Subject: Science Aficionados Amplifier Box B (ABB)
Memo: 16, Revision 1
From: Glen Langston
Date: 2017 May 25

This note describes a 2nd configuration of the Radio Frequency (RF) Ultra Low Noise Amplifier (LNA) box for the *Science Aficionado*s Radio Telescope. This amplifier box is called Amplifier Box B (ABB). This memo only describes the a new, simpler and lower cost, version of the amplifier box. Please see Light Work Memo 15 for the background information.

The B amplifier Box system has very high gain, +46 dB (a factor of 39,000). The first ultra low amplifier has an excellent noise figure (< 0.6 dB), corresponding to an effective receiver temperature of < 45 Kelvin. The measured system temperature of the telescope is better than 105 Kelvin, corresponding to a noise figure of 1.3 dB for the entire system. This memo describes the B Amplifier Box component configuration. Nick of GPIO.com provided the Red amplifier with modifications to allow powering the system via a bias-tee.

## Amplifier Box B (ABB)

ABB contains several components. First we list the components used for system temperature measurements, which was found to have an effective system temperature between 90 and 115 Kelvin, confirming the good performance of this configuration.

The components of ABB, are shown in Figure 1. The box is bolted to the feed port into the resonant cavity, the 6" diameter stove pipe.

Figure 1 shows the inside of the amplifier box. This system is built from two ultra low noise amplifier evaluation boards. The first board is a the TB-468+ evaluation board for the TAMP-152GLN+ amplifier, sold by Mini-Circuits. Between these two boards are 1) a VBF-1445+ band pass filter and 2) a 1 dB attenuator (VAT-1+), to reduce ringing between the two amplifiers. The filter and attenuator are sold by Mini-Circuits. All components have SMA connectors. As noted above, the DC voltage for powering the amplifiers is provided on the signal (coaxial) cable. The voltage and radio frequency (RF) signal using a "Red" amplifier box sold by GPIO.com. The input to the first amplifier is provided by a Male N-connector to Male SMA connector on the other end.

The prices of the parts used for the ABB are listed below:

1. N connector right angle. $2
2. N connector male to SMA male adaptor. $6
3. TAMP-1521GLN+ (Mini-Circuits) + 35dB, $79 on TB-468+ evaluation board
4. VBF-1445+ -2dB $34
5. VAT-1+, -1 dB, $14.
6. Semi-rigid Coaxial cable 6" $3 in bulk quantities
7. GPIO.com "Red" Amplifier with integrated bias tee. +15dB, $35 on small board.
8. Aluminum box - Hammond.com 1590 J. $13

The N-connector for the probe costs $1. The total parts cost is $184 for one complete ABB.

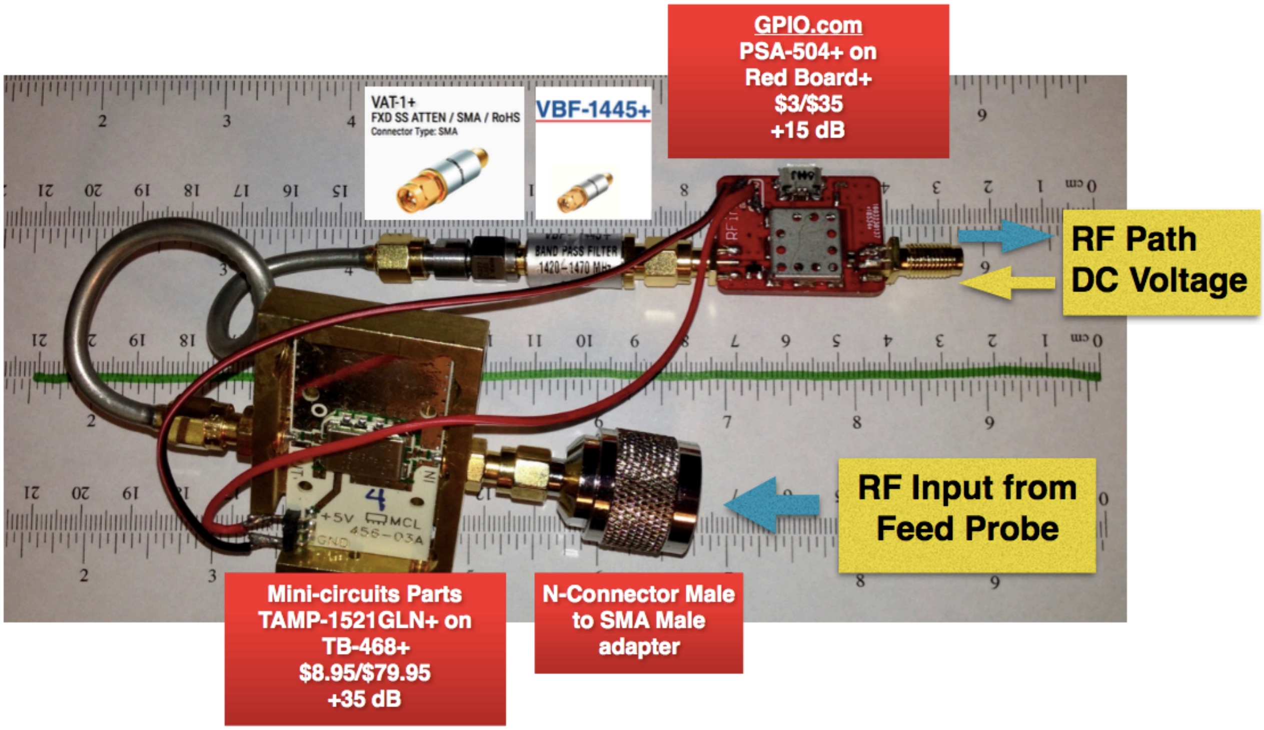


***Figure 1: Picture of Amplifier Chain Components.*** *The radio signals come into the low noise amplifier via the N- to SMA adaptor. The first amplifier in the chain uses the TB-468+ evaluation board with TAMP-1521GLN+ device. The output is attenuated and filtered. The second amplifier has lower gain but also functions as the Bias-Tee to power both amplifiers. The output is via an SMA connector. DC voltage is provided on the output. For scale, the green line in the background is the wavelength of atomic neutral hydrogen, 21cm (8.3 inches).*

