Dual Band HF CW transceiver

Hendricks kits and KD1JV Designs
QRPKITS.COM

Updated 5/20/09

Specifications:

Any two 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 circuit
500 mw audio amplifier with built in speaker

Small size, 4.6” wide, 1.6” tall and 5.5” deep.
Light weight, 13 ounces.

Modest supply current requirements, 55 ma on receive (no signal) and 550 to 750 ma on transmit at 5W out (current depends on band, higher bands draw more current)

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 stage they are used with.

Before you start assembly, it is helpful to sort the parts into types and values.

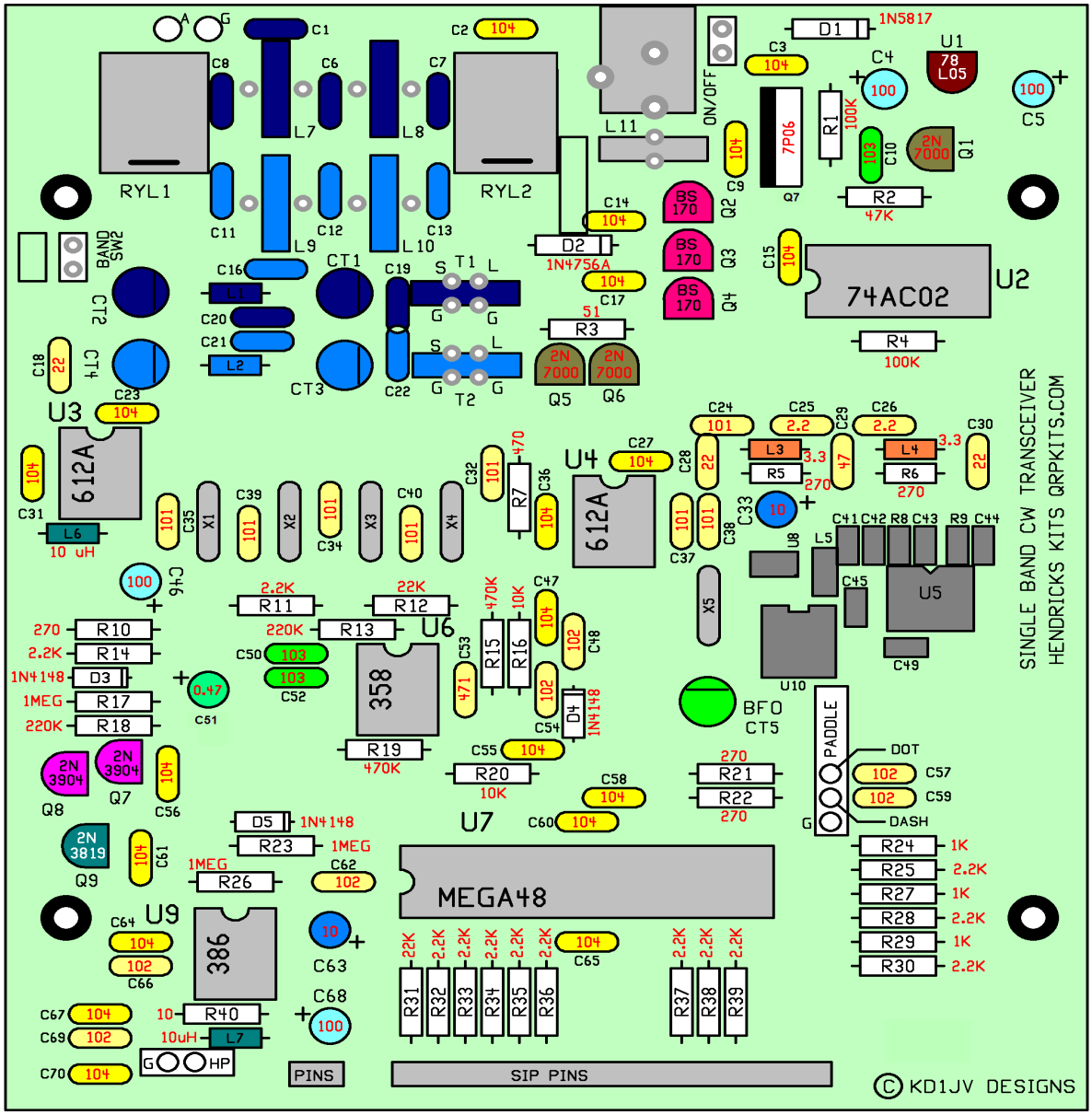
In general, parts are numbered on the board in rows, starting with the lowest part number in the upper left corner of the board (this is the back end) and then run left to right and then zig-zag down the board to the front end. Parts will be inserted in that order. Part values are marked in red on the parts placement diagram on the next page 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, inkjet friendly diagram is also included. At least one of these diagrams should be printed out for easy reference as you build up the board.

Parts filled in with dark blue / light blue are band specific values. Refer to chart for values. SMT parts filled in with dark gray are pre-installed. Experienced builds should be able to simply sort the parts and follow the placement diagram to assemble most of the board. It is still a good idea to review all the assembly instructions in case there are some details to pay attention to.

Parts check list:

