A Dual Band Low Noise Amplifier for 2 Meters and 70 Centimeters

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This article describes constructing a dual band low noise amplifier (LNA) for use on 2 meters and 70 centimeters. Bypass capability is included to permit transmitting on either band while listening to the downlink signal on the opposite band of a VHF/UHF satellite.

LNAs are needed when you have a long run of coax between the antenna and receiver. LNAs must be mounted as close to the antenna as is practical because, once you've lost the signal in your coax, there is no way to get it back. LNAs mounted at the antenna amplify the weak signals before they are attenuated in coax.

Total project cost is around $172, depending on what you can rummage from your or your friends' junk box and your hamfest/eBay shopping prowess. The design includes a weatherproof enclosure. The noise figure is around .5 dB on 2 meters and .8 dB on 70 centimeters with 20-25 dB gain. The power handling capability is limited by the relays and the coax. The relay manufacturer rates its units at 50 W up to 1 GHz. The coax used here withstood 50 W from a satellite transceiver.

A low-pass filter on the 2-meter LNA rejects 70-centimeter signals from the transmitter and a high-pass filter on the 70-centimeter LNA rejects 2-meter signals from the transmitter. This prevents overloading the LNAs while listening on one band and transmitting on the other (i.e., when listening to your uplink signal on the satellite downlink).

Performance

While I have not yet measured the noise figure on either band, I perceived a slight improvement with the LNA on SSB but a very noticeable improvement on FM. I performed testing for desense/overload on each band by listening to a very weak signal on a dipole on one band while transmitting 50 W on the opposite band with a dipole. The antennas were eight feet apart aligned parallel to each other. There was no degradation in signal.

The measured filter losses were:

- 2 meter low pass: -.1 dB @ 144 MHz/-70 dB @ 436 MHz
- 70 centimeter high pass: .4 dB @ 436 MHz/- 52 dB @ 144 MHz.

Parts

While at a yard sale, I noticed a home satellite TV multi-dish switch box for 50 cents (Figure 1). I had to have it but with no idea how I would use it. While my satellite TV multi-dish switch box came from a yard sale, they also are available on eBay. I bought my second one at a hamfest for $2. See the pictures showing various stages of disassembly.

The LNAs are available on eBay for $18.95 each ($2.45 shipping) from Chuck Steer, WA3IAC; you will need two. Download the datasheet for the low noise IC (a MiniCircuits PGA-103) to see the lead layout. You can also examine the impressive specs for yourself at **www.minicircuits.com**.

The four relays are available on eBay for $30 or less each. Make sure you get the type you need, latching or non-latching (see discussion below under "Issues and Modifications"). Latched relays need only a short pulse of voltage to switch position and the pole is always connected to one port or the other; non-latched relays must have voltage applied full time to one coil or the other.

The high and low pass filters use silver mica capacitors and air wound coils. Check hamfests and your ham friends' junk boxes for the capacitors and wire.

The N connectors are the hardest part to find. The thread that screws into the chassis is the same as that found on a type F connector. I found two in my junk box but obtained three more from old satellite TV downconverters and surplus LNA/LNBs. They are from the "old" C band satellite TV days when nine-foot dishes were the norm. See Figure 2.

I purchased the SMA cables on eBay for $1.45 each. You will need eight. They are 6" (15 cm) long with male connectors (center pin) on both ends. I had some doubts about the quality of the units I bought on eBay since they are not made in the U.S., so I tore

