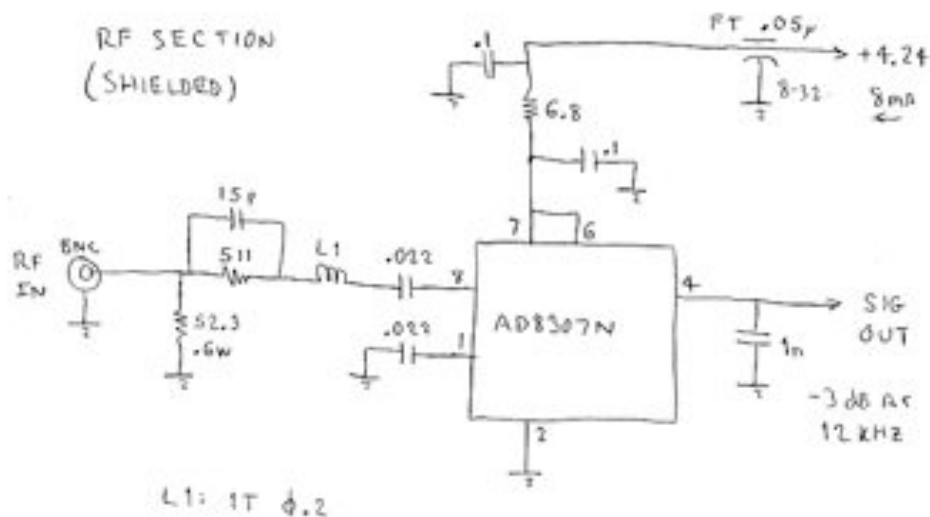# RF Power Meter

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January 15, 2007

This is my version of a simple RF power meter that has been published a couple of time before. I started with the first article by Hayward and Larkin[1] because it had the basic front-end and theory of operation, which was all I needed. A second article by Kopski[2] is closer to what I built because he added a DVM with scaling. Another article by R. Hayward[3] adds a PIC microcontroller and enable both dBm and milliwatt readouts. There are also some notes of general interest at the W7ZOI website.[4]

RF Section

Below is my RF section schematic. This is right out of the first article and it works great out to 700+ MHz and has an accurate 90 dB dynamic range. More on the specs later. The main thing is to keep the front-end very compact, use VHF construction techniques (tiny parts, very short leads), and shield it from everything else. The output filter capacitor on pin 4 is actually a feedthru. Watch out for those things, though; their tolerance are sometimes pretty bad, and in this case it does set the audio rolloff frequency.

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[1] Wes Hayward, W7ZOI, and Bob Larkin, W7PUA, "Simple RF Power Measurement," *QST*, June, 2001. Available from ARRL (members only) at http://www2.arrl.org/members-only/tis/info/pdf/0106038.pdf

[2] Bob Kopski, K3NHI, "An Advanced VHF Wattmeter," *QEX*, May/June 2002.

[3] Roger Hayward, KA7EXM, "A PIC-Based HF/VHF Power Meter,", *QEX*, May/June, 2005. Available from http://www.arrl.org/qex/2005/QX5Hayward.pdf

