Building Hints for the Simple RF Power Meter

8March2015, 1April2015 w7zoi

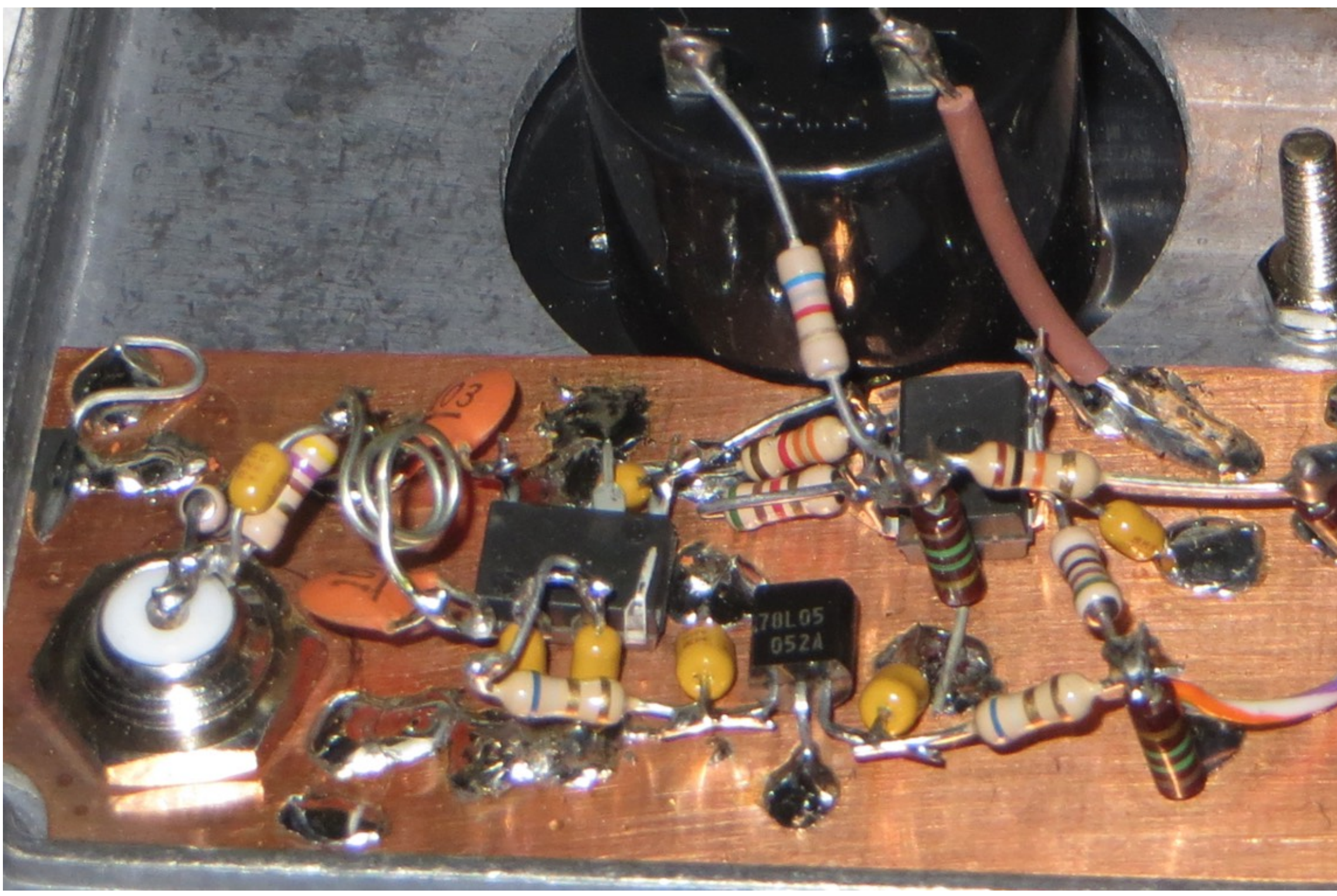
A few years ago Bob Larkin and I described a simple power meter in QST. See w7zoi and w7pua, "**Simple RF-Power Measurement,**" QST, June 2001, pp38-43. The design is based upon a logarithmic detector integrated circuit from Analog Devices. The IC has a very wide dynamic range, high gain, and wide bandwidth, making it ideal for numerous amateur radio applications. The IC functions as a wide bandwidth detector. An input RF voltage results in a DC output. The important feature is a DC output proportional to the logarithm of the input voltage. The IC output changes by 25 mV for every dB change in input. Log compliance ("linearity") is excellent, within a small fraction of 1 dB.

This instrument has a maximum input power of only 40 or 50 milliwatts. As such, it should not be used to measure a transmitter output unless a suitable attenuator or "tap" is included. This is discussed in the QST paper. The instrument has a 50 Ohm input impedance that dissipates the applied power. It is not intended to be an in-line VSWR or power meter. This is a measurement tool for the experimenter rather than an accessory for a radio station. (Of course, the experimenter with a radio station can find mutual applications.)

