

# Portable RF Sniffer and Power Meter

Paul Wade W1GHZ ©2003, 2004

RF power meters are extremely useful instruments. Whether we are tuning up homebrew equipment, checking antenna VSWR, adjusting a linear amplifier, or just monitoring output power during a contest, almost all aspects of ham operation can use a power meter.

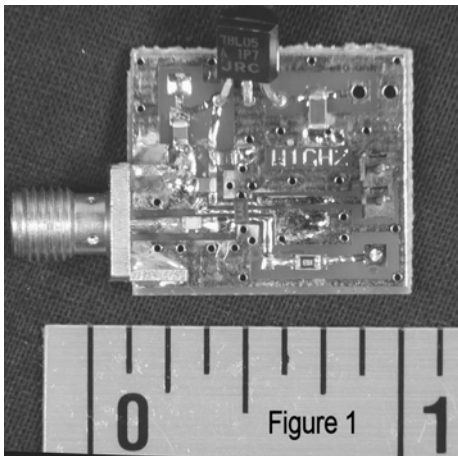
At the lower frequencies, most of us use Bird ThruLine wattmeters, because they are simple, dependable, rugged, and affordable. Microwave experimenters favor lab instruments like the HP431, 432 and 435 power meters, are not simple and are only affordable on the surplus market. Painful experience has taught many of us that these instruments do not tolerate much excess power. Finally, they require AC power.

This project began with a need for a portable RF indicator for rover operation, but I have since found that a cordless power meter, inexpensive enough to be careless with, is a handy device with many uses.

## **Portable RF sniffer – UHF & Microwaves**

Sooner or later, a rover station finds that no one will answer his calls. Is the equipment working? Failures are not surprising, since the gear is bounced around in the vehicle and then operated in various unpleasant conditions. So, how does a rover station check that the equipment is working? If you are lucky, there are beacons to check that the receiver can hear, but what about the transmitter? Is it generating power? Does it get to the antenna?

A couple of years ago, I put together a 10 GHz radiation indicator – a surplus horn connected to a surplus diode detector, with a waveguide attenuator between them to reduce the power. Since this was a last-minute job, I simply ty-wrapped everything to a microammeter and stuffed it into a cardboard box. Simply holding it in front of the dish did the job – when the rig was working, it pinned the meter. Later, when I got reports that my signal was weak, the meter barely moved. Fortunately, I had a backup rig and was able to keep operating.



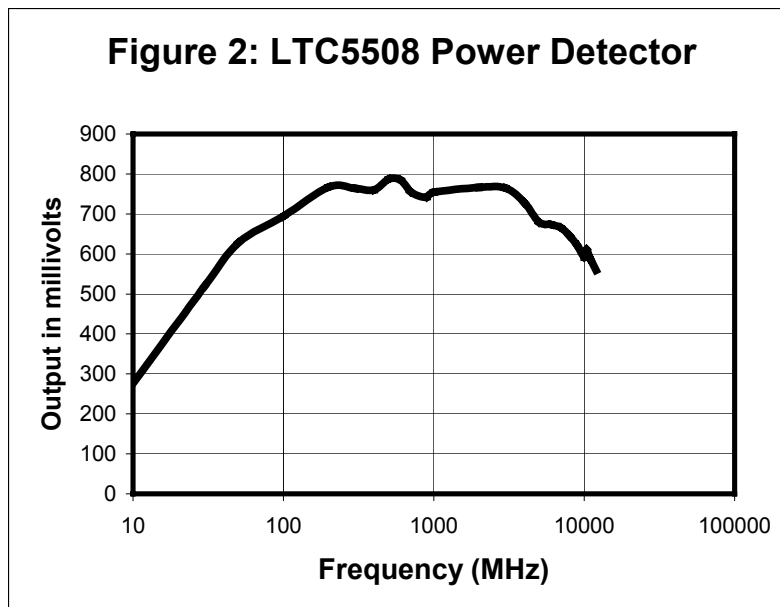
This past summer, I went roving for the UHF contest. I took the 10 GHz indicator and checked the transmitter each time I set up at a new location. However, it didn't help on other bands, particularly 5760, where activity is lower. Making an indicator for each band is one solution, but there are enough things loose in the back of the pickup already. I needed a multiband indicator.

Several semiconductor companies have come out with power detector chips for wireless networking. The first of these was the Analog Devices<sup>2</sup> AD8307, good to 500 MHz; W7ZOI and W7PUA used this chip to make a simple RF power meter<sup>1</sup>. New chips that work at higher frequencies have become available recently. Most are good to 2.5 GHz or so, but one, the Linear Technology<sup>3</sup> LTC5508, is rated to 7 GHz. Since Linear Tech is glad to sell them direct from their web page ([www.linear.com](http://www.linear.com)) for only \$1.75 each, I ordered a few.

