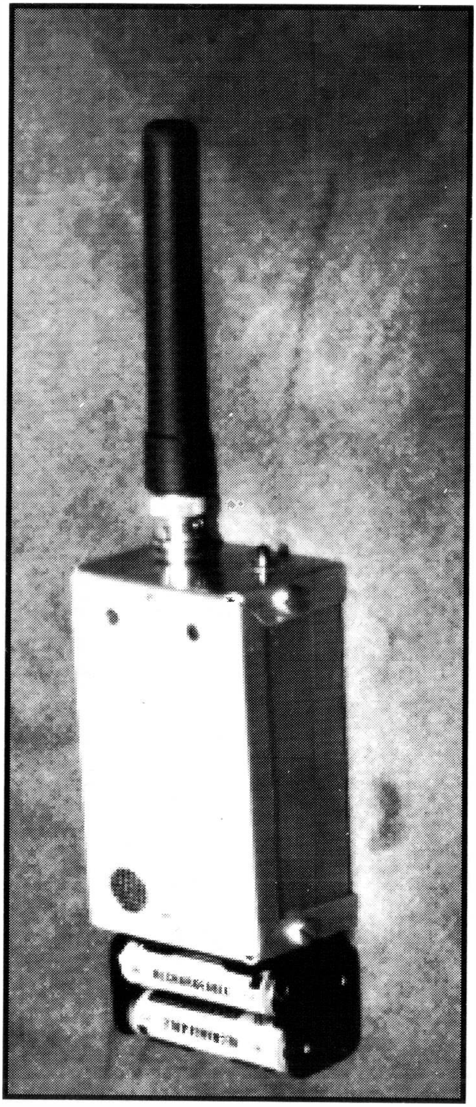
hambrew

FOR AMATEUR RADIO DESIGNERS AND BUILDERS



A Minimalist's FM Transmitter

Lew Smith, N7KSB

WINTER 1996

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• Contents •

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hambrew

FOR AMATEUR RADIO DESIGNERS AND BUILDERS

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• LETTERS •

From The Publisher

(Via E-Mail):
>I currently have a complete set of (and a subscription to) Hambrew except for the sold out Winter 1995 and Spring 1995 issues.
>Is there any possibility that these two sold out issues will be reprinted in their entirety?

Charles P. Sammut, K8MI
San Francisco, CA

Hi Charles-

I've considered the possibility of a future *hambrew Compendium* which would include many of the projects contained in these and other issues. I guess I need to roughly gauge whether or not the general interest would warrant the effort. Since all the subsequent issues to W95 and Sp95 have sold out (about 25 or so copies of the Autumn 95 issue remain), I truly think that by 1997 (possibly sooner?), there will be a lot of material to cover and present.

Charles, I really hope that the increased internet coverage will bring a deluge of subscribers so that *hambrew* could benefit. There are so many things possible if we had more financial resources. It has been a struggle to improve, since renewals tend to remember late. Fortunately, there have been enough renewals and new subs to allow some upgrades in production.

Whew, getting a little long-winded here for your simply-put inquiry. Didn't mean to begin the "litany", heh. Hope it makes sense, though. You are now on the list of Hambrew E-Mail Recipients. Any hot corrections to copy or component lists will be sent to you between issues, unless you choose not to receive them. Please advise if the latter is your preference so that I may remove your address from the list.

The above correspondence with Charles does echo a question which we have been asked several times, so I include it here for general consumption. It *is* difficult to reprint issues without a compelling demand. So far, it has not been possible. That could change, and we hope the future will hold a *hambrew Compendium* in store.

As for the HotList, please feel free to shoot us an E-Mail with your request to be placed. We will send updated information, in effect a cyber-"20/20 Hindsight", as is warranted. This will help to compress the time between issues when updated information, component info, typos in schematics or parts lists need to be sent ASAP for your use and convenience.

We welcome **Robert van der Zaal, PA3BHK,** to our growing list of new authors. His great DSB/CW 80 Meter Transceiver is in this issue. Many, many thanks also to **David Fifield, KE6ZBZ** for his great cross-reference to the European transistors in the PA3BHK article. An abundance of wonderful projects arebeing created abroad, and we would like to make more information available which will join the parts designators to those which are familiar to us here in the U.S. Any help from the readership will be much appreciated, since the info benefits both readers here and in other countries.

Another FAQ: When will I see the next issue of *hambrew*?
Answer: If you have not received your issue by the 4th week of January, April, July or October, something dreadful has happened. Let us know as soon as possible! 70s, Geo., WFØK

Hi George,

I'm hooked on *HamBrew* mag and just have to have a subscription. I especially liked:

1. articles on the Sierra and NorCal 40a with mods
2. reviews on QRP accessorys like the Tejas peaking filter
3. new product releases: S&S eng TAC-1
4. construction articles using surplus parts, I have a basement full of ARC-5 xmitrs and rcvrs
5. looking at and reading about MXM Ind. with Bruce Williams at his bench.

Would like to see

1. contruction articles on miniature ant tuners, using toroids and receiving variable caps.
2. construction ideas on the new CMOS-3 keyer and novel ways of packaging them With the keyer no longer needing batteries to keep the memories active, you can package it in a very small box and velcro it to the side of any QRP rig.
3. SCAF filters with bandwidths of 300, 500, 700 hz or better yet, variable bandwidth
4. sources for parts: variable caps, toroids. wouldnt it be great to spotlight a vendor every issue, the kind of parts he specializes in, his address/phone nr, Who carries B&W roller inductors, small variable caps, etc Better yet, how about a source list of the largest vendors, such as Digi-Key, Newark Ferguson, etc. Finding parts is the hardest part of any building projects.
5. more info on FAR circuits, whats available, whats the quality like, silk screening ? double sided plated thru holes ? tin plated copper ?
6. a simple wire antennas that works great, all band, quiet on receive in every issue
7. How do some of these guys make such a professional looking front panel. do they have their own silk screening lab at home ? are they using a laser printer ?
8. is silk screening too expensive to do at home ? if you already had a darkroom, can you buy the silk screening materials in small quantities at a reasonable price?
9. I would like to see some complete stations in small walk-about packages. xcvr, keyer, tuner, swr/pwr meter, antenna, key, log/computer, sling shot.

Is *Hambrew* going to six issues a year, anytime soon ?

Keep up the great work, I cant wait for the fall issue to arrive.

72,

Byron,WA8LCZ
Detroit, MI
Byron8LCZ@aol.com

Please see this issue for #4 above. Great timing, Byron! As to #7, we plan to do an article on the treatment of front panel graphics. We use transfer type and also have used laser printer outputs using a very powerful little drawing program called "Mighty Draw" from Abracadata Co. More on front panels and some of your other observations later.

Thank you very much indeed for your effort in the publication of *Hambrew*.

Yours Sincerely,

Luis Menéndez Fdez.-Escandón
EA1DWQ
Asturias, Spain

Muchas gracias, señor, por su carta tan especiál y sympática.

Your little magazine is the best ham magazine published! I've been home brewing for 65 years, and I think after that length of time I've seen just about everything on home brewing. Yours is the best.

73,

Alden Gamage, WA9QMO
Aurora, IL

Thanks, Alden, and thanks for renewing!

hambrew On The Internet...

HOTLIST

A free E-Mail service to update information published in *hambrew* Between Issues!

Send to:

hambrew@qadas.com

and mention that you wish to add your e-mail address to the hotlist.

If there are corrections to component lists, a typo on a resistor value in a schematic or any news of interest regarding *hambrew*, you will be the first to know!

MOVING?

Notify us of your new address - don't miss a single issue of Hambrew!

Back Issues of Hambrew:

To keep your *Hambrew* collection complete, we still have a number of back issues available. Our Inaugural Issue was Autumn, '93. Back issues up to and including Fall, '94 are $6 each ($8 International), issues published after Fall, '94 are $3.50 ea. ($6 International) mailed in an envelope via first class mail. The Winter, Spring and Summer '95 Issues are sold out and are now collectors' items. Supplies of the other back issues are limited.

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c Total Paid and/or Requested Circulation *Sum of 15b(1) and 15b(2)*	706	823
d Free Distribution by Mail *Samples Complementary and Other Free*	19	17
e Free Distribution Outside the Mail *(Carriers or Other Means)*	0	0
f Total Free Distribution *Sum of 15d and 15e*	19	17
g Total Distribution *Sum of 15c and 15f*	725	840
h Copies Not Distributed (1) Office Use Leftovers Spoiled	50	160
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i Total *(Sum of 15g 15h(1) and 15h(2))*	775	1000
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16 This Statement of Ownership will be printed in the WINTER '96 issue of this publication ☐ Check box if not required to publish

17 Signature and Title of Editor Publisher Business Manager or Owner — Date: 9-26-95

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3 Be sure to furnish all information called for in item 15 regarding circulation Free circulation must be shown in items 15d e and f

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5 In item 16 indicate date of the issue in which this Statement of Ownership will be printed

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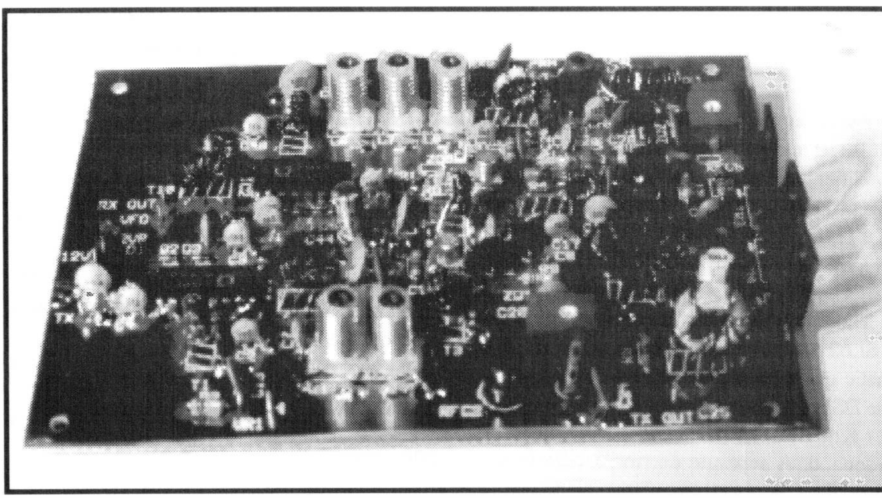
PS Form 3526, October 1994 *(Reverse)*

KIT REVIEW

The Hands Electronics 6 Meter RTZ Transceiver

Bill Kelsey, N8ET

3521 Spring Lake Dr., Findlay, OH 45840



RTZ-RF: Tx/Rx Mixer, Tx Amp and Bypass Filter (all on one board)

In the last issue of *Hambrew* I described the Kanga 6 meter cw transmitter - a fairly simple and straightforward 6 meter CW transmitter. This issue I am going to describe the Hands RTZ 6 Meter Transceiver which is a full blown ssb/cw 3w rig. An AGC module can be added later.

Hands Electronics

Hands Electronics is a one person company in Wales. Sheldon has designed a fairly broad range of kits for the serious QRP builder, from a simple cw transmitter, to a 10 band, microprocessor controlled, dds vfo, ssb/cw, 15 watt rig. All the rigs Sheldon designs and sells are modularized - start with the minimum modules to make a basic rig, and improve it by adding modules. Case kits are available for most of the Hands lineup, but the cost after shipping to the US is high.

Thr RTZ Transceivers

The RTZ series of rigs is a recent addition to his line. They are single band ssb/cw transceivers for 14, 18, 21, 24, and 50 Mhz. All consist of four boards: an IF board, a front end board, a low pass filter board, and a VFO. AGC can be added by installing the RTX AGC board.

The 6 Meter RTZ Transceiver

IF Board (4" x 5")

Sheldon has just recently released an upgraded version of his standard IF board. The IF board kit comes with a 2.1 Khz filter, and includes the IF and audio amplifiers, along with the USB, LSB, and CW carrier oscillators. Provision for external AGC is provided. Passive filtering is also provided in the form of 300 hz high pass and 3.0 Khz fifth order low pass filters which are always in the receive audio line. Muting is provoded by an FET switch in the audio line.

The IF amplification is provided by a pair of MC1350 integrated circuits. Output from the amplifier is coupled to an NE602 which is used as a product detector. The audio stages consist of a TL071 pre-amp and a TDA2003 amplifier which will easily drive any 3 to 8 ohm speaker.

The transmit side of the IF board consists of a SL6270 - a Plessy chip that provides automatic gain control. A Plessy SL1640 provides the DSB output through a FET amplifier to the 2.1 Khz filter which strips off the unwanted sideband. A separate carrier oscillator provides the CW signal.

RF Board (4" x 5.5")

The RF50 board provides the tx and rx mixers, and rf preamp for the receiver, and a 3 watt rf amplifier on transmit. Both the rx and tx mixers are Plessy SL6440 high level mixers. These active mixers provide a very high level of performance, especially in a high RF environment. Four poles of filtering are provided before the receive mixer.

The transmit section uses inexpensive VN66 transistors in the driver and push-pull final amplifier stage. The gain of the transmit chain (and therefore the output - if 3 watts is too much!) can be easily varied by an off board potentiometer.

VFO Board. (2.25" x 3")

The VFO runs at approximately 7 Mhz using a J310 FET in a Colpitts circuit. The 7 Mhz signal is fed to an NE602 mixer/oscillator which provides the necessary signal to the RF board. Provison for RIT is on the board. You will need to provide the RIT voltage.

LPF Board (2" x 2.75")

A three section filter is provided to be sure that the signal from the transmitter is clean. The three inductors used for the 50 Mhz LPF are air wound - no toroids here! An onboard relay switches the antenna between rx and tx.

General Comments on Construction

I would rate the RTZ to be of intermediate difficulty. There is nothing difficult about any of the kits, but a full transceiver is a complex system, with plenty of opportunities for mistakes in construction. If you have never built anything before, I would not recommend this as a starter kit. However, if you have built several kits on the order of single band CW transceiver (NorCal 40 for example) this is a good next step.

All the boards with the exception of the VFO are double sided boards with the top side used as a ground plane. The parts layout is silked screened on the boards, which together with the layout diagram provided in the documentation make it easy to assemble. The only catch is that you have to remember to solder all the ground connections on the TOP side of the board. Interconnections between the PC boards are made to pins that are soldered to the boards. This makes it very easy to test the boards, and also saves on wear and tear on the PC board traces if you are like me and change things around a lot!

