



## A 0-1.1 MC Frequency Counter with Time Interval Markers

A NEW *hp*-frequency counter has been designed which incorporates a number of new features and which also includes the previously-developed features that have always given *hp*-counters their leading position in the field. The new counter measures frequencies from 0 to 1.1 megacycles and time intervals from 3 microseconds to 27.8 hours. These ranges suit the instrument to much of the frequency-measuring work that goes on in a typical electronics laboratory as well as to almost any of the mechanical applications where a counter is useful such as in measuring rpm, velocity, flow rates, etc. Besides measuring frequency and time intervals, the instrument will also count events, i.e., totalize, for as long as desired, form the ratio of two external frequen-

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cies, measure the period or 10-period average of lower frequencies, and act as a secondary frequency standard by making available externally an accurately-controlled 100 kc frequency.

The basic circuit arrangement of the new counter is shown in Fig. 3. The frequency to be measured is passed through a gate circuit which is opened by a precision time-base circuit for an accurately-controlled interval such as 1 second. A panel switch permits the operator to select in decade steps any of five gate times from 1 millisecond to 10 seconds. The cycles of the frequency to be measured that pass through the gate are then applied to a series of six decade counting units which indicate in illuminated numerals the number of cycles that have occurred while the gate was open. The measured frequency can

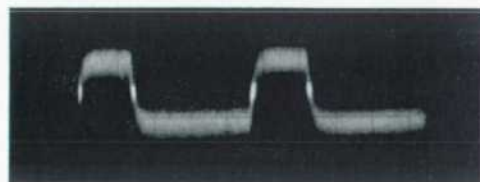
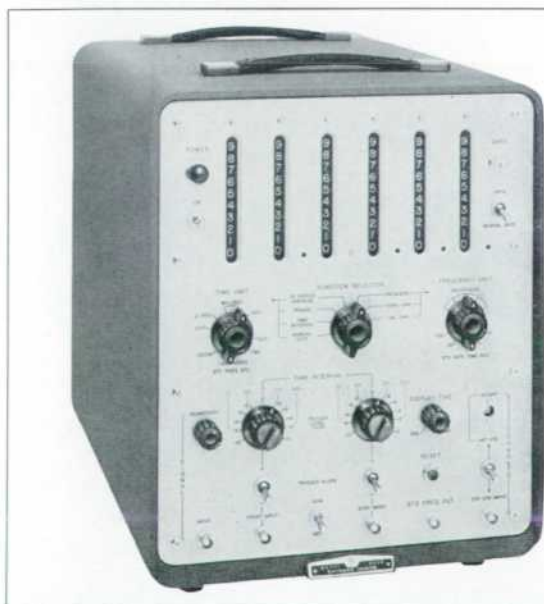


Fig. 2. Oscillogram showing how time interval markers (bright dots) can be used to insure measurement of pulse width on noisy signals.

Fig. 1. (left.) New *hp*-Model 523B Counter has been designed with such features as time interval measurement markers, circuit check lamps, and the *hp*-illuminated, automatically-positioned decimal point which prevents measurement ambiguities. (Chart on back page shows how new 523B fits into *hp*-counter line.)



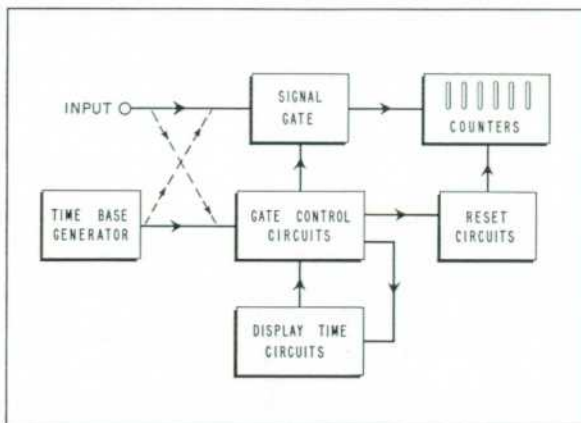


Fig. 3. Basic circuit arrangement of hp Model 523B counter.

have any common waveform and can also consist of random or periodic pulses. After the measurement has been displayed for the time selected by the operator, the instrument automatically repeats the measurement.

The same basic circuitry used to make frequency measurements is also used to measure time intervals and periods to a high accuracy. In this case the sub-circuits are re-arranged as indicated by the dashed lines in Fig. 3. For measuring time intervals the decade counters count the number of cycles from the precision time base that occur between two time signals or during the period of a low-frequency wave being measured. The counted time base frequency can be 10 cps, 1 kc, 100 kc, or 1 mc. An external frequency can also be counted where it is desired to have the measured value read directly in special units, such as distance, velocity, etc.

