A Replacement Display for the Yaesu FT301D HF Transceiver

by

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In the late 1970's or early 1980's (time prevents me from remembering exactly when) I purchased my first HF transceiver. It was a great radio with excellent specifications and capabilities, at least for those days. It came with a, somewhat new at the time, digital frequency readout. After a few years, though, the display developed some missing segments in the 6 digit 7-segment LED readouts. Those displays, Texas Instruments TIL306 and TIL308, had not only the LEDs in them, they also contained digital decade counters, latches and LED drivers. They ran hotter than blazes!, and, they were located in a tiny space at the front of the radio that had almost no cooling air movement. With all of that heat and no cooling, they didn't last long.

Initially, to fix those missing segments, I purchased some new TIL306 and TIL308 displays and just replaced them. All was fine again! Well, at least for a few more years, and then, poof, a few more burned out segments. I lived with the few missing segments for years… and slowly adapted to the "new hieroglyphic language" that it portrayed. I could still determine what frequency I was operating on, as the still working segments gave a unique signature, but anyone else had a pretty hard time deciphering it all. After many years of putting up with all of that and then with the radio sitting idle on the shelf for many years, I once again found myself staring at that display and thinking, it's time to really fix this thing! I figured that those displays had probably long ago gone "end of life." But, in the interest of not working too hard at fixing this old radio, I did a quick look on the web to see if anyone had those displays in stock… as expected, nothing… long gone obsolete! Next I did a quick search to see if anyone else had tackled this problem and I did find a fix that W5CEU had implemented (http://www.aade.com/applications/FT301D.htm). He used an LCD digital counter module to replace the display. While it provided the frequency readout, it wasn't a drop in replacement and it didn't have that same "red LED" look to it that would make the rig look original. And, it also required some modifications to the front panel bezel window along with picking up a new source for the LCD counter modules's input signal. His solution does directly count the radio's VFO signal instead of the output of the radio's "Counter Mix Unit." That does result in fewer things to keep in adjustment for accurate readings, but again, it is not a plug in replacement for the radio's stock display unit.

So, it was time to make "this project" a little more complicated! I got out the old manual for the radio and studied the schematic of the display. On the schematic it was listed as part number "PB-1542 Display Logic Unit." But, after taking apart the front panel of the radio and extracting the display board, I discovered that the part number on mine was a newer version, PB-1542**B**, than what was shown in the manual. That led me down the rabbit hole of checking the schematic against the actual circuit board I had to find the differences. There were a few changes, but nothing too serious.

The next task was a quick perusal of some various manufacturer datasheets to come up with a reasonable way to build a new display. I decided to use a microcontroller to pretty much do the entire function. A Microchip PIC16F887 part has plenty of I/O ports to capture all of the incoming knob functions/settings, generate all of the output signals to drive currently available simple 7-Segment LED displays, and even directly count the frequency, as the PIC16F887 has a "gate" function for the Timer1/Counter1 input. So, we were all set. The parts used would all be tiny surface mount (except for the displays), to keep the physical size small and easy to build, well, at least with a good magnifying glass! The prototype printed circuit board would be a bit of a challenge to do in the home lab, as the PIC16F887 package I chose was the TQFP-44. This small surface mount package (less than 0.5" on a side) wouldn't take up too much room on the circuit board, but it does have 0.8mm (0.031") lead pitch. To make the prototype PCB, I used the "direct etch method" using the Toner Transfer System tools and consumables from Pulsar. (http://pulsarprofx.com) that are also available from Digi-Key (www.digikey.com) All of the computer aided design tools used are freely available; TinyCAD (http://tinycad.sourceforge.net) for schematic capture , FreePCB (http://www.freepcb.com) for the printed circuit board layout, and Microchip's MPLAB (www.microchip.com) for the firmware design written in MASM.

The resulting circuit design and firmware code duplicates all of the original functions of the display, and even provides some corrected features in how the counter works and what happens at the band edges when the counters roll-over or roll-under. Such as, having the displayed MHz digit numbers go to 6 when tuning below 7.000.0 or go to 30 when tuning above 29.999.9 Likewise for all of the band edges that cause a roll-over or roll-under condition of the count. The way the original radio's counter/display works is that it has a "Counter Mix Unit" that preceeds the actual frequency counting function of the "Display Logic Unit." The "Counter Mix Unit" takes in the 5.0MHz to 5.5MHz VFO frequency and mixes it with an 18.5MHz signal to come up with a 13.0 to 13.5MHz signal that the display frequency counter counts. The counter only generates the hundreds of KHz, tens of KHz, ones of KHz, and hundreds of Hz digits. The MHz digits are generated by inputs from the front panel band switch. Somewhat of a complicated way of doing all of this, but back in the 1980's with those TIL306 and TIL308 integrated displays, I suppose it made things easier to implement. In order to make the new display a perfect drop in "form, fit, and function" replacement that perfectly plugs into the existing radio internal connectors and needs no modifications of the radio's circuitry, it operates in a similar fashion. That means it also makes use of some of the "diode" encoding that the high order MHz digits used to determine what number to display… it is actually a bit more complicated in that it has to back track that "diode" encoding to regenerate the MHz digits. Isn't doing some things in code wonderful?, instead of doing it all in hardware?!