Documentation is not in the old Heathkit style, but is more than adequate if you have built any kits before. Schematic, layout, and parts list are provided. General instructions on assembly are also included. They are not step by step, but rather a list of general instructions, i.e., solder resistors R1-15, solder TR1-3, etc.

The instructions for winding the toroids are the best I have seen in any kit. In addition to the number of turns, length and size of wire, etc, Sheldon describes how to make the bifilar and trifilar transformers that are becoming quite common now. The written description and the diagrams make it hard to do incorrectly.

Alignment instructions are included for each board, including current and voltage levels. He even includes things to check if the readings are not where they should be. No special equipment (counter/oscilloscope) is needed for alignment.

The weak spot in the documentation is on the interconnection of the modules. I feel this is because so many of the Hands Kits are modules, and he expects the builder to know what needs to be connected to each module. The interconnections are all clearly marked on the layout, schematic, and the PC board, but an overall block diagram is not included and would have been very helpful. I intend to have an interconnection diagram and instruction prepared before this is published and will include it with any kits shipped in the US.

Coming Enhancements

Sheldon is always improving his line of kits. I sent him a first draft of this article and asked for comments - he responded by saying that a new electronic (solid state) T/R switching setup will be available soon. Currently it is done by relays. He also mentioned a PLL system to improve the vfo that is currently being used. Stay Tuned....

Operation:

I wish I could say that I fired the RTZ up, called CQ, and had a pile of Europeans come back to me. However - I do not have a 6 meter antenna in the air, so all I was able to do was to check the operation with my test equipment. As has been the case with all the Hands kits I have built, it worked the first time I turned it on and operated as advertized. Perhaps by the time this is published I will have gotten an antenna in the air. Six meters is a band I have never spent any time on - the RTZ looks like a good way to get started!

Availability

All Hands kits are available in the US through:

Kanga US
Bill Kelsey
3521 Spring Lake Dr.
Findlay, OH 45840
419-423-4604
kanga@bright.net
http://qrp.cc.nd.edu/kanga/

A catalog is available for a dollar or an SASE with two units of postage.

A complete 6 meter RTZ transceiver including the new IF board with filter, LO crystals, RF board, VFO with variable capacitor, and LPF board is available for $290 plus $4.50 S/H. Units are still available with the original IF board at a special price of $250 plus $4.50 S/H. The original IF board does not include the CW carrier oscillator and the extra passive audio filtering; and the final audio amplifier on the old IF board is not as robust as the new board.

A case kit (punched cabinet, mounting hardware, connectors, knobs, etc) is available for $60 plus $4.50 S/H.

73 - Bill Kelsey - N8ET
Kanga US
kanga@bright.net
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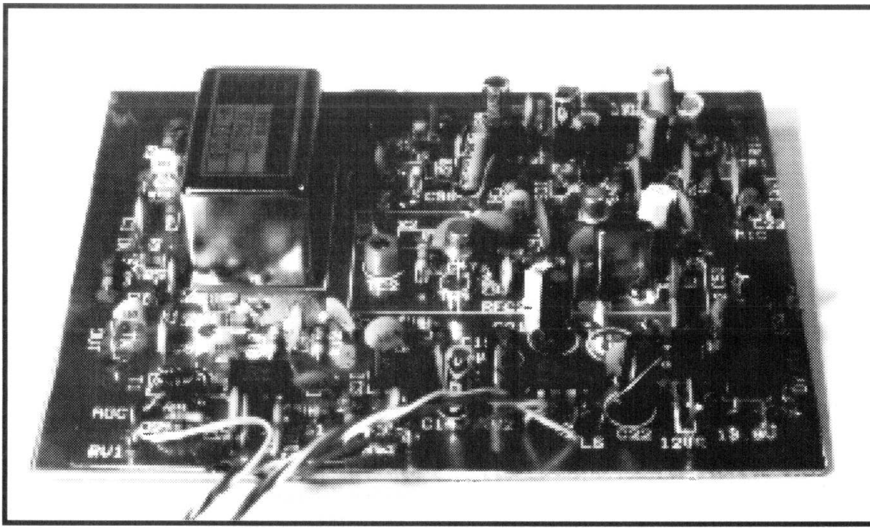
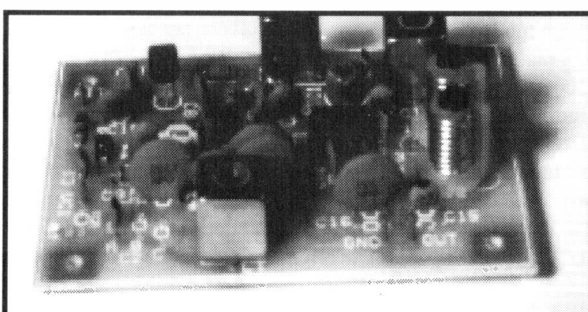
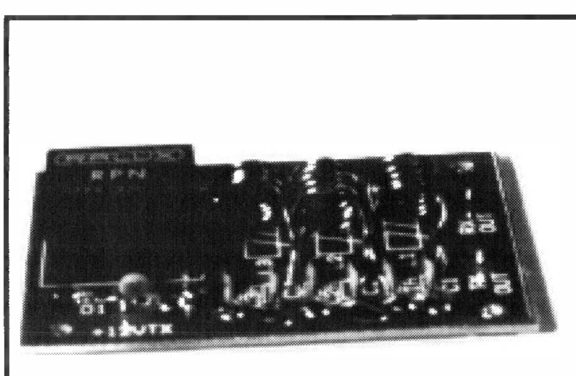
http://qrp.cc.nd.edu/kanga/

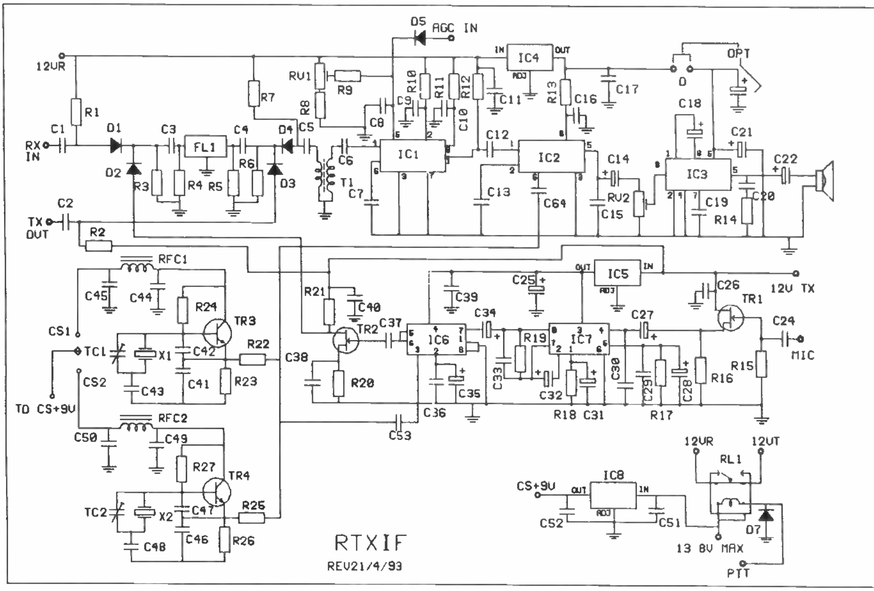


RTX/ I.F. Transceiver: SSB I.F. Strip



Left:
RTX-VFO VHF/MX:
VHF Mixer, 41 MHz.
Below:
LPF RTX/RTZ:
6 Mtr Low Pass
Filter/Antenna Relay





(All other schematics will appear in Spring '96 Hambrew.)

Parts List RTXIF

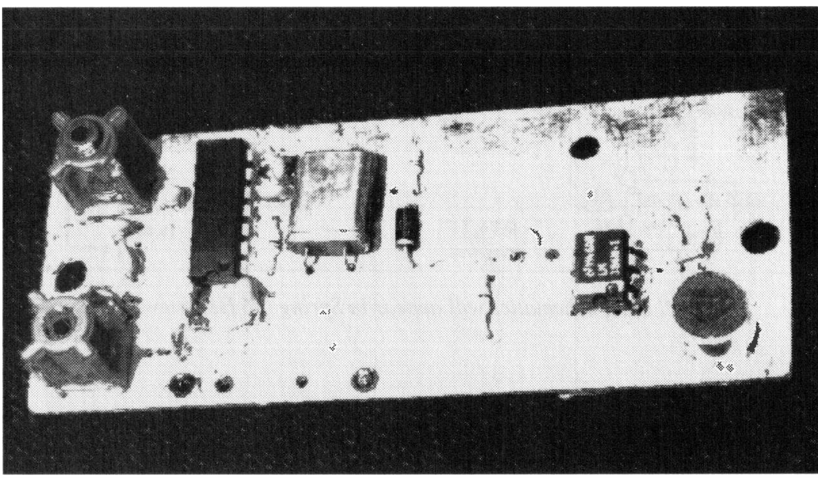
R1,2,3,6,7,	10K
R4,5,21,23,26	470R
R10,11,12 13,20	100R
R8 ,19	4k7
R9	27k
R14	5R6
R15,17	47K
R16,22,25	1K
R18	1M
R24,27	220K
RV1	4K7
RV2	10K
C7,8,9, 10,11,16,	
17,20,24,26,36 39,45,50,51,52	100N [104]
C12	100P [101J]
C1,2,3,4,5,6,13,15,33	
37,38,40 53,54	10N [103]
C14,34	1MFD 16V
C18	10MFD 16V
C19	Not used
C21,22	100MFD 16V
C23	470P [N470]

C25,31	47MFD 16V
C27,28,32	2.2MFD 16V
C29,30,44,49	1N [1O2]
C35	4.7MFD 16V
C41,42,47,46	150P
C43,48	27P
TC1,2	30P MURETA [GREEN]
IC1	MC1350P
IC2	NE602A
IC3	LM386
IC4	7806
IC5	78L06
IC6	SL1640
IC7	SL6270
IC8	78L08
TR1	2N3819
TR2	J310
TR3,4	2N2222
D1-4	BA244
D5,6,7	1N4148
RFC1,2	1mh 7BS [102J]
RL1	OUC [blue]
T1	K37X830 [6.3MM dia]

A Minimalist's FM Transmitter

Lew Smith, N7KSB

4176 N. Soldier Trail
Tucson AZ 85749



Circuit Board: Major components (left to right) are coils, 74AC04, Crystal, 1N4001 Diode, LM386 and microphone. This board was assembled with C1 and C12 on the "circuit" side.

If you are looking for a truly simple homebrew phone project, consider the minimalist's handheld 2 meter FM rig. It is a transmitter that can be built and put on the air in one weekend.

Circuit

The circuit consists of an LM386 audio amplifier, a varactor diode modulator, a 29 MHz crystal oscillator, and a quintipler (5X harmonic multiplier). The 2 meter output is 2 milliwatts.

The oscillator/quintipler is similar to a circuit described by Rick Campbell[1]. His circuit also included an unusually simple 40 milliwatt final amplifier.

Crystal

A fundamental mode (overtone types are not suitable) crystal ground for 1/5 the output frequency is required. I used a 29,548 kHz crystal to obtain the 147.74 MHz input frequency of the local 147.14 repeater. The crystal should be specified with a 6 pf parallel load capacitance. A 25 (or preferably 10) PPM tolerance is recommended. An HC-49 holder with wire leads was used.

Construction

A circuit board was fabricated by drilling and countersinking holes on a single-sided 1 1/2 by 3 3/4 inch piece of printed circuit board material. No etching is required.

As shown in figure 2, the copper foil is used as a top side ground plane. Component leads marked "X" on the component layout are bent and soldered to the top side ground plane. Leads marked "0" are fed through countersunk holes. Most bottom-side connections can be made by bending over and soldering nearby component leads. Longer bottom-side runs

N7KSB Minimalist's FM Transmitter

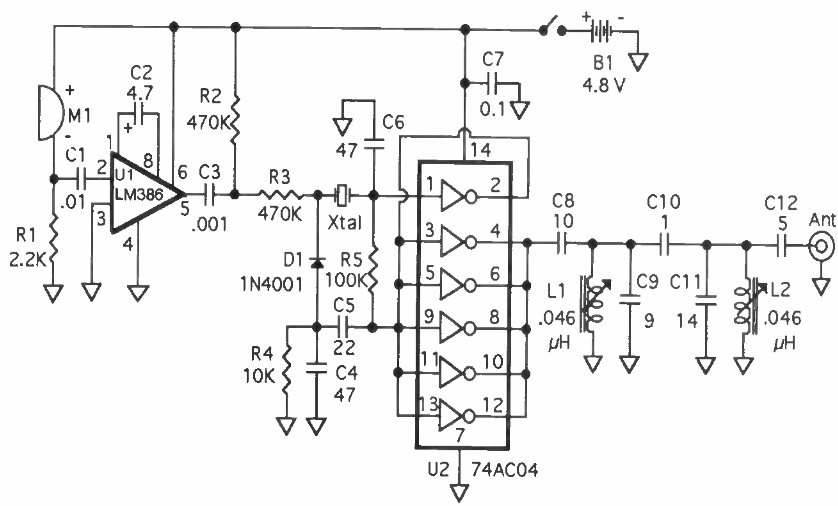


Figure 1: Circuit Diagram

and some IC connections are best made with #28 bare wire.

Since the holes are on a 0.1 inch grid, a piece of perfboard can be used as a drill guide. This will make drilling much easier and faster.

The metal housing of the microphone is connected to the junction of C1 and R1. The microphone housing and also the metal case of the crystal should be insulated from the ground plane. Two pieces of printed circuit board material can be glued to the ground plane foil for this purpose. Alternatively, the copper foil can be removed from the area under these components.

The transmitter was mounted in a 4 x 2 1/8 x 1 5/8 inch aluminum box. The four NiCd batteries were contained in a four-cell holder mounted on the outside of the box.

<u>Checkout</u>

After double checking the wiring, measure the supply current. It should be in the neighborhood of 30 milliamps.

