New All Band Power Meter

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In the April QST *Microwavelengths* column, I discuss microwave power detector ICs that work up to 10 GHz. Included was a picture of a simple microwave power meter that works from 1 MHz to 10 GHz. Most of the hams I have shown it to said something like "I want one. More details, please." Since then, I have found an even easier way to build one, with just a little soldering required.

In recent years, sensitive logarithmic power detector ICs have become available, starting with the Analog Devices AD8307, good to 500 MHz and providing linear-in-dB output voltage. An RF power meter using this chip was described by Wes Hayward, W7ZOI, in June 2001 QST[1], with a measurement range of -70 dBm to >0 dBm, nanowatts to milliwatts. A more recent digital QRP Wattmeter using the same IC and an Arduino was described by Phil Sittner, KD6RM, in QST October 2022[2]. I find analog meters more useful for tuning up projects, and simple bargraph displays handy for quick tests.

Until recently, the only power detector IC readily available that works at 10 GHz was the LTC5508, a temperature compensated Schottky diode detector. Although only rated to 7 GHz, it still detects RF at 10 GHz. The tiny 1x2 mm package with six leads is about as small as a human can solder by hand. I used this chip, paired with an AD8307 for lower frequencies, in a design that became the ABPM (All Band Power Meter) from Down East Microwave (no longer available). The new version covers the whole range with one IC and requires much easier soldering.

Figure 1 – Simple RF power meter covering 1 MHz to 10 GHz with LED bargraph displaying -30 dBm (1µwatt) at 3.4 GHz

Newer logarithmic power detector ICs rated to higher frequencies, up to 10 GHz, come in tiny surface-mount packages with even tinier contacts. Fortunately, some of them are available on Amazon or ebay as small assembled modules, at prices not much higher than the IC alone from a distributor. For 10 GHz, the AD8317 is offered in several different modules. I have tried the three versions shown in Figure 2 and all have similar performance. They are very sensitive with large dynamic range, with output voltage linear-in-dB (about -22 millivolts per dB), from approximately -55 dBm (0.003 microwatts) to -5 dBm (0.3 milliwatts). This means that, once calibrated at one power level, the difference in output voltage can be converted to dB difference and the measured power calculated within a couple of dB – adequate for most ham projects.

