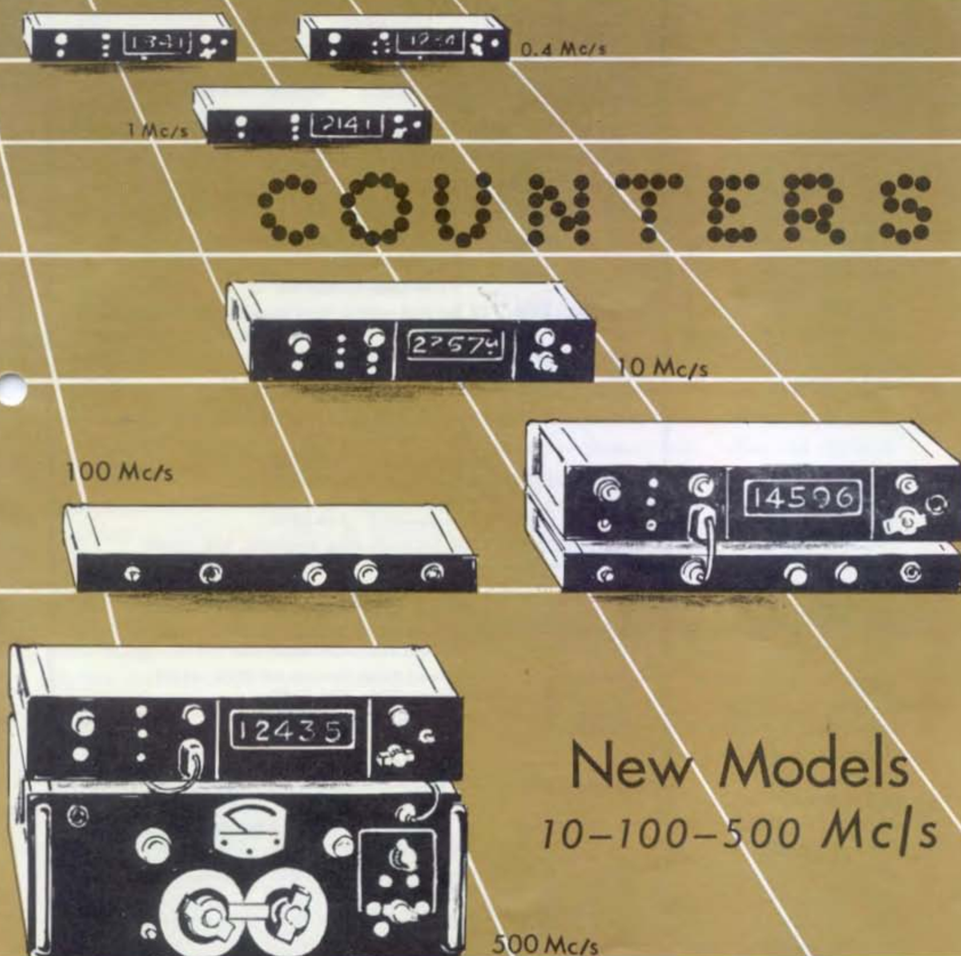
the GENERAL RADIO

experimenter

VOLUME 39 NO 9 SEPTEMBER 1965

COUNTERS



New Models
10–100–500 Mc/s

also in this issue:

DIGITAL-TO-GRAPHIC RECORDING ASSEMBLY
NMR MEASUREMENTS

the GENERAL RADIO
experimenter

©1965—GENERAL RADIO COMPANY, WEST CONCORD, MASS., U.S.A.

Published Monthly by the General Radio Company

VOLUME 39 NO 9 SEPTEMBER 1965

CONTENTS *Page*

10-Mc Solid-State Counter 3
100-Mc Decade Scaler 6
100-Mc Digital Frequency Meter 12
500-Mc Frequency-Measuring Assembly 13
Appendix—Counter Input Circuits and Sensitivity Specifications 14
Type 1510-A Digital-to-Graphic Recording Assembly . . 15
NMR Measurements with the Frequency Synthesizer . . . 15

The General Radio EXPERIMENTER is mailed without charge each month to engineers, scientists, technicians, and others interested in electronic techniques in measurement. When sending requests for subscriptions and address-change notices, please supply the following information: name, company address, type of business company is engaged in, and title or position of individual.

GENERAL RADIO COMPANY

West Concord, Massachusetts*, 01781

Telephone (Concord) 369-4400; (Boston) 646-7400
Area Code Number 617

NEW ENGLAND:	22 Baker Avenue, West Concord, Mass., 01781 *Telephone—617 646-0550*
METROPOLITAN NEW YORK:*	Broad Avenue at Linden, Ridgefield, N. J., 07657 *Telephone—N. Y., 212 964-2722* *N. J., 201 943-3140*
SYRACUSE:	Pickard Building, East Molloy Road, Syracuse, N. Y., 13211 *Telephone—315 454-9323*
PHILADELPHIA:	Fort Washington Industrial Park, Fort Washington, Pennsylvania 19034 *Telephone—215 646-8030*
WASHINGTON* and BALTIMORE:	11420 Rockville Pike, Rockville, Md., 20852 *Telephone—301 946-1600*
ORLANDO:	113 East Colonial Drive, Orlando, Florida, 32801 *Telephone—305 425-4671*
CHICAGO:*	6605 West North Avenue, Oak Park, Illinois, 60302 *Telephone—312 848-9400*
CLEVELAND:	5579 Pearl Road, Cleveland, Ohio, 44129 *Telephone—216 886-0150*
DALLAS:	2600 Stemmons Freeway, Suite 210, Dallas, Texas, 75207 *Telephone—214 MElrose 7-2240*
LOS ANGELES:*	1000 North Seward St., Los Angeles, Cal., 90038 *Telephone—213 469-6201*
SAN FRANCISCO:	1186 Los Altos Ave., Los Altos, Cal., 94022 *Telephone—415 948-8233*
TORONTO:*	99 Floral Parkway, Toronto 15, Ontario, Canada *Telephone—416 247-2171*
MONTREAL:	Office 395, 1255 Laird Blvd., Town of Mount Royal, Quebec, Canada *Telephone—514 737-3673*

*Repair services are available at these offices.

