The KD1JV Tri-Bander CW transceiver

Hendricks QRP kits

www.qrpkits.com

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Specifications:

- Any three ham bands, 80, 40, 30, 20, 17 or 15 meters, choose at time of order.
- 5 watts output on all bands with 13.8V supply
- Built in Iambic keyer with 5 to 40 wpm code speed, selectable Iambic A or B modes and two 63 character message memories.
- Receiver sensitivity, 0.2 uV MSD
- DDS VFO for rock steady stability with 50 Hz and 200 Hz tuning rates
- Easy to read four digit LED display with leading zero suppression.
- Rotary knob tuning
- RIT (receive incremental tuning)
- Four IF crystals for excellent selectivity and opposite side band rejection
- 600 Hz audio filter
- Audio derived AGC
- Small size, 6” wide, 1.5” tall and 4” deep.
- Light weight, 12 ounces.
- Modest supply current requirements, 90 ma on receive (no signal) and 600 to 800 ma on transmit at 5W out (current depends on band, higher bands draw more current)

Operation:

Power on/off:

Power switch is part of volume control.

Band selection:

One of the three available bands are selected with a three position toggle switch (on-off-on).

- When a band is selected, the display will indicate the band in meters for a second. (80 for 80 meters, 40 for 40 meters, and so on)
- When a band is first selected after the rig is powered up, the default start up frequency (QRP calling freq for that band) is loaded. Subsequently, the last used frequency is loaded when switching between bands. This can be useful in contest situations.
- Frequency is displayed as 100 kHz, 10 kHz, 1 kHz and .1 kHz (100 Hz). MHz digits are not displayed as you should know which band your on.

Tuning:

Operating Frequency is tuned using a mechanical rotary encoder. Tuning steps are 50 Hz in slow tuning rate and 200 Hz in fast tuning rate. The 50 Hz rate is selected on power up.

- To change tuning rate: Push and hold the tuning knob to activate the built in switch. Hold closed until the Morse letter "F" (for FAST) or "S" (for SLOW) annunciates (1 second), then release.
- Since the slow tuning rate is 50 Hz and the display only shows 100 Hz digits, the display will change on every other click of the tuning encoder.

Tuning Limits:

Tuning is limited to be within the bounds of the selected band. This includes the phone segments, but reception of SSB is usually not possible due to receiving on the wrong sideband, the narrow IF and audio filters used in the rig.

RIT:

Receive integral tuning (RIT) is turned on and off by pushing the tuning knob in to active the switch for less then 1 second. The Morse letter "R" is enunciated by the side tone when the switch is released. RIT "ON" is indicated by the decimal point after the MSD (100 kHz digit) being lite. There is no tuning limit to RIT other than the normal band ends, so be careful to turn RIT off when done using it!

Keyer operation:

The Tri-bander includes a built in Iambic keyer with a speed range of 5 to 40 wpm. The keyer can be programmed to use either A or B iambic modes. Two message memories are also included. Keyer operation is controlled by the push button switch located under the display 100's digit and will be referred to as "the KEYER Switch"

Changing Keyer speed:

To active speed change, click and release the keyer switch (short click). After a short pause, (a delay to allow sending keyer message), the display will now indicate the current code speed as [C x.x]. Use the paddle to change speed. Dot = down, Dot = down. Pausing for a second will automatically exit the change speed mode and revert to normal operation.

Message memories:

Two message memories are available. Message length can be up to 63 characters, including word spaces.

Storing a message:

Click and hold closed the keyer switch until the Morse letter "M" is enunciated by the side tone. The display will blank with dashes [- - -. -]when the switch is released to indicate your in this mode.

1. Start entering in your message via the paddle. Letter and word spaces are automatically inserted when the applicable pause is detected. The pause length is the "ideal" spacing of 3 dots for a letter and 7 dots for a word.

Since many people don't pause long enough between letters and words in normal on air sending, the best way to insure a space is inserted is to pause a little longer than your used to for letters and much longer for words. A little practice will likely be needed to master the timing.

2. Once you have completed entering your message, click the keyer switch. The message you just entered will be repeated via the side tone so you can check to see how it sounds and if you made any mistakes.

3. If a mistake was made: Restart the procedure by clicking the keyer switch again. The letters "EM" will be enunciated by the side tone.

4. To store the message: Tap either the Dot or Dash paddle. Dot will store into message 1 location and Dash to message 2 location. The letters "MS" (message stored) will be enunciated by the side tone. Once a message stored, normal operation of the rig is restored.

To send a stored message:

Click the keyer switch and then quickly tap either the dot or dash paddle.

Message pause and stop.

- To *pause* a message, close the DOT paddle. If a character is being sent when the paddle is closed, the pause will start when that character has finished sending.

- To *stop* a message, close the DASH paddle. Again, if a character is being set when the paddle is closed, it will finish sending.

Setting keyer Iambic A or B mode:

The default Iambic mode is A mode. This can be switched to B mode by holding closed the KEYER switch for three (3) seconds. After the keyer memory function letter "M" has been annunciated, the next function will be the toggling of the Iambic mode. If A is currently enabled, B will be toggled on, the letter "B" will be annunciated and the display will show [b .]. Conversely, if B is currently enabled, the letter "A" will be annunciated, the display will show [A .] for a second and then escape to normal operation.

The difference between A and B modes:

When using Iambic keying, holding closed both paddles will alternately send dots and dashes, with the first element being determined by which paddle was closed first. The difference between A and B modes is what happens after the paddles are released.

- In A mode, the keyer simply stops sending.

- In B mode, an extra and opposite element is sent from the last element being sent when the paddles are released. This extra element always sent if both paddles are sensed to be closed at the same time. This means care must be taken to release one paddle before closing the other if this extra element is not desired.

Straight key mode:

Straight key mode is activated if the Dash input is grounded when you turn on the rig. This automatically happens if a monaural phone plug (normally used with a straight key) is inserted into the stereo paddle jack.

Tune up mode:

It is sometimes handy to be able to temporarily key the transmitter on and off manually with the paddle for measuring power output or allowing an autotuner to do its thing (though this is not recommended).

This mode is activated by clicking and holding the KEYER switch closed for 2 seconds. The letter "T" will be first enunciated and then display will change to a character which sort of looks like a "t" when the switch is released and tune mode becomes active.

The transmitter can now be keyed on and off with the paddle. When done, exit back to normal operation by clicking the Keyer switch again.

Speaker or headphones:

There is sufficient audio output power to drive a small 8 ohm speaker. Care should be taken when using headphones to keep the volume turned now when tuning around the band. Although the audio AGC action will limit the volume of strong stations, this can still be too much when using headphones.

Power supply voltages and fusing:

Power supply voltage to the Tri-bander should be between 13.8 and 9.5 volts. A physical fuse is not included in the board or rig case. As a safety precaution, there is a narrow section of pcb track between the power jack positive output terminal and D3, the reverse polarity protection diode. Should a short on the raw DC input supply occur, this narrow section of track should burn out and will need to be repaired after the fault is found. Since this is a one time only protection feature, using a fused supply (1 A) is highly recommended.

High SWR warning:

Operating this transmitter into a high SWR can result in damage to the PA MOSFETS. Open circuit is fine, short circuit is okay for short periods (couple of seconds), but highly reactive loads need to be avoided. Damaging SWR can result when using an antenna tuner as your trying to find a match. Auto-tuners can be a problem as they search for a match. The best way to avoid this situation is to use a resistive SWR bridge. Reducing power is also acceptable, but the only way to do that is to reduce the supply voltage to the rig. This can be done by switching a 10 ohm, 1 watt resistor in series with the power supply positive lead, using a toggle switch.

Circuit description:

Microprocessor controller and DDS VFO:

The heart of the rig is the microprocessor controller and DDS VFO. An Atmel MEGA48 processor is used for the controller. The MEGA48 controls the DDS VFO, drives the frequency display, implements the keyer functions, controls transmit and receive switching and produces the side tone. An Analog Devices AD9834 DDS chip is used for the VFO. Using a 60 MHz clock, direct frequency output to 21 MHz is possible.

Receiver:

The receiver is a classic SA612 circuit, widely used in QRP rigs. The 1st mixer input is double tuned for good image and out of band signal rejection. A four crystal IF filter using matched crystals provides good selectivity and opposite side band rejection. The use of four crystals and low profile HU-49US crystals results in noticeably better performance than three crystal filters using the tall, HU-49U crystals.

