OPERATING G-E HI-FI TUBES AS MODULATORS

By P. H. Notholt, WQFA, and R. E. Mart

The High Fidelity audio equipment boom has spurred development of several new tube types—and improvements in existing types—for audio power amplifier service. Thus, consumers now have a broad choice of highly efficient tubes for plate modulator service in their transmitters.

The new audio tubes shown at the right are the G-E Receiving Tube Department's new family of high-performance power pentodes designed for both monophonic and stereo high fidelity audio equipment. Keeping pace with the trend to the "miniature" shape in audio equipment, these tubes pack more power capability into compact envelopes than ever before.

A newly developed five-ply bonded plate material (see cross-sectional drawing, Fig. 1), permitted sputtering the plate dissipation in the 6LE-6GC to 30 watts, as compared to 24 watts in the 6LE-6GB and older versions. A dramatic demonstration of this new plate material's capability can be seen in the photo showing a 4LE-GB and a 6LE-6GC, running side-by-side with each plate dissipating 80 watts! Note the "hot spots"—actually a bright orange in color—on the 6LE-6GB plate at left. The new five-ply plate in the 6LE-6GC, at right, is uniformly heated to a dull red color (although it appears black).

The new 7S61 beam pentode—electrically similar to the 6LE-6GC, but with a low-lose, mini-sized base—has the five-ply plate too. Another new pentode with the five-ply plate, the 7S67 for audio amplifiers in the 20-30 watt power range, packs 18 watts of plate dissipation into an envelope having a seated height of only 8 inches. The 7189A miniature pentode also has a plate made of the five-ply material.

The 6620 and 7189A pentodes—plus the new 6527 twin pentode, which is equivalent to two 6527's in one envelope—will soon be available (continued on page 7).

COMPARISON of plate size is the new 7S65 metal beam pentode (left), and the 7189A miniature beam pentode (right). The tubes have design maximum plate dissipation ratings of 18 and 12.3 watts, respectively.

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—Lighthouse Larry

NEW G-E 7S81 beam pentode with low-loss base, and the 6527 twin beam pentode (right). Both the 7S81 and the 6527 are only 3 1/2 inches in height when seated in sockets.
COMING NEXT ISSUE . . .

The TC-75, a compact 15-watt 5.8 to 40-
megacycle mobile transmitter/converter (tucked under the dash of the author's car, above) will be described by W4YKL. This
rig is only 3 inches high, 7 inches wide and
5 inches deep. It has five tubes and, with a
modern external power supply, draws only 3
amperes from a 12-volt electrical system.
Don't miss this issue, which also will
announce the recipient of General Electric's
1969 Edison Radio Amateur Award for out-
standing public service.

G.E.'S LME DEPARTMENT . . .

WARANU, W2LST and W2IQG, three of
the authors in this issue, all hail from Gen-
eral Electric's Light Military Electronics
Department, with headquarters in Utica,
New York. This department designs and
builds an impressive variety of electronic
equipment for the U.S. military services.
Included in their products are armament
and control systems, radar, countermeasures,
communication and navigational equipment
for airborne weapons. We can't go into more
details here, except to say that this depart-
ment also participated in the development
of the synchronized communications system,
better known as double sideband, and now
used by many radio amateurs.

NOTE: The accuracy of any information or statements
herein appears to have been under any punctual General
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ADDRESS YOUR QSL'S . . .

Make sure you fully address all QSL cards —
operator's name, number and street, city,
zone and state — you mail to other radio
amateurs. Don't just address them "Amateur
Radio, WVXJ, 3000 W. 17th Ave.,
Anytown, Ky. 40001." For those QSL's you
may wind up in the "dead letter" file. In some past issues, there
have been radio amateurs sorting stuff,
and they may watch for poorly addressed
QSL cards for amateurs they know, but
don't count on it.

We understand that some amateurs file a
change of address form with their local post
office, giving just their call letters and city
as the old address, and their house number,
street and city as the new address. This
helps delivery of incoming QSL cards with suffi-
cient addressing to you.

