The "Jersey Fireball 40" Transmitter

Technical Manual & Construction Guide

Introduction

Thank you for purchasing the Jersey Fireball 40 transmitter! You should be able to assemble this kit in about 30 minutes using common tools on your workbench: a low power soldering iron, wire cutters and a voltmeter. A well-lighted area and a magnifying glass will also help.

This document describes the operation of the Jersey Fireball 40 (or "FB40" for short!) and then takes you through construction of it step-by-step. We'll also illustrate simple use of the FB40 with a receiver to give you hours of satisfaction operating in the world of very low power communications called "QRPp".

The Jersey Fireball 40 isn't going to get you any trophies in the DX contests, any pelts in the Fox hunts, or any ooh's & aah's in the "bells and whistles" category of equipment in your shack ... but this little gem will go together quickly and provide all sorts of amazing contacts for you. See how many miles-per-watt you can get with just a 9V battery and antenna!

Okay, so just what is the "FB40"?

The "Jersey Fireball 40"[1] is a simple, easy-to-build low-power CW transmitter designed to operate in one of several amateur radio bands. Its name is derived from the fact that the project was designed and kitted[2] by the New Jersey QRP Club[3] members, and that the basic RF power output can be up to 40 milliwatts.

The FB40 uses a TTL crystal oscillator "can" as the heart of a milliwatt-level CW transmitter. The designer of our club project, Clark Fishman[4], WA2UNN, chose an oscillator frequency of 28.322 MHz as a starting point, added some simple circuits to divide this frequency down to hit 80m, 40m, 20m as well as 10m. We also put a low pass filter in the design to clean up all the ratty harmonics coming from the square waves of the ICs and to allow multi-band operation.

You get to select what band in which you want to operate! All you need to do is install a capacitor in the correct position on the printed circuit board to select one of the following frequencies: 28.322 MHz, 14.161 MHz, 7.080 MHz, or 3.540 MHz. The kit comes with filter components for 7.080 operation, but we supply a list of filter component values that can be used to put the transmitter on the other frequencies as well … just substitute a couple of parts from your junk box and you'll be able to operate on 10m, 20m and 80m in addition to the 40m band supplied.

We've also provided pads on the printed circuit board for an optional TiCK keyer chip! This is a small IC programmed as a fully-featured iambic keyer, including speed control and other options. All you need to do is drop this chip into the board, add a couple of components and you'll be paddling to your heart's content. (Note: the TiCK chip is not supplied in the FB40 kit. See the Notes section at the end for ordering instructions.[5])

If you add just a few more optional "T-R switch" components to the circuit board, you'll be able to allow an external receiver to be connected to the circuit board, thus providing transmit/receive switching using the same antenna connected to the FB40 transmitter.

And yet another option that should thrill many hams is that circuit board traces are provided for an optional RF power amplifier! Once you get expert at making contacts at low milliwatt levels, you might want to add some parts from your junk box to boost the FB40's output power to around 1.5 watt. The assembly guide and schematic make this a piece of cake to do.

The Jersey Fireball 40 is quite a feature-packed little project. All parts are supplied for stock operation on 40 meters and a 2" x 3" double-sided printed circuit card makes assembly a breeze.

A Little History

The "fireball" transmitter concept has been around for a number of years and has been published by several individuals. All of these designs, including our Jersey version, are based on the use of a pre-packaged oscillator contained in a metal "can" which is able to be plugged into a standard 14-pin IC socket. These cans are typically used in computers, test equipment and other devices as a source of a stable and accurate master frequency.

Oscillator cans come at various factory-prepared frequencies like 4 MHz, 10 MHz, 40 MHz, etc. However, designers are able to order the cans at specific frequencies they might need for their projects. Our FB40 oscillator frequency was chosen because it was readily available and its 28.322 MHz base frequency divides down relatively nicely into the amateur bands.

Prior articles concerning the use of oscillator cans appeared in Nov 1990 of *73*, April 1993 of *QRP Quarterly*, and Nov 1998 of *73*. You could reference these articles for additional background and use.

Circuit Description

Refer to the schematic shown later in figure 1. The heart of the Jersey Fireball 40 QRPp Transmitter is a pre-packaged TTL oscillator can in the form factor of a 14-pin IC. This oscillator operates at 28.322000 MHz and swings about 1.5 Vp-p.

The basic principle of operation is that the oscillator U1 provides a signal to a series of TTL flip-flop stages used to successively divide the frequency in half. These signals are then routed through a capacitor and on to a 5-element low pass filter. The LPF provides appropriate filtering and conditioning of the original square wave signal, thus turning it into a relatively clean transmitted signal.

The divider circuits are 74LS74N dual edge-triggered TTL flip-flops, selected for their low price and low power consumption.[6] They are configured as toggle flip-flops - meaning that the output changes state on the positive edge of each input clock signal. This is ideal for a divide-by-two function desired for the FB40, knocking the 10m frequency down by half each time we add another gate. The chips operate to well over 30 MHz, so there was little problem with response, delays or signal levels.