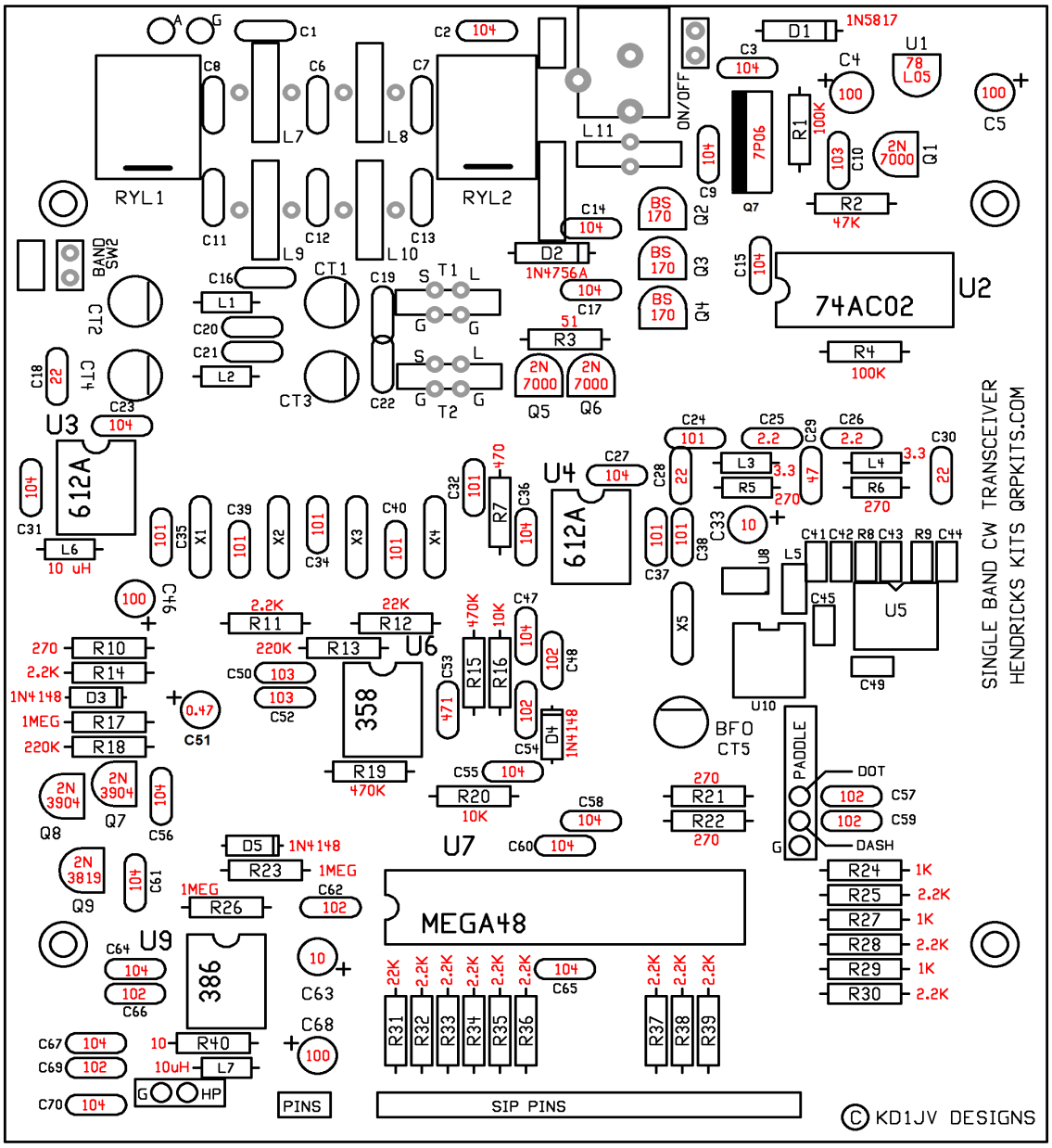
QTY	VALUE		QTY	VALUE		QTY	VALUE
1	10 Ω	BRN/BLK/BLK/GLD	2	2.2 pfd	2.2 NPO disk	1	FQPF7P06 PMOSFET/TO-220
1	51 Ω	GRN/BRN/BLK/GLD	3	22 pfd	22 NPO disk	3	BS170 NMOSFET TO-92
6	270 Ω	RED/VOL/BRN/GLD	1	47 pfd	47 NPO disk	3	2N7000 NMOSFET TO-92
1	470 Ω	YEL/VOL/BRN/GLD	8	100 pfd	101 NPO disk	1	2N3819 NJFET TO-92
3	1 K	RED/BLK/RED/GLD	1	470 pfd	471 disk	2	2N3904 NPN TO-92
13	2.2 K	RED/RED/RED/GLD	9	0.001 ufd	102 disk	1	78L05 5V reg TO-92
3	10 K	BRN/BLK/ORG/GLD	3	0.01 ufd	103 film (green)	2	SA612A mixer osc 8 pin dip
2	22 K	RED/RED/ORG/GLD	20	0.1 ufd	104 mono (yel)	1	LM358 dual op amp 8 pin dip
1	47 K	YEL/VOL/ORG/GLD	1	0.47 ufd/25V	0.47 electrolytic	1	LM386 audio amp 8 pin dip
2	100 K	BRN/BLK/YEL/GLD	2	10 ufd/16V	electrolytic	1	ATMEGA48 MPU 28 pin dip
2	220 K	RED/RED/YEL/GLD	4	100 ufd/16V	electrolytic	1	74AC02 quad NOR gate, 14 pin
3	470 K	YEL/VOL/YEL/GLD	1	30 pfd	Trimmer (green)	1	1N5817 power diode
3	1 MEG	BRN/BLK/GRN/GLD				1	1N4756A 47V, 1W zener
1	50K	Audio pot	1	Rotary	Encoder W/PBSW	3	1N4148 SS diode
2	3.3 uHy	RFC ORG/ORG/GLD/GLD	1	DPDT	Toggle switch	1	4 digit LED display module
2	10 uHY	RFC BRN/BLK/BLK/GLD	1	PB switch	TACT 6mm sq		
1	T37-43	Ferrite toroid, black	2	5V relays	DPDT	1	Red display filter
5	4.9512 MHz	HU-6S crystals, matched	1	DC power	Jack 2.1 mm		
1	1 foot	# 28 Magnet wire	1	1/4” stereo	Panel jack		
			1	1/4” stereo	Switched jack		
4	8 pin dip	sockets	1	Cabinet assy		1	Main circuit board
1	14 pin dip	socket	1	Tilt stand		1	Display board
1	28 pin dip	socket	4	Cabinet feet		2	knobs
1	18 pin SIP	Right angle pins	6	#4-40 1/4”	Pan head screws	1	2” dia speaker
			8	#4-40 1/4”	Flat head screws	2	Speaker mounting brackets
2		Band specific parts bags					

Parts placement guide. (color)



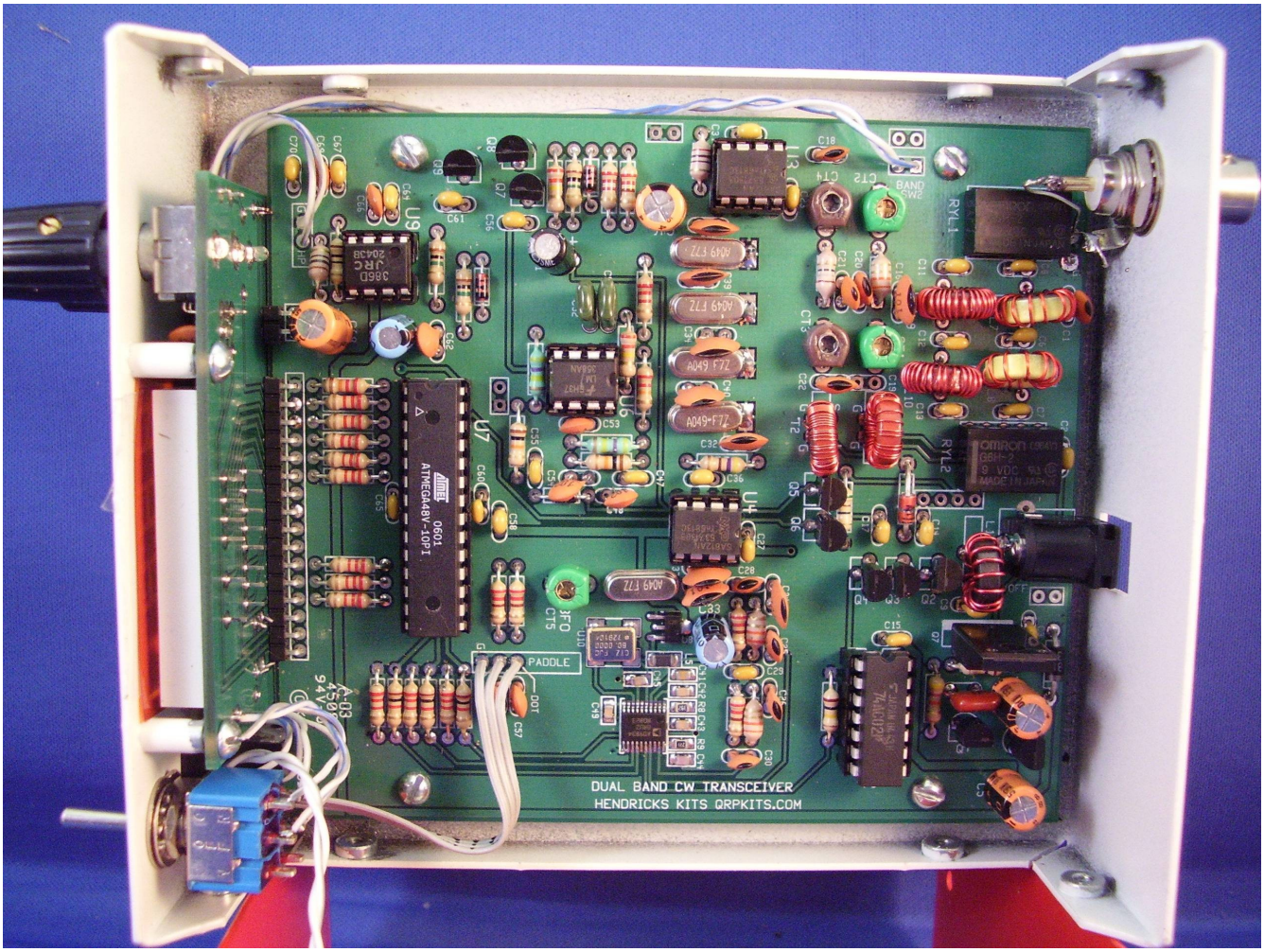
Note: Transistor Q10 is labeled Q7 on circuit board in upper right corner.

