COAXIAL DYNAMICS, INC.

SPECIALISTS IN RF TEST EQUIPMENT AND COMPONENTS

MODEL 81050
MULTI-RANGE
RF WATTMETER

INSTRUCTION MANUAL

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SPECIFICATIONS AND LEADING PARTICULARS

The Model 81050 Directional Wattmeter is an accurate and portable insertion RF Wattmeter using a non-removable, rotatable detector element to measure forward and reflected CW power on 5 individually selected power ranges. Model 81050 is fitted with Quick Match connectors for added versatility.

SPECIFICATIONS:
MODEL 81050, BROADBAND DIRECTIONAL RF WATTMETER

Power Ranges	5, 15, 50, 150, 500 Watts, Full Scale (150 Watts maximum from 800-1000 MHz)
Frequency Range	25 to 1000 MHz
Accuracy	25 to 100 MHz, ±7% of full scale, using correction chart 100 to 512 MHz, ±6% of full scale, no correction required 512 to 1000 MHz, ±7% of full scale, no correction required
Insertion Loss	0.10 dB max., 25 to 512 MHz 0.15 dB max., 512 to 1000 MHz (with UHF female connectors)
VSWR	1.08 max., 25 to 512 MHz 1.12 max., 512 to 1000 MHz (with UHF female connectors)
Element	Broadband (25 to 1000 MHz, 500 Watt max.), rotatable for forward and reflected power measurements, non-removable
Nominal Dimensions	7.3" High x 5" Wide x 4" Deep (excluding connectors)
Weight	3.8 lbs
Case Finish	Nitro-Blue
Connectors	Quick Match, Type UHF Female normally supplied

GENERAL DESCRIPTION

With the New Model 81050 Directional Wattmeter you can now measure RF Power in 50 ohm coaxial cable and transmission lines without the need for additional plug in elements.

The Model 81050 comes complete with the same 4-1/2" taut-band meter movement, "Quick Match" RF Connectors, and precision line section that are used in our 81000-A/83000-A Wattmeter Series.

These features plus a special non-removable Broad Band Element allow Full-Scale Power measurement on any one of 5 selectable ranges or 5, 15, 50, 150 and 500 Watts across a frequency range of 25 to 1000 MHZ.

Versatile and reliable, the Model 81050 is also easy to use. Simply connect the Wattmeter between the RF Power Source and the antenna or "dummy" load, select the appropriate power range on the 5 position switch, and read the power directly on the mirrored-backed meter when the frequency is between 100 and 1000 MHz. Below 100 MHz, multiply the meter reading by the correction factor found on the chart on the back of the Wattmeter.

SECTION 1 PURPOSE AND APPLICATION

1.1 Purpose - The Model 81050 is a directional RF wattmeter, which measures power flow and load match in coaxial lines. It is for use with CW, AM, FM, and TV modulation envelopes, but is not for use on pulsed transmitters.

1.2 Application - The wattmeter is designed for 50 ohm application. The insertion VSWR of this equipment is very low, less than 1.12:1 for frequencies up to 1000 MHz in a 50 ohm circuit. The meter is direct reading, multi-range, and mirrored backed, for easy reading.

SECTION 2 DESCRIPTION

2.1 Wattmeter Unit - The Model 81050 includes a meter, a non-removable element, and a line section with quick match RF connectors contained in an aluminum housing. The unit has four rubber bumper feet on the base. For mechanical protection the microammeter is shock mounted. Below the meter is the detector element.

2.2 Connectors - The Model 81050 RF Wattmeter is normally supplied with Type UHF Female connectors as described above. To avoid measurement errors caused by the use of "between series adapters" we recommend the use of proper Quick Match connectors. Reference the 88000 series RF connectors on Page 11.

2.3 Meter Scale - The meter scale, as described above, is read according to the full scale rating as selected by the 5 position switch.

SECTION 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.

<u>3.2 Traveling Wave vs Standing Wave</u> - The interference between 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. There is a simple relation between forward power, reflected power, and VSWR.

$$\text{VSWR} = \frac{1 + \sqrt{\dfrac{\text{RFL POWER}}{\text{FWD POWER}}}}{1 - \sqrt{\dfrac{\text{RFL POWER}}{\text{FWD POWER}}}}$$

It can be seen the VSWR is an index of the magnitude of the mis-match between the source and the load. However, the quantities of forward and reflected power are also an indication of the mis-match and are read directly on the Model 81050 Directional Wattmeter.

