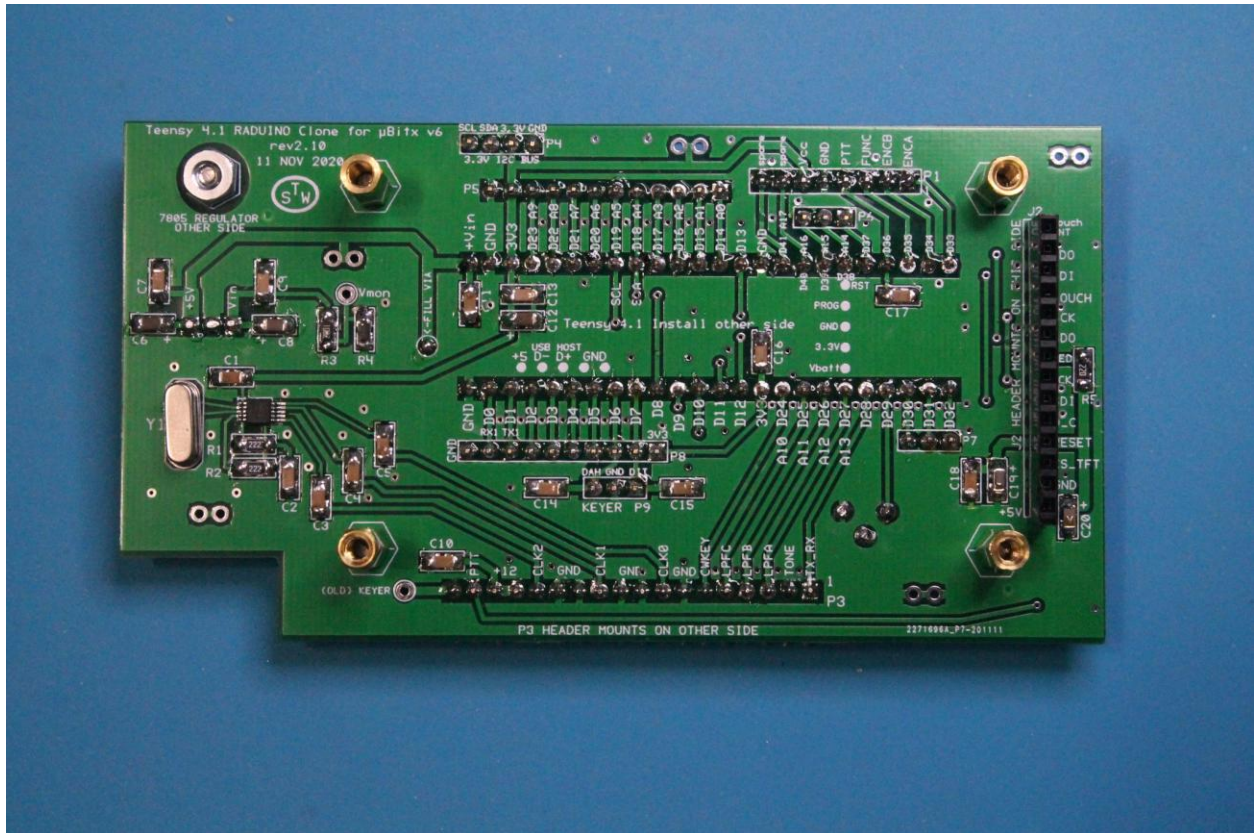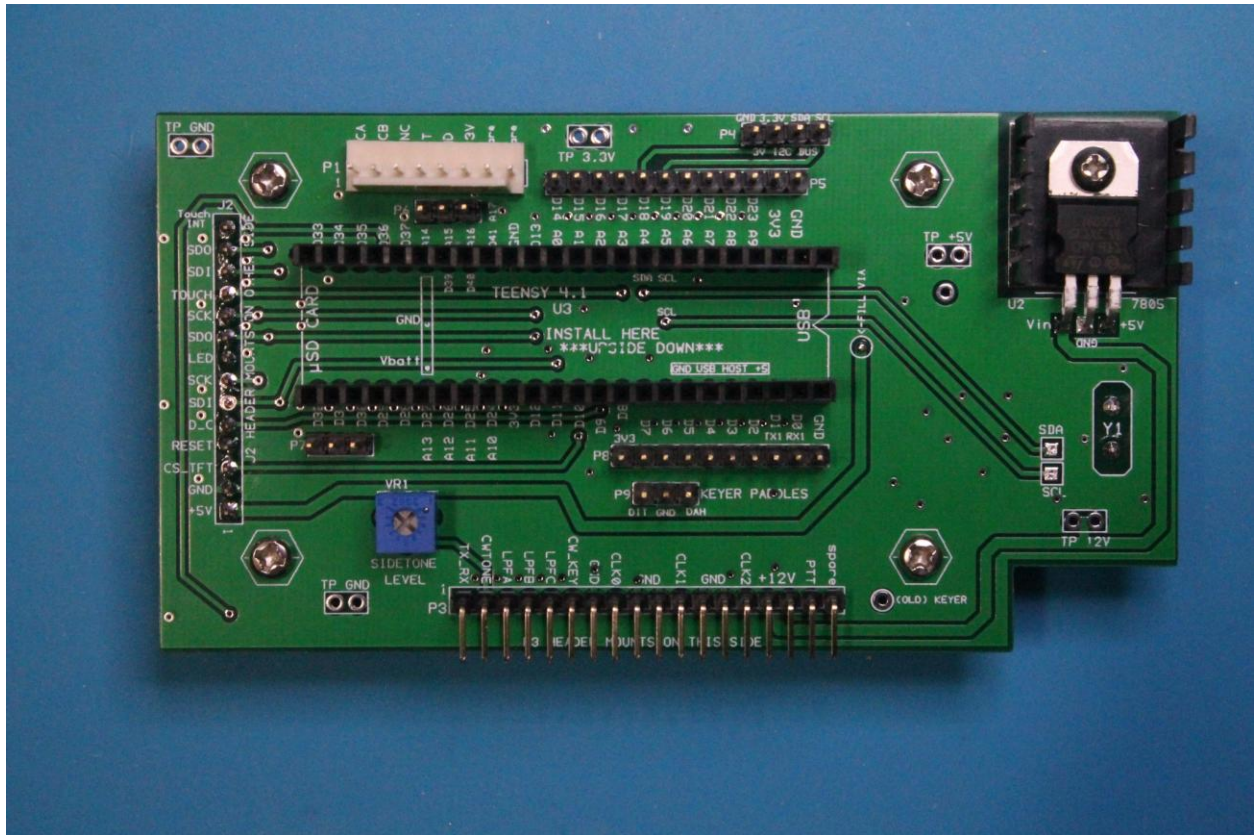# Construction Manual
"Triumvirate Skonk Worx" (TSW)
Teensy 4.1 Raduino Kit Version 2.13 for the HF Signals
uBITX Version 6 Transceiver

Manual Version 1.15, Copyright© TSW January 2022, All Rights Reserved

Assembled TSW Teensy 4.1 Raduino Clone Kit V2.10 PCB

Front Side (2.8" Display not yet installed)

Back side (Teensy 4.1 not yet installed)

VERY IMPORTANT!

Once you have completed this kit, and installed the firmware located on the TSW Website (www.w0eb.com), you MUST first perform the Touch Screen calibration or the touch will not work. You MUST also perform the BFO calibration or the receiver will not receive anything until this is done. These instructions are contained in the Software Manual for the T4.1 Raduino which comes in the firmware zip file OR can be obtained in the documentation section on the TSW website.

Introduction:

Shortly after the HF Signals (India) uBITX transceiver Version 6 hit the market, the TSW group produced a Raduino Clone for it that could use an Arduino NANO like the factory version did and operate with the factory's software or, with an adapter also produced by TSW, use a Teensy 4.0 by PJRC in place of the NANO with our own software for much faster display updates, easier calibration and much better Iambic keyer CW operation.

