Kanga US

3521 Spring Lake Drive
Findlay, OH 45840
419-423-4604
kanga@kangaus.com
www.kangaus.com

Feb. 4, 2007

Thanks for purchasing the microT2 transmitter kit! You are receiving one of the second batch of 50 kits produced, so don't be afraid to ask questions or make comments about the kit. Constructive criticism is appreciated!

Please remember this is not intended to be a "Heathkit" type of kit. You need to have some building experience, know how to read a schematic and layout, and know how to solder. If you are not comfortable with a project at this level, please return the kit for a full refund (less shipping costs). Access to test equipment (scope, counter, multimeter, etc.) and knowledge of how to use it is also highly recommended!

The microT2 was designed by KK7B and published in the December 2006 issue of QST. A copy of the article has been reproduced (with permission) and is included in the kit. Also included you will find a parts list, parts layout, schematic, and some constructions notes I have written up. There are no step by step instructions, and it is up to you to finish the project in your own cabinet.

If you want more background on the microT2, you will find most of the stages on the transmitter are in the ARRL book Experimental Methods in RF Design. The books is a good source of information about DC and phasing type rigs, and is a good source of info if you are interested in building your own gear.

The photos in the QST article are of the first version built by KK7B. The small box with the connector on the top of the microT2 is a small ½ watt amp. The schematic for the amp is in Figure 5 in the article. Parts for the amp are not included in the kit.

KK7B will be publishing more articles in QST about interfacing the microT2 with a receiver, and will also be publishing an article with an amplifier circuit that will provide up to 4 or 5 watts out. Information on putting the microT2 on other bands will also be coming.

There is a Yahoo group I have set up that was originally for the KK7B R2Pro receiver, but it has evolved into a group that covers items of interest to anyone building any of the KK7B designs. Go to groups.yahoo.com and search for R2Pro and get signed up.

Have fun with your microT2!

73 – Bill – N8ET
Kanga US

February 4, 2007

MicroT2 Construction Notes – Kanga US Version

In no particular order –

The 1% resistors and matched .01uf caps are in a separate small plastic bag. The 1% resistors are blue.

R33 and R36 have been supplied as 10k trim pots. The article shows 5k.

R32 has been supplied as a 5.1k resistor. The article shows 7.5k

R10 has been supplied as 1.50k. The article shows 1.52k

The crystal and VXO variable capacitor are connected in series and attached to W4.

Diode D2 is included in the schematic in the article but not in the separate schematic. The separate schematic shows jumper jp3 in it's place. Insert D2 (observe the correct polarity) in place of jp3 on the layout.

Connect +12 volts to the following: W1, W6, W10

Connect +12v to W5 to generate a spot signal from the VXO. The "SPDT" label over W5 in the article schematic should be "SPOT".

I used twisted pairs of insulted hookup wire for interconnections between stages on the microT2. Small diameter coax can also be used. (W2 to W8 and W3 to W9).

A strip of header pins has been supplied with the kit that can be snapped or cut into the two and three pin headers used on the board (if you decide to use the headers) . A 4 pin female header has been supplied to use where the three pin connection is used for the mic (J2). You will need to cut off one of the pins.

The inductors L1,2,4, and 5 came from the factory unmarked. I put a black mark on the top of L4 and L5 so you can tell them apart from L1 and L2.

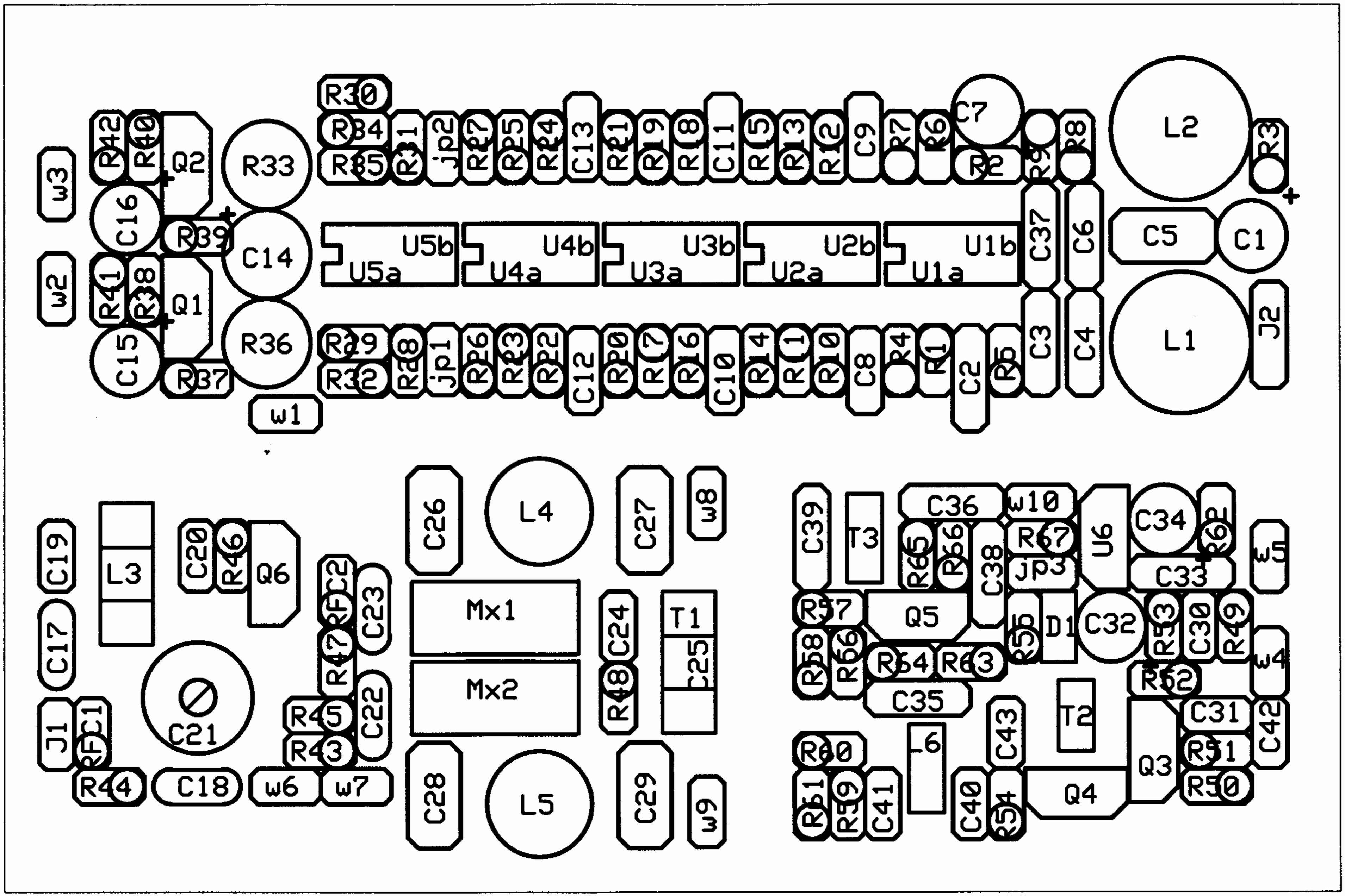
The 15uh molded rf chokes look like small green resistors.

