FB40 RF Amplifier Kit

Introduction

This document describes construction and operation of the Fireball 40 Amplifier … a broadband RF amplifier with 13 dB of gain capable of taking a low-milliwatt signal and boosting it to around 3 Watts.

The FB40 Amplifier is designed to work well with the FB40 QRPp Transmitter - a separate, low-power 40 meter transmitter kit designed by Clark Fishman, WA2UNN and kitted by the New Jersey QRP Club. The FB40 printed circuit board contains traces for components comprising an optional RF amplifier; and this Amplifier Bag-o-Parts Kit you now have contains these components, enabling you to finish off the FB40 transmitter with the RF amplifier.

Stated differently, this FB40 Amplifier Bag-o-Parts Kit does not contain a printed circuit card. This kit provides only the parts necessary to populate the FB40 transmitter PCB to create the RF amplifier. A blank PCB may be purchased separately from the NJ-QRP Club for a very reasonable price, enabling you to build a stand-alone amplifier for many of the other low power transmitter projects enjoyed by QRPers.

"T-R switch" components are provided in this Bag-o-Parts kit to enable connection of an external receiver, thus providing transmit/receive switching using the same antenna connected to the FB40 Amplifier.

Also provided in this Bag-o-Parts Kit is a TiCK keyer chip and associated components. This is a small IC programmed as a fully-featured iambic keyer, including speed control, 25-character memory and beacon mode. All you need to do is drop this chip into the board, and a couple of components and you'll be paddling to your heart's content.

The FB40 Amplifier is "broadband", meaning that there are no band-specific tuned circuits, other than the output low pass filter. The Amp comes ready for 40 meters, but if operation is desired on other bands from 10m to 80m, components in the output LPF must be changed accordingly.

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 laid 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, one merely needs to saw the board at the marks provided on the component side. Extra pads for input, +V and ground have been provided on the Amp side of the board for those who wish to take this "standalone" route.

Circuit Description

RF Power Amplifier

A number of years ago, Wes Hayward, W7ZOI had published an inspirational transmitter project called the Ugly Weekender. 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. With Wes' permission, the FB40 also provides this circuit design as an optional amplifier that one can easily construct right on the pcb. (A copy of Wes' article is supplied in this FB40 Amp Kit with permission from W7ZOI and ARRL.)

The amplifier is a fairly efficient Class C design consisting of driver transistor Q3 and power transistor Q4. Resistors R6 and R7 reduce the input power 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 KEY line control is brought low. Zener diode D4 is used in the biasing components for Q2 to prevent it from being turned on when the FB40 transmitter is used. (The FB40 oscillator presents a 5 volt signal to the KEY line during key-up times.)

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.

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

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 and the FB40 pc board provides 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 external 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. (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 bands other than 40m. Table 2 indicates suggested 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.) 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.

Construction Notes

Parts Inventory

Carefully empty the contents of the parts bag onto the table and identify all the supplied parts. Check all parts against the Parts List shown in Table 3. 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.

PC Board Orientation (optionally purchased)

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.).

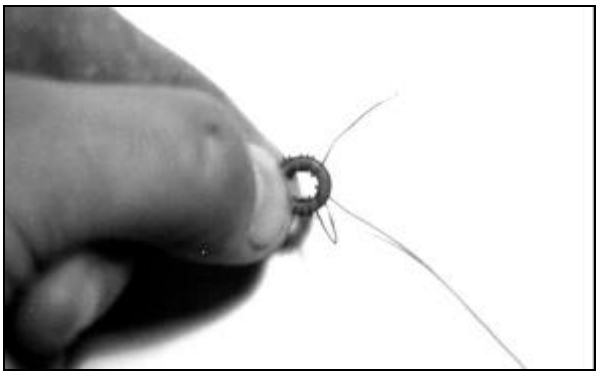
If you turn the board now over to look at the bottom side, you'll see little isolated pads surrounded by the ground plane. Such a large ground plane is used to help shield the weak signals from interference. When you solder the components, you will be doing it on this bottom side. Because of the close 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.

