The SESE80 80 Meter Receiver

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The SESE80 is a simple easy to build 80 meter superhet receiver. Eight 2N3904 transistors, one LM386 audio IC, and five microprocessor crystals are used along with three 10.7 MHz IF transformers. Tuning is accomplished with a 1N4001 diode. For the builders convenience a printed circuit board is available from Far Circuits, but the circuit can be built manhattan style or dead bug style at the builders' option. The SESE80 was designed to showcase the singly balanced mixer as an alternative to the NE602. Cost of the board mounted parts exclusive of the pc board is about $12.00. Three pots, antenna connector, power connector, speakerjack and cabinet complete the receiver.

My interest in the singly balanced mixer came from reading the web site of VK3AGJ describing his BC547 QRP SSB Transceiver. Just Google BC547QRPSSB and it should take you to his site. Another application of the singly balanced mixer is the "Direct conversion receiver using a discrete component product detector," page 1.13, *Experimental Methods in RF Design*. After building an abbreviated version of the direct conversion receiver I liked it so well I upgraded it to a superhet. The original prototype was built on a copper clad board dead bug style with the same architecture of the BC547 QRP SSB transceiver except with 2N3904 transistors. I built and tested the circuitry for a transceiver but I decided the transceiver market is pretty well covered so I trimmed it down to receive only. I often see posts on the QRP forums like BITX and MMR 40 from builders who want just a receiver. There are quite a few designs for direct conversion receivers, dating back to the Neophyte by John Dillon WA3RNC in Jan 1988 *QST*, but few superhets. For just a few dollars more, you can build a single conversion superhet and have the advantages of a crystal filter(single signal reception) and more audio that a direct conversion receiver offers. I believe the SESE80 will make a good companion for the Tuna Tin II and such. It is suitable as a first time project, with some help with soldering and component recognition. Advanced builders may find it useful as a platform to test out filters, audio amps, VFOs and such.

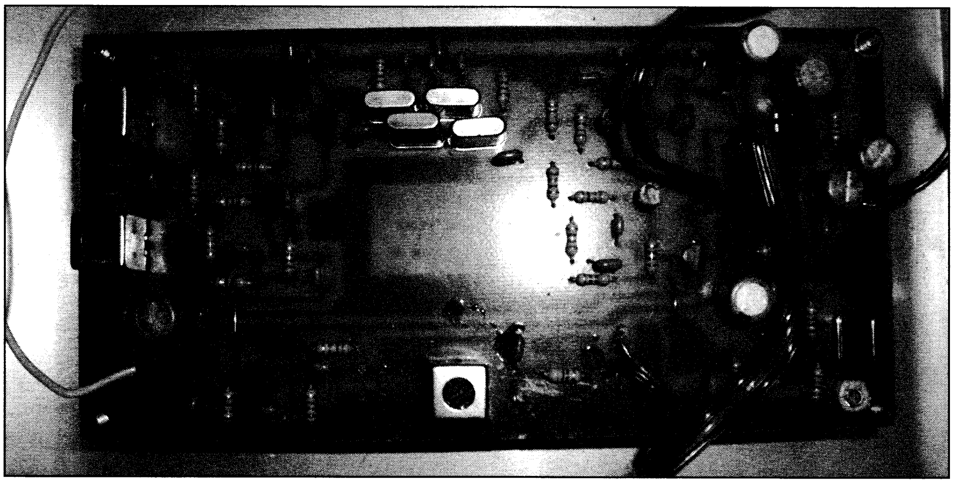
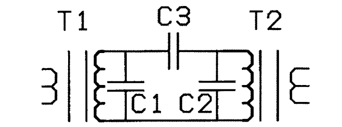


Figure 1—Inside the SESE80 80M receiver p.c. board.

Building Blocks—

1. Bandpass Filter

The band pass filter is a modification of the filter described by Chip Owens in Oct. 1990 *QRP Quarterly*. I made it link coupled and used the Mouser 42IF123RC if transformer in place of the TOKO TK1203 coil described in the original article. To couple to the mixer, I tried the link, high side of primary, and the low impedance tap on the primary of T2. I found the latter to be the best match for the first mixer. I know some builders will want to try putting this receiver on other bands, so I show component values for 80, 40, 30 and 20 meters in Fig. 2. I have used these values in other projects over the years. The Mouser IF transformers have an inductance range of 3 to 5.8 uH, nominal is 4.7 uH. The internal cap is 47 pF, I recommend removing the internal cap before installing so the transformer can be used on any band without considering the cap. The cap is easily removed by crushing it with a jeweler's screwdriver. Be sure to check the continuity of the windings before installing. The data sheet for these coils is available for download on Mouser's site.



