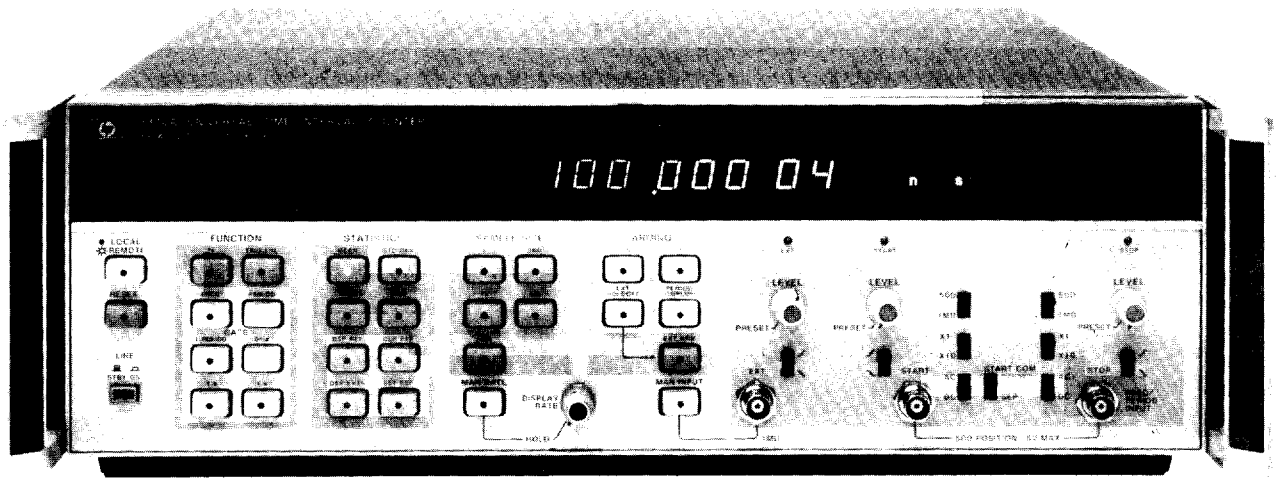
ELECTRONIC COUNTERS

Universal Time Interval Counter

Model 5370A

- 20 ps single shot time interval counter
- Statistics
- Automatic calibration of systematic errors
- Positive or negative time intervals
- Frequency and period to 100 MHz



5370A

DESIGNED FOR HP-IB SYSTEMS

The 5370A Universal Time Interval Counter represents the highest resolution single-shot time interval counter available today. The counter utilizes a new concept of phase locked vernier interpolation, which allows single-shot time interval measurements with ±20 ps resolution. This technique allows positive, zero and negative time intervals to be measured. High resolution period and frequency measurements may also be made.

All major front panel controls including trigger level are programmable by means of the Hewlett-Packard Interface Bus (HP-IB).

User convenience is increased by the inclusion of a microprocessor, which extends the usefulness of the instrument by offering the statistical functions of mean, standard deviation, max, and min for repetitive time intervals. A user-defined time interval reference is included for the cancellations of systematic errors.

The high resolution time interval capability makes the instrument ideal for IC testing, radar and laser ranging, digital communications, ballistics and nuclear measurements.

Functions

TI: time interval function measures time difference from the START to the STOP channel. In the ±TI mode, the counter will measure the time from the first event in either channel to the first event in the other channel. The microprocessor affixes a negative sign to the display if the stop channel event occurred first.

The negative time feature allows applications like differential phase measurement between two waveforms to be continuously monitored even though the phase changes from a positive to a negative drift. Statistical functions are available in both TI modes.

Trig Lvl: measures the trigger levels of START and STOP channels and displays both levels simultaneously with 10 mV resolution. Additional equipment like an oscilloscope or DVM is not required.

Freq: measures the frequency of the STOP channel signal by taking the reciprocal of a period average. Both timed gates and single period gates are available. In the single period mode, resolution may be improved by using a larger sample size. Statistics are available in the single period mode.

The exceptionally high resolution (11-12 digits per second) of the 5370A makes the instrument ideal for directly measuring the drift of oscillators and other applications requiring exceptionally high frequeny resolution.

Period: measures the period average of STOP channel events. Statistics are available in the single period mode, but not with timed gates.