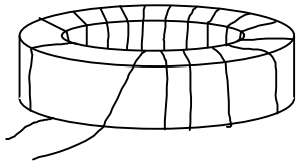
The PCB has a 1/8" hole in near each of the four corners that can be used for mounting the board in an enclosure when assembly is completed.

Wind the Filter Inductors

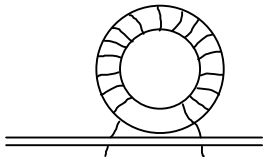
Now comes the real fun part of the project … the dreaded ***toroid winding exercise***! You first need to create four toroid inductors: L3, L4, L5 and L6, and two transformers T1 and T2. Toroid inductors really not that tough to construct, and transformers are merely toroids with two windings on them!. Uncoil the supplied red magnet wire and use the specified lengths for each of the inductors as described below.

L4 & L5: Both of these inductors will be constructed exactly the same way by wrapping 20 turns of the magnet wire around a T37-6 toroid core (yellow). Measure off a 15 inch length of magnet wire and begin winding the 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 L4 and L5 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 L4 and L5 into position on the circuit board as shown below.



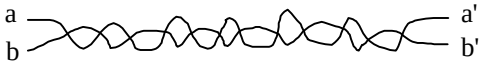
Tug the wires gently from the bottom of the board to ensure that the toroids are securely in place and then solder the wires to the pads.

L3: Measure off a 12-inch length of magnet wire and wind 10 turns on an FT37-43 toroid core (black/unpainted), similarly to the way L4 and L5 were shown.

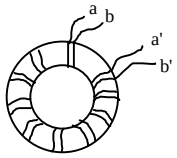
L6: You should next create inductor L6 in the same manner. Measure off 28” of red magnet wire and wind 52

turns around a T37-2 toroid core (red). That's a lot of turns for such a small toroid so you will need to keep the windings very closely spaced. In fact, there will be a need to overlap some of the winding at the end in order to get all turns on. That's okay.

T1 & T2: These transformers are each "bi-filar-wound" inductors on a toriod core, meaning that you'll be combining two magnet wires together and winding them at the same time. T1 and T2 are constructed identically. Measure off two 9-inch pieces of red magnet wire. These wires should be twisted tightly together as illustrated below.



(Suggestion: You can clamp the ends of the wires in a vise and use a twist drill to wind the length of the wires together.) You will then wind the combined, twisted wire pair around a FT37-43 toroid core (black/unpainted) in the same manner as previously. See the diagram below for proper connection of the four leads:



When two wires of the same color are twisted and wound together on a toroid, it's very hard to know which ends to connect together for the center tap of the transformer. You will need to use an ohmmeter to determine proper ends. On one of the wires, a is the start and a' is the end. On the other wire, b is the start and b' is the end. You should twist wires a' and b together to form the center tap.

Trim the leads to the correct length, prepare the ends with the soldering iron again, and install them onto the board. Prepare and install the second transformer in the same manner.

Populate the Board

You can now install the rest of the components onto the printed circuit board, using figure 2 "Parts Layout" as a guide. Most of the "axial" components (components with leads coming out the ends like a standard resistor) will be installed standing upright. Bend one lead down and around the resistor or diode and insert on the PCB as shown below:

Power transistor Q4 needs to have a heatsink installed before it is inserted and soldered to the PCB. Carefully squeeze apart the separation in the heatsink (e.g., using a small flat-blade screwdriver) and push it onto Q4. Now insert Q4 into the proper location of the PCB and have it sit relatively close to the board surface. Solder it in place and clip the leads. (Be careful not to have the heatsink touching other components in the immediate area … it is at V+ potential and may short out to the adjacent components.)