The AD8307 comes in a standard DIP package, but the higher frequency ones come in *tiny* surface-mount packages, so a PC board was necessary. I squeezed it onto a small board and piggybacked it in the corner of another board – I try to use every millimeter of an ExpressPCB<sup>4</sup> miniboard ([www.expressPCB.com](http://www.expressPCB.com)).

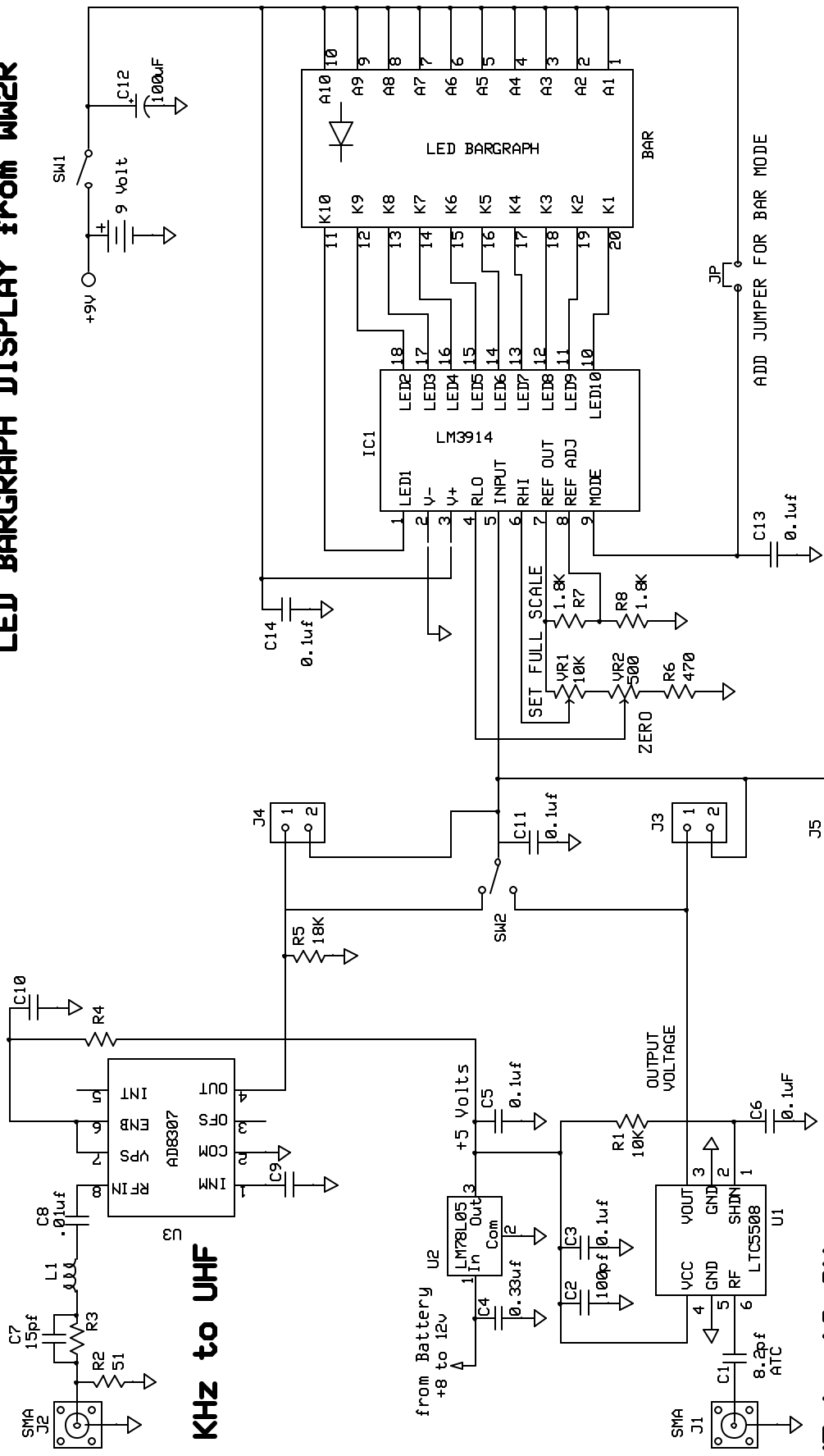
I wanted to see how high in frequency the chip would operate, so I assembled the board with a good SMA connector with a small pin, and a quality microwave ATC capacitor. The completed board is shown in Figure 1, and the schematic is in the lower left area of Figure 3, labeled “VHF to 10 GHz”.

