

Quickstart – Amplifier/Filter Board

Got to the website (WsprWithoutTears.com) for more information.

Parts List

Check the parts received against the parts list below. Unless you're reasonably comfortable reading color bands (chart below) on resistors, you might want to verify the resistances using a meter (digital volt meter – DVM).

A note about the color bands: The last band is a tolerance indicator (gold, silver, nothing). The tolerance (how close the actual resistor value is to what it's supposed to be) isn't a factor in the WSPR board, so if the tolerance band is not the same as listed, don't worry about it.

It's also easy to get the resistor backwards and read the values in reverse. Needless to say, you'll end up with the wrong resistance value.

What you'll need to complete the assembly

1. *Raspberry Pi 2.0 Model B or Raspberry Pi 3.0*
2. *2 amp (minimum) power supply w/micro USB connector.*
3. *Ethernet cable.*
4. *WiFi USB dongle.* You only need this if you're using an rPi 2.0 and you want to use WiFi. WiFi is built into the rPi 3.0.
5. *Soldering Iron and solder.* A small tip and adjustable temperature are good.
6. *DVM.*

I'm assuming that you know how to solder. If not, there are plenty of tutorials on the web. Probably the biggest thing to keep in mind is that dirt and oil do not solder very well, so it's important to clean the stuff you want to solder before you solder it. Isopropyl alcohol works well for this. ***Wear safety glasses when soldering!***

I can tell you to read all of the directions first, but if you're like me you'll just smirk and start building the kit anyway. That's okay. If you run into trouble read a little further to see if I've addressed the issue. The only thing you ***really*** want to look out for is putting the 40-pin connector on the correct ***side of the circuit board*** – it goes on the ***other*** side from the components. **Don't mess this one up!**

Part	Value	Description
C1	100nF	104
C2	100nF	104
C3	47uF	
C4	270pF	271
C5	560pF	561
C6	560pF	561
C7	270pF	271
C8	100nF	104
D1	1N4148	diode
J1	40-pin	connector
J2	BNC	RF connector
L1	FT37-43	toroid
L2	1uH	brn-blk-gold-sil
L3	1.2uH*	brn-blk-gold-sil (larger dumbell shape; incorrectly marked)
L4	1uH	brn-blk-gold-sil
LED1	LED	
Q2	BS170	MOSFET
R1	20K	pot
R2	47	yel-pur-blk-gld
R3	20K	red-blk-ora-gld
R4	1	brn-blk-gold-gld
R5	15K	brn-grn-ora-gld
R6	270	red-pur-brn-gld
R7	2K	red-blk-red-gld
S1	Switch	
wire		4 in piece of hookup wire for winding L1
pcb		printed circuit board
SD Card		programmed with Raspberry Pi Linux/WSPR image

* Component L3 is mismarked given basic color codes.
You can tell the difference between L2 and L4 and L3, because L3 has a more distinct dumbell appearance (see the assembly figures).

Figure 1: Amplifier/Filter Board (AFB) Bill of Materials

Let's Do It!

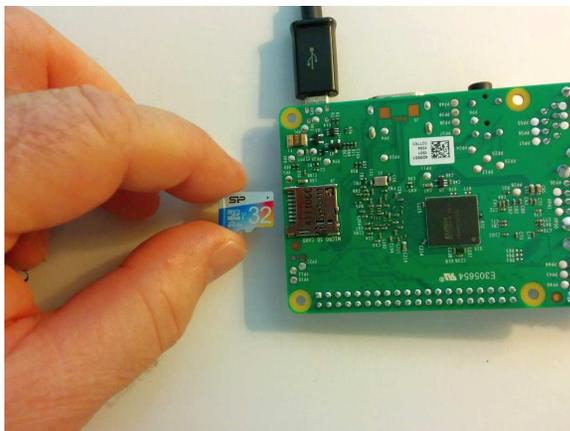


Figure 2: Inserting SD Card into rPi



Figure 3: SD Card Inserted into rPi

First, insert the SD card into the rPi (Figure 2: Inserting SD Card into rPi and Figure 3: SD Card Inserted into rPi). The SD card sorta slides in up side down. On rPi 2.0 it ratchets in (pops in then out a little). On rPi 3.0 there's a friction fit.

Figure 4: Resistor Color Code is the magic decoder ring for figuring out component values.

Color	Digit	Multiplier	Tolerance (%)
Black	0	10^0 (1)	
Brown	1	10^1	1
Red	2	10^2	2
Orange	3	10^3	
Yellow	4	10^4	
Green	5	10^5	0.5
Blue	6	10^6	0.25
Violet	7	10^7	0.1
Grey	8	10^8	
White	9	10^9	
Gold		10^{-1}	5
Silver		10^{-2}	10
(none)			20

Figure 4: Resistor Color Code

Here's how it works: *red-blk-ora-gld* is read as

red = 2, black = 0, orange = 3, gold = 5%, which translates into -

2 (red) 0 (black) 000 (orange) = 20,000 ohms = 20K ohms with a 5% tolerance

(third band is how many zeros to add on to the end), or 20K ohms.

