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# 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.

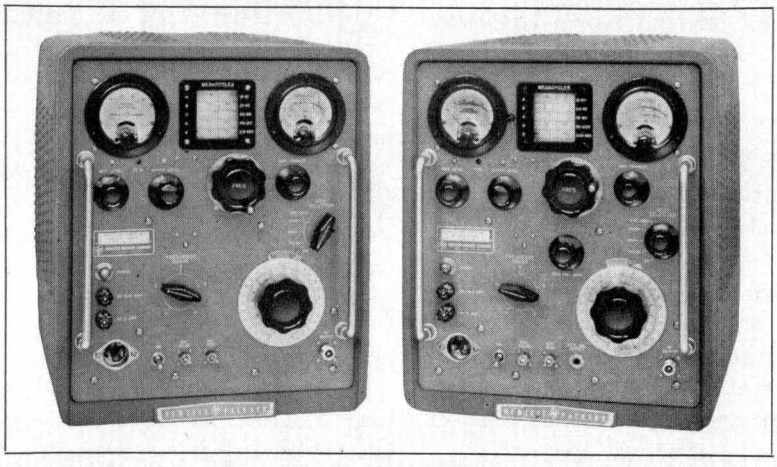

Fig.1. *Successors to the popular -hp- Model 608A-B's, new -hp- Models 608C (left) and 608D Signal Generators cover 10 to 400-plus megacycle range. MOPA type circuits are used in both instruments.*

## 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-

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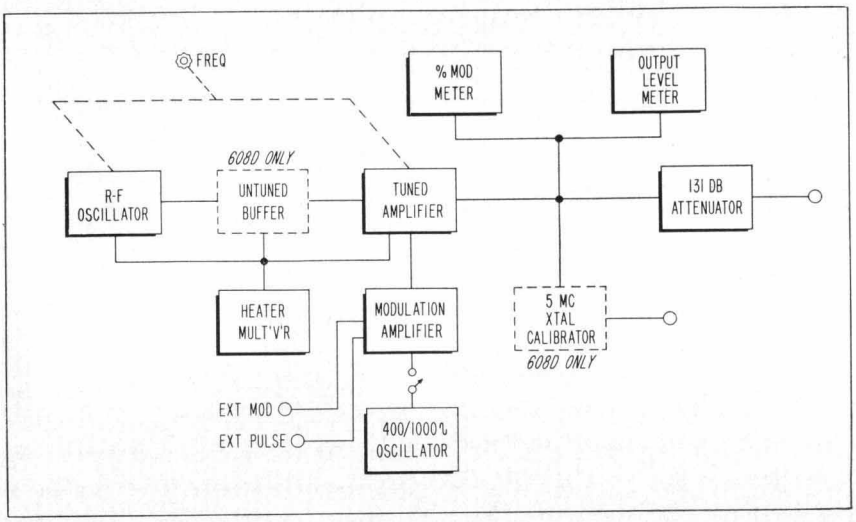



Fig. 2. *Circuit arrangements for -hp- 608C-D generators. Blocks drawn in dashed lines are included only in Model 608D.*

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**

| Band | 608C | 608D |
|---|---|---|
| "A" | 10-21 mc | 10-20 mc |
| "B" | 21-43 mc | 20-42 mc |
| "C" | *43-95 mc | *42-90 mc |
| "D" | 95-215 mc | 90-200 mc |
| "E" | 215-480 mc | 200-420 mc |

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 of 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

*For those working with 39-49 mc tv i-f circuits, the generators can be calibrated on special order down to 39 mc on the "C" band.

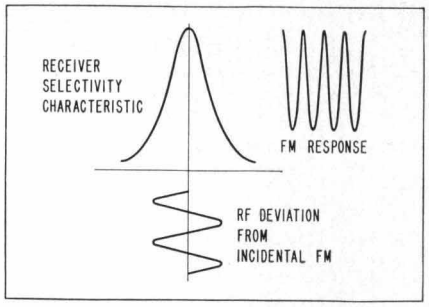



Fig. 3. *Representation of how a-m response is obtained in a-m receivers from f-m in signal source. Note that response from f-m will be largely second and higher harmonics of modulating frequency.*

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.