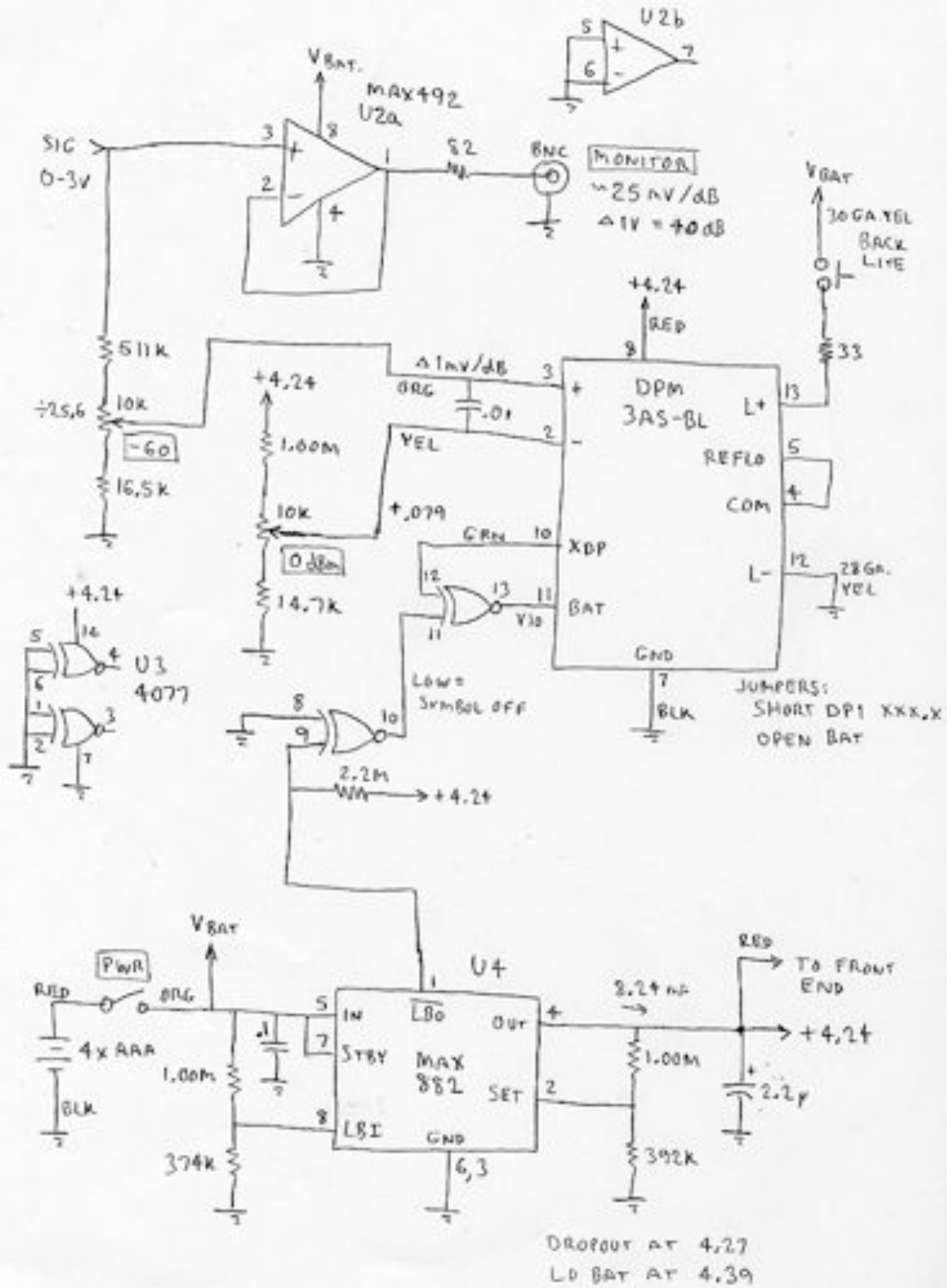[4] W7ZOI website, http://users.easystreet.com/w7zoi/pmeter.html

Audio Section

On the next page is the "audio" section of the meter. The RF section delivers a DC signal that ranges from 0 to 3 V, max. I used a rail-to-rail I/O, micropower opamp (MAX492) to buffer the signal for external monitoring purposes. Otherwise, no opamps are actually needed. The digital panel meter I used is Martel 3AS-BL, available from Digikey. It has a backlight that is actuated with a momentary button. The decimal point is fixed by a jumper. This is a 3½ place meter and ends up with a resolution of 0.1 dBm. Sometime I wish it was a 4½-place so that I could see smaller changes. An external voltmeter can do the same thing.

I used a micropower, low-dropout voltage regulator (MAX882) and fiddled with voltages to get a reasonable dynamic range on the AD8307 while getting good battery life on just four AAA cells. If your run the AD8307 on a slightly higher voltage you get a couple of extra dBm at the high end, but that's about it. So I compromised at 4.24 V. Regardless of the voltage you pick, you definitely want a stable regulator of some kind to maintain accuracy. This regulator has a low-battery comparator, so I added a couple of XOR gates to drive the low-battery indicator on the display.

