24
Net weight (kg)	≤ 0.24	≤ 0.27	≤ 0.27
Shipping weight (kg)	≤ 1.24	≤ 1.27	≤ 1.27
Recommended calibration interval	1 year		

Additional Specifications for X-Series peak and average power sensors

Measured rise time percentage error versus signal-under-test rise time

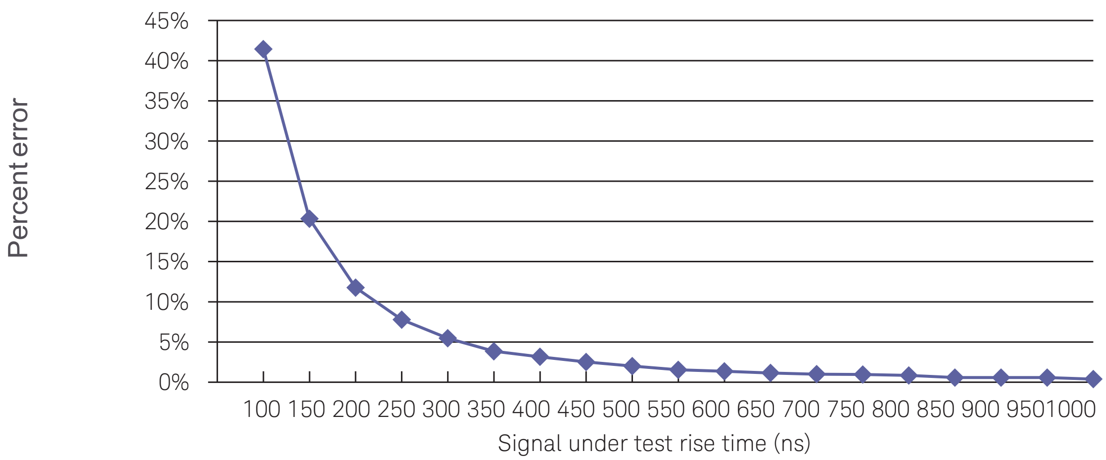


Figure 4. Measured rise time percentage error versus signal under test rise time.

Although the rise time specification is ≤ 100 ns, this does not mean that the X-Series peak and average power sensors can accurately measure a signal with a known rise time of 100 ns. The measured rise time is the root sum squares (RSS) of the signal-under-test (SUT) rise time and the system rise time:

$$\text{Measured rise time} = \sqrt{\left[(\text{SUT rise time})^2 + (\text{system rise time})^2\right]}$$

And the % error is:

$$\%\ \text{error} = \left[\frac{\text{measured rise time - SUT rise time}}{\text{SUT rise time}}\right] \times 100$$

Video bandwidth

The video bandwidth in the normal mode of the X-Series peak and average power sensors can be set to High (5 MHz), Medium (1.5 MHz), Low (300 kHz), 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 5 and Figure 6, "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

U2049XA (Option TVA) and L2065/66/67XT

Video bandwidth setting (normal mode)		LOW	MED	HIGH	OFF
Rise/fall time	< 300 MHz	*6.9 µs*	*6.9 µs*	*2.0 µs*	*2.0 µs*
	≥ 300 MHz	*0.6 µs*	*0.3 µs*	*0.1 µs*	0.1 µs
Overshoot [1]	< 300 MHz	*2%*	*2%*	*3%*	*4%*
	≥ 300 MHz	*12%*	*15%*	*9%*	*5%*

U/L2060 X-Series

Video bandwidth setting (normal mode)		LOW	MED	HIGH	OFF
Rise/fall time [2]	< 300 MHz	*5.3 µs*	*5.4 µs*	*1.8 µs*	*1.8 µs*
	≥ 300 MHz	*0.6 µs*	*0.64 µs*	*0.1 µs*	0.1 µs
Overshoot [1]	< 300 MHz	*2%*	*2%*	*3%*	*4%*
	≥ 300 MHz	*12%*	*15%*	*9%*	*5%*

The average mode of the X-Series peak and average power sensors provide accurate average power measurements for broadband modulated signals like a thermocouple sensors. This is due to the X-Series power sensors four path diode design, which enables all the diodes to operate in their square-law region.

1. Specification is based on pulse signal with ≥ 80 ns rise time.
2. Specification is based on pulse signal with 5 ns rise time.