The output of the product detector, U2 is first amplified by a differential input amplifier, U3b. The second section of U3a is used as an audio band pass filter with a pass band centered at 600 Hz. This audio filter, in addition to removing high frequency hiss, adds some gain. The audio is muted during transmit by the series connected N-channel JFET Q5.

U8, a LM386 audio amp provides final gain. In addition to headphones, it is able to drive a small, 8 ohm speaker. An audio AGC circuit is built around the audio amp to limit the output volume to help protect your ears if the volume is turned all the way up and you tune across a strong station. The output level is limited to 800 mv p-p or about 10 mw rms.

AGC Circuit: The audio output of U8 is coupled to base of Q9. Q9 has a little bias voltage of about 400 mv applied to it via the resistor divider R19/R17. This allows AGC action to start when the audio level from U8 starts to exceed 400 mv instead of 600 mv, the normal turn on voltage for a NPN silicon transistor. Q7 is a P-channel JFET and is used to attenuate the audio signal going into U8 from the volume control. A 22K resistor, R15 is in series with the volume control wiper and the input to U8 so that Q7 has a dropping resistor to work against if the volume control is turned all the way up.

As the audio output level of U8 starts to exceed 400 mv, Q9 starts to turn on, reducing the voltage at Q7's gate and thereby starting to turn Q7 on and attenuate the input signal to the amplifier. The gate voltage of Q7 will find a level at which it will keep the output voltage of U8 at 400 mv peak. C41 at Q7's gate holds the AGC voltage steady.

One common problem with audio derived AGC circuits is “thumping” due to the circuit being a little slow to act on the leading edge of a signal and then “over shooting”, reducing the gain too much. The circuit used here is remarkably free of those undesirable effects.

Transmitter:

The transmitter is as simple as it can get. The AD9834 DDS chip includes a built in comparator, which when enabled during transmit, directly produces a square wave output. This is then buffered by three OR gates in parallel, using a high speed

74AC02 logic chip, which in turn drives three BS-170 MOSFET's in parallel.

The square wave drive to the MOSFETs produces fast turn on and turn off times. This, combined with the low “ON” resistance and impedance matching achieved by the Low Pass output filter, results in a reasonably high PA efficiency of about 75%. This makes it possible to produce 5 watts of output power using three plastic TO-92 devices with no heat sinking. Something not easily achieved with a traditional analog amplifier chain using bi-polar transistors. The use of a high speed logic gate to drive the PA also results in a constant drive level, independent of frequency, allowing a full 5 watt output on the higher bands with out complicated frequency compensation or drive adjustment controls.

The PA is keyed on and off with a P-channel MOSFET. A 0.01 ufd cap between the Gate and Drain output produces a 5 ms rise and fall time to the keyed voltage for key click suppression. The use of a MOSFET here instead of a PNP transistor results in less voltage drop, easier control of the rise and fall times due to the high impedance gate input.

Parts List

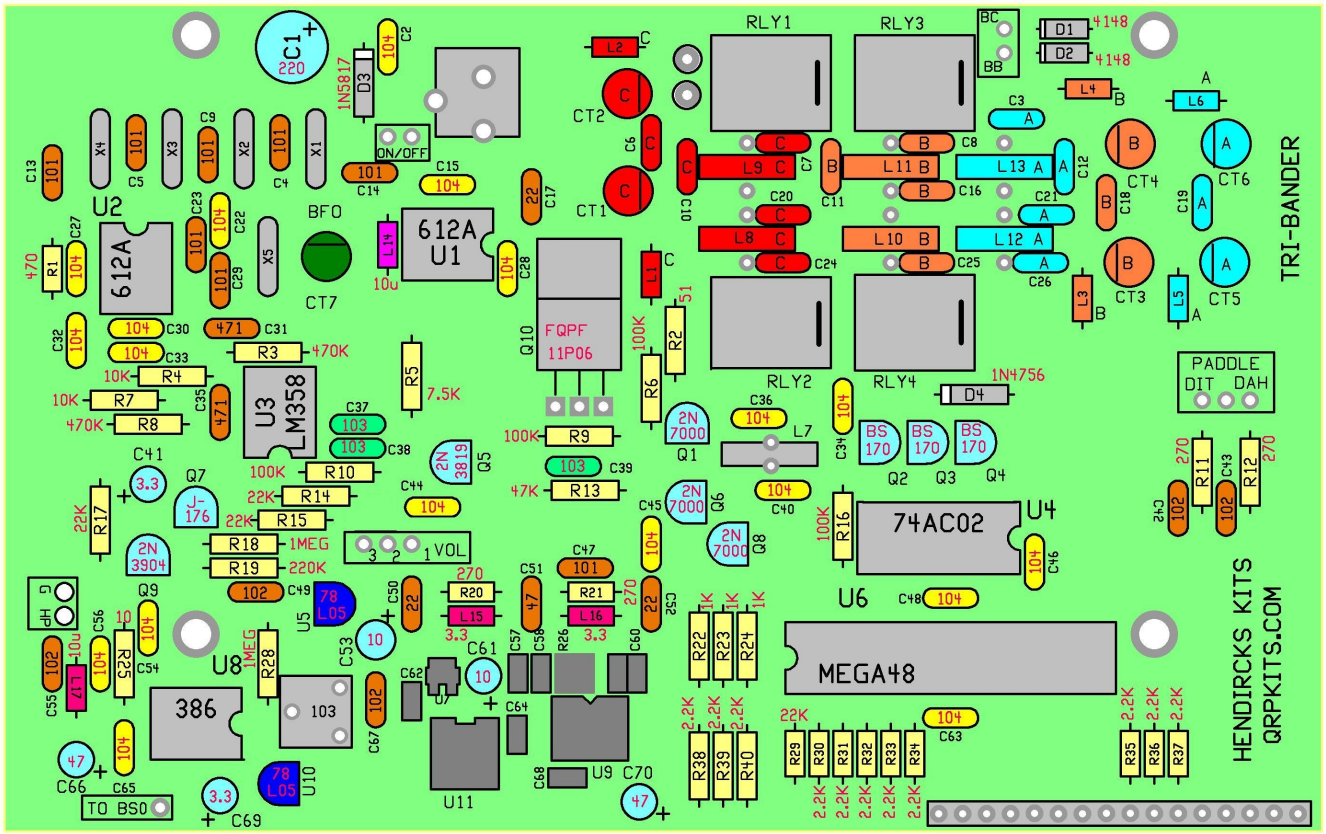
	QTY	VALUE	Markings/type			QTY	VALUE	Markings/type
	1	10 ohms	BRN/BLK/BLK/GLD			3	BS-170	MOSFET TO-92
	1	51 OHMS	GRN/BRN/BLK/GLD			1	J-171	P-channel j-fet TO-92
	4	270 OHMS	RED/VOL/BRN/GLD			1	2N3819	N-channel j-fet TO-92
	1	470 OHMS	YEL/VOL/BRN/GLD			1	2N3904	NPN TO-92
	3	1 K	BRN/BLK/RED/GLD			3	2N7000	MOSFET TO-92
	11	2.2 K	RED/RED/RED/GLD			1	FQPF11P06	P-CHN MOSFET TO-220F
	1	7.5 K	VOL/GRN/RED/GLD			2	78L05	5V, 100 ma regulator
	3	10 K	BRN/BLK/ORG/GLD			2	1N4148	SS diode
	5	22 K	RED/RED/ORG/GLD			1	1N4756B	47 V 1W zener
	2	47 K	YEL/VOL/ORG/GLD			1	1N5817	1A shottky diode
	4	100 K	BRN/BLK/YEL/GLD					
	1	220 K	RED/RED/YEL/GLD			2	SA612A	8 pin DIP mixer/osc
	2	470 K	YEL/VOL/YEL/GLD			1	LM358N	8 pin DIP dual op amp
	1	1MEG	BRN/BLK/GRN/GLD			1	LM386	8 pin DIP Audio amp
	1	10 K	6 mm trimmer resistor			1	74AC02N	14 pin DIP quad OR gate
	1	10 K	Volume with switch			1	ATMEGA 48	28 pin DIP microprocessor
						1	4 digit led	Multiplex display
	2	3.3 uHy	GRN/GRN/GLD/GLD - RFC			4	DPDT DIP relay	5V
	2	10 uHy	BRN/BLK/BLK/GLD - RFC			4	8 pin DIP socket	
						1	14 pin DIP socket	
	1	30 pfd	Green trimmer cap			1	28 pin DIP socket	0.3” width
	3	22 pfd	22 NPO disk			5	4.91520 MHz	HU-49US crystal matched
	1	47 pfd	47 NPO disk			1	FT37-43	Black, ferrite toroid core
	8	100 pfd	101 NPO disk			1	2.5 mm	Power Jack, PC mount
	2	470 pfd	471 disk			1	6 mm x 13 mm	TACK switch
	7	0.001 uFd	102 disk			1	16 pin, right angle	SIP pin strip
	3	0.01 uFd	103 Film			1	Rotary Encoder w/sw	
	18	0.1 uFd	104 MONO, X7R			1	DPDT toggle	Center off (on-off-on)
	2	3.3 uFd/16V	Alum electrolytic			2	Stereo panel jack	
	2	10 uFd/16V	Alum electrolytic			1	BNC panel jack	
	2	47 uFd/16V	Alum electrolytic			1	5 feet	Insulated hook up wire, #24
	1	220 ufd/16V	Alum electrolytic			1	Front panel	PCB
	1	1 foot	#28 magnet wire			1	Main PCB	
	1	270 ohm 0805	Pre-mounted SMT part			1	Case, top	
	1	3.6 K 0805	Pre-mounted SMT part			1	Case, bottom	
	1	0.1 ufd 0805	Pre-mounted SMT part			1	Red film	
	1	1000 pfd 0805	Pre-mounted SMT part			1	Small knob	
	4	0.01 ufd 0805	Pre-mounted SMT part			1	Large knob	
	1	22 pfd 0805	Pre-mounted SMT part			1	Tilt stand bale	
	1	60.00 MHz osc	Pre-mounted SMT part			2	Bale mounting blocks	
	1	AD9834 DDS	Pre-mounted SMT part			7	# 4-40 1/4” pan head	screws
	1	3.3V reg	Pre-mounted SMT part			2	# 4-40 1/4” flat head	screws

