W1GHZ

MICROWAVELENGTHS

Microwave Power Measurements

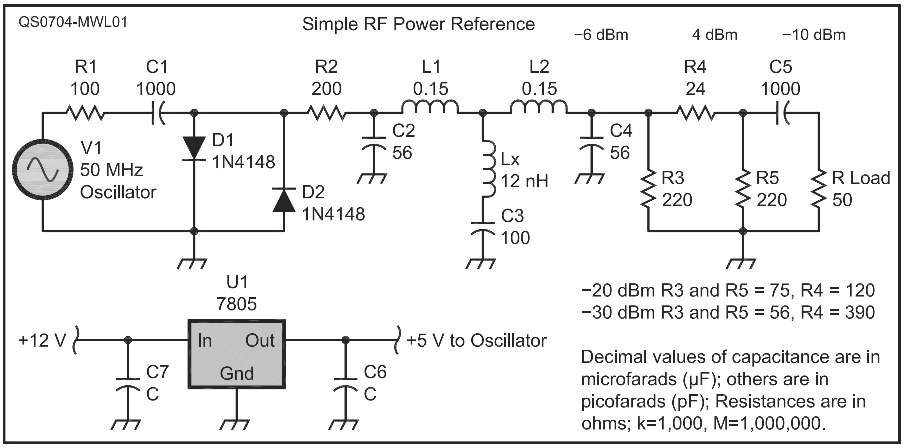
Power measurement is important in microwave work. When signals are weak and every bit counts, we want to maximize our output power. As we continue to explore microwave equipment we shall see that much of it is modular, and power measurement is useful in getting compatible power levels for all the modules. Finally, we must not exceed our maximum authorized output power — a concern that is only a dream for most microwavers.

At frequencies up through UHF, the amateur standard for power measurement is the Bird Model 43 Thruline Wattmeter, good for powers up to the legal limit; however, at microwave frequencies, we rarely deal with really high power — watts are hard to come by, and milliwatts are more common. A meter that is able to detect and measure milliwatts is useful, and we can still use it to measure higher powers using a directional coupler, as we discussed in the January 2007 Microwavelengths.

Laboratory microwave power meters typically measure milliwatts. The most common ones found in surplus are the HP models 431, 432 and 435, as well as some made by General Microwave. All of these use thermistor sensors in a bridge circuit, where one thermistor is heated by the RF power, and another is heated by dc or audio power by the instrument until the bridge is balanced so that the two powers are equal. Then the dc or audio power is measured and displayed. Some typical sensor heads with the power meters are shown in the photo.

The HP Model 431 and 432 use the same series of coaxial and waveguide sensors that are usually available at reasonable prices, while the Model 435 and newer models use a different series of sensors with much higher surplus prices. The General Microwave instruments use their own series of sensors, which seem to be less robust — I've heard frequent tales of woe by hams who have burned them out by applying too much power.

Digital power meters are also available, but quickly prove to be less useful than analog meters since it is difficult to tune or peak anything while looking at a flickering digital readout. The HP Model 436 is digital, but it incorporates an analog meter for peaking.



A schematic diagram for homebrew RF power reference.

The HP models 431, 432 and 435, surplus microwave power meters with waveguide and coax sensors.

Portable Power Indicator

These laboratory instruments are great for the workbench, but rather fragile and expensive for field work. A rover station will always find it reassuring to see an indication of power output, particularly if your CQs are unanswered. A better indicator would be cheap and reliable, even if not as accurate.

The most common power indicator is a diode detector — we've been using these for years. Diodes are temperature sensitive, not good for portable working, and nonlinear, so that there is little indication for small powers and then a sudden increase at higher powers. These deficiencies may be overcome by compensating with a second, identical, diode for comparison — electronically, of course. The best way to make identical diodes is on the same chip; RF power detector chips for cell phones and wireless networking include identical diodes and the comparison amplifier at a lower price than most microwave diodes. Some of these chips work up to around 12 GHz, and all of them are cheap enough