Optional Installation of a TiCK Keyer

Installing the TiCK keyer chip from Embedded Research makes operating a CW transmitter so much more fun. This little 8-pin IC will enable you to directly 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. (An 8-pin IC socket is actually recommended for this part. This will allow substitution of other pin-compatible TiCK products as they become available.)

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, and when programming the TiCK. A small piezo electric speaker has been graciously donated to this kit from Embedded Research. It is conveniently driven by U4 pin 3, connected in place of R1 and R2.

A pushbutton should 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.

Putting the Amp on the Air

All you need to do to operate the Amp is connect a 50-ohm antenna feedline to the ANT connector pads at the bottom edge of the board, and connect a power supply at the top edge. With a 4-to-40 mW signal driving the IN connector pad (or if you have the FB40 transmitter components also installed on the board), you will have 1-3 watts going up to your antenna.

If you have any problems with this kit, you may contact the NJ-QRP Club by contacting George Heron (n2apb@amsat.org) at 45 Fieldstone Trail, Sparta, NJ 07871. The NJ-QRP also keeps it's website very current with news and information concerning its various projects: http://www.njqrp.org .

Parts List

R4	1K-ohm	D3	35V Zener
R5	470-ohm	D4	6.8V Zener
R6, 7, 10	47-ohm	D1, 2	1N4148
R8	200-ohm	Q3	2N2222A
R9	2.2K-ohm	Q2	2N3906
R11	10-ohm	Q4	2N3553
R12	22-ohm	HS	Heatsink
R14	33-ohm		magn wire
C8, 9, 12, 18	0.01 uF		
C7, 10, 11, 13	0.1 uF	**TiCK Option**	
C14	10uF, 16V	U4	TiCK
C15	390 pF	R2	8.2K
C16	47pF	R3	4.7K
C17, 19, 20	470pF	Q1	2N2222A
T1, T2, L3	FT37-43 (black)		
L4, 5	T37-6 (yellow)	**PCB Option**	
L6	T37-2 (red)		PCB

