Packaging the HOT-1 Noise Source

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1. Introduction

I recently purchased a HOT-1 noise source from RF Associates [RFA] so that I could extend the calibrated range of the high frequency receivers I use to observe solar radio bursts. Prior to the HOT-1, I used an RF Associates RF-2050S noise source with a maximum noise temperature output of 1.4 million kelvin. My HOT-1 has a maximum output of 23.1 million kelvin at 18 MHz, about 70 times (18 dB) greater than the RF-2050S and closer to the noise temperature of the more powerful solar bursts I have been receiving in the first half of 2012.The HOT-1 normally is calibrated at a single frequency (20.1 MHz) although its useful frequency range extends from below 18 MHz to above 150 MHz. I asked RF Associates to calibrate the HOT-1 at five frequencies (described later).

The HOT-1 does not include a step attenuator like the RF-2050S. An attenuator is needed between the noise source and the receiver so that a number of calibration points can be plotted. My work area is cluttered enough as it is and I knew that adding an attenuator, two connecting coaxial cables (one to the noise source and one to the receiver antenna input), and the power cable would only add to the mess. I soon decided to put the HOT-1 in a metal enclosure with a step attenuator, noise output jack, dc power switch and dc power input jack. This article describes the simple construction project that makes a nice, neat, self-contained noise source (figure 1).

