Power Meters and Monitors

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General

Power measurements at RF and microwave frequencies may be divided into low, medium and high power levels. At low levels power is measured directly using diode or thermocouple detection elements. At medium (1 Watt) power levels an attenuator is inserted between the source and detector. For high power measurements, or when power is measured “in-line” a directional coupler is used to sample a portion of the power being developed. Accurate power measurements depend not only on the accuracy of the detection element itself but more importantly on the total measurement uncertainty of all the components (adapters, couplers, cables, etc.) that are used to make the measurement.

Design Of The Detector

The power absorbed by a mount when connected to a “perfect” 50 ohm source is, by definition, true power. Any power reflected due to the VSWR (Voltage Standing Wave Ratio) of the mount, any variation in the amount of reflected or absorbed power with frequency, and any variation in the conversion efficiency of the mount with frequency are accounted for in the calibration factor. Calibration factor is the ratio of the measured (or indicated) power at a given frequency to the true (or actual) power which would be delivered from a perfect 50 ohm source. A detector’s ability to measure power accurately is based on the design of the complete structure. Power that is reflected due to the VSWR and power that is absorbed into the walls and connections within the mount all degrade the efficiency and accuracy of the detector.

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Mismatch Uncertainty

When making power measurements, if the VSWR of both source and detector are not equal to 1.0:1 (which is impossible), there can be additional power reflected due to the impedence mismatch. This leads to a potential source of measurement error called mismatch uncertainty.

From the example to the right it can be seen that an accurate power measurement depends on the VSWR of the source and the detector. A simple method to improve the accuracy of this measurement is to use a high quality, low VSWR attenuator such as the Narda Model 779 or 4779 Series Attenuators. Readings would be adjusted by the amount of attenuation added.

Mismatch uncertainties become more complex when performing reflected power measurements. On the right is the method for calculating these uncertainties.

What can be rapidly seen from the equation is that directivity is the most critical value when performing reflected power measurements on a low reflection device. Conversly, the source VSWR will be the most critical factor when measuring devices with a high reflection. The figure on the right depicts the effects of directivity on a reflection measurement. When measuring a device with a reflection value of approximately 25 dBr (1.12:1 VSWR), the uncertainty of your measurement would be reasonable only if your measurement directivity is at least 35 dB. The example on the right depicts how overall accuracy degrades as the real return loss value approaches the directivity value. While it is not a significant error for 5 or 10 dBr, it becomes significant at 20 dBr and critical at 25 dBr. A general rule that can be employed is you will need at least 10 dB more in directivity than the value of return loss you are testing for, in order to obtain accurate results. The Narda Model 8450 specifies a minimum of 30 dB directivity therefore, it is accurate to measure cellular systems where the antennas are typically specified at a 1.4:1 VSWR (15.5 dBr).

Power Meter Measurement Uncertainty

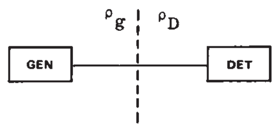
The Mismatch Uncertainty for this measurement in dB is:

$$M_{\mu dB} = 20 \log (1 \pm \rho_g \rho_D)$$

where: M_μ = mismatch uncertainty (maximum) in dB.

ρ_g = Generator Reflection Coefficient, RHO.

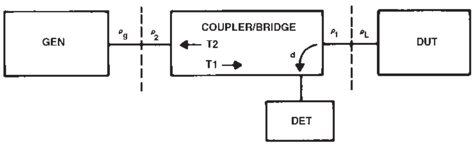
ρ_D = Load (Detector) Reflection Coefficient, RHO.



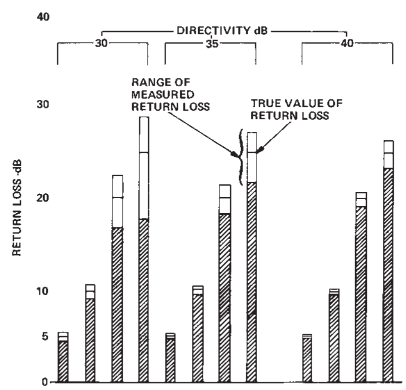
Reflection Measurement Uncertainty

A typical reflection measurement set-up is shown below. The measurement uncertainty of this set up, in terms of a measurement of a reflection coefficient, RHO is:

$$M\mu = d \pm \frac{(\rho_g T_1 T_2 + \rho_1)}{(1 - \rho_g \rho_2)} \rho_L^2$$



$T_{1\&2}$	" Through transmission of coupler/bridge	$= 10^{\left(\frac{-\text{Ins. Loss in dB}}{20}\right)}$
d	" Directivity of coupler/bridge	$= 10^{\left(\frac{-\text{Directivity in dB}}{20}\right)}$
DUT	" Device under test	



