2-meter transverter

Add a new band to your high-frequency transceiver with this hybrid circuit

The easy way for the owner of a high-frequency transceiver to get on VHF SSB is with a transmitting converter, or *transverter*. The essentials of a typical VHF transverter are shown in **fig.1**. A common heterodyne oscillator is used for both up conversion of the transmit signal and down conversion of the received signal. The 10-meter band is the customary intermediate frequency as it provides the widest tuning range on most transceivers, and its relatively high frequency favors good image rejection. A 2-meter transverter requires a local oscillator at 116 MHz to transform 28-30 MHz to 144-146 MHz.

In the block diagram I assume that the transceiver has a separate low-power output port from its driver or exciter. If this has not been provided by the manufacturer, it's usually a simple matter to so modify the transceiver. It's also advisable to add a switch that will remove heater voltage or supply voltage from the transceiver final amplifier when the transceiver is used with a transverter.

tubes versus transistors

The 2-meter transverter described here is a hybrid, which employs both tubes and transistors. It might be argued that tubes are now obsolete for all except high-power applications, but for Amateur work tubes have one important virtue: they're tough. Tubes are very forgiving of mistakes. A wiring error or accidental voltage transient can wipe out a transistor in less than a millisecond, whereas tubes will survive extreme overloads for a matter of minutes — plenty of time to locate a fault and correct it before the tube is destroyed. This is not so important where tubes can be replaced with inexpensive transistors, but VHF power devices are still far from inexpensive.

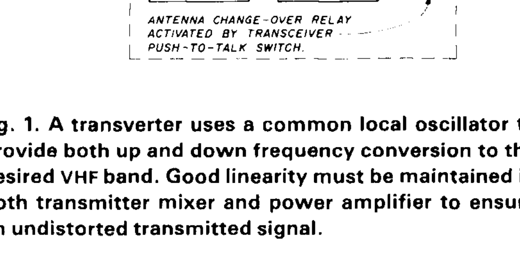

fig. 1. A transverter uses a common local oscillator to provide both up and down frequency conversion to the desired VHF band. Good linearity must be maintained in both transmitter mixer and power amplifier to ensure an undistorted transmitted signal.

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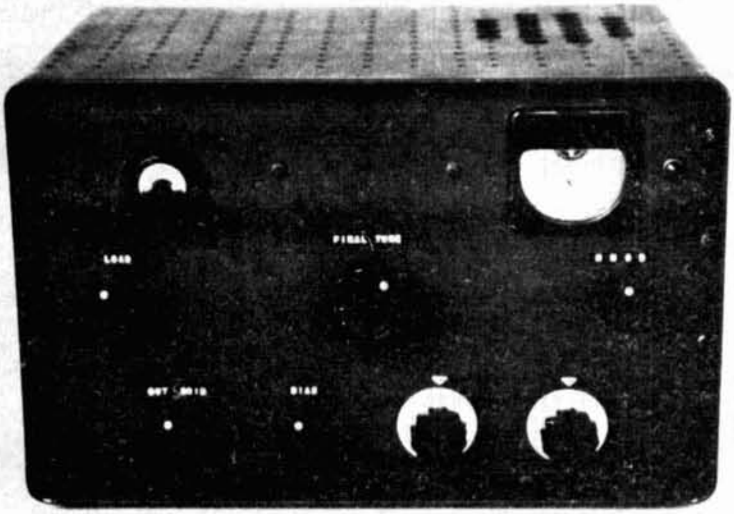
local oscillator

The heart of the transverter is the LO, and this circuit should be constructed first. A transverter local oscillator must supply considerably more rf power than a VHF converter LO, since a transmitting mixer typically requires an injection level of a few hundred milliwatts. In this 2-meter transverter, the LO, or heterodyne oscillator, constitutes a small, solid-state, 116-MHz exciter with a power output of about 1/8 watt.

Fig. 2 shows the LO circuit. The 58-MHz crystal oscillator, *Q1*, drives a push-push doubler, *Q2* and *Q3*, which doubles to 116 MHz and drives *Q4*, a class-C power amplifier. Feedback for *Q1* must pass through the series-tuned circuit, *L3-C1*. This high *L:C* ratio circuit resonates at 58 MHz and prevents the third-overtone crystal from oscillating on its fun-



The cabinet is 8.5 inches high by 13 inches long by 9 inches deep (21.6 by 33 by 23 cm). Meter at left reads either rf output voltage or PA grid current. The two flanged knobs at lower right are for adjustment of C4 and C5.