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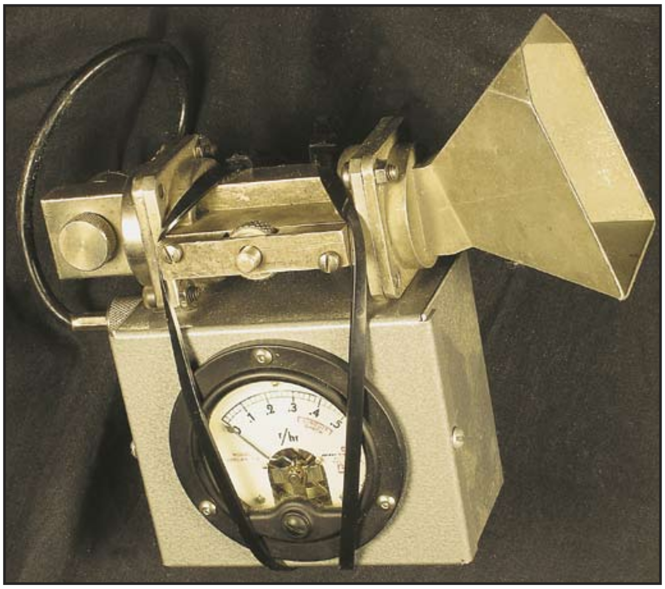
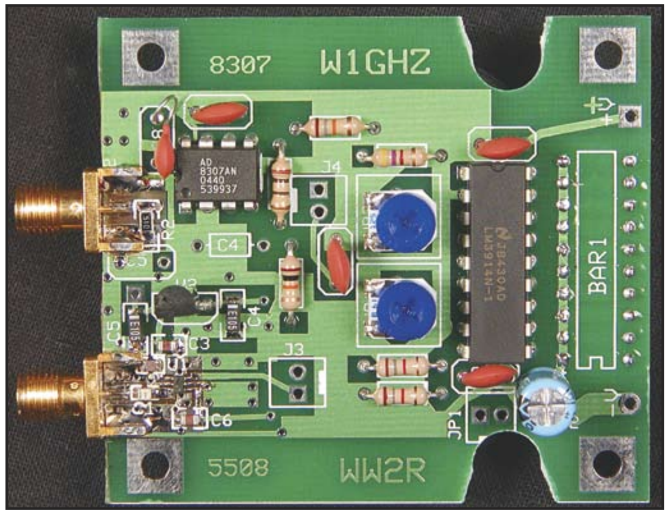
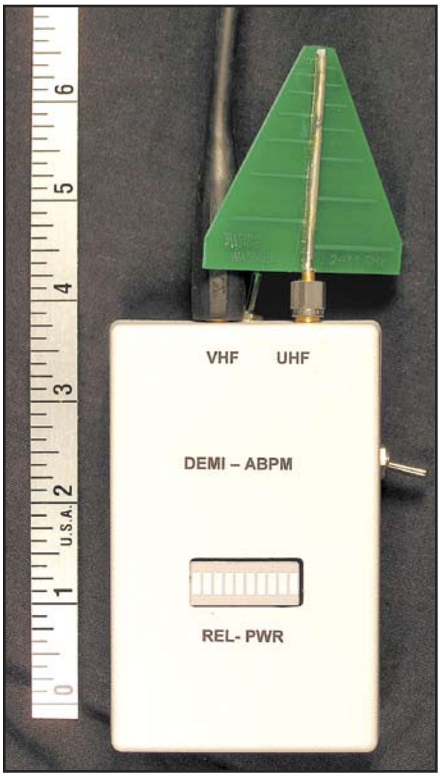


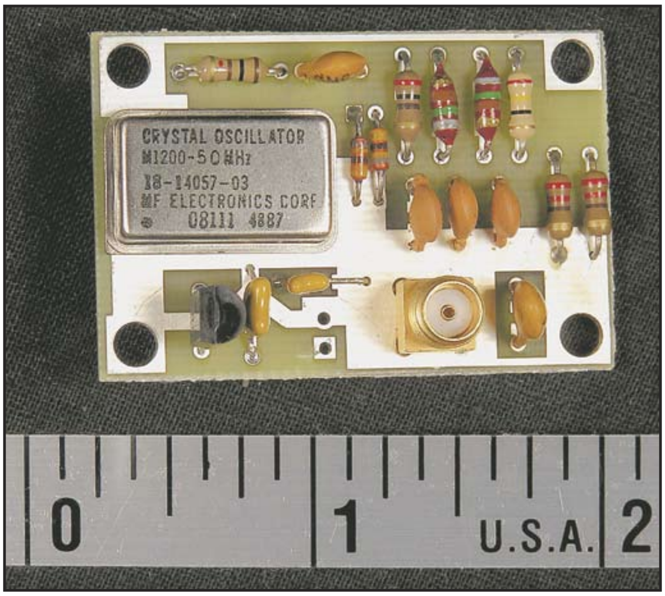
To check for radiated power, I used this 10 GHz radiated power monitor that I made from surplus parts.