Parts placement diagram, inkjet friendly.
Parts with no value indicated have band specific values



Note: Transistor Q10 is labeled Q7 on circuit board in upper right corner.

Assembled board, mounted in case.



Speaker mounting:

Part by part placement guide: Resistors

√	location	Value	Color code		√	Location	Value	Color code
	R1	100 K	BRN/BLK/YEL/GLD			R21	270 Ω	RED/VOL/BRN/GLD
	R2	47 K	YEL/VOL/ORG/GLD			R22	270 Ω	RED/VOL/BRN/GLD
	R3	51 Ω	GRN/BRN/BLK/GLD			R23	1 MEG	BRN/BLK/GRN/GLD
	R4	100 K	BRN/BLK/YEL/GLD			R24	1 K	BRN/BLK/RED/GLD
	R5	270 Ω	RED/VOL/BRN/GLD			R25	2.2 K	RED/RED/RED/GLD
	R6	270 Ω	RED/VOL/BRN/GLD			R26	1 MEG	BRN/BLK/GRN/GLD
	R7	470 Ω	YEL/VOL/BRN/GLD			R27	1 K	BRN/BLK/RED/GLD
	R8	3.9 K	SMT PREINSTALLED			R28	2.2 K	RED/RED/RED/GLD
	R9	270 Ω	SMT PREINSTALLED			R29	1 K	BRN/BLK/RED/GLD
	R10	270 Ω	RED/VOL/BRN/GLD			R30	2.2 K	RED/RED/RED/GLD
	R11	2.2 K	RED/RED/RED/GLD			R31	22 K	RED/RED/ORG/GLD
	R12	22 K	RED/RED/ORG/GLD			R32	2.2 K	RED/RED/RED/GLD
	R13	220 K	RED/RED/YEL/GLD			R33	2.2 K	RED/RED/RED/GLD
	R14	2.2 K	RED/RED/RED/GLD			R34	2.2 K	RED/RED/RED/GLD
	R15	470 K	YEL/VOL/YEL/GLD			R35	2.2 K	RED/RED/RED/GLD
	R16	10 K	BRN/BLK/ORG/GLD			R36	2.2 K	RED/RED/RED/GLD
	R17	1 MEG	BRN/BLK/GRN/GLD			R37	2.2 K	RED/RED/RED/GLD
	R18	220 K	RED/RED/YEL/GLD			R38	2.2 K	RED/RED/RED/GLD
	R19	470 K	YEL/VOL/YEL/GLD			R39	2.2 K	RED/RED/RED/GLD
	R20	10 K	BRN/BLK/ORG/GLD			R40	10	BRN/BLK/BLK/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 L3/L4 – 3.3 uhy ORG/ORG/GLD/GLD
- Install L6/L7 – 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 – 1N5817 large plastic body.
- Install D2 – 1N4756A large glass body
- Install D3/D4/D5 – 1N4148 small 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. 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.

- U3, U4, U6, U9 – 8 pin socket
- U2 – 14 pin socket
- U7 – 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: Although the electrolytic caps are listed in the table below, they should be installed last.

√	location	value	type	√	location	value	type
	C1	BAND SPEC	SEE BAND TABLE		C23	0.1 ufd (104)	MONO, YELLOW
	C2	0.1 ufd (104)	MONO, YELLOW		C24	100 pfd (101)	NPO DISK, BROWN
	C3	0.1 ufd (104)	MONO, YELLOW		C25	2.2 pfd (2.2)	NPO DISK, BROWN
	C4	100 ufd /16V	ELECTOLYTIC		C26	2.2 pfd (2.2)	NPO DISK, BROWN
	C5	100 ufd /16V	ELECTOLYTIC		C27	0.1 ufd (104)	MONO, YELLOW
	C6	BAND SPEC	SEE BAND TABLE		C28	22 pfd (22)	NPO DISK, BROWN
	C7	BAND SPEC	SEE BAND TABLE		C29	47 pfd (47)	NPO DISK, BROWN
	C8	BAND SPEC	SEE BAND TABLE		C30	22 pfd (22)	NPO DISK, BROWN
	C9	0.1 ufd (104)	MONO, YELLOW		C31	0.1 ufd (104)	MONO, YELLOW
	C10	0.01 ufd (103)	FILM, GREEN		C32	100 pfd (101)	MONO, YELLOW
	C11	BAND SPEC	SEE BAND TABLE		C33	10 ufd /16V	ELECTROLYTIC
	C12	BAND SPEC	SEE BAND TABLE		C34	100 pfd (101)	MONO, YELLOW
	C13	BAND SPEC	SEE BAND TABLE		C35	100 pfd (101)	MONO, YELLOW
	C14	0.1 ufd (104)	MONO, YELLOW		C36	0.1 ufd (104)	MONO, YELLOW
	C15	0.1 ufd (104)	MONO, YELLOW		C37	100 pfd (101)	MONO, YELLOW
	C16	BAND SPEC	SEE BAND TABLE		C38	100 pfd (101)	MONO, YELLOW
	C17	0.1 ufd (104)	MONO, YELLOW		C39	100 pfd (101)	MONO, YELLOW
	C18	22 pfd (22)	DISK		C40	100 pfd (101)	MONO, YELLOW
	C19	BAND SPEC	SEE BAND TABLE		C41	.1ufd	SMT PREINSTALLED
	C20	BAND SPEC	SEE BAND TABLE		C42	.01 ufd	SMT PREINSTALLED
	C21	BAND SPEC	SEE BAND TABLE		C43	.01 ufd	SMT, PREINSTALLED
	C22	BAND SPEC	SEE BAND TABLE		C44	22 pfd	SMT, PREINSTALLED
	C45	.01 ufd	SMT, PREINSTALLED		C58	0.1 ufd (104)	MONO, YELLOW
	C46	100 ufd/16V	ELECTROLYTIC		C59	.001 ufd (102)	DISK, BROWN

	C47	0.1 ufd (104)	MONO, YELLOW		C60	0.1 ufd (104)	MONO, YELLOW
	C48	.001 ufd (102)	DISK, BROWN		C61	0.1 ufd (104)	MONO, YELLOW
	C49	.01 ufd	SMT, PREINSTALLED		C62	.001 ufd (102)	DISK, BROWN
	C50	0.01 ufd (103)	FILM, GREEN		C63	10 ufd/16V	ELECTROLYTIC
	C51	0.47 ufd/25V	ELECTROLYTIC		C64	0.1 ufd (104)	MONO, YELLOW
	C52	0.01 ufd (103)	FILM, GREEN		C65	0.1 ufd (104)	MONO, YELLOW
	C53	470 pfd (471)	DISK, BROWN		C66	.001 ufd (102)	DISK, BROWN
	C54	.001 ufd (102)	DISK, BROWN		C67	0.1 ufd (104)	MONO, YELLOW
	C55	0.1 ufd (104)	MONO, YELLOW		C68	100 ufd/16V	ELECTROLYTIC
	C56	0.1 ufd (104)	MONO, YELLOW		C69	.001 ufd (102)	DISK, BROWN
	C57	.001 ufd (102)	DISK, BROWN		C70	0.1 ufd (104)	MONO, YELLOW

- Trimmer capacitor CT5 – Green trimmer. Make use flat side of part is facing the line drawn in the circle outline on the board.
- L11 – L11 is wound with 15 turns of # 28 wire on the black T37-43 core. However, do not install L8 yet. Put it aside for now. It will be installed after the initial tests have been completed.