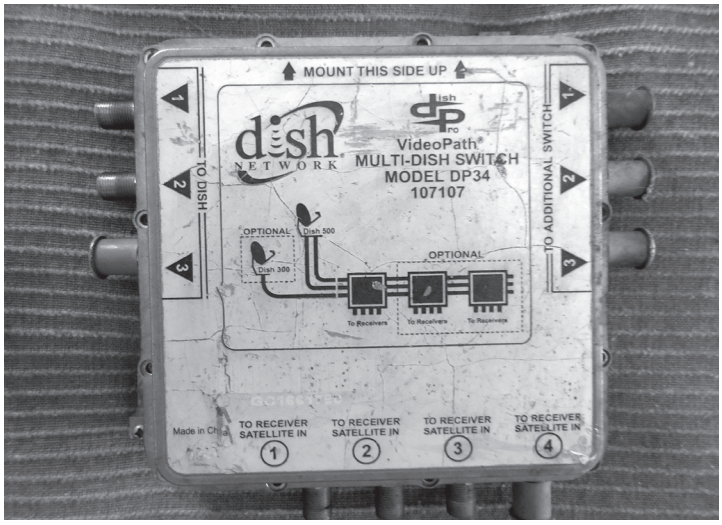

Figure 1 - Original chassis

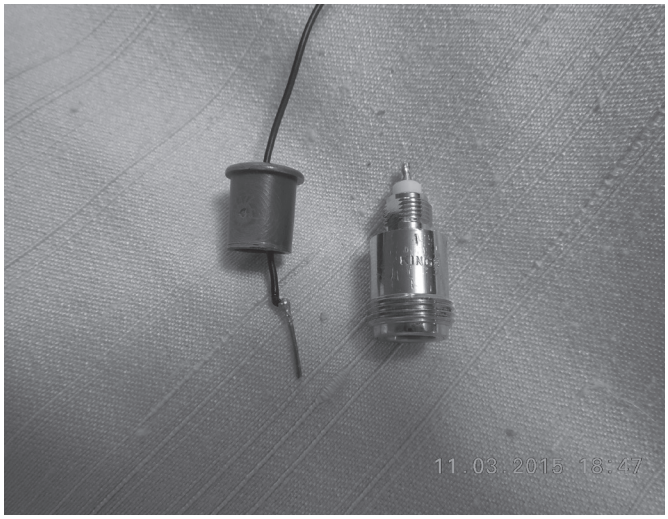

Figure 2 - N connector and plastic cap with wire connection to F connector

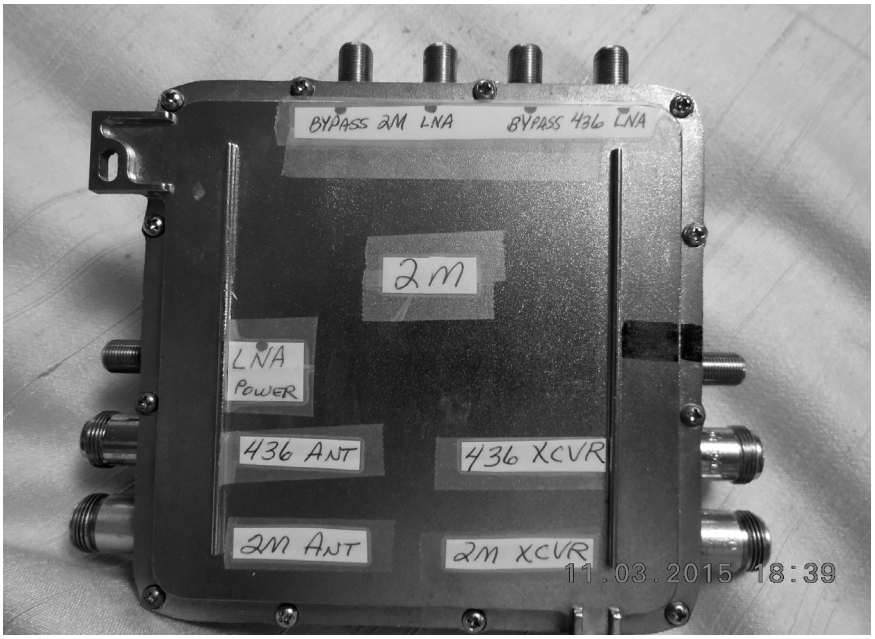

Figure 3 - Labels showing connections

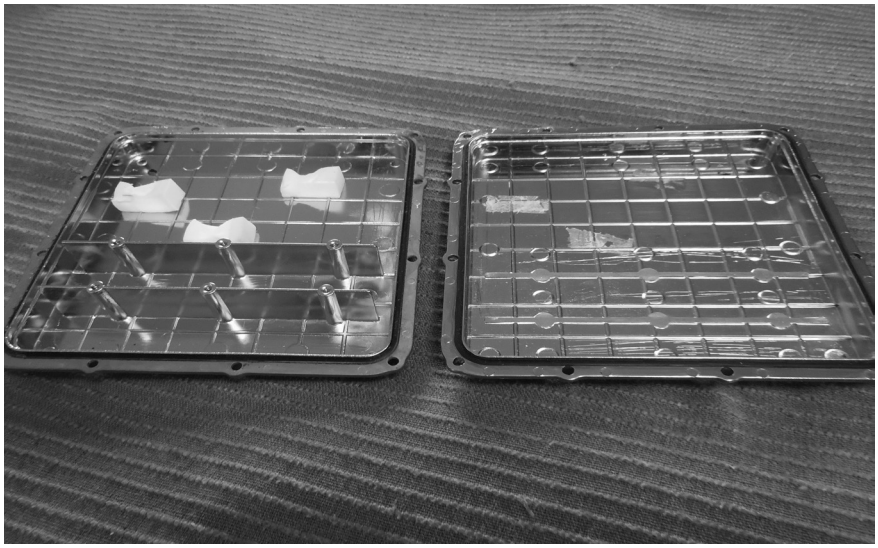

Figure 4 - Metal webs before and after

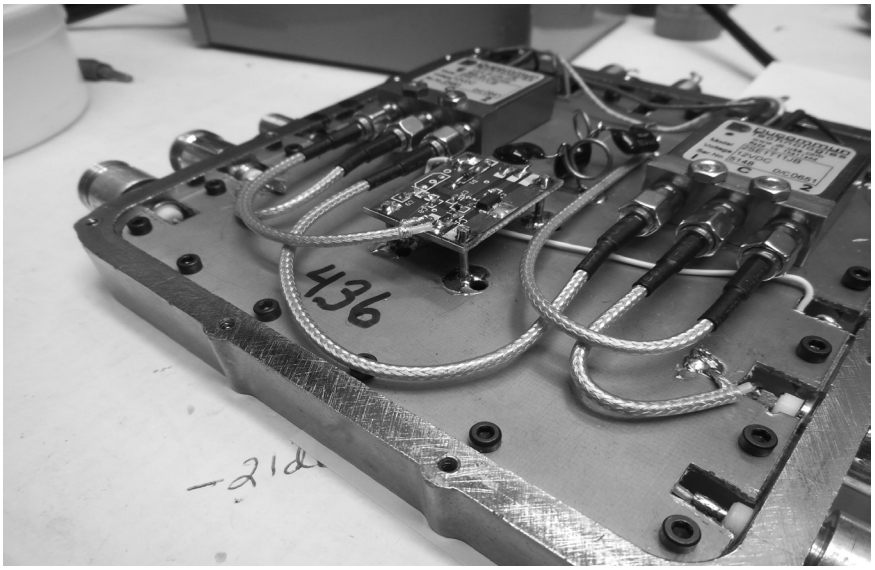

Figure 5 - LNA board mounted on wire standoffs

apart one end to verify they were properly assembled. Only two cables are used as-is. The others need one connector removed, the cable cut shorter, and tinned for soldering to the LNA, filters and N connectors.

Construction

Before removing the screws and covers, mark both covers and the center part of the chassis to show which cover goes on which side. I didn't mark them and spent a lot of time figuring out which cover goes on each side. I suggest a Dremel tool or etcher to make the marks. See Figure 3.

After marking, remove all the screws. The lids will not come free so you will have to pry them loose. Be careful not to damage the gasket around the edge. Once the covers are off, you will see the white blocks of foam that held them on so securely (Figure 4).

Unsolder all the connectors; de-soldering braid works well. Do not damage the connector center pins. One of the covers has metal webs that go deep into the chassis to shield each stage from the others. You will have to remove this webbing. Also, do not bend the webs back and forth thinking you can just break them off. I learned this the hard way; the webs in mine broke off but also made a big hole in the cover (Figure 4).

You will need to remove four of the connectors and replace them with type N connectors. They are threaded in very tightly and glued. To remove them, secure the chassis to a bench with C-clamps and then use a 7/16" socket to remove them. Use a small wire brush to remove the glue left in the hole so you can easily thread in the new N connectors and provide a good ground connection.

