Modifying the Yaesu FT-897 To Add 222 MHz

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Inspiration for this project came from an article by Dick Hanson, K5AND, who wrote "TS-850 with Down East Microwave Transverter" for the 1999 CSVHFS Proceedings. In that article Dick described how he modify a TS-850 to internally accept a Down East Microwave (DEM) 6m transverter resulting in a simple and straightforward high performance 6m radio. That article came to mind when a friend opened up his recently purchased Yaesu FT-897 to show me the radio's internal battery compartment. Upon seeing that open space my immediate thought was, "Wow, it sure looks like you could fit a transverter board inside that !" thus starting my research and bench work into adding a DEM 222 MHz transverter inside the FT-897. Unlike K5AND's work with the TS-850, my goal was to add 222 MHz capabilities with little or no impact to the radio's many features. After reviewing the Yaesu documentation I decided that such a modification was indeed possible.

Highlights of the Modified FT-897

- This modification does disable the FT-897's internal battery feature. In addition, the DEM transverter is mounted inside the battery bay area so you cannot use the Yaesu internal power supply option. Other than this, no other features or functions are affected. The radio remains fully usable on all bands and on all modes just as purchased.
- The functionality of the FT-897's A/B battery select rock switch, located on the top of the radio, is modified to allow the user to select between 28 MHz or 222 MHz operations. When operating on 222 MHz the FT-897's frequency readout will be on 10m (ex: 28.100 MHz = 222.100 MHz).
- The back panel DATA and CONTOL ports remain fully functional and available for typical usage. The modifications have no impact to these control ports.
- With the exception of an additional SO-239 on the back panel, the modification is invisible from the outside.
- In addition to the full features of the FT-897 this modification provides the user with a high performance 222 MHz transverter, all in one box. See the DEM website for transverter performance specifications.

Please note that this modification will nullify your radio's warranty quicker than a 222 MHz sporadic-E opening. Although this modification is not difficult, you should only attempt this if you are comfortable with it after reading this paper. The modification requires that you perform some high precision soldering in tight spaces in order to gain access to a few of the FT-897's control signals that originate inside the radio.

Overview of the Modification

Overall, the modification involves accessing the radio's Main, Power Amplifier (PA), and Battery Connector printed circuit boards (PCB), cutting and adding several wires and mini-coax lines, and drilling some new holes in the internal mounting plate that forms the bottom of the battery compartment. The FT-897's internal battery bay is used to hold the 222 MHz transverter board, two IF switching relays, and a small custom control circuit board. Performing this type of modifications on a newly purchased radio always gives one a second or two of pause. If only they made them right to begin with !

Along with adding the DEM transverter and two IF relays, the design includes a small custom circuit board for control. The custom control board schematic is shown in Figure 1. Understanding how the control circuit works helps to understand the basic modification. Please review Figure 1 while you read the next several paragraphs.

Inside the FT-897 there are two mini-coax lines that run between the Main PCB and the PA circuit board. These two mini-coax lines form a split transmit & receive pair and handle all frequencies from 160m through 70cm. The modification requires that you cut these two lines and insert an RF relay in each line. The RF relays are then used to control whether the radio is operating in its normal mode or when its operating on 222 MHz. On the transmit side there is about 10 watts of 28 MHz RF present here (this is with the Power menu set to 100, or maximum). Although you can control the amount of available output RF output power with the radio's menu control I decided to design it for the maximum output power setting so that I could QSY from 10m to 222 MHz without wondering what the power level is set to (i.e., rover proof). When operating on 222 MHz the 10 watts of 28 MHz energy is dissipated by a 35-watt RF power resistor where some of that power is tapped for driving the DEM transverter using a 5 pf capacitor.

Looking at Figure 1 you can see that the two RF relays are controlled by the effective ANDing of two inputs. The first input is the position of the FT-897's A/B battery select rocker switch while the second signal is an internal control signal that is active whenever the user selects the 10m band.

When the user selects the 28 MHz band the FT-897's PA board generates an internal signal that is used by the radio to activate the appropriate transmit and receive filters. This specific signal is called "24/28M" in the radio's documentation and it is an active high (5 vdc) signal. The modification requires that a small wire be soldered onto the PA PCB to access this signal (see Figure 4). That wire is then routed to the custom control circuit where the signal is buffered and then routed to the modified A/B battery select switch.