NEW ADDRESS FOR G-E HAM NEWS

Effective with this issue, the back-page
sign-off on the last few issues has been
changed from Schenectady, New York, to the
headquarters of General Electric's Receiving
Tube Department in Owensboro, Kentucky.
Please address your communications to G-E
HAM NEWS direct.

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Lighthouse Berry
(Colnel, that is)
ALL-BAND BALUN COIL

By Carl Byler - K2HDF*

Recently the writer was faced with two problems: 1. Matching the pi-network (unbalanced) output of a transmitter to a doublet (balanced) antenna.

2. Limited finances.

After considerable design work and testing, the All-Band Balun Coil was found to be the answer to the first problem without aggravating the second problem.

THE FEEDLINE BALANCING PROBLEM

is common to many radio amateurs since the pi-network is widely employed in transmitters. It has several advantages, among them being low harmonic output to prevent interference to nearby television receivers.

Also, balanced antennas — half wave dipole (doublet), Yagi beams with split driven element, horizontal trap antenna, etc. — are very popular. Since 72 ohm transmitting twin-lead is available at a lower price than coaxial cable — especially the RG11/U type — the balun was built into the transmitter and 72 ohm twin-lead connected from the transmitter to the antenna. The placement is not critical; the balun could easily be located some distance from the transmitter and fed with a coaxial cable (but this defeats our original purpose).

This balun represents a simple auto-transformer, tuned to resonate at approximately 14 megacycles by the distributed capacitance of the coaxial cable in the top half of the coil. The Q of the resonant circuit is approximately 200 (hence the low loss). When loaded with a 72 ohm load, the selectivity of the tuned circuit is broadened out to approximately a 50-megacycle bandwidth. The transmitter signal is coupled, via the coaxial cable of the top half of the coil, to the bottom half, which is simply a coil to ground. However, this bottom coil is inductively coupled to the top coil (with essentially unity coupling). Each coil feeds one side of the balanced output. Since each half of the coil has equal inductance, the output will be balanced.

CONSTRUCTIONAL DETAILS

The balun coil are shown in Fig. 1 and the side view photo. The phenolic board is drilled for the cable, chassis type coaxial cable connector (RO-239) and terminal posts. The coaxial cable for each coil is threaded through the holes and then soldered connections are made. Approximately 30 feet of RG-29/U cable are required for the balun illustrated.

The RG-59/U coaxial cable, used happened to be available. Actually, the attenuation would be slightly less with a larger coaxial cable; also the maximum voltage ratio was increased (see page 6).

FIG. 1. SCHEMATIC DIAGRAM and constructional details of the balun coil. One side of the 72-ohm balanced output connects to the shield of the coaxial cable in the upper coil, the other to the center conductor. Inner and outer conductors of the coaxial cable in the lower coil are connected together at each end, and grounded at the bottom end.

*K2HDF — is an engineer with the light Military Electronics Department, General Electric Co., Viera, N. Y.
SIMPLIFIED COIL DESIGN (Part I)

By R. H. Bealridge, W2DQ-

PROBLEM — HOW TO WIND COILS accurately for specific amateur radio applica-
tions. Solutions:

1. Calculating the coil inductance and di-

mensions from the formula

\[ L = \frac{2.54 \times 0.00348}{J^2 \times D} \text{ H} \]

— too complicated; forget it.

2. Estimating inductance with resistance charts, plot a coil nomograph. Usually after winding, finished coil must be proxied to the correct inductance value to compensate for inaccuracies.

3. Simplified graphs which can be pre-
pared with equipment found in most amateur radio stations.

Solution 3 takes the "try" out of "cut and

try" coil winding. The materials needed are:

1) Log graph paper (K & K No. 309 — 110,

log 2 x 2 cycles, or equivalent); 2) calibrated receiver; 3) two-terminal oscillator (see Fig. 1 for a Franklin oscillator circuit); and 4) at least two calibrated fixed capacitors in the range of 20 and 150 muf. Access to a "Q" meter will permit all of the measure-
ments to be made with no additional equip-
ment; or, a calibrated grid-dip oscillator will

take the place of the calibrated receiver and
two-terminal oscillator.