The copper plate that holds all parts is double-sided glass epoxy printed circuit board. Start with a piece 5" x 5" x .0625". Then slowly file and curve the corners of the plate until it fits snuggly inside the chassis. You may have to file the straight edges slightly, but take your time and make it fit right up against all four inside edges of the chassis.

Next put the plate inside the chassis and mark all screw holes very accurately. Remove the plate and punch a mark at each location. Drill 1/8" holes and lightly deburr them. I replaced the Phillips-head metal tappingscrews with 6 mm length x 2.5 mm thread Allen Head machine screws.

Notches are needed where each coax connector's center pin extends inside. I used a nibbling tool for this. Alternatively, a file can be used. The plate is located on the same side of the interior rail as the deeper cover so that neither cover touches the relays, coils or other tall parts.

The LNA kits require that you solder SMD parts. Do not mount the SMA connectors because you will be wiring directly to the board input/output tracks. Some of the surface mount parts are very small (see the picture on eBay). Use a low power soldering iron and toothpick to hold them in place. If you don't feel comfortable, ask a friend who works with SMD parts.

Use bright lights and a magnifying lens and take your time when soldering. One slip and the part will either end up on the floor or soldered out of place. (Don't ask me how I know this, but I will admit to ordering a third LNA kit.) I mounted the regulators below the LNA board and bent them toward the board to get a low profile on the top of the board. It's okay if the tab of the regulator touches the copper plate, as the tab is ground.

Make sure you haven't reversed the leads of the regulator! The power to both LNAs is connected to a single existing F connector (Figure 3). The LNA boards mount directly to the plate on pieces of #14 (.064") copper wire that are soldered to both sides of the plate (Figure 5).

Use the bare LNA circuit board as a template to locate the holes for the support wires. At first I tried to mount the LNAs using screws and spacers but could not get the holes aligned. It turns out the #14 wire supports provide a better ground connection than screws and spacers. Check each LNA before mounting it. Each should draw approximately 100 mA. If you have access to test equipment (a signal generator and something to check the input and output levels), make sure the gain is approximately 20-25 dB. Clean them with flux remover after mounting and after attaching the filters and input/output leads.

The high and low pass filters must be constructed with the components oriented as shown. The coils must be at right angles to each other to minimize coupling between them. The capacitors should have their leads cut as short as possible. See Figures 6 & 7.

When attaching the SMA connectors to the relays, attach the center one first. You cannot reach the center connector with a wrench if either of the outside connectors is in place. Use a 5/16" open-end wrench to gently tighten them. All four relays are mounted to the plate using machine screws that go through the plate.

The voltages to switch the relay positions and supply power to the LNAs pass through the remaining F connectors. To provide a waterproof entry inside, use plastic covers for unused F connectors. It is likely that your chassis will have a few plastic covers. Punch a small hole in the plastic cap and pass a wire to a stiff copper wire that makes contact with the connector center connection (Figure 2). Alternatively, you can pass all wires through a hole that is available after you remove one F connector and epoxy the wires in place for a watertight seal.

Issues and Modifications

The noise figure (NF) isn't record setting because a .8 dB NF on 436 MHz isn't great. However, it does improve reception significantly on FM and some on SSB in my satellite radio (an Icom 821, with sensitivity specs equivalent to the newest satellite radios). The total NF is the loss in the filter plus the NF of the LNA itself. I'm working on a filter for 436 MHz with lower loss but, at this point, haven't been able to get it lower than .4 dB. Perhaps with some experimenting/juggling of coil/capacitor values, you can get the NF lower. Even so, these LNAs will help you hear much better if you have a long coax run with significant loss and will definitely help when operating FM.

You may want to use latching relays to reduce the internal heating that would come from non-latching relays. Or you may prefer to use non-latching relays so that the interior always stays warm which keeps the inside dry. When I built the first LNA assembly and saw that it worked fine, I proceeded to order two more relays but accidentally ordered non-latching units, so I have both types in my unit. There are pluses and minuses either way. If moisture is a serious problem where you live, I recommend the non-latching type to keep it warm but dry inside.