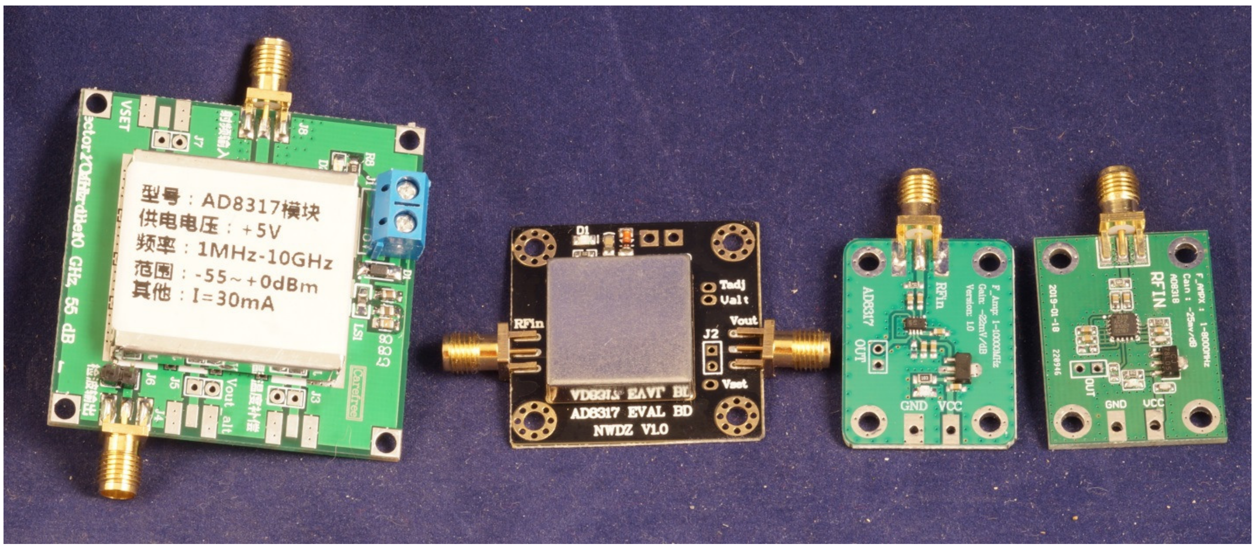

Figure 2 – RF power detector modules using the AD8317 and AD8318 (far right) found on ebay or Amazon that work up to 10 GHz

I measured the performance curves in Figure 3, which show only small variation at frequencies from <144 MHz up to at least 5760 MHz – the curves for different frequencies are nearly on top of each other. A quick test showed similar performance down to 1 MHz. However, at 10,368 GHz, the detector is about 20 dB less sensitive and the dynamic range is reduced, but it is still quite usable and will detect power down to less than a microwatt. The AD8317 data sheet does say that it is accurate up to 8 GHz with useful operation to 10 GHz , but no data shown above 8 GHz.

A similar IC, the AD8318, in a module also shown in Figure 2, is only rated to 8 GHz, but shows the same 20 dB reduction in sensitivity at 10 GHz. An AD8318 module including an Analog-to-Digital converter, ideal for building a digital power meter, is offered at SV1AFN.com. Chuck MacCluer, W8MQW, described a digital power meter[3] good to 2.5 GHz using an Arduino and an AD8313 module from SV1AFN; the frequency range could easily be extended to 10 GHz by substituting an AD8318 module.

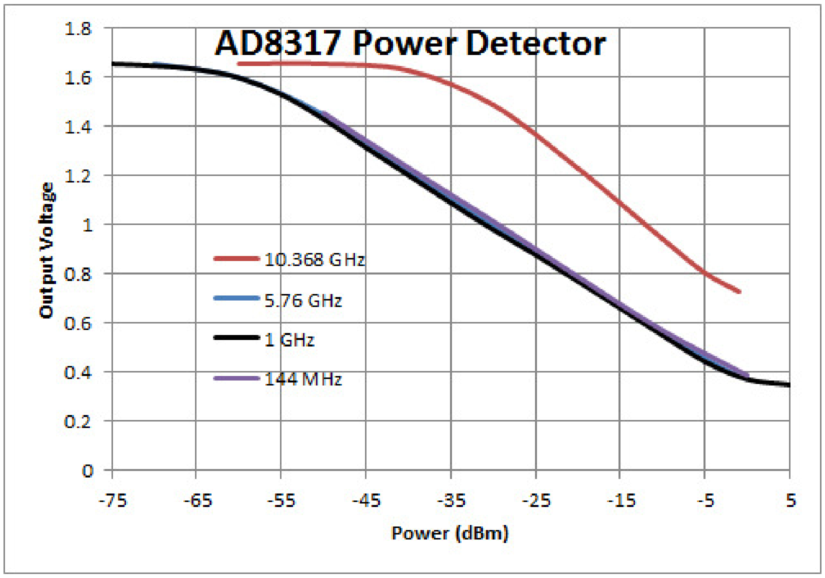

Figure 3 – Measured performance of AD8317 module shows consistent performance from 144 to 5760 MHz, somewhat reduced at 10.368 GHz. Note: Output voltage decreases with increasing power.

An AD8317 module paired with an LED bargraph display is all that is needed to make a sensitive RF power meter good from 1 MHz to 10 GHz, covering 15 ham bands. Figure 4 shows one packaged in an Altoids tin with a 9-volt battery to make a compact portable microwave power detector, with the LED display showing -30 dBm (one microwatt) at 3.4 GHz. This is sensitive enough to monitor output from an antenna without being directly on front of it.

I made two versions of the compact portable power meter; the insides are shown in Figure 4.

