

# Power Meters and Power Sensors

ML2430A CW Power Meter

ML2480B Wideband Power Meter

ML2490A Pulse Power Meter

MA2400A/D & MA24000A Power Sensors



## Introduction

Anritsu offers the world's most comprehensive range of power meters. The ML2490A series has the performance required for narrow fast rising-edge pulse power measurements (e.g., radar), while the ML2480B series is suited for Wideband power measurements on signals such as W-CDMA, WLAN, and WiMAX. The ML2430A series of power meters are designed for CW applications, offering a combination of accuracy, speed and flexibility in a low cost package.

Also available are seven different families of power sensors with frequency coverage to 50 GHz and dynamic range up to 90 dB. Most of the power sensors can work in either pulsed/modulated or CW mode (the ML2480B/90A series meters offer both modes). In choosing a power sensor, several factors must be considered, including: frequency range, dynamic range and the modulation. The rise time of the sensor should also be chosen to match the rise time of the modulation.

The MA24106A power sensor is a highly accurate instrument that communicates with a PC using the Universal Serial Bus interface (USB). Therefore, the MA24106A is ideal for measuring average (true RMS) power of any signal type or bandwidth, e.g. CW, multi-tone, and modulated RF waveforms such as 3G, 4G, and OFDM.

The MA24106A power sensor provides lab performance accuracy in a rugged and portable field solution.

PowerMax™ is a free graphical user-interface software, for the ML2480B and ML2490A Power Meter Series.

PowerMax provides an enhanced visualization of instrument display and simplified remote control of the instrument, allowing:

- Continuous view of measurement traces in real-time
- Multiple gates and markers readings displayed at a glance
- Archiving or printing of data and plots for future analysis

### *PowerMax requirements:*

#### **Hardware**

PC Processor: 1.5 GHz

Ethernet Interface: 10/100BaseT LAN

Memory: 1 GB RAM or greater

Monitor: 1024 x 768 or greater resolution

#### **Software**

Operating System: Windows XP, Service Pack 2 or higher

Browser: E.g. Microsoft Internet Explorer 5.1 or higher

### *PowerSuite*

Free software available for ML243xA power meters, to continuously view measurement traces on the PC in real-time, or archive data and plots for future analysis. PowerSuite runs on a standard PC running Windows® 95 or higher, via GPIB or RS232.

## Power Meter Specifications

	ML2430A Series		ML2480B Series		ML2490A Series		Comments
	ML2437A	ML2438A	ML2487B	ML2488B	ML2495A	ML2496A	
Signal Inputs	1	2	1	2	1	2	
Frequency range	100 kHz to 65 GHz (sensor dependent)						
Dynamic range	-70 to +20 dBm (dependent on sensor, external coupler or attenuator)						Continuous or Peak
Performance	100 kHz (Profile mode)		Pulse/Modulated mode 20 MHz with MA2491A sensor  CW mode 17 kHz ranges 1-4 35 Hz range 5		Pulse/Modulated mode >65 MHz range 7 >38 MHz range 8 >16 MHz range 9 (Repetitive Sampling) 20 MHz (One shot)  Combined B/W (with MA2411B sensor) >39 MHz range 7 >29 MHz range 8 >12 MHz range 9 MA2411B nominal Bandwidth = 50 MHz  CW mode 17 kHz range 1-4 36 Hz range 5		Nominal Video BW
	31.25 kS/s		Auto/Manual  CW Mode 75 kS/s  Pulse/Modulated Mode 31.25 kS/s to 62.5 MS/s (dependent on trigger capture time)  Conflicts between selected settings and other instrument settings are indicated through user warnings (displayed and GPIB)		Auto/Manual  CW Mode 75 kS/s  Pulse/Modulated Mode 31.25 kS/s to 62.5 MS/s Continuous Sampling (Trigger capture time 3.2 $\mu$ s to 7s, 200 data points)  1 GS/s Random Repetitive Sampling (Trigger capture time 50 ns - 3.2 ns, 200 data points)  Conflicts between selected settings and other instrument settings are indicated through user warnings (displayed and GPIB)		Sampling rate
	N/A		<18 ns (with MA2411B sensor)		Typical 8 ns, Maximum 12 ns (with MA2411B sensor) Fall-time typically 11 ns		System rise-time (10% to 90% at +10 dBm)
	N/A		10% to 90% Rise-time measurement of -20 dBm to +20 dBm Peak power (with MA2491A)				Rise-time measurement dynamic range
	N/A		$\leq$ 3% in linear power at +10 dBm				Overshoot (Pulse/Modulated mode)
Accuracy  (Defined by uncertainty calculations with relevant sensor and source match conditions)	<0.5%		CW Mode <0.5% ( $\pm$ 0.02 dB absolute Accuracy, $\pm$ 0.04 dB relative Accuracy)  Pulse/Modulated Mode <0.8% Nominal range 7, 8				Instrumentation Accuracy
	Equivalent Noise Power (512 Moving Average)		MA2472D	MA2491A	MA24002A		
	Range 1	0.5 $\mu$ W	2 $\mu$ W	N/A			
	Range 2	50 nW	100 nW	0.5 nW			
	Range 3	0.8 nW	2 nW	8 $\mu$ W			
	Range 4	0.2 nW	1 nW	2 $\mu$ W			
	Range 5 (CW mode)	50 pW	0.5 nW	0.5 nW			
	Range 7	5 $\mu$ W	15 $\mu$ W	N/A			
	Range 8	1 $\mu$ W	5 $\mu$ W	N/A			
	Range 9 (Pulse/Modulated mode)	0.5 $\mu$ W	2 $\mu$ W	N/A			