#### TIME INTERVAL MARKERS

One of the special features of the new counter is that it provides marker pips which occur precisely as the instrument begins and ends a time interval measurement\*. These markers are designed to be used to intensity-modulate an oscilloscope which is displaying the time signals whose interval is being measured. When the marker pips are superimposed on the oscilloscope display in this manner, the operator obtains a positive indication of the interval being

\*Marker pips are also provided on period measurements although not on 10-period measurements.

measured. By this means all possibility for misinterpreting the measurement is removed.

The value of markers in a typical time interval measurement is indicated in Fig. 2 (front page). This is the case where the width of a pulse is to be measured in the presence of noise. As will be seen, the markers

give a definite indication as to whether the noise is interfering with the measurement.

Another application where time interval markers assist in avoiding ambiguity in interval measurements is shown in Fig. 4.

#### MARKERS IN FREQUENCY MEASUREMENTS

The markers generated by the time-interval measuring circuitry can also be used to advantage in some types of frequency measurements.

One example of this is the case where pulses of random amplitudes are being counted and where it is desired to count only those pulses of a given minimum amplitude.

Such a measurement can be made with the new Model 523B by connecting the pulses to be counted to the "Stop" input of the instrument. When this is done, a marker pulse will be generated for each applied pulse whose amplitude exceeds the value to which the "Stop" channel threshold controls are set, as described below. This marker pulse can then be applied to the "Signal" input terminal of the Model 523B to be counted.

The arrangement will permit either positive or negative pulses to be counted and will further permit the counting threshold to be adjusted from 1 volt to 300 volts.

#### TIME INTERVAL CONTROLS

The panel controls provided for time interval measurements are arranged to accommodate a wide range

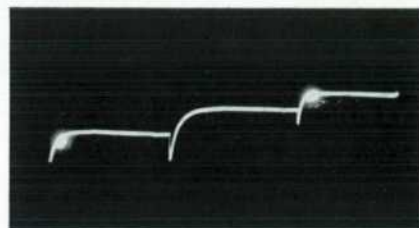


Fig. 4. Time interval markers used to insure measurement of desired interval of complex waveform.

of signal voltages and yet to be as simple as possible to operate. An identical set of controls is provided for both the "Start" and "Stop" channels (Fig. 5). In addition a COM-SEP switch enables the signals for the start and stop channels to be obtained from the same source as well as from separate signals.

The level at which the start and stop channels trigger can each be independently selected over a range from  $-300$  to  $+300$  volts and of either positive or negative slope. Nearly any signal encountered in practice can thus be used. The controls are further directly calibrated so that the triggering points can be quickly selected.

#### CIRCUIT CHECK LAMPS

Another of the special features of the new counter is that it is provided with lamps that indicate proper functioning of sub-circuits. Such lamps are provided at seven key points throughout the circuit. If a circuit malfunction occurs, it is often possible to isolate the section of the circuit where the trouble exists with-

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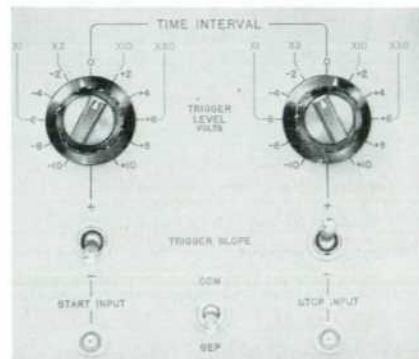


Fig. 5. Time interval controls are designed to permit measurement to be started and stopped at any voltage level and slope between  $-300$  and  $+300$  volts. Operation of each channel is independent of other.



## The *-hp-* Readout System

The readout system used on most *-hp-* frequency counters has at least six special design features which make these counters unusually easy to use and which further enable measurements to be made in most cases by non-technical personnel.

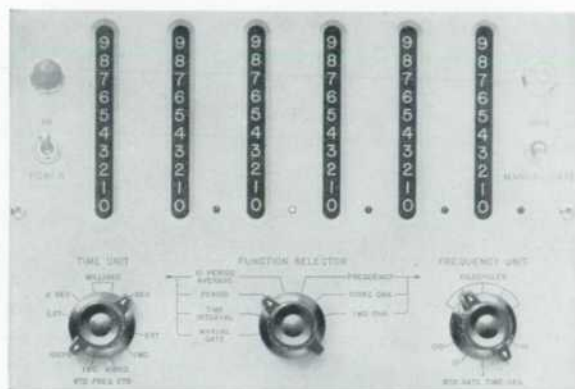
One of these features is the *-hp-* illuminated decimal point feature. This feature is such that an illuminated decimal point is *automatically positioned* in the readout with the result that no ambiguity can result regardless of the time or frequency unit selected for the measurement. This feature is of significant value when routine measurements are turned over to non-technical personnel because it minimizes the danger of readout errors. It is also of considerable convenience to the engineer since it substantially reduces the amount of cross-checking needed in a measurement.

