

# Power Sensors for Every Application



## High Accuracy Diode Sensors: MA2440D

With its built in 3 dB attenuator, the MA2440D minimizes input VSWR and are best used where the best measurement accuracy is required over a large dynamic range, for example when measuring amplifiers. High accuracy diode sensors have a dynamic range of 87 dB compared to the 90 dB of standard diode sensors. In all other respects the performance of the sensors is identical to the standard diode sensor.

## Universal Power Sensors: MA2480D

The MA2480A series are true RMS sensors with a dynamic range of 80 dB. These power sensors can be used for average power measurements on multi-tone or W-CDMA signals. The sensor architecture consists of three pairs of diodes, each one configured to work in its square law region over the dynamic range of the sensor. Option 1 provides TDMA measurement capability, calibrating one of the diode pairs for linearity over a wide dynamic range.

## Thermal Power Sensors: MA24000A

The Anritsu MA2400XA series thermal sensors provide excellent power measurement accuracy over 50 dB of dynamic range. Thermal sensors use Seebeck elements where the combined effect of a thermal gradient and charge migration between dissimilar metals gives a true reading of the average power of any incident waveform. Anritsu thermal sensors have class leading SWR and built in EEPROM with calibration factor and linearity correction data. This results in assured accuracy when measuring any signal.

## Sensor EEPROM

All Power Sensors through 50 GHz store calibration data and model information within internal EEPROMS. The user calibration factor tables allow extra frequency points or compensation for couplers and power attenuators.

## High Power Applications

Traditional high power sensors are expensive and have degraded accuracy specifications. What's more, annual calibrations require more time and expense. Using the new User Calibration Factor Tables avoids these problems. They can easily reduce operating costs and save time:

- Any attenuator or coupler can be compensated by entering frequency and attenuation values into the internal EEPROM.
- The attenuation device can be semi-permanently attached. The power meter automatically applies compensation during the 0.0 dBm, 50 MHz calibration reference process.
- User Calibration Factor Tables are easily deactivated – allowing the power sensor to be used as a stand-alone device.
- Up to six tables can be stored.

## Sensor and Power Meter Selection

Sensors	Standard Diode	(High Accuracy) Diode	Universal	USB	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 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 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 8 GHz  <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	<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					<7% 50 MHz to 300 MHz <3.5% 0.3 GHz to 18 GHz

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.

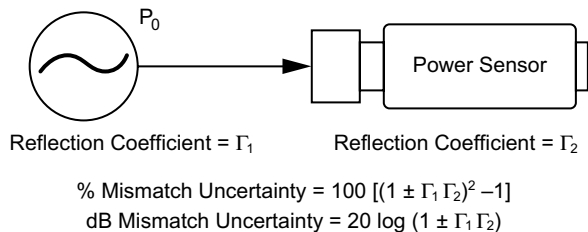
	MA2440D	MA2491A	MA2470D
Instrumentation Accuracy	0.50%	0.50%	0.50%
Sensor Linearity	1.80%	3.50%	1.80%
Noise, 256 Avg.	0.00%	0.00%	0.00%
Zero Set and Drift	0.00%	0.00%	0.00%
Mismatch Uncertainty	3.84%	4.49%	4.49%
Sensor Cal Factor Uncertainty	0.79%	1.59%	0.84%
Reference Power Uncertainty	1.20%	1.20%	1.20%
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.

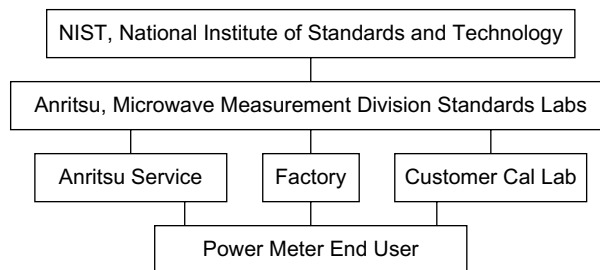


Mismatch is easily calculated in either dB or percentage terms from the source's and sensor's respective reflection coefficients.

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) 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
2000-1603	NiMH Battery
2000-996-R	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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