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The *-hp-* Direct-Reading UHF Signal Generators

THE *-hp-* Model 616A UHF Signal Generator was designed as the first commercially-available direct-reading signal generator for the upper UHF region. It operates over the range from 1800 to 4000 megacycles. A second generator, the *-hp-* Model 614A, was subsequently developed for use over the 800 to 2100 megacycle range as a companion instrument for the 616A. The 614A and 616A are similar in all characteristics except frequency range.

Both generators have three outstanding characteristics that give them a high degree of usability: they are direct-reading in frequency, direct-reading in output power, and cover a wide frequency range. The very real value of these characteristics will be recognized at once by those who have worked with frequency charts and power output curves for the once-common narrow-band UHF generators.

Fig. 1. -hp- Model 616A UHF Signal Generator operates from 1800 to 4000 megacycles with maximum output of at least one milliwatt. Model 614A is similar in appearance and circuitry but operates from 800 to 2100 megacycles.

Both generators provide c-w, pulse, and f-m type outputs. A versatile internal pulser permits the pulse modulation to meet a variety of requirements as to pulse rate, pulse length, and synchronization. The character of typical output pulses is illustrated in Fig. 2.

Probably the most common use for signal generators is in testing receivers. For receiver testing, it is desirable that the output power from the generator be adjustable down to very low levels. Thus, the 614A and 616A have been designed to provide outputs as low as 0.1 microvolt. This low level is more than sufficient to test present receivers.

The matter of high output from the generator is of secondary importance in receiver testing. A maximum generator output in the order of a hundred microwatts is usually adequate. However, the general usefulness of a signal generator is greatly increased if higher output is available. For example, one of the major uses for UHF generators with higher output is as signal sources for slotted line work. Several features of the 614A and 616A make these generators especially convenient for slotted line work. For one thing, the output of the generators is at least one milliwatt (0.22 volt) over the complete range of each generator. Although more power is sometimes desired, an output of one milliwatt is adequate for standing-wave measurements when using the *-hp-* slotted line sections and the Model 415A Standing Wave Indicator. The 415A has a full scale sensitivity of 0.3 microvolt which, in combination with a generator power level of

(a) (b)

Fig. 2. *Oscillograms of typical 1 microsecond r-f pulses (rectified) generated by (a) Model 614A and (b) Model 616A.*

1 milliwatt, will permit a loose coupling in the order of −50 db between detector element and slotted line. Such isolation is ample for accurate VSWR measurements using proper techniques. A typical set-up using these instruments is shown in Fig. 3.

In slotted line measurements it is common to use a square-law detector element in the sampling probe of the slotted line. Where the accuracy of the square-law characteristic of the detector element is questionable, the output attenuator on the generators can be used in such a way as to minimize detector inaccuracies. The attenuators in the generators are piston types in which attenuation is determined by physical dimensions. The attenuators are precision-constructed to have a high degree of linearity after the first few db of attenuation.

To use the attenuators for standing-wave measurements, the power fed to the line is decreased when measuring the amplitude of a maximum in the standing-wave pattern so that the detector reading is the same as when a minimum is measured. The standing-wave ratio can then be read directly from the two settings of the calibrated attenuator.

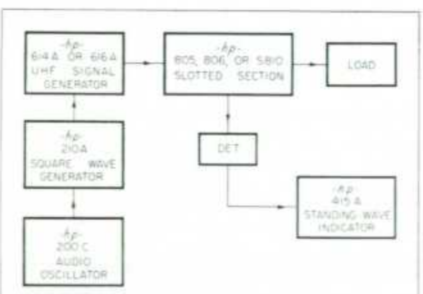

Fig. 3. *Typical set-up for standing-wave measurements using -hp- Model 614A or 616A. Use of high-gain Model 415A Standard Wave Indicator increases sensitivity of measurements.*

The generators are further designed to have low incidental f-m when square-wave modulated. Low f-m is desirable for standing-wave measurements so that the minimum of a high standing-wave can be adequately investigated. In the 614A and 616A incidental f-m is sufficiently low to permit measurement of standing-wave ratios of approximately 100:1.

OTHER APPLICATIONS

Because of their relatively high output, the generators lend themselves to a number of other types of applications. One such application involves the use of a silicon crystal diode for h-f mixing. In this type of work, applying substantial local oscillator power gives the crystal a high mixing sensitivity or conversion efficiency.

