Specifications and Characteristics

This chapter contains the specifications and characteristics for the HP 70120A universal counter.

These are the performance standards, or limits against which the instrument may be tested including typical characteristics as additional information for the user. (Only specifications are warranted.)

Table 4-1. Specifications and Characteristics

OPERATING MODE SPECIFICATIONS	
Frequency 1,2,3	
Range 1***	.001 Hz to 100 MHz (200 MHz with 2 prescaler)
Range 2***	.001 Hz to 100 MHz
Range 3	90 MHz to 2400 MHz (with 64 prescaler)
LSD*	(4 ns / Gate Time) FREQ
Resolution	LSD $\frac{(1\text{ ns rms} + 1\ 4\quad \text{Trigger Er}}{\text{Gate Time}}$
Accuracy	Resolution Time Base Error
Period 1,2,3	
Range 1,2	10 ns to 15,000 s (5 ns to 15,000 s on Input 1)
Range 3	11 ns to 420 ps
LSD*	(4 ns / Gate Time) PER
Resolution	LSD $\frac{(1\text{ ns rms} + 1\ 4\quad \text{Trigger Er}}{\text{Gate Time}}$
Accuracy	Resolution Time Base Error
Time Interval, 1 to 2	
Range	1 ns to 15,000 s (single-shot), 150 s (100 gate average)
LSD*	1 ns (100 ps using 100 gate average)
Resolution	LSD Start Trigger Error Stop Trigger Error 1 ns rms
Accuracy	Resolution Time Base Error Trigger Level Timing Error Trigger Level Setting Error 2ns

* See definition 1.
† See Figure 4-1.
‡ See definition 3.
§ See definition 2.
** 100 ps using 100 gate average.
†† See definition 4.
‡‡ See definition 5.
§§ Systematic error due to differential channel delay. Can be eliminated with optimized measurement technique (offsets, cable length, etc.).
*** Frequency range is dependant on auto-trigger state. See Auto Trigger under Input Specifications for restrictions.

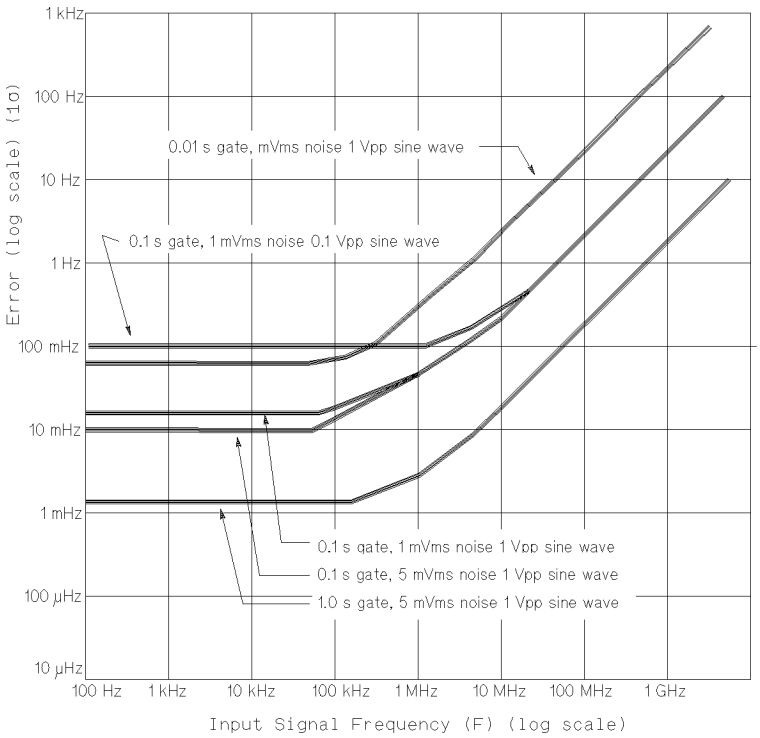

Figure 4-1. Frequency Resolution Error

Noise on the input signal and internal uncertainties affects Frequency and Period measurements. For Period, invert the period (P) of the input signal ($= \frac{1}{}$), and find frequency error (ΔF). Period error (ΔP) = ($\frac{\Delta F}{F}$) P.