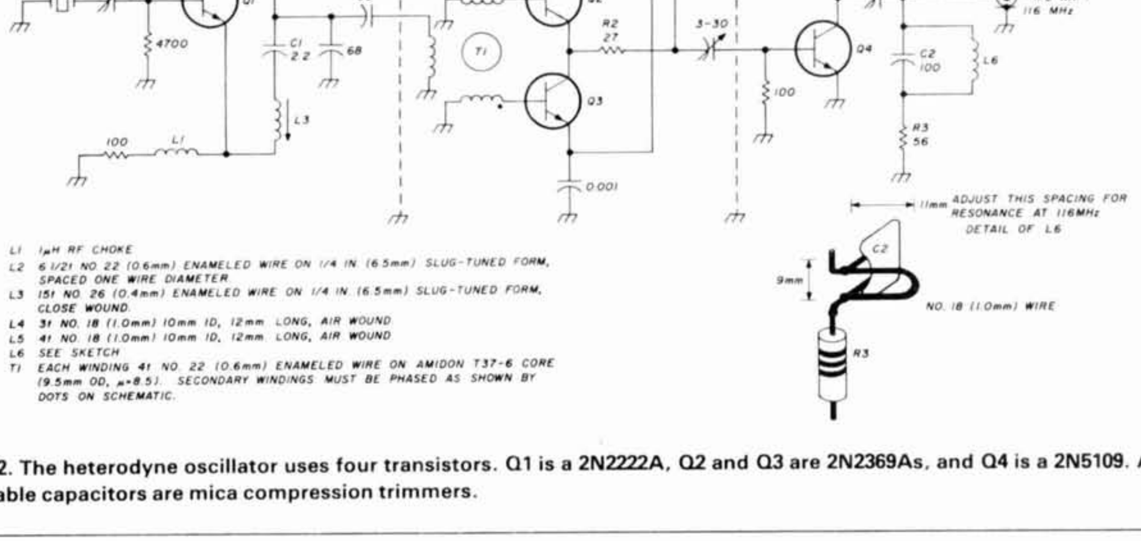


fig. 2. The heterodyne oscillator uses four transistors. Q1 is a 2N2222A, Q2 and Q3 are 2N2369As, and Q4 is a 2N5109. All variable capacitors are mica compression trimmers.