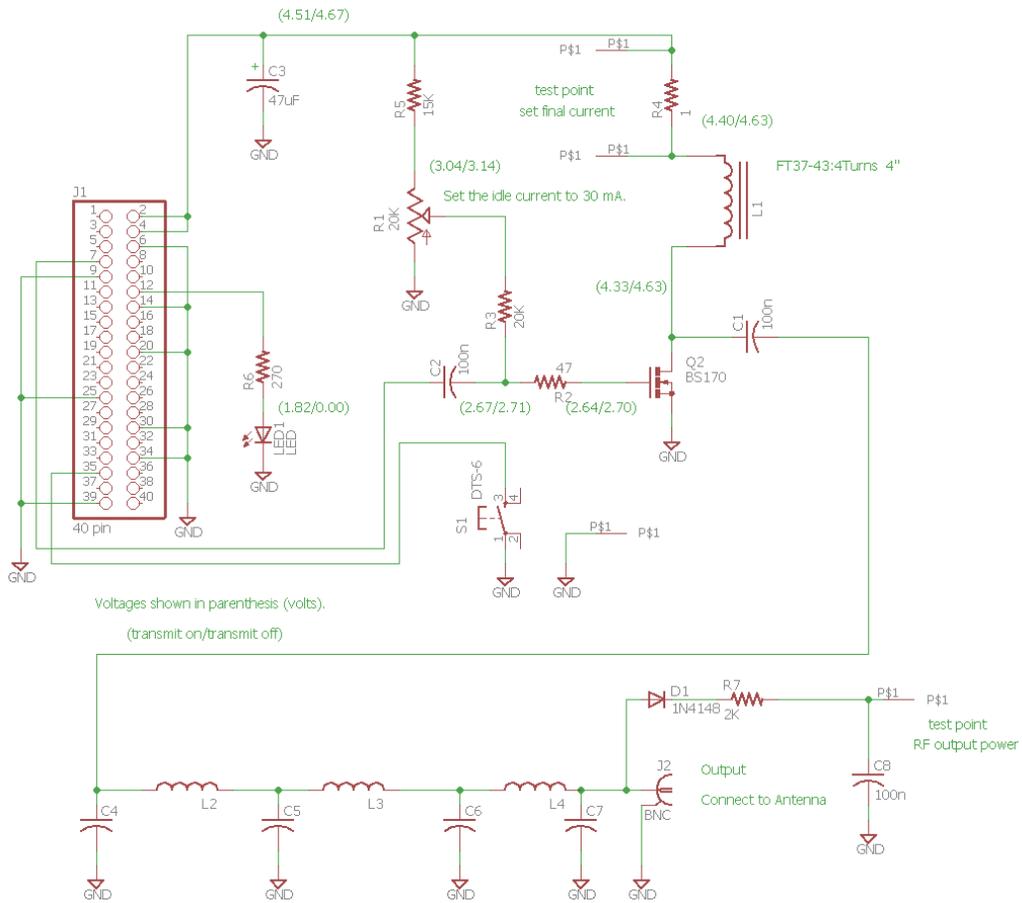


Figure 5: Amplifier/Filter Board Schematic

I figure the first order of business is to show you the schematic and some pictures of the journey so you can see what everything is supposed to look like along the way. First thing on the list is the bare Amplifier/Filter Board (AFB) circuit board; the foundation on which to build the kit.

