

## *Radio Power Meter*



The Radio Power Meter (RPM) accurately measures the power delivered from a radio transmitter into a load (typically an aerial), and displays the level on an LED bar graph.

It can be used for the following purposes:

- To set the transmit power level
- To measure transmission losses in cables
- To locate cable faults and mismatches

The RPM has two TNC connectors, allowing it to measure power in-line, or into a dummy load. It actually measures the voltage across its terminals, but displays the level as power into a load impedance of 50Ω. It measures power levels from 15...31dBm in 2dB increments, but the scale also shows the power in watts and in dBµV.

The unit is self-powered, and does not require calibration. It is supplied with two leads and a dummy load.

## TO SET TRANSMITTER POWER

The transmit power into a dummy load is simply set by fitting the dummy load to one of the RPM connectors and linking the other connector to the transmitter, using the longer lead. The LED bar graph will indicate the power level delivered to the load. All LED's except the first will give a positive on or off indication. The first LED lights at approximately 25mW, but is not calibrated. The 2dB resolution is adequate for regulatory purposes, but if more accuracy is required the level should be adjusted until the LED indicating the target level is just lit.

When the level has been set the dummy load can be replaced by the aerial. Provided the aerial is a good impedance match the indicated level should remain unchanged.

Note that the RPM measures the peak signal voltage. The reading is only valid if there is no amplitude modulation, so it should only be used on FM, FSK and DPFSK modulation systems (it can be used on AM transmitters, provided the modulation is turned off).

Note also that the calibration of the meter assumes the voltage is measured into a 50Ω load. The calibration will not be true if the characteristic impedance of the system is anything other than 50Ω.

MPT1329 and EN 300 220-1 allow an Effective Radiated Power (ERP) of 500mW. If the aerial has gain, the transmit power should be turned down to compensate. However cable loss can also be a factor, which could allow the transmit power to be increased. The following table shows typical gains and losses:

Omni-directional half-wave dipole	0dB gain (e.g. ENF450)
Centre-fed folded dipole	0dB gain (e.g. CDF450)
Omni-directional co-linear	6dB gain (e.g. FUC/6) 10dB gain (e.g. FUC/10)
4 element Yagi	7.5dB gain (e.g. UHF/4)
8 element Yagi	10dB gain (e.g. UHF/8)
RG213 cable	0.15dB/metre loss @ 458MHz
½" foam dielectric low loss cable	0.015dB/metre loss @ 458MHz

For those unfamiliar with the terminology:

**dB** is a dimensionless figure, being  $10 \times \text{Log}(\text{Ratio})$ , which usually applies to power. Conversely,  $\text{Ratio} = 10^{(\text{dB}/10)}$ . For example, a gain of 2dB represents a ratio of 1.585:1.

**dBμV** is a power measurement, being the level in dB relative to 1μV into a stated load impedance (normally 50Ω), and is generally used to measure low level signals such as receiver sensitivity. Note that  $0\text{dB}\mu\text{V} = -107\text{dBm} = 0.02\text{pW}$ .

**dBm** is a power measurement, being the level in dB relative to 1mW, and is generally used to measure high level signals such as transmitter output power. Note that  $0\text{dBm} = 107\text{dB}\mu\text{V} = 1\text{mW}$ .

The RPM is calibrated to display the power level in dBμV, dBm and milliwatts. It should be clear from the scale that, for example, 6dB down on 500mW is 125mW.

## TO MEASURE CABLE LOSS

If there is a joint in the cable between the transmitter and the aerial, the PFM can be inserted at the joint to measure the power at this point. The difference between this and the power measured at the transmitter is due to cable loss.

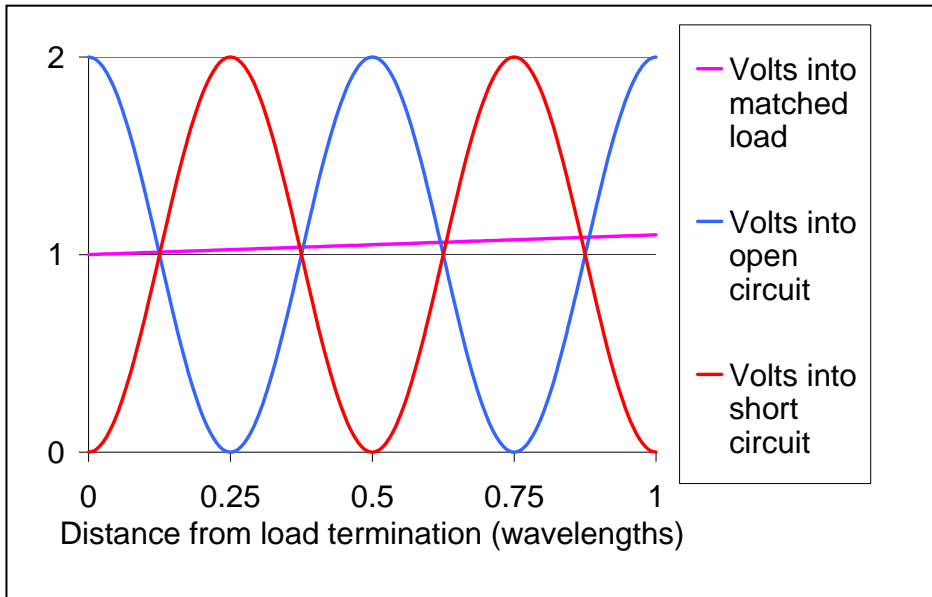
## TO LOCATE CABLE FAULTS

Before describing the method of locating faults, a basic understanding of transmission line theory is necessary:

If the cable length is significant relative to the signal wavelength, then a cable behaves as a transmission line rather than a simple resistive wire. The wavelength depends on the insulation used in the wire, but is approximately  $(450/F)$  metres for polythene insulation, where F is the signal frequency in MHz. Thus a 450MHz signal has a wavelength of about 1m.