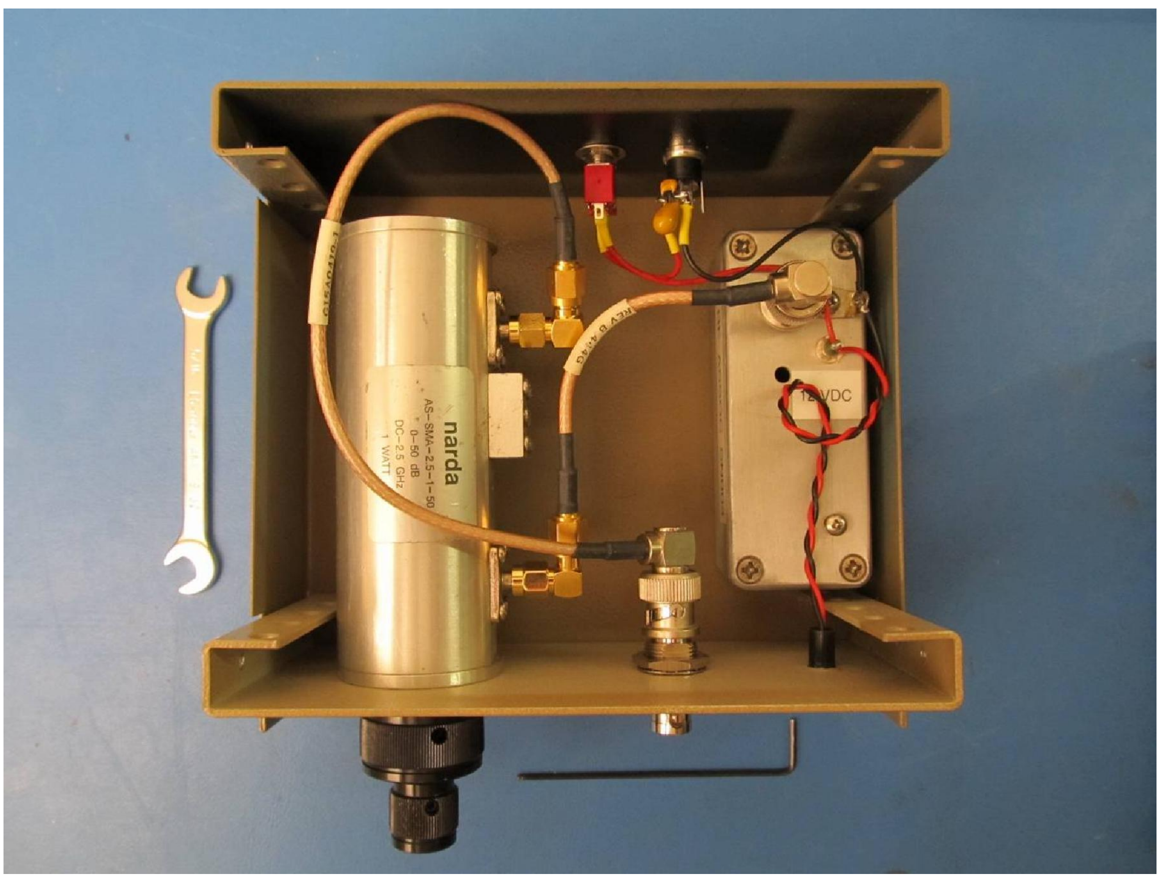

Figure 1 ~ Top view of the painted metal enclosure, which includes an RF Associates HOT-1 noise generator (right) and attenuator (left). The enclosure also includes a power switch and power input jack (top) and a BNC connector for the output (bottom). The 5/16 in wrench is for the SMA connectors and a 1/16 in hex L-wrench is for the attenuator knobs.

2. Bill of materials

Item	Qty	P/N	Mfr or Vendor	Description
1	1	HOT-1	RF Associates	Noise source, nominal 23 million kelvin at 18 MHz
2	1	50DR-003	JFW Microwave	Step attenuator, 50 dB in 1 dB steps (see text)
3	1	1458C3	Hammond Mfg	Metal enclosure, 6 in x 6 in x 3 in (152 mm x 152 mm x 76 mm)
4	2	Generic	Generic	SMA-M RA/BNC-M RA jumper cable, RG316/U
5	1	Generic	Generic	BNA-F/BNC-F coupler, panel mount
6	1	317287	Jameco	Toggle switch, miniature, SPST
7	1	151555	Jameco	DC coaxial power jack, 2.1 mm x 5.5 mm
8	1	545650	Jameco	Capacitor, 10 µF, 35 V, tantalum
9	1	15229	Jameco	Capacitor, 10 nF, 50 V, MLCC
10	1	637183	Jameco	LED, 12 V, Green, panel mount (with internal dropping resistor)
11	1	WH24-xx	NTE	Hookup wire, stranded 7x32, 24 AWG, 300 V PVC, red and black
12	2	Generic	Generic	Machine screw, pan head, 4-40 x 5/16 in
13	2	Generic	Generic	Washer, internal star, #4
14	3	Generic	Generic	Machine screw, pan head, 6-32 x 3/16 in
15	3	Generic	Generic	Washer, internal star, #6

