OPERATING INSTRUCTIONS

for

TYPE 1000-P6
CRYSTAL DIODE MODULATOR

Form 718-C
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GENERAL RADIO COMPANY

CAMBRIDGE 39 MASSACHUSETTS

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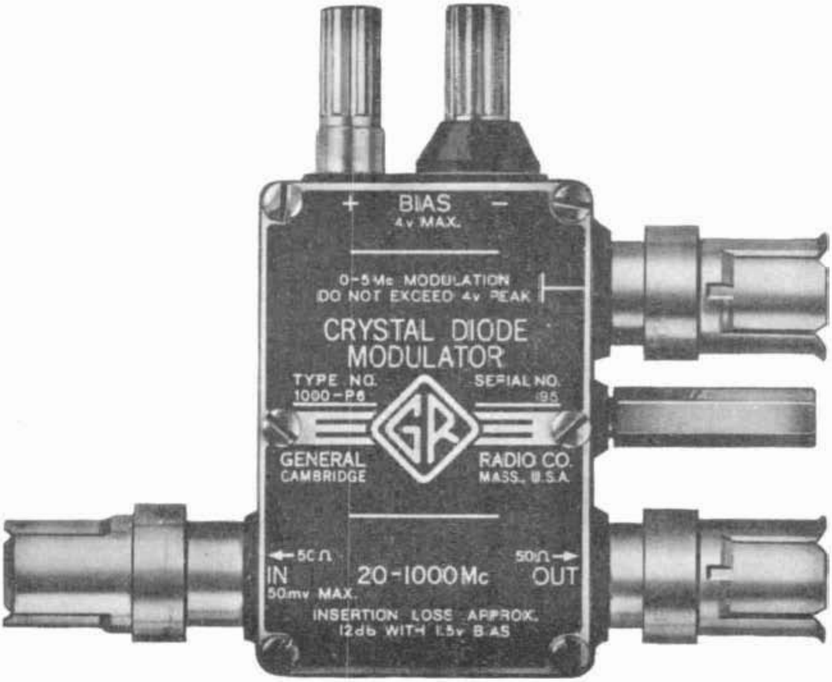

Panel View of Type 1000-P6 Crystal Diode Modulator

SPECIFICATIONS

Carrier Frequency Range: The useful carrier frequency range is 20 to 1000 megacycles.

Modulating Frequency Range: The modulating frequency range is 0 to 5 megacycles. The 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 a radio-frequency source and load of 50 ohms and no greater than 50 millivolts input, 30 percent amplitude modulation can be obtained over the 20 to 1000 megacycles carrier-frequency range. There is considerable variation of characteristics among 1N21-B crystal units. 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 percent modulation. At the higher frequencies the depth of modulation is limited to about 30 percent by the bypass effect of the crystal capacitance. At lower frequencies higher percentage modulation can be obtained at an increased insertion loss by reducing the bias. Negative modulating voltage at the high modulation terminal increases the radio frequency output.

Terminals: The radio-frequency and modulating terminals are provided with Type 874 Coaxial Connectors. The modulation terminal is provided with a grounding stud so that connection can also be made by means of a Type 274-M Plug. The bias terminals are provided with binding posts which will receive a Type 274-M Plug.

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INTRODUCTION

The Type 1000-P6 Crystal Diode Modulator is a simple device for amplitude modulating the output of a radio-frequency generator. It is particularly useful where wide-band modulation, such as required for television, is desired, or where the usual method of modulating a radio-frequency generator produces an excessive amount of incidental frequency modulation.

SECTION 1.0 PRINCIPLE OF OPERATION

As can be seen on the diagram, the crystal diode modulator consists of a crystal diode between input and output terminals, a simple output filter to 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 is equivalent to an impedance, capable of being modulated, which can be inserted in series with a radio-frequency generator and its load thereby providing a means of producing amplitude modulation.

SECTION 2.0 OPERATION

2.1 GENERAL

The radio-frequency source should have a 50-ohm or lower resistance from the carrier frequency down to direct current in order that the bias and modulation will be properly applied to the crystal. A 50-ohm, 20-db pad between the radio-frequency source and the modulator unit is a convenient means of satisfying this requirement if the proper conditions do not exist. The load presented to the output should be 50 ohms for a good modulation characteristic. If a higher resistance load is used it should be shunted by a resistance of the appropriate value. Alternatively, a 50-ohm, 20-db pad can be used between the output and load if this additional attenuation can be tolerated. The Type 874-GF Attenuator is recommended.

