75 Meter SSB Project

Design by KD1JV

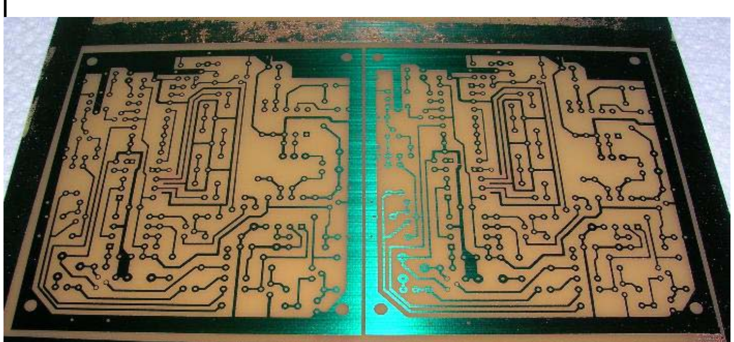
Built by Paul Jorgenson KE7HR NSS 39382FE

After completing a 75 meter DSB project (and using it underground, caving), I wanted to try building a SSB rig. I was searching the internet for a fairly simple circuit that would be easy to duplicate and have a fair chance at success. Success would be defined as being capable of having a QRP (low power) conversation similarly to the DSB radio and that could be used in caving. Taking expensive radios underground is ok, but taking radios that are quite a bit less expensive is better, so cost to build was one of the design criteria.

My search narrowed to a design by Steven "Melt Solder" Weber KD1JV. Steve keeps a website with projects (and sometimes kits) that had a "(Fairly) Simple SSB Rig with PTT for 75 Meters" project that looked great. I started gathering parts. Steve then put up a second version of the project called "Revised (Fairly) Simple SSB Rig". When the printed circuit diagrams were published, I was off the races! See the KD1JV website at http://kd1jv.qrpradio.com/ .

The radio is a single conversion super-heterodyne radio with a 5 MHz variable oscillator and a 9 MHz intermediate frequency which mixes to produce the approximately 4 MHz lower sideband signal in the 75 meter ham band. The project VFO is actually a PTO or permeability tuned oscillator. It uses a coil of wire wound on a nylon spacer that a brass threaded rod is screwed into. When the brass rod is inserted, the inductance of the coil goes down, changing the frequency of the oscillator.

The radio also features a four element crystal filter to select the proper sideband. The filter, and other parts of the circuit, is switched between transmit and receive by an analog switch IC circuit. This works quite well. NE612 mixer chips are used for both transmit and receive. They are very reliable and are used widely in amateur built circuits.



I started the project in earnest by etching the printed circuit boards. The artwork was printed on a sheet meant for overhead projectors. The circuit was then transferred to the sensitized boards with a contact frame, to keep the transparency and the board in contact without bubbles of air, and a fluorescent light for exposing the boards. Developing and then etching the boards (I did two at a time since that was the size of my circuit board stock) produces the product seen at the left. The boards are then drilled for each component with tiny (about .032 inch) carbide drills. It is a tedious process to do by hand, even with a drill press. After the drilling was done, it was time to cut the boards apart (using a large paper cutter as a shear) and start populating it with parts.

I found one tiny error in the PCB artwork - one bypass capacitor next to the voltage regulator did not have pads for drilling. I just added the part to the underside of the board since it is tiny. I also did not have the 7mm 10.7 MHz IF transformers called for in Steve's article. Instead, I used some larger transformer cans (10mm) that I had on hand by soldering extensions, made of resistor lead cutoffs, to the pins on the transformer. This way the wires could be bent into place fitting on the board. (It would have been nicer to have the smaller part.)

All of the other parts on the board went together well. I had bought some crystals for the local oscillator and the crystal SSB filter from Mouser and did not perform any sort of matching. The received pass band and transmitted signal sound fine, so the matching may not be needed. It takes some time to place the rest of the parts on the board because I buy many parts on the surplus market and they are often mixed together without regard to value. The money saved on buying surplus parts is time spent in sorting through the parts for the one you want! There is no free lunch!