The HOT-1 is the main component and operates from nominal 12 Vdc at 100 mA. Everything else listed in the bill of material (BOM) may be substituted to fit your setup. Items marked generic are available from many vendors and items marked Jameco (http://www.jameco.com) are suggested and not critical. The specified LED can be mounted directly on the panel and has stranded wire leads and an internal voltage dropping (current limiting) resistor. If an ordinary LED is used, a 600~1000 ohm, 1/2 W resistor should be placed in series with it to limit the current to about 20 mA.

3. Attenuator and associated cables

I initially used a 30 dB step attenuator (JFW 50DR-055-SMA). This provided a range of noise temperatures at 18 MHz from 23.1 million kelvin (0 dB) to 23.1 thousand kelvin (30 dB) in 1 dB steps. When testing the response of my receivers I found that more attenuation would be useful so I replaced the original unit with a 50 dB step attenuator, Narda AS-SMA-2.5-1-50 (the JFW 50DR-003-SMA is a direct substitute for the Narda unit). A 50 dB attenuator provides a theoretical range down to 231 K, although it would be impossible for the noise temperature to actually go below room temperature of about 293 K. I had both the 30 dB and 50 dB attenuators in stock and both were the same physical dimensions, so the change-out was easy. I probably would have ended up using a 40 dB attenuator if I had one.

JFW Microwave and Narda step attenuators are readily available from auction and used microwave equipment websites. Many other companies including Texscan and Trilithic make similar models. Be sure to coordinate the attenuator and enclosure size to make sure everything will fit. I recommend an attenuator with SMA connectors to reduce the space required. Be aware that the mounting screws for the specified attenuator have a maximum depth of 0.2 in.