8400 Series
Portable Power Meter

- **Compact, Portable**
- **Interchangeable Mounts**
- **Accurate to 26.5 GHz**
- **Field Replaceable Elements**
- **Rugged Design for Field Service**

Description

The 8400 Series Mini-Power Meter is an inexpensive, portable and battery operated power measurement system. Consisting of the model 8441 power meter, the model 8440-01 extension cable and one or more of the 842X series of power mounts, this system allows accurate measurements at frequencies up to 26.5 GHz[1]. Each 842X series power mount measures power over a 30 dB dynamic range and utilizes thermocouple based detection for true RMS averaged results, even with pulse modulated signals. Field service technicians have long used the 8400 series because of it's rugged cast aluminum housing, high accuracy and simple operation. Supplied in it's own cushioned carrying case, the 8400 series is small enough to be carried to remote transmitter measurement areas, yet accurate enough to be used to set output levels for communication systems. Each power mount is color coded to denote it's measurement range and the meter is supplied with corresponding color coded scales to simplify actual readings. Additionally, the model 8441 has a dBm to mW conversion chart mounted on it's rear panel, to allow conversions of measured levels.

Specifications

The Model 8441 Meter is a universal meter that can be used with 842X Series Power Mounts. The meter movement and front panel switches are protected by the shape of the cast aluminum housing that contains an easily accessible separate battery compartment. Readings are displayed on it's 1.5 inch (3.8cm) analog meter movement. Power mounts may be mounted directly on top of the model 8441 or through the Model 8440-01 extension cable. A complete operation and maintenance manual is supplied, along with a padded carrying case that houses the meter, ext. cable and one power mount.

[1] Previously available as a Model 8401 system. Units should now be ordered stating separate meter, extension cable and power mount part numbers.

Meter Type **Size** **Scales**	D'Arsonval 1.5 in (3.8 cm) 3, Color Coded
Dynamic Range	30 dB
Scale Ranges	0.1, 1.0, 10 mW
Scale Multipliers	x0.1, x1.0, x10
Battery Type **Life**	6.0V (2 ea.) NEDA 1410M 500 Hrs.
Size	4.7" x 2.7" x 1.75" 11.75 x 6.67 x 4.45 cm
Weight	1.3 lb., 0.6 kg
Accessories Supplied	Manual, Batteries and Carrying Case

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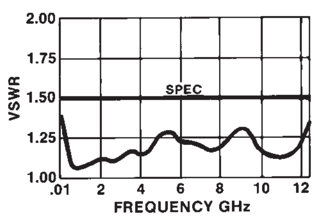
Specifications—Power Mounts

MODEL	FREQUENCY RANGE[a]	MEASURE-MENT RANGE	OVERLOAD CW	OVERLOAD PEAK	VSWR (MAX)	CONNECTOR	REPLACEMENT ELEMENT
8420	10 MHz to 12.4 GHz	1 μW to 1 mW	3 mW	0.1 W	1.5:1	Type "N" Male	818A
8421		10 μW to 10 mW	30 mW	3.0 W			819A
8422			300 mW	30 W			820A

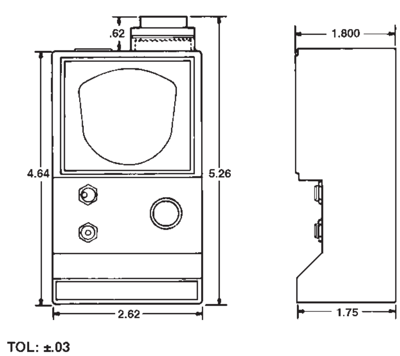
NOTES
a Frequency sensitivity all models ±0.5 dB
b Model 8427 VSWR, 50 MHz to 22 GHz - 1.5:1, 75 MHz to 20 GHz - 1.3:1
c Mates with SMA

Typical VSWR Performance

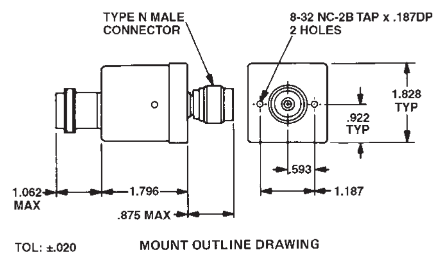


MODELS 8420, 8421, 8422

Outline Drawings



MODEL 8441



MODELS 8420, 8421, 8422

Integrated Thermocouple and Diode Power Monitors

- Broadband Frequency Coverage
- High Level Outputs
- Simplifies System Designs
- Excellent Stability, Accuracy
- Low Cost