2.2 BIAS

For sine-wave modulation, bias is most conveniently applied by connecting a 1.5-volt battery across the bias terminals with polarity as indicated on the nameplate. This reduces the crystal resistance from the high unbiased condition to a value which 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. A 3-volt battery is series with a 10,000-ohm rheostat is a convenient variable bias supply. With an asymmetrical modulating signal an adjustable bias supply is recommended if the maximum capabilities of the modulator are to be obtained. The applied bias should not exceed 4 volts. Since d.c. can also be applied through the modulation terminals the bias may be included as part of the modulating voltage in which case no bias need be applied at the bias terminals. Negative bias is required at the high modulation terminal, if it is applied in this manner. If no bias at all is applied the modulator will function on the negative cycles of the modulating voltage. This mode of operation is useful where all that is desired is to produce a chopped output. Of course, no bias is necessary if the applied modulation consists only of negative pulses.

2.3 MODULATION

Modulation over the range from zero to 5 megacycles can be applied at the modulation terminals. Connection can be made by means of a Type 874 Cable or a Type 274-M Plug. Negative modulation increases the radio-frequency output. The voltage required for a given percentage of modulation is dependent on the particular 1N21-B crystal diode used and the applied bias. For sine-wave modulation under the specified terminal conditions and 1.5 volts bias, the average crystal requires 0.2 volt r-m-s for 30 percent modulation.

This value is only very approximate since there are wide variations between crystals. The crystal supplied with the Type 1000-P6 has been selected so that the required modulating voltage is within $\pm 20\%$ of the stated value and the envelope distortion is low at 30% modulation.

Each Type 1000-P6, with a particular crystal diode, a fixed value of d-c bias, and fixed values of generator and load impedance can be calibrated at various carrier frequencies in terms of applied modulating voltage.

There are two suggested methods for determining the percentage of modulation in terms of applied modulating voltage and for determining the optimum bias. The first is the conventional a-c method in which an oscilloscope is connected to the i-f output of a receiver supplied with a modulated signal from the Type 1000-P6. The radio-frequency input voltage to the receiver should be kept at a minimum to prevent receiver nonlinearity. The modulating frequency should be sufficiently low so that there is no possibility of sideband cutting in the receiver. The use of the oscilloscope at the output of a receiver i-f is suggested because it is improbable that an oscilloscope would be available that has either the sensitivity or the frequency range to work directly at the output of the Type 1000-P6. A trapezoidal display of the modulation envelope, obtained by using the modulating voltage for the horizontal deflection of the oscilloscope, is best for observing the modulation linearity, for determining optimum bias and for measuring the percentage modulation.

The second method is merely that of determining the static modulation characteristic of the Type 1000-P6 by applying various values of positive and negative d-c voltage to the modulation terminals and plotting the variation of radio frequency against values of d-c voltage. The peak value of the a.c. required for a given percentage modulation is easily determined from this plot. A receiver with a carrier meter, a d-c vacuum-tube voltmeter across the detector diode load resistor, or a microammeter in series with the detector-diode load resistor is recommended as the device for measuring the radio-frequency output from the Type 1000-P6. To eliminate errors due to nonlinearity in the receiver it is recommended that the receiver output indicator be kept at a fixed reference level, at each value of d-c modulating voltage, by adjusting the signal generator output. The change in signal-generator output with a fixed modulator output is inversely proportional to the change in modulator output with a fixed radio-frequency input. Therefore the percentage modulation, linearity, and effect of changes in bias can be determined from the plots of signal generator output against the applied d-c modulating voltage.

The peak modulation voltage with respect to ground should not exceed 4 volts.

