A 3456 MHz LINEAR TRANSVERTER

By Dave Mascaro, WA3JUF, RD 1 Box 467, Ottsville, Pennsylvania 18942

Over the past few years Amateur microwave activity in the United States has increased dramatically. Many operators active on 1296 MHz have put their stations on the 2304-MHz band. Stations work 10-GHz SSB/CW, as well as wide-band FM with Gunnplexers®. There's more commercial equipment available for all bands up to 10 GHz. Homebrewers are using surplus TV receive only (TVRO) and outdated commercial equipment to build up to the next higher band, 3456 MHz.

As with other bands up to 2304 MHz, the main modes of communications on 3456 MHz are CW and SSB. There are many ways to generate RF power on this band — both CW and linear. Frequency multipliers with step recovery diodes (SRD) and active multipliers are used for CW, FM, beacon transmitters, and local oscillators. You can use linear transverters for SSB/CW and all other modes, just like on the 50 through 2304 MHz bands.

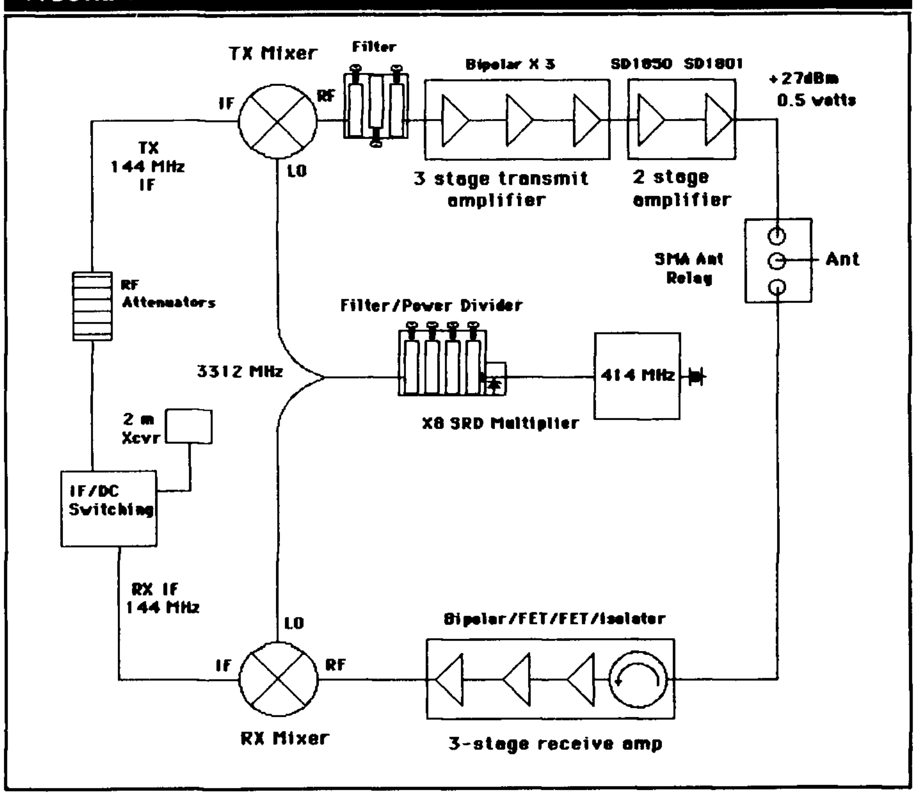
Figure 1 shows the block diagram of a 144 to 3456-MHz transverter. The transverter transmit and receive mixers use a common local oscillator at 3312 MHz. The 144-MHz transmit i-f is mixed with the local oscillator to produce 3456-MHz transmit signals. During reception, the 3456-MHz receive signals are mixed with the local oscillator to produce the 144-MHz receive i-f signals. A 2 or 3 section interdigital filter follows the transmit mixer to attenuate out the local oscillator and image frequencies.[1,2]

I didn't use a 144-MHz i-f post amplifier after the receive mixer. Unlike the 28-MHz "front end" in an HF transceiver that is normally used for a transverter, modern 2-meter transceivers have good front ends with plenty of gain. A post amplifier only makes the resting S-meter readings higher. The system noise figure is established in the 3456-MHz LNA.

Receive portion

Receive signals from the antenna relay are amplified by one-half of a modified TV receive only low-noise amplifier (TVRO LNA). The other half is used in the transmit portion of the transverter. My first modification involved installing an SMA antenna connector in place of the waveguide antenna input.[3] Normally a scalar-type feed horn is attached

FIGURE 1



Block diagram of a 144-MHz to 3456-MHz linear transverter.

directly to the LNA when used in a satellite receiving system. A feedthrough cap is also installed to bring +15 Vdc into the LNA housing without using an external bias-T attached to the output "N" connector.

Split TVRO LNA

The greater than 50-dB gain LNA is modified again to make two separate three-stage amplifiers. The amplifier I use is the Amplica model ACD 305331 (90 degree) LNA. The 305331 LNA has two GaAsFET stages followed by four bipolar stages and a filter. **Figure 2** shows the "split-in-half" LNA. The transmit amplifier portion provides greater than 20-dB gain. There is greater than 30-dB gain and a 2-dB system noise figure in receive mode.

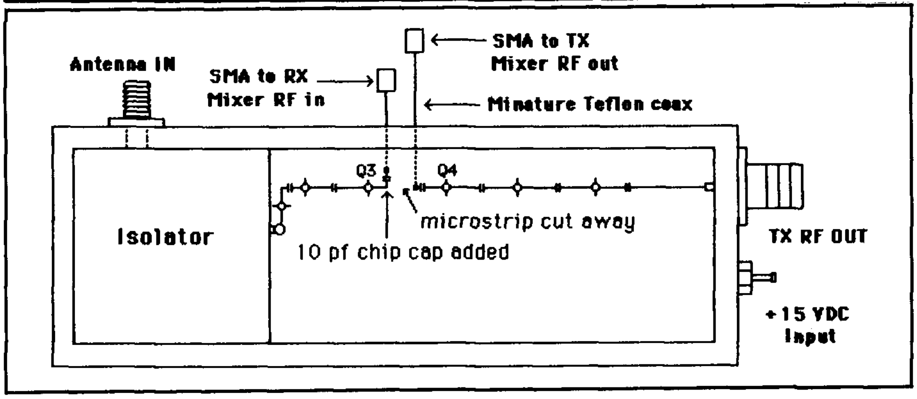
I modified the LNA by wiring two miniature 50-ohm Teflon® coax cables fitted with SMA male connectors into the amplifier between the third (Q3) and fourth (Q4) stages. The two coax cables should be long enough to go from inside the LNA and connect to the receive and transmit mixers in your transverter. Cut away the microstrip at the interstage DC blocking capacitor to create a gap in the line. Solder a 10-pF chip cap to the output line of stage Q3. This becomes the receive amplifier output. The existing DC blocking chip capacitor becomes the input of the transmit amplifier chain.

