TRANSISTORIZED VFOS

IDEAS
CIRCUITS
CONSTRUCTION

Last issue, we described a power type variable frequency oscillator. Now let's go to the other extreme and examine the aspects of flea-powered oscillators using popular transistors.

—Lighthouse Larry

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**TRANISTORIZED Vfos**

**DESIGN AND APPLICATION**

The low cost transistor types, such as the G-E 2N1017, lend themselves to experimentation with oscillators operating in the broadcast frequency range. Inexpensive components are readily available and the frequency stability is excellent when good mechanical rigidity is employed in the construction. Frequency drift is practically nil after a minute or two of operation because of the absence of any discernible heat in the transistors, which vary within the ratings and away from heat sources. Dial calibration and frequency drift checks are simply a matter of zero-beating broadcast station signals.

A few flashlight batteries in series or parallel cells designed especially for transistors are easily power sources. In fact, a two-stage oscillator-amplifier circuit has such a low current drain that several hundred hours is obtained from the batteries even when the transistors run continuously, according to battery manufacturers. Obviously, the supply voltage regulation is excellent and hum-modulation of the VFO output because of AC tube heaters of inadequately filtered rectifier-type supplies is not a problem. Outlines and connections for most popular transistors are pictured below.

**Circuit Details**

A choice of several frequency-tuning circuits, all designed for the 0.5 to 7.5-megacycle tuning range, are illustrated on page 4. Flip-tuned coils in each circuit give considerable latitude in exact frequency coverage, but best coil "Q" is obtained with the slug well inside the winding. In Figure 1's and 3a, this 200-kilocycle tuning range is covered in two segments by switching additional capacity across the series-tuned coilantiparallel circuits. If an inductance-capacitor variable capacitor is available, the circuit of Figure 2a is suggested. Figure 2a shows the components required if you wish to use the 2N939 output coupler slug for tuning. The 2N1017 and similar transistor capacitors Gs may be changed to cover other tuning ranges. A Miller No. 301 oscillator coil is used for L1 in the Hartley circuit, Figure 1c. The 2N1017 oscillator circuit in Figure 2b is similar except that this tank circuit can be used to obtain a proper impedance match. Variable capacitors C1 and C2 are for tuning and zero-setting, or alignment. In circuits showing them, their winding has been tuned, or an available component will suffice. Various of these oscillator circuits operate the transistor base as RF ground. The low impedance output required to match the amplifier base is taken from the emitter, approximately comparable to a tube receiver following a driving, grid-coupled cathode plate amplifier. Voltage stabilizers provide a negative bias for the base element in both stages, although a separate battery could be employed. The divider resistance is the same proportion that the collector battery voltage divides into the output voltage. The output voltage from all circuits is inversely proportional to the square of the frequency, ranging from 1.3 to 1.0 volts RMS with a 6-volt battery. The output...
Fig. 1. Schematic diagram of the capacitor-tuned lineal tuned VFO. Variable capacitor C, is 220-μuf and C2 is 15-
μuf maximum. All chokes are 3153; 2.5 mm. Tapped switch S1 is 5-pole, double-throw, single-throw. All fixed capacitors
be left of dotted line are Shrader size. Other capacitors are disc capacitors. All resistors are 1/2 watt, ±10%. 

Fig. 3a

Fig. 3b

Fig. 2b

Fig. 4

Fig. 2c

Variable capacitors same on Fig. 3a. In Fig. 2c, L, is a Mini. M3s. 2900 broadcast band translator oscillator coil and the 0.1-
μuf by-pass capacitors are 200-muf paper. Any of these frequency determining circuits may be substituted for that in
Fig. 1. By connecting points 1-1 to 8 through 6 to corresponding connections on Fig. 1.

Fig. 2e

Optimal output circuits for the amplifier stage in Fig. 1. 
Cell L, is the same as L in Fig. 2a.

Mounting block for the looped coils.
Voltage rises in proportion to increases in this voltage, but stability will be improved if the oscillator transistor is not operated at maximum ratings. The amplifier collector output impedance is high enough to operate directly into the grid of a low-level mixer tube. If a coaxial connecting cable is used, the length should be limited to less than 18 inches. Degeneration introduced by the RF bypassing the resistor to emitter ground prevents stage coupling, and the use of a fixed capacitor across the output terminals reduces the harmonic output previously mentioned.

A tapped output circuit with link coupling for longer runs of coaxial cable, shown in Fig. 3a, substitutes a second Miller No. 2020 coil in place of the 2.5-mh RF choke in the amplifier collector circuit. A third such coil will form an impedance step-up transformer at the other end of the coaxial cable. The amplifier output also may be taken across the 2000-ohm emitter resistor and fed directly into a coaxial cable through a coupling capacitor, as shown in Fig. 3a. The approximate output voltage using this connection is 0.3 volts RMS.