We had good success with the Teensy 4.0 using the adapter, but when we tried to mount the Teensy 4.0 directly on a board, for some reason we could not make it work right so abandoned that project. Fast forward a few months and PRJC has made available a new, larger footprint version of the Teensy called the Teensy 4.1 so we decided to make a limited attempt at using this on a unique Raduino clone that used only the T4.1 mounted directly on the board, no adapter.
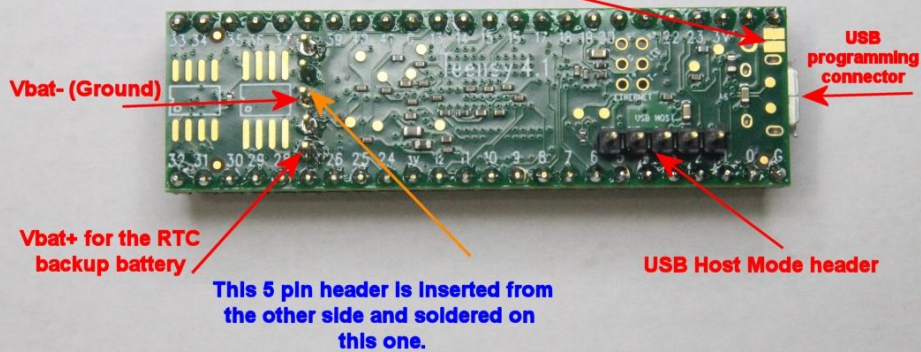
We had a very limited run of prototype boards made to test the concept. Much to everyone's delight, it works very well and seems to have eliminated most if not all of the noise problems inherent with the Factory (and our clone) Raduino using the Teensy 4.0 to NANO adapter.

Except for the very small Si5351 clock/vfo IC, we chose to use all 1206 size SMD resistors and capacitors to make kit construction a bit easier for those who don't like to work with the smaller (0805 and smaller) surface mount components. It was decided that all the TSW Raduino Clone kits would already have the Si5351a IC soldered in place and checked for proper connections to ensure the highest probability of successful kit completion and operation.

The CPU for this Raduino Clone must be a PJRC Teensy 4.1 and like the NANO on the Factory Raduino and Teensy 4.0 on TSW's adapter, The Teensy 4.1 will plug in upside down on the back side of the PCB. The photo below shows how to set up the (user supplied) pins on the Teensy 4.1 to plug into its socket on the T4.1 Raduino Clone and is shown in greater detail in Appendix D of this manual.

Mount the 48 Teensy 4.1 connector pins (24 on each edge) on what would normally be the TOP side as it will mount upside down on the back of the Version 6 T4.1 Raduino.

Be sure to cut the almost invisible jumper between these two pads. This is necessary to keep the 5 volt USB power from conflicting with the main input 5 volts to the Teensy when it's powered by the Raduino. Failure to cut it can result in catastrophic damage to the Teensy 4.1.

USB programming connector

Vbat- (Ground)

Vbat+ for the RTC backup battery

This 5 pin header is inserted from the other side and soldered on this one.

USB Host Mode header

TSW does NOT provide a Teensy 4.1 or the pins for it. The user has to order it from PJRC install the pins and load the program themselves). We do suggest getting gold plated pins if possible and be sure to read Appendix D thoroughly before installing the pins in your new Teensy 4.1 as there are some critical instructions that MUST be followed to keep your Teensy 4.1 safe.

Construction:

1. The first thing you want to do is inventory the supplied parts for the kit against the "bill of materials" located in an appendix to this document. If any are missing contact Jim, W0EB via email, w0eb@cox.net and let him know what you are missing. The replacement part(s) will be sent promptly. In a pinch, 0805 size SMD components WILL fit the pads (we designed it that way). NOTE: Seems like the newer uBITX factory cases have slightly smaller vertical dimensions than when we designed the card. It fits very tight on the right hand side. Since the regulator pad and heat sink are at ground potential, before starting construction, shorten the top of the card over the regulator so that the PCB is flush with the top of the regulator's heat-sink pad. This should make it a little easier to slide into the case. Also you might install the finished card with the front panel removed to make it a bit easier to position.

2. The first actual construction step will be to carefully install all of the SMD capacitors. Start with the 0.1 uF 1206 ceramic capacitors which are C1-C5, C7, C9-11, and C13-18 that are highlighted in RED on the PCB layout shown below. (Unfortunately SMD capacitors are not marked so be careful to remove them from the packaging and install each value in the sequence used in this manual.)
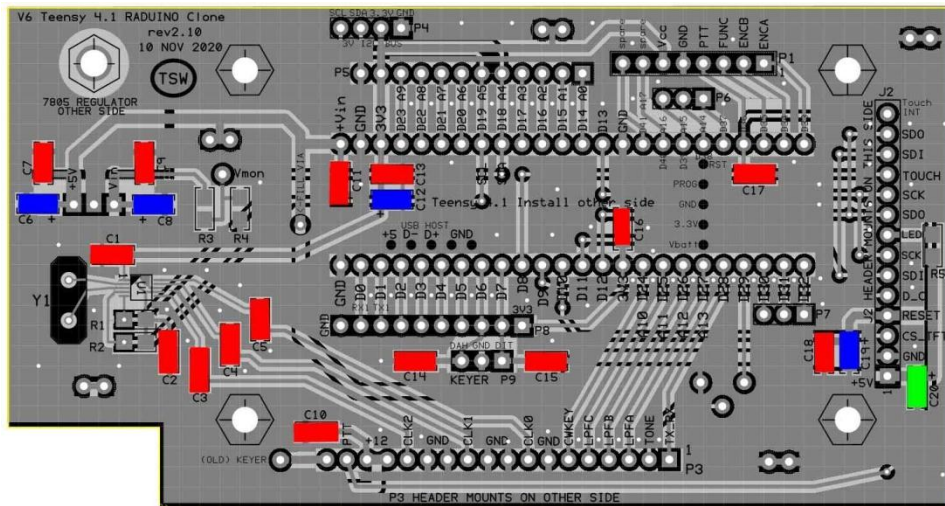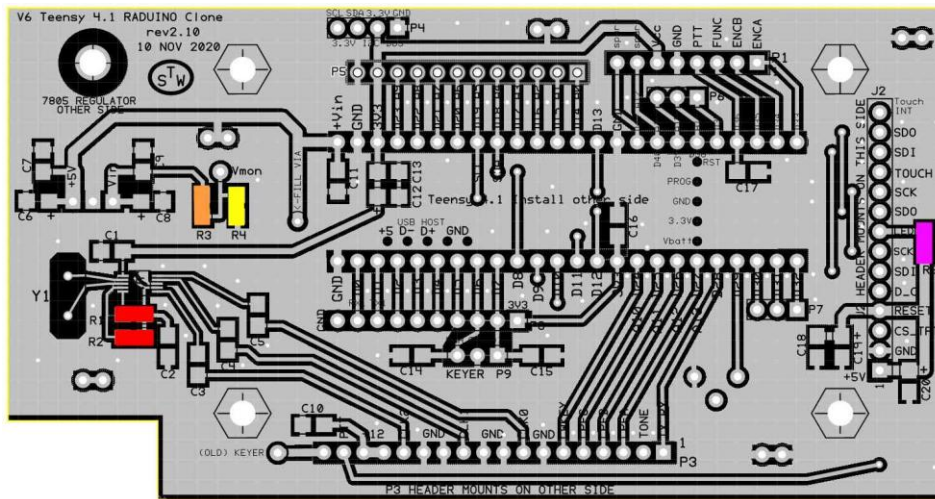

PCB Layout showing the capacitors outlined in colors

The easiest way to install these is to first apply a small amount of solder to one of its 2 pads. Pick up a capacitor very carefully with a pair of tweezers and place it next to that solder blob. Heat the solder to melt it while carefully sliding one end of the component onto that pad and once positioned, remove the soldering iron. Once the joint has cooled, carefully solder the other end. This technique should be used for all the surface mount (SMD) capacitors and resistors.

3. Install C20, the 1.0 uF 1206 ceramic capacitor, highlighted in GREEN on the above PCB layout, using the same technique described in step 2.