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, Q5, Q6 – 2N7000 mosfets – these are also static sensitive.
- Install Q7, Q8 – 2N3904 NPN
- Install Q9 – 2N3819 j-fet
- Install U1 – 78L05 5V regulator
- Install Q10, FQPF7P06 – line up the long side with the black rectangle on the board outline. Note: Q10 is labeled Q7 on circuit board in upper right hand corner.

- 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. C5 can explode if installed backwards!

☐ C4, C5, C46, C68 100 ufd/16V

☐ C33, C63 10 ufd/16V

☐ C51 0.47 ufd/25V

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

- Install DC power jack
- Install the two relays, RYL1 and RYL2. Note the line on one end of the relay and match this with the line on the relay outline.
- Install right angle SIP pin strips on front edge of board. *You will need to cut 2 pins from the strip, as these two pins are offset from the rest of the pins to the left. Don't forget to mount these two pins!* Simply snip the plastic between the pins with your side cutters. Insert the short pins into the main board. The pins will not quite stick all the way through the board, so make sure the pins are well seated.

Band specific parts:

In the color parts layout, the transmitter low pass filter and associated receiver input parts are filled in with the same color. **Band "A"** parts are colored in **light blue** and **Band "B"** is colored in **dark blue**. It doesn't matter which specific band you call "A" and which you call "B", that will be programmed later. Just note which one is which. Keep in mind that since the relays are non-latching, a small amount of additional current will be drawn by the rig when band "B" is selected, so you might want to put the band you think will be used most often as band "A". Part locations are indicated in the table for band "A" first, then band "B".

- Be sure to count the turns on L7/L8/L9 and L10 properly. 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.

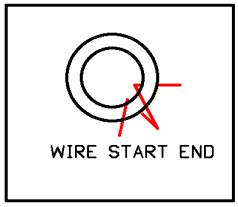
Winding T1/T2: See next page for instruction on winding T1/T2 so leads end up in proper locations for the outline.

80 meters	Value	Type		**40 meters**	Value	Type
C16/C1 [band a/band b]	100 pfd	101 NPO Disk		C16/C1 [band a/band b]	68 pfd	NPO disk
C11/C8	680 pfd	681 mono C0G		C11/C8	330 pfd (331)	C0G
C12/C6	1500 pfd	152 mono C0G		C12/C6	680 pfd (681)	C0G
C13/C7	680 pfd	681 mono C0G		C13/C7	330 pfd (331)	C0G
C22/C19	68 pfd	68 NPO Disk		C22/C19	47 pfd	disk
C21/C20	15 pfd	15 NPO Disk		C21/C20	10 pfd	NPO disk
CT3/CT4 CT1/CT2	70 pfd	Brown trimmer		CT3/CT4 CT1/CT2	70 pfd trimmer	Brown
L10/L8	24 turns	#30 wire T37-2 Red		L10/L8	18 turns	#28 wire T37-2 Red
L9/L7	29 turns	#30 wire T37-2 Red		L9/L7	20 turns	#28 wire T37-2 Red
L2/L1	18 uHy	BRN/GRY/BLK/GLD		L2/L1	8.2 uHy	GRY/RED/GLD/GLD
T1/T2	60 turns/ 6 turns	#32 wire T37-2 Red		T1/T2	45 turns / 4 turns	#30 wire T37-2 Red

30 meters				**20 meters**		
C16/C1 [band a/band b]	47 pfd	47 NPO Disk		C16/C1 [band a/band b]	22 pfd	22 NPO Disk
C11/C8	220 pfd	221 mono C0G		C11/C8	150	151 mono C0G
C12/C6	560 pfd	561 mono C0G		C12/C6	330	331 mono C0G
C13/C7	220 pfd	221 mono C0G		C13/C7	150	151 mono C0G
C22/C19	None			C22/C19	None	
C21/C20	4.7 pfd	4.7 NPO Disk		C21/C20	2.2 pfd	2.2 NPO Disk
CT3/CT4 CT1/CT2	30 pfd	Green trimmer		CT3/CT4 CT1/CT2	30 pfd	Green trimmer
L10/L8	13 turns	#28 wire T37-2 Red		L10/L8	13 turns	# 28 wire T37-6 Yellow
L9/L7	16 turns	#28 wire T37-2 Red		L9/L7	16 turns	#28 wire T37-6 Yellow
L2/L1	8.2 uHy	GRY/RED/GLD/GLD		L2/L1	5.6 uHy	GRN/BLU/GLD/GLD
T1/T2	45 turns / 4 turns	# 30 wire T37-2 Red		T1/T2	38 turns / 4 turns	# 30 wire T37-2 Red

17 meters				**15 meters**		
C16/C1 [band a/band b]	15 pfd	15 NPO disk		C16/C1 [band a/band b]	15 pfd	15 NPO disk
C11/C8	47 pfd	47 mono C0G		C11/C8	47 pfd	47 mono C0G
C12/C6	220 pfd	221 mono C0G		C12/C6	220 pfd	221 mono C0G
C13/C7	100 pfd	101 mono C0G		C13/C7	100 pfd	101 mono C0G
C22/C19	none			C22/C19	none	
C21/C20	2.2 pdf	2.2 NPO Disk		C21/C20	2.2 pfd	2.2 NPO Disk
CT3/CT4 CT1/CT2	30 pfd	Green trimmer		CT3/CT4 CT1/CT2	30 pfd	Green trimmer
L10/L8	13 turns	# 28 wire T37-6 Yellow		L10/L8	11 turns	#28 wire T37-6 yellow
L9/L7	16 turns	# 28 wire T37-6 Yellow		L9/L7	14 turns	#28 wire T37-6 yellow
L2/L1	3.3 uHy	ORG/ORG/GLD/GLD		L2/L1	3.3 uHy	ORG/ORG/GLD/GLD
T1/T2	25 Turns/ 4 Turns	#30 wire T37-2 RED		T1/T2	25 Turns/ 4 Turns	#30 wire T37-2 RED

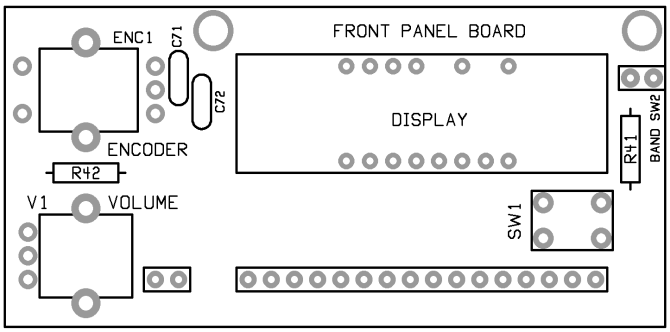
T1/T2 winding:



Hold the core in your left hand and start winding by passing 1/2” of the magnet wire up through the “bottom” side of the core as shown in the diagram. Then continue winding the remaining required number of turns by passing the long end of the wire in and down from the top of the core. When you get to the end of the required number of secondary turns, make about a 1/2” loop and continue winding the four link turns.

Snip the loop to separate the secondary from the link winding, then tin the wires. Insert the core into the board and solder. It will not matter along which side of the board outline the wide side of the core faces.