Suppose a coil 1 inch in diameter and 1½

inches long, having 30 turns, is available; and our standard capacitors are \( C_{20} = 20 \) muf, and \( C_{150} = 150 \) muf. Connecting the

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cation and Navigation section of General Electric's

Light Military Electronics Department, Utica, N. Y.

FIG. 1. SCHEMATIC DIAGRAM of a Franklin oscill-

ator with which the measurements outlined in the

text may be made. All resistances are in ohms, all

capacitance values in muf, unless otherwise specified.

Capacitances \( C_1 \) and \( C_2 \) should be as small as will

permit maintenance of oscillations, usually 1 or 2

muf each. Values for \( C_4 \) are given in the text.

coil to the Franklin oscillator, we can find the

resonant frequency by locating the fre-

quency of oscillation. If, with \( C_{20} \) across the
coil, the oscillation frequency is measured at

say 9 megacycles; with \( C_{150} \) across the coil it

would be 8.5 megacycles. This information can

also be obtained by connecting the coil to a "Q"

meter; or measuring resonance of the coil across the test capacitors with the

grid-dip oscillator.

Plot this information on log-log graph paper and connect the two points with a straight line, as shown in Fig. 2. Note that to tune from 8.5 to 4 megacycles requires an approximate capacitance variation from 162 to 121 muf, or a spread of 41 muf. A total fixed, distributed and tuning condenser mini-

mum capacitance of 121 muf, and a variable capacitance of 41 muf would spread the 8.5-

(continued on page 6)

FIG. 2. GRAPH PLOTTED on log paper

for a coil, 1 inch in diameter and 1½

inches long, with 30 turns equally spaced.

The tuning range with a 140-muf vari-

table capacitor is approximately from 8.5
to 4 megacycles.

4
FIG. 3. EXAMPLE OF DESIGN procedure for coils 1 inch in diameter and 1½ inches long, with total turns ranging from 100 (67 turns per inch) down to 3 (12 turns per inch) turns. Accuracy is excellent up to about 200 megacycles since method outlined in text takes into account distributed capacitance and other sources of error usually neglected because of calculation difficulty.

FIG. 4. FAMILY OF CURVES for coils wound on the National 38-50 slug-tuned cell form (¾ of an inch in diameter; 1½ of an inch winding length). The areas enclosed by dotted line to the left of each solid line indicates approximate change in inductance possible with 38-50 iron slug. Copper slug produces inductance shift in opposite direction.

FIG. 5. COIL DESIGN CHART for Combino 12-3 slug-tuned cell forms with combination iron/brass tuning slugs (¾ of an inch in diameter; 1½ of an inch winding length). The solid lines indicate the inductance when the brass slug is within the cell, and, the dotted broken lines indicate the inductance with the iron slug within the cell.
Simplified coil design (continued from page 4)

megacycle band over 180° shaft rotation. The same coil will tune from 7.0 to 7.2 megacycles with an approximate capacity variation from 560 to 500 mfd. This capacity change is produced by a 1 mm total fixed, distributed and tuned condenser, minimum capacitance of 33.5 mfd and a 5-mm variable would spread the megacycle band over 180° shaft rotation. If the distributed and input capacity, add up to 12 mm, a 150-mfd variable will tune both the 3.5 and 7-megacycle bands. A parallel 50 mfd variable and a fixed 100 mfd capacitor would make it impossible to tune the circuit to 7 megacycles, and the use of a 50 mfd variable alone would prevent inductance tuning to 5 megacycles. If the total input, output, and distributed C equals 15 mm, the coil will tune to 10.5 megacycles and will drive a doubler to 21 megacycles.

The system can be further expanded by plotting charts with different parameters as shown in Fig. 9, which illustrates a typical family of curves for coils 1 inch in diameter and 14 inches long.

Graphs for each individual coil of given number of turns are constructed as described. Note that the spacing between the graphs for the coils is proportional to the log of the number of turns. A slight slope change and bending of the individual coil plots is noted as the frequency approaches the natural resonant frequency of the tuning element, due to the increased proportional effect of the distributed capacitance, coil leads and terminals, and other factors impossible to eliminate and difficult to calculate in practical coil problems. These factors are usually neglected on the assumption that, makers of curves do not lose for practical applications requiring accurate calculations of small inductances.

