

# Agilent 53200A Series RF/Universal Frequency Counter/Timers

Data Sheet

**53210A** 350 MHz RF Frequency Counter, 10 digit/sec

**53220A** 350 MHz Universal Frequency Counter/Timer, 12 digit/sec, 100 ps

**53230A** 350 MHz Universal Frequency Counter/Timer, 12 digit/sec, 20 ps



**Agilent Technologies**

# Imagine your counter doing More!

## **More Bandwidth**

- 350 MHz baseband frequency
- 6 or 15 GHz optional microwave channels

## **More Resolution & Speed**

- 12 digits/sec
- 20 ps single-shot time resolution
- Up to 75,000 and 90,000 readings/sec (frequency and time interval)

## **More Insight**

- Datalog trend plot
- Cumulative histogram
- Built-in math analysis and statistics
- 1M reading memory and USB Flash storage

## **More Connectivity**

- LXI-C/Ethernet LAN, USB
- Optional GPIB interface
- Optional battery for portability and timebase accuracy

## **More Measurement Capability (53230A only)**

- Continuous gap-free measurements
- Basic modulation domain analysis (MDA) and timestamp
- Optional pulse/burst microwave measurement

## **Introduction**

*Frequency counters are depended on in R&D and in manufacturing for the fastest, most accurate frequency and time interval measurements.*

*The 53200 Series of RF and universal frequency counter/timers expands on this expectation to provide you with the most information, connectivity and new measurement capabilities, while building on the speed and accuracy you've depended on with Agilent's decades of time and frequency measurement expertise.*

*Three available models offer resolution capabilities up to 12 digits/sec single-shot frequency resolution on a one second gate. Single-shot time interval measurements can be resolved down to 20 psec. All models offer new built-in analysis and graphing capabilities to maximize the insight and information you receive.*

## **Definitions**

The following definitions apply to the specifications and characteristics described throughout.

### **Specification (spec)**

The warranted performance of a calibrated instrument that has been stored for a minimum of 2 hours within the operating temperature range of 0° C - 55° C and after a 45-minute warm up period. Automated calibration (\*CAL?) performed within ±5° C before measurement. All specifications were created in compliance with ISO-17025 methods.

Data published in this document are specifications unless otherwise noted.

### **Typical (typ)**

The characteristic performance, which 80% or more of manufactured instruments will meet. This data is not warranted, does not include measurement uncertainty, and is valid only at room temperature (approximately 23° C). Automated calibration (\*CAL?) performed within ±5° C before measurement.

### **Nominal (nom)**

The mean or average characteristic performance, or the value of an attribute that is determined by design such as a connector type, physical dimension, or operating speed. This data is not warranted and is measured at room temperature (approximately 23° C). Automated calibration (\*CAL?) performed within ±5° C before measurement.

### **Measured (meas)**

An attribute measured during development for purposes of communicating the expected performance.

This data is not warranted and is measured at room temperature (approximately 23° C). Automated calibration (\*CAL?) performed within ±5° C before measurement.

### **Stability**

Represents the 24-hour, ±1° C short-term, relative measurement accuracy. Includes measurement error and 24-hour ± 1° C timebase aging error.

### **Accuracy**

Represents the traceable measurement accuracy of a measurement for  $T_{CAL} \pm 5^{\circ} C$ . Includes measurement error, timebase error, and calibration source uncertainty.

Random measurement errors are combined using the root-sum-square method and are multiplied by M for the desired confidence level. Systematic errors are added linearly and include time skew errors, trigger timing errors, and timebase errors as appropriate for each measurement type.

### **T<sub>CAL</sub>**

Represents the ambient temperature of the instrument during the last adjustment to calibration reference standards.

T<sub>CAL</sub> must be between 10° C to 45° C for a valid instrument calibration.

### **T<sub>ACAL</sub>**

Represents the temperature of the instrument during the last automated calibration (\*CAL?) operation.

*All information in this document are subject to change without notice.*

## Input Channel Characteristics

	53210A	53220A	53230A
<b>Input characteristics (nom)</b>			
<b>Channels</b>			
Standard (DC - 350 MHz)	Ch 1	Ch 1 & Ch 2	
Optional (6 GHz or 15 GHz)	Ch 2	Ch 3	
<b>Standard inputs (nom)</b>			
<b>Frequency range</b>			
DC coupled	DC (1 mHz) to 350 MHz (2.8 ns to 1000 sec)		
AC coupled, 50 $\Omega$ <sup>1</sup> or 1 M $\Omega$	10 Hz - 350 MHz		
<b>Input</b>			
Connector	Front panel BNC(f). Option 201 adds parallel rear panel BNC(f) inputs <sup>2</sup>		
Input impedance (typ)	Selectable 1 M $\Omega$ $\pm$ 1.5% or 50 $\Omega$ $\pm$ 1.5%     <25 pF		
Input coupling	Selectable DC or AC		
Input filter	Selectable 100 kHz cut-off frequency low pass 10 Hz (AC coupling) cut-off frequency high pass filter		
<b>Amplitude range</b>			
Input range	$\pm$ 5 V ( $\pm$ 50 V) full scale ranges		
Sensitivity <sup>3,4</sup> (typ)	DC - 100 MHz: 20 mVpk > 100 MHz: 40 mVpk		
Noise <sup>3</sup>	500 $\mu$ Vrms (max), 350 $\mu$ Vrms (typ)		
<b>Input event thresholds</b>			
Threshold levels	$\pm$ 5 V ( $\pm$ 50 V) in 2.5 mV (25 mV) steps		
Noise reject <sup>4</sup>	Selectable On/ Off		
Slope	Selectable Positive or Negative		
Auto-scale	Acquires signal for current measurement channel, selects range (5 V or 50 V), sets auto-level 50%		
Auto-level	Selectable On or Off On: Sets auto-level (% of Vpp) operation Occurs once for each INIT or after a timeout. Measures signal Vpp and sets Trigger level to 50% Off: Selectable user set level (Volts)		
Signal frequency for auto level	User selectable (Slow (50 Hz), Fast (10 kHz))		
Minimum signal for auto level	300 mVpp		
<b>Maximum input</b>			
50 $\Omega$ damage level	1 W		
50 $\Omega$ protection threshold	Will not activate below 7.5 VpK 50 $\Omega$ internal termination auto-protects by switching to 1 M $\Omega$		
1 M $\Omega$ damage level	DC - 5 kHz: 350 Vpk (AC + DC) 5 kHz - 100 kHz: Derate linearly to 10 Vpk (AC + DC) >100 kHz: 10 Vpk (AC + DC)		