I built the PTO on a scrap of circuit board using "ugly" and "Manhattan" style construction. Parts that are grounded are soldered directly to the board and other parts are supported between grounded parts or are placed on pads of circuit board material that are glued to the base board. There are other methods of building but this one is fast and circuits can be changed by just a few touches of the soldering iron. I put the PTO inside a mint tin (one of the ham builders best friends) and insulated the tin with scraps of thin neoprene from a mouse pad. I hope that the neoprene will thermally insulate the box, helping keep drift to a minimum. Cutouts on the side of the box, under the lid edge, allow the power wires (attached to a screw terminal connection) and the RF output coax to get out to the main board.

I tested the main board out on the workbench. The first power up was a bit frustrating since little signal was being received. The problem traced to a bad LM358 IC (junk box parts…) and poor handling on my part when modifying the IF transformers. I had broken the teeny tiny wires on both(!) of the cans causing an open circuit. More carefully prepared transformers went into place and all became well - distant stations were received by my indoor antenna! A bit of tuning to peak the received signals and I was hearing stations from Great Brittan and listening to other stateside hams working them. DX on a homemade radio!

I bought a couple of cheap speaker microphone combination units on eBay. To keep the project compact I wanted to use the speaker mic instead of having to fit an internal or external speaker to the rig. This presented a challenge. The circuit as designed did not completely mute the input to the audio amplifier and, depending upon the microphone gain and the speaker volume setting, the speaker would howl like mad. It did not occur with an external speaker. It took a bit of head scratching, but I came up with a scheme to ground the input to the audio amplifier using an additional 2N7000 which is switched along with the transmit receive changeover, thus curing the problem.

Another bit of a problem was getting output from the exciter. I had to change the resonating capacitor in the transmit chain (next to the transformer) to a smaller value to put the transformer tuning slug near the middle of it's range. That brought up the signal to the output transistor. I also changed the transistor to a different NPN device with tiny heat sinks built in. I don't know if that really helped, but it made me feel better…

I also found that the audio amplifier was designed for a gain of 20. This produces a nice low current consumption and a good signal to noise ratio, but limits the audio output. The speaker in the microphone is not as efficient as a larger external speaker. I wanted more drive, at the expense of more power consumption and a slightly worse signal to noise ratio. Looking at the data sheet for the LM386 audio amp, showed that by the simple addition of a single capacitor, the gain could be increased to 200. Not bad for the addition of a single part. By adding a resistor along with the capacitor a gain between 20 and 200 was achievable. I experimented with resistors and with just the capacitor. I settled on the simple approach of switching the capacitor into the circuit and added an RF bypass capacitor. Now I have a High and Low switch for Audio Gain on the front panel of the radio. For really strong signals or when needing a better signal to noise ratio, I will use the low setting. The high setting helps me to pull out the weak station (and DX). This might not really be important with such a low output power transmitter, but again, it made me feel better…

The final amplifier for the Revised (Fairly) Simple project is a 25 watt external unit. For my first version of this radio, I wanted to keep a low power output, (we have been talking through over 200 vertical feet of cave rock with less than 5 watts!) so I chose to build the amplifier section from the original (Fairly) Simple schematic. I built it on a small scrap of circuit board (ugly, Manhattan - again) with the final transistor angled for easy mounting on the radio case for heat sinking. I am getting about 5 watts on voice peaks from the amp.