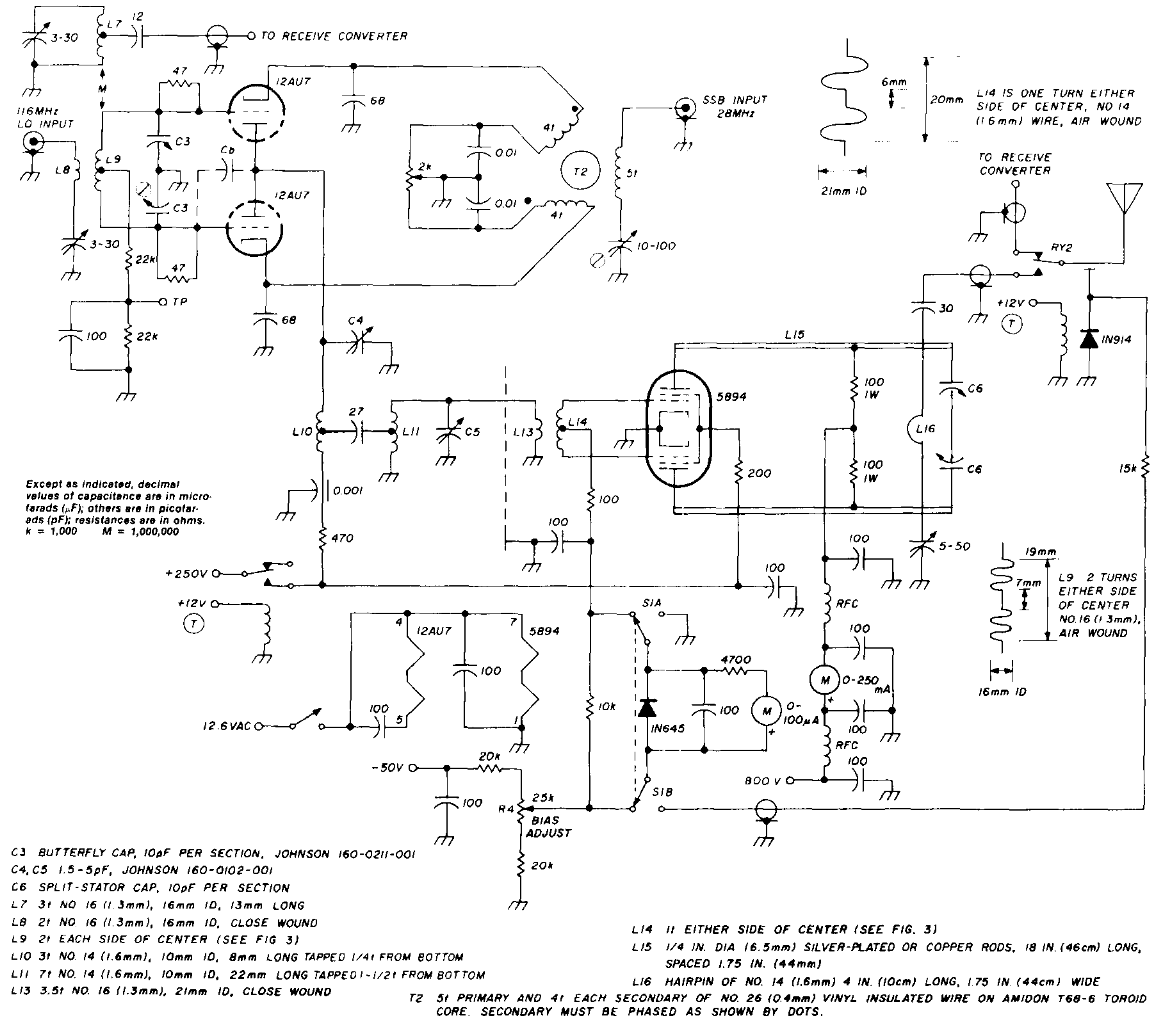


fig. 3. Transmit mixer and final amplifier. Relays RY1 and RY2 are actuated by the transceiver push-to-talk switch. The 3-30 pF capacitors connected to L7 and L8 are mica compression trimmers. The 47-ohm parasitic suppressors connected to the 12AU7 grids are 1/4-watt resistors shunting 3/4 inch (19 mm) of the No. 22 (0.6 mm) wire that connects C3 to the 12AU7 grid pins. Balancing capacitor C_b is explained in the text.

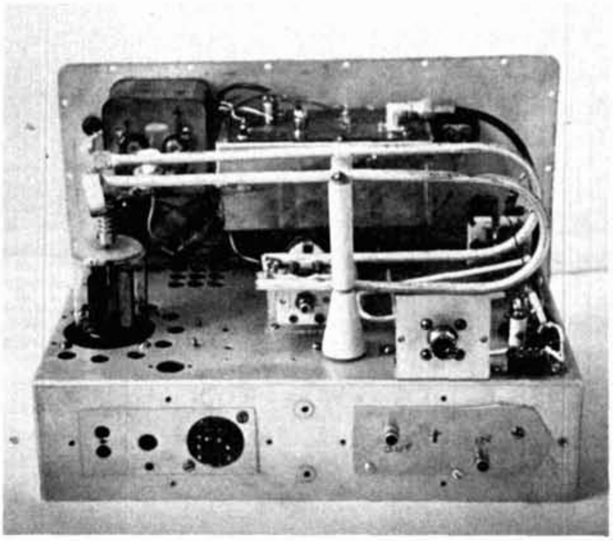
damental. It can be set to frequency with a grid-dipper by temporarily connecting *C1* across *L3*.

Potentiometer R1 can be adjusted to balance *Q2* and *Q3* for minimum third harmonic (174 MHz) output. Resistor *R2* is a parasitic suppressor. The purpose of *C2*, *L6*, and *R3* is to load the output of *Q4* at all frequencies except 116 MHz, and thereby discourage parasitics. The extremely low L:C ratio combination of *C2-L6* is parallel resonant at 116 MHz and thus prevents power loss into *R3* at the desired frequency.