The Problem:

Recent correspondence with several experimenters has brought a problem to the forefront. These builders seem to have been constructing the power meter without benefit of a clean ground plane. Rather, they have tried to use a breadboard intended for low frequency applications. The breadboard is, I suspect, a matrix of holes with attached islands, allowing parts to be soldered to the board and attached to other components. We used breadboards of this sort for experiments in the industry. These boards are suitable for low frequency (e.g., audio) applications, but are not ideal for VHF/UHF. Even when building a power meter for HF use, UHF methods are recommended, for the AD8307 is capable of operation at UHF. Sloppy construction may lead to parasitic oscillation.

Shown below is a photo of the version we built for the QST article and for Chapter 7 of EMRFD.

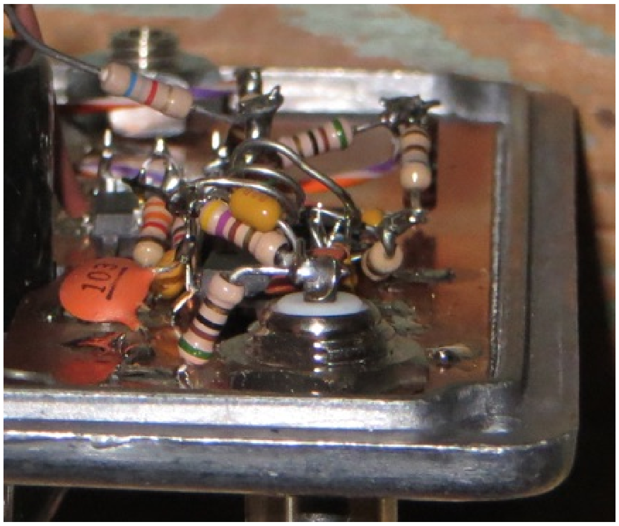


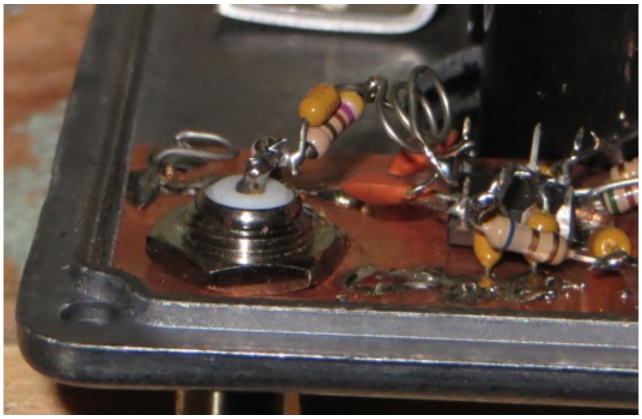
Take a look at the original QST article or the description in EMRFD (page 7.7) to see the schematic. The important construction detail here is the ground plane. This is formed with a scrap of circuit board material. All of the places in the schematic where a ground connection is shown match with a foil solder connection in the photo. There are a couple of 1.5 Meg-ohm resistors on the breadboard that do not appear in the schematic. These are mechanical support elements. The high value resistor is soldered to the ground foil. Other components are then attached to the ungrounded end. This is the essence of what we call ***Ugly Construction***. See KA7EXM and W7ZOI, "**The Ugly Weekender**," QST, August, 1981. The high resistance value guarantees that there will be little interaction with circuit operation. Exact resistance value does not matter so long as it is high.

This is not a pretty circuit. Components are NOT necessarily configured in a straight line and none are soldered to pads. But this is the essence of ***Ugly***. The circuit still functions well because the grounding is good. Signals flow in transmission-line-like paths. Parasitic inductance related to long component leads is small. Undesired coupling between circuit elements is small when the impedance to ground is very low for all grounded elements. (Keep leads short.) If care is taken to use just enough "standoff" resistors, the circuit will even be mechanically robust. Remember that a pretty circuit is no guarantee of functionality.

We are not saying that other construction methods won't work. However, methods that ignore the coupling and stray inductance issues may suffer. Surface mount circuits, implemented with proper microstrip design, are ideal for a power meter of this sort. See, for example, the system described by KA7EXM, "**A PIC-based HF/VHF Power Meter**", QEX, May 2005, page 3.

Here are two additional photos showing the input. A standard BNC connector is used to mount the board flush with the Hammond box.





More recent thoughts:

One recent builder wanted to add a negative power supply. The negative supply on the LM358 is within the common-mode input range of the op-amp, so a negative supply is **NOT** needed.

One other detail bears repetition: **This power meter will have a residual response.** Disconnecting the input cable to eliminate an input signal **will not** force the meter to go to zero. This is not a flaw in the instrument, but a simple fact. The power meter is responding to the noise generated in the IC input That noise is amplified by the many cascaded stages within the AD8307 until it is detected. This is no different than the noise we hear in a receiver. Even if a receiver has the antenna disconnected, there will be some output noise. Our version of the QST power meter has a residual indicated power of -75 dBm. Assuming a 500 MHz bandwidth, this response is consistent with a 12 dB noise figure. * Some builders have tried to re-design the op-amp circuit to get rid of the residual response, but we don't recommend this. (We don't do it with our receivers.)

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*The residual input power is kTBF where the terms are linear rather than dB. k is Boltzman's constant, T is temperature in

Kelvin, B is bandwidth in Hz, and F is noise factor which is the ratio corresponding to a noise figure in dB. In logarithmic terms, kT is -174 dBm, B is 87 dB, and F is 12 dB for the -75 dBm we observe.