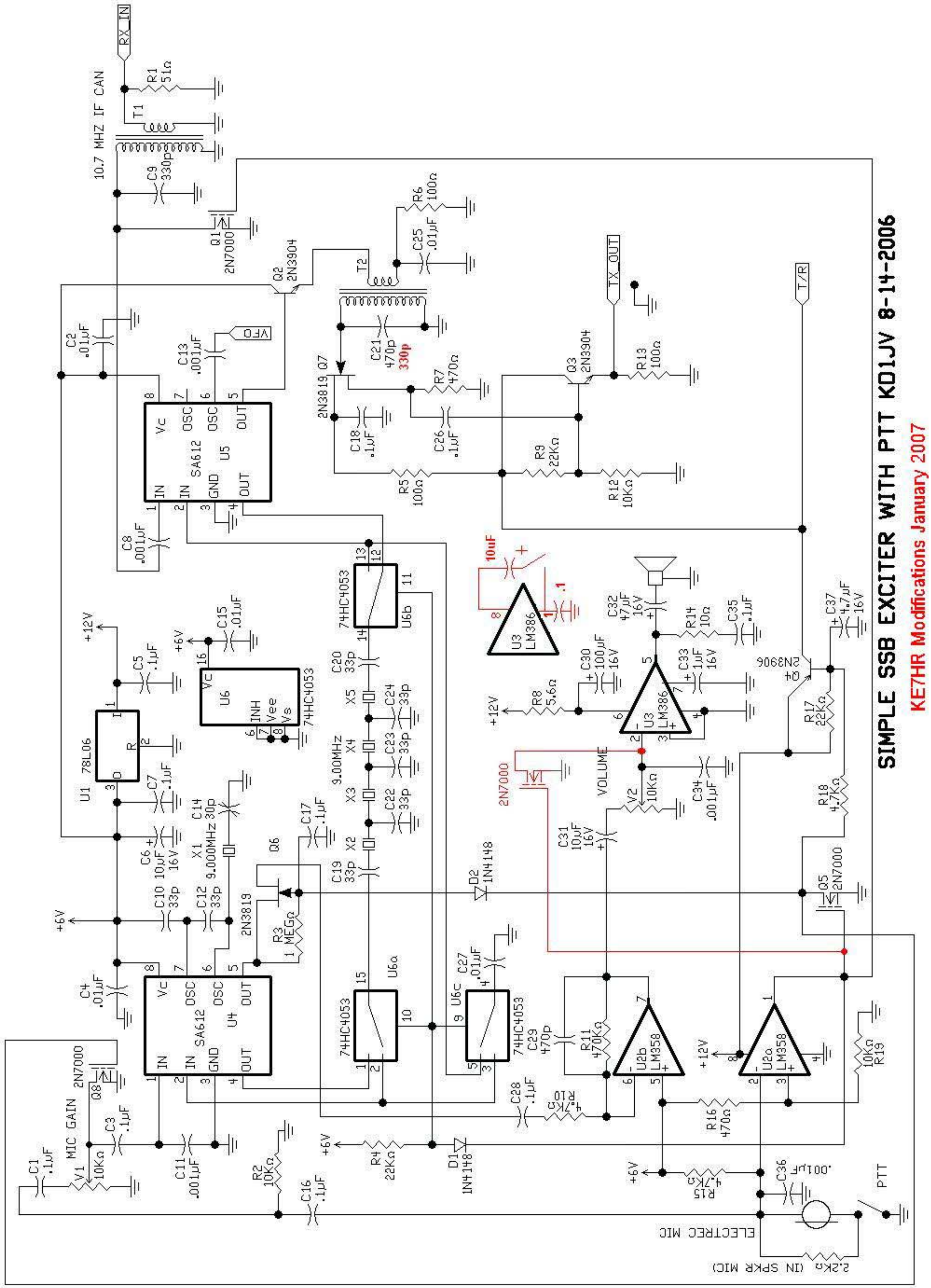
The project went together inside a project box I picked up at a hamfest this winter. It makes a neat package!