The meter is very flexible, running from 3 to 7.5 VDC and its inputs are differential and very high impedance. It is set for a ±200 mV range. That made it easy to scale the AD8307 output. I used a couple of 20-turn pots plus some fixed resistors to optimize the adjustment range. The objective is to end up with a slope of 1.0 mV/dB, and make 0.0 dBm deliver 0.0 V to the meter. No other adjustments are required (you can, optionally, trim the AD8307 slope and intercept, but that would be redundant here).

To calibrate, you need an RF source with a calibrated output. I work at a place where that's no problem… To make adjustment easier, I set the source to 0.0 dBm and had an attenuator after it. That way, I could jump back and forth between 0 and -40 dBm while alternately adjusting the two pots. If the values seem to be diverging, maybe you're turning the wrong pot, or going the wrong way. Trust me, it will eventually converge and the meter will be very accurate.

V_BAT.

MAX492
U2a

U2b
5
6
7

SIG
0-3V

3
2
8
1

82

BNC

MONITOR
~25 nV/dB
ΔIV = 40 dB

V_BAT
30 GA. YEL
BACK
LITE

33

+4.24
RED

511k

÷25.6   10k
-60
16.5k

+4.24
1.00M
10k
+.079
14.7k
0 dBm

Δ1mV/dB
ORG
YEL
.01
GRN
12
13
11
V3a

3
2
10
XDP
BAT

DPM
3AS-BL
L+   13
REFLO   5
COM   4
L-   12   28 GA. YEL

GND
7
BLK

+4.24
5
16
U3
4077
6
1
2
3
4
7

Low =
Symbol off

8
9
10
2.2M
+4.24

JUMPERS:
SHORT DP1 XXX.X
OPEN BAT

V_BAT
PWR
RED   ORG
4x AAA
BLK

.1
5   IN   LBo
7   STBY
MAX
882
8   LBI   GND
SET   2
6,3

1.00M
374k

U4
1

Out   4
3.24 nA

RED
TO FRONT
END

+4.24

1.00M
2.2µ

392k

DROPOUT AT 4.27
LO BAT AT 4.39

3

Performance

Frequency response was flat within my reference system's uncertainty (±0.1 dB) from 1 MHz to 80 MHz, and was within ±0.8 dB out to 550 MHz. This was measured at -38 dBm input. Response may be different at other power levels.
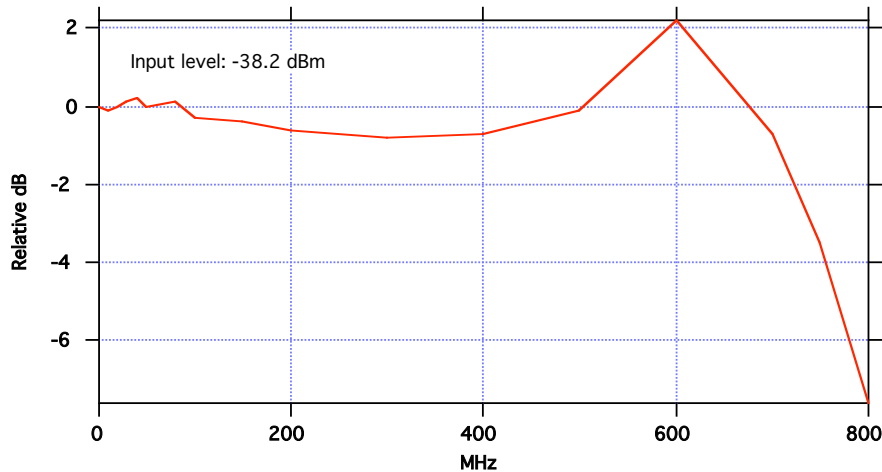
In the high-power region, the meter error was as follows. Clearly, this thing is accurate to at least +16 dBm. It has a 0.25 W input resistor, so you do need to avoid burning that up. In the first reference article, they show you how to make a high-power 30 dB attenuator.