Open the other compartment of the LNA. Drill two holes and run the miniature coax through the holes into the compartment. Now drill two small holes in the pc board beside each of the two DC blocking capacitors to pass the coax cable center conductors. Solder the center conductors to the blocking chip caps and solder the shield of each cable to the ground plane at the point where the cable goes through the pc board. The shield relieves strain on the cable, so the chip caps don't break. Apply a dab of RTV or silicone bathtub seal where the cables go through the housing to increase the strain relief and moisture proof the LNA.

You now have two separate amplifiers. The stability of the receive front end is maintained because the input isolator is still intact. It's okay to leave the +15 Vdc applied to the LNA; the front end won't oscillate into the open antenna relay during transmit. The LNA has an on-board 7812 voltage regulator, so you can use input voltages from 15 to 28 Vdc.

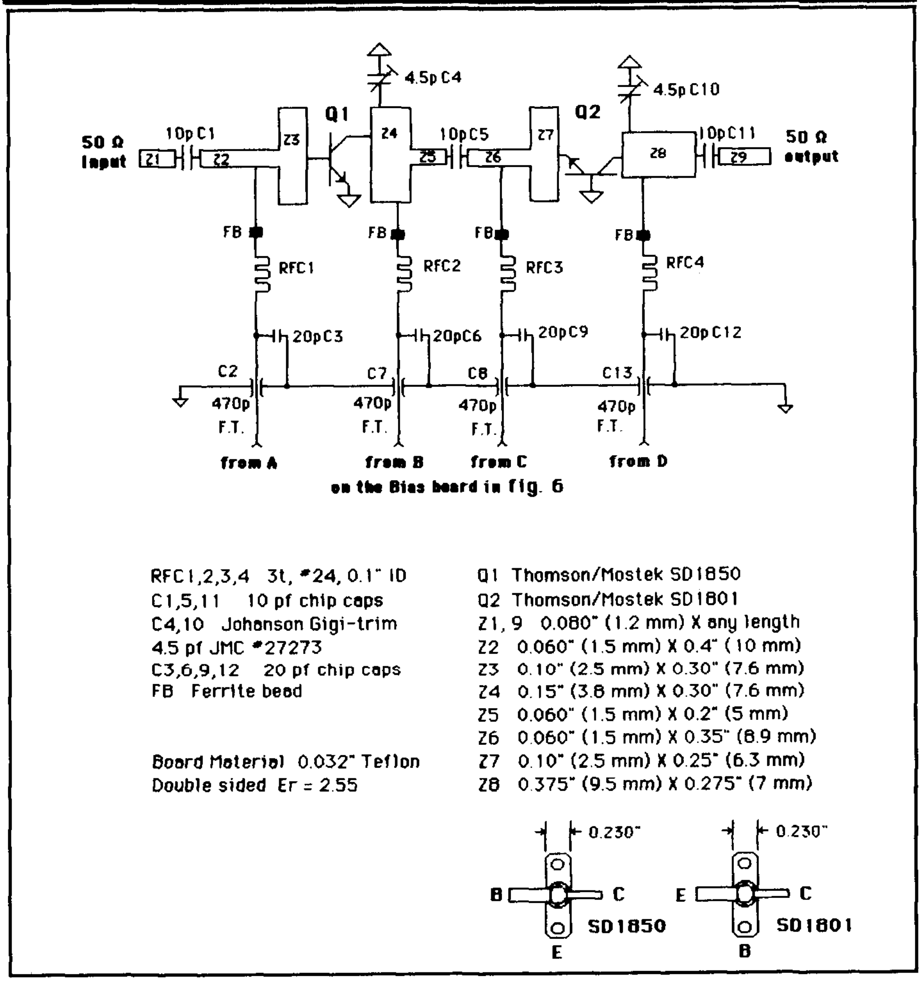
The receive amplifier output feeds the RF port of the receive mixer. The Mini-

FIGURE 2



A split TVRO LNA showing two separate 3-stage amplifiers.

FIGURE 3



The 2-stage 3456-MHz linear amplifier.

Circuits ZFM-4212 and ZAM-42* are suitable mixers because they are fitted with SMA connectors. The pc board mounted PAM-42 is also a good 3456-MHz mixer. I used the Anzac MD-169 (normally pc board mounted). I enclosed it in a homemade brass housing fitted with SMA connectors.

You can peak the receive amplifier in a noise figure set-up by tweaking the miniature trimmers mounted throughout the LNA. Gain can be maximized at 3456 MHz.

Another application for a split LNA in a transverter involves using one half to amplify the very low output of a 3312-MHz schottky diode multiplier for the local oscillator, and the other half to amplify the transmit mixer SSB output. Try using a second modified 50-dB gain TVRO LNA for the receive amplifier. This approach worked very well for me.

Transmitter stages

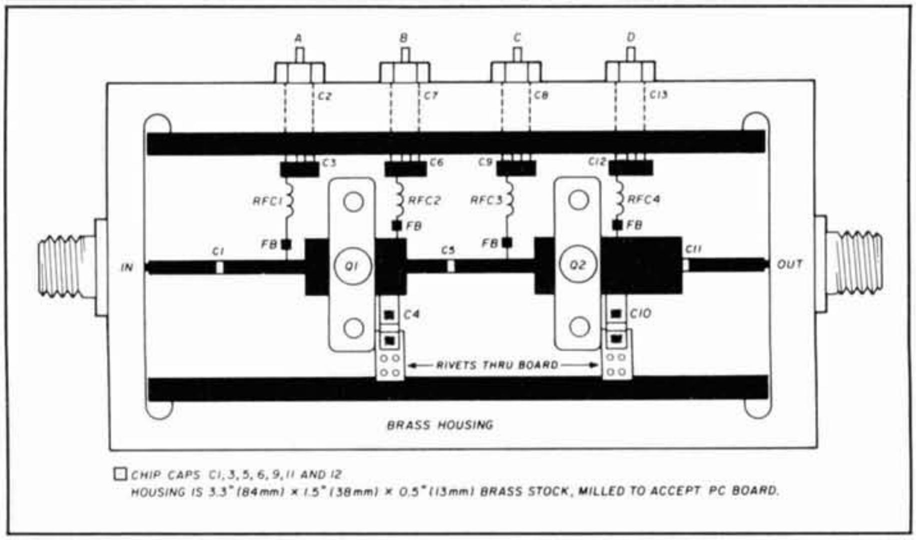
You can use the same type of mixer for the transmitter as you did for the receiver. I used the MD-169. The output of the transmit mixer (usually −10 dBm or so) is amplified by the second half of the split LNA, which provides +10 dBm (10 mW) output. The three bipolar stages and filter provide an excellent linear amplifier for low-level signals.

