By Rick Littlefield, K1BQT

A Wide-Range RF-Survey Meter

Find and measure the presence of RF energy over a 500-MHz range with this inexpensive, easy-to-build meter.

JOE BOTTIGLIERI, AA1GW

This handy RF-survey meter measures signal levels from –70 dBm to +10 dBm over a 500-MHz frequency range. The detector's wide response and pocket-size portability make it useful for design work and bench-testing, RFI hunting, EMR hazard detection, fox-hunts, surveillance sweeps and many other tasks around the shack and in the field—and it's cheap and easy to build!

Circuit Description

The heart of this project is U1, Analog Device's AD8307 wideband detector IC (see Figure 1). This eight-pin device is a specialized instrumentation chip that accurately reads RF levels over a huge 92-dB signal range, then generates a 0.5 to 2.5-V dc log-output signal to drive a signal-strength indicator. It works a bit like the RSSI (received signal-strength indicator) feature found on many FM receiver ICs, but covers a frequency range spanning VLF to over 500 MHz with a virtually flat response.[1] The IC's logarithmic output is important because it permits us to use a linear-scale voltage display to indicate signal strength in decibels (dB) or decibels referenced to a milliwatt (dBm)—just like a spectrum analyzer.

U1's output feeds an LM3914 LED driver (U2) that controls the meter's 10-segment color-coded LED array. The first LED lights with no signal present to function as a power-on and battery status indicator. The remaining nine LEDs illuminate sequentially, in 10-dB increments, as signal input increases over U1's 90-dB measurement range. U2 is configured in the bargraph mode, which means the LEDs illuminate collectively as the reading increases. This mode draws a bit more operating current than the single-LED mode, but yields a far more colorful and easy-to-read display. To compensate for increased current drain, a momentary press-to-test power switch is used to conserve power anytime measurements aren't being taken. I chose the solid-state LED array over an electromechanical meter because it delivers sufficient accuracy for casual survey work, and because it is virtually bulletproof.

Do you need greater resolution? The AD8307's accuracy is within 1 to 2 dB over its entire dynamic range and could be used to drive a more sophisticated display consisting of a dc-amplified large-scale meter or a recalibrated DVM module. For more complete technical information, data sheets and application notes are available at Analog Device's Web site: **http://www.analog.com/logamps**.

Construction

Nearly all of the parts required to build this project are readily available at your local RadioShack store or can be ordered via RadioShack's Web site **http://www.radioshack.com**. PC boards are available from FAR Circuits,[2] and single quantities of the AD8307s can be purchased from me.[3]

Assembling the meter is simple. The only tricky operation I encountered was mounting the LEDs at the correct height to mate with the panel openings. I solved this problem by making a small spacer-gauge from a scrap of PC board and slipping it under each LED during soldering. Spacing may vary slightly, depending on the LED manufacturer. The LED array is much easier to make if all the diodes are manufactured by the same company and have identical case styles. When mounting capacitors, lay C5 on its side so it clears the front panel. Use caution when installing U1. The AD8307 is static-sensitive, so use a wrist strap, a grounded soldering iron and standard CMOS-IC handling precautions.

Testing and Final Assembly

Perform the initial testing and calibration before mounting the PC board in its case. Attach a fresh 9-V battery to the snap clip. If you don't have a precision signal generator available, apply power and adjust the **ZERO** trim pot (R2) so only the first red LED illuminates. This will provide a rough calibration, and your meter will be

[1]Notes appear on page 44.

A Current Probe for the RF-Survey Meter

This little meter can be a useful accessory for the home experimenter. Microwattmeters can be quite expensive, even if they're used equipment. For example, this meter can be used to indicate the power from an LO in a receiver or transmitter design.

Microwattmeters also have other uses. With a small whip antenna (ie, a "rubber ducky"), the meter can be used as a relative field-strength indicator. With a rubber ducky, W1AW's signal registered at about half scale as I wandered, meter in hand, around ARRL HQ and the grounds. (HQ staff are used to seeing Lab personnel running around doing all sorts of weird things.) Be careful not to place the meter too close to an antenna, though; it is possible pick up too much RF and possibly damage the meter.