Front panel board assembly:



- Install resistor R42, 10 K (BRN/BLK/ORG/GLD)
- Install resistor R41, 470 K (YEL/VOL/YEL/GLD)
- Install C71 and C72, 0.001 ufd Disk cap. (102)
- Install 7 segment LED display module. This will only go in one way, due to missing pins on display module and corresponding missing holes in board.
- Install SW1, momentary TACT switch. This will go in one of two ways, both of which are correct, due to pins being spaced farther apart along one edge as opposed to the other.
- NOTE: Make sure volume control and encoder are pushed firmly square to board and are not tilted. Trial fit into front of cabinet before soldering pins.
- Install V1 volume control. Solder mounting tabs to board. Clip tab along bottom edge of board, flush to board.
- Install ENC1, the tuning encoder. Solder mounting tabs to board.

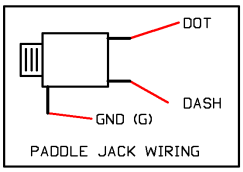
This completes assembly of the front panel board. Proceed to initial tests before soldering front panel board to main board.

Initial board tests:

Before applying power to the main board, it would be a good idea to inspect your workmanship. Look for any unsoldered part leads and IC socket pins. A fresh 9 volt radio battery can be used to power the board for initial tests. A 9 V battery has limited current capacity, so if there are any problems, it is unlikely any damage will result from too much current.

1. Wire up power source to power plug. Plus (+) goes to center pin
2. Plug power plug into DC jack
3. Check for +5 volts (+/- 0.25V) on pin 14 of U2, pin 8 of U3 and U4.
4. If no voltage is present, check for proper soldering of the U1 pins, shorts at input and output of U1 and that the supply voltage is getting to U1. A short could be present at any connection point along the 5 volt supply bus or DC input bus. Look carefully at where these supply buses are by-passed, such as at C5, C15, C23, C27, C58 and C65 for the 5 volt bus and C2, C3 and C4 for the DC supply bus. There may be a solder short across these one of these parts.
5. Remove power
6. Wire up the speaker and paddle jack to the main board. (See diagram next page)

The speaker is wired to the two pads labeled “G” and “HP” at the front, left hand side of the main board.
Paddle jack wiring is shown in the diagram below. The wires should be about 2” long so that the jack will reach the front panel for mounting later.



7. Insert U7, the MEGA48 processor chip and U9, the LM 386 audio amp. When installing U9 and the other IC's later, you will need to bend the leads inward slightly so they will go into the socket. This is best done by placing the leads on a flat surface such as your work bench and tilting the body of the IC slightly.
8. Plug in the paddle and apply power.
9. Operating the paddle should result in hearing the CW side tone from the speaker. Touching pin 2 of U9 should result in hearing a loud hum.
10. Connect a volt meter between ground and the pad of L11 just below the DC power jack.
11. While sending dashes, the voltage on the L11 pad should go to near the DC supply voltage and then slowly decay to zero (0) volts once you stop sending.
12. Remove power from main board.

- Mount the front panel board to the main board:

13. Insert the front panel board onto the SIP pins coming from the main board. (make sure you have installed the 2 pins to the left of the main row of pins) Trial fit board assembly into cabinet and make sure display mounting holes line up. There will be a small gap between the display board and front stand offs.
14. Remove board from cabinet and solder the pins to the display board, but before you solder more than one pin, make sure the front panel board is square and pushed all the way up against the main board.
15. Replace the 9 V battery (if your using one) with a 12 to 13.8 volt power supply. Apply power to the main board. The LED display should come on and show [8.8.8.8.] for a few seconds, then [80 .], then [560.0]. At this point, tuning the encoder should make the digits on the display change.
16. Remove power from main board.
17. Install U6, the LM358, U2 the 74AC02 and U3/U4, both SA612A ICs.
18. Install L11

Band selection and calibration of DDS:

The processor is programmed to use the 80 meter band as its initial power up band. You must now program the processor for the two bands you have chosen. This allows supplying one “generic” firmware program to be supplied, instead of one programmed for each of the possible band combinations the rig can be built for.

Band selection mode:

- Click and hold closed the KEYER switch and hold closed the DASH paddle, then apply power to the rig. (This almost takes three hands to do, and is meant to not be easy, so this mode is not accidentally enabled.)
- The display will read [bA8.0]
- Release the switches

To select operating band:

- Tapping the DOT paddle will increment through the available band selections, starting with 80 meters, then 40, 30, 20, 17, 15, then repeat from 80. These band numbers will appear on the display.
- Once the desired band is showing on the display, click the KEYER switch to store the selected band.
- Once the switch is pushed, the display will change to read [bb8.0], indicating the “B” band is now to be selected.
- As before, use the DOT paddle to select the desired B band.
- Exit the band selection mode by clicking the KEYER switch three times. Note that clicking the switch after the “B” band has been selected will advance to “C” band and then to “D” band. This is to accommodate the addition of two more bands should a band module daughter board be made available and added at a later date.
- Once the bands have been programmed, re-entering the band select mode will indicate the current band selected for each band memory location.

Calibration of DDS reference frequency and LO frequency:

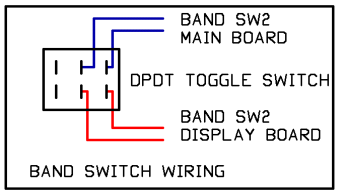
Calibration of the reference frequency and LO frequency is not absolutely necessary, but will improve the performance of the rig. If an accurate frequency counter and audio oscilloscope , either CRT or PC based, is not available, do not attempt calibration. Calibration can be done at a later time.
To enter the calibration mode, first power down the board if it is on. Then, while holding closed the KEYER switch and the DOT paddle closed, apply power to the board. The display will read [CAL.r] and release the switches.

- In the “CAL.r” mode, the DDS is producing about a 10.000,000 MHz signal. A counter can be placed at Pin 4 of the U2 socket to read this frequency. The paddle is then used to adjust the signal so that it is exactly 10.000,000 MHz. Tapping the dot paddle will increment the frequency up, while the dash paddle will increment it down.
- Once the frequency is adjusted to 10.000,000 MHz, click the “Keyer” switch to advance to the LO cal mode.
- The display will now read “CAL.O” and the LO frequency can now be tweaked.
- This adjustment is used to center the LO frequency into the pass band of the crystal filter, which might vary a little depending on the exact frequency of the crystals used in the filter. All the crystals are matched to the same frequency, but exactly where the center frequency falls can vary from crystal lot to lot.
- Pre-set the BFO trimmer to about 1/4 turn from its factory setting. 180 degrees or ½ turn changes the setting from maximum to minimum capacitance.
- Connect an Oscilloscope to pin 7 of U5, the LM358 IC.
- Use the paddles again to tune the LO frequency through the pass band of the crystal filter. Observe the points at which the amplitude of the signal starts to fall off on either side of the pass band. You will likely see a peak in the signal on each side of the pass band, just before it starts to quickly roll off. You will want to set the LO frequency about mid way between these two peaks.
- Once the LO frequency is set, move the Oscilloscope to pin 1 of U5.
- Now adjust the BFO trimmer to peak the amplitude of the signal. This will center the BFO note into the center of the pass band of the audio filter stage.
- Click the “KEYER” switch to finish up the calibration. The processor will reset, load the new values and the rig is almost ready to operate.

Please note that each time the calibration procedure is enabled, the default operating values are loaded as a starting point. This is done in the remote chance the calibration data stored in EEPROM has become corrupted and known good starting values are used.

Final assembly into case:

Wire up the band select switch to the main and front panel board.



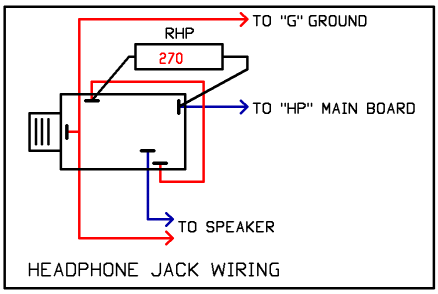
The two wires which run back to the pads on the main board labeled “BAND SW2”, located just below the RYL1 relay, should be routed along the left side of the board and then across the front edge of the board. Make these wires about 9” long. The two wires which go over to the front panel board will be about 2” long and connect to the two pads also labeled “BAND SW2”, located near the top, right hand side of the board. NOTE: The plastic used for the body of the switch can get soft when the terminals are heated, so be careful not to let them move while still hot or it can ruin the switch.

