BRIAN (SM) Construction Manual

BRIAN (SM) (**B**aofeng BF-888S **R**adio **I**nterface to the **A**llstar **N**etwork**)** is a kit construction project that implements a Raspberry Pi hosted Allstar node using the circuit board and other parts from a Baofeng BF-888S as the node radio operating in the amateur UHF (70 cm) band. An Allstar node can be implemented using BRIAN (SM) and a Raspberry Pi.

Figure 1 – BRIAN (SM) Allstar Node – Front and Rear Views

The BRIAN (SM) electronics is housed in an extruded aluminum enclosure measuring 3.94L x 2.98W x 1.42H inches. A "rubber ducky" antenna is mounted to an SMA connector on the rear of the enclosure. Internally, the Baofeng circuit board (modified by the builder) is mounted to a motherboard which contains the radio interface circuitry and jumper wire connection points to simplify wiring to the Baofeng board. The motherboard uses a combination of surface and through-hole parts. In the BRIAN (SM) kit, the motherboard is supplied with all the surface mount parts installed. The kit builder installs seven through-hole parts, modifies and installs the Baofeng board and completes final assembly.

BRIAN is connected to a Raspberry Pi using a USB A male to USB B male cable. This cable also supplies 5 VDC power to BRIAN (SM). Front panel LEDs on BRIAN (SM) indicate the status of the unit – BRIAN POWER (green), RADIO POWER (green), COMM STATUS (blinking green), COS (yellow) and PTT (red). The BF888S nominally supplies 1 watt of RF power (a USB Y cable may be required to supply sufficient current to BRIAN (SM)).

Optionally, this manual contains information on a method to modify the Baofeng BF888S board to reduce the output power to 20 – 50 milliwatts…. perfect for a local Allstar node! This modification also reduces the BRIAN (SM)current requirements to less than 300 mA.

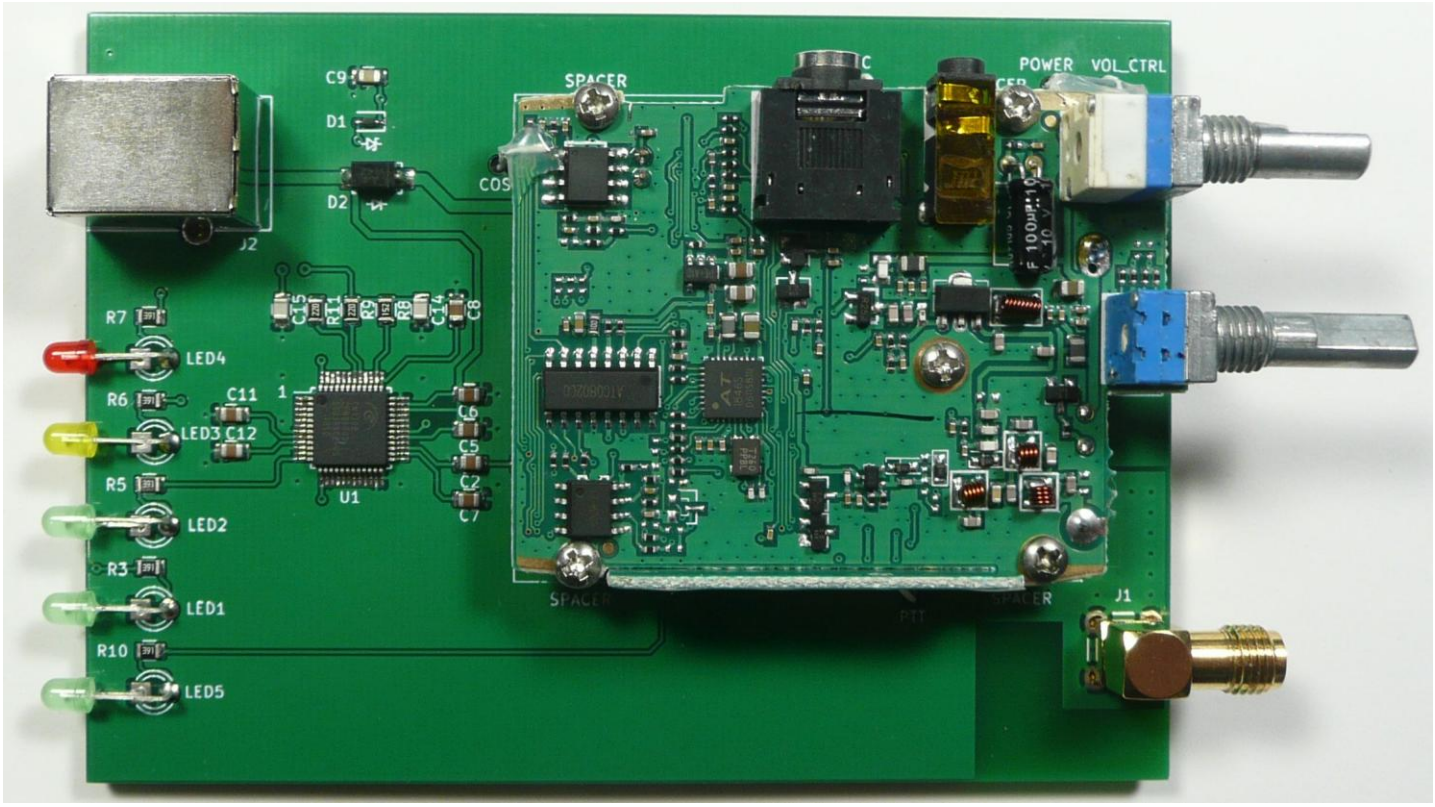


Figure 2 – BRIAN (SM) Motherboard and BF-888S Daughterboard

Disclaimer:

This device contains a radio that operates in the amateur 70 cm band. You are responsible for its proper operation including frequency, power level. Modulation deviation and harmonic content. This includes installing, configuring, testing and verifying that the device performs properly in your environment. The developers cannot be held liable for any direct, indirect, consequential or incidental damages to other pieces of software, equipment, goods or persons arising from the use of this device.

By constructing this device you accept the above terms.

Release Notes:

RELEASE	DATE	CHANGES
1.00	2019-09-19	Initial release
1.01	2019-10-03	Added construction Summary. Added note to program the radio before disassembly

Table of Contents

BRIAN (SM) Overview

Key Features

- Uses low cost, proven CM119B USB Audio IC
- Uses the circuit board from a Baofeng BF-888S UHF radio
- Small, portable with self contained radio and antenna
- Nominal 1 watt RF power
- Low power modification (20 to 40 mW) if desired
- Motherboard, daughter board design simplifies wiring
- Rugged RFI-resistant metal enclosure

Setting Expectations

- **What's missing from this design?**
    - No display or keypad for frequency selection. Rotary switch selects one of 16 preprogrammed frequencies
    - UHF (70 cm) only
    - BF-888S radio receiver may be degraded by strong nearby frequencies

Construction Difficulty

- **Degree of soldering difficulty –Medium**
    - Extracting the Baofeng BF-888S radio requires unsoldering and mechanical skill.
    - Modifying the BF-888S board for low power requires surface mount unsoldering skills. In addition, the added "white" wire requires soldering to small pads on the BF888S.
    - Assembly of the DINAH motherboard is standard through-hole soldering of leaded components.

- **Degree of mechanical difficulty**
    - The BRIAN motherboard may not fit in the metal enclosure. You may need a file or sandpaper to adjust the boards for a snug fit in the case
    - You will be drilling holes in the aluminum end caps. The locations and sizes are specified in drawings included in the Appendix. You must be able to read these drawings to successfully create the required holes. You will also need a precise measuring device such as a dial or digital caliper.

Required Materials

- Tools
    - Low wattage (50 watt) solder pencil with small tip and solder
    - Higher wattage solder iron to solder RF connector and USB connector shield
    - Phillips screwdriver (#1), small side cutters, small needle nosed pliers
    - Small Torx screwdriver to disassemble BF888S
    - Dial or digital caliper
    - Wire stripper for 30 gauge Teflon wire
    - A drill set with drills in 1/64 inch increments up to 11/32" or a good step drill bit
    - A small square file

Construction Summary

The BRIAN (SM) kit contains all of the parts required to build the device.