Several companies now sell hand-held current probes based on technology similar to that used in this project. Those probes have a current probe composed of a small clamp-on ferrite bead wrapped with a few turns of wire. The meter then can be used to accurately measure small RF currents and as a relative indicator of the amount of RF noise present on computer cables, the outside of a coaxial cable, telephone wiring, etc.

The commercial units I've seen have the ferrite probe mounted directly on the meter. Although this is handy, it can make the meter awkward to use in tight quarters. To measure noisy cables, I want something a bit more portable. I considered using various spring-type clamps available at hardware outlets, but they all seemed far too springy. As I strolled through the tool department at Lowe's, the Vise Grip clamp shown in Figure A caught my eye. The flat parts of the clamp seemed perfectly suited to the task I had in mind. The ferrite beads with plastic covers used here are available from Palomar Engineers, PO Box 462222, Escondido, CA 92046; tel 760-747-3343; **palomar@compuserve.com, http://www.palomar-engineers.com/** and from RadioShack (RS 273-104).

To build the probe, first trim the latch on the ferrite bead's plastic housing so that the sections no longer snap together. Use a few dabs of epoxy to hold each half of the bead to the Vise Grip clamp, as shown in Figure B. (Be careful not to get any glue on the ferrite material.) The clamp's flat sections are perfectly suited for this arrangement; other clamps don't have these flats. Once the glue sets, carefully pry out one ferrite section from the plastic housing. Wrap three to five turns of small enameled wire (#28 will do) on the bead half, leaving about 3/8 inch of wire for leads. Using a small dab of glue to hold it in place, press the bead back into its housing.

Remove about 3/16 inch of insulation from each of the probe's wire ends and solder them to a short length of RG-58 coaxial cable. Cover each lead connection with a length of heat-shrink tubing or insulated sleeving. Install a BNC male connector at the cable's other end. I used a couple of small plastic ties to secure the coax to the clamp; see Figures A and B. (For photographic purposes, I didn't add the heat-shrink tubing.) The probe is now ready to use.

To use the probe, adjust the Vise Grip clamp carefully so that the probe's ferrite sections *just* close when the clamp is squeezed. (Excessive closing pressure may damage the ferrite sections. Once the proper adjustment point is reached, consider locking the adjustment screw in place with epoxy or using a jam nut.) Clamp the probe over the cable you're checking. With four turns of wire on the bead, the cables on several computers at HQ just lit the meter's yellow LEDs. Significantly noisier computers lit the meter's red LEDs, indicating that those cables could be a source of RFI. If desired, you can calibrate the probe/meter combination using a signal generator and a 47-Ω resistor to create a known current.

Microwattmeters can be useful pieces of test equipment for the RF designer. New microwattmeters cost several thousand dollars. This project can get you nearly the same performance at a lot lower cost.—*Ed Hare, W1RFI, ARRL Laboratory Supervisor*

Figure A—A handy probe is made by attaching the two halves of a modified ferrite core to a Vise Grip clamp. Plastic ties secure the cable to the clamp.

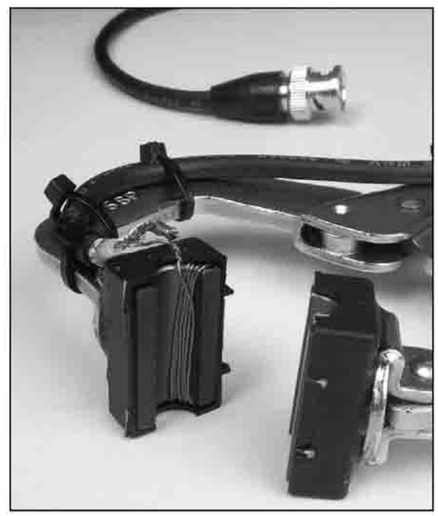

Figure B—Close up view of the modified ferrite core wound with a few turns of enameled wire.