- Remove BNC jack from wires connecting to the board.
- Tape the red LED filter film over the inside of the display cut out.
- Angle the board into the case from the back, lining up the controls with the holes in the front of the case.
- Secure the main board to the bottom of the case with four #4-40 ¼” screws.
- Secure the front panel board to the front of the case with two #4-40 ¼” screws using the two holes in the board

along the top edge of the board on either side of the display.

- Install the BNC jack and connect to the wires from the main board. HINT: To keep the BNC jack from spinning as you tighten the nut, put a BNC plug on the jack and hold that firmly.
- Install the paddle jack into the cabinet front panel hole.

Headphone jack wiring:



- Place the 270 ohm “RPH” resistor along the side of the jack and connect the leads to the jack terminals shown in the diagram. You can use the resistor lead to jumper over to the jack terminal shown connected from the resistor with the red line.
- Disconnect the wires from the speaker.
- Connect the wires which came from the speaker to the jack terminals labeled “HP” and “G”, making sure these wires go to their respective pads on the main board.
- Connect two 4” long wires the jack terminals labeled “To Speaker” and connect the other ends to the speaker.
- Install the jack into the cabinet front panel hole.
- Install the band select switch into the cabinet front panel hole located above the paddle and headphone jack.
- Install knobs to the volume and tuning encoder shafts.

Receiver alignment:

- If you skipped the calibration procedure, preset the BFO trimmer, CT5 by giving it about a ¼ turn.
- Attach appropriate antenna
- Apply power to board.
- Peak the trimmer capacitors CT3 and CT4 for band A and CT1 and CT2 for band B, for best atmospheric noise or signals. Note, the receiver might be quite “deaf” until the trimmers are set properly. Also note that the volume from the speaker will greatly increase once it is mounted onto the top cover and the cabinet fully assembled.

Peaking the BFO trimmer:

If the calibration procedure was skipped, the BFO trimmer can be properly set with the aid of another rig, preferably a commercial “big rig”.

- Connect a dummy load to both the dual band rig and the big rig.
- Transmit a signal with the dual band rig and tune it in with the big rig.
- Transmit a signal with the big rig and fine tune the BFO trimmer so the signal peaks. For best results, adjust the power output of the big rig so a fairly weak signal is being received or it will be hard to tell when the audio peak occurs. If adjusting the power output is not possible or is still too loud at minimum power, move the dummy loads farther apart.

Transmitter tests:

- Connect QRP power meter and 50 ohm dummy load to antenna jack.
- Power output levels are set using regulated 13.8 volt supply.
- Turn power on to the rig, keeping Dash paddle closed so straight key mode is enabled.
- Key transmitter with Dot paddle and note power output.

Power output should be near 5 watts on any band. Power output can vary (sometimes significantly) by how the turns on L8 or L10 are spaced around the core. The same is true for L7 and L9, but to a lesser degree. Initially, the turns should be more or less evenly spaced around the core. This will result in maximum power output. If the power output is more than 5 watts, reduce the output power by moving some of the turns on L8 or L10 closer together until the desired power output is achieved. If you put an Amp-meter in series with the supply line and monitor supply current and power output, it is possible to adjust the coils for best transmitter efficiency, especially on 20, 17 or the 15 meter bands. Strive to get 5 watts out with the least amount of supply current.

Adding a power on / off switch:

There are two pads on the board labeled “ON/OFF” located next to the DC power jack. The track connecting these two pads together can be cut on the bottom of the board and an on/off switch connected between these pads. A hole for the on/off switch will need to be drilled into the back of the case. For convenient access to the power switch, you might want to put the switch in the paddle jack hole on the front panel and move the paddle jack to the rear of the case.

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.

U2 74AC02 PA driver, Quad NOR gate

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

U3/U4 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.

U6 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.

U9 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

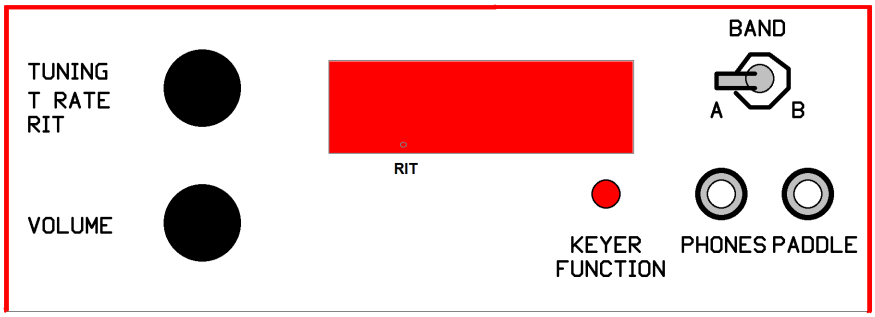
U7 MEGA48 Microprocessor

Volt	5V	5V	5V	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)

Operation:



FRONT PANEL CONTROLS

Power up:

Upon power up, the display will first show a display test, lighting all LED digit segments and decimal points for a couple of seconds. The display will then indicate the selected operating band for another couple of seconds. Finally, the initial operating frequency is shown and the rig is ready to operate. Initial power up frequencies are the QRP calling frequencies for each band.

Tuning range:

The rig will tune the full band, including the SSB sub-band. However, SSB reception is not possible due to the narrow CW filter used and receiving on the “wrong” sideband for SSB reception on most bands.

Tuning rate:

Tuning rate can be switched between a 50 Hz or 200 Hz per step of the encoder. The display only shows 100 Hz resolution, so the display will change on every other detent of the encoder at the 50 Hz rate. To switch tuning rates, momentarily push the tuning knob. The letter “F” will be annunciated by the side tone when the fast 200 Hz rate is selected and the letter “S” when the slow 50 Hz rate is selected. Default power on rate is 50 Hz.

Frequency memory:

The last used frequency for each band is restored when switching between bands. However, these frequencies are not stored in nonvolatile memory, so the default start up frequency is loaded on power up.

RIT (Receive Incremental Tuning)

Push in the tuning knob until the letter “R” is annunciated, about one (1) second, then release. This will toggle RIT on or off. When RIT is active, the decimal point to the right of the MSD display digit will light. Tuning range of RIT is not limited and will tune the whole band. So, be sure to turn it off after a QSO and you start tuning around the band again!

Keyer functions:

Keyer functions are accessed via the momentary “KEYER” switch located below the display. Some functions are accessed by clicking and holding the switch closed for various lengths of time. CW annunciation is used to identify the function which will be activated when the switch is released.

Changing keyer code speed:

Momentarily click and release the Keyer switch. After a short delay, the current code speed will be shown on the display, prefaced by the letter “C” [Cxx.] where xx is the current code speed. Code speed is changed using the paddles, with the dash paddle increasing the speed and the dot paddle decreasing the speed. Code speed is selected in 1 wpm increments, with a range of 5 to 40 wpm.

Tune Up Mode:

Clicking and holding closed the keyer switch for 1 second will access the “Tune Up Mode” function. Release the switch after the side tone annunciates the Morse letter “T” to activate this function. A character resembling a “t” will appear on the display to indicate this mode is active. The dot or dash paddle can now be used to key the transmitter on and off. Click the Keyer switch again to exit this function and return to normal operation. This function is primarily used if you have an Autotuner, which requires a steady carrier for a minute or so to find a match. When using a manual antenna tuner, you would be better off sending a string of dots or dashes to reduce strain on the transmitter.