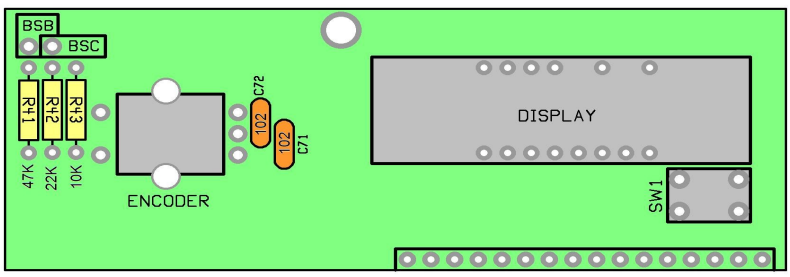
Assembly Instructions:

The quickest and easiest way to build the rig is in "layers". The lowest profile parts are installed first, such as resistors and diodes, then higher profile parts such as capacitors and so on. Once the board is populated with all the parts, testing will be done by inserting the various Integrated Circuit chips one at a time and testing the associated stages they are used with.

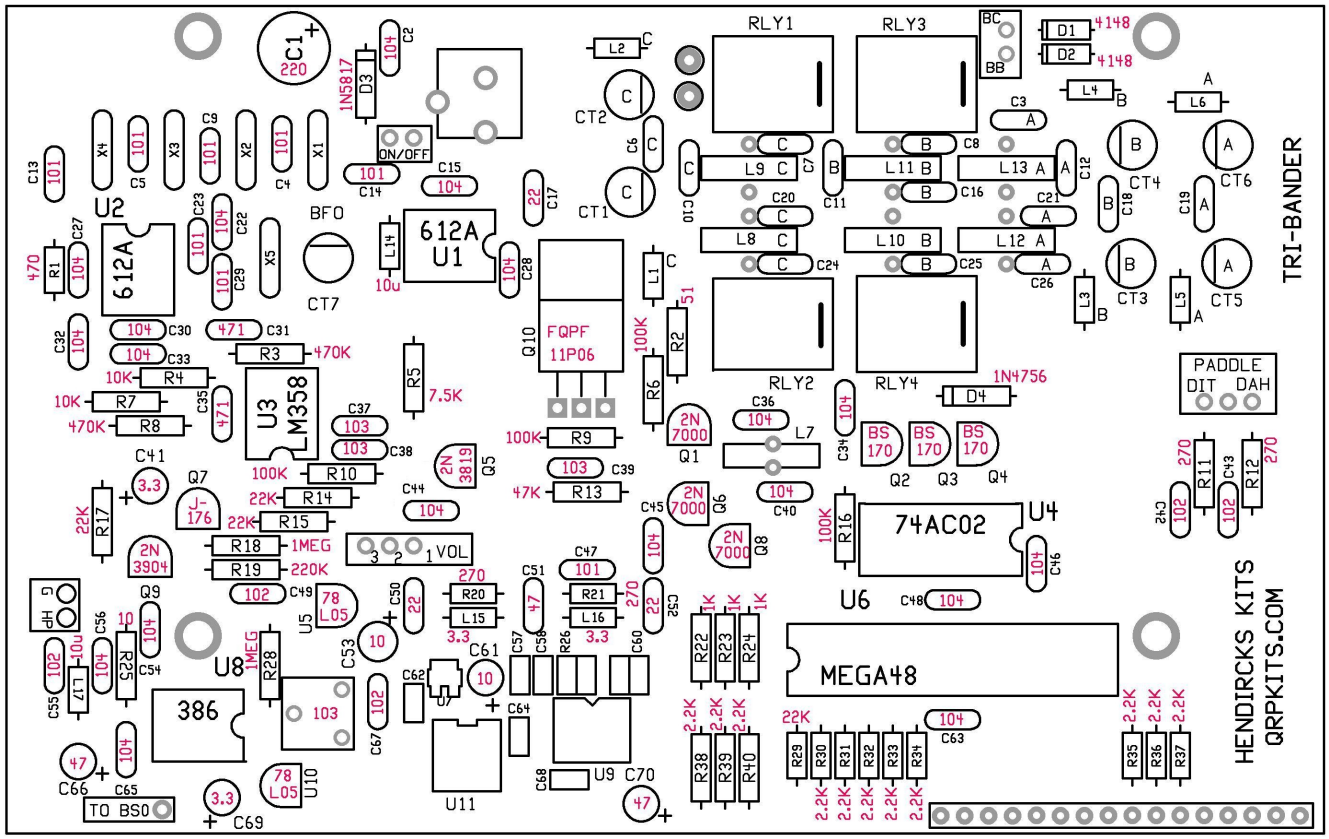
Before you start assembly, it is helpful to sort the parts into types and values. Using a number of paper or plastic picnic bowls to sort the parts into is a good idea to keep parts from getting lost on the bench. If you loose, damage or are missing a part, send a message to parts@qrpkits.com for a replacement. Please specify the part type and value. For example, instead of saying you need R22, say you need a 1K resistor. Otherwise, we will have to look up the parts list for the kit and figure out what R22 is and that can delay getting you that part.

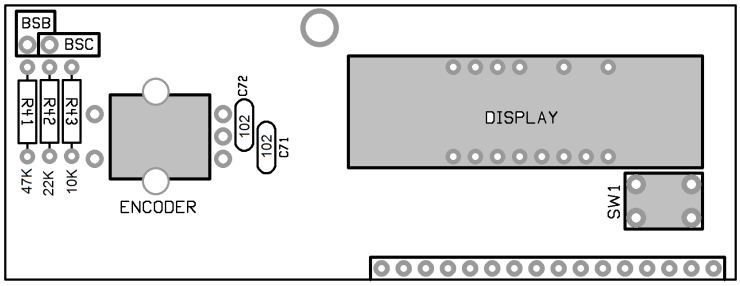
In general, parts are numbered on the board in rows, starting with the lowest part number in the upper left corner of the board (this is the back end), and then run left to right and then zig-zag down the board to the front end. Parts will be inserted in that order. Part values are labeled on the parts placement diagram for easy reference. There are two placement diagrams included. The first is in color, which makes the various parts types stand out better, but would use a lot of ink to print out. A second, ink jet friendly diagram is also included. At least one of these diagrams should be printed out for easy reference as you build up the board. Note that the band specific parts have no value labeled. See band table for values later in manual.





Ink jet friendly diagram:





Cabinet preparation:

Before starting on the board assembly, the cabinet should be prepared first. This way, it will be ready to go when you finish building the board.

1. Clean the cabinet.
2. (optional) paint the cabinet.
3. Apply decals.
    - When labeling the band select switch, note that the center position should be the lowest frequency band.
4. Attach tilt stand bale to bottom of cabinet.
5. Attach Red film over display cutout. Trim edges as required to clear mounting studs. Hole for switch can be made with paper punch. Tape in place.