The circuit board for the ABPM.



An ABPM (all band power monitor), available from Down East Microwave.



A homebrew RF power reference. The final unit produces an output of –10 dB mW, or 0.1 mW, and easily fits in the traditional Altoids tin.

that burning one out is not a calamity.

Other RF power detector chips for the "wireless" market use logarithmic amplifiers for detection, so that the dc output is proportional to the log of the input power. The output is then directly proportional to dB. These are more sensitive than diode detectors, but do not work as high in frequency, only up to around 3 GHz.

Many microwave rigs include a power detector, usually a directional coupler and diode detector, for indicating output power; however, this indicator only shows that power is being generated, not radiated. Matt Reilly, KB1VC, learned the difference in a recent 10 GHz contest while operating on Block Island, about 12 miles south of the Rhode Island coast. He had lots of meter indication but no detectable radiated power. Once we had determined that there was a problem, he was able to locate and repair it. Otherwise it would have been a very frustrating weekend for Matt, since our return ferry wasn't due until Monday.

At 10 GHz, even a slightly loose SMA connector can cause a huge power reduction. I've had this problem, and have seen other operators discover it, as well. As a result, I decided it was important to be able to check for radiated power. I built my own meter using a waveguide diode detector, a waveguide attenuator and horn antenna — all ancient surplus. Even the microammeter came from a surplus Geiger counter. It worked, but only as a crude indicator; lower power barely moved the meter, and higher power pinned the needle. As it is only good for a single band, I would have to scrounge up a set of waveguide components for each microwave band.

I started experimenting with the wireless detector chips and eventually arrived at the version shown in the photos, using two chips that can be seen on the PC board — an AD8307 (**www.analog.com**) log amp detector chip for 1 to 500 MHz at the top, and a tiny LTC5808 (**www.linear.com**) diode detector chip for 144 MHz to 12 GHz at the bottom. A simple rubber flex antenna is adequate for the lower frequency input, and a small printed log-periodic antenna covers 2-11 GHz. The indicator is an LED bar graph in a circuit published by WW2R, giving a good range of relative power. Down East Microwave (**www.downeastmicrowave.com**) offers a kit for this unit, and WA5VJB (**www.wa5vjb.com**) makes the log-periodic antenna available to hams at a very reasonable price.

A problem with a homebrew meter is calibration — with a surplus instrument, you can at least hope that it is still close to accurate. If a surplus or commercial instrument is available for comparison, then it may be used to calibrate the homebrew meter. Otherwise we must generate a known signal level. One way is thermal — apply RF power to a small 50 termination and measure the temperature rise, then repeat with dc power, which is easily measured, to reach the same temperature. A dc watt produces exactly the same amount of heating as an RF watt. This procedure is at best difficult, as precise temperature measurement is generally relegated to laboratory methods.

Reference Power Source

Another, perhaps more practical approach is to have a known quantity of RF power. The HP Model 435 power meter (and subsequent models) has a quite accurate calibration output providing 1 milliwatt at 50 MHz. The exorbitant surplus prices for the sensors for these meters make the meters unattractive as power meters, although the price for the meter alone can be low enough to justify it for use just as an accurate power source.

Of course, if we can homebrew the power meter, why not the source as well? I started with a common computer oscillator, followed by a pair of diodes, to limit the voltage to a known level, then a low-pass filter to eliminate harmonics and make a pure sine wave.

I used some free software: *Ansoft Designer SV* (**www.ansoft.com**) to calculate the filter values and *LTspice* (**www.linear.com**) to simulate the circuit, with the goal of making the output power less sensitive to component values so that output power would be reproducible without requiring adjustment. The final unit, shown in the photo, produces an output of −10 dB mW, or 0.1 mW, and easily fits in the traditional Altoids tin. Copies should be within 1 dB of this power level, quite accurate enough for amateur use, and probably as good as most surplus meters. Figure 1 is the schematic diagram.

Construction details are on my Web site at **www.w1ghz.org**. Kits are available from Chuck Steer, WA3IAC, at **chuckwa3iac@yahoo.com**.

All photos by the author.

Introduction to Microwaves Workshop

The 33rd Annual Eastern VHF/UHF Conference will be held April 20-22, 2007 at the Crowne Plaza Hotel in Enfield, Connecticut. Saturday afternoon features an Introduction to Microwaves workshop conducted by some of the leading microwavers in New England. There will be a special reduced fee for those attending only the workshop.