Performance is very good. The LTC5508 has a temperature compensated Schottky diode detector, so the readings are quite repeatable, and an output amplifier so it can drive a meter directly. The sensitivity is good, with usable output for input power from  $-20$  to  $+10$  dBm. Frequency response was good from about 100 MHz to 5 GHz, rolling off slightly to 8 GHz, and about 5 dB down at 10.368 GHz, as shown in Figure 2. The important thing is that it still works even at 12 GHz, and covers every VHF band from 2 meters up (low frequency rolloff is due to the small 8.2 pf input capacitor).



While the frequency response is not as flat as a laboratory power meter, for instance an HP 432, it appears to be comparable in sensitivity and repeatability. The detector chip does have some advantages: very low power, requiring only a couple of milliamps at 3 to 5 volts, and fast response – fast enough to demodulate data at rates up to about 2 MHz.

# LED BARGRAPH DISPLAY from W1W2R



**10 KHZ to UHF**

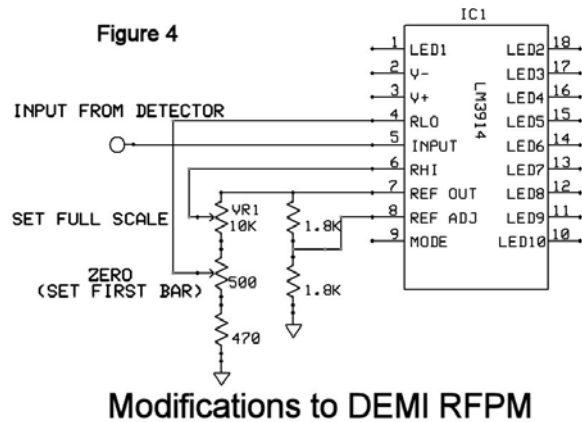
**VHF to 10 GHz**

EXTERNAL METER

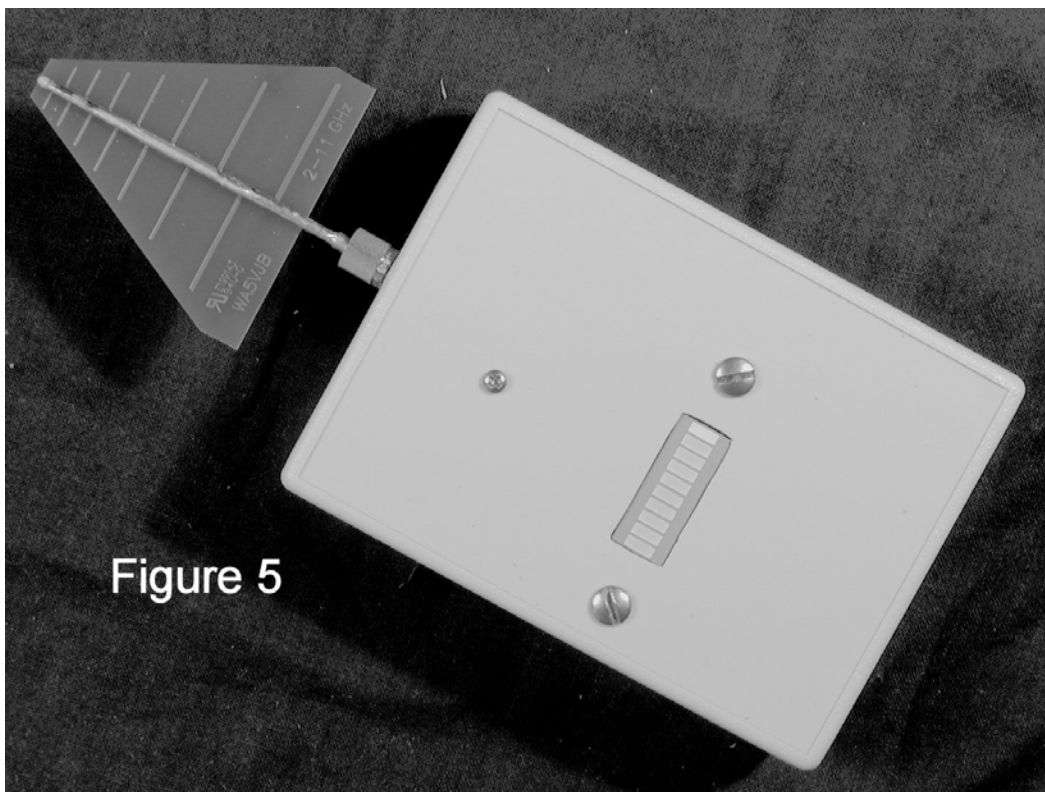
<b>W1GHZ</b>	
<b>Allband Power Meter</b>	
W1GHZ	Rev 1.0 2/18/2004
FIGURE 3	