**MECHANICAL DETAILS**

Size of these transistor oscillators is mainly dictated by the dimensioning of the dial mechanism and tuning medium employed. Bud CC-2107 aluminum MiniBoxes, 4 x 3 x 6 inches, easily house all components and the batteries. Bud CB-1027 51⁄2 x 41⁄2 x 11⁄2-inch deep miniature aluminum chassis can be used in all models. The oscillator coils should be rigidly mounted with the winding end at least 1 inch away from any metal. The metal end caps were removed from these coils and a mounting block made from 3⁄8-inch thick sheet plastic. Installation, drilled as shown in Fig. 4, is substituted. The tuning slug runs through the threaded portion of the hole into which the coil form is cemented. All wiring of chassis components, pictured in Figs. 5 and 6, was completed before the chassis was assembled 3 inches down from the top of the box. The Miller No. 10039 dial will support the shaft extension from an insulated coupling required when the insulated-ector circuit of Fig. 2c is constructed.

The slug-tuned oscillator unit, pictured in Fig. 7, requires extra depth for the coil and slug-drive assembly. A 13⁄4-inch thick brass mounting plate, also drilled according to Fig. 4, and a similar 11⁄2-inch thick sheet plastic bracket without threads hold the var-loop stick coil. Heart of the assembly is a slip-joint coupling made from three 4.00-brass 13⁄16-inch hex nuts soldered to the end of the loopstick slug screw after the brass mounting plate is assembled. Any excess solder is removed with a file so that the nuts will slide smoothly into the 13⁄16-inch hex inside a 11⁄2-inch length of flexible alignment wrench tubing (Watson No. 621-15-18). The tubing is then bolted, with the 11⁄2-inch zinc shown in Fig. 5, to the 1-inch diameter slug shown in Fig. 7. A 1-inch Scotch-tape mounting dial mounted at the end of the box. The dial shaft is shortened 13⁄16 inch overall. Removable covers in the assembly of this coupling should be removed to permit easy assembly of the tuning slug.

This model has the miniature chassis fastened to the side of the cabinet, permitting wiring to be done after the chassis and all small parts have been assembled. A similar battery mounting, described from 3 x 3 x 31⁄4-inch thin brass, holding the battery, as used in each unit, Bullseye flashlight battery holders, or a miniature battery box specially designed for powering transistors, may be installed instead.
3.5-MEGACYCLE VFO

A Transistorized VFO may be designed to operate directly in some circuits by employing transistors having an alpha cutoff frequency somewhat higher than the required lower frequency range. Although the Audio Amplifier (Fig. 6) used in this circuit is rated at 3.5 megacycles, when the inputs were reduced to 0.2 volts RMS, the 3N135 and 2N126 transistors operate satisfactorily at 3.5 megacycles. When the transistor was replaced by a 3N135, the 0.2 volts RMS, was obtained when 2N135 transistors were used in both stages. They have a minimum alpha cutoff frequency of 7 megacycles and "load" at 3.5 megacycles.

The low output voltage required that a vacuum tube class A amplifier, either tuned or untuned, follow the VFO in the transmitter to which it is connected. A 6AU6 or similar miniature pentode tube would provide sufficient output voltage to drive succeeding low level buffer and multiplier stages.

This oscillator also employs a series capacitor-tuned Colpitts frequency determining circuit shown in Fig. 9, with IB component values scaled down for this band. Variable capacitor C1, is used for setting the portion of the band to be tuned with bandwidth capacitor C2. Proper tuning is easy because the McMill 10026 panel dial covers the broadcast range in 9-kilo revolutions.

The "Q" of oscillator coil L1, should be made as high as possible. The form should be fused quartz, Pyrex glass, or similar tubing or coil with a low coefficient of expansion. A Centralab X-32 steelite pillar insulator coil form was used in this model. A winding length-to-diameter ratio of about 2.1 and space-round coil turns also should be used, rather than depend on the enamelled wire insulation, as would be the case with close-wound coils.

Construction of this oscillator, pictured in Figs. 10 and 11, is much the same as the broadcast band model in Fig. 3, except that the larger band setting capacitor, C4, is placed inside the chassis. The bottom of the chassis, as shown in Fig. 3, is occupied only by the 6AU6 socket, and at least 2 inches away from the surrounding metal. Two small 1/4-inch thick sheet plastic beads support both ends of the coil form. The coil wire should be heated as it is wound so that it will shrink on the form when cooled. A soldering lug is placed in a small groove filed in each plastic coil support and held with plastic cement when assembling the 1/20 x 1/4-inch long machine screw which is driven into each threaded end of the coil form.

Extra self-tapping sheet metal screws may be driven into the cabinet flanges and the rear of the chassis for added rigidity. These holes should be drilled before the battery holder is fastened to that edge of the chassis.