The first stage flip-flop (U2a) after the oscillator divides the 28.322 MHz signal in half to yield a 14.161 MHz signal. The second stage U2b divides the 14.161 MHz signal down to 7.080 MHz. And the third stage (U3a) divides the 7.080 MHz signal in half to 3.540 MHz. Admittedly, the specific frequencies are not necessarily hot beds of CW activity (except perhaps on 80m), but they are not too far off the beaten path. Additionally, other oscillators can easily be substituted to achieve better/different frequencies through the divider chain.

The outputs of the flip-flop stages, and the original 28.322 MHz signal itself, are all routed to some jumper pads where you can select which signal is presented onward to the next stage by proper placement of the capacitor Cx. The 40 meter kit needs to have the capacitor in the third position, allowing the 40m signal to pass on to the low pass output filter.

The output filter is a 5-element Chebychev filter with components determined by using Wes Hayward's popular RF Analysis software programs[7]. A table of values is shown below:

	C4	L1	C6	L2	C5
80m	1700 pF	2.17 uH	2400 pF	2.17uH	1700 pF
40m	820 pF	1.1 uH	1000 pF	1.1uH	820 pF
20m	450 pF	0.6 uH	630 pF	0.6 uH	450 pF
10m	230 pF	0.3 uH	330 pF	0.3uH	230 pF

Table 1: Output Filter Component Values

The filter inductors are constructed by winding toroids to achieve the desired values. The standard formula for the number of turns was obtained from Paul Harden's, NA5N "Data Book for Homebrewers and QRPers" (see reference at end of document[8]):

N = 100 * SQRT (Ldesired / AL)

So with 1.1 uH being the desired inductance, we need about 16 turns for 40m operation.[9] If you'd like to operate the FB40 on 80m, 20m or 10m (which would be really nice in the coming sunspot peak!), just substitute the appropriate caps and inductance (# turns) per Table 1 above.[10]

The output of the FB40 was measured using an HP spectrum analyzer. The second harmonic of the fundamental 40m signal was seen at 45 dB, and the third was seen at 52 dB … not to shabby for a TTL oscillator can, some divider chips and a simple filter. And certainly good enough for safe operation at these power levels.

The FB40 is keyed by bringing the pin 7 of the TTL oscillator to ground at the KEY connector pad on the left side of the board.

The output of the FB40 was measured at 10 dBm, which corresponds to 10 milliwatts into a 50 ohm load. This varied from unit to unit and tended to be a function of how strong the TTL totem pole outputs were in the 74LS74 chips. (They aren't optimally made to be looking at 50 ohms, so the interface to the output filter isn't quite ideal.) But even so, with almost no insertion loss, the filter takes the signal and presents it effectively to a 50 ohm load, such as a tuned antenna feedline or an ATU.

The power source input to the FB40 board can be any voltage in the range of 9-14 volts. The LM78L05Z three terminal regulator can supply 5V at 100ma safely, and this circuit design operates well within that limit.

Optional Circuit: T-R Switch

When operating a separate transmitter and receiver, it is oftentimes convenient to automatically switch the single antenna from the receiver to the transmitter during “key down” times. This transmit-receive switchover can be done by several means; circuit traces are included on the FB40 pc board to provide a simple version of T-R switching.

The T-R switch function is provided by a series resonant circuit connected between the RF source and an associated receiver. Capacitor C16 and inductor L6 are series resonant at 7 MHz and provide very little signal attenuation during receive. However when the transmitter is putting out its 5-40 mW signal, diodes D1 and D2 alternately conduct, bringing the junction of L6/C16 to near ground potential during transmit. This action limits the power going to the receiver input to only about 1 mW, and makes C16 effectively part of the output filter network. Most receivers should be fine with this configuration, although its automatic gain control (agc) system needs to have fast recovery. (The agc can be adjusted on many receivers.)

Side note: The series-resonant circuit going to the receiver is a critical element, and requires some different component values when used on the various bands of the FB40. Table 2 shows the component values for the different bands of operation:

Band	C16	L6
80m	56 pF	36 uH, 9T #28 wire on T50-2
40m	47 pF	10.8 uH, 52T #26 wire on T37-2
20m	33 pF	3.9 uH, 31T #28 wire on T37-2
10m	22 pF	1.4 uH, 19T #28 wire on T37-2

Table 2: T-R Switch Component Values

Optional Circuit: TiCK Iambic Keyer

The IC at U4 is a versatile little iambic keyer chip in an 8-pin package provided by Embedded Research (see reference at end.) This chip is not part of the components supplied in the FB40 kit, but the pc pads and traces have been provided on the board to allow you to easily add the keyer option to the basic kit. The TiCK enables you to connect a paddle to the DIT and DAH input pins, and key the transmitter through a 2N2222A driver transistor. The TiCK can be programmed by grounding the PGM connector pad at the bottom of the pc board, per the instructions provided by the vendor. Speed, memory, weighting are all controllable parameters for this chip.