Next listen for the signal on 2 meters. If the frequency is too high, add one or more 1N4148 diodes in parallel with the 1N4001. Each added 1N4148 will drop the frequency by about 2 1/2 kHz. If the frequency is too low, remove the 1N4001 and add up to seven 1N4148 diodes. Although holes can be drilled for inserting the extra 1N4148 diodes on the component side of the board, I found it easier to tack-solder these diodes on the bottom side.

Next, tune the two output coils for maximum output using an RF voltmeter. The simple RF voltmeter shown in figure 3 is adequate even though it is not very accurate on 2 meters - Output should be roughly 0.3 volts RMS across 50 Ohms corresponding to 2 milliwatts of RF.

The tuning slugs only allow for a ±10% inductance change. If you find that you are running out of adjustment range, you may have to add or subtract 1 pf from C9 and/or C11.

Before connecting an antenna, check the

N7KSB Minimalist's FM Transmitter

B1—four NiCd AA size cells in series
C1—.01 mf ceramic
C2—4.7 mf electrolytic
C3— .001 mf ceramic
C4 , C6—47 pf ceramic
C5—22 pf ceramic
C7—.1 mf monolythic ceramic
C8—10 pf ceramic
C9—9 pf ceramic (8 and 1 pf in parallel can be used)
C10—1 pf ceramic*
C11—14 pf ceramic * (12 and 2pf in parallel can be used)
C12—5 pf ceramic *

Note: The 1 through 22 pf capacitors can be found in a Radio Shack "Picofarad 50-Pack" Radio Shack part # 272-806

D1—1N4001 rectifier diode used as a 10 pf varactor diode—1N4148 diodes may have to be added in parallel—see text
L1, L2—.046 uh adjustable inductor, Toko MC120 series, Digikey part TK 2715-ND, Digikey telephone: 1-800-DIGI-KEY
M1—Electret microphone, Radio Shack part # 270-090
R1—2.2K
R2, R3—470 K
R4—10 K
R5—100 K
U1—LM386 audio amplifier IC
U2—74AC04 hex inverter IC, Digikey, Digikey telephone: 1-800-DIGI-KEY
XTAL—29,xxx kHz fundamental mode crystal—See text—Jan Crystal, telephone: 1-800-JAN-XTAL

audio quality and volume on a nearby receiver.

Results

My first request for a "radio check" was answered by a station 114 miles away. I was 3/10 mile from the repeater and was using a 1/2 wave antenna. My signal was not quite on frequency and the repeater distorted my audio. Later, after readjusting the frequency, good audio reports were obtained.

Although the 147.14 repeater could be keyed up when I was 4 1/2 miles away, contacts were possible when the distance was 2 miles or less. Between 2 miles and 1/2 mile, the repeater operated in its rather strange "no scratchy signals" mode. This particular repeater retransmits weak signals with the scratchy audio attenuated by about 40 db. Contacts are marginal when the repeater is in its "no scratchy signals" mode. Solid contacts were made at distances of 1/2 mile or less.

Conclusion

If you want to operate with an indoor antenna, QRP may not be a good choice. However, if you like to hike the mountaintops where the repeaters are located, QRP can be a lot of fun. If your tastes require more power, consider adding the simple 40 milliwatt amplifier used in Campbell's circuit.

Reference

1. R. Campbell, Single-Conversion Microwave SSB/CW Transceivers, *QST*, May 1993, page 31, figure 5

Additional figures and information, next page

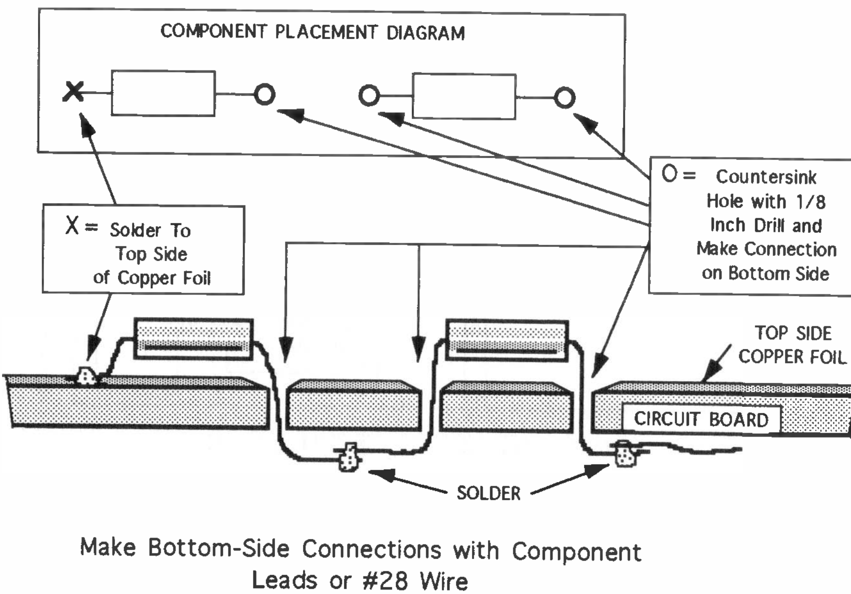


Figure 2: Etchless Circuit Board

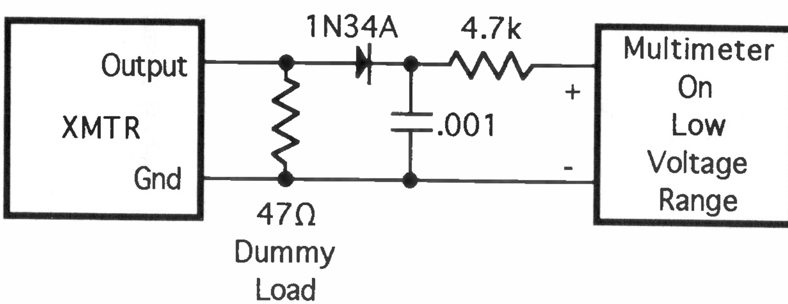
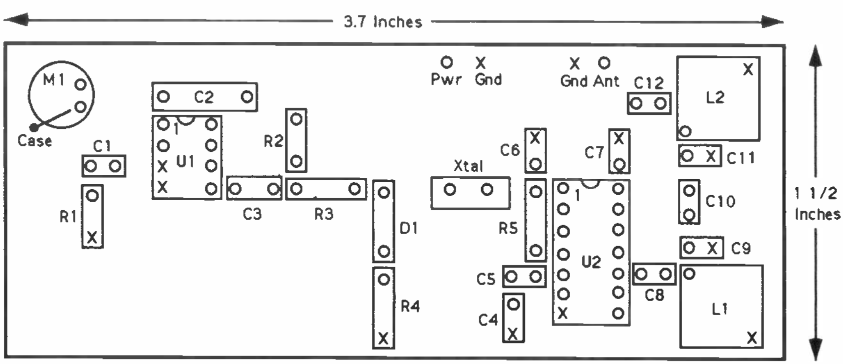
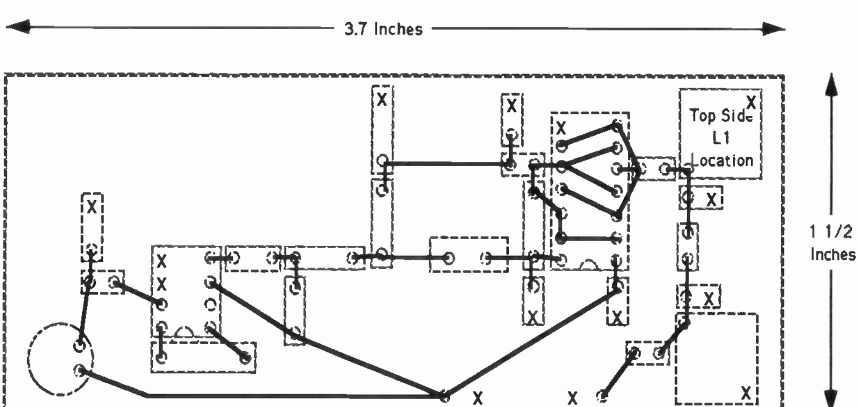


Figure 3: Dummy Load / RF Voltmeter



COMPONENT SIDE OF CIRCUIT BOARD

O = Countersunk Hole
X = Top Side Connection To Ground Plane



BOTTOM SIDE WIRING

QRP TO THE FIELD
SATURDAY, APRIL 27, 1996

GET READY FOR JUNE FIELD DAY, BY TESTING EQUIPMENT ON THE **"QRP TO THE FIELD"**- OPEN TO ALL RADIO AMATEURS USING ALL BANDS AND BOTH MODES (SSB/FM & CW). SPONSORED BY THE NORTHERN CALIFORNIA QRP CLUB. SINGLE TRANSMITTER ON THE AIR AT ONE TIME. ONCE STARTED, USE THE SAME POWER OUTPUT AND LOCATION CATEGORIES.

CONTEST PERIOD: SATURDAY - 1300 UTC TO SUNDAY 0100 UTC - (SATURDAY, 6 A.M. TO SATURDAY, 6 P.M. PDT) MARK LOGS TO INDICATE YOUR BEST (8) CONTINUOUS HOURS FOR SCORING

EXCHANGE: SIGNAL REPORT & STATE, PROVINCE, OR COUNTRY

QSO POINTS : 1 WATT OUT OR LESS - 10 POINTS (EITHER MODE)
5 WATTS OUT OR LESS - 5 POINTS (EITHER MODE)
OVER 5 WATTS -2 POINTS (EITHER MODE)

MULTIPLIERS **FIELD LOCATION** - 4.0 x MULTIPLIER (FIELD = BATTERY POWER &. TEMPORARY ANTENNAS)

HOME LOCATION - 2.0 x MULTIPLIER (HOME = COMMERCIAL POWER & PERMANENT ANTENNAS

HOME BREW EQUIPMENT - 3 x MULTIPLIER (IF YOU BUILT IT, IT IS CONSIDERED HOMEBREW)

COMMERCIAL EQUIPMENT - 2 x MULTIPLIER

FINAL SCORE :
BAND/MODE QSO POINTS x LOCATION MULT. x EQUIP. MULT.= BAND/MODE TOTAL ADD THE BAND/MODE TOTALS FOR THE FINAL SCORE

EXAMPLE:
(20) 20M/SSB QSO'S x 5(5W.) x 4(FIELD) x 2(COMM.) = 800 POINTS
(35) 40M/CW QSO'S x 5(5W.) x 4(FIELD) x 3(H.B.) = 2100 POINTS
FINAL SCORE = 2900 POINTS

SUGGESTED FREQUENCIES: 1.810, 3.560, 3.710, 3.865, 7.040, 7.110, 7.285, 10.120, 14.060, 14.285, 21.060, 21.110, 21.260, 28.060, 28.360, 50.060, 50.128, 51.700, 144.050, 144.200, 146.520

AWARDS "TOP TEN" SCORES CERTIFICATE (THE TEN STATIONS WITH THE HIGHEST POINT TOTALS)
PARTICIPANT CERTIFICATE FOR 20 OR MORE CONTACTS
(INCLUDE A 9x12 MANILA ENVELOPE WITH 3 UNITS OF POSTAGE)

SEND LOGS, WITH STATION AND LOCATION DESCRIPTIONS
TO: BOB FARNWORTH - WU7F
6822 131 AVE SE
BELLEVUE, WA 98006

GET THEM IN BY MAY 31st, 96. ALL CONTEST COMMITTEE DECISIONS ARE FINAL. INCLUDE A #10 SASE IF YOU WANT THE RESULTS. THE RESULTS WILL ALSO BE PRINTED IN THE NORCAL JOURNAL *QRPp*.

Simple DSB & CW Transceiver for 80 Metres

Robert van der Zaal, PA3BHK

Parklaan 89, 2171 Ed Sassenheim, The Netherlands

It must have been in 1972 when I first met Ham Radio. In our secondary school we had a station allowing pupils to practice their foreign languages. With England right across the Northsea and France and Germany nearby 80 was the most appropriate band. After the first few QSO's on 80, supervised by the responsible operator (a licensed biology teacher), a new ham was born! Soon I was an active SWL at home. And came my interest in Direct Conversion. Still being a schoolboy the first ideas came to use a similar principle to build a DSB transmitter or even a simple transceiver. In '82 I started using DSB on 144 MHz and in '85, after being inspired by a design by G3WPO, the first contacts were made with the rig I describe in this article.

The Radio

The heart of the radio is a VFO from 3.5 to 3.8 MHz so it covers the entire Region I allocation. Its output of about 10 mW drives a diode ringmixer. When the rig was built I was a student and could not afford custom made diode mixers. So I used a pair of two hole cores (called "pignoses" in The Netherlands) and four 1N4148 diodes (replaced by HP2800 later) to make the mixer myself. The mixer is used in both ways so is the lowpass filter with a cut off frequency of about 2.2 kHz. This might seem a bit narrow but it limits the total bandwith of the DSB- signal and the receiver to about 5 kHz. The 10 mH coils are custom made by eg. Toko or Neosid and look like small electrolytic capacitors. With a 1N4148 used as a capacitive diode an offset of about 800 Hz is introduced in the VFO frequency while transmifting CW. Of course this can be modified to make a RIT-control or clarifier.

To modulate I use a microphone pre-amplifier as designed for a small FM transmitter. The preemphasis makes the audio sound very clear and "flat-topping" of the audio forms a simple clipper. The DC value of the collector of the BC548 should be adjusted to 3.4 V. The op-amp functions as a signal follower with a low output-impedance driving the modulator. With a carrier suppression of at least 40 dB, after some fiddling with the trimmer in the mixer optimised to 60 dB, my DSB signal always got excellent reports. CW is made by "modulating" the mixer with a DC-current. With the CW- offset and a carrier suppression that can be adjusted to about 50 ciB this is a very effective way of making CW. Transistor switches are used to drive various stages so the rig can be operated "semi break-in". The power amplifier was designed by G3WPO ("A low cost DSB/CW transceiver for 80m", *Ham Radio Today*, March 1983). A BC548 (or any other universal NPN) is used as a voltage amplifier that drives a VN66AF, a power fet. The output of the PA will be around 3 Waft. More than enough for comfortable CW QSO's up to over 1000 Miles and usually enough for a local phone QSO. The bandpass filter is used bi- directionally and gives a harmonic suppression of at least 40 dB. Possibly a low pass filter will function just as well. The two anti-parallel diodes protect the rig from statics.