Any given cable has a characteristic impedance, determined by the spacing between conductors, the size and shape of the conductors and the insulating material. RF cables are generally designed with a characteristic impedance of either 50Ω or 75Ω. If a cable is terminated at each end by a source and load that matches its characteristic impedance, then virtually all the power from the source will be transferred to the load. If there is a mismatch then some of the power will be reflected back from the load to the transmitter. At any given point along the cable the incident and the reflected signals will interact, adding in some places and subtracting in others.

The interaction of these signals gives rise to a standing wave along the length the cable, as illustrated in the following graph:



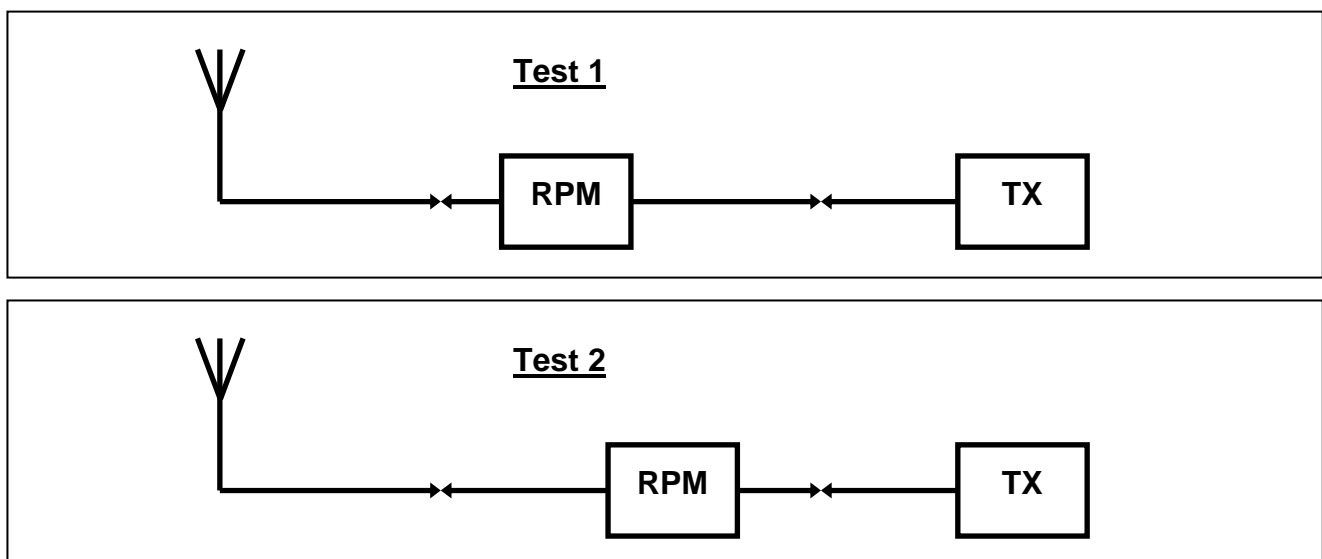
The graph shows that the voltage distribution along a cable that is correctly terminated exhibits a small attenuation which is proportional to distance. For example, the RG213 cable that is commonly used for UHF aerials loses about 0.15dB per metre, or 2% of the voltage per metre (@450MHz).

If the end of the cable is open-circuit, all of the incident power is reflected back, so a voltage standing wave is produced along the cable. The voltage is at a peak at the end of the cable, and varies from 0 to twice the normal level. A similar standing wave is produced if the end of the cable is a short-circuit, but the voltage at the end of the cable will be zero.

If the termination is any other impedance a standing wave will also be produced, by of a smaller amplitude.

It should be apparent from the graph that at certain points along the cable the voltage into a mismatch will be the same as that into a correctly terminated load. However, if an extra length of cable (say 0.125 of a wavelength) is added between the termination and the measuring point, the voltage will be different. For this reason the Radio Power Meter is supplied with two leads that differ in length by about 0.125 of a wavelength (at 450MHz).

The method of locating cable faults is thus to insert the RPM at a convenient point between the transmitter and the aerial and measure the transmit power. Then swap the leads and check again. If the displayed level remains unchanged the aerial is a good match. As a final test the aerial can be replaced by the dummy load to prove that the level again remains unchanged. This can be illustrated as follows:



## **COMPONENT PARTS:**

*Radio Power Meter  
30cm connection cable (TNC plug – TNC plug)  
15cm extension cable (TNC plug – TNC plug)  
Adaptor (TNC jack – TNC jack)  
50Ω dummy load (TNC plug)*

## **SPECIFICATIONS:**

**Size:** 112 x 62 x 32mm  
**Indicators:** 9 LED's  
**Calibration:** 15...31dBm in 2 dB steps (122...138dBμV or 25mW...1.25W)  
**Load Impedance:** 50Ω  
**Insertion Loss:** <1dB  
**Accuracy:** ±1dB  
**Frequency Range:** 100...900MHz  
**Connectors:** Two TNC 50Ω jacks  
**Power Supply:** None (self-powered)

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