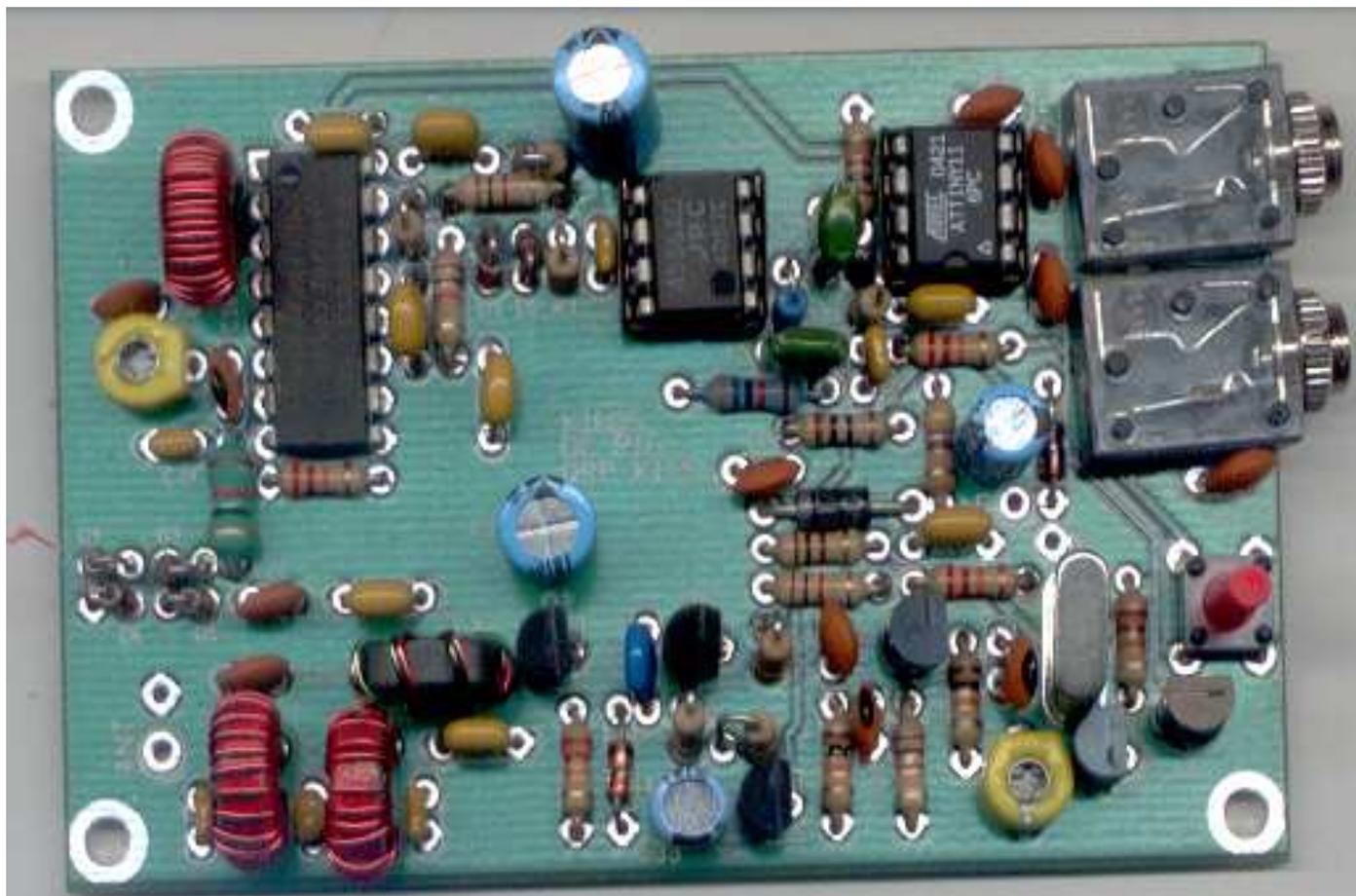


The DC40

A high performance Direct Conversion 40M transceiver.



A KD1JV "Melt Solder" design
Distributed by Hendricks QRP KITS
www.qrpkits.com

The DC40

A Direct Conversion, fixed frequency Transceiver.