It is desirable to further reduce the parts costs to enable more *Science Aficionados* to participate. It seems feasible, by putting most components on a single board, to reduce the cost below $150.

Figure 2 shows the components in the aluminum box. The “Red” amplifier was modified by the author to replace a standard size SMA output connector with a longer one, suitable for bolting to the outside of the aluminum box.

## Hot/Cold Load Measurements

The ABB performance was assessed by measurements of “hot” and “cold” load measurements. For this system the hot load is made by observations of the ground, with an assumed temperature of 295 Kelvin. The cold load observation is made looking at the sky, far from the Milky Way’s galactic plane. The cold load has an assumed temperature of 15 Kelvin, from both the atmosphere and the cosmic background radiation, 2.7 Kelvin.

Several measurements were made. Two are noted. One was made before replacing the Red amplifier output SMA connector with a longer one. The second was measured afterwards. The first measurements had lower system temperature (90 K), and possibly my soldering skills may be contributing to the higher (110 K), but still excellent performance, of the system after this

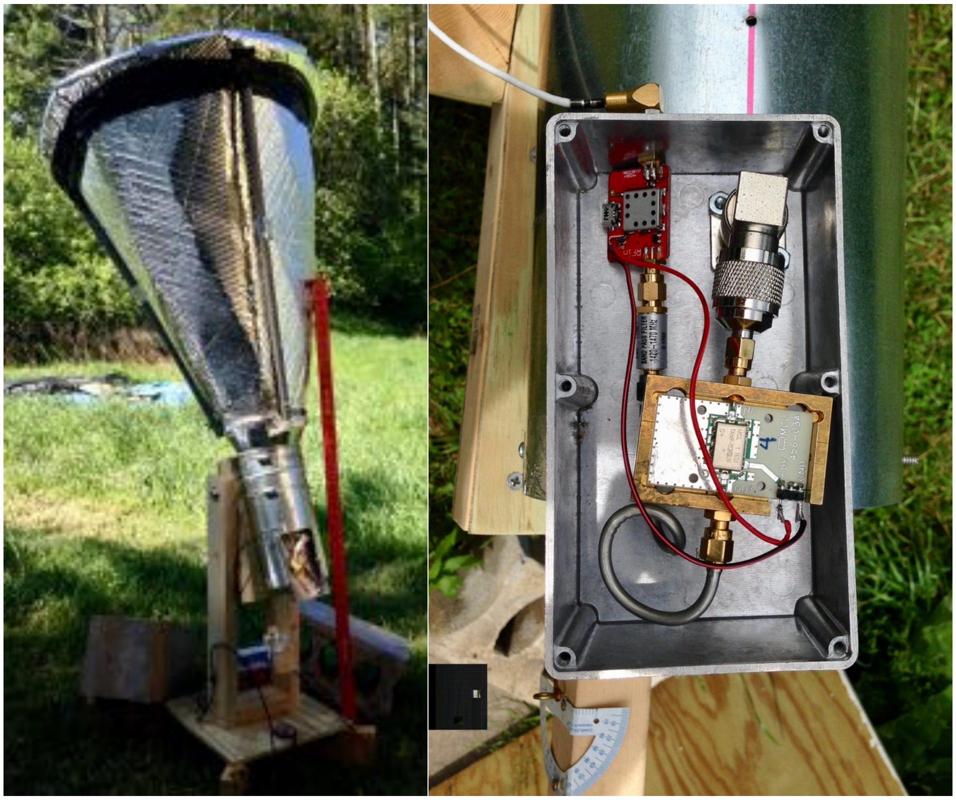

***Figure 2: Pictures of ABB on the telescope.*** *The telescope is a funnel shaped cone that channels the radio signals to the resonant cavity.*

*At left the AAB is shown mounted on the resonant cavity designed to collect the signals for amplification. The red ruler is 4ft long.*

*At right is a zoom in on the contents of the ABB.The radio signals come into box on a female N-Connector. The box has holes drilled for both the feed probe and the machine screws to hold the box on the resonant cavity. Output is via an SMA connector bolted to the ABB.*

modification. (The modification was made because the movement of the coaxial cable connecting the ABB to the software defined radio (SDR) dramatically changed the signal levels, because the cable was loose, since the connector was too short.)

## Conclusion

The design of Amplifier Box B is presented, showing good gain (> 46 dB) and low system temperature (< 115 K), so that the marvels of radio astronomy are within reach of high schools and *Science Aficionados*. Combined with a simple easy to construct telescope, the structure of the galaxy is visible in seconds of observations. It is possible to map the entire visible sky with this telescope in a single day. (This is good bit of work, but could be done by a small team or dedicated classroom). This amplifier configuration has improved convenience and robustness.

We plan to develop an third amplifier box, with all components on a single board, further reducing the cost and increasing capabilities.