## Input Channel Characteristics *continued*

	53210A	53220A	53230A
<b>Optional Microwave Inputs (nom)</b>			
<b>Frequency range</b>			
Option 106	100 MHz - 6 GHz		
Option 115	300 MHz - 15 GHz		
<b>Input</b>			
Connector	Front panel precision Type-N(f) Option 203 moves the input connector to a rear panel SMA(f)		
Input impedance (typ)	50 $\Omega$ $\pm$ 1.5% (SWR < 2.5)		
Input coupling	AC		
<b>Amplitude range</b>			
Option 106	Autoranged to +19 dBm max. (2 Vrms)		
Option 115	Autoranged to +15 dBm max. (1.25 Vrms)		
Sensitivity (typ) <sup>5</sup>	6 GHz (Opt 106): -27 dBm (10 mVrms) 15 GHz (Opt 115): 0.3 GHz – 2 GHz: -23 dBm 2 GHz – 13 GHz: -26 dBm 13 GHz – 15 GHz: -21 dBm		
<b>Input event thresholds</b>			
Level range	Auto-ranged for optimum sensitivity and bandwidth		
AM tolerance (CW only)	50% modulation depth		
<b>Maximum input</b>			
Damage level	> +27 dBm (5 Vrms)		

1. AC coupling occurs after 50 ohm termination

2. When ordered with optional rear terminals, the standard/baseband channel inputs are active on both the front and rear of the universal counter though the specifications provided only apply to the rear terminals. Performance for the front terminals with rear terminals installed is not specified.

3. Multiply value(s) by x10 for the 50 V range.

4. Stated specification assumes Noise Reject OFF. Noise Reject ON doubles the sensitivity.

5. Assumes sine wave.

# Measurement Characteristics

	53210A	53220A	53230A
<b>Measurement range (nom)</b>			
<b>Frequency, period (average) measurements</b>			
<b>Common</b>			
Channels	Ch 1 or optional Ch 2	Ch 1, Ch 2 or optional Ch 3	
Digits/s	10 digits/s	12 digits/s	12 digits/s
Maximum display Resolution <sup>1</sup>	12 digits	15 digits	15 digits
Measurement technique	Reciprocal	Reciprocal and resolution enhanced	Reciprocal, resolution-enhanced or continuous (gap-free)
Signal type	Continuous Wave (CW)		CW and pulse/burst (Option 150)
Level & slope	Automatically preset or user selectable		
Gate	Internal or external		
Gate time <sup>2</sup>	1 ms to 1000 s in 10 $\mu$ s steps	100 $\mu$ s to 10 $\mu$ s steps	1 $\mu$ s to 1000 s in 1 $\mu$ s steps
Advanced gating <sup>3</sup>	N/A	Start delay (time or events) and stop hold-off (time or events)	
FM tolerance	$\pm 50\%$		
<b>Frequency, period</b>			
Range <sup>9</sup>	DC (1 mHz) to 350 MHz (2.8 ns to 1000 sec)		
Microwave input (optional)	Option 106 - 100 MHz to 6 GHz (166 ps to 10 ns) Option 115 - 300 MHz to 15 GHz (66 ps to 3.3 ns)		
<b>Frequency ratio<sup>4</sup></b>			
Range	$10^{15}$ Displayable range		
<b>Timestamp/modulation domain analysis (MDA)</b>			
Sample rate <sup>5</sup>	N/A	N/A	Up to 1 MSa/s (Fast), 100 kSa/s (Medium), 10 kSa/s (Slow)
#Edges/ timestamp	N/A	N/A	Auto-acquired per acquisition
Acquisition length	N/A	N/A	up to 1 MSa or 100,000 s (max)
<b>Time interval (single-shot) measurements<sup>11</sup></b>			
<b>Common</b>			
Channels	N/A	Ch 1 or 2	
Single-shot time resolution	N/A	100 ps	20 ps
Gating	N/A	Internal or external gate Start delay (time or events) and stop hold-off (time or events)	
Slope	N/A	Independent start, stop slopes	
Level	N/A	Independent start, stop slopes	
Channel-to-channel time skew (typ)	N/A	100 ps	50 ps

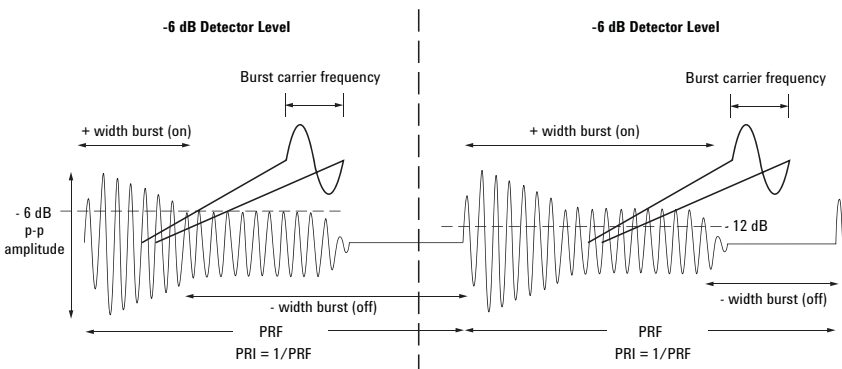
## Measurement Characteristics *continued*

	53210A	53220A	53230A
<b>Time interval A to B, B to A</b>			
Range <sup>9</sup>	N/A	-1 ns to 100,000 s (nom) -0.5 ns to 100,000 s (min)	
<b>Time interval A or B</b>			
Range	N/A	2 ns to 100,000 s (min)	
Minimum width	N/A	2 ns (assumes at least 4 ns from stop to start edge)	
Minimum edge repetition rate	N/A	6 ns	
Level & slope	N/A	Auto-level or user selectable	
<b>Single-period, pulse-width, rise time, fall time</b>			
Range	N/A	0 s to 1000 s	
Minimum width	N/A	Single-period: 2.5 ns Pulse width, rise/fall time: 2 ns (assumes at least 4 ns from stop to start edge)	
Minimum edge repetition Rate	N/A	6 ns	
Level & slope	N/A	Auto-level or user selectable	
<b>Duty</b>			
Range	N/A	.000001 to .999999 or 0.0001% to 99.9999%	
Minimum width	N/A	2 ns (assumes at least 4 ns from stop to start edge)	
Level & slope	N/A	Auto-level or user selectable	
<b>Phase A to B, B to A</b>			
Range <sup>6</sup>	N/A	-180.000° to 360.000°	
<b>Totalize measurements</b>			
Channels	N/A	Ch 1 or Ch 2	
Range <sup>9</sup>	N/A	0 to 10 <sup>15</sup> events	
Rate	N/A	0 - 350 MHz	
Gating	N/A	Continuous, timed, or external gate input Gate accuracy is 20 ns	
<b>Level measurements</b>			
Voltage level - standard input channels	±5.1 Vpk with 2.5 mV resolution or ±51 Vpk with 25 mV resolution		
Microwave power level (microwave channel option)	0 to 4 relative signal power		