Characteristic peak flatness

The peak flatness is the flatness of a peak-to-average ratio measurement for various tone separations of an equal two-tone RF input. Figure 5 and Figure 6 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 and applicable for carrier frequency ≥ 300 MHz.

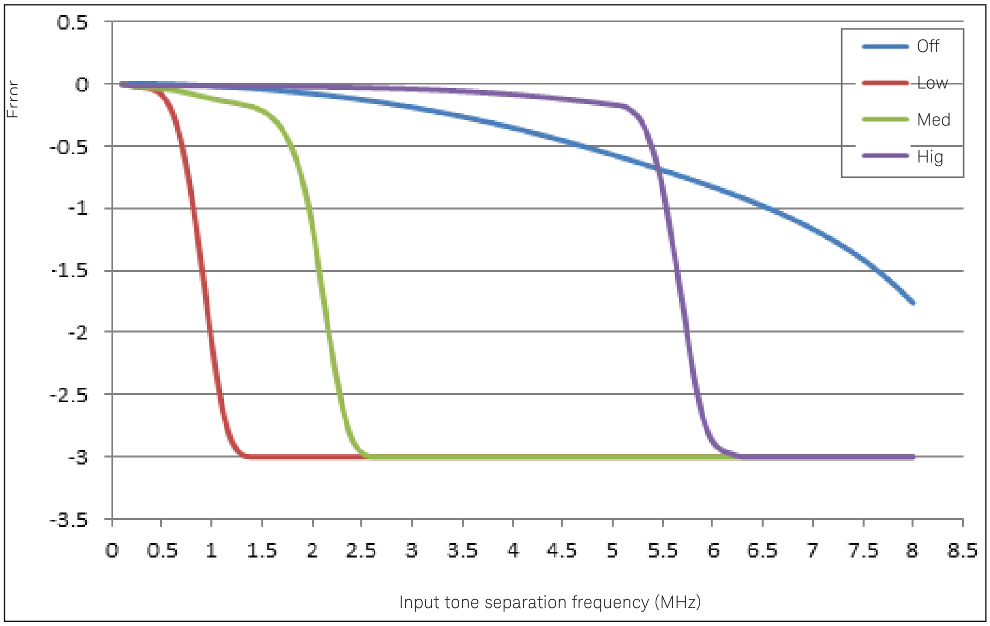


Figure 5. U2049XA (Option TVA) and L2065/66/67XT error in peak-to-average ratio measurements for a two-tone input (High, Medium, Low and Off video bandwidth settings)

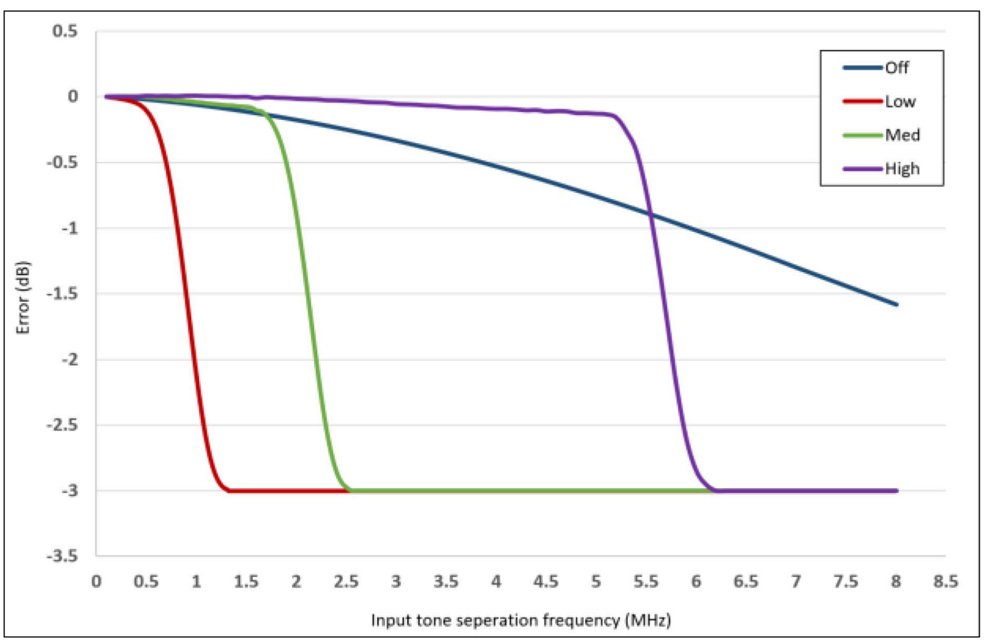


Figure 6. U/L2060 X-Series error in peak-to-average ratio measurements for a two-tone input (High, Medium, Low and Off video bandwidth settings).

