

THE GENERAL RADIO



Experimenter



GR'S NEW IC COUNTER

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the Experimenter

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Figure 1. Type 1191 20-MHz Counter, front and rear panel views.

A
PROGRAMMABLE
20-MHz
COUNTER-TIMER
USING
INTEGRATED
CIRCUITS

The instrument shown on our cover is an eight-digit, programmable, 20-MHz counter capable of measuring frequency, period, frequency ratio, and time interval. It is available with a choice of time bases and optional electrical data output. One of its most outstanding specifications is its price, which serves as evidence that, in at least some areas, technological progress can outrun inflation.

Electronic instruments, as everyone knows, have been getting smaller and smaller — in terms of signal-processing capability per unit volume — since the development of the transistor. Perhaps less widely appreciated is the fact that prices have also been shrinking. Now, with the arrival of integrated circuits, we are witnessing some truly remarkable reductions in instrument costs.

Nowhere is this happy trend more visible than in the area of frequency counters. Only seven years ago, for example, a vacuum-tube 10-MHz counter with period and time-interval capability was priced in the \$2500-\$3000 range. The transistor brought counter size down to the point where it was hardly a factor, but prices decreased only slightly. Integrated circuits, however, have made possible substantial savings, and General Radio has been able to take advantage of IC's to offer both advanced performance and rock-bottom price, specifically in a programmable 20-MHz, eight-digit counter-timer at less than \$1500.*

It is easy enough to credit the availability of IC's for the new counter's wide price and performance margins over vacuum-tube and transistor

* Price applies in USA only.

counters, but we must look further to find out why this counter alone among IC counters offers so much performance at such low cost. The answer lies in the way IC's have been applied. Just as some counters on the market in the early '60's were "transistorizations" of existing vacuum-tube designs, some of today's counters are "integrations" of "transistorizations." Not so GR's new IC Counter (TYPE 1191), which, in a first step toward large-scale integration, combines as many as four flip-flops and their various buffering and gating stages in a single package.

The integrated circuit shaped the design philosophy behind the 1191. In pre-IC design, for example, one could save money by using slow circuits in noncritical areas. With IC's, extra speed is often available at no cost premium; there may even be savings

The 1191 counter on this month's cover signals the debut of GR's new "light-look" instruments. The attractive new styling underscores several important design improvements that mean added convenience and longer instrument life.

Panels are now coated with a baked epoxy finish, for long wear and resistance to scratches.

All relay-rack units have handles for easy installation and removal from racks. The handles are at the ends, out of the way of controls and switches.

The new panel color conforms with Federal Standard 595 (gray, 26492), ensuring good match with companion instruments.

Removable dress panels on many

rack-mountable instruments facilitate installation of special-color panels for systems requirements.

New glass-fiber-reinforced knobs give solid protection against cracking and chipping. They also snap on and off without setscrew manipulation and give complete protection against hot shafts.

New binding posts are 12-pointed (double hex) for better finger grip. Standard $\frac{3}{8}$ -inch socket wrenches can be used to make permanent, tight connections.

Panel markings are silk-screened with epoxy for excellent legibility and baked for extra abrasion resistance and permanence.

We hope you like the new "light look."

resulting from the use of many identical fast circuits, and fast circuits can mean more efficient programs for the various measurement functions. In the 1191, for example, the minimum display time is not in the 10's or 100's of milliseconds, as with most other counters, but 100 microseconds. The propagation time through the eight identical decade counting units of the 1191 is only about 0.2 μ s, and it takes only about 0.3 μ s to transfer data into storage. Thus the 1191 can make a time-interval measurement and in only 0.5 μ s be ready for the next measurement. Other counters — even IC designs — typically require at least 50 milliseconds.

Today's counters are increasingly called upon to operate as components in automatic systems, responding to electrical control and presenting electrical outputs for use with computers, printers, recorders, etc. In the 1191, proper application of integrated circuits simplifies remote programming to the point where it does not add significantly to cost. At the relatively small cost of a control input socket and its wiring, one can completely avoid the need to shield and "hot-switch" fast, pulse-type electrical signals. In the 1191, the only hot switching is the choice of ac or dc coupling, the choice of whether the two input channels are connected in common or separately, and the signal attenuation. All other functions and ranges are switched by contact closures, dc voltages, or RC circuits.

The greatest savings arise from the simplicity of the measurement programs, achieved without sacrifice of user convenience or versatility of operation. Switching from one measurement function to another, for example, involves only the restructuring of a

system comprising two flip-flops and two gates.