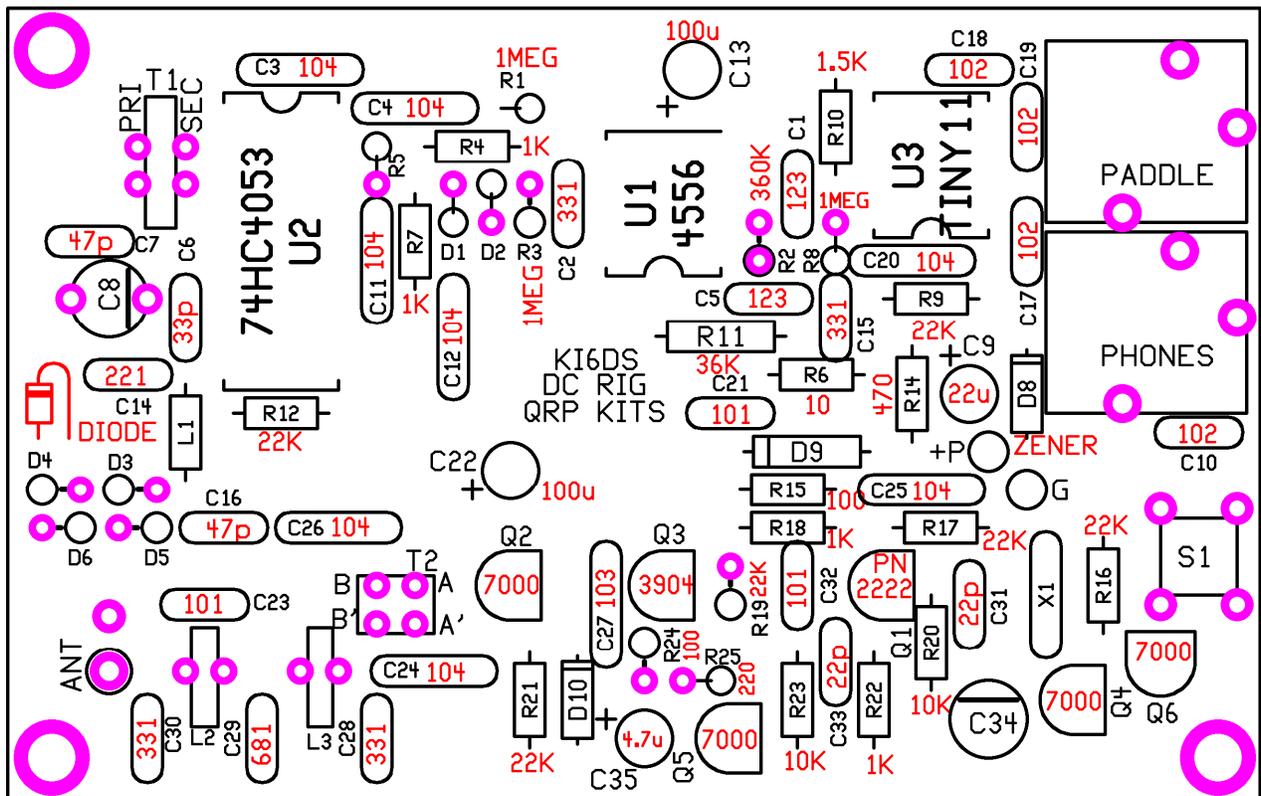
The DC40 is a moderately complex rig, which yields excellent performance, yet is small enough to fit into an Altoids tin. The receiver features nearly complete immunity to AM SWBC interference and can be run on an AC supply without hum pickup or AM BC interference common to most DC receiver designs. One stage of audio band pass filtering gives the receiver some selectivity. The transmitter puts out a respectable 750 mw of power, with a 12V supply and over 1 watt with 13.8 volts. The transmitter frequency is automatically shifted up about 600 Hz to provide the proper T/R offset. The rig also includes a simple keyer chip.

Assembly:

Assembly of the board will be done in several groups. You can test most of these stages when finished, or move onto the next group and test everything at once. If a group fails to pass the smoke test, see the trouble shooting section located after the assembly instructions.

If you plan on installing the board into an Altoids tin, trim off the corner of the board next to the paddle jack before you install the jack. You may also want to mark where the mounting holes and where the phone jacks will be in the tin before installing any parts.

The parts location diagram for the whole board is shown below. Component values are marked in red. Experienced builders should be able to build up most of the board using just this diagram.