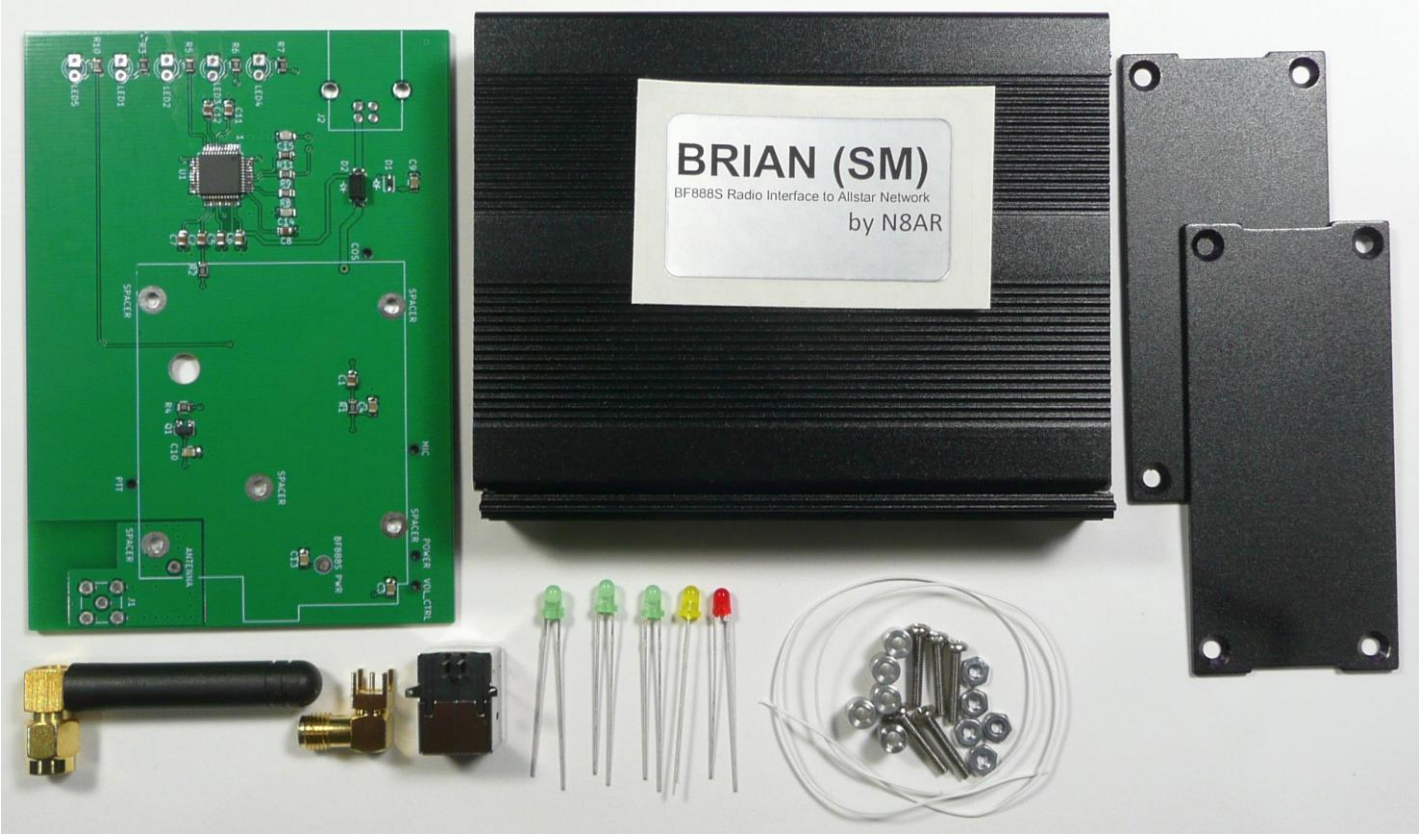


Figure 3: BRIAN (SM) Kit (BF888S Radio and USB Cable not Shown)

The motherboard in the BRIAN (SM) kit is provided with all of the surface mount parts installed.

The kit builder:

1. Completes the assembly of the motherboard by installing 5 LEDs, the USB Type B connector and the SMA RF connector.
2. Disassembles the Baofeng BF888S radio, removes and modifies the BF888S circuit board.
3. Mounts and wires the BF888S circuit board to the motherboard.
4. Drills/cuts holes in the blank end caps per supplied drawings.
5. Performs final assembly and test.

Step 1. Fitting the Motherboard PCB to the enclosure

In this step you will verify that the motherboard PCB fits into the extrusion mounting slots. If not, you will modify the boards as required by sanding/filing its edges.

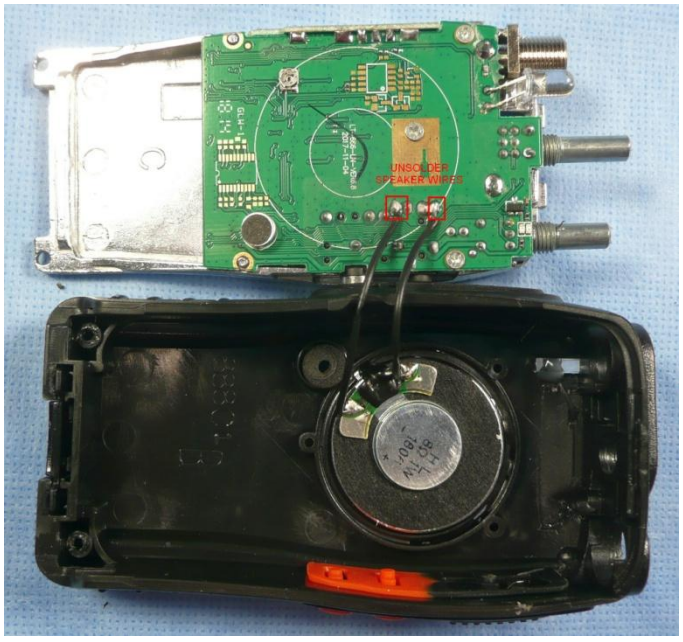
CAUTION: The BRIAN (SM) PC board contains static sensitive parts. Use static prevention procedures when working with the PC board.

The motherboard PCB location in the final assembly is as shown in the photo. Insert the PC board and verify that it fits and slides in the slots (slightly loose). If a board is too tight (try both extrusion halves), use fine sandpaper (220) or a file to remove material equally from both long edges of the PCB until you achieve a slightly snug fit. Remove the board from the extrusion. Clean the PC board of any dust you created in the sanding process using 91% Isopropyl alcohol. Keep track of which extrusion you have selected for mounting the board.	

Step 2. Disassembly of the Baofeng BF-888S and Low Power Modification

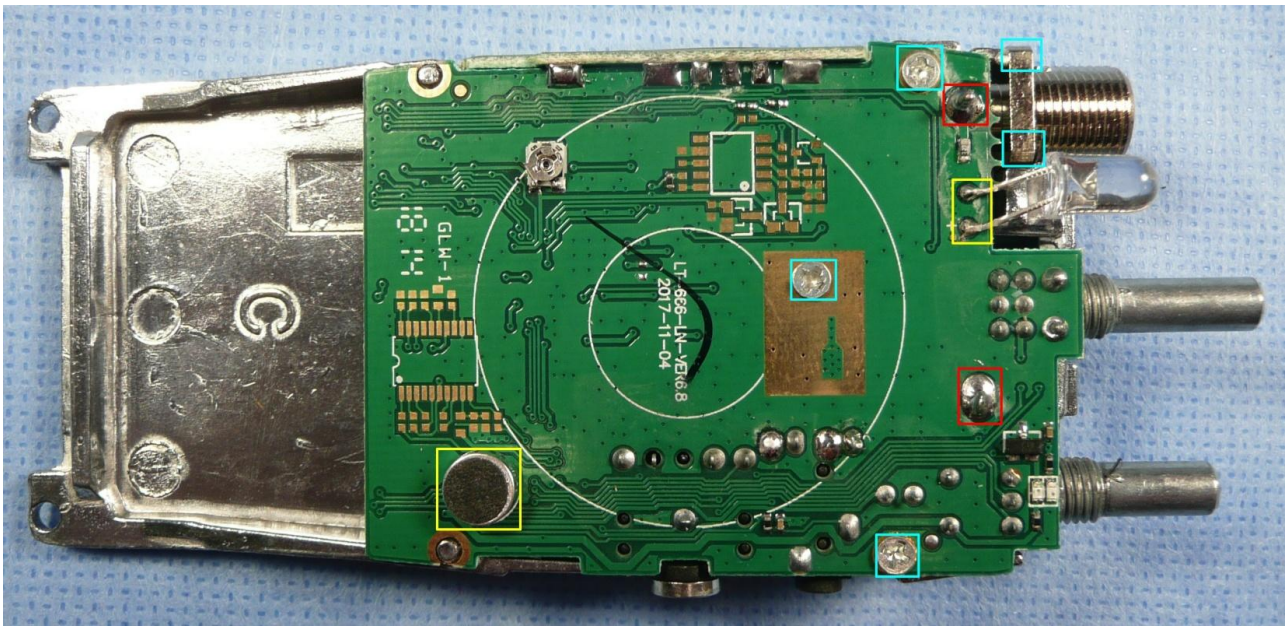
In this step you will disassemble the Baofeng BF-888S, remove the PCB and make electrical modifications to the board. Note that there have been at least five revisions to the BF-888S PCB. The various revisions resulted in a shortening of the PCB. The initial design used a "full length" PCB, followed by a ¾ length PCB and then at least three variations of a "half length" PCB. The BRIAN motherboard is designed to work with the half length variants.

Note: We suggest that the kit builder program the Baofeng BF888S with the desired operating RF and CTCSS frequencies before disassembly.