GENERAL RADIO COMPANY (Overseas), 8008 Zurich, Switzerland

GENERAL RADIO COMPANY (U.K.) LIMITED, Bourne End, Buckinghamshire, England

Representatives in Principal Overseas Countries

10-Mc SOLID-STATE COUNTER

> In this issue of the *Experimenter* we describe several additions to our line of frequency meters: an inexpensive 10-Mc counter, a unique 100-Mc decade scaler, and 100-Mc and 500-Mc frequency measuring assemblies.
>
> Accessory instruments for our counters—range-extension scalers, heterodyne converters, and data-recording instruments—have been designed as independent, self-contained equipment, usable not only with our counters but with other instruments for a variety of measurements. This "add-a-unit" philosophy has enabled us to design optimum instruments for a given task, unhampered by power-supply restrictions or artificial packaging constraints.

The Type 1153-A Digital Frequency Meter shown in Figure 1 is the newest member of GR's 1150 series of counters. In addition to extending the frequency range to 10 Mc/s, it introduces several new features that make frequency measuring easier and more accurate: a higher stability time-base oscillator, a full set of input controls, an automatic decimal point, and "spill" indication. The upper limit of the frequency range can be extended to 100 Mc/s by means of a decade scaler (Type 1156-A*) and to 500 Mc/s with a frequency converter (Type 1133-A†).

Time-Base Oscillator

The time-base oscillator uses a 200-kc, GT-cut, room-temperature quartz bar, which has a very low and uniform temperature coefficient and therefore maintains constant frequency without the fluctuations that would be caused by on-off cycling of a crystal oven. While not significant in lower-frequency counters, this cycling would be objectionable in a 10-Mc unit, and particularly in the 500-Mc combination, because of the increased resolution. In most laboratory and industrial environments, ambient temperatures change by less than one degree C over a five-to-ten-minute period. Under these conditions, with the long thermal time constant provided by the cabinet and crystal mount, the time-base frequency varies so slightly that short-term fre-

* See pages 6 and 12.
† See page 13.

Figure 1. Panel view of the Type 1153-AP Digital Frequency Meter.

quency-difference measurements can be made typically to a precision of a few parts in 10^8. (The temperature coefficient of the crystal is less than 5 parts/10^8 per degree.) Common measurements of this kind include oscillator warmup drift and frequency shift caused by such factors as shock, adjustment of trimming components, component replacements (or repositioning), and load changes.

For more exacting measurements, the time base can be locked to an external 100-kc standard-frequency source, such as the TYPE 1115-B Standard-Frequency Oscillator. Procedures for checking or calibrating the time-base oscillator are described in detail in the operating instructions.

Input Circuits

The input-circuit controls make it possible to minimize the effects of noise and to establish optimum trigger conditions for complex waveforms, pulses, and signals with large dc components; but they need only minor adjustment or no adjustment at all for such simple waveforms as sine waves and square waves. The input attenuator (IMPEDANCE) selects a sensitivity of either 0.1 volt or 1.0 volt, peak-to-peak.*

The TRIGGER LEVEL control adjusts the voltage level at which the input circuits trigger to form the pulse that is counted. The input coupling can be set to either AC or DC. For sine waves, the IMPEDANCE switch is usually set for maximum sensitivity (0.1 volt, peak-to-peak) and the coupling switch to AC to block any dc component. When the input is greater than about 2.5 volts, peak-to-peak (≅0.9 volt, rms), the signal is larger than the range of the trigger-level control, and the counter will operate properly at any setting of that control. If the input is greater than 25 volts, peak-to-peak (9 volts, rms), the counter will operate properly regardless of the settings of both controls.

The input circuit has been designed to work well, even on brief pulses, and is specified for pulses of 15-nanosecond and 30-nanosecond duration.

Control of Sensitivity and Trigger Points

A sensitivity of 0.1 volt, peak-to-peak, is fine for measuring low-level signals but can cause errors on large signals that contain noise pulses greater than 0.1 volt. To decrease the sensitivity for large signals, the input attenuator is switched to change the sensitivity from 0.1 to 1 volt.

The trigger-level control effectively shifts the hysteresis region (V_0 to V_1)

*See Appendix, page 14, for a discussion of sensitivity specifications for counters.

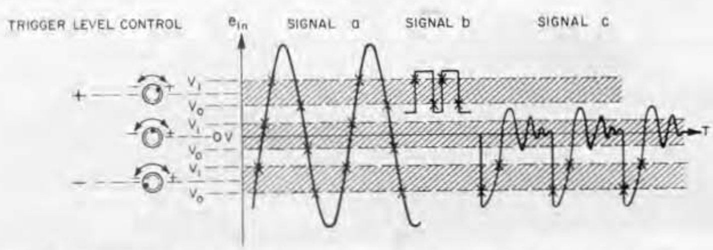


Figure 2. The trigger-level control adjusts the input trigger point. The control settings and the corresponding trigger points are shown for three types of input signals.

with respect to $0V$ as shown in Figure 2. This allows triggering at different points on the waveform (Signal 1), proper triggering on waveforms with a dc component (Signal 2), and triggering in a noise-free region of the waveform (Signal 3). The effective range of the level control is about ±10 times the setting of the sensitivity control (i.e., sensitivity at 0.1 volt, peak-to-peak, range of level control is ± 1 volt).

A small-amplitude signal (0.1 volt, peak-to-peak) with a large dc component (20 volts) can not be measured without removal of the dc component. The ac position of the coupling switch is provided for this purpose.