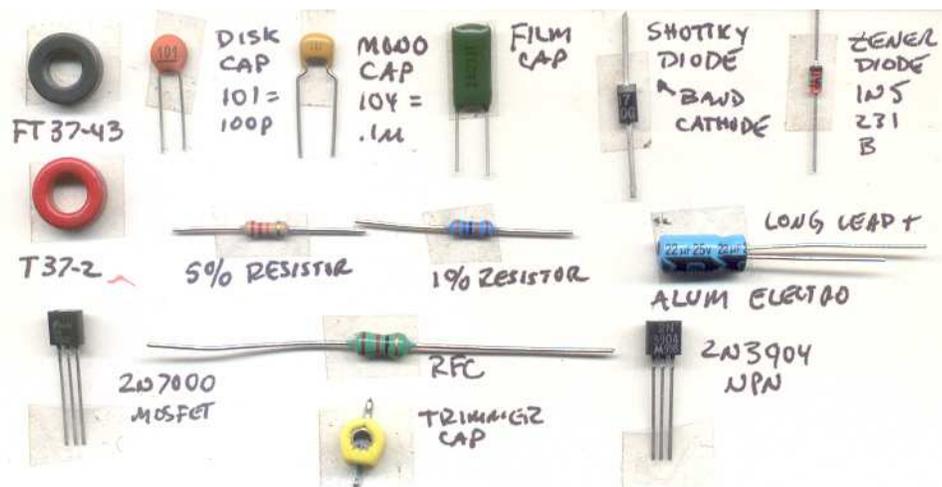


Note that Q1 and Q3 may be either 2N3904 or PN2222A

Parts list

<i>RESISTOR</i>	<i>VALUE</i>	<i>TYPE</i>	<i>Caps</i>	<i>Value</i>	<i>type</i>
R1	1 meg	5% 1/4w CF	C1	.012 uF	FILM
R2	360 K	1.00%	C2	330 p	DISC or mono
R3	1 meg		C3	.1 uF	.2LS MONO
R4	1 K		C4	.1 uF	MONO
R5	1 K		C5	.012 uF	FILM
R6	10 OHMS		C6	33 p	DISC
R7	1 K		C7	47 p	DISC
R8	1 MEG		C8	40 p	TRIMMER
R9	22 K		C9	22 uF / 16V	ALUM
R10	1.5 K		C10	.001 uF	DISC
R11	36 K	1.00%	C11	.1 uF	MONO
R12	22 K		C12	.1 uF	MONO
R13	Skipped	Not used	C13	100 uF/16V	ALUM
R14	470 OHMS		C14	220 p	DISC or mono
R15	100 OHMS		C15	330 p	DISC or mono
R16	22 K		C16	47 p	DISC
R17	22 K		C17	.001 uF	DISC
R18	1 K		C18	.001 uF	DISC
R19	22 K		C19	.001 uF	DISC
R20	10 K		C20	.1 uF	MONO
R21	22 K		C21	100 p	DISC
R22	1 K OHMS		C22	100 uF/16V	ALUM
R23	10 K OHMS		C23	100 p	DISC
R24	100 OHMS		C24	.1 uF	MONO
R25	220 OHMS		C25	.1 uF	MONO
			C26	.1 uF	MONO
			C27	.01 uF	.2LS

			C28	330 p	DISC or mono
			C29	680 p	DISC or mono
			C30	330 p	DISC or mono
			C31	22 p	DISC /NPO
			C32	100 p	DISC
L1	12uHy	RFC	C33	22 p	DISC /NPO
L2/3	T37-2	Red	C34	40p	TRIMMER
T1	T37-2	Red	C35	4.7uF/16V	ALUM
T2	FT37-43	Black			
			SEMI'S		
X1	7. 040 MHz		U1	NJM4556AD	High current opamp
SWITCH	6mm TACT	14mm shaft	U2	74HC4053	Analog multiplex
JACKS	PC mount stereo		U3	ATTINY11	MPU
PC Board			Q1/3	2N3904 or PN2222A	NPN
Red and Green	Magnet wire		Q2/4/5/6	2N7000	MOSFET
			D1/2/3/4	1N4148 or 1N914A	Small signal
D7 skipped	Not used		D8	1N5231B	5.1V
			D9	1N5718	Schottky power
			D5/6/10	1N4148 or 1N914A	Small signal



Tips and info for first time builders:

Installing parts:

You can insert several parts at a time onto the board. Parts should be pressed flush to the top of the board. The exception is the transistors, which should stand off the board by about 1/8", due to their three legged nature. Once you insert the part, kink one of the leads over slightly to keep it from falling out of the board when you flip the board over to solder.

The .1 uF caps used in the kit have formed leads, so these will not sit quite flush to the board. Several of the disk caps have lead spacing larger than the pads on the board. These leads you can reform with your pliers so they will sit flush to the board.

Once you solder a part in place, clip the lead nearly flush to the board. Clip at the top of the little fillet of solder which forms around the lead.

Finding the right part.

A picture at the bottom of the parts list on the previous page can be used to help identify some of the parts. The parts not shown should be obvious or deduced by the process of elimination. The numbers identifying the Monolithic caps (mostly yellow in color) can be hard to read. The use of a magnifying glass can help you to see them. In addition to the part value of the capacitor, there are a number of other letters and numbers printed on the part. Simply look for the three number group which matches the value your looking for, 331 for 330 pF, 104 for .1 uF and 681 for the 680 pF cap.

IC pin 1.

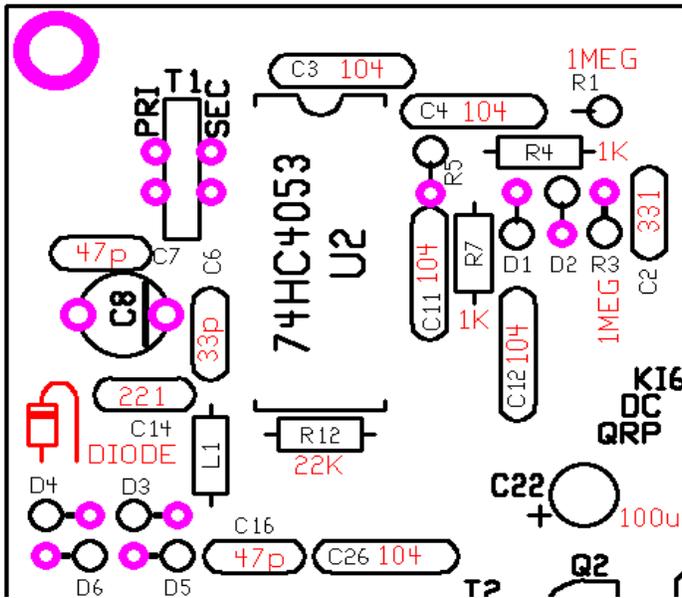
The outline on the board for the ICs has a "V" notch on one end. This indicates the pin 1 end of the IC. If a socket is used, there is also a notch on one end of the socket. This end goes over the V notch outline on the board. Finally, pin 1 of the IC is marked with a round dimple or dot. This end of the IC will go towards the notch on the socket or "V" on the outline.