Two-stage linear amplifier

A two-stage linear amplifier, providing 20-dB gain and +27 dBm (500 mW) power output at 1-dB compression, follows the modified TVRO amplifier. The amplifier is shown in **fig. 3**. It was built into one enclosure to eliminate two SMA connectors, and to reduce its overall size. The amplifier is built on 1/32″ Teflon double-sided pc board (Er = 2.55), using microstrip matching networks (see **figs. 4** and **5**). Although the two stages are etched on one pc board and housed in the same enclosure, you can build two separate amplifiers. The DC blocking capacitor (C5) is mounted in a 50-ohm line; the two stages could be separated at this point. Use DC blocking capacitors on the input and output of both stages.

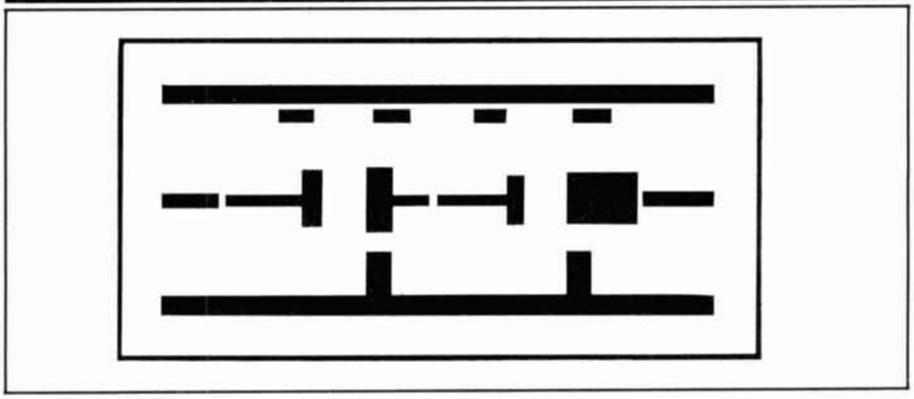
*Mini-Circuits, P.O. Box 166, Brooklyn, New York 11235, (718) 934-4500.

FIGURE 4



Component placement of the 2-stage 3456-MHz amplifier. All components mount on the trace side of the pc board.

FIGURE 5



Full scale artwork for 2-stage amplifier on 1/32″ Teflon® double-sided pc board. Er = 2.55. Opposite side (ground plane) is unetched.

Make all DC and RF grounds low inductance paths through to the ground plane side of the Teflon pc board. Do this by putting multiple rivets through to the ground side. Another method is to cut small slits into the board with an Xacto® knife, and insert and solder strips of copper foil on both sides.

All the amplifiers I build for 1296 MHz and up are constructed from milled-out brass housings. I solder the Teflon pc board into the brass enclosure, and mill two slots in the brass housing to accomodate the flanges of the two transistors. The bypass capacitors and tuning trimmers are mounted on the pc board close to the board edges. This allows direct connection to the brass housing and provides good DC and RF grounding. Holes drilled in the brass box enable you to externally tune the unit with a plastic tuning tool.

The input and output connectors of an amplifier should also be soldered to the ground plane side of the pc board. In my amplifier, I attached the two SMA connectors to the brass box with 2-56 screws and then soldered them permanently. I performed this step on a hot plate when I soldered the pc board in place. You could also solder the connectors on the ends of the pc board in a "launcher" configuration with the center pins of the connectors mounted and soldered parallel to the microstrip.

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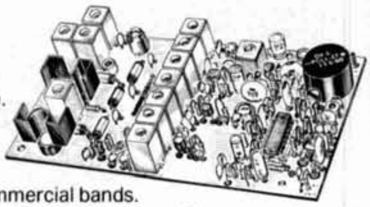

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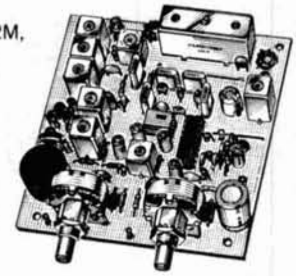

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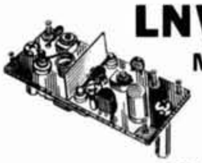

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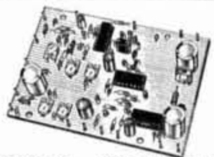

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144-146	28-30
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146-148	28-30
220-222	28-30
220-224	50-54
222-224	28-30
432-434	28-30
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110	122	134	146	158	170	182	194	206	218	230	242	254	266	278	290	302	314	326	338	350
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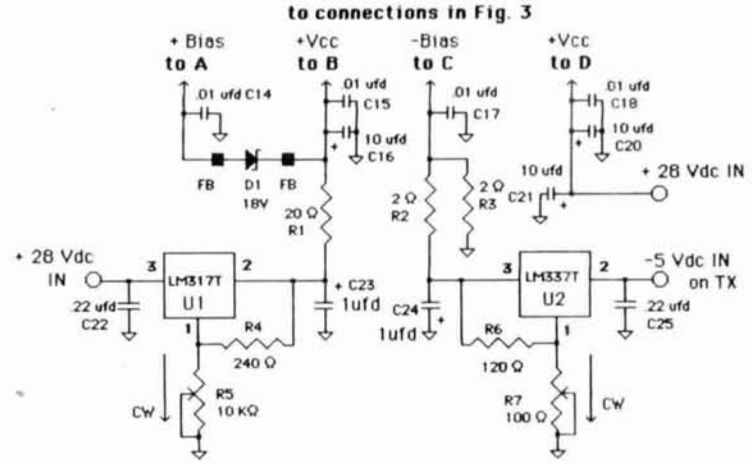
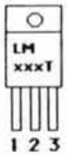


Resistors are 1/4 watt except where noted

C16,20,21 10 ufd/35 Vdc electrolytic
C23,24 1 ufd/35 Vdc Tantalum
D1 1N5248B 18 V/500mw zener diode
R1 20 Ω 1/2 watt
R2,3 2 Ω 1/2 watt
R5 10 KΩ minature pc mount pot
R7 100 Ω minature pc mount pot
U1 LM317T Positive regulator
U2 LM337T Negative regulator
FB Ferrite beads



LM317T
1-adjust
2-Vout
3-Vin

LM337T
1-adjust
2-Vin
3-Vout

Bias sources for the 2-stage 3456-MHz linear amplifier. Both regulators are mounted on a heatsink with mica insulators, shoulder washers, and heatsink compound.

