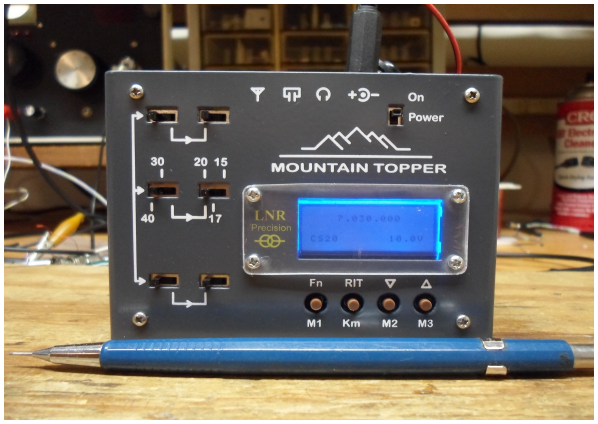
# The MTR-5B

Five Band Mountain Topper - KD1JV Designs
Manufactured by LNR Precision, Inc. www.LNRprecision.com
Manual Revision 12-12-15




*(shown with optional enclosure sold by LnR Precision, production kits use white backlight display)*

## ***Features:***

Switch selected 40/30/20/17/15 meter bands
(no band modules to lose or change out)

Wide operating voltage range, 6 to 12 volts
15 ma Rx current at 12V supply

Efficient transmitter. Low current with 4W output

LCD display

Push button or Optional rotary tuning

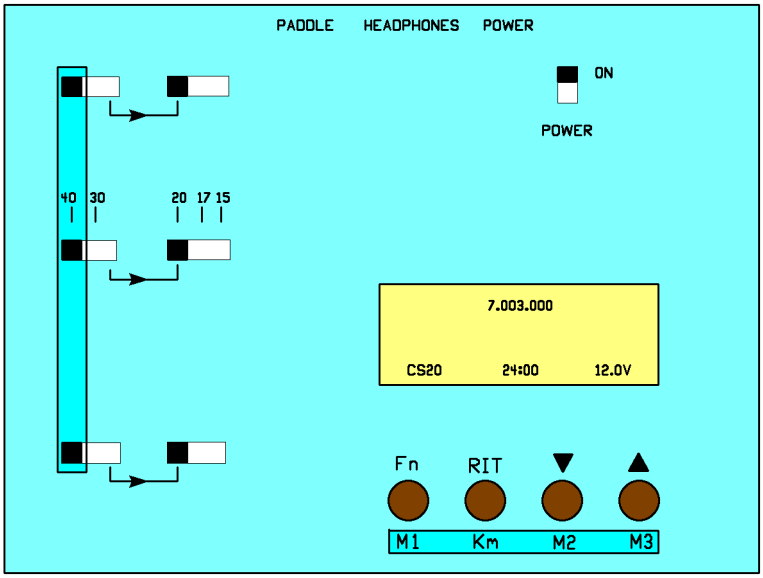
24 hour clock built in, with battery back up

Three 63 character programmable message memories

Message beacon mode with adjustable pause time

Small size: can fit into a 4" x 3" x 3/4" box

## Operating Instructions:




**Band Selection:**

Bands are selected with 2 sets of three-position slide switches. The three switches must be in the same position for the rig to work properly.

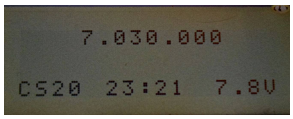
The band switches on the left select the 40 and 30 meter bands. When set to the right-most position, the second set of band switches are enabled: 20m, 17m and 15 meter bands.

The switches on top row state which band to operate.

When a band is changed, a Morse number corresponding to that band is annunciated by a side tone: 4 for 40m, 3 for 30m, 2 for 20m, 7 for 17m and 5 for 15m. The last used frequency for any band is restored when the band is selected.

**Display:**

A four line, 16 character LCD is used to display radio information.




Line 1: Normal – Operating frequency.
Alternate – Decoded Morse when using a paddle - either transmitting or entering a message.
Line 2: RIT delta frequency
Line 3: Menu selections
Line 4: Normal – Keyer Speed, 24 hour timer, battery voltage.
Alternate – switch functions

**Frequency Tuning:**

The UP arrow (Tune Up) and DOWN arrow (Tune Down) switches change the operating frequency in 50 Hz steps.

- Holding the switch closed for longer than 1 second begins a fast-tune mode where the frequency changes in 100 Hz steps.
- If the opposite tuning switch is held closed while in fast-tune mode, the step rate will increase to 30 steps/second for real fast tuning.

The frequency can also be rotary tuned by adding an optional rotary encoder. In this case, the tuning rate is fixed at 50 Hz steps, furthermore, the tune up and down switches are still enabled.

**RIT:**

- Enter RIT: HOLD RIT closed for 1 second or longer.
- Exit RIT: HOLD RIT closed for 1 second or longer.

Display: Line 2, [RIT  0.000+]

The plus (+) or minus (-) difference (delta) between the transmit frequency and the current receive frequency is shown below the primary frequency readout. The delta frequency is limited to +/- 1.550 kHz.

**RIT toggle:**

RIT can be toggled on and off to check the transmit frequency for activity.

- TAP <**Fn**> switch to toggle RIT.

Display: Line 2,  [RIT  R=T] Frequency tuning is locked out when R=T, however, radio can transmit and use message memories.

**Fn (Menu) Functions:**

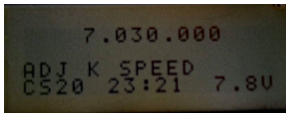
- Morse frequency annunciation (optional)
- Change Keyer speed
- Direct Frequency entry
- keyer Memory entry
- Tune
- Set time
- Config - Turn on/off options and store configuration

**Morse Frequency Annunciation**

This function can be turned ON or OFF in the CONFIG menu. Default is OFF.

- Tap the <**Fn>** switch.
- The current frequency is sounded by the side tone at the current keyer speed.
- Format: 000.0 kHz "T" is used for zeros, "R" indicates decimal point.

**Change Keyer speed: [ADJ K SPEED]**




- HOLD the <**Fn**> switch for 1 second until the message [ADJ K SPEED] is displayed on Line 3
- Speed is shown on Line 4 [**CS**xx] where xx is current CW speed.
- Use UP/DOWN arrow switches, DOT/DASH paddle or rotary encoder to change speed in 1 WPM steps. Range 9 to 35 WPM.
- Tap the <**Fn**> switch to exit

**Straight key Mode:**

Straight key mode can be enabled in two ways:

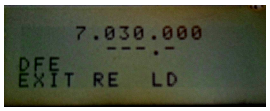
1) A mono phone plug in the paddle jack on power-up will turn on straight key mode.
2) TAP the RIT switch while in <Adjust Code Speed> mode. Tapping will toggle straight key mode ON and OFF. Straight key mode cannot be turned OFF if a mono plug is in the paddle jack.

- When Straight key mode is active, the code speed display will change from [**CS**xx] to [**SK**xx].
- The code speed can be changed using the <**UP/DOWN**> arrow switches or rotary encoder.
- **DFE, Message Memory** entry and **Tune** modes ***are not*** available when Straight Key mode is active.
- Straight key mode is reset on power-up, unless a mono plug is in the paddle jack.

**Direct Frequency Entry: [DFE]**

**DFE** mode allows the user to directly enter a new frequency via the paddle.

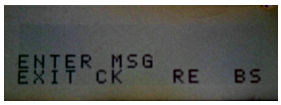
Display:
Line 1: current frequency…
Line 2: ---.-
Line 3: DFE
Line 4: EXIT RE LD {Switch function labels}




- Enter four Morse digits 0 to 9
- Short cut: TAP <LD> to reset current frequency to the bottom of the band or to load remaining decades as zero "0" **This feature is not available on the WARC bands.**
- TAP <**LD**> (DOWN Arrow) load the new frequency
- TAP <**RE**> (RIT) re-set entry to zero and start again
- TAP <**EXIT**> (Fn) exit with no change

**Message entry** [**ENTER MSG**]

Line 1 – blanks. Will display decoded Morse characters as entered.
Line 2 – blank
Line 3 – ENTER MSG
Line 4 – EXIT CK RE BS (Switch function labels)




Message count may use up to 63 characters (including word spaces) and there can be three unique posts. Word spaces are automatically inserted after a word-space pause of '7 dot' lengths. A "Back Space" switch can be used to correct errors or eliminate word spaces. Note: you cannot delete the first character entered. The menu display will scroll when the message exceeds 16 characters.

**Switch functions:**

- <**EXIT**> (Fn) TAP to EXIT any time before storing a message.
- <**CK**> (RIT) TAP to check (review) the message and hear how it sounds prior to actually storing the message.
- <**RE**> (UP Arrow) TAP to Re-enter (rest) the message entry mode. The only way to clear the first character.
- <**BS**> (Down Arrow) TAP to Back Space one location.

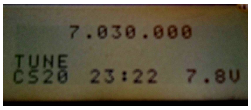
Once the Message has been reviewed and after tapping the <CK> switch, Line 4 will change to:

[M1 RE M2 M3]

- TAP M1, M2 or M3 to store the message in that memory location.
  - Once tapped, line 4 will change to [**STORING**]. A Morse "R" will sound when done and message entry mode will return for another message, if desired.
  - When done TAP <**EXIT**> to escape to normal operation.

- TAP <**RE**> to escape back to message entry mode without storing.

**TUNE** [**TUNE**]




Tune mode allows the user to toggle the transmitter ON and OFF to adjust an antenna tuner with both hands. If the operator uses one hand adjusting antenna tuner, sending a string of dots may be faster.

NOTE: If the DC power supply exceeds 10 volts, the output power is reduced by turning the supply to the PA ON and OFF at about a 1:3 ratio. This ensures no damage to the PA if excessive SWR is encountered while adjusting the antenna tuner for lowest SWR. Since this PWM of the PA supply voltage has no feedback, the output power switches low and gradually builds until it stabilizes at about one-third its steady-state output.

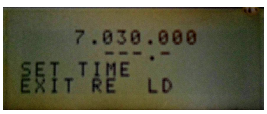
- Tap <**DOT**> paddle to toggle ON
- TAP <**DASH**> paddle to toggle OFF
- TAP <**Fn**> switch to exit back to normal operation

**SET TIME:** [**SET TIME**]

A 24 hour clock can be enabled and displayed on the bottom line of the LCD. The DFE function is used to enter the time via the paddle. The time is not displayed until the set time function is used. The "display time" flag is reset on power up if battery back-up is not used.

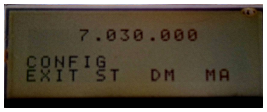
Display:

Line 1: operating frequency
Line 2: ---.-
Line 3: SET TIME
Line 4: EXIT RE LD



- Enter the current time + 1 minute (24 hour format) using the paddle: hours, then minutes. Leading zero *must* be entered if the time is before 10:00am.
- Tap <**LD**> (DOWN Arrow) to load the time and exit.
- Tap <**RE**> to clear and re-enter the time
- Tap <**EXIT**> to escape with no action taken.

**Configuration: [CONFIG]**




**Configuration** allows the user to turn ON or OFF the Morse frequency annunciation. The display of Morse while transmitting and storing of the current frequency for all the bands, plus the current keyer speed to be used as the power-on, frequency and code speed is annunciated.

- TAP <**EXIT**> (Fn) to escape
- TAP <**ST**> (RIT) to store
- TAP <**DM**> DOWN arrow) to toggle Display of Morse characters ON and OFF. The side tone will annunciate "ON" or "OFF" to indicate the selected state.
- TAP <**MA**> (UP arrow) to toggle the Morse audio annunciation ON and OFF. The side tone will annunciate "ON" or "OFF to indicate the selected state.

## Sending a previously stored message:

- TAP <**RIT**>
- Then TAP <**Fn**> (message 1), <**DWN Arrow**> (message 2) or <**UP Arrow**> (message 3) within one-half second of tapping <**RIT**>

If a message has not been stored in a selected location, no message will be sent.

**Pause, terminate and Beacon Mode:**

Once a message has begun, it may be paused, terminated or set to repeat (beacon mode).

