TWO NEW MIXERS FOR THE DETECTION OF RF SIGNALS

A sensitive, well-shielded detector system is a basic requirement in most audio- and radio-frequency measurements. Detector sensitivity determines the resolution in null-type bridge measurements as well as in the measurement of high values of attenuation. In both these measurements, adequate shielding is a primary factor in determining the ultimate accuracy. Detectors of this description have been available from General Radio for most of the spectrum up to 4000 kc. These are:

(1) The TYPE 1232-A Tuned Amplifier and Null Detector — 20 cps to 20 kc, with continuous coverage, plus 50 kc and 100 kc, fixed.

(2) The TYPE 1212-A Unit Null Detector — 50 cps to 5 Mc, untuned; 1 Mc, tuned, with the TYPE 1212-P1 1-Mc Filter.

(3) The TYPE DNT Detectors, which are heterodyne types, 40 to 4000 Mc.

Now two new rf mixers fill the gaps below 40 Mc. They operate by the heterodyne method, with low-frequency detector units serving as i-f amplifiers.

The heterodyne detector has a justly deserved preference over other types. It is currently the most convenient means of achieving high sensitivity, wide tuning range, and a high degree of harmonic rejection. It also has a great dynamic range because its amplification is essentially linear over 85-db of input-signal variation. Its disadvantages are few, but the principal one should be mentioned. In its simple form, no selectivity is provided in the signal input circuit, and so it can have some spurious responses from images and harmonics, which make it unsuitable for wave analysis. In general, these are not troublesome, and the addition of circuits to be tuned by the user would complicate the operation.

THE TYPE 1232-P1 RF MIXER

The circuit of the TYPE 1232-P1 RF Mixer is shown in Figure 1. Included are a microammeter for setting the level of the local oscillator and a high-Q tuned transformer to exclude the local-oscillator signal from the Tuned Amplifier and Null Detector.

Circuit elements are enclosed in an aluminum cylinder to which is appended, in a separate compartment, the meter housing. In addition, double-braid coaxial cable is used on all signal leads. As a result, the mixer is completely

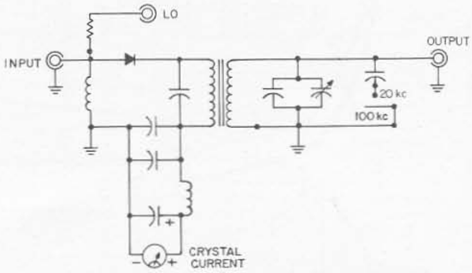

Figure 1. Schematic diagram of the mixer circuit.

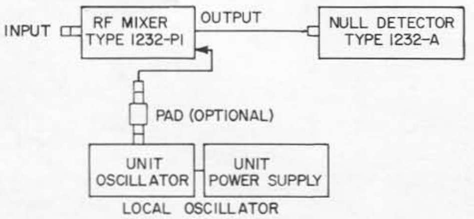

Figure 2. Block diagram of complete detector system using the Type 1232-P1 RF Mixer.

shielded from rf fields, thus preventing spurious null-balance indications.

In order to cover the range from 70 kc to 10 Mc, two i-f amplifier center-frequencies are required. One is 20 kc and is used to cover the range from 70 kc to 500 kc. Actually, the detector can be tuned continuously down to 25 kc, but sensitivity is reduced in this range, and spurious responses are more troublesome. Above 500 kc, the 20-kc frequency increment to which the local oscillator must be set is difficult to resolve, and the tuning is too critical. Therefore, above 500 kc, a switch is made to the 100-kc i-f circuit which is broader in bandwidth. The upper limit of 10 Mc was chosen because above this frequency it becomes difficult to set the 100-kc increment, and, again, the tuning becomes too sharp, so that any frequency drift of the signal source or the local oscillator becomes apparent. Also, above about 20 Mc, the local-oscillator tuning again becomes critical. Otherwise, however, the mixer performs perfectly well, at least as high as 60 Mc, and, with care, satisfactory results can be obtained.

In practice the operation of the system is quite simple. Figure 2 is a block diagram of the complete detector system. The 20kc-100kc switch on the mixer is set to the desired frequency, and the corresponding frequency is switched-in on the Type 1232-A Null Detector. The local-oscillator output is set to produce the required mixer meter indication and the oscillator is then tuned to frequency by adjustment for maximum output indication in the Type 1232-A Tuned Amplifier and Null Detector when an external signal is introduced. For maximum sensitivity in the frequency range below 150 kc, the crystal current must be set to a particular value, as shown in Figure 3.

