THE
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Experimenter

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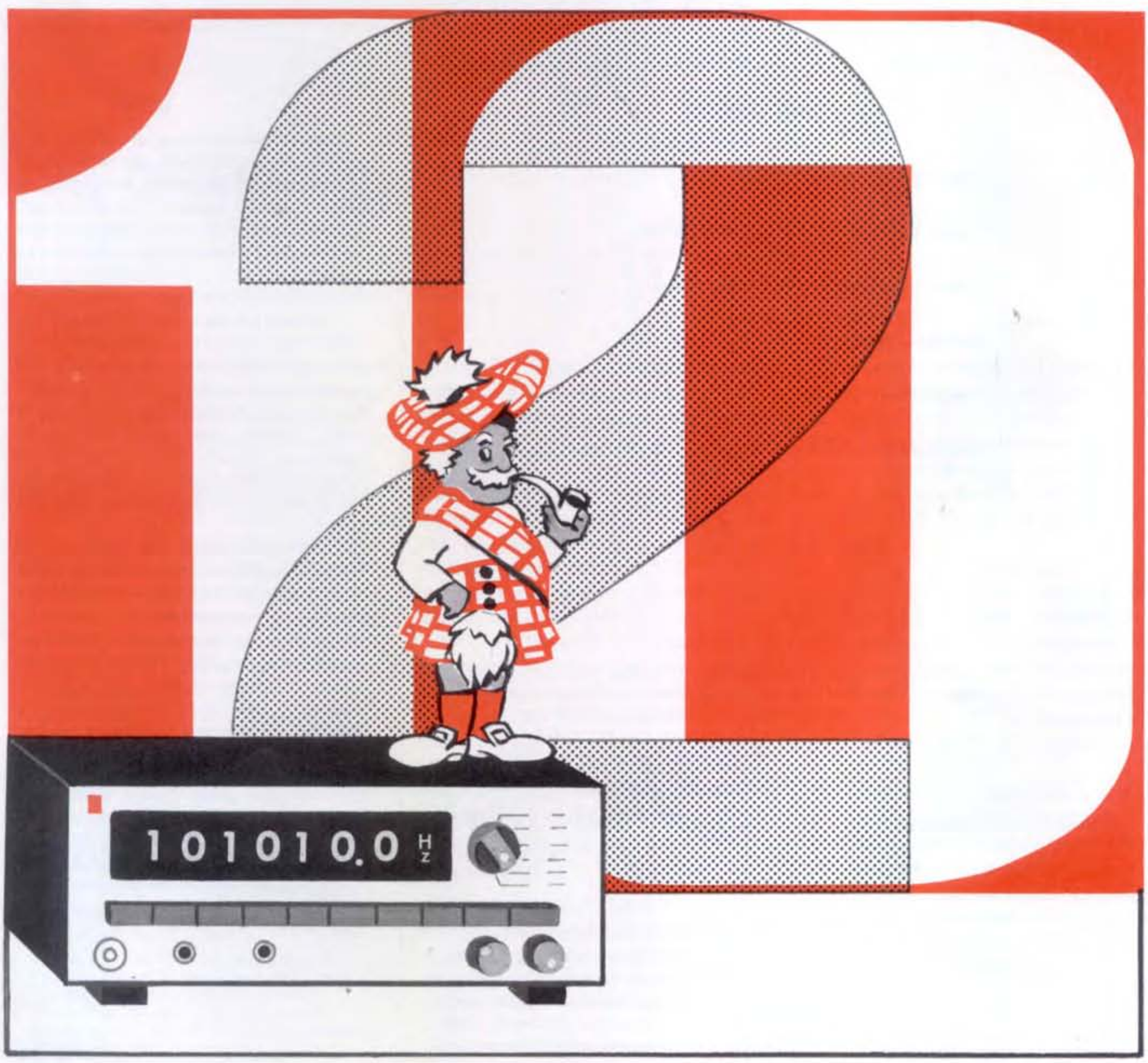

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The *General Radio Experimenter* is mailed without charge to engineers, scientists, technicians, educators, and others interested in the instruments and techniques of electrical and electronics measurements. Address all correspondence to Editor, *General Radio Experimenter*, General Radio Co., West Concord, Mass. 01781.

THE COVER — The multiplicity of numbers is the seed for computing processes and the basis for science in general. In prehistoric times, with his 10 fingers as a group control, man counted by using twigs and pebbles. The Greeks and Romans supplied graphic control with their symbolic number-figures. Modern technology confounds the centuries-old use of 10 as a number base by adopting 2 as its number base. The conversion from decimal to binary system is the subject of our cover and, in a not-too-subtle manner, our little friend draws the attention of our readers to our line of new, inexpensive counters.

Our last editorial touched upon the subject of performance specifications for instruments and was designed to elicit some response from our readers. In the interim period, while waiting for you to receive the issue and to consider the questions raised, our attention has been drawn to another aspect of the specification problem.

The bond between manufacturer and customer must be based, in equal parts, upon *truth* and *belief*. The presentation by the manufacturer must be truthful; the reception by the customer must be with a feeling of belief. Together, these conditions denote attainment of integrity. Without that bond of integrity between maker and user there cannot exist a successful manufacturing organization.