4. Install the four 10 uF, non-polarized 1206 ceramic capacitors C6, C8, C12 and C19, highlighted in BLUE on the PCB layout like the others.

5. Now that you have the capacitors installed, go back and check each one to insure both ends have been soldered properly and there are no shorts to ground or to other nearby components or PC traces.

6. Install the two 2.2K 1206 SMD resistors (marked 222), R1 and R2 highlighted in RED on the PCB layout shown below using the same soldering technique you used for the capacitors.


PCB Layout showing the resistors outlined in colors

7. Install R5, the 22 ohm 1206 SMD resistor (marked 220) highlighted in PURPLE on the PCB layout, located next to the display socket J2 on the right hand side of the board.

8. Install R3, the 10K 1206 SMD Resistor (marked 10002) outlined in ORANGE on the PCB Layout.

9. Install R4, the 2.7K 1206 SMD Resistor (marked 2701 or may be unmarked) highlighted in YELLOW on the PCB Layout below.

10. That completes the hardest part of constructing this kit. All other components   will be of the larger, through-hole variety. Before continuing, go over all SMD component positioning and solder joints to make sure they are correct.

11. Install Y1, the 25 MHz crystal. Insert it from the same side of the board as all the surface mount components are on. The solder pads on the underside of the crystal have been made deliberately small so the through-hole plating won't short out to the crystal's protective can. Turn the board over and solder one of the pins. Check to see the crystal is tight to the board. If not, heat that connection again while pressing down on the crystal until it is tight, then solder the other terminal, clip the leads short to the board and check for good connections and no shorts.

12. J2, the 14 pin female display connector. Insert it into the 14 holes on the front side of the PCB but turn the board over and solder the pins on the back side. Solder 1 pin first and check that the connector is perpendicular. Reheat the pin and reposition it as necessary. Once you're satisfied that everything is the way you want it, solder the remaining pins and check to make sure you get them all and there are no pins shorted to each other or ground (except of course, the ones that are supposed to be grounded – HA HA).

13. P3, the 18 pin, right angle male connector. Insert the short ends of the 18 pin Male plug into the holes labeled P3 on the BACK side of the board. Turn the board over and solder one of the middle pins to tack it in place. Examine the positioning of the longer pins. They should protrude and the long ends should be parallel to the PC Board. If not, heat the pin you just soldered and carefully reposition P3 until its separator strip is flat to the PCB.

14. Install VR1, the 5K through-hole Trim pot which acts as an adjustable level control for the CW side tone. Solder the pins on the front side and trim the excess wires flush with the board.

15. Install all of the male DuPont Style headers on the back side of the board, one at a time. Solder one pin of each on the opposite (front) side of the board, reheat as necessary while re-positioning until you are satisfied the header is tight to the board and the pins are vertical. Do this for headers, P4-P9.

16. Install the 24 pin female sockets for U3 (the Teensy 4.1) on the back side of the board – make sure your Teensy 4.1 will fit into the socket and that all pins are soldered properly with no shorts or cold solder joints.

17. Install P1, the polarized MOLEX style connector on the back side of the board using the same technique as for the DuPont style headers. Make sure the index tab on the connector is on the side away from the top edge of the PCB.

18. Install the LM7805 voltage regulator over the outline on the back side of the PCB, with the heatsink under it. Bend the pins so the mounting hole in the LM7805 matches up with the hole in the heatsink and the mounting hole in the PCB. Secure the regulator and heatsink to the PCB with the supplied 4-40 X ¼" Phillips head screw and a 4-40 nut. Tighten securely. Turn the board over, solder the 3 pins of the regulator to their respective pads and make sure the solder joints are good with no shorts between the pads. Trim the leads flush with the PCB. NOTE: NO heat sink grease or compound is needed.

19. Finally, there is a VIA (front to back +5V connection "VIA" with a white circle around it and silkscreened "Fill VIA" – solder through this hole for better high current carrying capability on the +5 Volt trace.
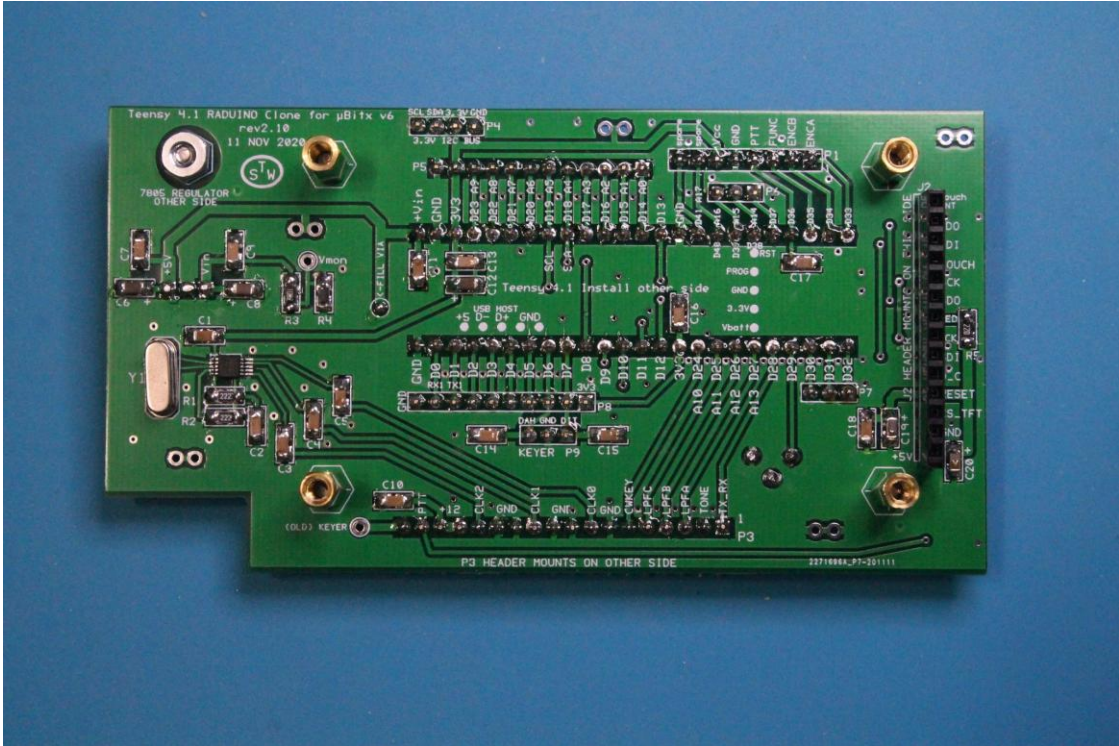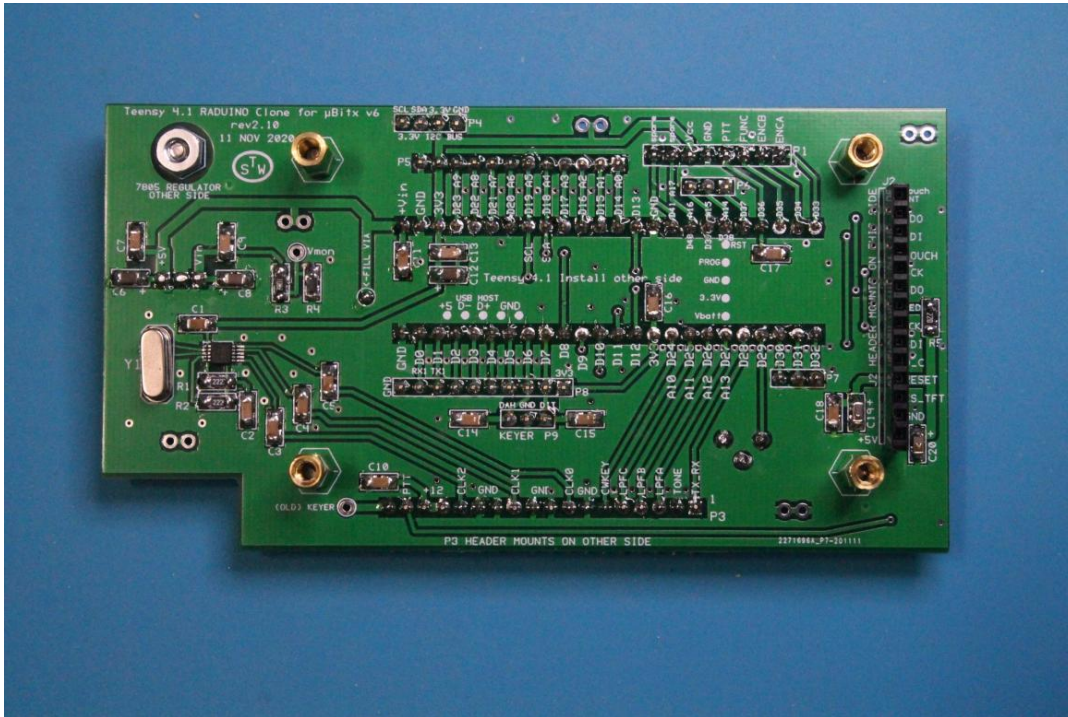
What the front side of the PC Board should look like when completed.
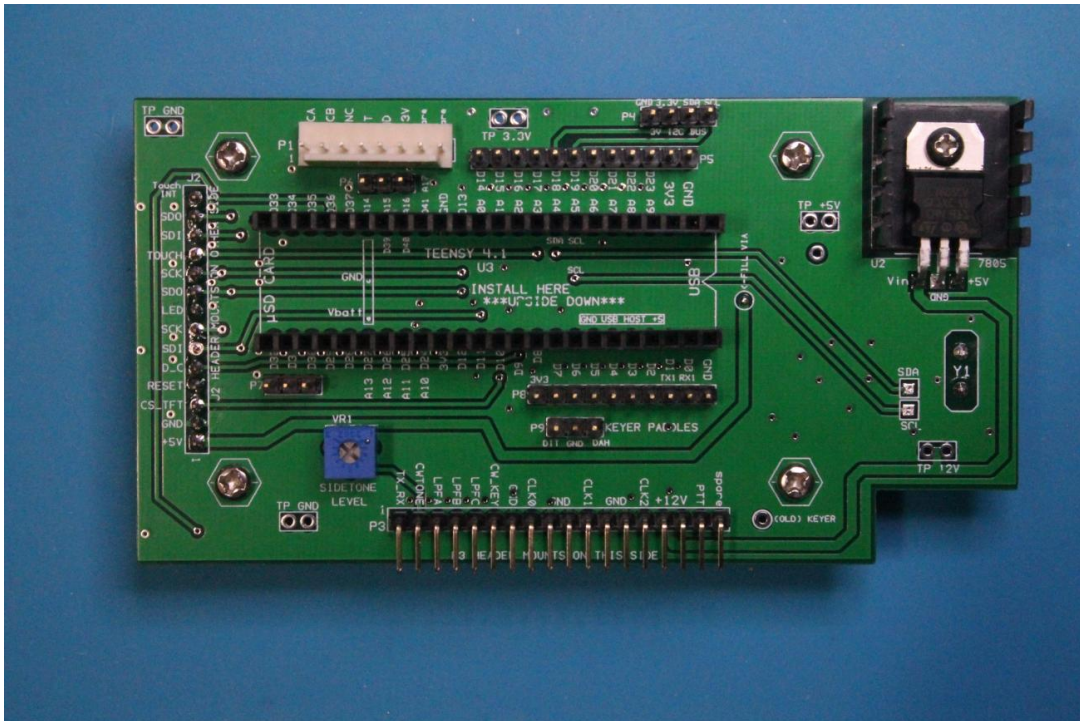
Backside of completed PC Board showing the regulator IC and heat sink properly installed.