You can use IC sockets to mount the IC's if you wish.

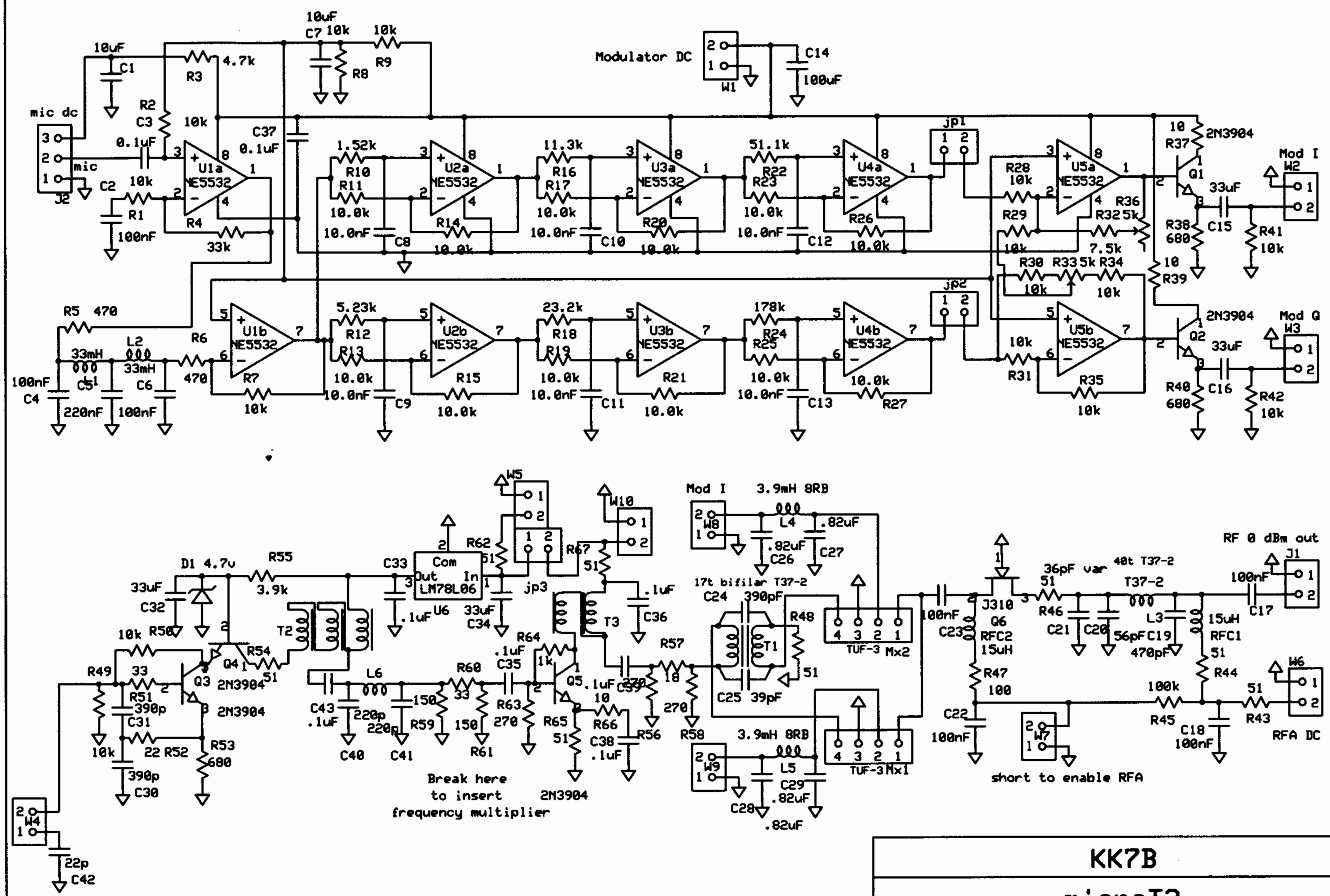
MicroT2 Parts List

Value	Description	Qty
Resistors		
R37,39,66	10 1/4w 5%	3
R57	18 1/4w 5%	1
R52	22 1/4w 5%	1
R51,60	33 1/4w 5%	2
R43,44,46,48, 54,62,65,67	51 1/4w 5%	8
R47	100 1/4w 5%	1
R59,61	150 1/4w 5%	2
R56,58,63	270 1/4w 5%	3
R5,6	470 1/4w 5%	2
R38,40,53	680 1/4w 5%	3
R64	1k 1/4w 5%	1
R7	2.7k 1/4w 5% Audio gain select resistor. Schematic shows 10k. See article Note E.	1
R55	3.9k 1/4w 5%	1
R3	4.7k 1/4w 5%	1
R32	7.5k 1/4w 5%	1
R1,2,8,9,41,42,49,50, 28,29,30,31,34,35	10k 1/4w 5%	14
R4	33k 1/4w 5%	1
R45	100k 1/4w 5%	1
R33,36	5k trimpot	2
R10	*1.50k 1/4w 1% Article shows 1.52k*	1
R12	*5.23k 1/4w 1%*	1
R11,13,14,15,17,19, 20,21,23,25,26,27	*10.0k 1/4w 1%*	12
R16	*11.3k 1/4w 1%*	1
R18	*23.2k 1/4w 1%*	1
R22	*51.1k 1/4w 1%*	1
R24	*178k 1/4w 1%*	1
Capacitors		
C42	50 pf Variable cap – off board mounting	1
C25	39 pf SMT	1
C21	36 pf trimmer (50 pf max trimmer supplied)	1
C20	56 pf NP0 ceramic	1
C40,41	220 pf NP0 ceramic	2
C24,30,31	390 pf NP0 ceramic	3

C19	470 pf NP0 ceramic	1
C43	.01 uF ceramic	1
C2,3,4,6,17,18,22,23, 33,35,36,37,38,39	0.10 uF 5% Polyester	14
C8,9,10,11,12,13	*10 nf (.01 uF) Polyester matched to 1%*	6
C5	0.22 uF 5% Polyester	1
C26,27,28,29	0.82 uF 5% Polyester	4
C1,7	10 uF 16v electrolytic	2
C15,16,32,34	33 uF 16v electrolytic	4
C14	100 uF 16v electrolytic	1
Transistors		
Q1,2,3,4,5	2N3904	5
Q6	J310	1
Diodes		
D1	4.7v zener	1
D2	1N4148	1
Inductors		
L1,2	33mH	2
L3	40t #30 T37-2	1
L4,5	3.9 mh *(Black dot on top of inductor)*	2
L6	22t #28 T30-2	1
T1	17t bifilar #28 T37-2	1
T2	5t #28 trifilar FT23-43	1
T3	7t #28 bifilar FT23-43	1
RFC1,2	15 uH molded RF Choke	2
Integrated Circuits		
U1,2,3,4,5	NE5532 or equiv.	5
U6	LM7806 or equiv.	1
Mixers		
Mx1,2	TUF-3	2
Misc		
W1-10, JP1,2, etc	2 pin headers (use is optional)	13
J2	3 pin header (use is optional)	1
	2 pin sockets to mate with headers	10
JP1,2, W7	Shorting/jumper block	3
	7.285 MHz Crystal	1
	PC Board	1