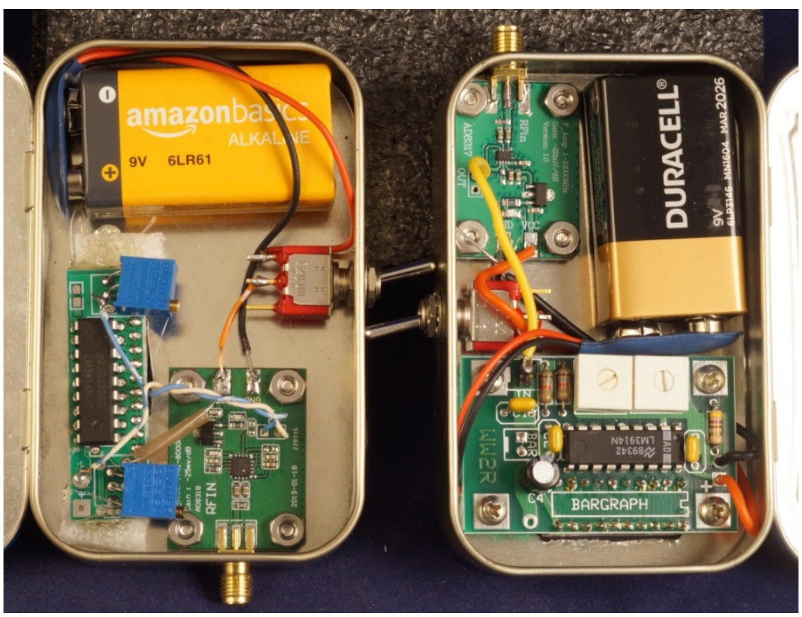

Figure 4 – Two versions of the simple RF power meter in Altoids tin

The first version, on the right, uses an LED bargraph circuit on PC board I made adapting a design by Dave, WW2R. PC boards are available. The circuit in Figure 5 is simple, with the LED bargraph driven by an LM3914, an IC made for this purpose that has been around for about 50 years. Two trimpots set the high and low voltages of the display range.