<u>3.3 Coupling Circuit</u> - 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 inducted 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 meter which is calibrated to represent the RF power in the main line.

INSTALLATION

SECTION 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, to the threaded ends of the meter unit line section and to the cable ends. Report shortages or any damage promptly to your dealer or to the factory.

SECTION 2 GENERAL

2.1 Handling Precautions - Take reasonable precautions when handling the wattmeter. *When moving or carrying the wattmeter unit, rotate the detector element which 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 microammeter is shock mounted firmly in the case, its delicate mechanism can be damaged by severe impact.

SECTION 3 INSTALLATION

3.1 Direct Installation - Connection may be made directly to the quick match RF 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. Power source and load can be connected interchangeably, since the direction of the detector element selects whether forward or reflected power will be sensed by the meter. Refer to Figure 1 for 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. Calculations of inaccuracies resulting from impedance mis-match are discussed in paragraph 4.1 on page 9.

3.2 Power Requirements - The wattmeter requires no external source of power, since the meter operates on power sensed from the transmission line into which it is connected. The unit contains no batteries or dry cells.

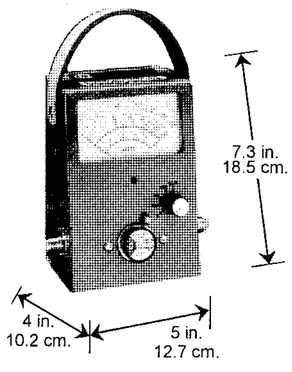


Figure 1 Wattmeter Overall Dimensions

OPERATION

SECTION 1 GENERAL PROCEDURE

1.1 Wattmeter Readings - To make readings with the wattmeter, it is necessary to select the proper power range, connect the wattmeter into a RF line, and read the meter scale which corresponds to the power range selected with the detector element in the forward and reverse direction. Subtraction of the reflected power from the forward power gives power dissipated in the load. Detailed operating instructions are provided in this section.

SAFETY FIRST

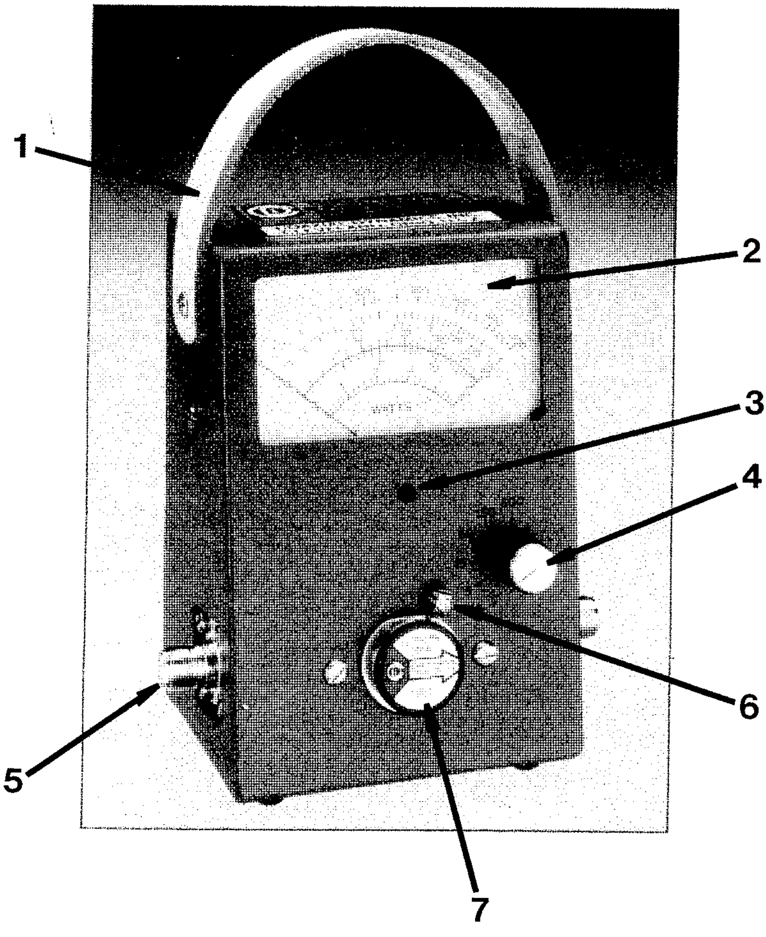
HIGH VOLTAGE WARNING. When operating this equipment conjunction with RF power of 200 Watts or higher, the potential of the center conductor of the RF line section will be 100 volts or higher. Do not contact the center conductor. If cleaning becomes necessary, shut off the RF power first.

