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ELECTRICAL MEASUREMENTS AND THEIR INDUSTRIAL APPLICATIONS

A STANDARD-SIGNAL GENERATOR FOR FREQUENCIES BETWEEN 50 AND 920 MC

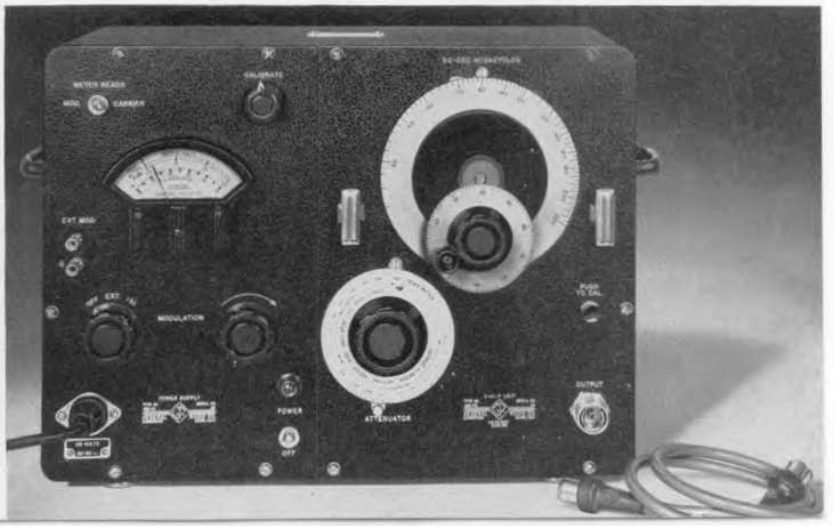
Also
IN THIS ISSUE

●**THE NEW** TYPE 1021-A Standard-Signal Generator performs at very-high and ultra-high frequencies all the functions of the common standard-signal generator which is ordinarily limited to much lower frequencies. Its main use is the determination of radio-receiver and circuit characteristics in the engineering laboratory and in production. In addition it is a convenient and well-shielded source of power for measurements with bridges, impedance comparators, and slotted lines.

In combination with a simple crystal-diode modulator (TYPE 1000-P6) and a source of video signals, it can be used to produce television picture modulation on all channels between 50 and 920 Mc.

With the TYPE 1023-A Amplitude Modulator, the generator out-

Figure 1. Panel view of the Type 1021-AV V-H-F Standard-Signal Generator.



put, up to 250 Mc, can be modulated to a known percentage at audio frequencies with no significant incidental fm.

Internal amplitude modulation is provided for those uses where a small amount of incidental fm is not serious.

Simplicity, economy, and reliability were important design considerations, and the resulting instrument is moderately priced, compact, light in weight, durably built, and convenient to use. Since range switching is impractical at these frequencies, two separate oscillator units are used, each with its own attenuator and rectifier for measuring output voltage. The V-H-F Unit covers frequencies between 50 and 250 Mc, and the U-H-F Unit, 250 to 920 Mc. A third unit, the power supply assembly, provides filament and plate power, means for amplitude modulation at audio frequencies, and a meter for indicating output voltage and percentage modulation.

For convenience in ordering, the generator is listed in two models, (1) the TYPE 1021-AV V-H-F Standard-Signal Generator, consisting of the V-H-F Unit and power supply in a cabinet, and (2) the TYPE 1021-AU, consisting of the U-H-F Unit and power supply in a cabinet. When both ranges are desired, the TYPE 1021-AV can be ordered plus the additional U-H-F Oscillator Unit as a separate item. Oscillator units are interchangeable mechanically, and the replacement of one by the other is easily and quickly accomplished.

Figure 3. View of the oscillator portion of the U-H-F Unit, with cover removed from casting to show tube, butterfly, and attenuator input.