T1,T2 MOUSER 42IF123-RC
10.7MHZ WITH
INTERNAL CAP REMOVED

BAND	C1,C2	C3
80M	390PF	33PF
40M	100PF	3.3PF
30M	47PF	1.5PF
20M	27PF	1.0PF

Figure 2—The bandpass filter.

2. Singly Balanced Mixer

The NE602 (and other ICs) using the doubly balanced mixer, Gilbert cell, have been the mainstays of QRP designs for over 20 years. Given the volatile nature of the IC market I am surprised the NE602 is still available. Though it lacks the port to port isolation of the doubly balanced mixer a singly balanced mixer performs well in this application, and it is very inexpensive when built with discrete components. Fig. 3A shows the basic differential amp/mixer. Fig. 3B shows the mixer with balanced input and output. Fig. 3C shows the mixers with single ended input and output as I used it. My first two breadboard prototypes were built with a balanced output to the filter via a trifilar wound torroid transformer. Changing to a single ended output caused a loss of gain but this was easily made up in the audio amp with an increase in the feedback cap. Scratch builders might want to try it both ways. Note the RF and IF ports are interchangeable, this may give some flexibility in layout .

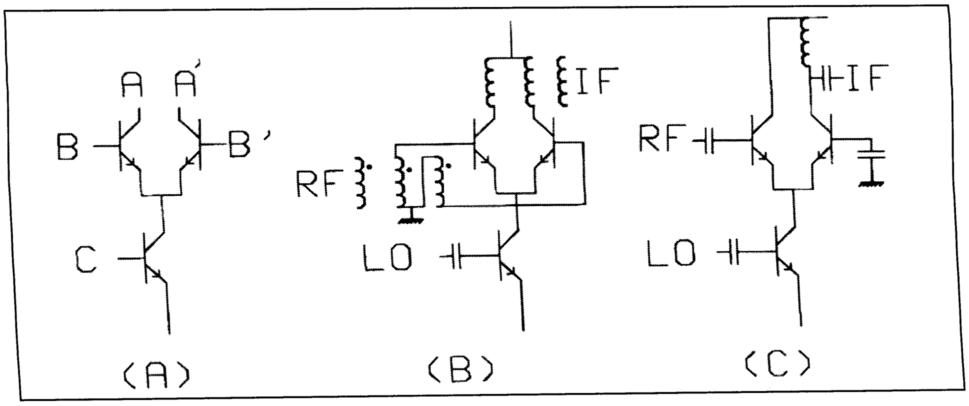


Figure 3—The singly-balanced mixer.

3. Filter

The XTAL filter was designed using the filter program downloaded from AADE site, www.aade.com. In the initial prototypes I tried 5 MHz, 6 MHz and 11 MHz XTALs before deciding on the 10.0 MHz. I wanted to use the 11.0 MHz but ran into image problems. With no filter on the VFO the 7.0 MHz second harmonic, 14 MHz beats with an 11 MHz IF and the 3.0 MHz image is within the band pass of the front end, and some images like CHU popped up. I used the default values for 10 MHz xtals in the AADE program for the final values. Without the 330 ohm resistors there was a pronounced dip in the middle of the pass band. One unusual feature of the filter is that it is returned to the B+ buss rather than ground. This was done as a matter of convenience in the original PC board layout that had two filters, one in series and one in shunt configuration. I later discarded the shunt configuration. The B+ bus s serves as well as ground since the buss is well bypassed to ground.

WINSCOPE, a free download program (Goggle WINSCOPE) with an audio spectrum analyzer built in is an excellent way to evaluate the filter. Simply feed noise into the receiver (from antenna or noise bridge), connect the audio from the SESE80 to the computer sound card, set WINSCOPE to storage mode in the spectrum analyzer function and it will paint a silhouette of the band pass response. Scale left to right is 0-5000 Hz, remember this is Lower Side Band, left to right is descending in frequency and the amplitude is in volts not dB. Check your Ricebox with this method.