Decimal Point and Spill Lamp

The spill lamp, which indicates that the register capacity has been exceeded, is actuated by a flip-flop that is triggered by the carry pulse of the last counting decade. Its purpose is to remind the operator that there are one or more digits to the left of the number displayed.

The decimal point is automatically positioned by the COUNTING TIME switch to indicate c/s, kc/s, and Mc/s.

Readout and Resolution

The five-digit readout indicators are bright, incandescent-lamp units designed for maximum legibility. Counting-time controls vary the resolution of the readout over a 1000-to-1 range so that any five digits of interest are displayed, depending upon the degree of precision desired.

— S. Bentzen
— D. S. Nixon, Jr.

SPECIFICATIONS

INPUT

Frequency: Dc to 10 Mc/s.

Accuracy: ±1 count ± time-base stability.

Sensitivity: 0.1 V, p-to-p, (30 mV, rms), at 100 kΩ and 50 pF; 1.0 V, p-to-p, (0.3 V, rms) at 1MΩ and 20 pF. For brief pulses, 0.1 V at 100 kΩ and >30-ns duration; 0.2 V at 100 kΩ and >15 ns; 1.0 V at 1 MΩ and >30 ns; 2.0 V at 1 MΩ and >15 ns. Max allowable input is ±400 V (at 1 MΩ).

Counting Interval: 0.01, 0.1, 1, or 10 s, extendible by multiplier switch, or as set manually.

Input Trigger: Ac or dc coupled. Trigger-level range is ±1 V at 0.1-V sensitivity, ±10 V at 1-V sensitivity. Trigger-level drift is typically 0.05 V, p-to-p, at 0.1-V sensitivity, 0.5 V, at 1-V sensitivity, from 0°C to 50°C.

Self Test: TEST position of measurement switch disconnects input and applies 100 kc/s to check all functions.

TIME BASE	*Stability*
100 kc/s, internal or external. Internal frequency derived from 200-kc, GT-cut, room temperature crystal; adjustment provided, adjusted to within 1 ppm when shipped.	**Cycling:** None **Temp Effects:** < 6 ppm, 0 to 50°C ambient rise; < ±0.1 ppm per °C, 20° to 30°C ambient rise. **Aging:** < 0.1 ppm per week.

DISPLAY 5-digit, in-line readout with decimal point and spill lamp, incandescent-lamp operated. Display time of 0.16, 0.32, 0.64, 1.28, 2.56, 5.12, 10.24 seconds, or infinity.

GENERAL

Input Terminals: TYPE 938 Binding Posts, ¾-inch spacing.

Rear-Mounted Connectors

Time-Base Output: 100 kc/s, 4 V, p-to-p, behind 2 kΩ.

External Time-Base Input: 100 kc/s at 1 V, p-to-p, into 1 kΩ.

Auxiliary Connector: Inputs — reset, start-stop. Outputs — carry pulse from last decade, print command, zero set, 100 kc/s, +20-V test point.

Photoelectric Pickoff Input Connector: 3-terminal telephone jack with +20 V dc and connection to main input.

Data-Output Connector (Type 1153-AP only): 10-line decimal for each digit — one wire binary 1 (+14-V level) and nine wires binary 0 (0 to +4-V level); source impedance 2.4 kΩ; +20-V power; ground; and print-command pulse.

Operating Temperature: 0° to +50°C.

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 c/s, 70 W.

Accessories Supplied: TYPE CAP-22 Power Cord, 8 replacement incandescent lamps, spare fuses.

Accessories Available: Type 1536-A Photoelectric Pickoff, Type 1133-A Frequency Converter and Type 1153-P1 Frequency Multiplier to extend range to 500 Mc/s, Type 1156-A Decade Scaler to extend range to 100 Mc/s. For Type 1153-AP only — Type 1136-A Digital-to-Analog Converter, Type 1137-A Data Printer, Type 1510-A Digital-to-Graphic Recording Assembly.

Mounting: Rack-Bench cabinet.

Dimensions: Bench model — width 19, height 3⅞, depth 12½ inches (485 by 99 by 320 mm); rack model — panel 19 by 3½ inches (485 by 89 mm), depth behind panel 11⅝ inches (298 mm).

Net Weight: 20 lb (9.5 kg).

Shipping Weight: 28 lb (13 kg).

Catalog Number	*Description*	*Price in USA*
1153-9801	**Type 1153-A Digital Frequency Meter,** Bench Model	**$1495.00**
1153-9811	**Type 1153-A Digital Frequency Meter,** Rack Model	**1495.00**
1153-9871	**Type 1153-AP Digital Frequency Meter,** with data output, Bench Model	**1550.00**
1153-9981	**Type 1153-AP Digital Frequency Meter,** with data output, Rack Model	**1550.00**
1153-9601	**Type 1153-P1 Frequency Multiplier**	**70.00**

100-Mc DECADE SCALER

Figure 1. Panel view of the 100-Mc Decade Scaler.

The Type 1156-A Decade Scaler shown in Figure 1 is a digital 10:1 scaler with its own power supply, output amplifier, trigger circuits, input amplifier, and input controls. The input circuit and controls will handle a wide variety of signals from dc to 100 Mc/s. The output amplifier provides a high-level signal adequate to drive counters without further amplification.

A major use of the scaler is to extend the frequency-measurement range of counters by a factor of 10. Thus, 10-Mc counters can measure frequencies to 100 Mc/s, 1-Mc counters to 10 Mc/s. Two scalers can be cascaded to extend the range of 1-Mc counters to 100 Mc/s, etc. The range of analog frequency meters such as the GR Type 1142-A Frequency Meter and Discriminator can be extended in the same manner.