Now for the details:

To remove the original display board:

- Remove the radio's top cover with the 4 plastic pull knobs.
- Unplug the speaker connector and set aside the top cover.
- Remove the 12 screws on the bottom cover and remove the bottom cover.
- Unplug the two square pin connectors on the bottom that are attached to the display board.
- Remove the main frequency dial knob by loosening the two set screws in it.

- Unsolder or cut the resistor that is attached to the display board and to the frequency calibrate control. You will need to re-attach this resistor when you install the new display circuit board.
- Loosen the two bracket screws at the side back of the metal bracket that is attached to the display board.
- Remove one screw located near/behind the frequency dial knob area.
- Gently remove the Display Logic Unit PB-1524B

Pictures of the original Logic Display Unit when removed from the radio are shown below:

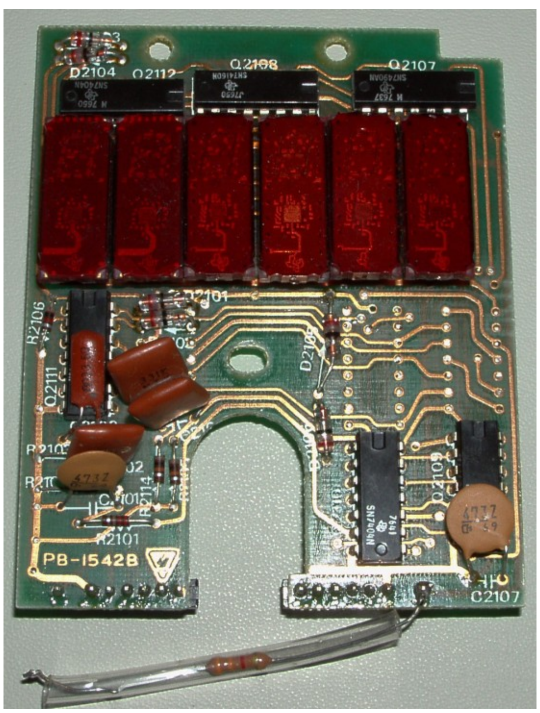

Figure 1 : PB-1542B Logic Display Unit

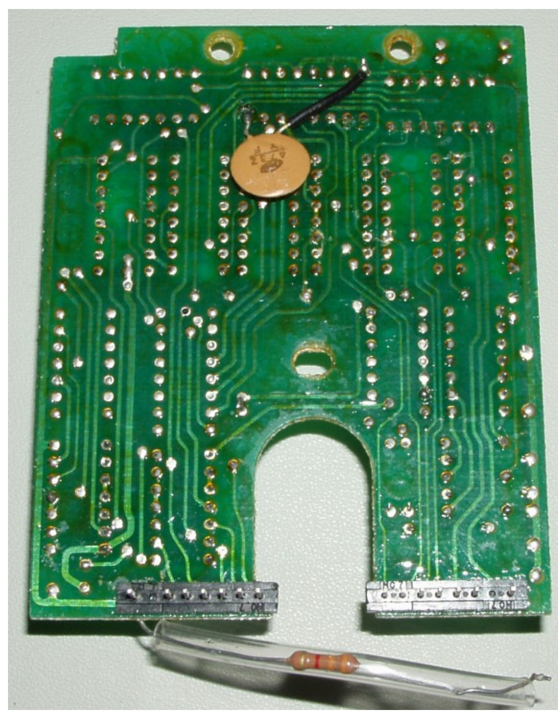

Figure 2 : PB1542B Logic Display Unit

The new display board is a two layer circuit board. Because I wanted to keep the etch feature sizes relatively large to aid in etching the circuit board in the home lab, instead of sending it out for initial fabrication, there are some wire jumpers added to the PCB. I still haven't come up with a really good way to fabricate more than two layer circuit boards at home. But, at least with jumper wires on the top and bottom side, I can "pretend" to have a four layer board! The jumpers on the top side are associated with the LED displays (blue 30 gauge wire-wrap wire in photo below). Those jumpers provide power to one set of the common anode pins on each display device. The jumpers on the bottom side of the PCB connect the programming header for the Quickwriter PIC Programmer (http://www.tech-tools.com) to the PIC16F887 device. These jumpers, and the programming header, are not needed if you never intend to program or re-program the microcontroller in-circuit. You might notice that the drill holes for mounting the new board are somewhat enlarged and off-center in the associated pads. This mechanical alignment anomaly has been corrected in the current design files and the mechanical drawing for the circuit board! Everything should now line up properly! Maybe we should fire the mechanical engineer on this project! To better show the jumper wiring placement, the 7-Segment LEDs have not yet been installed in the PCB.

