
Instruction Manual

Model 81041
USB Wattmeter



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SPECIFICATIONS AND LEADING PARTICULARS

The Model 81041 Directional USB Wattmeter is an accurate and portable insertion RF Wattmeter using plug-in power detectors and QUICK MATCH RF connectors, which measures forward and reflected CW power. The Model 81041 features a large scale, easily read meter movement in conjunction with a USB interface. Standard Ranges: 100 mW to 10 kW; 0.45-2300 MHz. Accuracy: +/- 5% of full scale

Specifications

Power Range	100 mW to 10 kW (FM, CW)
Frequency Range	0.45 MHz to 2300 MHz
VSWR	1.05:1 max. (with type N connectors)
Accuracy	±5% of full scale
Impedance	50-Ohms
RF Connectors	Type N Female standard (see note below)
Dimensions (H x W x D)	7.3 in. (18.5 cm) x 5 in. (12.7 cm) x 4 in. (10.2 cm)
Weight	4.5 lbs. (2.05 kg.)
Case Finish	Textured Blue Polyurethane Enamel
USB Interface Software	Included, requires Windows® Vista, 2000, XP or NT
USB Cable	Included, 6 ft USB A to B
USB Power Consumption	Less than 100 mA @ 5 VDC (via PC/USB Cable)

GENERAL DESCRIPTION

1. PURPOSE AND APPLICATION

1.1 **PURPOSE.** The Model 81041 is a directional RF wattmeter which measures RF power flow and load match in coaxial lines. It is for use with CW and FM modulation envelopes, but is not for use on pulsed/digital transmitters or for peak power measurements with AM or SSB modulation.

1.2 **APPLICATION.** The wattmeter is designed for 50-ohm applications. The insertion VSWR of this equipment is very low, less than 1.05:1 for frequencies up to 2300 MHz in a 50-ohm circuit. The analog meter is direct reading, expanded down scale for easy reading. The fifty divisions are graduated for 25, 50 and 100 full scale. By adjustment of the decimal point, these graduations may be used for any plug-in elements that are provided with this equipment. The USB PC interface provides a graphic display of forward and reflected power in watts and dBm as well as VSWR and Return Loss in dB. The display features numeric, simulated analog meter movement and color-coded bar graph data.

2. DESCRIPTION

2.1 **WATTMETER UNIT.** The Model 81041 includes a USB interface module, meter, dual socket line section with quick-match RF connectors contained in an aluminum housing. The unit has four bumper feet on the base. The USB type A jack is located on the rear panel. For mechanical protection, the meter is shock mounted. Below the meter is a socket for the plug-in detector elements and a switch to change the meter readings from forward to reflected.

2.2 **CONNECTORS.** Model 81041 is normally supplied with type "N" female connectors as specified above. To avoid measurement errors caused by the use of "between series adaptors" we recommend the use of proper QUICK-MATCH connectors.

2.3 **PLUG-IN DETECTOR ELEMENTS.** To make RF power measurements, the plug-in detector Elements are inserted in each socket of the line section. Each Element is designed for a particular RF power and frequency range. The high power Element is inserted in the socket marked "Forward" and the lower power Element is inserted in the socket marked "Reflected." The arrow indicates the direction of power flow.

2.4 **METER SCALE.** The analog meter scale, as described above, is read according to the full-scale rating indicated on the cap of the plug-in element. The PC will display the precise forward or reflected power in watts and dBm and automatically calculate SWR and Return Loss. The software allows the user to enter the full-scale rating indicated on the plug-in elements for both forward and reflected power.

3. THEORY OF OPERATION

3.1 TRAVELING WAVE CONCEPT. The operation of this wattmeter is based on the traveling wave concept of RF transmission. As RF is applied to a transmission line, there is a forward wave traveling from the transmitter to the load, and a reflected wave traveling from the load to the transmitter. The closer the load is matched to the transmission line, the smaller the reflected wave will be. To determine the RF power dissipated in the load, it is necessary to determine the RF power of the forward wave and the RF power of the reflected wave. The difference between the two will indicate power absorbed by the load.

3.2 TRAVELING WAVE VERSUS STANDING WAVE. The interference between the forward and reflected waves produces a standing wave in the system. In the standing wave concept, VSWR (voltage standing wave ratio) is a widely used tool. This is a simple relation between forward power, reflected power and VSWR.