- HOLD <**DASH**> to pause a message. The message will pause at the first word space after the paddle is closed.
- HOLD <**DOT**> to terminate the message. The message will terminate at the first word space after the paddle is closed and normal operation restored when the paddle is released.

**Beacon (repeat) mode:**

After a message is in progress, the message may be set to repeat by **HOLDING** the respective switch for that memory location closed until a word space is detected. For example, if Message 1 was started, hold the <**Fn**> switch closed, if Message 2, <**Down arrow**> and if Message 3, <**Up arrow**>.

Line 3 will read: [BEACON  3] Where {3} is the repeat delay in seconds.

- During a word space, the delay can be set up to 9 seconds using the up and down arrow switches or rotary encoder.

The message may be paused or terminated using the DOT or Dash method. The message must first be terminated before transmitting will begin again.

**Battery Backup:**

A 12 mm, 3V lithium coil cell is used to power the processor when power is removed from the transceiver. When the processor detects the input voltage below 4.5 V, the processor is in sleep mode, but the 32.768 kHz clock and timer remains active to keep the RTC running. In this mode, current from the coin cell is a mere 10 uA. All the current operating settings are retained in RAM thus the rig returns to the same state on power up as it was when power was turned off. If the rig is to be stored for a long period of time, it would be a good idea to disconnect the battery by slipping a small piece of paper between the top contact and battery.

To access the battery: Turn off power. Remove the two side panel screws and the knurled nuts securing the "paddle" and "phones" jacks. Carefully separate the "bottom" of the case to expose the battery holder.

# Assembly:

- The work area should be reasonably clean and uncluttered. Good lighting is a must.
- Empty the packets containing the parts into a small bowl for this will ensure the parts will not be lost. Some builders like to assembly over a cookie sheet as the lip around the edge helps to keep parts from going far. The metal sheet also provides some measure of static control, especially if the sheet is grounded. A white sheet under the work area could help in finding stray parts which might wander away.
- Very thin (0.015") solder is supplied for soldering the surface mount parts where very little solder is needed for each connection. Ideally, a convex fillet at the end of chip resistors and capacitors is desired. Try not to finish with a solder ball at the end of the part.
- **Do not use liquid solder flux.** It simply creates a mess and is difficult to clean off the board and from under parts. If not completely removed from the board, it can cause problems.
- Before placing a part onto the board, lightly tin one pad for where the part will be placed. Assembly time may be increased by first tinning one pad at all the locations for which a particular part will be placed. There is no need for a low wattage soldering iron. It is best to have a hot tip which will get the job done quickly. A small tip on the iron perhaps 1/32" to 1/16" chisel or round point is best.

    - Most of the surface mount parts come in part carriers. To remove the part(s), hold the carrier close to the work surface and carefully peel back the clear plastic covering. This can be done with the tip of a sharp hobby knife such as an #11 Xacto blade or pointy tipped tweezers. Once the clear plastic strip is removed, lay out the part onto your work surface.
    - If tweezers are used, be careful not to grab onto the part too tightly. Surface mount parts have a way of flying out from between the tips of the tweezers--never to be seen again. Be careful!
    - An alternative to using tweezers for small parts is to use a tooth pick or 'chop stick' with the end rubbed onto a little bees wax. The bees wax makes the end tacky enough for the part will adhere to it. For smaller ICs, clutch the part length wise with the tweezers.
    - Tack one end of a part in its place by applying heat to the end of the part over the tinned circuit board pad, while applying little pressure to be sure it lays flat on the PC board. Be sure to heat both the pad and the end of the part. Generally, additional solder is not needed for this connection. Secondly, solder the other end of the part. If both ends are not soldered at this time, there is a blameless chance the builder will forget to return and solder all the parts which require it.
    - It is nearly impossible not to make solder shorts between pins on the DDS and processor chip due to the close pin spacing. Remove any shorts with solder wick.

**Using solder paste:**

Using solder paste is the ideal way to build the board. Small amounts of solder paste in an application syringe can be purchased for about five dollars from 'Cash Olson' on the internet. Also needed is a warming plate to preheat the board to about 250 degrees F and a low power heat gun. An "Embossing" heat gun is commonly used (found at craft stores). A soft air flow is required as to not to blow parts off the board. A typical hot air gun is too high-powered with air and heat.

For chip, caps and resistors, a very small dab of solder paste is placed on the pads and then the part placed onto the pads. The SMT parts will slide around very easily, so one must be careful not to nudge them from their correct location. For ICs, placing the IC down first and then engaging a bead of paste along the leads appears to be a better method than placing the paste on the pads first followed by the IC.

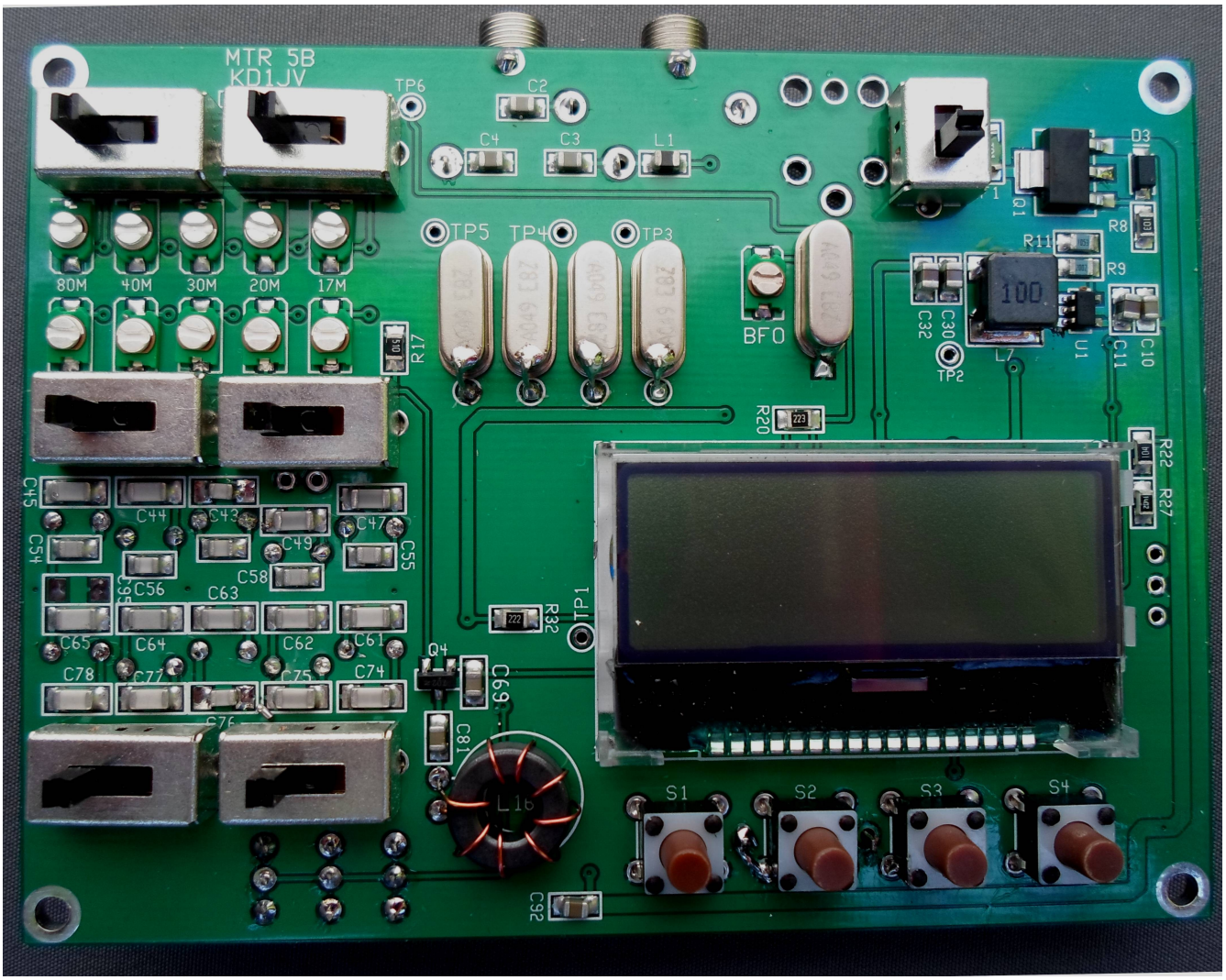
The LCD display should be hand soldered, along with all the through-hole parts. Begin with the side of the board with the most parts first, which in this case, is the bottom for the MTR.

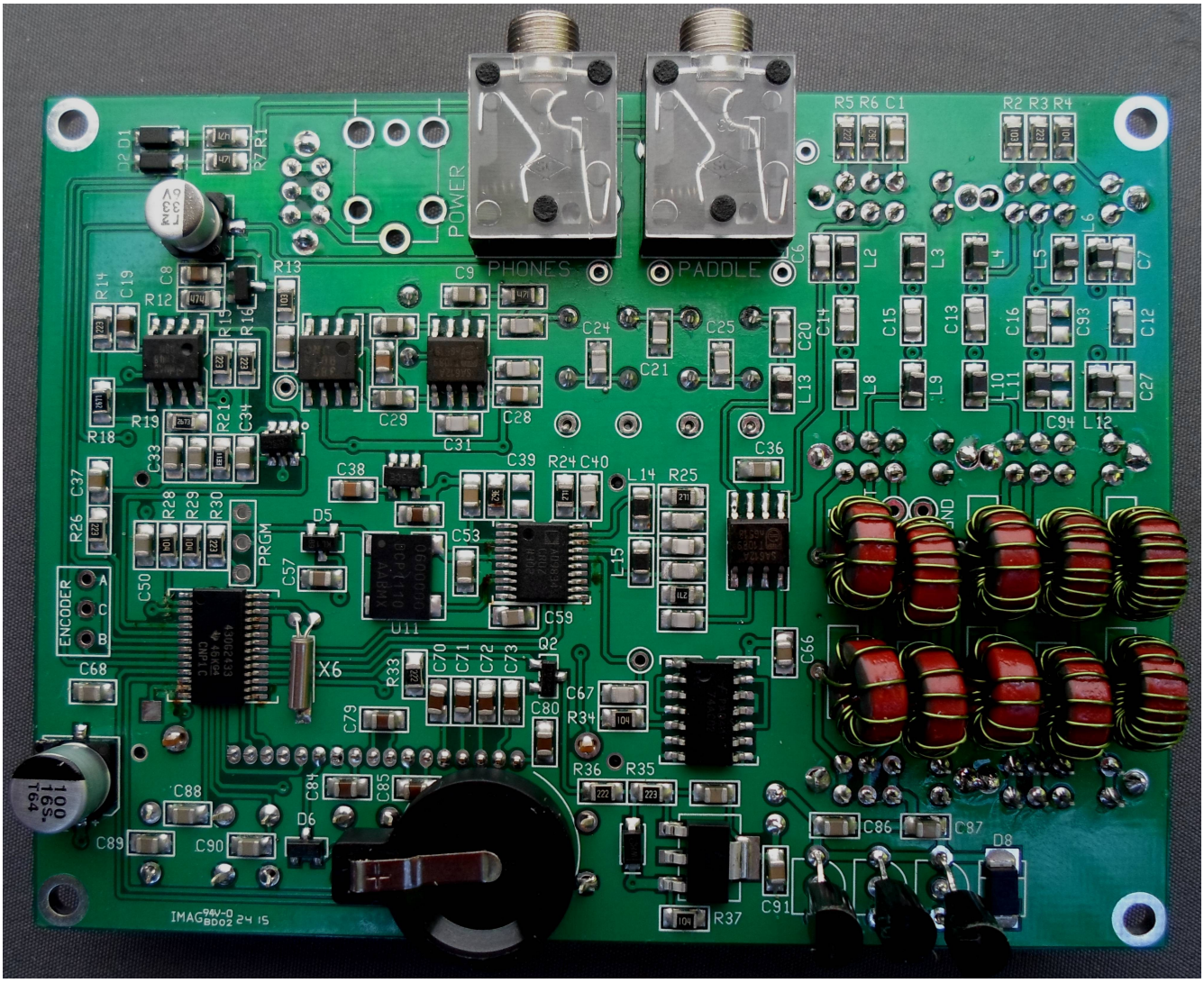
Once all the parts have been placed, place the board on the warming plate and heat to about 250 degrees F. Slowly heat the top of the board with a hot air gun. When the solder paste reaches its melting point, the solder will liquefy and the parts snap into alignment on the pad. Here is where the solder paste turns color from a dull gray to shinny brown. Be aware of "tomb stoning," which is when an SMT chip capacitor or resistor will stand on one end making no connection. Once all the solder has reflowed, remove power from the heating plate and let MTR cool down slowly.