Some simple changes are needed to isolate the A/B battery select rocker switch from its normally intended function. Once these changes are completed, the buffered "24/28M" control signal discussed above is routed from the control board to the rocker switch. In operation, when the rocker switch is open, nothing happens, and the FT-897 performs as it always does. When the rocker switch is closed AND when the user select 28 MHz, the "24/28M" control signal is routed through the control circuit resulting in the two RF relays closing and operation on 222 MHz.

ANDing the same signal from above with a second control signal that is generated on the FT-897's PA board achieves 222 MHz PTT control. That second signal is the "HF TX" signal. The ANDed signal creates a PTT-H (PTT high) signal that is used with the DEM PTT-H input control (see Figure 1).

Other Possibilities

While this modification describes my work to add the full size DEM 222 MHz transverter board to the FT-897, there are other interesting possibilities. W1GHZ's smaller 222 MHz transverter would fit inside, leaving room for other modifications. Other suppliers of transverters such as the new Elecraft transverter boards may also fit inside. Other bands besides 222 MHz may be considered such as 902 or 1296 using the 2m signals that can be grabbed in the same way as I am grabbing the 28 MHz signals. Overall, the radio's design lends itself to easy modification.

Modification Instructions

These steps should be considered guidelines. I have tried to include as much information as I could. Please remember that this work is based on a sample size of one and that Yaesu does reserves the right to make changes to their radio and that those changes may impact this modification.

Step 1. You will need the following information and components.

- Documents. A copy of the "Yaesu FT-897 Technical Supplement". You can find it on the Internet as a PDF file. It comes with block diagrams, full schematics, and board layout information. It is extremely useful to be able to trace between the schematics and the board layouts.
- Down East Microwave items.
  - For my modification I installed the DEM 222-28B, their preassembled 222 MHz transverter PCB. If you would like, you can save some money and gain some experience by ordering the 222-28K kit and assembling it yourself. As this board is only good for 200 mW of output power make sure that you also order the 25-watt power module that goes with it.
  - You will need some relays for controlling and switching the IF signals. You can roll your own, or in my case it was DEM to the rescue with their UTR-12 PC board mounted RF relays (without connectors). You will need two of these. These come in kit form but are a snap to construct. If you roll your own, make sure that you use low loss RF relays as the radios transmit and receive signals flow through these.
- Hardware and other components. I purchased these through DigiKey, RadioShack, and a local hobby store.
  - 51 ohm, 25 watt, power RF resistor, Ohmite TBH25 or equivalent, quantity = 1
  - 3.3 K ohm, 1/8 watt resistor, quantity = 2
  - 2N2222 NPN transistor or equivalent, quality = 2
  - 5 pf capacitor, quantity = 1.
  - CD4081 quad 2-input AND gate, quantity = 1
  - Heat sink for the DEM 9 vdc regulator.
  - 4-40 screws and nuts. Used for mounting the transverter PCB to the FT-987's Shield Plate.
  - M3 metric screw, quantity = 2. These are the two tapped holes in the side of the FT-897. They are used to hold the 1" aluminum angle bracket that has the power module mounted to it in place.
  - SO-239 panel connector (for 222 MHz In/Out)
  - Perforated PCB (for customer control circuit). You could also do your own layout.
  - About 18" of high quality mini-coax.
  - Approximately 8 inches of 1" aluminum angle bracket. This is used for mounting the 222 power module.

Step 2. Mechanical modifications (Reference Figure 2). Remove the top and bottom covers to the FT-897. With the radio upside down, identify the shield plate that forms the bottom of the battery compartment. It is held in place with eight screws. Remove these eight screws and lift off the plate exposing the PA board underneath. You will need to determine how the transverter will mount onto this plate, along with the two RF relay boards and the custom control PCB. You will need to consider how the transverter will fit while still allowing access to the eight mounting screws. Don't forget to add a heat sink to the DEM transverter's 9 vdc regulator as the heat sink will occupy some space. It is best to lay the two relays, the transverter board, the customer circuit board, and the 222 power module all inside the radio before you start to drill holes. The 222 MHz power module is attached to a length of 1" aluminum angle bracket that is itself then attached to the side of the FT-897 using the two tapped holes that are intended for the mobile bracket. I did have to file down the top of the aluminum bracket just a little bit in order for the bottom cover to properly fit. Its best to mock up the planned layout, then lay the cover back on to see if it will indeed all fit as intended. Once you have determined how the boards will be positioned mark and drill holes accordingly. In my design I used 4-40 hardware to mount the DEM transverter PCB to the shield plate much like how DEM mounts their boards inside their box. The SO-239 panel mount can be mounted in one of the two battery connector holes that are protected with a plastic knock-out. Simply remove the plastic knock out and drill the necessary mounting holes. As you are marking the location for drilling any holes, make sure that you double check for interference issues when you go to reassemble the radio. It is best to complete all the mechanical modifications before proceeding onto the electrical modifications.