The LO output is loaded by the 12AU7 transmit mixer (**fig. 3**), and *Q4* should be stable with the 12AU7 heater turned either off or on; or for that matter, under any load conditions. The LO is best checked for parasitics with a spectrum analyzer; if one is not available a tunable UHF receiver can be used. Enough 116-MHz drive should be available to produce at least 1 mA of grid current from the 12AU7 mixer, or 22 volts measured at the test point.

transmit mixer

The 12AU7 transmit mixer shown in **fig. 3** is a *doubly* balanced mixer. Most vacuum tube mixers described in Amateur literature to date have been either singly balanced, or simple unbalanced types. What is worse, the singly balanced mixers are usually balanced for the high-frequency signal, not the LO



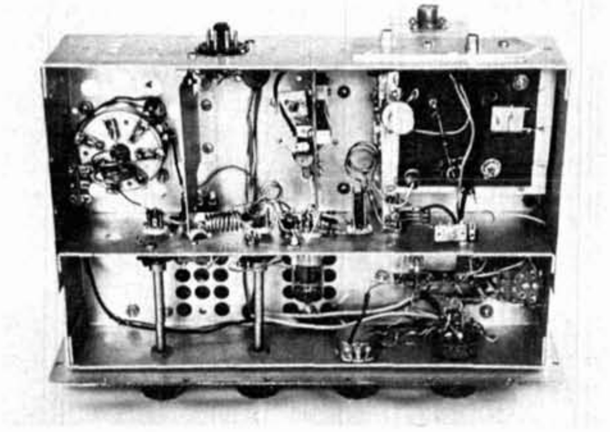
The 5894 plate lines have been bent back upon themselves to save space. Metal box behind plate lines houses the receive converter.

signal. **Fig. 4** shows the difference. No particular advantage results from a mixer that is balanced with respect to the transceiver output since there is little chance that 28-MHz energy will get through the 144 MHz tuned circuits and be radiated by the antenna. But it is important that the mixer be balanced with respect to the LO port to suppress the 116-MHz signal.

The 12AU7 balanced mixer requires about 1/2 watt PEP of 28-MHz drive from the transceiver. The 144-MHz output is linear up to a level of about 1 watt — more than enough power to drive the 5894 class AB_1. Perfect rf balance of the 12AU7 requires equal grid-to-plate capacitances in the two triode sections. The mixer will work well with unequal capacitances but will not completely reject the LO. If desired, the two sections can be equalized by adding a small capacitor to the triode section with the lesser C_{gp}. Two short insulated wires twisted together will provide enough capacitance (C_b in **fig. 3**).

The trimmer capacitor in series with the primary of *T2* can be adjusted for minimum SWR at 29 MHz as measured with a sensitive (low power) reflectometer or impedance bridge.

Three tuned circuits are used between the mixer and the 5894 grids. It might have been possible to get by with two, but the extra filtering certainly does no harm. One of the three is the grid coil of the 5894, *L14*, which broadly resonates to 145 MHz with the



Underchassis view. Controls at lower left are, from left, the 5894 grid control, C5; 12AU7 plate control, C4; bias-adjust pot, R4; and the grid-meter switch. The 5894 PA tube-base compartment is at upper left. Shielded box at upper right houses the heterodyne oscillator.

