RF Power Meter v2

Operator's Manual

Rev 1.20 - Sep 2022

ImmersionRC is a member of the Orqa group of companies.

	Warning: Do not leave the power meter connected to a high power RF source (> 500mW) 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.

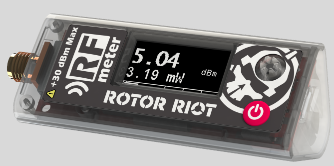
It can be used to accurately measure power emitted by RF sources (Video Transmitters, R/C Radios) used in the FPV hobby.

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 Versions

Three versions of the RF Power Meter v2 have been produced over the years. The white EU produced version being the latest.

Original Power Meter v2
Chinese production
Cardboard 'gift box'
No Longer Produced

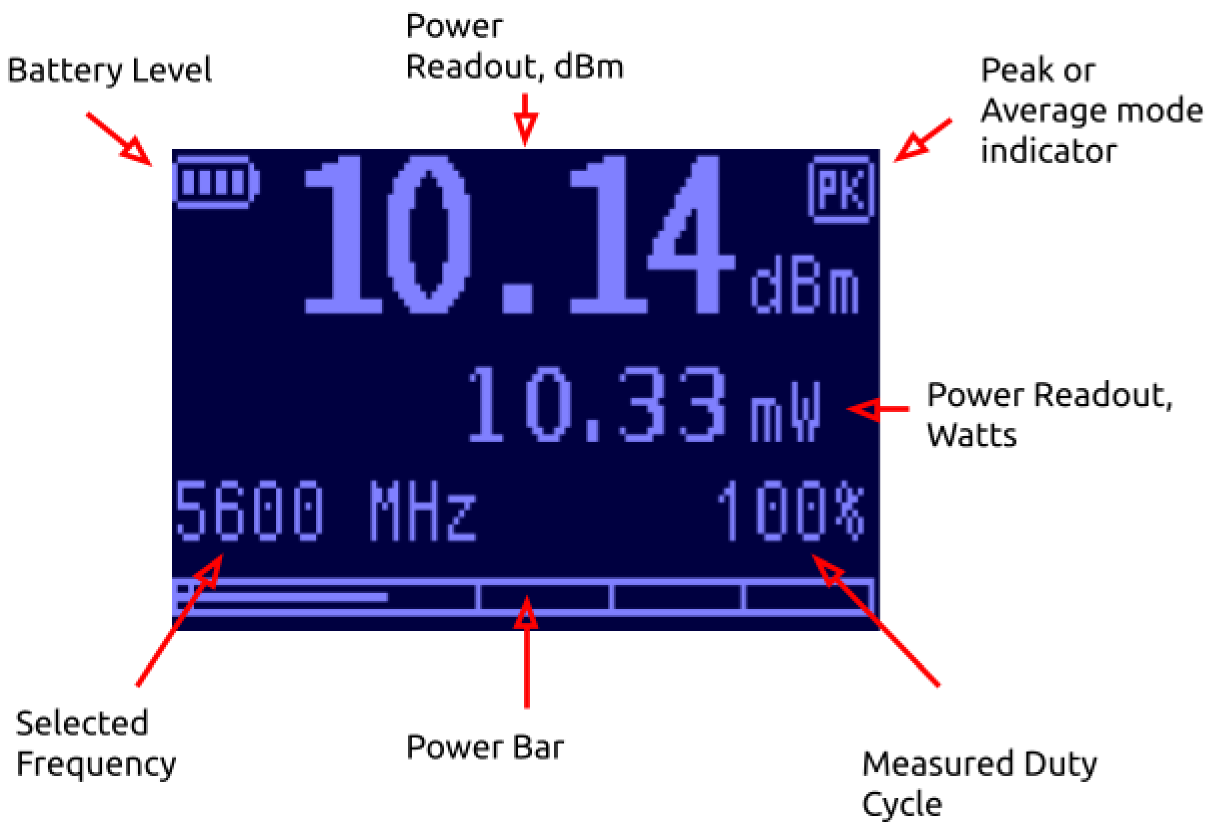


Rotor Riot special build
Identical internally to the original red power meter
Cardboard 'gift box'
No Longer Produced

First European Production at Orqa d.o.o
Slightly better calibration accuracy in the 27-30dB range (500-1000mW)
Plastic storage case
Current Production

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. *Be sure to enter the correct frequency in order to guarantee calibrated results.*
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.