Statistics

Statistical functions allow much more complete characterization of time intervals. In addition to the mean, both the max and min within a selected sample size are available and also the standard deviation. In many cases, these parameters are of more interest than the mean. For example, in a digital communications system, the limits of pulse jitter as described by the max and min could be of primary interest. For a normal distribution of jitter, the standard deviation gives the rms jitter directly.

Sample size: push-button selectable to 1,100, 1K, 10K, and 100K samples.

Mean: displays the mean estimate which is the average for the selected sample size.

Std dev: displays a standard deviation estimate for the selected sample size.

Min: displays the minimum time interval measured within the selected sample size.

Max: displays the maximum time interval measured within the selected sample size.

Arming

Extremely flexible arming greatly extends the usefulness of the 5370A into new applications. "Hold-off" features allow complex pulse trains to be measured by preventing "stop channel" arming until the removal of an external "gating" signal. An example could be the measurement of time from a radar or laser send pulse to the return pulse, where depending on the range of the object, several return pulses may occur before the return pulse of interest.

Other methods of arming allow the counter to be externally gated by an input waveform which very precisely controls both measurement duration and the time position at which the measurement occurs. Applications are in the frequency profiling of VCO's, pulsed rf bursts, or sweep linearity investigations.

The following modes of arming are available:

+TI

Internally armed – no hold-off
Externally armed – no hold-off
Externally armed – external hold-off

±TI

External arming
Internal arming

Programming

Major controls are programmable as standard via the HP-IB making the 5370A an economical, versatile unit for systems applications.

Data Output Rate

1) HP-IB: 10-20 readings per second.
   Dead time between measurements within a sample is 330 μs.
2) Fast Binary: 6 kHz
   Dead time between measurements is 165 μs.

5370 Specifications

Sensitivity: 100 mV p-p, 35 mV rms sine wave × attenuator setting.
Impedance: selectable 1 MΩ//30 pF or 50 Ω nominal.
Trigger level: −1.3V to 0.5V, adjustable; 10 mV displayed resolution.
Trigger slope: independent selection of + or − slope.
Attenuators: ×1 and ×10 nominal.
Dynamic range (preset):
50 Ω ×1: 100 mV to 1 V p-p pulse; **×10:** 1 V to 7 V p-p pulse
1 MΩ ×1: 100 mV to 1 V p-p pulse; **×10:** 1 V to 10 V p-p pulse
Dynamic range for rms sine wave is one-third of the above values.
Signal operating range:
50 Ω ×1: −2.5 V to 1 V; **×10:** −7 V to 7 V
1 MΩ ×1: −2.5 V to 1 V; **×10:** −25 V to 10 V
Coupling: AC or DC switch selectable.
Minimum pulse width: 5 ns
Maximum input:

50 Ω	**X1:**	±7 V DC 7 V rms below 5 MHz 3.5 V rms (+24 dBm) above 5 MHz
	X10:	±7 V DC, 7 V rms (+30 dBm)
1 MΩ	**X1:**	±350 V DC 250 V rms to 20 kHz decreasing to 3.5 V rms above 5 MHz
	X10:	±350 V 250 V rms to 20 kHz decreasing to 35 V rms above 5 MHz

Common Input
All specifications are the same as for separate operation with the following differences:
Impedance: 1 MΩ becomes 500 kΩ shunted by <60 pF. 50 Ω same as in separate.
Sensitivity (preset):
50 Ω ×1: 200 mV p-p, 70 mV rms; **×10:**2 V p-p, 700 mV rms
1 MΩ: same as in separate
Dynamic range (preset):
50 Ω ×1: 200 mV to 2 V p-p pulse; **×10:** 2 V to 5 V p-p pulse
1 MΩ: same as in separate
Maximum input:
50 Ω ±5 V DC or 5 V rms
1 MΩ same as in separate
Attenuators: Becomes ×2 and ×20 for 50 Ω