## Measurement Characteristics *continued*

	53210A	53220A	53230A
<b>Pulse/burst frequency and pulse envelope detector (Option 150)<sup>12</sup></b>			
Pulse/burst measurements	N/A	N/A	Carrier frequency, carrier period, pulse repetition interval (PRI), pulse repetition frequency (PRF), positive and negative width
Pulse/burst width for carrier frequency measurements <sup>10</sup>	N/A	N/A	>200 ns Narrow: <17 us Wide: >13 us
Minimum pulse/burst width for envelope measurements	N/A	N/A	>50 ns – 1000 s
Acquisition	N/A	N/A	Auto, Manual <sup>7</sup>
PRF, PRI range	N/A	N/A	1 Hz – 10 MHz
Pulse detector response time (typ) <sup>8</sup>	N/A	N/A	15 ns rise, fall
Pulse width accuracy (typ) (0 dbm, 23° C)	N/A	N/A	20 ns + (2*carrier period)
Power ratio (typ)	N/A	N/A	>15 dB
Pulse measurement sensitivity (typ)	N/A	N/A	-13 dBm (50 mVrms)

1. Maximum display resolution for frequency. Totalize display resolution is 15 digits, time interval is 12 digits.
2. Continuous, gap-free measurements limits the gate time setting to 10  $\mu$ s to 1000 s in 10  $\mu$ s steps.
3. Refer to the gate characteristics section for more details on advanced gate capabilities.
4. Measurements on each input channel are performed simultaneously using one gate interval. The actual measurement gate interval on each channel will be synchronous with edges of each input signal.
5. Maximum sample rate. Actual sample rate will be limited by the input signal edge rate for signals slower than the selected sample rate.
6. Assumes two frequencies are identical, only shifted in phase.
7. Manual control of gate width and gate delay are allowed only for wide pulsed mode.
8. For pulsed signals > -7 dBm (100 mVrms) while gated on.
9. For totalize, time interval and frequency measurements, you may get measurement readings beyond the range stated, but the accuracy of those readings is not specified.
10. Applies when burst width \* Carrier Freq > 80.
11. Specifications apply if measurement channels are in 5 V range, DC coupled, 50 ohm terminated and at fixed level for: time interval single and dual channel, pulse width, duty, phase, single period and rise/fall time measurements.
12. Option 150 microwave pulse/burst measurement descriptions:



## Gate, Trigger and Timebase Characteristics

	53210A	53220A	53230A
<b>Gate characteristics (nom)</b>			
<b>Gate</b>			
Source	Time, external	Time, external or advanced	
Gate time (step size) <sup>1,2</sup>	1 ms - 1000 s (10 μs)	100 μs - 1000 s (10 μs)	1 μs - 1000 s (1 μs)
<b>Advanced: gate start</b>			
Source	N/A	Internal or external, Ch 1/Ch 2 (unused standard channel input)	
Slope	N/A	Positive or negative	
Delay time <sup>1</sup>	N/A	0 s to 10 s in 10 ns steps	
Delay events (edges)	N/A	0 to 10 <sup>8</sup> for signals up to 100 MHz	
<b>Advanced: gate stop hold-off</b>			
Source	N/A	Internal or external, Ch 1/Ch 2 (unused standard channel input)	
Slope	N/A	Positive or negative	
Hold-off time <sup>1</sup>	N/A	Hold-off Time settable from 30 ns to 1000 s	
Hold-off events (edges)	N/A	0 to 10 <sup>8</sup> for signals up to 15 MHz	
<b>External gate input characteristics (typ)</b>			
Connector	Rear panel BNC(f) Selectable as external gate input or gate output signal		
Impedance	1 k Ω when selected as external gate input		
Level	TTL compatible		
Slope	Selectable positive or negative		
Gate to gate timing	3 μs gate end to next gate start		
Damage level	<-5 V, >+10 V		
<b>Gate output characteristics (typ)</b>			
Connector	Rear panel BNC(f) Selectable as external gate input or gate output signal		
Impedance	50 Ω when selected for gate output		
Level	TTL compatible		
Slope	Selectable positive or negative		
Damage level	<-5 V, >+10 V		



## Trigger and Timebase Characteristics (nom)

	53210A	53220A	53230A
<b>Trigger characteristics (nom)</b>			
<b>General</b>			
Trigger source	Internal, external, bus		
Trigger count	1 to 1,000,000		
Trigger delay <sup>1</sup>	0 s to 3600 s in 1 $\mu$ s steps		
Samples/trigger	1 to 1,000,000		
<b>External trigger input (typ)</b>			
Connector	Rear panel BNC(f)		
Impedance	1 k $\Omega$		
Level	TTL compatible		
Slope	Selectable positive or negative		
Pulse width	> 40 ns min.		
Latency	Frequency, period: 1 $\mu$ s + 3 periods time interval, totalize: 100 ns		
External trigger rate	300/s max	1 k/s max	10 k/s max
Damage level	<-5 v, >+10 v		
<b>Timebase characteristics (nom)</b>			
Timebase reference	Internal, external, or auto		
Timebase adjustment method	Closed-box electronic adjustment		
Timebase adjustment Resolution	10 <sup>-10</sup> (10 <sup>-11</sup> for Option 010 U-OCXO timebase)		
<b>External timebase input (typ)</b>			
Impedance	1k $\Omega$ AC coupled		
Level (typ)	100 mVrms to 2.5 Vrms		
Lock frequencies	10 MHz, 5 MHz, 1 MHz		
Lock range	$\pm$ 1 ppm ( $\pm$ 0.1 ppm for Option 010 U-OCXO timebase)		
Damage level	7 Vrms		
<b>Timebase output (typ)</b>			
Impedance	50 $\Omega$ $\pm$ 5% at 10 MHz		
Level	0.5 Vrms into a 50 $\Omega$ load 1.0 Vrms into a 1 k $\Omega$ load		
Signal	10 MHz sinewave		
Damage level	7 Vrms		