Using the X-Series Power Sensors with the BenchVue Power Meters/Sensors App

Keysight BenchVue Power Meters/Sensors App 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. The X-Series power sensors are supported by the Keysight BenchVue Power Meters/Sensors App (BV0007B). Once you plug the X-Series power sensors 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. BenchVue Power Meters/Sensors App license (BV0007B) is now included with your instrument.

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

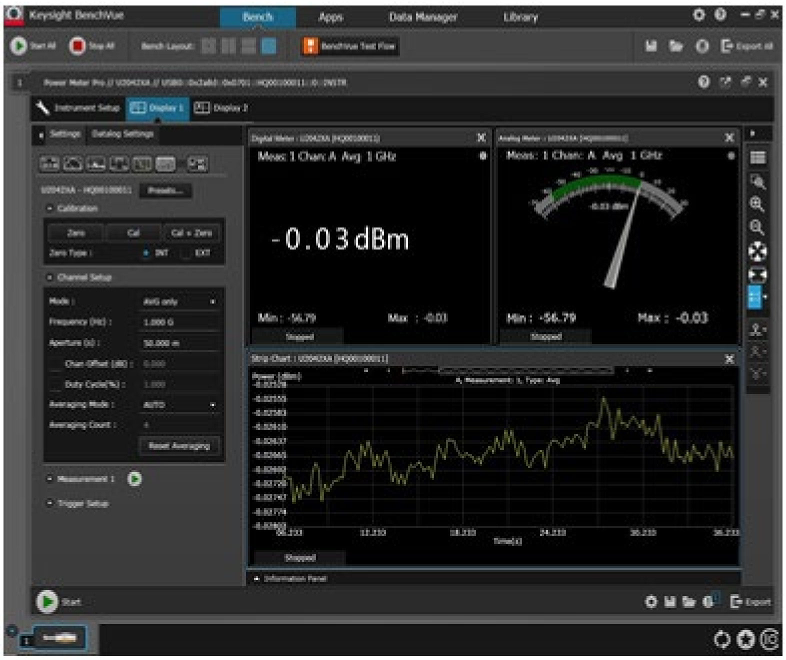


Figure 7. Digital Meter, Analog Meter and Datalog view

Figure 8. Multi-channel trace display with 4-pairs of gates and automatic pulse parameters measurement (sample screen shot with two X-Series power sensors

