Section 1
General Information

Introduction

Description

The VX4223 Universal Counter/Timer is a microprocessor controlled instrument with high resolution measurement capabilities. The VX4223 is designed to be used under the control of a Slot 0 Resource Manager and conforms to the *VXIbus System Specification, Version 1.3. July 14, 1989.*

Measurement Capabilities

The VX4223 has the following measurement capabilities:

- Frequency A — frequency measurement up to 160 MHz using input A
- Frequency B — frequency measurement up to 100 MHz using input B
- Period A — period measurement from 6.25 ns — 1700 s using input A
- Period B — period measurement from 10 ns — 1700 s using input B
- Time Interval — time interval measurements in two modes:
  - Separate Mode — events at inputs A and B start and stop the measurement, respectively. Measurement from 5 ns — 800,000 s.
  - Common Mode — events at input A both start and stop the measurement. Measurement from 5 ns — 800,000 s.
- Total A by B — counts the number of events (up to 10^{12}) that occur at input A between events at input B
- Total B by A — up to 10^{12} events.
- Manual Totalize — counts the number of events (up to 10^{12}) between device dependent commands to open and close the counter gate
- Ratio $\frac{A}{B}$ — measures the ratio of the frequencies applied to inputs A and B
- Rise/Fall A — measures the rise or fall time (depending on the slope selected) of a signal at input A

- Pulse Width A — measures the interval between successive rising to falling or falling to rising edges (depending on the slope selected) of a signal at input A. Measurement from 5 ns — 20 ms.

- Phase A rel B — measures the phase difference between signals at inputs A and B

Additional Capabilities

In addition to the previously described measurement capabilities, the VX4223 has the following features:

- External Arming — An additional qualification of the trigger conditions of a measurement is provided by input D, or by the VXI Trigger bus. Arming conditions are selected by the use of special functions available in the alternate command set.

- External Frequency Standard Input — The VX4223 can be locked to an external reference applied to this input. The selection of the reference frequency is under software control.

- Math Function — When the math function is active, the VX4223 returns values of the form $\frac{(Result - X)\,Y}{Z}$, where Result = a measured value, and the values of X and Y are constants entered by the user.

- Averaging Mode — An additional digit of resolution is added to the VX4223 output in this mode. The averaging id done over 100 measurements.

- Check Mode — The Check mode allows the user to verify that the VX4223 is operating correctly. The capabilities of the Check mode can be extended by the use of special functions.

- Special Functions — The measurement and diagnostic capabilities of the VX4223 are extended by the special functions available in the alternate command set.

Input Signal Conditioning

The following signal conditioning capabilities are available to both input A and input B, independently:

- ac or dc coupling
- 1 MΩ or 50 Ω input impedances
- X1 or X10 input attenuations
- + or - slope triggering conditions
- Automatic or user-defined input trigger level setting. (The use of auto-trigger may cause the VX4223 to change the setting of the attenuation.)
- A switchable low pass filter that reduces the bandwidth of input A to 50 KHz (nominal)

Options

The following option is available for the VX4223:

- Option 1 — Input C. This option extends the frequency range of the VX4223 to 1.3 GHz. Input C has a fixed impedance of 50 Ω, and a bandwidth of 40 MHz — 1.3 GHz. This option also provides for a Ratio $\frac{C}{B}$ measurement.

Specifications

Table 1-1. Environmental

Characteristic	Performance Requirement
Temperature:	
Operating	0 — 50° C
Non-operating	-40 — +70° C

Table 1-2. Electrical

Characteristic	Performance Requirement
Maximum Current Required:	
+24 Vdc	200 mA
+5 Vdc	3.1 A
-5.2 Vdc	1.6 A

Table 1-3. Mechanical

Characteristic	Description
Dimensions:	
Height	261.62 mm (10.3")
Width	30.18 mm (1.188")
Depth	349.89 mm (13.775")
Weight	≈6.6 kg (3 lbs)

Table 1-4. Input

Note

Inputs A and B are available as front panel BNC connectors. Input A can also receive a signal from any one of the internal SUMBUS lines on the VXIbus Backplane.