Step 3. Electrical modifications. For the small precision soldering I used a 15 watt grounded tip soldering pen.

- Locate the battery selector PCB and lift connectors J 4904 and J 4905 (see Figure 3). This will electrically isolate the rocker switch from its intended function. The connectors can be allowed to float.
- Review Figure 3 and find the two IF lines. The receive line is connected to J3 and has a green band on it while the transmit line is connected to J2 and has a red band on it. Disconnect these two lines and route them to their appropriate relay (see Figure 2). I cut the little stock mini-connector off of mine and solder then directly to the DEM UTR-12 PC board. You will need some mini-coax to then run from the normally closed contacts back to J2 and J3 on the main board. On the receive IF line, the normally open relay contact is connected directly to the transverters 28 MHz receive port. On the transmit IF line the normally open relay contact is connected to a 25 watt, 51 ohm RF power resistor to dissipate the 10 watts that is present. I mounted my power resistor to the shield plate where it is held in place by the same hardware that holds one of the UTR-12 relays. A small 5 pf capacitor is then connected from that point to the transverters 28 MHz transmit input port.
- On page 59 of the Yaesu FT-897 Technical Supplement is the schematic for the PA board. At the top left, find IC Q-3013, a 4094 serial-to-parallel converter. Pin 12 of this device is where the "24/28M" control signal originates while Pin 14 is the "HF TX" control signal. I found it somewhat easier to grab these two signals on Q-3031 and Q-3024 as shown in Figure 4. Carefully route these two control signals to the custom control board. For my radio I used tie-wrap wire grouped and sheathed in small shrink-wrap tubing. While I was there, I also grabbed the +5 vdc on pin 14 of Q-3013 to power the custom control board. If you wanted to you could build a separate 5 vdc regulator on the control board and power it directly with 13.8 vdc.
- Connect the A/B battery select rocker switch as follows. Connect a wire from the control board (per the Figure 1 schematic) to the battery board J-4902 connector, pin 3 (see Figure 2) and battery board connector J-4905, pin 1 (see Figure 3).
- Finish all wiring. Connect the appropriate line from the control board (Figure 1) to the DEM transverter PTT-H line. Also make sure that the transverter board is connected to 13.8 vdc. I installed the PWR and XMT LEDs on the DEM transverter board to help me detect proper operation.

Step 4. That's it. You should first confirm that your FT-897 is performing normally on all other bands. Then switch to 28 MHz and flip the A/B battery switch to activate the 222 transverter. Using a voltmeter you should be able to confirm that the control board has activated the two IF relays. Tune up the DEM transverter per their instruction sheet. On my modification I was able to get a smooth change in output power with the transverters XMT adjustment pot from just a few watts to better than 25 watts. The module felt cool to the touch. I set my transverter up for 10 watts to best drive my solid-state brick amplifier.