## Power Meter Specifications continued

	ML2430A Series		ML2480B Series		ML2490A Series		Comments
	ML2437A	ML2438A	ML2487B	ML2488B	ML2495A	ML2496A	
Operation	2		2 (CW or Pulse/Modulated measurement modes)				Measurement Display-Readout (Numerical)
	Power vs. Time graphic of readout data or Profile of Peak power for analysis of repetitive pulse or transient waveforms		2 (Pulse/Modulated measurement mode)				Measurement Display-Profile (Graph)
	Single channel power sweep or frequency sweep						Source sweep
	±5 dB range CW (Readout mode) only						Peaking meter
	Dynamic range covered by five overlapping amplifier ranges, R1, R2, R3, R4 and R5 Universal Sensor MA2481/82D ranges 1 to 6		Pulse modulated mode: Dynamic range covered by three overlapping amplifier ranges, R7, R8 and R9 CW mode: Dynamic range covered by five overlapping amplifier ranges, R1, R2, R3, R4 and R5 Universal Sensor MA2481/82D ranges 1 to 6				Amplifier Range
	Auto or Manual (current range or selectable 1 through 5)		Automatic or manual. When in manual clear indication given to user (display and GPIB) of fault conditions (under or over-range)				Range Hold
Features (summary)	0.1 to 0.001 dB Linear power units, 3 to 6 digit, 1 to 3 digits selectable to right of decimal nW to W; Voltage, 1 to 2 digits selectable to right of decimal		0.1 to 0.001 dB				Display resolution in Readout mode
	0.01 dB						Display resolution in Profile mode
	Profile and P vs. T modes: 200 pixels display resolution For a 1 ms Profile window, cursor resolution on the display is 5 µs		16 ns Pulse/Modulated mode 15 µs CW Mode		1 ns (RRS mode) 16 ns (non RRS mode) Pulse/Modulated mode 15 µs CW Mode		Time measurement resolution
	Hold, Max, Min						Measurement hold
	Average, Min, Max		Average, Min, Max, Peak, Crest, PAE (Power Added Efficiency)				Measurements
	—		PDF, CDF, CCDF				Power statistics
	0.00 to 20.00V nominal						Voltage measurement range
	Watt, %, Volts						Display units (Lin) Display units (Log)
	dBm, dB, dBµV, dBmV, dBr		dBm, dBW, dB, dBµV, dBmV				Display range
	-199.99 to +199.99 dB						Display range
	1		Four Independently set Gates or eight repeated Gates One Fence per Measurement gate Gate measurement supports Average, Peak, Crest, Max and Min				Measurement Gates
	2		Four Markers and One Delta Marker, Marker to Max/Min, Pulse Rise/Fall-time, Pulse Width, Off Period, Pulse Repetition Interval Rise Fall/Search Parameter Variable % Reference: Max Marker or Gate Power Level				Markers
	Fixed value high and low limits with audible, rear panel TTL output, and/or visible Pass/Fail alarm indication Failure indication can latch for transient failure detection		Simple pass/fail for CW Complex limits for pulsed and TDMA systems 30 Limits Stores available on the instrument				Limit lines
-199.99 to +199.99 dB (Fixed value or frequency dependent table)						Offset range	