Let W_f represent the forward power
 W_r represent the reflected power

Then

$$VSWR = \frac{1 + \sqrt{\frac{W_r}{W_f}}}{1 - \sqrt{\frac{W_r}{W_f}}}$$

For example: 1% reflected power is about 1.2:1 VSWR and 10% is about 2.01:1 VSWR

This calculation is automatically performed by the PC when using the USB software.

It can be seen that the VSWR is an index of the magnitude of the mis-match between the source and the load. However, the quantities of W_f and W_r are also an indication of the mis-match and are read directly on the 81041 analog meter.

3.3 COUPLING CIRCUIT. When the wattmeter is inserted in a transmission line the RF power flows thru a precision section of 50-ohm air line. The element installed in the line section socket is coupled capacitively and inductively to the main line. Voltages proportional to the RF voltage and current in the main line are therefore induced in the element circuitry. The coupling is so adjusted that the induced voltages add in the sensitive direction and cancel for the opposite direction. These voltages are rectified and the resulting DC current is applied to the analog meter, which is calibrated to represent the RF power in the main line. These same voltages are simultaneously coupled to microprocessor-based circuitry that measures the voltages and converts them into an appropriate USB format for personal computers.

INSTALLATION

1. UNPACKING AND CHECKING

1.1 CHECKING. Check all components of the wattmeter for damage. Give particular attention to the meter in the wattmeter unit, the QUICK MATCH connectors, and the USB cable ends.

2. GENERAL

2.1 HANDLING PRECAUTIONS. Take reasonable precautions when handling the wattmeter unit and the plug-in detector elements. When moving or carrying the wattmeter unit, rotate the plug-in detector element that is installed in the built-in line section so that the arrow is pointing down. This will shunt the meter connection circuit and damp needle movement during handling or shipping. Do not drop or bump the wattmeter. Though the meter is shock-mounted in the case, its delicate mechanism can be damaged by severe impact. Use reasonable care when handling the plug-in detector elements. Dropping and rough handling may change the calibration of the elements.

3. INSTALLATION

3.1 DIRECT INSTALLATION. RF connections may be made directly to the quick-match connectors mounted on the internal line section. Make connections with any suitable coaxial cable of 50-ohm impedance. Connect the power source to one side of the wattmeter and connect the load to the opposite side. The 81041 is a bi-directional device. Power source and load can be connected interchangeably, since the direction (of the arrow) of the plug-in detector element determines the direction of power measured. Refer to page 6 for the dimensions of the wattmeter unit. Use only 50-ohm impedance cables for making connections to the wattmeter unit. Impedance mis-match can introduce inaccuracies in the power reading.

3.2 SOFTWARE INSTALLATION. Insert the installation CD into a personal computer operating with Windows Vista, XP, NT or 2000. Insert the USB cable into the jack on the rear of the 8041 and to any available USB port on the computer. There is no need for RF connections or power at this point. Most systems will recognize a new device is connected and will automatically load the drivers into the appropriate pc directories from the CD-Rom. All that remains is to install the USB software on the computer. Browse the CD-Rom to locate the installation executable which is /coaxial/setup.exe. Run the setup. Software installation is now complete. See the troubleshooting chart on page 12 if the drivers or software fail to load.

3.3 POWER REQUIREMENTS. The wattmeter requires no external source of power when not connected to a computer, since the analog meter operates on power sensed from the transmission line into which it is connected. When connected to a computer, the USB cable supplies all the power necessary. No additional source of power is required for USB operation. The unit contains no batteries or dry cells.