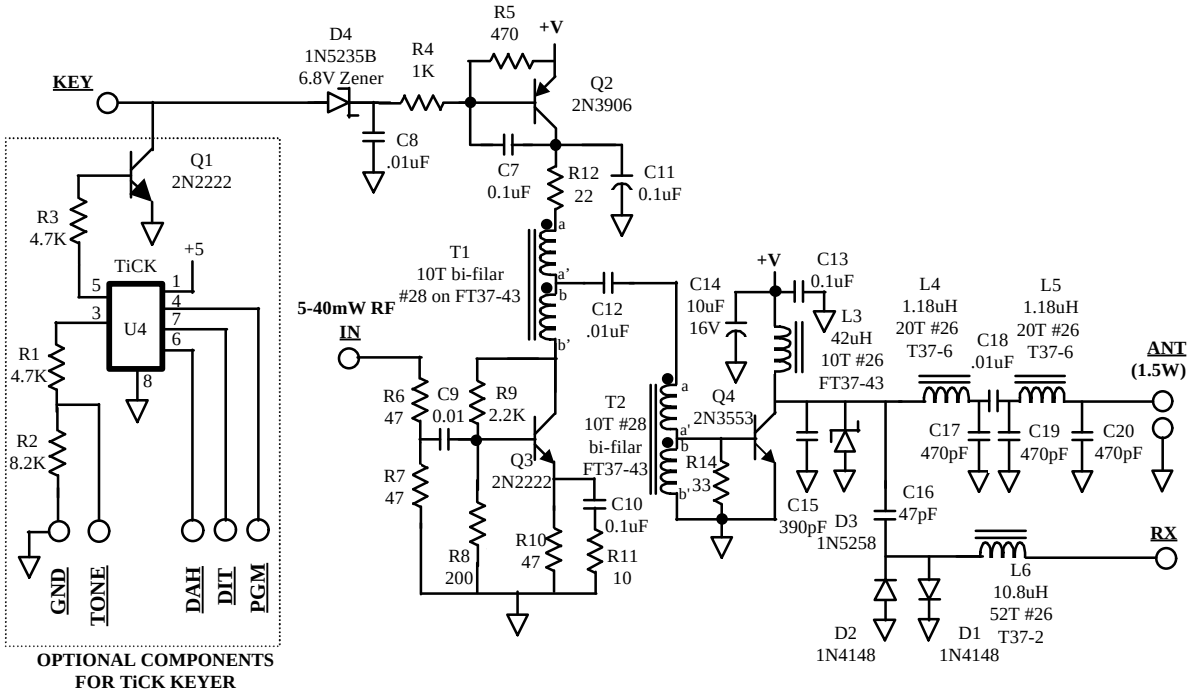


Figure 1: Schematic

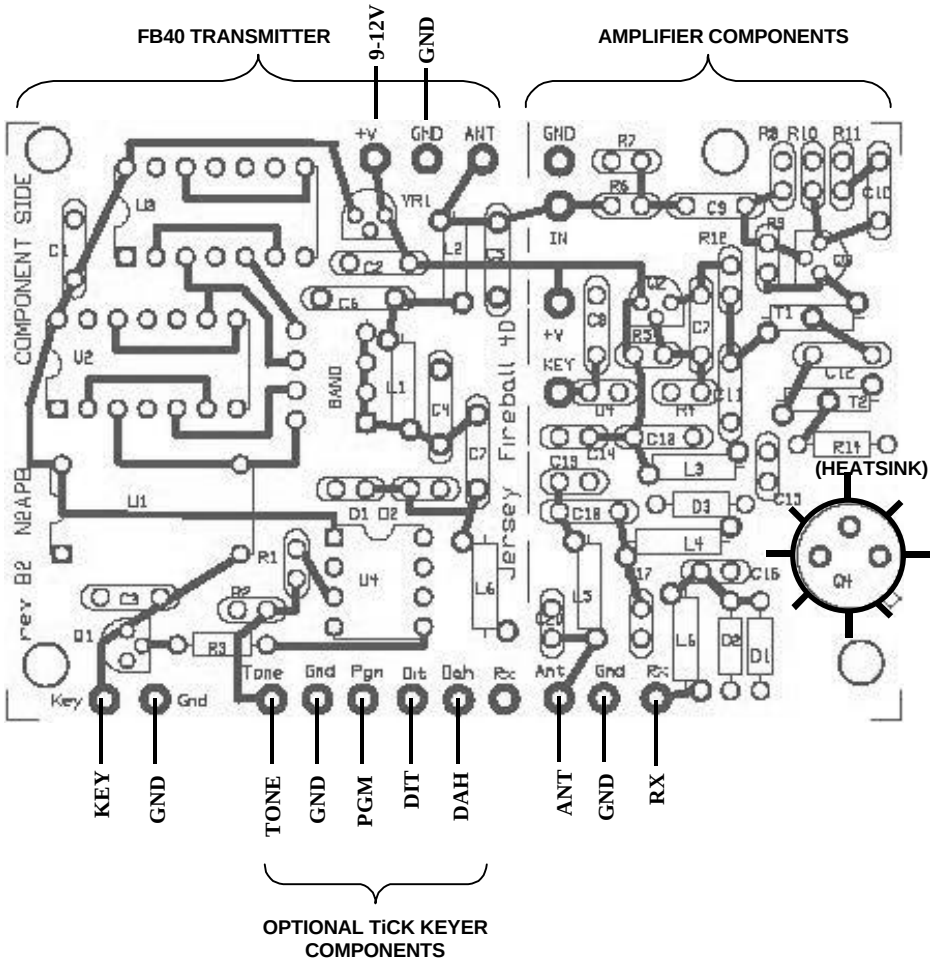


Figure 2: Parts Layout