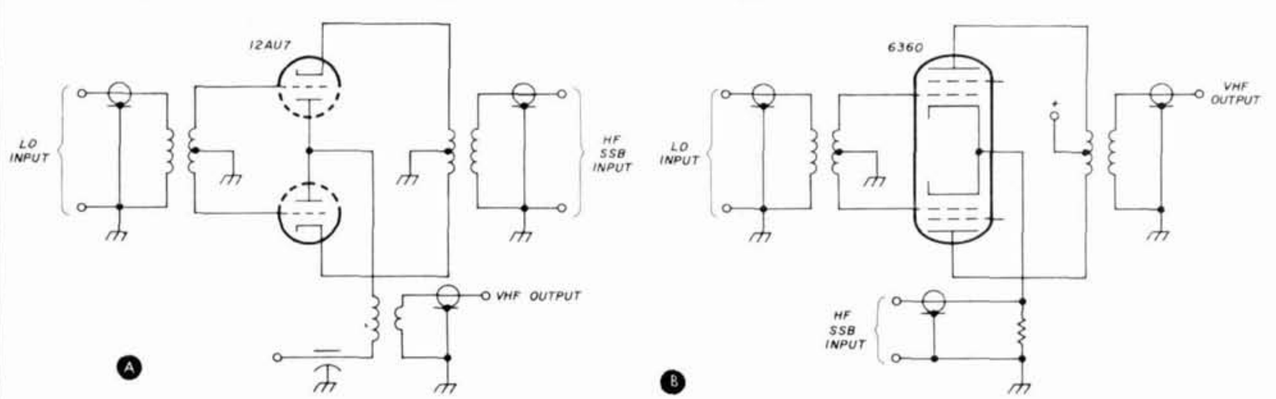


fig. 4. The right and wrong ways to make a balanced mixer. Shown at (A) is a doubly balanced mixer with a push-pull LO input and single-ended output, which isolates the LO from the output port. At (B) is the way it is usually done, push-pull in and push-pull out, which provides no isolation for the LO in the output.

5894 input capacitance. The other two, *C4* and *C5*, are separately tunable by front panel controls. These two capacitors could have been ganged into one control, but I did not bother to do so because large frequency changes are not frequent at my station. The position of the swinging link, *L13*, should be experimentally optimized with respect to *L14* for maximum grid drive to the 5894.

final amplifier

Stability of the 5894 final required that plate current be fed to the half-wave plate line through the two 100-ohm, 1-watt resistors shown in **fig. 3**. These resistors will not absorb any significant amount of 144-MHz power provided they are tapped onto the line at the point of minimum rf voltage. The exact point can be determined by sliding a screwdriver blade along the line and noting the point where detuning is minimum.

The 100-microampere grid meter can be switched to also function as an rf output meter, or line sampler, for tune-up. Rf voltage is rectified by the 1N914 diode, which is very loosely coupled to the coax output connector. The 1N645 diode across the meter terminals prevents meter damage from accidental over-deflection.

Resting plate current of the 5894 is set between 35 and 40 mA by adjusting the dc grid bias to the vicinity of minus 26 volts. The bias adjustment pot, *R4*, is a front-panel control. Ten-meter drive is normally adjusted so that grid current appears on only occasional voice peaks.

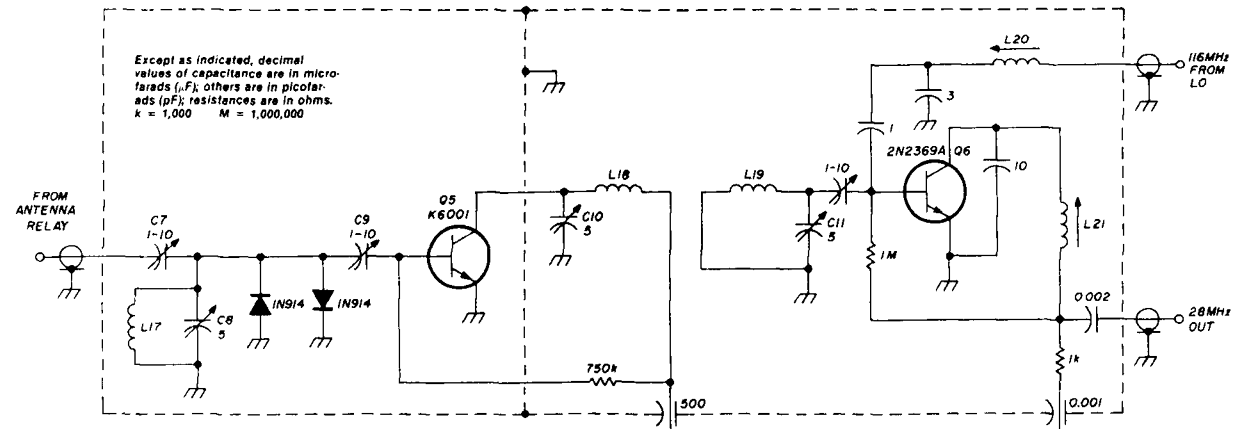
The position of the output coupling link is critical, and should be adjusted for maximum output to a 50-ohm matched nonreactive load under full drive conditions; that is, with about 50 microamperes of 5894 grid current.

