Sensitive RF Detector for Sun Noise and other uses

Paul Wade W1GHZ ©2013,2025

w1ghz@arrl.net

The Microwavelengths column in ***QST*** for July 2013 discussed Sun Noise measurement. The detector circuit I used is shown schematically in Figure 1 of the column, but there isn't room in a two-page column for a full description.

Sun noise is an increase in the noise level when pointing a reasonably high gain antenna at the sun. For most amateur antennas, the noise increase is small, only a few dB above the noise floor of a low-noise receiver.

How do we accurately detect such a small difference in noise? Certainly an S-meter is not up to the task. We can connect a VU meter to the receiver output and turn the AGC off (otherwise it will attempt to keep the noise output constant), but we will find that the meter jumps around far too much to be useful – noise is random and varies from moment to moment. We must find a way to integrate, or average, the noise output for a long enough time, perhaps one second, so that the meter holds still, but not so long that we cannot see a change as we move the antenna.

One possibility is a microwave power meter, for instance the HP 432, which detects heating of a small thermistor, and has a large meter which can easily resolve tenths of a dB. The power meter provides two benefits: the thermistor detector has a slow response time, so that the needle doesn't dance, and the scale on the meter is only about 5 dB on each range, so that tenths of a dB are easily discerned.

However, a power level in the milliwatt range is needed for a stable reading. The noise level at the antenna is on the order of -174 dBm/Hz, or -140 dBm in a typical receiver bandwidth. Using a larger bandwidth of 1 MHz (even more is better) increases the level to -114 dBm, so only 110 dB of stable gain is needed for the power meter. Part of this is provided by the microwave preamplifier and transverter, but much more is needed. At the microwave IF frequency, 144 or 432 MHz, I use a series of small amplifiers, since putting more than about 30 dB of gain in a box is asking for trouble, and filters between the amplifers to limit the bandwidth to a few MHz. The last amplifier, the one driving the power meter, must be capable of at least 12 dB more power than the noise level, so that it can handle 99.9% of the noise peaks without clipping or saturating the amplifer. Theoretically, noise peaks may be infinite – we can't handle those, but we should be able to handle almost all the rest. A variable attenuator somewhere in the chain is useful to adjust the level for convenient meter reading.

