SIDEBAND HANDBOOK

First Edition
AN EDUCATIONAL PUBLICATION OF RECEIVING TUBE DEPARTMENT
GENERAL ELECTRIC
Owensboro, Kentucky
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INTRODUCTION

Interest by radio amateurs in single sideband and other suppressed-carrier transmission and reception techniques for voice communication has grown by leaps and bounds since some pioneering experiments were conducted by radio amateurs back in the 1940's.

And a large part of this pioneering happened right at General Electric, where scientists (who also were radio amateurs) at General Electric's world-famous Research Laboratory developed wide-band audio frequency phase-shift networks.

These patented networks made possible the generation of a single sideband, suppressed-carrier signal at high radio frequencies. They simplified the design of single sideband transmitters by eliminating additional circuits required to convert the SSB signal usually generated in a low frequency filter up to the operating frequency.

From this key research, the design and construction of simple phasing type projects which have been described in G-E HAM NEWS followed. These articles include the famous "SSB Jr.," 5-watt SSB transmitter; the "Signal Slicer" receiving adapter; and similar circuits. Our records show that thousands of radio amateurs constructed their first SSB equipment from the original G-E HAM NEWS designs.

And, again in the 1950's, pioneering work by radio amateurs at General Electric resulted in still more simplification of suppressed-carrier transmitters by using the double sideband techniques evolved from synchronous communications studies made by General Electric.

All of this wealth of background material from G-E HAM NEWS has been reprinted in this first edition of Lighthouse Larry's Sideband Handbook. In addition, later information on many of the articles on sideband has been compiled and follows the reprints of the original articles.

We've also included some key articles on subjects related to sideband in this handbook, such as linear amplifiers, RF and audio accessories, and power supplies. Especially noteworthy is the original G-E HAM NEWS articles on Dynamic Power Supply Regulation which prompted more radio amateurs to use high-capacitance filter.

We dedicate this book to the radio amateurs who have pioneered and furthered suppressed-carrier communications techniques. And, at G-E HAM NEWS, we're proud of our small part in making sideband in amateur radio a success.

73,
—Lighthouse Larry
CHAPTER I — HETERODYNE AND MIXING
What About Mixer Circuits? From November-December, 1956 I-5
Using the G-E 6A5A Beam-Beam Tube I-11

CHAPTER II — SIDEBAND GENERATORS AND EXCITERS
SBE, Jr., 3-Watt SSB Transmitter From November-December, 1950 II-1
600-Watt Double Sideband From May-June, 1959 II-2
Double Sideband Junior From March-April, 1958 II-13
KSDET 6166 Double Sideband Transmitter II-24
DSB Considerations and Data II-31
Heterodyne Exciter With 6BC8 Twin Pentode Balanced Mixer II-33
Heterodyne VFO for 9-Mc SSB Generators II-36

CHAPTER III — TRIODE LINEAR AMPLIFIERS
Lazy Linear Amplifier With Push-Pull GL-811A Triodes From July-August, 1949 III-1
Power Peaker Linear Amplifier From September-October, 1952 III-16
Compact Triode Kilowatt From September-October, 1959 III-26
Comparisons of DSB and SSB III-27
Maximum Ratings and Typical Operating Conditions for Transmitting Tubes III-28
Computing Driving Power for Transmitting Tubes III-29
Frequency Limitations on Transmitting Tubes III-30

CHAPTER IV PENTODE LINEAR AMPLIFIERS
Kilowatt Grounded-Grid Linear Amplifier With Parallelized GL-515’s From November-December, 1959 IV-1
600-Watt 45-Band Amplifier for CW, AM or SSB Linear Source From November-December, 1954 IV-2
Technical Tidbits — Cautions — Screen Grid at Work IV-15
Bandswitching Mobile Linear Amplifier with GL-4D21/4A-125-A’s From November-December, 1966 IV-19
Technical Tidbits — Proper Tank Circuit Padding IV-20
Proper Tank Circuit “Q” and Leading IV-25

CHAPTER V SIDEBAND RECEPTION AND ADAPTERS
The Signal Slicer From July-August, 1951 V-1
Packaged Selectivity From March-April, 1957 V-13
Mobile SSB Reception V-18
Bandswitching Mobile Converters V-19
Single Band Mobile Converters V-27
Converting the BC-455 Receiver V-26
12-Tube Adapter for Single Sideband Reception From November-December, 1948 V-36
The G-E Model YRS-1 Adapter for Single Sideband Reception V-36
CHAPTER VI RF ACCESSORIES FOR SIDE BAND
Solid High-C VFO From July-August, 1959 VI-1
The Hamscope From September-October, 1956 VI-5
The Duplex From March-April, 1953 VI-14

CHAPTER VII AUDIO ACCESSORIES FOR SIDE BAND
Restricting Frequency Range in Transmitter Audio Systems From July-August, 1949 VII-1
Restricted Range Speech Amplifier From September-October, 1949 VII-5
Laparoscopic Compressor From May-June, 1960 VII-17
High Attraction Low-Pass Audio Filter From March-April, 1965 VII-17
Comb Monitor From September-October, 1968 VII-18
Power Control Panel From March-April, 1964 VII-20

