

## Chapter 17 Specifications

All the specifications are guaranteed except the parameters marked with “Typical” and the oscilloscope needs to operate for more than 30 minutes under the specified operation temperature.

### Sample

Sample Mode	Real-time sample
Real-time Sample Rate	Analog channel: 4.0 GSa/s (interweave); 2.0 Gsa/s (non-interweave)
	Digital channel: 1.0 Gsa/s
Peak Detect	Analog channel: 250 ps (interweave); 500 ps (non-interweave)
	Digital channel: 1 ns
Averaging	After all the channels finish N samples at the same time, N can be 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024, 2048, 4096 or 8192
High Resolution	when $\geq 5 \mu\text{s}/\text{div}$ @ 4 GSa/s (or $\geq 10 \mu\text{s}/\text{div}$ @ 2 GSa/s): 12 bit resolution
Minimum Detectable Pulse Width	Digital channel: 5 ns
Memory Depth	Analog channel: Auto, 14k pts, 140k pts, 1.4M pts, 14M pts and 140M pts (interweave); Auto, 7k pts, 70k pts, 700k pts, 7M pts and 70M pts (non-interweave)
	Digital channel: maximum 28M pts

## Input

Number of Channels	MSO40X4: 4-analog-channel + 16-digital-channel MSO40X2: dual-analog-channel + 16-digital-channel DS40X4: 4-channel DS40X2: dual-channel
Input Coupling	DC, AC or GND
Input Impedance	Analog channel: $(1\text{ M}\Omega \pm 1\%) \parallel (15\text{ pF} \pm 3\text{ pF})$ or $50\ \Omega \pm 1.5\%$ Digital channel: $(101\text{ k}\Omega \pm 1\%) \parallel (9\text{ pF} \pm 1\text{ pF})$
Probe Attenuation Coefficient	Analog channel: 0.01X to 1000X, in 1-2-5 step
Maximum Input Voltage (1 M $\Omega$ )	Analog channel: CAT I 300 Vrms, CAT II 100 Vrms, transient overvoltage 1000 Vpk with RP2200 10:1 probe: CAT II 300 Vrms with RP3300 10:1 probe: CAT II 300 Vrms with RP3500 10:1 probe: CAT II 300 Vrms with RP5600 10:1 probe: CAT II 300 Vrms Digital channel: CAT I 40 Vrms, transient overvoltage 800 Vpk

## Horizontal

Time Base Scale	MSO405X/DS405X: 1 ns/div to 1 ks/div MSO403X/DS403X: 2 ns/div to 1 ks/div MSO402X/DS402X: 2 ns/div to 1 ks/div MSO401X/DS401X: 5 ns/div to 1 ks/div
Deviation between Channels	1 ns (typical), 2 ns (maximum)
Max. Recording Length	140 Mpts
Time Base Accuracy <sup>[1]</sup>	$\leq \pm 4$ ppm
Clock Drift	$\leq \pm 2$ ppm/year
Delay Range	Pre-trigger (negative delay): $\geq 1$ screen width Post-trigger (positive delay): 1 s to 100 ks
Time Base Mode	Y-T, X-Y, Roll, Delayed
Number of X-Ys	2 paths at the same time (four-channel model)
Waveform Capture Rate <sup>[2]</sup>	110,000 wfms/s (digital channels are turned off, dots display) or 85,000 wfms/s (digital channels are turned on, dots display)
Zero Offset	$\pm 0.5$ div*minimum time base scale

