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Electronic Oscillators

Part 2: Local Oscillators in A-M Receivers

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THIS article discusses local oscillators in receivers designed for frequencies below about 30 mc. VHF and UHF oscillators are covered in part 4 of the series.

A great majority of the local oscillators in AM receivers are part of converter-tube circuits. In short-wave communications receivers, separate-tube arrangements are frequently encountered, especially when the coverage extends to frequencies of 30 mc or higher.

Arrangements Used.

The most popular oscillator circuit in AM receivers is the Hartley, although it does not usually appear in its basic form. Most frequently it is found as the grounded-plate version.

A typical pentagrid converter oscillator circuit is shown in Fig. 1 (A). The basic triode grounded-plate Hartley is shown at (B) for comparison. In the pentagrid converter, grids 2 and 4 take the place of the triode plate.

The circuit variation of Fig. 2 is particularly popular in small, low-priced AM receivers. An additional winding L1 is interwound with L2. L1 is called a "bifilar" winding. One end is left open. The capacitance between L1 and L2 takes the place of the capacitor C1 in Fig. 1.

Two examples of the use of inductive feedback in AM receivers are shown in Fig. 3 and 4, respectively. The circuit of Fig. 3 employs the pentagrid converter version of the "tuned grid feedback" type. Figure 4 shows a cathode-coupled feedback arrangement. The latter can be pictured as the circuit of Fig. 3 with the plate feedback coil moved through the plate power supply and into the cathode circuit.

Inductive feedback circuits are not very frequently encountered in medium and higher-frequency receivers because of the expense of the additional coil winding and its connections, and because of the inconvenience of switching frequency bands. However, at low and very low frequencies, inductive feedback is often employed because of the difficulty in obtaining sufficient feedback other ways.

A typical dual triode oscillator-mixer circuit is shown in Fig. 5. This arrangement is popular in TV and communications receivers where low noise level and minimum oscillator/r-f interaction are required. Sometimes a small capacitor connected between grid or cathode of the oscillator and mixer grid is used for injecting oscillator voltage to the mixer. In other cases, the cathodes of the mixer and oscillator are either common or coupled together.

Requirements.

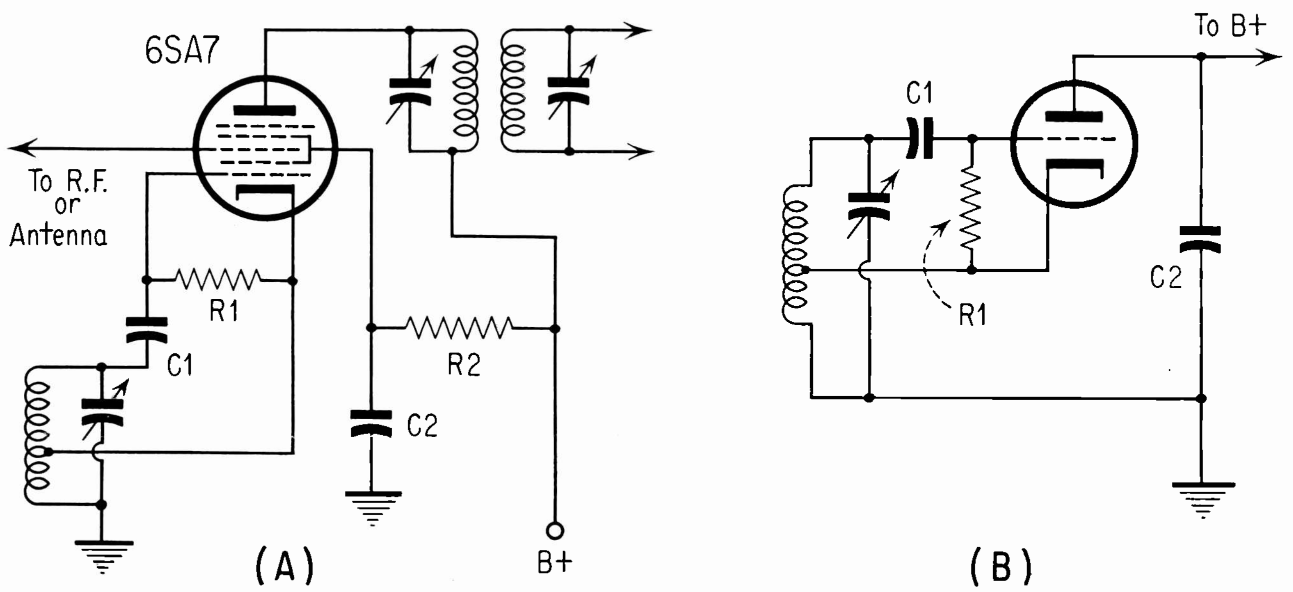
The following are important requirements in the design of oscillators in low-frequency AM receivers:

(1) East of oscillation
(2) Freedom from undesired resonances
(3) Constant output amplitude
(4) Frequency stability
(5) Minimum of harmonic output
(6) Tracking

Ease of Oscillation

Conditions for oscillation must be well fulfilled, so there is no tendency toward delay or failure in starting or maintaining oscillation. The nature of these conditions was discussed in the first article of this series. Oscillation criteria show that from a general theoretical standpoint, the tuned grid feedback and Hartley are the easiest oscillators. The Colpitts circuit also oscillates easily, but is seldom used in receivers because of the added components required (capacitors in the tank circuit).