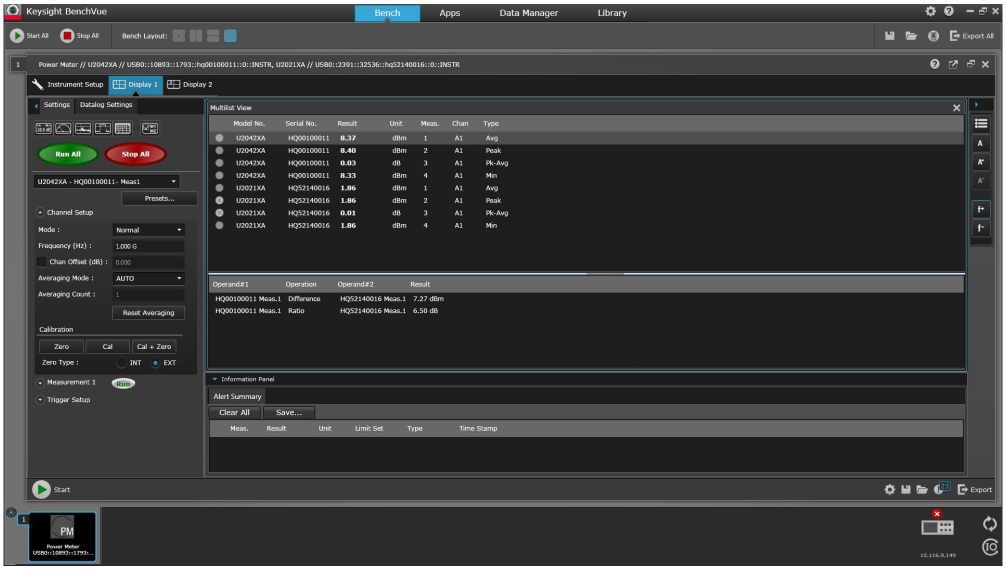


Figure 9. Multi-list view with ratio/difference function

Supported functionality	
Measurement displays	Digital meter Analog meter Data log view Trace view (up to 4 channels or traces on one graph) 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 includes 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	Processor: 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, LAN
Display resolution	1024 x 768 minimum for single instrument view (higher resolutions are recommended for multiple instrument view)

Additional requirements

Keysight BenchVue Power Meters/Sensors App 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
U2049XA	LAN peak and average power sensor, 10 MHz to 33 GHz
U2049XA, Option TVA	LAN peak and average power sensor, 10 MHz to 33 GHz, thermal vacuum option
U2051XA	USB wide dynamic range average power sensor, 10 MHz to 6 GHz
U2052XA	USB wide dynamic range average power sensor, 10 MHz to 18 GHz
U2053XA	USB wide dynamic range average power sensor, 10 MHz to 33 GHz
U2054XA	USB wide dynamic range average power sensor, 10 MHz to 40 GHz
U2055XA	USB wide dynamic range average power sensor, 10 MHz to 50 GHz
U2055XA, Option 053	USB wide dynamic range average power sensor, 10 MHz to 53 GHz
U2056XA	USB wide dynamic range average power sensor, 10 MHz to 54 GHz
U2057XA	USB wide dynamic range average power sensor, 10 MHz to 67 GHz
U2061XA	USB wide dynamic range peak and average power sensor, 10 MHz to 6 GHz
U2062XA	USB wide dynamic range peak and average power sensor, 10 MHz to 18 GHz
U2063XA	USB wide dynamic range peak and average power sensor, 10 MHz to 33 GHz
U2064XA	USB wide dynamic range peak and average power sensor, 10 MHz to 40 GHz
U2065XA	USB wide dynamic range peak and average power sensor, 10 MHz to 50 GHz
U2065XA, Option 053	USB wide dynamic range peak and average power sensor, 10 MHz to 53 GHz
U2066XA	USB wide dynamic range peak and average power sensor, 10 MHz to 54 GHz
U2067XA	USB wide dynamic range peak and average power sensor, 10 MHz to 67 GHz
L2051XA	LAN wide dynamic range average power sensor, 10 MHz to 6 GHz
L2052XA	LAN wide dynamic range average power sensor, 10 MHz to 18 GHz
L2053XA	LAN wide dynamic range average power sensor, 10 MHz to 33 GHz
L2054XA	LAN wide dynamic range average power sensor, 10 MHz to 40 GHz
L2055XA	LAN wide dynamic range average power sensor, 10 MHz to 50 GHz
L2055XA, Option 053	LAN wide dynamic range average power sensor, 10 MHz to 53 GHz
L2056XA	LAN wide dynamic range average power sensor, 10 MHz to 54 GHz
L2057XA	LAN wide dynamic range average power sensor, 10 MHz to 67 GHz
L2061XA	LAN wide dynamic range peak and average power sensor, 10 MHz to 6 GHz
L2062XA	LAN wide dynamic range peak and average power sensor, 10 MHz to 18 GHz
L2063XA	LAN wide dynamic range peak and average power sensor, 10 MHz to 33 GHz
L2064XA	LAN wide dynamic range peak and average power sensor, 10 MHz to 40 GHz
L2065XA	LAN wide dynamic range peak and average power sensor, 10 MHz to 50 GHz
L2065XA, Option 053	LAN wide dynamic range peak and average power sensor, 10 MHz to 53 GHz
L2066XA	LAN wide dynamic range peak and average power sensor, 10 MHz to 54 GHz
L2067XA	LAN wide dynamic range peak and average power sensor, 10 MHz to 67 GHz
L2065XT, Option 053	LAN peak and average power sensor, 10 MHz to 53 GHz, thermal vacuum compliance
L2066XT	LAN peak and average power sensor, 10 MHz to 54 GHz, thermal vacuum compliance
L2067XT	LAN peak and average power sensor, 10 MHz to 67 GHz, thermal vacuum compliance
Standard shipped items	
U2050/60 X-Series USB power sensors	USB 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
U2049XA & L2050/60 X-Series LAN power sensors	LAN 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
U2049XA (Option TVA) and L2065/66/67XT TVAC LAN power sensors	TVAC LAN cable 5 ft (1.5 m), default cable length TVAC BNC male to SMB female trigger cable, 50 Ω, 1.5 m (Quantity: 2) TVAC sensor bracket Thermal interface material Certificate of calibration