Soldering

There are two important things which need to be done to ensure the successful operation of a kit. One is getting the right part into the proper place on the board. The second is good soldering. To insure a good connection, the soldering iron should touch both the component lead and the circuit board pad it is to be soldered to. Heat the connection for just a second, then put the solder to the iron/pad/lead junction. Allow just enough solder to flow to fill the hole and wick around the lead. Go easy on the solder, you don't need a whole lot. If you use a thin solder like 0.02" instead of the more common 0.032" type, you have better control of the amount of solder used. For parts which connect to the ground plane, you may have to heat the connection a little longer.

headphones. If you don't hear the side tone, check to see if there is about 5 volts on pins 1,2,3,5,6 and 7 on the op amp U1. Pin 4 is ground, 0 volts, and pin 8 is supply, about 12V.

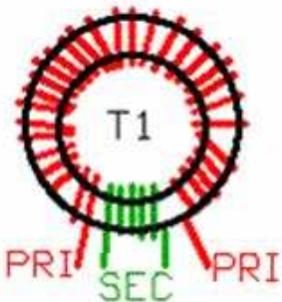
Group 2: Receiver front end:



NOTES:

C8: the flat side of the trimmer goes towards the line on the outline.

Diodes D1-5 These parts are installed vertically. Note the diagram in red above, showing the way the cathode lead (the end marked with a black band) is bent over and installed into the hole opposite the one marked with a circle.



T1: Wind 32 turns of the red magnet wire on the red core (T37-2). This is the primary. Wind 8 turns of the green magnet wire in the space between the start and finish of the primary winding. You can over lap these turns if there isn't enough room to make a single layer.

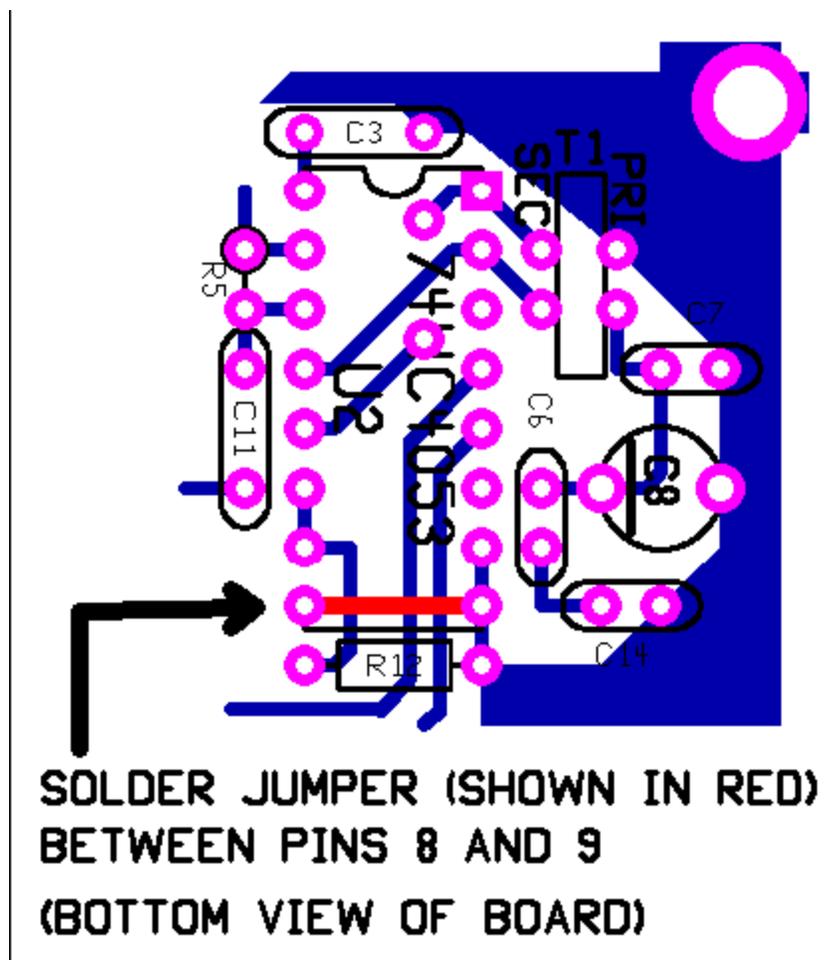
location	value	markings	✓
R1	1 MEG	BRN/BLK/GRN	
R3	1 MEG	BRN/BLK/GRN	
R4	1K	BRN/BLK/RED	
R5, R7	1K	BRN/BLK/RED	
R12	22K	RED/RED/ORG	
L1	12uHy	BRN/RED/BLK	
C2	330p	331 DISC	
C3	.1u	104 mono	
C4	.1u	104 mono	
C11	.1u	104 mono	
C12	.1u	104 mono	
C26	.1u	104 mono	
C7	47p	47 DISC	
C16	33p	33 DISC	
C14	220p	221 DISC	
C16	47p	47 DISC	
C8	40p	Yellow trimmer	
C22	100u/16V	Alum Electro	
D1/6	1N4148	See notes	
T1	32T / 8T	See notes	
U2		74HC4053	