## Power Meter Specifications continued

	ML2430A Series		ML2480B Series		ML2490A Series		Comments
	ML2437A	ML2438A	ML2487B	ML2488B	ML2495A	ML2496A	
Averaging	Auto (Moving), Manual (Moving, Repeat)						Type
	1 to 512						Range
	Low, Medium and High settings apply post average low pass filter to improve visibility at high display resolution			N/A			Low-level Averaging
Triggering	Internal, External (TTL or RF Blanking), GPIB, Manual, Continuous		Continuous (not in Random Repetitive Sampling mode) Internal, External TTL (Rising or falling Edge), GPIB or external Bus				Source
	Manual Single power value set to cover entire measurement dynamic range of sensor						Trigger modes
	Auto Automatically sets trigger level for signal over measurement dynamic range						
	N/A		Variable-auto set and manual 20 MHz, 2 MHz, 200 kHz, 20 kHz				Nominal Internal Trigger Bandwidth
	Sets the trigger arming, unless the trigger source is set to EXTTL  When ARMING is set to Blanking ON, only samples taken when the rear panel Digital Input BNC is active will be averaged in the measurement		Repetitive Sampling Modes: Automatic Frame for QAM and multi-pulse  Continuous Sampling Modes: Single Automatic Frame for QAM and multi-pulse				Arming Sources
	N/A		0 to 64 x trigger capture time range or 120s whichever is the greater				Frame Arming Time range
	-15 to 20 dBm (all diode sensors, selectable to -25 dBm)		-28 dBm to +10 dBm with MA2472D CW mode -18 dBm to +14 dBm with MA2491A -30 dBm to +10 dBm with MA2472D Pulse/Modulated mode				Internal Trigger dynamic range
	1 dB						Internal Trigger level Accuracy (typical)
	0.1 dB						Internal Trigger settable resolution
	N/A		±2 ns or display resolution, whichever is the larger (Trigger Capture time 50 ns to 3.2 µs)  ±16 ns or display resolution whichever is the larger (Trigger Capture time 3.2 µs to 7s)				Trigger time resolution Uncertainty
	0.0 to 999 ms		<b>Pulse modulated mode</b> Pretrigger (-ve): 95% of the Trigger Capture range Post Trigger: Set by 256K buffer and sample rate <b>CW mode</b> Post Trigger Only: 0-999 ms depending on Trigger Capture period setting				Trigger delay range
	TTL rising or falling edge (BNC input)						External Trigger range
	N/A		90% of trigger capture range				Pre-trigger range
0.5% of display period or 100 ns		200 display points 1 ns or 0.5% of trigger capture time, whichever is the larger 400 display points 1 ns or 0.25% of trigger capture time (400 points), whichever is the larger				Trigger delay settable resolution	

## Power Meter Specifications continued

	ML2430A Series		ML2480B Series		ML2490A Series		Comments
	ML2437A	ML2438A	ML2487B	ML2488B	ML2495A	ML2496A	
Triggering	N/A		±2 ns for pre and post trigger (Trigger capture time of 3.2 µs or 50 ns)				Trigger delay uncertainty
	N/A		±15 ns (20 MHz trigger BW)				Trigger latency
	Profile mode: 10 ms to 7s P v T mode: 1m to 24 hrs		3.2 µs to 7s		50 ns to 7s		Trigger/Display capture range
	N/A		200 display points 16 ns or 0.5% of trigger capture time, whichever is the larger 400 display Points 16 ns or 0.25% of trigger capture time, whichever is the larger		200 display points 1 ns or 0.5% of trigger capture time, whichever is the larger 400 display Points 1 ns or 0.25% of trigger capture time, whichever is the larger		Trigger capture time settable resolution
	On-screen indicator/message		Trigger point depicted by trigger edge waveform (edge represents trigger point of signal). Display position of trigger edge waveform adjustable.				Trigger point display (on-screen)
System Configuration	10 storage registers plus RESET default settings		20 settings stores Preset accessible on Front Panel Offset tables				Save/Recall
	Wipes non-volatile memory on power up when active.						Secure mode
Interfaces	Yes		No				Remote monitoring
	Yes		No				Modem Compatibility
	>600 readings/sec (per input channel) Emulation of Anritsu ML4803, Agilent 436, 437 and 438		>400 Readings/second CW Mode [TR3 mode] >350 Readings/second Pulse/Modulated Mode (Continuous Sampling) [1 µs pulse, readout mode, Display turned off, TR3 Mode] >10 profile transfers/sec Pulse/Modulated Mode (Profile data) [200 points per sweep, Binary Float Output, 5 µs Trigger Capture Time] >20 Readings/sec Pulse/Modulated Mode (Repetitive Sampling) [50 ns pulse, readout mode, Display turned off, TR3 Mode] Back Compatible with ML2480B with Additional functionality added				GPIB (IEEE-488.2, IEC-625)
	N/A		Allows remote control, direct from a PC or Local/Wide-area network, using Dynamic (Auto) or Static IP assignment				Ethernet (10/100 BaseT LAN)
	Supports software download, Instrument control and modem dial-out. 1200, 2400, 4800, 9600, 19200, 38400, 57600 Baud rates supported		Supports software download and Instrument control 1200, 2400, 4800, 9600, 19200, 38400, 57600 Baud rates supported				RS232
	Operating Modes: Display voltage reading on selected channel Voltage proportional to frequency for sensor calibration factor compensation Blanking Input -TTL levels only Selectable positive or negative polarity Input Range: 0 to 20V Resolution: 0.5 mV Control: Adjustable voltage to frequency relationship		Can be configured for: Cal factor correction from synthesiser, Ext Voltage Voltmeter, Connection:- current probe for PAE applications				Cal Factor Voltage Input (BNC)
	TTL, maximum frequency of 800 kHz		TTL, maximum frequency of 10 MHz				External trigger (BNC)
	Two outputs configurable to Log or Lin Operating Modes: Selectable channel adjusted for calibration factors and other power reading correction settings Pass/Fail – Selectable TTL High or Low Channel output -Near real time analog Uncalibrated AC Modulation Output -Output 1 only Dwell Output -Output 2 only Output Range: -5.0 to 5.0V Resolution: 0.1 mV		Output 1 can be configured for: Analog Output, Pass/Fail TTL o/p Limits, Levelling: -Sensor Input A  Output 2 can be configured for: Analog Output, Pass/Fail TTL o/p Limits, Levelling: -Sensor Input B, Trigger Output				Analogue Output (BNC)