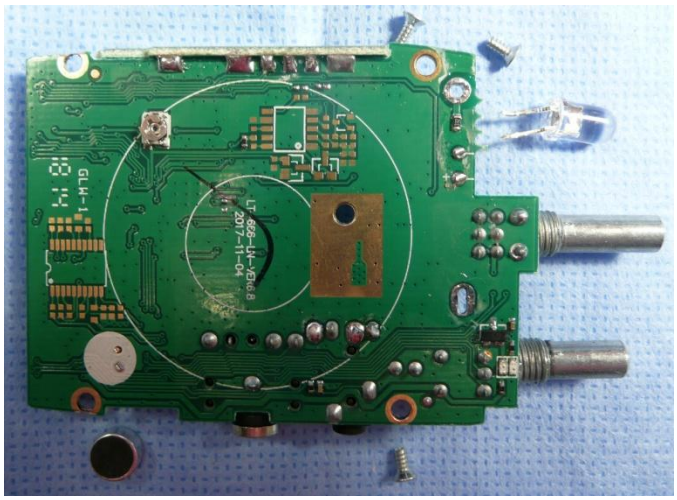
Remove the antenna and battery from the radio (if installed). Your radio should now look like the photo to the right. The labeling may be different. Take note of the shape of the case, it is different on earlier units.	
Remove the two plastic control knobs. The longer knob fits tightly. Use a flat bladed screwdriver to pry it off if necessary. Save the knobs for final assembly. Remove the two Torx head screws and the two Phillips head screws. Remove the three brass nuts with slots used on the antenna jack, volume control and frequency selection switch.	
Remove the cast chassis and PCB by lifting the casting out of the plastic enclosure at the end which was held by the Torx screws. Position the two pieces as shown and unsolder the two speaker leads at the PCB. Recycle the speaker/plastic enclosure.	

Refer to the picture to the right (magnified below). Remove the LED by cutting its two leads (yellow rectangle) and recycle it. Remove the microphone (yellow rectangle) by twisting it off with alternating circular motion. Discard it.

Referring to the cyan rectangles, remove the three PCB mounting screws and the two RF connector mounting screws (if used) and save for possible use later. Use solder wick or a solder sucker to remove the solder on the center pin of the RF connector and the power connection to the board (red rectangles) and remove the board from the casting. Save the RF connector for later assembly unless it has no screw holes as described at the beginning of this section. Recycle the casting.



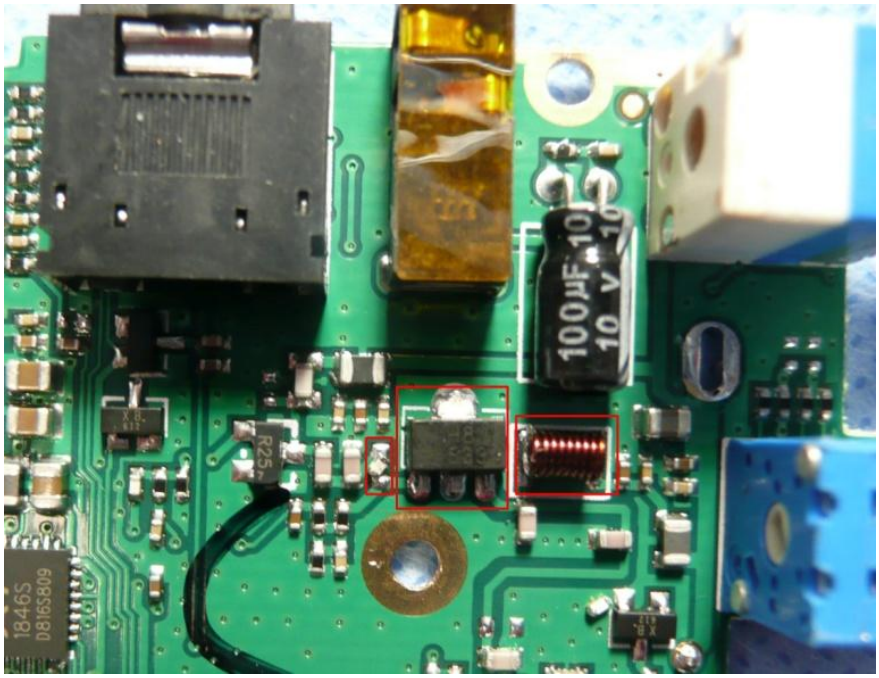
This is the BF-888S PCB assembly with the LED removed, the mic removed, the RF connector removed and the solder removed from the antenna center conductor and DC power connection points.



In the original BRIAN design, in order to avoid possible RFI interference from the nodes transmitted signal back into the audio you receive from your node, we recommended modifying the Baofeng BF-888S board to reduce the output power from the 0.5 to 2 watts level to a level of 20 to 50 milliwatts. In BRIAN (SM) this self interference is no longer an issue. However, depending on the actual power level of the BF888S you modify, the current required by BRIAN (SM) in the transmit mode may exceed the capability of the Raspberry Pi USB port supplying power to BRIAN (SM). If this is the case a USB "Y" cable (2 USB A males to a single USB B female cable) may be necessary. However, in many BRIAN (SM) applications, the user will be very close to the node so that lower power would be desireable. In this case, the following modification reduces the RF power output from from the 0.5 to 2 watts level to a level of 20 to 50 milliwatts which is ideal for a local node for use in a mobile application or locally around your shack. The low power modification also removes the risk of your radio being damaged by excess heat running at a near 100% duty cycle as an Allstar node.
If desired, perform the following 2 paragraphs to do the low power modification to your board. Otherwise skip to the third paragraph below.

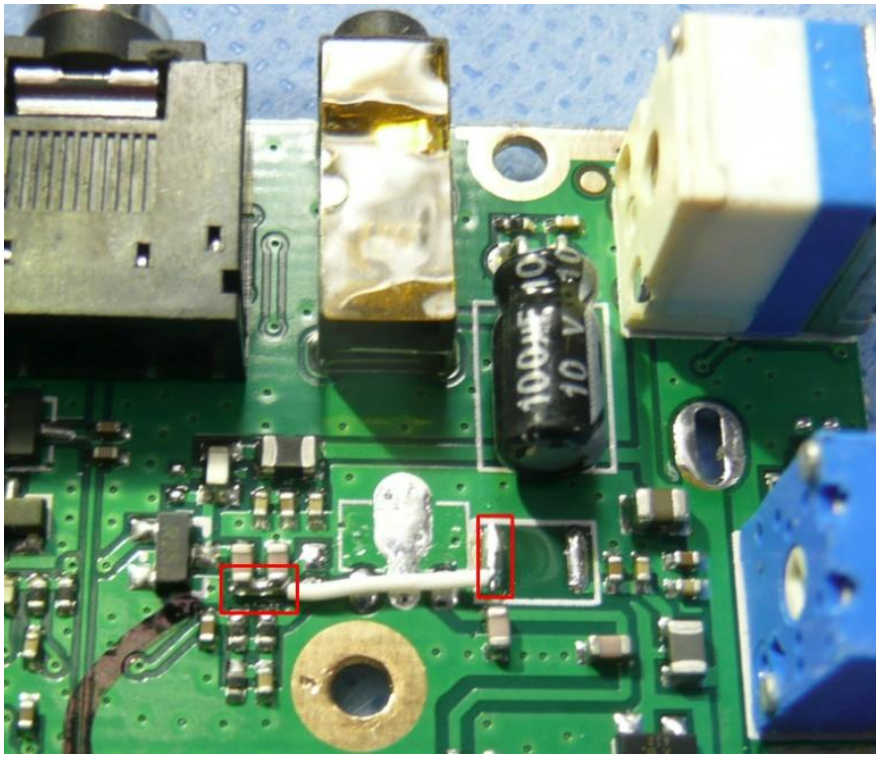
Skip this step if not doing the low power mod.

Unsolder and remove the 3 parts outlined with red rectangles in the photo. These parts are the final amplifier transistor (PA), the choke (coil) feeding DC to the PA to the right of the PA and a tiny SMD part to the left of the PA. The use of two soldering irons and steady hands works well for this task. A hot air rework station works even better!