If the basic design does not allow easy oscillation, then excessive plate and/or grid currents may be necessary, with resulting overheating and



VERSIONS OF GROUNDED-PLATE HARTLEY CIRCUIT

FIG.1

instability as well as excessive power requirement.

Undesired Resonances

Undesired resonances are most likely to occur in the inductive feedback type of circuits (tuned grid and tuned plate types). In these circuits the feedback or tickler coil may resonate with its distributed capacitance or with stray circuit capacitance. If the resonant frequency is within the tuning range, sufficient power may be absorbed to stop oscillation at and around that frequency. At least operation in the vicinity of the frequency of undesired resonance becomes unstable and undependable.

If the receiver is of the multi-range type, the coil of one range which is unused may self-resonate within the tuning range of the coil in use, with results similar to those mentioned above. The unwanted frequencies of resonance and their effects are often referred to as "dead spots" and "suck-outs".

Undesired resonances can, to an appreciable extent, be avoided by careful initial design. However, all possible resonances naturally cannot be anticipated, so a breadboard test for suck-outs is a sensible precaution. The best test is observation of the value of rectified grid current as the oscillator is tuned through its range. The rectified current of the mixer injection grid is also a good indicator if separate oscillator and mixer tubes are used. Any tendency toward unwanted resonances will show up as sharp variations of this grid current as the resonant frequencies are approached. Such conditions can also be traced with a grid-dip oscillator, but it must be remembered that such an analysis is not complete unless the tuning capacitor of the tested oscillator is varied through its complete range. Sometimes the tuning capacitor is part of the undesired resonant circuit.

No general formula for eliminating unwanted resonances can be given; it's just a matter of changing the circuit constants so that these resonances are moved outside the tuning range, or better, but seldom possible, eliminated altogether. In multi-range receivers in which the coils of different ranges interfere with each other, the resonant frequency can be moved out of the range by adding a section of the switch which shorts each unused coil. On some ranges it may be better to leave the coil open when unused. In any event, a large percentage of troubles can be avoided by careful initial study of the inductances and capacitances involved, and the checking of each coil as to its self-resonance and its mutual inductance with other coils after installation in the circuit.

Constant Amplitude

The amplitude of oscillator injection voltage has an important effect on the operation of a superheterodyne receiver. If the amplitude is excessive, and the mixer is driven beyond cutoff, sharp discontinuities in the conversion characteristic occur, and excessive oscillator harmonics result. These harmonics lead to many spurious responses, manifested by whistles and "birdies" in reception. On the other hand, if the injection voltage is too low, conversion transconductance falls off sharply, and receiver sensitivity is limited.

Thus it is important that the output amplitude of the oscillator remain constant over the tuning range. Unless compensated, the output of a capacitance-tuned oscillator increases as it is tuned from the low to the high frequency end of its tuning range. To compensate for this, some method of reducing relative output toward the high frequency end must be employed.

One convenient method employs the grid-cathode capacitance of the tube, with an added resistor to form a voltage divider, as shown in Fig. 6. Since the grid cathode capacitance portion of the divider is a lower impedance at the higher frequencies, less voltage is applied to the grid from the grid circuit. Compensation for high frequency amplitude increase is thus afforded. Typical effect of compensation is illustrated in Fig. 7.

The circuit of Fig. 6 also compensates amplitude by its loading effect on the grid coil. The resistor and capacitor in series damp the coil with a shunt resistance which decreases ators, a low L/C ratio at the high frequency end of the tuning range is not consistent with full tuning range possible from a given tuning capacitor. Ordinary tuning capacitors, when connected into an oscillator circuit, provide a maximum tuning ratio of about 3 to 1. This ratio is attained only at the expense of a relatively high L/C ratio at the high frequency end of the tuning range. This problem can be overcome by inductance tuning, but such tuning is not practical or desirable in many receiver applications. Thus if harmonic output is to be minimized in wide-range tuning, other harmonic-reduction measures must be considered.

(2) Increased coil Q. Higher effective Q during operation can of course be obtained by increasing coil Q as much as possible. Use of Litz wire within its favorable frequency range, use of bank and other special windings, and optimum dimensional relations are well known methods. In the appropriate frequency ranges, addition of a powdered iron core can provide an appreciable increase in Q.