Table 1
Signal levels falling within the survey meter's range span a 90-dB range.

Power (dBm)	*Power (W)*	*Approximate Potential Across 50 Ω*
+10	10 mW	1 V
0	1 mW	300 mV
–10	100 µW	100 mV
–20	10 µW	30 mV
–30	1 µW	10 mV
–40	100 nW	3 mV
–50	10 nW	1 mV
–60	1 nW	300 µV
–70	100 pW	100 µV

reasonably accurate for most survey tasks.

If you have access to a signal generator, install two short leads on the BNC connector and tack-solder them temporarily to the PC-board-input connections. With power applied and nothing connected to the BNC connector, adjust R2 so the first LED illuminates. Then, set the generator for CW output at 100 MHz and connect its patch cable to the BNC jack. Reset R2, as needed, so the last LED just illuminates with +10 dBm of signal applied. When calibrated, reducing the generator's output in 10-dB increments should extinguish one LED per step. If the bargraph reading doesn't change reliably with each step change between +10 and –60 dBm, reset R2 slightly until it does. Note that the low-level green LED (–70 dBm) may remain on continuously because of stray RF pickup on the generator cable.

Once alignment is complete, remove the BNC connector and install the PC board in its case. Secure the PC board in position by the **POWER** switch, omitting the switch's lock washer when installing. Make sure all LEDs are seated in the case openings before fully tightening the switch's mounting nut. Install the BNC connector in its panel and, using short leads, permanently connect it to the PC board.