R-F OSCILLATORS

Structurally, the two carrier oscillator units are much alike. They differ in carrier frequency range covered, but each uses as the tuning element a butterfly circuit[1,2], in which the inductive and capacitive components are built integrally, and tuning is achieved by simultaneous variation of both without use of sliding contacts. The U-H-F Unit uses a $2\frac{1}{2}''$ diameter symmetrical butterfly circuit adapted for use with the Sylvania Type 5767 Coplanar U-H-F Triode, or Rocket Tube, while the V-H-F Unit uses a $4\frac{1}{2}''$ semibutterfly with a standard miniature twin triode (12AT7) in a push-pull connection.

[1]Eduard Karplus, "The Butterfly Circuit," *General Radio Experimenter*, October, 1944.
[2]Eduard Karplus, "Wide-Range Tuned Circuits and Oscillators for High Frequencies," *Proceedings I. R. E.*, July, 1945.

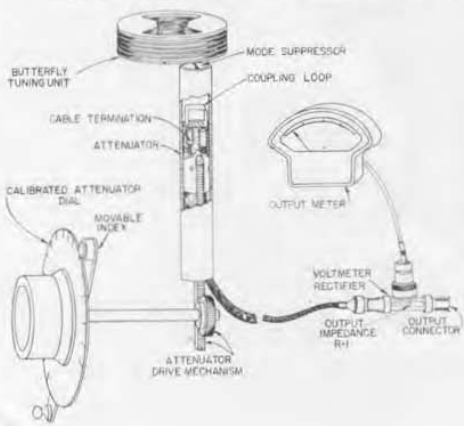


Figure 2. Functional diagram of the output system.

POWER SUPPLY UNIT

The power supply unit provides regulated plate and heater power for the oscillator. A modulator tube is connected in a simple *L-C* oscillator circuit to provide internal amplitude modulation at 1000 cycles per second, or as an amplifier to permit amplitude modulation over the audio frequency range. A single panel meter is used to indicate carrier output voltage and modulation percentage, and to check the calibration of the crystal detector used in the output meter. An internal calibrating voltage derived from the regulated power supply is provided for this check.

OUTPUT SYSTEM

Output between 0.5 microvolt and 1.0 volt, at an internal output impedance of 50 ohms, is available at a coaxial connector on the panel. This output is obtained through a mutual inductance (waveguide-below-cutoff type) attenuator. A coaxial cable connects the attenuator to a crystal voltmeter on the front panel. Following the voltmeter is a 50-ohm resistor which determines the output impedance. The rectifying element of the voltmeter and its mounting are similar to the TYPE 874-VR Voltmeter Rectifier[3]. The indicating meter is in the TYPE 1021-P1 Power Supply Unit. At 920 Mc the voltmeter error caused by resonance is about +6%.

Voltages between 0.5 volt and 2 volts are indicated directly by the output meter. Since the meter is connected across the output of the attenuator, it will not read at low output voltage settings. For voltages under 0.5 v, the output is first set to 0.5 volt, as indicated by the meter, and the adjustable attenuator index is moved to the 0.5-volt point on the attenuator dial which is calibrated down to 0.5μv. Other low output voltages are then determined accurately by setting the attenuator dial, as long as the load is not changed. In this output system, the accuracy of output voltage at the panel terminal is determined by the accuracy of the voltmeter and attenuator alone, and the effective output impedance is determined by the resistor R_1. The resistor R_2 at the attenuator input is a matching resistance which prevents high-amplitude standing waves from being set up in the cable when the output is open circuited.

The output system used here differs from the more conventional arrangement[4, 5, 6] whereby the field at the attenuator input is sampled by a probe and indicated on a panel meter. The out-

[3]W. R. Thurston, "Simple, Complete, Coaxial Measuring Equipment for the U-H-F Range," *General Radio Experimenter*, January, 1950.

[4]Eduard Karplus, "Components of U-H-F Field Meters," *Electronics*, November, 1946.
[5]Arnold Peterson, "Output Systems of Signal Generators," *General Radio Experimenter*, June, 1946.
[6]D. B. Sinclair, "A Simple Standard-Signal Generator for F-M Broadcast Use," *General Radio Experimenter*, November, 1949.