## Power Meter Specifications

	ML2430A Series	ML2480B Series	ML2490A Series	Comments
Reference Calibrator	1 mW			Power
	±1.2% per year, ±0.9% RSS			Power accuracy (Traceable to National Standards)
	50 MHz (nominal)	50 MHz (standard), 1 GHz (optional)	50 MHz, 1 GHz (both standard)	Frequency
	<1%	<1% (50 MHz) <2% (1 GHz)		Frequency Accuracy
	<1.04	<1.12 (50 MHz) <1.2 (1 GHz)		VSWR
	N female			Connector type
Display	Monochrome LCD, with backlight and adjustable contrast	Color LCD		Display
External Video Output	N/A	1/4 VGA		External Video Output
Parallel Printer Port	Compatible with Deskjet 540 and 340 Models. Other 500 Series and 300 Series and later are typically compatible. Also Canon BJC 80	N/A		
General	MIL-T28800F, class 3			
Non Volatile RAM Battery	Lithium (10 year life)	Lithium (5 year life)		
Battery Option	>6 hr usable with 3000 mAh (NiMH) battery	N/A		
DC Power Requirements	12 to 24 VDC, Reverse protected to -40V Maximum input 30V	N/A		
AC Power Requirements	90 to 250 VAC, 47 to 440 Hz, 40 VA Maximum	90 to 250 VAC, 47 to 440 Hz		
EMI, EMC, Safety	Complies with requirements for CE marking EN 61326, EN61010-1			
Operating Temperature	0° C to 50° C			Mainframe only, see sensor specification for performance of sensors
Storage Temperature	-40° C to 70° C			
Moisture	Splash and rain resistant, 95% humidity non-condensing			
Dimensions	213 mm x 88 mm x 390 mm			Width x Height x Depth
Weight	3 kg (excluding battery option)	3 kg		
Warranty	1 year Standard, 3 year Optional			

## USB Power Sensor Specifications

### MA24106A Power Sensor

Frequency range	50 MHz to 6 GHz
Dynamic range	-40 dBm to +23 dBm
Input return loss	>26 dB (50 MHz to <2 GHz) >20 dB, (2 GHz to 6 GHz)
Measurement ranges	Range 1, -40 dBm to -5 dBm Range 2, -5 dBm to +23 dBm
Signal channel bandwidth	100 Hz, typical

### Measurement Uncertainty

Linearity	±0.13 dB (power level <+18 dBm) ±0.18 dB (power level ≥+18 dBm)
Calibration factor <sup>Ⓐ</sup>	±0.06 dB
Noise <sup>Ⓐ</sup>	<2.5 nW (-40 dBm to -5 dBm) <0.6 μW (-5 dBm to +23 dBm)
Zero set	<10 nW (-40 dBm to -5 dBm) <1.7 μW (-5 dBm to +23 dBm)
Zero drift <sup>Ⓐ</sup>	<3.0 nW (-40 dBm to -5 dBm) <0.5 μW (-5 dBm to +23 dBm)
Temperature compensation <sup>Ⓐ</sup> (0° C to 50° C)	±0.06 dB
Effect of digital modulation <sup>Ⓐ</sup>	±0.02 dB (power level <+18 dBm) ±0.10 dB (power level ≥+18 dBm)

### System

Measurand	True-RMS/Average power
Measurement resolution	0.01 dB
Offset range	±100 dB
Averaging range	1 to 256
Measurement speed <sup>Ⓐ</sup>	10 measurement per second, typical
Range	Auto ranging between Range 1 and Range 2
Interface	USB 2.0
Host operating system	Microsoft® Windows® XP and Windows® 2000 (for PC application)

### General

Current (via host USB) <sup>Ⓐ</sup>	100 mA typical at 5V
Maximum DC voltage at RF port	±25 V
Maximum CW power	+33 dBm
Size (W x H x D) <sup>Ⓐ</sup>	56 mm x 30 mm x 85 mm typical (2.2 in. x 1.18 in. x 3.35 in.)
Weight	180 grams typical (6.4 oz.)

### Environmental<sup>Ⓐ</sup>

Operating Temperature Range	0° C to +55° C
Storage Temperature Range	-51° C to +71° C
Humidity	45% relative humidity at 55° C (non-condensing) 75% relative humidity at 40° C (non-condensing) 95% relative humidity at 30° C (non-condensing)
Shock	30 g half-sine, 11 ms duration
Vibration	Sinusoidal: 5-55 Hz, 3 g max. Random: 10-500 Hz, Power Spectral Density 0.03 g/Hz
EMC	Meets EN 61326, EN 55011
Safety	Meets EN 61010-1

### Notes:

All specs are applicable after twenty minutes warm-up at room temperature unless specified otherwise.