Entering messages into keyer memory:

Two, 63 character message memories are available. To enter this function, click and hold the keyer switch closed until the Morse letter “M” is annunciated by the side tone and release the switch. The display will blank to indicate it is not in normal operating mode.

Now key in your message. Ideal letter and word space timing is used to add letter group and word spacing. Therefore, if you tend to run your letters and words together, the message may come out garbled. It can take some practice and a few tries to get the message entered correctly.

Once you have completed entering the message, click the KEYER switch. The message will repeat via the side tone so you can check it's accuracy. If you need to re-enter the message, click the KEYER switch again and the Morse characters “EM” will be annunciated and you can start again.

Once the message has been keyed in correctly, tap the DOT paddle to store the message in location 1 or the Dash paddle to store in location 2. The characters “MS” be annunciated to indicate the message was stored and the frequency display will be restored.

Sending a message:

Click the KEYER switch, then within one (1) second, tap the DOT or Dash paddle to send either message 1 or 2.

Stopping or pausing the sending of a message:

Once a message has started sending, it can be terminated by holding closed the Dot paddle. Closing the DASH paddle will pause the message and continue sending from the point at which is was paused when the paddle is released. The paddle is sensed during word or letter spaces, so it has to be held closed until one of these occurs.

Straight key mode:

Straight key mode is automatically enabled if a monaural phone plug is used in the paddle jack at the time the rig is turned on. This grounds the Dash input and tells the rig to go into straight key mode. This mode can also be enabled by keeping the Dash paddle closed on power up.

Note: In straight key mode, none of the KEYER switch functions will be available, since these all require the Dash input to be active. However, you can still used the Message 1 memory if a message has been stored, but it will send at the default keyer speed of 20 wpm.

Paddle plug wiring:

Standard paddle plug wiring is used, Tip = dot, Ring = dash. Paddle sense is not programmable.

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 and the letter “B” will be annunciated and the display will show [b .]. Conversely, if B is currently enabled, the letter “A” will be annunciated and 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. The “both paddles closed” condition is sensed at the end of an inter-element space. This helps ensure that when sending a simple two element letter like “A” or “N”, an extra dot or dash isn't tacked on the end. Therefore, to send a letter such as “C”, the paddles would be released as the second dash is being sent and the final dot will automatically added. B mode is only useful for aiding in the sending of a couple of letters and can be more trouble than its worth, as your timing has to be very good.

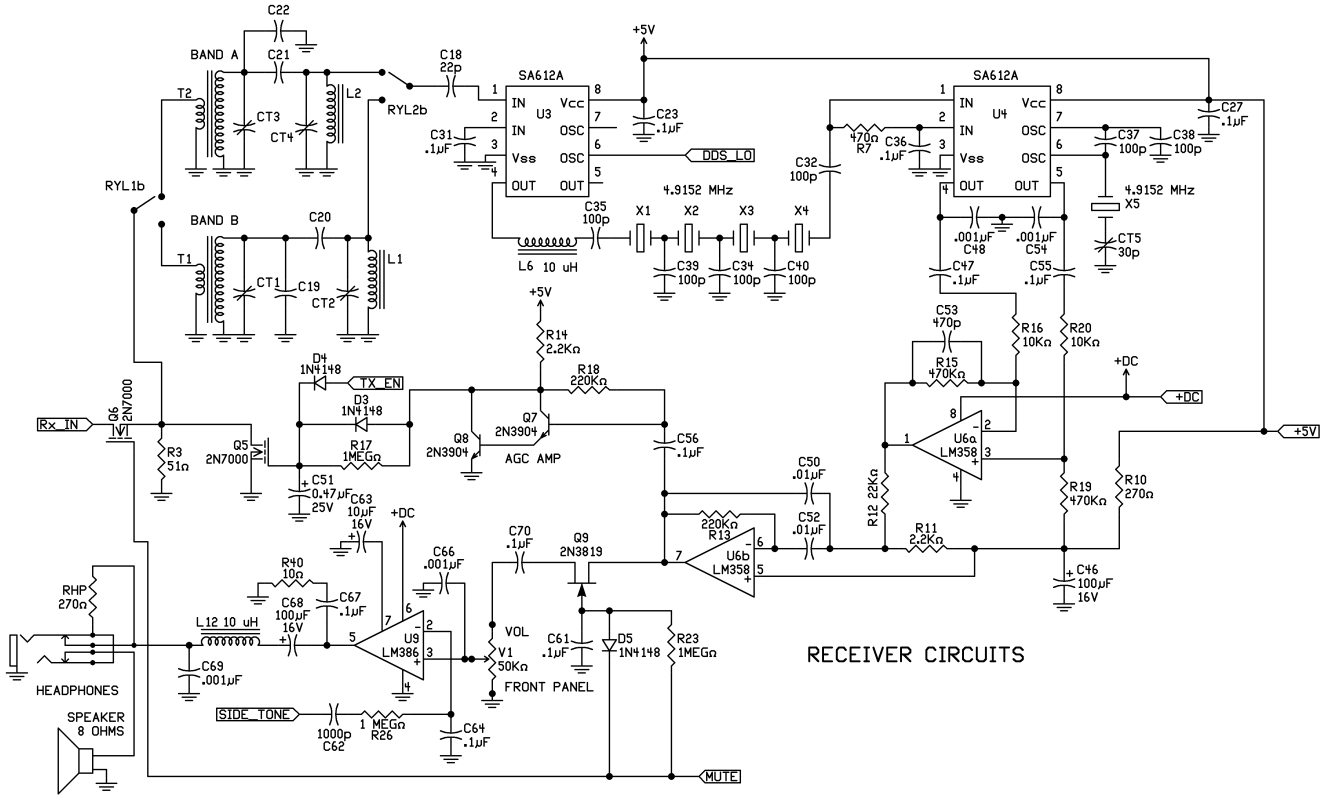
AGC action:

The AGC is audio derived and kicks in when a fairly strong signal is received. There maybe a slight popping noise as the AGC kicks in with very strong signals, as it takes a few audio cycles to activate. The main purpose of the AGC is to keep strong signals from “blowing your ears out” and reduces the need to ride the volume control when tuning across the band.