Amplifier biasing

The first amplifier stage (Q1) is a common emitter Thomson SD 1850 transistor,* operated as a Class A amplifier. The SD 1850 can be used as a 150-mW Class A linear amplifier from 432 to 3456 MHz. Q1 uses standard zener diode biasing. The second stage (Q2) is a Thomson SD 1801 transistor (a 1 to 2 watt/1 to 3 GHz CW transistor). Q2 is a common base transistor (operating Class AB), and requires a negative voltage for bias in addition to the 28-Vdc collector supply.

I have forward biased many common base devices in the past — many are being used on 1296 and 2304 MHz. In most cases linearity is as good as with a common emitter amplifier. Because microwave power output is at a premium, Amateurs running common base linear amplifiers usually run them closer to power saturation (P_{sat}), rather than in the linear region. This is why the amplifier may sound slightly rough. Other than a few local SSB ragchews, most communications on 2304 and 3456 MHz are on CW.

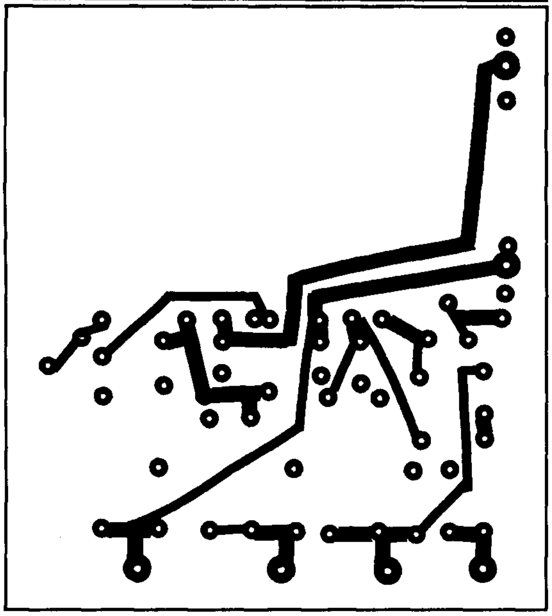
Low-power devices like the 1-watt SD 1801 are easy to bias linearly. Higher power devices like an SD 1597 transistor** require a little more care and a higher current bias source. A common base linear amplifier requires mainly that the bias source be of very low impedance. This is true for the −5 Vdc supply, as well as the associated components of the LM337T regulator. Use an LM337K for higher power common base amplifiers. The regulator in a TO-3 style case is capable of higher power dissipation.

The two bias sources in **fig. 6** were made on an etched G-10 double-sided pc board (shown in the **figs. 7** and **8**). All

*SGS-Thomson Microelectronics, Commerce Drive, Montgomeryville, Pennsylvania 18936, (215) 362-8500. All Thomson transistors are available through: RF Gain, Ltd., 100 Merrick Road, Rockville Centre, New York 11570, (516) 536-8868 and (800) 646-2322.

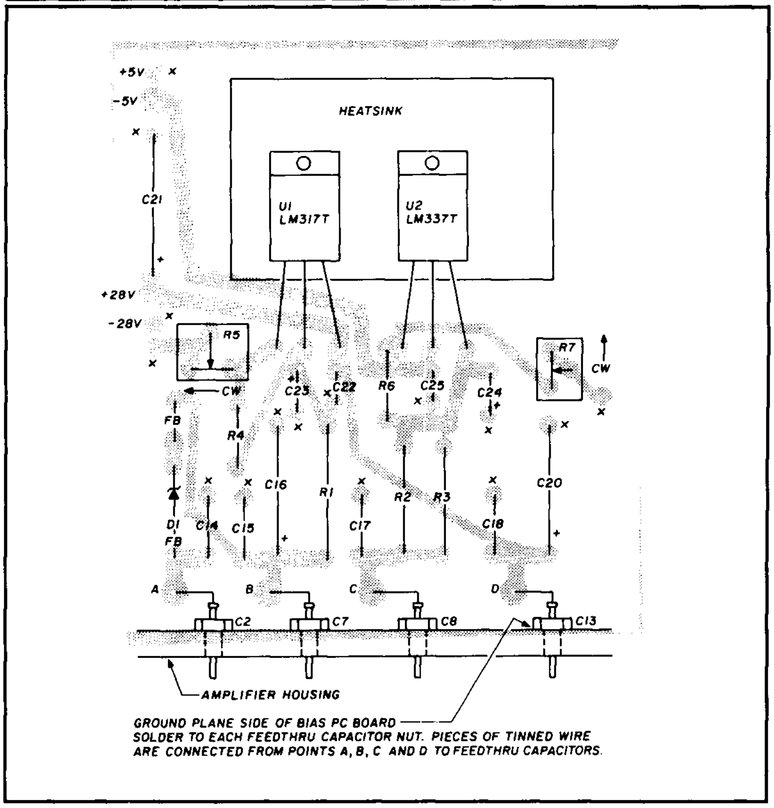
**The SD1597 is a Thomson 25 watt/1296 MHz transistor for Amateur applications.

FIGURE 7



Full-scale artwork of bias board. Etched side shown. Opposite side is the ground plane and is unetched. Board material is 1/16″ (1.6 mm) G-10 double sided.

FIGURE 8



Component placement on the bias board, showing x-ray view of the traces. Parts are mounted on the ground plane side of the pc board, which is unetched. Clear all nonground holes on this side of the board. Solder all grounds on both sides of the board of points "x".

non-ground holes must be "cleared" on the unetched side to prevent component shorting. Begin by drilling the non-ground holes. Remove the copper by counterboring the holes with an oversized bit. Set the depth of the hole to about half the pc board thickness. Drill the ground holes last to prevent confusion about which holes get cleared. Solder components or wiring connected to ground on both sides of the board, as indicated by an "x" in **fig. 8**.

Solder the ground plane side of the pc board directly to the ground posts of feedthrough capacitors C2, C7, C8, and C13 as shown in **fig. 8**. Do this so that the bypass capacitors C14, C15, C16, C17, C18, and C20 will be close to the amplifier (where they will bypass RF most effectively). Use small-gauge tinned wire to connect the bias board to the feedthrough capacitors.

Two power-supply voltages (+28 Vdc and −5 Vdc) are supplied to the board. You can also build a power supply that provides all the positive voltages for a complete transverter (including this bias board).[4] An LM317T (U1) supplies a variable collector voltage for Q1. Adjust the collector voltage without power input (P_{in}), until the 18-Vdc zener diode conducts and biases on Q1. Set the optimum current while tuning the amplifier for power output.