<sup>Ⓐ</sup> Expanded uncertainty with K=2 for absolute power measurements on CW signal at 0 dBm calibration level from 50 MHz to 6 GHz.

<sup>Ⓐ</sup> Expanded uncertainty with K=2 after zero operation when measured with 128 averages for 5 minutes.

<sup>Ⓐ</sup> In high aperture time mode, noise is 1.3 nW and 0.3 μW in range 1 and range 2 respectively.

<sup>Ⓐ</sup> After one hour warm-up and zero operation. Measured with 128 averages for one hour keeping the temperature within ±1° C.

<sup>Ⓐ</sup> Measurement error with reference to a CW signal of equal power and frequency at 5° C.

<sup>Ⓐ</sup> One measurement per second, typical in high aperture time mode.

<sup>Ⓐ</sup> 150 mA max.

<sup>Ⓐ</sup> Not including N connector.

<sup>Ⓐ</sup> Tests were performed per MIL-PRF-28800F (Class 2)

## Power Sensor Specifications continued

	Frequency Range	CW Dynamic Range (dBm)	SWR	Rise Time <sup>1</sup> (ms)	Sensor Linearity <sup>7</sup>	RF Connector <sup>2</sup>
<b>Standard Diode Sensors</b>						
MA2472D	10 MHz to 18 GHz	-70 to +20 CW mode -40 to +20 (ML243xA, Profile mode)  -34 to +20 (ML2480A/B or ML2490A, Pulse/Mod mode)	<1.17; 10 MHz to 150 MHz <1.90; 10 MHz to 50 MHz <1.17; 50 MHz to 150 MHz <1.12; 0.15 GHz to 2 GHz <1.22; 2 GHz to 12.4 GHz <1.25; 12.4 GHz to 18 GHz <1.35; 18 GHz to 32 GHz <1.50; 32 GHz to 40 GHz <1.63; 40 GHz to 50 GHz	<0.004	<1.8%, 18 GHz <2.5%, 40 GHz <3.5%, 50 GHz For MA2475D (see Note 4)	N(m)
MA2473D	10 MHz to 32 GHz					K(m)
MA2474D	10 MHz to 40 GHz					K(m)
MA2475D	10 MHz to 50 GHz					V(m)

Temperature accuracy: <1% < 40 GHz, <1.5% <50 GHz, 5° C to 50° C

### High Accuracy Diode Sensors

MA2442D	10 MHz to 18 GHz	-67 to +20 CW mode -43 to +20 (ML243xA, Profile mode)  -37 to +20 (ML2480A/B or ML2490A, Pulse/Mod mode)	<1.90; 10 MHz to 50 MHz <1.17; 10 MHz to 150 MHz <1.17; 50 MHz to 150 MHz <1.08; 150 MHz to 2 GHz <1.16; 2 GHz to 12.4 GHz <1.21; 12.4 GHz to 18 GHz <1.29; 18 GHz to 32 GHz <1.44; 32 GHz to 40 GHz <1.50; 40 GHz to 50 GHz	<0.004	<1.8%, 18 GHz <2.5%, 40 GHz <3.5%, 50 GHz For MA2445D (see Note 5)	N(m)
MA2444D	10 MHz to 40 GHz					K(m)
MA2445D	10 MHz to 50 GHz					V(m)

Temperature accuracy: <1% < 40 GHz, <1.5% <50 GHz, 5° C to 50° C

### Universal Power Sensors

MA2481D	10 MHz to 6 GHz	-60 to +20	<1.17; 10 MHz to 150 MHz <1.12; 0.15 GHz to 2 GHz <1.22; 2 GHz to 12.4 GHz <1.25; 12.4 GHz to 18 GHz	<0.004 (with option 1 only)	<3%, 6 GHz <3%, 18 GHz (1.8% CW with option 1)	N(m)
MA2482D	10 MHz to 18 GHz					

Temperature accuracy: <1%, 15° C to 35° C

MA2480/01 Adds fast CW mode to Universal Power Sensors for high speed measurements of CW signal plus TDMA and pulse measurements

### Wideband Sensors

MA2490A <sup>3</sup>	50 MHz to 8 GHz	CW Mode -60 to +20	<1.17; 50 MHz to 150 MHz <1.12; 0.15 GHz to 2.5 GHz <1.22; 2.5 GHz to 8 GHz	<18 ns	<7% 50 MHz to 300 MHz <3.5% 0.3 GHz to 8 GHz	N(m)
MA2491A <sup>3</sup>	50 MHz to 18 GHz	Pulse/Modulated Mode -25 to +20 (with ML2480B) -30 to +20 (with ML2490A)	<1.17; 50 MHz to 150 MHz <1.12; 0.15 GHz to 2.5 GHz <1.22; 2.5 GHz to 12.4 GHz <1.25; 12.4 GHz to 18 GHz		<7% 50 MHz to 300 MHz <3.5% 0.3 GHz to 18 GHz	N(m)