4. BFO

The BFO is a simple Colpitts circuit. Best performance of the receiver requires the BFO to be set to the correct frequency with respect to the filter bandpass response curve. Winscope is an excellent way to do this. The left hand slope of the curve should be between 300 and 500 Hz of the carrier frequency. Another test is to tune down on a steady carrier. As the frequency is lowered the signal will come into the bandpass, rise to a peak, fall off and dissapear near zero beat. Adjust trimmer to set BFO frequency.

5. VFO

ARRL guidelines state a VFO should be capable of stability in the order of 100 Hz over a ten minute period. This is reasonable as you can listen to a SSB QSO with out retuning until the shift is 100 to 200 Hz. Stability of 115 Hz per ten minutes was achived in the SESE 80 VFO.

My original choice for tuning was the polyvaricon capacitor. Problems with mounting the polyvaricon to a reduction drive lead to a change to varactor tuning. I tried LEDs and diodes and settled on the 1N4001 diode. Best data I had from the internet indicated a change of only 10 pF from 0 to 9 volts so I tried 3 then 4 diodes in parallel. Drift was terrible, about 400 Hz per minute. Cause of the drift was determined to be the 100k resistor. With four diodes in parallel I had about 4 volts drop across the 100k resistor. Changing to a 470 uH RF choke solved the drift and the voltage drop so I could get 500 kHz coverage in the VFO with only 5 volts swing and a single diode. A further reduction in drift was accomplished by changing the bias values. Toroid cores, T50-2 and T50-7, in place of the Mouser 10.7 if coil were tested, but no advantage was found so the 10.7 ift was retained. I encourage the builder to use multi-layer ceramic COG (NP0) caps in the VFO. My experience of late with disc ceramic types has been poor. Note there are three unused holes to the left of the VFO coil. I put these in the PC board layout in case the builder wants to pad the VFO down to another frequency.

Running stability trials is like watching paint dry. I used a program called ARGO to record the drift. Argo will be familiar to those who have copied beacons running qrss, very slow speed CW. In the wide band mode a waterfall display of 0-1500 hz is presented. Time span top to bottom is only 30 seconds but Argo has a capture feature that allows you to save a screen at any time you specify. I set the capture to record every two minutes then overlapped the printouts as shown in Fig 6. You just

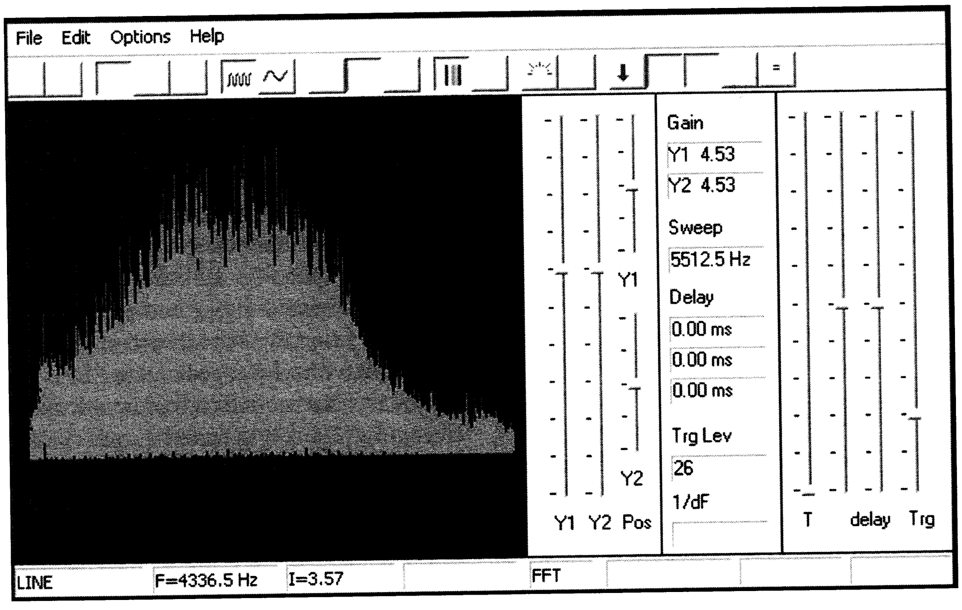


Figure 4—WINSCOPE PC screen and display.