20. In preparation for mounting the display, , install the 11 mm threaded standoffs to the 4 holes in the front side of the PCB using 3mm x 3/8" Phillips head screws and tighten snugly.

Teensy 4.1 Raduino Clone ready to mount the display

21. Display. The 2.8 inch ILI9341 TFT display that was supplied with your original uBITX V6 kit can be installed on this board unless it has been broken somehow. If it can't be used, you will have to procure a new display. The ones I use here in the US are by "HiLetGo" and are available for about $14 on Amazon.com Make sure they are the ones WITH TOUCH as they sell a cheaper one that does NOT have the touch screen. Once you get a new display, the first thing you need to do is check the back of the display board. There is a "solder blob" jumper called J1. The ones that come from Amazon do NOT have this jumper shorted by solder. You first need to drop a solder blob on this jumper as it puts the display's 3.3Volt regulator in circuit. The main power to the display is +5 Volts so the 3.3V regulator needs to be in circuit or the display's I/O will be 5 volts and it needs to be 3.3. Without the jumper it will not work for sure.

22. Plug the 2.8" ILI9341 TFT display into J2 (the 14 pin female socket) and make sure its 4 corner holes rest on and match up with the threaded holes in the female ends of the standoffs. Locate the four 3 by 5mm standoffs that have a threaded male end. Insert the male end through the 4 corner holes in the display and screw them into the standoffs that are mounted to the main PC board. Snug these but do not over tighten them or you may damage the display. This completes your TSW V6 Raduino Clone kit.

Real Time Clock Backup battery for the Teensy 4.1:

Since the Teensy 4.1 has a reasonably good RTC (Real Time Clock), the V6 Teensy 4.1 Raduino Clone software makes use of it and there needs to be a 3 volt battery connected to the "Vbat" input on the T4.1 to maintain power to the RTC when the radio is turned off or disconnected from power. TSW found that the easiest way to implement this was create a small "daughter" card with a 5 pin female connector on the bottom and a CR2032, 3V coin cell holder on the top. The completed daughter card plugs into the 5 pin male header on the back side of the Teensy 4.1 that has Vbat, Ground and several other (not used here) connections. We only use Vbat and Ground. It was found that in some cases, if the 5 pin header for the RTC backup on the Teensy 4.1 itself was not shortened and the spacer removed to allow the plug-in daughter card to sit tightly against the T4.1, with the CR2032 battery installed in its holder, the positive side could possibly short against the speaker magnet with the top cover of a factory case mounted.

An alternative method to prevent this would be to cover the mounted CR2032 coin cell with a piece of electrical or Kapton (polyamide) tape. This might be a good idea even if the header pins on the Teensy 4.1 are shortened.

The plug-in daughter card will be pre-built and shipped with the Raduino Clone kit so all the user will have to do is provide a CR2032 battery and make sure the daughter card is plugged in to the proper pins. See the photograph of the properly configured Teensy 4.1 on page 3 of this manual and the photo of a completed T4.1 Raduino with the daughter card installed on page 12 below. The marked pin on the daughter card's female connector MUST be positioned to connect to the "Vbat" pin on the Teensy 4.1 or it will not work.
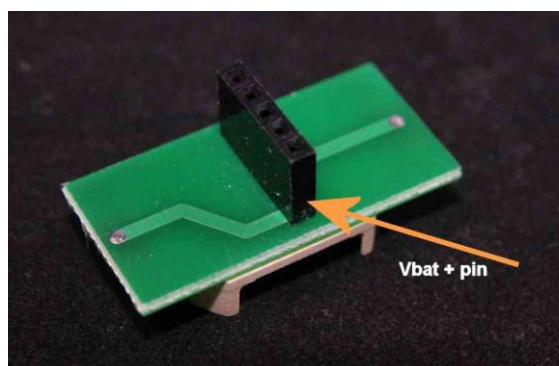
A fresh CR2032 coin cell battery should last for almost a year (maybe more) if a good quality battery is used.
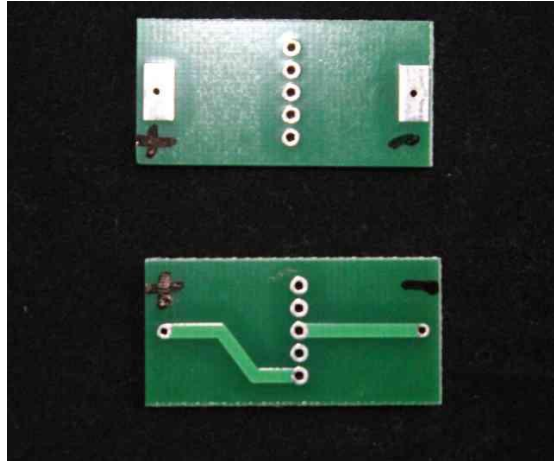
Unbuilt Battery Backup PCB top and bottom.
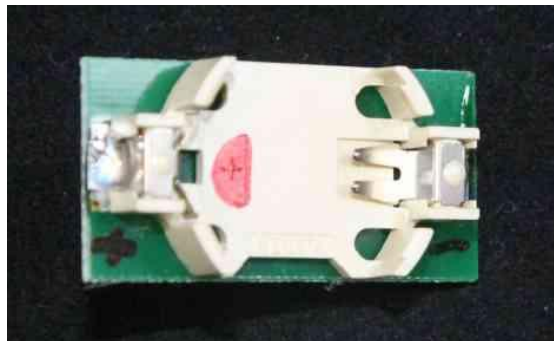
Completed Battery Backup daughter card from the battery side.