THE COUNTER

The 1191 is a general-purpose 20-MHz counter-timer for measuring frequency, period (single or multiple), frequency ratio, and time interval. All measurement functions, ranges, and most of the secondary controls are programmable. The counter functions are de-controlled, most by simple contact closures to ground.

It is important to note that the 1191 is capable of true time-interval measurements, with full input circuits for both its start and stop signals. It is not a counter that can be converted into a brute-force timer by injection of start and stop pulses into the main gate.

Readout is eight digits of high-intensity neon indicators, with automatic display of decimal point and of measurement units. Internal storage gives continuous display of rapidly changing data without flicker. The operator has front-panel control of all input trigger-circuit characteristics.

The counter is available with either of two time bases. The less-expensive room-temperature-crystal oscillator has a basic stability specification of less than 0.2 ppm/ $^{\circ}$ C from 0 to 50 $^{\circ}$ C and a drift of less than 2 ppm per month. Those who require greater stability may either phase-lock this oscillator to an external standard or purchase the counter equipped with a high-precision oscillator operating in a proportional-control oven. The stability specification for this oscillator is less than 2 parts in 10¹⁰/ $^{\circ}$ C from 0 to 50 $^{\circ}$ C in continuous operation, and drift is less than 1 part per 10⁹ per day.

Another important option is the electrical data output, a fully buffered

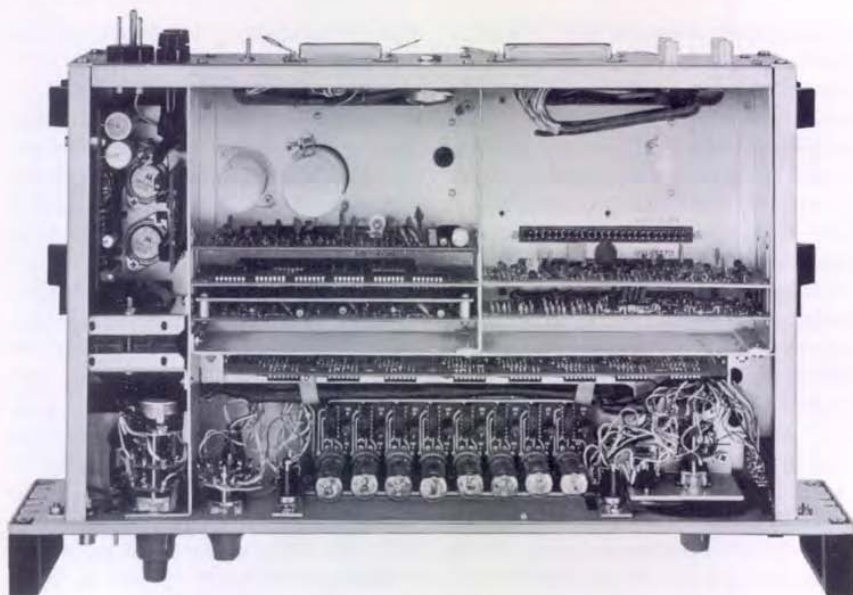


Figure 2. Top interior view.

1-2-4-8 BCD output available at the rear panel of the counter. In addition to the measured data, the output connector carries monitoring data on the main gate and a print-command pulse.

One of the major features of the counter is its "jam transfer" system for holding the displayed or electrical data until the measured data change.* In storage-type counters without jam transfer, all registers momentarily switch off and on between measurements, even where the count in only one of the registers actually changes. Advantages of jam transfer are less rf noise from the counter due to readout tube switching and less noise in the electrical output data.

The simplicity of the counter's design is immediately apparent in an interior view (Figure 2). All circuits except the

indicator drivers and the indicators are on plug-in boards, easily removable for repair or replacement. A socket for an extra card is included for specialized systems requirements. Also useful in systems applications are the rear-panel connectors for A and B channel inputs, programming inputs, data-output plug, external-time-base input, and the 10-MHz time-base output.

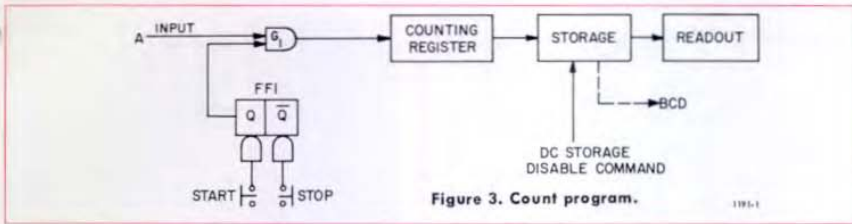
HOW IT WORKS

The simplicity of the counter's design is apparent in the following brief descriptions of the circuit programs.