1.2 Zero Adjust Meter - Before taking any readings with the wattmeter, it is necessary to zero the meter under no-power conditions. Using a small screwdriver, turn the meter zero-adjust screw (3) clockwise or counter-clockwise as necessary so that the meter pointer aligns exactly with the zero of the meter scale.

CAUTION

Do not use the 500 Watt range over 150 Watts at frequencies above 800 MHz.

1.3 Power Range Switch - The range switch should be placed in the highest power setting (i.e., 500 Watts). This is especially true when the amount of power being applied is unknown. After the RF power is applied the range switch may be switched down so that a power indication is given in the upper one-third of the scale.



1. Carrying Strap
2. Meter Assembly
3. Meter Zero-Adjust Screw
4. Power Selector Switch
5. Line Section RF Connector
6. Element Locking Assmelby
7. Installed Detector Element

Figure 2 Wattmeter Components

SECTION 2 NORMAL OPERATING PROCEDURES

2.1 Correction Factor - At frequencies below 100 MHz, a correction factor must be applied to the indicated reading to obtain a more precise power measurement. A correction factor table will be found on the back cover plate of the unit, or refer to the correction factor graphs on Pages 12 & 13.

2.2 Determining Load Power - Use the following step-by-step procedure to determine load power:

1.) With the transmitter energized, rotate the element so that the arrow on the element points in the direction of the load connection to the Rf line section. Read the meter to determine forward load power in watts. If the meter indicates a power level too low for accurate reading, rotate the range switch downward to a lower power rating.

2.) Rotate the element so that the arrow points in the direction of the power source connection to the line section. The meter will then indicate reflected power in watts.

3.) 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.

2.3 Determine VSWR - The wattmeter is not designed to provide direct VSWR readings. It is felt that VSWR readings are no more valuable than the ratio of forward to reflected power. In fact, most operators find that, in transmitter tune-up, antenna matching, and similar problems dealing with RF circuits, the forward power to reflected power ratio is a highly useful tool. However, VSWR readings can be determined easily by the use of the provided graphs as follows:

1.) Determine the forward and reflected power as described in paragraph 2.2.

2.) Refer to the appropriate graph 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.

SECTION 3 TESTING LINES, CONNECTORS, FILTERS, AND RELATED COMPONENTS

3.1 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 below.

3.2 Testing Lines Using Load Resistor - The standing wave ratio 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 2.2.

3.3 Determining Line Attenuation Using Two Meters - Line attenuation (power lost by heat in the line) can be determined by inserting the line of unknown value between two wattmeters or between two wattmeters' accessory line sections. If the latter method is used one wattmeter unit and one element can be used to make both readings. In either case, 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. Slight juggling of zero settings is permissible for convenience of eliminating computations, provided the readings are fairly high on the meter scale.

3.4 Determining Attenuation by Open Circuit Method - Attenuation can also be determined by the open circuit method. The wattmeter exhibits good equality between forward and reflected readings when the load connector is open or short circuited. When this is checked on an open circuit and an open circuit length of line of unknown attenuation is connected to the load connector, the new ratio shown is the attenuation in two passes along the line (down and back). This can be converted to decibels as follows:

$$\text{Attenuation (dB)} = \frac{10}{2} \log \frac{\text{forward power}}{\text{reflected power}}$$

The decibel reading must be halved because twice the line length is being measured (down and back). This measurement must be supplemented with a reflected power to forward power ratio check (paragraph 3.2) or with a DC continuity check or leakage check since open circuits or shorts may exist part of the way along the line.

3.5 Determining Attenuation Using Short Circuit Method - Attenuation can also be determined as described in paragraph 3.4 above by using a short circuit rather then an open circuit. The open circuit method is preferred because the initial equality (forward power to reflected power) is more easily achieved in an open circuit.