Trim back the leads to about 1/8" and tin. Tinning can be done with a **HOT** soldering iron, it helps to have a blob of solder on the tip when you do this. Or, you can burn the insulation off with a lighter or match and clean with some fine grit emery cloth. Insert the two red wire leads into the holes labeled "PRI" on the diagram (the two holes to the left) and the two green wires into the holes labeled "SEC" (the holes on the right). Note that one of the green and red wires will have to cross over the outside of the core, so that both red and both green wires are on the same side of the core.

U2: A socket is not used with this IC, solder directly to board.

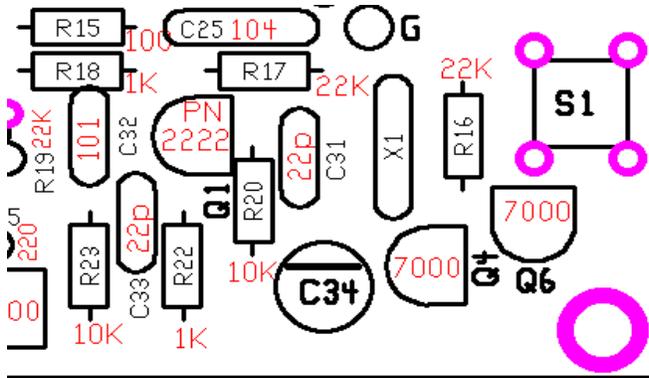
Missing ground fix:

Pin 9 of U2 was mistakenly left floating on the final board layout. This pin needs to be grounded in order for the mixer to work. After U2 is soldered onto the board, simply use a resistor or diode lead clipping and solder between pin 9 and pin 8 of U2. See below:



Smoke test: There is no test for this group, move onto the next group.

Group 3: Oscillator:



<i>location</i>	<i>value</i>	<i>markings</i>	√
R15	100 ohm	BRN/BLK/BRN	
R18	1K	BRN/BLK/RED	
R22	1K	BRN/BLK/RED	
R20	10K	BRN/BLK/ORG	
R23	10K	BRN/BLK/ORG	
R16	22K	RED/RED/ORG	
R17	22K	RED/RED/ORG	
C31	22p	22 DISC	
C33	22p	22 DISC	
C32	100p	101 DISC	
C25	.1u	104 mono	
C34	40p	Yellow trimmer	
Q1	PN2222 A	NPN	
Q4	2N7000	mosfet	
Q6	2N7000	mosfet	
X1	7.040M	Crystal	
S1	TACT	PB SWITCH	

NOTE:

Q4/Q6 are mosfets and can be damaged by static. Those who live in dry areas and prone to static problems need to take precautions before handling. This can simply be to touch a large metal object to discharge yourself.

C34: The flat side of the trimmer goes towards line on layout diagram.

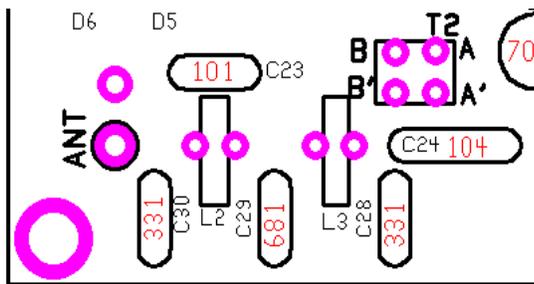
S1: You may want to mount the switch on the bottom of the board. If you are going to mount the rig into an Altoids tin, you won't have to open the lid to access the switch. If you mount the rig into some other kind of enclosure, mounting the switch on the bottom may be the only practical way of accessing it.

Smoke Test:

Connect a test lead antenna to a rig which tunes 40M. Tune the receiver to 7.039000 MHz. Place the test lead antenna near the board. Apply power. Tune the receiver around a little until you hear the boards crystal oscillator. Remove power and connect a paddle or straight key to the paddle jack and a pair of headphones to the phones jack. Re-apply power to the board. If your using a paddle, click the S1 switch and you should hear the letter "S" in the headphones. This is the keyer speed adjust. Shortly after you hear the "S", you should hear an "I". This indicates the speed adjust mode has been exited. Now click and hold closed the switch until you hear the letter "T". The keyer is now in Tune mode. Tapping the DOT paddle will put the rig into transmit mode. It will remain so until you tap the DASH paddle. You can continue to toggle back and forth between transmit and receive using the DOT and DASH paddles. To exit tune mode, click the switch again.