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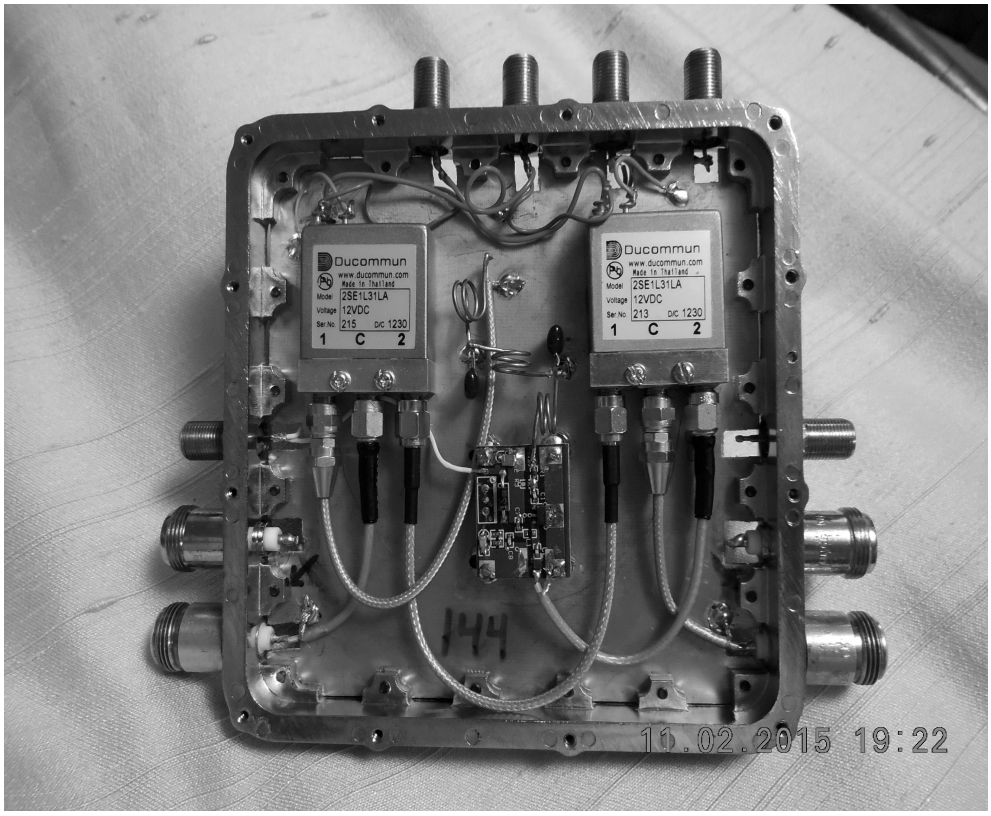