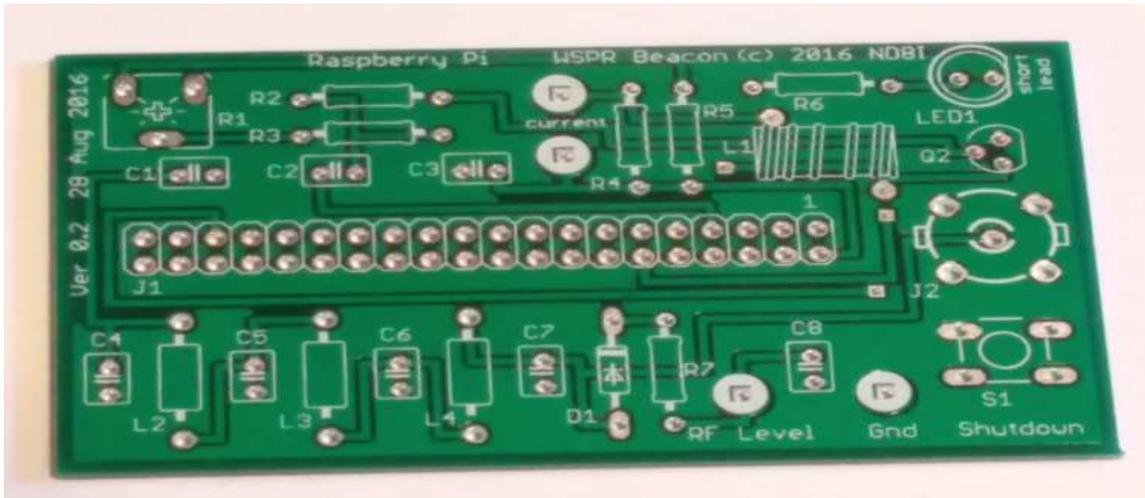


Figure 6: Unpopulated Circuit Board (Top View)

Here is what the AFB should look like when it's populated –

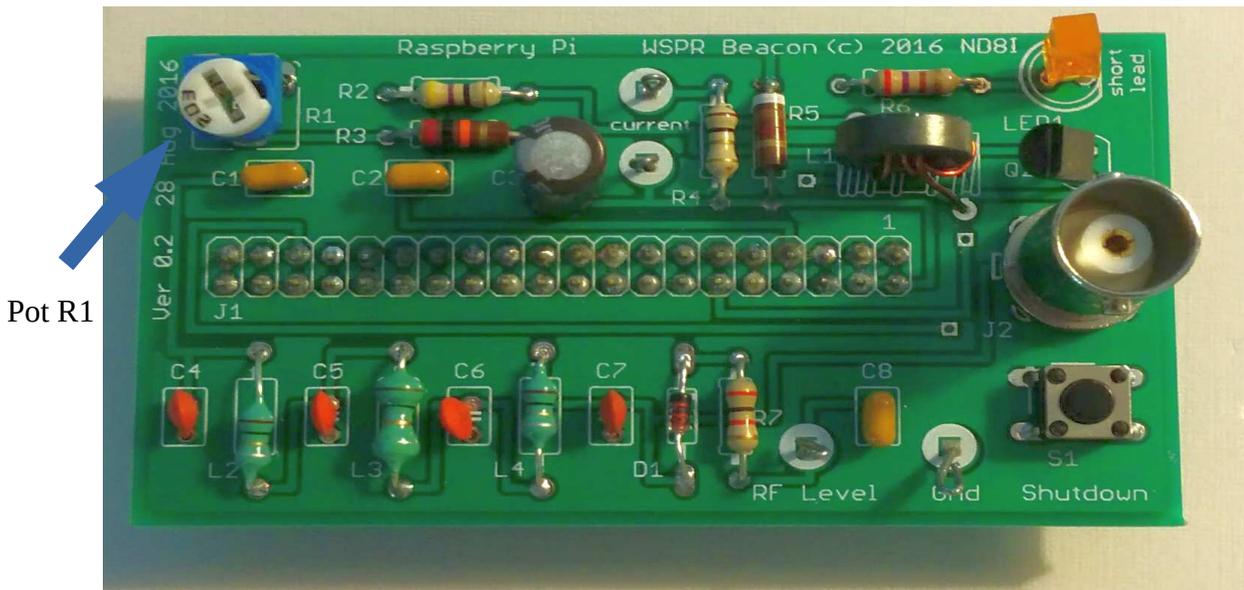


Figure 7: Populated Circuit Board

Here's a side view of the AFB when it's populated –

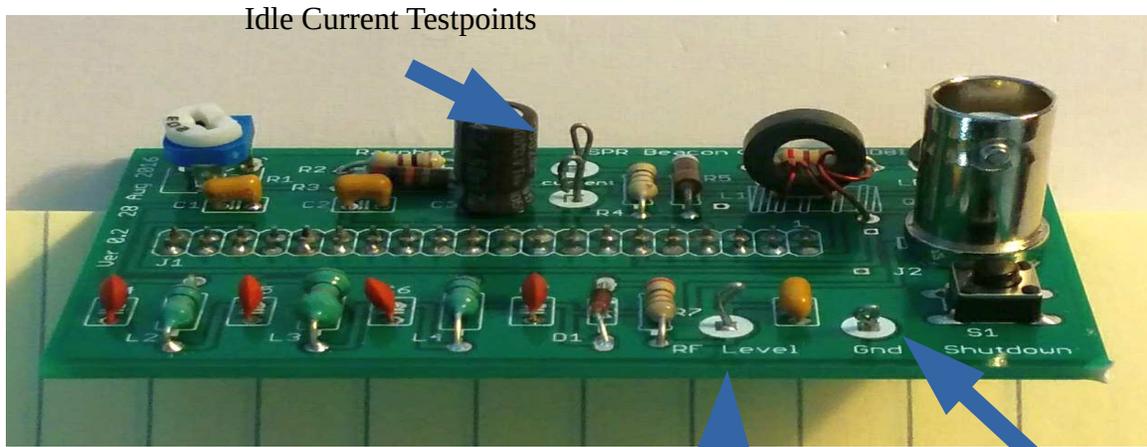


Figure 8: Populated Circuit Board (Side View)

RF Output Testpoint

Gnd Testpoint

And finally the underside. Note the connector on the **underside** of the board. I emphasize this multiple times because this is the one mistake you don't want to make – putting the connector on the wrong side of the board. It's pretty much impossible to unsolder all 40 pins and put the connector on the correct side of the board.