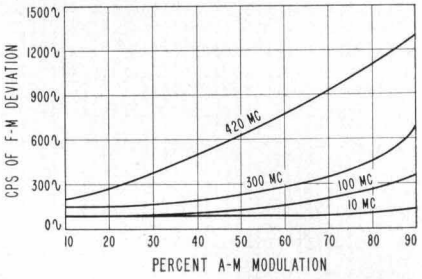
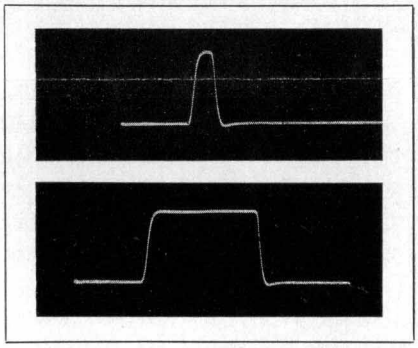


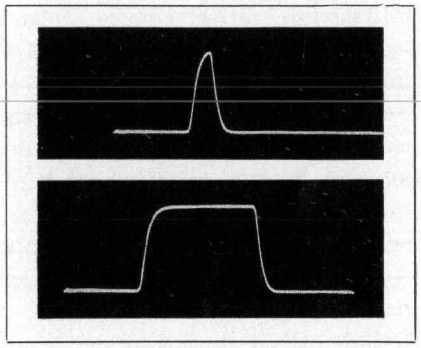

Fig. 4. *Typical incidental f-m in Model 608D VHF Signal Generator.*

The bandwidth of the r-f circuits determines the minimum width practical for pulse modulation. At the higher frequencies pulses as short as 1 microsecond will result in good output pulse shape as shown in Fig. 5*a*. At lower and lower carrier frequencies, the rise time of the r-f circuits increases (Fig. 5*b*) so that pulses having a minimum width of approximately 5 microseconds



*(a)*

*One and five microsecond pulses at 400 mc carrier.*



*(b)*

*One and five microsecond pulses at 90 mc carrier (top of C band).*

Fig. 5. *Oscillograms of typical rectified output pulses from new Model 608C-D Signal Generators.*

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.

*—H. E. Overacker*

**SPECIFICATIONS**

***-hp-***

**MODEL 608D**

**VHF SIGNAL GENERATOR**

*FREQUENCY RANGE:* 10 mc to 420 mc in 5 bands.

*TUNING CONTROL:* Main dial calibrated in megacycles and a vernier dial for interpolation purposes. Total scale length: Approx. 50". Calibration: Every other megacycle 100 to 200 mc; every 5 mc from 200 to 420 mc.

*FREQUENCY CALIBRATION ACCURACY:* Within ±1% over entire frequency range.

*RESETABILITY:* Better than ±0.1% after initial instrument warm-up.

*CRYSTAL CALIBRATOR:* Provides frequency check points every 5 mc over the range of the instrument. Headphone jack provided for audio frequency output (headphones not included). Crystal frequency accuracy better than 0.01% at normal ambient temperatures. Cursor on frequency dial adjustable over small range to aid in interpolation adjustments.

*FREQUENCY DRIFT:* Less than 0.005% over a 10 minute interval after initial instrument warm-up.

*OUTPUT LEVEL:* 0.1 microvolt to 0.5 volt (into a 50-ohm resistive load). Attenuator dial calibrated in volts and dbm. (0 dbm equals 1 milliwatt in 50 ohms.)

*OUTPUT VOLTAGE ACCURACY:* ±1 db over entire frequency and attenuation range (into a 50-ohm resistive load).

*GENERATOR IMPEDANCE:* 50 ohms, maximum SWR 1.2.

*INTERNAL MODULATION FREQUENCIES:* 400 cps ±10% and 1,000 cps ±10%.

*EXTERNAL AM MODULATION:* From 0 to 95% above 15 mc at output levels of 0 dbm and below for modulation frequencies 20 cps to 100 kc. Input requirements, 0.5 v rms across 15,000 ohms.

*MODULATION METER ACCURACY:* ±10% of reading from 30% to 95% modulation.

*ENVELOPE DISTORTION:* Less than 5% at 30% sine wave modulation and less than 10% at 50% sine wave modulation.