Count Program

The simplest of the programs is the COUNTING mode (Figure 3). Manually operated or electrically programmed switches set a control flip-flop (FF1). When FF1 is in the Q state, the input gate passes pulses generated from

*US Patent 3,328,564.



the A input signal to the counting register. When a "stop" command resets the control flip-flop to the \bar{Q} state, the total number of pulses accumulated in the counting register is displayed. In the counting mode, the storage units are used as amplifiers.

Frequency Program

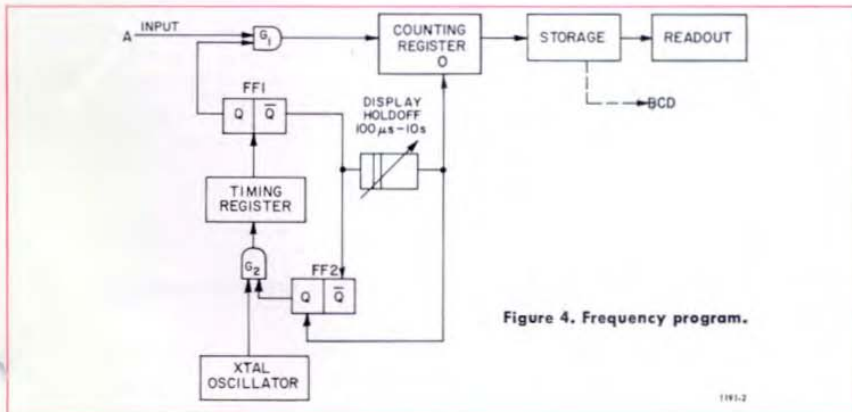
For the frequency program, an additional eight-decade counting register, called the timing register, and a crystal-oscillator time base are added to the components used for the counting mode (Figure 4). The function of the additional circuit is to open the counting gate for a precise length of time. If, for example, the counting gate is opened for exactly one second, the number of pulses accumulated in the

counting register will be the average number of cycles in one second of the A signal, or the A signal frequency in hertz. The time interval is established by the timing register, which counts up to 10^8 zero crossings of the crystal oscillator (which may, in turn, be phase-locked to an external standard).

The closure of the main gate (G_1) generates commands that move the contents of the counting register into storage, clearing FF2 and closing G_2 , and, after a display hold-off interval that can be as short as 100 microseconds, FF2 is reset and the timing sequence is repeated.

Frequency-Ratio Program

The frequency-ratio program is similar to the frequency program, the only



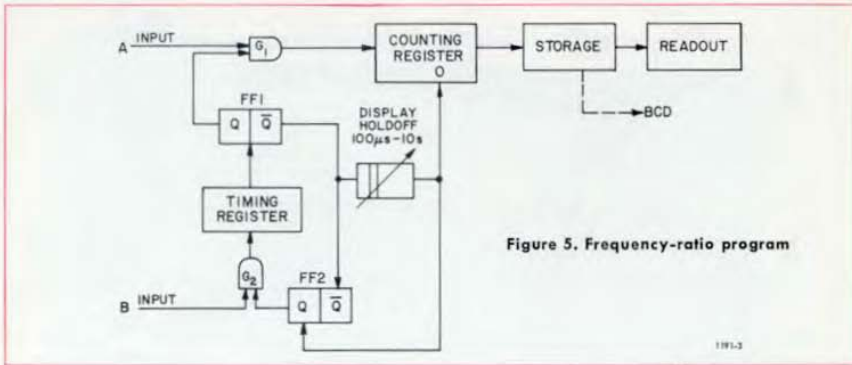


Figure 5. Frequency-ratio program

difference being that the B channel input is substituted for the crystal oscillator (Figure 5). The accumulated count is thus the number of cycles of the A signal during a time interval established by the B signal period.

One very useful application for this program is the use of longer gate intervals than can be obtained with the internal crystal oscillator. If, for example, a 1-MHz standard frequency is available, a 100-second gate will be established with the 10^8 range-switch setting in the ratio program. Similarly, a 1000-second gate can be established with a 100-kHz standard frequency.