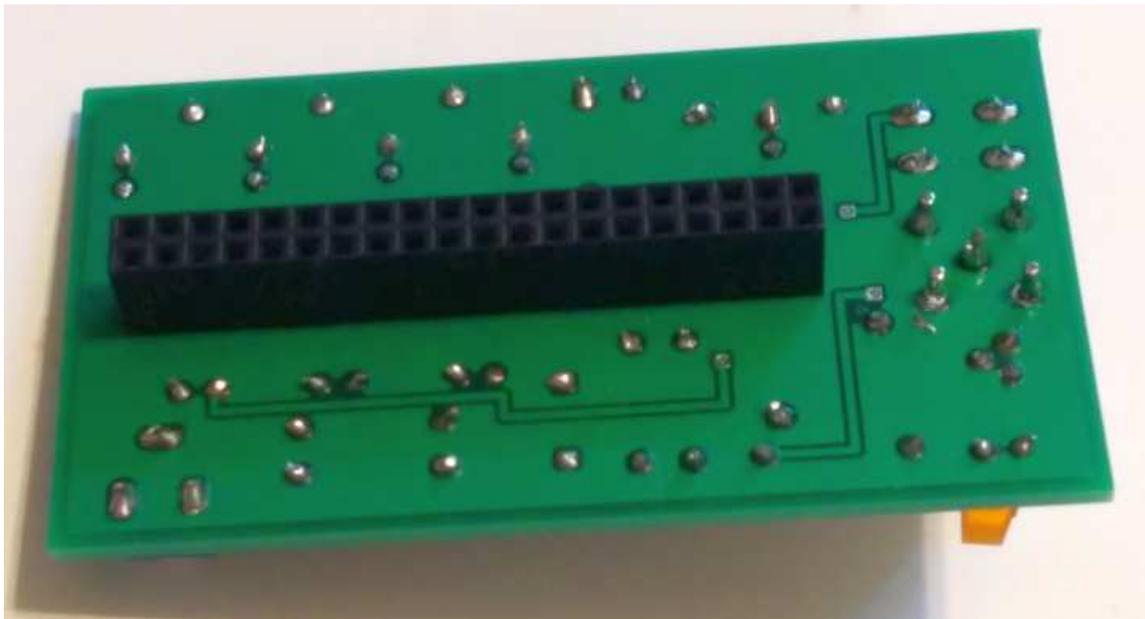


Figure 9: Circuit Board (Bottom View)

The finished assembly is shown in Figure 10: WSPR Beacon. This is the AFB plugged into an rPi 2.0. The micro USB power connector is coming out of the lower left. RF output comes through a BNC connector shown in the upper left. (A short jumper cable is shown rather than the BNC-BNC adapter in this picture.) A WiFi dongle is plugged into one of the USB ports. The rPi LEDs are on the left hand side of the rPi board below the AFB board. They are not visible in the picture.