Precise determination of coil parameters can be obtained by limiting the use of a given chart to a 10-4 to 10-1 turns ratio when determining resonances from data taken with a few turns. Figs. 4 and 6 show a similarity of curves for widely used commercial coil forms. The inductance variation made by positioning the slots as illustrated by the dashed lines.

All combinations of coils such as B & W Miniductors can be made from a couple of insulated lengths of ordinary magnet wire. The fact that length and number of turns vary, changed simultaneously, should not void the chart; the slope remains the same but the relationship between graphs of the coils will be slightly changed.

A number of similar charts may be rapidly prepared. From two or more experimentally plotted graphs of individual elements approximately within the desired range, a family of curves may be drawn to permit accurate selection of the desired tuning element. Frequency changers or power amplifiers thus may be accurately gauged.

Note that for a small increment of frequency, such as a typical amateur band, the use of fixed capacitors to set the operating point and a small variable inductance to control the plate will give essentially straight line tuning. The tuning of circuits with straight line tuning is no problem. As changes for progressively larger power coils or doubler coils all have the same slope, the choice of capacitors and inductors to swing and track tuned circuits becomes elementary.

Put it will occur in a simplified manner (see 6.)

ALL-BAND BALUN COIL

(continued from page 3)

Input (2000 volts for RG-59/U-U) would be higher. However, the loss in this model is negligible and the voltage across the line (under 1000 volts peak to peak for a one-kilowatt amplifier) is large enough to be kept in mind.

The baluns, such as RG-8/U, RG-11/U, RG-11/1, RG-11/U, RG-3/U, RG-36/U, and RG-50/U may be used in a balun of this type. The coil usually must be redesigned to compensate for the different characteristic of the cable, such as the outside diameter. The procedure in this case would be to adjust the length and size of the coil to resonate at 14 megacycles, while maintaining the required bandwidth under loaded conditions.

This balun was tested with both low level (signal generator) and high level (pair of RFI filters modulated by a pair of RFI filters) signals. From 18 through 30 megacycles, the voltage standing wave ratio (V.S.W.R.) was measured to be less than 1.2:1. The imbalance and inner losses were measured and found to be less than 0.5 decibels.

The chart is checked in high power by attaching two 300-watt light bulbs—one watt and 75-watt balanced line to the transmitter. The light bulbs used a 75-watt bulb to have the same resistance with less than 75 watts DC input to the RFI filters. As proof of the pastime, the writer finished and installed the assembly about 30 o'clock on a Friday night. After loading the transmitter into the balun into a simple double antenna, he called "QV" to the crowded 14-megacycle phone band. Before retiring at 11 o'clock, numerous QSO's were completed, with the strongest signal report received being 10 dB over S9.
OPERATING C-E HI-FI TUBES AS MODULATORS

(continued from page 13)

This hi-fi tube family. These tubes normally are rated in the technical data for push-pull class AB, operation at low harmonic distortion — about 2 percent — in high fidelity amplifier service. These ratings are given in the "HI-FI Service" column in Table 1.

Plate modulator service in amateur transmitters, however, usually permits the audio power tubes to be operated with higher distortion — up to about 10 percent — in the output. This allows the modulator tubes to be driven harder — up to the maximum ratings — with a resultant 25 to 50 percent increase in power output, depending on tube type.

A session with the "OPERATION CHARACTERISTICS" curve on the DESCRIPTION AND RATING sheets for these tubes revealed in the figures listed in the "Modulator Service" column in Table 1. These operating conditions are all within the "MAXIMUM RATINGS" listings for each tube type. A typical class AB amplifier circuit is used to obtain this data.

A 24-watt modulator with a single tube output stage can be built around a 6EZ7 twin triode, operated with 400 volts on the plate. Or, a pair of 6BG5's can be substituted if desired. For high power output at a moderate 400 plate volts, a pair of 735's will deliver 44 watts of plate power. These figures do not include output transformer losses.

Plot your new plate modulator around the above data. As makers of high fidelity equipment can verify, they really deliver the watts, and with low distortion too.