Characteristic	Performance Requirement
Input A Frequency Range	dc coupled: dc —160 MHz ac coupled: 10 Hz — 160 MHz
Input B Frequency Range	dc coupled: dc — 100 MHz ac coupled: 10 Hz — 100 MHz
Input Impedance	1 MΩ or 50 Ω, selectable
Input Attenuation	X1 or X10, selectable
Sensitivity	
Sinewave (X1)	25 mV rms to 100 MHz 50 mV rms to 160 MHz
Pulse (X1)	75 mV_{pp}, at 5ns pulse width
Dynamic Range (X1)	36 db to 50 MHZ (75 mV_{pp} — 5 V_{pp}) 30 db to 100 MHz (75 mV_{pp} — 2.5 V_{pp}) 24 db to 160 MHz (150 mV_{pp} — 2.5 V_{pp})
Maximum Input	
50 Ω	5 V rms
1 MΩ	X1: 260 V (dc + ac rms), dc — 2 KHz, decreasing to 5 V rms at 100 KHz and above X10: 260 V (dc + ac rms), dc — 20 KHz, decreasing to 50 V rms at 100 KHz and above
Low Pass Filter	50 KHz (nominal), Input A only
Crosstalk	<-36 db between channels, measured at 100 MHz with 50 Ω input impedance
Input C (Option 1):	
Frequency Range	40 MHz — 1.3 GHz
Sensitivity (sinewave)	25 mV rms to 1 GHz 50 mV rms to 1.3 GHz
Dynamic Range	40 db to 1 GHz
Input Impedance	50 Ω (nominal)
VSWR	<2:1 at 1 GHz
Maximum Input	
Operating	1 V rms
Without damage	7 V rms

Table 1-5. Trigger

Characteristic	Performance Requirement
Trigger Level Range	X1: ±5.1 V in 20 mV steps (automatic or manual selection) X10: ±51 V in 200 mV steps (automatic or manual selection)
Trigger Level Accuracy	X1: ±1% of trigger level ±30 mV X10: ±1% of trigger level ±300 mV
Auto-trigger Minimum Amplitude	150 mV_{p-p}
Auto-trigger Level Accuracy	+5 through -4 V: ±30 mV relative to displayed reading -4 through -5.1 V: ±100 mv relative to displayed reading
Auto-trigger Frequency Range	dc, 50 Hz — 100 MHz (typically to 160 MHz)

Definitions

The following definitions apply to terms used in Table 1-6:

Trigger Error

$$\frac{SQR\ (e_i^{\,2} + e_n^{\,2})}{\text{Input slew rate at trigger point}}$$

where:
e_i = input amplifier rms noise (typically 150 µV, 450 µV maximum in a 160 MHz bandwidth)
e_n = input signal rms noise in a 160 MHz bandwidth

Trigger Level Timing Error

$$\pm\frac{\tfrac{1}{2}\ \text{Hysteresis Band}}{\text{Input Slew Rate at START Trigger Point}} + \frac{\text{Trigger Level Accuracy}}{\text{Input Slew Rate at STOP Trigger Point}}$$

Where:
Hysteresis Band is nominally 25 mV

Trigger Level Setting Error

$$\pm\frac{\text{Trigger Level Accuracy}}{\text{Input Slew Rate at START Trigger Point}} + \frac{\text{Trigger Level Accuracy}}{\text{Input Slew Rate at STOP Trigger Point}}$$

Differential Channel Delay Error

The difference in propagation times between signals applied to input A and B.

Time Base Error

The fractional deviation of the time base frequency from 10 MHz due to aging, temperature, voltage variations, etc.; determined by the reference frequency used by the VX4223 in the VXI Mainframe. The default reference frequency is the VXIbus CLK10 signal.

Resolution and Gate Time

Gate time is related to the resolution selected in the frequency, period, ratio, and check functions as follows:

Resolution (number of selected digits) in Frequency, Period, Ratio, and Check[a]	Gate Time
9 = overflow	10 s
9	1 s
8	100 ms
7	10 ms
6	1 ms
5[b]	1 ms
4[b]	1 ms
3[b]	1 ms

[a]The most significant digit is permitted to exceed the resolution by 1 digit, providing a 10% overrange. This precludes unnecessary shifting of digits.
[b]Measurements of frequency, period, ratio, and check are averaged when these gate times are set.

