



RF Power Meter v2

Operator's Manual

Rev 1.10 - Mar 2019



Warning: Do not leave the power meter connected to a high power RF source ($> 500\text{mW}$) for long periods of time (30 seconds or more). This will cause heating of the internal components of the meter which could affect long term accuracy. For long term tests of high power sources, use an external attenuator, and enter it's attenuation value into the meter's menu.

Introduction

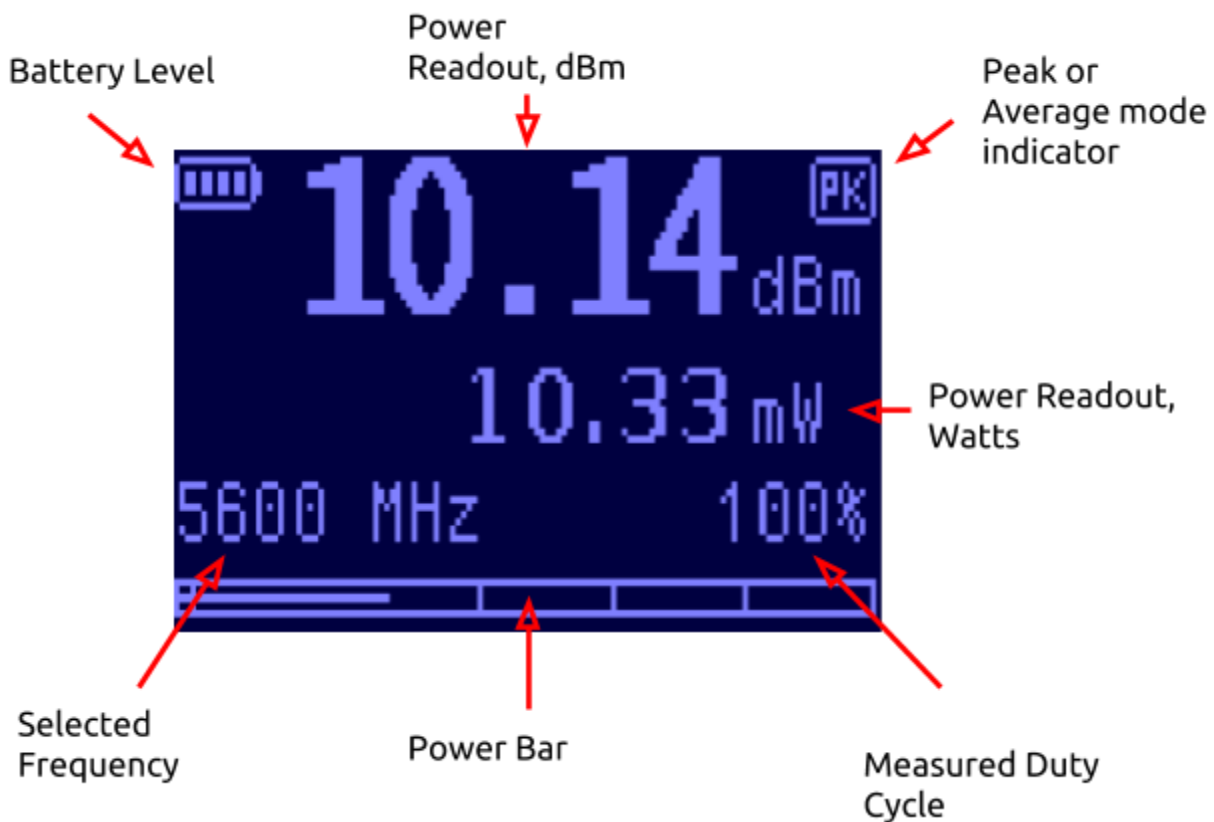
The Power Meter v2 is a low-cost, but accurate RF power meter designed for the FPV market.

It can be used to accurately measure power emitted by RF sources (Video Transmitters, R/C Radios) used in the FPV hobby.

Think of it as a way to 'see' RF power, something that is normally only available on test and measurement equipment costing upwards of \$1000 USD.

Meter Display Mode

The primary display mode of the meter shows the measured power level in dBm, and Watts, plus various other status indicators, as shown below:



Setup Menu

A short press on the joystick will enter the simple setup menu. Four options may be modified:

Menu Item	Description
MHz	Measurement Frequency, in MHz. <i>Be sure to enter the correct frequency in order to guarantee calibrated results.</i>
Mode	Measurement mode, Peak or Avg . Use Avg for continuous power measurements, e.g. Video Transmitters. Use Peak for pulsed power measurements, e.g. R/C Radios.
Attn	External attenuation correction. Use when an external attenuator is used to increase usable range.
Span	Time span of the Power Scope mode. This is the time, in milliseconds, of the horizontal timebase of the Power Scope.