A second feature of the *-hp-* readout system is that the control arrangement is unusually straightforward. As shown in the accompanying illustration, the main control, the *Function Selector*, always indicates in a direct manner whether the instrument is set to make a frequency or a time measurement and further indicates with arrows which auxiliary control should be used. In addition, the auxiliary *Frequency Unit* and *Time Unit* switches themselves directly indicate in exactly

what units the readout is presented (kilocycles, seconds, milliseconds, etc.). Coupled with the automatically-positioned decimal points, this straightforward control arrangement gives non-technical personnel confidence in making measurements and, more important, enables such personnel to make measurements accurately.

The third distinguishing feature of the *-hp-* system is that the sensitivity control is removed from active use when period or 10-period measurements are made. The arrangement is such that these measurements are always made at maximum sensitivity, i.e., maximum accuracy, regardless of the setting of the sensitivity control. The arrangement normally gives more accuracy in period measurements even over arrangements that combine high nominal sensitivity with a zero-center type sensitivity control where there is no definite indication of maximum sensitivity setting.

Another feature of the *-hp-* system is that the readout is designed as a *two-state* rather than a three-state system. In other words, the *-hp-* system is either displaying or counting and does not have a third disabled state where it displays only zeroes. There are two practical advantages to the two-state system. One is that when short gate times such as 1 or 10 milliseconds are used, there is essentially no flicker to the two-state system. As a result, reading fatigue is considerably reduced. The second advantage is that when longer gate times are used with short display times, it is not possible with the two-



*-hp-* readout system used on most *-hp-* counters. Controls are straightforward and easy to use, numerals are bright, illuminated decimal point is automatically positioned.

state system to obtain a condition where the display consists only of zeroes and where the actual readout value itself is impossible to discern.

The fifth feature is the careful engineering that has been done to make the readout itself as bright as possible. As is well known, the amount of light produced by the neon lamps that constitute the indicating elements of decade counting units is limited. In the *-hp-* DCU's this factor has been recognized and the units have been carefully designed with behind-the-lamp reflectors to project as much as possible of the produced light through the face plate where it becomes useful to the eye. In addition, reverse engraving is used on the backs of the face plates to improve light refraction by the face plate itself. As a result of these precautions, the *-hp-* readout is both significantly brighter and significantly easier to read from side angles than other designs.

A final feature is that in all of the *-hp-* counters all of the DCU's are available for all measurements. In particular, separate decade dividers are used for 10-second gates and 10-period measurements so that the readout capacity is not reduced for measurements where the largest display is likely to be encountered.

### VISIT *-hp-* AT THE NEC

*-hp-* will exhibit a number of interesting new instruments at the National Electronics Conference, Hotel Sherman, Chicago, on Oct. 1-3.

You are cordially invited to visit the *-hp-* booths, 1050 and 1051, to see and discuss these and any other *-hp-* instruments of interest. Both factory and field engineers will be on hand.



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out resort to special equipment by comparing the on-off conditions of these lamps with a chart provided.

#### COUNTING SENSITIVITY

Like the other *-hp-* counters, the new Model 523B is provided with a straightforward control for selecting the sensitivity of the instrument for counting measurements. The advantage of this conventional "volume" type of sensitivity control is that maximum sensitivity is obtained at a known position of the control. This is a marked advantage over other arrangements where no positive indication of maximum sensitivity is provided. As a result of the Model 523B arrangement, the full 0.2 volt rms sensitivity of the instrument is available at any desired time, where with other arrangements it is usually impossible as a practical matter to obtain maximum sensitivity.

#### GENERAL

The new counter is also distinguished by the quality of its mechanical design. Fan cooling is used to achieve a low operating temperature for components with consequent increase in life expectancy. All aluminum construction is used with particular emphasis on obtaining structural rigidity. The form factor of the

instrument is such as to facilitate bench use, while control locations are kept in a small, centralized area. Several of the sub-circuits such as decade dividers and trigger units are constructed in plug-in form, as are

the DCU's, to facilitate troubleshooting and to allow spare units to be kept on hand if desired. Finally, etched circuit type construction is used to achieve a good order of component accessibility.

—Jeffery B. Wolfington

#### SPECIFICATIONS -hp- MODEL 523B ELECTRONIC COUNTER

##### FREQUENCY MEASUREMENT

Range: 10 cps to 1.1 mc.  
Accuracy:  $\pm 1$  count  $\pm$  stability (see General).  
Input Requirements: 0.2 volt rms minimum.  
Input Impedance: Approx. 1 megohm, 30  $\mu$ mf shunt.  
Gate Time: .001, .01, 0.1, 1, 10 seconds.  
Reads In: Kilocycles; decimal point automatically positioned.