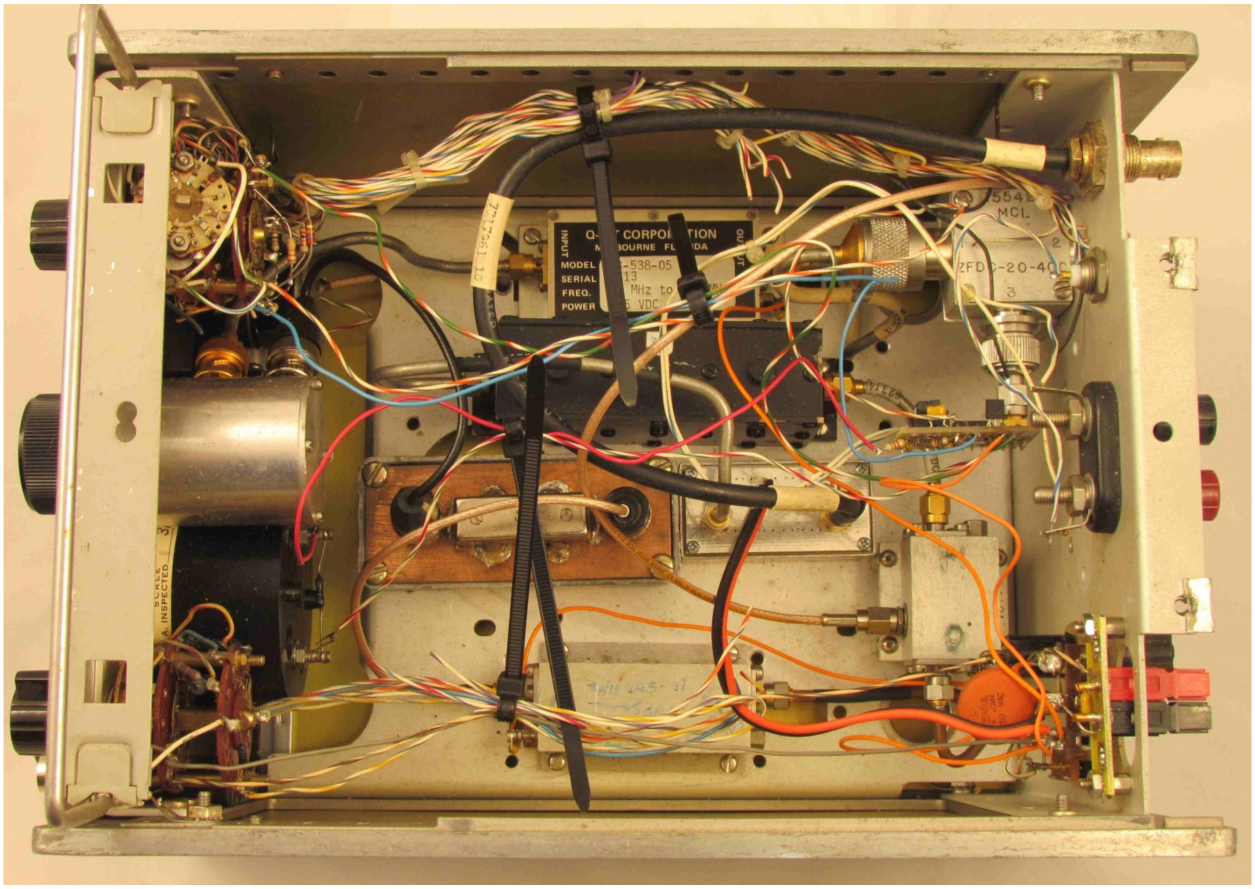

Figure 1 - Sun Noise Detector built in defunct HP Power Meter Cabinet

I built this system, shown in Figure 1, using a collection of surplus parts into the cabinet of an older defunct power meter, which still has the large meter movement. The front panel is visible in Figure 2 of the ***QST*** column, behind the dish. To make use of the existing meter movement and to eliminate the need for a separate power meter that requires AC power to operate, I included a detector circuit. The detector circuit is a power detector IC, an AD8307, whose output is linear in dB – 25 millivolts per dB.

I followed the detector with an amplifier to drive the meter movement, with enough gain so that full meter range is only 5 dB. The amplifier has a very small bandwidth, or long time constant, to average the noise and keep the needle from dancing. The voltage at the “METER ZERO” terminal is adjusted with an off-board potentiometer, Rz, to get the noise reading on scale – a ten-turn pot might make it easier to adjust. The schematic diagram of the detector and amplifier is shown in Figure 2, and a photo in Figure 3.