The amplifier used for receiving is another design by G3WPO (same article). The double potentiometer (a linear one!) not only reduces the output of the pre-amplifier but also its gain. Hence strong local stations become less likely to overload the pre-amp. Thc CW filter is extremely simple yet very effective. G3RJV showed it in *SPRAT* quite a number of years ago. One of my friends was much impressed by the filter and started modif\ring all his radios! The high- gain amplifier could start oscillating, or should I say squeaking? Careful decoupling of supply- voltage, use of shielded DC leads and careful placing of the loudspeaker cured my radio.

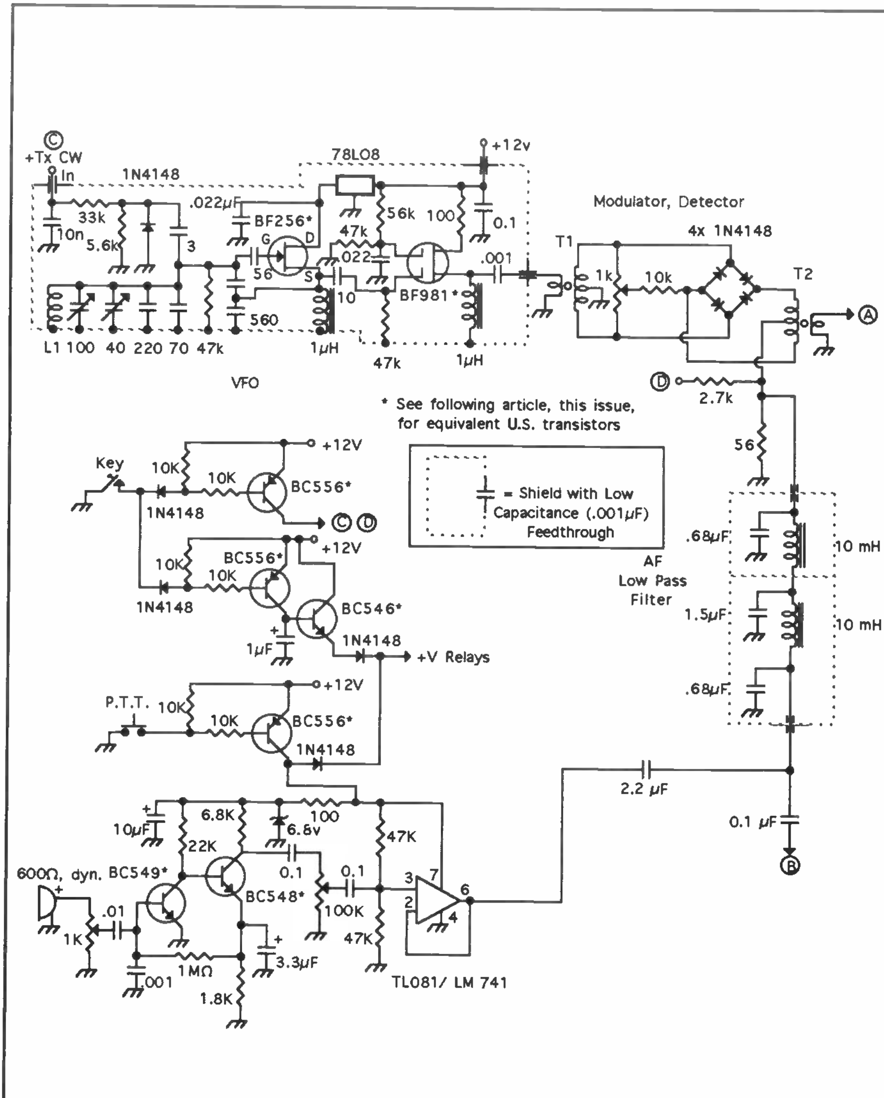
Hardware

I built most of the rig on pieces of PCB in which I cut small "islands" and tracks. As my home brew rigs are not meant for mass-production I don't bother about designing a circuit board and prefer to stick to methods like this one and "Solder Where It's NEeded" (SWINE) Fortunately in my student years I had access to one of the University workshops and to cheap sheets of all kinds of metal. I used aluminium to make the box and thanks to the facilities available in those years it looks quite professional. Although I'm glad that these years are "past perfect" there are still a few things that I miss!

Results and Further Remarks

During my last years at University I enjoyed operating the radio very much. With a coaxial fed half-wave dipole with its centre hoisted up to about 42 ft above groundlevel (with a pulley under the rotator that turned my 2m yagi) I worked all over Europe, both in CW and DSB. Reports were as to be expected from QRP in a good aerial: usually not strong but sufficient for good QSO's. Even now I sometimes use this radio rather than my US or JA blackboxes and always feel a certain pride after a good contact. I have never built in a sidetone, I never really needed one as I used the rig with a "handpump" only. But a simple AF oscillator could bring even more luxury to the rig.

The basic concept can be used for all HF bands. Of course, on higher bands a pre-amp is needed and extra care should be taken to obtain acceptable frequency stability. Also a multibander can be built. li is even possible to make a similar rig for our VHF bands. I have experimented using a 144 MHz crystal controlled driver to drive the "universal" part of the rig consisting of the mixer and the AF-stages. With the HF end of the mixer connected to a 9 el. yagi a contact was made over about a mile confirming the possibility to make a similar radio for VHF. However, with the enormous difference in signal strenghts usually received on VHF- bands a simple AGC circuit in the receiver might be considered a necessity rather than a luxury Also a VIIF receiver needs a low-noise RF pre-amp. As you see, similar circuits have a wide range of applications. I am looking forward to see more about simple rigs alike!

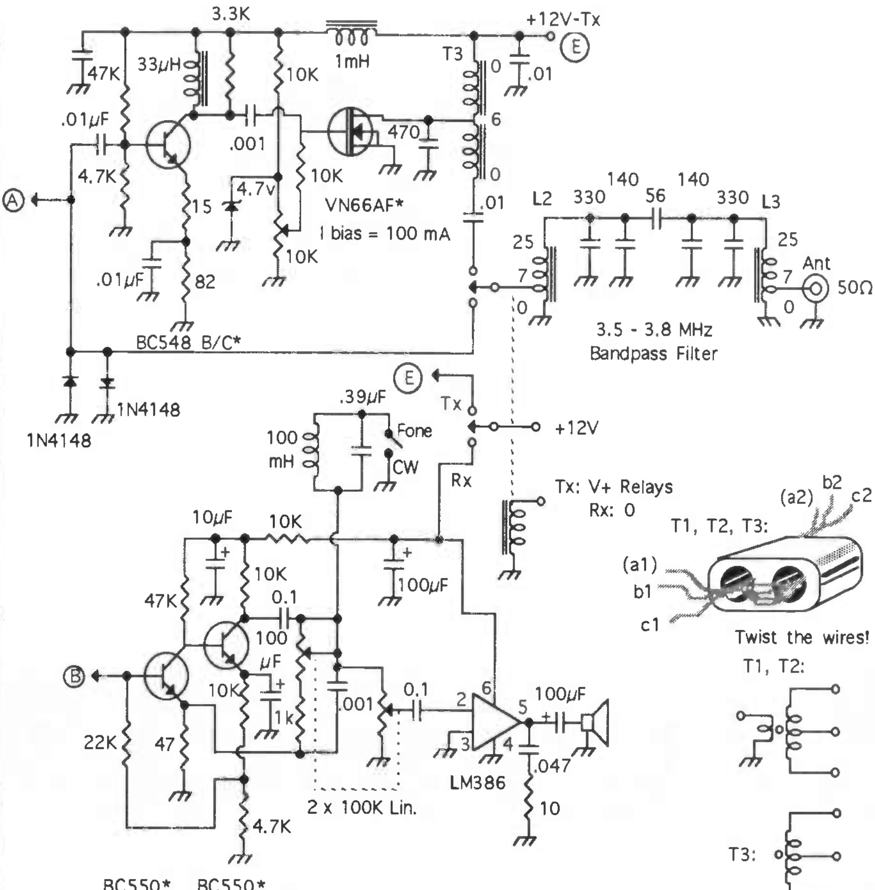


Notes:

The NPNs and PNPs used are mainly universal ones in plastic cases (TO92), but for the mic-preamp (BC549) and audio preamp (2xBC550), I used low-noise transistors. The power FET is known in the ARRL Handbook, but experimenters might try an IRF510.

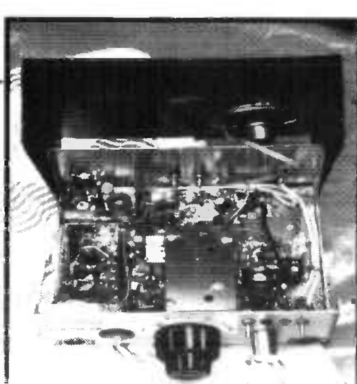
"CuL": just the way I've seen enamelled wire being described through the years...just use the nearest SWG...insulated wire is a must, especially in the transformers.

MKM-capacitors refer to a construction used mainly by Siemens. the caps are small blocks of multi-layered metal and insulation and indeed are low-drift devices. Not really suitable for RF but excellent for AF purposes.



Rx - AF Amp.

L1:	38 turns., 0.3 mm CuL, 05 mm
L2, L3	0.5 mm CuL, T68-2
T1, T2:	10 Trifilar turns, 0.3 mm CuLs
T3:	6 Bifilar turns, 0.5 mm CuLs



U.S. Equivalents for European Transistors : PA3BHK Transceiver

Dave Fifield, KE6ZBZ

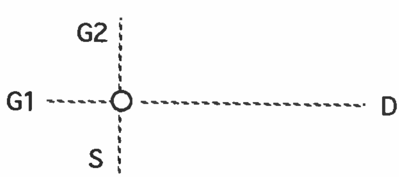
1717 Andover Lane
San Jose, CA 95124-4744

BF256
*****

Small signal JFET, TO92 package,
Spec. is: +/-Vdss = 30V, Idss = 3-7mA (BF256A) 6-13mA (BF256B) 11-18mA (BF256C), Crs @ 0V = 0.7pF (typ.)
Can't find a direct US equiv. but I'm sure any good quality GP JFET would do just fine (MPF102, 2N5457, U310, 2N3819 whatever)....check pinout!

BF981
*****

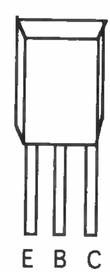
Philips makes this, and it should be available in the USA. I have used 3SK88 as a replacement for this myself at 144MHz. Dual Gate MOSFET, SOT103 package:



Spec is: Vds = 20V, Idss = 4-25mA, -V(p)g1-s = 2.5V max, yfs = 14mA/V typ., Noise Figure = 1.0dB and Gain Product = 26dB at 200MHz, Crs = 25pF typ.

BC548, BC548A/B/C
****

NPN, TO92 package, USA equiv is 2N5818
Spec. is: Vcb max = 30V, Vce max = 30V, Veb max = 6V, Ic max = 100mA, Tj max = 150 degC, Ptot = 500mW, Ft min = 200MHz, Cob max = 4.5pF, hfe = 110 min (BC548, BC548A), 200 min (BC548B), 420 min (BC548C), hfe bias = 2mA.



BC546
*****

NPN TO92, USA equiv. = 2N5818, same pin out as BC548 Specs are: 80V, 65V, 6V, 100mA, 150degC, 500mW, 200MHz, 4.5pF, 125min, 2mA.

BC556
*****

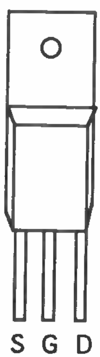
PNP TO92, USA equiv. = 2N6015, same pin out as BC548 Specs are: 80V, 65V, 5V, 100mA, 150degC, 500mW, 150MHz, 8pF, 75/450, 2mA.

BC526
*****

PNP TO92, USA equiv. = 2N5401, same pin out as BC548 Specs are: 60V, 50V, 6V, 200mA, 150degC, 625mW, 200MHz, 5pF, 60min, 2mA.

BC549
*****
NPN TO92, USA equiv. = 2N5818, same pin out as BC548 Specs are: 30V, 30V, 6V, 100mA, 150degC, 500mW, 200MHz, 4.5pF, 110min, 2mA.

BC550
*****
NPN TO92, USA equiv. = 2N5818, same pin out as BC548 Specs are: 50V, 45V, 5V, 100mA, 150degC, 500mW, 200MHz, -, 240min, 2mA.

VN66AF
******


Siliconix VHF N-Channel V-MOSFET, TO220 Package

No equiv. given, but I understand that Siliconix sells these in the USA. Specs are: Ptot = 12.5W max, Vds max = 60V, Vdg max = 60V, Vgs max = 15V, Gate thres. = 0.8V min - 2.0V max, Igss = 10uA max, Idss = 10uA max, Cin max = 50pF, forward transconductance = 250mS, Id max = 2A, freq. max = 600MHz.