Decal instructions:

The decals are applied in the same manor as model decals. Cut around each group of text or symbols you wish to apply. It doesn't have to be perfect as the background film is transparent. Use the picture on the first page as a guide for where the decals go. Be sure to get the correct spacing away from the holes, as it is very easy to do a great decal installation and have a portion covered up with a knob.

Thoroughly clean the surface of the panel to remove any oils or contamination. Use dish washing liquid soap and water (rise well), denatured alcohol or paint thinner. We have found that moving the decals into position on bare aluminum chassis is difficult, due to the brushed surface, so we advise pre-coating the chassis with the Krylon clear before applying the decals. (Unless you have elected to paint the chassis first).

1. Trim around the decal.
2. After trimming, place the decal in a bowl of lukewarm water, with a small drop of dish soap to reduce the surface tension, for 10-15 seconds.
3. Using tweezers, handle carefully to avoid tearing. Start to slide the decal off to the side of the backing paper, and place the unsupported edge of the decal close to the final location.
4. Hold the edge of the decal against the panel, with your finger, and slide the paper out from under the decal. You can slide the decal around to the right position, as it will float slightly on the film of water. Use a knife point or something sharp to do this.
5. When in position, hold the edge of the decal with your finger and gently squeegee excess water out from under the decal with a tissue or paper towel. Work from the center, to both sides. Remove any bubbles by blotting or wiping gently to the sides. Do this for each decal, and take your time.
6. Allow to set overnight, or speed drying by placing near a fan for a few of hours.
7. When dry, spray two **light** coats of matte finish, Krylon, clear to seal and protect the decals, and allow to dry in between coats.

- All decals come with two complete sets, in case you mess one up.

Part by part placement guide: Resistors

pay attention to values highlighted as they can be easily confused with values with similar color coding.

√	location	Value	Color code		√	Location	Value	Color code
	R1	470 Ω	YEL/VOL/BRN/GLD			R21	270 Ω	RED/VOL/BRN/GLD
	R2	51 Ω	GRN/BRN/BLK/GLD			R22	1 K	BRN/BLK/RED/GLD
	R3	470 K	YEL/VOL/YEL/GLD			R23	1 K	BRN/BLK/RED/GLD
	R4	10 K	BRN/BLK/ORG/GLD			R24	1 K	BRN/BLK/RED/GLD
	R5	7.5 K	VOL/GRN/RED/GLD			R25	10	BRN/BLK/BLK/GLD
	R6	100 K	BRN/BLK/YEL/GLD			R26	3.9 K	SMT PREINSTALLED
	R7	10 K	BRN/BLK/ORG/GLD			R27	270 Ω	SMT PREINSTALLED
	R8	470 K	YEL/VOL/YEL/GLD			R28	1 MEG	BRN/BLK/GRN/GLD
	R9	100 K	BRN/BLK/YEL/GLD			R29	22 K	RED/RED/ORG/GLD
	R10	100 K	BRN/BLK/YEL/GLD			R30	2.2 K	RED/RED/RED/GLD
	R11	270 Ω	RED/VOL/BRN/GLD			R31	2.2 K	RED/RED/RED/GLD
	R12	270 Ω	RED/VOL/BRN/GLD			R32	2.2 K	RED/RED/RED/GLD
	R13	47 K	YEL/VOL/ORG/GLD			R33	2.2 K	RED/RED/RED/GLD
	R14	22 K	RED/RED/ORG/GLD			R34	2.2 K	RED/RED/RED/GLD
	R15	22 K	RED/RED/ORG/GLD			R35	2.2 K	RED/RED/RED/GLD
	R16	100 K	BRN/BLK/YEL/GLD			R36	2.2 K	RED/RED/RED/GLD
	R17	22 K	RED/RED/ORG/GLD			R37	2.2 K	RED/RED/RED/GLD
	R18	1 MEG	BRN/BLK/GRN/GLD			R38	2.2 K	RED/RED/RED/GLD
	R19	220 K	RED/RED/YEL/GLD			R39	2.2 K	RED/RED/RED/GLD
	R20	270 Ω	RED/VOL/BRN/GLD			R40	2.2 K	RED/RED/RED/GLD

Molded inductors:

There are four (4) molded inductors (RFC) to install. These look like resistors but are a little shorter and fatter. Like resistors, the value is also color coded on the body of the part.

- Install L15/L16 – 3.3 uhy ORG/ORG/GLD/GLD
- Install L14/L17 – 10 uhy BRN/BLK/BLK/GLD

Diodes: Be sure to observe proper polarity. Band near end of part goes towards line on part outline.

- Install D1/D2 – 1N4148 small glass body
- Install D3 – 1N5817 large plastic body.
- Install D4 – 1N4756A large glass body

Crystals:

The crystals are now installed, the locations are shown filled in with light gray. All the crystals are matched and the same frequency, so it doesn't matter which ones go where. The cans of the X1 to X4 crystals should be tack soldered to the solder pad located next the the body of the crystal. This should be done now, as getting an iron in after the near-by capacitors are installed will be difficult.

- Install X1 to X5

IC sockets:

- IC sockets are now installed. Make sure notch in socket is aligned with notch on part outline on board.
- Before soldering, make sure they are flush to the board and that all the pins are sticking out of the holes on the bottom of the board. If a pin gets bent over as you are inserting the socket, this will be difficult to fix once the other pins have been soldered.
- U1, U2, U3, U8 – 8 pin socket

- U4 – 14 pin socket
- U6 – 28 pin socket

Capacitors:

There are four types of capacitors used.

- Multi-layer (MONO) caps, which are generally yellow and rectangular is shape.
- NPO type disks will have a black dot on the top edge of the cap. Note. Some of the ceramic disk caps will have lead spacing wider then the hole spacing on the board. In this case, use your needle nose pliers to kink both leads inward slightly to match the board hole spacing.
- Film capacitors. These will be green in color.
- Aluminum Electrolytic. These are round cylinders and have polarity. They must be installed with the correct polarity. Electrolytic caps inserted with the wrong polarity across the DC supply can heat up and explode! The negative lead is marked with a black stripe and the positive lead is always the longer lead.

Capacitor value markings:

The capacitor value is marked on the part with a two or three digit number and is read in picofards. The third digit is the zero multiplier. Values of less than 100 pfd generally show only two digits, but sometimes three. Therefore, if a part is marked 470, that means it is a 47 pfd cap and not a 470 pfd cap. A 470 pfd cap would be marked 471. Mono caps also often have letters printed on the part. These letters indicate the type or tolerance and can be disregarded.

NOTE: Electrolytic, band specific values (will be installed later) and pre-installed SMT caps are not listed in table below

√	location	value	type	√	location	value	type
	C2	0.1 ufd (104)	MONO, YELLOW		C37	0.01 ufd (103)	FILM, GREEN
	C4	100 pfd (101)	NPO DISK, BROWN		C38	0.01 ufd (103)	FILM, GREEN
	C6	100 pfd (101)	NPO DISK, BROWN		C39	0.01 ufd (103)	FILM, GREEN
	C9	100 pfd (101)	NPO DISK, BROWN		C40	0.1 ufd (104)	MONO, YELLOW
	C13	100 pfd (101)	NPO DISK, BROWN		C42	.001 ufd (102)	DISK, BROWN
	C14	0.1 ufd (104)	MONO, YELLOW		C43	.001 ufd (102)	DISK, BROWN
	C15	0.1 ufd (104)	MONO, YELLOW		C44	0.1 ufd (104)	MONO, YELLOW
	C17	22 pfd (22)	DISK		C45	0.1 ufd (104)	MONO, YELLOW
	C22	0.1 ufd (104)	MONO, YELLOW		C46	0.1 ufd (104)	MONO, YELLOW
	C23	100 pfd (101)	NPO DISK, BROWN		C47	100 pfd (101)	NPO DISK, BROWN
	C27	0.1 ufd (104)	MONO, YELLOW		C48	0.1 ufd (104)	MONO, YELLOW
	C28	0.1 ufd (104)	MONO, YELLOW		C49	.001 ufd (102)	DISK, BROWN
	C29	100 pfd (101)	MONO, YELLOW		C50	22 pfd (22)	DISK NPO
	C30	0.1 ufd (104)	MONO, YELLOW		C51	47 pfd (47)	DISK NPO
	C31	470 pfd (471)	DISK, BROWN		C52	22 pfd (22)	DISK NPO
	C32	0.1 ufd (104)	MONO, YELLOW		C54	0.1 ufd (104)	MONO, YELLOW
	C33	0.1 ufd (104)	MONO, YELLOW		C55	.001 ufd (102)	DISK, BROWN
	C34	0.1 ufd (104)	MONO, YELLOW		C56	0.1 ufd (104)	MONO, YELLOW
	C35	470 pfd (471)	DISK, BROWN		C63	0.1 ufd (104)	MONO, YELLOW
	C36	0.1 ufd (104)	MONO, YELLOW		C65	0.1 ufd (104)	MONO, YELLOW
					C67	.001 ufd (102)	DISK, BROWN

- Trimmer capacitor CT5 – Green trimmer. Make sure the flat side of the part is facing the line drawn in the circle outline on the board.