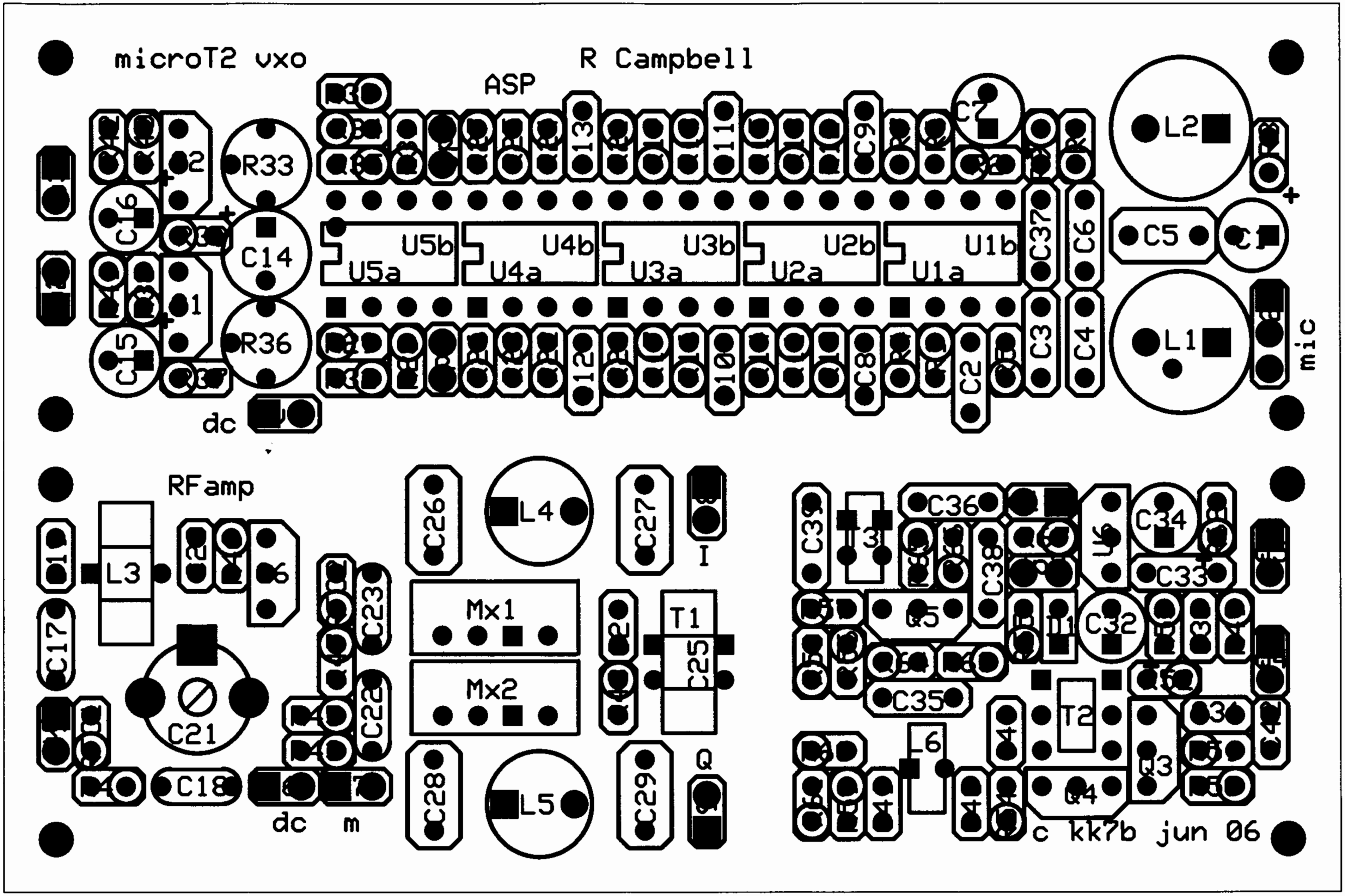


C:\Documents and Settings\rcampbe\Layouts\T2microVXO.pcb (Silkscreen)



KK7B		
microT2		
Rick Campbell	Rev 1 7/7/06	Page # or name

C:\Documents and Settings\rcampbe\Layouts\T2micro1.sch - Sheet1



C:\Documents and Settings\rcampbe\Layouts\T2microVXO.pcb (Silkscreen & pads)

The MicroT2 — A Compact Single-Band SSB Transmitter

KK7B offers a transmitter to go with his single-signal SSB/CW receiver featured in October QST

Rick Campbell, KK7B

October *QST* presented a basic single band, single signal receiver that may be used as a companion to an independent CW or SSB transmitter. Here is a simple SSB transmitter that generates a high-quality USB or LSB signal on any single band from 1.8 MHz to 50 MHz.

The basic radio station shown in Figure 1 has a receiver, transmitter (exciter plus amplifier), antenna, batteries and assorted wires and switches. In October we presented one approach to a simple, independent receiver.[1] April 2006 *QST* featured the MKII, a single band CW transmitter.[2] Those two pieces make a very capable CW station. On the 100th anniversary of voice radio, it's appropriate to think about a station with a microphone. While it is a bit more involved to generate an SSB signal, we greatly simplify the task if all the necessary circuitry is on a single PC board exciter module. Once we have a high-quality low-level SSB signal, a 5 or 500 W SSB transmitter is as easy to build as a 5 or 500 W CW transmitter.

Growing the Amateur Radio Station Piece by Piece

In 1960, most radio amateurs started by listening to a shortwave receiver. The licensing process focused on acquiring knowledge and experience needed to build, maintain, and operate transmitters using lethal voltages and radiating signals that could be heard around the world. A receiver is your ears, a transmitter is your mouth, and it's pure common sense that your mouth will get you in trouble much faster than your ears. By treating the receiver and transmitter as separate boxes, we recapture the fun of building up a station by selecting (and perhaps building) the receiver, selecting (and perhaps building) a transmitter, stringing up an antenna, interconnecting everything, and then putting a new station on the air that is as unique and personal as our call sign. Then we make improvements in small steps as our understanding, finances, and flea market acquisitions permit.

I approach receiver and transmitter design very differently. An antenna collects a whole universe of signals. The receiver selects a narrow slice of that spectrum, translates it down to an audible frequency range, and amplifies it so the ears and brain can process it. I like simple receivers that do as little to the signal as possible before the brain has a chance to work on it. Such receivers reward listening skill. In a transmitter, once the key is pressed or a syllable is spoken, the brain can't do a thing to modify what has been said. The antenna radiates that signal for the whole world to hear. Simple transmitters are delightful, but relaxed standards are not. So I design transmitters that are clean, stable and reliable. I also make sure they exceed FCC Part 97 requirements. Since I listen to them on receivers with exceptional audio, they need to sound good, too.