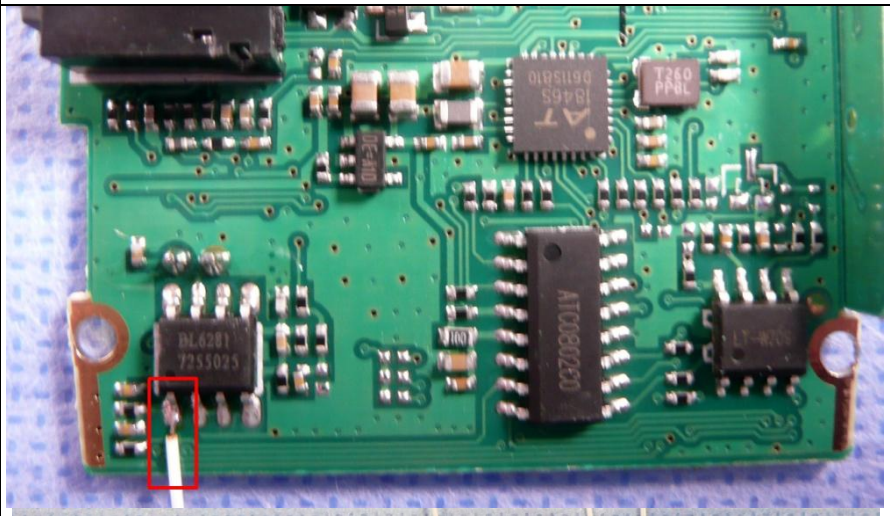


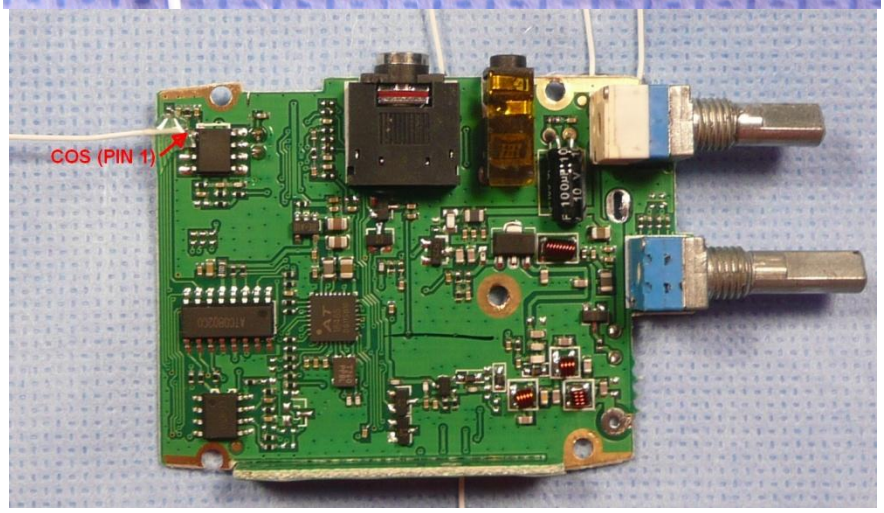
Skip this step if not doing the low power mod.

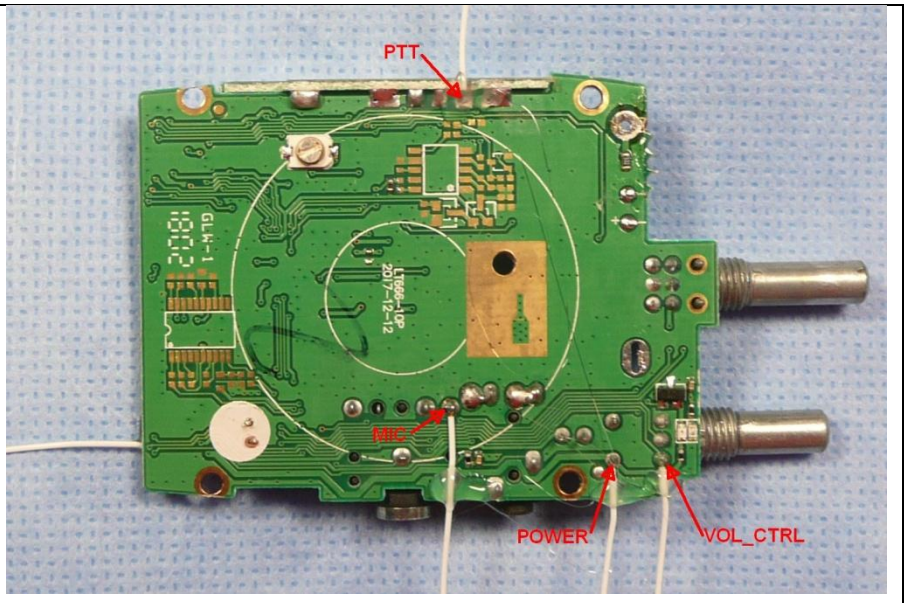
Fashion a jumper wire from the 30 gauge Teflon wire and solder it as shown in the photo. One end solders to the pad exposed by removing the PA DC feed choke and the other end solders to the ends of the two SMD capacitors as shown.



Prepare a 1 ½ inch piece of 30 AWG solid core Teflon wire and solder one end to pin 1 of the IC on the BF-888S board as shown in the photo. While not absolutely necessary, it is suggested that hot glue or silicone RTV be applied to the wire near the edge of the board to provide strain relief to minimize the possibility of the wire breaking at the solder joint.

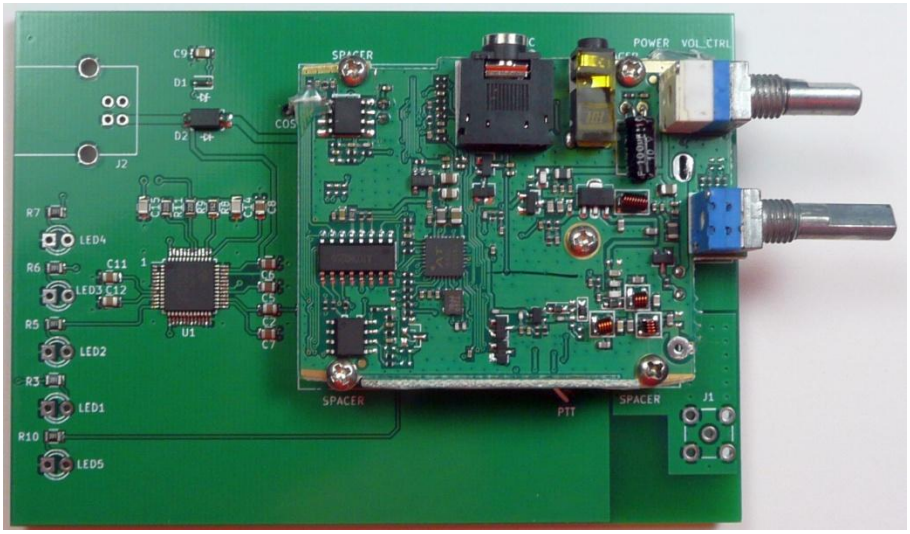
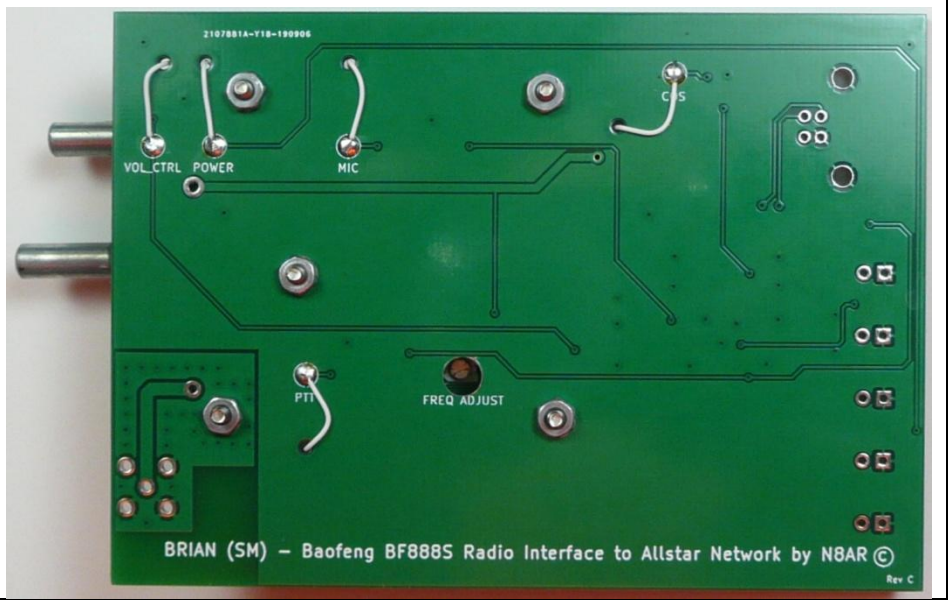




Using solid core 30 AWG Teflon wire, solder four 1 ½" jumper wires to the points on the BF888S board shown in the photo (PTT, MIC, POWER and VOL_CTRL). While not absolutely necessary, it is suggested that hot glue or silicone RTV be applied to the wire near the edge of the board to provide strain relief to minimize the possibility of the wire breaking at the solder joint.	