##### PERIOD MEASUREMENT

Range: .00001 cps to 10 kc.  
Accuracy:  $\pm 0.3\%$  (for measurements of one period);  $\pm 0.03\%$  (10 period average) at 1 volt rms. Improved by greater input voltage.  
Input Requirements: 1 volt rms minimum; direct coupled.  
Input Impedance: Approx. 1 megohm shunted by 40  $\mu$ mf.  
Measurement Period: 1 or 10 cycles of unknown.  
Standard Frequency Counted: 10 cps, 1 kc, 100 kc, 1 mc, or external applied frequency.  
Reads In: Seconds, milliseconds, microseconds; decimal point automatically positioned.

##### TIME INTERVAL MEASUREMENT

Range: 2 microseconds to 100,000 seconds (27.8 hours).  
Accuracy:  $\pm 1$  unit of standard frequency counted  $\pm$  stability (see General).  
Input Requirements: 1 volt minimum. Direct coupled input.  
Input Impedance: Approx. 1 megohm shunted by 25  $\mu$ mf.  
Start and Stop: Independent or common input.  
Trigger Slope: Positive or negative on start and/or stop input.  
Trigger Amplitude: Continuously adjustable on both input channels from -300 to +300 volts.  
Standard Frequency Counted: 10 cps, 1 kc,

100 kc, 1 mc; or external frequency.  
Reads in: Seconds, milliseconds, microseconds; decimal point automatically positioned.

#### GENERAL

Registration: Six places on neon lamp decade units.  
Stability: 2 ppm per week. May be standardized against WWV.

Display Time: Variable from approx. 0.1 to 5 seconds; display can be held indefinitely if desired.

Output Frequencies: Secondary standard frequencies available at front panel: 10 cps, 1 kc rectangular, 100 kc and 1 mc sine-wave (stability as above).

Trigger Output: Start and Stop pulse output (width approx. 5  $\mu$ secs). Available for:

1. Voltage level selection of input signal for frequency measurements.
2. Z-axis modulation of oscilloscope for time interval measurements.

Self Check: Panel control provides automatic count of internal 100 kc and 1 mc frequencies to assure accuracy of gate and proper operation of counters.

External Standard: 100 kc from external primary standard can be applied to unit for highest accuracy.

Power Supply: 115/230 volts  $\pm 10\%$ , 50-60 cps, approx. 285 watts.

Size: Cabinet Mount: 13 $\frac{3}{4}$ " wide x 16 $\frac{1}{4}$ " high and 21" deep. Rack Mount: 19" wide x 14" high x 21" deep.

Weight: Cabinet Mount: 48 lbs., shipping weight approx. 85 lbs. Rack Mount: 47 lbs., shipping weight approx 80 lbs.

Accessories Furnished: Two *-hp-* AC-16K Cable Assemblies, 4 feet of RG-58/U 50 ohm coaxial cable terminated at each end with UG-88/U Type BNC male connectors. Can of Air Filter Oil.

Accessories Available: *-hp-* AC-16D Cable Assembly, 44 inches of RG-58/U 50 ohm coaxial cable terminated at one end only with a UG-88/U Type BNC male connector. \$2.65 f.o.b. Palo Alto, California.

Price: *-hp-* Model 523B Electronic Counter, \$1175.00 f.o.b. Palo Alto, California. Data subject to change without notice.

### SUMMARY OF *-hp-* ELECTRONIC COUNTERS

<i>-hp-</i> Model Number	Frequency Range	Frequency Accuracy	Time Measuring Range	"Journal" Issue
521A	1 ~ - 120 KC	0.01% or power line	----	July, 1955
522B	0 - 120 KC	10 PPM $\pm 1$ count above 10 cps	10 $\mu$ sec - 10 <sup>5</sup> secs	Sept. - Oct., 1953
523B	0 - 1.1 MC	1 PPM $\pm 1$ count above 10 cps	3 $\mu$ sec - 10 <sup>5</sup> secs	July - Aug., 1956
524B	0 ~ - 10 MC	1 PPM $\pm 1$ count above 10 cps	----	Mar. - April, 1954
524B + 525A	0 ~ - 100 MC	1 PPM $\pm 1$ count above 10 cps	----	Mar. - April, 1954
524B + 525B	0 ~ - 10 MC, and 100 MC - 220 MC	1 PPM $\pm 1$ count above 10 cps	----	Mar. - April, 1954
524B + 526B	0 ~ - 10 MC	1 PPM $\pm 1$ count above 10 cps	1 $\mu$ sec - 10 <sup>7</sup> secs	Mar. - April, 1954
524B + 525B + 540A	0 ~ - 12,000 MC (Higher with special det'rs)	Approx. 1 PPM $\pm 1$ count above 10 cps	----	August, 1955
<b>Transducers</b>				
506A Optical Pickup	300-300,000 RPM	----	----	July, 1955
508A/B Tachometer Generator	15- 40,000 RPM	----	----	Nov. - Dec., 1953