Figure 6 - The 436 MHz LNA complete

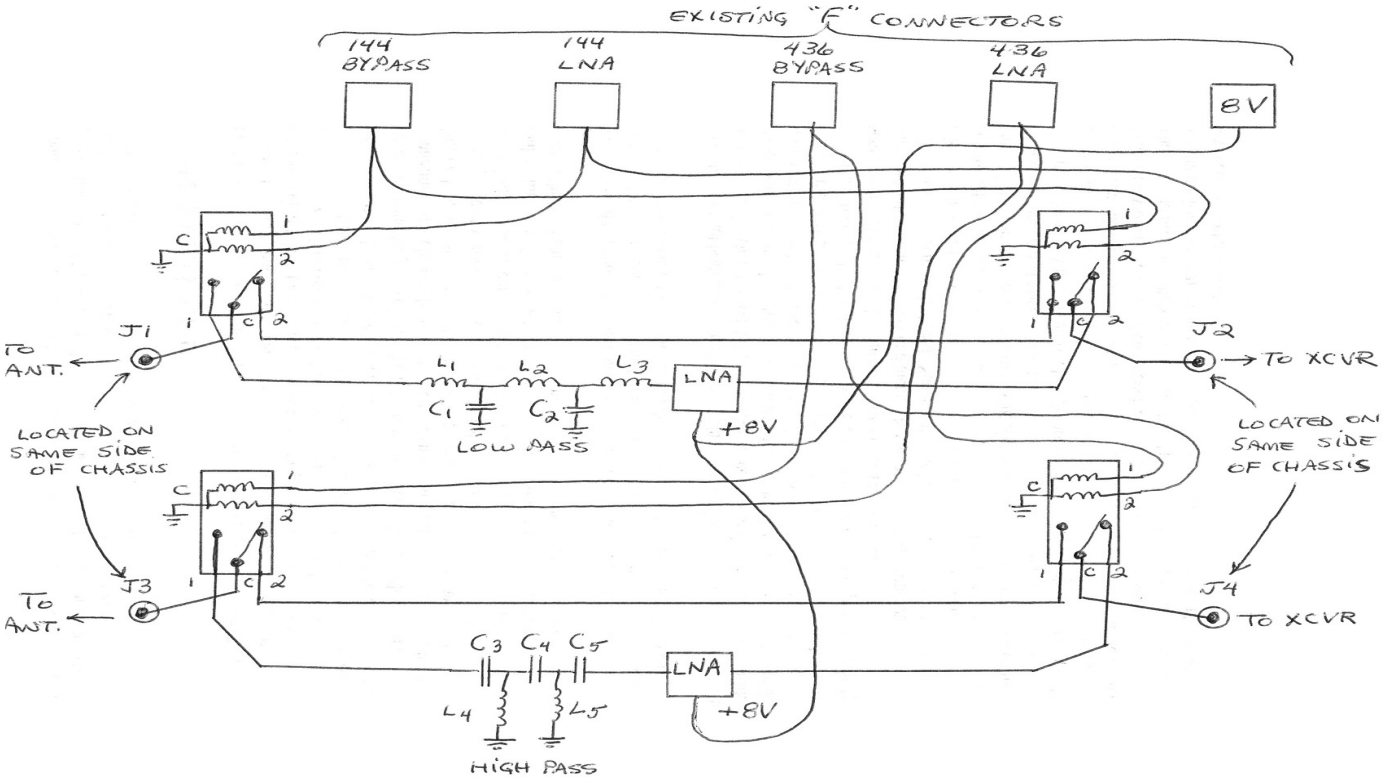

Figure 8 - Dual LNA schematic

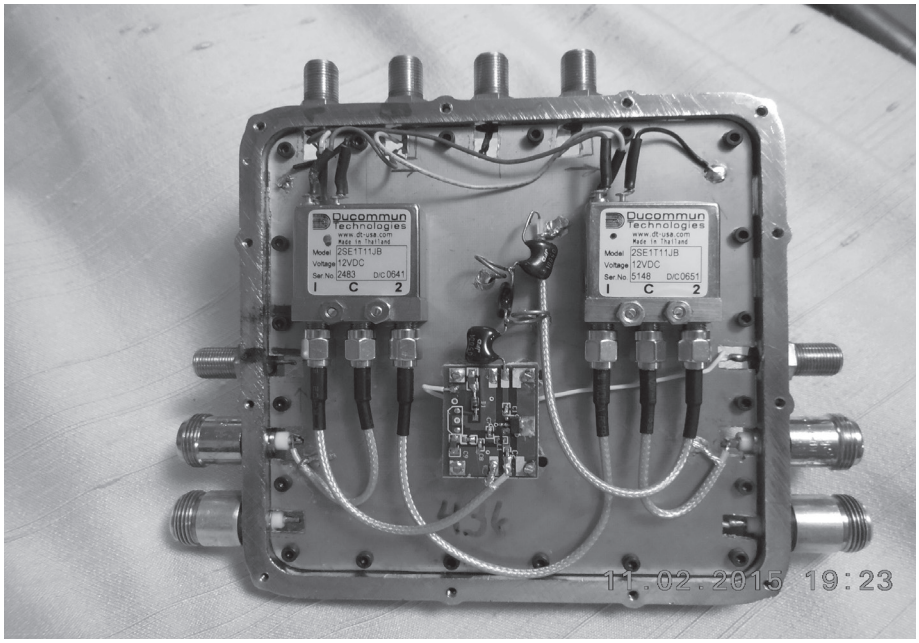

Figure 7 - The 144 MHz LNA complete

Using these LNAs for terrestrial operations requires a sequencer that switches the state of the relays before transmitting. For satellite operation, a simple toggle switch can be used to set one LNA to bypass (uplink) and the other to LNA (downlink).