*EXTERNAL PULSE MODULATION:* 40 mc to 220 mc: Combined rise and decay time of r-f pulse less than 4 microseconds. 220 mc to 420 mc: Combined rise and decay time of r-f pulse less than 1 microsecond. Positive 5 volt peak pulse required.

*RESIDUAL FREQUENCY MODULATION:* Less than 1,000 cycles at 50% amplitude modulation for RF output frequencies above 100 mc and less than 0.001% at RF output frequencies below 100 mc.

*LEAKAGE:* Negligible; permits receiver sensitivity measurements down to at least 0.1 microvolt.

*FILAMENT REGULATION:* Stabilizes oscillator and amplifier against line voltage changes.

*POWER:* 115/230 volts ±10%, 50/1000 cps. Approx. 150 watts.

*SIZE:* 13¾" wide x 16⅛" high x 20⅜" deep.

*WEIGHT:* Cabinet, 63 lbs.; shipping weight, 100 lbs.

*ACCESSORIES FURNISHED:* *-hp-* M-72 Power Cord.

*ACCESSORIES AVAILABLE:* *-hp-* 608A-16D Output Cable provides 50 ohm termination and standard binding posts at the end of a 40" length of cable. Allows direct connection of the signal generator to high impedance circuits. $10.00 f.o.b. Palo Alto, California.

*PRICE:* $950.00 f.o.b. Palo Alto, California.

***-hp-***

**MODEL 608C**

**VHF SIGNAL GENERATOR**

Same as Model 608D, except:

*FREQUENCY RANGE:* 10 mc to 480 mc in 5 bands.

*EXTERNAL AM MODULATION:* From 0 to 95% above 15 mc at output levels of +7 dbm and below for modulation frequencies 20 cps to 100 kc. Input requirements, 0.5 v rms across 15,000 ohms.

*EXTERNAL PULSE MODULATION:* 40 mc to 220 mc: Combined rise and decay time of r-f pulse less than 4 microseconds. 220 mc to 480 mc: Combined rise and decay time of r-f pulse less than 1 microsecond. Positive 5 volt peak pulse required.

*CRYSTAL CALIBRATOR:* Included in Model 608D only.

*FREQUENCY DRIFT:* Less than 0.005% over a 10 minute interval after initial instrument warmup.

*OUTPUT LEVEL:* 0.1 microvolt to 1.0 volt (into a 50-ohm resistive load).

*RESIDUAL FREQUENCY MODULATION:* Less than 0.0025% at 30% amplitude modulation for RF output frequencies from 21 to 480 mc.

*PRICE:* *-hp-* Model 608C VHF Signal Generator, 10 mc to 480 mc—$850.00 f.o.b. Palo Alto, California.

Data subject to change without notice.

# Signal Generator Output Fuse

A special fuseholder has been designed to protect the output circuits of the *-hp-* Model 608 signal generators from accidental application of reverse powers of burnout magnitude. Such burnouts can occur with aircraft type transceivers when the microphone button is pressed or the muting relay sticks while the generator is connected to the antenna cable. The output of the transmitter is then applied to the low-power components in the signal generator output circuits with the result that burnout of some of these components may occur.

The fuseholder shown in the illustration prevents these accidental burnouts. A 1/16 ampere fast instrument fuse supplied in the holder permits continuous operation at full generator output but burns out at approximately 0.4 watt, sufficient to protect the generator circuits. Ten extra fuses are provided with the holder.


**SPECIFICATIONS**

***-hp-***

**MODEL 608A-95A**

**FUSEHOLDER**

*OVERLOAD PROTECTION:* Burnout occurs at approximately 0.4 watt. Fuse may be operated continuously at 0.2 watt.

*SWR:* 1.35 or less when terminated by 50-ohm matched load. 1.60 or less when terminated by *-hp-* 608 Attenuator.

*INSERTION LOSS:* Nominally 0.5 db.

*FUSE:* Military—F01GR062A. Commercial—8AG 1/16 amp fast instrument fuse. (Littelfuse No. 361.062 or Buss MJW 1/16.)

*CONNECTORS:* Type N male to Type N female.

*SIZE:* 13/16" diameter x 4⅝" long.

*WEIGHT:* 1 lb. packed for shipment.

*ACCESSORIES FURNISHED:* 10 extra fuses.

*PRICE:* $30.00 f.o.b. Palo Alto, California.