OPERATION

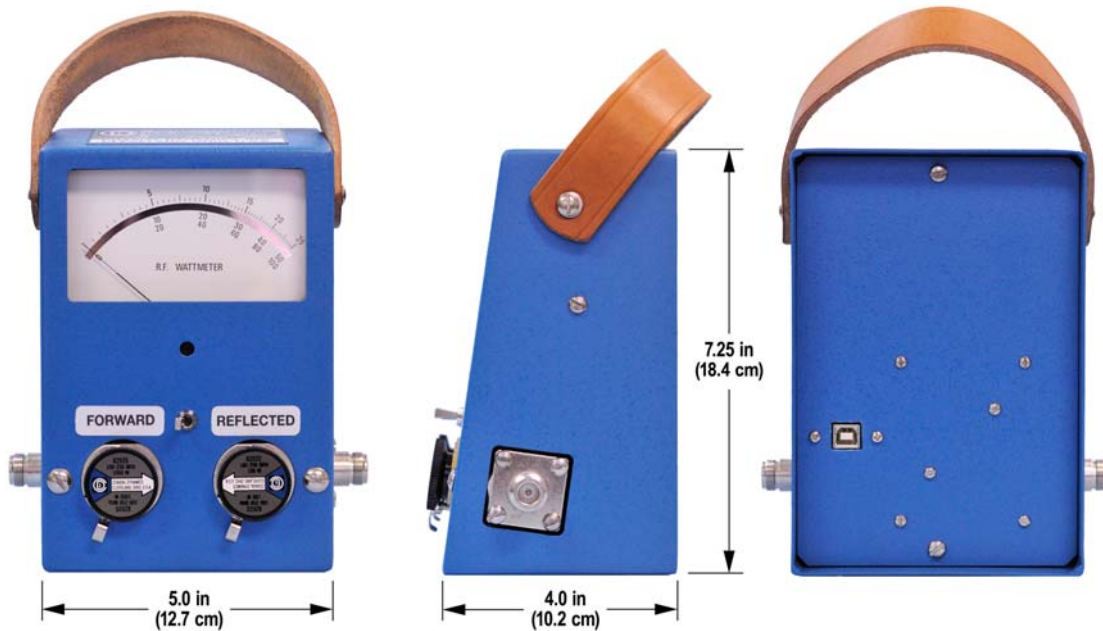


Figure 1 – Wattmeter Overall Dimensions

1. GENERAL OPERATING PROCEDURE

1.1 **WATTMETER READINGS.** To make readings with the wattmeter, it is necessary to select and install a plug-in detector element of the proper frequency and power range, connect the wattmeter into an RF line, and read the meter with the plug-in detector element in the forward and reverse direction. Subtraction of the reflected power from the forward power gives the power dissipated in the load. Detailed operating instructions are provided in this section.

SAFETY FIRST

HIGH VOLTAGE WARNING. When operating this equipment in conjunction with RF power of 200 watts or higher, the potential of the center conductor of the RF line section will be 100 volts or higher. Do not contact the center conductor. If cleaning becomes necessary, shut off the RF power.

1.2 **ZERO ADJUST METER.** Before installing the plug-in element and taking any readings with the analog meter on the wattmeter, it is necessary to zero adjust the analog meter under no-power conditions. Using a small screwdriver, turn the meter zero-adjust screw clockwise or counterclockwise as necessary so that the meter pointer exactly aligns with the zero of the meter scale.

1.3 PLUG-IN ELEMENT SELECTION AND INSERTION. Use plug-in detector elements that have a high enough power rating and the required frequency range to properly indicate the power flowing in both directions in the RF line. If the approximate RF power of the line is not known, start with an element, which will be sure to adequately cover the maximum RF power of the transmitter to prevent overloading the wattmeter. Substitute a more sensitive element for the first element if the indication is too low for accurate power determination.

1.4 ELEMENT REMOVAL AND INSERTION. The selected elements must be installed in the line section of the wattmeter unit connected into the RF line to be checked.

- (a) Open the latch that secures an element in the line section body of the wattmeter.
- (b) Hold the latch in the disengaged position and insert the plug-in element in the line section body. Return the latch to retain the element.

2. NORMAL OPERATING PROCEDURES

DETERMINING LOAD POWER. Use the following step-by-step procedure to determine load power.

2.1.1 Using the analog meter alone:

- (a) With the transmitter energized, the switch in the forward position and the elements pointing in their respective directions read the analog meter to determine forward power in Watts. The meter face is marked in three scales of 25, 50 and 100 full-scale readings. By adjusting the position of the decimal point, these scales provide direct reading of the values indicated when any plug-in detector element is inserted. If the meter indicates a power level too low for accurate reading, use a plug-in detector element with a lower power rating.
- (b) Flip the switch and the meter will then indicate reflected power in Watts.
- (c) To determine the power dissipated in the load, subtract the reflected power from the forward power. This step is necessary where appreciable power is reflected by the load, as is the case with many antennas. When a good load resistor is used, reflected power will be negligible and frequently unreadable.

2.1.2 Using the PC and USB Software:

- (a) Open the USB software program on the computer. Connect the USB cable from the wattmeter to the PC.
- (b) Enter the forward and reflected power in (Watts) of the plug-in elements in the window forms provided. Press Return or Enter to confirm each range.
- (c) Directly read forward and reflected power and VSWR on both the simulated meters and bar graphs.