Figure 4. Rear view of the V-H-F Unit showing the casting that completely encloses the oscillator. Connections to the power supply unit are made through the connector at the upper right.

put voltage is then independent of load, and the internal impedance is that seen when looking back into the attenuator cable terminated in a coupling loop and resistor. Such a system can be made to work satisfactorily at frequencies up to a few hundred megacycles, but, at higher frequencies, both higher output voltages and more accurate voltage indications can be obtained with the system chosen for use in this generator.

MODULATION

A general-purpose internal amplitude modulation system is provided, and external modulation can be applied, but no provision is made for pulsing or for frequency modulation.

In addition to its obvious uses in receiver testing, the modulated signal has a considerable advantage when the generator is used as a power source for impedance measurements with bridges, slotted lines, and admittance comparators, because it permits audio amplification to be used following the detector to increase sensitivity.

The oscillator is modulated directly, and consequently incidental fm is inherent in the system.

Where incidental fm cannot be tolerated, and where wide-band modulation is desired, external modulating units, operating on the output side of the attenuator, can be used. Because the modulator is isolated from the oscillator by the attenuator, reaction on the oscillator frequency, with its attendant incidental fm, is completely negligible. Two such external modulating units are available, the TYPE 1023-A Amplitude Modulator and the TYPE 1000-P6 Crystal Diode Modulator.

The TYPE 1023-A Amplitude Modulator[7] can be used at carrier frequencies up to 250 Mc and will give output up to 150 millivolts. Percentage modulation can be adjusted accurately up to a maximum of 80%.

For amplitude modulation, without incidental fm, over the entire range of the TYPE 1021-A Standard-Signal Generator, the simple TYPE 1000-P6 Crystal Diode Modulator, described in the following article, is recommended. The output of this modulator is of the order of 10 millivolts. The actual percentage modulation, which is limited to about 50%, is not accurately known without measurement, but the modulation characteristic is flat within 2 db up to 5 Mc. It is possible, therefore, to produce television picture signals on all channels between 50 and 920 Mc. A convenient source of television video signals is a standard television receiver tuned to a local station.

FEATURES

Probably the outstanding feature of the TYPE 1021-A Standard-Signal Generator is its convenience and reliability.

[7] D. B. Sinclair, "A Versatile Amplitude Modulator for V-H-F Signal Generators," *General Radio Experimenter*, November, 1949.

Figure 5. The Type 1021-AV V-H-F Standard-Signal Generator and the Type 1023-A Amplitude Modulator, arranged for tests on a communications-type receiver.

It brings to the V-H-F and U-H-F ranges the same ease of operation that is characteristic of most signal generators at lower frequencies, but which has not hitherto been available at frequencies as high as 920 Mc.

The carrier oscillators cover wide frequency ranges with smooth control, since no sliding contacts are used in the tuned circuits. The tuning element is driven by a worm gear. The driving shaft carries a 100 division dial which makes over eleven turns to cover the range. Frequency calibration extends over 270° on a 6″ dial. The oscillator units are enclosed in double shields, and all supply leads are well filtered. Residual output voltage and leakage are below the sensitivity of most receivers. The butterfly oscillators are of rugged design, which ensures good stability and low drift. Regulated supply voltage helps to produce clear beat tones when the output is heterodyned. The mutual inductance type attenuator has a smooth rack and pinion drive. The output terminals are fitted with the new TYPE 874 Universal Coaxial Connectors, which fit a wide variety of output accessories.

—EDUARD KARPLUS
ERVIN E. GROSS

SPECIFICATIONS

Type 1021-AU U-H-F Standard-Signal Generator

Carrier Frequency Range: 250 Mc to 920 Mc in one band.

Frequency Calibration: Direct reading to ±1%.

Output Voltage: Continuously adjustable from 0.5 μv to 1.0 volt, open-circuit.

Output Impedance: 50 ohms ±10%.

Output Voltage Accuracy: Over-all accuracy of output voltage is better than ±20%. The accuracy of output voltmeter calibration between 0.5 volt and 1.0 volt is better than ±10%. The accuracy of the attenuator dial calibration for voltages between 1.0 μv and 0.1 volt is better than ±5%; from 0.1 volt to 0.5 volt, better than ±10%. At 920 Mc, the reasonance error in the voltmeter is +6%.