Vbat + pin

Completed Battery Backup daughter card shown from the connector side. On the supplied daughter cards, the Vbat pin will be marked with white paint.
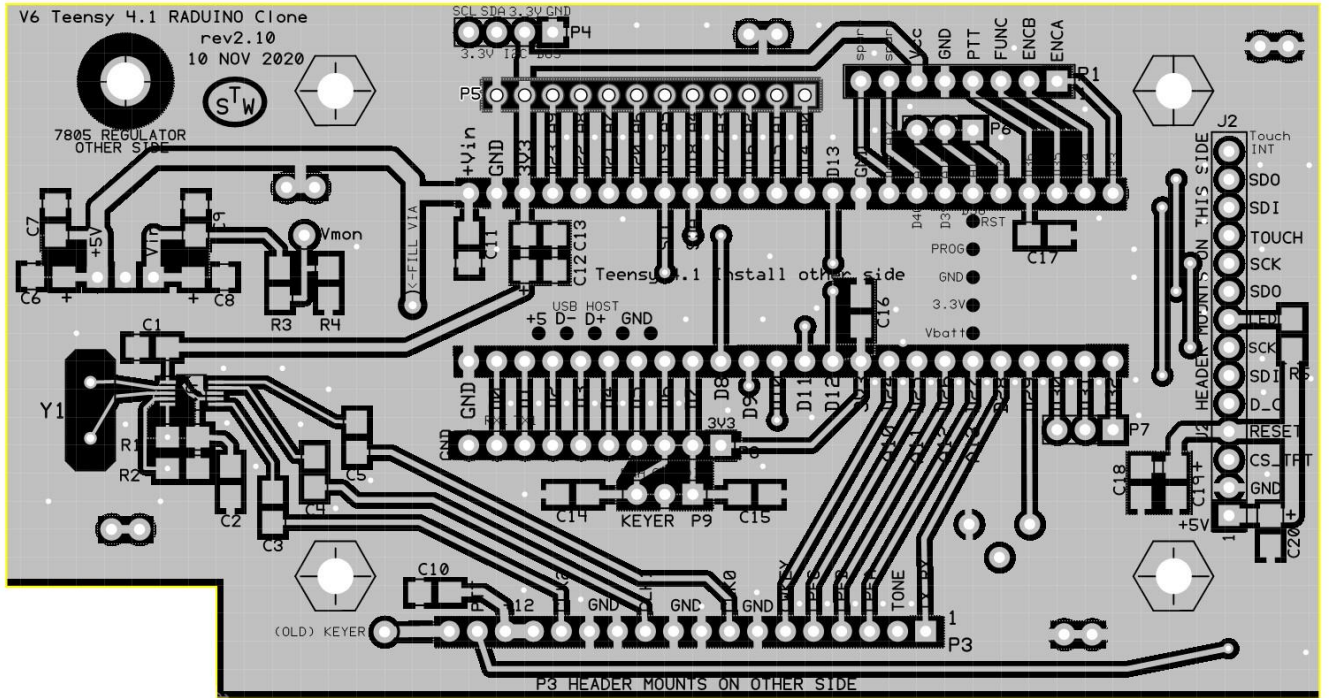
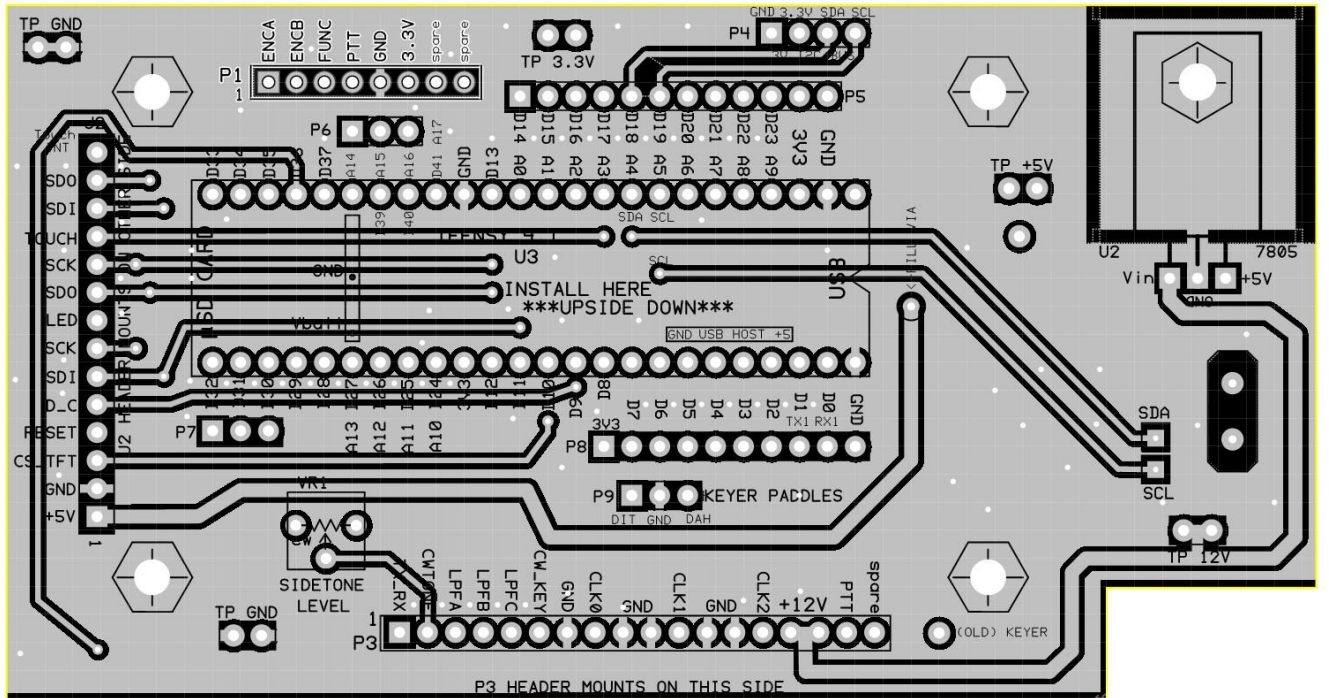Completed V6 Raduino clone (shown from the rear) ready to plug in and use.

Completed V6 Teensy 4.1 Raduino clone (shown from the front) ready to plug in and use.