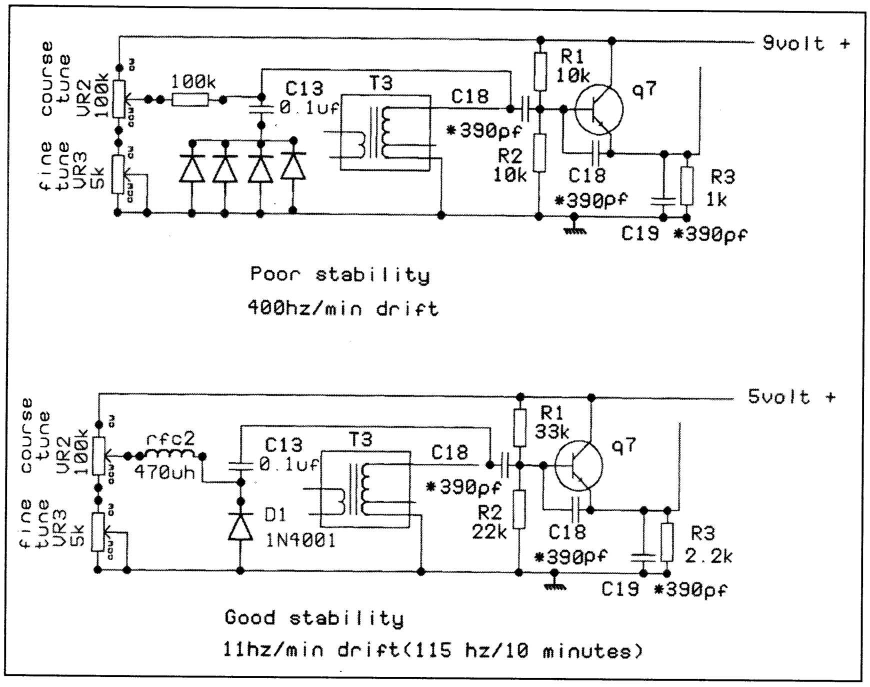


Figure 5—VFO development: first try (top) and final design (bottom).

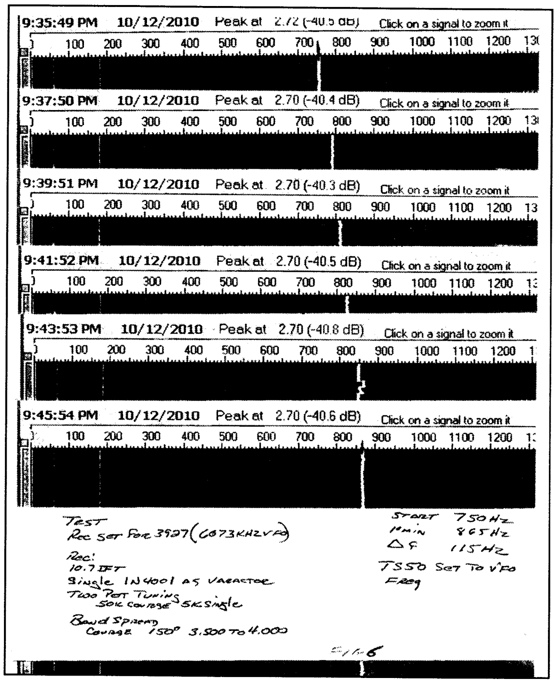


Figure 6—VFO stability test results with ARGO.

set the general coverage receiver about 1 kHz away from the VFO frequency start ARGO, set for capture every two minutes or so, and go do something else while it runs. Argo may be downloaded from www.weaksignals.com .

6. Audio

I used the LM386 for audio. This is a pretty standard circuit. Audio may be a little hot with the 10 uF cap between pins 1 and 8, this sets the gain. If there is any distortion at full volume you may lower the value of C31 from 10 uF to 4.7 uF or less. In the pictures I used flat ribbon cable for the connection to the volume control, I don't recommend this use two wire shielded cable to avoid any hum pickup.

Construction and Alignment.

First step in assembly is to remove the internal caps from the IF transformers. Be sure and check the continuity of the winding before installing. Proceed with the installation of the parts on the board. When completed install the board in a metal case and connect the power, speaker, antenna, volume and tune controls.