A "YouTube" video showing how to solder SMT parts, both by hand and using solder paste is: **http://youtu.be/Ah5HEjDTHUo**. The builder may want to view other suggested videos on SMT soldering which are done a bit more professionally. Work slowly and be patient!

**Construction:**

Reference photos of assembled board




POWER
PHONES
PADDLE
ENCODER
PRGM
X6
U11
Q2
D5
D6
D8
R1
R2
R3
R4
R5
R6
C1
L2
L3
L4
L5
L6
C7
C8
C9
C12
C13
C14
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R13
R14
R15
R16
R18
R19
R21
R24
R25
R26
R28
R29
R30
R33
R34
R35
R36
R37
GND

Parts list:

| | QTY | Resistors | | | QTY | Capacitors | |
|---|---|---|---|---|---|---|---|
| | 1 | 510 | 51 ohms 5% 0805 | | 5 | 3.3 pfd | GRN/GRN 50V C0G 2% 0805 |
| | 3 | 271 | 271 ohms 5% 0805 | | 9 | 22 pfd | RED/RED 50V C0G 5% 0805 |
| | 3 | 471 | 470 ohms 5% 0805 | | 1 | 33 pfd | ORG/ORG 50V C0G 5% 0805 |
| | 4 | 222 | 2.2 K 5% 0805 | | 2 | 47 pfd | YEL/VOL 50V C0G 5% 0805 |
| | 2 | 362 | 3.6 K 5% 0805 | | 1 | 68 pfd | BLU/GRY 50V C0G 5% 0805 |
| | 3 | 103 | 10 K 5% 0805 | | 8 | 100 pfd (101) | BRN/BLK/BRN 50V C0G 5% 0805 |
| | 9 | 223 | 22 K 5% 0805 | | 4 | 1000 pfd (102) | BRN/BLK/RED 50V X7R 10% 0805 |
| | 5 | 104 | 100 K 5% 0805 | | 22 | 0.01 ufd (103) | BRN/BLK/ORG 50V X7R 10% 0805 |
| | 1 | 474 | 470 K 5% 0805 | | | | |
| | | | | | 10 | 0.1 ufd (104) | BRN/BLK/YEL 50V X7R 10% 0805 |
| | 1 | 2761 | 2.76 K 1% 0805 | | 10 | 1.0 ufd (105) | BRN/BLK/GRN 50V X7R 20% 0805 |
| | 1 | 1372 | 13.7 K 1% 0805 | | 3 | 10.0 ufd (106) | BRN/BLK/BLU 50V X7R 20% 0805 |
| | 1 | 2002 | 20 K 1% 0805 | | 1 | 33 ufd (336) | Alum electrolytic |
| | 1 | 1053 | 105 K 1% 0805 | | 1 | 100 ufd (107) | Alum electrolytic |
| | 1 | 1133 | 113 K 1% 0805 | | | | |
| | 1 | 2763 | 276 K 1% 0805 | | 4 | 100 pfd (101) | Brown 100V C0G 10% 1206 |
| | | | | | 2 | 150 pfd (151) | Yellow 100V C0G 10% 1206 |
| | 1 | 101 | Resettable fuse 1206 | | 4 | 220 pfd (221) | RED 100V C0G 10% 1206 |
| | | Semiconductors | | | 3 | 330 pfd (331) | Orange 100V C0G 10% 1206 |
| | 2 | SA612AD01112 | MIXER/OSC SO-8 | | 1 | 560 pfd (561) | Green 100V C0G 10% 1206 |
| | 1 | LM386MX-1/NOPB | AUDIO AMP SO-8 | | 1 | 680 pfd (681) | Blue 100V C0G 10% 1206 |
| | 1 | LM4808M | AUDIO AMP/DUAL SO-8 | | 11 | 30 pfd green | Trimmer caps |
| | 1 | MSP430G2433IPW28 | 16 BIT, 8K PROCESSOR TSSOP-28 | | | | |
| | 1 | AD9834BRUZ | 24 BIT DDS TSSOP-24 | | 4 | 3.3 uhy RFC | 0805 (Green) |
| | 1 | 74AC02M96 | QUAD OR GATE SO-14 | | 4 | 10 uhy RFC | 0805 (Brown) |
| | 1 | SN74LVC1G3157DBV | SPDT ANALOG SWITCH SOT-23-6 | | 2 | 8.2 uhy RFC | 0805 (Gray) |
| | 1 | TPS560200 (GRN) | SWITCHING BUCK REG SOT-23-5 | | 4 | 4.7 uhy RFC | 0805 (Yellow) |
| | 1 | TC1014-3.3VCT713 | (ORG) 3.3V LDO SOT-23-5 | | 1 | 10 uhy power | Inductor (100) |
| | 1 | ASVMB-60.000MHZ | 60.000 MHZ CLOCK 10 ppm | | 10 | T30-2 red toroid | |
| | 1 | BAV99 (YELLOW) | DUAL SILICON DIODE SOT-23 | | | | |
| | 2 | BAT54 (Blue) | DUAL SHOTKEY DIODE SOT-23 | | 1 | FT37-43 | Ferrite core |
| | 4 | BZT52C5V1-F | 5.1 V 500 mw ZENER DIODE | | 1 | 32.768 kHz | Cylinder watch crystal |
| | 1 | DZ247000L (PG) | 47 V, 2W ZENER DIODE | | 5 | 4.9152 MHZ | HU-49/US crystal, matched |
| | 3 | BS170 | N-CHANNEL MOSFET TO-92 | | | | |
| | 2 | NDT2955 | P-CHANNEL MOSFET SOT-223 | | 4 | Push button | Tack switch |
| | 2 | 2N7002 (RED) | N-CHANNEL MOSFET SOT-23 | | 6 | DP3T slide switch | |
| | 1 | NHD-C12832A1ZFSW-FBW-3V3 | NEWHAVEN 128X24 LCD GRAPHICS DISPLAY, WHITE BACKLIGHT | | 1 | DPDT slide switch | |
| | 2 | 3.5mm phone jack | | | 1 | 12mm button cell | holder |
| | 1 | 1.7mm power jack | Panel mount | | 1 | 1225 3V lithium | Button battery |
| | 1 | 1.7mm power plug | 4mm dia x 10mm length | | | | |
| | 1 | 15 mil solder | | | | | |
| | 1 | 9 feet | #28 Magnet wire | | | | |

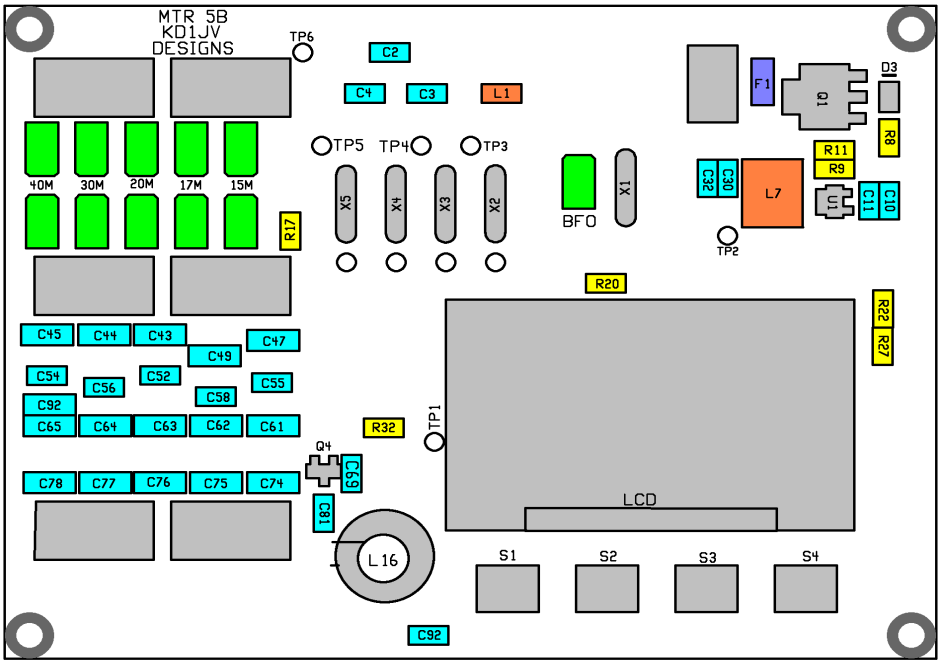
**Using the parts placement guides:**

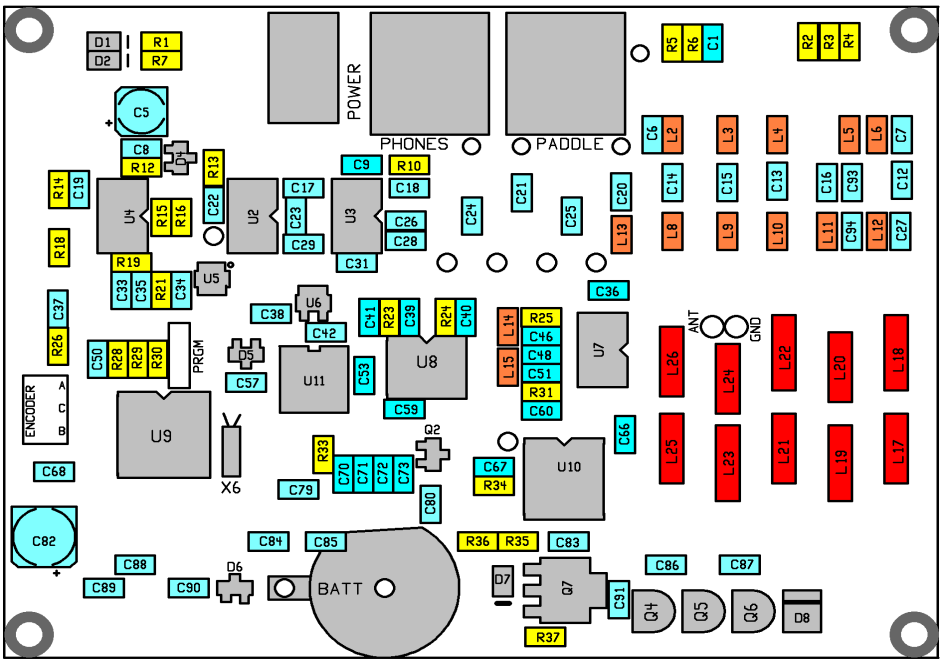
The parts placement guides on the following pages are color coded to show the location of the various types of parts. Parts to be installed are highlighted in various colors to help identify their locations. The guides are scaled so that the writing on them is easy to see on a computer monitor and come out crisper after the conversion to pdf. Unfortunately, if you print all these pages out, it will use up a bunch of your ink jet ink.

Some parts do not have values marked on them or are very hard to read. Capacitors are not marked so these have been color coded with a marker on the part carrier using the resistor color code to indicate their value in pfd.

SOT-23 parts have numbers printed on them, but are very hard to read. Therefore, these parts are also color coded, but with a color sticker, as they come in plastic carriers. The color on the carrier matches the color shown on the placement guide diagram.

Resistors have their value printed on them, though it might take a magnifying glass to read the numbers. Therefore, individual values are not color coded.