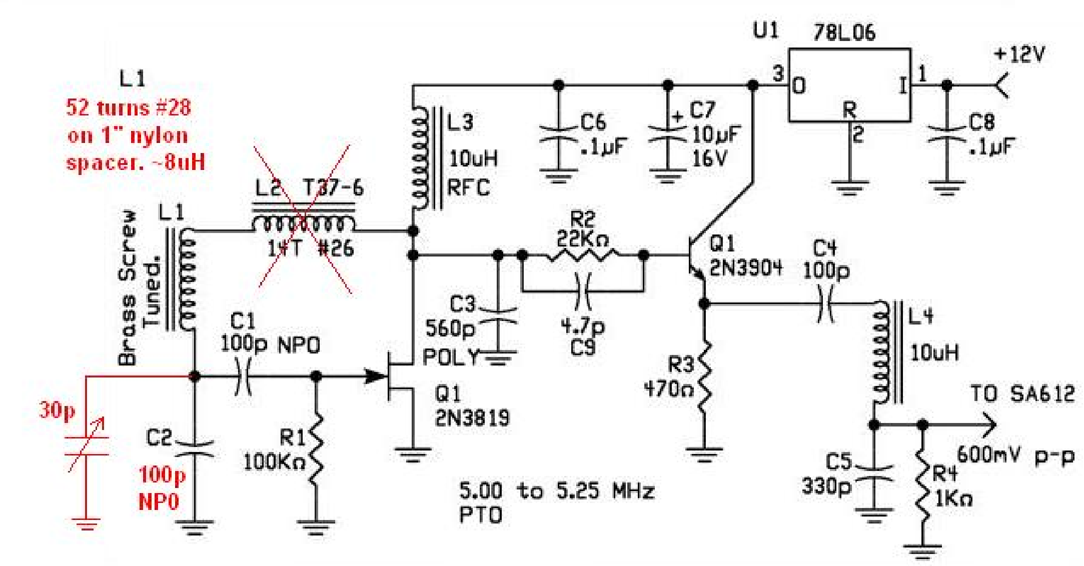
I used some screw connector strips soldered to a scrap of circuit board (Manhattan again) to be a power buss and a ground buss. It helps to make a neat package and will make future modifications or additions easier. The relay for switching the antenna from transmit to receive and power to the amplifier during transmit is mounted behind the main circuit board using some fast setting silicone. I used the same silicone to help stabilize the PTO coil.

This project is readily repeatable. Future plans call for an external transverter to get down to the LF band (where other cave radios live) or just building the radio directly for LF. I have some 5 MHz and some 5.185 MHz crystals…

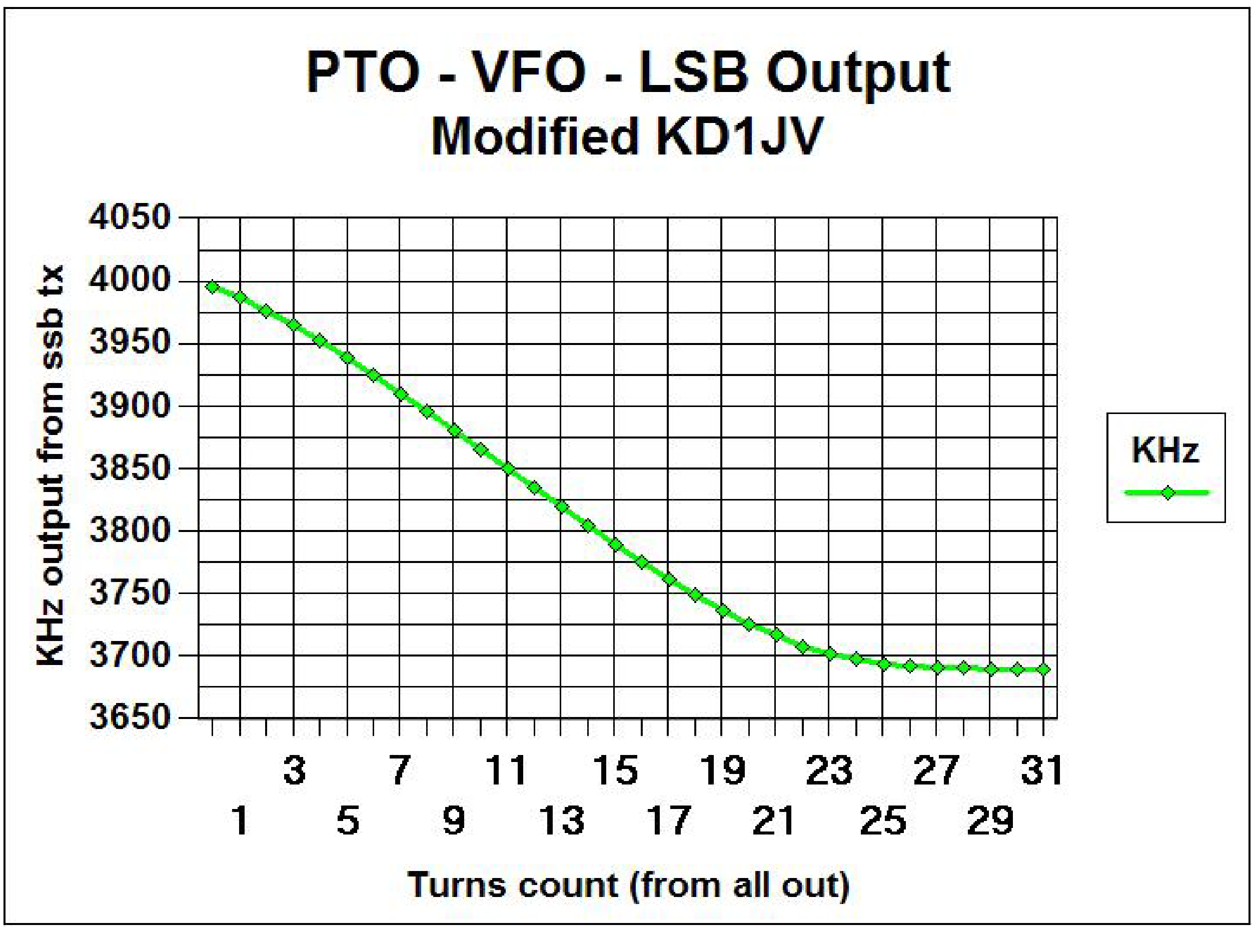
For easy use underground I will probably replace the PTO-VFO with a couple of crystal controlled channels. That way there is less likelihood of getting far off of frequency, especially when the signals get very weak at the far reaches of a cave.