Description

Narda integrated power monitors are complete, integrated power measurement subsystems which provide an output signal proportional to their RF input level. A system designer need only supply DC power to the RF power monitor for it to measure RMS average power levels. Measurements can be made over the designer's choice of 20 or 30 dB dynamic range with repeatable, accurate performance. All units are designed to operate in hostile RF environments and are sealed to reduce emissions of, and susceptibility to, stray RF signals. Input connectors are precision type "N" or 3.5mm connectors that comply with MIL-C-39012, and output connections are through a MIL-C-26284 type connector for environmental and EMC considerations. This design feature allows these units to be mounted close to high power output stages while maintaining accurate output readings. These power monitors operate from a wide range of supply voltages. Single ended supplies of either ±24 to 36 VDC unregulated, or dual supply voltages of ±12 to ±18 VDC regulated are acceptable for all thermocouple monitors. However special versions are available to match system supply voltages. These devices may be used as either constant current of constant voltage devices. In a system where variations of the resistance of the DC wiring may be encountered (such as through the slip rings of a rotating antenna system), or where the length of wire would cause a voltage reduction, a constant current source is desirable since any resistance, or resistance fluctuation would not affect the accuracy of the remote readout. In a system where the remote readout might be a high impedance device, such as a PC based data acquisition card the most desirable configuration is a constant voltage source. The choice of either a constant current or constant voltage configuration does not require any change or modification of the internal circuitry of the power monitor. Either configuration is obtained by proper wiring of the external circuitry. The supplied operation and maintenance manual contains numerous examples of external wiring configurations that may be employed.

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Specifications

MODEL NUMBER	426B	427B	460B	462B	466B	4491
FREQUENCY RANGE	10 MHz to 12.4 GHz					0.1 to 26.5 GHz
DETECTION	TRUE RMS AVERAGE					
DYNAMIC RANGE*	30 dB				20 dB	30 dB
MEASUREMENT RANGE	0.1 μW to 100 mW	1.0 μW to 1.0 mW	1.0 μW to 1.0 mW	100 μW to 100 mW	1 mW to 100 mW	10 μW to 10 mW
OVERLOAD CW PEAK	300 mW 30 W	3.0 mW 0.1 W	3.0 mW 0.1 W	300 mW 30 W	300 mW 30 W	30 mW 5.0 W
REPLACEMENT ELEMENT	820A	818A	818A	820A	820A	4813
OUTPUT CONNECTOR	15 PIN MS3116A-14-15P (mates with MS3116A-14-15S, Narda P/N 30931302)		18 PIN MS3116A-14-18P (mates with MS3116A-14-18S, Narda P/N 30931301)			

*Units can be configured for two or three 10 dB ranges or for a single 20 dB 0r 30 dB range

Common Specifications (All Units)

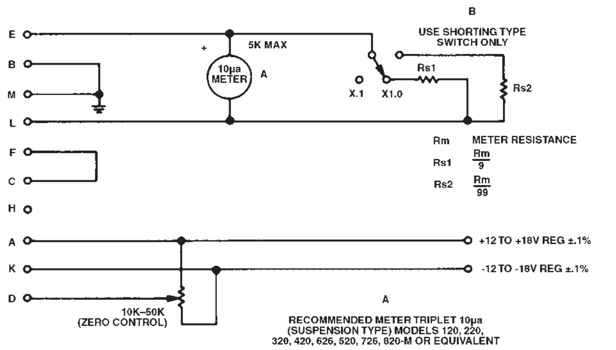
INPUT CONNECTOR	Type N male (Except 4491 - 3.5 male)
INPUT VSWR (max)	1.5:1 (except 4491*, 2.0:1)
ZERO OFFSET (typ)	.005%/C° on least sensitive range, 10dB higher on each lower range
LINEARITY	2% of full scale

*(50 MHz to 22 GHz 1.5:1)(75 MHz to 20 GHz 1.3:1)

Environmental Specifications

TEMPERATURE RANGE	Operating -55° to +85°C Non-operating -55° to +125°C
HUMIDITY	0 to 99% (Non-condensing)
ALTITUDE	0 to 30,000 ft.