Gate time is also programmable in increments of 25.6 µs — 99.999 s. The default state is 100 ms Gate Time and 8 digits of resolution. Note that the Gate Time can be extended by:

- one period of the input signal on Frequency B and Ratio $\frac{A}{B}$.
- two periods of the input signal on Frequency A and Period A.

When setting the resolution by programming the number of digits, use the following formula to determine the value of the Least Significant Digit (LSD):

$LSD = F \times 10^{-D}$

Where:
F = Frequency
D = Number of digits rounded up to the next decade.

Gate Out

A TTL compatible signal coincident with the measurement gate is accessible to any one of the TTLTRG bus lines. The signal is low when the gate is open.

Miscellaneous

The resolution of phase and totalize is determined by the input signal.

Time interval, rise/fall time, and pulse width measurements have the resolution determined by both the input signal and the resolution set.

Resolution is programmable from 3 — 9 digits, but the minimum LSD that the counter will achieve is 1 ns, regardless of programmed gate time or resolution in time interval mode.

Table 1-6. Measurement

Characteristic	Performance Requirement
Frequency A & B	
Range	Input A: 6 x 10^{-4} Hz — 160 MHz Input B: 3 x 10^{-4} Hz — 100 MHz
Least Significant Digit (LSD)	$\frac{1\ ns}{Gate\ Time}$ x *Frequency*
Resolution	$\pm(2 \times LSD) \pm 1.4 \times \frac{Trigger\ Error}{Gate\ Time} \times Frequency$
Accuracy	±Resolution ±Timebase Error x Frequency
Frequency C (Option 1)	
Range	40 MHz — 1.3 GHz
Least Significant Digit (LSD)	$\frac{1\ ns}{Gate\ Time}$ x *Frequency*
Resolution	$\frac{1\ ns}{Gate\ Time}$ x *Frequency*
Accuracy	±Resolution ±Timebase Error x Frequency
Period A	
Range	6.25 ns — 1.7 x 10^3 s
Least Significant Digit (LSD)	$\frac{1\ ns}{Gate\ Time}$ x *Period*
Resolution	$\pm(2 \times LSD) \pm 1.4 \times \frac{Trigger\ Error}{Gate\ Time} \times Period$
Accuracy	±Resolution ±Timebase Error x Period
Time Interval	
Separate Inputs	Input A start / Input B stop Input B start / Input A stop
Common Inputs	Input A start / Input B stop
Range	- 2 ns — 8 x 10^5 s
Trigger Slopes	Start, + or - Stop, + or -
Least Significant Digit (LSD)	1 ns (100 ps with Average mode)
Resolution	±LSD ±1 ns ±Start Trigger Error ±Stop Trigger Error
Accuracy	±Resolution ±(Timebase Error x Time Interval) ±Trigger Level Setting Error
Totalize A by B	
Range	0 — 100 Mhz; 1 — 10^{12} - 1 events
Pulse Width	5 ns minimum at trigger points
Maximum Rate	10^8 events / s
Start / Stop	Input B
Least Significant Digit (LSD)	±1 count
Resolution	LSD
Accuracy	LSD

Table 1-6. Measurement (cont.)