Using these properties, the generators have been used as local oscillators in laboratory bread-board receiver set-ups like that shown in Fig. 4. Sensitivities in the order of a few microvolts are readily obtainable from such set-ups using the 614A and 616A.

The 127 db range of output power also makes the generators useful for such applications as measuring characteristics of r-f networks, filters, etc.

CIRCUITRY

The circuit of each generator consists of the main parts shown in Fig. 5. Of special interest is the r-f oscillator which includes a reflex klystron operating with a variable-length shorted-line type external resonator. A cross-sectional view of the oscillator appears in Fig. 6. The length of the resonator is adjusted by a contacting short of the type described in a previous article.[1] The short is constructed of tempered beryllium copper overlaid with silver blocks at the areas where actual contact occurs between the short

[1] "Inexpensive Quality," Hewlett-Packard Journal, Vol. 2, No. 9, May, 1951.

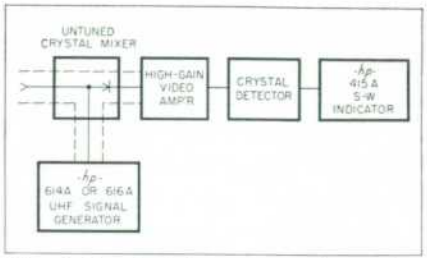

Fig. 4. *Simple laboratory receiver using -hp- Model 614A or 616A as local oscillator.*

and the resonator walls. The silver block overlays are carefully lapped after assembly of the short to insure a low-resistance contact having long life. Life tests of these contacts consistently show many tens of thousands of cycles of operation with negligible deterioration either of the short or the resonator walls.

The klystron is held in the resonator by a collet arrangement on the inner end of the resonator center conductor. The collet shaft extends out of the resonator and is secured by a thumb screw. This arrangement makes for quick replacement of the klystron, since it is only necessary to remove the tube socket cover and rear resonator grid clamp. By then releasing the collet shaft thumb screw, the klystron can be moved out of the end of the resonator.

DIRECT-READING OUTPUT SYSTEM

The system for selecting output power includes a high-level monitoring circuit and a 0 to 127 lb continuously-variable attenuator. The monitoring system is of the type in which the power level of the oscillator is

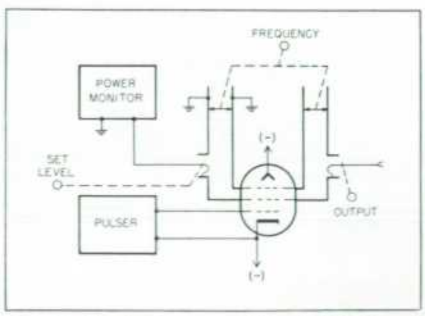

Fig. 5. *Block diagram of Model 614A and 616A circuit.*

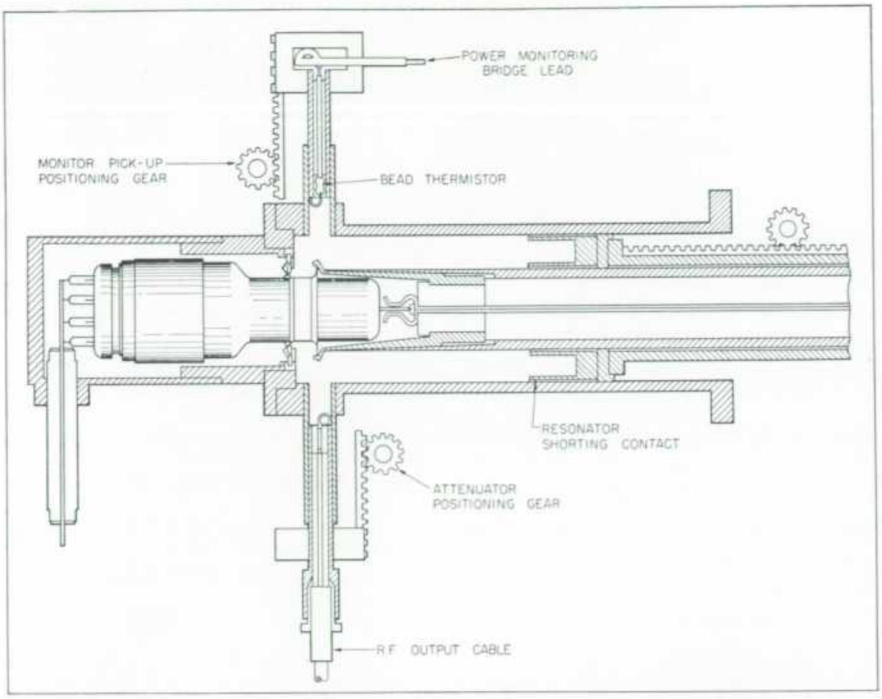

Fig. 6. *Cross-section of UHF oscillator.*

continuously monitored.