Jumper cables with SMA connectors are tedious to make by hand. Considering the cost of individual connectors, I find that it is cheaper and much less hassle to purchase ready-made cables from various eBay sellers. These cables are inexpensive and default lengths typically are 150 mm, which is fine for this application. I always test the cables on receipt with a spectrum analyzer and tracking generator up to 2 GHz and have never found any problems. The cables required for this project should have right angle connectors at both ends, or you can use a right angle adapter (as seen on the attenuator in the previous figure).

4. Construction

Remove the four screws from the top of the HOT-1 aluminum box and set the top with the printed circuit board aside. Drill and tap the bottom of the box for two 4-40 (or size of your choice) screws. The hole locations are not critical except they should not be too close to the corners. I placed two holes 1/2 in from the edges in opposite corners. Drill corresponding clearance holes in the bottom of the metal enclosure. The screws for mounting the HOT-1 box in the enclosure should not extend into the HOT-1 by more than about 1/8 in.

Drill clearance holes for the attenuator, BNC coupler and LED power indicator in the front panel and for the dc power jack and toggle switch in the rear panel. The hole dimensions will depend on the actual hardware but in my project they are as shown on the drawings (figure 2).

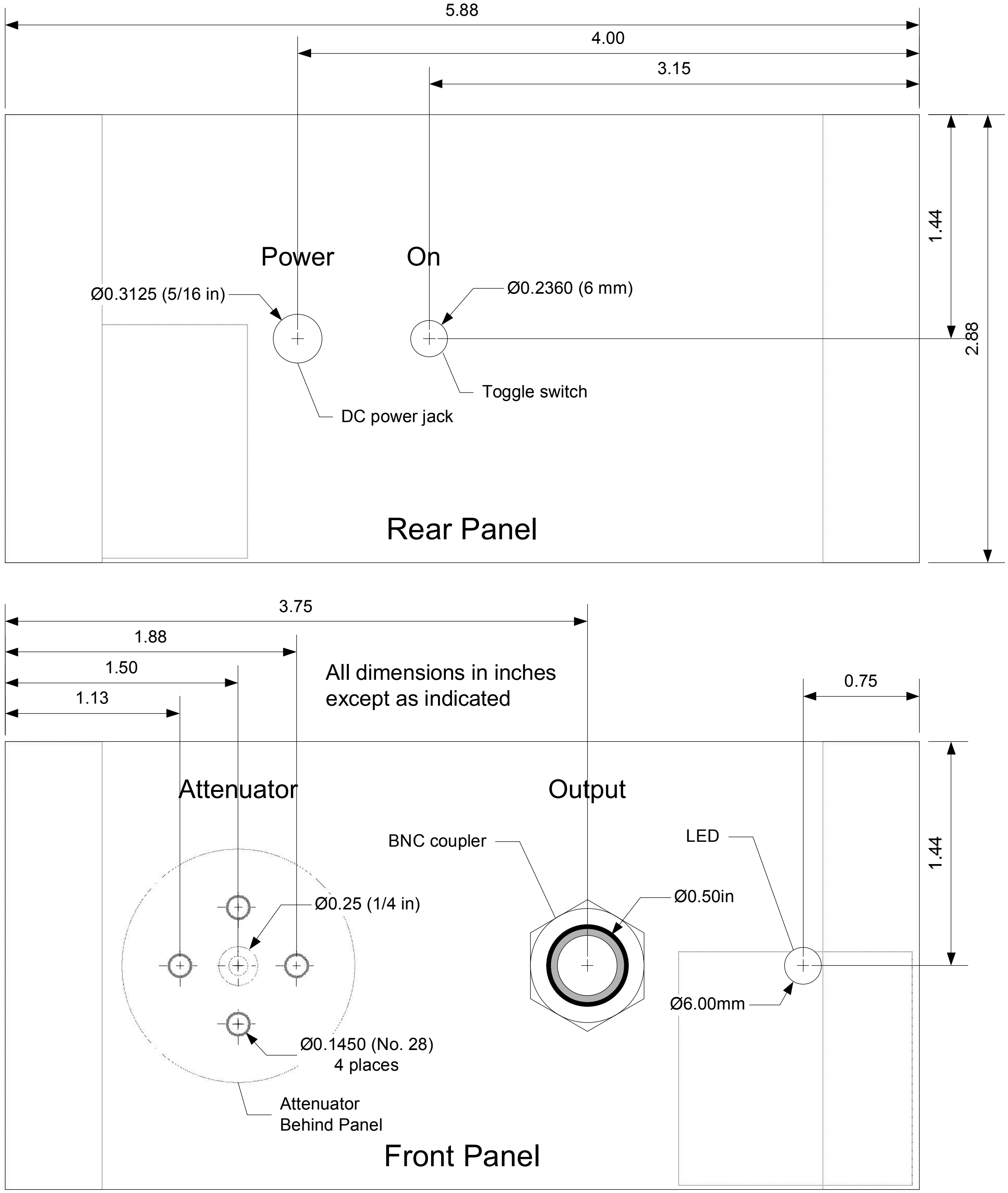

Figure 2 ~ Front and rear panel layouts for the HOT-1 Package. Dimensions shown correspond to the items listed in the bill of materials.

After all holes are cut, clean and paint the enclosure. Be sure to put rubber feet on the bottom to protect table surfaces from the HOT-1 mounting screws (rubber feet are supplied with the specified enclosure). The various items are then mounted in the enclosure and the HOT-1 power input connections (a ground lug and feed-through capacitor) are wired through the SPST toggle switch to the dc power coaxial jack (figure 3). The LED is soldered directly across the HOT-1 power connections. Solder the two filter capacitors specified in the BOM with very short leads to the power jack being sure to observe the polarity of the tantalum capacitor (figure 4).

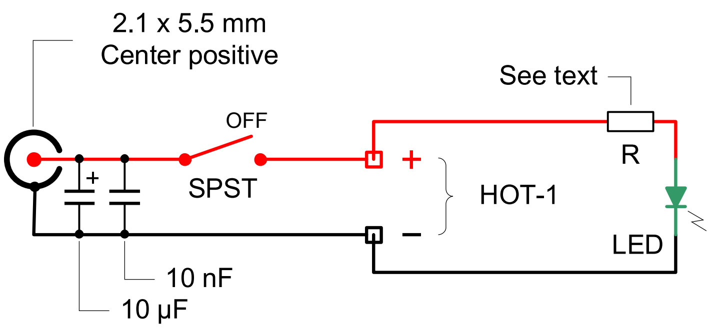

Figure 3 ~ Power wiring schematic. The current limiting resistor, R, is not required if the specified LED is used.