The Case for Crystal Control

A jumper on the PC board makes it easy to use an external variable frequency oscillator (VFO) for frequency control if you wish. For some applications the narrow tuning range offered by the on-board variable crystal oscillator (VXO) is sufficient, and

[1]Notes appear on page 00.

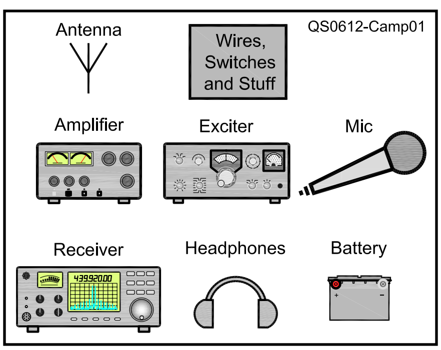


Figure 1 — A block diagram of a basic radio station. It includes a receiver, transmitter, antenna, batteries and assorted wires and switches.

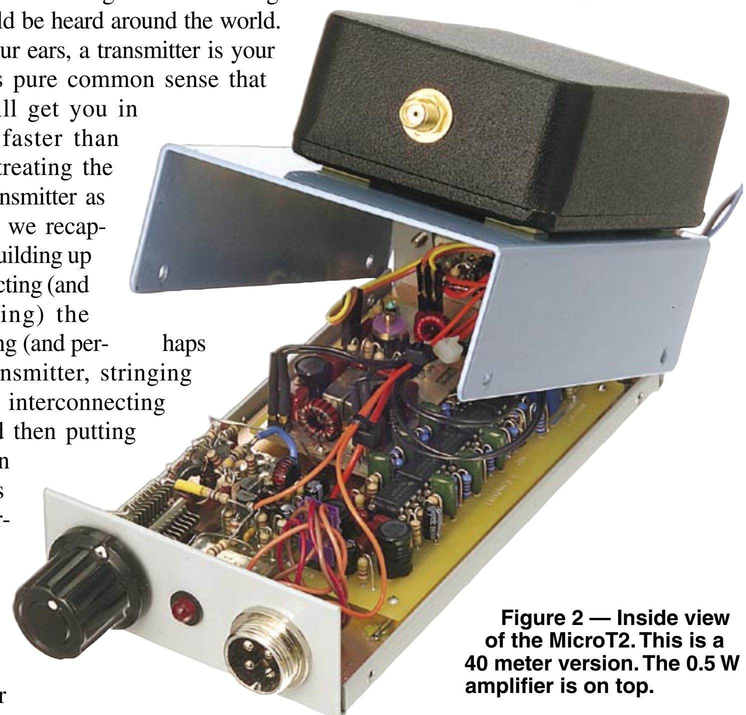


Figure 2 — Inside view of the MicroT2. This is a 40 meter version. The 0.5 W amplifier is on top.

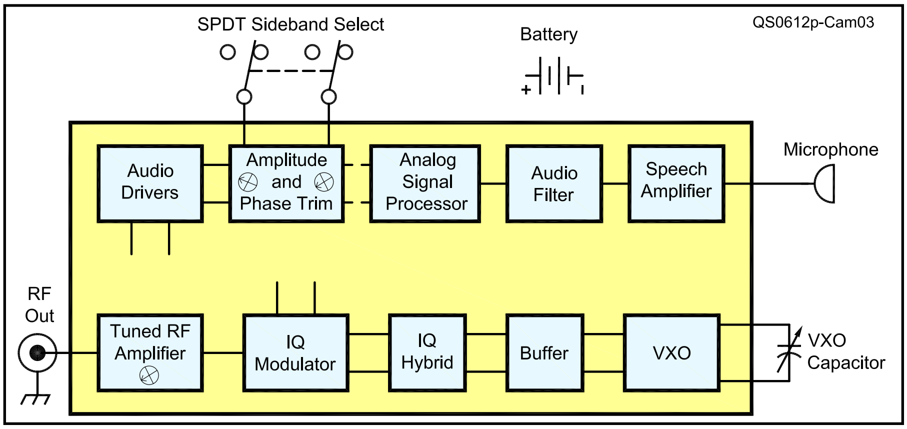


Figure 3 — Block diagram of the circuitry on the PC board.

the secure knowledge that the transmitter is actually on frequency and stable is a real virtue. In a future article we'll discuss a number of stations built around these modules. The photograph shows just one example — a simple battery operated transmitter intended to keep in touch with the folks back home on an HF net frequency. The crystal controlled transmitter is set to the desired frequency before leaving home and then left alone. The crystal oscillator in the transmitter functions as a calibrator for the receiver, so that the receiver may be tuned around the band and then easily reset to the net frequency. The current drain during receive is only 60 mA, because the entire transmitter is turned off except when actually transmitting. Figure 2 shows the inside of the exciter with a 1W amplifier mounted on top.

Exciter Block Diagram

Figure 3 is the block diagram of the circuitry on the PC board. It is a complete VXO SSB exciter on a 2.5 × 3.8 inch circuit board with 1 mW (0 dBm) peak output. The exciter uses the phasing method of SSB generation, which makes it easy to operate on different frequencies. In a phasing SSB exciter, two identical signals with a 90° phase difference are generated and then combined so that one sideband adds and the other subtracts. This method is covered in detail in *The ARRL Handbook for Radio Communications*.[3] The signal quality from this exciter is not merely adequate for the HF amateur bands — it is exceptional.

RF Circuitry

Frequency Generator

The frequency generator consists of a VXO, buffer amplifier and quadrature hybrid. It has a lot of parts: three transistors; a voltage regulator IC, a Zener diode, four toroids and many resistors and capacitors. There are no adjustments. You just build it and it works. The frequency stability is better than that of most commercial radios, even when portable.

VXO

There are simpler VXO circuits, but this one is the best I've ever used. It provides 0 dBm sine wave output, draws 4 mA, and has virtually no start-up drift — about 2 Hz at 7 MHz. (It makes a lovely keyed CW generator too.) The three-resistor attenuator between the output of the VXO and input of the buffer amplifier is a convenient place to insert a frequency multiplier or externally generated VFO. Just leave off the top resistor to break the path. Note that the crystal and variable capacitor are mounted off the PC board. Frequency stability is determined by the temperature of the crystal. I like to slip a foam packing bead over the crystal and support it by its leads between the PC board and VXO capacitor. I used a front-panel-mounted crystal socket in one prototype version of this exciter. It looks very classy, but noise picked up by the crystal body gets into the oscillator, and the signal radiated by the crystal sounds like one with poor carrier suppression. If you use a crystal socket, put it inside the case or behind a shield door as in the old E. F. Johnson and Heathkit transmitters.