A suitable filter for experimenters is detailed at **www.zs6wr.co.za/ham-mag/Diplexer.pdf**. It is inexpensive to make, physically small, has reasonable attenuation at the reject frequency and, most importantly, very low attenuation at the pass frequency (.15 dB).

The instructions for the LNA specify 12 V for the LNA, but I found the regulator got too hot to touch because of the current drawn by the regulator and required voltage drop. I suggest using 8-9 V instead.

When wiring the cables to the relays and N connectors, make very sure that you have the output and input to the LNA connected properly. The layout on one side is the mirror image of the other side if flipped over. Both antenna connectors should be on one side and both rig connectors should be on the other side. Check and double-check where the wiring goes before you solder and before you connect the coax cables and relay wiring! See Figures 3 & 8. Label each connector to show which signal goes where.

Parts List

- DISH Network Video Path Multi-Dish Switch Model DP34 107107, eBay, buy two if you see them at a hamfest or yard sale for a low price (spares are good to have just in case….)
- 5" x 5"x .0625" double sided glass epoxy copper clad board
- 4 type N connectors with thread same as F connectors, J1, J2, J3, J4
- Four 12 VDC SMA relays, Duocomm 2SE1T11JB or 2SE1L31LA (latching or non-latching)
- Two 12 pf silver mica capacitors, C1, C2 - Digikey 338-2819-ND
- Three 5 pf silver mica capacitors, C3, C4, C5 - Digikey 338-2818-ND
- 2 LNA kits, on eBay search for "PGA103 LNA" then scroll down to an LNA from seller "chuckwa3iac"
- #14 copper wire, 8 inches long, cut to 2 inch lengths
- 20 metric screws, Allen Head - 6 mm length x 2.5 mm thread
- Four 4-40 x 1-1/8" machine screws, four 4-40 nuts
- Coil dimensions, #18 tinned wire, 12"
- L1, L2, L3 - 2M low pass: 2 turns, 5/16" ID, spaced wire diameter
- L4, L5 - 436 high pass: 1 turn, 5/16" ID, spaced wire diameter

For any questions, please contact the author via email (**wa9pyh@arrl.net**).

Also see Addenda on next page

FoxTelem Version 1.02 Now Available!

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FoxTelem Version 1.02 is now available for download. Like the last release, you can patch your installation by downloading the patch file. In this case, it is a single file to replace.

You can download it from **amsat.us/FoxTelem/**.

Everyone should upgrade to 1.02 because this readies FoxTelem for transition to the new Telemetry Server, which will be more reliable.

Additionally, this release fixes a number of issues and adds the ability to download data from the Server to view/analyze in FoxTelem. If you download data, please make sure you save it to a separate directory to your local data, otherwise you will overwrite it. Of course, frequent backups of your data minimize this risk.

The release notes are as follows:

- Fixed bug where opening the Fox-1A spacecraft menu would cause a crash
- Added horizontal and vertical lines to the graphs if button clicked
- Fixed typo on measurements tab
- Fixed a bug where UTC was not displayed for the Diagnostic tables
- Capture the string version of the STP date in ENGLISH for all users, but leave other dates in local language
- Fixed bug where TCA date could be null and a SERIOUS error was reported
- Fixed issue where the tabs were always refreshed when the spacecraft menu closed
- Fixed bug where UTC date was sometimes wrong on the spacecraft T0 panel
- Ready FoxTelem for sending server data via TCP
- Support downloading server data

dedicated efforts to support AMSAT were instrumental in helping Martha to keep the office up and running, ensuring that computers, printers, fax machines, postage meters, modems, credit card machines, and other devices were working as intended, thereby allowing Martha to complete the tasks that she needed to do. Without Bob's efforts, Martha's effectiveness would have been significantly diminished.

Most noteworthy is Bob's dedication to providing that IT and administrative support to AMSAT. Think about it: he essentially went to the AMSAT office one day every week for over 24 years -- an impressive amount of time dedicated to helping AMSAT!

Bill Hook, W3QBC, was another individual who also spent many years helping Martha at the AMSAT office. Indeed, Bob would bring Bill to the AMSAT office when Bill was no longer able to drive. Unfortunately, Bill's health continued to decline to the point where he couldn't come to the office with Bob. Now, with Bob no longer with us, and Bill unable to get to the office, Martha no longer has the two "anchors" who came every Wednesday to help out with various administrative functions.