2.2 DETERMINING VSWR (ANALOG METER ONLY). The analog meter on the wattmeter is not designed to provide direct VSWR readings. VSWR readings can be determined easily by the use of the provided graphs as follows:

- (a) Determine the forward and reflected power as described in paragraph 2.1.
- (b) Refer to the appropriate graph (Fig 3.) to convert the forward wattage readings and reflected wattage readings to VSWR. Note that the graphs convert the readings directly to VSWR without any intermediate computations.

SAFETY FIRST

When making low reflection readings, take care to insert the lower reading element so that it senses reflected power only. Do not rotate the lower reading element in the socket so that the unit is subjected to forward power. This will result in damage to the plug-in element, the micro ammeter, or both.

- (c) Select a pair of elements that has a power rating difference greater than 10 to 1 or at the very greatest, 25 to 1.

3. FREQUENCY RESPONSE

3.1 FREQUENCY CURVE. Each plug-in element of the wattmeter is designed to operate within a specific frequency range. The use of these elements to measure direct power outside of the stated frequency range is not recommended. The frequency response of the elements is flat over the designated range. The response generally falls off above and below the assigned frequency range, greater for lower power elements than for high-power elements.

4. TESTING LINES, CONNECTORS, FILTERS, AND RELATED COMPONENTS

4.1 TEST METHODS. Lines, connectors, filters and related components can be tested using the wattmeter. The method of testing used depends upon the circumstances involved for any particular test. Some of these tests are described as follows.

4.2 TESTING LINE USING LOAD RESISTOR. The standing wave ration or the reflected power-to-forward power ratio of a line can be determined by terminating the line with a good load resistor. Proceed as described in paragraph 2.1. Low reflected power may be measured as described in paragraph 2.3.

4.3 DETERMINING LINE ATTENUATION USING TWO WATTMETERS. Line attenuation (power lost by heat in the line) can be determined by inserting the line of unknown value between two wattmeters with the appropriate elements in each Wattmeter. The end of the line must be terminated by a load resistor. By comparing readings made at the two places, the attenuation of the line can be determined. Where very small values of attenuation are involved, allowances must be made for normal instrument error.