PERFORMANCE CHARACTERISTICS

The significant performance characteristics of the mixer are given in Figures 4 to 7. The linearity is shown as a function of input signal level in Fig-

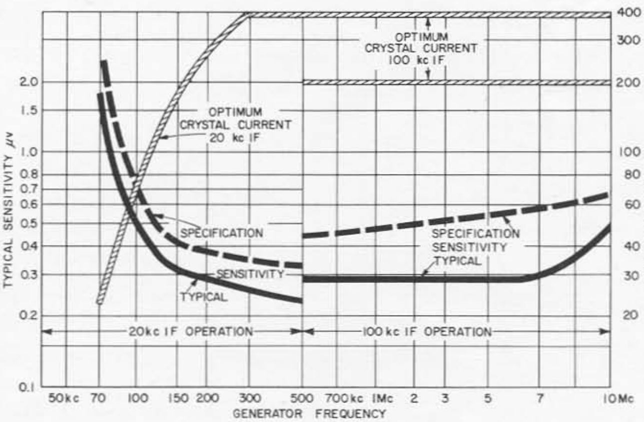

Figure 3. Sensitivity (open-circuit voltage from 50-ohm source, equivalent to noise level) and local-oscillator drive vs signal frequency.

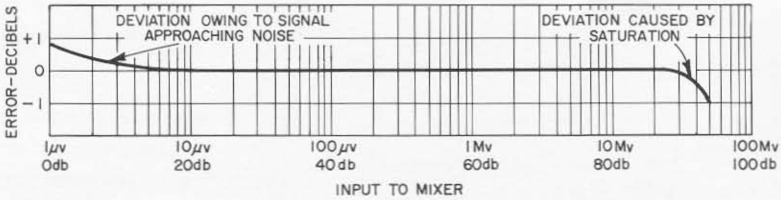

Figure 4. Linearity of the 1232-PL/1232-A detector as a function of input voltage.

ure 4; it can be seen that above about 50-mv input an increase in input voltage produces a smaller-than-proportionate increase in output indication. The sensitivity, defined as the input signal voltage required to increase the output indication 3 db above the noise level, is shown in Figure 3. Other data of interest are given in Figure 5, which shows the sensitivity as a function of local-oscillator drive level, and in Figure 6, which shows the relative conversion loss also as a function of local-oscillator drive level. The degradation of sensitivity below the normal tuning range is shown in Figure 7. The mixer is still usable in this range, but local-oscillator feed-through produces a larger output indication.

APPLICATIONS

Null Detector

The combination of the Type 1232-P1 Mixer, the Type 1232-A Null Detector, and a local oscillator is an excellent bridge null detector for the frequency range from 70 kc to 10 Mc. Figure 8 is a block diagram of a complete bridge system using this detector, and a typical setup with the Type 916-AL Radio-Frequency Bridge is shown on the front cover.

Attenuation Measurements, etc.

This detector system is particularly well suited for the measurement of attenuation, especially high values of attenuation. For example, with a 100-mw source and reasonable padding (10 to 16 db at the detector) attenuation values as high as 120 db can be measured. A substitution method is employed wherein the attenuation to be measured is compared with a calibrated adjustable attenuator, such as the Type 874-GA. The Type 1232-A Tuned Amplifier and Null Detector is used as level indicator, since it does not have its own calibrated attenuator. For maximum resolution in these measurements it is essential that the detector circuits be operated within their linear range. Detector linearity for the 1232-P1/1232-A combination is shown in Figure 4, and applies for all diode-current levels above 200 μa. Figure 9 is a block diagram of the measuring setup.

Attenuation of 10 db or less can be measured with an accuracy of $\pm\frac{1}{20}$ of the db increment being measured by use of the db scale on the meter of the null detector. In this measurement, linearity at both the lowest and highest usable input-signal extremes, for the detector, are important. The usable input-signal

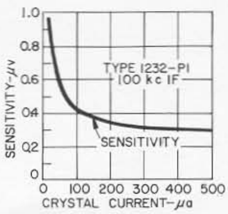

Figure 5. Sensitivity vs local-oscillator drive for 100-kc intermediate frequency.

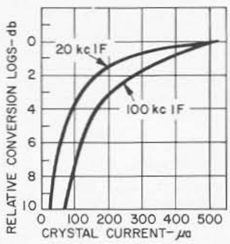

Figure 6. Relative conversion loss vs local-oscillator drive.

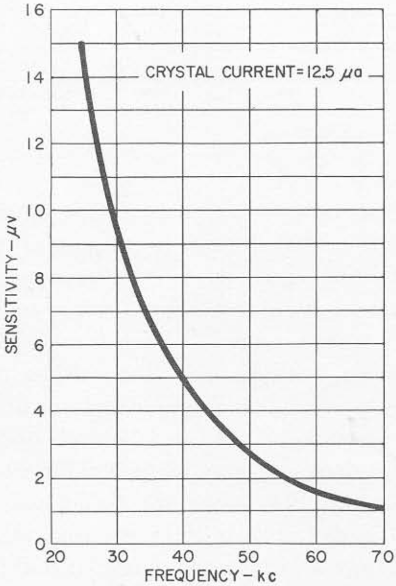

Figure 7. Typical sensitivity at frequencies below normal range.

range can be determined from Figure 4. The deviation from linearity at low levels arises from the relative contribution of the amplifier noise in the output indication, when the signal-to-noise ratio is small.