Multiple-Period Program

As seen in Figure 6, the multiple-period program uses the same circuits as the frequency ratio program, re-structured so that the time-base signal is fed through the input gate to the counting register and the A input is applied to the timing register. The clock interval fed to the timing register is one period of the signal to be measured, and the counted signal is the 100-nanosecond period of the 10-MHz time base. Depending on the position of the range switch, from one to 10^8 periods of the unknown are measured in terms of the time base.

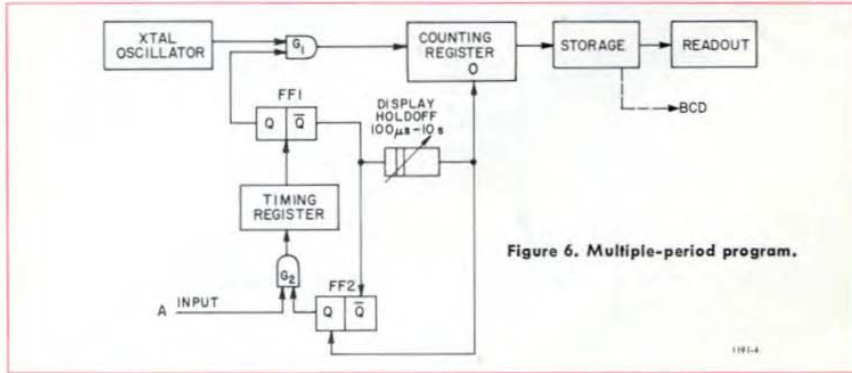


Figure 6. Multiple-period program.

Richard W. Frank, Leader of GR's Frequency and Time Group, received his SB and SM degrees in electrical engineering from the Massachusetts Institute of Technology in 1950 and 1951. He joined GR in 1951 as a development engineer and was appointed Group Leader in 1957.



With the eight-digit counting register and the 10-MHz time base, single periods of signals as low in frequency as 0.1 Hz can be measured in the multiple-period mode. For periods of lower frequency signals, a lower-frequency time base must be counted. Use of the time-interval mode is then indicated.

Time-Interval and Single-Period Program

Figure 7 shows the restructuring of the circuits for the time-interval measurement. The A-channel input circuits are used to generate a pulse that opens G_1 to start the counting of the time-base signal. The B channel is used to produce a stop pulse. Clock frequencies as low

as 0.1 Hz can be produced by the timing register, for a maximum measurable time interval of 10^9 seconds (a little over three years). When both A and B inputs are present, the register indicates the time between A and B. If there is no input to channel B, a single-period measurement of the A-channel input is made.

The time-interval mode can be used for pulse-duration measurements. For example, in the measurement of the duration of a positive pulse, the A-input controls are set to start the counter on the positive-going slope and the B-input circuits to produce the stop pulse on the negative-going slope. Maximum resolution for such measurements is 100 nanoseconds.

PROGRAMMABILITY

Almost all the counter's functions are programmable simply by switch closures to ground. The user chooses those functions he wishes to program by setting the corresponding front panel switches to the EXT PROG position. The extent to which the various controls are programmable is indicated by the

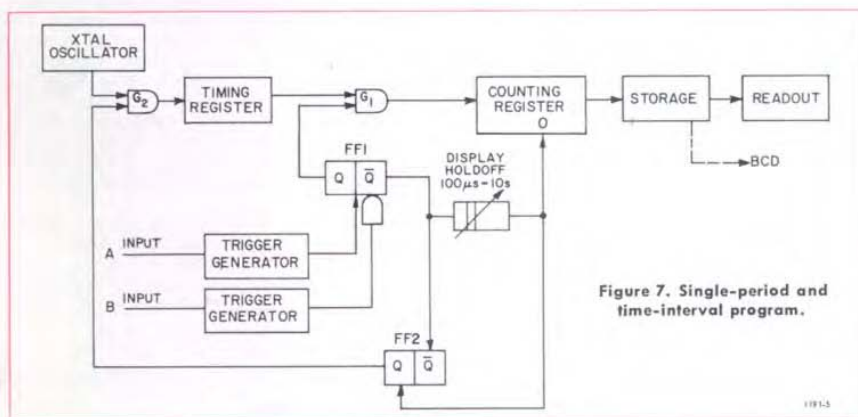


Figure 7. Single-period and time-interval program.

following table. Note that only a few secondary controls are not programmable, and even this limitation can be removed in certain cases on special order.