CHAPTER VIII POWER SUPPLIES FOR SIDE BAND
About Power Supplies From January-February, 1954 VIII-1
Two High-C Power Supplies VIII-4
Designer's Corner — Designing Power Supplies VIII-8
Dual-Voltage Power Supplies From September-October, 1967 VIII-10
High Power Mobile Power Systems VIII-20
Mobile Power Supply Ideas From July-August, 1960 VIII-21
Construction Details for 3-Phase Distribution Stepup Transformer VIII-26

CHAPTER IX TRANSMITTING TUBE TESTING AND OPERATING HINTS
Simple Test Procedures for Popular Transmitting Tubes IX-1

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I-4
### THE MIX-SELECTOR CHART

<table>
<thead>
<tr>
<th>SSU GENERATOR</th>
<th>SBG SIGNAL</th>
<th>CW OSCILLATOR</th>
<th>AMATEUR BAND</th>
<th>SBB SIGNAL</th>
</tr>
</thead>
</table>

Watch your signals when designing new multi-band SSU mixer or heterodyne-type VFO for your present CW or AM transmitter. Our MIX-SELECTOR chart explains why signal frequencies employed in heterodyning must be carefully selected to avoid the transmission of spurious signals along with your desired signal. Examine our typical signal combination examples—then try working out your own ideas on a logarithmic graph paper.

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**What About Mixed Circuits?**

From November-December, 1956

Mixers (modulators) can have simple or complex, single-ended or push-pull (balanced) circuits, operate at low or high level, and employ single or multi-element tubes. A single-ended dode minor (the circuit used in most UHF television tuners) and the balanced dode minor (two of them are used in the SBG, Jr.) are more footproof than multi-element tube mixers, but no power gain can be obtained, and the dode minor is likely to have high harmonic output. This is the price of simplicity plus low distortion in the output signal.

Although a triode tube may be used as a mixer, both input signals must be applied to the control grid, or to the control grid and cathode respectively. Even though it is possible to build a low-noise mixer in a triode, the output signal is apt to be lower than in a dode circuit. The operating conditions must be carefully controlled to obtain maximum exploitation of the output signal. This applies equally to pentagrid mixers and the multi-grid tubes designed specifically for mixer service in superheterodyne radio receivers. Mixer circuits for these tubes usually feed each mixer input signal into a separate grid, where the signals are combined in the tube's electron stream. A circuit tuned to the desired output signal frequency is connected to the tube's plate. Each of the mixer tubes' input signal grids should operate in the Class A region for lowest harmonic output, since the amplitude of input signal harmonics generated in the mixer depends on the operating point and amplitude of the input signals. Even though a pentagrid mixer stage requires critical adjustment for maximum distortion, it will have a lower harmonic output when properly adjusted than the other types of mixers.

Since normal Class A amplifier efficiency is only 25-30 per cent, that of a Class A mixer is even lower, much of a properly operated mixer tube's input power is dissipated instead of appearing as output power. For this reason, a high-level mixer tube will have much lower power output than the same tube in a linear amplifier. Even the minimum power output from a low-level mixer stage can be brought up to a respectable level in one high gain linear amplifier stage.

Even though single-ended mixer circuits are widely used, the balanced mixer circuit offers the inherent advantage of minimizing the fundamental and certain harmonics of the input one, and possibly both, input signals. Usually this type of mixer can be precisely balanced for maximum attenuation of the fundamental or a particular harmonic of either input signal, but not all simultaneously. In general, a properly operated balanced mixer using pentagrid tubes will have low harmonic generation properties, but other mixers will, whether balanced or otherwise.

The actual circuit for a pentagrid balanced mixer may have both pairs of input signal grids connected to separate push-pull tank circuits, with the tube plates connected in parallel to a single-ended tuned circuit, or one pair of grids may be connected in push-pull, the other pair of signal grids in parallel, and the plates connected to a push-pull tank circuit. The mixer input signal on which cancellation is desired should be applied to the signal grids through the push-pull tank circuit. However, under certain conditions, it is possible to cancel out the undesired signal in the desired frequency range. Any balanced mixer may become unbalanced due to component aging and operating voltage changes, so a mixer balancing adjustment should be provided in the circuit. Finally, the pentagrid balanced mixer circuit may help reduce those spurious signals which cannot be readily attenuated by tuning or trap circuits, or by depending on the skirt selectivity of cascaded tuned circuits at the main output frequency.
Single Sideband

The rapidly increasing interest in single-sideband transmission and reception is the amateur bands
first drawn attention to the basic differences between single-sideband and double-sideband
operation in wideband non-coherent transmitters. A conventional RF system used in CW and AM
transmission would yield a blank diagram of the usual AM or CW rig. Fig. 1, shows the RF tape lineup
with RF as the main element, often followed by buffer
amplifiers which then drive one of more
amplifier stages at the output frequency. Modulation
usually is applied to the final RF amplifier stage in
one of several ways which differ mainly in the amount
of audio power required for the modulation process.