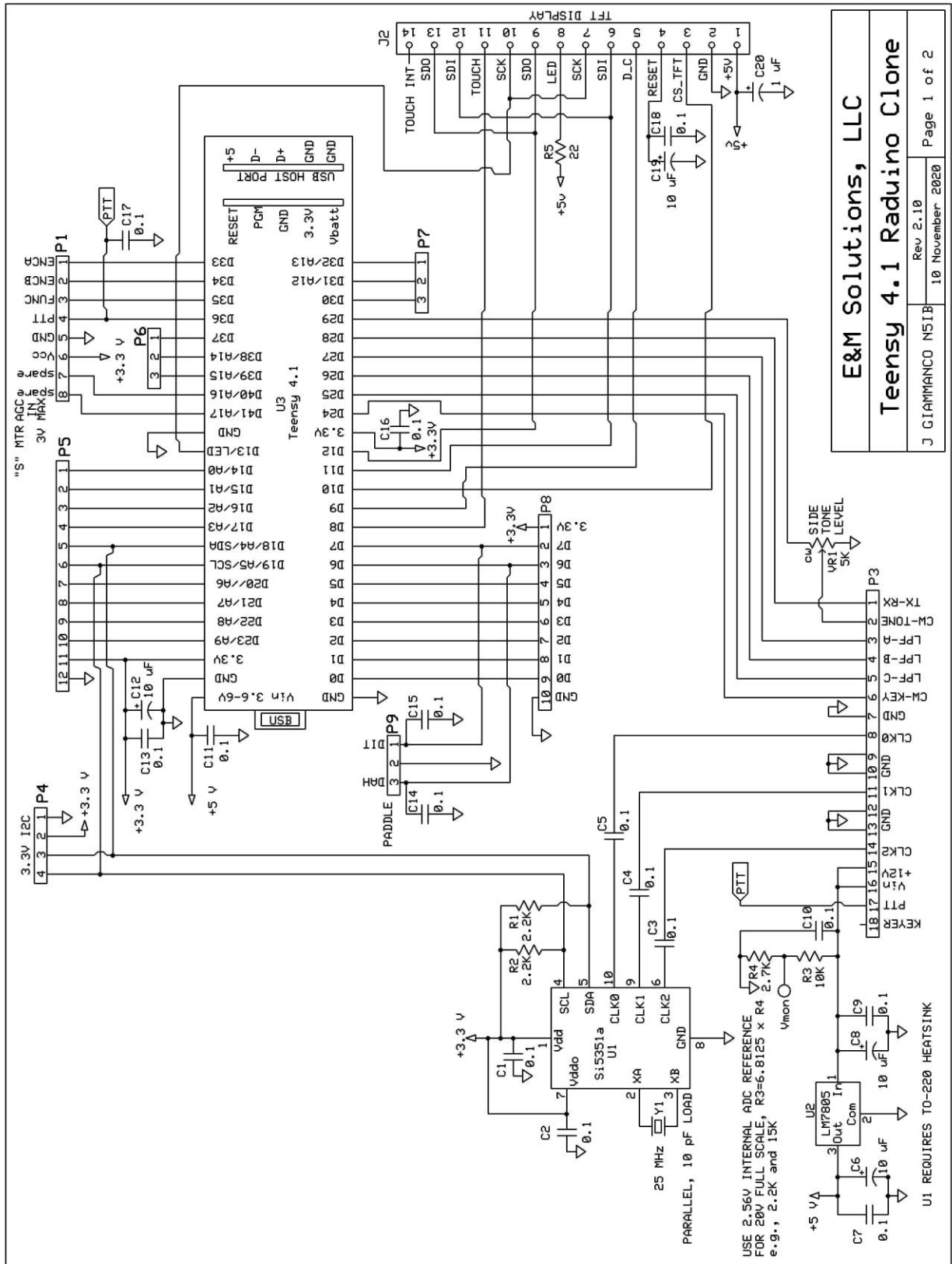## Appendix A: PC Layout Drawings

PC Board Front Side Layout Diagram

Board Back Side Layout Diagram

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Appendix B: Schematic Diagram

E&M Solutions, LLC

Teensy 4.1 Raduino Clone

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Appendix C: Bill of Materials

Capacitors:

C1-C5   0.1 uF 50V 1206 SMD

C6   10 uF Non Polarized 25V 1206 SMD

C7   0.1 uF 50V 1206 SMD

C8   10 uF Non Polarized 25V 1206 SMD

C9-C11   0.1 uF 50V 1206 SMD

C12   10 uF Non Polarized 25V 1206 SMD

C13-18   0.1 uF 50V 1206 SMD

C19   10 uF Non Polarized 25V 1206 SMD

C20   1.0 uF Non Polarized 25V 1206 SMD

Connectors:

J2   14 pin DuPont style female socket (for the TFT display)

U3 Socket – two 24 pin DuPont Style female sockets for the Teensy 4.1

P1   8 pin Molex style Polarized male connector

P3   18 pin Right Angle DuPont style male header

P4   4 pin DuPont style male header

P5   12 pin DuPont style male header

P6-P7   3 pin DuPont style male header

P8   10 pin DuPont style male header

P9   3 pin DuPont style male header

Resistors:

R1-R2   2.2K 1/4w 1206 SMD

R3   10K 1/4w 1206 SMD (may be unmarked as supplied – color will still be black)

R4   2.7K 1/4w 1206 SMD

R5   22 ohm 1/4w 1206 SMD

IC's:

U1   Silicon Labs Si5351a

U2   LM7805 (heatsink supplied with kit – Mouser 532-507302B00)

U3   Teensy 4.1 from PJRC.com, user supplied (order with pins separate, not installed from factory)

Misc:

VR1   5K through hole mount Trim pot

Y1   25 MHz Crystal (10-18pF Parallel Load) obtainable from Tayda Electronics, SKU-A215
          or Mouser ABL-25.000MHZ-B2F

PCB   TSW Teensy 4.1 PC board with the Si5351a clock/VFO chip soldered in place and continuity checked.

RTC backup battery holder assembly. (Already assembled, included at no extra charge in the kit).

CR2032 Lithium coin cell NOT included.

Hardware:

4, 11 mm x 3mm threaded standoffs for display mounting + four 3mm x 4mm Phillips head screws for mounting.

4, 4 mm x 3mm threaded standoffs with 3mm male threading on one end to space display from front panel of radio.

1, 4-40 x 3/8" Phillips head screw & nut for mounting LM7805/heatsink to the PCB.

Display (user supplied) 2.8" ILI9341 TFT Color Touch Screen available from Amazon.com, eBAY and other sources.
Make sure to order the one WITH TOUCH as they are also sold without the touch function for slightly less money.

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Appendix D: Preparing the Teensy 4.1 for use with this Raduino

You should have ordered your Teensy 4.1 without pins installed as it will have to be unconventionally installed UPSIDE DOWN in its socket or it WILL be destroyed the instant you apply power.

There are two 5 pin headers that will be installed so their pins protrude from the bottom side (the side opposite the main pins). One of these (the USB Host Mode header) will be installed normally and the pins soldered on the opposite side of the Teensy 4.1.

The 5 pin header that will be used to mount the Real Time Clock backup battery assembly needs a bit more care to install. First prepare that header as shown in the following photo's & paragraphs.
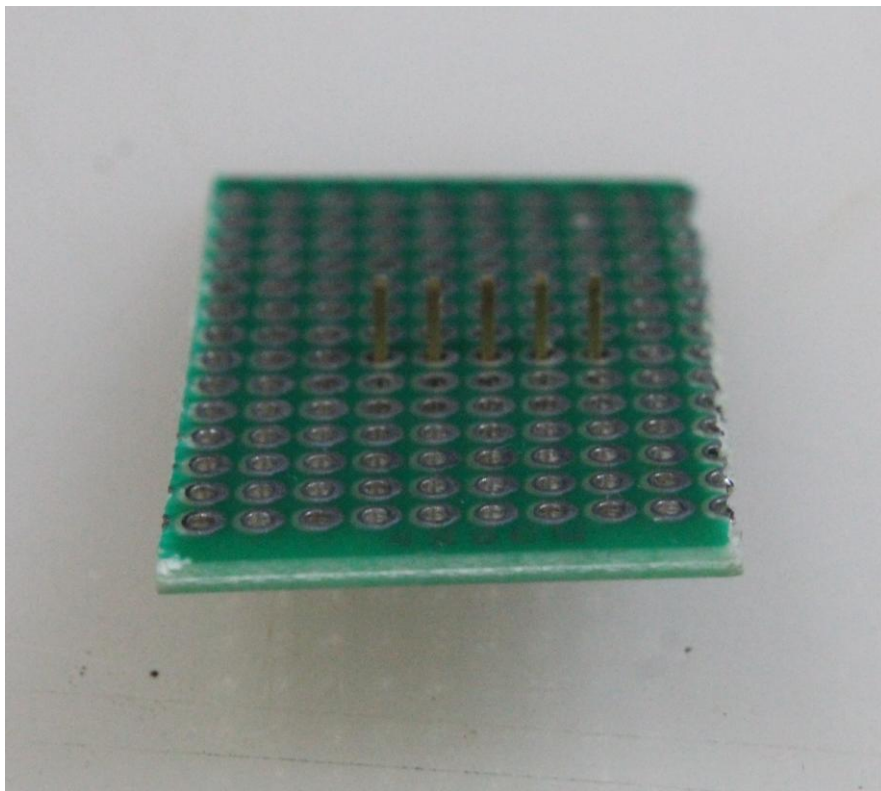

Using a small piece of perfboard, take a 5 pin DuPont header and insert it into the board as shown in the above photograph.