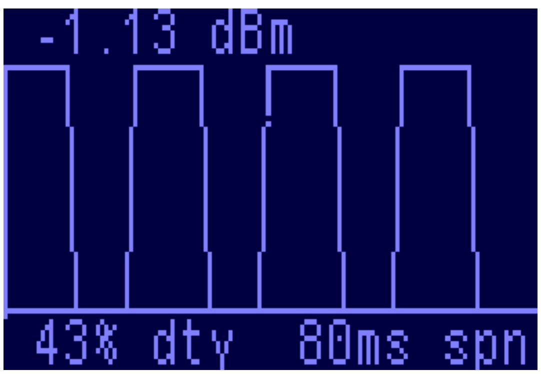
PowerScope Display Mode

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

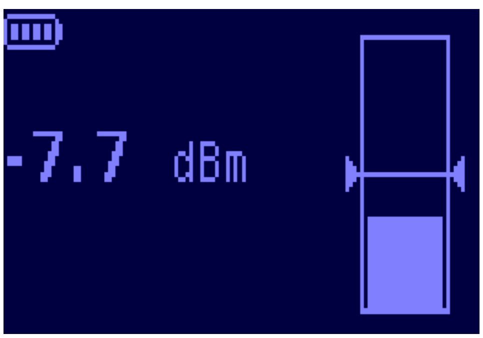
When in the Power Scope display mode, rocking the joystick right enters the Sniffer display. Sniffer display mode is a tool for race directors to quickly judge transmitter power on the starting grid.

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 labeled 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.

How Does The Meter Work?

The RF Power Meter uses a power sensor known as a 'demodulating logarithmic amplifier'.

This sensor accurately converts RF power into a signal that the processor in the power meter can use to create its readout, in dBm, or mW (or both).

During production, the assembled meter is calibrated against a high-end Rohde & Schwarz signal generator, with approx. 0.25dB accuracy. Calibration is a 3d map which covers various select frequencies and power levels, and also with temperature as a factor.

The two modes of the meter, **Peak** and **Avg**, don't affect the RF part of the meter, but the way the data from the sensor is interpreted.
In **Avg** mode, more suitable for signals with continuous transmission (such as Analog Video, or DiviMath HDZero), at various points in time (much slower than the RF signal itself) the value reported by the power sensor is averaged with a few preceding values. This is just a noise reduction technique, and results in a more stable display.

The time period over which the values are sampled may be specified in the meter as the **Span** value.

The **Peak** mode is a little different, and is for use primarily with pulsed RF measurements, as would be the case for the DJI digital video system. In this mode, the peak sensor value measured during the selected Span is used. This means that the reading is not affected by the periods between packets when the transmitter is shut off.

How Accurate Is It?

To be honest, pretty damn accurate, especially for such a low-cost instrument. Our test limits during factory calibration are +/- 0.25dB for all spot power and frequency settings.

When thinking about accuracy though, there are some things to watch out for.

Harmonics

Unlike a spectrum analyzer, which can measure power in just a limited, selected frequency band, the RF Power Meter is reporting the total power presented at its input.

This means that if you had a lower frequency signal with second harmonic levels (for example) that are measurable (the kind of stuff that would never pass CE or FCC), these are summed into the measurement. 20dBm signal + 2dBm harmonic content = 22dB reading.

The meter does not discriminate between these frequencies (same for just about any power meter on the market, even those costing 10k USD or more).

In practice, for any production equipment that was designed to pass CE/FCC, this is just not a problem as these harmonic levels have to be low as defined by the RTT&E standards. .