Optional Circuit: RF Power Amplifier

In order to provide the builder with an easy way of boosting the RF output power, circuit traces have been provided on the FB40 board for a broadband small-signal RF amplifier.

A number of years ago, Wes Hayward, W7ZOI had published an inspirational transmitter project called the Ugly Weekender[11]. He provided some "boots" for a 4 mW flea power VFO and buffer amp such that he could bring the output power up to several watts.[12] With Wes' permission, the FB40 also provides this circuit design as an optional amplifier that the user can easily construct right on the pcb.

The amplifier is a fairly efficient Class C design consisting of driver transistor Q3 and power transistor Q4. Resistors R6 and R7 reduce the FB40's output by half so as not to overdrive the amplifier. (A 100 ohm potentiometer could be conveniently added here as a drive control.) In order to reduce the current drain of the Q3 driver transistor stage, transistor Q2 supplies +V only when the oscillator is keyed. D3 is a Zener diode used to protect power transistor Q4 in case the transmitter is keyed without an antenna connected; and C15 is used to create a total capacitance of 450 pF at the Q4 collector, including the capacitance of the transistor, the Zener, the receiver pick-off cap and the fixed cap itself. (A variable cap could be used for C15 in order to peak transmitter efficiency.) A 50-ohm input / 50-ohm output network is also used and is shown with component values are shown for 40 meter operation. (Components for operation on other bands may be determined by consulting the ARRL Handbook.) Similar to the T-R switching used with the stock version of the FB40, this amplifier uses a series-resonant L/C circuit to connect to the receiver's antenna terminal. [Note: Only one T-R switching circuit is needed – if the power amplifier and its T-R switch components are employed, components L6/C7/D1/D2 are not needed.]

Many thanks to W7ZOI and W7EL for providing a circuit to give us a signal with just a little more respect on the air!

Building the Kit

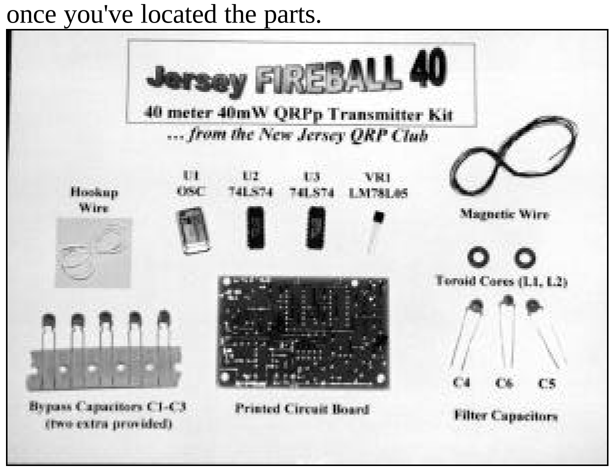
This section describes how to put your kit together. As you progress through each step, be sure to put a checkmark in the boxes to help you keep track of things during the interruptions (phone calls, kids pulling at the sleeves, dog biting your slippers, rare DX coming from the rig's speaker, etc.)

❑ Step 1: Set up

The first thing you should do is find a clear, well-lighted spot on the bench or table. You'll need a fine fine-tipped 30W (or so) soldering iron, wire cutters/strippers, and a voltmeter or DVM. (It will be helpful if the DVM is able to read milliamps too.) If you have difficulty reading small print up close, you might want a magnifying glass to help out in some areas of the construction. If you have an oscilloscope, you'll be able to see waveforms of the RF signals as you build the board.

❑ Step 2: Parts Inventory

Carefully empty the contents of the parts bag onto the table and identify all the supplied parts. This section will help you do that. Put a small checkmark in the box once you've located the parts.



- ❑ Printed Circuit Board (qty 1). This is a light-green, 2" x 3" board with traces on one side (the top, or component side) and a full ground plane on the other (bottom). You will carefully place all the components into the little holes of this board and solder the connections.
- ❑ Oscillator, 28.322000 MHz (qty 1). This is the heart of the project. It's in a metal can about the size of a standard IC. It has four pins on the bottom that will be soldered into the circuit board.
- ❑ 74LS74A integrated circuit (qty 2). This is a 14-pin IC that has some other markings on it, but you'll definitely see "74LS74" someplace on it.
- ❑ LM78L05Z voltage regulator (qty 1). This is a 3-terminal regulator that looks like a transistor, with a flat side on which the part numbers are printed.