Temperature accuracy: <1% 10° C to 45° C

### Pulse Sensor

MA2411B Requires 1 GHz Calibrator (Option 15) to be fitted on the meter, if used with ML248xA.	300 MHz to 40 GHz	-20 to +20 dBm	<1.15; 0.3 GHz to 2.5 GHz <1.35; 2.5 GHz to 26 GHz <1.50; 26 GHz to 40 GHz	<8 ns, typical 12 ns, maximum <18 ns when used with ML2487/8A	<4.5% 0.3 GHz to 18 GHz <7% 18 GHz to 40 GHz	K(m)
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Temperature accuracy: <2% 10° C to 45° C

### Thermal Sensor

MA24002A MA24004A MA24005A	10 MHz to 18 GHz 10 MHz to 40 GHz 10 MHz to 50 GHz	-30 to +20 dBm	<1.90; 10 to 50 MHz <1.17; 50 to 150 MHz <1.10; 0.15 to 2 GHz <1.15; 2 to 12.4 GHz <1.20; 12.4 to 18 GHz <1.25; 18 to 32 GHz <1.30; 32 to 40 GHz <1.40; 40 to 50 GHz	<15	1.8% <18 GHz 2.0% <40 GHz 2.5% <50 GHz (see note 6)	N(m) K(m) V(m)
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Temperature accuracy: <1% <30 GHz <+10 dBm, <1.5% ≥30 GHz ≥+10 dBm

<sup>1</sup> 0.0 dBm, room temperature with standard 1.5m sensor cable.

<sup>2</sup> Each MA2400A/D Series sensor incorporates precision RF connectors with hexagon coupling nut for attachment by industry standard torque wrench.

<sup>3</sup> MA2490/1A and MA2411B sensors must be used with ML2480B or ML2490A series power meters.

<sup>4</sup> MA2475D Linearity applicable from -70 to +15 dBm. Add 1% for power levels >+15 dBm

<sup>5</sup> MA2445D Linearity applicable from -67 to +15 dBm. Add 1% for power levels >+15 dBm

<sup>6</sup> MA24005D Linearity applicable from -30 to +15 dBm. Add 1% for power levels >+15 dBm

<sup>7</sup> Sensor linearity specifications are ± value.

Pulse/modulated performance only specified with 1.5m sensor cable length option

2000-1537-R supplied as standard with the power meter.  
Refer to 10585-00004 for detailed specs.

## Measurement Accuracy

Power measurement accuracy can be split into several parts. The table below shows how the measurement uncertainty is composed for several power sensors. The source is presumed to be a 16 GHz, 12.0 dBm signal with a source SWR of 1.5:1.

The uncertainties can be calculated as an RSS term as each parameter is independent. Alternatively they can be added together for a worst-case analysis.

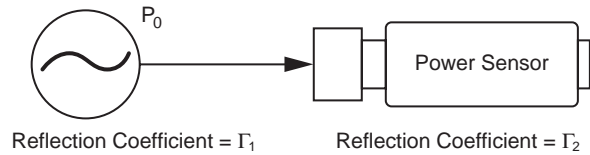
	MA2440D	MA2491A	MA2470D
Instrumentation Accuracy	0.50%	0.50%	0.50%
Sensor Linearity	1.80%	3.50%	1.80%
Noise, 256 Avg.	0.00%	0.00%	0.00%
Zero Set and Drift	0.00%	0.00%	0.00%
Mismatch Uncertainty	3.84%	4.49%	4.49%
Sensor Cal Factor Uncertainty	0.79%	1.59%	0.84%
Reference Power Uncertainty	1.20%	1.20%	1.20%
Reference to Sensor Mismatch Uncertainty	0.23%	0.31%	0.23%
Temperature Linearity	1.00%	1.00%	1.00%
RSS, Room Temp	4.51%	6.06%	5.09%
Sum of Uncertainties, Room Temp	8.36%	11.59%	9.06%
RSS	4.62%	6.14%	5.18%
Sum of Uncertainties	9.36%	12.59%	10.06%

The **Instrumentation accuracy** of 0.5% is a very small component of the overall uncertainty budget and describes the linear voltage measurement accuracy of the power meter.

**Sensor linearity** describes the relative response over the dynamic range of the sensor, and is included when the sensor is measuring power levels relative to the 0 dBm calibrator reference level. Temperature linearity is included when operating the sensor at other than room temperature.

**Noise, Zero Set and Drift** are all measured on the lowest power range of the power sensor. Different types of power sensors have different noise characteristics. Noise can be reduced by averaging.