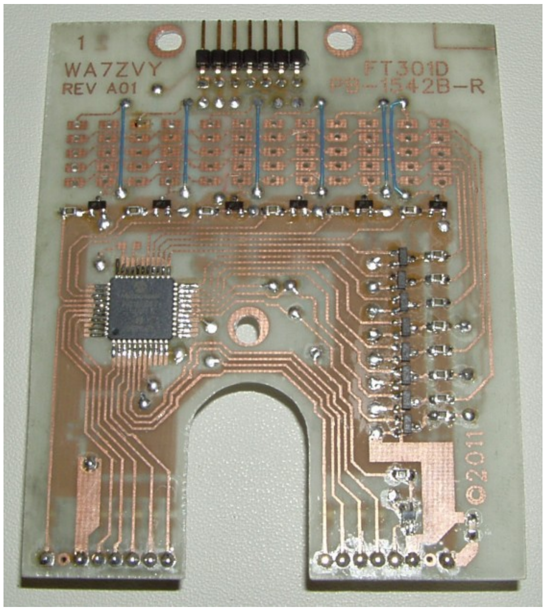

Figure 3: New Logic Display Unit (top)

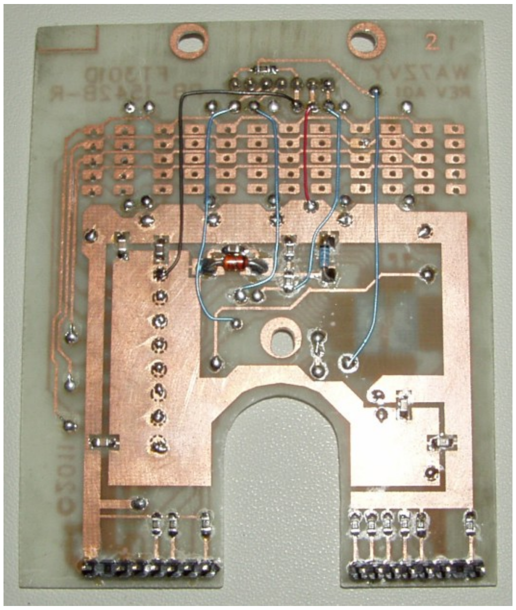

Figure 4: New Logic Display Unit (bottom)

The next picture shows the new, completed, and ready to install display board. I have given this new display board the part number "PB-1542B-R" (where "R" stands for "Replacement"). This board's revision level is "A01". The latest version is now "A02". The "A02" version has an improved frequency input buffer using discrete transistors instead of a simple logic gate. This improves the temperature stability of sensing the Mix Units output signal.

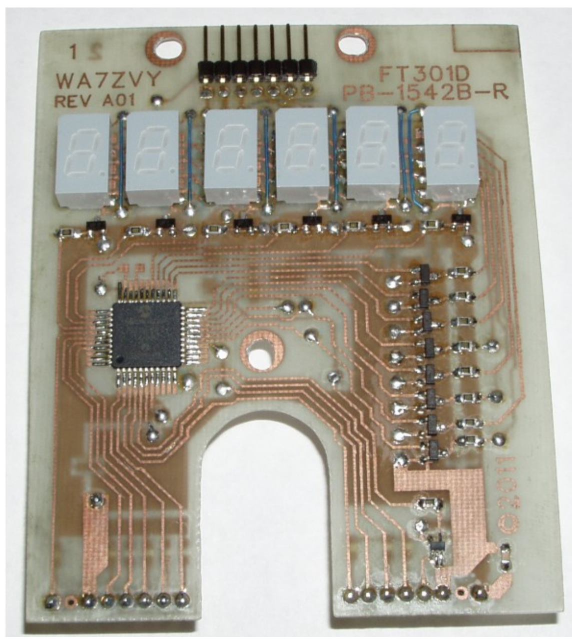

Figure 5: PB-1542B-R Display Unit(top)

To install the new display board:

- Remove the metal mounting bracket from the backside of the old display board.
- Install the old top bracket on the backside of the new display board with the two screws previously removed.

- Gently slide the new Display Logic Unit PB-1542B-R into the front of the radio behind the front bezel.
- Install one screw located near/behind the frequency dial knob area.
- Install two screws through the mounting bracket at the top of the display board.
- Re-attach the 3.3K ohm resistor coming from the front panel's "Calibrate" potentiometer. Solder it to the backside of the new display board at J1-1.
- Push the two cabled square pin connectors onto the associated square pin connectors on the new Display Logic Unit PB-1542B-R. The connectors are keyed for proper alignment.
- Install and tighten the main frequency dial knob.
- Install the bottom cover and attach with 12 screws.
- Plug in the speaker connector from the top cover.
- Install the top cover and attach it by pushing down the 4 plastic buttons.
- Power up and enjoy your new readable display!

Figure 6: FT-301D with the new PB-1542B-R display installed

For those who want to do some further custom programming of the display features, the programming header on the new display board allows a PIC programmer to be connected and the firmware to be updated. The chassis of the FT-301D has a factory cut out in the chassis frame that worked out like it was actually made for the user programming header feature!

Figure 7: PIC Programmer Attached

Figure 8: PIC Programmer Attached

The accompanying zip file contains the complete set of design, fabrication, source code, and documentation for this project:

FT301D_Replacement_Display
- Docs
- FW
- PCB
- Schematic

Enjoy, and 73!,

Paul