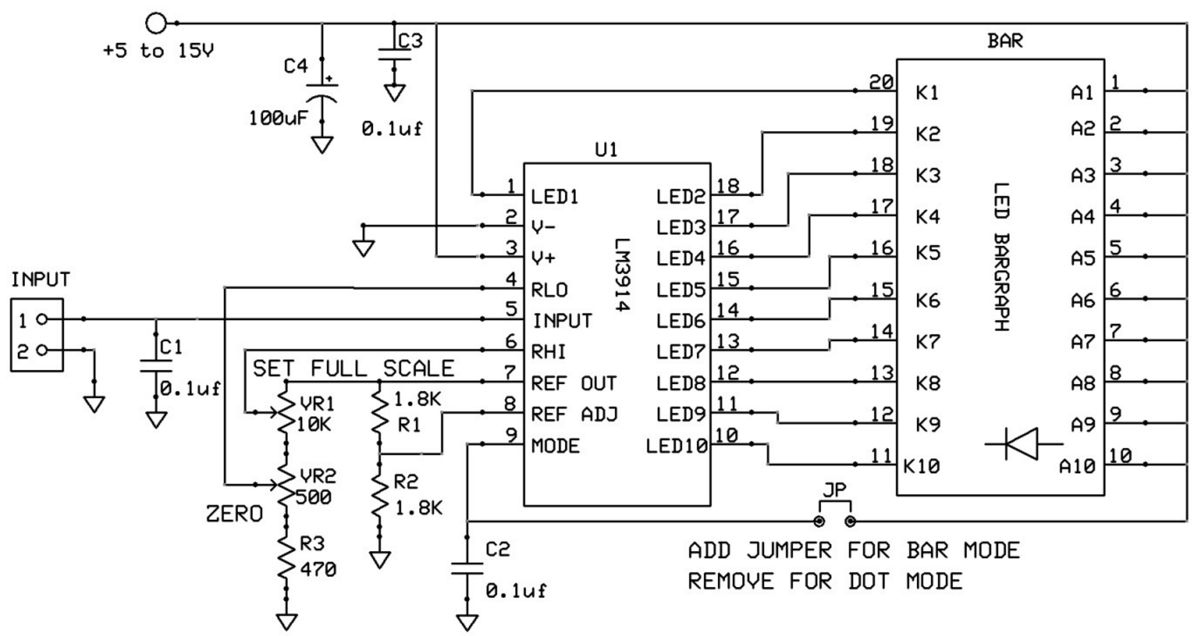

Figure 5 – Schematic diagram of the LED bargraph PC board

The PC board is easy to assemble, and the parts are available on Amazon or ebay (cheaper), but not as a kit. Looking for a more readily available alternative on those sources, I found the module shown in Figure 6, sold as a "Battery Indicator Module" kit for displaying the charge level of a battery (search for LM3914). The circuit is a stripped-down version of Figure 5. With a simple modification, it works fine as an RF power indicator: the trimpot lead marked "INPUT from AD8317" is not connected to the PC board but instead lifted up and connected to the output of the AD8317 module. An optional modification is to omit the momentary switch in the kit and use a separate switch for both the bargraph module and the AD8317 module, so you don't have to hold the switch to make measurements. The positive voltage then connects to the terminal marked "V+" and the negative (-) terminal on the PC board and the AD8317 both connect to the battery. The connections can be seen in the left-hand version of the RF power meter in Figure 4.

Those with sharp eyes will note that the left-hand version in Figure 4 uses an AD8318 module, the right-hand one in Figure 2. The output voltages to the LED display are slightly different, but RF performance is about the same.