Our personal sensitivity on this subject has been sharpened lately by a change in position. Recent assumption of the duties and responsibilities of editorship has not diluted our memories of, and experiences as, a customer rather than a supplier. From these experiences we are able to draw upon a fund of information related to customer problems. Formerly we were able to accept nothing we saw or heard in the manufacturing world without question. Our working relationship with engineers within General Radio, however, has been established upon the common ground of mutual respect and a continuing desire to give to our readers information, service, and a faith in the integrity of our engineering and in the quality of our product.

C E White

C. E. White
Editor

GR 1192 Counter

The Counter-Punch

Diminutive in size and cost, the GR 1192 Counters successfully match their bigger brothers in versatility, sensitivity, and immunity from noise. These instruments can interface with computers; they count up to 500 MHz (using the GR 1157-B Scaler) and offer precisions of 5, 6, or 7 digits.

The digital electronic counter is today a widely accepted, basic measuring tool used side by side with the oscilloscope, voltmeter, and signal source. It is also the youngest member of that family of tools inasmuch as we find first mention[1] of a counting-rate meter in a report from a meeting of the American Physical Society in April 1936. The development of the meter is an interesting study in evolutionary engineering, from its original application as an averaging device to register the output of a Geiger-Muller tube counter[2] to today's omnipresent tool for counting components and for measuring frequency and time. Performance, operability, and reliability have consistently improved while cost has steadily decreased.

General Radio has made notable contributions to this progress. The GR 1130 Counter was the first to apply the principle of parallel entry storage to prevent the intermittent read-in and display flicker of earlier counters.* Within the past two years we have introduced one of the first all-integrated-circuit general-purpose counters,[3] as well as creating a completely new concept in low-frequency counters.[4]

The new counters to be described in this article reflect the present state of device technology. These counters take full advantage of the latest developments in integrated circuits, display devices, packaging, and manufacturing procedures to produce a high degree of performance at a modest price.

Economics of Resolution and Number of Digits

The majority of users of counters apparently consider the measurement of frequency to be one of the counter's most important functions. They want a counter that operates over the maximum possible frequency range consistent with the cost and the current state of the art. The GR 1192-series of counters, designed with a recognition of this fact, covers the range from dc to 32 MHz. Use of the GR 1157-B Scaler (page 13) will extend the upper limit to 500 MHz.

The cost of a counter is highly dependent upon the number of digits in its display. Each displayed digit calls for a counting decade, a storage register, and the display device itself. All these items are relatively costly. In the interest of maximum economy, the number of digits is varied in the GR 1192 series from 5 to 7.

The number of displayed digits does *not* affect resolution. Resolution for frequency measurements, determined by the duration of the counting gate, is a maximum of 0.1 Hz for all counters of the series. Resolution for period and interval measurements is determined by the internal clock frequency (10 MHz), corresponding to a maximum resolution of 0.1 μs for each of the 1192-series instruments.

[1] Gingrich, et al, "A Direct-Reading Counting Gate Meter for Random Pulses," *Review of Scientific Literature*, December, 1936.

[2] Bousquet, A. G., "A Counting-Rate Meter for Radioactive Measurements," *GR Experimenter*, July-August, 1947.

[3] Frank, R. W., "A Programmable 20-MHz Counter-Timer Using Integrated Circuits," *GR Experimenter*, June-July, 1968.

[4] Westlake, N. L. Jr., and Bentzen, S., "The Recipromatic Counter," *GR Experimenter*, June-July, 1968.

*U. S. Patent No. 3,328,564

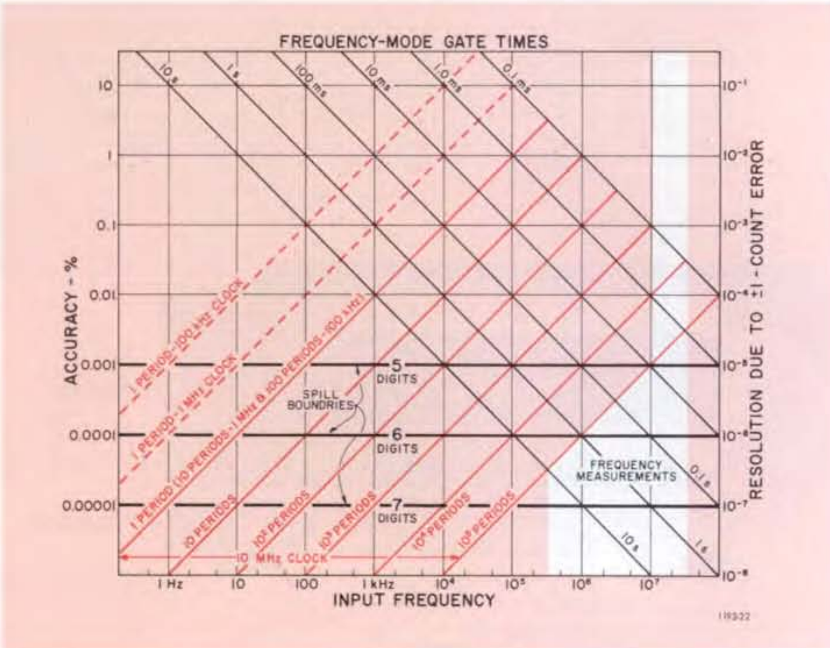

Figure 1. A summary of the GR 1192 resolution and display characteristics in its PERIOD and FREQUENCY modes. Within the white area resolution is highest in the FREQUENCY mode. The 1-ms GATE TIME prevents spill-over at the highest counting frequency; for period measurements, the 100-kHz counter clock permits up to 1-s periods to be measured without spill-over in the 5-digit counter, while the 10^5-PERIODS control permits parts-per-million resolution at an input frequency of 1 MHz.