I used an LM337T (U2) as the negative bias source for the output stage (Q2). The output voltage of U2 is halved by voltage divider R2-R3, because 1.2 Vdc is about as low as a three-terminal regulator will go. Note that the −5 Vdc supply must have a floating negative terminal. Peak the idling current while tuning for power output. The −5 Vdc is applied to the amplifier bias board during transmit only. This minimizes heating and possible oscillations into the open antenna relay during receive.

If maximum rather than linear power output (for a rover rig, for example) is a requirement, you could operate the second stage Class C with greater than 1-watt power output. This would eliminate the negative power supply (possibly a 6-volt Gel cell or lantern battery). You'd ground the emitter of Q2 by connecting RFC2 to ground. The microstrip dimensions would stay the same and the stage would be tuned up in the same manner as a linear one.

Tune-up

While I was tuning my amplifier, the two piston trimmer capacitors peaked at minimum capacitance. To bring the trimmers into range, I had to trim off some of the microstrip capacitors with an Xacto knife. I'd used the microstrip dimensions for some single amplifiers that I designed and built earlier. Not going out to 50-ohm connectors interstage produced slightly different impedance matching. Other than this, the amplifier came right up to power and gain expectations. The artwork in **fig. 5** reflects the microstrip dimension changes.

To tune this amplifier and most of others I've built, I used the following equipment: a Wavetek 2005 RF generator, HP435B power meters, and an HP spectrum analyzer (part of an RF test station at Thomson). You'll need an RF generator and a "real" power meter to check linearity. Do this by changing the P_{in} in 1-dB steps, while looking for the same change in the output. Use the spectrum analyzer to check gain and linearity. Also look for spurious responses.

Now, set the quiescent current (idling current without power input). Attach a 50-ohm load to both the input and output connectors. Adjust both bias adjust pots (R5 and R7) for minimum voltage as measured on the output of U1 and U2. Do this before making connections to the amplifier, to prevent transistor damage. Adjust the Q1 collector current to 80mA with a current meter connected in series with the 20-ohm resistor (R1). Next, adjust the collector current of Q2 to 50 mA with a current meter in series with the collector supply feedthrough capacitor (C13).

Apply 5 mW of 3456-MHz RF to the amplifier input, with a power meter and spectrum analyzer attached to the output. Adjust the two trimmers (while looking at the analyzer and power meter) for maximum output.

The two-stage amplifier will produce maximum power output with 10 to 12 mW of drive. You can readjust the idling current on each stage slightly, under power output conditions for either maximum gain or maximum power output. It's possible to adjust the idling current of Q1 for 80 to 110 mA, and for Q2 up to 65 mA, for proper operation. The total current at 28 Vdc will be 200 to 250 mA when the two-stage amplifier is running at maximum power output.

My two-stage amplifier performed as follows:

Power output at 1 dBc +27.6 dBm (580 mW)/Gain = 19.8 dB

P_{sat} +29.3 dBm (850 mW)/Gain = 18.9 dB

Local oscillator

The local oscillator is probably the most important part of a transverter. It sets the transverter's frequency stability. The i-f frequency is usually very stable and accurate, because it's almost always a commercially made transceiver. Of course, all we're really interested in is the short-term stability. The actual frequency operated on at 3456 MHz can vary many kHz over normal temperature ranges. If you need the exact frequency (i.e., for schedules), use a frequency counter. If a 3.5-GHz counter is unavailable, measure a lower frequency stage of the local oscillator chain on a UHF counter. The 3312-MHz local oscillator frequency will give the 3456-MHz transmit/receive frequency.

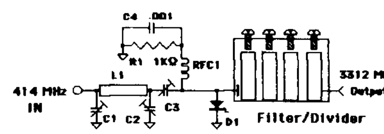
The local oscillator chain in my transverter starts out with a surplus 400-MHz telemetry transmitter strip, which uses a temperature-compensated crystal oscillator. You can find surplus crystal-controlled strips at flea markets; they make stable microwave local oscillator sources.

Step recovery diode multiplier

The 400-MHz module (crystalled up for 414 MHz) drives a X8 step recovery diode (SRD) multiplier (**fig. 9**). The multiplier functions as follows: A pi-network input circuit is used between the 414-MHz module and the SRD, to provide some impedance matching into the diode at 414 MHz. The output of the pi-network (C3) connects directly to the input of the SRD holder. The SRD provides a comb output, consisting of many harmonics of the 414-MHz driving signal. The RF is coupled into the 4-pole comb filter, which filters out the wanted signal (3312 MHz). Dual SMA connectors on the filter output provide the local oscillator signal to both mixers in the transverter.

Most SRDs are packaged without wire leads and require special clamp-type holders for mounting and heat sinking. You can make a brass housing to hold the SRD and provide output coupling into the 4-pole comb filter that follows. **Figure 10** shows the SRD holder. Clamp the step recovery diode between part no. 4 (the RF input/output connection) and part no. 6 (a 1/4-20 brass set screw). Use a dab of heat sink compound where the SRD mounts into part no. 6; this aids thermal conduction to the main housing. I made the brass diode holder on a milling machine to fit into the input end of the comb filter. You

FIGURE 9



L1 0.2" (5 mm) X 1.25" (32 mm) brass strip
C1,2,3 10pf Johanson trimmer JMC #5200
C4 .001 ufd disc
R1 ≈ 1 KΩ (adjust for performance)
D1 HP 5082-0320 step recovery diode
or HP 5082-0800
or M/A-Comm MA 44608-1
or TRW A45365
or Thomson DH252 or DH256
RFC1 12t, #24, 1/8" (3mm) ID

X8 SRD frequency multiplier and filter.

can make a functional unit with ordinary hand tools.

Depending on the SRD, you can make the 1/4-20 brass set screw (part no. 6) with the appropriate mounting hole. Some SRDs have 3-48 UNC threaded posts that would screw into part no. 6. You could use a glass-packaged SRD by making a Teflon spacer with the glass diode mounted in the center. Fold the wire leads over at both ends and clamp the Teflon spacer into the diode holder.

Attach the SRD holder to the comb filter as in **fig. 11**. It's possible to use an interdigital filter, but a comb filter is easier to mount and tune up because the tuners are on one side.[1,2] A comb filter uses the same dimensions as an interdigital type, but is configured with all the tuning elements on the same side. I used all brass construction. The end walls are 1/4" thick brass stock. Drill holes for the four filter poles, and on the opposite side for the four tuning screws. Solder two SMA connectors to the sheet brass covers. Attach the two covers with 2-56 × 3/16" screws to hold the filter together while soldering all joints on a hot plate.