![Diagram](image)

**Fig. 1** Block diagram of a typical multi-stage transmitter to which a CW or AM system may be connected.

**GENERATING SINGLE SIDEBAND SIGNALS**

What are the "sidebands" usually associated with

voice modulation of a transmitter? Basically, they are
groups of radio frequencies which result from mixing

or modulating a fixed radio frequency signal with one or

more audio signal frequencies. These signals add to

and subtract from the fixed frequency to form the audible

signals as described above, mentioned groups of closely related radio frequency signals

are referred to as the "sidebands." The number of

individual signals present in both a single sideband

at any one time depends upon the number of

individual signal frequencies present in the modulat-

ing signal.

Prolonging the mysteries of present-day single-sideband

transmitters brings forth a multitude of other terms such as

sideband filter, phase-shift networks, balanced

modulators, etc. Understanding single sideband

is further complicated by mention of two systems of gener-

ating a single-sideband suppressed-carrier signal

which we will (all SSB in the balance of this discus-

sion): (1) the filter system, and (2) the phasing system.

In both systems, SSB signals are derived from

amplitude-modulated signals. In the filter system, an

amplitude-modulated signal is passed through a filter

which attenuates one of the two sets of sidebands

characteristic of amplitude modulation. The phasing

system couples a set of o amplitude-modulated signals

of the same frequency, in a 180-degree phase

relationship. The sideband frequencies are

reduced while the other is cancelled. In either system, it

is necessary to balance the output of the filter or the

source of a signal that would otherwise be a completely

standard amplitude-modulated signal. When properly

adjusted, both systems will deliver the same type of

output signal.

Obviously, the filter requirements in that system are

quite strict, since all desired signals in one set of sideband

frequencies must be passed, yet the signals appearing

in the unwanted set of sideband frequencies should be

attenuated at least 30 dB (1000 to 1) or more. The

required rate of filter selectivity is most easily

achieved at frequencies below 500 kilocycles. Thus,

many filter-type SSB transmitters now on the

air have the SSB generator circuits operating on

450 kilocycles, using either mechanical filters or other

type filters made from quartz crystals.

In the phasing-type SSB signal can be generated at

any desired output frequency, but it is inconvenient
to change the frequency range. In fact, it is difficult—

that is, cumbersome and expensive—to generate SSB

at a number of chosen frequencies and select one

by handswitching with either system.

A further limitation in obtaining an SSB output is the
natural center frequency of both filter and phasing

systems, such that harmonics of the SSB generator cannot

be utilized for desired audio frequencies. To some
to that end, several methods are employed. A

typical SSB generator yields an output signal which may be

utilized with an AM or SSB receiver.

We now have indicated, first, that components are

not readily available for a filter-type SSB generator

designed to operate directly on an amateur band,

that the phasing system can be used at any

desired output frequency, but does not lend

itself easily to conventional handswitching; and third,

that harmonics of the SSB generator signal cannot be

used. The practical solution to the band-changing

and adjustable-frequency SSB generator problem,

for the home constructor, is to employ the same principle

used in superhet receivers. That process is to

heterodyne an SSB generator signal, which may be

outside the amateur bands, to the desired amateur

frequency. The block diagram on page 1 shows the two

signal generating stages connected to a mixer stage.

**FREQUENCY CONVERSION**

Frequency conversion, also known as heterodyning, is

simply the process of combining two signals differ-

ently frequency to form two new additional signals having

frequencies which are, respectively, the sum and

difference of the two original signal frequencies.

The circuit in which heterodyning takes place is usually

called a mixer, convertor or modulator. (They are

essentially the same thing.)

There are many types of mixer circuits, but most will

generate harmonics of both frequencies being applied to

them (though the harmonic content of the output

signal is very low). Thus, many signal frequencies

may be present in the output of a mixer stage—the two

input signals, their sum and difference signals, and the

harmonics of both input signals.

All signals except the one desired output signal frequen-

cy must be considered as spurious signals. Therefore

adequate preselection must be used to prevent these

spurious signals from appearing in the transmitted

output.

An important step in ensuring adequate suppression of

spurious signals is to have at least two high-sensitiv-

ity tuned circuits resonant at the desired output

frequencies in the stages following the mixer circuit. If

each of these tuned circuits has a Q of 100, spurious

signals less than 0.1 percent of the output signal

frequency are then expected to be attenuated

quently the mixer output signal will be attenuated

more than 50 db (1000 to 1) in power). Spurious

signals within 10 percent of the output signal

frequency will be attenuated much less. Practically speaking,

any spurious signal frequencies within 10 percent of the

output signal frequencies should have fallen within this 10 percent range. or

they may appear along with the output signal to an

appreciable extent.