- Trimmer resistor V2 – (between R28 and C67, to the right of U8). You will need to reform the leads some to match the hole spacing.

Transistors:

Be sure to properly ready the part number on the three legged transistors so they go in the proper place. A magnifying glass maybe helpful for this. When installing the part, look out of thin shavings of the plating on the leads which might come off as you push the legs into the holes. These can cause shorts between the leads. Space the package about 1/8" above the board – no not push real close to the board. Also, be sure to orientate the flat side of the package with the flat side of the part outline.

- □ Install Q2, Q3, Q4 – BS170 mosfets – these are static sensitive!
- □ Install Q1, Q6, Q8 – 2N7000 mosfets – these are also static sensitive.
- □ Install Q9 – 2N3904 NPN
- □ Install Q5 – 2N3819 j-fet
- □ Install Q7 – J-176 j-fet
- □ Install U5/U10 – 78L05 5V regulator
- □ Install Q10, FQPF11P06 – bend leads 90 degrees to body and mount flush to board.

- Now install all the Electrolytic capacitors. Be sure to observe proper polarity. Long lead is plus side. Black stripe on the body of the can indicates negative side. C1 can explode if installed backwards!

  - □ C1 - 220 ufd /16V
  - □ C41, C69 3.3 ufd /16V
  - □ C53, C61 10 ufd /16V
  - □ C66, C70 47 ufd /16V

- DC power jack relays and the right angle SIP pin strips.

  - □ Install DC power jack
  - □ Install the four (4) relays, RLY1, RLY2, RYL3 and RYL4. Note the line on one end of the relay and match this with the line on the board relay outline.

- Wind L7 – 10 turns #28 magnet wire on FT37-43 core (black) Do not install at this time, put aside for use later after initial board testing.
- Proceed to installing band specific parts as listed in table on next page.

Band specific parts:

Part locations are listed in table for band A, then band B and then Band C. The lowest frequency band should be made band A and the highest frequency band C. For example, band A could be 80 meters, while band C would be 15 meters, but not the other way around. This ensures the highest frequency band has the shortest track lengths.

On the color parts layout, band A parts are shown highlighted in light Blue, band B parts in Orange and band C parts in Red.

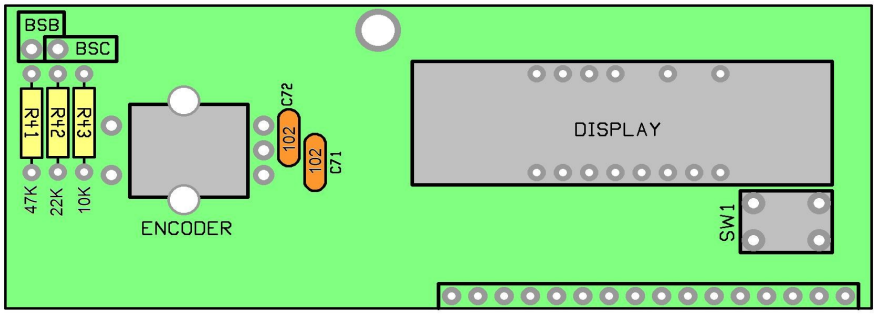
- Be sure to count the turns on the low pass filter coils, L8 through L13 correctly. Each time the wire passes through the center of the core, this is one turn. Having one extra turn, which is a common mistake, will result in reduced power output. Also the turns should be reasonably tight to the core. Sloppy winding can result in reduced performance. Evenly space the turns around the core.

80			Value	Type		**40**			Value	Type
A	**B**	**C**				**A**	**B**	**C**		
C12	C11	C10	100 pfd	101 NPO Disk		C12	C11	C10	68 pfd	NPO disk
C3	C8	C7	680 pfd	681 mono C0G		C3,	C8	C7	330 pfd (331)	C0G
C21	C16	C20	1500 pfd	152 mono C0G		C21	C16	C20	680 pfd (681)	C0G
C26	C25	C24	680 pfd	681 mono C0G		C26	C25	C24	330 pfd (331)	C0G
C19	C18	C5	15 pfd	15 NPO Disk		C19	C18	C5	10 pfd	NPO disk
CT5/6	CT3/4	CT1/2	70 pfd	Brown trimmer		CT5/6	CT3/4	CT1/2	70 pfd trimmer	Brown
L12	L10	L8	24 turns	#30 wire T37-2 Red		L12	L10	L8	18 turns	#28 wire T37-2 Red
L13	L11	L9	29 turns	#30 wire T37-2 Red		L13	L11	L9	20 turns	#28 wire T37-2 Red
L5/6	L3/4	L1/2	39 uHy	ORG/WHT/BLK/GLD		L5/6	L3/4	L1/2	12 uHy	BRN/RED/BLK/GLD

30			Value	Type		**20**			Value	Type
A	**B**	**C**				**A**	**B**	**C**		
C12	C11	C10	47 pfd	47 NPO Disk		C12	C11	C10	22 pfd	22 NPO Disk
C3	C8	C7	220 pfd	221 mono C0G		C3,	C8	C7	150	151 mono C0G
C21	C16	C20	560 pfd	561 mono C0G		C21	C16	C20	330	331 mono C0G
C26	C25	C24	220 pfd	221 mono C0G		C26	C25	C24	150	151 mono C0G
C19	C18	C5	4.7 pfd	4.7 NPO Disk		C19	C18	C5	2.2 pfd	2.2 NPO Disk
CT5/6	CT3/4	CT1/2	30 pfd	Green trimmer		CT5/6	CT3/4	CT1/2	30 pfd	Green trimmer
L12	L10	L8	13 turns	#28 wire T37-2 Red		L12	L10	L8	13 turns	# 28 wire T37-6 Yellow
L13	L11	L9	16 turns	#28 wire T37-2 Red		L13	L11	L9	16 turns	#28 wire T37-6 Yellow
L5/6	L3/4	L1/2	8.2 uHy	GRY/RED/GLD/GLD		L5/6	L3/4	L1/2	5.6 uHy	GRN/BLU/GLD/GLD

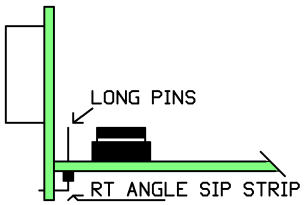
17			Value	Type		**15**			Value	Type
A	**B**	**C**				**A**	**B**	**C**		
C12	C11	C10	15 pfd	15 NPO disk		C12	C11	C10	15 pfd	15 NPO disk
C3	C8	C7	47 pfd	47 mono C0G		C3,	C8	C7	47 pfd	47 mono C0G
C21	C16	C20	220 pfd	221 mono C0G		C21	C16	C20	220 pfd	221 mono C0G
C26	C25	C24	100 pfd	101 mono C0G		C26	C25	C24	100 pfd	101 mono C0G
C19	C18	C5	2.2 pdf	2.2 NPO Disk		C19	C18	C5	2.2 pfd	2.2 NPO Disk
CT5/6	CT3/4	CT1/2	30 pfd	Green trimmer		CT5/6	CT3/4	CT1/2	30 pfd	Green trimmer
L12	L10	L8	13 turns	# 28 wire T37-6 Yellow		L12	L10	L8	11 turns	#28 wire T37-6 yellow
L13	L11	L9	16 turns	# 28 wire T37-6 Yellow		L13	L11	L9	14 turns	#28 wire T37-6 yellow
L5/6	L3/4	L1/2	3.3 uHy	ORG/ORG/GLD/GLD		L5/6	L3/4	L1/2	3.3 uHy	ORG/ORG/GLD/GLD

Front panel board assembly:



- R41, 47 K (YEL/VOL/ORG/GLD)
- R42, 22 K (RED/RED/ORG/GLD)
- R43, 10 K (BRN/BLK/ORG/GLD)
- C72, 102 disk
- C71, 102 Disk
- LED display module. This can only go in one way, keyed to missing pins on display and board.
- TACK PB Switch. This can also go in only one way. NOTE: Clip leads along bottom side of switch (just above the holes for the SIP pins) flush to the board and solder pins from front side of board.
- Encoder.