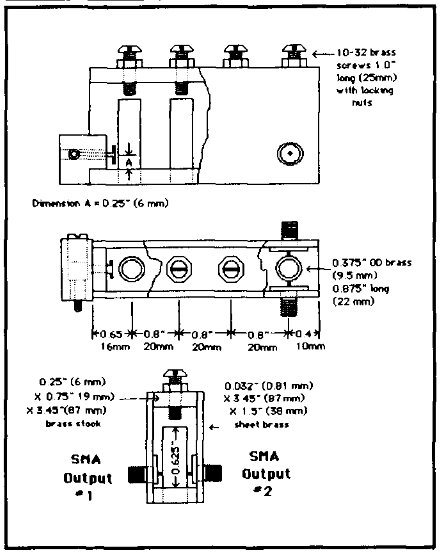
After you've built the filter, attach the SRD holder to it with 2-56 × 3/16" screws. Use a small piece of sheet brass as a mounting platform for the pi-network input circuitry. Attach this assembly to the filter so the SRD input connection (part no. 3) is in close proximity to the trimmer capacitor (C3) of the input circuitry.

Apply the 414-MHz RF to the SRD/filter assembly. Adjust the input network and the filter for maximum power output with a power meter attached on one output port, and a 50-ohm load and spectrum analyzer on the other. Use a spectrum analyzer during tune-up to ensure a clean local oscillator output. Adjust the output coupling probe by threading it in or out of part no. 4. First loosen part no. 3, then tighten it up after the output coupling is optimized. You'll need to adjust the 414-MHz drive for proper output at 3312 MHz (5 to 10 mW at each output connector). The two outputs will be within 1 dB of each other — more than sufficient to properly supply a local oscillator signal to the two transverter mixers. You can change the 414-MHz drive using an LM317T voltage regulator which supplies an adjustable collector voltage to the 414-MHz output stages. In my transverter, power input at 414 MHz was 500 to 600 mW. I made no attempt at optimum input/output matching of the SRD; power at UHF is easy to come by.[5,6]

I provided two outputs on the comb filter instead of using a 3-GHz power divider to split the local oscillator for the two mixers (see **fig. 11**). This is a very simple power divider and you can use it on any comb or interdigital-type filter. You can take two different levels off the filter (for use in a duplex system) if one output uses capacitive coupling. For example, the center pin of an SMA connector provides coupling ≈ 15 dB down from a normally connected output.

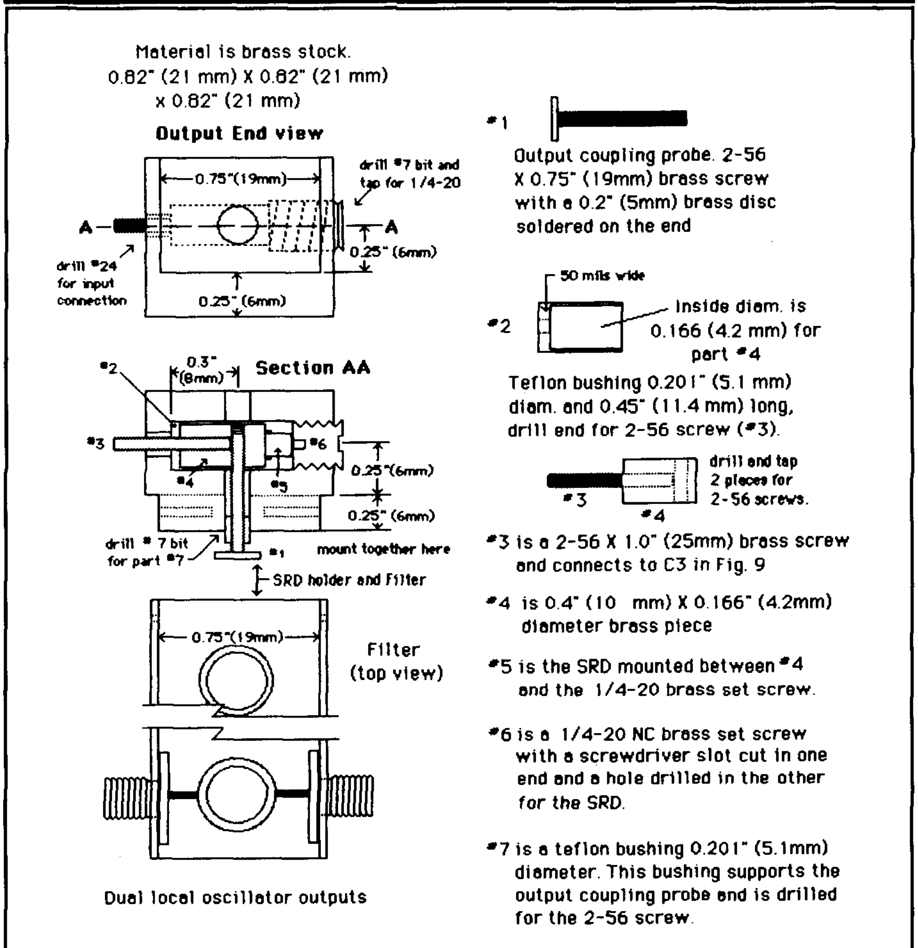
There are a number of combinations for the local oscillator chain. In addition to what's shown in the block diagram, you could also generate 3312 MHz using a 1-GHz local oscillator strip (crystalled for 1104 MHz) driving an active tripler to 3312 MHz. There are a few sources for stable crystal-controlled 1-GHz local oscillator chains.*

FIGURE 11



The SRD/Filter/Power divider assembly. At top, the SRD holder is shown mounted to the 4-pole filter. The middle is a cut-away view showing the position of the SRD output probe and dual local-oscillator outputs. The bottom is the end view filter/power divider. Connector input-output taps are 0.25″ (6 mm) from the cold end.

FIGURE 10



3456-MHz SRD holder and output coupling detail.

Active frequency multiplier

Figure 12 shows the ×3 to 3312 MHz multiplier. The active device is an SD 1801 transistor (Q1). The multiplier is built on 1/32″ Teflon double-sided pc board (Er = 2.55) and mounted in a brass carrier (shown in **fig. 13**). The multiplier is connected to a five-section interdigital filter.[1,2] I used an SMA connector on the input instead of the SRD holder. The input connector is tapped at 0.25″ from the cold end of the input pole.