Great thanks go out to Steve Weber KD1JV for putting such great designs on the web where others can share in the building fun!


SIMPLE SSB EXCITER WITH PTT KD1JV 8-14-2006
KE7HR Modifications January 2007
RX_IN
TX_OUT
T/R
VFO
10.7 MHZ IF CAN
R1 51Ω
T1
C9 330p
Q1 2N7000
Q2 2N3904
T2
R6 100Ω
C25 .01µF
C21 470p
330p
Q7 2N3819
R7 470Ω
Q3 2N3904
R13 100Ω
C2 .01µF
C13 .001µF
SA612
U5
C18 .1µF
C26 .1µF
R5 100Ω
R9 22KΩ
R12 10KΩ
C8 .001µF
74HC4053
U6b
10uF
.1
U3 LM386
C32 47µF 16V
R14 10Ω
C35 .1µF
C30 100µF 16V
R8 5.6Ω
C33 1µF 16V
C37 4.7µF 16V
Q4 2N3906
R17 22KΩ
+12V
U1 78L06
C5 .1µF
C7 .1µF
C6 10µF 16V
+6V
C15 .01µF
U6
C20 33p
X5
C24 33p
X4
9.00MHz
C23 33p
X3
C22 33p
X2
C19 33p
C14 30p
X1 9.000MHz
C10 33p
C12 33p
Q6
2N3819
R3 1 MEGΩ
C17 .1µF
D2 1N4148
2N7000
VOLUME
V2 10KΩ
C34 .001µF
C31 10µF 16V
R18 4.7KΩ
Q5 2N7000
C4 .01µF
U4
U6a
U6c
C27 .01µF
C29 470p
R11 470KΩ
U2b LM358
U2a LM358
R19 10KΩ
Q8 2N7000
MIC GAIN
C3 .1µF
C1 .1µF
V1 10KΩ
C11 .001µF
R2 10KΩ
C16 .1µF
R4 22KΩ
D1 1N4148
C28 .1µF
R10 4.7KΩ
R16 470Ω
R15 4.7KΩ
C36 .001µF
PTT
ELECTREC MIC
2.2KΩ (IN SPKR MIC)



PTO - VFO
Modified by KE7HR
January 2007



The modified PTO-VFO becomes very stable after a few minutes of warm up. The 5 MHz signal is mixed with the 9 MHz IF in the radio to produce the 75 meter signal.

The chart above was created from actual measurements (listening to the transmitted 75 meter LSB signal) after about 10 minutes warm up. The actual frequency output is plotted against the number of turns of the brass screw.

The 'toe' after about turn number 23 is due to the fact that the brass threaded rod is slightly too long and extends beyond the coil turns.