OPERATING MODE SPECIFICATIONS (continued)	
Time Interval Delay, 1 to 2*	
Delay Range	1 ms to 99.999 s (1 ms steps)
Delay Accuracy	100 μs 0.05% Delay Time
Frequency Ratio 1/2, 2/1, 3/1	
Input Range 1, 2	.001 Hz to 100 MHz (200 MHz on input 1 if 2 prescaler is selected)
Input Range 3	90 MHz to 2400 MHz
LSD†	$\frac{4 \quad \text{RATIO}}{\text{Numerator Input FREQ} \quad \text{GateTime}}$
Resolution	LSD $\frac{\text{Denominator Input Trigger E}}{\text{Gate Time}}$ RATIO
Accuracy	Same as resolution

* Used with TI, 1 to 2, a selectable delay can be inserted between START (Input 1 trigger) and STOP (Input 2 trigger). Electrical inputs during delay are ignored. Specifications are the same as TI, 1 to 2.
† See definition 1.
‡ See definition 3.

OPERATING MODE SPECIFICATIONS (continued)	
Totalize 1, 1 by 2, 2 by 1	
Range	0 to 1 10^{12} 1 events
LSD*	1 count of input signal
Resolution	1 count
Accuracy	1 count
Maximum Frequency	20 MHz
Rise/Fall Time 1	
Range	1: 15 ns to 15,000 s (150 s with 100 gate average) 10: 50 ns to 15,000 s (150 s with 100 gate average)
LSD*	1 ns (100 ps using 100 gate average)
Resolution	LSD Start Trigger Error Stop Trigger Error 1 ns rms
Accuracy	Resolution Time Base Error Trigger Level Timing Error Trigger Level Setting Error 2 ns
Levels	10%/90% MAX (20%/80% MAX in 10 mode)
With Automatic Triggering	
Range	15 ns to 1 ms
Minimum Amplitude	500 mV p-p
Frequency Range	1 kHz to 20 MHz
Pulse Width 1, 2	
Polarity	Positive or Negative
Range	5 ns to 1 ms
LSD*	1 ns (100 ps using 100 gate average)
Resolution	LSD Start Trigger Error Stop Trigger Error 1 ns rms
Accuracy	Resolution Time Base Error Trigger Level Timing Error Trigger Level Setting Error
With Automatic Triggering	
Minimum Amplitude	200 mV p-p (70 mV rms sine wave)
Frequency Range	1 kHz to 20 MHz
Voltages 1,2	
Measurements	MIN, MAX, DC, AC
Frequency Range	dc, 1 kHz to 20 MHz
Dynamic Range	
dc signals	10.2 V (30V in 10 mode)
ac signals	200 mV p-p to 10.2 V p-p

* See definition 1.
† See definition 3.
‡ 100 ps using 100 gate average.
§ See definition 2.
** See definition 4.
†† See definition 5.
‡‡ Systematic error due to differential channel delay. Can be eliminated with optimized measurement technique (offsets, cable length, etc.).
§§ AC voltage reading gives RMS value assuming a sine wave input.

OPERATING MODE SPECIFICATIONS (continued)	
Voltages 1,2 (continued)	
Resolution	
Min, Max, AC/DC	30 mV
Accuracy	
Min, Max, DC, AC	AC 50 mV 5% of p-p voltage (20% in 10 mode)
INPUT SPECIFICATIONS	
Input 1 Range	
dc coupled	0 to 100 MHz (200 MHz with 2 prescaler)
ac coupled	100 Hz to 100 MHz (200 MHz with 2 prescaler)
Input 2 Range	
dc coupled	0 to 100 MHz
ac coupled	100 Hz to 100 MHz
Input 3 Range	
ac coupled	90 MHz to 2400 MHz
Sensitivity 1,2 (MAX)	35 mV rms sine wave; 100 mV p-p at a minimum pulse width of 5 ns.
Sensitivity 3	30 dBm at 100 MHz 10 dBm at 2400 MHz
1 MΩ 1,2	
Dynamic Range (ac)	10 V p-p (100 V p-p in 10 mode)
Signal Operating Range (dc)	10 Volts (100 V in 10 mode)
50 Ω 1,2,3	
Dynamic Range (ac)	10 V p-p
Signal Operating Range (dc)	10 Volts
AC + DC	not to exceed 10 Vrms (5 Vrms input 3)
Trigger Level Range 1,2	10.2 V with step
Trigger Level Range 3	fixed at 0 V
Trigger Level Accuracy 1,2	30 mV 1% of trigger level* (20% in 10 mode)
Auto Trigger†	
Frequency Range	1 kHz to 20 MHz
Minimum Amplitude	70 mV rms sine wave, 200 mV p-p
External Arming	
Input	Front-panel BNC
Minimum Start to Stop Time	50 ns
Sensitivity	500 mV p-p
Signal Operating Range	5 V dc to +5 V dc
Dynamic Range	500 mV to 5 V p-p

* Same as Autotrigger Level Accuracy

† Can be selected to determine trigger levels for all measurements except totalize and Input 3 measurements.