Mating Front panel board to Main board:

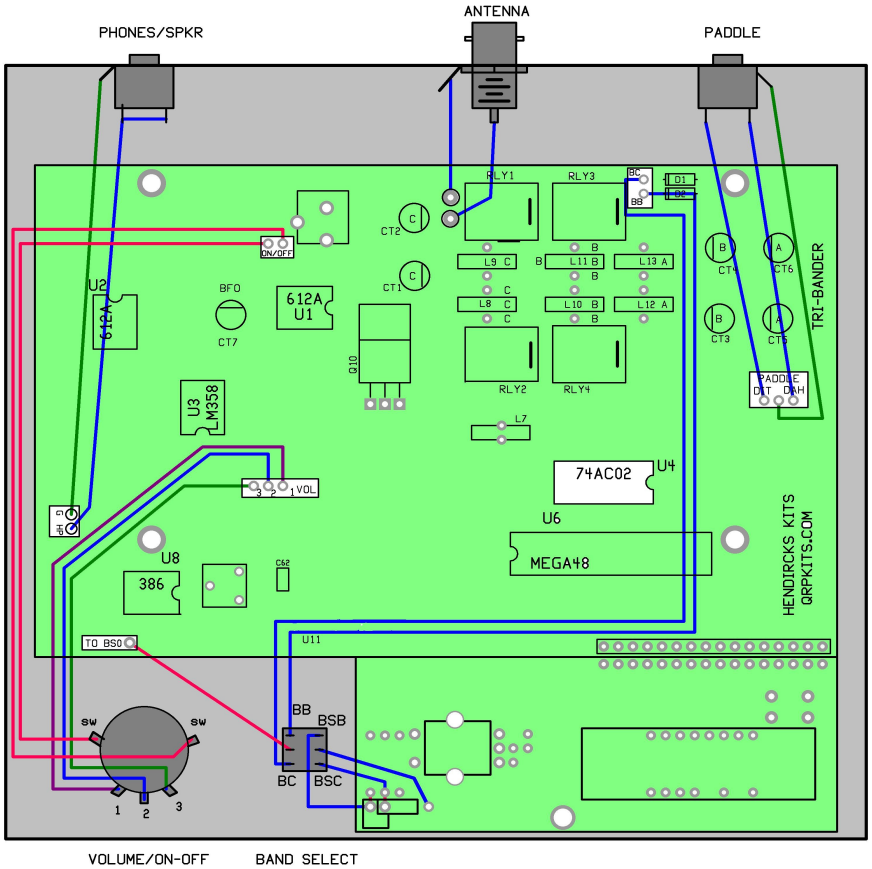


1. Insert long leads of SIP pin strip up through bottom side of main board.
2. Solder pins and clip off excess pin length
3. Attach front panel board to pins. Very little of the pins will stick through the pads on the front panel board. Solder one pin on the end of the strip from the back side of the board.
4. Make sure front panel board is pushed tight up against edge of main board and is at an exact right (90 degree) angle to the main board.
5. Solder the rest of the pins, again from the back side of the board.

Board mounting into cabinet and wiring:

- The band select switch and volume control are best wired to the board before it is installed into the case.
- Cut the hook up wire to the lengths listed in the table.
- Wires connecting to the on/off switch and volume control should be routed under the board.
- The two wires connecting from the band switch to the relays should be routed as shown in the diagram and *not* the shortest possible path diagonally across the board.
- Insert and solder the wires for the rear panel jacks, headphone, paddle and antenna.
- The board is now inserted into bottom section of the case by angling it in, making sure the shaft for the tuning encoder and Keyer PSB switch are lined up with their respective holes. In addition, the Band select switch and volume control will need to lined up and inserted into their mounting holes before the board can be fully inserted into the cabinet bottom.
- Once the board is in place, the headphone, paddle and antenna jacks can be installed and wired up.

On/Off	2 wires, 5" long
VOL 1,2,3	3 wires, 3" long
RLY BB/BC	2 wires, 7" long
Band SW BSB/BSC	2 wires, 1" long
Band SW BS0	1 wire, 1" long
Phones/Spkr	2 wires, 3 1/2" long
Paddle	3 wires, 2 1/2" long
ANTENNA (BNC jack)	2 wires, 1" long



Power up and test:

1. Wire up the power plug, center pin plus. Connect to power supply, plug into power jack on rig.
2. Turn power on via volume control.
3. Test for 5 volts between pins 8 and 3 of U1 or U2 (tests analog 5V reg, U5) and between pins 14 and 7 of U4 (tests digital 5V reg, U10).
4. Remove power from rig.
5. Insert ATMEGA-48 chip into U6 socket. Just in case you put the socket in backwards, verify chip direction with parts layout diagram.
6. Insert LM386 chip into U8 socket
7. Plug a paddle into the paddle jack.
8. Plug speaker or headphones into headphone jack
9. Apply power to rig and turn on.
10. The display should now come on and read [bA8.0]

- You must now program the processor so it knows which frequency (in meters) you have selected for band A, B and C. bA80 shown on the display indicates band A is currently set to 80 meters.

1. Change the band setting by tapping the DOT paddle. This will advance the setting from 80 to 40, 40 to 30 and so on. The display will change accordingly and a beep will sound. [bA4.0], [bA3.0] and so on.
2. Once the proper band setting is selected, advance to the next band by clicking the keyer switch located under the display. The display will now show [bb80]
3. Select the band setting for the B band
4. Click keyer switch to advance to C band.
5. Select the band C band
6. Click the keyer switch to finish. The rig will reset to it's normal operation.

- If a mistake is made or at some point you what to change the filters on one of the band positions to operate on a different band, the band select mode can be enabled by holding closed the DASH paddle and the KEYER switch while turning power to the rig on.

- The keyer will now be operational and you can send some Morse. Side tone level can be adjusted using the trimmer resistor to the right of U8.

Receiver testing and BFO adjustment:

1. Disconnect power from rig
2. Insert SA162A chips into U1 and U2 sockets
3. Insert LM358 into U3 socket.
4. Insert LM386 into U8 socket.

- Hold closed the DOT paddle and KEYER switch while turning power to the rig on.
- The rig will now be in a calibration mode and the display will show [CAL.r]
- If an accurate frequency counter is available, the DDS reference frequency can now be calibrated. Since the typical frequency error is usually 50 Hz or less, the calibration can be skipped by going to step 4 if a suitable frequency counter is not available.

    1. DDS frequency can be picked off of Pin 7 on U1 or at the U9, Pin 20/C60 junction.
    2. The DDS frequency is calibrated to exactly 10.000,000 MHz
    3. Use the Dot and Dash paddles to tune the DDS frequency up or down as required to set the frequency to 10.000,000 MHz.
    4. Finish by clicking the KEYER switch. This will advance to the offset/BFO adjust mode. The display will now show [CAL.o]

- If an Oscilloscope is available (it can be audio PC based 'Scope) the IF offset frequency can be set in addition to the BFO frequency. If a 'Scope is not available, the BFO trimmer will have to be set by ear. (skip to step)
    1. Connect the 'Scope to pin 7 of U3 (output of 1st audio stage).
    2. Preset BFO trimmer (CT7) about ¼ turn.
    3. Using the paddle, tune LO frequency up and down, noting the point at which the signal amplitude starts to drop off.
    4. Tune the LO frequency be more or less centered in the pass band of the IF filter.
    5. Move the 'Scope to pin 1 of U3 (or top of volume control)
    6. Adjust BFO trimmer to peak signal in pass band of Audio Filter. If a 'Scope is not available, peak by ear, keeping volume control turned down so that AGC is not engaged.
    7. Once adjustments are finished, click the KEYER switch again to store these values and rest the rig.

- NOTE: When entering the Calibration mode, the default frequency values for reference and IF offset are loaded.

This is done in case the values now stored in EEPROM become corrupted. Therefore, it is not possible to "test" the calibration by re-entering the calibration mode. If you wish to test the calibration, measure the transmit frequency on the highest band you have chosen to install into the rig, before and after calibration.

If you were able to set the BFO trimmer, everything up to the 1st mixer is working correctly. You can now connect up an antenna (or signal generator) and peak the receiver input trimmer caps for each band. Peak for band noise or signal strength. The receiver will be quite deaf until the trimmers are properly peaked.