<i>Function</i>	<i>Method of Programming</i>
MEASUREMENT mode	Switch closure to ground
RANGE switch	Switch closure to ground
Trigger-polarity controls	Switch closure to ground
THRESHOLD controls	Dc voltage at desired level
DISPLAY TIME control	RC circuit to ground
START-STOP controls	Switch closure to ground
RESET button	Switch closure to ground
Attenuator controls	not programmable
AC-DC coupling switch	not programmable
SEPARATE-COMMON switch	not programmable

Programming connections are made through a multiterminal connector on the rear panel of the counter. Also available at this connector are several

outputs for use with auxiliary equipment. These include a carry pulse from the highest decade, an end-of-display pulse, and a print-command pulse.

ABOVE 20 MHz

The 1191 is easily adapted for use at frequencies to 100 MHz by the addition of the Type 1156 Decade Scaler.¹ The resulting combination is a versatile, programmable, 100-MHz frequency-measuring system priced in the \$2000* area.

— R. W. FRANK

ACKNOWLEDGMENT

This design project, extending over the last 10 months, was directed by the author. Such an accelerated development program required the cooperation of too many people, both within and outside the Engineering Department, to make an individual listing of contributors practical; however, particular mention of the contribution of Brian Sargent is in order. Brian contributed to the electrical design and energetically followed the many details necessary for the smooth entry of this instrument into production.

R. W. FRANK

* Price applies in USA only.
¹ D. S. Nixon, Jr., "100-Mc Decade Scaler," *General Radio Experimenter*, September 1965.

SPECIFICATIONS

MEASUREMENT RANGES AND ACCURACY

Frequency: Dc to 20 MHz; 1- μ s to 10-s counting gate times. Accuracy, ± 1 count \pm time-base accuracy.

Single Period: 1 to 10⁹ s measured by counting 0.1- μ s to 10-s intervals derived from internal 10-MHz clock. Accuracy (see note) is dependent on the signal-to-noise ratio of the input signal, the counter input noise, and the ± 1 -count error.

Multiple Period: 1 to 10⁸ periods measured by counting internal 10-MHz clock. Accuracy, see note.

NOTE— Trigger error in time measurements: $\pm 0.3\%$ of one period \div number of periods averaged, for a 40-dB input signal-to-noise ratio. This assumes no noise internal to the counter. For input signals of extremely high signal-to-noise ratio, the trigger error in μ s will be $< 0.0005 \div$ the signal slope in V/ μ s.

Time Interval: 0.1 μ s to 10⁹ s measured by counting 0.1- μ s to 10-s intervals derived from internal 10-MHz clock. Accuracy (see note), ± 1 clock pulse \pm trigger error \pm time-base stability. Interval is measured between "start" and "stop" pulses driving the input channels independently, or from a single signal with common connection between channels, as for pulse-duration measurements.

Frequency Ratio: 1 to 10⁸. Frequency "A," dc to 20 MHz, is measured over 1 to 10⁸ periods of frequency "B," dc to 10 MHz. Accuracy, ± 1 count of "A" \pm trigger error divided by number of "B" periods.

Count: Register capacity, 10⁸. Events are accumulated between "start" and "stop" commands from manual panel buttons or, externally, from contact closures or solid-state switches. In "count," storage is automatically disabled.

INPUT

Frequency: Channel "A," dc to 20 MHz (3 Hz to 20 MHz ac-coupled); channel "B," dc to 10 MHz (3 Hz to 10 MHz ac-coupled).

Sensitivity: 10 mV rms sine wave, 30 mV pk-pk pulse; trigger level variable ± 100 mV.

Attenuator: x1, x10, x100 (0, 20, 40 dB); low-capacitance 10:1 probe available.

Voltage Rating: Input voltage should not exceed 150 V on x1 or 300 V on x10 or x100.

Impedance (all attenuator settings): Approx $1\text{M}\Omega$ shunted by 35 pF. At rear connectors (supplied mounted, unwired), shunt C increases to approx 70 pF.

Signal Polarity: Front-panel control permits selection of positive- or negative-going signal sense for triggering.

10-MHz TIME-BASE OPTIONS

Room-Temperature Oscillator

Stability: $< 2 \times 10^{-7}/^\circ\text{C}$ from 0° to 50°C . Drift less than $\pm 2 \times 10^{-6}$ per month. With $\pm 10\%$ line-voltage variation, $< 2 \times 10^{-8}$.

Manual Adjustment Range: $\pm 1 \times 10^{-5}$ at rear-panel control.

High-Precision Oscillator (in proportional-control oven)

Stability: $< 2 \times 10^{-10}/^\circ\text{C}$ from 0° to 50°C when operated continuously. Drift $\pm 1 \times 10^{-9}$ per week, approx 2×10^{-9} per day after 1 month of continuous operation. With $\pm 10\%$ line-voltage variation, $< 2 \times 10^{-10}$.