1. Gate, Delay, and Holdoff time parameter accuracy is the same as the instrument timebase accuracy.

2. Continuous, gap-free measurements limits the Gate Time setting to 10  $\mu$ s to 1000 s in 10  $\mu$ s steps.

## Math, Graphing and Memory Characteristics (nom)

	53210A	53220A	53230A
<b>Math operations</b>			
Smoothing (averaging) <sup>1</sup>	Selectable 10 (slow), 100 (medium), 1,000 (fast) reading moving average Selectable filter reset .1% /1000 ppm (fast), .03%/300 ppm (medium), .01%/100 ppm (slow) change from average		
Scaling	mX-b or m(1/X)-b User settable m and b (offset) values		
Δ-change	(X-b)/b scaled to %, ppm, or ppb User settable b (reference) value		
Null	(X-b) User settable b (reference) value		
Statistics <sup>1</sup>	Mean, standard deviation, Max, Min, Peak-to-Peak, count	Mean, standard deviation, Allan deviation <sup>2</sup> , Max, Min, Peak-to-Peak, count	
Limit test <sup>3</sup>	Displays PASS/ FAIL message based on user defined Hi/ Lo limit values.		
Operation	Individual and simultaneous operation of smoothing, scaling, statistics, and limit test		
<b>Graphical display selections</b>			
Digits	Numeric result with input level shown		
Trend	Strip chart (measurements vs. readings over time) Selectable screen time		
Histogram	Cumulative histogram of measurements; manual reset HI/LO limit lines shown Selectable bin and block size		
Limit test	Measurement result, tuning bar-graph, and PASS/ FAIL message		
Markers	Available to read values from trend & histogram displays		
<b>Memory</b>			
Data log	Guided setup of # of readings/counts; automatically saves acquisition results to non-volatile memory		
Instrument state	Save & recall user-definable instrument setups		
Power-off	Automatically saved		
Power-on	Selectable power-on to reset (Factory), power-off state or user state		
Volatile reading memory	1 M readings (16 MBytes)		
Non-volatile internal memory	75 Mbytes (up to 5 M readings)		
USB file system	Front-panel connector for USB memory device		
Capability	Store/ recall user preferences and instrument states, reading memory, and bit map displays		

## Speed Characteristics<sup>4</sup> (meas)

	53210A	53220A	53230A
Measurement/IO timeout (nom)	0 s (no timeout or 10 ms to 2000 s, in 1 ms steps)		
Auto-level speed	Slow mode (50 Hz): 350 ms (typ) Fast mode (10 kHz): 10 ms (typ)		
Configure-change speed	Frequency, Period, Range, Level: 50 ms (typ)		
Single measurement throughput <sup>5</sup>	<b>Typical (Avg. using READ?):</b> LAN (VXI-11): 150 Readings/sec LAN (sockets): 210 Readings/sec USB: 210 Readings/sec GPIB: 240 Readings/sec  <b>Optimized (Avg. using *TRG:DATA:REM? 1, WAIT)</b> LAN (VXI-11): 145 Readings/sec LAN (sockets): 350 Readings/sec USB: 380 Readings/sec GPIB: 400 Readings/sec		
Block reading throughput <sup>5</sup>	<b>Typical (Avg. using READ?):</b> LAN (VXI-11): 9,800 readings/sec LAN (sockets): 10,500 readings/sec USB: 10,900 readings/sec GPIB: 4,800 readings/sec  <b>Optimized (Avg. using *TRG:DATA:REM? 1, WAIT)</b> LAN (VXI-11): 48,000 readings/sec LAN (sockets): 66,500 readings/sec USB: 66,500 readings/sec GPIB: 17,200 readings/sec		

### Maximum measurements to internal memory speed<sup>6</sup>

Frequency, period, totalize	300 readings/sec	1,000 readings/sec	75,000 readings/sec
Frequency ratio			44,000 readings/sec
Time interval, rise/fall, width, burst width	N/A		90,000 readings/sec
Duty cycle	N/A		48,000 readings/sec
Phase	N/A		37,000 readings/sec
PRI, PRF	N/A		N/A

### Transfer from memory to PC via:

LAN (sockets)	600,000 readings/sec
LAN (VXI-11)	150,000 readings/sec
USB	800,000 readings/sec
GPIB	22,000 readings/sec

1. These Math operations do not apply for Continuous Totalize or Timestamp measurements.
2. Allan Deviation is only calculated for Frequency and Period measurements. Allan Deviation calculation is available on both 53220A and 53230A, it is only gap free on 53230A.
3. Limit Test only displays on instrument front panel. No hardware output signal is available.
4. Operating speeds are for a direct connection to a >2.5 GHz dual core CPU running Windows® XP Pro SP3 or better with 4 GB RAM and a 10/100/1000 LAN interface.
5. Throughput data based on 53230A with a 1 µsec gate time. Typical reading throughput assumes ASCII format, Auto level OFF with READ? SCPI command. For improved reading throughput you should also consider setting (FORM:DATA REAL,64), (DISP OFF), and set fastest gate time available.
6. Maximum 53230A rates represent >= 20 MHz input signals with min gate times, no delays or holdoffs. Measurement rates for the 53210A & 53220A are limited by min gate time. Actual meas rates are limited by the repetition rate of the input being measured.