**Mismatch uncertainty** is typically the largest component of the uncertainty budget – caused by the different impedances of the device under test and the sensor. To help resolve this issue, the sensor has been designed to have a good return loss over a wide frequency range, typically achieving significantly better results than the specification. In many cases the major contributing factor is the match of the source under test.



$$\% \text{ Mismatch Uncertainty} = 100 [(1 \pm \Gamma_1 \Gamma_2)^2 - 1]$$

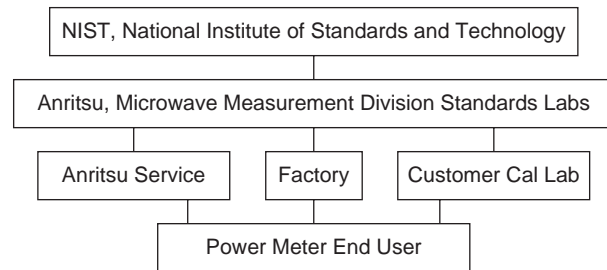
$$\text{dB Mismatch Uncertainty} = 20 \log (1 \pm \Gamma_1 \Gamma_2)$$

*Mismatch is easily calculated in either dB or percentage terms from the source's and sensor's respective reflection coefficients.*

The source match of the device under test can be improved by the use of precision attenuators with good return loss or by the use of external levelling with a high directivity coupler or splitter.

Connector damage has significant accuracy and repeatability effects, and is also the most common cause of sensor damage – although it is frequently undetected. Every MA2400A/D Series includes a hex nut connection for application of a calibrated torque wrench. Torque wrenches assure compliance with the quality requirement and result in more consistent measurements.

**Sensor calibration factor uncertainty** identifies the accuracy of the sensor's calibration relative to a recognized standard for absolute power level. Sensor calibration factor uncertainty is included in accuracy calculations for any absolute power measurement (in dBm or Watts) and for relative power measurements if the signals are different frequencies.



*ML2400A Series is NIST traceable for more accurate, dependable measurements.*

Reference power uncertainty specifies the maximum possible output drift of the power meter's 50 MHz, 0.0 dBm power reference between calibration intervals.

Reference power uncertainty and reference to sensor mismatch uncertainty do not generally impact relative power measurements.

See the Anritsu website ([www.anritsu.com](http://www.anritsu.com)) for more information and tool to calculate measurement uncertainties.

# Ordering Information

## Power Sensor and Power Meter Selection Guide

Sensors	Standard Diode	(High Accuracy) Diode	Universal	USB Sensor	Wideband	Pulse	Thermal	Comments
	MA2470D Series	MA2440D Series	MA2480D Series	MA24106A	MA249XA Series	MA2411B	MA2400xA	
Power Measurement	Average (RMS)	Average (RMS)	Average (RMS)	Average (RMS)	Average (RMS), Peak	Average (RMS), Peak	Average (RMS)	
Measurement Application (Examples)	CW, GMSK, GFSK, 8PSK	CW, GMSK	CW, GMSK, GFSK, 8PSK, QPSK, QAM	Any	CW, GMSK, 8PSK, QPSK, QAM	Pulse, QAM	Any	Modulation
	TDMA, FDMA, IS136	TDMA, FDMA	TDMA, FDMA, CDMA, OFDM, Radar	Any	TDMA, FDMA, CDMA, OFDM, Radar	Radar, OFDM	Any	Access Scheme
Compatible Power Meters	ML24xxA/B	ML24xxA/B	ML24xxA/B	Only requires PC with Windows 2000/XP, USB 2.0	ML2480A/B, ML2490A	ML2480A/B, ML2490A	ML24xxA/B	

Choose the right sensor and meter for your measurement application.

### Power Meter Models

ML2495A	Pulse Power Meter, Single Input
ML2496A	Pulse Power Meter, Dual Input
ML2487B	Wideband Power Meter, Single Input
ML2488B	Wideband Power Meter, Dual Input
ML2437A	CW Power Meter, Single Input
ML2438A	CW Power Meter, Dual Input

### ML2490A Series

ML2400A-01	Rack Mount, single unit
ML2400A-03	Rack Mount, side-by-side
ML2400A-05	Front Bail Handle
ML2490A-06	Rear Mount Input A on ML2495A
ML2490A-07	Rear Input A and Reference on ML2495A
ML2490A-08	Rear Mount Inputs A, B and Reference on ML2496A
ML2490A-09	Rear Mount Inputs A, B on ML2496A
ML2490A-98	Calibration to Z540, ISO Guide 25
ML2490A-99	Premium Calibration
13000-00238	Extra Operation manual ML2480B/90A
13000-00239	Extra Programming manual ML2480B/90A

### ML2480B Series

ML2480B-001	Rear Mount, right (for ML248xB models)
ML2480B-003	Rear Mount, right, dual (for ML248xB models)
ML2480B-005	Front Handle (for ML248xB models)
ML2480B-006	Rear Mount Input A on ML2487A
ML2480B-007	Rear Input A and Reference on ML2487A
ML2480B-008	Rear Mount Inputs A, B and Reference on ML2488A
ML2480B-009	Rear Mount Inputs A, B on ML2488A
ML2480B-015	Factory Fitted 50MHz and 1GHz Calibrator (required by MA2411B Sensor)
ML2480B-098	Calibration to Z540, ISO Guide 25
ML2480B-099	Premium Calibration
13000-00238	Extra Operation manual ML2480B/90A
13000-00239	Extra Programming manual ML2480B/90A