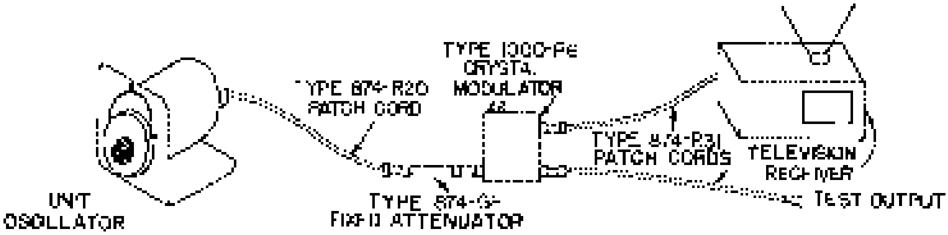
For television picture modulation the composite video signal applied must have the synchronizing pulses negative for standard modulation. A suitable source of television video signals for test purposes is a standard television receiver tuned to a local television station. The output can be taken from 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 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 to 1 voltage divider at the output of the television receiver supplying the video signal has been found to give satisfactory results.

2.4 CRYSTAL REPLACEMENT

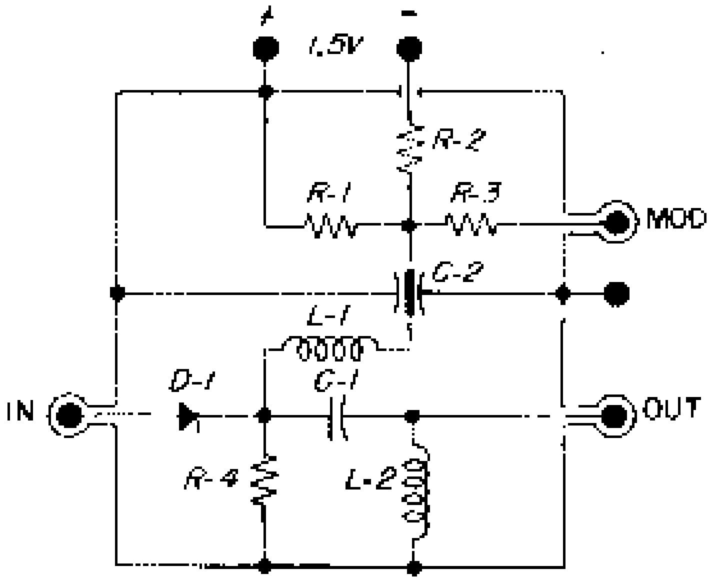
The Type 1N21-B crystal diode can be easily removed by taking off the input connector. This connector is held in place by the threaded ring on which is imprinted the words General Radio Co. Type 874. To remove connector turn ring clockwise when looking at input until it falls free of threads. The connector can then be lifted off and the crystal cartridge will fall out if the unit is inverted. If means are available for observing the modulation envelope, it is recommended that replacement crystals be selected by choosing those which give linear 30% modulation with 1.5 volts bias and 0.2 volts r-m-s modulation applied at a carrier frequency of 100 megacycles. As a rough guide, replacement crystals should have a d-c forward resistance of between 200 and 300 ohms with 0.25 volts applied, and a back resistance of over 10,000 ohms with 1.5 volts applied.

2.5 CONNECTORS

The terminals used on the Type 1000-P6 Crystal Diode Modulator are General Radio Type 874 Coaxial Connectors. This universal-type connector has been designed especially for use in v-h-f and u-h-f measuring equipment. Its low standing-wave ratio makes it suitable for use over the entire u-h-f range. For use as accessories with the Type 1000-P6 Modulator and with other General Radio equipment, a complete line of coaxial elements is available, including tees, ells, rigid lines, patch cords, attenuators, adjustable lines, filters, and many others. Consult the latest General Radio catalog for details, or write for literature.



Functional Diagram of the Unit Oscillator with Video Modulator to Form a Television Signal Generator



Wiring Diagram for Type 1000-P6
Crystal Diode Modulator

RESISTORS			TYPE
R-1 =	180 Ohms	±5%	REC-20BF
R-2 =	910 Ohms	±5%	REC-20BF
R-3 =	510 Ohms	±5%	REC-20BF
R-4 =	560 Ohms	±5%	REC-20BF

CONDENSERS			
C-1 =	50μμf	±10%	N750-A50 (ERIE)
C-2 =	300μμf	±10%	COU-B-2

DETECTOR

D-1 = 1N21B

CHOKES		
L-1 =	7.5μh	2CHA-19
L-2 =	0.5μh	CHA-18