Amplitude Modulation: Adjustable, 0 to 50%. Internal, 1000 c ±5%. External, flat within 3 db from 30 c to 15 kc. For 50% modulation, external audio oscillator must supply 12 volts across a 100 kilohm load.

Envelope Distortion: Approximately 5% at 50% modulation.

Noise Level: Carrier noise level corresponds to about 0.2% modulation.

Incidental Frequency Modulation: For 50% amplitude modulation the incidental fm is approximately 100 parts per million for frequencies up to 400 Mc and is approximately 1000 parts per million at 920 Mc. When lower values of incidental fm are required, the TYPE 1000-P6 Crystal Modulator is recommended.

Leakage: Stray fields and residual output voltage cannot be detected with a receiver having 2 to 3 μv sensitivity.

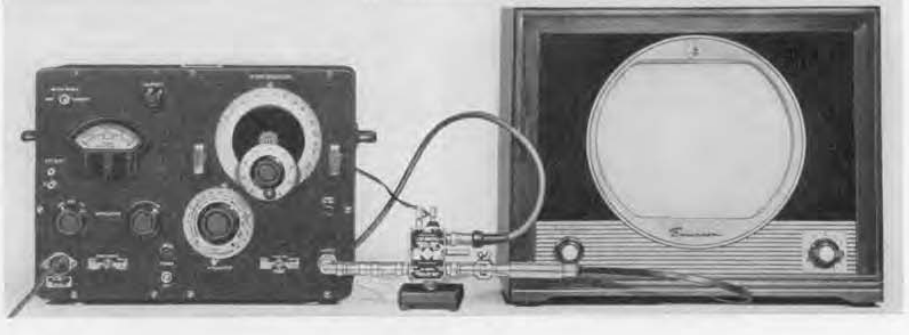
Terminals: TYPE 874 Coaxial Terminals are provided for the output connection.

Power Supply: 115 or 230 volts, 50 to 60 cycles. Power input is approximately 50 watts.

Tubes: Supplied with the instrument:

1	Sylvania 5767 (Oscillator)		
1	6X5-GT	1	Amperite 6-4
1	6K6-GT	2	OC3/VR105

Figure 5. The Type 1021-AV V-H-F Standard-Signal Generator with Type 1000-P6 Crystal Diode Modulator, set up for tests on a television receiver.



Accessories Supplied:
1 TYPE 874-R20 3-foot Coaxial Cable (50 Ω)
1 TYPE 874-C Coaxial Cable Connector
1 TYPE CAP-35 Power Cord

Other Accessories Available: Not supplied, but available on order are TYPE 874-GF 20 db Attenuator Pad, TYPE 874-GG 10 db Attenuator Pad, TYPE 874-K Coupling Capacitor, and TYPE 1000-P6 Crystal Modulator.

Mounting: The aluminum cabinet has a black wrinkle finish. The left-hand side houses the TYPE 1021-P1 Power Supply; the right-hand side houses the TYPE 1021-P2 U-H-F Unit. Panels are black crackle-finished aluminum.

Dimensions: (Height) 14⅜ x (width) 20¼ x (depth) 10⁹⁄₁₆ inches, overall.

Net Weight: 34 pounds.

Type 1021-AV V-H-F Standard-Signal Generator

Same as TYPE 1021-AU (above) except as noted.

Carrier Frequency Range: 50 Mc to 250 Mc in one band.

Incidental Frequency Modulation: For 50% amplitude modulation the incidental fm is approximately 100 parts per million for frequencies up to 100 Mc, and is approximately 500 parts per million at 250 Mc. When lower values of incidental fm are required, the TYPE 1000-P6 Crystal Modulator or the TYPE 1023-A Amplitude Modulator is recommended.

Tubes: Supplied with the instrument:
1 GE 12AT7 (Oscillator)
Other tubes as listed above.

Net Weight: 36 pounds.

