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A New Signal Generator for the 7,000 to 11,000 MC Range

THE new *-hp-* Model 620A SHF Signal Generator operates over the frequency range from 7,000 to 11,000 megacycles and incorporates all of the features that have given an unusual measure of popularity to the other *-hp-* high-frequency generators. For example, the new 620A is direct-reading in frequency and in power output, provides a maximum of approximately 1 milliwatt over most of its frequency range, has an accurate continuously-adjustable output attenuator to provide output levels as low as 0.1 microvolt, and has a flexible modulation system that provides for both internal and external modulation.

The flexibility of the modulation system is such as to enable the generator to be used for nearly any application desired for a signal source in this frequency region. For radar work and other pulse type applications, the modulation system includes a pulser so that any r-f pulse width is obtainable from ½ to 10 microseconds at any repetition rate from 40 to 4,000 pps. Both the pulse width and pulse repetition rate are selected by direct-reading controls.

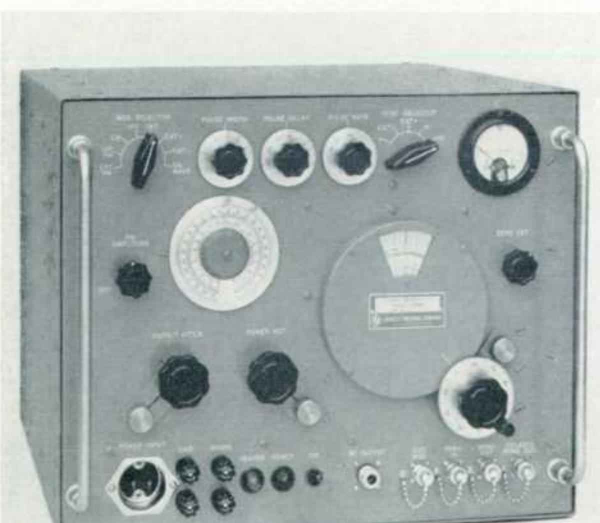

Fig. 1. *New -hp- Model 620A SHF Signal Generator provides for cw, pulse, square-wave or f-m output over 7 to 11 kmc range.*

For applications such as slotted line work, the modulation system provides for a square-wave modulated r-f output which is adjustable over a range from 40 to 4,000 cps. The repetition frequency of the square-wave modulation is selected by the same direct-reading controls that select the repetition frequency for pulse modulation.

The modulator further provides two synchronizing pulses of at least 25 volts peak amplitude into 1,000 ohms. One of these pulses begins approximately concurrently with the start of the pulsed r-f output. The other sync pulse is adjustable over a range from 3 to 300 microseconds ahead of the r-f output in order to position the sync pulse suitably for external triggering purposes. The rise time of the sync pulses is less than 1 microsecond. The modulation system can also be synchronized with external sine or pulse voltages of either polarity and as low as 5 volts amplitude.

A third type of internal modulation available is sawtooth f-m. The repetition frequency of the sawtooth is adjustable from 40 to 4,000 cps, while the r-f deviation is adjustable up to at least ±3 mc. Both the external synchronization feature and the sync out pulse feature are available for use when internal sawtooth modulation is used.

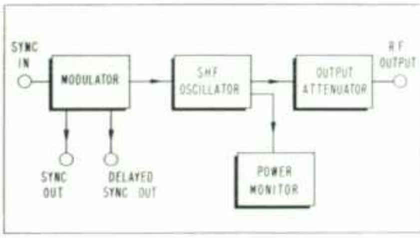

Fig. 2. *Block diagram of Model 620A circuit arrangement.*

The generator can also be modulated externally by pulses (a-m) or by external sine or sawtooth voltages for frequency modulation. On externally-applied modulating voltages, r-f deviations of up to ±5 megacycles are obtainable. The deviation is adjustable by the same panel control that adjusts deviation when using internal f-m.

RF OSCILLATOR DESIGN

The circuit of the 620A can be considered to consist of the sub-circuits shown in Fig. 2. The oscillator portion of the generator uses a type 5721 reflex klystron in combination with a shorted coaxial-line resonator. To make the oscillator direct-reading in frequency, the *-hp-* developed arrangement is used whereby the repeller voltage, resonator plunger position, and tuning dial are automatically tracked. The plunger positioning mechanism is designed so that the calibration of the frequency dial is expanded at the higher frequencies in order to achieve a more linear calibration.