Use with Counters

The scaler output signal is adequate to drive any counter over its entire range. The input sensitivity of some vacuum-tube counters is no better than 1 volt, rms, and the input is shunted by as much as 40 pF. The Type 1156-A Scaler, however, will deliver to these counters, through a patch cord, at least 1 volt, rms, even at 10 Mc/s (100-Mc scaler input). Newer counters and lower-frequency counters have better sensitivity and will be well over-driven. Figures 2 and 3 show output waveforms.

The combination of counter and scaler counts by tens instead of by units. To read the frequency being measured one mentally shifts the decimal point in the counter display one place to the right. The fractional accuracy of the measurement, however, is not affected

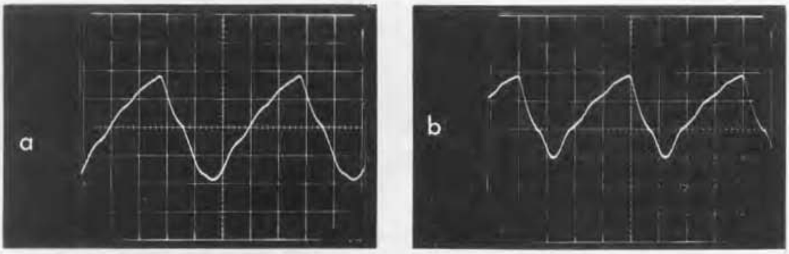


Figure 2. Scaler output waveforms (a) 10 Mc/s (100-Mc input); (b) 12.5 Mc/s (125-Mc input). Vertical scale is 1 V/cm. Measurement setup is shown at right.

by the use of the scaler. It is strictly a function of the counter and is usually specified as ±1 count ± crystal-oscillator stability, where the ±1 count is actually ±1 unit in the least significant digit displayed on the counter. The scaler offers a means of increasing the upper frequency limit of existing 10-Mc counters by a factor of 10. Its usefulness to update existing counter designs has been recognized by a few manufacturers, who have supplied plug-ins that fit only their own counters.

The Type 1156-A Decade Scaler is a completely independent instrument *and will work with any counter.*

Use with the Analog Frequency Meter

The GR Type 1142-A Frequency Meter and Discriminator is an analog-type frequency meter, which measures frequency from 3 c/s to 1.5 Mc/s with an over-all accuracy of ±0.2%. It can be used with a recorder to produce time records of frequency change or drift. Its highly linear discriminator, when used with an external voltmeter, can measure fm deviation. With a wave analyzer it can measure individual components of incidental fm.

When this frequency meter is used with the scaler, its range is extended to 15 Mc/s or, with two scalers, to 100 Mc/s, and the fractional accuracy of measurement is unchanged (+0.2% of the frequency measured).

When the combination is used as a discriminator, the fm deviation at the input to the scaler is 10 times the fm deviation measured at the terminals

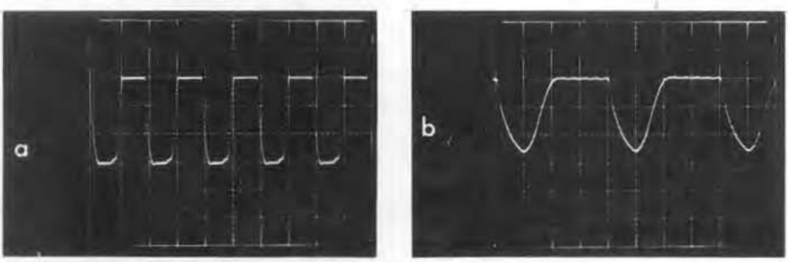


Figure 3. Output into 50 ohms. (a) 5 Mc/s (50-Mc input); (b) 12.5 Mc/s (125-Mc input). Vertical scale is 0.5 V/cm.

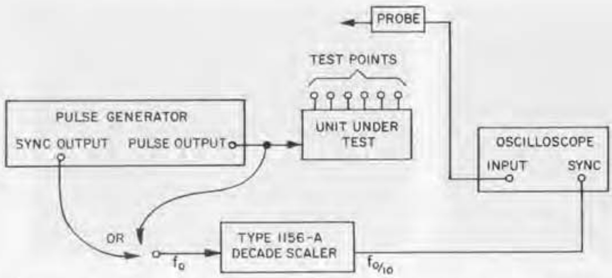


Figure 4. Oscilloscope synchronizing setup for testing decade scalers and frequency dividers.

of the frequency meter. Thus the carrier and the fm deviation are both scaled by a factor of 10. The frequency at which the signal is modulated is not affected by the scaler, and the residual fm noise introduced by the scaler is negligible. The residual noise of the combination is more than 100 dB below full output of the frequency meter.

Synchronizing Oscilloscopes

Another use of the Type 1156-A Decade Scaler is the synchronization of an oscilloscope for the observation of waveforms in scalers and other frequency dividers. With the scope sweep synchronized directly with the input to the device under test, as shown in Figure 4, waveforms at test points can be observed in their proper time relationship to the input signal, malfunction and failure points can be detected, and the usable ranges of operating parameters can be determined.

DESCRIPTION

Figure 5 is a block diagram of the Type 1156-A Decade Scaler. The 50-ohm input circuit is designed for low vswr. The input connector is a GR874 Locking Connector. The input attenuator (sensitivity control) consists of a resistive ladder network mounted between a ground plane and a switch wafer. The input and output connections of the attenuator are made with ground-plane configurations that minimize reflections at the input terminal. When the sensitivity switch is in the 0.1-volt position, the attenuator acts only as a 50-ohm load, and the input is connected directly to the input amplifier. A 500-ohm position is also provided.

A two-transistor, dc-coupled input amplifier provides gain and buffers the input connector from switching transients generated by the Schmitt circuits that follow.

The Schmitt circuits use conventional emitter-coupling with Zener diodes for dc translation.

The scale of 5 is a unique circuit first described by Rudolph Englemann[1]. It

[1] Rudolph Englemann, "Bi-quinary Scaling: Accuracy and Simplicity at 500 Mc," *Electronics*, p 34, November 15, 1963.