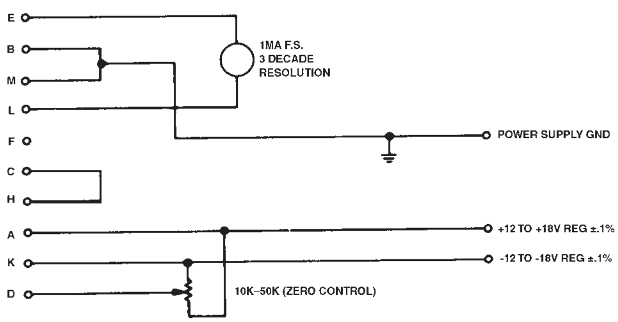
Typical Interconnection Diagrams



Constant Current Dual Supply, 3 Ranges

In this external wiring configuration, the RMS power monitors will generate a 0 to 100 mV output for each 10 dB range (x.1, x1, x10).

If the switch is left in the x.1 range, the RMS monitors will generate 0 to 1 V and 0 to 10 V if **operated** in the x1 and x10 power ranges, respectively.



Constant Current Dual Supply Connection, Single Range

In this external wiring configuration, the RMS power monitor will generate up to 1 mA of current. When operated in the most sensitive range it will generate 0 to 10 μA, mid range and 0 to 100 μA and in the least sensitive range 0 to 1 mA.

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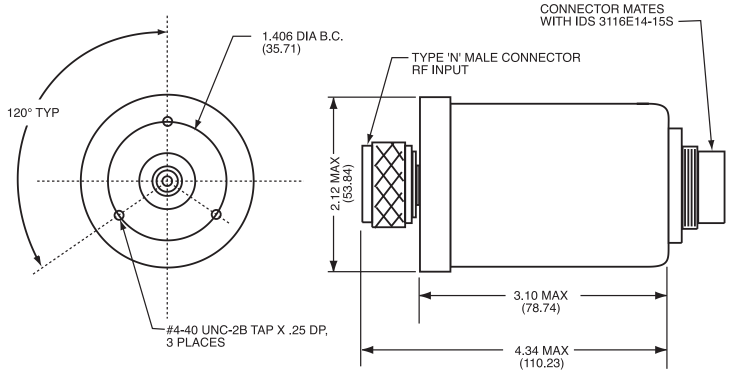
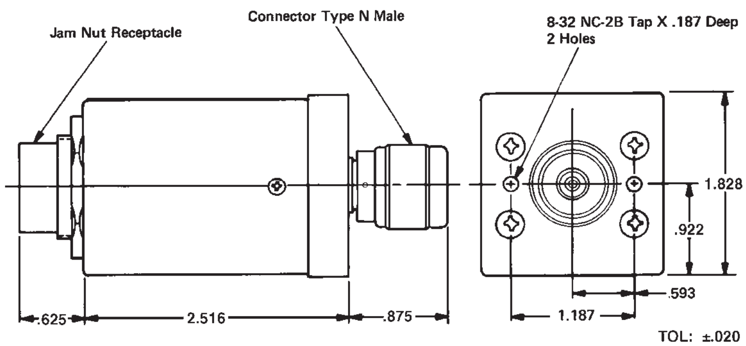
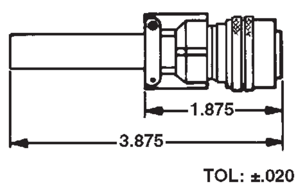
Outline Drawings



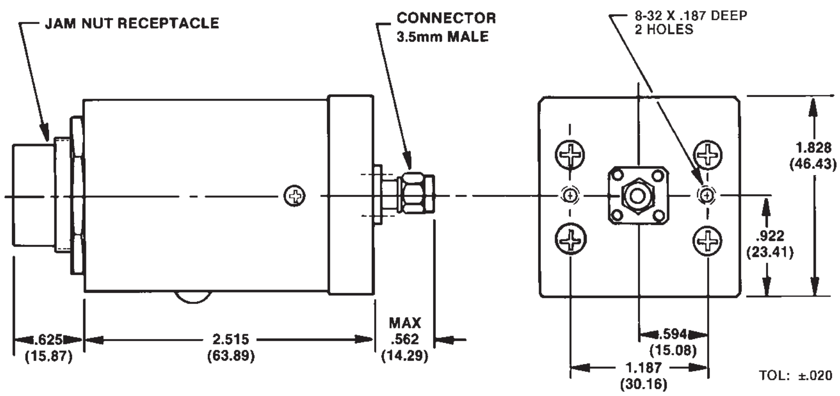
MODELS 426B AND 427B





MATING CONNECTOR
PART NO. 309313 (Accessory)

MODEL 460B SERIES AND MODEL 491



MODEL 4491

Dimensions in parentheses are in millimeters and are for reference only.