Buffer

The buffer amplifier provides broadband 50 Ω drive to the quadrature hybrid and isolates the frequency generator from impedance variations at the mixer local oscillator (LO) ports. The simple arrangement used in the MicroR2 receiver doesn't work here, because high-level audio into the diode ring mixers

Other Modes with the MicroT2

This exciter is very similar to the one in a 1958 Central Electronics 20A SSB exciter. If you look at the front panel of the 20A you see a mode switch marked USB, LSB, DSBsc, AM, NBPM, CW. The back of the switch has just a bunch of wires and resistors used to unbalance a modulator, turn off the I or Q audio channel, etc. We could get all of those modes out of this exciter, too, by inserting a switch in the wires connecting the I and Q modulator outputs to the I and Q mixer IF inputs.

Connecting either the I or Q signal path (but not both) will result in DSB. Connecting only the I (or Q) path and inserting a little carrier by connecting a 4.7 kΩ resistor from that side to the +12 V supply will generate AM. Connecting only the I path and inserting a 4.7 kΩ resistor from the Q mixer IF port to +12 V will generate narrow band phase modulation (NBPM). Disconnecting both the I and Q paths, or simply turning off the power to the AF section, and connecting 4.7 kΩ resistors from either or both mixer IF ports will generate CW.

I like my radios simple, particularly the ones I take portable, so I have only ever included that switch in one transmitter. (The switch has been in the USB position for over 10 years now…) For CW, I recommended keying both the voltage on the mixer IF ports and the RF amplifier enable line. Figure A is a good circuit to accomplish this.

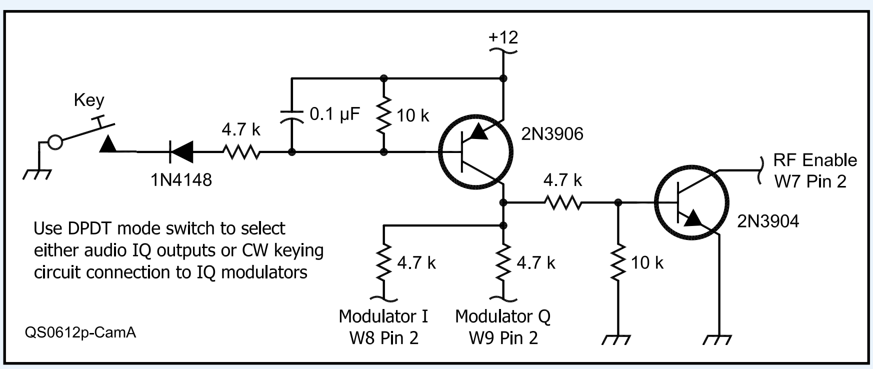


Figure A — Schematic diagram of suggested keying circuit.

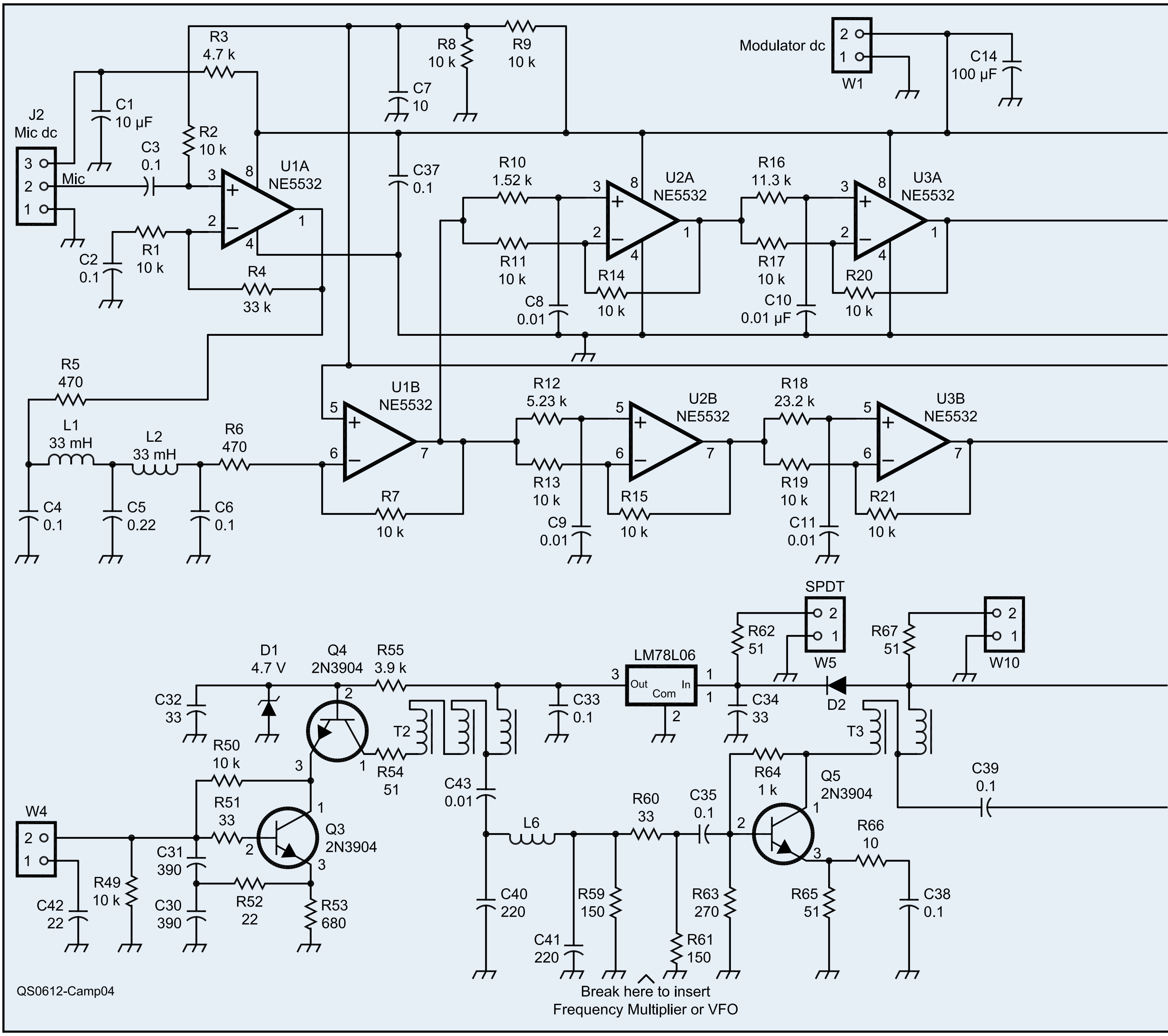


Figure 4 — Schematic diagram of the 40 meter version of the MicroT2.