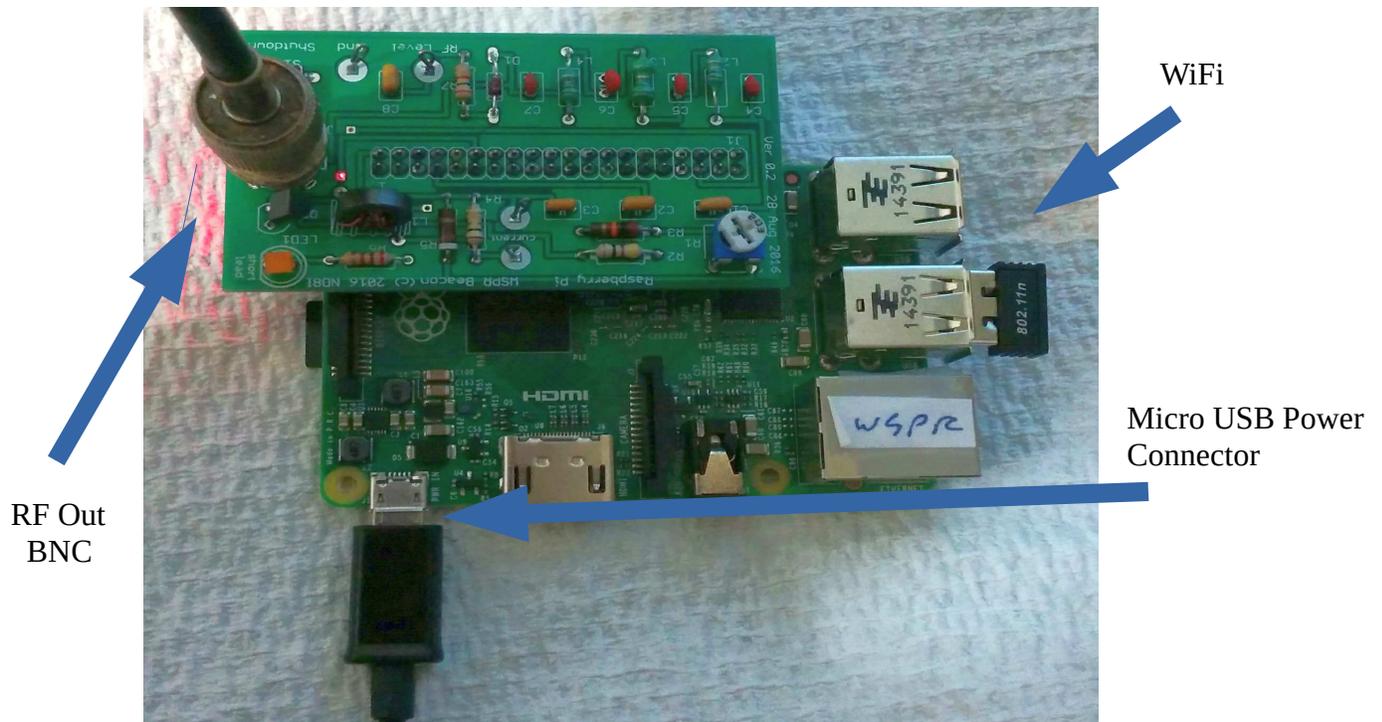


Figure 10: WSPR Beacon

The side view of the completed assembly (Figure 11: WSPR Beacon (Side View)) shows how the AFB is plugged into the rPi. It's definitely possible to connect them incorrectly. Notice from this view that the rPi USB connectors are on the right hand side and the AFB BNC connector is on the left. That's how it should be. Also, make sure that the rPi pins and the AFB plug are lined up. It is possible to offset one from the other.

Assemble the AFB

1. Install all resistors (except for R1) one at a time. Save four of the clipped leads to use later for P1, P3, P5 and P6 (test points). Measure resistor values with a DVM if you're even slightly unsure.
2. Install all capacitors and inductors (except for the toroid, L1) one at a time.

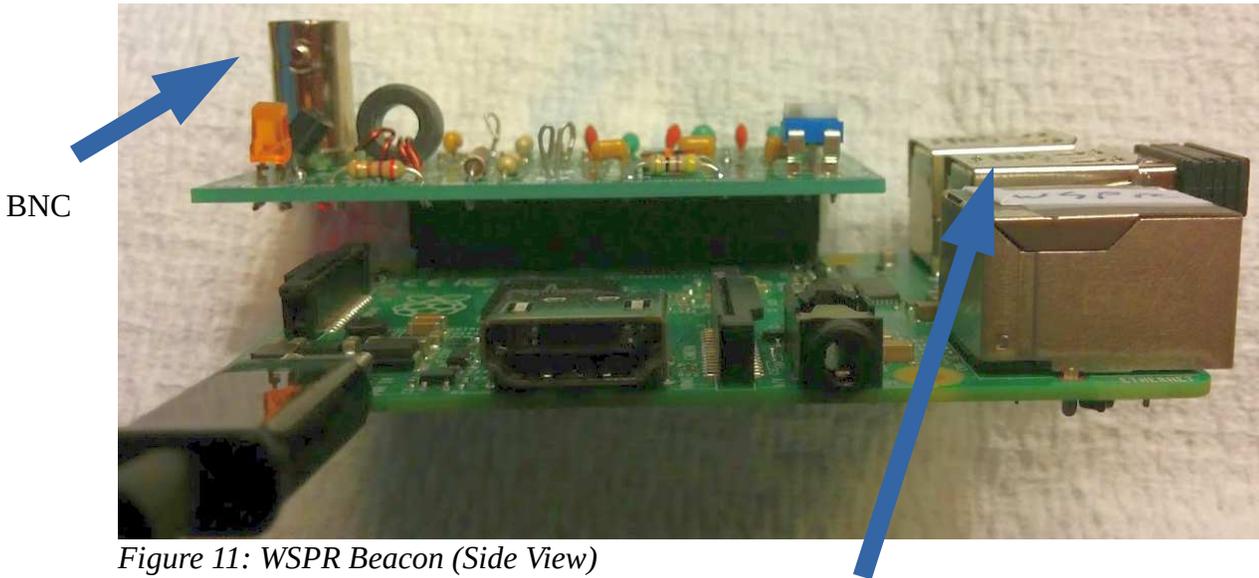


Figure 11: WSPR Beacon (Side View)