The up/down joystick actions move between menu items. Click on any item to change its value.

For numeric items such as Frequency, and Attenuation, one click selects the item, and up/down changes the value.



PowerScope Display Mode

When in the main Meter display mode, rocking the joystick right enters the PowerScope display. The PowerScope shows an Oscilloscope-like display of measured power over time.

This is not useful for a video transmitter, which emits a fairly constant power level, but for a R/C tx it can be a useful tool.

Some examples of what it can show:

1. The relative strengths of each antenna in a multi-antenna R/C transmitter. Moving around the 'sniffer' antenna shows the location of the antennas, and their polarizations.
2. Transmitters which follow correctly the ETSI standards for 'Listen Before talk' (a requirement in most countries these days) show missing frames from time to time, so compliant transmitters are easy to spot.
3. Using a sniffer antenna, two R/C transmitters can be (roughly) compared. Installation issues with antenna modifications are easy to spot by comparing a known good transmitter, and the modified one.
4. The approx. frame rate of transmitters can be determined. Use the up/down joystick controls to change the span.



Note that the power display is auto-scaled to the full vertical space.

Sniffer Display Mode

When in the Power Scope display mode, rocking the joystick right enters the Sniffer display. Sniffer display mode is a tool for race directors to quickly judge transmitter power on the starting grid.

Described in more detail in 'Conducted vs. Radiated Power' below, this mode lets a reference level be set (using the 'up' joystick action), which can then be compared with levels from other quads.

For example, for a 25mW race, take a 'known good' quad/antenna pair, which is known to emit 25mW, and set the reference.

Then when walking down the start grid, put the sniffer antenna beside each quad's antenna, and judge whether the power is too high, or too low.

No, this is not calibrated, nor super-precise. The measurement varies depending upon where the sniffer antenna is placed relative to the transmitter antenna, but with a bit of practice it is a very useful tool.



A Word on Calibration

Any piece of test and measurement equipment requires calibration in order to present trustworthy values.

The RF Power Meter v2 is no exception, and it is fully calibrated in our factory before being shipped.

Due to variations in component behavior with frequency, especially in the multi-GHz range, the calibration of this meter is repeated on many spot frequencies.

In the critical 5.6-6GHz band, which is of importance to the FPV community, the calibration is repeated every 50MHz.

This does mean that if precise measurements are required, the meter must be set to a frequency that is as close as possible to the frequency setting of the transmitter.

Note that the power meter.. being a power meter, and not a frequency counter... cannot measure frequency. It needs to be told the measurement frequency.

For quick measurements, or measurements with the sniffer antenna, which are normally 'approximate' in nature, the frequency setting is far less critical.

Think in dBms, not mW!

It is a common mistake for hobbyists who deal with RF to think primarily in 'Watts', or 'milli Watts'. With products being sold labelled as '25mW', or '600mW', it is easy to understand why.

When dealing with RF though, it actually makes more sense to think in the logarithmic unit, the dB.

Why?, well let's think about the power required to fly twice as far, with the same received signal level.

In logarithmic terms, 'twice as far' equates to 4x the power, or 6dB. So if you have a 25mW vTx (14dBm), and you want to go twice the distance, you require a 14dBm + 6dB = 20dB power level, which corresponds to 100mW, and not the 50mW that one would expect when doubling 25mW.

This kind of calculation is far easier to do in your head with logarithmic units, than dealing with mW.

For a little more detail on this concept, refer to the blog on our website:

<https://www.immersionrc.com/rf-range-demystified/>

Conducted vs. Radiated Power

The RF power meter can be used to measure power two ways. One is 'Conducted Power', where the power meter is physically connected to the SMA connector of the RF source.

This measurement technique allows the full accuracy of the meter to be used, and will produce repeatable measurements.

Another way to measure power is to connect an antenna to the input of the meter, and measure radiated power (power transmitted through the air, with no physical connection).

This is interesting for two applications. One is comparing antennas, and even plotting radiation patterns for antennas.

The other is what we refer as the 'Scully Wand method', which works as follows:

In FPV racing, at least in 2017/2018 where quads are all DIY, and held together with bits of electrical tape, the chances of 100 pilots at a large race event emitting power levels in the order of 25mW, not much more, and not much less, is extremely low.