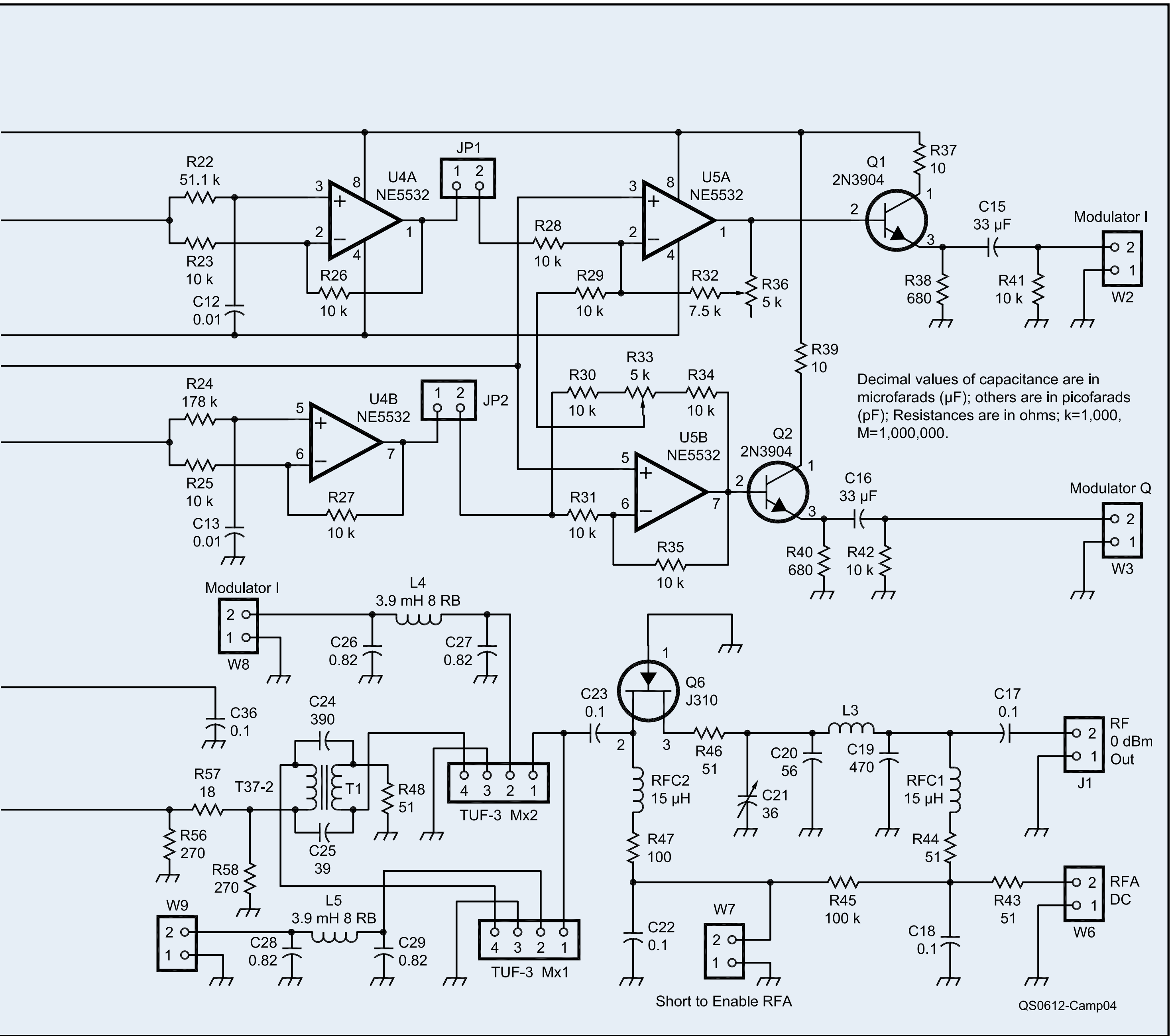
modulates not just the signal at the RF port, but the impedance at the LO and IF ports as well.[4] Experiments confirm that a directly connected VFO experiences severe frequency pulling on voice peaks. The gain of the buffer is set to provide +7 dBm drive to each mixer with an input level of 0 dBm. It draws some current and the transistor gets a little warm—but only while transmitting.

Quadrature Hybrid

This is a venerable circuit first described by Reed Fisher in *QST*.[5] It is the lumped-element equivalent of a pair of tightly coupled quarter-wavelength transmission lines. The total capacitance does not need to be symmetrical between the two ends of the inductor, as is commonly shown. It may all be at one end or divided unequally. When driven from a 50 Ω source and terminated in a 51 Ω resistor and two mixer LO ports, the 90° phase difference is nearly perfect across a wide band and the amplitude difference between the two outputs is within 0.5 dB across a 10% bandwidth — more than enough bandwidth to cover the usual SSB portion of any amateur band.

Mixers

A pair of Mini-Circuits TUF-3 mixers serves as the I Q balanced modulators. These provide good carrier suppression without adjustment, and reasonable output at a modest distortion level. IM products in the opposite sideband are more than 30 dB down at the exciter output. For even lower distortion, the circuitry from Chapter 9 of *Experimental Methods in RF Design*, (*EMRFD*) may be used — but this exciter will already sound better than the average commercial radio.[6] The aggressive low-pass filtering right at the mixer IF ports prevents wideband noise and harmonic distortion in the audio stages from contributing to the I and Q modulation. Energy outside the modulation bandwidth is then just intermodulation distortion in the mixers and linear amplifiers. Sideband suppression will be more than 40 dB if the four 0.82 μF capacitors and two 3.9 mH inductors are matched to within 1%. The resultant



carrier suppression is greater than 50 dB on any of the HF bands.

Adjusting the gain distribution from mic input to PA output for minimum distortion will be discussed in an upcoming article.

RF Amplifier

The exciter's output RF amplifier uses a common-gate JFET. This stage provides a broadband resistive termination to the mixer RF port IQ summing junction to isolate it from variations in impedance at the exciter output. The RF amplifier has relatively low gain, good harmonic suppression and a very clean 0 dBm SSB signal at the output. This is an appropriate level to drive a linear amplifier, balanced mixer or transverter. It is also a low enough level that it is easy to adjust the exciter with simple equipment. The exciter output signal meets FCC regulations for direct connection to an antenna for flea power experiments.

The transmitter in Figure 2 adds the simple two transistor circuit in Figure 5, copied directly from Figure 2.93 in *EMRFD*, for 0.5 W PEP output. The seventh order Chebychev low-pass filter on the output is non-critical and assures a clean signal that easily meets FCC regulations. See the accompanying text in *EMRFD* for a complete description. Several options for higher power will be explored in a future article.

Audio Section

The top half of the PC board contains all of the audio circuitry. There are no PC board traces connecting the two halves, and it is okay to cut the board into separate functional blocks for packaging flexibility, or to use the audio and RF portions of the circuitry in other projects.

Speech Amplifier

The speech amplifier drives a passive low-pass filter using two series inductors and three shunt capacitors. The combination of this low-pass filter and the mixer IF port filters limits speech frequencies to just over 3 kHz for natural sounding speech and good spectral purity. There is no ripple in the audio passband.