More About Resolution

The wide range of counting-gate times (100 μs to 10 s) and period-measurement clock frequencies (0.1 μs to 10 μs) permit even the 5-digit counters to display the most significant figures of a measurement without spill-over (Figure 1). All the counters incorporate a lamp indicator to warn that, in the interest of increased accuracy, the more significant figures have been spilled-over from the register.

Since the best time resolution of a counter is established by a maximum counter-clock rate, period measurements become less accurate as the input frequency is increased. For example, in a single period, a 1-MHz signal will produce a reading of 10 counts. In order to increase the accuracy of time measurements, up to 10^5 periods of the input signal may be averaged. This time-averaging process has the side benefit of reducing the effects, in the displayed data, of noise on the input signal by approximately the amount of the averaging (20 dB per decade of averaging).

The resolution of the GR 1192 for measurement of different input signals of good waveshapes, using frequency-, period-, or multiple-period measurements, is shown in Figure 1. The figure is relatively complex; fortunately, all the complexity is in the figure because the GR 1192 has both an automatically-positioned decimal point and a display of the dimensional unit of the measurement. Note that the same resolution is obtainable whether you measure with the 5-, 6-, or 7-digit counter because the largest numbers are displayed by using sufficiently short gating times. Conversely, the smallest numbers are displayed by using relatively long gating times. Since each counter in the 1192 series has identical gating-time controls, resolution is identical from one counter model to another.

Other Characteristics

In addition to making single- or multiple-period frequency measurements, the GR 1192 performs the other basic counter functions of serial accumulation or time-interval measurements, or it can establish non-decimal time-base ratios. As with the measurement of frequencies, the wide range of clock ratios (and time-base scaling) permits full resolution while accommodating even the least-costly 5-digit display.

- In serial accumulation or simple counting, a measure is continuous as long as the operator permits the counting-gate in the instrument to remain open. In the GR 1192, control of the gate is either manual or remote by means of start and stop pulses, or by a remote signal. Often it is desired that the counter present a total count over an extended interval, rather than the repetitive short interval counts. Such requirements exist in production control, or when intervals such as pulse duration are measured. A total count can

S. Bentzen received his BSEE degree from Indiana Institute of Technology in 1962, joined General Radio the same year, and completed work for his MSEE degree from Northeastern University in 1966. Presently he is a development engineer in the GR Frequency Group. He is a member of IEEE.

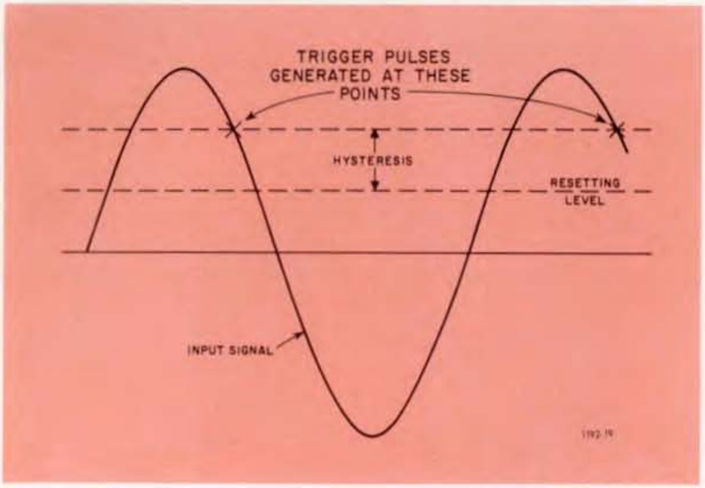

Figure 2. Illustration of hysteresis applied to trigger pulses.

be retained by the counter memory until the counter is directed to present it or to erase the memory.

- Measurement of a time interval can be defined by the duration of a single pulse. In the time-interval mode it is important that the internal clock frequency be high for good resolution, but not so high that a long time interval would cause register spill-over. The highest obtainable resolution in interval measurements is 0.1 μs in the 1192 series. In order to prevent loss of the more significant digits, the counter clock frequency can be reduced to 100 kHz, which permits the measurement of an interval as long as 100 seconds without spill-over.

- Another useful measurement mode is that of RATIO. The frequencies of two signals A and B are related: A/B. The B signal is used effectively to establish a new time base for the counter, as in these examples: A 100-Hz signal connected to the B INPUT can produce a gating time as long as 1000 seconds. Ratios of a non-decimal relationship, e.g., 60 ms, can be obtained when a stable input frequency of 16.6 kHz is fed into the B INPUT. Such a ratio is useful if you desire to display rpm. In a similar manner, it is possible to establish ratios that permit displays of flow in gpm, velocity in mph, and other parameters.

Some Design Notes

There are no panaceas in the design of counter input circuits. The thoughtful designer gives the user what he wants – high input impedance, good sensitivity, and low internal noise. It is necessary, however, that the user understand, and use intelligently, the input controls designed into the GR 1192 series.