- ☐ 0.01 uF capacitors (qty 4). These small orange disc caps are connected together on a tape. The marking on the caps show "103Z", which indicates the .01uF value.
- ☐ 820 pF capacitors (qty 2). These light tan caps also have their values marked on the side: "821M"
- ☐ 1000 pF capacitor (qty 1). This light tan cap has its value marked the side: "102"
- ☐ Toroid cores (qty 2). These T37-2 cores look like little donuts that are .37" in diameter. They are painted red on one side and gray on the other.
- ☐ Magnet wire (about 24" coiled up). This thin #24 wire with a red coating will be wound upon the toroid cores to make the low pass filter inductors.

If you are missing any parts, please contact the NJ-QRP Club at the address listed at the end of these notes so we can replace them.

☐ Step 3: PC Board Orientation

Okay, now that you've got a lay of the land, let's get to work. The first order of business is to inspect the printed circuit board (PCB) and understand how you will mount the components.

The first thing you'll note is that the board has "copper" on both sides. The top (component) side has most of the signal lines and the component labels (like U1, U2, C3, etc.).

If you turn the board now over to look at the bottom side, you'll see little isolated pads surrounded by the ground plane. Such a large ground plane is used to help shield the weak signals from interference. When you solder the components, you will be doing it on this bottom side. Because of the close spacing of the ground plane to the isolated pads, you will need to be very careful not to use too much solder and bridge across the pad to ground. We'll check your work at various points to help ensure that there are no shorts.

By the way, you'll probably note that it is quite possible to solder all the components from the top side, thus reducing the chance of solder shorts to ground … you might consider doing this if your solder iron tip is not fine enough, or if your hand isn't steady enough. All of our prototype assemblies went together fine by soldering on the bottom, so you shouldn't have problems.

The PCB has a 1/8" hole in near each of the four corners that can be used for mounting the board in an enclosure when assembly is completed.

☐ Step 4: Install the Voltage Regulator

Locate the LM78L05Z three terminal voltage regulator and carefully insert its pins into the location shown as "VR1" along the top edge of the Component Layout (figure 2). The flat portion of this TO-92 package should be oriented as shown. Carefully solder the three pads on the bottom side of the board and clip off the excess lead lengths.

Make sure your battery is disconnected from its clip, or that your power supply is turned off and insert the wire of the positive lead of your voltage source through the hole in the +V pad at the board edge. Do the same for the negative lead in the GND pad. Solder both in place from the bottom side.

☐ Step 5: Install the Oscillator

Locate the metal can oscillator and ensure that its 4 pins are straight and perpendicular to the bottom of the device. Orient the oscillator package with pin 1 in the upper left corner as shown in the Component Layout (fig 4). Insert the device into the PCB at U1 with pin 1 going into the square hole pad. Solder the device in place on the bottom of the board and clip off excess lead length.

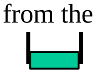
NOTE*: If you have 14-pin IC sockets available, you might find it convenient to use sockets for the oscillator and ICs. Doing this will make it much easier to find and fix problems that might occur downstream. Also, if you later want to change out the oscillator for that of another frequency, you'll be able to do so much more easily by using sockets.*

☐ Step 6: Install Bypass Capacitors

Locate the 0.01 uF capacitors (orange) and insert them through the holes at C1, C2 and C3 on the Component Layout (fig 4). Solder the pads for these components, making certain not to create a solder bridge. Clip off the excess lead length.

☐ Step 7: Install U2 & U3 "74LS74" ICs

You will need to prepare the 74LS74 integrated circuit chips prior to insertion and soldering. First ensure that all leads on the chips are perpendicular to the body of the device. You can bend all the leads against the table such that the packages look like a square "U" when viewed from the end, like below:



Now the chips may be inserted into the positions for U2 and U3. Refer to the Component Layout (fig 4) to ensure proper orientation of the package. Solder the pins of the chips on the bottom side of the board. Again, be very careful to avoid solder bridges to the ground plane.

☐ Step 9: Install Filter Caps C4, C5, C6

Locate the light tan colored capacitors and install them as per the Component Layout (fig 4). Be sure to place the 820 pF caps ("821M") into positions for C4 and C5, and the 1000 pF cap ("102") into the position for C6. Solder the pads, trim the excess leads and check for solder shorts.