Transmitter testing:

1. Remove power supply from board.
2. Insert the 74AC02 into U4 socket
3. Install L7. You will need to remove the board from the case to do this.
4. Connect power meter and dummy load to antenna jack.
5. Plug a straight key into the paddle jack or close the Dash paddle when turning on power so transmitter can be keyed on and off.
6. Check power output on all three bands. Using a 13.8 volt supply, the power output should be about 5 watts.

- Power output can be tweaked to some extent by changing the spacing of the turns on the low pass filter cores. With a little experimentation, it should be possible to achieve 5 watts output on each band.
    - Coils L8, L10 and L12 will have the most effect on power output. These are the inductors which follow the PA FETS, and influence the matching between the PA and load. When the turns on L8. L10 and L12 are most evenly spaced around the core, this will result in the maximum power output. Moving the turns closer together will reduce power output.
    - The inductors L9, L11 and L13 also have some effect on power output. These work opposite of the input side inductors, moving the turns closer together reduces power output.

Trouble shooting guide:

In most cases, any problems with the getting the rig to work will be tracked down to soldering problems or miss placed parts. A close visual inspection of the board is often enough to find soldering problems or the miss-placed parts.

Soldering problems fall into four groups:

1. Missing solder connections
2. Solder bridges between closely spaced pads which should not be connected togther.
3. Solder which stuck to the part lead but did not flow into the solder pad on the board. This is often caused by not using enough heat or not placing the iron tip on both the lead and the solder pad.
4. Not making connection to the wires on the toroid coils. Even if you pre-tined the magnet wire, you may have pulled it past the tinning when inserting the wires into the board and are not making a connection. Buzz out the connection to ensure continuity.

Miss-placed parts:

The most common error here is not reading the resistor color code correctly. Some values have identical colors, but in a different order. It is easy to mistake a 51 ohm resistor (Green/Brown/Black) for a 1 Meg resistor (Brown/Black/Green)

Trouble shooting technique:

The trick to trouble shooting is being able to narrow down the area to look at to find the problem. Just using a DVM will be sufficient for basic trouble shooting. For more difficult cases, an Oscilloscope and signal generator may be needed to track signals through the circuits.

In any case, one should first determine which parts of the circuit are working properly and this will lead you to what is not. If the rig is completely dead, the problem is likely with the power supply and could very well be a short to ground somewhere on the 5 volt supply feeding most of the IC's. If the display comes on, the microprocessor is working and if you get side tone when you use the paddle, or hear hiss when the volume control is turned all the way up, the audio amp is working. If there is no side tone or hiss, the problem maybe a simple as the wiring to the speaker/headphone jack or you may have forgotten to install the two SIP pins to the left of the main row of pins. If missing pins is the problem, use resistor lead clippings to make the connections, as unsoldering the main row of pins to add the missing ones will be difficult.

If you get audio, but can not hear any off air signals, the problem is more difficult to find as it could be anywhere between the antenna jack and the audio amp. In this case having a signal generator and Oscilloscope are of great help in tracing the signal though the circuits.

Transmitter:

There is not a whole lot which can go wrong with the transmitter portion. Check for PA keying voltage coming out of Q10, proper soldering of the toroid magnet wire.

The voltage tables below may be of help.

U4 74AC02 PA driver, Quad NOR gate

Pin#	Voltage	Pin#	Voltage
1	0	14	5V
2	0	13	0
3	5V	12	5V
4	0V	11	0
5	5V	10	5V
6	0	9	0
7	0	8	0

U1/U2 SA612A Mixers

Pin#	Voltage	Pin#	Voltage
1	1.4V	8	5V
2	1.4V	7	4.25V
3	0	6	4.96V
4	3.9V	5	3.9V

Pin1/2 signal in Pin 6 Osc in
Pin 4/5 signal out Pin 7 Osc out

DC Voltage on pins 6/7 maybe influenced by RF present on pins.

U3 LM358 audio preamp / BP filter

Pin#	Voltage	Pin#	Voltage
1	5V	8	DCIN
2	5V	7	5V
3	5V	6	5V
4	0 (GND)	5	5V

DCIN = board supply voltage, less diode drop.

U8 LM386 audio power amp

Pin#	Voltage	Pin#	Voltage
1	1.33V	8	1.34V
2	0	7	½ DCIN
3	0	6	DCIN
4	0 (GND)	5	½ DCIN

U6 MEGA48 Microprocessor

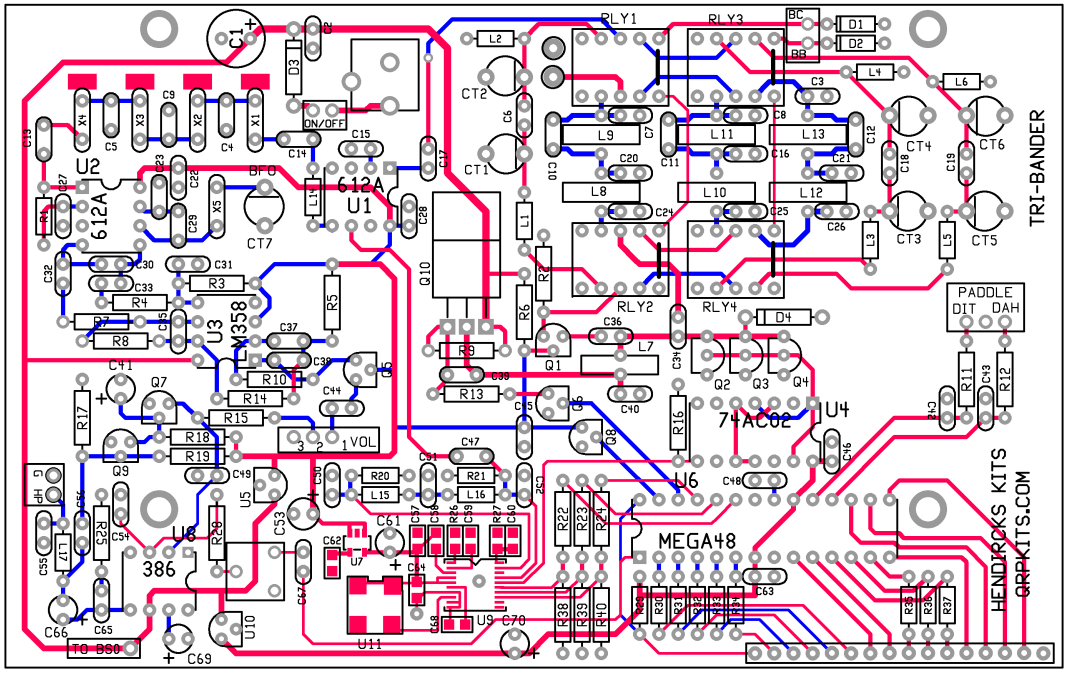
Volt	5V	0V	0V	0V	5V	0V	0V	5V	5V	5V	5V	DS	5/0	5/0
Pin#	28	27	26	25	24	23	22	21	20	19	18	17	16	15
Pin#	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Volt	0V	DS	DS	DS	DS	DS	5V	0V	DS	DS	DS	DS	DS	DS

DS = Display segment or digit select voltage varies depending on digits displayed and duty cycle.