Operation

Avoid connecting this meter to signal sources more powerful than +20 dBm (100

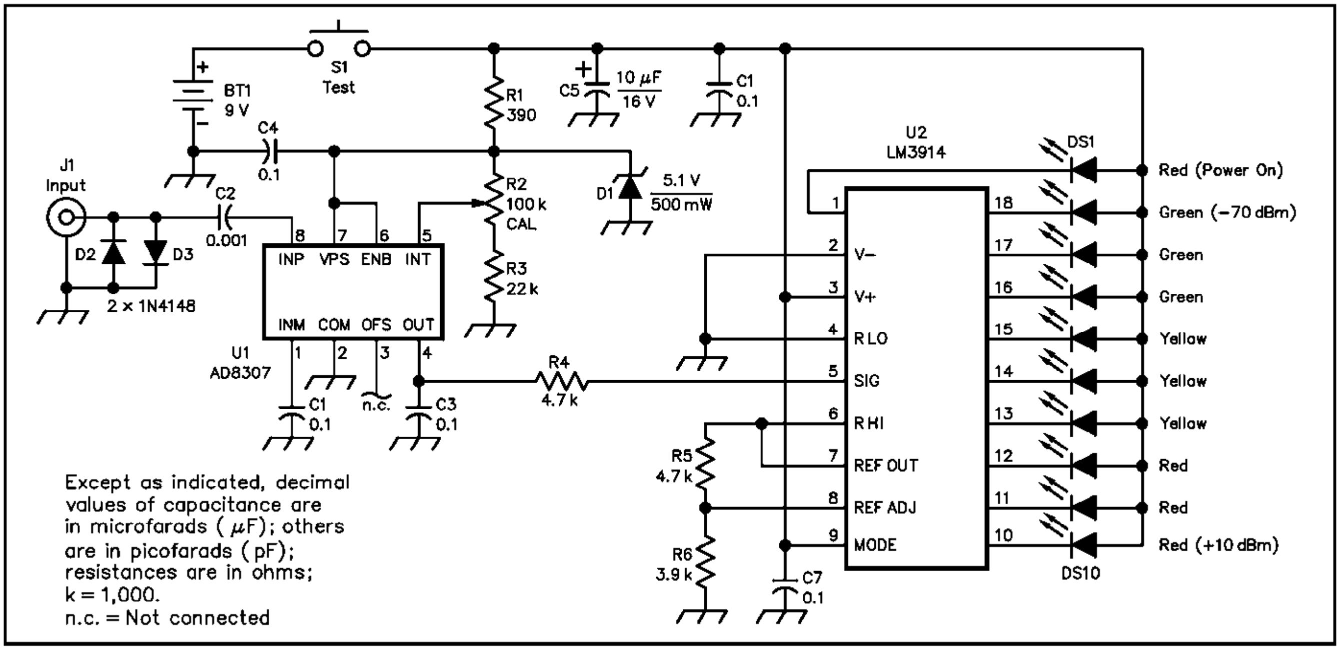

Figure 1—Schematic of the RF-survey meter. Unless otherwise specified, resistors are 1/4-W, 5%-tolerance carbon-composition or film units. Part numbers in parentheses are RadioShack; numbers with 900 prefix are for RadioShack's on-line catalog (http://www.radioshack.com). Equivalent parts can be substituted; n.c. indicates no connection.

C1, C3, C4, C6, C7—0.1 µF disc ceramic
C2—0.001 µF disc ceramic
C5—10 µF, 16 V electrolytic or tantalum
DS1, DS8-DS10—3 mm LED, red (900-6085)
DS2-DS4—3 mm green LED (900-6086)
DS5-DS7—3 mm yellow LED (900-6087)
D1—1N5231B, 5.1 V, 500 mW Zener diode (900-3088)
D2, D3—1N4148
J1—BNC chassis mount connector (RS 278-105)
R2—100 kΩ, 6-mm horizontal-mount trim pot (RS 271-284)
S1— SPST momentary, normally open switch (RS 275-1571)
U1—Analog Devices AD8307
U2—National LM3914 (900-6840)
Misc: Case—2 3/4×4 5/8×1-inch (HWD) box with 9-V snap clip (RS 270-211)

mW) without first installing an attenuator or sample tap to reduce the input to a safe level. To operate your meter, press the TEST switch and observe the bargraph display. If the lowest segment fails to illuminate, check the battery condition before proceeding. The meter draws approximately 20 mA (depending on how many LEDs are lit), so frequent use will necessitate periodic battery replacement.

When making measurements, remember this is a basic survey tool designed for gathering ballpark indications rather than precise data. Also, as with any broadband device, it cannot discriminate between narrowband and wideband energy sources or tell you the frequency of an applied signal. Finally, remember that the dBm is a unit of RF power referenced to a 50-Ω load. The unterminated input impedance of U1 is approximately 1 kΩ at 100 MHz, so readings taken across unknown loads will be *relative* indications that are comparable in dB, but not absolute values in dBm.

Summary

This simple hand-held project uses a low-cost instrumentation IC to detect the presence of RF energy over a 500-MHz range. Approximate signal intensity is displayed on an easy-to-read LED display, and a wide range of sampling attachments may be used for picking up signals. I find I use it often, both on the bench and in the field, whenever I need a quick "reality check" for the presence of RF. It's especially useful for tracking down RFI sources, as Ed (W1RFI) Hare's sidebar, "A Current Probe for the RF-Survey Meter," illustrates.

Notes

[1]Rick Littlefield, K1BQT, "The Analog Devices AD8307 92-dB Logarithmic Amplifier," *Communications Quarterly,* Summer 1999, pp 77-80.

[2]A PC board is available from FAR Circuits, 18N640 Field Ct, Dundee, IL 60118-9269, tel 847-836-9148 (voice and fax). Price: $4 plus $1.50 shipping for up to four boards. Visa and MasterCard accepted with a $3 service charge; **http://www.cl.ais.net/farcir/**.

[3]Contact the author for information.

Rick Littlefield, K1BQT, is an Extra Class licensee and active ham since 1957. An avid builder, RF-product designer and author, he's written for a wide range of Amateur Radio publications since 1969, and was inducted into the QRP-ARCI Hall of Fame in 1996. Rick holds a Master's Degree from the University of New Hampshire and currently works as a technical writer in the electronics industry. You can contact Rick at 109A McDaniel Shore Dr, Barrington, NH 03825; **k1bqt@aol.com**.

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