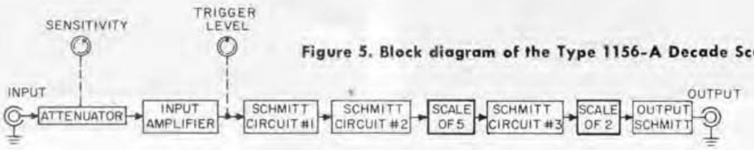


Figure 5. Block diagram of the Type 1156-A Decade Scaler.

Figure 6. Tektronix oscilloscope probe (foreground) can be plugged directly into the scaler. The scaler input and output terminals can be mounted either on the panel or at the rear. Cover plates are provided for the panel when rear connections are used.

consists of five bi-stable Schmitt circuits serially connected to form a ring counter. This ring differs from most counting circuits; it does not require pulses but operates on the transitions of the input waveform. The Schmitt-circuit propagation delay and the stray capacitance of the output transistor of each stage provide the required interstage storage or memory. No additional energy-storage elements need be added.

The scale of 2 is an emitter-coupled flip-flop, with inductive memory, and is driven from a pulse generated by Schmitt No. 3. The output of the flip-flop drives the output Schmitt circuit, which provides at least 1 volt, peak-to-peak, into 50 ohms at the output connector. This output is approximately square wave from dc to 10 Mc/s for an input to the scaler from dc to 100 Mc/s.

Input Characteristics

The 50-ohm input impedance has a VSWR of less than 1.1 up to 100 Mc/s and causes a reflection of less than 10% when a 0.4-nanosecond rise-time pulse is applied. The scaler input can be used as a 50-ohm cable termination or as a 50-ohm load up to ½-watt dissipation.

The Tektronix oscilloscope probes for use at a 50-ohm impedance level, such as the TYPES P6026, P6034, and P6035, can be used with this scaler. They are equipped with GR874 Connectors, so that no adaptors are necessary. See Figure 6.

The input sensitivity of the scaler is specified at 100 Mc/s as 0.1 volt, peak-to-peak, or 35 millivolts, rms, for a sine wave. It is generally even better at lower frequencies; Figure 7 shows the actual sensitivity of a typical instrument as a function of frequency for a sine wave input.

It is often necessary to measure the repetition rate of a signal composed of very brief pulses. To determine the sensitivity of the scaler to signals of this kind, a pinch-off diode and a clipping line were used to generate pulses at 105 Mc/s. These signals, shown in Figure 8, trigger the scaler reliably. For

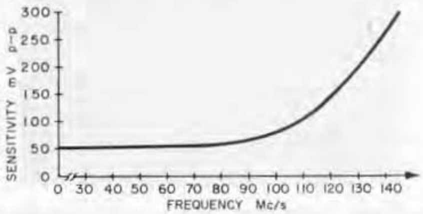


Figure 7. Scaler sensitivity vs frequency. The scaler will operate reliably over a temperature range of 0 to 50°C with an input frequency of at least 125 Mc/s and a sensitivity of better than 300 mV, peak-to-peak.

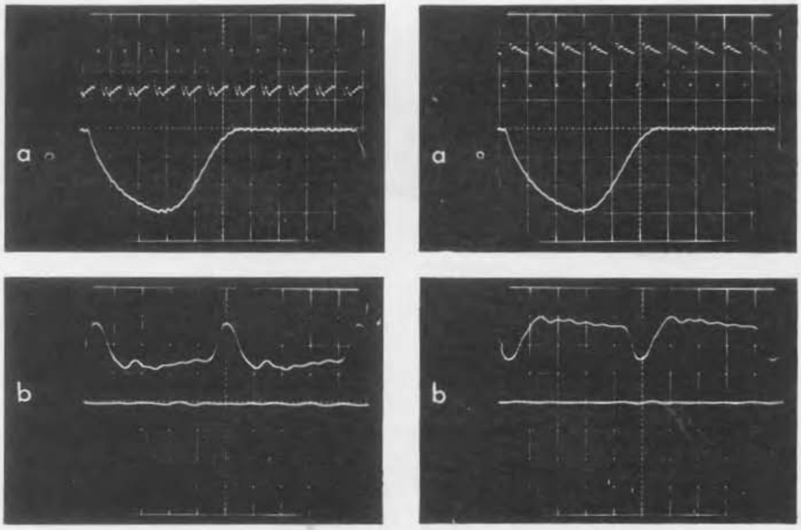


Figure 8. Operation on brief pulses at 105 Mc/s. Positive pulses at left, negative at right. Upper trace shows input; vertical scale is 0.1 V/cm. Lower trace shows output into 50 ohms; vertical scale is 0.5 V/cm. For (a), horizontal scale is 10 ns/cm; for (b), 2 ns/cm.

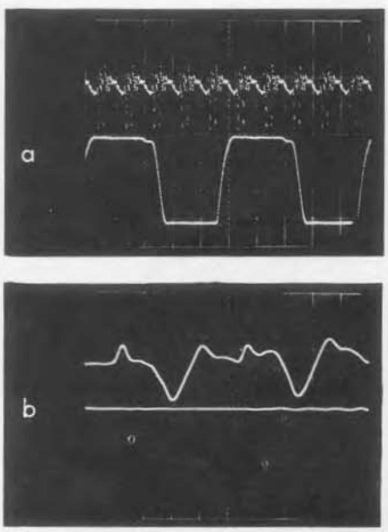


Figure 9. Resolution of pulse pairs occuring at a 20-Mc rate. Upper trace shows input; vertical scale is 0.1 V/cm. Lower trace shows 4-Mc output into 50 ohms; vertical scale is 0.5 V/cm. For (a), horizontal scale is 50 ns/cm, for (b), 2 ns/cm.