The input circuit of the GR 1192 feeds a level detector that produces a pulse when the signal to be measured passes through a predetermined level. The level detector has a 10-mV hysteresis magnitude, referred to the input terminals, which effectively prevents

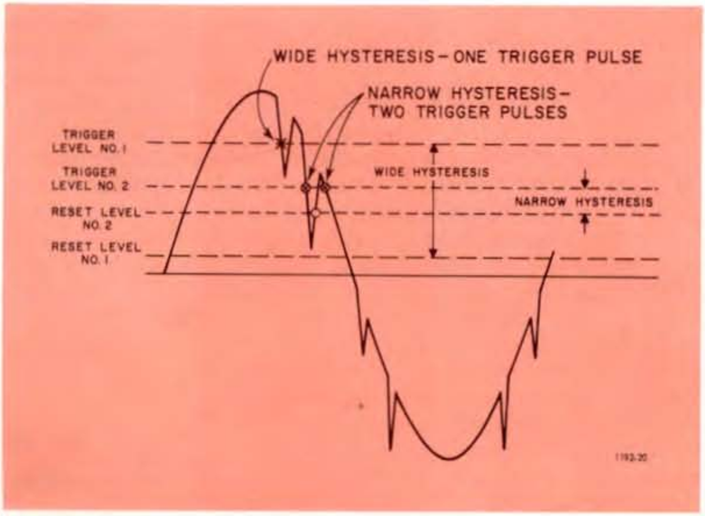

Figure 3. Example of hysteresis widening to reduce false triggering.

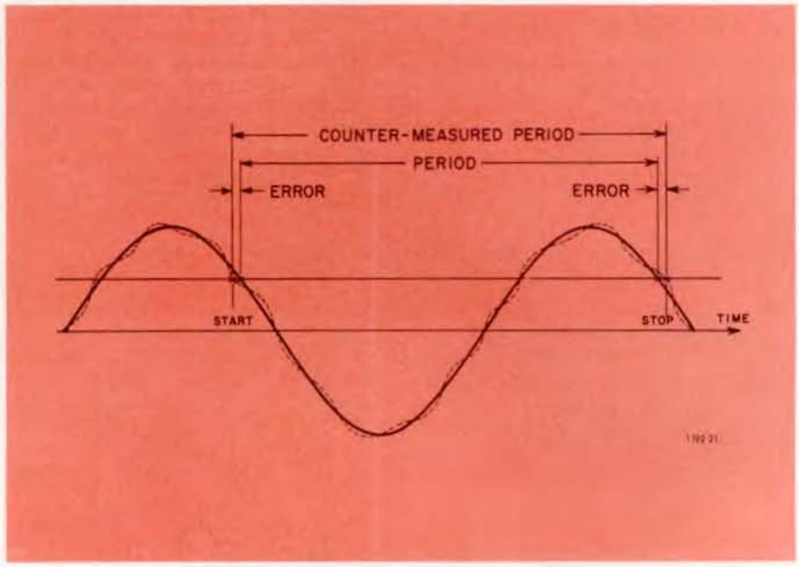

Figure 4. Effect of internal counter noise upon trigger point.

any false triggering actions by an input signal containing noise (Figure 2). Pulse triggering by noise may be prevented by expanding the hysteresis magnitude to such an extent that the hysteresis is greater than the superimposed noise (Figure 3).

Good practice indicates that the hysteresis magnitude should always be kept as wide as practical to overcome the effects of additive noise. In the GR 1192, hysteresis magnitude can be made great enough, by adjustment of the INPUT ATTENUATOR control, to overcome the triggering effects of unwanted noise levels from 10 mV to 10 V. If noise is superimposed on a waveform, the TRIGGER LEVEL control can be adjusted to move the triggering level to a point on the waveform which has less noise.

Optimum performance in the face of superimposed noise is obtained when the counter triggers on the maximum slope position of the input waveform. The TRIGGER LEVEL control, in combination with the INPUT ATTENUATOR control, permits threshold adjustment over a range of ±100 volts. Since the negative transitions are usually faster, we have chosen a negative triggering wave slope in our design.

The input impedance of a counter should be high enough so that very little loading of the input circuit takes place under operating conditions. The input impedance of the GR 1192 is 1 MΩ shunted by 27 pF. These values permit the operator to use an input probe such as the GR P6006 which has an impedance of 10 MΩ shunted by 7 pF.

In a good counter, the internal input noise should be very low and usually will be insignificant compared to the noise that has already been imposed upon the input-signal waveform. Internal noise adds to the signal and will cause the triggering point to vary in time (Figure 4).

Error in a period measurement due to noise impressed upon a signal can be expressed as:

$$\epsilon = \frac{N}{\pi S n} \times 100\%,$$

in which N is the noise level and S the signal level in the same units of measurement, and n is the number of periods averaged. If we assume a signal-to-noise ratio of 40 dB, the error in a single-period measurement is calculated to be: $\epsilon = 0.318\%$. This value is well within the resolution of the counter.

When the input signal is very, very clean, the limit of measurement accuracy is established by the noise in the input circuitry of the counter. The effective input noise of the 1192 counter typically is of the order of 50 to 100 μV. Thus the external triggering error in microseconds is less than $\frac{0.0002}{\text{signal slope in } \mu s}$. Interested readers can refer to the December 1962 issue of the *GR Experimenter* for a general article discussing error sources encountered in counter measurements, and to the February 1966 issue for an article specifically discussing noise-produced errors.[5, 6]

The accuracy of any counter is almost completely dependent upon the accuracy and stability of its time-base oscillator. Economical compromises involved consideration of low-cost ovens or crystals that operate over the instrument ambient-temperature range. The GR 1192 employs a very stable 5-MHz crystal, operating in the ambient-temperature range of the counter, for internal-frequency control. Its temperature coefficient is less than 3×10^{-7} in the range 0 to 55°C. Total frequency shift due to temperature is less than 4×10^{-6} while long-term drift is less than 2×10^{-6} per month. If higher stability is desired in the counter, it can be locked to an external frequency standard, with the attendant gain in accuracy and stability.