U2050/60 X-Series USB power sensors options

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	USB cable 5 ft (1.5 m) – default selection
U2000A-302	USB cable 10 ft (3 m)
U2000A-303	USB cable 16.4 ft (5 m)
Cables (ordered standalone)	
U2031A	USB cable 5 ft (1.5 m)
U2031B	USB cable 10 ft (3 m)
U2031C	USB cable 16.4 ft (5 m)

U2049XA (Option TVA), L2050/60 X-Series and L2065/66/67XT LAN power sensor options[1]

Options	Description
Standard LAN cables (selectable during sensor purchase and orderable standalone)	
U2034A	LAN cable 5 ft (1.5 m) – default selection for LAN power sensors
U2034B	LAN cable 10 ft (3 m)
U2034C	LAN cable 16.4 ft (5 m)
U2034D	LAN cable 50 ft (15.2 m)
U2034E	LAN cable 100 ft (30.5 m)
U2034F	LAN cable 200 ft (61 m)
U2037A	TVAC LAN cable, 5ft (1.5m) - default selection for TVAC LAN power sensor
U2037B	TVAC LAN cable, 10ft (3m)
U2037C	TVAC LAN cable, 16.4ft (5m)
U2037D	TVAC LAN cable, 50ft (15.2m)
U2037E	TVAC LAN cable, 100ft (30.5m)
U2037F	TVAC LAN cable, 200ft (61m)

1. PoE injector is not included. A commercially available 802.3at or 802.3af compliant PoE injector can be used with the LAN power sensors.

X-Series USB/LAN power sensors options

Trigger cable	
U2032A	Standard trigger cable BNC Male to SMB female, 50 Ω, 1.5 m (For X-Series power sensors except U2049XA Option TVA and L2065/66/67XT)
U2033A	TVAC trigger cable BNC Male to SMB female, 50 Ω, 1.5 m (For U2049XA Option TVA and L2065/66/67XT only)
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
U2041XA-CD1 [1]	Documentation Optical Disk (consists of documentation CD-ROM and Keysight Instruments Control DVD)
U2053XA-CD1 [2]	Documentation Optical Disk (consists of documentation CD-ROM and Keysight Instruments Control DVD)
Software	
BV0007B	BenchVue Power Meters/Sensors App license
Calibration	
UK6	Commercial calibration with test data
A6J	ANSI Z540 compliant calibration and test data
1A7	ISO 17025 compliant calibration and test data

1. Available for U2049XA (Option TVA) only.
2. Available for U/L2050/60 X-Series and L2065/66/67XT only.

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 <u>underlined</u>.)

Process	
1. Measured power level	W
2. Frequency of measured signal (use to get calibration uncertainty and SWR)	Hz
3. Calculate sensor uncertainty: Calculate noise contribution (from page 11) • Average-only mode: <u>Noise</u> = ***Measurement noise*** x average-only-mode noise multiplier • Free-run normal mode: <u>Noise</u> = ***Measurement noise*** for video bandwidth setting • Gated-average normal mode (Trigger normal mode), Noise = ***Noise-per-sample*** x noise-per-sample multiplier	
Convert noise contribution to a relative term 1 = <u>Noise</u>/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*** (from page 12)	
(Sensor, measurement mode, frequency, and humidity 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, $\vert \rho_{Sensor} \vert$ = (SWR–1)/(SWR+1) = ...	
Max DUT SWR (frequency dependent) = ...	
Convert to reflection coefficient, $\vert \rho_{DUT} \vert$ = (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.