## Vertical

Bandwidth (-3 dB) (50 $\Omega$ )	MSO405X/DS405X: DC to 500 MHz MSO403X/DS403X: DC to 350 MHz MSO402X/DS402X: DC to 200 MHz MSO401X/DS401X: DC to 100 MHz
Single Bandwidth (50 $\Omega$ )	MSO405X/DS405X: DC to 500 MHz MSO403X/DS403X: DC to 350 MHz MSO402X/DS402X: DC to 200 MHz MSO401X/DS401X: DC to 100 MHz
Vertical Resolution	Analog channel: 8 bits, two channels sample at the same time Digital channel: 1 bit
Vertical Scale	1 M $\Omega$ input impedance: 1 mV/div to 5 V/div 50 $\Omega$ input impedance: 1 mV/div to 1 V/div
Offset Range	1 M $\Omega$ input impedance: 1 mV/div to 225 mV/div: $\pm 2$ V 230 mV/div to 5 V/div: $\pm 40$ V 50 $\Omega$ input impedance: 1 mV/div to 124 mV/div: $\pm 1.2$ V 126 mV/div to 1 V/div: $\pm 12$ V
Dynamic Range	$\pm 5$ div
Bandwidth Limit <sup>[1]</sup>	MSO405X/DS405X: 20 MHz/100 MHz/200 MHz MSO403X/ DS403X: 20 MHz/100 MHz/200 MHz MSO402X/DS402X: 20 MHz/100 MHz MSO401X/DS401X: 20 MHz
Low Frequency Response (AC Coupling, -3 dB)	$\leq 5$ Hz (on BNC)
Calculated Rise Time <sup>[1]</sup>	MSO405X/DS405X: 700 ps MSO403X/DS403X: 1 ns MSO402X/DS402X: 1.8 ns MSO401X/DS401X: 3.5 ns
DC Gain Accuracy	$\pm 2\%$ full scale
DC Offset Accuracy	200 mV/div to 5 V/div: $\pm 0.1$ div $\pm 2$ mV $\pm 0.5\%$ offset

	1 mV/div to 195 mV/div: $\pm 0.1 \text{ div} \pm 2 \text{ mV} \pm 1.5\% \text{ offset}$
ESD Tolerance	$\pm 2 \text{ kV}$
Channel to Channel Isolation	DC to maximum bandwidth: $> 40 \text{ dB}$

## Vertical (Digital Channel) (MSO4000)

Threshold	adjustable threshold with 8 channels in 1 group
Level Type	TTL (1.4 V) 5.0 V CMOS (+2.5 V) 3.3 V CMOS (+1.65 V) 2.5 V CMOS (+1.25 V) 1.8 V CMOS (+0.9 V) ECL (-1.3 V) PECL (+3.7 V) LVDS (+1.2 V) 0 V User
Threshold range	$\pm 20.0 \text{ V}$ , with 10 mV step
Threshold accuracy	$\pm (100 \text{ mV} + 3\% \text{ of threshold setting})$
Dynamic range	$\pm 10 \text{ V} + \text{threshold}$
Min Voltage Swing	500 mVpp
Input Resistance	//101 k $\Omega$
Probe Load	$\approx 8 \text{ pF}$
Vertical resolution	1 bit

## Trigger

Trigger Level Range	CH1 to CH4: $\pm 6$ divs from center of the screen EXT: $\pm 0.8$ V
Trigger Mode	Auto, Normal, Single
Holdoff Range	100 ns to 10 s
High Frequency Rejection <sup>[1]</sup>	50 kHz
Low Frequency Rejection <sup>[1]</sup>	5 kHz

### Edge Trigger

Edge Type	Rising, Falling, Rising&Falling
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### Pulse Trigger

Pulse Condition	Positive Pulse Width (greater than, lower than, within specific interval); Negative Pulse Width (greater than, lower than, within specific interval)
Pulse Width Range	4 ns to 4 s

### Runt Trigger

Pulse Polarity	Positive, Negative
Qualifier	None, >, <, <>
Pulse Width Range	4 ns to 4 s

### Nth Edge Trigger

Edge Type	Rising, Falling
Idle Time	40 ns to 1 s
Number of Edges	1 to 65535

### Slope Trigger

Slope Condition	Positive Slope (greater than, lower than, within specific interval); Negative Slope (greater than, lower than, within specific interval)
Time Setting	10 ns to 1 s