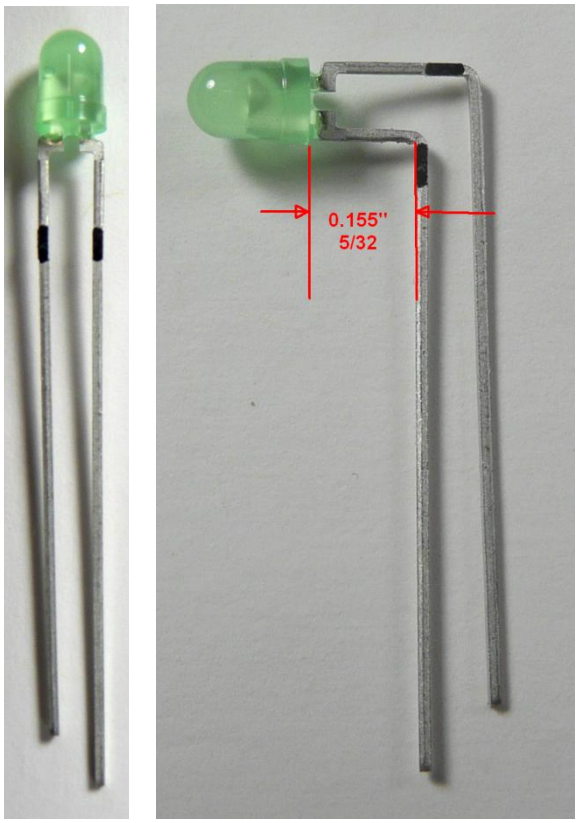
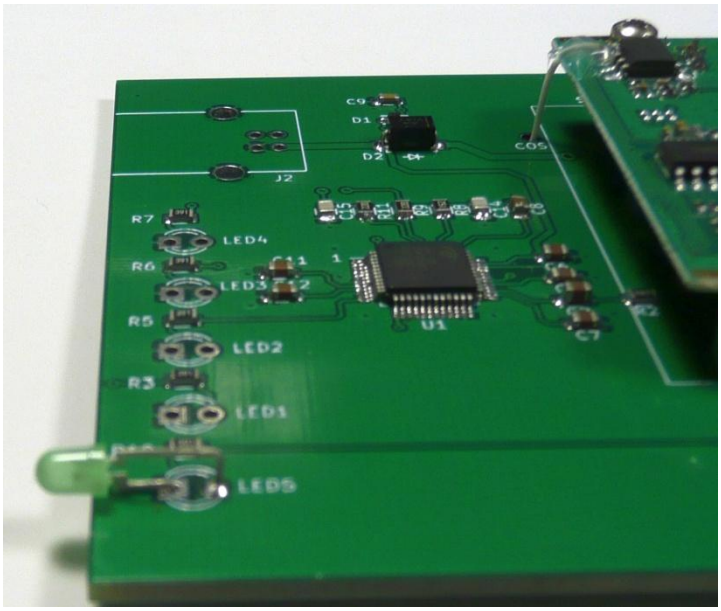
Step 3. Assembling the Baofeng BF-888S Daughterboard to the Motherboard

In this section, you will install the Baofeng BF-888S daughterboard onto the motherboard and connect jumper wires between them.

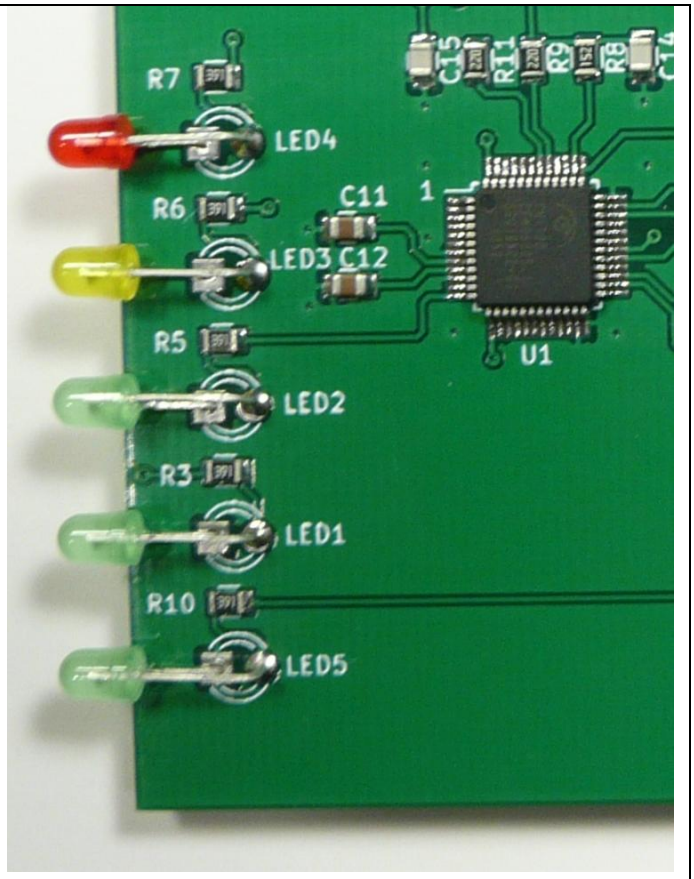
Mount the Baofeng board to the motherboard using five 2-56 x ½" screws and nuts. Use five, 3/16 OD x .094 ID x ¼" long aluminum spacers between the boards. As you place the board, route the 5 wires soldered to the board through the appropriately labeled holes in the motherboard. Tighten the five screws and nuts securely.	
Solder the five wires to the appropriate labeled pads (VOL_CTRL, POWER, MIC,COS and PTT) on the motherboard by melting a pool of solder on each pad and let it cool. Place the stripped wire onto the solder. Apply the tip of your soldering iron to the wire and push it down into the solder.	

Step 4. Final Assembly of the Motherboard

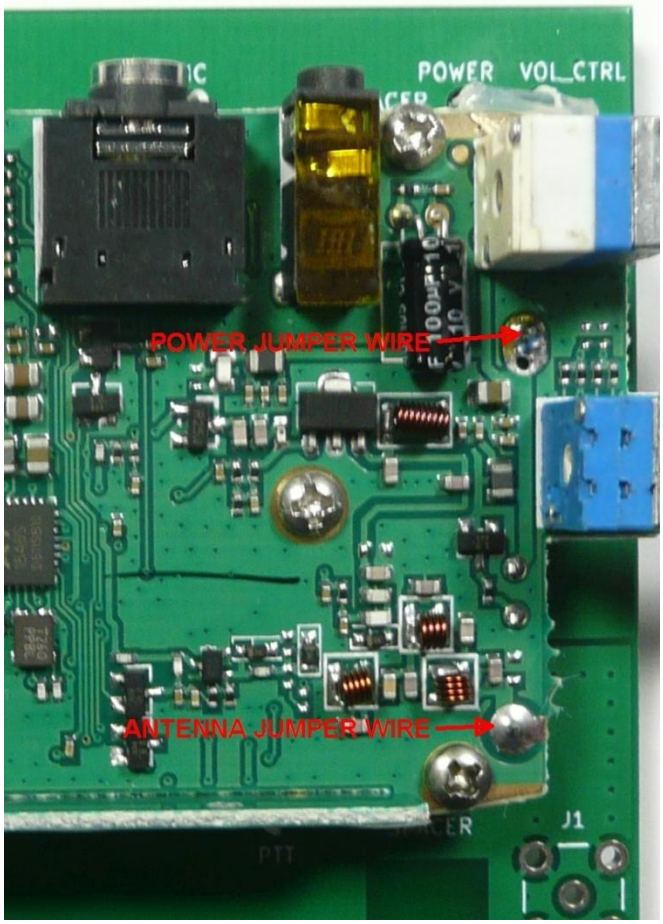
In this section, you will install the seven through-hole components on the motherboard and add two connections between the BF888S board and the motherboard.