Analog Signal Processor

The analog signal processor and baseband

Table 1

Micro T2 Parts List

Parts for 40 meter version. See Note A,

C1, C7, C32, C34 — 10 µF, 16 V electrolytic capacitor.
C2-C4, C6, C17, C18, C22, C23, C33, C35-C39 — 0.10 µF, 5%polyester capacitor.
C5 — 0.22 µF, 5% polyester capacitor.
C8-C13 — 0.01 µF polyester matched to, 1% capacitor.
C14 — 100 µF, 16 V electrolytic capacitor.
C15, C16 — 33 µF, 16 V electrolytic capacitor.
C19 — 470 pF NPO ceramic capacitor.
C20 — 56 pF NPO ceramic capacitor.
C21 — 3-36 pF poly trimmer capacitor.
C24, C30, C31 — 390 pF, NPO ceramic capacitor.
C25 — 39 pF, NPO ceramic on back of board capacitor.
C26-C29 — 0.82 µF, 5% polyester capacitor.
C40, C41 — 220 pF, NPO ceramic capacitor.
C42 — 36 pF, VXO Variable off board capacitor.
C43 — 0.01 µF ceramic capacitor.
D1 — 4.7 volt zener.
D2 — 1N4148 diode.
L1, L2 — 33 mH inductor .
L3 — 40 turns #30 enameled wire on T37-2 toroid core.
L4, L5 — 3.9 mH inductor .
L6 — 22 turns #28 enameled wire on T30-2 toroid core.
Mx1, Mx2 — Mini-Circuits TUF-3 diode ring mixer.
Q1-Q5 — 2N3904 transistor.
Q6 — J310 field effect transistor.
RFC1, RFC2 — 15 µH molded RF choke.
R1, R2, R8, R9, R28-R31, R34, R35, R41, R42, R49, R50 — 10 kΩ resistor.
R3 — 4.7 kΩ resistor.
R4 — 33 kΩ resistor.
R5, R6 — 470 Ω resistor.
R7 — 2.7 kΩ audio gain select resistor.
R10 — 1.5 kΩ, 1% resistor.
R11, R13-R15, R17, R19-R21, R23, R25-R27 — 10.0 kΩ, 1% resistor.
R12 — 5.23 kΩ, 1% resistor.
R16 — 11.3 kΩ, 1% resistor.
R18 — 23.2 kΩ, 1% resistor.
R22 — 51.1 kΩ, 1% resistor.
R24 — 178 kΩ, 1% resistor.
R32 — 5.1 kΩ resistor.
R33, R36, R37 — 10 kΩ trimpot resistor.
R38, R40, R53 — 680 Ω resistor.
R39, R66 — 10 Ω resistor.
R43, R44, R46, R48, R54, R62, R65, R67 — 51 Ω resistor.
R45 — 100 kΩ resistor.
R47 — 100 Ω resistor.
R51, R60 — 33 Ω resistor.
R52 — 22 Ω resistor.
R55 — 3.9 kΩ resistor.
R56, R58, R63 — 270 Ω resistor.
R57 — 18 Ω resistor.
R59, R61 — 150 Ω resistor.
R64 — 1 kΩ resistor.
T1 — 17 turns two colors #28 enameled wire bifilar wound on T37-2 toroid core.
T2 — 5 turns #28 enameled wire trifilar wound on FT23-43 toroid core.
T3 — 7 turns #28 enameled wire bifilar wound on FT23-43 toroid core.
U1-U5 — NE5532 or equivalent dual low-noise high-output op-amp.
U6 — LM7806 or equivalent 6 V three terminal regulator.
.

Note A: C19, 20, 24, 25, 30, 31, 40, 41; L3, L6 and T1 values are for operation in the 40 meter band. A future article will provide detailed information on configuring the MicroT2 on other bands.

Note B: The total reactance of the parallel combination of C24 and C25 plus the capacitance between the windings of T1 is –*j*50 ohms at the center of the tuning range. Placing most of the capacitance at one end is a different but equivalent arrangement of the quadrature hybrid we often use with equal capacitors. C25 is only needed if there is no standard value for C24 within a few percent of the required value. C25 is tack soldered to the pads provided on the back of the PC board, and may be a surface mount component if desired.

Note C: Capacitor C42 is the VXO tuning capacitor for the exciter.

Note D: L3, L6, and T1, T2 and T3 are listed as number of turns on the specified core rather than a specific inductance. This is how I build duplicate versions of the same design. For those who wish to study the design with a calculator, simulator and inductance meter, L3 should be about +*j*300 ohms at 7.2 MHz, L6 should be +*j*100 ohms at 7.2 MHz and each winding of T1 should be *j*50 ohms at 7.2 MHz. T2 and T3 are non-critical broadband transformers with about 40 µH total inductance using the specified number of turns.

Note E: Resistor R7 sets the audio signal processor gain. If the gain is set too high, intermodulation distortion products generated in the diode ring modulators will be objectionable. Select R7 for a peak exciter output level no greater than 0 dBm.

amplitude and phase trim circuitry are taken directly from figures 9.56 and 9.35 of *EMRFD*. The position of the sideband select switch in the signal path allows switching without readjusting the amplitude and phase trimmers. For most applications, one sideband will be used exclusively, and the sideband switch may be replaced by a pair of jumpers on the PC board. If that results in the wrong sideband, reverse the connections between the audio driver transistors and mixers.

Class A Audio Drivers

The I and Q audio drivers are emitter followers directly driven by the amplitude and phase trim op-amps. Emitter followers were used successfully in the original T2 and work well.[7] An emitter follower can only source current, so it must be biased with more than the negative peak current required by the mixer IF ports. See the discussion on page 2.11 of *EMRFD*, and the output waveforms in figures 2.32 and 2.33. Q1 and Q2 each have a quiescent current of more than 10 mA. For a receive application, I would have used a different approach to save operating current, but since the exciter draws only a fraction of the total transmitter current in most applications and is turned completely off during receive, I elected to use class A emitter followers to drive the mixer IF ports. I could also have connected the feedback resistor to the emitter rather than the base of each follower. A circuit simulator shows a tiny bit less distortion — but also some potential high frequency instability with that connection. I chose the proven, conservative approach, and dropped the distortion still further by burning a little more current in each of the transistors.

Adjusting the SSB Exciter

There are only three adjustments on the SSB generator PC board: RF AMPLIFIER TUNING, AMPLITUDE TRIM and PHASE TRIM.