Next, take your fingers and press down on the perfboard, forcing the plastic spreader to move down to the desk (or bench) top to make one end of the header's pins flush with the bottom of the plastic spreader like in the following photo.
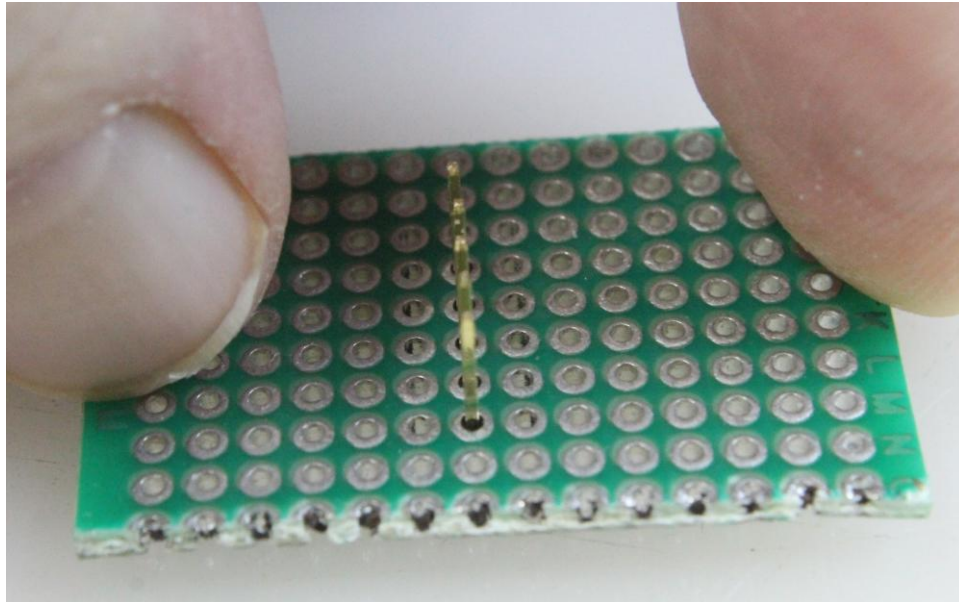
The result will be a 5 pin DuPont header that looks like the one in the following photo.
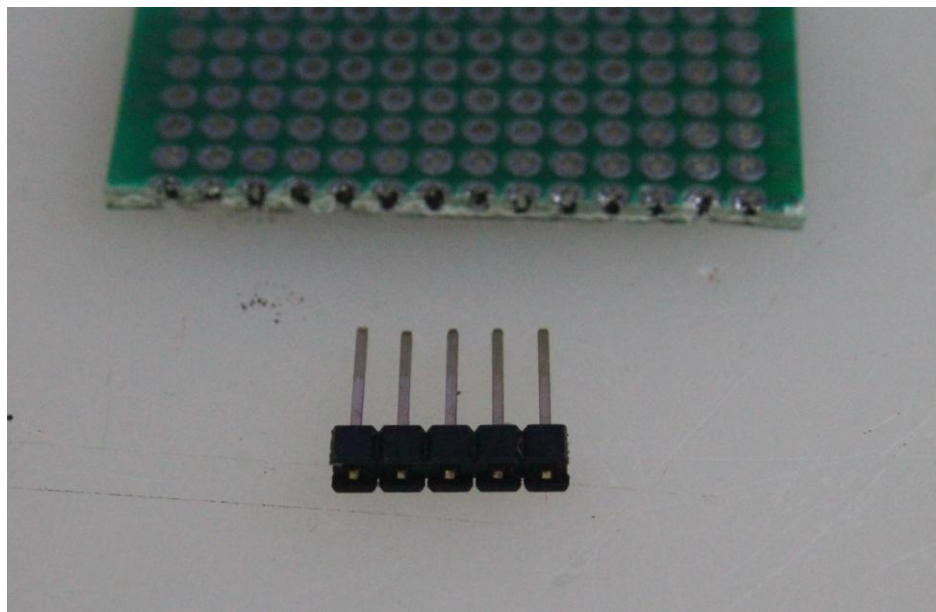
Now, take this header and insert it into the Teensy 4.1's 5 pin header position that is closest to the Micro SD card socket and on that same side. Make sure the plastic spreader seats flush with the Teensy's board. Flip the Teensy back over so the long side of the pins are protruding and CAREFULLY solder them in place while making sure the plastic spreader remains FLUSH with the opposite side. Make sure you don't use anymore solder than absolutely necessary and don't short any of the pins or any adjacent traces on the top of the Teensy itself.
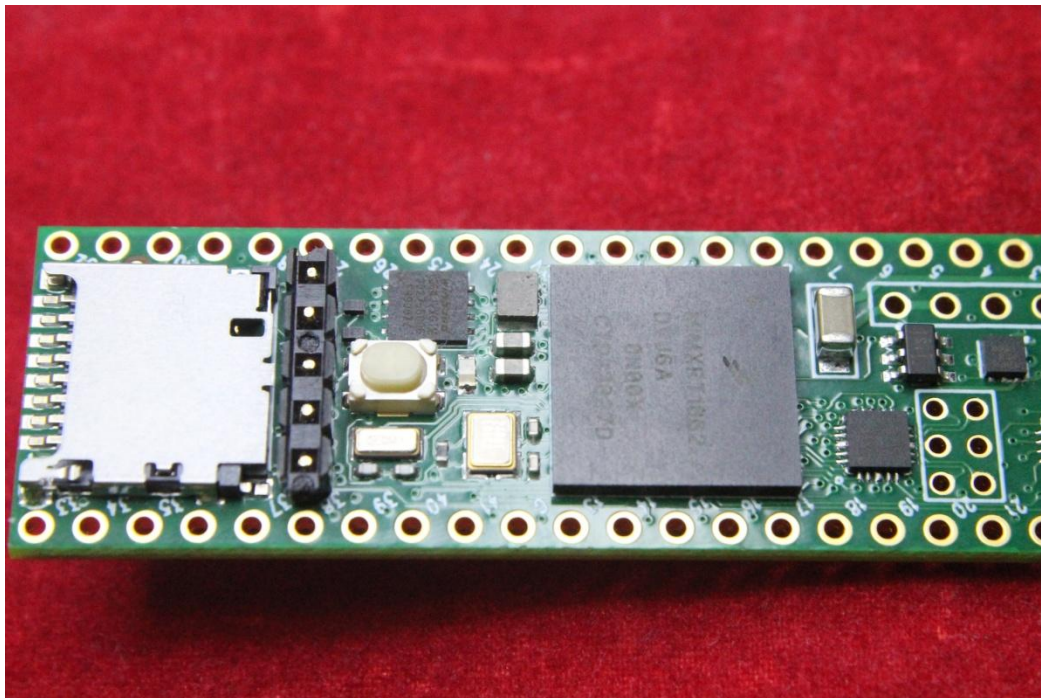
The reason for doing it this way is to insure the Real Time Clock backup battery assembly's socket fits flush with the Teensy when it's installed. If you don't do this the battery might contact the uBITX factory case's speaker when the top of the case is installed. This gives it about a quarter of an inch clearance. It might also be a good idea to cover the + side of the battery with some electrical tape as a bit of insurance so the battery doesn't get shorted to ground and prematurely discharged. There is no need to remove the plastic spreader from the opposite side as it will serve to help insulate the tips of the pins and keep from having to very delicately trim those short ends flush with the board and risk damaging traces on the topside of the Teensy 4.1.
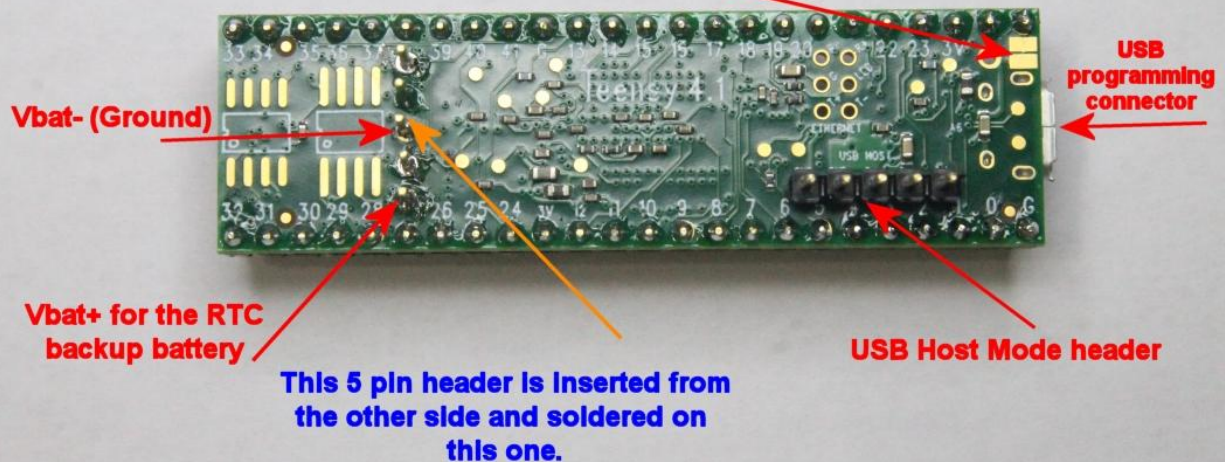
Now turn the Teensy back over and insert the USB Host Mode's 5 pin header in the proper place and solder it carefully on the opposite side so the pins are vertical and square with the Teensy's PCB when finished – make sure you don't short any of the pins or have a cold solder joint but use minimal solder here as well.
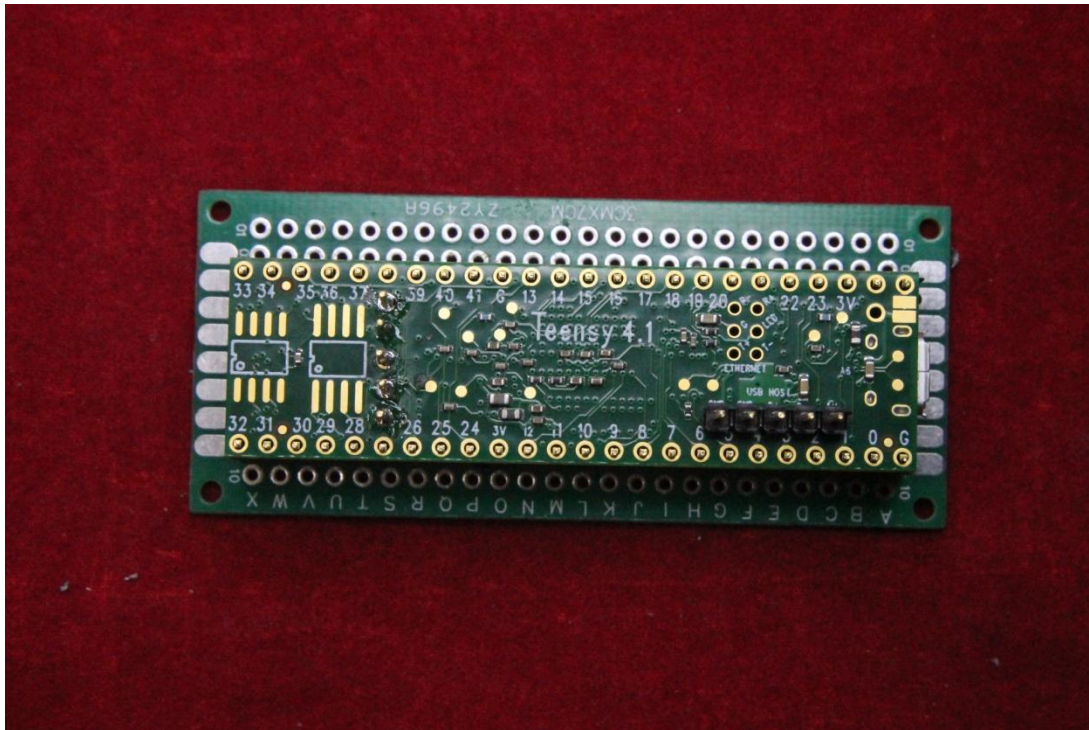
A soldering jig was used here to align the main pins with the 48 pin holes on the Teensy for easier soldering. The short ends of the pins should be inserted from the top side of the Teensy as shown here – the short ends will just slightly protrude. It helps to have some sort of jig like this to make sure they align properly and will easily plug into a socket when you are finished. Solder all 48 pins from the side shown in the above picture. Make sure all are soldered well and there are no shorts or cold solder joints.   Finally before installing the Teensy 4.1, be SURE to install the current TSW Teensy 4.1 software and THEN cut the almost invisible jumper between the two larger rectangular pads indicated in the photo on the next page. Cutting this jumper IS CRITICAL!