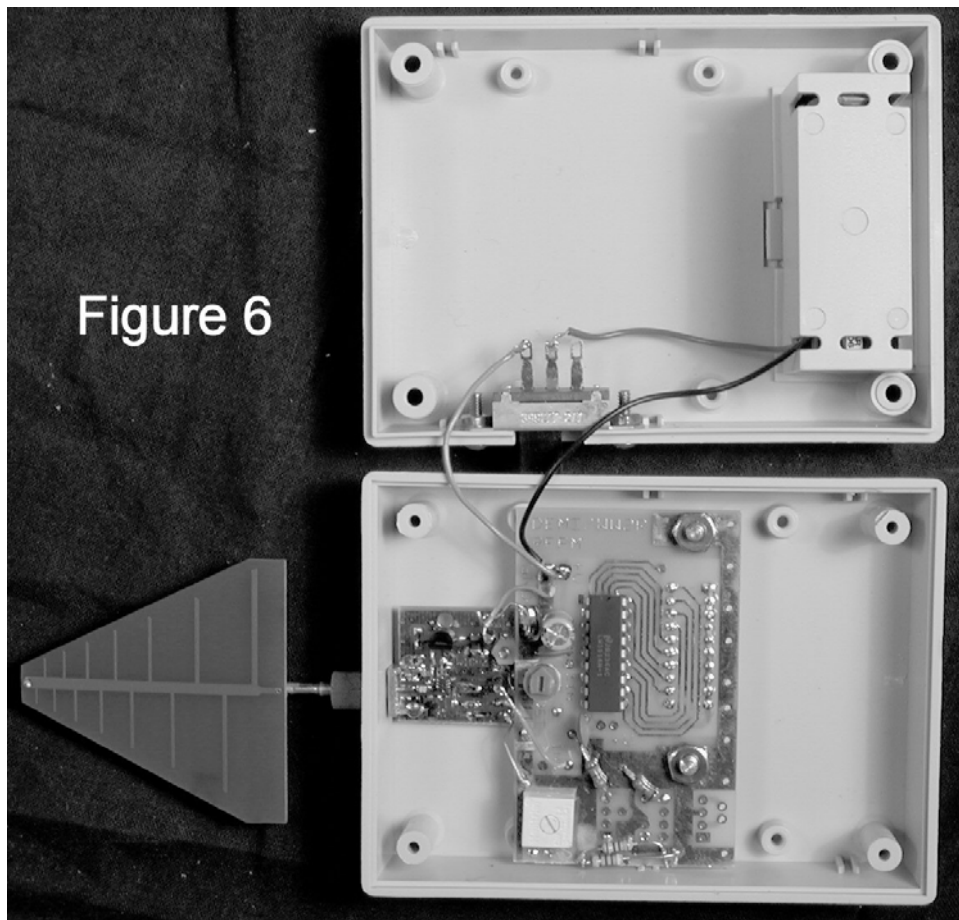
To compensate for the frequency response, we could make a calibration chart for each band, or even make a separate unit for each band – the chips are cheap enough.

The low power required is ideal for my application, a portable power indicator. Rather than a fragile meter, I chose the RFPM LED power meter from DEMI<sup>5</sup> ([www.downtownmicrowave.com](http://www.downtownmicrowave.com)), an LED bar indicator designed by WW2R. Since the LTC5508 has an offset, about 260 millivolts output with no RF input, I had to hack up the RFPM to zero the offset; three resistors and a pot were needed. The modifications are shown in Figure 4.



The detector board and the RFPM board both fit in a small plastic case with a 9-volt battery compartment (LMB 502 or Philmore PB524). I adjusted the ZERO pot so that the first LED bar is lit as a pilot light, and the full-scale pot for +10 dBm. The second bar lights at -14 dBm, so we have 24 dB of dynamic range. The final piece of the puzzle is a 2 to 11 GHz printed log-periodic antenna from WA5VJB. The complete RF sniffer is shown in Figure 5 – broadband, cheap, portable, and battery-operated. The insides are shown in Figure 6.