5 McAleer, H. T., "Digits Can Lie," *GR Experimenter*, December 1962.
6 Frank, R. W., "Input Noise," *GR Experimenter*, February, 1966.

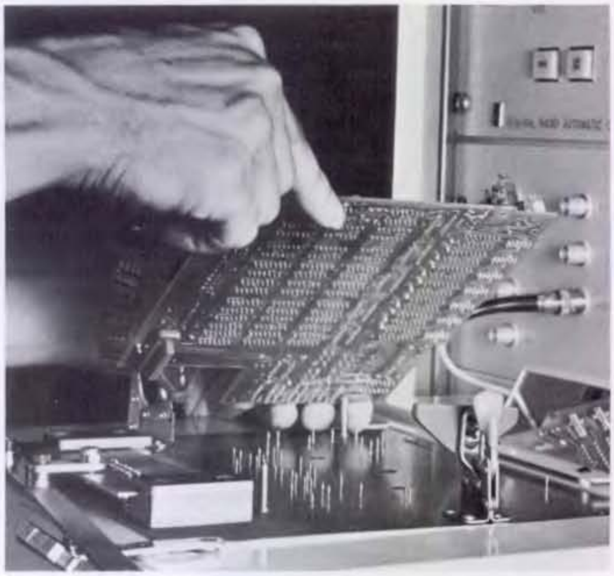

Figure 5. Automatic testing system for the GR 1192 etched-board subassemblies.

The physical size of counters has been decreasing steadily and this GR unit is no exception. In height, the progress has been from 16 inches to 3-1/2 inches, with a corresponding shrinkage to one-half rack width.

A Word About Production Control

The GR 1192 incorporates numerous computer-type integrated circuits mounted upon three etched-circuit boards. In order to test each circuit board, GR constructed an automatic computer-controlled test assembly that receives each type board in an individual test jig (Figure 5). A total of 90 points is tested on one board. The associated computer is programmed to perform more than 300 independent tests after it has first determined that the circuit has been conditioned for testing. The test assembly identifies failures and reports the failures in a printed record, using an associated teletypewriter. Upon completion of the automatic test program, the boards, okayed by the computer, are removed by the operator and installed in the instrument for a final over-all functional check.

—S. Bentzen

ACKNOWLEDGMENT

The author gratefully acknowledges the assistance of B. Sargent in the electrical design of this instrument and of J. McCullough for production engineering.

Complete specifications for the GR 1192 are available on the catalog page, included as a tear sheet inside the back cover of this issue, removable for insertion in GR Catalog T.

Recent Technical Articles by GR Personnel

"On Estimating Noisiness of Aircraft Sounds," R. W. Young and A. Peterson, *Journal of the Acoustical Society of America*, April, 1969.*

"Spectrum Analysis of Stationary Noise Signals," W. R. Kundert and A. P. G. Peterson, *Sound and Vibration*, June 1969.*

"High-Gain Phase Detector Circuit Uses No Transformers," C. C. Evans, *Electronic Design*, May 24, 1969.

"Microwave Tuners," T. E. MacKenzie, *Electronic Instrument Digest*, April 1969.

*Reprints available from General Radio.

A major instrument we employ to promote service to our readers is, of course, the *Experimenter*. Do not overlook, however, the existence of the supplementary handbooks, application notes, and reprints of technical articles, such as those above, available to our readers. A listing of these publications will be mailed to you upon request to the Editor. Other questions related to GR instruments or engineering are also welcomed.

Calibration of High-Voltage Transformers

This article, by an Australian reader, is presented as a calibration note of general interest to readers in the high-voltage and power fields.

Standard voltage transformers for comparison with the unknown transformer at voltages above 110 kV are expensive and rarely available. An absolute method must then be used.

The ratio and phase angle of the transformer under test are compared, at rated voltage, with those of a stable and loss-free capacitance divider of negligible voltage coefficient of capacitance. The ratio of the divider is then measured at low voltage. It is generally held that the ratio should be determined as a ratio, that is, derived by a transfer process and not by the measurement of individual quantities. This applies when you are striving for the limit of attainable accuracy while using a special divider with gas-dielectric three-terminal capacitors in both arms. For industrial purposes an uncertainty of measurement of 0.03% in ratio and 1 minute in phase angle is sufficient.

It is convenient to measure the two capacitances with the GR 1620-A direct-reading, 0.01% capacitance-measuring assembly. The ratio is obtained from

$$k = \frac{|V_P|}{|V_S|} = \frac{C_2}{C_1}\left(1 + \frac{\phi^2}{2}\right)$$

wherein ϕ is the phase angle of the transformer in radians and C_1, C_2, V_P, and V_S are as given in Figure 1. The expression for ratio differs from C_2/C_1 by less than 2 parts in 10^5 for phase angles smaller than 20 minutes.

The transformer under test is connected in series aiding, and the ratio balance is obtained by adjusting C_2. The capacitor C_1 is a three-terminal compressed-gas type of suitable voltage rating. Commercially available models have capacitance values of 50 or 100 pF. Reputable makes with clean, conditioned, and well-centered cylindrical electrodes have a loss angle of less than 10^{-5} radian and insignificant voltage- and frequency-coefficients of capacitance. It is therefore sufficient and convenient to measure C_1 at 1000 Hz.