Since it already has been pointed out that most mixer

circuits will generate harmonics of the input signals,

these harmonic frequencies also should not fall within

15 percent of the desired output ( carriers which may be

located in any of the audio (carrier or 20-kilocycle

band). Since the phasing-type SSB generator circuit is

frequencey is not similarly restricted, the signal may

be located in any of the audio (carrier or 20-kilocycle

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The **LEGEND** on page 3 pictures the marks used for Identifying shielded and unshielded conductors and conductors in lines. Fixed frequency input signals are shown as black blocks whose sides are labeled "fixed frequency." Each fundamental frequency signal is identified with a figure "1," and the harmonics by numbers representing their order. The height of the lines and blocks decrease as the harmonic orders increases to illustrate the decreasing relative importance of the higher order harmonics as opposed signals. Frequencies from 1 to 10 megacycles are numbered on line 1 and indicated by vertical lines running down the chart. This frequency span covers most microphone bands and on which SSB techniques presently are employed. The U.S. amateur radiotelephone segments in each amateur band are identified by the solid black blocks on line 2, which are then carried down the chart in grey shaded bands.

The **FREEDOM DANGER ZONE**, previously described under **FREQUENCY CONVERSION**, is marked by the pink areas beginning at line 3 and running down on either side of each amateur band segment. The left margin of each pink area is con- densed to be 50 per cent lower in frequency than each phone band lower edge, and the right pink mark represents a frequency 10 per cent higher than the upper limit of the same phone segment. Of course, these danger zones apply only to the amateur band on which the desired mixer output signal is shown, for each harmonic using the chart. The **FILTER-TYPE SSB FILTER GENERATOR FREQUENCIES**

Low 4 shows the harmonic signals of a 6.0-megacycle filter-type SSB generator, beginning at 1.8 megacycles with its fourth harmonic. The 6.0-megacycle signal frequency must be determined to the amateur bands used, combining with the 1.8-2.6 megacycle harmonic signals. Low 1-2 shows a 1.0-2.6 megacycle filter-type SSB generator. The mixer or output signal can be obtained by operating on the lowest voice channel line. Variable frequency is shown as the solid black block marked "1" on line 3. Notice that the SSB generator fourth harmonic signal at 1.8 megacycles is within the freedom danger zone and may appear in the output. The strength of this spurious signal will depend upon the type of mixer circuit used. It is clear that a mixer using extremely low harmonic output is necessary to avoid troublefree operation caused by the fourth harmonic generated within the mixer. The high sensitivity tuned circuits which follow show the stage for the purpose of attenuating the 2.1-3.9 megacycle signal also will attenuate the higher harmonic, shown by the other black blocks marked "2," "3," "4," and "5." When a mixer output signal in the 3.8-4.0 megacycle range is desired, a heterodyning signal either lower than (3.33-3.35 megacycles) or higher than (4.2-4.25 megacycles) the desired signal may be used, as shown in lines 4, 5, 6, and 7, respectively. Notice that both heterodyning signal ranges (3.33-3.35 megacycles) and 4.2-4.25 megacycles) have a 3.2 megacycle lower limit within the freedom danger zone of 3.4-4.4 megacycles. Remembering that some of these signals and any heterodyning signal with a trap circuit is more difficult than filtering out a fixed frequency, every possible attempt of the trap probably will not be effective over the entire range. In a truly harmonic signal, on whose output to avoid from the variable frequency mixing signal would be desirable.

Scores the heterodyning signals mentioned thus far permit operation on only two bands, the practice followed in many filter-type SSB transmitters is to again heterodyne the 3.8-4.0 megacycle SSB signal described in lines 4 and 6 to the other amateur bands in a second mixer stage. A block diagram of a typical double conversion SSB filter is shown in Fig. 2. This variable SSB signal frequency, its spurious signals and harmonics must now be considered as an input signal to the second mixer, as plotted on line 8. If an output signal from the second mixer is in the 1.8-2.6 megacycle range is again desired, a fixed frequency signal of either 2.9 or 3.4 megacycles also should be used to mix the 3.8-4.0 megacycle SSB generator signal. A 3.0 megacycle signal would be a poor choice, since it falls within the freedom danger zone, but line 9 on the chart shows that the 3.4 megacycle input signal is satisfactory.

![Fig. 2. Block diagram of a double-conversion SSB exciter.](image)

**SECOND ORDER INTERMEDIATE FREQUENCY**

First and second mixer stages to avoid transmitting spurious signals from either mixer.

For a second mixer output signal on 7.2-7.4 megacycles, the second harmonic signal of the SSB generator, 7.6-8.0 megacycles, falls within the freedom danger zone. This also happens with the second harmonic of a 3.2-megacycle mixing signal shown in line 10. One spurious signal can be avoided by choosing 11.1 megacycles, on line 11, for a missing signal frequency instead. As before, a mixer which does not generate harmonics is necessary. On line 12, the fourth harmonic of the SSB generator signal falls within the danger zone for 14.4-14.6 megacycle second mixer output, but the 13.9-megacycle mixing signal should not prove troublesome.