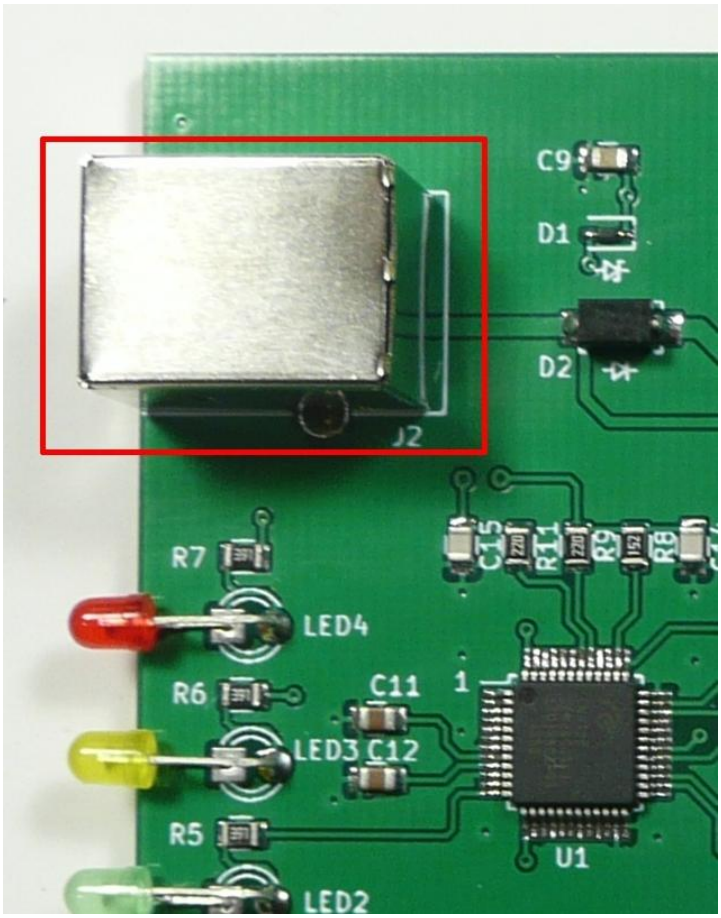
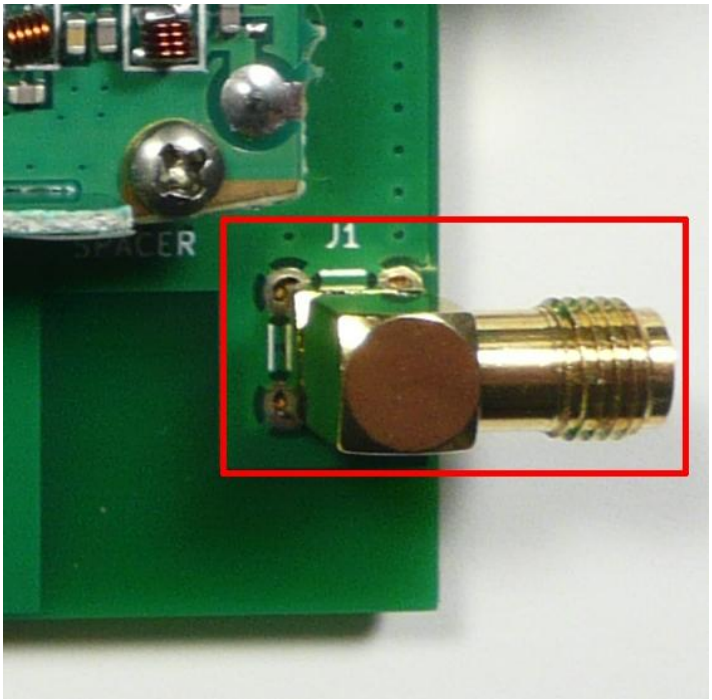
Prepare three green LEDs, the yellow LED and the red LED by bending the pins as shown in the photo to the right. If you look carefully, you will see a slight flattening of the leads starting about 5/32 inch from the LED (highlighted in black in the photos). Bend the **shorter** LED lead 90 degrees before the beginning of the flattening in the lead – about 5/32 inch from the LED body. The shorter lead is the negative lead of the LED and installs in the square pad of the LED footprint. Bend the longer lead 1/10 of an inch beyond the first lead bend. (Note that after forming, the shorter lead extends beyond the longer lead as shown in the photo). This will provide about 1/16'" protrusion of the LED out the front of the end cap. **NOTE:** The objective is for the slightly larger diameter annular ring of the LED body to be located behind the edge of the PC board when the LED is installed on the PC board so the end cap does not push on the LED annular ring when it is installed over the LED.	
Install a green LED in the LED5 position on the motherboard. The annular ring at the base of the LED should be in contact with the PC board and behind the edge of the board	

Install the remaining 4 LEDs on the motherboard in the positions shown in the photo. Trim the excess lead length from all five LEDs. Save two of the longer pieces of wire for use in the next paragraph.



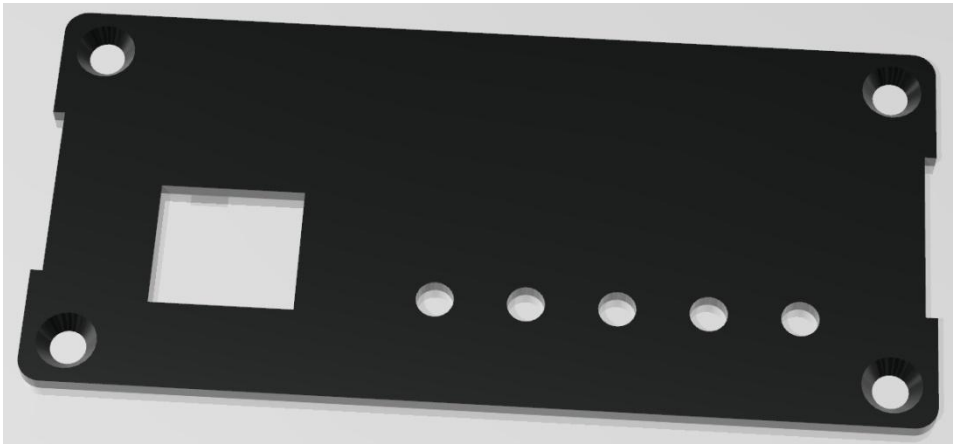
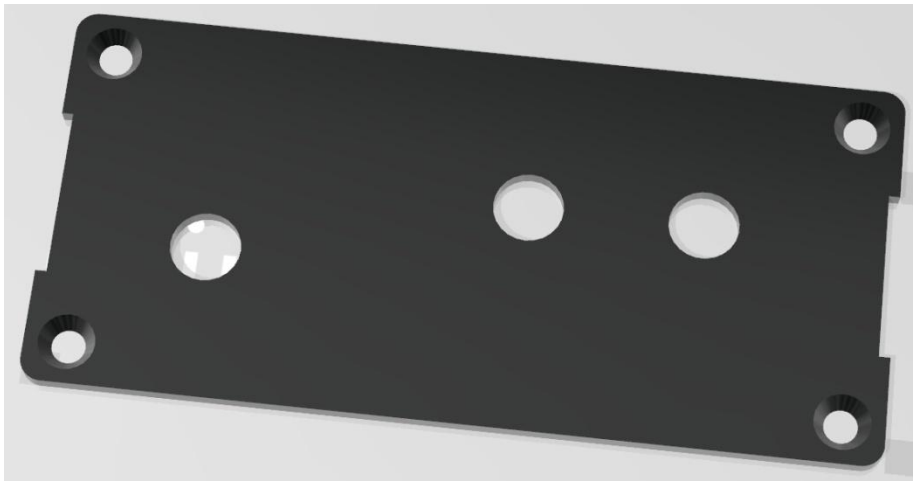
Solder ANTENNA and POWER jumper wires made from the two LED leads between the motherboard and the BF888S board in the positions shown in the photo to the right. Note that the correct solder pads are labeled on the motherboard.



Install the USB B female connector in the J2 position on the motherboard.	
Install the SMA antenna connector in the J1 position on the motherboard.	

Step 6. Mechanical Preparation (Front and Rear Covers)

The next step in the assembly is to drill/file the required holes in the End Caps as shown in Appendix 3. Note that the drawings show the End Caps as viewed from the outside of the enclosure.

Referring to the rendering at the right of USB End Cap and the detailed drawing in Appendix 3, drill the five holes for LEDs and drill/file the cutout for the USB connector. Note that the dimensions on the drawings are for a view from the outside of the end cap.	
Referring to the rendering at the right of Antenna End Cap and the detailed drawing in Appendix 3, drill the three holes for Antenna ad Control Shafts. Note that the dimensions on the drawings are for a view from the outside of the end cap.	

Step 7. Final Mechanical Assembly

In this section, you will perform final assembly of BRIAN (SM).

Install the USB End Cap on the two extrusion halves using four screws. Slide the motherboard assembly into the extrusion from the open end. Screw the ANTENNA End Cap on the open end to the two extrusion halves using four screws. Install the four feet on the bottom of the extrusion. Install the BRIAN label (location your choice) Install the knobs on the Volume and Frequency shafts. Install the antenna.	 

Step 8. Setup and Test

Connect the USB cable to your Raspberry Pi which has an Allstar distribution installed.