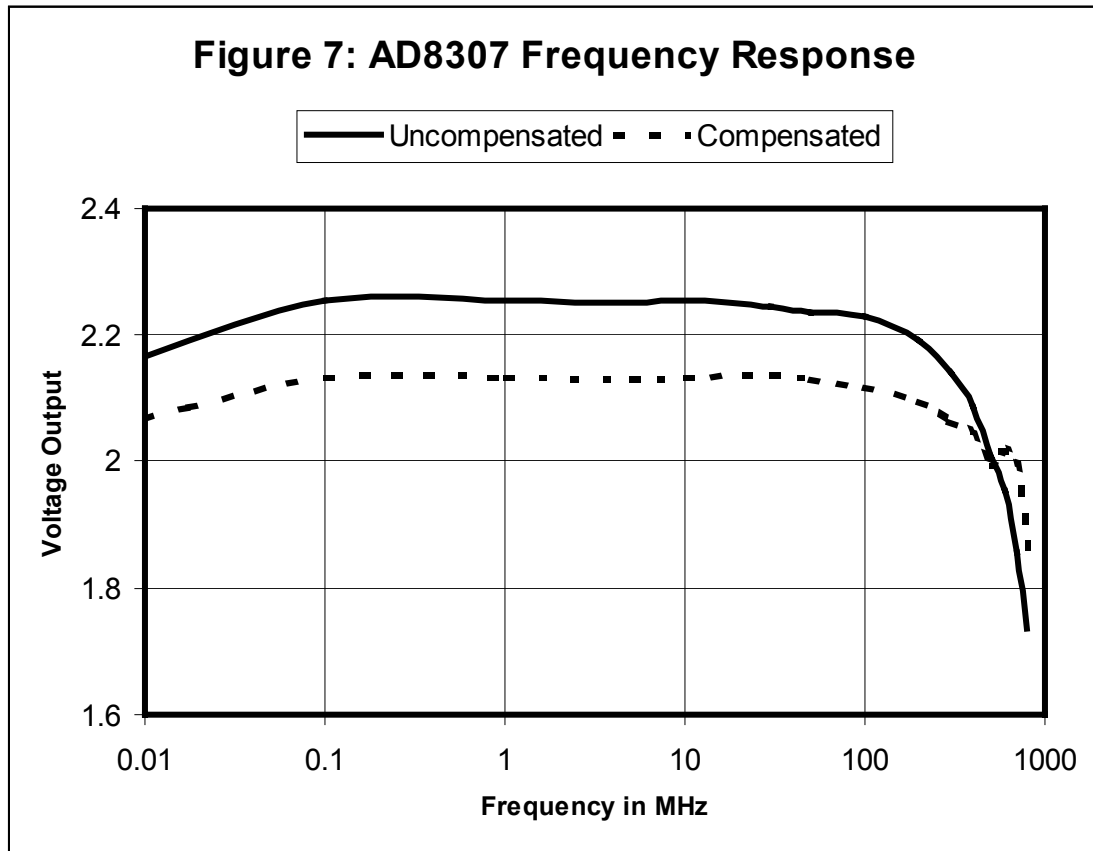
### All-band Power Meter

The unit in Figure 6 works well, but is just hacked together. There is a lot of empty space in the case, only part of the RFPM circuit board is used, and none of the molded mounting holes were used. I fired up the ExpressPCB software to try a new PC board layout.

The first step in the layout was the modified WW2R circuit – using a double-sided board could eliminate all the long, convoluted traces in Figure 6, and make the board smaller. Then I pasted in the LTC5508 layout from my test board, and added mounting holes for the smallest plastic box I could find with a 9-volt battery compartment, an LMB 501. This left an empty corner next to the LTC5508, so I thought about adding a lower-frequency RF detector.

I had also previously experimented with the AD8307, with the results shown the curve marked “Uncompensated” in Figure 7. The response rolls off above 100 MHz, and the LTC5508 rolls off below 200 MHz, so neither would be very good at two meters. The W7ZOI and W7PUA article described the compensation circuit they added at the

AD8307 input to flatten the response, so I added a similar circuit to the new layout. This makes the response flatter: the “Compensated” curve in Figure 7.