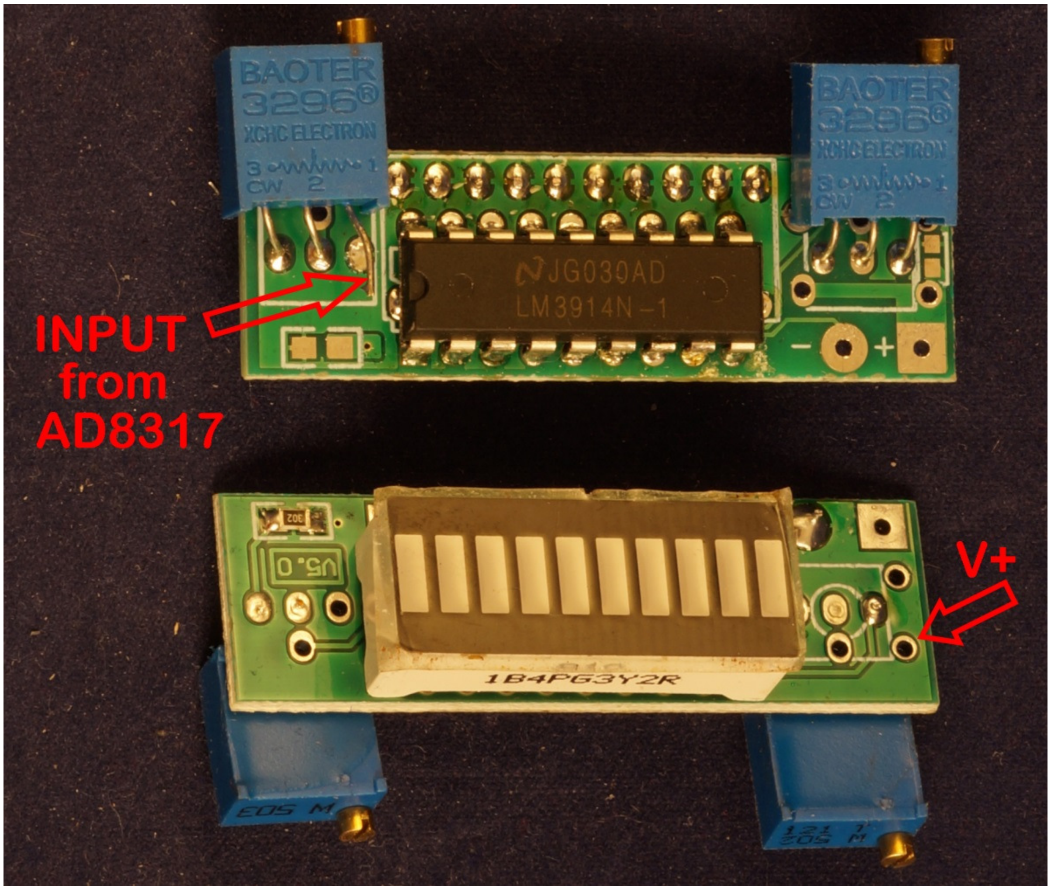

Figure 6 – Bargraph display from kit showing modifications

The kit is easy to assemble, if you solder the LED bargraph first, trim the leads, then install the LM3914 IC. Some of the IC leads must be soldered from the top side since they are under the bargraph. Then add the trimpots, with the indicated lead on the 50K pot left floating, and one surface mount resistor. If you are uncomfortable with surface mount soldering, simply short those pads together with a blob of solder – it will still work.

Adjusting the bargraph before assembly will make final RF adjustment easier. A variable power supply is needed, connected to the input pin, with the bargraph module powered up. Set the power supply to about 1.5 volts and adjust the 50K pot so that one LED bar is lit at the other end of the bargraph. Then lower the voltage to about 0.6 volts and adjust the 5K pot so one bar at the other end of the bargraph is lit. Varying the voltage from 0.6 to 1.5 volts should make the intermediate bars light sequentially.

Both versions of the simple RF power meter use the smaller modules on the right in Figure 2, which have an on-board voltage regulator to operate over a range of voltage from about 7 to 15V. The other two AD8317 boards operate from 5 volts or less. The bargraph displays will also operate on 5 volts. A good 5-volt power source might be a small USB power pack instead of a 9 volt battery.

Assembly

The hardest part of assembly is cutting the rectangular hole in the Altoids tin. I recommend starting with two tins – I did better on the second try. I scribed around the LED bargraph (before soldering to the board), then drilled a series of holes inside the scribe lines, shown in Figure 7. (Brad-point drills, if you have them, make cleaner holes in thin metal.) Then I nibbled away at the edges with flush-cutting pliers until the bargraph fit through the hole.