receive converter

Fig. 5 shows the down converter, consisting of the rf stage, *Q5*, and the mixer, *Q6*. Bipolar transistors have a poor reputation for cross modulation immunity, but no problems with cross modulation have yet been experienced. There are many low-noise transistors that could have been used in the rf stage; the Microwave Associates K6001 was used only because it happened to be on hand. No neutralization was found to be necessary, and the noise figure turned out good without much time spent on adjustments. Collector current of the rf stage is about 1 mA, and the mixer runs at about 0.5 mA. The rf stage collector current can be disconnected by a front-panel switch, S3, to prevent cross modulation from strong signals. This switch is also useful for ascertaining that the received signal is actually a 2-meter station, and not 10-meter leak-through.

The three tuned circuits ahead of the mixer provide about 40 dB of image rejection. The image band is in TV channel 6, and 40 dB will not be enough in strong channel 6 areas. If trouble is experienced with channel 6 interference, an 87-MHz trap can be added to the converter input.

The 116-MHz injection for *Q6* is picked off *L9* by a very loosely coupled tuned circuit (*L7* in **fig. 3**). Less than a milliwatt of injection is needed. Mixer performance can be tested by disconnecting collector voltage from *Q5*. When this is done, receiver noise output should drop by at least 10 dB.



L17	3 turns No. 16 (1.3 mm) wire, 10 mm ID, 6 mm long	L20	0.85 μH. 12 turns No. 28 (0.3 mm) wire, close wound on 5.5-mm diameter slug-tuned form
L18	2 turns No. 16 (1.3 mm) wire, 10 mm ID, 5 mm long	L21	2.7 μH. 26 turns No. 28 (0.3 mm) wire, close wound on 5.5-mm diameter slug-tuned form
L19	3.5 turns No. 16 (1.3 mm) wire, 10 mm ID, 9 mm long		

fig. 5. Receive converter. Two-meter signals are amplified by Q5 and converted to 28 MHz by the mixer, Q6. The 1N914 diodes at the input are for overload protection.

The three trimmer capacitors *C8*, *C10*, and *C11* are peaked for maximum gain at 145 MHz. Capacitors *C7* and *C9* are adjusted for minimum noise figure from a 50-ohm source; these adjustments will not coincide with maximum gain.

power supply

The transverter requires 12 Vdc at about 65 mA, 12.6 Vac at 1.2 amps for heaters, 250 Vdc at about 30 mA, minus 50 Vdc at 1 mA for bias, and 800 Vdc at about 150 mA peak. If your transceiver is a tube type, or uses tubes in the final, these voltages can be obtained from the transceiver power supply, since the transceiver final will not be used when transverting. Also needed is a 12-Vdc source controlled by the transceiver push-to-talk switch for the transmit-to-receive change-over relays, RY1 and RY2.

construction

Old timers will recognize the cabinet and chassis as the remains of a Viking 6N2, a 6 and 2 meter a-m/CW rig manufactured by E.F. Johnson in the 1950s. However, any chassis of similar size can be used. The 6N2 was stripped down almost completely; about the only items left intact were the 5894 socket, the plate lines (which were shortened 2 inches, or 5 cm), and the plate-current meter. When rebuilt, the front panel ended up with a couple of empty holes; these were filled in with body putty, sanded smooth, and the panel repainted.

The usual common-sense VHF construction practices should be adhered to. Most of the rf bypass capacitors are 100 pF, as this value, with short leads, is approximately series resonant at 2 meters. The receive converter is built on double copper-clad circuit board and housed in a completely shielded box. The heterodyne oscillator is built on a 3 by 4 inch (7.6 by 10 cm) circuit board and placed in a shielded compartment located on the underside of the chassis to keep it away from final-amplifier rf. This also keeps it away from most of the heat, which would cause frequency drift of the crystal oscillator.

results

A spectrum analyzer was used to search for spurious products in the 0-300 MHz range. All were found to be more than 50 dB below full output. On-the-air reports of audio quality have been unanimously favorable.

The rig has been used on the air for some months now and many enjoyable contacts made. Without qualification it can be said that if you haven't tried VHF SSB, you are missing one of the best operating modes available to the Amateur.

ham radio