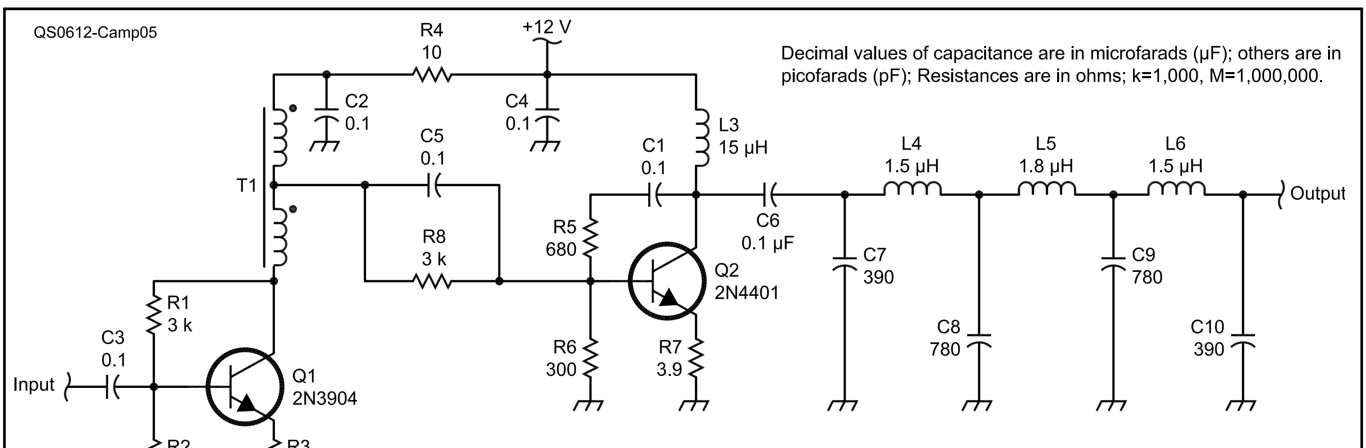


Figure 5—Schematic diagram of 0.5 W power amplifier with low pass filter shown in the photographs. T1 is 10 turns of #28 enameled wire bifilar wound on an FT37-43 toroid core.

Each adjustment may be set once and then left alone. I adjust SSB exciters by ear using a wideband audio noise source — usually just a spare SSB receiver tuned to noise. Plug a cable into the "noise receiver" headphone jack and connect to the exciter microphone input, starting with the volume all the way down. With about 60 dB of attenuation on the RF output of the exciter, feed it directly into another receiver with selectable sidebands. Turn off the receiver AGC, if possible, and reduce the RF GAIN so that the peak exciter signal does not move the S-meter. Tune the receiver to zero beat on carrier leakage and then slowly turn up the volume on the noise source until the exciter noise output is a strong signal in the receiver.[8]

Switch back and forth between upper and lower sideband on the receiver and confirm that one sideband is much stronger than the other.[9] Switch to the desired sideband (if it is the wrong one, reverse the connections between the I and Q modulators and audio drivers) and peak the RF amplifier capacitor. Then switch to the opposite sideband and adjust the amplitude and phase trimpots for zero noise output. Alternate between the two trimpots, as these two adjustments become increasingly critical as each one approaches zero. Once adjusted, the energy in the opposite sideband will be more than 40 dB below the energy in the desired sideband. At that level, intermodulation products in the opposite sideband will dominate, and all you will hear are the familiar unintelligible pops and clicks on voice peaks common to any clean SSB signal driving a practical linear amplifier.

So, How Does it Sound?

I evaluate my SSB exciters this way: First, I translate the frequency to some very quiet spot in the HF spectrum using a crystal oscillator and mixer. I put enough attenuators before and after the mixer to obtain a peak SSB output level of around –60 dBm — weak enough to not overload the receiver but strong enough that I can hear off-channel garbage another 60 or 70 dB below the peak transmitter output. I connect a CD player with some good acoustic folk music — lots of voice, guitar transients, perhaps a mandolin but no drums — to the exciter microphone input. Then I connect the frequency converted exciter output directly into the input of a good receiver and tune it in.

My current lab receiver is a Racal 6790/GM, but any receiver with selectable sidebands and a manual RF gain control will do. I turn the receiver AGC off and manually reduce the gain so the receiver noise floor is well below the peak signal level. The Racal has very low distortion up to the product detector, but an audio system that doesn't do justice to a good-quality signal. So I run the receiver "line out" into my stereo amplifier. I play the CD through the SSB exciter, through the attenuators and frequency translator, into the receiver, and back into the stereo and out the speakers. The frequency stability of this exciter and the Racal lab receiver are good enough that once warmed up, they will hold zero beat within 1 Hz for hours. It's an acid test, and this exciter sounds pretty good — better than most AM broadcast stations, and even some badly adjusted FM stations. Friends who run into me on the air say, "Wow, it sounds exactly like you!"

Next Step: Assembling a Station.

OK, now we have a cute little receiver module and an SSB exciter. It's time to assemble a few stations. We'll have some options in future issues of *QST* — stay tuned!

Notes

[1] R. Campbell, KK7B, "The MicroR2 — An Easy to Build "Single Signal" SSB or CW Receiver," *QST*, Oct 2006, pp 28-32.

[2] W. Hayward, W7ZOI, "An Updated Universal QRP Transmitter," *QST*, Apr 2006, pp 28-32.

[3] Available from your local ARRL dealer, or from the ARRL Bookstore, ARRL order no. 9760. Telephone 860-594-0355, or toll-free in the US 888-277-5289, fax 860-594-0303; **www.arrl.org/shop/**; **pubsales@arrl.org**.

[4] R. Campbell, KK7B, "The MicroR2 — An Easy to Build "Single Signal" SSB or CW Receiver," *QST*, Oct 2006, pp 28-32.

[5] R. Fisher, W2CQH, "Twisted-Wire Quadrature Hybrid Directional Couplers," *QST*, Jan 1978, pp 21-24.

[6] W. Hayward, W7ZOI; R. Campbell, KK7B; R. Larkin, W7PUA; *Experimental Methods in RF Design*. Available from your ARRL dealer or the ARRL Bookstore, ARRL order no. 8799. Price, $49.95 plus shipping. Telephone 860-594-0355, or toll-free in the US 888-277-5289; **www.arrl.org/shop/**; **pubsales@arrl.org**.

[7] R. Campbell, KK7B, "A Multimode Phasing Exciter For 1 to 500 MHz," *QST*, Apr 1993, pp 27-32.

[8] Some amateur receivers have inadequate shielding, and may overload on signal leakage from the exciter crystal oscillator — in that case, use a simple frequency converter to translate the exciter output to a different frequency. The converter may also be used to translate the frequency all the way down to 10 kHz as discussed on *EMRFD* page 7.35 to analyze the exciter signal using a computer sound card and audio spectrum analyzer software.

[9] Even a poorly adjusted phasing single sideband generator will have significant opposite sideband rejection. If it has little or none, stop and find the construction error. With over 100 parts on a PC board, I frequently have an error — a lead I forgot to solder or swapped components.

Rick has a BS in Physics from Seattle Pacific University and MS and PhD degrees in EE from the University of Washington. He started building receivers as a young child, and his career has followed a twisted path from church camp counselor through the US Navy as a Radioman, four years of basic physics research at Bell Labs, 13 years on the faculty at Michigan Technological University and seven years designing receiver integrated circuits at TriQuint Semiconductor. He is now with the advanced development group at Cascade Microtech, Inc and an adjunct professor at Portland State University, where he teaches RF Design. Rick was recently elected chair of IEEE MTT Committee 17, which studies and promotes HF-VHF and UHF Technology. He is one of the authors of EMRFD. *He divides his spare time between music, playing with old radios and windsurfing, and is a full time husband and dad.*

You can contact Rick at 4105 NW Carlton Ct, Portland, OR 97229, or at **kk7b@ieee.org**.