WIDEBAND 20-dB/RANGE AC MILLIVOLTMETER

The ac millivoltmeter is a fundamental tool in electronic measurements. Although many instruments of similar capability are already in existance, the new millivoltmeter from GR makes a unique contribution to ac measurements.

Basically, the GR 1808 is an average-reading voltmeter calibrated to indicate the rms-value of sine waves. But what sets this voltmeter apart from others is its 10-Hz to 10-MHz bandwidth coupled with a 20-dB dynamic range per range. This wide dynamic range makes possible a single voltage scale that, in turn, avoids confusion in reading the meter. The single scale is not only convenient for many amplifier response measurements but is also necessary in some automatic testing or calibration set-ups.

Applications

Because the millivoltmeter is a general-purpose, laboratory- and production-type voltmeter it is difficult to describe a particular application as a "typical" application. Here are some illustrations of interesting applications:

- Most operational amplifiers have the open-loop frequency-response curve shown in Figure 1. Quite often it is desired to know the frequency, f_2, where the second breakpoint occurs in order to maximize the design stability of the amplifier.

  The GR 1808, with its 10-MHz bandwidth, is well suited for this type of measurement.

- The wide dynamic range and wide bandwidth of the GR 1808 encourage its use for attenuator calibration or testing. For a 10- or 20-dB attenuator, no range change is necessary in order to read the input and output. For higher value attenuators, minimum of range changing is involved.

- Frequently, we wish to make ac measurements with higher resolution than the specified accuracy of the available instruments. For example, in tests of the stability of an amplifier with temperature, the absolute value of a measurement is not so important as the change in the measurement as a function of temperature.

  The dc output from the 1808 may be coupled into a GR 1807 DC Microvoltmeter/Nanoammeter[1] to form such a high resolution system. The GR 1807 has an interpolation feature that will enable the user to read the dc output with 0.1% resolution. The system shown in Figure 2 will increase resolution of ac voltages approximately ten times compared with the GR 1808 meter reading. It is also important to note that the dc-voltage output of the GR 1808 can be used to drive a GR 1522 Recorder[2] for a permanent recording of data. The output of the GR 1807 can be connected to the recorder if high resolution recording is desired.

- An important application for the millivoltmeter is voltage measurement from accelerometers, strain gauges, microphones or other similar transducers. In general, such transducers can be reduced to an equivalent-voltage source in series with a capacitance (Figure 3). The voltage source is usually less than 100 millivolts and the capacitor C may be a

(cont. on page 11)

[1] Balekdjian, K. G., "A Unique DC Voltmeter," *GR Experimenter*, August-September, 1968.

[2] Basch, M. W., "A Programmable High-Speed DC Recorder," *GR Experimenter*, May/June 1969.

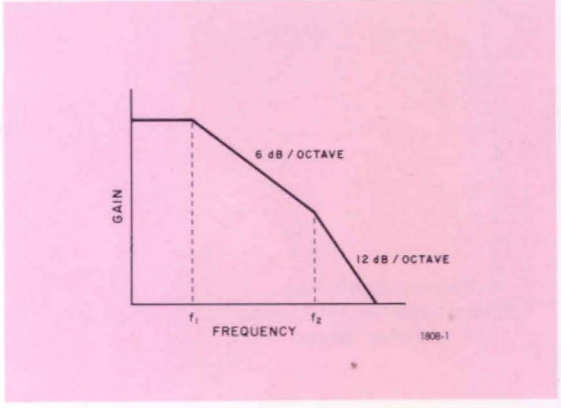


Figure 1. Typical open-loop frequency-response curve.

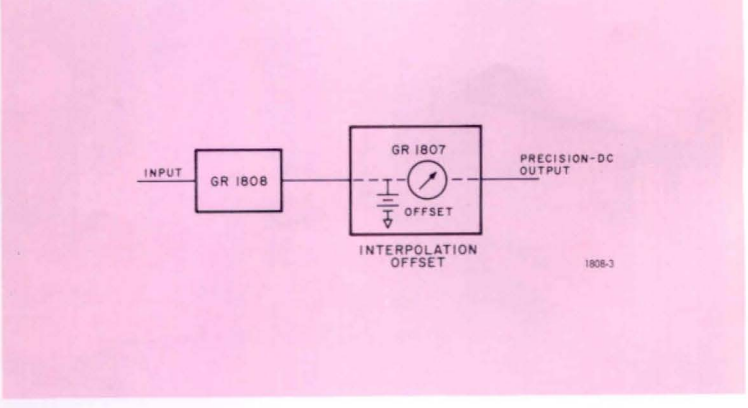


Figure 2. System for increased measurement resolution.

few hundred to a few thousand picofarads.

To measure the output of such a device with reasonable accuracy (1% - 5%), it is essential to have a voltmeter with very low input capacitance. The GR 1808 millivoltmeter with a Tektronix P6008 probe and GR 1808-P1 Probe Adaptor becomes an ideal combination for such measurements. The input capacitance of the probe will be approximately 7.5 pF and the sensitivity of the resulting combination will be 15 mV for full-scale deflection.

Theory of Operation

Figure 4 shows the block diagram of the GR 1808. The input buffer uses a field-effect transistor in order to achieve the high input impedance of the instrument. Both attenuator No. 1 and attenuator No. 2 are resistive type with capacitive frequency compensation. Attenuator No. 1 is used on the 150-V and 15-V ranges, and all switching is done by means of reed relays. This keeps high level ac signals from the sensitive detector circuits.