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The Home-brewer
by Wayne Burdick, N6KR

The old home-brewer and his wife were dining late one night
When suddenly she noticed that he'd frozen in mid-bite
His face was stuck in neutral and no protest would dislodge it
But his brain was working overtime...on an idea...for a Project

She'd seen this look before—she knew just what it foretold:
Weekend projects 'round the house indefinitely on hold
Instead of painting, patching cracks, lawn-mowing and weed-whacking
There'd be tinkering, and soldering, and several kinds of hacking

Her suspicion was confirmed when he arose before the dawn
(Then later there were little clues to what was going on, like
The chewed-up wad of wire and tape the cat left in the bathroom
And the sound electronic parts made as they were sucked up by the vacuum)

What thing would he invent? This is the home-brew paradox:
The question's not "What do I need?" but "What fits in this box?"
He thought up something quite unique—they'd pay to own the rights!
(But to the untrained eye it was just switches, knobs and lights)

Now, a true home-brewer knows a special kind of E-lectronics
A multi-decade self-paced course a bit like "Hooked on Phonics"
One learns that quantum physics works on big things—like resistors
And how repeated contact with real hot ones might cause blisters

So it didn't take him long to wire-up a dozen chips
With the help of Elmer's glue and ancient alligator clips
(Sure—some amplifiers oscillate, and some oscillators don't
But you tweak things till they all behave and toss the things that won't)

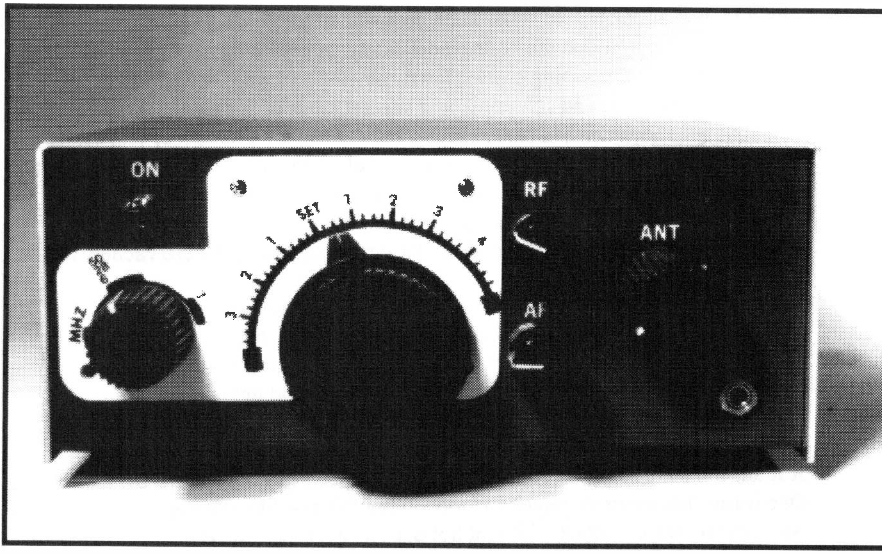
The parts must fit inside the box, and at this he was no klutz
(With one hand he can fix your watch, while the other torques lug-nuts)
He used mixed screws—6-32, 4-40—what the heck?
This was a prototype device—it need not be Mil-spec

A mix of pride and fear did then well up inside his chest
He cleared a spot upon the bench to perform the ol' Smoke Test
Before he turned the power on he prayed the home-brew prayer:
"Dear Lord, don't let this one explode; you know I've had my share!"

After all the tests were done, the old home-brewer smiled
He'd done this kind of engineering even as a child
Yes, he missed five football games; and sure, the back yard looked like hell
But just think of all the glory that he'd have at Show and Tell!

A Receiver for 6, 10 and 40 Meters

G. De Grazio, WFØK



Due to the use of existing variable capacitors and a mounting flange in the "junque" box, the front panel ended up squished to the left, leaving the bandspread tuning (large knob) a tad bit constricted. Not bad enough to change, however.

While building a Ten Tec 6 meter receive converter for a kit review last fall of 1994, I noticed that the 22 MHz oscillator scheme should work also for a conversion to 6 MHz from 28 MHz. If a stock Neophyte receiver circuit could be tuned to 6 MHz from 7 MHz, a stable 10 meter receiver could result. Naturally, considering that the 6 meter converter combined with 28 MHz for the VHF conversion, two converters chained into the modified Neophyte would yield a two-band receiver which would receive both 10 and 6 meters.

Shortly thereafter, I received a Kanga 6 meter converter from Bill Kelsey, N8ET. I liked the fact that the Kanga version (also a 22 MHz oscillator) had more physically substantial slug-tuned coils than the Ten Tec (though the Ten Tec kit would doubtless work for this purpose also). The Kanga "cans" are built like the 10.7 MHz I.F. coils available from Mouser in the U.S.

The first task at hand was to see if the Neophyte could tune down to 6 MHz without major modifications. After building a Neophyte from a home-etched board[1], I tried removing the limiting capacitor C10 to provide a greater range for the main tuning. By substituting an available air-variable for the front end tuning, reaching 6 MHz was indeed possible. This was confirmed with an RF signal generator. An added dividend: the main tuning also reaches up to 7.080 MHz. Hmm, now this could be a three band ham receiver with bonus limited general-coverage access to the international short wave broadcasts between 6 and 7 MHz.

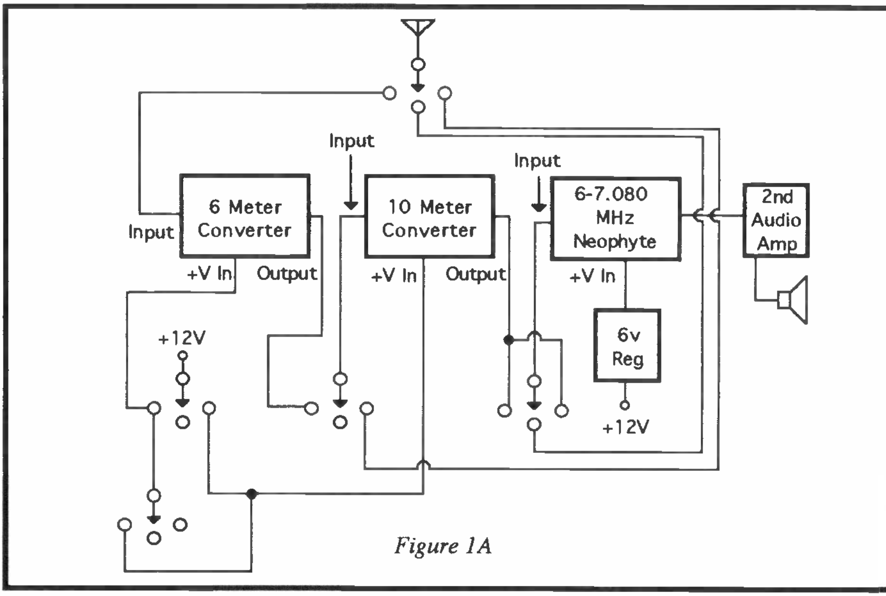


Figure 1A

But what of the 10 meter converter? The stock Kanga 6 meter kit had a front end tuned for 50 MHz. Using the existing board configuration of holes for the Kanga front end transformer (T1 on the Kanga schematic), a toroidal transformer of 2 turns primary, 11 turns secondary tapped 2 turns from the ground end of the secondary was substituted (Amidon toroid T37-6, #24 enameled wire).

Kanga provides a 2-22pF variable board-mounted capacitor in parallel to T1. This was replaced with a 7-70pF variable. The holes for the capacitor needed to be enlarged carefully with an "Exacto®" knife for a good fit to the new variable cap. These were the only mods needed.

A second Kanga converter was built stock for the 6m section, completing the three board scheme.

Having an RF signal generator is the main key to easy alignment of this receiver project. Without this aid, proper alignment will be hit or miss, unless a signal is found on a general coverage receiver near the 6 MHz mark for comparison to the signal on the basic Neophyte, in addition to signals on the 6 and 10 meter band.

Switching the two converters in and out of the circuit is also a problem to be solved. It would not be desirable to have the converters oscillating while they are not needed, so a system is needed to switch input and output of the two converters, input of the Neophyte section, and power on/off to the converters.

A hamfest provided the switch needed for the solution. The diagram above (1A) shows the configuration, and I do not know if it is widely available, but suffice it to say that the above switching criteria must be met to satisfy a 4 band result. For a two band receiver (6 and 10 meters), a standard Radio Shack non-shorting rotary switch will suffice as shown in figure 1B.

This receiver is not without some compromises in performance. Strong broadcast band international stations can be heard on top of the signals while receiving during the evening hours (the Neophyte is a direct conversion receiver after all). They can be nulled sufficiently by use of a noise antenna.[2] Also, a receive preamp may be desirable in front of the 6 meter converter.

However, as the cost of the Kanga kits is approximately $23 each[3], and the cost of the Neophyte is minimal for parts and board, the resulting receiver (*Continued pg. 29, bottom*)

Deep Six

Fred Bonavita, W5QJM

PO Box 2764
San Antonio, Texas 78299

Eye on 50 MHz

Some interesting developments this quarter:

NPJ has discovered 6 meters: Add MFJ to the list of manufacturers turning out 6-meter gear these days. The company has introduced an ssb "Adventure Radio" in an apparent bid to attract the no-code Technicians to the band.

The first ads for this transceiver boast a 10-Watt PEP output, a superhet receiver and a built-in low-pass filter to battle TVI. It's packaged in the same size box as the comapny's 94XX series of QRP transceivers for HF.

Unfortunately, MFJ made CW an after-thought by charging $40 for a plug-in mdoule as it did for its 20-meter ssb QRP rig. The new rig tunes only 50 to 50.3 MHz. Other 6m accessories include a special microphone, power supplies, antennas and a pair of antenna tuners.

The basic transceiver is $250, but depending on the number of optional extras one buys, the tab can run as much as $550 for the package. That ought to bring down the asking price of many used 6m rigs and perhaps persuade the folks at Yeacomwood to price their products more realistically.

While the $250 is attractive at first blush, it's still more than twice the cost of Ten-Tec's 6m transverter at $95 in kit form or $159 wired and tested for the same power out.

Speaking of TVI: Low-pass filters to keep TVI and RFI problems from ruining operations on 6m are a must in most metropolitan areas, and a little company near Austin, Texas, has come to the a~d of the cause.

J.R. Adams, KB5MER, offers two models of TVI filters at very reasonable prices: $10 or $20, depending on the number of elements and the type of connectors (BNCs or SO-239s). I find J.R.'s $10 so-called "first filter" to be ideal for my purposes in a neighborhood bristling with tv antennas. The construction is a little crude, but the thing works. Above 55 NHz, the response curve drops like it has rocks tied to it. And for ten bucks, what can I say?

For more information, try him at J.R. Enterprises, Box 573, Leander, Texas 78641, phone 512-267-7385.

Sporadic E: In the mail after the first Deep Six appeared was a letter from Ken Neubeck, WB2AMU, author of "Six Meters," a primer on the band published by Worldradio and which was reviewed in passing in last issue of hb.

Ken took me to task for pointing out his book is void of articles on homebrewed 6m gear while playing up the new and used commercially made rigs and antennas.

While he does not deny that, Ken says,

"I can honestly say that at the time I put the book together, there were few homebrew six meter articles (QST, CQ, etc,) available. Believe me, I would have put a homebrew project or kit in the book if something was around."

Ken wrote most of his book in a five-hour plane flight between coasts and aimed it at no-code Technicians, who "may not necessarily be into homebrewing yet."

A second edition — sort of a Son of Six Meters I suggested — is in the offing, and Ken is looking for articles and suggestions for it.

Meanwhile, Ken has resurrected The Sporadic E, which he describes as "the premier Amateur Radio underground newsletter." The emphasis is on sporadic, however. Ken publishes it when the mood strikes — about twice a year. It ought to be of more than passing interest ror those who, like Ken, are "into" sporadic-E operations on 6m.

Even for the more casual 6m operator, there are some things to make it worth the $1 a year he asks. Send offers of articles for Son of Six Meters and/or a buck to subscribe to The Snoradic E to Ken at 1 Valley Road, Patachogue, New York 11772.

CQ VHF: That's the title of a new monthly magazine now published by our friends at ~ magazine, and it may be worth a trial, one-year subscription ($19.95).

Publisher Alan Dorhoffer, K2EEK, promises this one will explore "Ham Radio Above 50 MHz!" The first issue has yet to be seen as of this writing (mid-November), but Alan promises every issue will offer, among other things, technical articles and projects to build. I plan to hold Alan's feet to the fire on that, especially as it applies to 6m. The last thing we need is a whole magazine that perpetuates and expands the deadly dull monthly VHF columns in the Amateur Radio press. Remind ~ there is life beyond grid squares and EME!
More information may be had from the November 1995 issue of ~ or by writing CQ VHF, 76 North Broadway, Hicksville, New York 11801. Subscriptions may be sent to the same address, and be sure to stress the interest in 6m when writing.

That's it for this issue. If you have any items of 6m interest, send them to me at the above address. Thank you.

(Continued from page 27)

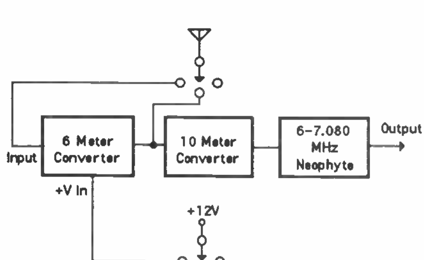


Figure 1B

is considerably less in cost than one of commercial manufacture. Its versatility is a real plus as well.

In this first version, the main tuning sets the band tuning (see photo), and a bandspread variable allows fine tuning. For 6 and 10 meters, the main tuning is set to or near 6 MHz, and the bandspread allows further exploration.

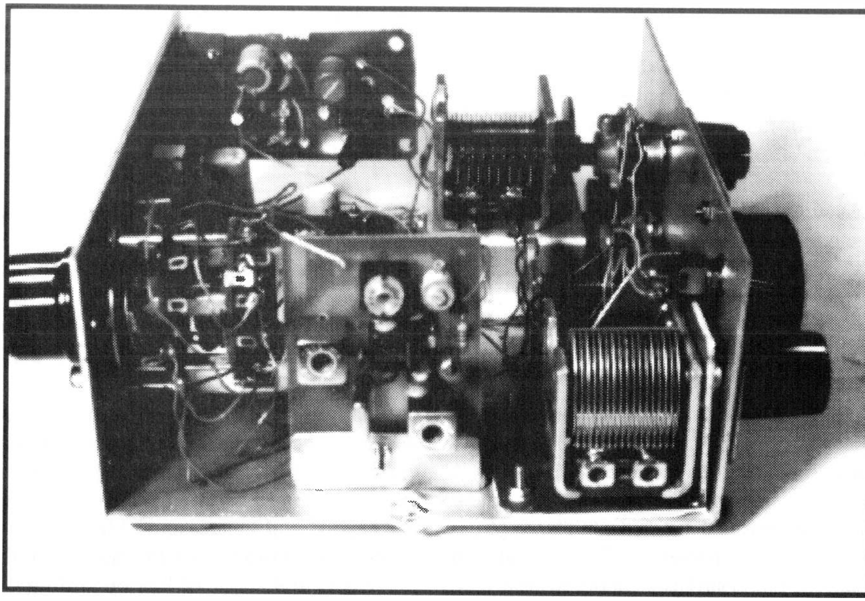
Footnotes:

1. Etched Neophyte boards are available from FAR Circuits, 18N640 Field Court, Dundee, IL 60118

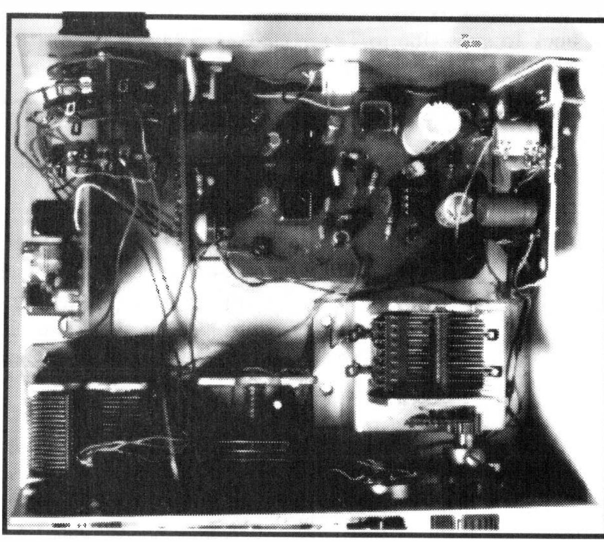
2. *Hambrew*, Autumn, '94

3. Available from Kanga U.S. See address, page9 , this issue.

More Photos, page 30



Interior of the Four-Bander. The receive converters are mounted upright to save space. A bracket designed to secure the vernier mechanism of a HW-7 is pressed into service to support a 12-66pF air variable used for the front end tuning of the 6MHz Neophyte. A physically smaller variable could certainly be used. The band / power switch is located on the rear panel to keep the leads short to the converters.