SECTION 4 IMPEDANCE MIS-MATCH

4.1 Impedance Mis-Match Computations - This wattmeter is designed to check power in a 50 ohm circuit. When the wattmeter is connected into the RF line, it inserts a section of 50 ohm line into that circuit. When this is inserted into a line having an impedance other than 50 ohms, the load on the transmitter will change because of the insertion. This change is not too serious if the power reflection factor is less than 10 percent or if the frequency is less than 200 MHz. At values higher than these, the insertion of the 50 ohm line will result in a very different load impedance even if the transmitter is tuned up with the wattmeter inserted into the line. The wattmeter will indicate zero reflection when the unit is connected into a 50 ohm pure resistive line. When a 70 ohm line is connected on the load side of the wattmeter, under ideal conditions, the 50-ohm wattmeter will indicate 3 percent reflected power or VSWR of 70/50=1.4. The wattmeter can show this same reflected percentage when a 50/1.4=35.7 ohm, pure resistive load is applied to the 50 ohm line. This could exist with 10 percent reflected power on the 70 ohm line (VSWR = 2). From this it can be seen that the 70 ohm line could have as much as 10 percent reflected power with a VSWR of 2.0, but the meter would indicate only 3 percent reflected power (VSWR = 1.4. If it is necessary to make wattage readings on a 70 ohm line with the 50 ohm wattmeter, it is especially important to subtract the reflected power from the forward power.

MAINTENANCE

SECTION 1 MAINTENANCE

1.1 Scope of Maintenance - Maintenance of the Model 81050 is normally limited to cleaning. The amount of cleaning necessary is kept to a minimum as the detector element is non-removable, sealing against the entry of dust and dirt. 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 ensure low resistance connections to and within the unit.

1.3 Cleaning of RF Connectors - Clean RF connectors with a cotton swab stick dampened with Inhibisol or Trichlorethylene.

SAFETY FIRST

Do not use any solvent other than Inhibisol or Trichlorethylene for cleaning the wattmeter. When using this fluid, avoid inhalation of fumes and avoid unnecessary and repeated contact with the skin. Make sure the cleaning area is well ventilated.

SECTION 2 TROUBLESHOOTING

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

TROUBLE	PROBABLE CAUSE	REMEDY
NO METER INDICATION	-Arrow on detector 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 line. -Clean DC contacts. -Replace meter.
HIGH PERCENTAGE OF REFLECTED POWER	-Faulty load. -Poor connectors. -Shortened or open transmission line.	-Correct faulty load. -Check for resistant connection. -Correct fault in line.

Table 1 Troubleshooting Chart

88000 Series RF Quick Match 50 ohm Connectors

88000	N Female
88001	N Male
88002	BNC Female
88003	BNC Male
88004	UHF Female
88005	UHF Male
88006	LC Female
88007	LC Male
88008	C Female
88009	C Male
88010	7/8" Swivel Flanged
88011	TNC Female
88012	TNC Male
88013	HN Female
88014	HN Male
88020	SMA Female
88021	SMA Male
88026	Miniature UHF Female
88027	SC Female
88028	SC Male