The lesson from this is two-fold: (1) AMSAT volunteers can make a huge positive impact on our organization no matter how mundane the task -- someone has to do the administrative tasks that keep our organization going; and (2) consistent, methodical volunteerism creates huge impacts over time. Bob and Bill dedicated a couple of hours each week to help at the AMSAT office. Generally, Martha knew when both Bob and Bill would be at the office, and she ensured that they had tasks to do when they arrived. Both individuals did the tasks that allowed Martha to handle other duties. And, while Bill may be the quiet one and Bob was often the "curmudgeon," both individuals exhibited their desire to see AMSAT succeed by dedicating a set amount of time each week to come to the office and help out. Martha appreciated both the work they did as well as their presence in a "one-person office."

I ask that if you live in the Washington Metro area and have some time on your hands, please consider contacting Martha to see what you can do to assist in the work that is done at the office. She needs assistance in a variety of areas, from data entry to stuffing envelopes to taking items to the Post Office. She also could use some IT support from knowledgeable individuals. A couple of hours by AMSAT volunteers at the office will help Martha immensely in terms of both getting tasks accomplished, as well as providing an opportunity for conversation. Bob and Bill were able to dedicate a portion of their free time to helping out at the AMSAT office. We can follow their example and encourage our Washington area members to help out, as they are able.

Fox-1C/1D Launch Update

The AMSAT Engineering team is finalizing the Fox-1C and Fox-1D spacecraft as I write this column in mid-January. Spaceflight, Inc., has informed AMSAT that it now expects our flight to take place sometime between March 1 and May 31, 2016. I expect that AMSAT will be notified in the near future of a specific launch date as the delivery date for these two spacecraft is based upon the launch date. Stay tuned for further developments; we're looking forward to the launch of three Fox-1 class spacecraft in 2016.

Addenda to "Dual Band Low Noise Amplifier for 2 Meters and 70 Centimeters," Nov/Dec 2015 issue:

1. When removing the covers, remove the shallow one first. Remove all the screws on the circuit board since they hold the deep cover in place. If you attempt to pry the deep cover off first, you will bend it.

2. Remove the deep cover second.

3. The two 10 ufd chip caps on the input and output of the 7805 regulator are polarized. The + side of the capacitors has a brown line. If you hold the capacitor so you can read the value, the line will be on the left side. If installed backwards they will eventually fail and smoke.

4. If possible obtain some RF absorbing material. The ham that measured the NF noticed that a lower NF was observed if a 2" x 3" square of this material was installed above the LNA circuit board. I am trying to find a source of more to make available to all who build the project.

5. The final NF are: 144 MHz = .6 dB 436 MHz = .95 dB

SKN 2016 BEST FIST WINNERS

Ray Soifer • W2RS

Thanks to all who participated in AMSAT's Straight Key Night 2016, held in memory of Ben Stevenson, W2BXA.

The following participants each received at least one Best Fist nomination: AA5PK, WA5KBH, WA8SME, W3TMZ, W4CVV, W5PFG. Special kudos go to Glenn Miller, AA5PK, who received three.

Activity was down this year for a variety of reasons, some having to do with availability of suitable satellites and others with changes in amateur radio in general. Since this was AMSAT's 25th annual SKN, it's a good time to consider changes.

While Morse as a license qualification has gone the way of the spark gap, amateur CW activity is as popular as ever. Straight keys and "bugs," however, have found a niche primarily with the "boat anchor" crowd, and AMSAT's insistence on their use in OSCAR SKN is probably limiting participation. Similar considerations have led ARRL to broaden its annual HF event to include all forms of CW, even computer-generated. The idea is to encourage everyone to enjoy CW operation, no matter how they choose to do it.
So, in with the new: AMSAT CW Activity Day on OSCAR.

As with the old SKN, it will be a fun event, not a contest, and will run for 24 hours on January 1. All forms of CW will be welcome. Instead of best fist nominations, all participants will be encouraged to post "Soapbox" comments to AMSAT-BB.

A further announcement will be posted to ANS in December.