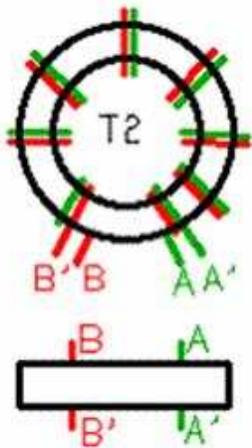
Now you can set the C34 trimmer for the proper T/R offset. Put the keyer back in Tune mode, so you can toggle the oscillator between the receive and transmit frequencies. With the board in receive mode, determine the frequency of the oscillator, either with a frequency counter or with your station receiver. Toggle the board into transmit mode and adjust the C34 trimmer so the oscillator is now 600 Hz higher in frequency than it was when in receive mode.

Group 4: Low pass filter



location	value	markings	√
C23	100p	101 DISC	
C30	330p	331 DISC	
C29	680p	681 DISC	
C28	330p	331 DISC	
C24	.1uF	104 mono	
T2	Black core	See notes	
L2, 1.3uH	18 turns	Red T37-2 core	
L3, 1.0uH	16 turns	Red T37-2 core	

When winding the toroid cores, remember that one pass of wire through the center of the core is one turn. Also try to keep the wire snug to the outside of the core. The picture below shows 8 windings, you will only wind 6.

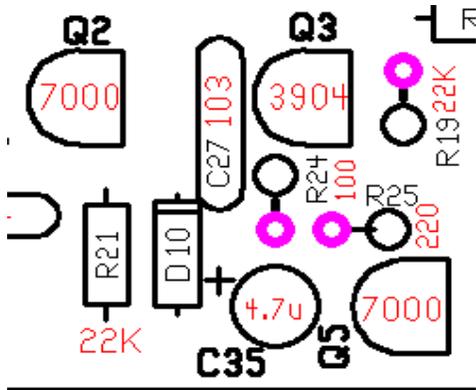


T2 is a bifilar wound transformer. This simply means we wind two wires on the core. Two colors of wire are used to help identify which is which. You can twist the wires together, or simply lay them side by side as you wind the turns. **Wind 6 turns** of the wire pair. When you are done, there will be a red/green pair at the start and finish of the windings. Reverse the red and green wires on one side of the core, so that both ends of the red and green wires are opposite each other on the core, as shown in the bottom diagram. Now trim back the leads and tin them. Insert the wires into the board, with the red wires in the B holes and the green wires in the A holes, then solder into place.

Smoke Test.

The receiver section is now complete. You can connect an antenna (or some wire) to the antenna pad and see if you can hear any stations or your station transmitter (using a dummy load, of course) Note: You may hear some noise “whoosh” by. This is from the oscillator in the keyer chip. The chip uses an R/C clock which is temperature sensitive and so wanders around a little.

Group 5: Transmitter driver and PA



<i>location</i>	<i>value</i>	<i>markings</i>	√
R21	22K	RED/RED/ORG	
R19	22K	RED/RED/ORG	
R24	100 ohm	BRN/BLK/BRN	
R25	220 ohm	RED/RED/BRN	
C27	.01uF	103 (blue)	
D10	1N4148 or 1N914A		
Q3	2N3904	NPN	
Q2	2N7000		
Q5	2N7000		
C35	4.7u/16V	4.7/16	

NOTE: Q3 maybe supplied as a PN2222A

Smoke Test:

All the parts should now be on the board.

If you have been testing along the way, the only thing left is to see if the transmitter section is putting out power. If at all possible, connect up a QRP power meter and dummy load to the rig. Apply power to the rig and put the keyer into tune mode. Tap the Dash paddle to turn the transmitter on and see how much power is being produced. Depending on the supply voltage your using, power out should be between 700 mw and 1.2 watts. Power output can vary depending on how the wire on the low pass output filter cores (L2 + L3) are spaced. Try moving the wire around the core to make the turns closer together or farther apart and see how this affects the power out. However, if your powering the rig with a 13.8V supply, don't exceed about 1 watt out, or the PA FET will start to get hot!

If you pass this test, time to hook up the antenna and try to make some contacts! Good luck!

Trouble shooting guide:

The most common reason a kit does not work right is due to soldering issues. Therefore, the first thing to look for if something doesn't work is the solder connections. Look for solder splashes which might be shorting two pads together which shouldn't be connected and for solder which might have stuck just to a lead and didn't flow into the circuit board pad. Connections to the ground plane need extra heat, so look closely to these connections to make sure the solder flows into the hole. It's also possible to have solder on the circuit board pad, but it didn't flow around the lead.

The second most common error is mis-placed parts. You may have mis-read a resistor color code, or put it in the wrong spot. The same goes with capacitors. So, if your soldering looks good, double check the parts placement.

Having an actual bad part is rare. It is possible to damage them though. The 2N7000 can be damaged by static due to improper handling and ICs can be damaged if they are installed backwards.

Making contacts with a fixed frequency, Direct Conversion rig.