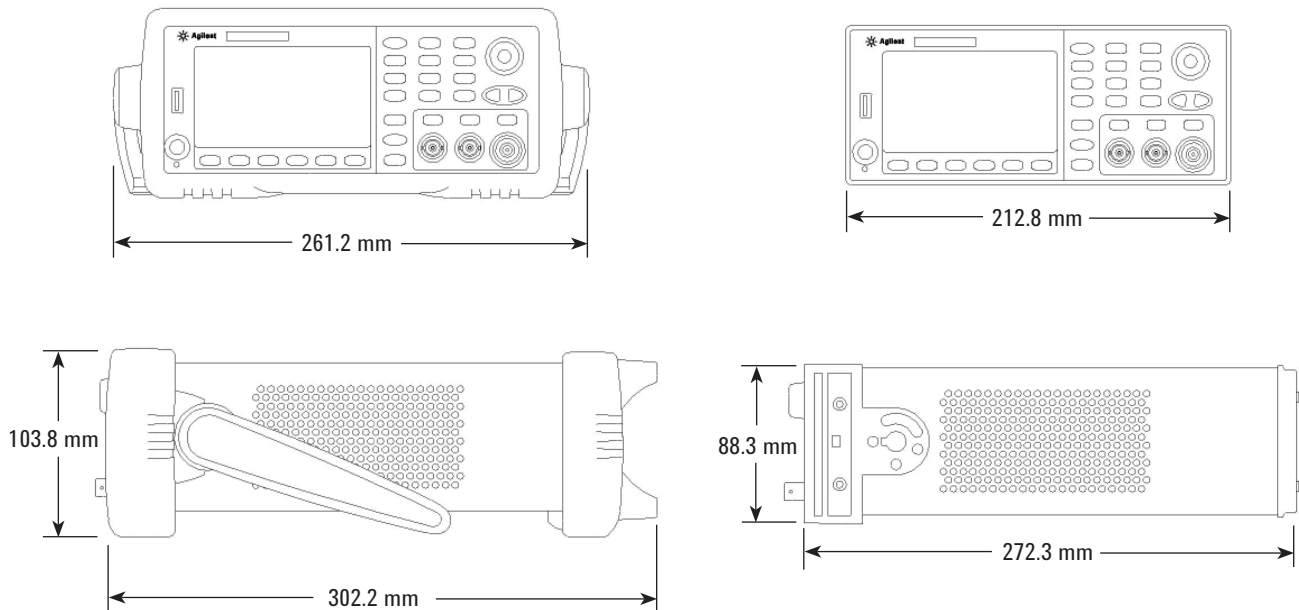
## General Characteristics (nom)

	53210A	53220A	53230A
Warm-up time	45-minutes		
Display	4.3" Color TFT WQVGA (480 x 272), LED backlight		
User interface and help languages	English, German, French, Japanese, Simplified Chinese, Korean		
USB flash drive	FAT, FAT32		
<b>Programming language</b>			
SCPI	532xx Series and 53131A/53132A/53181A Series compatibility mode		
<b>Programming interface</b>			
LXI-C 1.3	10/ 100/ 1000 LAN (LAN Sockets and VXI-11 protocol)		
USB 2.0 device port	USB2.0 (USB-TMC488 protocol)		
GPIB interface (Option 400)	GPIB (IEEE-488.1, IEEE-488.2 protocol)		
Web user interface	LXI Class C Compatible		
<b>Mechanical</b>			
Bench dimensions	261.1 mm W x 103.8 mm H x 303.2 mm D		
Rack mount dimensions	212.8 mm W x 88.3 mm H x 272.3 mm D (2U x ½ width)		
Weight	3.9 kg (8.6 lbs) fully optioned		
<b>Environmental</b>			
Storage temperature	- 30° C to +70° C		
Operating environment	EN61010, pollution degree 2; indoor locations		
Operating temperature	0° C to +55° C		
Operating humidity	5% to 80% RH, non-condensing		
Operating altitude	Up to 3000 meters or 10,000 ft		
<b>Regulatory</b>			
Safety	Complies with European Low Voltage Directive and carries the CE-marking Conforms to UL 61010-1, CSA C22.2 61010-1, IEC 61010-1:2001, CAT I		
EMC	Complies with European EMC Directive for test and measurement products. IEC/EN 61326-1 CISPR Pub 11 Group 1, class A AS/NZS CISPR 11 ICES/NMB-001 Complies with Australian standard and carries C-Tick Mark This ISM device complies with Canadian ICES-001 Cet appareil ISM est conforme a la norme NMB-001 du Canada		
Acoustic noise (nom)	SPL 35 dB(A)		
<b>Line power</b>			
Voltage	100 V - 240 V 50/60 Hz -5%, +10% 100 V - 120 V 400 Hz ±10%		
Power consumption	90 VA max when powered On or charging battery; 6 VA max when powered off/standby		

## General Characteristics (nom) *continued*

	53210A	53220A	53230A
<b>Battery (Option 300)</b>			
Technology	Internal lithium ion battery with integrated smart battery monitor & charger		
Operating temperature limits	0 to 55° C Battery will only charge under 35° C Instrument running on battery power above 50° C will turn off to minimize battery capacity degradation.		
Storage temperature limits	-10° C to 60° C. Extended exposure to temperatures above 45° C could degrade battery performance and life		
Operating time (typ)	3 hours when operated below +35° C		
Standby time - OCXO powered (typ)	24 hours		
Recharge time (typ) <sup>1</sup>	4 hours to 100% capacity; 2-hours to 90% capacity		
<b>Accessories included</b>			
CD	User's guide, SCPI/programmers reference, programming examples, drivers (IVI-COM, LabView), IO library instructions		
Cables	Power line cord, 2 m USB 2.0		
<b>Warranty</b>			
Standard	1-year		

1. Assumes calibrated battery.



Dimensions apply to all three models: 53210A, 53220A, 53230A.

## Timebase

Timebase Uncertainty = ( Aging + Temperature + Calibration Uncertainty )

Timebase	Standard TCXO	Option 010 Ultra-high stability OCXO
<b>Aging <sup>1</sup> (spec)</b>		
24-hour, T <sub>CAL</sub> ±1° C		± 0.3 ppb (typ)
30-day, T <sub>CAL</sub> ±5° C	± 0.2 ppm (typ)	± 10 ppb
1-year, T <sub>CAL</sub> ±5° C	± 1 ppm	± 50 ppb
<b>Temperature (typ)</b>		
0° C to 55° C relative to 25° C	± 1 ppm	± 5 ppb
TCAL ± 5° C	± 0.5 ppm	± 0.5 ppb
<b>Calibration uncertainty</b>		
Initial factory calibration <sup>2</sup> (typ)	± 0.5 ppm	± 50 ppb
<b>Supplemental characteristics (typ)</b>		
5-min. warm-up error <sup>3</sup>	± 1 ppm	± 10 ppb
72-hour retrace error <sup>4</sup>	< 50 ppb	< 2 ppb
Allan deviation $\tau = 1$ s	1 ppb	0.01 ppb

1. All Timebase Aging Errors apply only after an initial 30-days of continuous powered operation and for a constant altitude ±100 m. After the first 1-year of operation, use ½ x (30-day and 1-year) aging rates shown.
2. Only use the Factory Calibration error values for the period before your first re-calibration. Factory Calibration uncertainty includes the instrument settability error, the factory calibration source uncertainty, and additional timebase uncertainty due to factory calibration before the required initial 30-days of powered operation. Settability defines the resolution increments you can reach in steps of 0.1 ppb (0.01 ppb on Option 010).
3. Warm-up error applies when the instrument is powered on in a stable operating environment. When moved between different operating environments add the Temperature error during the initial 30-minutes of powered operation
4. Retrace error may occur whenever the instrument line-power is removed or whenever the instrument is battery operated and the battery fully discharges. Retrace error is the residual timebase shift that remains 72-hours after powering-on an instrument that has experienced a full power-cycle of the timebase. Additional frequency shift errors may occur for instrument exposure to severe impact shocks >50 g.