Type		*Code Word*	*Price*
1021-AU	**U-H-F Standard-Signal Generator, 250–920 Mc***	EVADE	**$615.00**
1021-AV	**V-H-F Standard-Signal Generator, 50–250 Mc***	EVENT	**595.00**
1021-P2	**U-H-F Oscillator Unit only, 250–920 Mc***	ETHIC	**420.00**
1021-P3	**V-H-F Oscillator Unit only, 50–250 Mc***	EVOKE	**400.00**

*U. S. Patent No. 2,125,816; also Patent Applied For.

AN AMPLITUDE MODULATOR FOR VIDEO FREQUENCIES

The TYPE 1000-P6 Crystal Diode Modulator is a small, convenient device for amplitude modulating the output of a radio-frequency source. With standard-signal generators it modulates the radio-frequency signal at normal attenuator output levels, and, because it is isolated from the oscillator by an attenuator, reaction on the oscillator frequency, or incidental fm, is usually completely negligible.

The crystal diode modulator is designed for wide-band modulation, 0 to 5 megacycles, at carrier frequencies between 20 and 1000 megacycles. Hence it is particularly useful in testing television receivers, whether in the laboratory, in production, or in the service shop. It converts a conventional standard-signal generator or oscillator to a useful test-signal generator for television receivers, and its range covers both the currently used bands and the proposed new u-h-f bands, as well as receiver intermediate frequencies.

This modulator is also useful with other types of receivers operating within its carrier-frequency range, for a-m tests where the incidental fm that is inherent in a directly modulated oscillator cannot be tolerated.

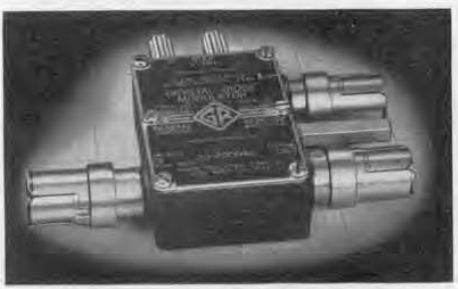


Figure 1. View of the Type 1000-P6 Crystal Diode Modulator.

As shown in Figure 2, the TYPE 1000-P6 Crystal Diode Modulator consists of a crystal diode between input and output terminals, a simple output filter to

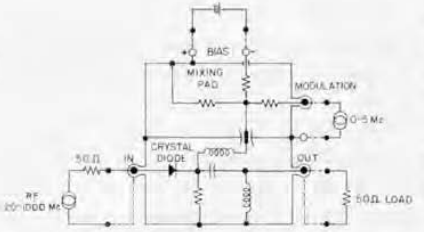


Figure 2. Circuit of the modulator.

prevent appreciable modulating voltage appearing in the output, and a means of isolating and applying modulating and bias voltages. Since the resistance of the crystal diode is a function of the voltage across it, this resistance can be modulated by applying a varying voltage. This unit, therefore, when inserted in series with a radio-frequency generator and its load, will produce amplitude modulation.

The modulator has been designed to operate between 50-ohm source and load impedances. The r-f source impedance must be low, not only at the carrier frequency but also at the modulating frequency and dc, in order that the modulation and bias will be properly applied to the crystal. The use of 50-ohm, 10- or 20-db, resistive pads[1] at the input and output of the modulator will make its characteristics relatively independent of the source and load impedance and, in addition, the combination will present an essentially constant impedance to the source and load. 20-db pads are preferable if the attenuation can be tolerated.

The maximum r-f input voltage should be limited to about 50 millivolts behind 50 ohms to avoid serious carrier and modulation distortion. Below this level, the percentage modulation is practically independent of the radio frequency applied so that any desired attenuation can be introduced ahead of the modulator.

For sine-wave modulation, bias can be applied by connecting a 1.5-volt battery to the bias terminals. This reduces the crystal resistance from the high unbiased condition to a value that is approximately in the center of the characteristic of an average crystal. Increasing the bias increases the output. If means are available for observing the modulation characteristic, some improvement may be had by adjusting the bias for optimum results. With an asymmetrical modulating signal, an adjustable bias supply is recommended if the maximum capabilities of the modulator are to be obtained. Since dc can also be applied through the modulation terminals, the bias may be included as part of the modulating voltage. If no bias at all is applied, the modulator will function on the negative cycles of the modulating voltage to produce a chopped output. Of course, no bias is necessary if the applied modulation consists only of negative pulses.