The two pot tuning works well and a 10-turn pot has been tried, too. The nonlinearity of the diode is very noticeable with a ten turn pot for the main tuning, I compensated for the non linearity by using an audio taper pot for the coarse tuning. I found I could compress the 500 kHz span into 180 degrees of rotation by first setting the fine tune to middle of its rotation, then set the coarse tuning pot at the clockwise stop and install the know pointing to

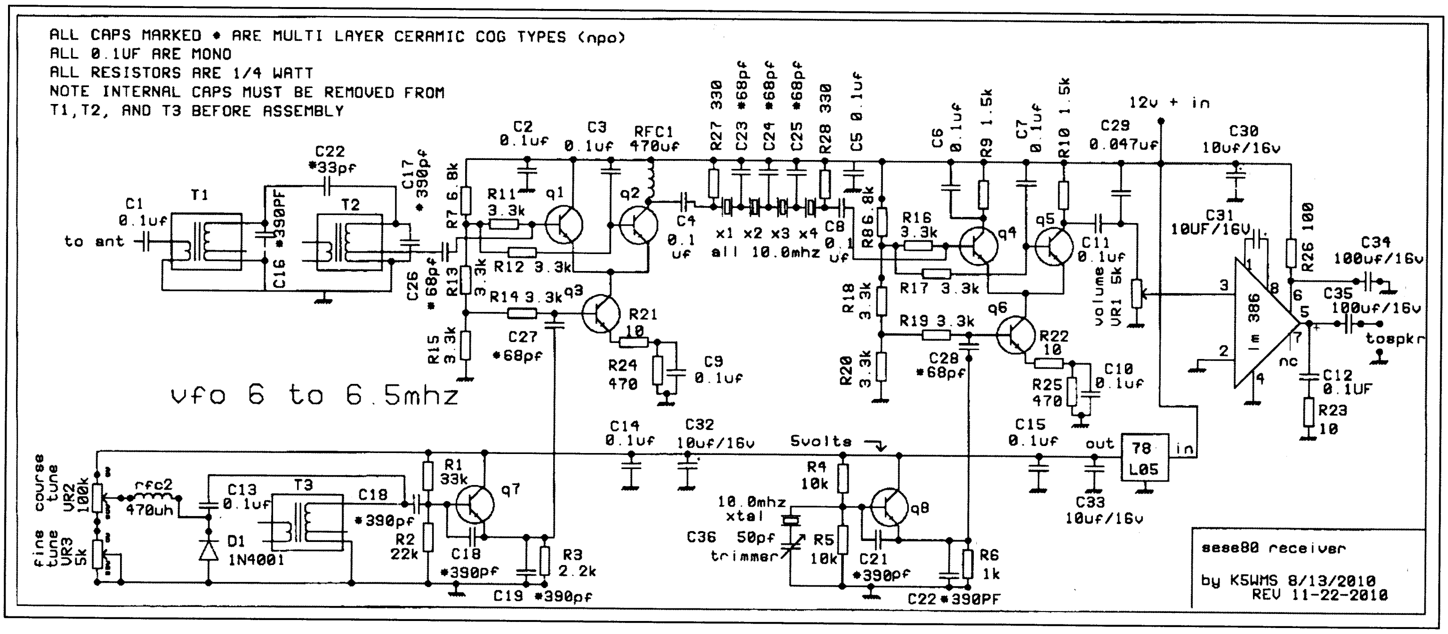


Figure 7—Schematic diagram of the receiver.

Figure 8—Front panel of the SESE80 receiver.

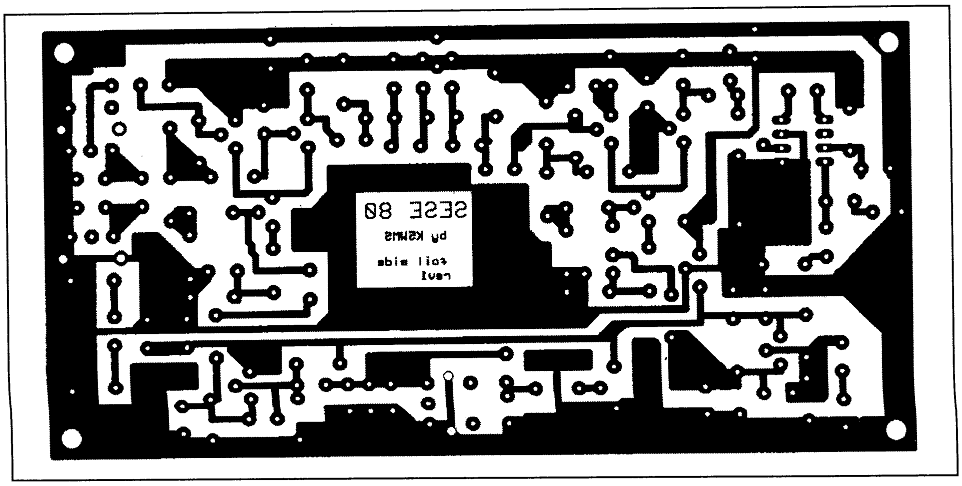


Figure 9—Foil pattern for the p.c. board.