# Accuracy Specifications

## Definitions

### Random Uncertainty

The rss sum of all random or Type-A measurement errors expressed as the total RMS or 1-σ measurement uncertainty. Random uncertainty will reduce as 1/√N when averaging N measurement results for up to a maximum of approximately 13-digits or 100 fs.

### Systematic Uncertainty

The 95% confidence residual constant or Type-B measurement uncertainty relative to an external calibration reference.

Generally, systematic uncertainties can be minimized or removed for a fixed instrument setup by performing relative measurements to eliminate the systematic components.

### Timebase Uncertainty

The 95% confidence systematic uncertainty contribution from the selected timebase reference. Use the appropriate uncertainty for the installed timebase or when using an external frequency reference substitute the specified uncertainty for your external frequency reference.

**Basic accuracy**  $^1 = k * (\text{Random Uncertainty} \pm \text{Systematic Uncertainty} \pm \text{Timebase Uncertainty})$

Measurement Function	1-σ Random Uncertainty	Systematic Uncertainty	Timebase Uncertainty <sup>2</sup>
Frequency <sup>3</sup> Period (parts error)	$\frac{1.4 * (T_{SS}^2 + T_E^2)^{1/2}}{R_E \times \text{Gate Time}}$	If $R_E \geq 2$ : $10^{-11}/\text{gate max, } 2 * 10^{-12}/\text{gate typ}^4$ If $R_E < 2$ or REC mode ( $R_E = 1$ ): $2 * 10^{-10}/\text{gate}$	•
Option 106 & 115: Frequency <sup>3</sup> Period (parts error)	typ: $\frac{1.4 * (T_{SS}^2 + T_E^2)^{1/2}}{R_E \times \text{Gate Time}}$  max: $\frac{4 * (T_{SS}^2 + T_E^2)^{1/2}}{R_E \times \text{Gate Time}}$	If $R_E \geq 2$ : $10^{-11}/\text{gate max, } 2 * 10^{-12}/\text{gate typ}^4$ If $R_E < 2$ $10^{-10}/\text{gate}$	•
Frequency Ratio A/B (typ) <sup>5</sup> (parts error)	1.4 x Random Uncertainty of the <i>worst case</i> Freq input	Uncertainty of Frequency A plus Uncertainty of Frequency B	
Single Period measurement (parts error) <sup>16</sup>	$\frac{1.4 * (T_{SS}^2 + T_E^2)^{1/2}}{\text{TI Measurement}}$	$\frac{T_{\text{accuracy}}}{\text{Period Measurement}}$	
Time Interval (TI) <sup>16</sup> , Width <sup>6, 16</sup> , or Rise/Fall Time <sup>7, 16</sup> (parts error)	$\frac{1.4 * (T_{SS}^2 + T_E^2)^{1/2}}{\text{TI Measurement}}$	linearity = $\frac{T_{\text{accuracy}}}{\text{TI Measurement}}$ offset <sup>8</sup> (typ) = $\frac{T_{\text{LTE}} + \text{skew} + T_{\text{accuracy}}}{\text{TI Measurement}}$	•
Duty <sup>5, 9, 10, 16</sup> (fraction of cycle error)	$2 * (T_{SS}^2 + T_E^2)^{1/2} * \text{Frequency}$	$(T_{\text{LTE}} + 2 * T_{\text{accuracy}}) * \text{Frequency}$	
Phase <sup>5, 9, 16</sup> (Degrees error)	$2 * (T_{SS}^2 + T_E^2)^{1/2} * \text{Frequency} * 360^\circ$	$(T_{\text{LTE}} + \text{skew} + 2 * T_{\text{accuracy}}) * \text{Frequency} * 360^\circ$	
Totalize <sup>11</sup> (counts error)	$\pm 1 \text{ count}^{11}$		
Volts pk to pk <sup>12</sup> (typ) 5v range		DC-1 KHz: $\pm 0.15 \% \text{ rdg} \pm 0.15 \% \text{ of range}$ 1 KHz-1 MHz: $\pm 2 \% \text{ rdg} \pm 1 \% \text{ range}$ 1 MHz-200 MHz: $\pm 1 \% \text{ range} \pm 5 \% \text{ rdg}$ $\pm 30 \% \times (\text{Freq}/250 \text{ MHz}) \text{rdg}$	
<b>Optional Microwave Channel Opt 150 - Pulse/Burst Measurements<sup>3</sup></b>			
PRF, PRI <sup>13</sup> (parts error) (0 dBm, -6 dB threshold)	$\frac{2 * (T_{SS} + \text{Carrier Period})}{R_E \times \text{Gate Time}}$	$10^{-10}/(R_E * \text{gate})$	•
Pulse/burst Carrier Frequency <sup>13, 14</sup> (Narrow Mode) (parts error) (0 dBm, -6 dB threshold)	$\frac{10 * T_{SS}}{\text{Burst Width}}$	$\frac{2 * T_{\text{accuracy}}}{\text{Burst Width}}$	•
Pulse/burst Carrier Frequency <sup>14, 15</sup> (Wide Mode) (parts error) (0 dBm, -6 dB threshold)	$\frac{2 * T_{SS}}{R_E \times \text{Burst Width}}$	$10^{-11}/\text{Burst Width}$ if Burst Width < 10ms $10^{-10}/\text{Burst Width}$	•