As indicated on line 13, the fifth and sixth harmonics of the SSB generator signal will fall within the freedom danger zone when a second mixer output signal on 21.2-24.4 megacycles is desired. However, the 21.9-megacycle mixing signal required for this output signal frequency is well outside the danger zone. Again, when a mixer output signal frequency is shown on line 14, the seventh and eighth harmonics of the SSB generator signal should not appear in the second mixer output. The 21.7-megacycle mixing signal appears to be a safe choice. All the foregoing examples indicate that a mixer which has very low harmonic output, plus a balanced type in some cases, should be chosen.

**THE 0-MEGACYCLE PHASING-TYPE SSB GENERATOR**

A common practice when designing a chopper-type all-band SSB exciter is to chose an SSB generator signal frequency which permits the same mixing signal range to be used for a mixer output signal on either of two bands. But, this is not the present consideration, since a frequency where harmonics fall outside the freedom danger zone of any desired operating band should be chosen. The widely-used 9-megacycle SSB generator signal frequency is good, but has certain disadvantages. Line 13 on the chart shows that the third harmonic, at 27 megacycles, falls within the danger zone when a mixer output signal in the 14.4-14.6 megacycle band is desired. A different mixer design is necessary to reduce the severity of this problem.

(Continued on page 1-I0)
A variable frequency oscillator must be used with this band SSB generator signal if an acceptable frequency mixer output signal is desired for the lower fading bands. The VFO tuning ranges required for mixer output on 1.8, 2.8, 2.8-6.8 megacycles (7.0-7.2 and 5.0-5.2 megacycles, respectively) are shown on lines 18 and 19. These two examples both illustrate the desirable feature of having both mixer input signals of higher frequency than the output signal.

The VFO tuning ranges for the 3.7-7.2 megacycle mixer output signal, shown on lines 20 and 21, is extended from 3.7-3.9 megacycle VFO range on line 18 within the design range, in the 3.7-7.2 megacycle VFO range is a better choice. For a 4.1-4.3 megacycle mixer output signal on line 20, the VFO tuning range of 3.7-4.0 megacycles may be used. However, the VFO third harmonic signal at 5.6-5.9 megacycles is within the 3.7-4.1 megacycle VFO range. A trap circuit in the mixer output to attenuate this spurious signal is included in the design of this type of commercial SSB exciter. Note that lines 17 and 20 show typical examples of getting two band operation with one VFO signal range.

The mixer input signals required for 2.15-2.45 and 28.5-29.0 megacycle mixer sum output signals (3.75-3.85 and 3.75-3.92 megacycles, respectively) are shown on lines 21 and 22 present no special problems. On VFO signals of the 3.0-3.5 and 3.7-3.8 megacycle range, respectively, may be used for mixer output on these bands if the stability of the higher frequency VFO is adequate. This problem is even greater when a 50-megacycle mixer output signal is desired. A VFO range of 39-45 megacycles is then required, as shown on line 23.

Methods of obtaining a 50-megacycle SSB output signal are shown on chart lines 24 and 25. A variable frequency SSB exciter having output on the 21- or 28.5-megacycle bands may be fed into a second mixer stage from which the output signal is obtained. On line 24, a signal on 36.75 megacycles, and the SSB exciter output on 21.25-24.65 megacycles are mixed to obtain a 50.0 megacycle SSB output signal.

On line 25, an SSB exciter output signal in the 28.5-38.0 megacycle range is mixed with a 23.5-megacycle SSB output signal to obtain a 50.5-50.6 megacycle SSB output signal (RFS, AC-11). Feeder circuits in the mixer output are influenced by difficulties may be experienced with this combination. Although a non-linear characteristic of a double-heterodyne mixer stage (to itself only) should be free of spurious signal if real. If not, a filtering of spurious signals and the use of a well designed input stage for the mixer output is necessary. This is even greater as the 3.7-4.3 megacycle VFO range from feeding though a mixer, the third harmonic signal will cancel the SSB generator signal, and the seventh harmonic will cancel the output signal. Obviously, the combination is an excellent spurious signal output of "third-order" generation, on the 3.7-4.3 megacycle VFO signal is preferable.

The mixer output signals on both the 21.25- and 28.5-megacycle bands may be obtained with VFO tuning ranges of 14.0-15.15 megacycles (line 38) or 14.0-16.2 megacycles (line 39), respectively. The only special precaution necessary with the signal combinations listed on line 34 is that is a trap circuit to attenuate the fifth harmonic of the SSB generator signal on 31 megacycles, when operating the exciter on the 28.5-megacycle VFO output signal.

**DO IT YOURSELF SUGGESTIONS**

Although other SSB generator signal frequencies may be used, those of one of the following frequency ranges is suggested for the SSB generator when designing as described here for the 3.7-7.2 megacycle input signal. The third, fourth or harmonic is examined to see if there are less complications from spurious signals that a double conversion system. In addition, it is possible to vary the frequency drift by the same factor as the harmonic. Generally speaking, the double conversion system is preferable when a variable frequency mixer input signal higher than 10 megacycles is required to obtain a mixer output signal in the 7.2, 21.5, and 28.5 megacycle bands.