TCXO TIME BASE SPECIFICATIONS	
Frequency	10 MHz
Stability	
Aging Rate	< 1 ppm/year
Temperature	< 5 ppm, 0 – 55
INPUT CHARACTERISTICS	
Hysteresis 1,2 (@1 MHz)	
Adjustable to: (typical)	
MIN	30 mVp-p (300 mVp-p in 10 mode)
MAX	100 mVp-p (1.0 Vp-p in 10 mode)
DEF	60 mVp-p (600 Vp-p in 10 mode)
Coupling 1,2	ac, dc
Trigger Slope 1,2	Independent selection of + or slope
Impedance 1,2	1 MΩ shunted by < 45 pf or 50 Ω
Impedance 3	50 Ω (ac coupled)
Damage Level 1,2 (AC + DC)	
50 Ω	10 Vrms
1 MΩ	
≤ 20 kHz	100 V peak
> 20 kHz	10 Vrms
Damage Level 3	5 Vrms ac (30 V dc)
Common Input Routing	
Input 1 Range	Limited to 100 MHz
Impedance	500 kΩ shunted by < 90 pF or 50 Ω
External Arm	
Range	0 to 20 MHz
Trigger Levels	0 V (GND), 1.5 V (TTL), 1.3 V (ECL)
Slope	Independent Selection of START and STOP ARM slopes, +, , or OFF.
Impedance	dc coupled. 1 MΩ shunted by < 45 pF
Damage Level	
≤ 20 kHz	85 Vrms
> 20 kHz	10 Vrms
External Trigger	TTL level input

* Resistance values are measured at dc and capacitance at 1 MHz.
† All specifications are the same as separate operation except for those shown.
‡ Front panel ARM input can be used to determine Start and/or Stop point of a measurement. External Arm can be used with all measurements.

TIME BASE CHARACTERISTICS		
Standard Time Base	Uses Internal TCXO as default	
External Reference Input	Rear panel SMB accepts 10 MHz, 500 mV to 5 V rms into 1 kΩ shunted by < 30 pF	
External Reference Output	The TCXO Time Base signal can be routed out the rear panel SMB	
Signal	10 MHz, Square wave into 50 Ω, amplitude 320 mVp-p	
GATE TIME CHARACTERISTICS		
Range	1 ms to 99.999 seconds in 1 ms increments. (100 ms default)	
Resolution	1 ms	
Accuracy	100 μs (0.05% Gate Time) + up to one period of input signal	
100 Gate Average	100 gates accumulated and average is returned. This adds an additional digit of resolution. It can be used with all functions except Totalize.	
Gate Output	Level is TTL low while gate is open during all measurements except Totalize.	
MEASUREMENT THROUGHPUT CHARACTERISTICS		
Short Speeds		
Free-run	Up to 60 measurements/second	
Switching	Up to 40 measurements / second	
Comprehensive Single Reading Times		
Frequency/Period	100 Hz signal, .1 Hz resolution (3 digits)	60 ms
	100 Hz signal, .0001 Hz resolution (6 digits)	60 ms
	10 MHz signal, 10 kHz resolution (3 digits)	24 ms
	10 MHz signal, 10 Hz resolution (6 digits)	25 ms
Totalize	10 MHz signal, Time to read total (FETC?)	9 ms
Ratio	100 kHz signal, .0001 resolution (4 digits)	426 ms
	10 MHz signal, .0001 resolution (4 digits)	31 ms
Time Interval	10 ms signal, 10 ns resolution (6 digits)	40 ms
	100 μs signal, 100 ns resolution (3 digits)	21 ms
	100 μs signal, 1 ns resolution (5 digits)	173 ms
Automatic Pulse Width	5 ms signal, 5 ns resolution (6 digits)	290 ms
	50 μs signal, 50 ns resolution (3 digits)	280 ms
Automatic Rise/Fall Time	1 ms per., 6 Vp-p, 1 μs rt/ft, 1 ns res (3 digits)	284 ms
Voltage	1 MHz, 6 Vp-p, .06 V resolution (2 digits)	438 ms

* See "Definitions".