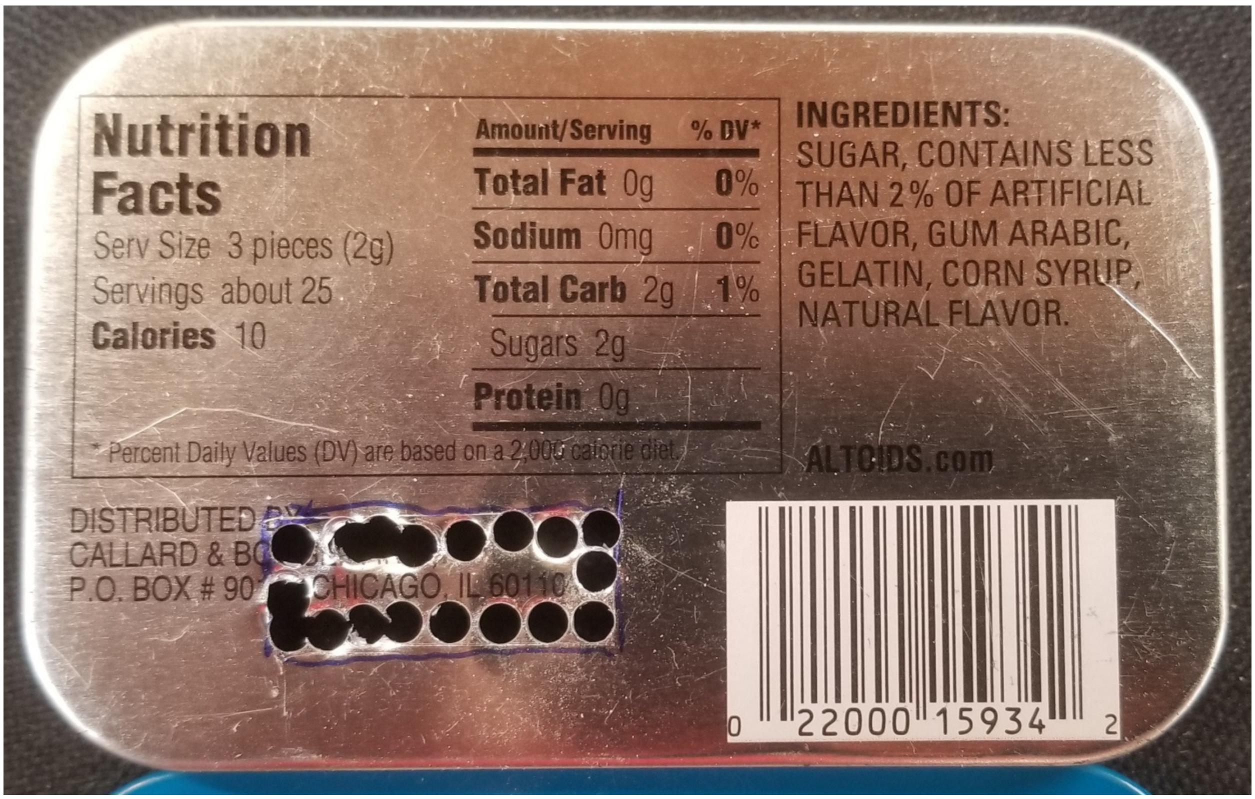

Figure 7 – Drilling holes for square cutout

Drill holes for the SMA connector, switch, and mounting holes for the AD8317 module.   For the AD8317 module, I use hex nuts under the board as short standoffs. I cut pieces of packing foam to hold the bargraph level with the tin, then used a hot-glue gun to hold everything together. The battery is held in place with double-sided tape. A battery connector might be found in a piece of defunct consumer electronics.

A possible enhancement would be to bring the output of the AD8317 module to a connector so that the voltage can be measured with a digital volt meter for more accurate measurements.

Test

A quick test is to put a thin wire an inch or so long into the SMA connector as an antenna, turn it on, and hold it near your wireless router. Some of the LED bars should flicker as data packets go by. Put a mobile phone near the antenna and make a call. Higher bars should flicker.

If you have a calibrated signal generator, the bargraph can be calibrated better. With no RF applied, I adjust the 50K trimpot (or VR1 on my PC board) so only the first bar is lit. Then a signal of -5 dBm is applied and the 5K trimpot (VR2) adjusted so the bar at the far end is on. A final adjustment is with -50 dBm applied; the 50K trimpot is tweaked until the second bar lights. The ten bars now cover a range of -55 dBm to -5dBm in ten steps, so that each step differs by roughly 5 dB, close to an S-unit. Of course, you can adjust for a smaller range with smaller steps if desired.

Summary

A sensitive RF power meter can be used to detect small signals, through coax, or radiated signals with an appropriate antenna. A simple whip antenna can provide reassurance that a QRP station is transmitting. Inexpensive printed log-periodic antennas for UHF and up available from WA5VJB.com are great for microwave rover stations, which are usually QRP.

Another use is to track down unwanted or interfering signals – there are many out there. And you can check for leakage from your microwave oven. And it should be possible to make crude antenna patterns at safe power levels.

You can build this simple, useful project in a couple of hours, and the two modules total about $25 on Amazon, or less if you are willing to wait for ebay delivery from China.

Notes

1. Wes Hayward, W7ZOI, "Simple RF-Power Measurement," ***QST***, June 2001, p. 38.
2. Phil Sittner, KD6RM, "Constructing an Accurate Digital QRP Wattmeter," ***QST***, October 2022, p. 30.
3. Chuck MacCluer, W8MQW, "A low effort, 1-2.5 GHz dBm power meter," *Proceedings of Microwave Update 2019*, ARRL, 2019.