You can figure out your own SSB exciter signal frequency combination by: (1) plotting the fundamental and harmonic mixer output signal frequency on graph paper; (2) plotting the VFO tuning ranges for obtaining output on the desired band; and (3) observing the harmonic in the VFO tuning range to see which is suitable for the double-heterodyne design for the band on which the mixer output signal appears. If it happens that the SSB generator signal may be shifted, then new VFO tuning ranges plotted which will in this manner be the double-heterodyne design for the mixer output signal frequency which may be found which permits the same tuning range is extended. However, if any doubt exists, it is advisable to check the resulting signal distribution which produces a mixer output signal in a different frequency range from the VFO tuning range, then you've really got the job right.
USING THE G-E 6AR8 SHEET BEAM TUBE

DESCRIPTION AND RATING

The G-E 6AR8 sheet beam tube has attracted much attention for balanced modulator applications. It has the ability to perform mixing action of two input signals and cancel hum in the output to provide an output signal equal to their sum or difference frequencies. Complete technical information is repeated on these pages, along with typical circuits in which radio amateurs have expressed an interest.

GENERAL
Cathode—Casted Unipotential
Heater Voltage: AC or DC
Heater Current: 0.8 A
Grid-TO-Grid, Glass Box—ES-1, Small Button 9-Filament Position—Any
Direct Interelectrode Capacitances, approximate:
Deflector-Number 1 to all... 4.8 μF
Deflector-Number 2 to all... 4.8 μF
Grid Number 1 to all except plates... 7.5 μF
Plate-Number 1 to all... 50 μF
Plate-Number 2 to all... 50 μF
Grid-Number 1 to Deflector-Number 1, minimum... 0.040 μF
Grid-Number 1 to Deflector-Number 2, maximum... 0.080 μF
Plate-Number 1 to Plate-Number 2... 0.4 μF
Deflector-Number 1 to Deflector-Number 2... 0.38 μF

MAXIMUM RATINGS
Design-Center Values
Plate-Number 1 Voltage... 300 Volts
Plate-Number 2 Voltage... 200 Volts
Accelerator Voltage... 200 Volts
Peak Positive Deflector-Number 1 Voltage... 150 Volts
Peak Negative Deflector-Number 1 Voltage... 150 Volts
Peak Positive Deflector-Number 2 Voltage... 150 Volts
Peak Negative Deflector-Number 2 Voltage... 150 Volts
Peak Positive DC Grid Number 1 Voltage... 90 Volts
Peak Negative DC Grid Number 1 Voltage... 90 Volts
Plate-Number 1 Dissipation... 2.0 Watts
Plate-Number 2 Dissipation... 2.0 Watts
DC Cathode Current... 30 Milliamperes
Graded Number 1, Circuit Resistance
With Fixed Bias... 0.1 Megohms
With Cathode Bias... 0.33 Megohms

BASING DIAGRAM

TERMINAL CONNECTIONS
Pin 1—Deflector Number 2
Pin 2—Deflector Number 1
Pin 3—Accelerator
Pin 4—Heater
Pin 5—Matic, Internal Shield, and Plate Electrodes
Pin 6—Grid Number 1
Pin 7—Cathode
Pin 8—Plate Number 2
Pin 9—Plate Number 1

PHYSICAL DIMENSIONS

1-11
CHARACTERISTICS AND TYPICAL OPERATION

AVERAGE CHARACTERISTICS WITH DEFLECTORS GROUNDED
Plate-Number 1 Voltage.................................................. 250 Volt
Plate-Number 2, Connected to Plate-Number 1.................. 250 Volts
Accelerator Voltage................................................... 0 Volts
Deflector-Number 1 Voltage.......................................... 0 Volts
Deflector-Number 2 Voltage.......................................... 0 Volts
Cathode-Ring Resistor................................................. 300 Ohms
Total Plate Current................................................... 10 Milliamperes
Accelerator Current.................................................. 0.4 Milliamperes
Grid-Number 1 Voltage.............................................. 4500 Volts
Grid Number 1, Voltage, approximate Lg band=10 Microamperes
................................................................. -14 Volts

AVERAGE DEFLECTOR CHARACTERISTICS
Plate-Number 1 Voltage.............................................. 120 Volts
Plate-Number 2 Voltage.............................................. 200 Volts
Accelerator Voltage.................................................. 150 Volts
Cathode-Ring Resistor.............................................. 300 Ohms
Deflector Switching Voltage, maximum................................ 20 Volts
Deflector-Bus Voltage for Minimum Deflector Switching Voltage:...................................................... 8 Volts
Voltage Difference between Deflectors for Lg=150 volts: approximate........................................... 0 Volts
Plate-Number 1 Current, maximum...................................... 1.0 Milliamperes
Plate-Number 2 Current, maximum...................................... 1.0 Milliamperes
Deflector-Number 1 Current, maximum...................................... 0.5 Milliamperes
Deflector-Number 2 Current, maximum...................................... 0.5 Milliamperes
Fr = ± 15 Volts, F2 = ± 15 Volts
F1 = ±25 Volts, F2 = ±25 Volts
F1 = ±25 Volts, F2 = ±25 Volts
F1 = ±25 Volts, F2 = ±25 Volts

* Without external shield.
1 Plate 2 should be connected directly to ground.
2 Deflector switching voltage is defined as the total voltage change on either deflector with an equal and opposite charge on the other deflector required to switch the plate current from one plate to the other.
2 The XAB should be so located in the receiver that it is not subjected to stray magnetic fields.