The complete 7 to 11 kilomegacycle frequency range for the oscillator is covered by using two repeller modes: the $3\frac{3}{4}$ mode from 7 to 9 kmc and the $4\frac{3}{4}$ mode above 9 kmc. The tuning mechanism includes a sensitive switch that provides a step in repeller voltage at approximately 9 kmc in order to accommodate the mode change. The resonator is operated in the $\frac{3}{4}$-wavelength mode throughout.

A cross-sectional drawing of the resonator is shown in Fig. 3. The plunger is basically designed as a non-contacting type, although it has been provided with contacting fingers at the tube end in order to suppress undesired resonances that otherwise occur at the periphery of the plunger. Such resonances can occur with a non-contacting type plunger because the periphery of the plunger acts with the inner surface of the resonator to form a type of strip transmission line which is circled back on itself. The end result is that peripheral resonances, if they occur in or near the frequency range of the resonator and are not suppressed, will absorb power from the resonator and will usually damp the oscillations completely.

To suppress a peripheral resonance that occurred in the gap between the plunger and the center conductor, the gap has been dielectrically loaded by means of a plastic sheath. This has the effect of lowering the frequency of the resonance to a frequency below the frequency range of the generator where it is ineffective since it cannot be excited.

MODE SUPPRESSION

In designing the resonator it was found necessary to suppress the 1,1 mode ($\frac{1}{4}$-wavelength resonator, $1\frac{3}{4}$-wavelength repeller mode) which interfered with the desired mode. To suppress this mode, a new suppression technique was evolved, a technique so straightforward that the final design of the resonator is entirely free from recesses or protuberances of any kind except for the attenuator and power meter waveguides.

An examination of the undesired 1,1 mode disclosed that its frequency was everywhere below 6,000 megacycles, considerably below the 7,000 megacycle lower frequency limit of the generator. In considering this fact, an arrangement was devised whereby the space between the inner surface of the plunger and the surface of the inner conductor was designed to appear to the resonator as a low-pass filter having a cutoff frequency of approximately 6,500 megacycles. The filter consists of a number of low- and high-impedance line sections in cascade. The filter is terminated at the back of the plunger with a powdered iron mixture to absorb the energy passed by the filter.

The use of such a low-pass filter prevents the undesired mode from supporting itself and thus is an effec-

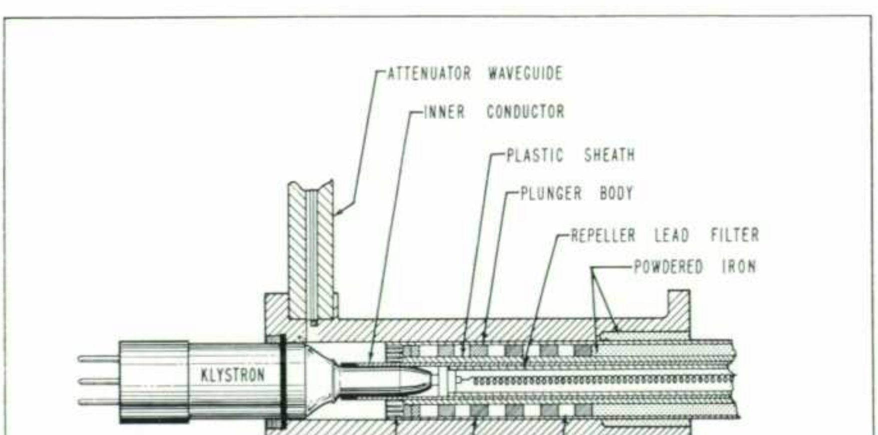

Fig. 3. *Simplified cross-sectional view of resonator used in Model 620A.*

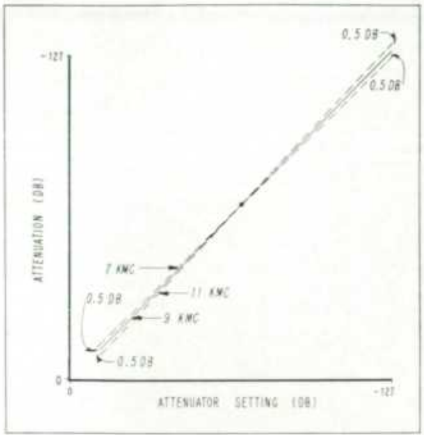

Fig. 4. *Curve of actual attenuation as a function of attenuator settings for ends and middle of frequency range of Model 620A. Effect of frequency variation of attenuator is minimized by special calibration arrangement.*

tive suppression measure. At the same time the relatively high capacity of the input to the first filter section appears as a low impedance at the higher frequencies of the desired mode so that the terminating characteristics of the plunger are not significantly affected in this region. As a result of this arrangement, the resonator appears to the tube as a terminated transmission line at frequencies below 6,500 megacycles and as a shorted, tunable high-Q transmission line resonator at frequencies above 6,500 megacycles.