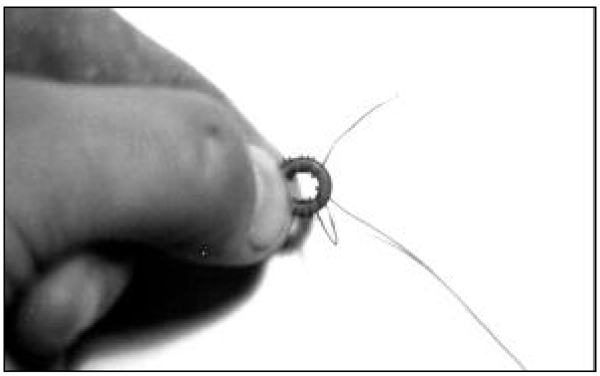
☐ Step 10: Install the Band Selection Cap Cx

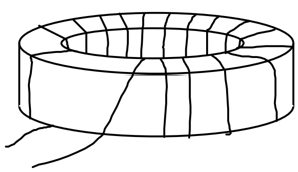
Locate one of the 0.01 uF capacitors (orange) and install it at the BAND position labeled as Cx in the Component Layout (fig 4). This capacitor couples the signal from the oscillator and divider circuits to the output filter and isolates the DC voltages of the ICs. The diagram shows Cx placement for 40 meter operation (the basic FB40 works on 40m) – if you decide to supply filter components for operation on another band, place Cx in the appropriate position for desired band.

❑ Step 10: Wind the Filter Inductors

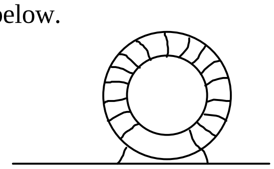
Now comes the real fun part of the project … the dreaded ***toroid winding exercise***! You need to create two inductors, L1 and L2, for the low pass filter. It's really not that tough. Uncoil the red magnet wire and cut in half - you should end up with two pieces each about 12" long.

Both inductors will be constructed exactly the same way by wrapping 16 turns of the magnet wire around a toroid core. Count one turn each time the wire is passed through the core. Refer to the photo and figure below for guidance.





The heat strippable magnetic wire being used requires no scraping to clear the red insulation off the leads being soldered to the PCB pads. Once the wires of each inductor are trimmed to the right length (determined by temporarily inserting them on-end into position L1 and L2 on the board), tin the ends of the wires by doing the following. Using a good hot soldering iron, place the tip under the end of the wire to be tinned and add a little solder so that there is a small pool of molten solder and flux on top of the iron with the wire in the pool. After several seconds, the insulation will melt away and the wire will be tinned where it is in contact with the iron. Continue moving the iron slowly toward the toroid core adding solder as you go, until the wire is tinned within 1/16 inch or so of the core. Repeat the procedure for the other leads and brush off any carbon residue from the ends of the wires before you insert L1 and L2 into position on the circuit board as shown below.



Tug the wires gently from the bottom of the board to ensure that the toroids are securely in place and then solder the wires to the pads.

Assembly of the stock version Fireball 40 is now complete! Go have a cup of coffee as a reward.

Optional Installation of a “T-R” Switch

If you wish to connect your receiver to the same antenna as your Fireball 40 transmitter, you will need to add four components from your junk box to the FB40 circuit board: L6, C7, D1 and D2. Be sure to properly orient the diodes as their polarity must be opposite of each other. You will need to construct L6 by winding 26 turns of magnet wire on an FT37-2 powdered iron core, using the same toroid winding techniques previously described.

Optional Installation of a TiCK Keyer

Installing the TiCK keyer chip from Embedded Research makes operating a CW transmitter so much more fun. Costing only about $5, this little 8-pin IC will enable you to use your Bencher, NorCal, or whatever kind of paddles you might happen to own.

Insert the TiCK into the PCB at the spot indicated for U4, being careful to align the device with pin 1 in the upper left corner as shown in Figure 2.

Insert a 2N2222A transistor at Q1 and place a 4.7K ohm resistor at R3.

If sidetone is desired, add R1 and R2 next to the TiCK. The sidetone output of the board can be used to feed an audio amplifier or a small speaker, providing a tone whenever the DIT or DAH paddle input is grounded. Alternatively, a small piezo electric speaker[13] may be conveniently driven by U4 pin 3, connected in place of R1 and R2.

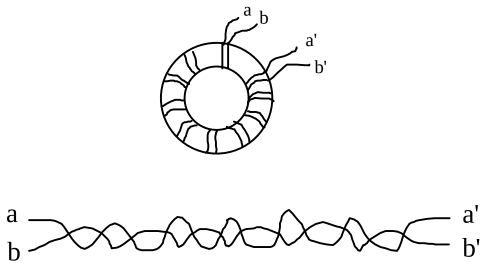
A pushbutton may be connected from the PGM connector pad to ground, allowing the TiCK to be programmed in the manner described in its data sheets. The paddle connections are made to the connector pads DIT, DAH and GND.

Optional Installation of an RF Power Amp

If you'd like to operate at more than the low milliwatt level, you can add parts for a relatively common one-transistor power amplifier and boost your RF output to about 1.5 watts.

Add the components indicated on the right side of the parts layout for the board to produce a two stage amplifier with a double pi-filter as the output network.

Transformers T1 and T2 are bi-filar-wound. Two wires are twisted together (e.g., clamp the ends of the wires in a vise and use a twist drill to wind the length of the wires together) and wound together around the toroid core. See the diagram below for proper connection of the four leads:



Power transistor Q4 should have a heatsink, as it will be getting fairly warm during normal operation.