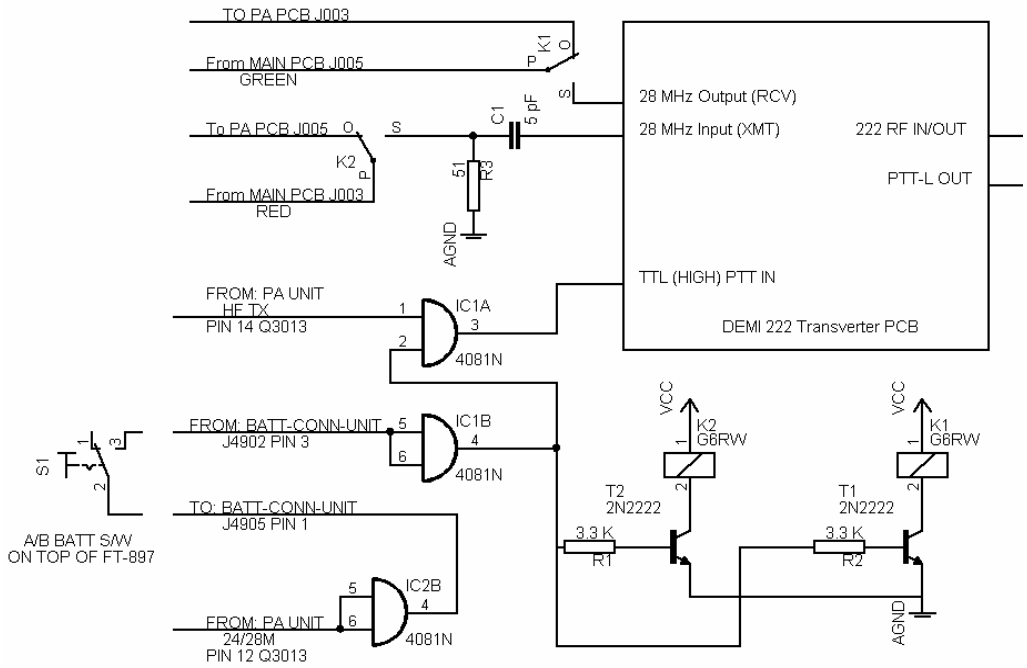

Figure 1 - Schematic For Custom Control Board

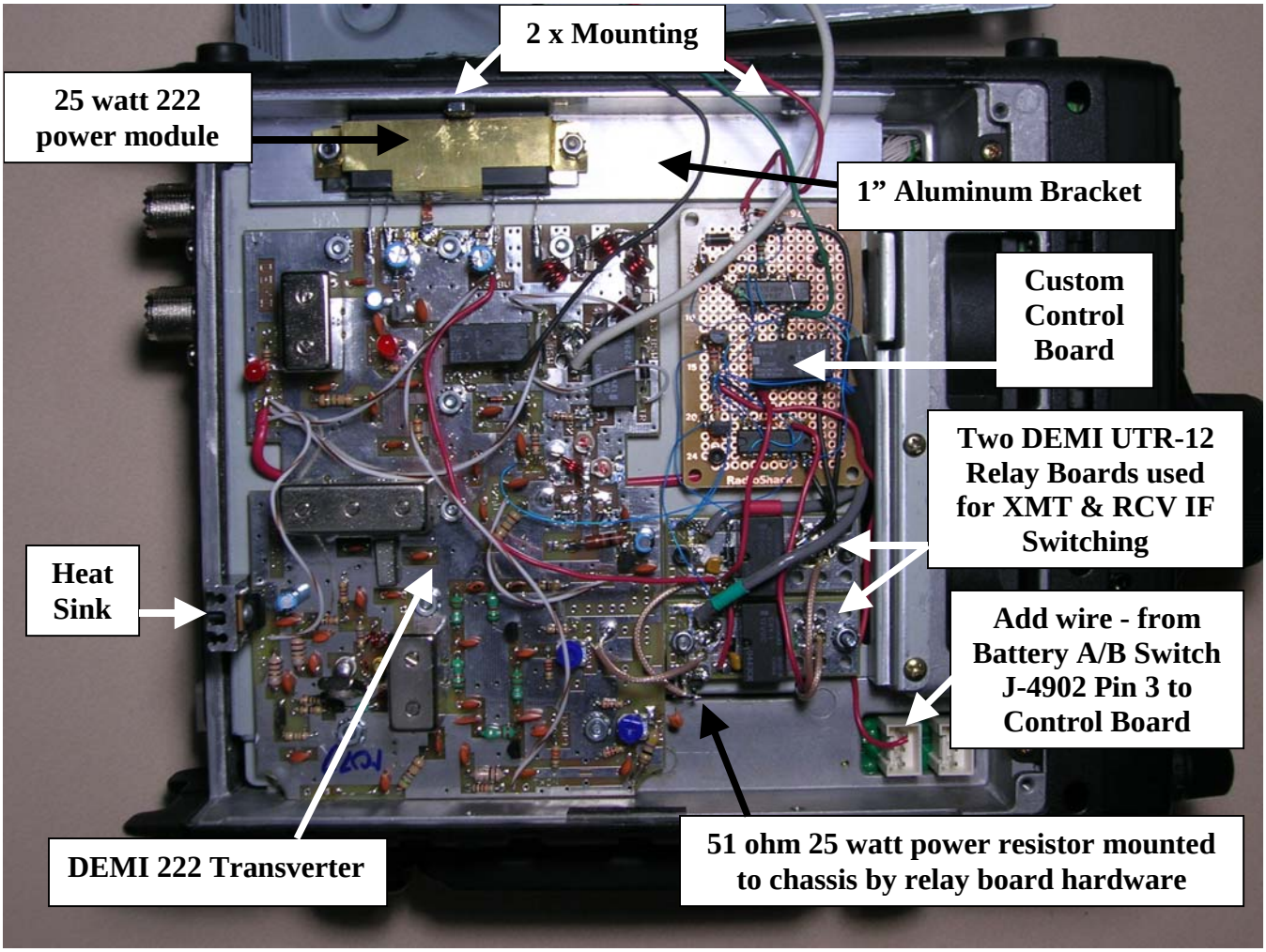

Figure 2 – FT-897 Bottom View (Battery