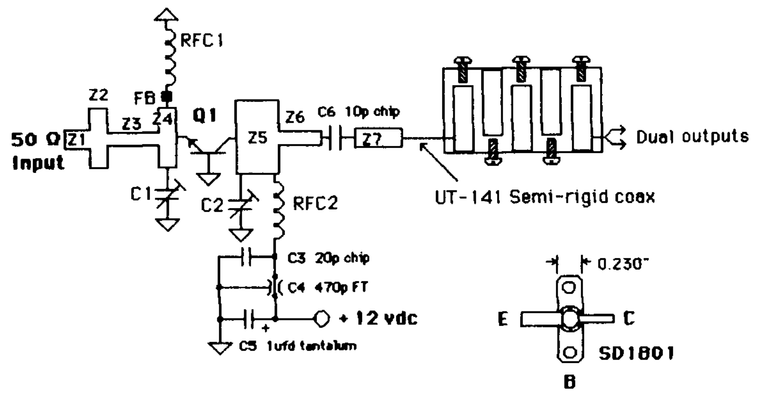
The multiplier and filter are connected in the transverter with a small piece of UT-141 semi-rigid coax. The exact length of the cable seems to have an effect on the performance of the multiplier. Try different lengths of intercon-

*Down East Microwave, Box 2310, RR #1, Troy, Maine 04987, (207)948-3741. (W3HQT sells the LMW Electronics, model ULO, Universal Local Oscillator kit.) SSB Electronics, 152-MHz Local oscillator chain for their 2304 MHz transverter, crystalled and retuned to 1104 MHz.

necting cable to provide the best match into the filter. The multiplier and filter are effectively one stage and are tuned as such. Again, a power meter is attached to one output, and a 50-ohm load and spectrum analyzer to the other. After tuning the filter for maximum power output at 3312 MHz, you can adjust the 1104-MHz drive level to provide the proper level outputs for the two mixers.

Here's how the multiplier operates. The input of Q1 is tuned to 1104 MHz (or 1152 MHz in a 3456-MHz beacon transmitter). The output is tuned to 3312 MHz (or 3456 MHz). An interdigital filter removes the fundamental and second harmonic frequencies and also provides two outputs for the two transverter mixers. The typical performance of the tripler and filter with one output is 30-mW power input at 1104 MHz (or 1152), which produces 40 to 60 mW output. P_{in} of 50 mW produces greater than 100 mW. When running the multiplier on 15 Vdc, I've seen +23 dBm (200 mW) out of one of these units. You could use this for a beacon transmitter. The 3312-MHz (3456 MHz) outputs are very clean; all unwanted harmonics are down greater than 45 dB and all non-harmonically related signals are down greater than 60 dB.

FIGURE 12

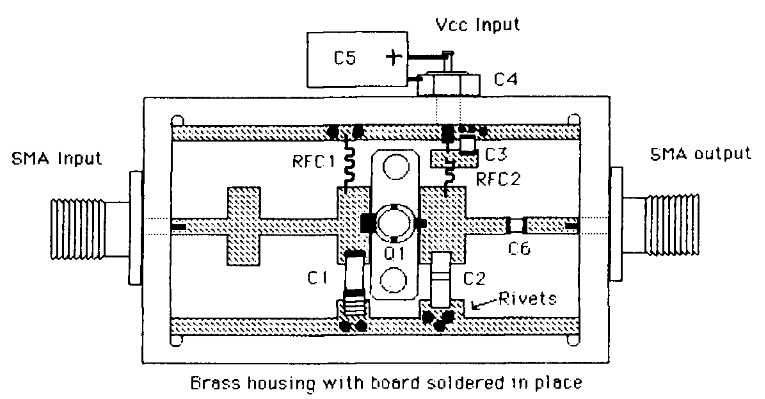


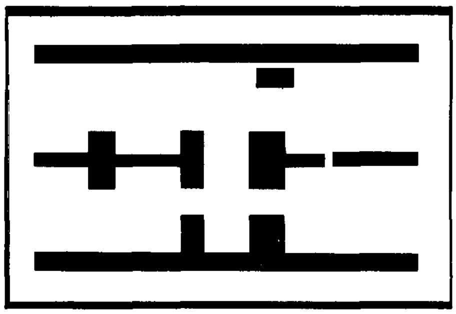
Board material is 0.032" Teflon double-sided
Er = 2.55

C1 3.5 pf Johanson piston trimmer, JMC #5801 or 5802	Q1 Thomson/Mostek SD1801
C2 4.5 pf Johanson Gigi-trim cap, JMC #27273	Z1,7 0.080" (2 mm) X any length 50Ω line
RFC1 6t, #26, 0.1" (2.5 mm) ID	Z2 0.150" (3.8 mm) X 0.30" (7.6 mm)
RFC2 3t, #24, 0.1" (2.5 mm) ID	Z3 0.060" (1.5 mm) X 0.35" (9 mm)
FB Ferrite bead	Z4 0.150" (3.8 mm) X 0.30" (7.6 mm)
	Z5 0.200" (5.0 mm) X 0.30" (7.6 mm)
	Z6 0.060" (1.5 mm) X 0.20" (5.0 mm)

X3 Multiplier to 3312 or 3456 MHz with a 5-section interdigital filter on the output.

FIGURE 13





Parts placement on the X3 multiplier and full-scale artwork below. Trace side shown. Opposite side is unetched.

I-F and DC switching

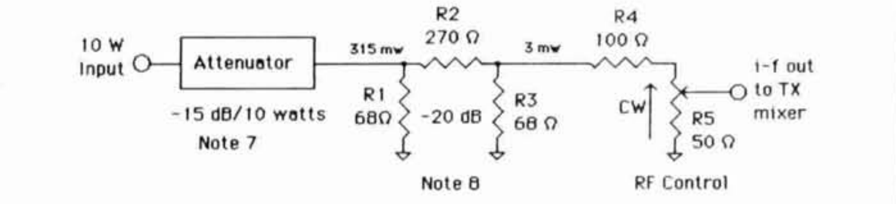
It's necessary to have some means of switching the i-f transmit and receive lines when connecting the 2-meter transceiver to the 3456-MHz transverter. You'll also need a keying circuit to control the transmit/receive of the transverter. This requires one of two different hookups — depending on whether the 2-meter i-f will be a transceiver or another transverter (an MMT-144/28, for example*).

Two-meter transverter as an i-f

Separate receive and transmit connectors are available on the MMT-144 transverter. The i-f output of the receive mixer is connected to the 144-MHz receive port on the 2-meter transverter. On the transmitter side, you must insert an attenuator between the transmit output (nominally 10 watts) of the 2-meter i-f and the 3456-MHz transmit mixer (see **fig. 14**). Adjust the i-f drive level to the

*Microwave Modules Ltd., Liverpool, England, makes a complete line of VHF/UHF transverters.

FIGURE 14



I-f attenuator and adjustable RF control.