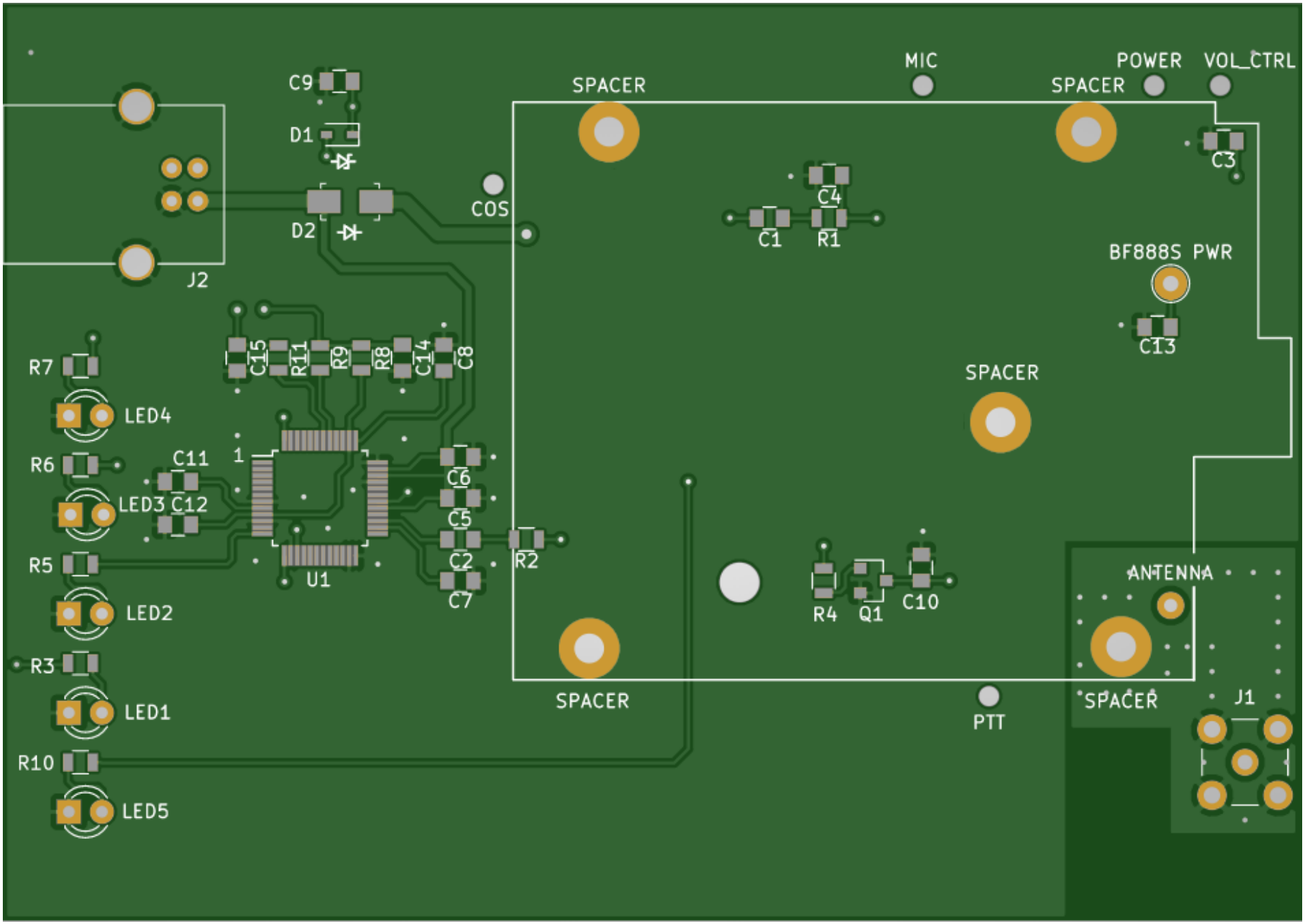
- Set the Frequency selector switch as desired.
- Monitor with a radio on this frequency.
- Rotate the Volume so that the Baofeng power switch is ON (Volume setting does not matter).
- Apply power to the Raspberry Pi. You should see 2 illuminated green LEDs.
- Your Raspberry Pi should begin initialization.
- The third green LED should begin to blink.

If you are using the HamVOIP distribution and are connected to the internet you should hear your IP address announced over your radio.

You should also check your output frequency. If can be adjusted using the small trimmer capacitor on the back side of the BF-888S board. You can access it by removing the four antenna end cap screws and sliding the mother board together with the end cap rearward far enough to see the FREQ ADJUST access hole in the bottom of the motherboard.

Appendix 1. BRIAN Parts List and Board Layouts

REF	NAME	PART NO	DESCRIPTION	MFG	QTY
	PC Board		BRIAN-SM PC Board	PCBway	1
R1,R2	Resistor	RC0805JR-0710KL	Resistor, 10K ohm, SMD, 0805,	Yaego	2
R8	Resistor	RC0805JR-071K5L	Resistor, 1.5K ohm, SMD, 0805,	Yaego	1
R4	Resistor	RC0805JR-071KL	Resistor, 1K ohm, SMD, 0805,	Yaego	1
R3,R5,R6,R7,R10	Resistor	RC0805JR-07390RL	Resistor, 390 ohm, SMD, 0805,	Yaego	5
R9,R11	Resistor	RC0805JR-0722RL	Resistor, 22 ohm, SMD, 0805,	Yaego	2
C1,C2	Capacitor	CC0805KY5V6BB106	Capacitor, 10uF, 10V, SMD, 0805, Y5V	Yaego	2
C3,C4,C9,C10,C13	Capacitor	CC0805KRX7R8BB102	Capacitor, 1000pF, 10V, SMD, 0805, Y5V	Yaego	5
C6,C7,C8,C11,C12	Capacitor	CC0805ZRY5V6BB475	Capacitor, 4.7uF, 10V, SMD, 0805, Y5V	Yaego	5
C5	Capacitor	CC0805ZRY5V9BB104	Capacitor, 0.1uF, 50V, SMD, 0805, Y5V	Yaego	1
C14,C15	Capacitor	CC0805JRNPO9BN101	Capacitor,100pF, 50V, SMD, 0805, COG	Yaego	2
D2	Diode	FM4005	Rectifier Diode, 2 A, 400 Volt	Rectron	1
D1	Diode	BAT43XV2	Shottky Diode, 200 mA, 30 Volt	ONSemi	1
Q1	Transistor	2N7002	Transistor, Mosfet, N-Channel, 60 V, 200 mA	ONSemi	1
LED1,LED2,LED5	Green LED	LTL-4231N	3mm, Through Hole, Green, Diffused	Lite-On	3
LED3	Yellow LED	LTL-4251N	3mm, Through Hole, Yellow, Diffused	Lite-On	1
LED5	Red LED	LTL-4221N	3mm, Through Hole, Red, Diffused	Lite-On	1
J1	RF Connector		RF Connector, RA, PCB mount	Unknown	1
J2	Connector	UJ2-BH-1-TH	Connector, USB, Female, Horizontal,Type B	CUI	1
	Antenna	SW433-WT36	Antenna, UHF, RA	Unknown	1
	Wire		Wire, Solid, PTFE, 30 Ga	Varies	1
	Enclosure		Extruded Enclosure, Aluminum,Black, 100x76x35mm		1
	Spacer	B00DIHVKQ0	Spacer, Aluminum, 2-56, 1/4L x 0.180Dia		5
	Machine Screw		2-56 x 1/2", Pan Head, Phillips,18-8 SS		5
	Nut		2-56, 18-8 SS		5
	Radio	BF-888S	HT, UHF, 2 watts (Newer 1/4 length board)	Baofeng	1
	Label		DINAH I/O Aluminized Label	Stickers Int'l	1