If C_1 has values of 50 or 100 pF, the capacitor C_2 may have values to 0.5 microfarad, for ratios between 1000 and 5000. The dielectric of C_2 is polystyrene for the decade steps and air for the variable part. In tests carried out so far on three-phase transformers rated up to 330 kV/110 V, 3 phase, the capacitor C_2 was home built; a GR 1412-BC is an excelent commercial substitute. The losses of polystrene-dielectric capacitors are very low; for calibration purposes it is sufficient to use a constant correction of +0.3 minute. Tests have shown that the voltage coefficient up to 100 volts is less than 2 parts in 10^5 and thus negligible for the purpose. The capacitance of C_2 was measured at 2½ times the power frequency, viz 125 Hz, to avoid errors due to stray fields at the

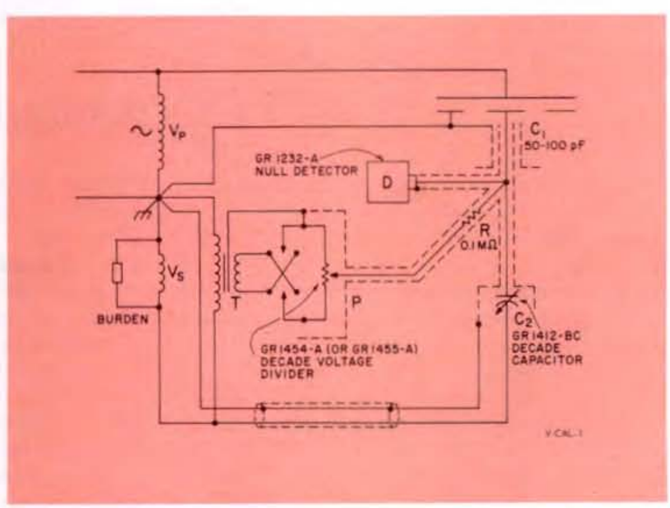

Figure 1. Schematic diagram of high-voltage transformer calibration circuit.

low voltage level employed in the GR 1620-A assembly. For polystyrene capacitors, the frequency error of capacitance is negligible between 50 and 125 Hz. Errors due to temperature changes were minimized by measuring C_2 immediately after the calibration of the unknown transformer and without shifting its physical position.

The battery-operated GR 1232-A tuned amplifier is a suitable null indicator (D in Figure 1) and presents no problems with double earthing, as would be the case with a mains-operated device.

The phase angle is adjusted by means of P and is obtained from

$$\phi = \left[\frac{1}{\omega C_2 (R + r)} \alpha \frac{3438}{10}\right] + 0.3 \text{ min},$$

wherein R is the measured resistance of the nominal 100,000-ohm 1-W high-stability, carbon current-injection resistor, r is the output resistance of the GR 1454-A 10,000-ohm voltage divider* and α is the dial reading of the 1454-A divider.

The permalloy-core stepdown transformer T has a ratio of 10/1; its primary impedance exceeds 100,000 ohms and thus presents a negligible burden to the transformer under test; its resistances referred to the secondary are less than 1 ohm.

If the transformer to be calibrated is designed for a small burden, the loading due to C_2 may cause an error which is not negligible. To correct for this, the ratio and phase angle are first measured in the normal way (k_1, PA_1). The measurements are repeated (k_2, PA_2) with an auxiliary capacitor of approximately the same value as C_2 connected across the burden. This will make the ratio smaller and the phase angle more negative. The corrected results are then:

$$k = k_1 \left(1 + \frac{k_1 - k_2}{k_1}\right); \quad PA = PA_1 + (PA_1 - PA_2).$$

Direct-reading measurement was not sought because calibrations are done infrequently, and generally only on the first transformer of a production run. This unit serves as a standard for the remainder.

While all work was carried out at 50 Hz there is no question that the arrangement is suitable for the calibration of voltage transformers at 60 Hz.

L. Medina is an EE graduate of the Technical University of Vienna, 1932, with an ME awarded him in 1959. He recently retired from the High Voltage Laboratory, which he helped establish, of the Commonwealth Scientific and Industrial Research Organization, Sydney, Australia. Presently he is teaching part time at the University of New South Wales and at Sydney University, while acting as consultant in high-voltage engineering.

* Type 1455-A replaces Type 1454-A.

Seminar Scheduling

A series of lecture-seminars on the subject of manufacturing/plant noise will be presented by Laymon N. Miller of Bolt, Beranek, and Newman. The series will be conducted in six cities on the dates tentatively scheduled below.

Seattle, Washington	October 3, 1969
Denver, Colorado	October 22, 1969
Houston, Texas	November 14, 1969
Atlanta, Georgia	November 22, 1969
Charlotte, North Carolina	December 3, 1969
Washington, D. C.	December 10, 1969

The lectures will deal with practical acoustics and noise control. Readers interested in attending the lectures can contact the GR District Office closest to the locations listed above for information related to exact location and fee.

Reports from the Field

MATING THE GR 1680-A WITH THE IBM 1800

Another successful marriage of the GR 1680-A Automatic Capacitance Bridge Assembly to the digital computer is illustrated by an example supplied us by Tom King of the IBM Data Acquisition and Control System (DACS) Center in San Jose, California. The center has successfully interfaced the IBM 1800 computer, using the Multiprogramming Executive (MPX) Operating System, with several asynchronous test stations for demonstration purposes. The computer has been able to control, at one time, such diverse manufacturing devices as the GR 1680-A, a relay test station, a carburetor test station, a distributor test station, and a dynamometer. As demonstrated at the 23rd Annual Conference of the Instrument Society of America in New York, the tests were run asynchronously, with output reports recorded on the IBM 1443 printer, IBM 1053 and 1816 keyboard printers, and on the Tektronix 611 storage oscilloscope. The same bridge program now is being run at IBM DACS.