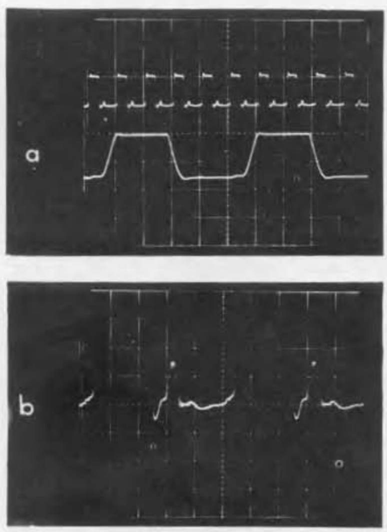


Figure 10. Resolution of pulse pairs when first pulse has 10 times the amplitude and 4 times the duration of the second pulse. For (a), upper trace shows input, lower trace output; vertical, 1 V/cm; horizontal, 50 ns/cm. (b), input signal expanded to show smaller pulse; vertical scale is 0.1 V/cm; horizontal, 10 ns/cm.

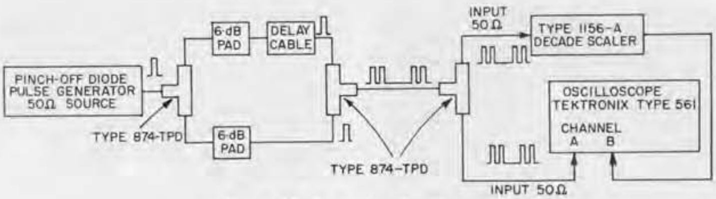


Figure 11. Test setup for Figure 9.

reliable triggering on briefer pulses, however, the amplitude must be larger.

Pulse-Pair Resolution and Operation with Random Inputs

The input circuits of the Type 1156-A Decade Scaler are direct coupled straight through to the trigger circuits and operate well even with pulse trains of random amplitude and duration. Figure 9, for instance, shows input and output signals when the scaler counts pairs of pulses. The pairs occur at a 20-Mc rate, and the pulses in each pair are separated by about 10 nanoseconds. Note the large amount of base-line noise on this signal. The trigger-level control is adjusted so that the scaler triggers only on the pulses.

Figure 10 shows another train of pulse pairs. Here, the first pulse has about 10 times the amplitude of the second pulse and about four times the duration. This is a somewhat more severe test of the input circuits. It checks the operation with pulses of different amplitude, duration, and repetition rate and shows that the amplifier and trigger circuits do not change their bias conditions because of amplifier nonlinearity and stray inductance and capacitance. Figures 11 and 12 show the setups used to make these tests. — D. S. Nixon, Jr.

SPECIFICATIONS

Frequency	*Impedance*	*Remarks*
INPUT Dc to 100 Mc/s	50 or 500 Ω	VSWR: 1.1 max at 100 Mc/s (50 Ω). Reflection: 10% max with 0.4-ns step (50 Ω).
OUTPUT Dc to 10 Mc/s	250 Ω	Approximately square-wave output, 20 mA; 1 V into 50 Ω, over 5 V open circuit, all p-to-p.

Sensitivity: 0.1, 0.2, 0.5, and 1 V, p-to-p, at 50 Ω; 1 V, p-to-p, at 500 Ω. Maximum input is 20 times sensitivity or ½ W, whichever is smaller.

NOTE: With an input of 0.3 V, p-to-p, at 50 Ω, the scaler will operate reliably at frequencies up to at least 125 Mc/s.

GENERAL

Operating Temperature: 0 to 50°C.

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 c/s, 15 W.

Terminals: GR874 Locking Connectors. For connection to other types of coaxial connectors, use locking adaptors, which lock securely in place, yet are easily removed.

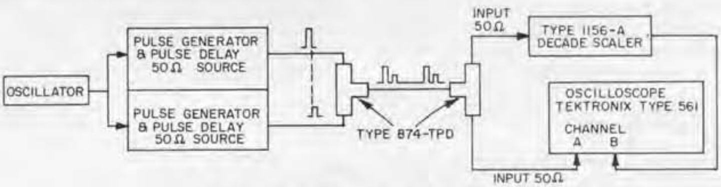


Figure 12. Test setup for Figure 10.

Accessories Supplied: TYPE CAP-22 Power Cord, spare fuses.
Accessories Available: TYPE 874-K Coupling Capacitor for ac coupling to input or output connectors. For output connection to TYPE 1142-A Frequency Meter and Discriminator, use TYPE 874-R34 Patch Cord.
Mounting: Rack-Bench cabinet.

Dimensions: Bench model — width 19, height 2⅛, depth 12¼ inches (485 by 54 by 315 mm); rack model — panel 19 by 1¾ inches (485 by 45 mm), depth behind panel 11⁵⁄₁₆ inches (288 mm).

Net Weight: 10¾ lb (4.9 kg).

Shipping Weight: 25 lb (11.5 kg).

Catalog Number	*Description*	*Price in USA*
1156-9801	**Type 1156-A Decade Scaler, Bench Model**	**$490.00**
1156-9811	**Type 1156-A Decade Scaler, Rack Model**	**490.00**

US Patent No. 2,548,457

100-Mc DIGITAL FREQUENCY METER

This direct-counting, dc-to-100-Mc Digital Frequency Meter is a combination of completely independent instruments — the 10-Mc Counter (TYPE 1153-A) and the 100-Mc decade scaler (TYPE 1156-A) described elsewhere in this issue. The two instruments are assembled and shipped as a unit. The special short patch cord shown connecting the counter and the scaler is included.

The frequency at the input is 10 times the frequency measured by the counter. A mental shift of the decimal point one place to the right gives the frequency at the input to the scaler. The accuracy of the measurement is unaffected by the scaler and is still ± 1 count ± crystal-oscillator stability. The ±1 count is in the least significant digit displayed on the counter. Sensitivity and other input specifications are identical with those for TYPE 1156-A Decade Scaler, page 6.