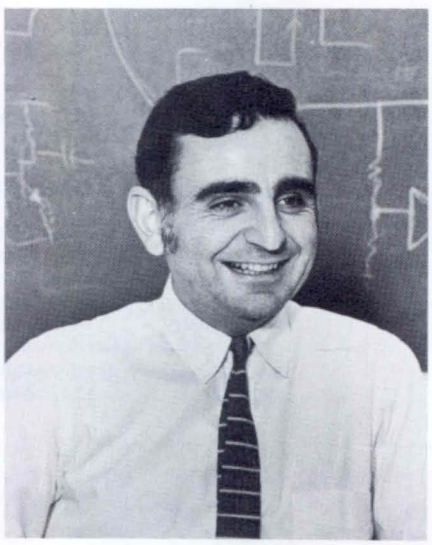
In order to achieve maximum stability, the gain of the 20-dB amplifier is never changed. Instead, attenuator No. 2 provides the proper signal levels for all ranges.

The heart of GR's new voltmeter is the ac-to-dc converter shown in Figure 5. Diodes CR1 and CR2 form a full-wave rectifier circuit. The dc-output voltage (read by the meter) is proportional to the difference between the rectified voltages V_1 and V_2. An important feature of this type of converter is the fact that nonlinear effects due to the diodes are eliminated from accuracy considerations, because the diodes are inside the feedback loop of amplifier A. The unbalance-leakage currents of these diodes are small enough to justify neglecting their effect since only the unbalance leakage current enters the accuracy considerations.

The key to the wideband and wide dynamic range of this converter is amplifier A. It has high open-loop voltage gain even at 10 MHz, to provide sharp rise and fall times at its output. Since most diodes will require 0.3 to 0.5 volt to draw at least 0.1-mA current, sharp rise/fall times are especially necessary at low level and high frequencies if errors are to be avoided.

The GR 1808 AC Millivoltmeter is not just another ac voltmeter; it is a distinct contribution to this basic branch of electronic measurements.

—K. G. Balekdjian



K. G. Balekdjian is a member of the GR Component and Network Testing Group. He received his SB and SM Degrees from Massachusetts Institute of Technology in 1955 and 1957 respectively and joined GR as a development engineer in 1964. George is a member of IEEE, Tau Beta Pi, Eta Kappa Nu, and Sigma Xi.

Complete specifications for the GR 1808 are included as a tear sheet at the back of this issue.

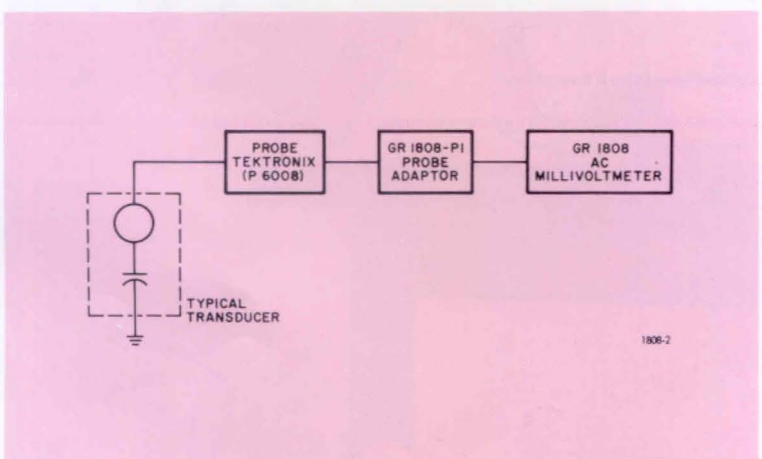


Figure 3. Suggested measurement system for transducer response.

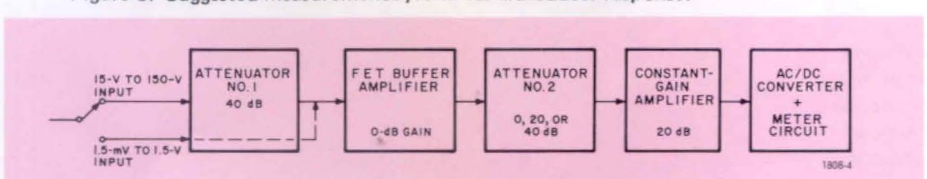


Figure 4. Block diagram of GR 1808 Millivoltmeter.

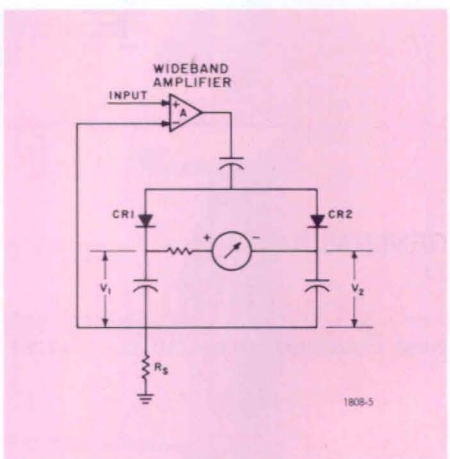


Figure 5. Schematic of ac-to-dc converter.