Making contacts with this type of rig can be a challenge, but its not impossible. In fact, it can be a lot of fun and satisfying. Just remember, its easier to have stations come to you. The reason for this is because the receiver will hear stations on both sidebands, you don't know which side band your hearing them on. They could be on your transmit frequency of 7.040000 or down at 7.038800. Also, although the audio band pass filter adds some selectivity, its hard to tell how close to your operating frequency they really are, especially if the station is pretty strong. You could be hearing them well, but your transmitting too far from their operating frequency for them to hear you. That being said, it can pay to try and answer a CQ you hear anyway, especially if they are signing QRP or QRPp. Then you pretty much know they are on 7.040 and some operators actually use RIT to tune around a little for answering stations. Or they could be using one of these rigs or a Rock Mite.

It also helps to carefully pick the time of day and day of the week to operate this rig. You want to pick a time of day and day of the week when the band isn't overly active. Contest weekends and early evening prime time are out. Good times are Sunday afternoon or evening, mornings, afternoons and late evenings during the week.

Keyer operation:

The momentary switch is used to access three keyer functions, speed, tune mode and iambic A/B selection. Clicking and holding closed the switch for various lengths of time will access these functions.

Changing code speed.

Keying speed can be selected from about 7 to 30 wpm, in 1 wpm steps. Momentarily click the switch closed until the letter "S" is heard. Tapping the Dash paddle increases the speed and tapping the Dot paddle decreases speed. A dot will sound at each code step. The letter "I" will sound when the upper or lower speed limit is reached. Code speed mode will automatically exit if neither paddle is closed for about 1 second.

Tune mode.

This mode allows you to toggle the transmitter on and off, using the paddles. This frees up both hands to fiddle with an antenna tuner. To access Tune mode, click and hold closed the switch until the letter "T" sounds. Tapping the Dash paddle will toggle the transmitter on and tapping the Dot paddle will toggle it off. To exit tune mode, click the switch again.

Iambic A/B mode.

The keyer used iambic B mode as default. This can be changed to A mode by clicking and holding closed the switch until the letter "A" sounds (about 2 seconds). This change isn't remembered by the keyer chip, so has to be changed each time power is cycled. In either A or B mode, holding closed both paddle will produce alternating dots and dashes. In B mode, an extra dot or dash is added to the end of the string, provided the paddles are not released before the end of the inter element space.

Straight key mode:

If a mono plug is in the paddle jack at power up, the keyer will go into straight key mode. In this mode, there is no need for the function switch, so it is disabled.

How it works:

Receiver:

Signals from the antenna first travel through the transmitters low pass filter. It then enters a series tuned circuit comprised of L1 and C14 and is resonant at 7 MHz. During transmit, a pair of back to back diodes limits the amplitude of the signal at the junction of L1 and C14 to about 1.2 volts peak to peak. This protects the mixer from damaging voltages. A capacitive matching divider couples the output of the series L/C network into the parallel tuned receiver input circuit.

The tuned input circuit then couples the signal into the receiver mixer, through a secondary turn on the core. The mixer is an analog multiplexer. The analog switches in the multiplexer connect the output load resistor across the secondary of the input tuned circuit at the LO frequency. On each half cycle, the phase of the input signal across the load resistor is switched. This produces the mixing of the LO signal and input signal, producing an audio beat note at the load resistor. Note that there is no bias voltage on the analog switches. Biasing the switches to $\frac{1}{2}$ the supply voltage would improve the mixers' dynamic range, but was found to be not necessary. Any signal strong enough to overload the mixer without bias, would "blow your ears off".

A high gain, differential input audio amplifier is connected to the mixer's load resistor. This stage provides most of the gain for the receiver. A pair of back to back diodes across the amplifiers feedback resistor limits the peak to peak output of the amplifier, to offer some hearing protection from strong signals. These diodes also reduce clicks created by switching transients when switching from receive to transmit and back again.

The output of the first high gain audio stage is then routed through another analog switch, again without bias, for audio muting during transmit. The signal then goes into an audio bandpass filter stage. This filter has a Q of 8. However, since only a single stage of filtering is provided, the filter isn't as narrow as a Q of 8 would imply when strong signals are present. The output of this filter drives the headphones. A 10 ohm resistor helps keeping the amplifier stable when driving the relatively low impedance of headphones and the .001 cap across the output helps keep RF, which might be picked up by the headphone leads, out of the amplifier. The NJM4456 op amp used has a high current output, so has no trouble driving headphones.