Characteristic	Performance Requirement
Frequency Ratio $\frac{A}{B}$	
Range, Inputs A and B	dc — 100 MHz
Least Significant Digit (LSD)	$\frac{10 \times Ratio}{F_A \times Gate\ Time}$
Resolution	$\pm LSD \pm \frac{Trigger\ Error\ B}{Gate\ Time}$
Accuracy	$\pm LSD \pm \frac{Trigger\ Error\ B}{Gate\ Time}$
Frequency Ratio $\frac{C}{B}$ (Option 1)	
Input C	40 MHz — 1.3 GHz
Input B	dc — 100 MHz
Least Significant Digit (LSD)	$\frac{640 \times Ratio}{F_C \times Gate\ Time}$
Resolution	$\pm LSD \pm \frac{Trigger\ Error\ B}{Gate\ Time}$
Accuracy	$\pm LSD \pm \frac{Trigger\ Error\ B}{Gate\ Time}$
Rise / Fall Time	
Range	20 ns — 20 ms
Rise Time	Start: + slope, 10% trigger point Stop: + slope, 90% trigger point
Fall Time	Start: - slope, 90% trigger point Stop: - slope, 10 % trigger point
Input Channel	Input A
Minimum Pulse Height	500 mV_{pp}
Minimum Pulse Width	20 ns at signal peaks
LSD Displayed	1 ns (100 ps using Averaging mode)
Resolution	±LSD ±1 ns ±Start Trigger Error ±Stop Trigger Error
Accuracy	±Resolution ±Trigger Level Timing Error ±Trigger Level Setting Error at 10% Trigger Point ±Trigger Level Setting Error at 90% Trigger Point ±2 ns ± (Timebase Error x Rise / Fall Time)

Table 1-6. Measurements (cont.)

Characteristic	Performance Requirement
Pulse Width	
Range	5 ns — 20 ms
Positive Pulse Width	Start: + slope, 50% trigger point Stop: - slope, 50% trigger point
Negative Pulse Width	Start: - slope, 50% trigger point Stop: + slope, 50% trigger point
Input Channel	Input A
Minimum Pulse Height	150 mV_{pp}
Least Significant Digit (LSD)	1 ns (100 ps using Averaging mode)
Resolution	±LSD ±1 ns ±Start Trigger Error ±Stop Trigger Error
Accuracy	±Resolution ±Trigger Level Timing Error ±Trigger Level Setting Error ±2 ns ± (Timebase Error x Pulse Width)
Phase A rel B	
Range	0.10 — 360°
Least Significant Digit (LSD)	0.1° to 1 MHz 1° to 10 MHz 10° to 100 MHz
Resolution	$\pm LSD \pm \frac{TI\ Resolution \times 360°}{Period\ A}$
Time Interval Delay	
Time Interval	Programmable 200 µs — 800 ms
Resolution	25 µs
Accuracy	±50 µs ±0.1% of reading
Peak Signal Measurement	Indicates the peak maximum, peak minimum, or dc value of the measurement signal.
Frequency Range	dc, 50 Hz — 20 MHz (usable to 100 MHz)
Dynamic Range	150 mV — 51 V_{pp}
Resolution	X1: 20 mV
Accuracy (sinewave)	±6% of peak-to-peak voltage ±50 mV
Accuracy (dc)	±1% of reading ±40 mV
Averaging Mode	Can be applied to all functions except Totalize. Adds an extra digit of resolution.
Sample Size	100
Math	Can be applied to all counting/timing measurement functions except Trigger Level and Gate Time.
Result	$\frac{(Reading - X)\ Y}{Z}$ Where X, Y, and Z are constants entered by the user.
Constant Range	$\pm 1 \times 10^{-9}$ — $\pm 1 \times 10^{9}$

Table 1-6. Measurements (cont.)

Characteristic	Performance Requirement
Gate Time	
Range	200 µs — 99.9 s
Resolution	25.6 µs
External Standard Input	
Frequency	10 MHz
Level	Minimum, 100 mV rms; maximum, 10 V rms
Maximum Input Level	400 V peak to 500 Hz, decreasing to 10 V rms at ≥30 KHz
Impedance	1 KΩ (nominal) for signals < 1 V peak-to-peak, decreasing to 500 Ω (nominal) for signals 10 V peak-to-peak and above. ac coupled.
External Arming	
Applicability	All functions, except phase, pulse width, and rise/fall time
Input Signal	TTL, available from front panel BNC or eight TTLTRG lines, selected under program control
Arming Mode	1. Start - Off[a] Stop - Off[a] 2. Start - Positive Stop - Off[a] 3. Start - Negative Stop - Off[a] 4. Start - Positive Stop - Positive 5. Start - Negative Stop - Positive 6. Start - Positive Stop - Negative 7. Start - Negative Stop - Negative [a]Off state indicates the counter's internal arm/stop is used
Minimum Start/Stop Arm Period	100 ns