USB Connectors

3. Install D1, LED1, C3, and Q2. The orientation is important for all four parts.
 - LED1 has one lead that is shorter than the other. The short lead should be placed in the hole towards the edge of the circuit board (pcb) labeled *short lead*.
 - D1 has a black band around one end. The end with the band should be oriented with the silk screen white band on the pcb.
 - C3 positive (longer lead) should face towards the BNC connector. The negative lead (marked -) should face towards C1 and C2.
 - The flat side of Q2 should be aligned with the flat side of the silk screen on the pcb. The middle lead of Q2 will have to be bent outward to match the hole.
4. Wind four turns of hookup wire around the toroid. Each time the wire passes through the middle of the toroid counts as one turn. You have to wind the wire in the correct direction so that it lines up with the holes in the pcb. Install, solder and clip leads for the toroid (L1).
5. Install S1 and R1. Push these parts all the way through the holes. They should sorta snap in once you've got them installed (they should be seated). Solder them and don't bother clipping the leads.
6. Install J1 (40-pin header). This piece goes on the **BOTTOM** of the pcb. I want to emphasize this because it's very painful to undo if you get it wrong. All of the rest of the parts are installed on the top side of the pcb. **J1 is installed on the bottom** so that the pcb can attach to the matching pins on the Raspberry Pi (rPi).

The best way to install a header like this is to have it in position and solder **one** corner pin. Then pick the pcb up with one hand and put slight pressure on the 40-pin connector, pressing it into

the pcb. Use your other hand to hold the soldering iron to remelt solder on the pin just soldered. This takes all of the play/slop out of the connection.

Repeat the operation with the pin on the opposite corner. The connector is now firmly attached to the pcb. Solder all of the remaining pins to complete connector installation.

7. Install J2 (BNC). Place the BNC connector in the pcb (**top** side) and solder the middle pin. Now push on the BNC connector with one hand and melt the middle pin solder with your soldering iron just like you did with the 40-pin header in step 6. The BNC connector is now seated. Go ahead and solder the remaining four pins. **CAUTION:** The pins are connected to the barrel of the BNC connector. Soldering the pins will heat up the BNC connector barrel. Don't touch the barrel!
8. Solder four short pieces of wire (what's left from the resistor leads works just fine here) into the holes marked *RF Level*, *Gnd* and *Current*. There are two holes by *Current*. Clip the wires to about 3/4" and make a small loop in the ends (see Figure 7: Populated Circuit Board and Figure 8: Populated Circuit Board (Side View)).
9. Check your work. Actually, take a break at this point. Go get a cup of coffee to clear your head. Now come back and walk through the parts list and verify that every part on the AFB is correct.
10. Hold the assembled pcb (AFB) next to the connector on the rPi to verify that everything looks about right. Plug the AFB into the rPi noting that the BNC connector should be adjacent to the SD card. Make sure that the header pins and the connector on the AFB are actually lined up – I haven't done it, but I suspect that you (well, not you, but somebody else) could misalign the two and still assemble the parts.
11. If you have a heat sink on your rPi CPU, remove the AFB from the rPi and place a piece of electrical tape on the underside of the AFB so that the heat sink doesn't touch anything on the underside of the AFB and short something out.

Setup and Adjustment

What You Need

I'm assuming that you have on hand -

1. Assembled Amplifier/Filter Board (AFB)
2. Raspberry Pi version 2.0 or later
3. 2+ amp power supply for the rPi
4. DVM
5. Assembled antenna kit
6. Small flat blade screw driver
7. Ethernet cable to connect rPi to your router

8. SSID and passkey for your router (go to the Troubleshooting/Getting SSID and Passkey section if you don't have these)
9. PC connected to your network
10. Optional: USB WiFi adapter for rPi 2.0 (rPi 3.0 has WiFi built in)

Initial Setup

The AFB should be connected to the rPi and power is **off** at this point.

1. Plug the SD card into the rPi and connect the power supply. The SD card sorta slides in up side down. On rPi 2.0 it ratchets in (pops in then out a little). On rPi 3.0 there's a friction fit.
2. Connect the rPi to your router with the Ethernet cable. This part is a little tricky. The rPi has to be connected to a DHCP server. That's normally your router. *It won't work if you plug the rPi into your laptop.*
3. Connect the antenna to the AFB BNC connector using the BNC-BNC adapter.
4. Turn the pot (R1) on the AFB **counter clockwise** until it stops turning with the small screw driver.