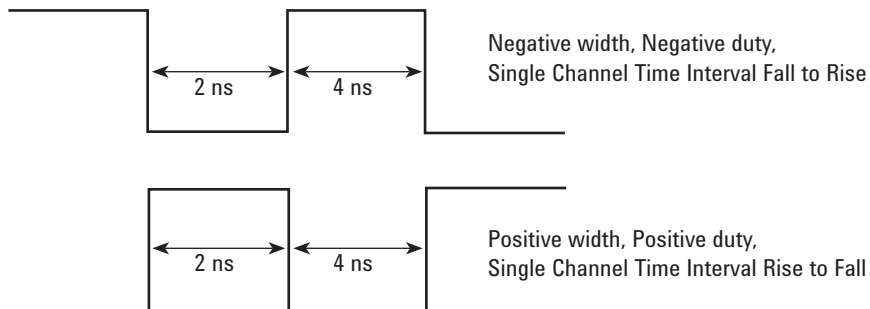
## Accuracy Specifications *continued*

1. Apply the appropriate errors detailed for each measuring function.
2. Use Timebase Uncertainty in Basic Accuracy calculations only for Measurement Functions that show the ● symbol in the Timebase Uncertainty column.
3. Assumes Gaussian noise distribution and non-synchronous gate, non-gaussian noise will effect Systematic Error. Note all optional microwave channel specifications (continuous wave and pulse/burst) assume sine signal.
4. Typical is achieved with an average of 100 readings with 100 samples per trigger. Worst case is trigger and sample count set to 1.
5. Improved frequency ratio, duty and phase specifications are possible by making independent measurements.
6. Minimum Pulse Width for using stated Taccuracy is 5 ns; Pulse Widths of 2-5 ns use Taccuracy=400 ns.
7. Residual instrument Rise/ Fall Time 10%-90% 2.0 ns (typ). Applies to fixed level triggering.
8. Input signal slew rates and settling time have effects on offset. Offset is calibrated with rise times < 100 ps.
9. Constant Duty or Phase are required during the measurement interval. Duty and Phase are calculated based on two automated sequential measurements - period and width or TI A to B, respectively.
10. Duty is represented as a ratio (not as a percent).
11. Additional count errors need to be added for gated totalize error, latency or jitter. If gated, add gate accuracy term (See Totalize measurements in the the Measurement Characteristics section).
12. Volts pk error apply for signal levels between full range and 1/10th range. Spec applies to sine wave only.  
50 v range reading accuracy is 2% at DC-1 KHz, 5% 1 KHz -1 MHz band. Accuracy above 200 MHz is not specified on both ranges.
13. Use the  $R_E$  calculation, but FIN in equation is now Burst Rate. Assume sharp envelope transition.
14. Applies when Burst Width \* Carrier Freq > 80.
15. Specifications based on gate and width for automated detection. If in manual mode, delay and width selected will impact accuracy specification. For approximate accuracy for manual gate. Use the  $R_E$  calculation, but Fin is now  $10^6$  and use gate as burst width.
16. The following minimum pulse width requirements apply:

Single-Period: <250 MHz, 50% Duty

Phase, Dual Channel Time Interval: <160 MHz, 50% Duty

Specifications apply if measurement channels are in 5 V range, DC coupled, 50 ohm terminated and at fixed level.



## Definition of Measurement Error Sources and Terms used in Calculations

	53210A	53220A	53230A
$R_E$	1	use $R_E$ equation	use $R_E$ equation
$T_{SS}$	100 ps	100 ps	20 ps
Skew		100 ps	50 ps
$T_{accuracy}$		200 ps	100 ps

### Confidence Level (k)

For 99% Confidence use k= 2.5 in accuracy calculations.

For 95% Confidence use k= 2.0 in accuracy calculations.



# Definition of Measurement Error Sources and Terms used in Calculations *continued*

## Resolution enhancement factor ( $R_E$ )

The resolution enhancement ( $R_E$ ) calculates the added frequency resolution beyond the basic reciprocal measurement capability that is achieved for a range of input signal frequencies and measurement gate times. The maximum enhancement factor shown is for signals  $T_{SS} > T_E$  and is limited due to intrinsic measurement limitations. For signals where  $T_{SS} \ll T_E$ ,  $R_E$  may be significantly higher than the specified levels, but will always be  $\geq 1$ .

$R_E = \sqrt{(FIN * Gate\_time/16)}$   $R_E$  is limited by gate time as show below

Gate time 1 s,  $R_E = 6$  (max)

Gate time 100 ms,  $R_E = 4$

Gate time 10 ms,  $R_E = 2$

Gate time 1 ms,  $R_E = 1$  (min) Interpolation between listed gate times allowed.

## Single shot timing ( $T_{SS}$ )

Timing resolution between a single pair of start/stop edges.

## Skew

Skew is the additional time error if two channels are used for a measurement. It is not used for width, rise/fall time, and single channel time interval.

## $T_{accuracy}$

$T_{accuracy}$  is the measurement error between two points in time.

## Threshold error ( $T_E$ )

Threshold error ( $T_E$ ) describes the input signal dependent random trigger uncertainty or jitter. The total rms noise voltage divided by the input signal slew rate (V/s) at the trigger point gives the rms time error for each threshold crossing. For simplicity  $T_E$  used in the Random Uncertainty calculations is the worst  $T_E$  of all the edges used in the measurement. RSS of all edge's  $T_E$  is an acceptable alternative.  $V_x$  is the cross talk from the other channel. Typically this is -60 dB. (Note: the best way to eliminate cross talk is to remove the signal from the other channel).

$$\text{For } 5v \frac{(500\mu V^2 + E_N^2 + V_x^2)^{1/2}}{SR_{TRIG POINT}}$$

$$\text{For } 50v \frac{(5000\mu V^2 + E_N^2 + V_x^2)^{1/2}}{SR_{TRIG POINT}}$$

## Threshold level timing error ( $T_{LTE}$ )

This time interval error results from trigger level setting errors and input hysteresis effects on the actual start and stop trigger points and results in a combined time interval error. These errors are dependant on the input signal slew rate at each trigger point.

$V_H = 20$  mV hysteresis or 40 mV when Noise Reject is turned ON. Double  $V_H$  values for frequencies  $> 100$  MHz.

$$\pm \frac{T_{LSE-start}}{SR_{-start}} \pm \frac{T_{LSE-stop}}{SR_{-stop}} \pm \left[ \frac{1/2 V_H}{SR_{-start}} - \frac{1/2 V_H}{SR_{-stop}} \right]$$

## Phase Noise and Allan Deviation

The input signal's jitter spectrum (Phase noise) and low-frequency wander characteristics (Allan variation) will limit the achievable measurement resolution and accuracy. The full accuracy and resolution of the counter can only be achieved when using a very high-quality input signal source or by externally filtering the input signal to reduce these errors.