To assist in obtaining a long life for the klystron and to maintain a relatively low temperature for the glass-to-metal seals on the tube, a forced air stream is passed through the resonator. This measure keeps the tube seals at a temperature of 140°C compared to the 160°C maximum rating for the seals.

OUTPUT ATTENUATOR

A feature of the Model 620A which is unusual for a wide-band generator in its frequency range is that the output attenuator is direct-reading and does not require correction for frequency effects. The attenuator used in the generator is a waveguide-beyond-cutoff type, a type which is unexcelled for signal generator use because of its high accuracy.

In designing such an attenuator for use over wide frequency and attenuation ranges, it is desirable that the cutoff frequency of the attenuator be approximately 10 times the highest frequency at which the attenuator is to be used. In the case of the Model 620A where the highest frequency used is 11 kmc, this requirement would mean that the cutoff frequency of the attenuator would have to be in excess of 100 kmc or in physical terms about 1.6 mm in diameter. The attenuator plunger and pickup loop would thus have to be constructed to clear this small diameter. At best this would be a painstaking and consequently expensive assembly operation.

To avoid this situation, an arrangement has been used whereby the diameter of the attenuator waveguide has been increased to more practical dimensions. However, the frequency effect that is incurred by increasing the attenuator dimensions has been held to a quite acceptable value by distributing the total effect over the frequency and attenuation range of the generator.

The manner in which this distribution is accomplished is indicated in Fig. 4. First, the attenuator is calibrated in the middle of its frequency range (in the vicinity of 9 kmc) so that the total frequency effect is halved and so that even this half is incurred only at the extreme ends of the frequency range of the generator. Second, the power monitoring circuit is designed so that its calibration as a function of frequency has a slight slope. The arrangement is such that the attenuator readings are theoretically without error at the mid-point of the attenuation range (in the vicinity of −55 dbm) anywhere in the 7-11 kmc range. This means that the frequency effect is further halved, being a maximum of one-quarter. At −55 dbm, then, the frequency error in the attenuator is theoretically zero and increases to less than 0.5 db at the extreme limits of maximum or minimum attenuation with maximum or minimum frequency.

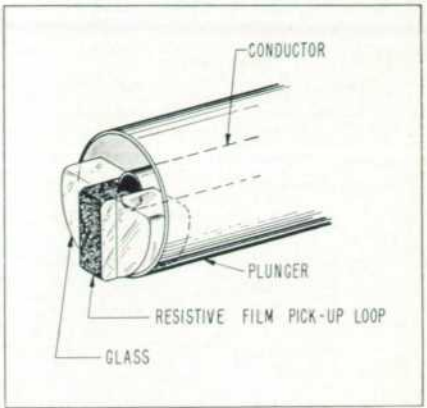

Fig. 5. *Enlarged view of pick-up loops for attenuator and power monitor plungers.*

It should be emphasized that the accuracy of the output level from the generator has a wider tolerance than 0.5 db in order to accommodate impedance mismatches arising from connector reflections and an imperfect source impedance for the generator. Accuracy of power output is good, however, and the error is less than 2 db into a matched load below −10 dbm at any output frequency. At levels higher than −10 dbm (0.1 milliwatt), the attenuator plunger enters the non-linear region existing at the mouth of the attenuator waveguide where the error is not controlled.

POWER MONITORING SYSTEM

As in all *-hp-* high-frequency generators, the direct-reading power output feature is obtained by providing a reference point for the operation of the output attenuator. This reference point is obtained by sampling the power level in the resonator with a built-in power meter.

The power sample applied to the power meter and the power absorbed by the output attenuator are received by identical pick-up loops that operate in identical waveguides opening into the resonator. Because of the small dimensions of these waveguides as described above, the pick-up loops have been designed with a new approach. Instead of forming the pick-up loops from pieces of small wire, the construction shown in Fig. 5 has been used. The leads for the pick-up loops are attached to small glass beads located in the ends of the attenuator and monitor waveguide plungers. A recess is provided in each bead to make this connection mechanically secure. Across the radius of the bead is a raised surface of approximately the same width as the diameter of the lead secured to the bead. This raised surface is coated with a special mixture of platinum so as to have a resistance of approximately 50 ohms. The end result is that the pick-up loop has low inductance and at the same time has a resistive value of approximately the correct value to represent the 50-ohm source impedance desired for the generator.