Manual Adjustment Range: $\pm 1 \times 10^{-6}$ at rear-panel control.

Time-Base Output: 10-MHz square wave, 2 V pk-pk behind 50Ω at rear-panel BNC connector.

External Phase-Lock: Both time-base oscillators can be locked to external standard frequency at 0.1, 1, 2.5, 5, or 10 MHz, of at least 1 V rms into 1 k Ω . A front-panel phase-lock indicator lamp is provided.

DATA PRESENTATION

Display: 8-digit display with automatically positioned decimal point and measurement dimensions. High-intensity neon readout tubes.

Storage: Display can be either stored or not. Operator can select from approx 100 μs to 10 s or infinity for display time (in normal mode) and for data holdoff time (in storage mode).

Data Output (in some models): Fully buffered 1-2-4-8 BCD output at standard DTL levels; data zero is 0.5 V max and data 1 approx 5 V behind 6 k Ω .

PROGRAMMING

Input: All instrument functions controllable by closure to ground within capabilities of DTL micrologic (2- to 6-mA sink current required), except:

PERIOD and TIME INTERVAL require approx 50-mA-capacity external closures for added load of dimension-display lamps. Functions controlled by other than contact closure:

Input Threshold: Requires dc voltage of ± 100 mV corresponding to desired threshold level.

Display Time: Requires RC circuit to ground. Display/hold-off interval is approx one RC time constant.

Nonprogrammable functions: Input attenuator, input ac/dc coupling, separate/common switch, self-test, internal/external control of time-base oscillator, and frequency adjustment of time-base oscillator.

GENERAL

Environmental: 0° to 50°C operating range.

Power Required: 100 to 125 or 200 to 250 V, 50 to 400 Hz, 32 W.

Accessories Supplied: Rack-mounting hardware set, power cord, spare fuses.

Accessories Available: Input probe, 1156 Decade Scaler for measurement to 100 MHz; 1137 Data Printer, 1136 D/A Converter, and other GR digital-data acquisition equipment.

Dimensions (width x height x depth): Bench model, $19 \times 37\frac{1}{2} \times 12\frac{1}{4}$ in. (485 x 99 x 325 mm); rack model, $19 \times 37\frac{1}{2} \times 11$ in. (485 x 89 x 280 mm).

Net Weight (approx): 22 lb (10 kg).

FOR INPUT PROBE — 1158-9600

Input Impedance: $10\text{M}\Omega$ shunted by approx 7 pF when used with 1191 counter.

Attenuation: $\times 10$ (20 dB).

Voltage: 600 V dc or ac pk-pk, max up to 5.7 MHz; less at higher frequencies.

Length: $3\frac{1}{2}$ ft.

Catalog Number	Description	Price in USA
1191 Counter		
1191-9700	Bench Model	\$1340.00
1191-9701	Rack Model	1340.00
1191-9702	Bench Model with Data Output Option	1390.00
1191-9703	Rack Model with Data Output Option	1390.00
1191-9704	Bench Model with High-Precision Time-Base Option	1490.00
1191-9705	Rack Model with High-Precision Time-Base Option	1490.00
1191-9706	Bench Model with both Options	1540.00
1191-9707	Rack Model with both Options	1540.00
1158-9600	P6006 Probe, Tektronix Catalog No. 010-0127-00 (not sold separately)	22.00

NEW UHF BRIDGE WITH PRECISION CONNECTORS



In terms of impact on instrument design and performance, one of the most important new products to come from General Radio in recent years has been one of the smallest, the GR900[®] precision coaxial connector. The GR900 has been the springboard for substantial improvements in many instruments and standards made by GR and other manufacturers. The time-tested admittance meter is the latest beneficiary of GR900 precision, as well as of several other noteworthy improvements.

The development of precision coaxial connectors has led to significant improvement in the performance of many coaxial instruments. The reduction in error introduced at the interface between the unknown and the instrument has made possible not only higher direct-reading accuracy but even greater gains through the use of reference standards equipped with precision connectors. The exceptional repeatability of the GR900[®] connector has already been put to good use on slotted lines

and rf bridges; now users of admittance meters can share in the many advantages of the precision connector.