ITEM	DESCRIPTION	SOURCE	PART NUMBER	NO. REQ'D
Board Mounted Components:				
T1,T2,T3	10.7 MHZ IFT	MOUSER	452IF123-RC	3
Q1-Q8	2N3904	MOUSER	610-3904	8
U1	78L05	MOUSER	511L05ACZ	1
U2	LM386			1
X1-5	10 MHZ XTAL	MOUSER	559-FOX100-20-LF	5
C1-15	0.1 UF MONO CAP	MOUSER	581-SR215E104MAA	15
C16-21	390 PF MLC COG	DIGIKEY	BC1020-ND	6
C22	33 PF MLC COG	DIGIKEY	BC1007CT-ND	1
C23-28	68 PF MLC COG	DIGIKEY	BC1011CT-ND	6
C29	0.047 DISC CER	MOUSER	140-US-472M-RC	1
C30-C33	10 UF/16V	MOUSER	647-USW-121C100MDD	4
C34-35	100 UF/25VOLT	MOUSER	647UV21E101MUTA	2
C36	50 PF TRIMMER	MOUSER	659GKG50015	1
D1	IN4001	MOUSER	512-1N4001	1
R1	33K ¼ W			1
R2	22K 1/4W			1
R3	2200 1/4W			1
R4,5	10K 1/W			2
R6	1000 1/4W			1
R7,8	6800 1/4W			2
R9,10	1500 1/4W			2
R11-20	3300 1/4W			10
R21-23	10 1/4W			3
R24,25	470 1/4W			2
R26	1000 1/4W			1
R27,28	330 1/4W			2
RFC1, 2	470 UH	MOUSER	542-78F471-RC	2
Chassis mounted components:				
Audio gain pot	5 or 10 k audio taper			1
Coarse tune pot	100k audio taper	Radio Shack	271-1722	1
Fine tune pot	5k linear taper	Radio Shack	271-1714	1
Power connector	size M jack	Radio Shack	274 1563	1
Speaker jack	1/8 in mono jack	Radio Shack	274-0251	1
Antenna conn.	chassis mount SO239			1

Parts list

5 o'clock. Then turn the knob back to the 3 o'clock position and set the VFO coil (T3) for a VFO frequency of 6.5 MHz, or a receive frequency of 3.500 MHz. Rotate the course control back to 9 o'clock and the VFO should be at 6.0 MHz or a receive frequency of 4.0 MHz. The 100 kHz marks can then be added to the panel. Note this works with the Radio Shack 100k audio taper pot but may differ with other manufacturers as the taper may be different. The fine tuning pot has more effect in the higher portion of the tuning range. Compressing the tuning range into a 180 degree arc allows the use of a plastic vernier drived with stops at 0 and 180 degrees. If a reduction drive is used the builder may not want to retain the fine tune pot.

BFO may be set as described in the section above with WINSCOPE or listening to where the received signal drops out at or near zero beat by adjusting the trimmer C36.

Alignment of the front-end bandpass filter is not very critical. It can be set by listening to background noise , set T1 for peak at 3.9 MHz and then set T2 for peak at 3.7 MHz. I also set the front end with a MFJ SWR analyzer by hooking the analyzer to the antenna input and tuning for min SWR at 3.9 MHz. Once when I had T2 too far down (CW direction) I heard some foreign broadcast feed through. This was eliminated by turning the core in T2 ccw a couple of turns and re-peaking T1.

In conclusion I hope you enjoy this project if you decide to build it or use the ideas to build your own design. I am not an engineer just a hobbyist. I have an engineering background but it is in fractional HP electric motors, not radio. I encourage builders to read up on differential amplifiers and the notes on balanced mixers in *EMRFD* and the ARRL handbooks. Printed circuit boards will be available from Far Circuits and Fred Riemers is looking into producing a kit of the circuit boards and the board mounted components. That will be Fred's enterprise and I will have no financial involvement. Keep an eye on Fred's site at www.farcircuits.net for developments. Fred and I are working on an pictorial assembly manual to go with the boards. I will support the builders in any way I can. I may be reached at k5wms@centurytel.net

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