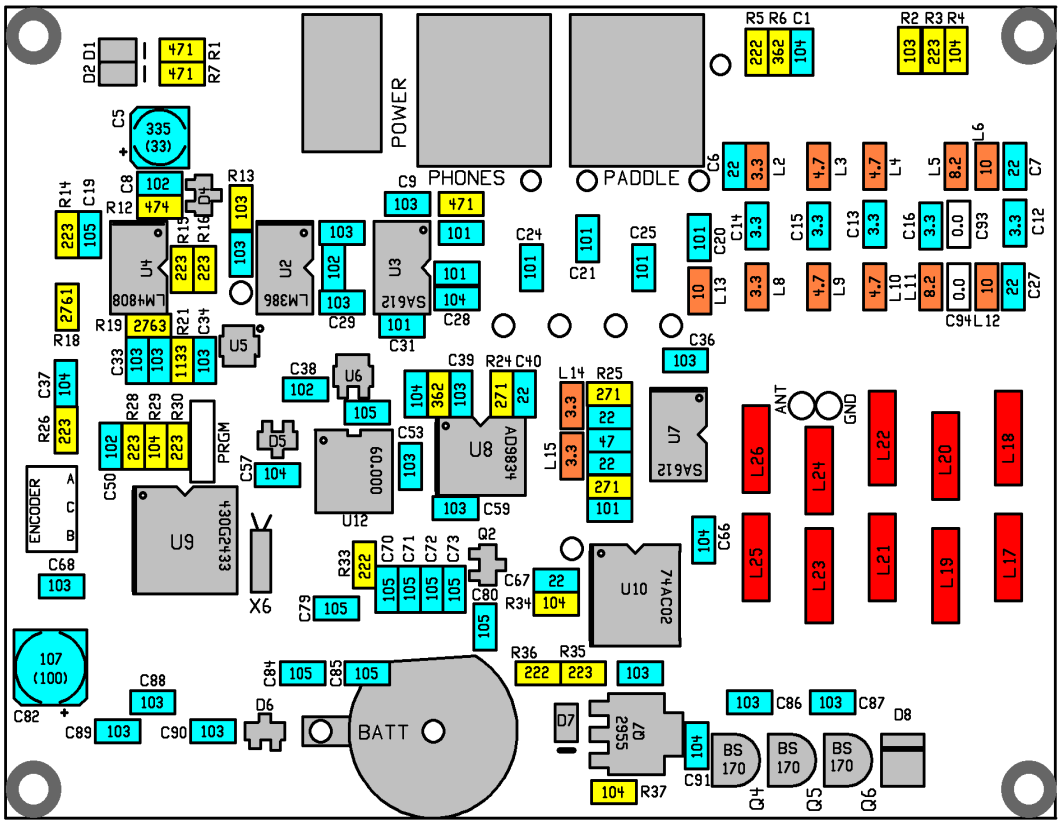


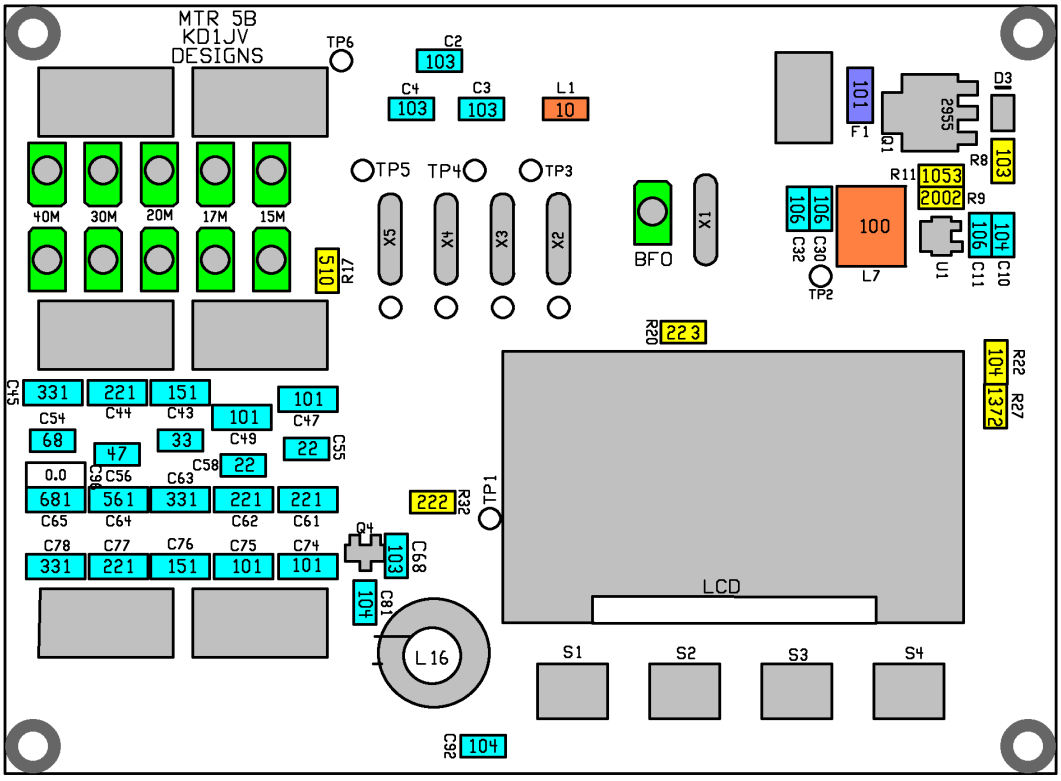




Due to the tight spacing of parts, not all of them have their designation number printed next to them on the board. These two diagrams show the part number designation for each part location.

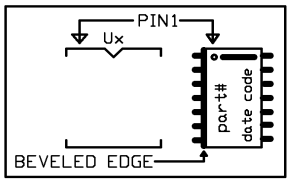
**Part locations with values.**

Capacitors are highlighted in light Blue (101 = 100 pfd, 103 = 10,000 pfd = 0.01 ufd)
Resistors are highlighted in yellow
Inductors are highlighted in Orange
Through-hole and semiconductors are highlighted in gray.



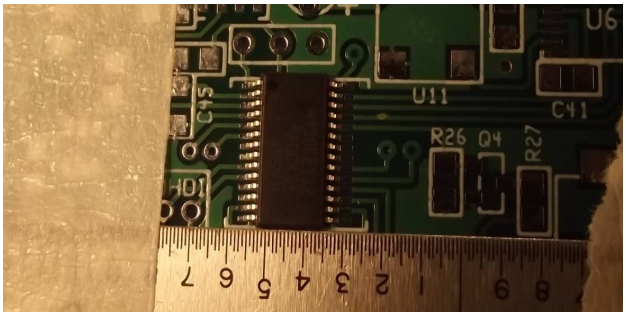



# Semiconductor placement




- Finding Pin 1. Some of the ICs used in this kit have a dot or indentation at Pin 1 corner of the chip. For others, the Pin 1 locations isn't as obvious. The manufactures logo is sometimes used (as is the case for U1 and U3) or sometimes there is a line along the Pin 1 end of the chip. In all cases, there is a beveled or rounded edge along the side of the Pin 1 (left) side of the IC package. When the package is orientated vertically and the beveled edge is to the left, Pin 1 is always in the upper left corner as shown in the diagram.

- U3 and U7, (SA612) use the manufactures log (NXP) for the pin 1 corner designator.
- Before placing an IC or transistor, tin one corner pad and then tack that lead of the part down first. Before soldering any other pins, make sure all the leads are lined up on the pads. This is especially important for U8 and U10, where these isn't much room for error. (See hint below to line up the leads with the pads.) Solder the lead of the opposite corner from the tacked lead to be sure the body doesn't move when you finish solder the rest of the leads.
- You will have to carefully check the number on the 8 pin ICs to tell them apart. Using a magnifying glass and tilting the part slightly to the light will aid in reading a part number. The rest of the ICs are in unique packages and are easier to determine their locations.
- Tilting an IC to the light can make reading the part number easier.
- U1 and U6 part carriers are color coded to make it easier to tell them apart.
- There are several different SOT-23 devices. The packages they are in are each color coded to match the layout diagram.
- D1, D2, D3, and D7 have a very faint line on one end to indicate the cathode end. Look carefully for this line and face it towards the line printed on the board.
- There may be more numbers or letters on the semiconductor packages then indicated on the layout diagram. These numbers/letters are date or lot codes and can vary depending on when the parts were purchased. Therefore, these are not used for part identification on the layout diagrams.
- HINT: Taping a straight edge, such as a thin metal ruler, across the board and lined up with the bottom outline of U8 or U9 (as the case maybe) will aid in keeping the part aligned with the pads. Do U8 first followed by U9. After soldering the leads, clean up any solder shorts with the supplied solder wick. Be sure to only pull the wick parallel to the leads and not against the grain!



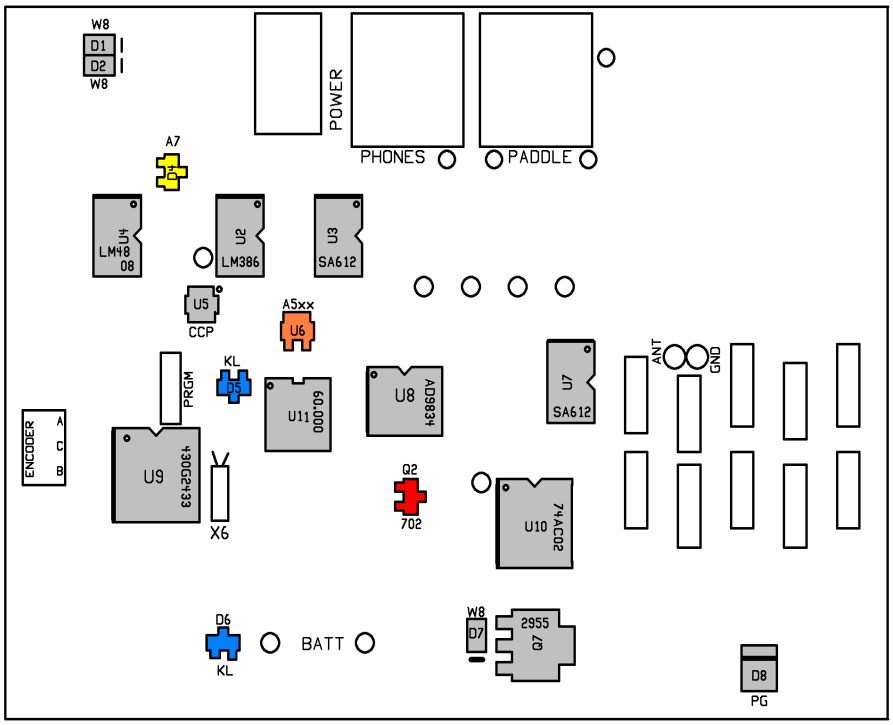
Semiconductor locations:

Semiconductors are mounted first.

Hand soldering notes:

- First mount U8 (AD9834) followed by U9 (430G2433). Use the straight edge hint on page 12 to line up the pins on the pads.
- Soldering U11, the 60 MHz clock, will be a little tricky since there is not much of a lead sticking out the side of the part. Tin all four corner pads and the ground pad in the center to put a little solder bump on them. As the lettering on the part is hard to read, make sure you have it orientated properly, then hold the part in place with a little downward pressure while heating each corner pin in turn. Flip the board over and heat the ground pad up, flowing a little solder into the hole. It's not overly important if this isn't soldered.
- The pin 1 dot and lettering on U5 is also not very easy to read. You'll have to be extra careful to get this orientated properly. Note that when properly installed, the lettering on the part will be "upside down," *i.e.* facing the top edge of the board.
- The cathode line printed on the D1, D2, and D7 diodes is also hard to grasp.
- D8 should be easy to identify as it is the only two legged part of its size, and somewhat larger than the D1 type diodes.
- Color coding is used on the part carriers for D4, D5, D6, Q2 and U6 to make it easier to identify.
- Pin 1 of the remaining ICs should be easy to identify as they all have an obvious dot in the upper left corner. The exception is U3 and U7. On these parts, look for "NXP" printed in the upper left corner.
- Use the supplied solder wick to remove any solder bridges between pins on the ICs. It is nearly impossible not to make shorts when soldering the processor (U9) and the DDS chip (U8), whether if it is done with solder paste or hand soldering. The pins on the SO-23-5 parts are also prone to shorts.