The TYPE 1602 Admittance Meter has over the years found widespread application for impedance and admittance measurements in the awkward range between lumped-constant and distributed-parameter frequencies. Its frequency range of 20 to 1500 MHz includes frequencies at which slotted lines become long and expensive and conventional bridges suffer from errors due to stray inductances and capacitances. Now a new admittance meter, the 1609, joins the 1602 to bring a new order of accuracy to measurements in this area. (The admittance meter, incidentally, is a null instrument more properly called a bridge, a point we are happy to put right in the naming of the new instrument.)

The 1609 Precision UHF Bridge is a completely new instrument, different in several important respects from the older 1602. In addition to GR900 connectors, the 1609 has more rugged

over-all construction, improved, lockable conductance and susceptance standards, and several features that facilitate bridge-arm adjustment. Integral multiplier settings, for example, are detented. The real and imaginary arms can be precisely adjusted by means of a vernier attachment and can be locked into position.

The direct-reading accuracy of the 1609 UHF Bridge is quite good, but truly spectacular results are possible through the use of GR900-equipped calibration standards. For example, through the use of GR900 reference air lines and standard terminations, low SWR's can be measured to within ± 0.002 . Recently introduced precision air capacitors, standard resistive terminations, and GR900 air lines, used as *C*, *R*, and *L* standards, similarly improve the accuracy of measurement of capacitance and inductance of

lumped- and distributed-parameter circuits to well beyond the direct-reading accuracy.

Precision measurements are not limited to circuits and components equipped with GR900 connectors. Through the use of GR900 precision adaptors, the UHF Bridge connects easily to any of the popular coaxial connectors, including Types N, TNC, BNC, etc. The deterioration in accuracy introduced by the adaptor is usually negligible compared with the inherent uncertainty characteristics of the lower-performance connectors. For measurements on lumped-parameter components with wire leads, the TYPE 900-M Component Mount can be used.

Method of Measurement

Use of the UHF Bridge is simple and straightforward. With a suitable generator and detector and the conductance



New uhf bridge in use measuring SWR of termination, with 7.5-cm reference air line connected as impedance standard.



John F. Gilmore received his BSEE in 1961 and his MSEE in 1963, from Northeastern University. He joined the Microwave Group at General Radio as a development engineer in 1963 and is currently engaged in microwave circuit design.

and susceptance standards (supplied) connected to the bridge, the unknown is connected and the bridge arms are adjusted for a null. At this balance the bridge arms indicate the real and imaginary terms of the normalized admittance of the unknown at a point about 4.9 cm from the GR900 connector face. A short or open circuit is then measured to establish a known reference plane, and a Smith Chart or transmission-line equations are used to determine the impedance or admittance at any reference plane, just as in slotted-line measurements.

Since this is a null instrument, detector response does not affect measure-

ment accuracy, as it can in slotted-line measurements. Multiplier plates are supplied for better resolution of very small or very large values.

SWR Measurements

When only the SWR of a component is of interest, the bridge can be used as a reflectometer. With the component connected to the bridge, the detector output level relative to a calibration level can readily be converted to SWR. Since no balancing is involved, this method is particularly useful for measurement of large numbers of components.

For accurate measurement of low SWR's, a GR900 reference air line can be used as an absolute impedance standard. The bridge then acts as a tunable hybrid. The unknown is connected and the bridge is balanced. The air line is then inserted between the bridge and the unknown, and the detector output is then an accurate indicator (± 0.002) of the SWR of the unknown. — J. F. GILMORE

SPECIFICATIONS

Accuracy: Applies to each term of normalized admittance reading separately.

Frequency	Larger term < 1	Larger term 1 to 20
20-500 MHz	$\pm(0.02 Y_N + 0.01)$	$\pm(0.02\sqrt{M} Y_N + 0.01M)$
500-1000 MHz	$\pm(0.03 Y_N + 0.01)$	$\pm(0.03\sqrt{M} Y_N + 0.01M)$
1000-1500 MHz	$\pm(0.05 Y_N + 0.01)$	$\pm(0.05\sqrt{M} Y_N + 0.02M)$

$|Y_N|$ = magnitude of bridge reading (normalized units)

= $\sqrt{(\text{real term})^2 + (\text{imag term})^2}$

M = setting of multiplier arm, values > 1 to 20 required if normalized real or imaginary term is > 1.

Impedance accuracy same as above substituting $|Z_N|$ for $|Y_N|$. SWR accuracy $\pm 2\%$ from 20 to 1000 MHz, $\pm 4\%$ 1000 to 1500 MHz, for measurements near unity (matching to 50- Ω system).