The upright board next to the right of theNeophyte board is a combination final audio amp and voltage regulating board. The Neophyte requires 6v, the converters and the final audio amp use 12v. A simple 6.1 volt zener diode regulator circuit does the trick for the Neophyte.

How to EASILY Test / Troubleshoot an Audio Circuit

By Bill Hickox, K5BDZ, Tejas Kits

No Audio Generator? Make your own simple 750 Hz Square Wave Sidetone Oscillator Circuit!

Why are we dealing with the audio section only? Three reasons:

1. No (or seldom any) variable tuned circuits in audio.
2. Most simple DC receivers homebrewed today are 95% audio circuitry.
3. Easiest sections of receiver to learn the basics of troubleshooting, which can later be expanded into other receiver circuitry with experience.

Testing an audio circuit in any receiver can and should be a simple task. You don't need an expensive $300 to $2,000 audio generator. For all you beginners and old pro's alike, here's how you can quickly build your own audio test oscillator and with it, learn to be the best audio technician, all for under $3.00 (or free if you have a small junkbox full of parts)!

First study the schematic diagram of the ~imple square wave audio oscillator shown in Figure 1. There are no secrets in this design, but there are a couple of additions you should be aware of. First, VRl is a trimpot or potentiometer to control the output amplitude of the oscillator. VRl will save your ears as it controls the test oscillator signal to keep from overpowering your audio section - and your ears - with its test tone. Ci is a coupling capacitor 1 voltage blocking capacitor that keeps the value of VRl from severely altering or interfering with both the voltage and I or audio frequency signal impedance of the circuit under test. Finally, the oscillator positive voltage (9 to 12 volts DC works well) should be connected through a switch or key in order to turn it on and off easily. These modifications also improve this circuit when installing it for its intended sidetone use in your rigs.

We have chosen to use a 750 Hz. audio signal because it falls in the passband of almost all receivers and narrow audio filters of all types, including AM, SSB, CW, and FM. To slightly alter the 750 Hz oscillator frequency, you may vary the values of R1 and R3 +1-5 K ohms, using either small trimpots or fixed resistors.

Before we go any further, let's not take anything for granted. Read and remember this!

> CAUTION: OBSERVE PROPER CAUTION IF THE RECEIVER OR TRANSCEIVER IS A TUBE TYPE OR OTHER DESIGN USING HIGH VOLTAGE IN ITS DESIGN OR OPERATION. THIS INCLUDES 110 VOLT AC CONNECTIONS.
>
> HIGH VOLTAGES CAN BE LETHAL

After you build the simple audio circuit in Figure 1, make and connect the simple test probe refer to Figure 3. Set VR1 to mid range. To test your newly built oscillator, use a known working audio circuit (in another receiver, etc.) and connect the grounded alligator clip of the test probe to a receiver ground point and touch the probe to the wiper (center terminal) of the receiver audio gain control. You should get a 750 Hz tone sound, and it may be loud. This will verify your test audio oscillator is working. Adjust VR1 to a comfortable listening level. Turn off your audio circuit and your test oscillator. Disconnect your test oscillator.

UNDERSTANDING THE BASIC TEST / TROUBLE SHOOTING PROCEDURE

Study Figure 2. At the risk of your boos and hisses, take your finger, place it on the product detector I detector box, and then move your finger to the right across all the test points and stop your finger when it reaches the speaker picture, then pick up your finger and stick it in your ear! That's the path the AF signal will take. Please note our sample circuit includes three stages of gain to amplify the very weak signal from the detector up to a signal sufficiently strong enough to drive a loud speaker to hearing level. These three stages of amplification are the 1st. Audio Amp, the 2nd Audio Amp, and the Audio PWR Amp (PA).

Working backwards from the speaker (which is the method we use to test and troubleshoot the system), the speaker has no circuit amplification. IC3 PWR Amp has one section of gain. IC2, the 2nd audio Audio Amp gain is added to the PWR Amp, making two sections of gain. IC1, the 1st Audio Amp is finally added making three sections of gain. The more sections of gain amplify the test signal, the louder the amplified test signal will be into the speaker. (The theoretical AF gain in our Figure 2 sample circuit is: 15 db in 1st audio amp + 15 db in second Audio Amp + 40 db in Audio PWR amp PA = 70 db total audio gain.)

For beginners and old pros alike, let's look at some of the important roles played by the "minor components" in the circuit in Figure 2. Capacitors "C" add no gain to the circuit. They are bypass to ground or coupling capacitors that, among other things, block voltage but allow RF / AF (Audio frequency) signals to pass. Yes. a capacitor can be "open" keeping signals from passing. That can very much cause your problem. A Bypass Capacitor can be shorted, taking the signal to ground thus stopping the signal flow. R is a resistor that could be used as a part of an RC filter, input impedance matching to a circuit, or other use. Yes a resistor can be "open". "shorted" or changed in value affecting signals passing. That can very much cause your problem. VR1 is the volume control, and it adds no gain to the circuit. Yes VR1 can be bad, keeping your signals from passing. Ql is a mute circuit, adds no gain, and only operates as a Off or On switch. If you ground TP9 (between the diode and Q1 gate) it "opens Q1, stopping the receive signal flow, which is like turning the circuit "off" at that point and not letting signals pass from IC2 to the main audio amp IC3. Yes, Ql can be bad (or have an accidentally grounded gate) and be "open", keeping the signals from passing. What does this tell you? If a component of *any type* is in the audio chain from the detector to the speaker, it is suspect. So test on either side of the component to insure signals are passing through it properly. If not, check for external wiring shorts, etc. and if none are found, replace the component.

Remember, we will be running our tests "backwards" from the signal flow, so start at TP1and work toward TP8.

Refer to the "arbitrary loudness" chart below as you touch the test probe to each test point shown in Figure 2. If no 750 Hz signal is heard at any one test point, it could indicate a problem in the circuit as will be discussed later.

Arbitrary Loudness Chart Procedure

Refer to Figure 2. For each test point TP2 through TP8 touched with the audio generator test probe, the loudness level should be greater than the audio level at TP1. The following chart *arbitrarily* rates the loudness level on a scale from 0 (min.), meaning no sound at the speaker, to 10, with 10 being the *maximum* signal level of the inserted signal. Different receiver designs will vary in gain, thus the *arbitrary* judgment.

(Chart on page 34)

Figure 2 Representative Audio Sections of Receiver

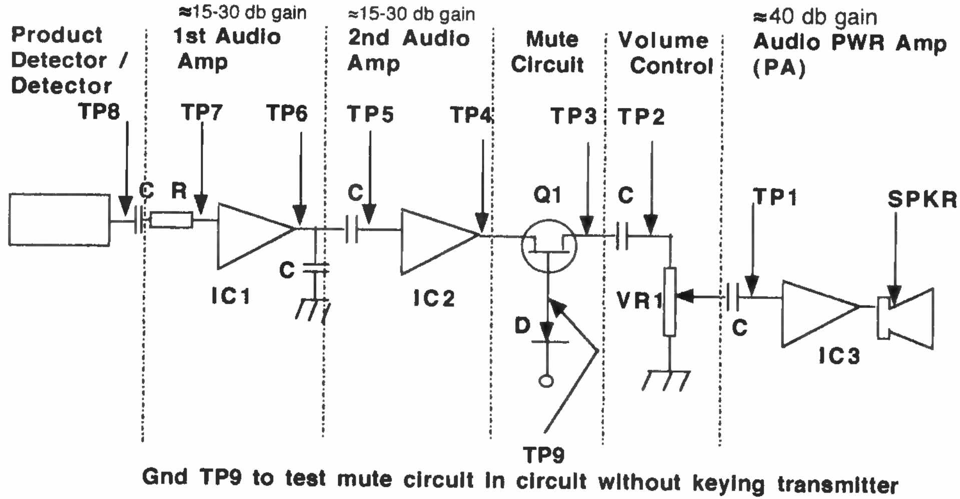


Figure 3 Test Probes

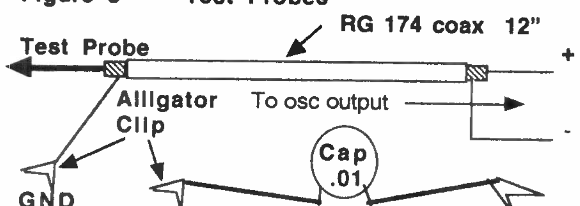
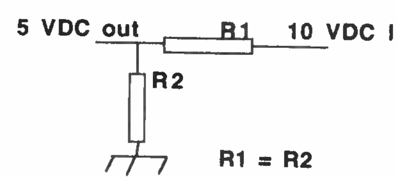


Figure 4 Sample Voltage Divider circuit



Test Point	SPKR	TP1	TP2	TP3	TP4	TP5	TP6	TP7	TP8
Loudness Level	0(min.)	1	1	1	1	5	5	9	9

Refer to your receiver schematic diagram, identify the proper test points, and, with the receiver power off (and unplugged) locate these test points on your actual receiver, making notes to speed the process during your actual testing.

Using your new Audio Oscillator to Trouble Shoot

Connect a speaker or headphones to the test receiver audio section and turn on the receiver. There should be a slight noise coming from the speaker indicating the final audio amp is working. Adjust the receiver audio gain to about the 9 o'clock listening level.

Connect the grounded alligator clip of your oscillator test probe to a ground point of the receiver under test.

To locate the problem area, start by touching your test probe to test points as follows:

Test Point Number	Results	Meanings
TP1	750 Hz note	Audio Amp to speaker section working (Adjust receiver AF gain to preference).
TP1	No Signal	Problem in Audio Amp between TP1 and speaker

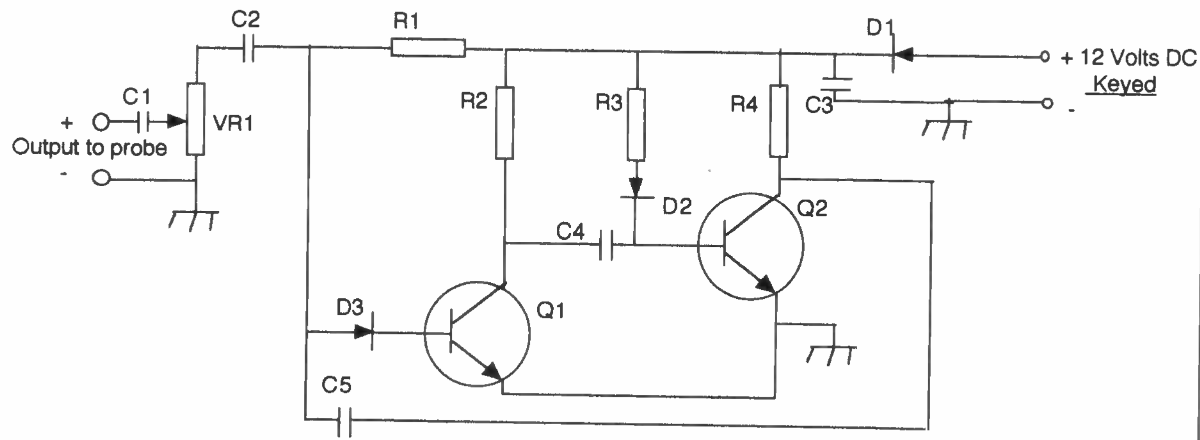
REMEMBER if *no signal* is heard at a specific test points below, the problem should lie between that quite test point and the previous working test point.

TP2	750 Hz note	AF Gain control working.
TP3	750 Hz note	C working properly.
TP4	750 Hz note	Mute section working.
TP5	750 Hz note	Tone stronger than TP1 test. 2nd Audio Amp OK
TP6	750 Hz note	C and R working properly.
TP7	750 Hz note	Tone stronger than TP5 test. 1St Audio Amp OK
TP8	750 Hz note	C "series" and "C" bypass working properly.

If any test point, TP1 thru TP8, does not pass your 750 Hz signal, it indicates a problem in the section between the last working test point and the nonworking test point. Test the next stage to insure you touched the proper previous test point. If still no signal, look for problems in nonworking section.

750 Hz. Square Wave Oscillator
Also use as a simple Audio Signal Generator or Sidetone Oscillator
K5BDZ - *Tejas Kits*

Figure 1



C1, C2, C3 -	.001 Fixed Cap (marked 102)	R2, R4 -	10 K 1/4 watt resistor
C4, C5 -	.022 Poly Cap (marked 223)	VR1 -	10 K to 47K Trimpot
D1 - D3 -	1N914, 1N916, 1N4148, etc. Si Diode	Q1, Q2 -	2N2222, 2N3904, or similar NPN
R1, R3 -	47 K 1/4 watt resistor		

Assuming you have a problem and before we check for voltages, let's do come common sense and continuity tests.