Bay) With Added Transverter

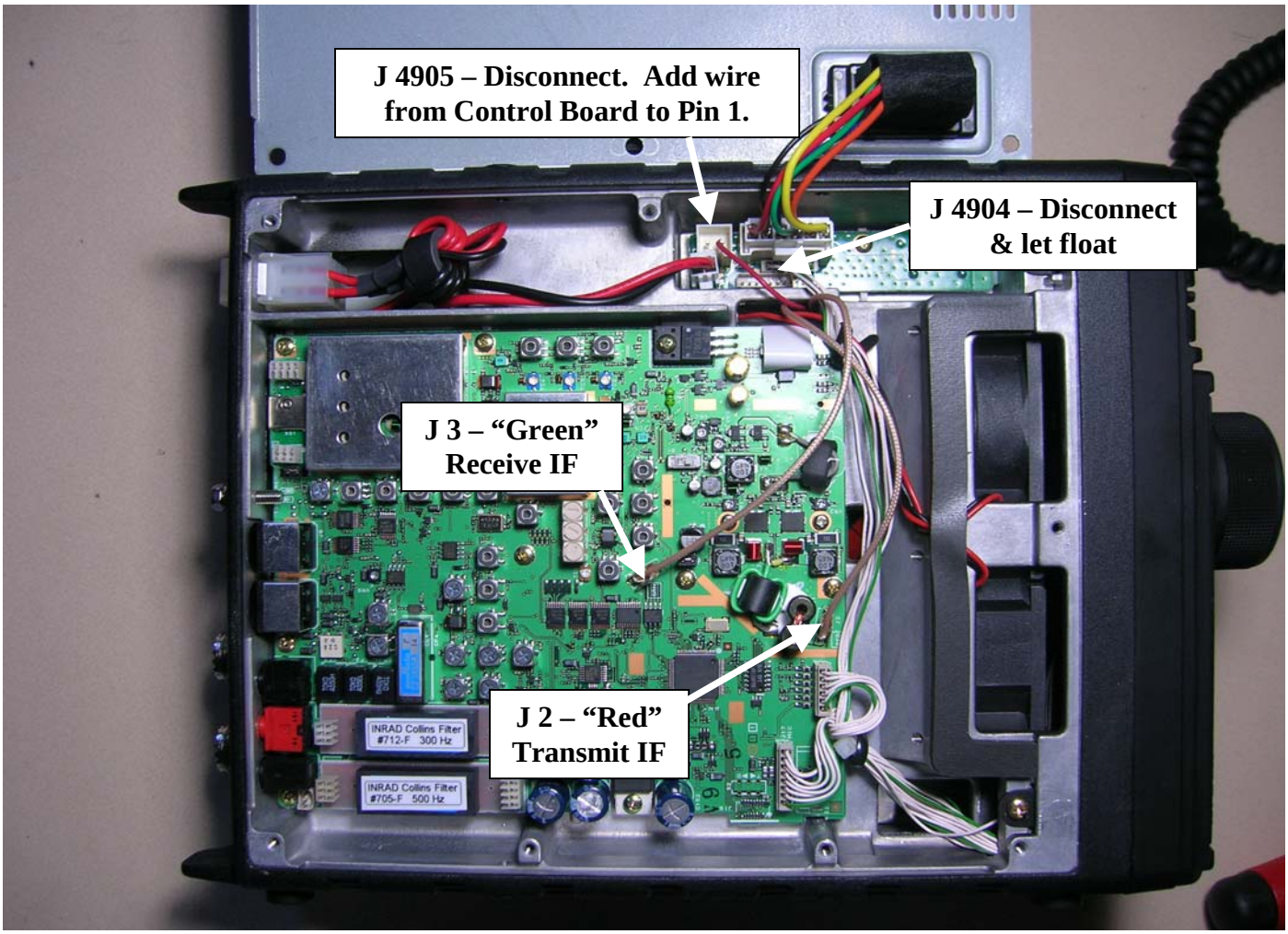

Figure 3 – FT-897 Top View Showing XMT & RCV IF Lines Along With A/B Battery Switch Modifications.