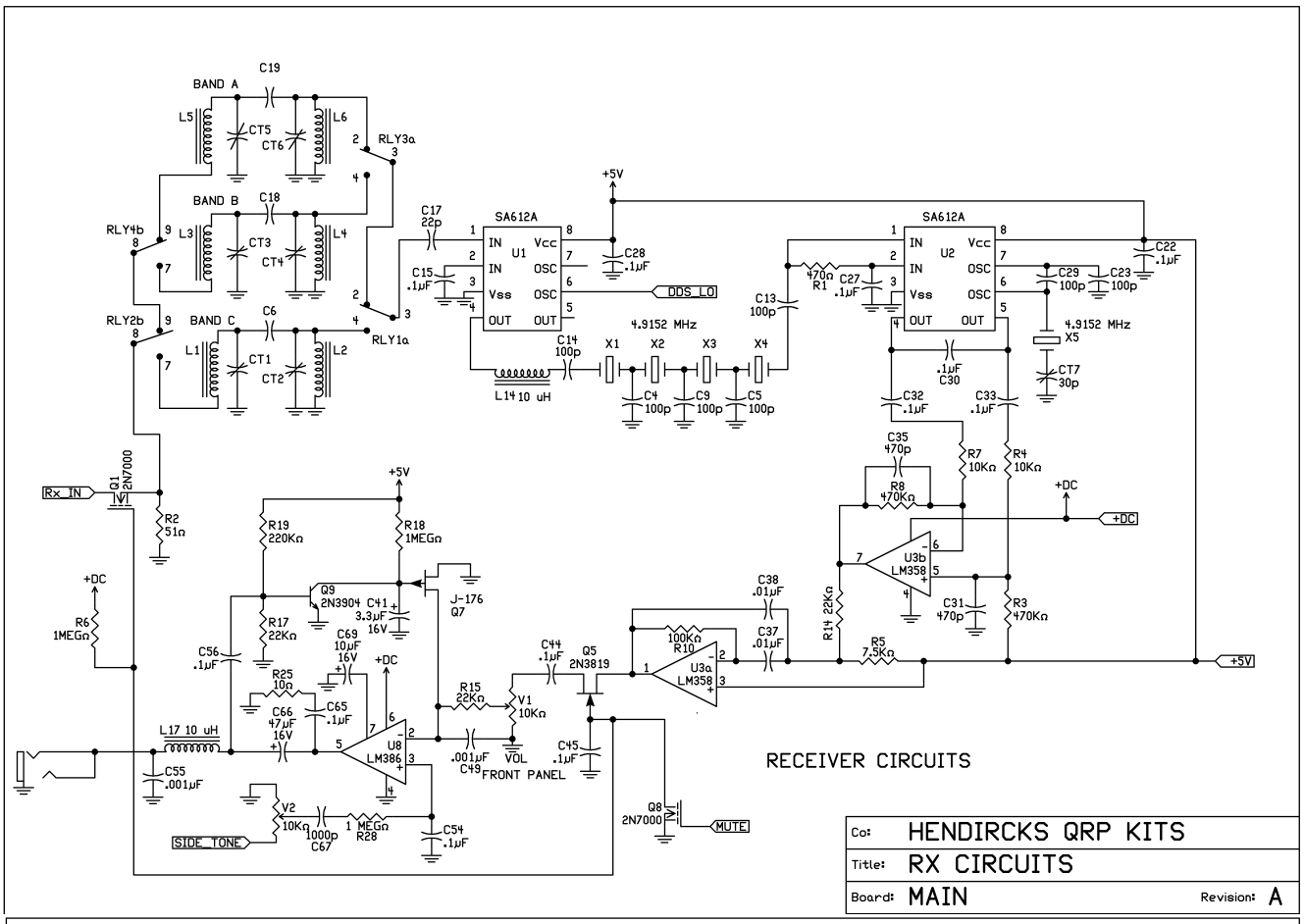
Pins 15/16 Tuning encoder inputs, voltage depends on position of encoder, may be high (5V) or low (0V)

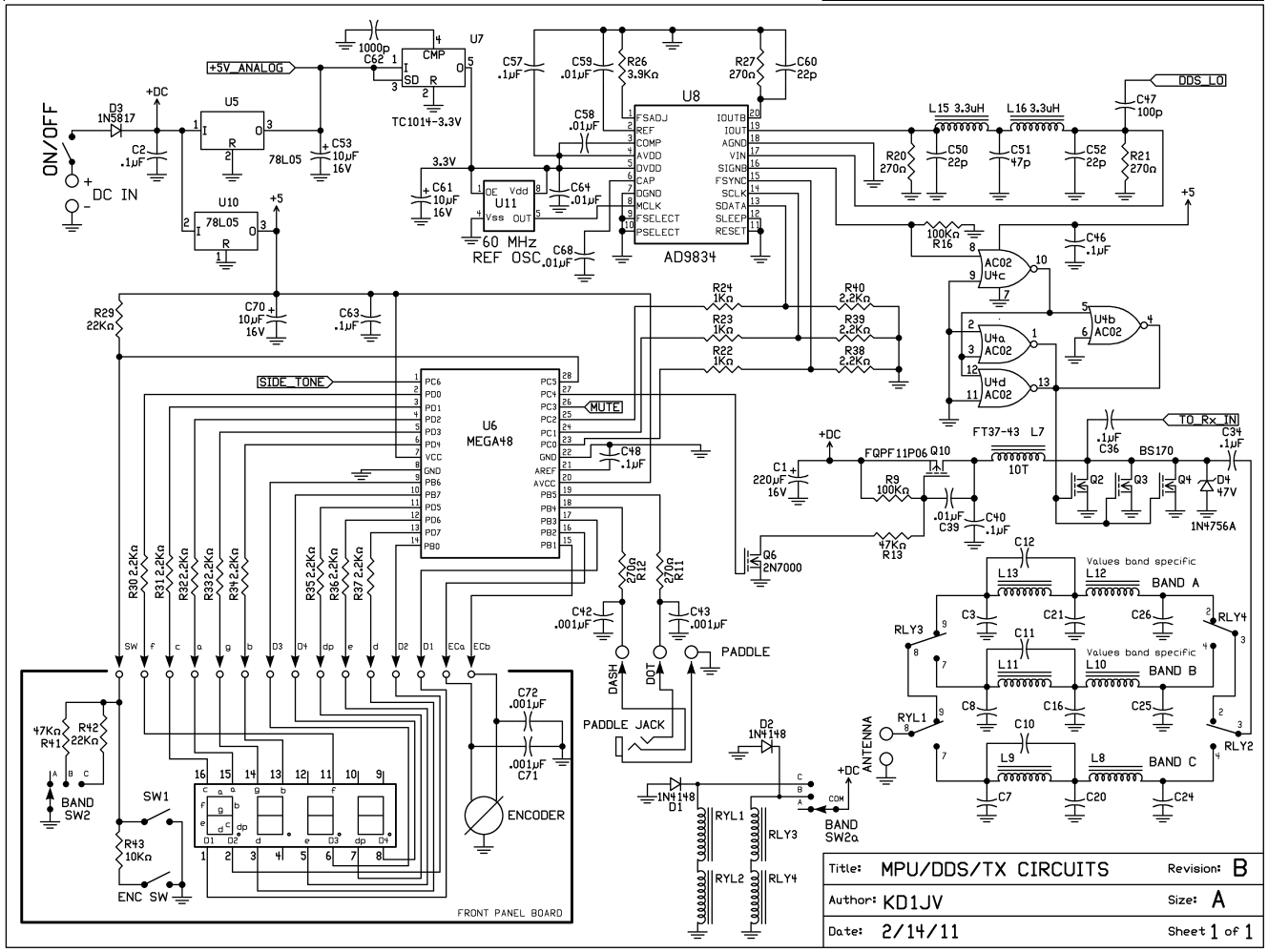
Board Track layout diagram.

This track diagram shows the connections between parts as a possible aid to trouble shooting. Note that the ground plane is not shown for clarity. Most of the “floating” pads are connected to the top and bottom ground planes on the actual board.



Schematics:


BAND A
BAND B
BAND C
RLY3a
RLY4b
RLY2b
RLY1a
SA612A
U1
U2
DDS_LO
4.9152 MHz
X5
L14 10 uH
Rx_IN
Q1 2N7000
+5V
+DC
U3b LM358
U3a LM358
U8 LM386
Q9 2N3904
J-176 Q7
Q5 2N3819
V1 10KΩ
VOL
FRONT PANEL
SIDE_TONE
MUTE
Q8 2N7000
L17 10 uH
RECEIVER CIRCUITS
Co: HENDIRCKS QRP KITS
Title: RX CIRCUITS
Board: MAIN
Revision: A


ON/OFF
DC IN
D3 1N5817
U5 78L05
U10 78L05
TC1014-3.3V
U7
+5V_ANALOG
U11 60 MHz REF OSC
U8 AD9834
DDS_LO
L15 3.3uH
L16 3.3uH
U6 MEGA48
SIDE_TONE
MUTE
PADDLE
DASH
DOT
PADDLE JACK
ENCODER
SW1
BAND SW2
ENC SW
R43 10KΩ
FRONT PANEL BOARD
FQPF11P06 Q10
FT37-43 L7
10T
BS170
Q2
Q3
Q4
D4 47V
1N4756A
TO_Rx_IN
Values band specific
BAND A
BAND B
BAND C
ANTENNA
RLY1
RLY2
RLY3
RLY4
D1 1N4148
D2 1N4148
Q6 2N7000
BAND SW2a
Title: MPU/DDS/TX CIRCUITS
Revision: B
Author: KD1JV
Size: A
Date: 2/14/11
Sheet 1 of 1