Advanced Performance in
Two New VHF Signal Generators

In order for an amplitude-modulated signal generator to be suitable for testing high-performance receivers, one of its most important requirements is that it have a low order of incidental f-m. The reason for this is that appreciable f-m in a signal generator usually causes serious errors in evaluating receiver performance and further leads to misalignment of the receiver. Although ordinarily not present in troublesome proportions in lower frequency generators, incidental f-m tends to be a significant problem in vhf generators, especially when inelegant modulation methods are used.

In the design of -hp- signal generators, freedom from incidental f-m has always been an important consideration. It has led to the use of master-oscillator-power-amplifier type designs for the -hp- generators that operate in the r-f, vhf and lower uhf regions. The advantage of the MOPA arrangement is, of course, that the r-f oscillator circuit in the generator does not have modulation applied to it. As a result, modulation voltages do not react on the oscillator and incidental f-m is of a low order.

The MOPA circuit arrangement has quite naturally been followed in the design of two new signal generators which have been developed for the r-f to lower uhf range. The more technically refined of these new generators, the Model 608D, operates from 10 to 420 megacycles, is capable of sine-wave or pulse modulation, delivers a maximum of 0.5 volt across 50 ohms, and incorporates a 0.01%-tolerance crystal calibrator to permit unusually high accuracy of output frequency.

The second generator, the Model 608C, operates from 10 to 480 megacycles and provides a maximum output of 1 volt across 50 ohms. It is generally similar to the Model 608D except that it does not include a crystal calibrator and that some of its characteristics have not been refined to such a high degree as in the 608D.

R-F Section

Circuit arrangements for the two new generators are shown in block form in Fig. 2. The r-f oscillators in both generators are essentially the same and use type 5675 pencil triodes operating in modified Colpitts circuits. In both generators the oscillators cover their respective ranges in 5 bands as shown in the accompanying table. Each band has a calibrated scale length of approximately 10 inches, giving an overall scale length of some 50 inches for the complete range. The tuning capacitors are de-
signed with a modified straight-line-frequency plate shape so that the tuning dial calibrations, although not linear, are not unduly compressed at the high frequencies.

**BAND COVERAGE**

<table>
<thead>
<tr>
<th>Band</th>
<th>608C</th>
<th>608D</th>
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<tbody>
<tr>
<td>&quot;A&quot;</td>
<td>10-21 mc</td>
<td>10-20 mc</td>
</tr>
<tr>
<td>&quot;B&quot;</td>
<td>21-43 mc</td>
<td>20-42 mc</td>
</tr>
<tr>
<td>&quot;C&quot;</td>
<td>43-95 mc</td>
<td>42-90 mc</td>
</tr>
<tr>
<td>&quot;D&quot;</td>
<td>95-215 mc</td>
<td>90-200 mc</td>
</tr>
<tr>
<td>&quot;E&quot;</td>
<td>215-480 mc</td>
<td>200-420 mc</td>
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</table>

To achieve a high order of stability for the generated frequency, a number of special measures have been taken in the design of the r-f oscillator circuits. Mechanical instabilities have been reduced by designing the tuning capacitors to be split-stator types which avoid sliding contacts. To reduce temperature effects, the tuning capacitor plates and some of the tuning coils have been formed from low temperature coefficient invar. The tuning coils are mounted on a heavy turret formed from glass-fiber-reinforced polyester resin which has a low temperature coefficient of expansion.

Line voltage effects have been minimized through use of regulated plate supplies and by supplying heater power for the r-f tubes from a special regulator multivibrator. Use of this multivibrator maintains heater voltage on the r-f tubes constant within approximately 0.05 volt for ±10% line voltage changes.

The r-f amplifiers in both generators use type 5876 pencil triodes operating in grounded-grid cathode-modulated circuits. Tuning capacitors for the oscillators and amplifiers are ganged to achieve single-dial tuning, although the amplifier capacitor is provided with a peaking trimmer operated from the front panel. The drive system for the ganged capacitors and tuning dial is a 50:1 ground worm reduction drive which is ball-bearing supported throughout. A constant-tension type spring loading minimizes backlash.

**ACCURACY**

The basic tolerance in the frequency calibration of both the 608C and 608D has been held to 1%. This is the tolerance of the tuning dial calibration under all normal conditions of line voltage, room temperatures, and reasonable state of tube and component age.

Since the Model 608D includes a crystal calibrator, however, it is possible to obtain much higher accuracy of output frequency in that instrument. The calibrator operates at a fundamental frequency of 5 megacycles and provides check points at multiples thereof throughout the 10 to 420 megacycle range of the 608D.

The calibrator itself is rated as being accurate within 0.01%, a rating derived from the use of a 0.005%-tolerance crystal in the calibrator circuit. The accuracy of generator frequency obtainable through use of the calibrator naturally depends somewhat on the generator frequency selected. If an integral multiple of 5 megacycles is desired, it can be selected within at least a hundred cycles of the 0.01% calibrator tolerance. Frequencies between the 5-megacycle check points can be interpolated using the linear calibrations which are provided on the frequency control.