✓ 154

✓ 155

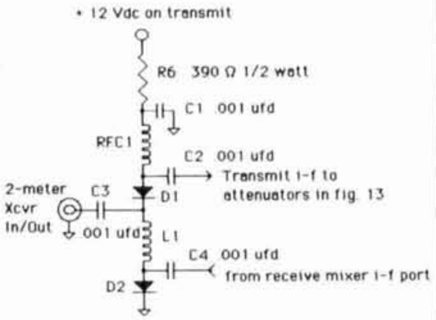
transmit mixer as follows: Turn the RF control (R5) CCW (maximum attenuation). Attach a power meter to the output of the 3456 transverter. Put the 3456-MHz transverter into the transmit mode and apply the 10 watts of drive. Adjust the RF control (R5) for a maximum power output at 3456 MHz. Reduce the 2-meter RF; it should show a decrease in the 3456-MHz output. If there's no reduction in power output, the mixer is being overdriven and you must insert additional attenuation in front of the RF control.

It's important that the i-f radio be operated at its normal output level, and not with the gain or CW control turned down. The RF control in the transverter is adjusted to match the i-f level, **not vice versa.** This ensures that the transverter will never be overdriven, even when the i-f radio's gain controls are adjusted improperly. The procedure is correct for any transverter system.

Two-meter transceiver for the i-f

Figure 15 shows a Pin diode RF switch that provides switching for the 2-meter i-f during transmit and receive. The i-f transceiver is connected to the Pin diode switch; this gives two separate ports similar to the outputs of the 2-meter transverter described earlier. The RF attenuators* and RF control are also used in this installation. The i-f drive adjustment is the same as if you were using a transverter. Don't make changes in the RF drive with the 2-meter transceiver in the "low power" position or you'll be asking for trouble.

FIGURE 15



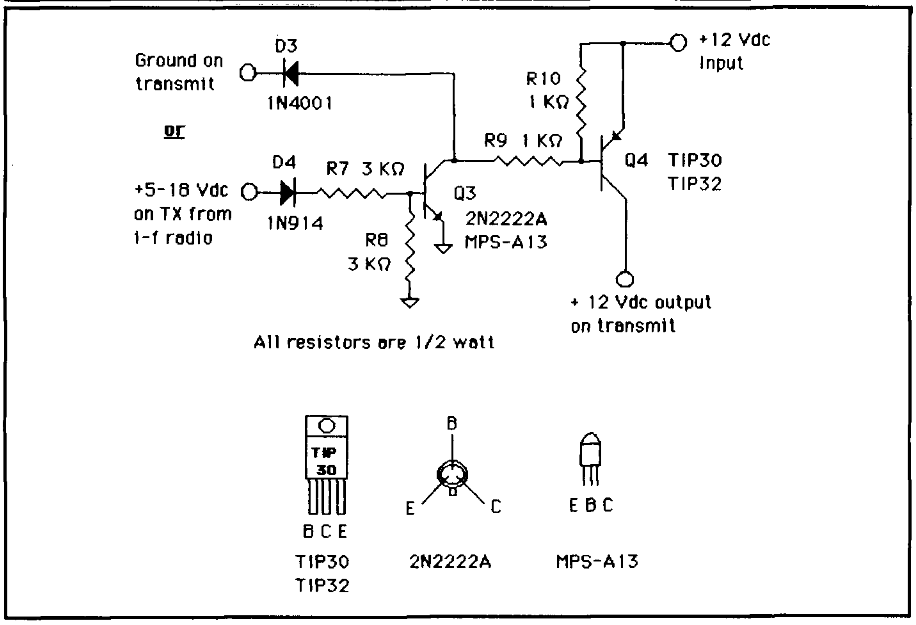
Pin diode RF switch.

DC control circuits

Control the 3456-MHz transverter with "hard keying." Use RF sensing *only* as a last resort. Hard keying is simple. Take a transmit voltage off the i-f radio — either via an accessory jack, or by going inside and soldering a wire to a resistor lead. You just need a voltage between 5 and 18 volts on transmit at a few milliamps of current. Check your radio's schematic to determine where to look with a voltmeter. **Figure 16** shows a DC switching circuit that provides 12 volts on transmit to control the Pin diode switch in **fig. 15.** The 12 volts will also key your 3456-MHz transverter control circuits and power supply[4].

*Microwave Modules RF Attenuator Models: MMR 3/25 = 3dB/25 watt, MMR 7/3 = 7dB/3 watt, MMR 15/10 = 15dB/10 watt

FIGURE 16



DC switching circuit, controlled by the i-f transceiver in the transmit mode.

Antenna relays

You can use antenna change-over relays manufactured by Transco Products, Inc. (and other manufacturers) at 3456 MHz. Look for surplus relays at flea markets. Some have specially made connectors designed for the military. Unfortunately, matching connectors usually aren't available. I use a Transco latching-type relay, P/N 82132-909C. It cost me $5.00 at a flea market. The connectors resembled an SMA female jack, but had male center pins. I removed the threaded-in connectors and installed female SMA connectors. Insertion loss, measured at 3456 MHz, is 0.1 dB; isolation is greater than 60 dB. Surplus relays manufactured by Electronic Specialty Company are usually good for 3456 and 5760 MHz.

Conclusion

The design for this transverter is relatively simple. A few basic components are all you need to build a "bare-bones" unit for mountaintop work. Besides the local oscillator, two mixers and the "split" TVRO LNA will get you on the air. You can use manual transmit-receive change-over (moving a coax cable between RF ports) with good results, as speed isn't usually a requirement. Microwatt transmitters and diode receivers are adequate for most line-of-sight communications. You can always add fancy switching and higher power output later.

You can use some of the component designs for other microwave projects. For example, the SRD multiplier is suitable for a beacon transmitter. The HP 5082-0320 diode is capable of much more power output at 3456 MHz than is used in this transverter. It's possible to find other 1 to 5-watt SRDs that will fit into the same holder. Try using the active multiplier for the output or driver of a beacon transmitter. Adjusting the collector voltage and RF power input for maximum yields 200 to 300-mW power output.

This transverter is one of many possible designs.* Microwave enthusiasts in other parts of the country are using surplus phase-locked sources for their local oscillators. TVRO mixers are also in service. GaAsFETS and surplus tube-type amplifiers are being used for the transmitters. There's also an assortment of TVRO, surplus, and homebrew GaAsFET receivers at work.

The majority of activity on this band comes from mountain-topping stations and local QSOs. Many stations will soon be on the 3.4-GHz band, and QSOs similar to 2304 MHz will be commonplace. Besides the parabolic antennas normally used on the microwave bands, the loop Yagi is becoming a popular antenna for 3456 MHz.**

*The ARRL Handbook
**Down East Microwave, Box 2310, RR #1, Troy, Maine 04987, (207) 948-3741 sells loop Yagi antennas for all bands 902-3456 MHz.

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Article I **HAM RADIO**