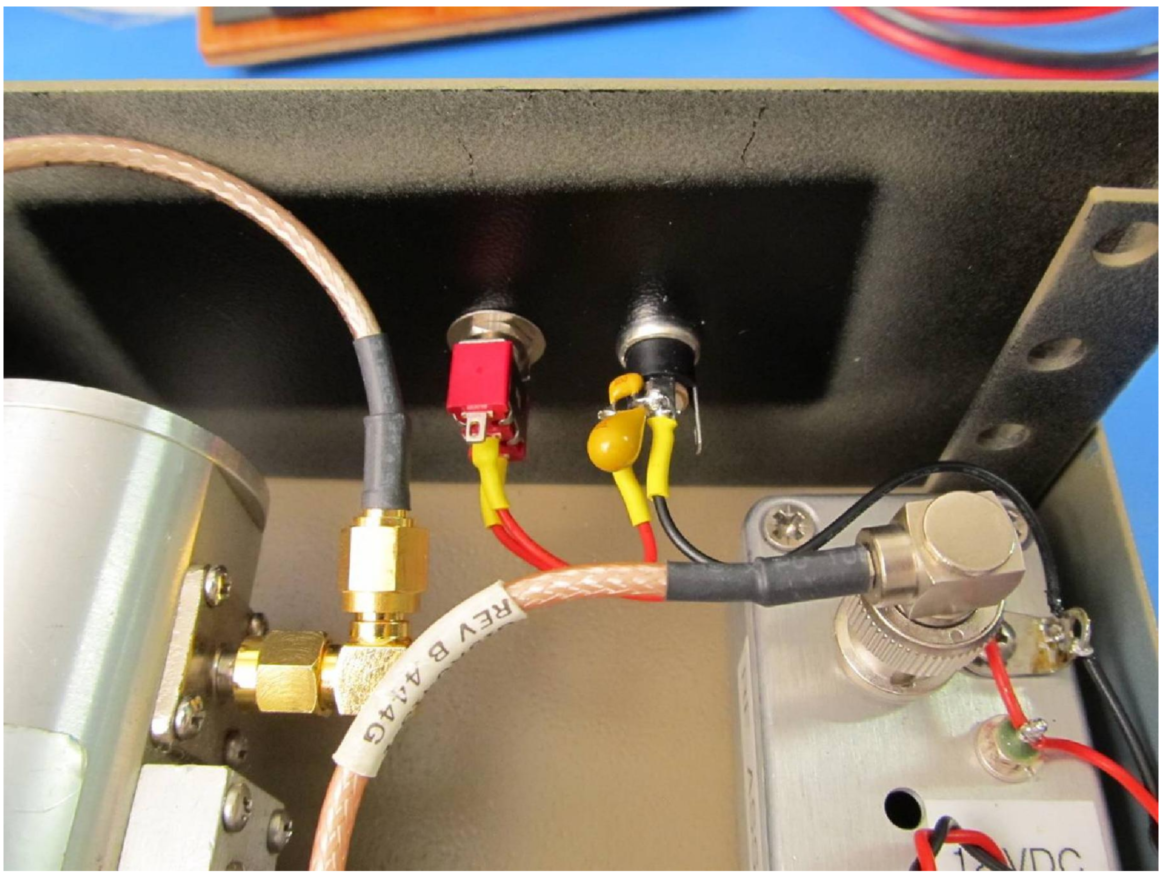

Figure 4 ~ Close-up of the filter capacitors soldered directly to the coaxial dc power jack on the rear panel. The panel was factory painted black, and some overspray from the new color, dark taupe, can be seen around the components.

5. Calibration chart

I made a calibration table in Microsoft Excel that shows the attenuator setting and output for each of the calibrated frequencies. Each HOT-1 may have slightly different calibration frequencies and noise temperatures, but I will describe the method using my values so you can make your own table (figure 5).

HOT-1 s/n 004						
Attenuation	18 MHz	25 MHz	32 MHz	50 MHz	150 MHz	Units
0	23100	23400	24800	25300	17100	x 1000 K
1	18349	18587	19699	20097	13583	x 1000 K
2	14575	14764	15648	15963	10789	x 1000 K
3	11577	11728	12429	12680	8570	x 1000 K
4	9196	9316	9873	10072	6808	x 1000 K
5	7305	7400	7842	8001	5407	x 1000 K

Figure 5 ~ Calibration table showing a few of the rows. For a 50 dB, 1 dB step attenuator, there will be 52 rows, one for each step value including zero and a legend row.

The first column in the calibration cable is the attenuator setting. There should be an entry for each step value. For example, if you use a 50 dB attenuator with 1 dB steps, there should be a 51 values (including 0 dB). The next column should be your first calibrated frequency. You will have a column for each calibrated frequency, and you can insert additional columns for uncalibrated frequencies. The noise temperatures for the uncalibrated frequencies can be interpolated. I specified five calibrated frequencies when I purchased the HOT-1 noise generator, 18, 25, 32, 50 and 150 MHz, so my table has a total of six columns including the attenuation column. I added a seventh column for convenience to indicate the units.