You will have a few left over semiconductors. The PTC fuse (used later) is also in the semiconductor bag. Put these in a safe place to use later.




| | | |
|---|---|---|
| U8 | AD9834 | |
| U9 | 430G2433 | |
| U3 | SA612A | |
| U2 | LM386 | |
| U4 | LM4808 | |
| U7 | SA612A | |
| U10 | 74AC02 | |
| U11 | 60.000 MHz | clock |
| U5 | CCP 6 pin | black |
| D4 | A7 diode | Yellow |
| U6 | A5xx 5 pin | Orange |
| D1 | W8 small 2pin | |
| D2 | W8 small 2 pin | |
| D5 | KL Diode | Blue |
| D6 | KL diode | Blue |
| D7 | W8 small 2 pin | |
| D8 | PG large 2 pin | |
| Q2 | 702 | Red |
| Q7 | 2955 | SOT-223 |

Resistors:

Resistors used in more than one location are shown color coded on the diagram to make it easier to find where they are placed. The parts themselves are not color coded.

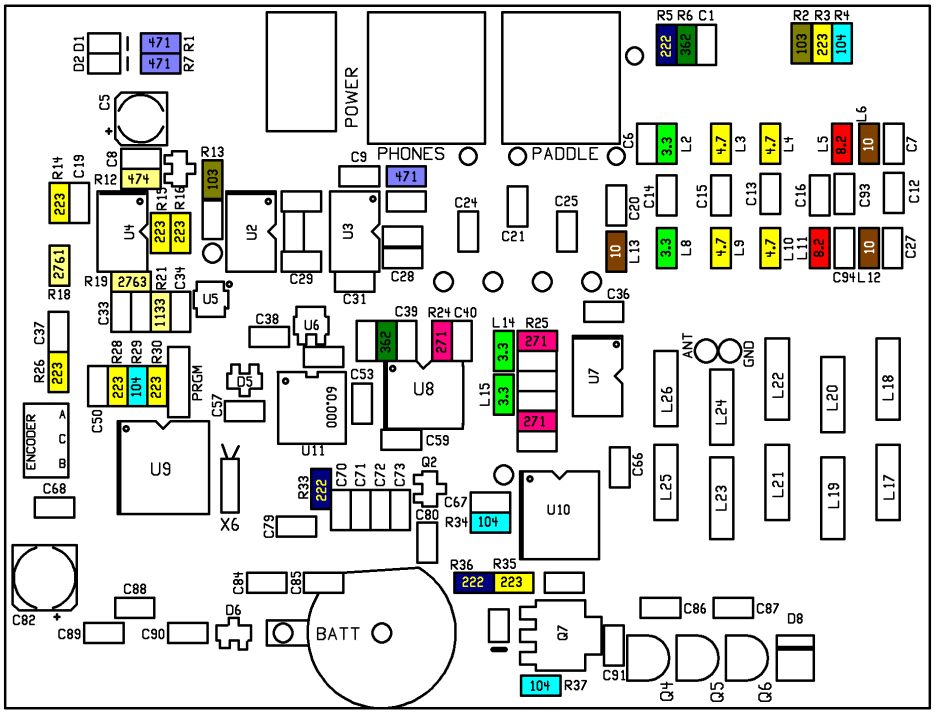
Be careful not to mix up R18 and R19 since they differ only by the last digit. By the same token 222 and 223 along with 103 and 104 value could be easy to mix up too, so read the numbers carefully.

**Inductors:**

The inductors are in a clear plastic carrier and marked with a single color representing the first digit in its value. 10 uHy = brown, 8.2 = gray, 4.7 = yellow, 3.3 = green.

You will have a few left over resistors and one 10 uHy inductor which will go on the top side of the board. Be sure to put these in a safe place for later use.

- If planning adding the 80M band and eliminating one of the standard bands, you will need to place L12 to L3 and R4 to R6 values one position to the left. This assumes the operator will be eliminating 15 meters. If desiring to eliminate one of the other bands, the same approach applies.




| # | Location | value |
|---|---|---|
| 3 | R24/25/31 | 271 |
| 3 | R1/7/10 | 471 |
| 3 | R5/33/36 | 222 |
| 2 | R6/23 | 362 |
| 2 | R2/13 | 103 |
| 8 | R3/14/15/16/26/28/30/35 | 223 |
| 4 | R4/29/34/37 | 104 |
| 1 | R12 | 474 |
| 1 | R18 | 2761 |
| 1 | R21 | 1133 |
| 1 | R19 | 2763 |
| | Inductors: | |
| 3 | L6/12/13 | 10 (brown) |
| 2 | L5/11 | 8.2 (Gray) |
| 4 | L4/10/3/9 | 4.7 (yellow) |
| 4 | L2/8/14/15 | 3.3 (green) |
| 80 M | L6/L12 Not supplied | 18 uHy |
| 80 M | R4 | 0 ohm jumper. |

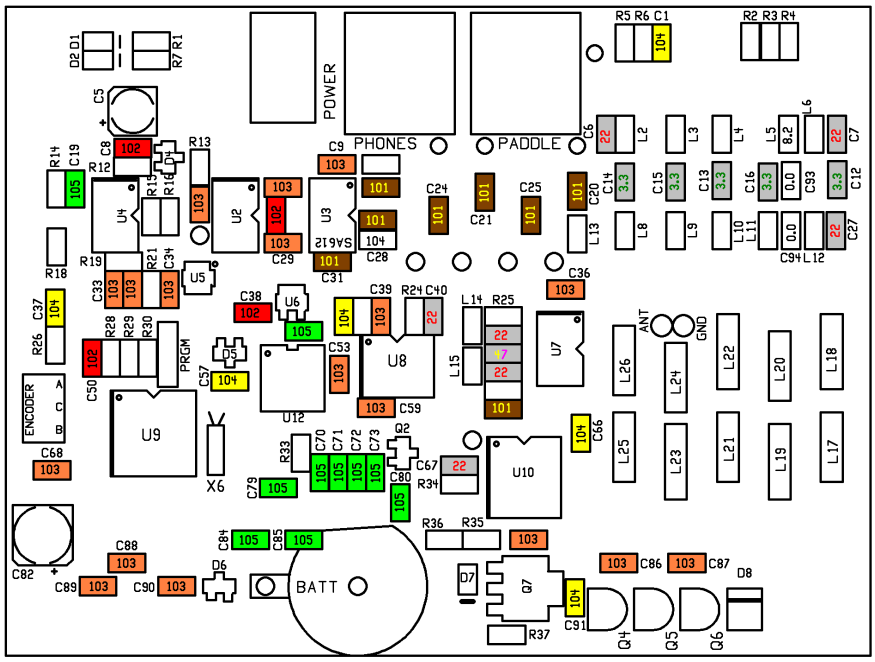
## Capacitors:

The paper strips holding the chip caps are color coded to identify their value. The color coding is the same as used for through-hole resistors but instead of ohms it represents picofarads. Therefore, a .01 ufd cap (10,000 pfd) is color coded Brown/Black/Orange. Values of less than 100 pfd are coded with just the two digit colors. 22 pfd is Red/Red.

The placement diagram highlights the color of the multiplier to help you locate where a particular value is placed on the board. Values less than 100 pfd have their numerical value colored to match that on the carrier.

Because of their height, the two aluminum electrolytic caps will be installed later with the through-hole parts. Otherwise the board will not sit flat when you install the top side parts.

You will have a few caps left over to be used on the top side of the board. Be sure to put these in a safe place for later.




| # | Color code |
|---|---|
| 5 | **Green/Green** (3.3pfd) |
| 6 | **Red/Red** (22 pfd) |
| 1 | **Yellow/Violet** (47 pfd) |
| 8 | Brown/black/**brown** (101) |
| 4 | Brown/black/**red** (102) |
| 18 | Brown/black/**orange** (103) |
| 6 | Brown/black/**yellow** (104) |
| 9 | Brown/black/**green** (105) |
| 80M | C7/27, 100 pfd C12, 15 pfd (parts not supplied) |

C93 and C94 are not used unless you are adding 80M, in which case the 40M caps (C7+C27) caps go there since all the band filter parts will be moved one location to the left.

That completes the bottom side SMT components. On to the top side!

## Top side SMT components:

Since there aren't many SMT parts on top side, only one diagram will be used for all of them.

Notes:

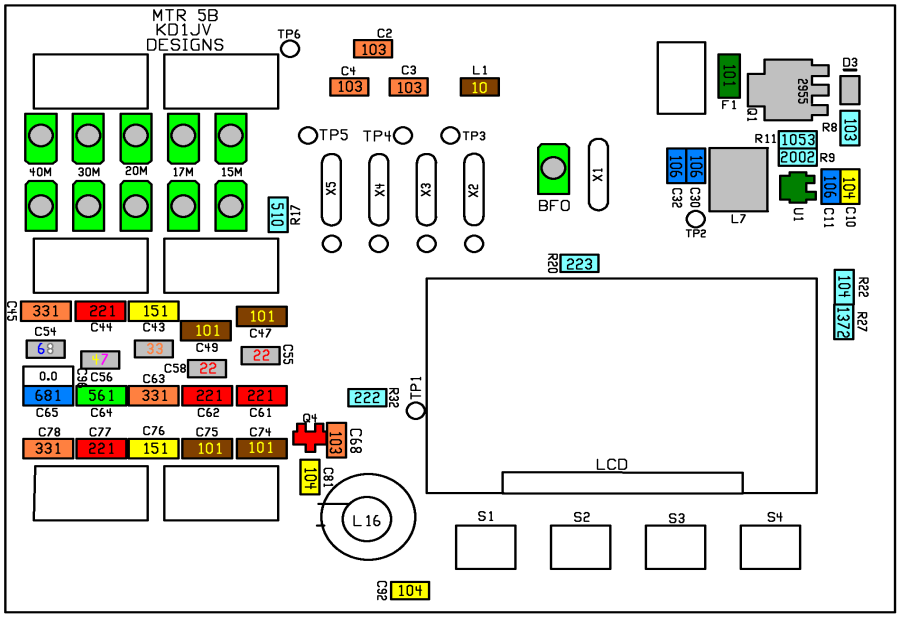
L7: L7 is a power inductor which is a little tricky to solder in place due to the minimal solder tabs sticking out the bottom. Tin the pads on the board so you have a little bump of solder. Place the part over the pads and heat up the bottom edge of the inductor with your iron, adding a little bit of solder to help the transfer heat; then do the other side. Use an ohm meter to verify the solder connections.

Inasmuch most of the colors were used identifying the caps, all the resistors are highlighted in the same color.

Most of the caps in the output filter use 1206 size parts and are on a clear plastic carrier. These parts are identified with a single color equal to its most significant digit. With the exception of the 150 pfd caps, which use Brown/Green, the 560 pfd cap uses green and the 100 pfd cap uses brown.

Trimmer caps: Be sure to match the notched end of the cap with the notched end of the board outline. This ensures the adjustment screw is grounded and will not be affected when using a metal screw driver to adjust it.

F1 is a resettable fuse. It is different than the other 1206 sized cap parts, as it has a green body with notches on the ends and has the numbers “101” printed on it. This part was found in the semiconductor parts bag.