GENERAL CHARACTERISTICS	
Memory	Ten measurement set-ups, including trigger levels, may be stored in memory and subsequently recalled. Set-ups are lost when power is removed from the instrument.
Programming Language	SCPI 1991.0
Operating Temperature	0 to 55 C
Power Requirements	27 VAC 40 kHz; < 25 watts average
Size	One slot module
Weight	< 2.5 kg
Auto-Trigger	Auto-trigger can be used to automatically set trigger levels at 50% point (10%, 90% for Rise/Fall Time) of the input signal. The standard auto-trigger will evaluate the input signal, set the trigger level, measure and repeat. Single-measurement auto-trigger will evaluate the input signal only once, and then measure repeatedly, speeding up the process. Trigger levels can be specified in Volts or percentage of signal height. Percentage trigger levels will activate the auto-trigger to evaluate the signal amplitude.

Definitions

1. **LSD**

   Unit value of Least Significant Digit. Calculations should be rounded to the nearest decade (i.e., 5 Hz becomes 10 Hz and 4 ns becomes 1 ns).

2. **Time Base Error**

   Maximum fractional frequency change in the time base frequency due to all errors (aging, temperature, line voltage) multiplied by the measurement result.

3. **Trigger Error** (See Figure 4-2.)

   $$\text{TE} = \frac{\overline{(ei)^2+(en)^2}}{\text{Input Slew Rate at Trigger Point}}$$

   ei = Effective rms noise of counter's input channel (1.5 mV typical)

   en = rms noise of input signal for input bandwidth

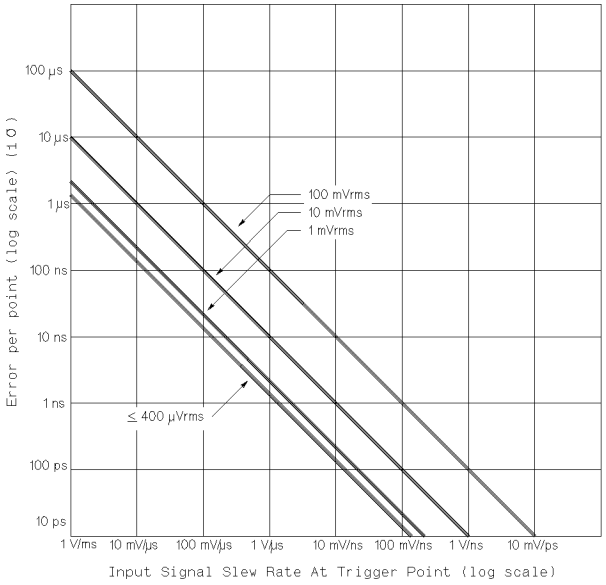

Figure 4-2. Input Noise Trigger Error

Noise on the input signal affects both the Start and Stop points of all time interval measurements.

4. **Trigger Level Timing Error** (See Figure 4-3.)

   Larger of:

   a. 0.5 × hysteresis band/input slew rate at start trigger point. (See list item 5.)

   b. 0.5 × hysteresis band/input slew rate at stop trigger point. (See list item 5.)

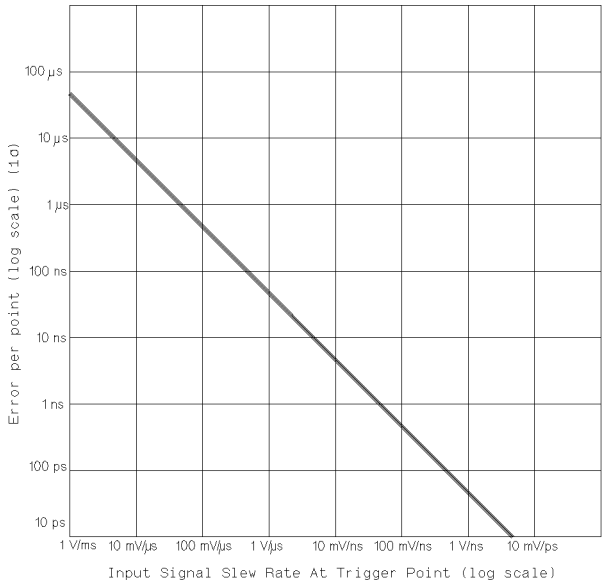

Figure 4-3. Trigger Level Timing Error

Affects the Start and Stop points of all time interval measurements. Total error is the larger of the two trigger point errors. (For sine waves, Slew rate at midpoint = 2 frequency amplitude, where amplitude is 1.2 of the peak-to-peak voltage.)