C9
D1
D2
J2
COS
SPACER
MIC
SPACER
POWER
VOL_CTRL
C3
C4
C1
R1
BF888S PWR
C13
SPACER
R7
LED4
R6
LED3
C11
C12
1
C15
R11
R9
R8
C14
C8
C6
C5
C2
C7
U1
R2
R5
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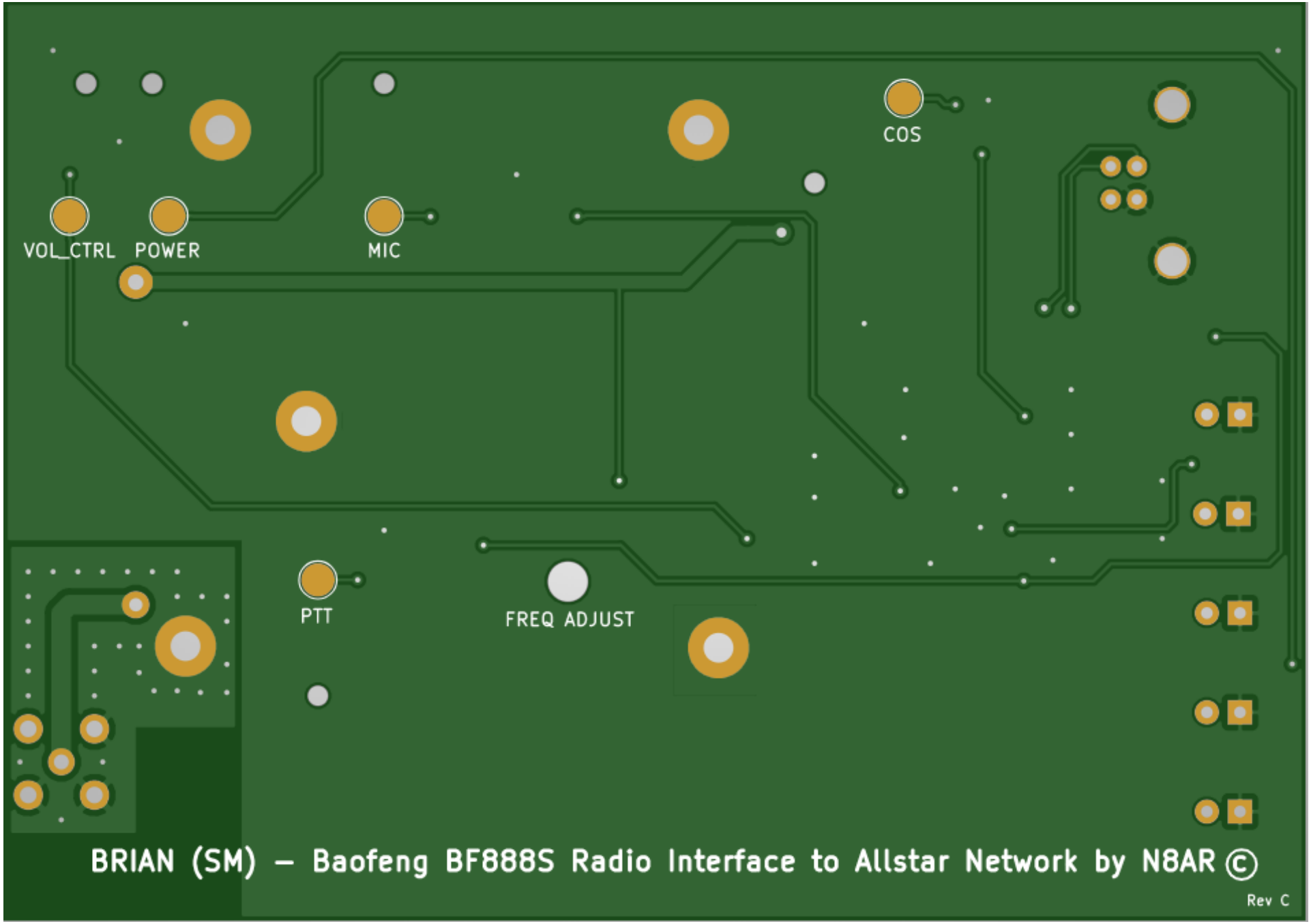
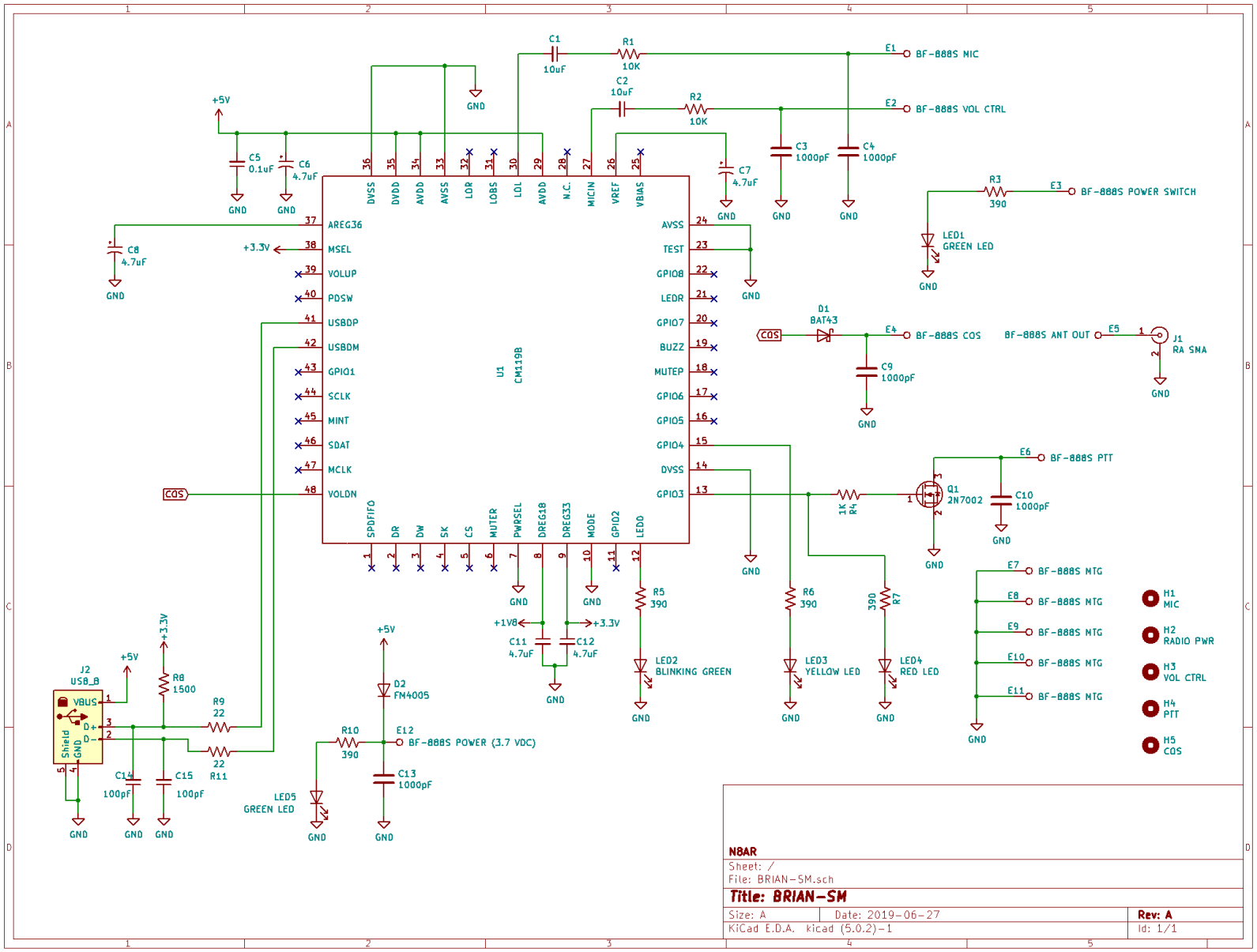
Q1
C10
ANTENNA
SPACER
SPACER
PTT
J1


COS
VOL_CTRL
POWER
MIC
PTT
FREQ ADJUST
BRIAN (SM) – Baofeng BF888S Radio Interface to Allstar Network by N8AR ©
Rev C

Appendix 2. BRIAN (SM) Schematic Diagram



Appendix 3. End Cap Drawings

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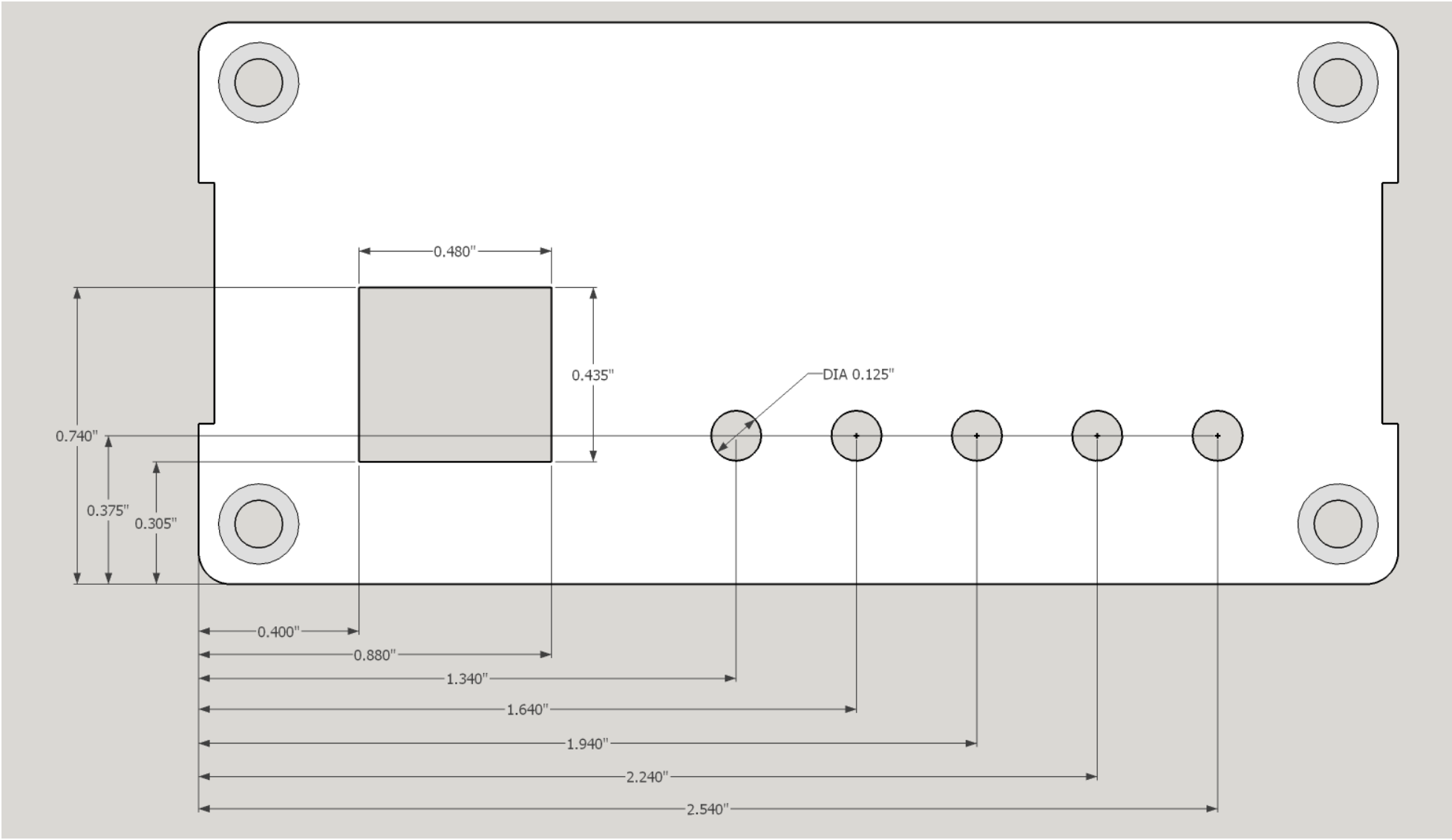
USB End Cap


0.480"
0.435"
DIA 0.125"
0.740"
0.375"
0.305"
0.400"
0.880"
1.340"
1.640"
1.940"
2.240"
2.540"

ANTENNA End Cap