Worked Example

Uncertainty calculations for a power measurement (settled, average power)

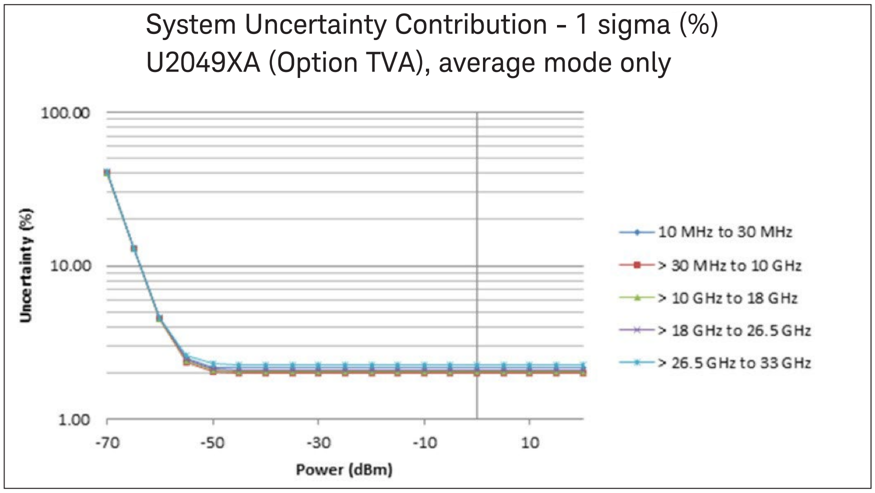
(Specification values from this document are in ***bold italic***, values calculated on this page are underlined.)

Process	
1. Measured power level	1 mW
2. Frequency of measured signal (use to get calibration uncertainty and SWR)	1 GHz
3. Calculate sensor uncertainty: In Free Run, auto zero mode average = 1 Calculate noise contribution, assuming 50 ms aperture (default) (from page 11) • Average-only mode: Noise = ***Measurement noise*** x average-only-mode noise multiplier = 80 pW x 4.0 = 0.32 nW • Free-run normal mode: Noise = ***Measurement noise*** for video bandwidth setting • Gated-average normal mode (Trigger normal mode), Noise = ***Noise-per-sample*** x noise-per-sample multiplier	
Convert noise contribution to a relative term[1] = Noise/Power = 0.32 nW/1 mW = 0.000032%, value clipped to 0.01% =	0.01%
Convert zero drift to relative term = ***Drift***/Power = 25 pW/1 mW	0.0000025%
RSS of above terms = ...	0.01%
4. Zero uncertainty	
(Mode and frequency dependent) = ***Zero set***/Power = 70 pW/1 mW..	0.000007%
5. ***Sensor calibration uncertainty*** (from page 12)	
(Sensor, measurement mode, frequency, and humidity dependent) = ...	3.7%
6. System contribution, coverage factor of 2 ≥ sys_{rss} = ...	3.7%
(RSS three terms from steps 3, 4 and 5)	
7. Standard uncertainty of mismatch	
Max SWR (frequency dependent) = ...	1.20
Convert to reflection coefficient, $\|\rho_{Sensor}\|$ = (SWR–1)/(SWR+1) = ...	0.091
Max DUT SWR (frequency dependent) = ...	1.26
Convert to reflection coefficient, $\|\rho_{DUT}\|$ = (SWR–1)/(SWR+1) = ...	0.115
8. Combined measurement uncertainty @ k = 1 $U_c=\sqrt{\left(\frac{Max(\rho_{DUT})\cdot Max(\rho_{Sensor})}{\sqrt{2}}\right)^2+\left(\frac{sys_{rss}}{2}\right)^2}$ $U_c=\sqrt{\left(\frac{0.091\cdot 0.155}{\sqrt{2}}\right)^2+\left(\frac{0.037}{2}\right)^2}$	1.99%
Expanded uncertainty, k = 2, = UC • 2 = ...	3.98%

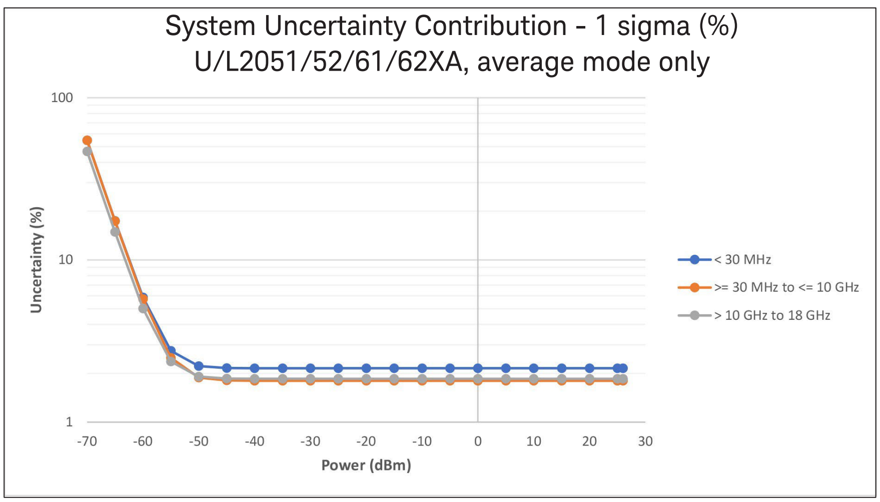
1. The noise to power ratio for average only mode is capped at 0.01% for measurement uncertainty calculation purposes.