Frequency Range: 40 to 1500 MHz, direct reading; down to 20 MHz with correction factor applied to imaginary term.

Measurement Range: 0 to 400 m Ω or 0 to 1000 Ω , direct reading; can be extended to 4000 m Ω or 10,000 Ω with multiplier plates (supplied). Instrument measures admittance 4.9 cm inside mating plane of GR900[®] connector; readings normalized with respect to 20 m Ω (50 Ω). The addition of air line of appropriate length makes instrument direct-reading at any desired reference plane.

Accessories Supplied: 50- Ω conductance standard, adjustable stub and variable air capacitor for susceptance standards, two multiplier plates, 874-R22LA Patch Cord, wooden storage case.

Accessories Required: Generator with 20 mW to 2 W output, detector with better than 10- μ V sensitivity. Recommended, GR oscillators, GR Type DNT Detector or 1236 I-F Amplifier, 874-MRAL Mixer, and appropriate oscillator.

Accessories Available: 900-LZ Reference Air Lines as impedance standards, GR900 Standard Terminations and Standard Mismatches for calibration, GR900 adaptors to other connector types.

Dimensions (width x height x depth): 5 x 7 $\frac{1}{4}$ x 5 $\frac{1}{2}$ in. (130 x 185 x 140 mm).

Weight: Net, 16 lb (7.5 kg); shipping, 20 lb (9.5 kg).

Catalog Number	Description	Price in USA
1609-9701	1609 Precision UHF Bridge	\$795.00

NEW RECORDING WAVE ANALYZERS

In the May-June *Experimenter*, we described a new dial drive for automatic stepped or continuous third-octave analysis (as well as continuous tenth-octave analysis) with the Type 1564-A Sound and Vibration Analyzer.^{1,2} This dial drive, the analyzer, and the Type 1521-B Graphic Level Recorder are now available in combination, as the TYPE 1912 Third-Octave Recording Analyzer. Stepped third-octave analysis is finding increasing application, especially through the impetus of military and industry testing standards (e.g., Mil Std 740-B, ASHRAE 36A-63), and this new system makes these measurements simple and convenient.

In addition to the instruments mentioned above, the system includes 10 rolls of chart paper. The recorder is equipped with a 40-dB potentiometer. The system cabinet includes a storage drawer and a system power control that

switches the analyzer battery supply as well as the ac line.

Another new system combines the TYPE 1568-A Wave Analyzer³ with the graphic level recorder. The 1568 is a 1%-bandwidth analyzer capable of separating very closely spaced frequency components over a frequency range from 20 Hz to 20 kHz. Applications include harmonic-distortion measurements, harmonic analysis (the 1568 will separate about 50 harmonics), and measurements on modulated signals. The analyzer is especially useful in measurements of low-frequency noise or vibration from machinery.

The new Type 1913 Recording Wave Analyzer includes, in addition to the analyzer and the recorder, an 80-dB potentiometer (plus the 40-dB potentiometer supplied with the recorder), 10 rolls of chart paper, and the drive and link units through which the recorder drives the analyzer frequency dial.

¹ B. A. Bonk, "A Dial Drive for Stepped or Swept Analysis," *General Radio Experimenter*, May-June 1967.
² W. R. Kundert, "New Performance, New Convenience With the New Sound and Vibration Analyzer," *General Radio Experimenter*, September-October 1963.

³ W. R. Kundert, "A One-Percent-Bandwidth Wave Analyzer," *General Radio Experimenter*, September 1966.

Catalog Number	Description	Price in USA
1912-9700	1912 Third-Octave Recording Analyzer for 115-V, 60-Hz supply	\$3510.00
1913-9700	1913 Recording Wave Analyzer, 1% Bandwidth for 115-V, 60-Hz supply	3180.00
1913-9701	1913 Recording Wave Analyzer, 1% Bandwidth for 230-V, 50-Hz supply	on request

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Precision Measurements Association Conference

The first annual conference of the Precision Measurements Association will be held at the Disneyland Hotel in Anaheim, California on January 22, 23, and 24, 1968. Instructional courses, technical sessions, and exhibits will be presented.

General Radio will participate in this program by demonstrating the use of GR900® precision connectors and

standards in the calibration of instruments. GR will also demonstrate a technique for calibrating capacitance standards at high frequencies by means of a microwave slotted line equipped with a precision connector.

For further information on the PMA Conference, write to the Precision Measurements Association, 826 N. Victory Blvd., Burbank, California 91502.

General Radio wishes all Experimenter readers
a happy and prosperous 1968.

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