Specific attenuation measurements to which this procedure is applicable are:

Attenuator or network insertion loss
Filter stop-band response
Coaxial cable loss[1]
Coaxial switch cross-talk
Coaxial cable or connector leakage[2]

Coaxial Switch Crosstalk or Multiport Component Measurements

The same basic procedure can be used in the measurement of crosstalk between connections in multiport components, such as coaxial switches, semiconductor switches, and duplexers or multiplexers.

The component to be measured is, for example, driven at its input and the "through" channel (the output connection to which the input is intended to produce an output signal) is terminated in a matched termination, or other desired impedance, depending on the impedance with which the device is normally terminated. The other unused ports are similarly terminated. The detector is connected to the port in which crosstalk is to be measured, and the attenuation with this connection is measured by the substitution method. In the substitution method, a known amount of attenuation is inserted to produce the same output indication that was produced with the component installed.

Most systems operate at a nominal impedance of 50 ohms. The mixer input impedance is about 200 ohms. It can be made very nearly 50 ohms by the addition of an 874-G10 10-db attenuator at its input.

For operation at other than the 50-ohm level, transformers are required.

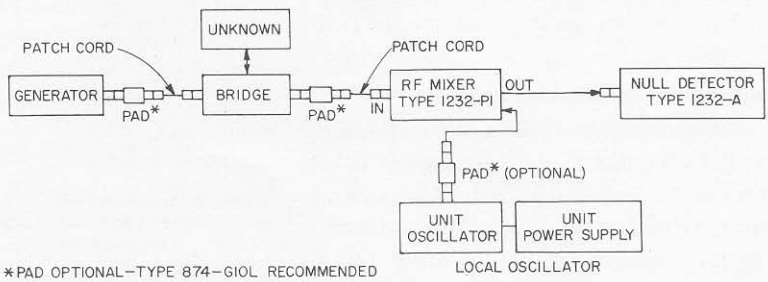

Figure 8. Block diagram of the detector system used as a bridge null detector.

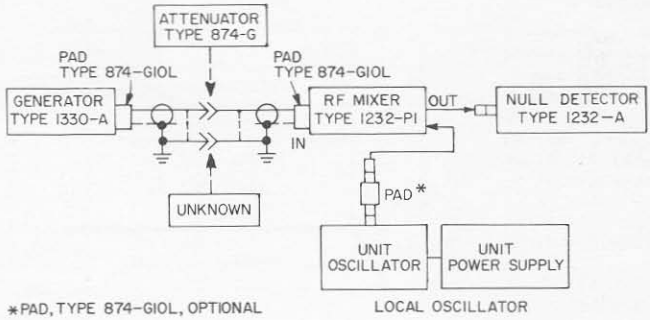

Figure 9. Block diagram of the 1232-P1/1232-A detector system as set up for the measurement of attenuation.

Cable Connector or Leakage Measurements

The leakage or shielding effectiveness of cables or connectors can also be measured by the same procedure as for attenuation measurements. A special test fixture is required in this case. Specific details of this fixture and the procedure are described in the reference cited.[2]

[1] W. R. Thurston, "The Measurement of Cable Characteristics," General Radio Reprint No. E-104.

[2] J. R. Zorzy & R. F. Muehlberger, "R-F Leakage Characteristics of Popular Coaxial Cables and Connectors, 500 Mc to 7.5 Gc," *Microwave Journal*, November, 1961, General Radio Reprint No. A-93.

SPECIFICATIONS

Frequency Range: 70 kc to 10 Mc. (Can be used up to 60 Mc, with care in the selection and identification of local-oscillator frequencies.)

I-F Output Frequencies: Switch-selected to 20 kc or 100 kc.

Bandwidth: 0.8 kc in 20-kc position, 10 kc in 100-kc position with a 20-kilohm output load (Type 1232-P1 RF Mixer alone).

Sensitivity: See Figure 3.

Input Impedance: Approximately 200 ohms.

Output Impedance: Approximately 20,000 ohms.

Dimensions: Diameter 2¼, length 6¾ inches (58 by 175 mm).

Net Weight: 1 pound (0.5 kg).

Shipping Weight: 2 pounds (1 kg).

Type		*Code Number*	*Price*
1232-P1	**RF Mixer**	1232-9601	**$105.00**

TYPE 1212-P3 RF MIXER

The 1212-P3 RF Mixer is essentially of the same construction as the 1232-P1, differing principally in the choice of i-f center frequency, 1 Mc. The circuit is shown in Figure 10. With the 1212-A Unit Null Detector, the lowest frequency of operation is 3 Mc. Below this, the local-oscillator signal feeds through directly into the Unit Null Detector, producing a meter indication in spite of the filter networks provided in the mixer unit. The highest frequency of operation,

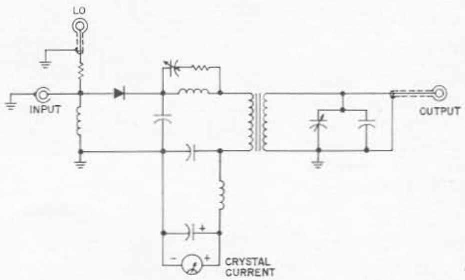

Figure 10. Schematic of the Type 1212-P3 RF Mixer.