'Bad Video' on the first corner, is generally a sign that the u.FL popped off the transmitter, or that the clone antenna purchased from a dubious Chinese source actually contains factory-dust and nothing else.

'Who is on my channel' is generally a sign that at least one of the pilots forgot to switch down from 600mW, to the 25mW accepted from racing, and stomped on his racing competitors (this issue is generally resolved using a rather large hammer, using a technique known as 'Hammergate').

So the 'Scully Wand' method, developed by a legendary FPV race director/commentator, is to walk down the starting grid with a power meter, with 5.8GHz antenna attached, 'sniffing' the power from each quad.

The reading is not exact, but with a little practice the very low power transmitters, and the Hammergate transmitters can easily be weeded out before precious time is wasted re-running a race.

This technique works so well that we actually supply a small 5.8GHz whip in the power meter package.

Measuring Vtxs >1Watts

In order for the Power Meter V2 to measure >1W RF output power you will need to use an external attenuator, preferably one that allows the instrument to make best possible use of its measurement range. The attenuator will also need to be specified to work at the frequency you plan to be measuring, i.e. cheap, run-of-the-mill attenuators off of eBay are usually not suitable for use in the 5.8GHz band.

What you want to buy is an attenuator from a reputable manufacturer which preferably goes up to at least 6GHz, good brands to look for are Radiall, Pasternack, Amphenol, Telegartner, Huber & Suhner, Mini-Circuits, etc. Expect to pay upwards of \$25 for a 10dB 6GHz attenuator, or upwards of \$40 for a 10dB 18GHz attenuator.

If a 10dB attenuator is used you can measure up to 10W (provided the attenuator is up to the task) and still make proper use of the instrument's capabilities. Take note that using an attenuator that's too large won't help with the granularity of the measurement, as when using a 60dB attenuator it is like asking the Power Meter to listen to a whisper and understand what's being said.

Take note that when you make such measurements it is required to calibrate out the attenuator and any adapters or cables you plan to use, as obviously you'd want accurate results, not skewed by tolerances from the attenuator and losses from the adapters or cables.

Best way to do that is to use a lower power Vtx, with an RF output power of less than 1W, on the same band and channel as the higher power Vtx you plan to test and measure it without the attenuator, note down the exact output after it has settled (higher temperature usually causes output to drop, so give it a few minutes for the output to settle).

Now repeat this same measurement with the attenuator and any adapters or cables you plan to use and hook up the same, lower power, Vtx and measure the output again and adjust the attenuator value in the menu (Attn option) to best match the value you measured without the attenuator.

Now you can go ahead and measure the higher power Vtx and get an accurate reading, as you'll have calibrated out the attenuator's + adapter + cable tolerance, which can be as high as several dB. Your measurements should now accurately reflect reality!

USB Interface (CDC)

The power meter is equipped with a USB interface which implements the CDC stack.

Simple commands may be sent to the meter:

V	Query meter version
D	Query current average power, dBm
E	Query current peak power, dBm
F <i>(no arguments)</i>	Query current frequency
F<freqIdx>	Set current frequency based on index (0 = first supported freq., 1 = next, etc.)

To test the interface, a serial communications tool such as Putty may be used.

Specifications

RF Specifications	
Power Level	-20dBm -> +30dBm (1)
Calibrated Frequencies	35, 72, 433, 868, 915, 1200, 2400, 5600-6000MHz in 50MHz steps
Accuracy	+/- 0.5dB @ 25C
Attenuator	30dB Internal, no external attenuator required up to +30 dBm input power
Absolute Maximum Input Power	1.3W (31dBm), > 30 second use with > 500mW (27dBm not recommended)
Power	
Battery	3.7V Lithium Ion cell, 10440 size, 600mAh
Current Consumption	~35mA
Battery Life	~8 hours
Auto Shutdown	5 minute timeout
Charging	Micro USB cable
User Interface	
Display	OLED, 128x64 pixels, monochrome
User Input	Joystick
Interfaces	
USB	CDC Interface with limited control, and power readout
Accessories	
Antenna	5.8GHz 'Sniffer Antenna' (linearly polarized ~2dBi dipole).
Male-Male	Male to Male SMA adapter, to use for conducted power measurements

Notes:

- (1) For high power levels, exceeding 25dBm, try to avoid leaving the meter attached to the RF source for longer than 30 seconds, to avoid unnecessary heating of internal components, and potential damage.

Package Contents

- 1x RF Power Meter v2, with internal battery
- 1x Male->Male SMA adapter
- 1x 5.8GHz 'Sniffer' Antenna

