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 constaints.

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.

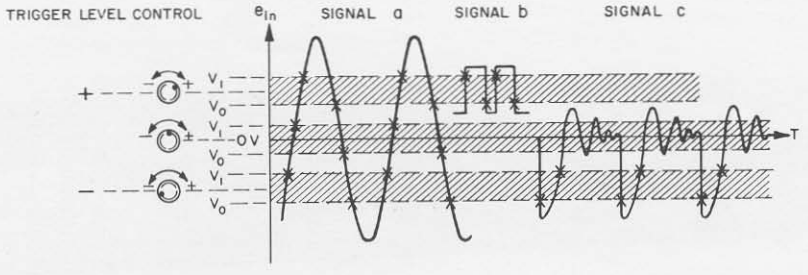

Figure 2. The trigger-level control adjusts the input trigger point. The control settings and the corresponding trigger points are shown for three types of input signals.

with respect to *OV* 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 1155-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