This feature is intended chiefly for use at the higher frequencies where interpolation will give accuracies within at least 0.1%.

The calibrator is designed to be used with headphones and is arranged so that the beat-notes appear automatically as the main frequency dial is tuned through check points. An audio amplifier with a panel control for adjusting the amplifier output to a convenient audio level is included as part of the calibrator.

To complete the calibration arrangement in the Model 608D, the fiducial for the frequency dial has been made adjustable. A control near the dial positions the fiducial horizontally over a limited range to standardize the dial calibration, if desired, in the vicinity of any check point.

**MODULATION**

Although both generators have been designed so that the r-f oscillator is isolated from the modulated stage, isolation of the oscillator has been made even more complete in the Model 608D by inserting a buffer...
amplifier between the oscillator and amplifier (Fig. 2). The buffer is designed as an untuned, wide-band stage using a type 6BC4 triode and a four-terminal coupling network.

The importance of achieving a low order of incidental f-m in the design of any a-m signal generator is indicated in Fig. 3. While this illustration is a simplified portrayal of a complicated mathematical problem involving a number of variables such as sweep rate, selectivity curve shape, and modulation index, it serves to represent the results obtained. If the carrier deviation caused by f-m in a generator is significant compared to the bandwidth of an a-m receiver under test as shown in the illustration, the receiver will have a considerable output arising from the f-m. This output will be in addition to the desired a-m response. Two modulation responses will thus be combined in the receiver's detector so that an erroneous evaluation will be made of the receiver's sensitivity. In high-selectivity receivers, it is not at all uncommon for the f-m response to mask the desired a-m response. If the generator is being used for alignment purposes, the receiver will usually be misaligned under these circumstances, because maximum receiver response will often occur when the carrier frequency falls on a high-slope portion of the receiver selectivity characteristic. The result is that the alignment procedure will tend to shift the center frequency of the receiver selectivity characteristic to one side or the other of the carrier frequency.

These considerations show that for proper receiver evaluation it is necessary that the f-m deviation be small compared to the bandwidth of the receiver to be tested. In the vhf range where receivers may have 3 db bandwidths of 50 to 100 kc, only a few kilocycles of f-m deviation can be tolerated if accurate measurements of receiver sensitivity are to be made.

Actual f-m deviation in the output of the Model 608D is shown in the typical performance curves of Fig. 4. By comparison, when the Model 608D is 50% a-m modulated, incidental f-m is rated as causing carrier deviations of less than 1 part in 10^5 or 1,000 cps, whichever is smaller. As shown in Fig. 4, incidental f-m deviation in the Model 608D is typically much less than even this stringent rating.

In the 608C's, where a buffer stage is not used, incidental f-m is still small because of the master-oscillator-power-amplifier circuit arrangement. Typically, however, f-m deviation is some three to four times greater than in the 608D's.

**SINE AND PULSE MODULATION**

Both the 608C and 608D have been designed to be capable of sine-wave or pulse modulation, and both are provided with a direct-reading modulation meter which monitors percentage modulation for sine-wave modulation. For self-modulation purposes, the generator circuits include an internal sine-wave modulating oscillator which can be switched for either 400- or 1,000-cps operation.

The modulation circuits have been made sufficiently wide-band so that the generators can be modulated by externally-applied frequencies from 20 cps to at least 100 kc or by pulses as short as 1 microsecond.
should be used at the lowest carrier frequencies.

From a voltage standpoint, the modulation sensitivity has been made high. Approximately 0.5 volt rms of external sine-wave voltage will give 95% modulation. For external pulse modulation, 5 volts peak are required.

**OUTPUT SYSTEM**

As in all -hp- signal generators, the output systems in the new generators are direct-reading. Output level is selected by precision piston attenuators which are calibrated directly in maximum available output power and in output voltage.

The calibrated range in the Model 608D extends from +4 dbm (0.35 volt) to -127 dbm (0.1 microvolt). In the Model 608C it extends from +7 dbm (0.5 volt) to -127 dbm. Higher outputs are read on the output meter. The accuracy of the attenuator calibration together with the tolerances on generator impedance are such that, when the generators are operated into their rated load resistances of 50 ohms, the output systems are accurate within 1 db at all frequencies and levels. This rating takes into account a slight attenuator non-linearity at the highest output levels. At outputs below about 0 dbm, the accuracy is usually improved by a factor of two or three times.

The internal impedance of both generators is held sufficiently close to 50 ohms so that a VSWR of less than 1.2 is obtained. Thus, if the generators are operated into a 50-ohm resistive load, less than 0.04 db of power loss due to generator mismatch will occur. If the load VSWR is, say, 1.2, less than 0.2 db mismatch loss will occur.

**MODELS 608A-B DISCONTINUED**

The new Models 608C and 608D Signal Generators supersede the former Models 608A and 608B which have been discontinued.