Options 1, 3, 5 are mutually exclusive for any given ML2480B/90A  
Options 6, 7, 8 and 9 are mutually exclusive for any given ML2480B/90A

### ML2430A Series

ML2400A-01	Rack Mount, single unit
ML2400A-03	Rack Mount, side-by-side
ML2400A-05	Front Bail Handle
ML2400A-06	Rear Mount Input A on ML2437A
ML2400A-07	Rear Input A and Reference on ML2437A
ML2400A-08	Rear Mount Inputs A, B and Reference on ML2438A
ML2400A-09	Rear Mount Inputs A and B on ML2438A
633-19	NiMH Battery
2000-996	Desktop Battery Charger with power supply
2000-1534-R	Desktop Battery Charger (For use in Japan only)
2000-1538-R	3m Sensor Cable
2000-1539-R	5m Sensor Cable
2000-1540-R	10m Sensor Cable
2000-1541-R	30m Sensor Cable
2000-1542-R	50m Sensor Cable
2000-1543-R	100m Sensor Cable
2000-1545	Bulkhead Adapter
10585-00001	Extra Operation and Programming Manual ML2437/8A
10585-00003	Maintenance Manual ML2400A Series
ML2400A-98	Calibration to Z540, ISO Guide 25
ML2400A-99	Premium Calibration
ML2400A-30A	Option 30, Extra Operation/Prog manual (For use in Japan only)

Options 1 to 5 are mutually exclusive for any given ML2430A unit.  
Options 6, 7, 8 and 9 are mutually exclusive for any given ML2430A unit.

Pulse/modulated performance only specified with 1.5M sensor cable length option.

Software upgrades, Labview drivers and application notes can be downloaded from the Anritsu web site at [www.Anritsu.com](http://www.Anritsu.com)

### Standard Accessories

- PowerMax (ML249xA and ML248xB only)
- PowerSuite (ML243xA only)
- Power Cord for destination country
- One 1.5m sensor cord per meter input
- Operation Manual
- Programming Manual
- Certificate of calibration (also included with sensors)

## General Options and Accessories

760-209	Hardside Transit Case
D41310	Soft Carry Case with Shoulder Strap
2000-1535	Front Panel Cover
2000-1536-R	0.3m Sensor Cable
2000-1537-R	Spare 1.5m Sensor Cable
2000-1544	RS232 Bootload Cable

## Power Sensor Models

MA2472D	Standard diode sensor (10 MHz to 18 GHz, -70 dBm to 20 dBm)
MA2473D	Standard diode sensor (10 MHz to 32 GHz, -70 dBm to 20 dBm)
MA2474D	Standard diode sensor (10 MHz to 40 GHz, -70 dBm to 20 dBm)
MA2475D	Standard diode sensor (10 MHz to 50 GHz, -70 dBm to 20 dBm)
MA2442D	High accuracy diode sensor (10 MHz to 18 GHz, -67 dBm to 20 dBm)
MA2444D	High accuracy diode sensor (10 MHz to 40 GHz, -67 dBm to 20 dBm)
MA2445D	High accuracy diode sensor (10 MHz to 50 GHz, -67 dBm to 20 dBm)
MA2481D	Universal sensor (10 MHz to 6 GHz, -60 dBm to 20 dBm)
MA2482D	Universal sensor (10 MHz to 18 GHz, -60 dBm to 20 dBm)
MA2490A	Wideband sensor (50 MHz to 8 GHz, -60 dBm to 20 dBm)
MA2491A	Wideband sensor (50 MHz to 18 GHz, -60 dBm to 20 dBm)
MA2411B	Pulse Sensor (300 MHz to 40 GHz, -20 dBm to 20 dBm)

MA24002A	Thermal Sensor (10 MHz to 18 GHz, -30 dBm to 20 dBm)
MA24004A	Thermal Sensor (10 MHz to 40 GHz, -30 dBm to 20 dBm)
MA24005A	Thermal Sensor (10 MHz to 50 GHz, -30 dBm to 20 dBm)
MA24106A	True-RMS USB power sensor (50 MHz to 6 GHz, -40 dBm to 23 dBm)

## General Options and Accessories (USB Sensor)

2000-1566-R	1.8 meter USB A to Mini-B cable
2000-1593-R	3 meter USB A to Mini-B cable
2000-1594-R	5 meter USB A to Mini-B cable
2300-512	MA24106A Installation CD

## Available Options (USB Sensor)

MA24106A-097	Option 97, Accredited calibration
MA24106A-098	Option 98, Standard calibration to Z540, ISO Guide 25
MA24106A-099	Option 99, Premium calibration

See your Anritsu Representative or Components catalogue for available Attenuators, Limiters, Coaxial adapters, Waveguide-to-Coaxial adapter, Splitters & Dividers, Loads, Bridges, Open/Shorts, and Calibrated Torque wrenches.

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