Smoke Test & Set Idle Current

1. Turn on the power for the rPi (connect the power supply lead to the rPi, then connect the power supply to the wall outlet). The red and green LEDs will flash for a while. No flashing at all indicates a problem. Wait until they're done flashing (20-30 sec) then go to the next step.
2. Make sure that nothing is hot or smoking. Smoke coming off anything is always a bad sign ...
3. Using the DVM, measure the power supply voltage between the lower test point by *Current* and *Gnd*. This should be between 4.5 – 5.0 volts (see Figure 8: Populated Circuit Board (Side View)).
4. Using the DVM, measure the voltage across the terminals labeled *current* on the AFB (near the toroid). Turn pot *R1* on the AFB **clockwise** until the voltage across the terminals is roughly 0.030 volts. It's not really critical, just get it in the general range (say 0.025-0.035 volts) (see Figure 7: Populated Circuit Board and Figure 8: Populated Circuit Board (Side View)).

Note: This is the idle current adjustment for the MOSFET. You're measuring voltage across a 1 ohm resistor, so you're setting the idle current to about 30 mA. Make sure that the LED is *off* when you're making this measurement. If it's on, wait until it goes off to make the measurement (less than 2 mins).

Bonus: You do know that everything electronic works from magic smoke? The way you know this is true is because if you ever let the magic smoke out, the electronics never work again.

Locate the rPi IP Address

1. Working from your PC, download *WSPR Executables* (zip file) from the web site (WsprWithoutTears.com), unzip the zip file, and extract the program *WSPR_Locate.exe* to a suitable work area.
2. Execute *WSPR_Locate.exe*. The program will take about five minutes to execute and will (hopefully) give you the IP address of the rPi.

Some assumptions have been made: 1) your network is a private Class C network (IP addresses begin with 192.168..), and 2) you have DHCP enabled on your router (router hands out IP addresses). If you have no idea what I'm talking about then don't worry about it – these are typical settings for a home network.

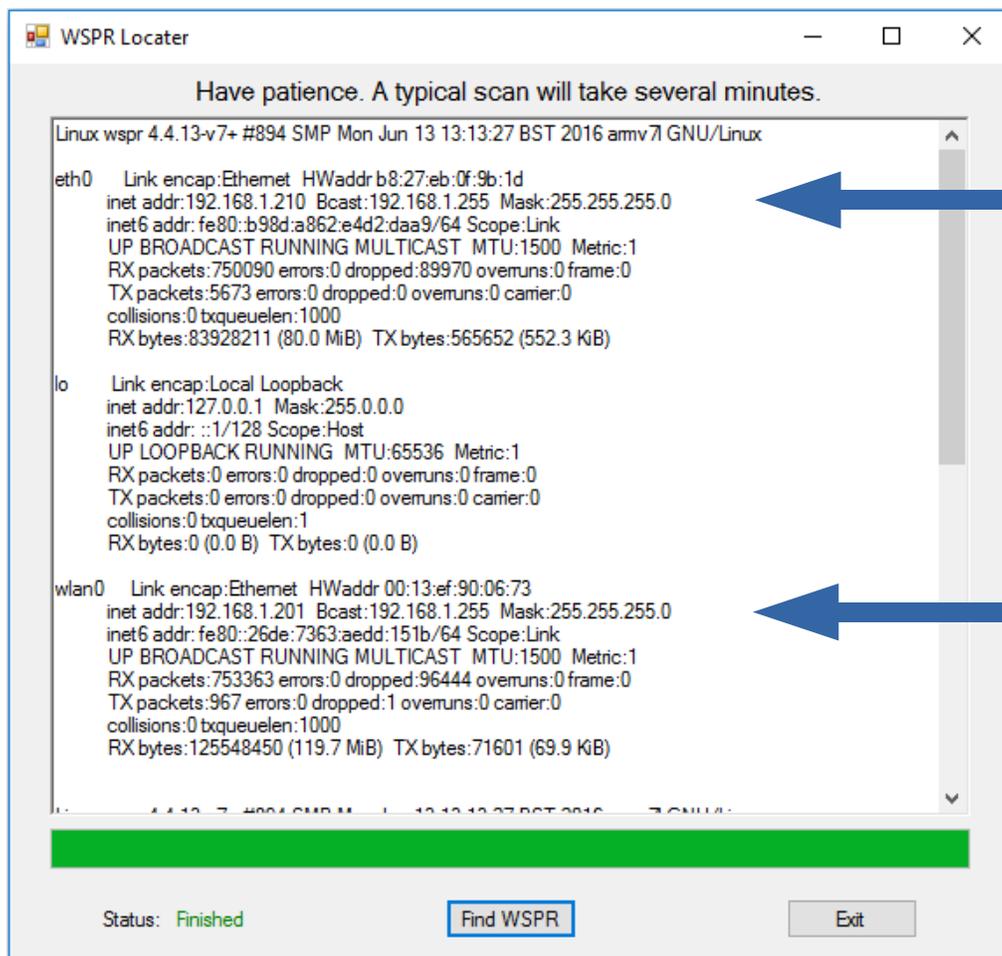


Figure 12: WSPR Locater

With any luck, the display will look something like Figure 12: WSPR Locater. Look for the line starting with *eth0*. The line below it shows *inet addr: 192.168.1.210*. Your setup should be similar