Smell the suspect area to see if you can detect a burned or abnormal smell.

Look at the section for burned or broken components, mission components, loose wires, bad solder joints, broken (or burned) PC board traces, or any other suspicious clue.

In 12 volt DC or lesser voltage units only, with power applied and test probe applied to non-working test point, use your finger to probe the suspect area looking for loose connections, components, or telltale noises.

Fix any offending problems found and re-test section.

If suspect section is still not working, it's time to check the voltages. Take *great care not to short the pins of any active device when the power is turned on.* With a multi meter or VOM set to the proper voltage scale, measure the voltages that power the offending section. If no voltage chart is available, follow the schematic, noting the voltage supply, and test for the presence of proper voltage at the appropriate connection to the active device in the section under test. As a note, many solid state devices are powered by 12 volts DC and utilize a resistor voltage divider network to power other sections (note Figure 4). Also remember to check for good ground return connections. Do this with the power off and with continuity (multi meter in Ohms position)

Simple Trouble Shooting Procedure

This is a "quick-test short cut" without using an audio generator to troubleshoot your once working receiver audio section, provided you are getting a *hiss* from your speaker (indicating the final audio system is working) and the receiver gain (volume) control works. You will also need an RF signal source such as a 100 KHz crystal calibrator, a crystal oscillator of any kind with crystal frequency that falls in the receiver tuning range, or short antenna to pick us a strong signal such as WWV (yes, you can use your RF signal generator but I'm trying to keep it simple for those without all the fancy test equipment).

First, put on your thinking cap and use your logic (common sense). The received signal comes from the antenna into your receiver, is amplified, and exits through the receiver speaker. Any problem that blocks the signal path, including a disconnected 1 shorted antenna or bad speaker, will stop your receiver from working. It can be a part malfunction, a short, an open circuit (such as a disconnected wire or broken trace on PC board), or even as simple as a loose screw that seems to just hold the PC board in place, but actually serves as a ground return path for voltage or circuit signals.

Refer again to Figure 2. Simple procedure. Turn on receiver and adjust the audio gain to about the 9:00 o'clock listening level. Use the two alligator clip jumper cables with .01 capacitor as shown in Figure 3. (We use the DC voltage blocking .01 cap to insure an audio signal path without causing damage due to shorting unwanted voltages.) Connect one alligator clip to TP2. (At this time you may hear an AM radio station from your Speaker. Do not be alarmed, as your unterminated test wire is now temporarily serving as an antenna and detector for strong local RF signals.) Connect the free alligator clip of the other lead to each of the Test Points 3, 4, 5, 6, 7, and 8, one point at a time (each connection should cause AM signal to cease). Each connection bypasses the section(s) between TP2 and the point being tested. Hopefully, along the way, you can once again hear some signal through your speaker, indicating the problem probably lies between TP2 and that "live" test point. Then narrow the test area by leaving the last test point connection, and moving the TP2 clip up the line one TP at a time until once again no signal passes through your jumper wire into the audio section. Go back to the last working test point, and the problem should lie between the two test point connections

FINALE

Well, we can go on forever with testing procedures of many types. However, this will help you understand the basic logic of troubleshooting, give you enough curiosity to try it for yourself, and gain experience and confidence that, YES, you too can trace, identify, and fix your own problems. • • •

My List of Mail Order Electronics Companies

John Woods, WB7EEL

jfw@jfwhome.funhouse.com (http://www.funhouse.com/jfw/RF_PARTS.txt)

Here is my list of companies which will sell electronic components in small quantities. Many of these places I have bought from, several I haven't. Being a ham radio operator, I am most interested in RF components, and in particular, air variable capacitors, which tend to be scarce (and tend to be used or surplus even if I've otherwise labelled the seller as "NEW").
Categories are: • NEW COMPONENTS: Distributors and sellers of new components, or "new and some used" in a couple of cases.• SURPLUS ELECTRONICS: Usually overstocks, occasionally used equipment. Ideal for stocking the junkbox, usually have dependable stock lines of resistors, capacitors, and some semiconductors, but won't have those LCD modules forever... An invaluable resource, don't shy away from them.• SPECIALTY COMPONENTS: In particular, crystals and toroidal cores. • KITS: Ham radio kits, random electronic kits, whatever they have. • LITTLE GUYS: Separated out because of some twisted sentimentality, I suppose. Intended to honor one or two ham spare-bedroom operations. Note that sending $1 along with catalog requests is a big help for these folks. ª PUBLICATIONS: A small selection of publications dealing with electronics, especially RF electronics. • QRP CLUB PUBLICATIONS: Clubs for low-power amateur radio enthusiasts; frequently have publications with quite a bit of technical content (which is why I'm a member of QRP clubs headquartered thousands of miles from where I live. Note, this is generally practical technical content (how to build it) rather than theoretical technical content (why it works), but definitely more than Contester's Quarterly.
Note on shipping costs: I don't always update these frequently enough, and they're generally for continental US unless otherwise mentioned.

NEW COMPONENTS:

Digi-Key: 701 Brooks Ave. South, P.O.Box 677, Thief River Falls, MN 56701-0677;
1-800-DIGI-KEY (344-4539)
1-218-681-3380 (FAX)
No minimum, $5 handling under $25, free and very complete catalog, very nice indeed. Prices aren't always the best, but rarely excessive. Weak on RF specialty parts (though they now have the ever-popular NE602AN), but they do have blue LEDs.

Mouser Electronics: 11433 Woodside Ave. 2401 Highway 287 North 12 Emery Ave. Santee CA 92071 Mansfield TX 76063 Randolf NJ 07869 Mouser Electronics 370 Tomkins Court Gilroy CA 95020.
Catalog Subscriptions: (800) 992-9943 (Continental US only).
Sales & Service: (800) 34-MOUSER (800-346-6873) (US, Puerto R., Canada)
Very complete catalog of brand-new components (though no air variables). Usually quick service, no minimum order. When ordering, you may want to be sure to ask about availability and shipping locations; they have several warehouses, and frequently orders will get sent from several warehouses (which drives up the shipping costs). Export orders have a $100 minimum, except for Canada and Mexico.

Ocean State Electronics, P.O. Box 1458, Westerly RI 02891
1-800-866-6626 (orders), 1-401-596-3080, +1-401-596-3590 (FAX)
Minimum $5, S&H $4, $2 for catalog. Wide array of RF parts, especially air variables and B&W coils. Reportedly getting a bit slow filling orders.

Radiokit: P.O.Box 973, Pelham NH 03076

(store is located at:) 169 Jeremy Hill Rd., Pelham NH 03076,
1-603-635-2235,
1-603-635-2943 (FAX)
No minimum ($3 service charge if under $20), many kits, lots of J. W. Miller chokes & coils, B&W coils, RF switches, Millen variable capacitors, lots of parts in general. As of 24-Feb-94, they are again STILL out of catalogs, and just barely might have one by Dayton this year. They do accept mail orders, but you'll have to call for prices and availability. A classified ad in 3/94 QST says "Call/SASE", I guess they may have fliers.

Circuit Specialists Inc: P. O. Box 3047, Scottsdale AZ 85271-3047,
1-800-528-1417
No minimum with check or money order, $15 otherwise. $3 S&H. New electronics, good RF assortment, increasing infestation of computers.

Active Electronics: 11 Cummings Park, Woburn, MA 01801
237 Hymus Blvd, Pointe Claire, Quebec, H9R 5C7,
1-800-677-8899 (Main number for US and Canada),
1-514-630-7410 (International),
1-514-697-8112 (FAX)
$25 minimum, $5 S&H UPS, catalog has a "$10 Suggested retail price" but they sent mine for free. They have 7(?) stores in the US (Chicago IL; Baltimore MD; Woburn MA; Detroit MI; Mt. Laurel NJ; Long Island NY; Seattle WA) and 10 stores in Canada (Quebec City; Montreal (2); Ottawa; Mississuaga; Winnipeg; Calgary; Toronto; Edmonton; Vancouver BC). Each store has its own 800 number and FAX number, call the main number(s). International orders are to be mailed to the Canadian address, but they want payment in US funds! Lots of stuff, oriented more toward supplying last-minute requirements of companies than hobbyists, but perfectly happy to take your money in small doses (stores have no minimum order). The $25 minimum for certain items is no longer explicit, but they note that some items will "ship in factory minimum package quantities", which might be worse.

Maplin Electronics Ltd., P.O. Box 3, Rayleigh, Essex, SS6 8LR, U.K.
Phone numbers: your international code + 44 702 554161 for sales 44 702 553935 Fax,
44 702 556001 Tech enquiries (2-4pmGMT)
"Over here [in the United Kingdom] the main hobbyist electronics supplier is Maplin Electronics who stock a wide variety of equipment. They have a catalogue which can be shipped for 10.65 pounds sterling by air or 5.50 pounds sterling by surface mail. They accept Mastercard, American Express and International Reply Coupons. They have at least one type of air-filled variable capacitor!" (Thanks to Kev White at Cambridge University).

Newark Electronics: Send catalog requests to: Newark Electronics, ATTENTION CATALOG DEPARTMENT, 4801 N. Ravenswood Ave., Chicago IL 60640-4496
1-312-784-5100.
They don't have a single mail address or phone; instead, one is supposed to call the closest of three pages worth of branch offices. I don't feel like typing in the entire list (it's copyrighted, anyway), so send email for your "local" distributor, or call their administrative offices at the number above. They have a $25 minimum order; they are a Real Distributor but accept small orders (over the minimum, of course). Their catalog is currently 1488 pages;

they are very complete (except, of course, for my favorite scarce item, the air-variable capacitor). Note that the catalog prices tend not to match reality all that often, so order by phone rather than by mail; prices tend to be higher than other places, but they have a lot of things that are hard to find from other outlets. Also note that they have six Canadian offices, and one UK office, and will take international orders at 500 N. Pulaski St., Chicago IL 60624-1019,
1-312-784-5100,
(FAX +1-312-638-7652,
TLX 6718690 NEWARK U).

Arrow Electronics, Inc. Catalog requests to: Catalog Division, 1860 Smithtown Ave., Ronkonkoma NY 11779. Catalog Division: 25 Hub Drive, Melville NY 11747-982
1-800-93-ARROW
Minimum $25; they no longer have a catalog. They are a Real Distributor, but also didn't mind my placing a personal order (a couple of years ago).

MCM Electronics: 650 Congress Park Drive,Centerville OH 45459-4072
1-800-543-4330
1-800-824-TECH (product questions)
1-513-434-6959 (FAX)
Minimum $20 ($25 for charge cards, and they don't take personal checks), handling $1.95 + shipping. Oriented toward repair technicians, really heavy on VCR parts and somewhat overpriced doodads, lots of useful stuff not easily found elsewhere.

Fordham Radio Supply: 260 Motor Parkway,Hauppauge NY 11788-5134
1-800-695-4848
Tools for technicians. One or two items are not outrageously overpriced.

Jameco: 1355 Shoreway Road, Belmost CA 94002
1-800-831-4242
1-800-237-6948 (FAX)
1-415-592-8097
No longer have a minimum order, reasonable selection of parts again (in addition to computer components).

JDR Microdevices (Just moved!): 1850 South 10th Street, San Jose, CA 95122-4108
Orders: 1-800-538-5000, 1-408-494-1400
FAX: 1-800-538-5005
1-408-494-1420
Cust. Service: 1-800-538-5001
Tech Support: 1-800-538-5002
BBS: 1-408-494-1430
No minimum, $5+ shipping. Mostly computers now, but they haven't yet decided to abandon components; indeed, they recently dropped their minimum order requirement entirely.

Johnson Shop Products: P.O.Box 160113, Cupertino CA 95016
1-408-257-8614,
1-408-253-6288 (FAX)
Catalog $1. No minimum. Shipping charge is based on UPS; very small orders that can be sensibly shipped in a first-class letter, include money for first-class postage. New and some used electronic parts.

DC Electronics: P. O. Box 3203, Scottsdale AZ 85271-3203
1-800-423-0070 (orders)
1-602-945-7736 (stock/price checks)
1-602-994-1707 (FAX)
$15 minimum charge order, no minimum for checks, $3 min. shipping&handling. Wide array of ICs, good assortment of electronic components.

Communications Specialists, Inc.: 426 West Taft Ave., Orange CA 92665-4296
1-800-854-0547, 1-714-998-3021, 1-714-974-3420 (FAX)
Surface mount chip component prototyping kits, $49.95. Call for free detailed brochure.

Kelvin Electronics: 7 Fairchild Ave., Plainview NY 11803
1-800-645-9212, 1-516-349-7620
1-516-349-7830 (FAX)
Minimum order $20; S&H 5% of order ($5 minimum, extra for large stuff, overnight, export (like to Hawaii), and etchant; based on

UPS charges). Lots of electronic parts & tools, some robotics supplies, model rockets.

H & R Company (Herbach and Rademan): 18 Canal Street, P.O.Box 122, Bristol PA 19007-0122
1-800-848-8001 (Orders), 1-215-788-5583
1-215-788-9577 (FAX)
Minimum order $25 ($5 processing charge under $25), shipping $4.75 under $30; Most items are new overstocks, much regularly stocked stuff as well. Tools, electrical supplies, motors, mechanical components, robotic components.