Fig. 1 CROSS-SECTION SCHEMATIC DIAGRAM OF THE XAB

The tubes and arrangements disclosed herein may be covered by patents of General Electric Company or others. Neither the disclosure of any information herein nor the sale of tubes by General Electric Company implies any license under patent, claims covering combinations of these tubes with other devices or elements. In the absence of an express written agreement to the contrary, General Electric Company assumes no liability for patent infringement arising out of any use of the tube or other devices or elements by any purchaser of tubes or others.
A cross-section schematic diagram of the construction of the EABS is shown. In this tube, the electron Gunn from the anode to one of the two plates in the form of a linear beam or "sheet." Before the electron stream emerges from the openings in the anode structure, it is acted on by the focusing or control-grids. The focus electrode tends to converge the electrons into the required sheet beam, while the conventional grid-number 1 structure which surrounds the cathode serves to control the intensity of the beam.

Between the accelerating and the plates the electron beam passes through the deflector electrode. Depending on the voltages applied to the deflector, the beam will be directed vertically or to either side or the other of the two plates or proportioned between them.

The direction of current flow in the plates is such that the top plate is positive with respect to the bottom plate or vice versa. Since the beam carries a certain number of electrons, the two plates are in effect the secondary emission-electrodes between the plates. The upper and the lower electrodes are indirectly connected to the cathode, and thus the plate voltages are varied through the respective control grids.

In normal operation, dynamic plate voltages are applied to the accelerating plates and signal voltages are applied to the deflector and deflector grid. The frequency of the signal applied to the deflectors determines the rate at which the plate current is switched between the two plates, the grid-number 1 values vary the magnitude of the plate current. The interlocking tube characteristic which results from the unique construction of the EABS is indicated by the anode plate characteristic curves below which the tube may be considered an equivalent to a voltage-controlled single-triode with respect to which current, the magnitude of which is AC voltage-controlled, flows.

If both plates and the accelerating are opened at + 250 volts and a cathode-line resistor of 300 ohms is employed, the deflectors require a peak switching voltage of 20 volts for a peak voltage difference between deflectors of 40 millivolts to switch the plate current from one plate to the other, is a practical circuit however, in which the deflectors are driven in push-pull with the cathode of the source grounded, a higher voltage is necessary of deflectors drive voltage must be used. The increase drive voltage is required to allow for those tubes in which the switching characteristics are somewhat offset with respect to zero voltage difference between deflectors.

For an equalization of plate voltages, the maximum plate voltage should be limited to the minimum plate voltages occur on a or deflect the plates of approximately. A volt, however, the def-plate-line is not extremely critical for focus as the deflection sensitivity is rather low in these tubes. Care must be taken to avoid placing excessive currents to cause that deflection effects are not present whenever the tube is operated at conditions other than those recommended.

The circuit diagram for two EABS tubes employed as quadrature detectors in a color television receiver is shown. In this arrangement, plate voltages are applied directly to the anode grid and through load resistors R1, R2, R3 and R4 to each of the plates. The chrominance signal is applied to the control grid of each tube. The 1.5- megacycle reference signal is applied in push-pull between the deflectors of each tube, the small coupling capacity C1 between the tuned plate circuits provides the necessary 90-degree phase shift for the line and color detector, also each tube is biased with a constant resistor, R3 and R6, resistor R6 is variable so that the relative gains of the two demodulators can be adjusted.

In principle, the EABS circuit is a product-demodulator type of symbol deflection, however, because the circuit was a double-plate sheet-beam tube rather than a dual-crest plate or pedestal, certain significant operating features result. First the EABS circuit is capable of delivering adequately large and balanced output voltages which exhibit good linearities. Because output voltages are available both positive and negative polarities, the need for the incorporation of phase-shifting circuits in the matrix matrix at the time of the color signal is obviated. Also, plate voltages are automatically adjusted to the desired plate and color signal is applied to the control grid of each tube. Further, plate voltages are adjusted to the output of the quadrature detectors. Furthermore, the signal voltages applied to the output of the quadrature detectors which is the third grid is driven positive by the oscillator reference voltage, the deflection of the electron beam being excited positive. Consequently, the power is removed from the 3.5-megacycle reference oscillator in the dual-plate tube circuit.