Setting WSPR Configuration

WSPR Configuration (c) ND8I 2016

Callsign and Grid Square (required)

Callsign:
Grid Square:

WiFi Parameters (optional)

SSID:
Passkey:

Transmit Times

default is to repeat transmission once every 10 mins.

transmit every 2 mins (only for testing)

Transmit Power (dBm)

Power:

Transmit Band (e.g. 30m - include the 'm')

Band:

Network Information

```
eth0    Link encap:Ethernet  HWaddr b8:27:eb:0f:9b:1d
        inet6 addr: fe80::b98d:a862:e4d2:daa9/64 Scope:Link
        UP BROADCAST MULTICAST  MTU:1500  Metric:1
        RX packets:0 errors:0 dropped:0 overruns:0 frame:0
        TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
        collisions:0 txqueuelen:1000
        RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

lo      Link encap:Local Loopback
        inet addr:127.0.0.1  Mask:255.0.0.0
```

Figure 13: WSPR Configuration Screen

except for the last two numbers (it will begin with 192.168, but the last two numbers will probably be different). Record the full number (192.168.aaa.bbb – aaa and bbb are the numbers for your rPi) for the next step. That's the IP address of your rPi. If the program fails to find the rPi, try it again. If that fails, go to the Troubleshooting section in the full documentation.

Note: The first time you run `WSPR_Locater inet addr` will be displayed for `eth0`, the Ethernet connection. After setting the WiFi portion of the WSPR configuration (see Figure 13: WSPR Configuration Screen), `WSPR_Locater` will display `inet addr` for `eth0` if the Ethernet cable is still connected and `inet addr` for `wlan0`, the WiFi connection.

1. Open a web browser (Internet Explorer, Firefox, Chrome, ...) and type in the IP address you just recorded (192.168.0.67 for example). This will bring up the configuration screen shown in Figure 13: WSPR Configuration Screen -
2. Enter your *callsign* and *gridsquare parameters*.
3. Enter the *SSID* and *passkey* (password) for your WiFi network. These are what you use to enable your cell phone and things like Roku to use your home network. If you don't know what they are you'll have to go digging through your router to figure them out (see the *Troubleshooting* section).

If you elect to not use WiFi then you don't need to enter SSID and Passkey. You will have to keep the rPi connected to the network by Ethernet cable because the rPi uses the Internet for time synchronization.

4. Check/uncheck the *transmit every 2 mins* checkbox. (I recommend leaving it unchecked.)

A WSPR message takes just under two minutes to send. The fastest you can send WSPR messages is every two minutes. It's considered bad form to flood the WSPR servers with messages. The default is to send a WSPR message every ten minutes. If you check the *transmit every 2 mins* checkbox then messages will be sent every two minutes. This setting is useful for testing and short term experiments.

5. The *Transmit Power* and *Transmit Band* should be left as *23 dBm* and *30m* for the current configuration.
6. When all done click on the *update* button. This will store the data on the rPi.

Restart rPi

1. Press the pushbutton on the AFB. Hold for two seconds and release. This commands the rPi to enter shutdown mode (you're always supposed to shutdown a computer properly or the file system can be damaged – pulling the plug is bad).
2. Unplug the power supply, wait 30 sec, then plug the power supply back in and wait until the LEDs on the rPi stop flashing.

Measure RF Output

1. LED1 on the AFB turns on when the AFB is transmitting. Wait until LED1 is on and measure the voltage across the test points labeled *RF Level* and *Gnd*. This should be in the range of 3-5 volts.

2. Finally, string your antenna up around the room, over doors and lamps to get some of it off of the floor. Later, you can find ways to arrange it so that it radiates better – like you would with any antenna. This is good enough for now.

IP Addresses

Ignore this section if you're not using WiFi.

I have made the assumption that you are using WiFi to connect to the rPi. This is my preference, but it is by no means necessary. What may be confusing is that initially you have to use an Ethernet (wired) connection to talk to the rPi. This is because the WiFi login information has not yet been programmed into the rPi.

After you have set up WiFi (see Figure 13: WSPR Configuration Screen) you will have two valid IP addresses assigned to the rPi. Either one will work. You probably wouldn't have gone to the trouble of setting up WiFi if you were just going to use Ethernet. So now is the time to remove the Ethernet cable. Your rPi will now have one IP address. There is no advantage to having two IP addresses, so you should remove the Ethernet cable if you're planning on using WiFi.