To monitor the power level of the oscillator, a pick-up loop in a piston attenuator (Fig. 6) is coupled into the resonator. The pick-up loop applies a sample of the resonator field level to a bead thermistor which is connected as one arm of a wheatstone bridge. Changes in power level within the resonator change the resistance of the thermistor, resulting in a change in the reading of the calibrated bridge meter. The bridge circuit is compensated against changes in sensitivity and balance with variations in ambient temperature.

A second pick-up loop and piston attenuator couple power from the resonator to the output jack. The output attenuator and the monitoring attenuator are each operated by identical gear trains coupled to separate shafts at the front of the instrument. The shaft from the output attenuator is coupled to a calibrated attenuator dial, while the fiducial for this dial is connected to the shaft from the monitor gear train (Fig. 7).

Since both attenuators are identical and since both are operated by identical gear trains, the foregoing arrangement results in a direct-reading output system. Any change in field level within the resonator will be reflected in a change in the reading of the power monitor meter. When such a change is compensated by adjusting the monitor attenuator so as to keep constant the reading of the meter, the fiducial for the attenuator dial will automatically be rotated the proper amount to correct the reading of the attenuator dial.

OUTPUT CIRCUIT

The output attenuator is connected to the output jack on the panel through a length of coaxial line. As a measure for obtaining a fixed internal impedance of the proper value with the Model 616A, a section of lossy line is inserted immediately preceding the output connector. The line is made lossy by the use of a special center conductor consisting of a thin film of platinum coated on a glass rod. Approximately 6 db of attenuation is introduced by this line.

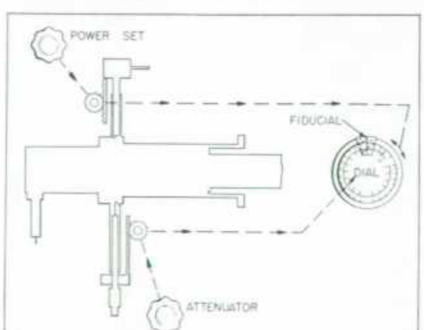

Fig. 7. *Schematic representation of mechanical system for selecting and indicating output power level.*

The physical arrangement of the lossy line with respect to the output connector is shown in Fig. 8. In early designs the center pin of the output connector was pressed into a teflon centering bead. In this design it was found possible to break the glass rod by radially straining or skewing the center pin of the output connector.

To reduce this danger, the center pin is currently molded into a polystyrene bead so that the radial force required to skew the center pin is much increased. This arrangement further minimizes the danger of forcing backward the center pin by over-tightening an improperly assembled mating connector.

In the 614A the desired internal impedance is obtained through use of an internal resistive termination on the piston attenuator.

OUTPUT POWER CALIBRATION

The power output systems of the 614A and 616A are calibrated in terms of the power absorbed by a load that is the conjugate of the internal impedances of the generators. This calibration is accurate within 1 db and includes any error arising from frequency sensitivity of the power monitoring and output attenuator systems.

Another factor that influences indirectly the accuracy of the output system is the magnitude and constancy of the internal impedance of the generators. The generators are designed to be used with type N con-

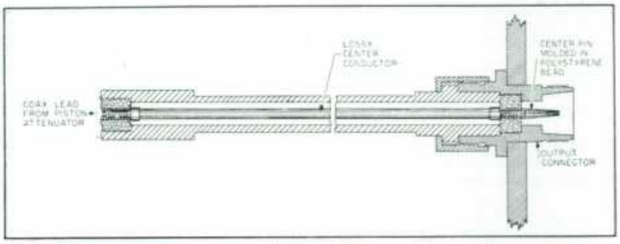

Fig. 8. *Arrangement of lossy line section and output connector.*

nectors and common type cables and therefore have a nominal internal impedance of 50 ohms. This impedance is maintained sufficiently accurate that only small error occurs when the load is reasonably "flat." For example, if the generators are used with a load having a VSWR not higher than 1.5, a maximum error of only 1 db will result.