Provisions have been made to have the KEY pad by the U1 oscillator can also key the first stage of the power amplifier. Because this KEY line floats at 5 volts when not keyed, a Zener diode (D5) is used to prevent the 2N2222A first stage of the amplifier from being turned on all the time. This is a nice feature when operating from the firls with limited battery supply.

You should ensure that this amplifier stage is indeed OFF when the key is up … measure the collector of Q2 to ensure that it is near zero volts with the key up. (The collector is at the junction of C7, R12 and C11 on the board.) If Q2 is not turned off, you may need to lower the value of R4 slightly until Q2 does turn off when the oscillator is unkeyed. No harm is done if Q2 is always ON, and normal operation of the amplifier is permitted; but power consumption will be slightly higher.

An interesting feature of the circuit board design and layout is that this power amplifier can be quite independent from the FB40 transmitter. The components and ground plane are layed out such that the amplifier portion of the board may be cut off in order to form a general purpose amplifier for the bench or other projects. If this is desired, merely saw the board at the marks provided on the component side. Extra pads for input, +V and ground have been provided if you do take this “standalone” route.

Putting the FB40 on the Air

Connect a 50-ohm 40 meter antenna to the ANT and GND connector pads on top end of the board.

If the T-R switching components are installed, connect your receiver antenna terminals to the Rx and GND pads at the bottom end of the board. Otherwise, do not connect the FB40 transmitter directly to the same antenna as is feeding the receiver (or transceiver in receive mode). You will likely damage the receiver. If you only have one antenna to use for both transmit and receive, and if you do not have the T-R switching components installed on the board, you could put a SPDT toggle switch in to alternately connect the antenna between the transmitter and receiver, thus providing a manual T-R switch.

If you have the amplifier side of the board populated, you'’l be using the ANT and RX connector pads at the bottom-right side of the board. Using the amplifier also includes the T-R switching components, so you can feel safe in connecting your receiver to the Rx connector pads.

Connect a hand key (or a temporary jumper) between the KEY and GND connector pads on the bottom end of the board. Or, if you have the TiCK keyer option installed, connect a paddle to the Dit, Dah and Ground pads at the edge of the board.

Apply power to the +V and GND pad at the top end of the board and go through some preliminary checks to ensure that there are no shorts. Check for 5V to the ICs and ensure that the voltage regulator VR1 isn't getting too warm. If either condition is not right, go back and look for the solder bridges and proper placement of components. The total current being supplied to the board should be less than 100ma.

With a receiver tuned close to 7.080 MHz, you should hear the Fireball 40 signal. The tone should be steady and free of any hash-like interference.

That's it! You can mount your Jersey Fireball 40 in a suitable enclosure, or just have it sitting out on the desk. Several of us in the NJ-QRP Club have put the FB40 into Altoids tins …. It's amazing how the size of the PCB worked out just right for that.

Go forth and communicate!