The 1680-A assembly operates in conjunction with an Atescar mechanical handler (Figure 1). Test pallets, which contain inductors, capacitors, or resistors in lots of 25 or 50 units, are subject to test specifications recorded in an IBM 1810 disk file. When the test process is started, the 1800 program calls for a record of the pallet and lot numbers, retrieves the related test specification data from the memory disk, and instructs the handler to position the components sequentially for test by the GR 1680-A. Upon completion of a measurement, the data are fed back to the IBM 1800 program for comparison and temporary storage prior to calculations.

Upon completion of tests of 25 or 50 positions, the IBM 1800 executes calculation of the output programs, meanwhile preparing for another test run by the GR 1680-A. Output reports and scope displays are generated from the variable-core storage area, making it possible to overlap tests by the GR 1680-A with reports of previous runs.

Typical data that can be economically stored in disk files are test specifications, life-test data, and other historical information. Required reports can be generated later from this stored information.

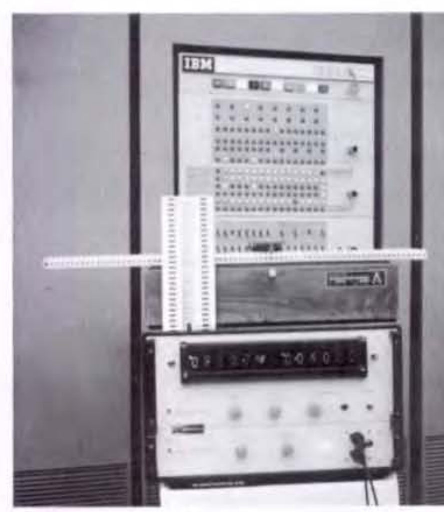

Figure 1. Control of GR 1680-A bridge assembly by IBM 1800 computer.

Photo courtesy of IBM.

PROGRAMMING TESTS OF COMMUNICATION CABLES

We have had a report that the GR 1680-A assembly is involved in tests of communication cables.[1] The requirements here are measurements of mutual capacitance between the two wires of a pair, of unbalanced capacitances between conductors of one pair and those of another pair, and of unbalance of a pair to ground. Cables may range in size to 100 pairs; two-pair measurement combinations reach 4950. Previously, to carry out a manual check of pair-to-pair unbalance was impractical; measurements were made only on pairs known to be physically close.

[1] For complete details refer to "An Automatic Computer-Controlled System for the Measurement of Cable Capacitance," R. G. Fulks and J. Lamont, *IEEE Transactions on Instrumentation and Measurement*, December 1968.

The automated system has the ability to alter its measurement sequence. The computer quickly determines whether the first direct capacitance of a combination is less than a programmed value. This result indicates the pairs are physically separated and more precise measuring is eliminated. At a rate of four measurements per second, the over-all automatic measurement time is reduced to 15% of the manual time by incorporating overlapping operations into the sequence of operations. The bridge can balance itself, the computer can calculate capacitance, and the typewriter can type the results – almost simultaneously!

Measurements are normalized to nanofarads per mile and typed out in a table showing the distribution of measurements. Average and standard deviations are calculated also. Test tolerances are determined automatically from two values typed in by the operator – number of pairs to be tested and cable length.

The assembly performing this task is shown in Figure 2. It includes the GR 1680-A assembly, PDP-8/S digital computer, scanner, teletypewriter, and an interface unit to perform signal-translation and data-storage functions. The assembly is self-calibrating; a test employing a standard capacitor is performed before and after each test sequence, to verify correct operation of the bridge and scanner assembly. Cable-measured values outside programmed tolerances trigger an alram to alert the operator to check for the cause of trouble.

Figure 2. Automatic test assembly for communication cable inspection.

DESIGNING FIRE-RESISTANT NAVY CABLE

From time to time we at GR are made aware of the extreme environmental conditions to which "ordinary" electrical products are subjected and of the part played by our instrumentation during extraordinary inspections. Recently we learned of the rigorous development tests of Navy cabling used on board US Navy ships for transmission of audio and data information. These cables must perform, without failure, during exposure to shipboard fire. Failure could result in severe compartment damage, loss of personnel, and even destruction of the ship because of the loss of an instruction or command.

The Naval Applied Science Laboratory, Brooklyn, N.Y. has responsibility for design of fire-resistant, interior-communications, ship-board cabling. Part of the task of proving a successful design is exposure of cable samples to flame while electrical measurements of cable capacitance and conductance are made. An assembly that performs such measurements (Figure 3) includes the GR 1680-A Automatic Capacitance Bridge Assembly plus the GR 1521-B Graphic Level Recorder and GR 1136-A Digital-to-Analog Converter. Engineers know that rapid fluctuation of the capacitance of twisted-pair communication cables, during exposure to simulated-fire conditions, is difficult to monitor manually. Use of the automatic measuring assembly simplifies the measurement task considerably. Mr. M. DeLucia, Project Engineer at the Naval laboratory, notes that a test response, similar to that shown in Figure 4, is typical of improved-cable response to exposure to extreme environment, represented by the gas flame in Figure 3.