A feature that is particularly attractive coupling effects which may be present in dual-crest plate and pedestal, are insensitive to the EABS. Also, when used with dual-crest plate and pedestal, which is the signal current is an important percent of the current the electron current remains constant which is less than 0.5 microamp of its plate current.


Fig. 7 - CIRCUIT DIAGRAM OF TWO EABS TUBES USED AS SYNCHRONOUS DETECTORS

I-13
The G-E 6AR8 sheet beam tube is, by its very nature, suited for a number of circuit applications in amateur radio single sideband transmitting and receiving equipment. The following circuits illustrate these applications.

Component values as shown will provide normal performance of these circuits in most cases. However, in certain instances, the values of cathode resistances may require lowering to obtain optimum circuit performance. Also, shielding and other r.f. constructional practices, have not been shown.

Fig. 3  Suggested circuit for a balanced modulator using the 6AR8 sheet beam tube with the audio signal applied to one beam deflecting plate, and the r.f. signal to be modulated applied to the control grid. All resistances are in ohms, 1/2 watt unless otherwise specified. "K" equals 1,000. Capacitance values are in microfarads (mfd), except where specified. Capacitors C1 and C2 should be equal in value, with a total series capacitance of 10 pfd, to resonate the input side of the sideband filter at the operating frequency.

Fig. 4  Suggested schematic diagram of a simplified filter-type single sideband generator operating at 455 kilocycles. The G-E 6AR8 sheet beam tube combines the functions of carrier oscillator, and balanced modulator. The output from the 6AR8 plates is a double sideband, suppressed carrier signal. One sideband is removed after passage through the bandpass filters at the right. All resistances are in ohms, 1/2 watt rating unless specified. Potentiometers R1, R2, and R3 have composition elements. Capacitances are in micro-microfarads, unless value is specified in microfarads (mfd). Capacitors with polarized markings are electrolytic types.
Fig. 5. Suggested schematic diagram of a G-E 6A88 sheet beam tube operating as a combined tunable oscillator (VFO) and mixer. Circuit values are shown for a tunable oscillator operating at 3.5 to 5.5 megacycles, with a 455-hertz oscillator signal applied to one beam deflection plate. The sum of the two input frequencies appears in the output circuit, T1, tuned to the 3.5 to 4.0-megacycle range. The oscillator coil, L1, has an inductance of 2.1 microhenries. It was wound on a 3/4-inch iron core, GR2440-344, with 21 turns of No. 20 enameled wire spaced wound 1 inch long. The cathode tap is 3 turns, and the grid tap 10 turns, from the grounded end.

Fig. 6. Suggested schematic diagram for a 6A88 tube in a balanced mixer circuit. This circuit is suitable for combining two input signals from a SSB generator and tunable oscillator (VFO), and obtaining either the sum or difference signal in the tuned output circuit, C1-C4. Conventional tuned circuits may be used here, and in T1. All resistances are in ohms, 1/2 watt, unless specified. Capacitances are in microfarads (mfd). All linear taps composition potentiometer should be used for R1.

Fig. 7. Suggested circuit for a 1-tube product detector using the G-E 6A88 sheet beam tube. The circuit contains its own carrier oscillator utilizing the cathode, control grid and number three grid elements. The beam deflecting plates are in the detection circuit, and the audio output signal is taken from the plates. The oscillator tuned circuit should have high capacitance for beat stability. Taps 1 and 2 on L1 should be about 1 turn, respectively, from the grounded end. Resistances are in ohms, 1/2-watt rating. Capacitances in decimals are in microfarads (mfd). Those in whole numbers are in micro-microfarads (mmd).
Fig. 8. Suggested schematic diagram for a phasing-type SSB generator featuring a double balanced modulator with two 6AG8 a9e-beam tubes. This circuit is suitable over the range from intermediate frequencies to approximately 30 megacycles. Capacitances are in micromicrofarads (mfd), except those marked "dual", which are in microfarads (mfd). Resistances are in ohms, 1/2 watt rating unless otherwise specified. Values for capacitances C1, C2, C3, C4, C5, C6, and C7 will depend on the operating frequency. Values for C3 and C4 should be chosen so that their reactance at the operating frequency is equal to the resistance of R1 and R2, which should be 100 ohms each, with exact values closely matched.

A 6 AG8 exciter construction article with the 6AG8 as a balanced modulator was described in the July, 1956 issue of CQ on pages 29 to 31. This filter type exciter was designed and constructed by William L. Orr, W6SAI.

Additional material on applications of a盛宴 beam receiving tubes has been published in the March, 1960 issue of QST magazine.

A new article showing the C-E 6 AG8 as a balanced modulator in a simple double sideband transmitter, reconstructed from a surplus Command for transmitter, appears in the May, 1961 issue of CQ magazine, on pages 48 through 51.

A new type of miniature beam beam tube which has low output capacitance, and thus is capable of operating in balanced modulator circuits well into the VHF region, has just been announced by the General Electric Receiving Tube Department. It is known as the T85S and will appear in C-E HAM NEWS articles during 1962.

J.06