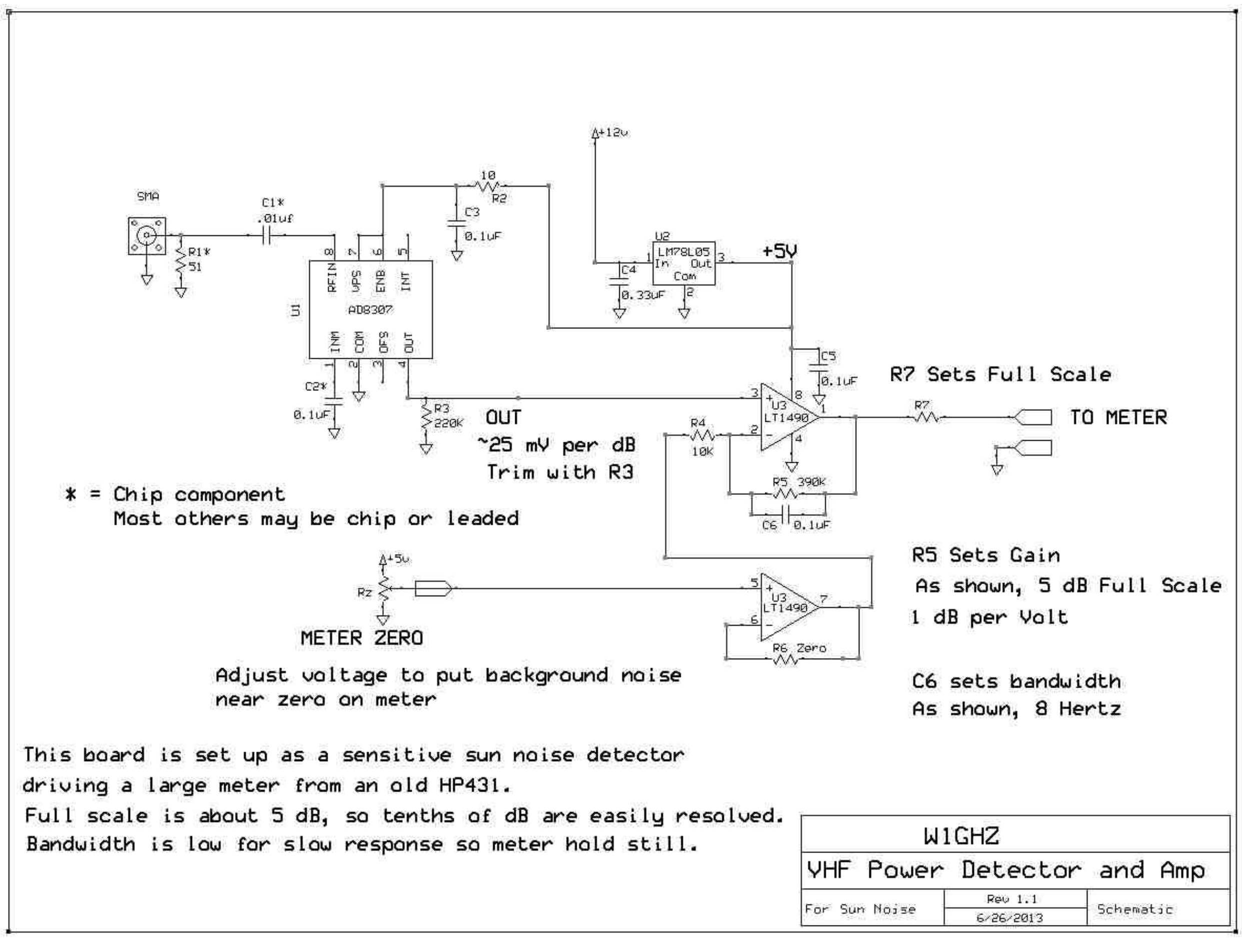

Figure 2 – Schematic of Sun Noise Detector and Amplifier

The amplifier uses an op-amp to provide the required gain; the op-amp output is 0 to 5 volts, or 1 volt per dB for a 5 dB scale, so a voltage gain of about 40 is needed. R5 sets the gain, and can be adjusted as needed – the meter range could be 2 dB or 10 dB if you prefer. A 5 volt output should be full scale on the meter; R7 (off board) sets the meter full scale. Finally, capacitor C6 sets the time constant – a tradeoff between response time and meter dancing – so play with it until it feels right. Op-amp U3 is a "rail-to-rail" type, but the output still doesn't quite go to zero and maximum voltage, so try to avoid the very ends of the meter range for best accuracy.

While I used the large meter movement in the defunt power meter, any analog meter movement would do – the 1 milliamp meters that used to be common would be fine. A digital meter might provide better resolution, but would be difficult to peak on the sun. Of course, you could have an analog meter for peaking and a digital one for precise readout.

PC Board

The PC board is small and not too complicated, so I am going to make the ExpressPCB (www.expresspcb.com) board file available and urge you to have your own made. The layout as seen in the ExpressPCB free software is shown in Figure 4, with the top metal layer in red, the bottom metal in green, and silkscreen in light blue. Feel free to modify it for your own needs, and there is plenty of space on the Miniboard panel to add some other circuits.

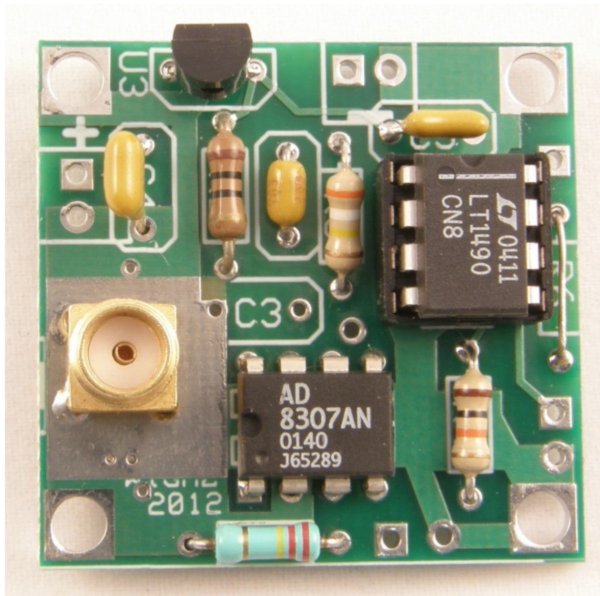

Figure 3 – Sun Noise Detector and Amplifier

If you haven't tried designing PC boards before, there is a short tutorial PowerPoint presentation that K3TUF and I did last year at a conference available on the www.w1ghz.org website. It should be enough to get you started, and it doesn't cost anything to download the software and play with it. If you come up with something that others might find useful, please share it also.