Figure 3. Test assembly for fire-resistant cables.

Photo courtesy of US Navy.

Figure 4. Graph of cable-characteristic response to extreme environmental change.

Art courtesy of US Navy.

Deviations from Accuracy

Our apologies to "PK" McElroy for moving his home location, as included in the article in the *Experimenter* for May/June, page 21. In reality, he still lives at 58 Douglas Road, Belmont, Mass., not at Gayles Road as printed.

Also, we were quite surprised to find that our paragraph which mentioned the honor to Dr. A. P. G. Peterson, same issue and page, could be construed as alluding to APGP as a "foundling" of the Audio Engineering Society. In spite of the Editor's story, Dr. Peterson was *not* abandoned as a child. It was the twentieth anniversary of the *founding* of the Audio Engineering Society that was the occasion for the award to Dr. Peterson. Finally, investigation has proven that Dr. Peterson did not, as reported, publish his first *Experimenter* article in August, 1941. In the October 1937 issue, before joining GR, he printed an article "An Ultra-High Frequency Oscillator" which reported the results of a project jointly sponsored by MIT and GR.

Combination of GR 1157 Scaler and GR 1192 Counter assembled for rack mounting.

NEW

The GR 1157-B Scaler, compatible with the GR 1191- and 1192-series Counters, replaces the popular GR 1157-A Scaler. This model includes improvements such as:

- Greater counter resolution at frequencies that only require prescaling by 10, by the addition of a divide-by-10 function to the divide-by-100 function.
- Smaller size, that permits side-by-side combination with the GR 1192 Counter.

The new scaler-counter combination forms a single, standard-rack-width package (GR 1192-Z) that provides an economical way to obtain high-frequency counting up to 500 MHz (Figure 1).

The signal applied to the 1157-B INPUT terminal is fed to an attenuator that reduces its amplitude by a factor of 1 (no reduction), 2, 5, or 10, so the instrument can handle signals from 0.1 to 7.0 volts rms amplitude. In order to indicate the proper attenuator (SENSITIVITY) control setting, the output of the attenuator is rectified, amplified, and applied to a "green-sector" meter. Generous overlaps in range are provided so that attenuator settings may easily be made to bring the meter reading into the green sector. In order to give a clear indication of the range of proper operation, the upper two-thirds of the meter scale is electronically compressed by the meter amplifier. Thus an actual 7:1 signal range represented by the green sector is compressed into a 3:1 deflection ratio.

The attenuated input signal is amplified and applied to a pulse generator circuit that provides a pulse of 0.5-ns duration, as required by the tunnel-diode binary divider.[1] The binary output, now at one-half the input frequency, is fed to a scale-of-five divider using three integrated-circuit flip-flops in a ring-type configuration. The output of this quinary-divider circuit, now at one-tenth the input frequency, is applied to another integrated-circuit flip-flop for frequency division by two. This signal is finally applied to a second scale-of-five divider, similar to the first, to obtain a continuous end output at one-hundredth the input frequency at the 100:1 SYNC OUTPUT. In addition, a main output is provided that can be switched from the divided-by-100 output to a divided-by-10 output taken from the high-frequency (first) quinary-circuit output.

When the GR 1157-B is used as a prescaler for a counter, the divide-by-10 feature of the prescaler is an advantage since it provides ten times greater frequency resolution in conventional frequency measurements than that provided by the divide-by-100 feature. When the counter's maximum frequency-handling capability is exceeded by the input frequency-divided-by-10 signal, the scaler must be operated in the divide-by-100 mode. Engineering of this product was by J. K. Skilling and B. J. Sargent.

[1] Similar circuitry is described in the *GR Experimenter*, page 13, October 1968 and in *NASA Technical Note D-1337*, "A Tunnel-Diode Counter for Satellite Applications," by E. G. Bush, June 1962.

Complete specifications for the GR 1157-B are available on the catalog page, included as a tear sheet inside the back cover of this issue, removable for insertion in GR Catalog T.

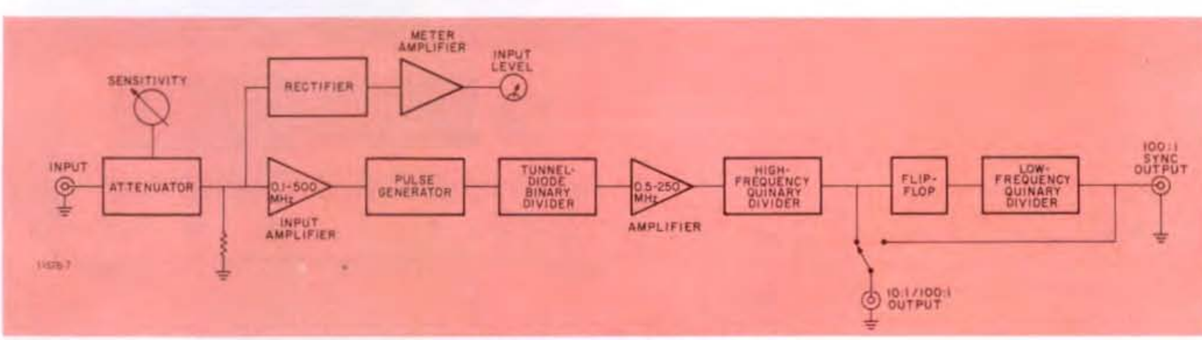

Figure 1. Block diagram of the GR 1157-B.

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