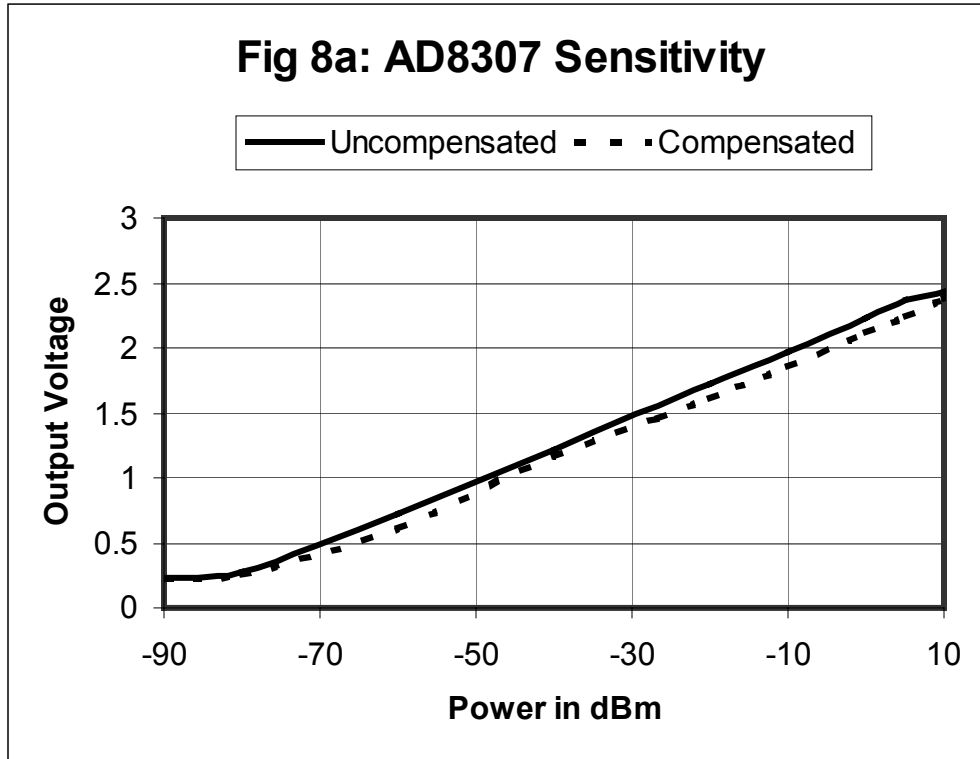


Schematics of all three parts are shown in Figure 3: the UHF and microwave detector, the lower frequency detector, and the LED bar indicator that is switched between two detectors. With this combination, we have an RF indicator good from 10 KHz to 10 GHz.

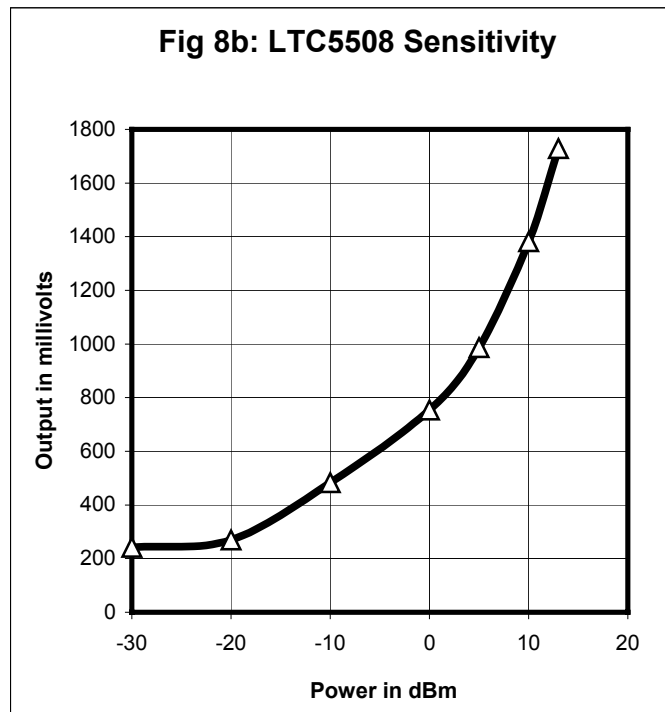
When I demonstrated my first version at a NEWS Group<sup>6</sup> meeting, WITDS asked why I didn't have an output to drive my Tonemeter<sup>7</sup> audio indicator. *DUH!* I added an output jack, which can drive either the Tonemeter, for audio indication, or a Digital Voltmeter, for precise readings. A 1-dB change in power makes a very distinct change in audio tone, and the DVM provides stable indication of much smaller changes, making the device a useful power meter for tuning and testing.

### **Calibration**

We have already seen in Figure 2 and Figure 7 that there is some variation with frequency, so any fine calibration must be at specific frequencies. For most purposes, however, relative calibration within a few dB will suffice.



The two detectors have different sensitivity curves, shown in Figure 8. The AD8307 output is a straight line from about  $-70$  dBm to about  $+5$  dBm, a much greater dynamic range than any commercial power meter.



The straight line response of the AD8307 means that we can read power differences directly, at 25 millivolts per dB. The LTC5508 does not have a linear response, nor is it as sensitive, with a useful range of around  $-20$  dBm to about  $+13$  dBm, comparable to an