Time Interval Measurements

Time Interval Range
± Mode: −10 seconds to +10 seconds including 0 seconds
+ Only mode: 10 ns to 10 seconds
Sample size. (N): 1, 100, 1000, 10,000, 100,000
1 to 16777215 via HP-IB
Statistics: Mean, Standard Deviation, Maximum, Minimum. Time between measurements 330 μs; minimum rise time 1 ns
Least significant digit displayed: 20 ps / $\sqrt{N}$
Resolution:
(± 100 ps rms ± Start Trigger Error ± Stop Trigger Error) ÷ $\sqrt{N}$
Accuracy: ± Resolution ± Time Base Error × Time Interval
± Trigger Level Timing Error ± 1 ns Systematic
Trigger error =

$$\frac{\sqrt{(150\ \mu V)^2 + e_n^2}}{\text{Input voltage slew rate (V/s) at trigger point}} \text{ secs rms}$$

where 150 μV is the typical rms input amplifier noise on the 5370A and e_n is the rms noise of the input signal for a 500 MHz bandwidth.
Trigger level timing error =
25 mV ÷ Input voltage slew rate (V/s) at trigger point

Frequency Measurements

Frequency range: 0.1 Hz to 100 MHz
Timed gates
Internal gate time: 1 period, 0.01, 0.1, 1 seconds
Least significant digit displayed: $\frac{20\text{ ps}}{\text{Gate Time}} \times \text{FREQ}$
Resolution:

$$\pm \frac{100\text{ ps}}{\text{Gate Time}} \times \text{FREQ} \pm 1.4 \frac{\text{Trigger Error}}{\text{Gate Time}} \times \text{FREQ}$$

Accuracy: ± Resolution ± (Time Base Error) × FREQ
± (100 ps Systematic ÷ Gate Time) × FREQ
Statistics: Mean
Sample Mode (Single Period)
Sample size: same as Time Interval
Least significant digit displayed : 20 ps/$\sqrt{N}$ × FREQ
Resolution:

$$\pm \frac{100\text{ ps}}{\text{Gate Time}} \times \text{FREQ} \pm 1.4 \frac{\text{Trigger Error}}{\text{Period}\sqrt{N}} \times \text{FREQ}$$

Accuracy: ± Resolution ± (Time Base Error) × FREQ
± (100 ps Systematic ÷ Period) × FREQ
Statistics: Mean, Standard Deviation, Maximum, Minimum.
External Gate
Gate input: 20 ns to 10 seconds
Resolution and accuracy estimates may be made with the same specifications as Timed Gates above.

Period Measurements

Period range: 10 ns to 10 seconds
Timed gates
Internal gate time: 1 period, 0.01, 0.1, 1 seconds
Least significant digit displayed: $\frac{20\text{ ps}}{\text{Gate Time}} \times \text{PERIOD}$
Resolution:

$$\pm \frac{100\text{ ps}}{\text{Gate Time}} \times \text{PERIOD} \pm 1.4 \frac{\text{Trigger Error}}{\text{Gate Time}} \times \text{PERIOD}$$

Accuracy: ± Resolution ± Time Base Error × PERIOD
± (100 ps Systematic ÷ Gate Time) × PERIOD
Sample Mode (Single Period)
Sample size (N): same as Time Interval.
Least significant digit displayed: 20 ps/$\sqrt{N}$
Resolution: ± 100 ps/$\sqrt{N}$ ± 1.4 Trigger Error/$\sqrt{N}$
Accuracy: ± Resolution ± Time Base Error × PERIOD
± 100 ps Systematic
Statistics: Mean, Standard Deviation, Maximum Minimum
External Gate
Gate input: 20 ns to 10 seconds
Resolution and accuracy estimates may be made with the same specifications as timed measurements above.

Time Base

High Stability Oven Oscillator
Frequency: 10 MHz
Aging: $<5 \times 10^{-10}$ per day
Temperature: $<2.5 \times 10^{-9}$, 0° C to 50° C

General

Display: 16 digits, suppressed leading zeros.
Size: 133 H × 426 W × 521 mm D (5.25″ × 16.75″ × 20.5″).
Weight: 32 lbs.
Power requirements: 100, 120, 220, or 240 V ac +5%−10%, 48 to 66 Hz, less than 250 VA.
Front handles: supplied with instrument.

5370A Universal Time Interval Counter	**$8950**
Option 908: Rack Flange Kit for use without handles	add$30
Option 913: Rack Flange Kit for use with supplied front handles	add$35
10870A: Service Kit Accessory	add $650