A suitable source of television video signals for test purposes is a standard television receiver tuned to a local television station. The output can be taken from the plate circuit of the last video amplifier by means of a large coupling capacitor and a suitably compensated voltage divider. The polarity of the video signal obtained at this point is

[1]Such as General Radio Type 874-GF Fixed Attenuator (20 db) or Type 874-GG Fixed Attenuator (10 db).

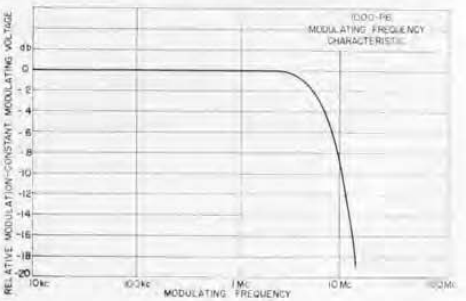


Figure 3. Modulating frequency characteristic.

correct for applying to the modulator, and a large voltage division is possible, permitting a minimum disturbance of the receiver circuit conditions. The exact modulating and bias voltages required are best determined experimentally. A 60:1 voltage divider at the output of the television receiver supplying the video signal has been found to give satisfactory results. The TYPE 1000-P5 Transformer is available for coupling the modulator to a television receiver input.

The TYPE 1N21-B crystal can be easily replaced by taking off the input connector. The connector is held in place with a threaded ring.

—W. F. BYERS

SPECIFICATIONS

Carrier Frequency Range: 20 to 1000 megacycles. The insertion loss increases approximately 10 db at a carrier frequency of 10 megacycles due to output filter.

Modulating Frequency Range: 0 to 5 megacycles. Response is approximately 2 db down at 5 megacycles with a gradual roll-off to prevent serious phase distortion of video signals.

Impedance: The impedance looking into either the input or output terminals is a function of the bias and modulating voltages. This unit was designed for use with a 50-ohm source and a 50-ohm load. The impedance at the modulation terminals is approximately 600 ohms.

Modulation: With no greater than 50 millivolts r-f input, 30% amplitude modulation can be obtained at carrier frequencies between 20 and 1000 Mc. For optimum sine-wave modulation, an average crystal requires 1.5 volts at the bias terminal. The insertion loss under these conditions is approximately 12 db, and approximately 0.2 volt r-m-s at the modulation terminals will produce 30% modulation. Maximum percentage modulation is an inverse function of carrier frequency, and at 1000 megacycles is limited to about 30%. Peak modulation voltage with respect to ground should not exceed 4 volts.

Terminals: The radio-frequency and modulating terminals are provided with TYPE 874 Coaxial Connectors. The modulation terminals will accept either a TYPE 874 Coaxial Connector or a TYPE 274-M Plug.

Crystal Diode: 1N21B.

Accessories Supplied: One TYPE 274-M Plug.

Other Accessories Required: Terminal adaptors, unless generator and load are equipped with TYPE 874 Coaxial Connectors; 1.5-volt battery for fixed bias, or a 3-volt battery and a 10,000-ohm rheostat for adjustable bias.

Accessories Available:

TYPE 874-GF Fixed Attenuator, 20 db
TYPE 874-GG Fixed Attenuator, 10 db
TYPE 874-R20 Patch Cord
TYPE 1000-P5 V-H-F Transformer
(For descriptions and prices, see *Experimenter*, Nov. '49 and Jan. '50.)

Dimensions: (Width) 5 x (height) 4 x (depth) $1\frac{1}{16}$ inches, overall.

Net Weight: 1 pound.

Type		*Code Word*	*Price*
1000-P6	**Crystal Diode Modulator***	APPLE	**$35.00**

*U. S. Patent No. 2,125,816; also Patent Applied For.

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