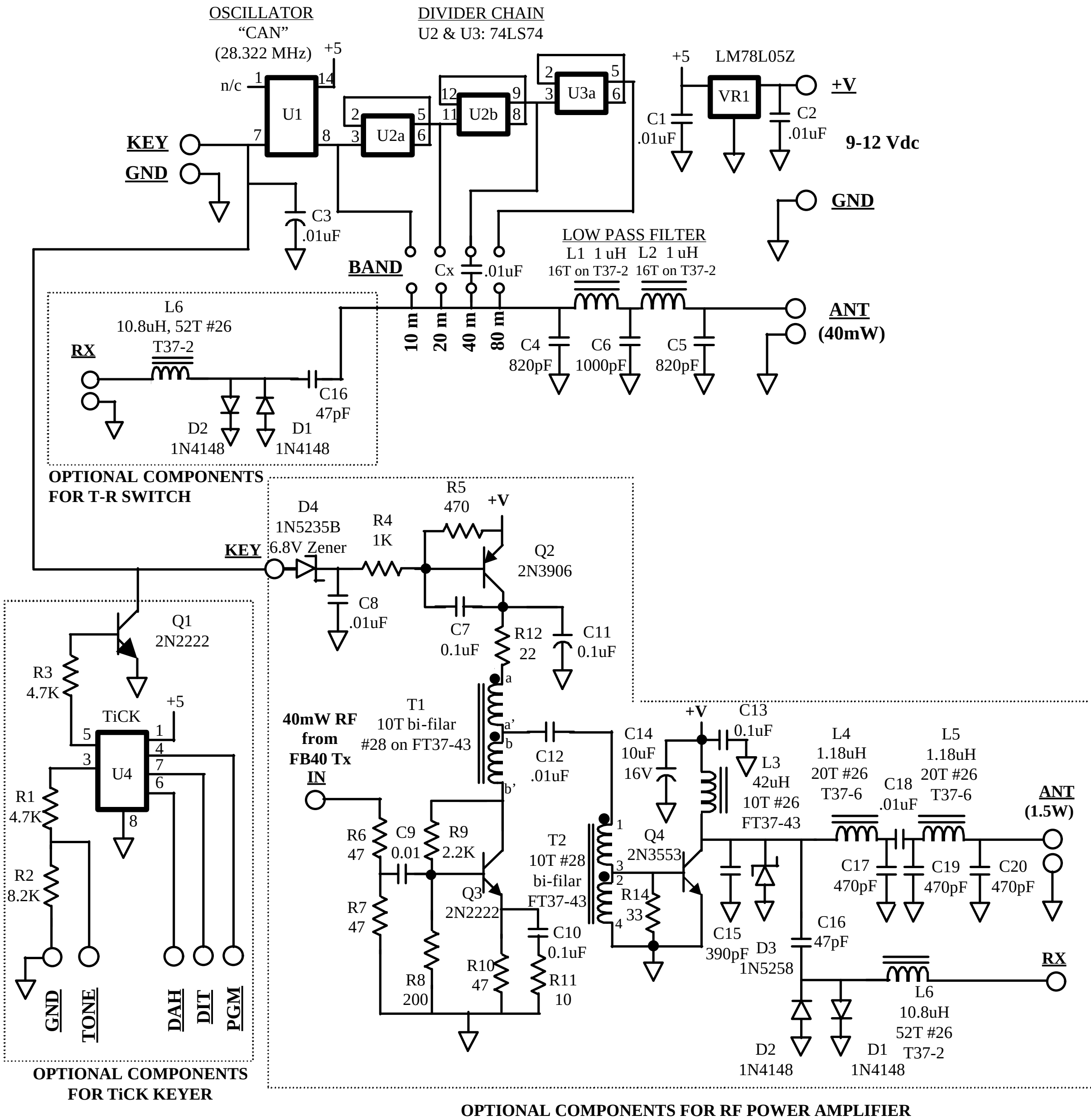


Figure 1: Schematic for the JERSEY FIREBALL 40

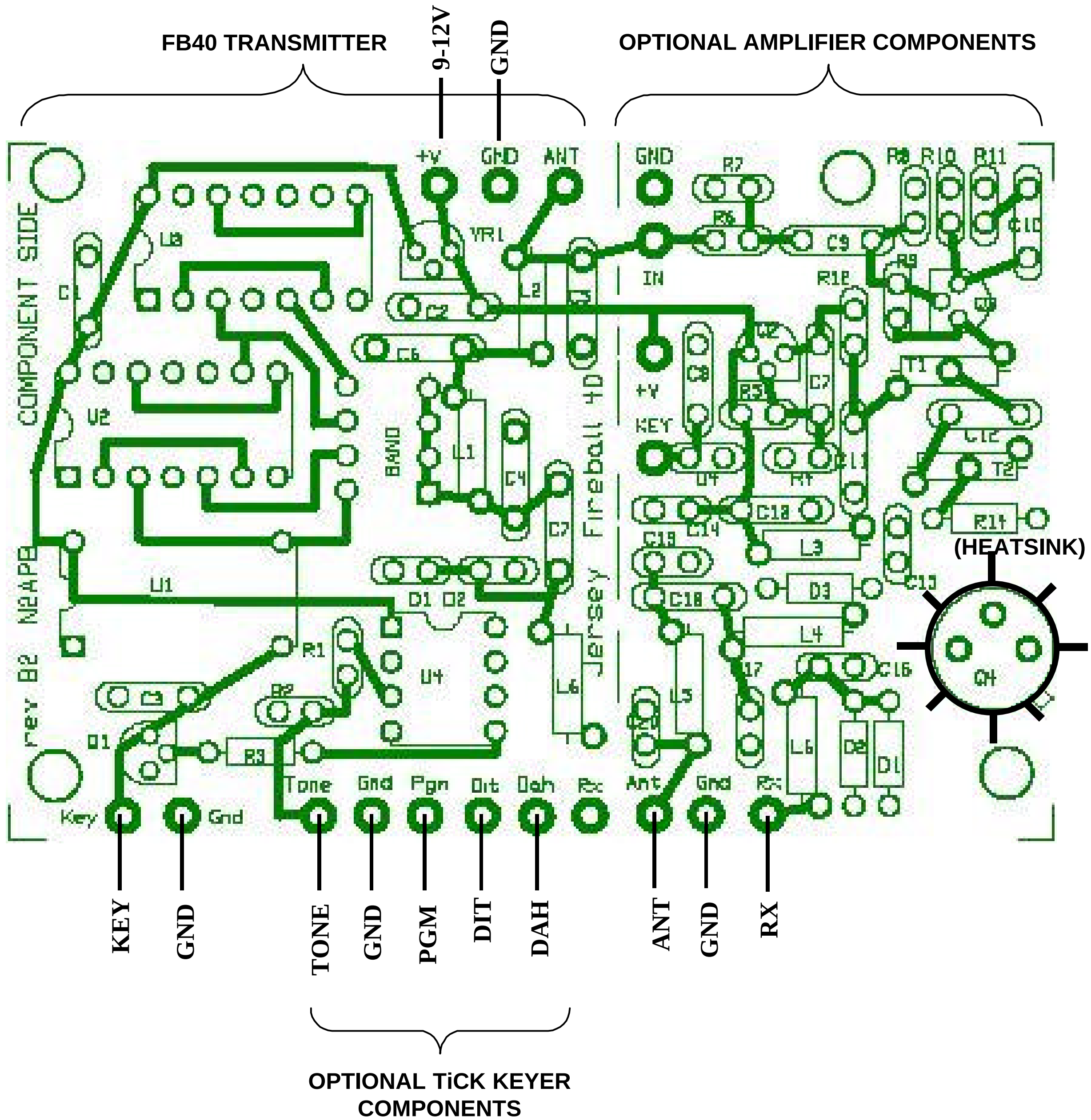


Figure 2: ***FULLY POPULATED FIREBALL 40 CIRCUIT BOARD (INCLUDING OPTIONAL POWER AMP)***

NOTES:

[1] The "Jersey Fireball 40 QRPp Transmitter" is copyright 1998/1999 by C. Fishman and G. Heron. All rights reserved

[2] NJ-QRP Club is selling the basic 40m kit of parts and pc board for $10 postpaid. Write to NJ-QRP Club, George Heron, N2APB, 45 Fieldstone Trail, Sparta, NJ 07871. Website: http://www.njqrp.org E-mail n2apb@amsat.org

[3] The New Jersey QRP Club is a group of amateurs located in-or-around New Jersey with a common interest of low power communications, efficient operating skills, and a love for homebrewing of electronic equipment. Membership is free. Monthly meetings are held near Princeton. Club members are in regular contact via an Internet mail listserver. To subscribe, put SUBSCRIBE NJQRP in the body of an e-mail and send to LISTSERV@NJQRP.ORG. A comprehensive and fun club website is regularly maintained at http://www.njqrp.org.

[4] Clark Fishman, WA2UNN, PO Box 150, Andover, NJ 07821. E-mail: wa2unn@nac.net

[5] Embedded Research (supplier of the TiCK keyer chip), PO Box 92492, Rochester, NY 14692. E-mail: http://www.frontiernet.net/~embres/

[6] By using "Advanced CMOS" TTL devices instead of the "Low-power Schottky" ones used for U2 and U3 (74LS74), one could get more effective power transfer from the chips. The AC devices provide an output impedance much closer to the 50-ohms that the output filter was designed for, thus providing a better match and more power to the antenna work using the FB40 on 20m through 80m.