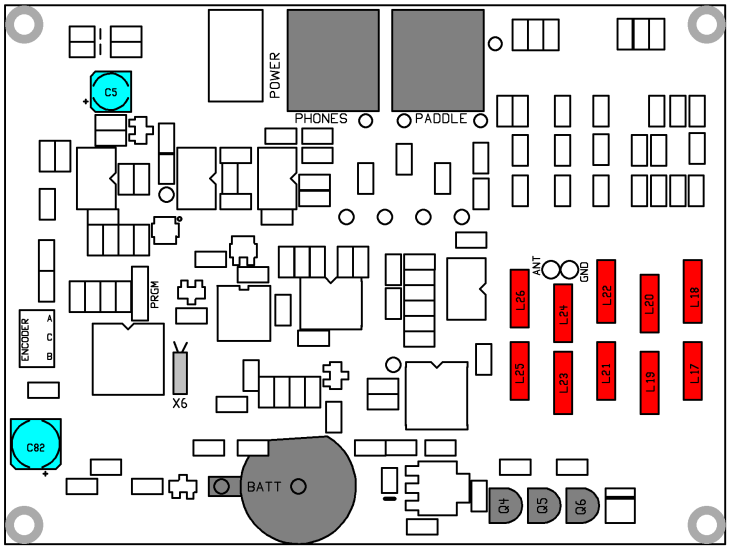

| # | Loc. | Color/value/type |
|---|---|---|
| 1 | F1 | 101,green body,1206 |
| 1 | L7 | Large square inductor |
| 11 | | Green trimmer caps |
| 1 | D3 | – Small 2 leg diode. |
| 1 | Q1 | – 2955 SOT-233 |
| 1 | U1 | – Green SOT-23-5 |
| 1 | Q4 | – Red SOT-23 |
| 1 | R8 | 103 Resistor |
| 1 | R11 | 1053 Resistor |
| 1 | R9 | 2002 Resistor |
| 1 | R17 | 510 Resistor |
| 1 | R20 | 223 Resistor |
| 1 | R22 | 104 Resistor |
| 1 | R27 | 1372 Resistor |
| 1 | R32 | 222 Resistor |
| 1 | L1 | Brown Inductor |

| # | Location | color | Color code | # | Location | color | Color code |
|---|---|---|---|---|---|---|---|
| 4 | C2, C3, C4, C68 | Orange | BRN/BLK/ORG | 3 | C45,C78,63 | Orange | ORG, 1206 size |
| 3 | C10, C81, C92 | Yellow | BRN/BLK/ORG | 1 | C65 | Blue | Blue, 1206 size |
| 3 | C11, C30, C31 | Blue | Blue 0805 size | 4 | C44,C77,C62,C61 | Red | Red, 1206 size |
| 1 | C54 | gray | Blue/Gray | 1 | C64 | Green | Green, 1206 size |
| 1 | C56 | gray | YEL/VOL | 2 | C43,C76 | Yellow | Yellow 1206 (not related to value) |
| 1 | Not labeled (C52) | gray | ORG/ORG | 4 | C47,C49,C74,C75 | Brown | Brown, 1206 size |
| 1 | C58 | gray | Red/Red | | | | |
| 1 | C55 | gray | Red/Red | | | | |

80M : C45/78/65/96 = 680 pfd 100V C0G 1206  C54 = 220 pfd C0G 50V 0805 (parts not supplied)

## Through-hole components:

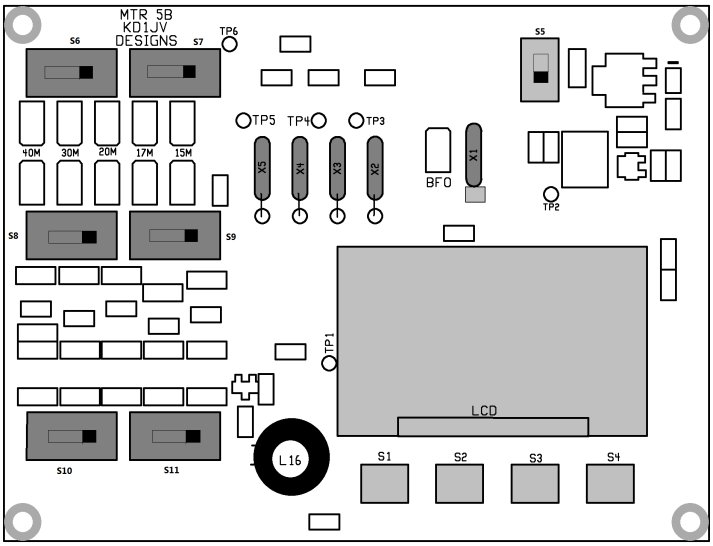
- Install the bottom side through-hole parts first, with the exception of the battery holder since the holder sits above the pads for the push button TACK switches.
- Depending on the type of enclosure the board in mounted, the builder may elect not to install the two phone jacks onto the board. It may be more convenient to panel mount the jacks and use jumpers to wire them to the board.
- The toroids will be wound and installed later.




**Top side:**

- X6: once soldered, clip the leads flush with the board on the top side as the display will sit on top of these connections. Tack solder the end of the crystal to the solder pad to hold it in place.
- C5: 33 ufd/6.3V Note the negative end is the side with the black "half-moon."
- C82: 100 ufd/16V
- Q4/5/6 – BS170 TO-92

**Bottom side:**




- **X1-5:** sit flat to board.
- **X1:** Tack solder end of case to solder pad to ground.
- **X2-5:** use lead clipping to ground case to solder pads directly below the case. Tack solder wire to the top edge of the can.
- **S5:** DPDT slide switch.
- When installing the slide switches, solder just one pin and then double check to make sure switch is sitting flat and square to the board. If the switch is cocked and more than one pin is soldered, straightening it again will not be easy.
- **S6 to S11:** 3PDT slide switches
- **LCD:** Getting all the pins to line up with the holes can take a little prodding.
  - Make sure the display sits flat and snug to the board.
  - Make sure there are no shorts between the pads when soldered since the pads are very closely spaced.

- **S1-4: TACK PB switches.** The spacing on the leads will only line up properly one way.

- **Battery holder:** Now that the PB switches have been installed, mount the battery holder. I made a mistake and called out the mounting holes to be VIAs instead of solder pads so they came covered with solder mask. The solder mask has been scraped off around the hole for you so there is a better chance of making a good connection.
  - Subsequently, there isn't much space between the switches soldered to the battery terminal pins. Be very, very careful not to touch the switches and melt them!!! Check the positive terminal with an ohm meter to make sure it's not shorted to ground.

Go to next page for toroid winding data.

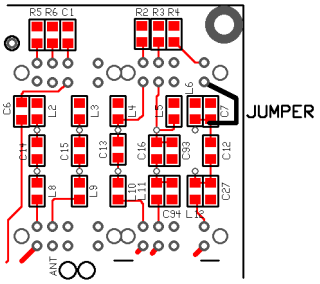
**Toroid winding data:**

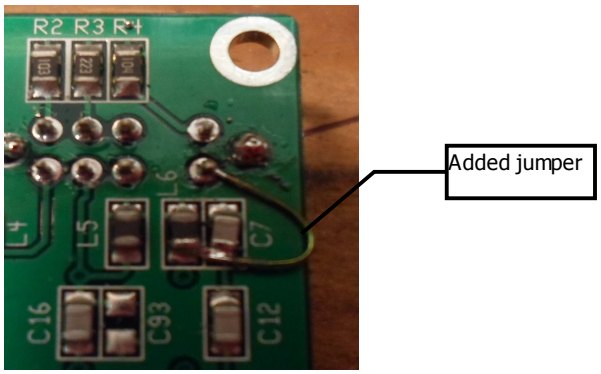
- Wind the wire snug to the core. A sloppy and loose winding will result in poor power output and an increase in spurious emissions.
- After winding, arrange the wire so that the turns are as evenly spaced as possible.
- The magnet wire can be tinned with the soldering iron by melting through the insulation, but this must be done before the wire is placed onto the pad. Tin the wire up to the core to avoid wire insulation in the hole after the core has been snugged onto to the board.
- L16: 8 turns (~6") on black FT-37-43 core, mount on top side of board.
- 80M option: On the 80 meter inclusion, the band sequence will start with 80m in the L17/L18 positions and all the other bands will move over one slot. Typically when adding 80m, 15m will be deleted but any other band can be eliminated instead. Just keep the left to right sequence of increasing frequency scheme. This will of course also apply to the receiver input filters and band select resistors which will have to be repositioned accordingly. NOTE: parts for 80 meter filters are not included and must be obtained by the builder from a parts distributer.

| | | | |
|---|---|---|---|
| 40 M | L17 | 18 turns | 11" #28 |
| 40 M | L18 | 20 turns | 12" #28 |
| | | | |
| 30 M | L19 | 13 turns | 8" #28 |
| 30 M | L20 | 16 turns | 10" #28 |
| | | | |
| 20 M | L21 | 12 turns | 8" #28 |
| 20 M | L22 | 15 turns | 9" #28 |
| | | | |
| 17 M | L23 | 11 turns | 7" #28 |
| 17 M | L24 | 14 turns | 9" #28 |
| | | | |
| 15 M | L25 | 9 turns | 6" #28 |
| 15 M | L26 | 13 turns | 8" #28 |
| | | | |
| 80 M | L17 | 23 turns | #32 wire not supplied |
| 80 M | L18 | 25 turns | #32 wire |

**Fix a defect on board:**

An open VIA was discovered which needs to be fixed with a short piece of magnet wire. Use the least amount of exposed tinned lead as possible to make the connections. This fix connects the output side of the 40 meter receiver band pass filter to the selector switch. This may not be a problem on all boards, thus check for continuity with an ohm meter to find if it's needed before adding the jumper.



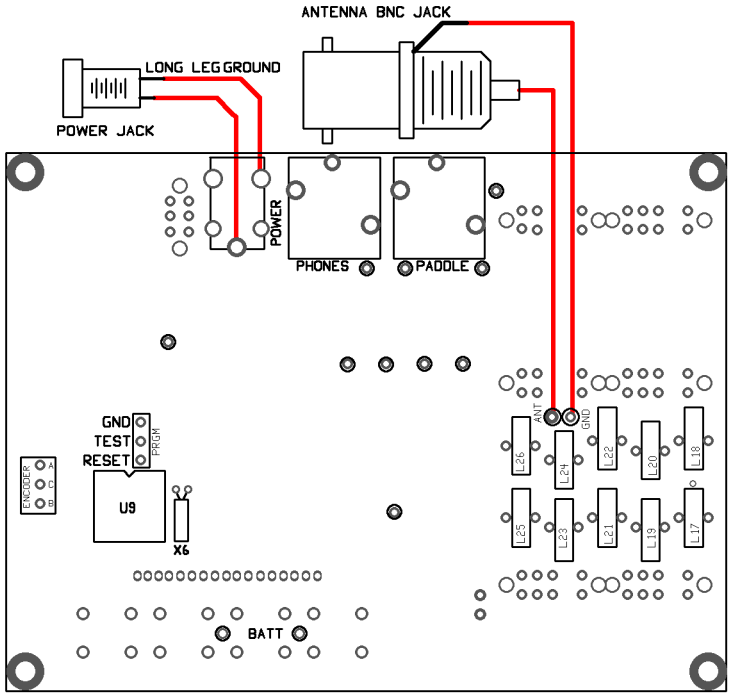




## *Inspect your work!*

Now that the board is complete, it's time to review it very carefully looking for bad or missing solder connections or shorts between leads on the ICs. Use a magnifying glass and inspect the connections on all the parts. Removing flux residue can make inspecting the connections easier. “Electrical parts cleaner” which can be found in the automotive section of Walmart works well for removing flux. Soldering issues are the number one reason a kit does not work and catching them now will save much time and effort (and possible damage) later.

**Power Jack and Antenna jack wiring:**

The power jack will need to wired to the board before the board can be tested. The wiring of the BNC antenna jack can be put off for now, as it will just get in the way until you need to align the receiver front end and test the transmitter.




Once the power jack has been wired, wrap the exposed connections on the jack with electrical tape so there is no possibility of then shorting out to something on the board while you move it around.

**Adding a rotary tuning encoder:**

The encoder is wired to the three pads to the right of the display viewed from the top of the board and to the left of U9 from the bottom, where the pads are labeled.

Any mechanical or optical encoder with Quadrature outputs can be used. There are many to choose from. A suitable panel mount encoder would be Mouser part # 652-PEC11R-4220F-S12. This encoder also has a push switch built in which the builder might elect to wire to the **Fn** switch.