Input Power, dBm	Meter Reading
+16	+15.9
+17	+16.6
+20	+18.5

For very low frequencies, I noted the following -3 dB points:

Input Level, dBm	-3 dB Freq
0	10 kHz
-40	100 kHz
-60	670 kHz

With no input, the display usually reads -74 dBm, now that it's fully calibrated. Battery life should be well over 100 hours.

The Build

Here's what it looks like inside. The enclosure is a Hammond 1590B, which is pretty tight, but with care you can make it fit. I used my vertical mill to machine the rectangular cutout for the meter. You can also drill and file it.
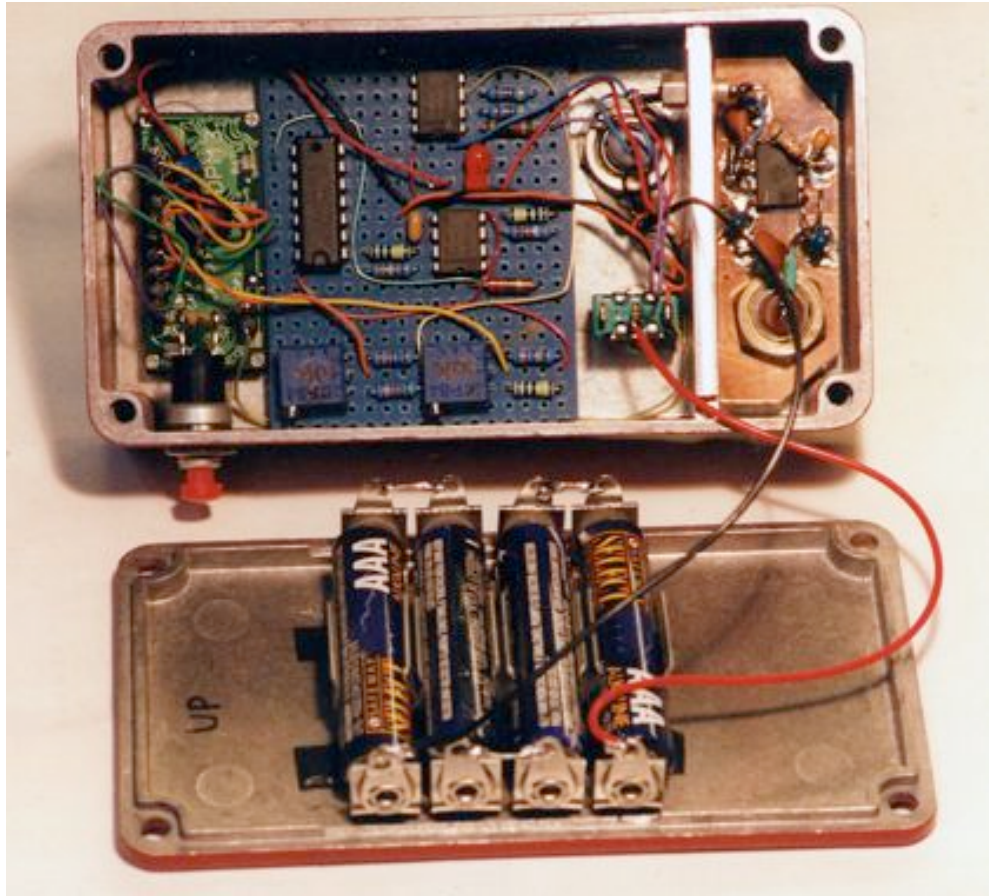
The RF section is walled-off at the upper right. I machined a piece of 0.125-inch aluminum to fit exactly between the inside walls of the case and then fixed it in place with #2-56 screws. The RF section circuit board is held in place by the BNC connector's nut. There are feedthru capacitors through the divider wall. The AD8307 is mounted dead-bug and lead lengths are absolutely as short as possible. That's why it works way out into the UHF region.

A tidy package. The red button is for the backlight. I had labeled it "RF +13 Max" before final testing; it should read +16. The crinkle finish is made by painting the box with enamel and then clear-coating it with a lacquer or acrylic spray that tends to lift the paint. A good use for incompatible finishes, eh?