The values for 0 dB attenuation in each frequency column will be the calibration values supplied with your HOT-1 noise generator or the interpolated value for uncalibrated frequencies. These numbers are fixed. The value for 1 dB in each frequency column will be the calibrated noise temperature reduced by 1 dB or a factor of $1/(10^{1/10}) = 0.7943$. In the example table, the calibrated noise temperature for 0 dB at 18 MHz is 23 100, and for 1 dB attenuation, the value is

$$23100/(10^{1/10}) = 23100 \cdot 0.7943 = 18349\ .$$

Similarly, for 2 dB, the factor is $1/(10^{2/10}) = 0.6310$ and the corresponding noise temperature is

$$23100/(10^{2/10}) = 23100 \cdot 0.6310 = 14575\ .$$

The values calculated in the above examples are x1000 kelvin as indicated in the right-most column in the example table. The spreadsheet makes these calculations fast and simple for all frequencies and attenuator settings. The final step is to print and laminate the calibration chart and fasten it to the top of the enclosure (figure 6). When done, the HOT-1 Package is ready for service (figure 7).

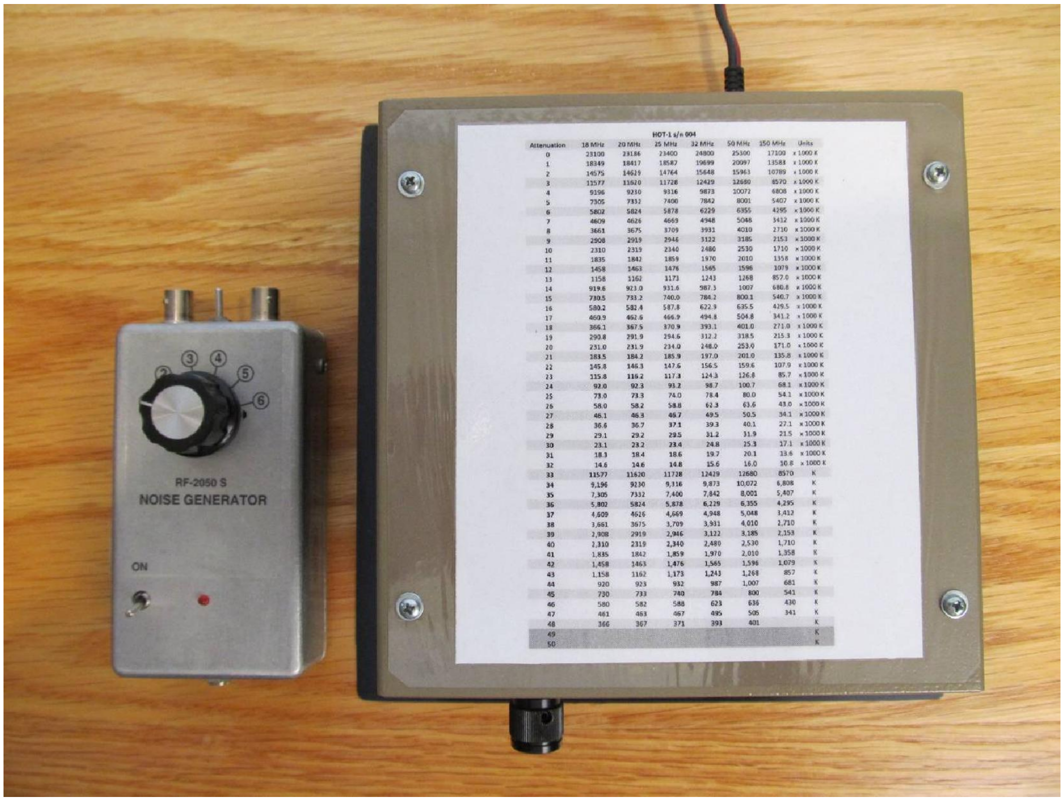

Figure 6 ~ Packaged HOT-1 with calibration chart (right) next to RF-2050S (left). The calibration chart was laminated and fastened to the top of the enclosure with small self-threading screws and washers.

Figure 7 ~ Packaged HOT-1 at the receiver station ready for service.

6. References

[RFA] RF Associates LLC, 1721-I Young Street, Honolulu, HI, Email: rf@hawaii.rr.com