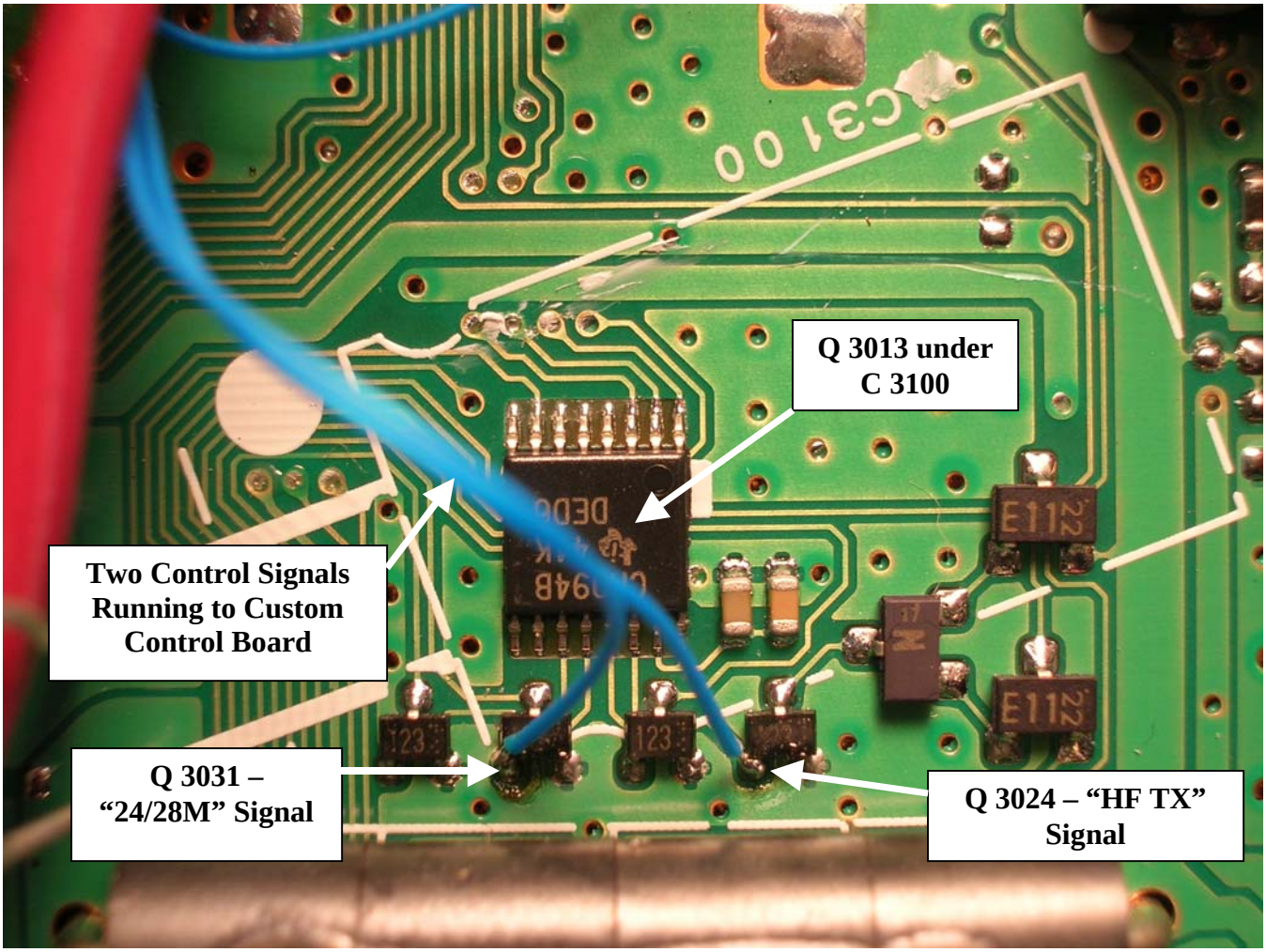

Figure 4 - FT-897 Power Amplifier Board, Access To Control Signals