SPECIFICATIONS

Range: dc to 100 Mc/s.

Power Required: 100 to 125 or 210 to 250 V, 50 to 60 c/s, 85 W.

Accessories Supplied: Power cord, spare fuses, patch cord, hardware for rack mount.

Input Terminal: GR874 Coaxial Connector (locking type); use TYPE 874-Q Adaptors to connect to other coaxial types.

Data-Output Connector (-AP model only): 10-line decimal for each digit — one wire binary 1 (+ 14-V level) and nine wires binary 0 (0 to +4-V level); source impedance 2.4 kΩ; +20-V power; ground; and print-command pulse.
Dimensions: Width 19, height 11¼, depth 12½ inches (485 by 150 by 320 mm).
Net Weight: 46 lb (21 kg).
Shipping Weight: 61 lb (28 kg).

Catalog Number	*Description*	*Price in USA*
1144-9701	**Type 1144-A 100-Mc Digital Frequency Meter**	**$1995.00**
1144-9829	**Type 1144-AP 100-Mc Digital Frequency Meter, with data output**	**2050.00**

US Patent No. 2,548,457

500-Mc FREQUENCY-MEASURING ASSEMBLY

The TYPE 1143-A Frequency-Measuring Assembly is a combination of the previously described TYPE 1153-A Digital Frequency Meter and a heterodyne converter, the TYPE 1133-A Frequency Converter[1]. A frequency multiplier, which multiplies the 100-kc standard frequency output of the counter to the 5-Mc reference frequency required by the converter, is included. This assembly will measure frequencies to 500 Mc/s with simplicity and with a sensitivity and optional selectivity not available elsewhere.

In the converter the input frequency is heterodyned against a 10-Mc multiple of the counter's time-base-oscillator frequency and the less-than-10-Mc difference frequency is applied to the counter. In-line numerals indicate directly the heterodyne reference frequency to be added to the counter reading, and a panel meter indicates proper input and output level. Level adjusting controls are provided.

The converter can be operated in one of two modes: a wide-band mode for simplified measurement of clean signals of greater than 100-millivolt, rms, level; and a narrow-band mode for measurement of noisy signals of greater than 10-millivolt level. In the narrow-band mode a tuned amplifier is switched into the system to provide selectivity and increased sensitivity. Panel lights indicate proper control settings.

In this assembly, ruggedness and lasting reliability accompany several unique features — high sensitivity, optional selectivity, and simple operation — to produce an instrument of outstanding performance for frequency measurement to 500 Mc/s.

[1] H. T. McAleer, "A New Converter for Frequency Measurements to 500 Mc," *General Radio Experimenter*, December, 1962.

SPECIFICATIONS

Range: dc to 500 Mc/s.

Sensitivity: Better than 10 mV, rms, on narrow band (above 100 kc/s); better than 100 mV on wide band.

Data-Output Connector: 10-line decimal for each digit — one wire binary 1 (+14-V level) and nine wires binary 0 (0 to +4-V level); source impedance 2.4 kΩ; +20-V power; ground; and print-command pulse.

Power Required: 105 to 125 or 210 to 250 V, 50 to 60 c/s, 140 W.

Input Terminal: GR874 Coaxial Connector; use TYPE 874-Q Adaptors to connect to other coaxial types.

Accessories Supplied: Patch cords for interconnection, spare fuses, hardware for rack mount.

Dimensions: Width 19, height 11¼, depth 19 inches (485 by 290 by 485 mm).

Net Weight: 54 lb (24.5 kg).

Shipping Weight: 84 lb (39 kg).

Catalog Number	*Description*	*Price in USA*
1143-9701	**Type 1143-A Frequency-Measuring Assembly**	**$3090.00**
1143-9829	**Type 1143-AP Frequency-Measuring Assembly,** with data output	**$3145.00**

US Patent No. 2,548,457

APPENDIX

COUNTER INPUT CIRCUITS AND SENSITIVITY SPECIFICATIONS

Why does GR specify the input sensitivity of its counters in volts peak-to-peak instead of rms? This is a question often asked by those who are not familiar with the operation of counter input circuits. Those who are lucky enough to be making frequency measurements of large amplitude, clean sine waves don't need to know. For those whose lot it is to deal with all sorts of waveforms, the answer will be apparent from the following discussion.

The input circuits of digital frequency meters, period meters, and time-interval meters all operate on the same basic principle. They must transform the input waveform, regardless of shape and amplitude, into a pulse with a fixed amplitude and transition time. To do this requires a switching circuit of some kind. The most common ones are Schmitt circuits and tunnel diodes.

The output of a switching circuit has two states, a high state whenever the instantaneous value of the input voltage is above a certain level (V_1 in Figure 1), and a low state whenever the instantaneous input voltage is below a certain level (V_0).

V_1 and V_0 are sometimes called the set and reset voltages, or the trigger voltages, of the switching circuit. V_1 is larger than V_0, and the region between V_1 and V_0 is often called the hysteresis region. If the input voltage is below V_0 (output in low state) and is then raised to V_1, the circuit will switch to the high state. Even though the input voltage swings above and below V_1, the circuit will not switch again until the input goes below V_0. Therefore, a signal applied to the circuit must be greater than $V_1 - V_0$ and must be applied so that it goes above V_1 and goes below V_0 during each cycle for the circuit to change state each cycle. Figure 1 shows several different inputs to the switching circuit and their corresponding outputs. Note that the output is in the high state whenever the input signal exceeds V_1 and in the low state whenever the input is less than V_0. Note also that the amplitude of the output waveform is constant but that the duration of the output pulse is a function of the input signal. Since the internal counting circuits are actuated by a pulse of fixed duration and amplitude, a pulse shaper follows the switching circuit to establish the duration. It operates from either the rising or the falling edge of the output.