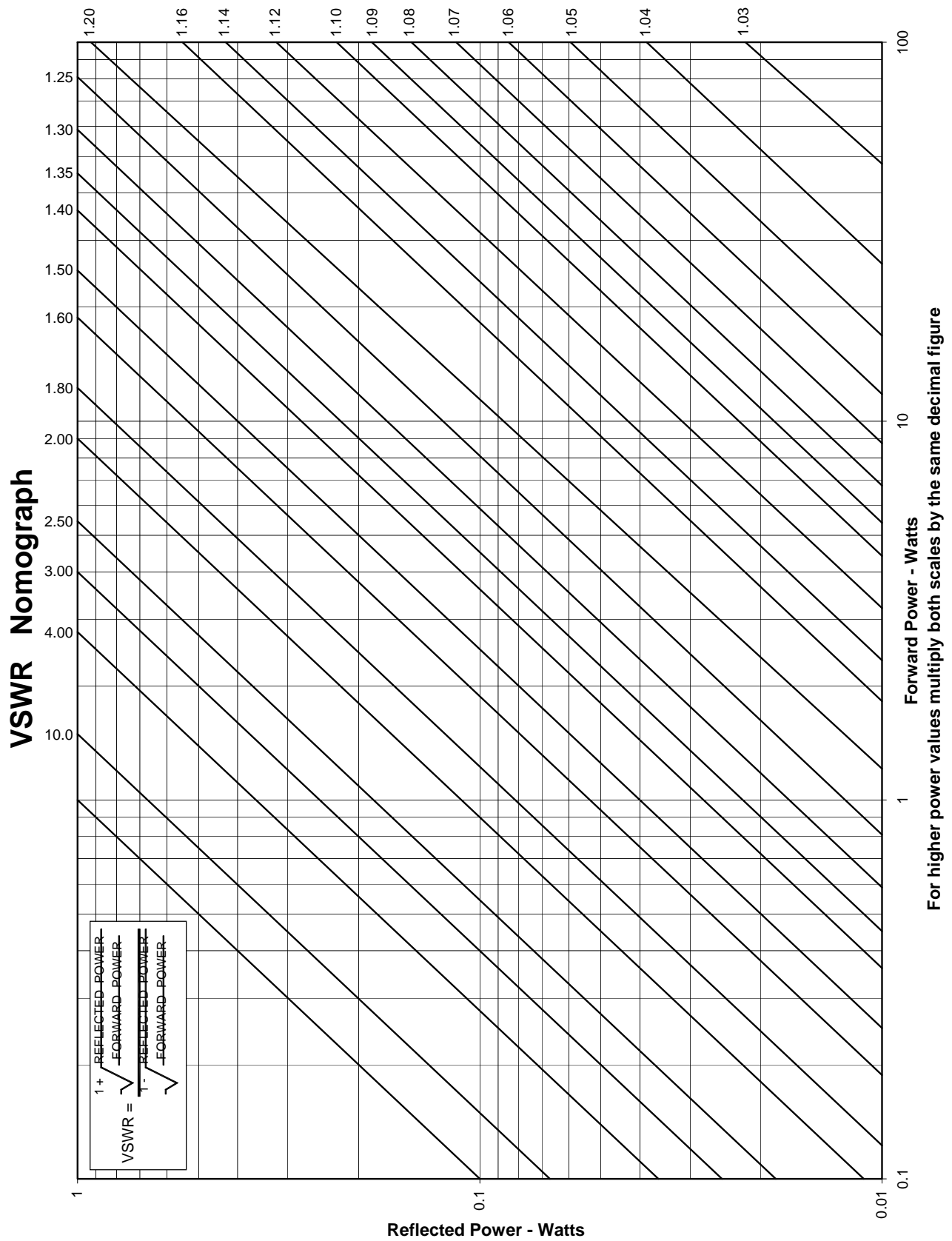


Figure 2 – VSWR Nomograph

MAINTENANCE

1. MAINTENANCE

1.1 SCOPE OF MAINTENANCE. Maintenance of the Model 81041 is normally limited to cleaning. The amount of cleaning necessary can be minimized by keeping the plug-in element in the socket of the line section as much as possible. This serves as an effective seal against the entry of dust and dirt. Cover the socket opening when the element is removed. Also, protect the RF connectors on the line section against the entry of dust and dirt by keeping them connected to the line or by covering them when the line is disconnected.

1.2 CLEANING. All contacts must be kept clean to assure low resistance connections to and within the unit.

1.2.2 CLEANING LINE SECTION SOCKET. Clean the inside of the line section socket bore and the entire circumference of the plug-in element with a cotton swab. Pay particular attention to the cleaning of the bottom rim of the element body and to the seat of the socket in the line section. When cleaning the socket bore, take care not to disturb the spring finger of the DC contact. If necessary, the spring finger of the DC contact can be adjusted manually. The button must be positioned out far enough to make good contact with the element body, but it must not restrict entry of the element body. Remove two machine screws that secure the DC jack to the line section. Remove the DC jack from the line section, taking care not to lose the small position bead that straddles the base of the phosphor bronze spring and nests in the counterbore on the side of the RF body. After adjusting to meet the requirements, make sure that the bead is properly inserted.

1.2.3 CLEANING INSIDE OF LINE SECTION. Check the inside of the line section for dirt and contamination. Clean the reachable portions of the line section with a cotton swab stick. Blow out the remaining dirt with low-pressure, dry compressed air. Do not attempt to remove the RF line center conductor from the line section. Any attempt to remove it will ruin the assembly.

2. TROUBLESHOOTING

2.1 TROUBLESHOOTING CHART. Refer to Table 1 for a listing of trouble that might occur during operation of the wattmeter. Probable causes and remedies for the troubles are also listed.

TABLE 1. TROUBLE SHOOTING CHART

TROUBLE	PROBABLE CAUSE	REMEDY
NO METER INDICATION	Arrow on plug-in element in wrong direction. No radio frequency power. No pickup from DC contact finger in line section. Open or shorted DC meter cable. Meter burned out or damaged.	Correct arrow direction. Check transmitter for faults. Adjust finger. Replace cable. Replace meter.
INTERMITTENT OR INCONSISTENT METER READINGS	Faulty load. Faulty transmission line. Dirty DC contacts on elements. Sticking or defective meter.	Correct fault in load. Correct fault in transmission line. Clean DC contacts. Replace meter.
HIGH PERCENTAGE OF REFLECTED POWER	Faulty load. Poor connectors. Shortened or open transmission line. Foreign matter in line section.	Correct fault in load. Check for high resistance connections. Correct fault in transmission line. Clean line section thoroughly.