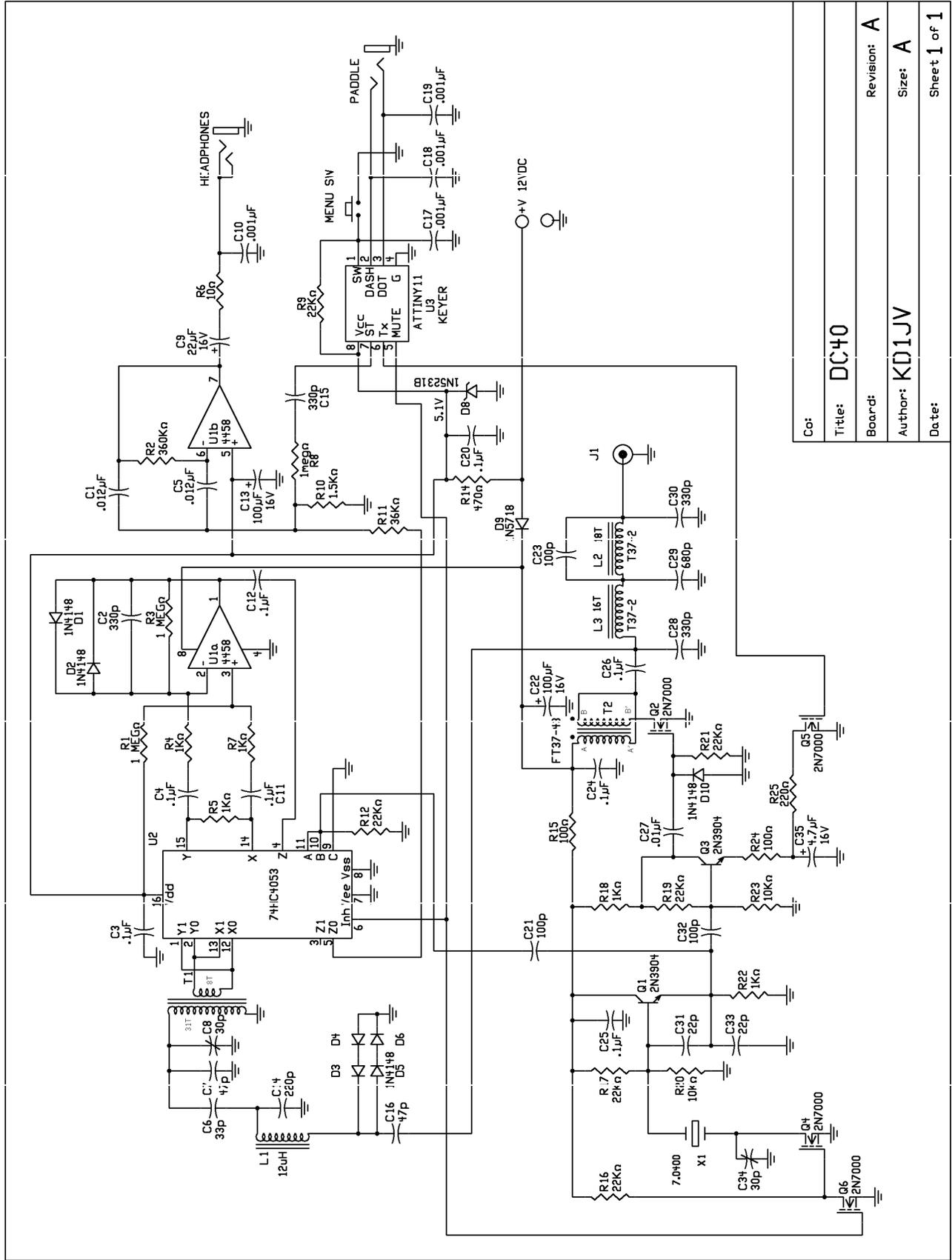
Oscillator and transmitter.

A classic Colpitts crystal oscillator provides the Local Oscillator. During receive, Q4 is turned on, which disables any effect C34 has on the oscillator frequency. During transmit, Q4 is turned off, allowing C34 to increase the oscillator frequency. C34 is used to set the transmit frequency about 600 Hz higher than the receive frequency, providing proper T/R offset. When going from receive to transmit, the keyer chip will first mute the receiver and shift the oscillator frequency before enabling the transmitter output. When going from transmit to receive, the transmitter is first turned off, then after a delay of about 5 ms, the receiver is un-muted and the oscillator frequency shifted.

Q3 buffers and amplifies the LO output signal in order to drive the PA. This stage is turned on and off by the keyer chip, with the help of Q5. R23 and R25, in combination with C35 form an R/C time constant which causes the output of Q3 to ramp on and off in about 5 ms. This provides wave shaping to the output signal, to eliminate key clicks.

The output of Q3 in turn drives the PA stage, a 2N7000 MOSFET. Diode D10 across the gate acts to double the drive voltage by charging the coupling cap, C27 on negative cycles. This ensures there is enough drive voltage to turn Q2 reasonably well on. The output of the PA, Q2 is coupled to the low pass filter through a bifilar wound transformer. This provides some impedance matching and increase power output and efficiency. Capacitor C23 tunes the L3 coil to the second harmonic, which forms a trap. This ensures the spurious output of the transmitter is well below required FCC limits. It also improves PA efficiency and power output.

A simple 5.1 volt zener diode is used to supply the required voltage for the keyer chip and Mixer. It also is used as a bias voltage on the audio amplifier op amp.



Co:	
Title:	DC40
Board:	
Author:	KD1JV
Date:	
Revision:	A
Size:	A
Sheet	1 of 1