## Threshold level setting error ( $T_{LSE}$ )

Threshold level setting error ( $T_{LSE}$ ) is the uncertainty in the actual signal threshold point due to the inaccuracies of the threshold circuitry.

$$\pm(0.2\% \text{-of setting} + 0.1\% \text{-of range})$$

## Slew rate (SR)

Slew rate (SR) describes the input signal's instantaneous voltage rate of change (V/s) at the chosen threshold point at customer BNC.

For sine wave signals, the maximum slew rate  $SR = 2\pi F * V_{0 \text{ to PK}}$

For Square waves and pulses, the max slew rate =  $0.8 V_{pp} / t_{RISE 10-90}$

Using the 100 KHz low pass filter will effect Slew Rate.

V/s (at threshold point)

## Signal noise ( $E_N$ )

The input signal rms noise voltage ( $E_N$ ) measured in a DC - 350 MHz bandwidth. The input signal noise voltage is rms combined with the instruments equivalent input noise voltage when used in the Threshold Error ( $T_E$ ) calculation.

# Ordering Information

## Model numbers

**53210A** 350 MHz, 10-digit/s RF Frequency Counter

**53220A** 350 MHz, 12 digit/s, 100 ps Universal Frequency Counter/Timer

**53230A** 350 MHz, 12-digit/s, 20 ps Universal Frequency Counter/Timer

## All models include:

- Shipping to your destination
- Certificate of Calibration and 1-year standard warranty
- IEC Power Cord, USB cable
- Documentation CD including Quick Reference Guide, Operating Guide, Programming Guide, and Example programs
- Agilent IO Library CD and IVI-COM instrument driver software

## Available options

Option 010	Ultra-high-stability OCXO timebase
Option 106	6 GHz microwave input
Option 115	15 GHz microwave input
Option 150	Pulse microwave measurements (53230A only)
Option 201	Add rear panel parallel inputs for baseband channels <sup>1</sup>
Option 202	Optional microwave input - front Type N (default if 106 or 115 ordered)
Option 203	Optional microwave input - rear panel SMA(f) connector
Option 300	Add internal lithium ion smart battery and charger
Option 400	Add GPIB interface

## Recommended accessories<sup>2</sup>

1250-1476	BNC(f) to type-N adapter
N2870A	Passive probe, 1:1, 35 MHz, 1.3 m
N2873A	Passive probe, 10:1, 500 MHz, 1.3 m
N2874A	Passive probe, 10:1, 1.5 GHz, 1.3 m
34190A	Rack mount kit
34191A	2U dual flange kit
34194A	Dual-lock link kit
34131A	Transit case

## Support options

- 3-year Extended warranty
- 5-year Extended warranty
- 3-year Annual calibration service
- 5-year Annual calibration service

- 1. When ordered with optional rear terminals, the standard/baseband channel inputs are active on both the front and rear of the universal counter though the specifications provided only apply to the rear terminals. Performance for the front terminals with rear terminal options is not specified.*
- 2. All probes must be compatible with a 20 pf input capacitance.*

## Appendix A - Worked Example

### Basic Accuracy Calculation for Frequency Measurement

**Parameter assumptions:**

- 53220A
- 95% Confidence
- 100MHz signal, 1sec gate
- AUTO
- Level: 5V
- OCXO standard timebase for unit plugged in for 30 days
- Assumes 100 samples per trigger taken

**Process:**

Basic Accuracy =  $k * (\text{Random Uncertainty} \pm \text{Systematic Uncertainty} \pm \text{Timebase Uncertainty})$

1. Use  $k=2$  for 95% confidence and  $k=2.5$  for 99% confidence calculations)..... $k = 2$

$$2. \text{ Random Uncertainty for Frequency Measurement} = \frac{1.4 * (T_{SS}^2 + T_E^2)^{1/2}}{R_E * \text{Gate Time}} = \frac{1.4 * (100\text{ps}^2 + .159\text{ps}^2)^{1/2}}{6 * 1} = \boxed{23.3 \text{ ps}}$$

$$T_{SS} = 100 \text{ ps}$$

$$T_E \text{ (for 5 V)} = \frac{(500 \mu\text{V}^2 + E_N^2 + Vx^2)^{1/2}}{SR_{\text{TRIG POINT}}} = \frac{(500 \mu\text{V}^2)^{1/2}}{3.14 * 10^9} = .159 \text{ ps}$$

$E_N$  = Assume input signal RMS noise voltage is 0.

$Vx$  = N/A (remove signal from other channel)

$SR_{\text{TRIG POINT}}$  = maximum slew rate (sine)  $SR = 2\pi F * V_{0 \text{ to PK}} = 2\pi(100 \text{ MHz}) * 5 \text{ V} = 3.14 * 10^9$

$R_E = 6$

Gate time = 1 sec

$$3. \text{ Systematic uncertainty for frequency measurement} = \text{If } RE \geq 2: 10^{-11} / \text{gate max, } 2 * 10^{-12} / \text{gate (typ)} = \boxed{2 \text{ ps}}$$

*Note: Typical is achieved with an average of 100 readings with 100 samples per trigger. Worst case is trigger and sample count set to 1.*

$$4. \text{ Timebase uncertainty} = (\text{aging} + \text{temperature} + \text{calibration uncertainty}) = (0.2 \text{ ppm} + 1 \text{ ppm} + 0.5 \text{ ppm}) = 1.7 \text{ ppm}$$

Aging: 0.2 ppm

Temperature: 1 ppm

Calibration uncertainty: 0.5 ppm

$$(10 \text{ MHz})(1.7 * 10^{-6}) = 17 \text{ Hz} = \boxed{58.8 \text{ ms}}$$

$$\text{Basic accuracy} = k * (\text{random uncertainty} \pm \text{systematic uncertainty} \pm \text{timebase uncertainty}) = 2(23.3 \text{ ps} \pm 2 \text{ ps} \pm 58.8 \text{ ms}) = .1176 \text{ s}$$

*Note: Using a higher accuracy timebase or locking to an external timebase standard will have the biggest impact on improvement to accuracy calculations.*



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