**Alignment:**

- Use a 9 volt transistor radio battery to power up the board for the first time. If there are any problems, the 9V radio battery can't deliver enough current to do any serious damage.
- Power up the board and the display should come on. Everything should be functional but the BFO trimmer needs to be set.
- The BFO can be adjusted by ear with off air signals, but it is best done using the **BFO ADJUST** mode. This allows you to set the BFO trimmer so that the beat note is peaked in the audio band pass filter.
- The reference oscillator frequency constant used for frequency calculations can be adjusted to match the actual frequency of the oscillator. An accurate frequency counter is required for this adjustment.
- The Local Oscillator frequency can be tweaked so it is centered better in the pass band of the IF crystal filter. It should be pretty close to center by default, but the exact center frequency can vary by a few 100 Hz due to the sorting of the crystals which matches them to 10 Hz.This adjustment is best done with the aid of an Oscilloscope. If you don't have one, it can be done with a sound card running an Oscilloscope or PSK program.

**Reference oscillator adjustment:**

If you do not have an accurate frequency counter, advance directly to BFO adjust mode by pushing the <**Fn**> switch.

- Enter calibration mode by powering up the board with both the <**Fn>** and <**RIT>** switches held closed.
- The display will read "CAL REF" on the lower line.
- Connect an accurate frequency counter to TP1 (located the left of the display and just below R32)
- Use the tune up or tune down switches to set the frequency to exactly 10.000,000 MHz.
- When done, push the <**Fn**> switch to advance to the BFO adjustment mode.

**BFO Adjustment:**

- Connect an Oscilloscope at test point 3 (TP3, just below headphone jack) or plug in a set of headphones.
- While simultaneously holding closed the <Fn> and <RIT> switches, turn the power on.
- The display will read [BFO ADJUST]
- Adjust the BFO trimmer cap to peak the signal, which should occur at about 600 Hz.

**L.O. Adjustment:**

- Skip this if no scope and are peaking by ear.
- Connect the oscilloscope to TP2.
- Use the Up and Down tuning buttons to find where the signal starts to roll off, then return to where it is centered in the pass band of the filter. This might be a little hard to see due to the noise on the signal from the switching supply ripple.
- Once center of the IF filter pass band is determined, return to TP3 and readjust the BFO trimmer to peak the signal in the audio band pass filter again.

**Complete the BFO alignment:**

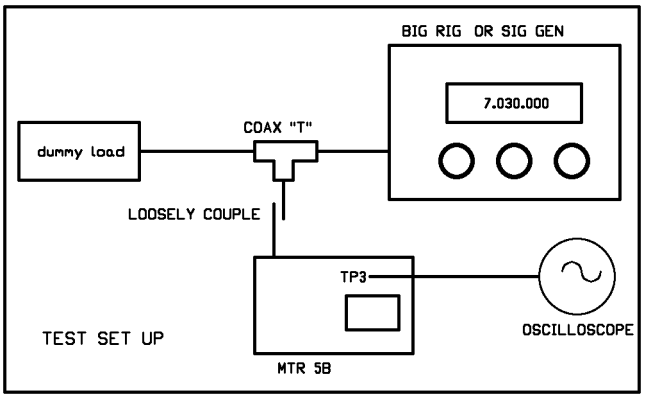
- Tap the <**Fn**> switch to exit and store the data. The display will blank for a second and then the board will rest and normal operation will begin.

**Entering BFO adjustment mode later:**

- Remove the backup battery.
- Turn on power while holding closed both the <**Fn**> and <**RI**T> switches.
- This will reload the default values and clear the band frequency memory locations.
- The BFO tone and LO centering can now be changed as previously described.
- TAP <**Fn**> to store and exit.

**Receiver input tuning and transmitter testing:**

While peaking the receiver input by ear and using off air signals, the receiver inputs are best peaked by using a signal generator and oscilloscope. If neither are available, use another transmitter for the signal generator and a PC sound card Oscilloscope or PSK program.




**Receiver peaking:**

- Set the signal source
- The trimmers are labeled 80 to 17, but should have been labeled 40 to 15.
- Preset the trimmer caps by turning them about one-quarter turn.
- Apply the signal to the antenna jack, tune in the signal and peak the trimmers for best audio amplitude as seen on the 'Scope or as heard by ear.
- Once the initial peak has been determined, reduce the amplitude of the input signal to keep the audio amp from being limited by the clipping diodes.
- Work back and forth between the two trimmers to get the best peak as the two are somewhat interactive.
- Advance to the next band.

**Transmitter testing:**

- Connect the MTR-5B antenna jack to a suitable power meter and dummy load.
- If possible, use a regulated power supply for best results, 9.0 or 12.0 volts.
- Set the rig to ‘Straight’ key mode.
- Select the 40 meter band.
- Key the transmitter and note the power output.
- Power output should be about 2.5 watts with a 9V supply and about 4.5 watts with a 12V supply.
- Advance to the next band and test. Repeat for next band.
- Power output is sensitive to inductance of the input side transmitter low pass filter, L17, L19, L21, L23 and L25. The variations are primarily due to how tight the wire is wound on the toroid core and the wire spacing around the core. There can also be variations in the permeability of the cores.
- If power output is significantly higher than it should be, move some turns closer together. If power output is somewhat lower than it should be, space the turns as much as possible.

**Battery Backup:**

Once all the adjustments are made and the board is working properly, now install the lithium coin cell backup battery.

- Turn the rig on.
- Install the CR1225 battery into the socket, plus (+) side up.

**Troubleshooting:**

With very, very few exceptions, any trouble getting the board to work will be tracked down to soldering issues. By now all solder “bugs” should have been found and fixed on the first inspection, but some can be missed. Shotgun approaches to fixing soldering problems by re-soldering everything should be avoided. There is a good chance most of the circuits are working properly. The trick is to narrow down the problem to a specific area by figuring out what does work. No transmit or receive is often the soldering to the DDS reference clock chip which is a bit tricky to solder in place.

**Packaging the board:**

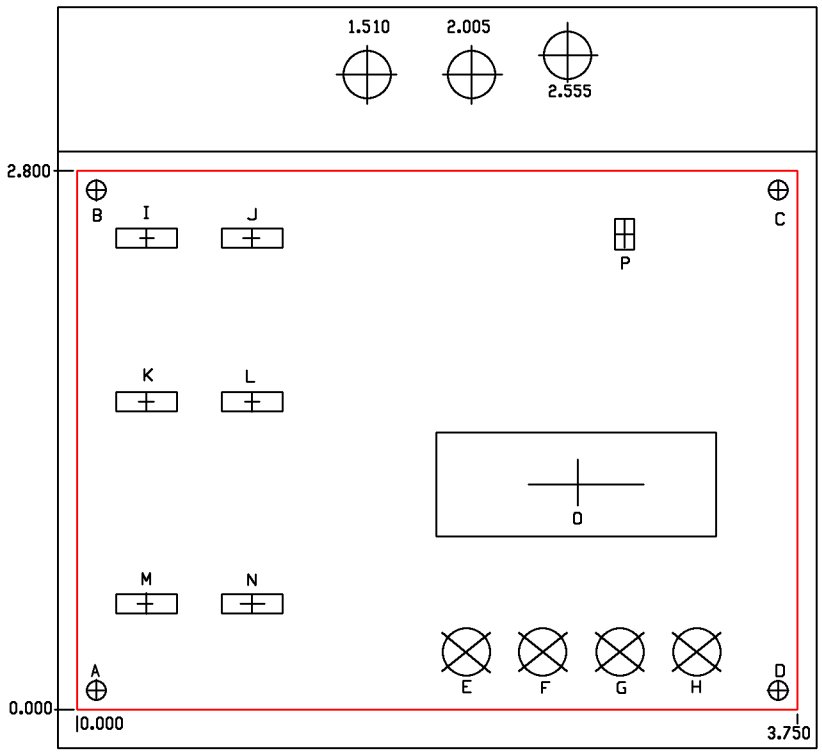
The diagram below can be used as a drill template, but before using--it confirm that it printed to actual size using a ruler and checking the dimensions of the red board outline.

An "off the shelf" enclosure could be used, or you can make one yourself. One option is to make the front panel and back side from a sheet of aluminum and the rest of the box made out of thin wood. Check eBay for sources of 0.032" aluminum sheets. While the 3.5mm stereo jacks can be PC-board mounted, they can also be panel mounted which increases the number of options of enclosures to choose, especially if a plastic box is used.

Making the rectangular holes for the slide switches is a bit of a pain. In metal, one first needs to drill a hole at the center of the outline and then use small files to produce the final rectangular shape. Another option is to drill an oversized round hole and make a thin plastic overlay to cover the panel and hide all the sins.

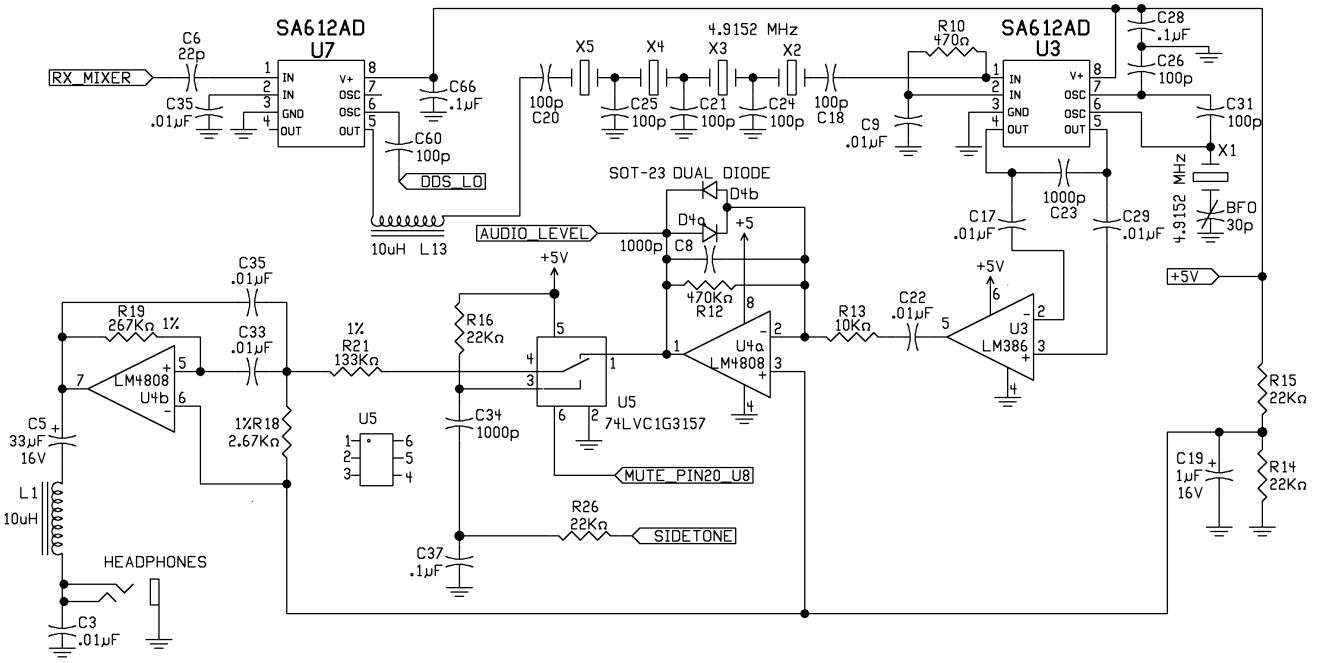
Cutting the large rectangular hole for the display is most easily done with a Dremal drilling tool with a cutting wheel. Be careful and wear a dust mask and eye protection. One can drill a small hole in each of the four corners first so as not to cut beyond the edges. The other option is simply to drill a row of small holes along the edge of the cut out and then use a file to clean it up to the final size.

Mounting hardware is included in the form of four 3/16 #2 threaded spacers, 1/2" #2 screws and nuts. These are used to mount the board under the front panel and provide the proper spacing. A clear plastic window should be placed between the panel and the display to protect it. A piece of clear film is supplied for this purpose. The easiest way to secure it to the panel is to cover it with some clear shipping tape, while trying not to trap air bubbles under it.