(3) Limited power and drive. In most AM receivers, injection power requirements of the mixer are low enough to allow good operation with relatively low oscillator power output. Since harmonic content is greatly increased by use of large bias and drive voltage, it is desirable that feedback be reduced to a minimum necessary for easy oscillation. For lowest harmonic content with appreciable output, most oscillators should approach class B operation. The design procedure would be as follows:

(a) With no limitation on feedback path, adjust operating conditions, *including feedback ratio,* for maximum grid current. This would include adjustment of the tap on Hartley coil, capacitors in Colpitts divider etc. The objective of this step is to obtain optimum feedback phase relation.

(b) Reduce applied plate and/or screen voltage to minimum values necessary for easy oscillation, also

(c) simultaneously decouple the resonant circuit to minimize grid current for desired output. Greatest reduction of feedback amplitude with maintenance of optimum feedback phase should be the objective.

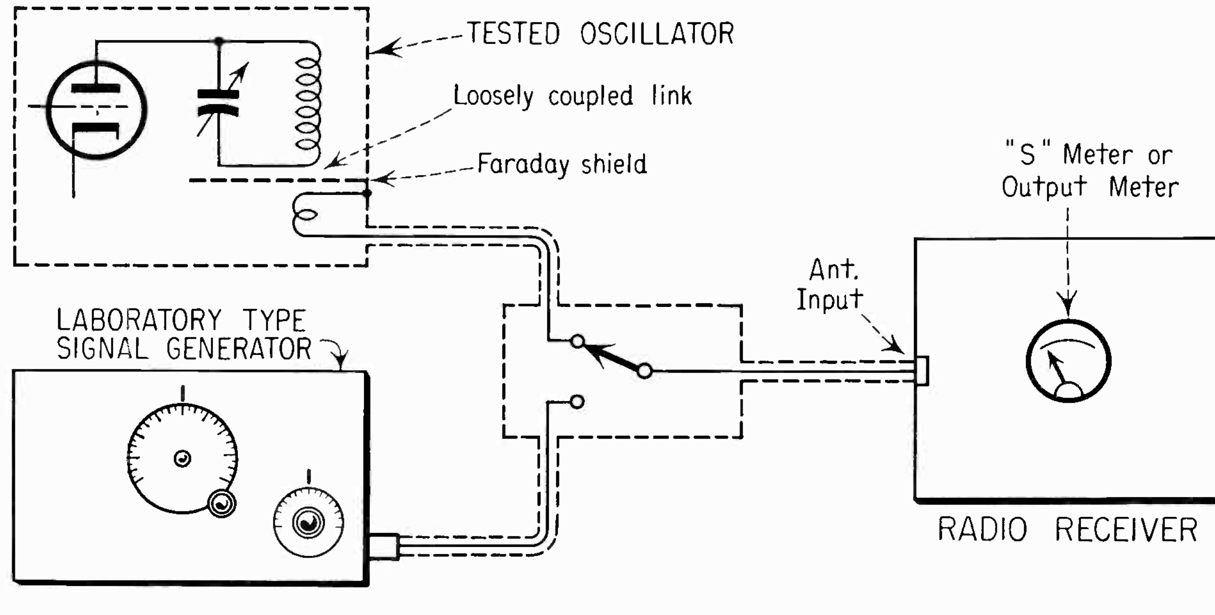
If the frequency range of the oscillator is such that a suitable sensitive radio receiver covering the fundamental and several harmonic frequencies is available, the method of Fig. 8 can be used for testing harmonic output. The signal generator should be of the laboratory type, with low leakage and dependable attenuator and output voltage readings. The coupling to the tested oscillator should be light and through a shielded link with as little capacitive coupling as possible. The receiver must be well shielded, and should have a signal meter. If it does not have a signal meter, VTVM measurement of AVC or detector d-c voltage output can be used. The coaxial lead should be terminated at the receiver with a composition resistor matching the characteristic impedance of the cable. The switch should be completely shielded in a box, to which connections are made through coaxial connectors.

The receiver is first tuned to the fundamental frequency of the oscillator, which should be the highest frequency of its range (for worst harmonics). The signal generator is shut off. The receiver controls and the coupling to the oscillator are adjusted for convenient reference indication on the indicating meter.

Now switch S is thrown to the signal generator. The latter is turned on and the oscillator turned off. The signal generator attenuator is now adjusted for the same receiver output and its output voltage indication noted.

Next, without touching the coupling to the oscillator, repeat the whole process, with the receiver tuned to the second harmonic of the oscillator frequency. The ratio of the signal generator voltages is the ratio of harmonic to fundamental. The same process should be repeated through at least the third, and preferably the fifth harmonic.

The final important requirement for the oscillator in the low frequency AM receiver is tracking. Since tracking is so important, it is discussed by itself in the next article of this series.



TEST SETUP FOR CHECKING HARMONIC OUTPUT

FIG. 8