Fig. 7. Side view of the slug-tuned oscillator showing slug drive and mounting blocks supporting coil 2 inches below chassis. Nearest chassis lip was removed to show coil part placement.

Fig. 8. Detail view of slip-joint coupling. Straighten lugs of coupling screw to run true with slug, if necessary.

5
N.P.N type transistors, such as the G.E. 2N178 and recently announced 2N167, may be operated in all broadcast range VFO circuits simply by reversing the battery polarity. The 2N167 has a 5-megacycle minimum cutoff frequency and is rated for 30 volts maximum on the collector. It also is applicable for the 3.5-megacycle oscillator, with a higher supply voltage.

Warmup frequency drift measurements were made on a batch of three oscillators, using a laboratory-type frequency counter reading to the nearest cycle. For comparison purposes, drift of the TRI-RANGE VFO (see G.E. HAM NEWS, Nov. 11, Nov. 21, and a BC-896 surplus command transmitter) were checked. The test results, listed below, show the better time required for frequency stabilization in transistor oscillators.

<table>
<thead>
<tr>
<th>Time</th>
<th>2 min</th>
<th>10 min</th>
<th>30 min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cycle-count 0.5-jc</td>
<td>-5</td>
<td>-12</td>
<td>-15 cycles</td>
</tr>
<tr>
<td>Cycle-count 2.5-jc</td>
<td>-35</td>
<td>-55</td>
<td>-50 cycles</td>
</tr>
<tr>
<td>Cycle-count 2.5-jc</td>
<td>-95</td>
<td>-120</td>
<td>-90 cycles</td>
</tr>
<tr>
<td>BC-896 VFO</td>
<td>-19</td>
<td>-45</td>
<td>-90 cycles</td>
</tr>
</tbody>
</table>

Fig. 9. Schematic diagram of the 3.5-megacycle VFO. Variable capacitor C1 is 300-uf and C2 is 3 to 15-uf maximum, depending on bandwidth desired. Coil L1 is 54 airwounds, 60 turns of No. 24 enameled wire spaced-ground 2½ inches long on a 1-inch diameter x 2½-inch long mica sleeve. Ferrite core (Centralab X-321), L2 is a 3.5-ohm RF choke. All capacitors except the 0.01 and 0.001-mfd disc ceramics are shielded type.

Fig. 10. View of the 3.5-megacycle VFO showing output transformer on oar side. Coil breakout is fashioned from ¼-inch thick sheet plastic with coil ensurine being 3½ inches above chassis.
In spite of the many hours I spent poring over the records of past G-E HAM NEWS DX Logs and ARRL Official Country lists, a couple geraniums in the form of mis-placed countries crept into the latest DX LQG, published in the January-February, 1956 issue. Under “Official Countries,” DXV, Phillipines, on page 2, should be Dominica, not Antic; and CDS, Lebanon, on page 6, is Aena, not Africa. A clarification is in order for PK, Indonesia; and Java, PRT, 2, 2, 1/3 on page 5. These actually are the same country, but the ham on amateur communications with these prefixes is still in effect, according to recent information. A recent addition to the Official Countries list, Trotinl, FFB, also has come to my attention. This island is located about 360 miles south east of Madagascar, in the Indian Ocean. EC2CC credit will be given starting May 1, 1956, for confirmations dated on or after November 15, 1955. Many thanks to sharp-eyed Ed Hopper, WZG7, and Cedrick Justia, W5E3EB, for helping me keep the listings on the beam.

While we're on the subject of DX, here's a tale for your mon-Fee-heard-everything-far. I recently received a very nice note from Russ Bues, W5HDP, in which he explained the operation of his recently organized "OUTGOING DX QSL BUREAU SERVICE." For a nominal charge, you put all your QSL cards going to DX stations in one envelope and send it to him. He then collects all cards going to the established foreign QSL bureaus and sends them first-class or air mail once each week. Russ says that this provides a fast and efficient forwarding service, at less than half the cost, for all routine cards which you normally would send individually to these QSL bureaus. It is not intended for those rare countries where you usually send your QSL directly to the amateur. For further details on this non-profit DX QSL bureau-in-reverse, send him a stamped, self-addressed envelope.

It's happened again! Someone says he just finales printing an issue which describes some gadget which has been carefully designed to do a specific job and—along comes a flood of mail asking whether that gadget can be slightly changed to work on other frequencies—with higher voltages—or different tubes. This time the TRAFFIC TUNEScope was introduced in the March, 1956 issue of G-E HAM NEWS, is on theopping.