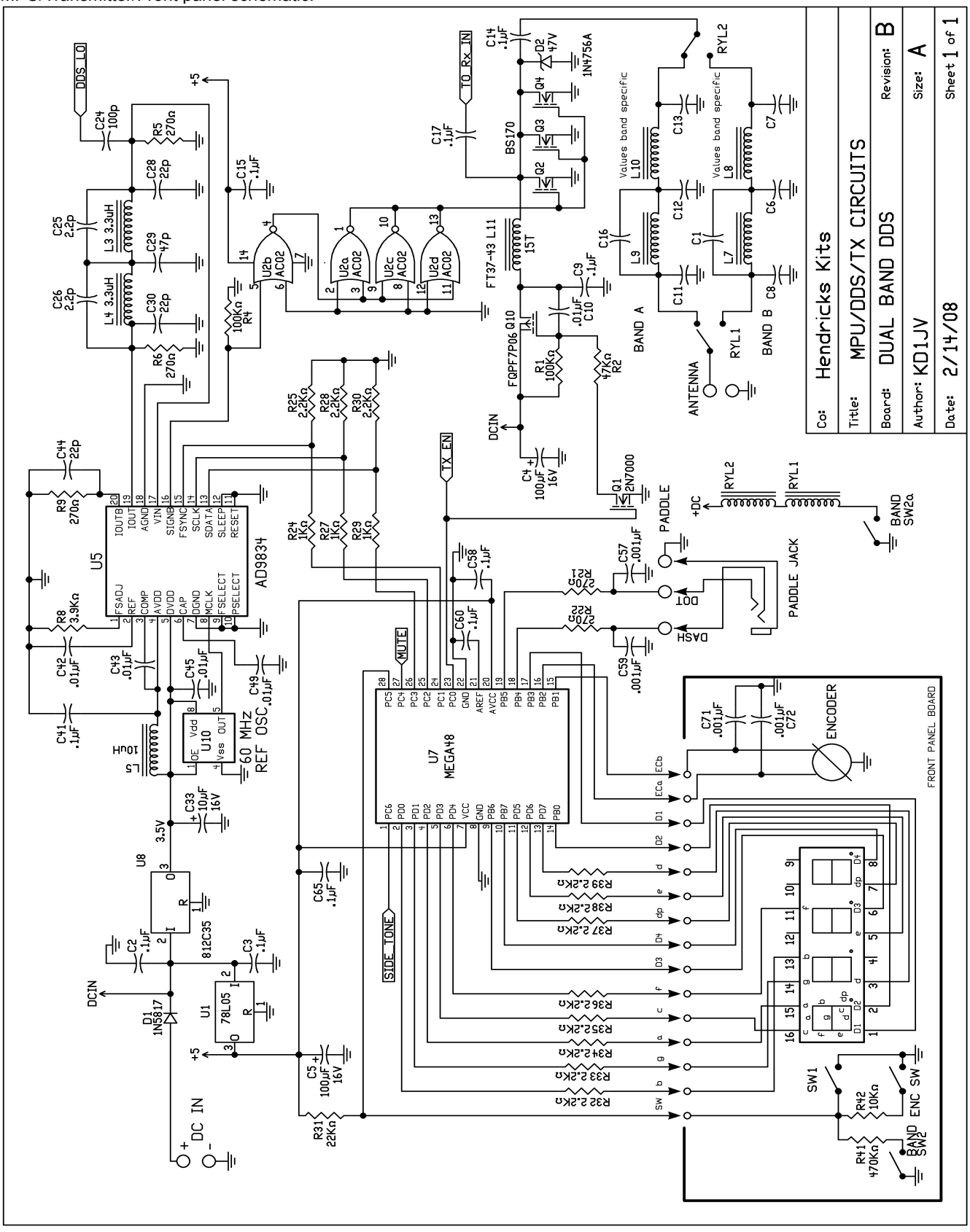
Power supply:

The power supply voltage to the rig should be no more than 13.8 volts and no less then 10.5 volts. It is strongly recommended that a fused power cord be used between the rig and power supply with a 1 amp, fast blow fuse.

Receiver circuits schematic:



MPU/Transmitter/Front panel schematic:



How it works:

Signals from the antenna first pass through the transmitters Low Pass Filter, which are selected for the current operating band by two relays, RY1 and RY2. The receiver signal is picked off from the drains of the transmitters PA FETs and routed through a QSK switch, Q6 a 2N7000 MOSFET. During receive, this FET is biased ON to allow signal to pass through and a 51 ohm resistor, R3 is used to terminate the LPF to keep its frequency response correct.

The output of the QSK switch Q6 is then routed to the double tuned receiver input filter, which are selected by the other set of contacts on relays RY1 and RY2. The top of the second tuned circuit is connected to the input of the 1st mixer, U3, a SA612A Gilbert Cell active mixer. A Local Oscillator signal generated by the DDS (Direct Digital Synthesizer) is mixed in U3 to produce an IF frequency of 4.915 MHz. The output of the 1st mixer is then filtered by a four crystal IF filter to provide selectivity and opposite sideband suppression. The crystal filter is terminated by a 470 ohm resistor across the inputs of the product detector mixer, another SA612A (U4). This termination resistor helps flatten out the response of the filter. Without this termination, there would be peaks in the filter response.

The product detector mixer uses the on chip crystal oscillator function to generate the BFO signal needed to produce the audio beat note from the IF signal. The balanced output of the product detector mixer feed a balanced input audio amplifier. 0.001 ufd caps from the mixer outputs to ground by-pass RF products on the mixer output to ground. The output of the first audio amplifier (U6a, a LM358 dual op amp) then feeds an audio band pass filter. This filter has a peak response at 600 Hz and is used to help reduce high frequency hiss and provide some additional selectivity.

The output of the audio band pass filter is then routed through an audio mute switch, Q9. R23 and C61 on the gate of the FET switch delays the turn on time when going from transmit back to receive. This eliminates an audio “thump” caused by the RF QSK switching FET Q6 turning back on and propagates through the receiver circuits.

The output of the audio mute switch then goes to the volume control and then into the final audio power amplifier, U9 a LM386. A RF choke between the output of the audio amp and the speaker or headphones keeps which might be picked up by the speaker or headphone leads out of the amplifier, which can cause distorted or raspy side tone. Side tone, which is generated by the microprocessor, is feed into on the of the amplifier inputs though a low pass filter comprised of R26 and C64. This RC filter reduces the amplitude of the uP generated square wave signal and improves its sound. Injecting the side tone signal into the audio amplifier in this way allows for volume control independent side tone level.

AGC operation:

The audio signal from the audio band pass filter is amplified by a high gain Darlington pair amplifier, Q7/Q8. These transistors are normally biased into saturation by the base resistor R18. Negative going portions of the audio signal cause Q7/Q8 to start to turn off, allowing the collector voltage to rise. Diode D3 allows this voltage to charge C51, which holds the AGC voltage during positive portions of the audio signal and in conjunction with R17 provides the AGC “hang” time. The voltage on C51 is applied to the gate of Q5. When the voltage on the gate gets to be about 3 volts, Q5 starts to turn on. Since Q5 is connected across the signal input to the receiver, this attenuates the input signal.

AGC action does not start until an input signal reaches about S7 or 8 and stops being effective with signals above S9+20 dB. Although the AGC range is somewhat limited, it is enough to keep strong signals from becoming too loud and making you ride the volume control while tuning across the band. The AGC is also effectively disabled for weak signals, where AGC action can be more of a hindrance then a help. Because it takes several audio cycles for the AGC to respond, very strong signals can cause a slight “popping” sound as the leading edge of the signal will be at full volume. This is most noticeable if the code speed being sent is slower than the hang time of the AGC. The hang time is made relatively short so that it recovers quickly when coming out of transmit.

Transmitter:

The transmitter is very simple and effective. During transmit, the DDS chip produces the direct transmit frequency so no mixing and filtering is needed. It also generates a square wave signal, which is feed into some NOR gate high speed logic buffers. The DDS output is first inverted with U2a to produce a normally HIGH signal, then inverted again the remaining three gates in the chip which are connected in parallel to produce a normally LOW signal to apply to the PA FET gates.

Three BS170 MOSFETs connected in parallel are used for the power amplifier. The 5 volt square wave logic drive to the gates allows the MOSFETs to have a low “ON” resistance and switch on and off quickly. This produces a very efficient Class C amplifier, of about 70%. This high efficiency is the key to using PA transistors in TO-92 packages which do not get very warm, even when putting out 5 watts of RF power. The output Low Pass Filter is designed to provide some impedance matching between the PA and antenna load, which also improves efficiency.

In order to eliminate key clicks, the supply voltage to the PA is keyed on and off and has a few millisecond rise and fall time.

Q10, a P channel power MOSFET switches the supply voltage to the PA. The gate pull up resistor R1 in conjunction with C10 slows down the turn on and off times to provide the proper voltage ramp. Q1 connected back to the uP is used to turn Q10 on and off for keying.

Microprocessor control:

An Atmel MEGA48 processor is used to control the rig. This processor provides all the logic functions needed to control the DDS chip, operate the LED display, input switches, provide the keyer functions, generate side tone and do the T/R switching control.