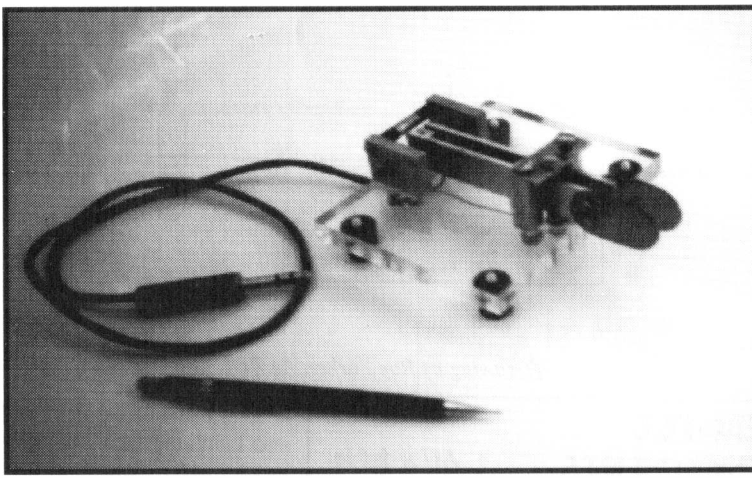
John Birkitt, 1, The Strait, Lincoln
44 522 520767
Lots of stuff for the practical enthusiast. Many bargains to be had if you've the patience to sort through the extensive heaps of assorted electronic miscellany. Good stocks of new components, tools and books, masses of RF gear and very competetive prices. Two shops side by side cater for the "consumer" type goods and the "electronics" type. Does mail order, takes visa/access etc. Mail order list contains lots of unusual goodies that you'll possibly never see on offer anywhere else. (thanks to Dave Walster @ lincoln.gpsemi.com)
N R Bardwell, Abbeydale Road, Sheffield
44 742 552886
Possibly the busiest electronics emporium I've ever visited. Specialises in radio gear and alarm equipment but many of the obligatory bags of "unmarked, untested" goodies makes Bardwell's *the* place to go. Friendly, efficient and knowledgeable staff. Cheap. Very cheap. Thriving mail order business with some good bargains in IC's and discrete's. Write/phone for a price list. (thanks to Dave Walster @ lincoln.gpsemi.com)

International Components Corporation: 1803 NW Lincoln Way,Toledo OR 97391-1014
1-800-325-0101 (US & Canada)
1-503-336-4400 (FAX)
Cabinets & Enclosures, Capacitors, Diodes, ICs, Potentiometers, Resistors, Sockets, Transistors, Books. No minimum order, $2 handling under $25.

Junkbox Keyer Paddle

Roy Parker, AAØB

237 E. Clearview Dr., Columbia, MO 65202



The AAØB Keyer Paddle (Photo: Roy Parker, AAØB)

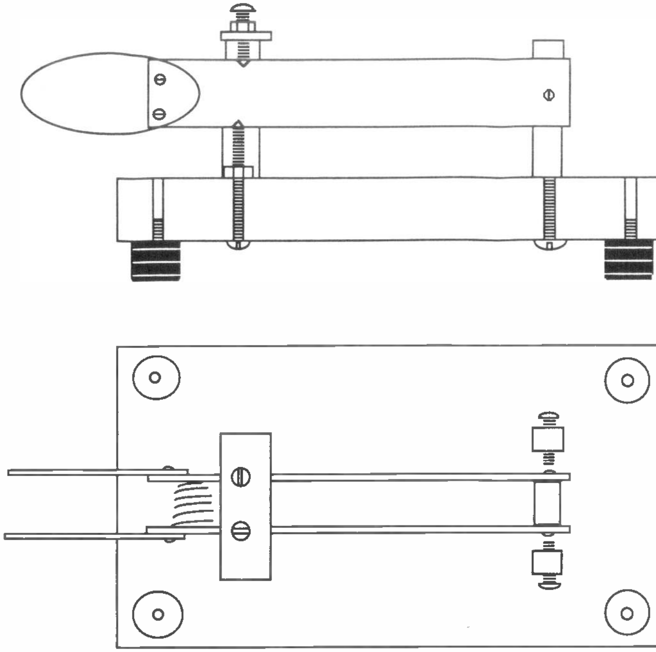
I was browsing through the junkbox and found a piece of clear plexiglas about 3/4 inch thick, and some aluminum bars about 1/8 inch thick. As I was nearing the completion of my QRP transmitter, I was looking for something that might do for a keyer paddle.

The plex' was already trimmed about 5 inch square and had drilled and tapped holes in the corners. These were just right for some rubber-bumpers for feet and 8-32 machine screws.

The aluminum stock was about 5/8 inch tall and was trimmed to about 4 inches long. I clamped each in a machine vice and drilled pivot holes in the edges. I started with a drill just smaller than the 1/8 inch thickness and moved down in drill size to make the cone shape dimple. The contact surface needed something, so I drilled and tapped the contact end of each for a 2-56 thread machine screw. Then attached some red plastic scraps (carved to shape) to the front end, also with 2-56 machine screws. I did NOT use any thread-lock for fear that electrical contact would be lost.

For the pivot pins I chucked up some 6-32 screws in a drill press and shaped them with a hand file (A machine lathe might be better here). The pivots on the bottom are fixed and the upper ones are adjustable and have jam nuts to keep them in adjustment.

For the other posts I found some aluminum piece about 1/4 inch square. I drilled and tapped the bottoms for 8-32 screws for attachment, and 6-32 screws for the contact pins. The contact pins are 6-32 screws and are adjustable with jam-nuts. The contact posts



(Drawing by Roy Parker, AAØB)

need to be insulated from each other and insulated from the rest of the paddle. So any bracing of the contact posts need to have phenolic or nylon fasteners or connections.

The spring is from one of those horrid plastic hand keys and is kept in place only by it's own spring tension. The spring force *is* adjustable to some extent by moving the spring closer to the pivot for less tension, and closer to the front for more tension.

In use the paddle is pretty good, but could use some more weight to keep it from sliding around. The clear base looks nice, but exposes any messy wiring connections on the bottom.

Some of the 'heavy-duty contesters' in the area have used it and brag on it.

DESIGN BASICS SERIES

Thoughts On Theory

Transistor Biasing - Part II

James G. Lee, W6VAT

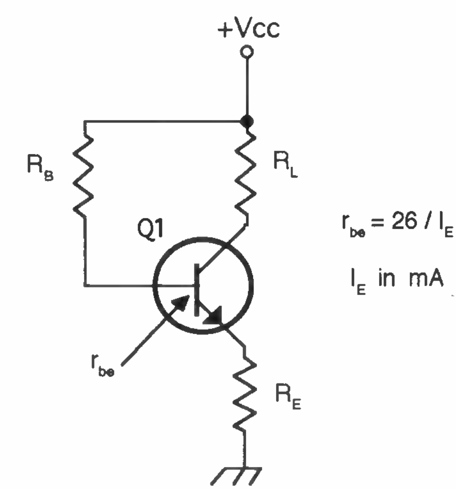


Figure 1:
Emitter Degeneration Added to Base-Bias Stage

Last time I showed base bias to be the poorest possible method of biasing a transistor. Can you improve on it? Yes you can, and in fact there are several things you can do. To improve it you use something called feedback. Feedback has either a positive or a negative characteristic which you can adapt for your use. Positive feedback acts as an "amplifier" in the sense that it increases the amount of signal through an amplifier. Too much of it causes oscillation which is undesirable - unless that is what you want. Stabilizing the operating point is your main goal, so negative feedback is the one to choose.

A couple columns ago I talked about low frequency response being affected by the bypass capacitor on the emitter resistor. When the frequency gets too low, the emitter resistor becomes visible to the signal and acts to limit the gain at the signal frequency. This effect also works at DC levels so you can limit the excursion of the operating point under no-signal conditions.

FIGURE 1 shows one method of adding negative feedback- i.e., degeneration - to the base bias circuit. Degeneration introduced into the circuit when an emitter resistor, R_E, is added. It causes β to have less effect on the DC operating point. To understand this a bit more, assume that β has increased for some reason. This causes an increase in emitter current, I_E, which causes the voltage across R_E to rise.

Since the base-emitter diode is forward-biased, and base current is a part of the emitter current, there is less voltage across the base bias resistor, R_B This reduces the base current, and so reduces the effect of an increase in β. What size should the emitter resistor be? To determine the size of R_E, we look at another characteristic of the transistor called the intrinsic base-emitter resistance, rbe. This resistance is temperature dependent, as are most transistor characteristics.

At room temperature, the base-emitter resistance is given by the formula:

$r_{be} = 26 / I_E$

where I_E = emitter current in mA.

Depending upon the type of transistor, this can vary by a factor of 2:1 up to $50 / I_E$. (For my purposes I'll use the number 26 whenever I talk about this resistance). Note that the base-emitter resistance is dependent on the emitter current, so when you choose an emitter current you do have some control over this resistance. But there are a couple of other ways that are just as good as increasing the emitter current. Both use a technique called "swamping out" the base-emitter resistance.

If you make R_E much larger than rbe, the effects with temperature change on rbe will essentially be swamped out. Opinions vary, but if you make R_E at least 5 times the value of r_{be}, it should be sufficient. Stated another way, make the voltage drop across R_E at least 5 times that of V_{be} - the intrinsic base emitter voltage of the transistor. For silicon transistors V_{be} is 0.7 volts at room temperature and for germanium transistors it is 0.3 volts. So for whatever emitter current you choose, R_E should have a voltage across it of 5 times 0.7 = 3.5 volts for a silicon transistor.

Another opinion says that R_E should be at least one-tenth of the load resistance, R_L. If it sounds as if you can attack the problem from different directions, you're right. There is a bit of give and take in all circuit design. and sometimes one or more values will be fixed so you must design with those values in mind. For example. if you need to have a low output impedance, then an emitter resistor whose value is one-tenth of the load resistor may not produce enough voltage across it to completely swamp out the effects of the base-emitter resistance.

FIGURE 2 shows a method of biasing which further restricts the effects of temperature and β on the operating point. It adds a new stabilizing resistor, R_s, to the circuit. This resistor, along with R_B, forms a voltage divider which stabilizes the DC bias on the base. This divider must be somewhat "stiff" to hold the base voltage very close to that of the emitter. This is done by making the current through R_s approximately 10 times the desired base current. The current through R_B will then be 11 times the base current.

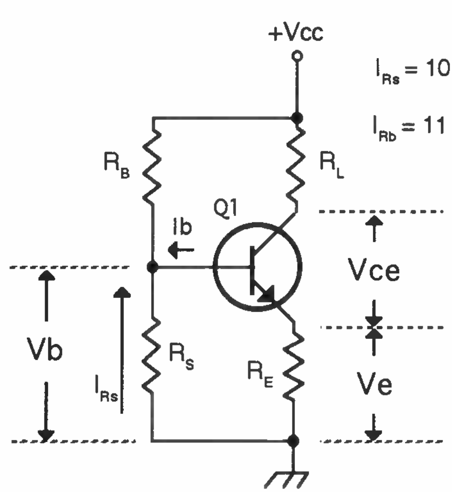


Figure 2: H-Bias of Common Emitter Stage

This method of biasing is one of the best possible methods of biasing a transistor stage. It removes β from all calculations except determining what the base current is for a given collector current. The degeneration provided by the emitter resistor and the stiffness of the base bias voltage divider keeps the circuit relatively free of temperature effects. The voltage divider is stiff due to the greater amount of current which flows through both R_B and R_S than the base current I_B. This bias method is sometimes called the "H-bias method" referring to the position of the resistors in the form of an H.

Somewhere in all of this you must pick a starting place. There are a couple ways of doing this as well. First you can pick an operating current. Again opinions vary here, with some saying pick an arbitrary collector current between 1 and 20 mA. Others say that you should use the point at which the low-frequency parameters (such as DC β) are measured since these are made under the most linear conditions. These values of V_{CE} and I_C are associated with the measurement of β, and are usually given on the transistor spec. sheet. Note that V_{CE} is the voltage between the collector and the emitter whether the emitter is grounded directly or not.

Once you pick the current, divide it by β and you get the base current. Knowing the base current. you calculate the current in R_S since you want it to be 10 times I_B. The current in R_B is then 11 times I_B. If you make V_E = 5 times Vbe, then the value of R_B - for a silicon transistor - will be 3.5 volts divided by I_C, and so on. A list of these equations are as follows:

$R_L = (V_{CC} - V_{CE} - 3.5) / I_C$

$R_E = 3.5 / I_C$

$I_{RB} = 11 \text{ times } (I_C / \beta) = 11 \text{ times } I_B$

$R_S = (3.5 + 0.7) / I_{RS} = 4.2 / 10 (I_B)$

and finally $R_B = (V_{CC} - 0.7 - 3.5) / 11 (I_B)$

The only term left to choose in the above is V_{CC} since I have not specified it. It is easily determined from the fact that it will be more than 3.5 volts plus V_{CE}. If, for example, you choose to operate the transistor at V_{CE} = 5 volts then V_{CC} must be at least as large as (5 + 3.5 volts + V_{RL}) = (8.5 volts + V_{RL}). In this instance you might choose a 12 volt supply for V_{CC}.

Note these calculations are not complicated and are simply applications of Ohm's Law. You have to do some initial choosing of the collector current in this instance and then the remaining calculations are relatively straightforward. So let's say you want to operate a 2N2222A at a collector-to-emitter voltage of 5 volts and a collector current of 1 mA. Use the median value of β = 200 for the calculations. In doing so you find that the base current is (1 mA / 200) = 5 uA. If you make the emitter voltage (5 times 0.7 volts) = 3.5 volts, and since the emitter current is essentially equal to the collector current, you calculate the emitter resistor as (3.5 / 1 mA) = 3500 ohms. So choose a standard value 3.6K resistor for R_E.

The current through R_S is 10 times 5 uA = 50 uA, and since the base voltage is 0.7 volts higher than the emitter voltage of 3.5 volts, the base voltage across R_S = 4.2 volts. The value of R_S is then (4.2 volts / 50 uA) = 84000 ohms. So choose a standard value of 82K. If V_{CC} is 12 volts, then R_B is (12 - 4.2) / 55 uA = 141,818 ohms, so choose a 150K resistor. The load resistor, R_L, is now (12 - 5 - 3.5) / 1 mA = (3.5 volts / 1 mA) = 3500 ohms and again choose a 3.6K resistor for the load resistor R_L.

STABILITY

How good is the design? One way to find out before you build it is to do a stability calculation on it. One formula for this is:

$$\text{Stability(S)} = 1 + (R_S / R_E)$$

As a rule of thumb, the value of S should be 20 or less. In our case, (82000 / 3600) = 22.8, and S then equals 23.8. This is close enough to 20 so that you have confidence in the stability of the amplifier's operating point. Even if it gets up into the mid-30's, amplifier operation will still be okay, although there will be a bit less tolerance with temperature and B spread.

So, transistor biasing is not complicated at all. Nothing more than Ohm's Law is needed to calculate all of the resistor values. You must pick a starting point, and next time I'll talk about "load lines" and starting the design from something called the collector "saturation current". •••

Editor's Note: Last issue we erroneously placed the subheading "The Concept of Duality" under the heading. This should have read "Transistor Biasing: Part I". We regret any confusion caused.

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