Many radio amateurs wish to substitute a 2.5 meter vacuum tube in the Hammarlund 3X, 35-8X, for the 35-8X unit specified for C5, and cover 5.5-40 megacycles in two ranges, same coils specified for L5 and L6, plus changing C5 and C10 to 50 meg., then buy the appropriate tuning ranges of 5.5—3.0 and 3.7—4.0 megacycles. Those 144-megacycle hounds who require more bandwidth than the 15 dial divisions obtained with the original 5.5-4.5-megacycle range also may change C5 or C10 to 30 mmf and set 4.11 megacycles on 100 on the tuning dial by adjusting either C5 or C10. If your main tuning capacitor has nonlinear shaped plates, 344—144 megacycles will cover about 30 dial divisions.

If you plan to do just Field Day and potable hamming during the summer, conforming these QRO's can be a problem. An easy solution—try a stack of Log Form QSL cards and use an insulating rubber stamp to imprint your portable call letters and location. They will continue to be available from the above address, in packages of 500 cards for $1.00, postpaid.

The word has gone out! The G-E HAM NEWS SECOND BOUND VOLUME, containing all issues printed in 1953 through 1955 (Volume 6, No. 1 to Volume 8, No. 6), is now available! My fingers took a beating typing addresses on the more than 500 postal cards I sent notifying persons who had written and asked for this. If you'veever seen or heard of the G-E HAM NEWS FIRST BOUND VOLUME, every five years we bind all issues from that preceding period into a convenient 3 x 1/2-inch book covering still black bletterette, gold-stamped covers. Also included is a handy cross-index listing of all information contained there-in. Only a limited number of copies have been prepared, so was the case with the G-E HAM NEWS FIRST BOUND VOLUME, now extinct. The original price for that volume, two dollars per copy, postpaid, has been maintained for this new book by holding produc- tion to the very minimum.

If you live in the continental United States, Canada, Alaska, Hawaii, and the Panama Canal Zone, send your order to Lighthouse curly, Tujpe Department, General Electric Co., Schenectady 5, New York, U.S.A. Canadian orders also may be sent to me at the Canadian General Electric Co., Burlington Tube Marketing Section, 830 Lansdowne Avenue, Toronto, Ontario, Canada. In all other countries, write me at the International General Electric Co., 570 Lexington Avenue, New York 22, N. Y., U. S. A.
### Technical Information

The G.E. Type 2N107 is an inexpensive diffused junction P-N-P germanium transistor for audiotrons, experimenters, hobbyists and hams. The G.E. Types 2N135, 2N136 and 2N137 are also junction germanium transistors intended for RF and IF service in broadcast receivers. All are of hermetically sealed construction.

### ABSOLUTE MAXIMUM RATINGS: (25°C)

<table>
<thead>
<tr>
<th>2N107</th>
<th>2N135</th>
<th>2N136</th>
<th>2N137</th>
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<tbody>
<tr>
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<tr>
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<td></td>
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</tr>
<tr>
<td>12</td>
<td>30</td>
<td>20</td>
<td>10 volts</td>
</tr>
<tr>
<td>Common Emitter (( R_{e} ) = 100 ohms), ( V_{ce} )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>30</td>
<td>20</td>
<td>10 volts</td>
</tr>
<tr>
<td>Collector Current, ( I_{c} )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>30</td>
<td>50</td>
<td>100 ma</td>
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<tr>
<td>Emitter Current, ( I_{e} )</td>
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<td></td>
</tr>
<tr>
<td>100</td>
<td>30</td>
<td>50</td>
<td>100 ma</td>
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<tr>
<td>Collector Dissipation</td>
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<td>100</td>
<td>100</td>
<td>100 w</td>
</tr>
<tr>
<td>Storage Temperature</td>
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<tr>
<td>85</td>
<td>85</td>
<td>85</td>
<td>85°C</td>
</tr>
</tbody>
</table>

### ELECTRICAL CHARACTERISTICS: Design-coneer Values

| Common Base, 25°C, \( V_{ce} = 3.5 \) |
| Voltage feedback ratio (input open circuit) | 1 | 100 |
| \( h_{fe} \) |
| 1 | 100 |
| Output Capacitance \( C_{o} \) |
| 40 | 11 | 14 | 14 mfd |
| Alpha Collector Frequency, \( f_{ca} \) |
| 5.0 | 5.5 | 5.5 | 10 mhz |
| Minimum Alpha Collector Frequency, \( f_{cm} \) |
| 0.5 | 0.5 | 0.5 | 1 mhz |
| Collector Current, \( I_{c} \) |
| 10 | 5 | 3 | 5 vu |
| Base Current amplification (Common emitter, \( f = 200 \) CPS) |
| 20 | 20 | 40 | 60 |

### TYPICAL OPERATION: (Common Emitter, 25°C)

| Collector Voltage |
| -5 | -5 | -5 | -5 volts |
| Emitter Current |
| 1.0 | 1.0 | 1.0 | 1.0 ma |
| Frequency |
| 30 | 20 | 31 | 33 db |

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