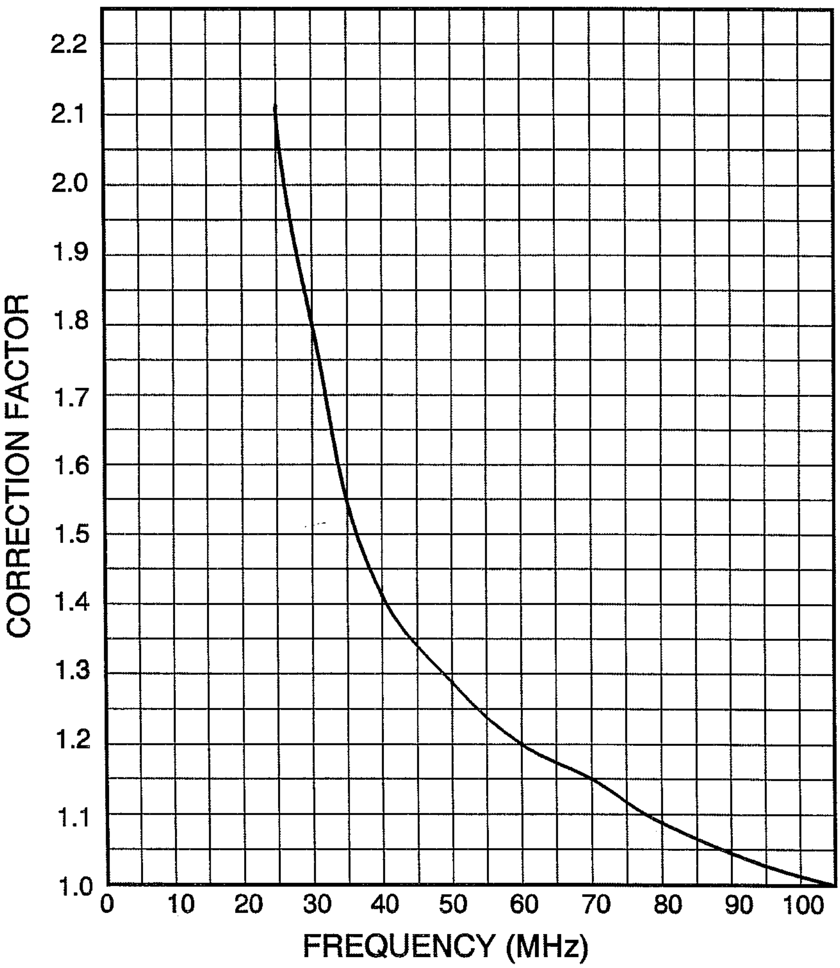
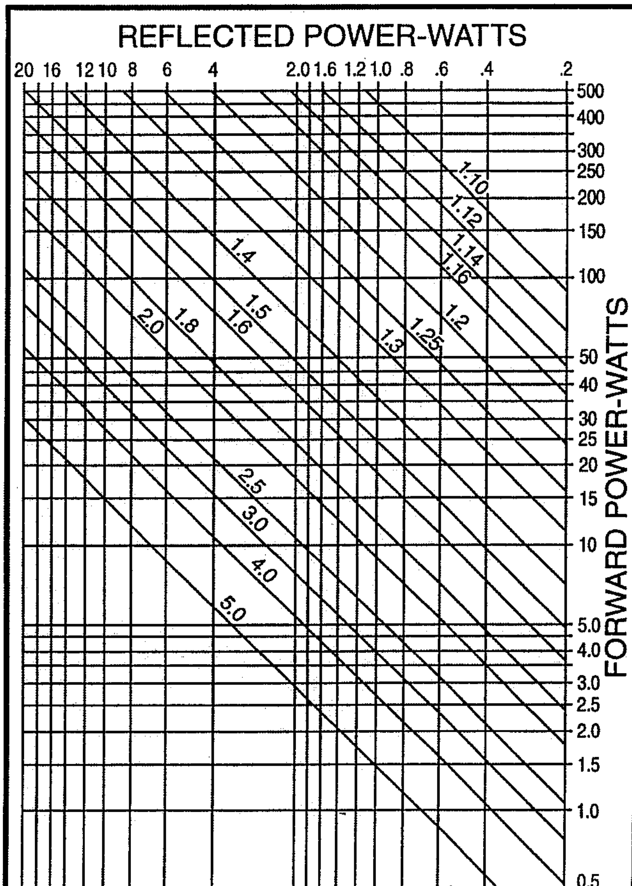


Figure 3 Frequency Calibration Chart



CORRECTION FACTOR

FREQ. (MHz)	25	30	40	50	60	70	80	100-1000
MULTIPLIER	2.15	1.80	1.43	1.29	1.20	1.15	1.09	1.00

Figure 4 VSWR Nomograph Chart

YOUR PRODUCT WARRANTY

WE TAKE GREAT PRIDE IN THE HIGH QUALITY OF OUR PRODUCTS AND WE WARRANT ALL RF INSTRUMENTATION PRODUCTS TO BE FREE FROM DEFECTS IN MATERIAL AND WORKMANSHIP FOR A PERIOD OF TWO YEARS FROM THE DATE OF SHIPMENT AND AGREE TO REPAIR OR REPLACE AT OUR OPTION ANY DEFECTIVE PARTS RETURNED TO US, TRANSPORTATION PREPAID, TO OUR CLEVELAND, OHIO FACILITY, PROVIDED OUR EXAMINATION DISCLOSES THAT DEFECTS ARE DUE TO DEFECTIVE WORKMANSHIP OR MATERIAL AND THAT THE EQUIPMENT HAS NOT BEEN MISUSED, ALTERED, REPAIRED, OR IMPROPERLY INSTALLED. CDI SHALL NOT BE LIABLE FOR CONSEQUENTIAL, CONTINGENT, OR INCIDENTAL DAMAGES WHATSOEVER, AND NO OTHER WARRANTY, EXPRESSED OR IMPLIED (EXCEPT TITLE) IS GIVEN. UNLESS PRIOR NOTICE OF SHIPMENT IS RECEIVED, ANY UNIT RECEIVED FOR REPAIR AFTER THE EXPIRATION OF THIS WARRANTY WILL BE SUBJECT TO NORMAL CHARGES FOR PARTS AND LABOR.

NOTES

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