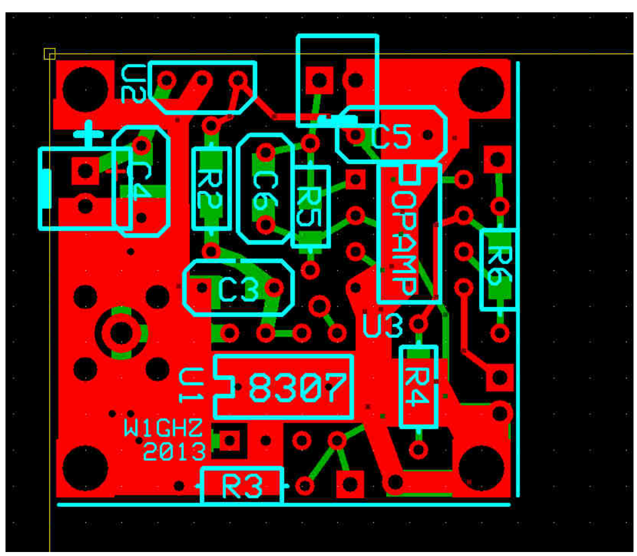

Figure 4 – PC Board layout in ExpressPCB software

Surface Mount Version

The AD8307 in the DIP package is hard to find, but readily available in the surface-mount SOIC version. I made an alternate PC board with all SMT parts, shown in Figure 5. The schematic diagram is unchanged from Figure 2. Resistors and capacitors are 0805 or 1206 size – both fit.

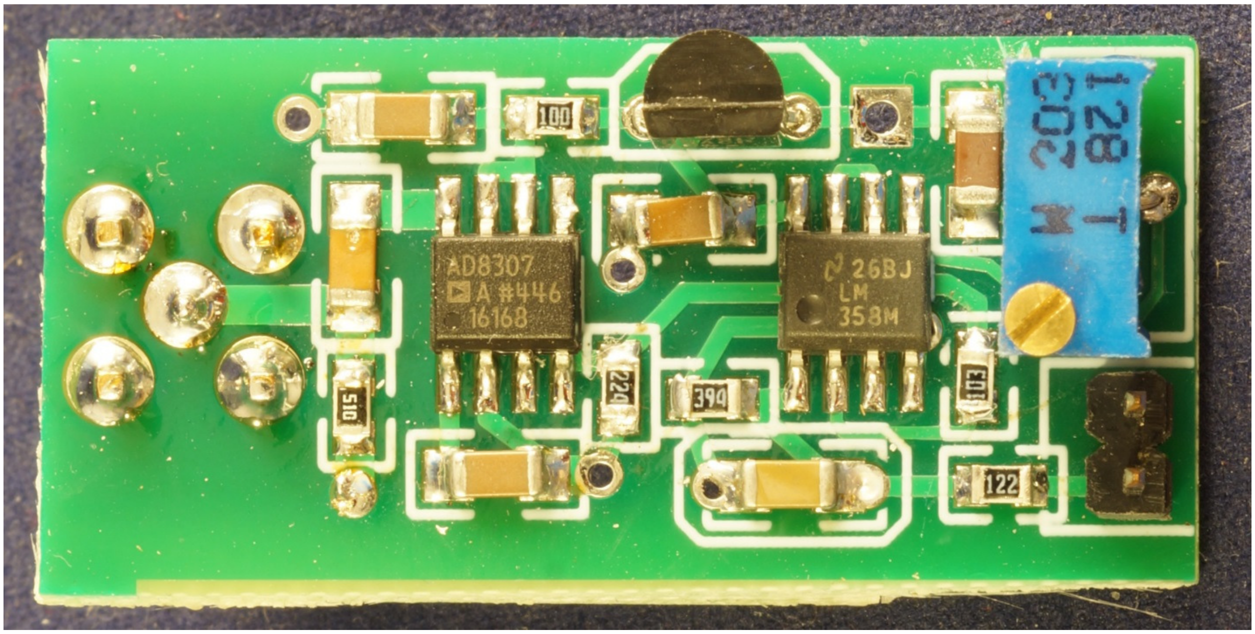

Figure 5 – Surface-Mount version of Sun Noise Meter and Amplifier

Suggestions

The AD8307 is a very useful power detector for VHF and UHF (and lower). In addition to sun noise, it can make a pretty accurate power meter in a transverter or amplifier. With a simple LED bargraph display, it can be a handy battery-powered RF detector.

The AD8307 price has increased significantly, but many can be found on ebay at much lower prices. You can also find modules similar to this one, with or without the amplifier, for loss than the cost of the chip alone. I've found some AD8307 modules for under $5 and used them as RF power indicators in transverters.

The sun noise meter is useful for peaking an antenna on the sun or moon, but for measurements, there are software solutions that do a better job. The sun noise meter either has a flickering meter pointer or a very slow response time (laws of physics). The software versions can average better to reduce uncertainty and record the results for more precise interpretation. I recommend TotalPower by Mario, I0NAA. The latest version includes a tone output which is really handy for peaking.