Mount the 48 Teensy 4.1 connector pins (24 on each edge) on what would normally be the TOP side as it will mount upside down on the back of the Version 6 T4.1 Raduino.

Be sure to cut the almost invisible jumper between these two pads. This is necessary to keep the 5 volt USB power from conflicting with the main input 5 volts to the Teensy when it's powered by the Raduino. Failure to cut it can result in catastrophic damage to the Teensy 4.1.

USB programming connector

Vbat- (Ground)

Vbat+ for the RTC backup battery

This 5 pin header is inserted from the other side and soldered on this one.

USB Host Mode header

IMPORTANT: Before cutting the jumper indicated in the above photo, you should flash the Teensy 4.1 with the current version of TSW's software. Either that, or you will have to have the Teensy installed in the Raduino, the Raduino plugged into the V6 uBITX AND the uBITX powered up. Do NOT operate the Raduino with the Teensy 4.1 installed and the Raduino powered up as this will cause a voltage conflict between whatever voltage your USB programming cable supplies AND the voltage supplied from the Raduino! If there is very much difference between the two voltages, the Teensy (or the Raduino) may be damaged!

Appendix E: Miscellaneous

Optional CW and HOST MODE modifications to the V6 uBITX are contained within the current Software Operating manual as they are separate from the kit construction.

We have tried to make the construction of the kit as easy as possible by using the larger size 1206 SMD components. We did layout the PC trace pads so that if necessary, size 0805 SMD parts can be used if 1206 parts are not available. Most people who have even basic kit building skills should have very little difficulty, if any, constructing it.

Credits:

Manual Author and Photograpy:

Jim Sheldon, W0EB, TSW Project Coordinator.

PC Board design:

Jim Giammanco, N5IB, PC Layout Engineer.

Programmer:

Ron Pfeiffer, W2CTX, TSW Master Programmer.

µBITX TSWT4.1 Raduino Clone V2.13 Running on W0EB's test rig.

TSW Teensy 4.1 Raduino Clone Kit V2.10, construction manual Version 1.15 – ©TSW 01/12/2022

NOTES:

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