Input signals 1, 2, and 3 will all operate the counter properly. Signal 1 is, however, of minimum usable amplitude. Therefore, the sensitivity of the circuit is a peak-to-peak voltage of $V_1 - V_0$ volts, which is determined by the design of the switching circuit. If an instrument is to accept signals of less than $V_1 - V_0$, an amplifier must be used between the input connector and the switching circuit. The amplifier in the Type 1153-A Counter provides an effective $V_1 - V_0$ of 0.1 volt at the input terminals, thus, a sensitivity specification of 0.1 volt, peak-to-peak. This, of course, applies to input signals of any shape and has nothing to do with the rms and average values of the input signal.

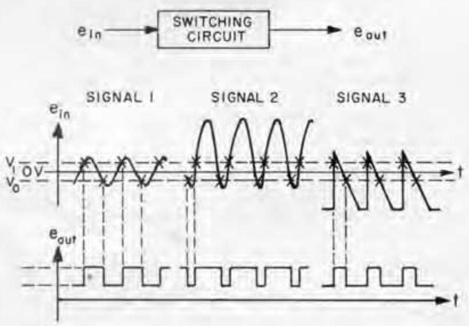


Figure 1. Switching-circuit input trigger points and corresponding output signals for three different input signals.

TYPE 1510-A DIGITAL-TO-GRAPHIC RECORDING ASSEMBLY

This convenient assembly of the TYPE 1136-A Digital-to-Analog Converter and the TYPE 1521-B Graphic Level Recorder will operate from the output of General Radio digital instruments to produce a strip-chart record that is the analog of the digital data as a function of time. It is equally usable with other digital equipment that is coded for 1-2-4-2, 1-2-2-4, or 1-2-4-8 output.

Shipped assembled, as shown, with 10 rolls of chart paper and input cable. Rack-mount hardware also supplied.

Catalog Number	*Description*	*Use**	*Price in USA*
1510-9401	**Type 1510-A Digital-to-Graphic Recording Assembly** (60-cycle operation)	For use with Types 1143-AP, 1144-AP, 1150-BP, -BPH, 1151-AP, 1153-AP Counters	**$1855.00**
1510-9571	**Type 1510-AQ1 Digital-to-Graphic Recording Assembly** (50-cycle operation)		**on request**
1510-9402	**Type 1510-A Digital-to-Graphic Recording Assembly** (60-cycle operation)	For use with Type 1680-A Automatic Capacitance Bridge Assembly	**$1725.00**
1510-9572	**Type 1510-AQ1 Digital-to-Graphic Recording Assembly** (50-cycle operation)		**on request**

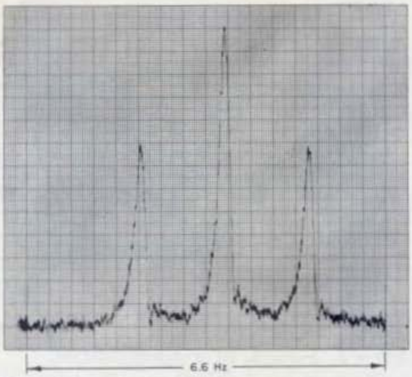
*Converters and cables for use with other digital instruments are available on special order. Write for information.

NMR MEASUREMENTS WITH THE FREQUENCY SYNTHESIZER

The General Radio TYPE 1161-A4C Coherent Decade Frequency Synthesizer has found unique use in the field of nuclear magnetic resonance at Mellon Institute of Industrial Research, Pittsburgh.

In nuclear magnetic resonance, a strong uniform magnetic field is applied to the sample. The sample is then excited by an rf field from a coil oriented around the sample. At Mellon an rf carrier near 60 MHz is first modulated by 1.0 kHz to produce a side band at 60.001 MHz. This side band is then phase-locked to a known resonance of the sample. Other resonances of interest lie between 60.0 and 60.001 MHz, and they can be stimulated by additional amplitude modulation of the 60-MHz carrier. The detected resonances are extremely narrow, typically 0.1 to 0.2 Hz wide, and several of these may appear in a 10-Hz band.

To measure these side bands, it is most convenient to use a slowly swept oscillator as the modulating source and to display the resonances on an X-Y recorder. The swept source, however, must be stable to 0.01 Hz or better during the sweep interval (typically 10



Typical plot obtained by the modulation method. Sample is CF_3CF_2COOH.

minutes) in order to produce sharply defined peaks on the recorder.

Physicists at the Institute have found the GR 1161-A4C Synthesizer to meet these demanding requirements. A variable dc source is used to control the continuously adjustable decade through a 5- or 10-Hz band. Because of the synthesizer's extreme stability, one can calibrate the recorder by peaking the synthesizer to an arbitrary resonance and measuring the output frequency on a digital counter. Even a 10-second counting interval can be used since this synthesizer will remain on the peak for extended periods of time. This method of calibration is not possible with conventional oscillators because of their relative instability.

Although frequency synthesizers have been widely used in studies of nuclear magnetic resonance, they ordinarily are used directly at the high frequency (in this case, 60 MHz). The modulation method has many advantages. It does not require extreme stability in the applied magnetic field, thus allowing more time for the taking of data. It also permits the use of a less expensive, lower-frequency synthesizer.

—D. L. WOODWARD

Credits: We gratefully acknowledge the cooperation of Dr. A. A. Bothner-By, of the Mellon Institute, who supplied the information on which this brief article is based. — Editor

DO WE HAVE YOUR CORRECT NAME AND ADDRESS—name, company or organization, department, street or P.O. box, city, state, and zip code? If not, please clip the address label on this issue and return it to us with corrections, or, if you prefer, write us; a postcard will do.

PRINTED IN U.S.A.

GENERAL RADIO EXPERIMENTER
GENERAL RADIO COMPANY
WEST CONCORD • MASSACHUSETTS • USA

RETURN REQUESTED

50 ANNIVERSARY