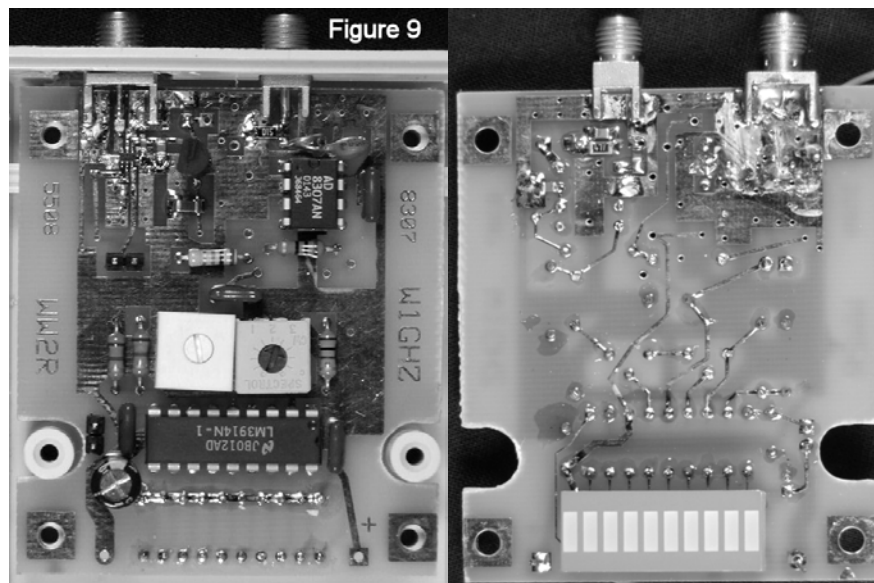
HP432 meter. So we have a combination of great sensitivity on the lower-frequency side and great frequency response on the higher-frequency side.

The bar graph indicator is handy as a quick, no thinking required, indicator. Many times, that's all you need. Since the sensitivity curves in Figure 8 are so different, some compromise is required for the LED bar graph to make sense for both detectors. The output of the AD8307 may be loaded down, by R5 in the schematic to adjust the slope of the response. I found that an 18K resistor gave similar full-scale readings for both detectors. I set the "ZERO" pot so that the first bar on the high-frequency side is lit, to provide a free pilot light, and set the "FULL SCALE" pot to light at +10 dBm. Then I measured the response of both sides at 144 MHz, shown in this Table:

<b>BARS</b>	<b>Low Frequency</b>	<b>High Frequency</b>
<b>1</b>	-70 dBm	—
<b>2</b>	-59	-15 dBm
<b>3</b>	-51	-10
<b>4</b>	-43	-5
<b>5</b>	-35	0
<b>6</b>	-26	+3
<b>7</b>	-18	+6
<b>8</b>	-10	+7
<b>9</b>	-2	+9
<b>10</b>	+5	+10

The LED indicator may be operated as a bargraph or as a series of dots, with only one LED on at time. Since each LED draws about 20 mA., battery life will be much longer in dot mode. The mode is selected by a jumper, J4, on the board.

### Construction





Top and bottom views of the PC board are shown in Figure 9, and the completed all-band unit is shown in Figure 10. The PC board layout in Figure 11 will show up better in color, so the layout and board file are available on my website, [www.w1ghz.org](http://www.w1ghz.org). Kits will be available from Down East Microwave. The complete schematic is in Figure 3.