In order to cover the frequency range of the Model 620A, the klystron oscillator is operated in high-order repeller modes where the power output from the klystron is relatively low. For this reason a more sensitive power meter has been used than has been customary in *-hp-* signal generators. The power meter itself is a conventional thermistor bridge which is compensated against temperature and sensitivity changes resulting from changes in ambient temperature over a range from −20°C to +40°C.

GENERAL

R-f leakage from the generator is more than 85 db below 1 milliwatt as measured with an untuned antenna held between 2 and 6 inches from the generator cabinet. The r-f conducted from any panel connector except the r-f output connector is also less than −85 dbm.

Besides forced air cooling for the resonator, the cabinet for the generator is force-cooled. A renewable type air filter element is mounted at the air intake.

Provided with the generator are three cables in addition to the power cable. One of these is the r-f output cable which consists of six feet of RG-9A/U coaxial cable with type UG-21D/U male connectors at either end. The other two cables are identical and consist of four feet of type RG-58/U coaxial cable with type UG-88/U male connectors at either end. These connectors mate with the connectors provided on the panel of the generator for sync and external modulation.

—Arthur Fong

SPECIFICATIONS
—hp—
MODEL 620A
SHF SIGNAL GENERATOR

FREQUENCY RANGE: 7,000 to 11,000 mc covered in a single band.

FREQUENCY CALIBRATION: Calibration accuracy better than 1%.

OUTPUT RANGE: 0.1 milliwatt or 0.071 volt to 0.1 microvolt (−10 dbm to −127 dbm) into 52 ohms. Directly calibrated in microvolts and db (coaxial Type N connector). Maximum output is approximately 1 milliwatt over most of frequency range.

ATTENUATOR ACCURACY: Within ±2 db.

OUTPUT IMPEDANCE: 52 ohms nominal.

MODULATION: Internal or external pulse and f-m; internal square wave.

INTERNAL PULSE MODULATION: Repetition rate variable from 40 to 4,000 pps; pulse width variable from ½ to 10 microseconds.

SYNC OUT SIGNALS: Two provided. 1. Simultaneous with r-f pulse. 2. Adjustable from 3 to 300 microseconds in advance of r-f pulse. Both pulses have less than 1 microsecond rise time and 25 to 100 volts amplitude into 1000 ohm load.

EXTERNAL SYNCHRONIZATION: 1. Sine wave: 40 to 4,000 cps, amplitude 5 to 50 volts rms. 2. Pulse signals: 40 to 4,000 pps and 5 to 50 volts amplitude, both positive and negative, pulse width 0.5 to 5 microseconds, rise time 0.1 to 1 microseconds.

INTERNAL SQUARE WAVE MODULATION: Variable from 40 to 4,000 cps; controlled by panel control.

INTERNAL FREQUENCY MODULATION: Sawtooth sweep rate adjustable between 40 to 4,000 cps. Frequency deviation up to ±3 mc.

EXTERNAL PULSE MODULATION: Pulse requirements: amplitude from 15 to 70 volts positive or negative, width 0.5 to 2,500 microseconds.

EXTERNAL FREQUENCY MODULATION: Provides capacitive coupling to repeller of klystron. Maximum deviation approximately ±5 mc.

POWER SOURCE: 115 volts, ±10%, 50/60 cps, 250 watts.

SIZE: 16¾" x 13½". Weight: 90 pounds. Shipping weight: 165 pounds.

ACCESSORIES SUPPLIED: 61B-16K (2) Four-foot cable with UG-88/U connector at each end. 812-58 (1) Six-foot cable with UG-21B/U connector at each end. 61B-16H (1) Power cable.

PRICE: $2,250.00 f.o.b. Palo Alto, California.
Data subject to change without notice.

HEWLETT ELECTED I.R.E. PRESIDENT

The Institute of Radio Engineers has announced the election of William R. Hewlett as I.R.E. President for 1954.

Mr. Hewlett received his A.B. degree from Stanford University in 1934 and his M.S. degree from M.I.T. in 1936. In 1939 he received the degree of Electrical Engineer from Stanford.

From 1936 to 1938 he was engaged in electro-medical research in Palo Alto, California, where he joined with David Packard in 1939 in starting the Hewlett-Packard Company. In 1942 he entered the Army, serving with the Office of the Chief Signal Officer and the New Developments Division of the War Department's Special Staff in Washington, D.C. He was awarded the Army commendation ribbon and star for services in these capacities. In late 1945 he resumed active participation in the Hewlett-Packard Company and is at present its Vice President.

In 1949 Mr. Hewlett was appointed a Fellow in the I.R.E. He served from 1949 to 1953 on the Board of Directors and has also served on numerous committees of the Institute. Mr. Hewlett is also a member of Sigma Xi and the A.I.E.E.