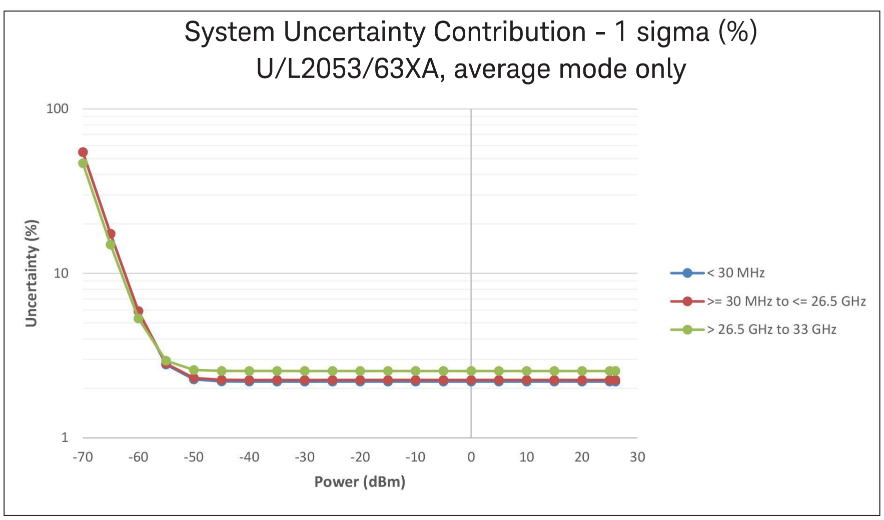
Graphical Example

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

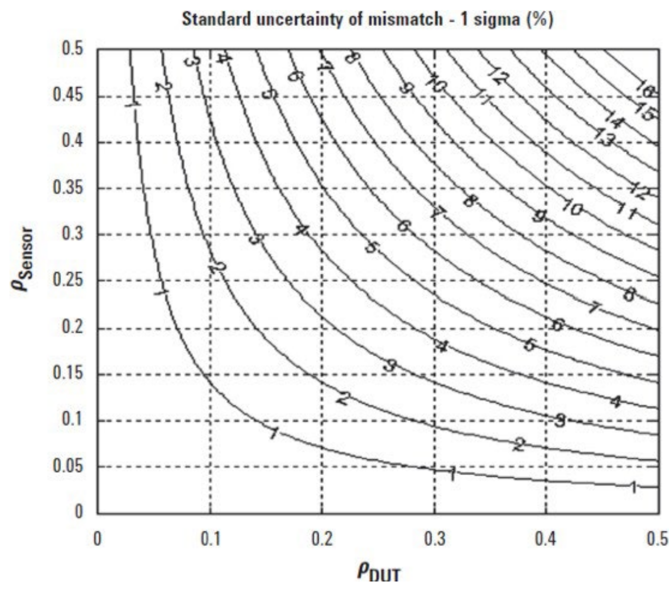


Note: The above graph is valid for conditions of free-run operation, with a signal within the video bandwidth setting on the system. Humidity < 70 %.





B. Standard uncertainty of mismatch



SWR	r	SWR	r
1.0	0.00	1.80	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	046
1.50	0.20	2.80	0.47
1.60	0.23	2.90	0.49
1.70	0.26	3.00	0.50

Note: The above graph shows the Standard Uncertainty of Mismatch = ρDUT. ρSensor / √2, rather than the Mismatch Uncertainly Limits. This term assumes that both the Source and Load have uniform magnitude and uniform phase probability distributions.

C. Combine A and B

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

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

Learn more at: www.keysight.com

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