[7] Some builders have questioned how we obtained the output filter component values for operation on the different bands. The computer program used is one called "L.exe - Low Pass / High Pass Filters, version 1.50", a Wes Hayward program supplied by the ARRL. This is a neat program that automates one of the standard filter calculations in the Handbook to provide all sorts of filters with varying parameters: Butterworth, Chebyshev, Elliptical, variable number of elements, cut-off frequencies, and maximum ripple values. In each case, we chose a 5-element Chebyshev low pass filter with 50-ohm input and output impedance, with 1 dB maximum ripple, and a cut-off frequency at the next higher megahertz value from where we were operating. [e.g., a cut-off frequency of 4 MHz was selected for the 80m filter, etc.]

[8] Paul Harden's, NA5N, excellent reference book is called "Data Book for Homebrewers and QRPers", ISBN 0-913945-57-9, and costs about $20. You can contact Paul at na5n@rt66.com

[9] In order to accommodate the greatly varying core permeabilities at different frequencies of use, each core has an inductance index, or "AL". Thus looking up the T37-2 core used in the FB40, you'll find its AL = 40 uH per 100 turns. So if we wanted the 1.1uH value for our filter inductor, the equation computes to: N=100*SQRT(1.1/40)=16.58. Since we can't have fractional windings with toroidal inductors, we rounded this to 16 Turns. Close enough!

[10] You might need better quality capacitors when attempting to build your output filters for the higher frequencies. At 14 MHz and 28 MHz, the el cheapo disc capacitors are quite lossy and results in a low Q filter. Try using some silver mica caps (or equivalent) and your output power at the higher frequencies might improve.

[11] W7ZOI's Ugly Weekender was published in QST for August 1981

[12] Wes had also based this amplifier directly on the work on Roy Lewallen, W7EL, in a project Roy did called "An Optimized QRP Transceiver" in QST for August 1980.)

[13] For a short time, this piezo device is available free from Embedded Research with the purchase of a TiCK keyer chip.