* WROGS is an engineer in the Technical Data Unit, and R. E. Max is the Manager of Engineering in OWENSCOMBE's Rf. tube Division, Owensboro, Ky.

![FIG. 1. CROSS-SECTIONAL VIEW OF G. E.'s new fivelply bonded plate material. The metal "sandwich" gives better heat conduction and realizes more conventional single-layer anode materials.](image)

### TABLE 1 — COMPARISON OF HI-FI AND MODULATOR SERVICE

<table>
<thead>
<tr>
<th>TUBE TYPE</th>
<th>PUSH-PULL CLASS AB</th>
<th>AMPLIFIER, VALUES FOR TWO TUBES</th>
</tr>
</thead>
<tbody>
<tr>
<td>6E27</td>
<td>6BG5</td>
<td>3 — 3E30</td>
</tr>
<tr>
<td>6EZ7</td>
<td>6BG5</td>
<td>3 — 3F30</td>
</tr>
<tr>
<td>6E35</td>
<td>6BG5</td>
<td>3 — 7235</td>
</tr>
<tr>
<td>Plate Voltage</td>
<td></td>
<td>400 V</td>
</tr>
<tr>
<td>Source</td>
<td>250 V</td>
<td>250 V</td>
</tr>
<tr>
<td>Grid-Number 1 Voltage</td>
<td>11 V</td>
<td>11 V</td>
</tr>
<tr>
<td>Peak-plate Number 1 Voltage</td>
<td>22 V</td>
<td>22 V</td>
</tr>
<tr>
<td>Zero-Signal Plate Current</td>
<td>80 mA</td>
<td>80 mA</td>
</tr>
<tr>
<td>Maximum-Signal Plate Current</td>
<td>100 mA</td>
<td>100 mA</td>
</tr>
<tr>
<td>Zero-Signal Screen Current</td>
<td>4.0 mA</td>
<td>4.0 mA</td>
</tr>
<tr>
<td>Maximum-Signal Screen Current</td>
<td>15 mA</td>
<td>15 mA</td>
</tr>
<tr>
<td>Effective load Resistance, Plate-to-Plate</td>
<td>28.5 V</td>
<td>28.5 V</td>
</tr>
<tr>
<td>Total 50-ohm Output Power</td>
<td>2.5 W</td>
<td>2.5 W</td>
</tr>
</tbody>
</table>

*Without feedback.*

Power output figures quoted do not include losses in output transformers, coupling, or feedforward, and may be increased or decreased in practice.
A FEEDLINE TEST FOR TRANSMITTER PARASITICS

TRANSMITTERS that are stable under CW or no-modulation conditions sometimes break into parasitic oscillation or other instability when amplitude modulated. The test described here has proved useful in checking for instability during modulation peaks.

Ideally, transmitters should be tested feeding dummy loads before on-the-air operation. If such a test is made, one simple additional test permits a simultaneous check for parasitics. This modification consists of shunting the dummy load with a parallel-tuned circuit. If tuned to the operating frequency and having a moderate Q, the added circuit is electrically invisible at the desired frequency but very much in evidence at other frequencies. Thus a standing wave ratio (SWR) bridge will indicate a normal standing wave ratio if only a pure modulated output wave is present. If parasitics or off-frequency oscillation occurs during modulation, the SWR meter will kick because the tuned circuit (L-C) is not resonant at other frequencies. The test circuit used successfully at WAZANU is shown, Fig. 1.

If an antenna system is matched to a low standing wave ratio and resonant, the SWR meter by itself may be used to show the presence of spurious output on the feedline. This test is mainly useful to check massive errors and should not be considered a valid check for very low power parasitics and harmonics.

WAZANU is a component engineer with General Electric’s Light Military Electronics Department, Utica, N. Y.

FIG. 3. BLOCK DIAGRAM of parasitic test circuit. Tuned circuit LTC is tuned to the operating frequency. Capacitor C should be about 5 nfd per meter (400 nfd for 80 meters; 45 nfd for 10 meters). Off-frequency emissions are shown up by an indication of reflected power on the SWR meter.

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