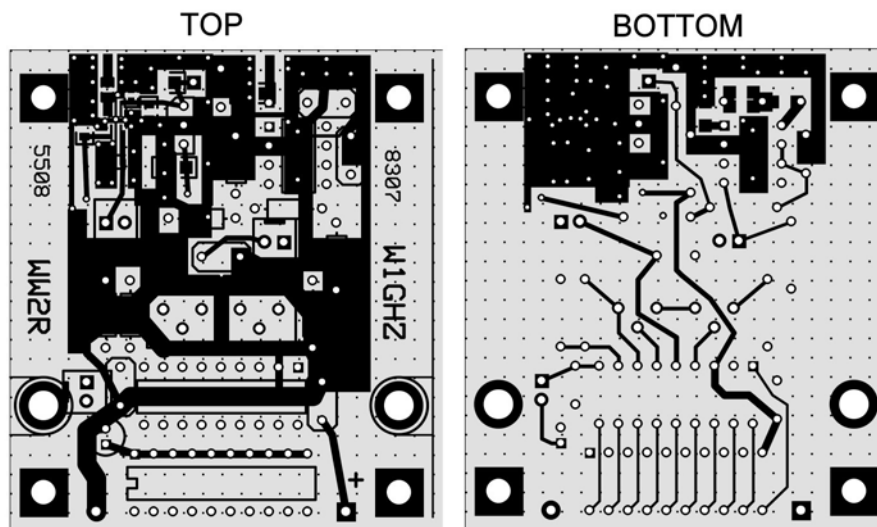
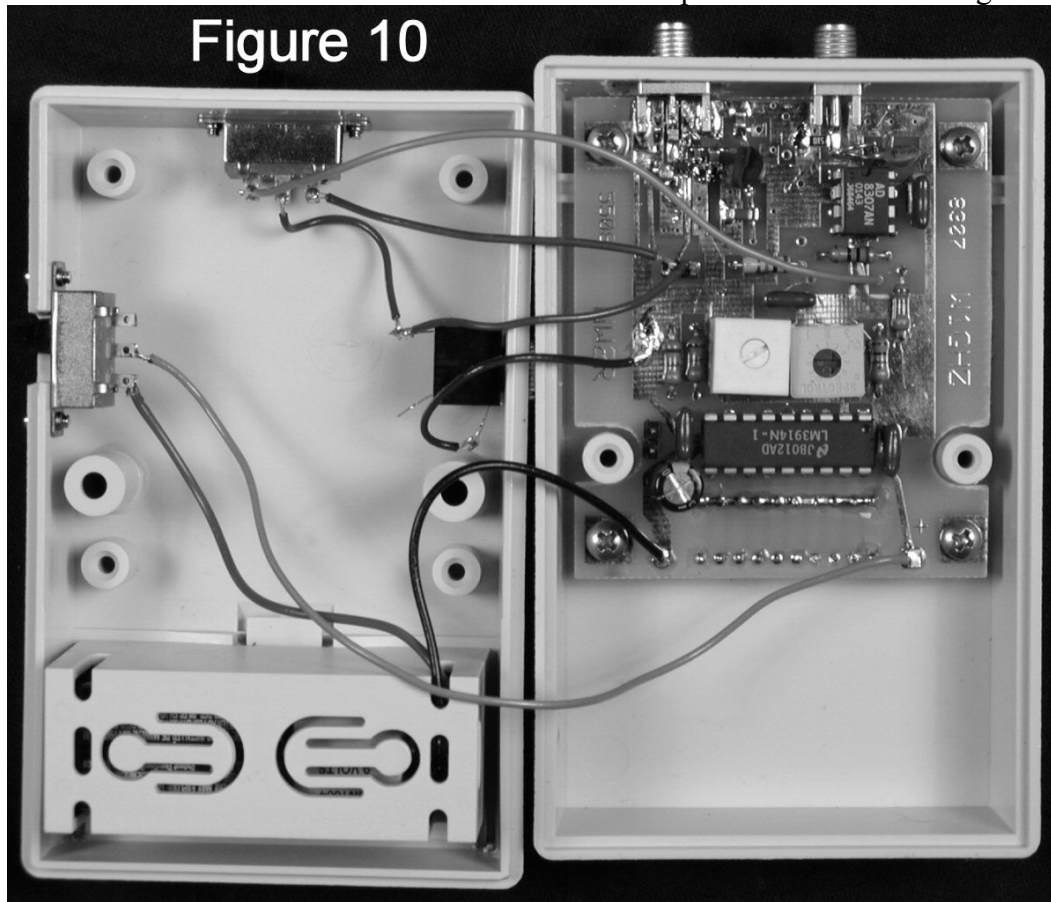


Figure 11 - PC Board Layout

## **Applications**

One obvious application is the RF sniffer, for rover stations, with a broadband antenna like the one in Figure 5. Next summer, if someone doesn't answer, I'll suspect their receiver.

Another is to detect RF leakage. The first thing I did with a sniffer was to check my microwave oven. Leakage was small, and the see-thru window in the door was worse than the door seals.

The high sensitivity of the low-frequency side makes it even more useful. Using a "rubber-ducky" antenna, leakage from my FT-817 running 2.5 watts on two meters lit about 3 bars, and other transceivers showed similar leakage. It's not much power, but certainly enough to clobber a nearby receiver.

A less obvious use is to measure noise levels. My AIL 75 Noise Figure Meter requires external gain to read properly, but only reads accurately with a limited range of input level. There is a green light that comes on when the minimum is reached, but there is no indication for excess power – I use a step attenuator to find a good level. With the portable power meter, I was able to measure the required levels: between –50 and –20 dBm. So if the noise level is at the IF input must show between 3 and 7 bars – a simple check.

If the unit proves sensitive enough to show sun noise (measuring the transverter output) at portable locations, it will be even more useful. The sun must be higher in the sky and provide more warmth before this test will be possible.

## **Summary**

This device makes it possible to quickly make a rough measurement of RF power almost anywhere. I started out wondering if it would prove useful – and keep finding new uses!

## **References:**

1. Wes Hayward, W7ZOI, and Bob Larkin, W7PUA, "Simple RF-Power Measurement," *QST*, June 2001, pp. 38-43.
2. [www.analog.com](http://www.analog.com)
3. [www.linear.com](http://www.linear.com)
4. [www.expresspcb.com](http://www.expresspcb.com)
5. [www.downeastmicrowave.com](http://www.downeastmicrowave.com)
6. [www.newsvhf.com](http://www.newsvhf.com)
7. Paul Wade, W1GHZ, "An Audio Tone Indicator for Tuning or Antenna Measuring," *Proceedings of the Joint Conference – Microwave Update 2002 and the 28<sup>th</sup> Eastern VHF/UHF Conference*, ARRL, 2002. (also [www.w1ghz.org](http://www.w1ghz.org))