Attenuator Leakage

In older versions of this manual, we would recommend a fairly high value attenuator to measure signals > 1W, the limits of the meter.

This advice is no longer current, for the following reason;

When a high power, high frequency signal is measured by first passing through a high value attenuator, such as a 20dB model, there is an effect that won't be described here where some power 'leaks' along the outside of the attenuator and influences the measured power value.

One way to see this effect is to use a 20dB attenuator, and hold with your hand the outside of the attenuator near the meter. The value will be affected, and will drop to closer to the actual power value.

The workaround is simple, for GHz-class frequencies, don't use an attenuator larger than actually required.
For most FPV use, measuring transmitters up to 2.0W is possible with a 3dB attenuator. Using a 6dB attenuator takes this up to 4.0W which is more than we will see in the FPV world except in some fringe cases.

<u>If we lost you on this topic, take this simple advice, use nothing larger than a 3dB attenuator to measure up to 2.0W transmitters, and nothing larger than a 6dB attenuator for up to 4.0W transmitters.</u>

Signal Type

A question that we get often is whether the meter is accurately measuring digital video standards, such as DJI™ or HDZero™.

As far as we know, the answer is yes, a recent lab test measuring a 200mW HDZero Race transmitter, showed just a 0.34dB difference between a band-limited measurement with a Rohde & Schwarz 20GHz spectrum analyzer, and the RF Power Meter with a 3dB attenuator installed.

Logarithmic power sensors do have some waveform dependency, but in practice, with the sensor that we use, we find this to be a minimal influence.

Signal Frequency

A common misconception with the RF Power Meter is that the meter's frequency setting means that it is only sensing that frequency (or frequency band). <u>This is not the case</u>.

The frequency setting <u>only</u> selects the set of calibration factors that were learned during the factory calibration. If the frequency is correctly entered, and matches the incoming frequency, then the meter will be showing the correct value.

This is a fairly common practice for power measurement devices, and if used correctly provides an extremely accurate measurement on these spot frequencies.

Measuring Vtxs >1Watt

As described in the previous section, 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 **3dB** attenuator is used you can measure up to **2W** (provided the attenuator is rated for this power level) 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 (also note the previous section, 'Attenuator Leakage').

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 *(no arguments)*	Query current frequency
F<freqIdx>	Set current frequency based on index (0 = first supported freq., 1 = next, etc.)

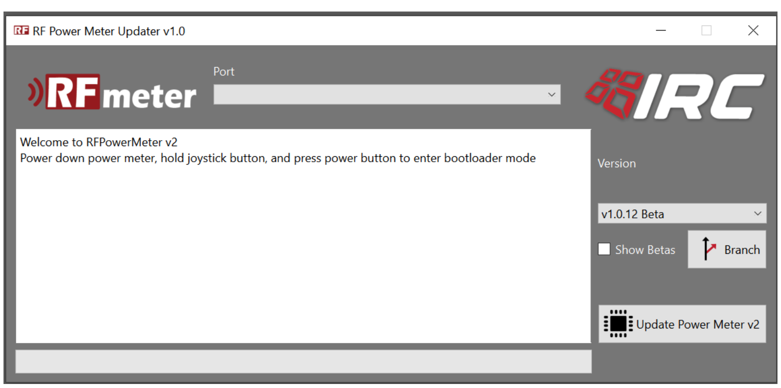
To test the interface, a serial communications tool such as Putty may be used.

Updating your Meter

From Sept 2022 it is possible to update the firmware in your power meter (without affecting it's factory calibration).

The updater tool is available on the Power Meter page of the IRC website, and automatically downloads firmware from our server.

The first update, v1.0.12, should be of interest to anyone who's meter was delivered with the OLED slightly misaligned within the rather tight bezel. V1.0.12 leaves a few more pixels empty around the display to fix this.



To start the update process, power down your meter, press the joystick button, and press the power button. The bootloader screen should be white, and will show a cycling progress bar during update.

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

Original Meter

EU Built Meter