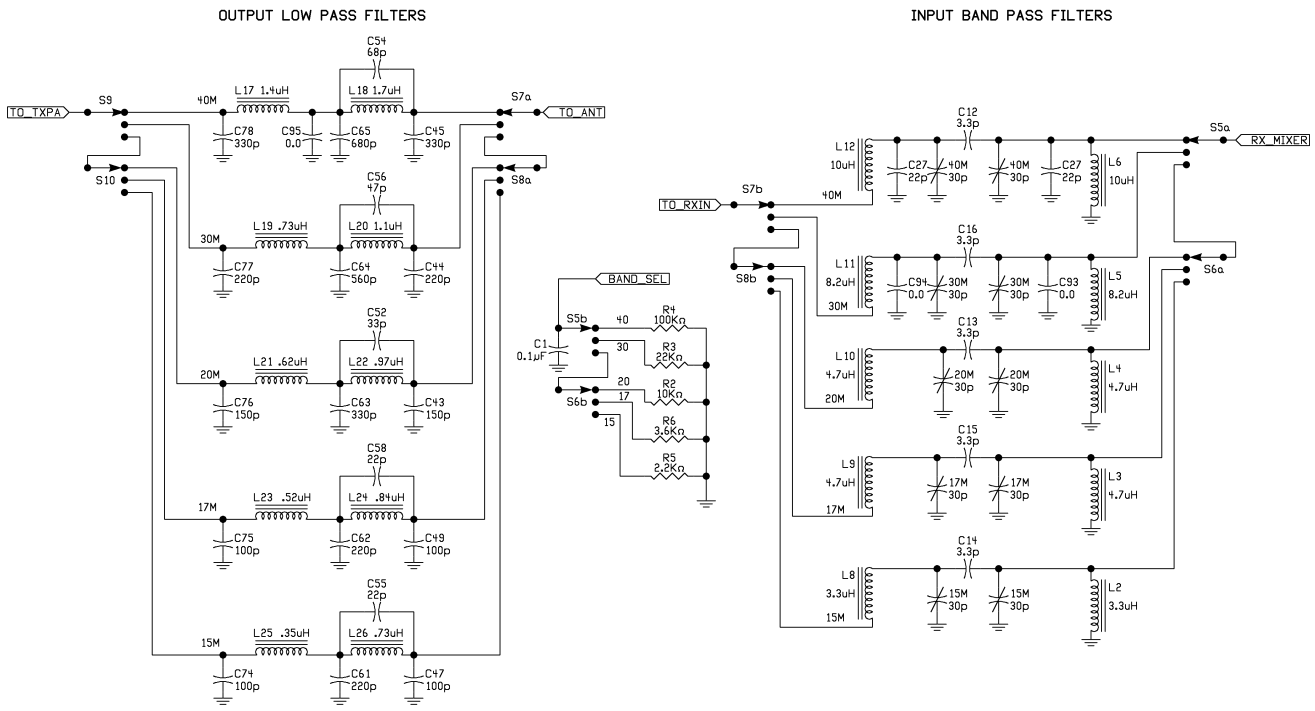


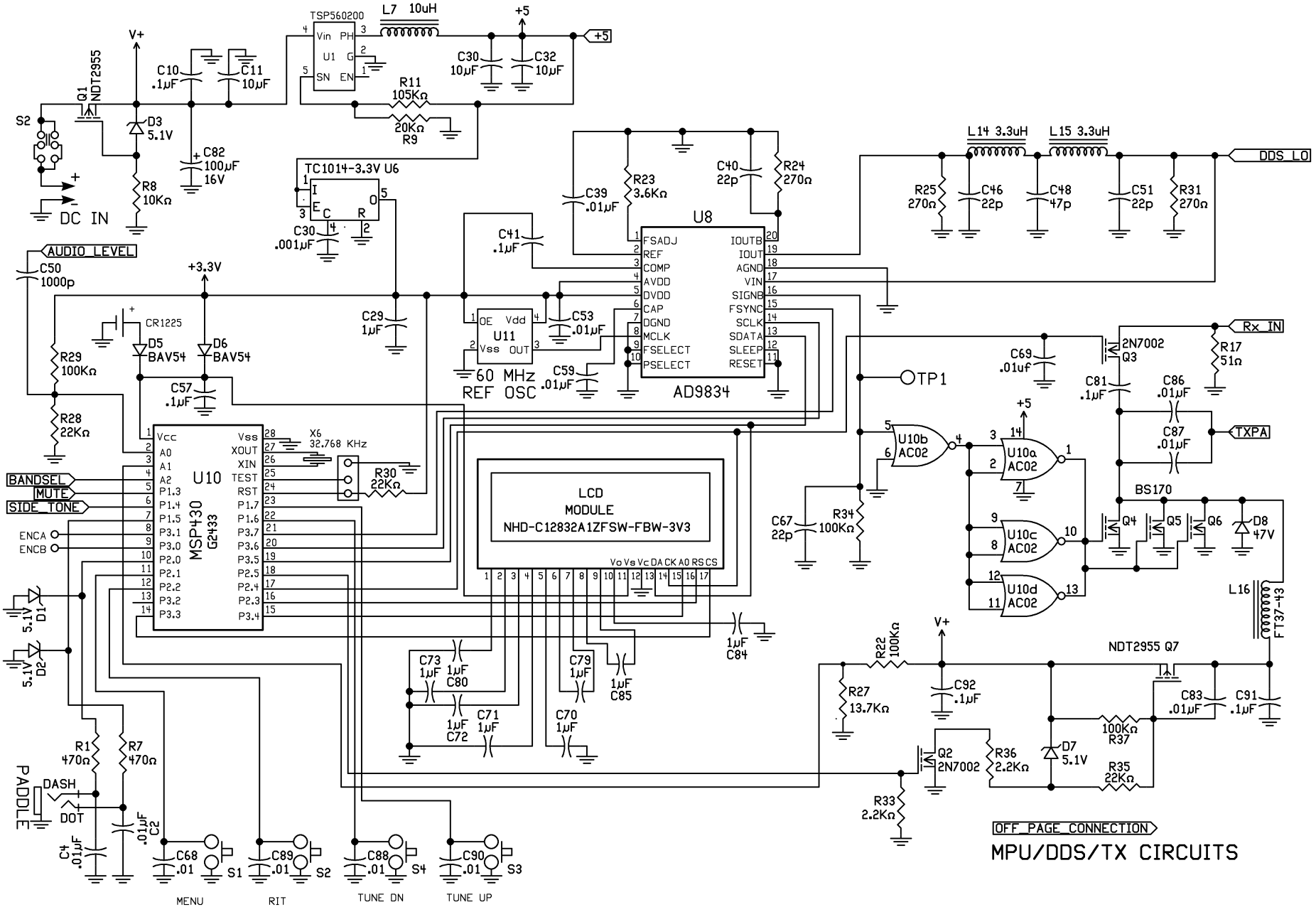

| | X | Y | SIZE |
|---|---|---|---|
| A | 0.100 | 0.100 | 0.125 ROUND |
| B | 0.100 | 2.700 | 0.125 ROUND |
| C | 3.650 | 2.700 | 0.125 ROUND |
| D | 3.650 | 0.100 | 0.125 ROUND |
| E | 2.025 | 0.300 | 0.250 ROUND |
| F | 2.425 | 0.300 | 0.250 ROUND |
| G | 2.825 | 0.300 | 0.250 ROUND |
| H | 3.225 | 0.300 | 0.250 ROUND |
| I | 0.360 | 2.450 | 0.320 X 0.100 |
| J | 0.910 | 2.450 | 0.320 X 0.100 |
| K | 0.360 | 1.600 | 0.320 X 0.100 |
| L | 0.910 | 1.600 | 0.320 X 0.100 |
| M | 0.360 | 0.550 | 0.320 X 0.100 |
| N | 0.910 | 0.550 | 0.320 X 0.100 |
| O | 2.605 | 1.170 | 1.500 X 0.540 |
| P | 2.850 | 2.470 | 0.100 X 0.160 |

RX Schematic:



Filters:


OUTPUT LOW PASS FILTERS
INPUT BAND PASS FILTERS
TO_TXPA
S9
S10
40M
L17 1.4uH
L18 1.7uH
C54 68p
C78 330p
C95 0.0
C65 680p
C45 330p
S7a
S8a
TO_ANT
30M
L19 .73uH
L20 1.1uH
C56 47p
C77 220p
C64 560p
C44 220p
20M
L21 .62uH
L22 .97uH
C52 33p
C76 150p
C63 330p
C43 150p
17M
L23 .52uH
L24 .84uH
C58 22p
C75 100p
C62 220p
C49 100p
15M
L25 .35uH
L26 .73uH
C55 22p
C74 100p
C61 220p
C47 100p
BAND_SEL
S5b
S6b
C1 0.1µF
R4 100Kn
R3 22Kn
R2 10Kn
R6 3.6Kn
R5 2.2Kn
40
30
20
17
15
TO_RXIN
S7b
S8b
S5a
S6a
RX_MIXER
C12 3.3p
C16 3.3p
C13 3.3p
C15 3.3p
C14 3.3p
L12 10uH
L11 8.2uH
L10 4.7uH
L9 4.7uH
L8 3.3uH
C27 22p
C94 0.0
C93 0.0
40M 30p
30M 30p
20M 30p
17M 30p
15M 30p
L6 10uH
L5 8.2uH
L4 4.7uH
L3 4.7uH
L2 3.3uH


MTR-5B Page -26-
TSP560200
L7 10uH
+5
V+
Q1 NDT2955
C10 .1µF
C11 10µF
C30 10µF
C32 10µF
R11 105KΩ
R9 20KΩ
S2
D3 5.1V
R8 10KΩ
C82 100µF 16V
DC IN
TC1014-3.3V U6
C30 .001µF
C39 .01µF
R23 3.6KΩ
C40 22p
R24 270Ω
U8
AD9834
FSADJ
REF
COMP
AVDD
DVDD
CAP
DGND
MCLK
FSELECT
PSELECT
IOUTB
IOUT
AGND
VIN
SIGNB
FSYNC
SCLK
SDATA
SLEEP
RESET
L14 3.3uH
L15 3.3uH
DDS_LO
R25 270Ω
C46 22p
C48 47p
C51 22p
R31 270Ω
AUDIO_LEVEL
C50 1000p
+3.3V
CR1225
D5 BAV54
D6 BAV54
R29 100KΩ
R28 22KΩ
C57 .1µF
C29 1µF
C41 .1µF
U11
60 MHz REF OSC
C53 .01µF
C59 .01µF
TP1
C69 .01uF
2N7002 Q3
C81 .1µF
C86 .01µF
R17 51Ω
Rx IN
C87 .01µF
TXPA
BS170
Q4
Q5
Q6
D8 47V
U10
MSP430 G2433
Vcc
A0
A1
A2
P1.3
P1.4
P1.5
P3.1
P3.0
P2.0
P2.1
P2.2
P3.2
P3.3
Vss
XOUT
XIN
TEST
RST
P1.7
P1.6
P3.7
P3.6
P3.5
P2.5
P2.4
P2.3
P3.4
X6 32.768 KHz
R30 22KΩ
BANDSEL
MUTE
SIDE_TONE
ENCA
ENCB
LCD MODULE
NHD-C12832A1ZFSW-FBW-3V3
Vo Vs Vc DACK A0 RS CS
U10b AC02
U10a AC02
U10c AC02
U10d AC02
C67 22p
R34 100KΩ
L16 FT37-43
D1 5.1V
D2 5.1V
C73 1µF
C80 1µF
C72 1µF
C71 1µF
C79 1µF
C70 1µF
C85 1µF
C84 1µF
R22 100KΩ
R27 13.7KΩ
C92 .1µF
NDT2955 Q7
C83 .01µF
C91 .1µF
100KΩ R37
Q2 2N7002
R36 2.2KΩ
D7 5.1V
R35 22KΩ
R33 2.2KΩ
R1 470Ω
R7 470Ω
PADDLE
DASH
DOT
C4 .01µF
C2 .01µF
C68 .01
C89 .01
C88 .01
C90 .01
S1
S2
S4
S3
MENU
RIT
TUNE DN
TUNE UP
OFF_PAGE_CONNECTION
MPU/DDS/TX CIRCUITS