5. **Trigger Level Setting Error** (See Figure 4-4.)

Normal mode:

$$\pm\frac{30mV \pm 1\% \text{ of trigger level setting (TI only)}}{\text{Input slew Rate at Start Trigger Point}}$$

$$\pm\frac{30mV \pm 1\% \text{ of trigger level setting (TI only)}}{\text{Input Slew Rate at Stop Trigger Point}}$$

$\times$ 10 mode:

$$\pm\frac{300mV \pm 20\% \text{ of trigger level setting (TI only)}}{\text{Input slew Rate at Start Trigger Point}}$$

$$\pm\frac{300mV \pm 20\% \text{ of trigger level setting (TI only)}}{\text{Input Slew Rate at Stop Trigger Point}}$$

(See definition 6.)

Note that rise/fall times use 10% and 90% points of signal for trigger points, unless programmed differently.

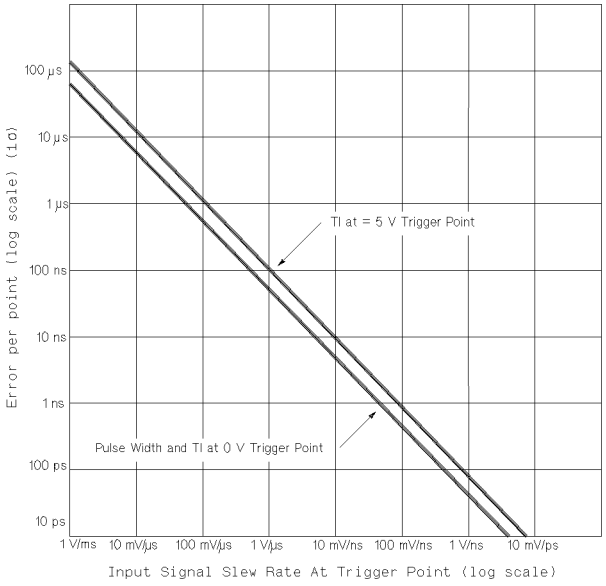

Figure 4-4. Trigger Level Setting Error

Affects both the Start and Stop points of all time interval measurements.

6. **Trigger Point and Hysteresis**

Auto trigger disabled: trigger point = trigger level reading

Auto trigger enabled: For all measurements except Rise/Fall Time,

trigger points = $\frac{\text{Max peak} + \text{Min peak}}{2}$

For Rise/Fall Time,

10% trigger point = .1 max peak + .9 min peak

90% trigger point = .9 max peak + .1 min peak

Min/Max voltage function is used to measure peaks.

For X% trigger point = $(\frac{X}{100})$ Max peak + $(1 \quad \frac{X}{100})$ Min peak

Measurement Throughput Definitions	
Short Speeds	Quick indicator of maximum counter speeds.
Setup	Embedded controller
Signal	> 1 MHz; signal does not limit speed of measurement.
Gate	1 ms; measurement << counter processing time.
Triggering	Manual
Free Run	Indicates speed of measuring and outputting results.Important if many measurements are made from one setup.
Algorithm	Setup Frequency Measurement, then do multiple reads.
Switching	Indicates speed of setup, measurement and output. Important if measurement mode or parameters are changed frequently.
Algorithm	Setup Frequency Measurement, then make one read; Setup Time Interval Measurement, then make one read; Setup Period Measurement, then make one read; Repeat.
Setups	
Frequency setup	Input 1 AC, Neg Slope, 50 Ω, Trig Level 0.2 V.
Time Interval setup	COMMON, Input 2 Pos Slope, 50 Ω, Trig Level 0.2 V.
Period setup	Input 1 DC, Pos Slope, 1 MΩ, Trig Level .35 V
Comprehensive Single Reading Times	Single Reading Times indicate the times needed for command transfer, instrument setup, measurement, and result transfer.
Hardware Setup	HP 9000 Series 300 computer (320)
Software Setup	HPBASIC Version 5