OSCILLATOR TUBES

The reflex klystron used in the Model 616A is a type 2K28. In the past some of these tubes have exhibited an hysteresis effect that influenced the operation of the generator, especially under pulse modulation. Two conditions were traceable to this hysteresis. First, a condition sometimes occurred where the oscillator operated properly when tuned, say, from a lower to a higher frequency but did not operate when first turned on with the dial tuned at the higher frequency. By tuning to a different frequency, the oscillator would begin to operate and could thereafter be used usually over the complete frequency range. In the second condition the oscillator did not operate satisfactorily when pulse-modulated. At some frequencies no output would be obtained; at other frequencies operation was unstable with extreme jitter, usually in the leading edge of the pulse. Sometimes these conditions could be bettered by adjustment of repeller voltage. At the factory roughly one tube out of four was rejected because of hysteresis.

The problem of hysteresis has been investigated both in our own laboratories and by the tube manufacturer with the result that an improved tube is currently available. The new version is presently supplied in all 616A's and is available as a replacement tube. One of the specifications of the new tube requires satisfactory operation in a resonator identical to that used in the *-hp-* Model 616A.

In the lower frequency Model 614A, a type SD1104 reflex klystron was formerly used. This tube is now supplied under the RMA designation 5837.

PULSE CIRCUITS

Both the 614A and 616A include flexible pulsers that have a wide range as to repetition rate, pulse width, and pulse position. The pulse rate is adjustable over a range from 40 to 4000 pps by means of direct-reading controls, while pulse width is adjustable from 1 to 10 microseconds by a calibrated control.

The pulser can be operated either free-running or synchronized from external voltages. The position of the r-f pulse is adjustable over a range from 3 to 300 microseconds following the occurrence of a synchronizing voltage.

The pulser provides two video sync out pulses for use with associated external equipment. One of these pulses is approximately coincident with the occurrence of the output r-f pulse; the second occurs from 3 to 300 microseconds prior to the r-f pulse as determined by the pulse-positioning circuits. The oscillator is also arranged so that it can be modulated by externally-applied pulses or square waves.

—*Arthur Fong* and *W. D. Myers*

SPECIFICATIONS

-hp- Models 614A and 616A UHF Signal Generators

FREQUENCY RANGE: (614A) 800 to 2100 mc; (616A) 1800 to 4000 mc. Selection is made with a single direct-reading control. No charts are necessary.

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FREQUENCY CALIBRATION ACCURACY: Within 1%.

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OUTPUT RANGE: 1 milliwatt (0.223 volt) to 0.1 microvolt (0 dbm to −127 dbm). Directly calibrated in microvolts and db; continuously monitored.

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ATTENUATOR ACCURACY: Within 1 db from −7 to −127 dbm (614A: −10 to −127 dbm) without correction charts. A correction chart is provided when greater accuracy is desired.

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OUTPUT IMPEDANCE: 50 ohms nominal.

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

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INTERNAL PULSE MODULATION: Repetition rate variable from 40 to 4000 pps; pulse length variable from 1 to 10 microseconds; delay variable from 3 to 300 microseconds (between synchronizing pulse and r-f pulse).

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TRIGGER PULSES OUT: 1. Simultaneous with r-f pulse; 2. in advance of r-f pulse, variable 3 to 300 microseconds.

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EXTERNAL SYNC PULSE REQUIRED: Amplitude from 10 to 50 volts of either positive or negative polarity and 1 to 20 microseconds width. Can also be synchronized with sine waves.

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FM MODULATION: Oscillator frequency sweeps at power line frequency. Phasing and sweep range controls provided. Maximum deviation approximately ±5 mc.

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POWER SOURCE: Operates from 105-125 volt 50/60 cycle single phase source.

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DIMENSIONS: 17" wide, 13¼" high, 13½" deep.

•

SHIPPING WEIGHT: Approximately 100 lbs.

•

PRICE: $1950.00 (each instrument) f.o.b. Palo Alto, California

Data subject to change without notice.