### Video Trigger

Polarity	Positive, Negative
Synchrony	All Lines, Line Num, Odd Field, Even Field
Signal Standard	NTSC, PAL/ECAM, 480P, 576P, 720P, 1080P and 1080I

**Pattern Trigger**

Pattern Setting	H, L, X, Rising Edge, Falling Edge
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**RS232/UART Trigger**

Polarity	Normal, Invert
Trigger Condition	Start, Error, Check Error, Data
Baud	2400 bps, 4800 bps, 9600 bps, 19200 bps, 38400 bps, 57600 bps, 115200 bps, 230400 bps, 460800 bps, 921600 bps, 1Mbps, User
Data Bits	5 bits, 6 bits, 7 bits, 8 bits

**I2C Trigger**

Trigger Condition	Start, Restart, Stop, Missing ACK, Address, Data, A&D
Address Bits	7 bits, 8 bits, 10 bits
Address Range	0 to 127, 0 to 255, 0 to 1023
Byte Length	1 to 5

**SPI Trigger**

Trigger Condition	CS (Chip Select), Timeout
Timeout Value	100 ns to 1 s
Data Bits	4 bits to 32 bits
Data Line Setting	H, L, X
Clock Edge	Rising Edge, Falling Edge

**CAN Trigger**

Signal Type	Rx, Tx, CAN_H, CAN_L, Differential
Trigger Condition	SOF, EOF, Frame Type, Frame Error
Baud	10 kbps, 20 kbps, 33.3 kbps, 50 kbps, 62.5 kbps, 83.3 kbps, 100 kbps, 125 kbps, 250 kbps, 500 kbps, 800 kbps, 1 Mbps, User
Sample Point	5% to 95%
Frame Type	Data, Remote, Error, OverLoad
Error Frame Type	Bit Fill, Answer Error, Check Error, Format Error, Random Error

**FlexRay Trigger**

Baud	2.5 Mb/s, 5 Mb/s, 10 Mb/s
Trigger Condition	Frame, Symbol, Error, TSS

**USB Trigger**

Signal Speed	Low Speed, Full Speed
Trigger condition	SOP, EOP, RC, Suspend, Exit Suspend

## Measure

Cursor	<p>Manual Mode: voltage deviation between cursors (<math>\Delta V</math>), time deviation between cursors (<math>\Delta T</math>), reciprocal of <math>\Delta T</math> (Hz) (<math>1/\Delta T</math>)</p> <p>Track Mode: voltage and time values of the waveform point</p> <p>Auto Mode: allow to display cursors during auto measurement</p>
Auto Measurement	<p>Analog channel:          Measurements of Maximum, Minimum, Peak-Peak Value, Top Value, Bottom Value, Amplitude, Average, Vrms-N, Vrms-1, Overshoot, Pre-shoot, Area, Period Area, Period, Frequency, Rise Time, Fall Time, Positive Pulse Width, Negative Pulse Width, Positive Duty Cycle, Negative Duty Cycle, Delay <math>A_f \rightarrow B_f</math>, Delay <math>A_t \rightarrow B_t</math>, Delay <math>A_f \rightarrow B_t</math>, Delay <math>A_t \rightarrow B_f</math>, Phase <math>A_f \rightarrow B_f</math>, Phase <math>A_t \rightarrow B_t</math>, Phase <math>A_f \rightarrow B_t</math>, Phase <math>A_t \rightarrow B_f</math></p> <p>Digital channel:          Frequency, Period, Positive Pulse Width, Negative Pulse Width, Positive Duty Cycle, Negative Duty Cycle, Delay <math>A_f \rightarrow B_f</math>, Delay <math>A_t \rightarrow B_t</math>, Delay <math>A_f \rightarrow B_t</math>, Delay <math>A_t \rightarrow B_f</math>, Phase <math>A_f \rightarrow B_f</math>, Phase <math>A_t \rightarrow B_t</math>, Phase <math>A_f \rightarrow B_t</math>, Phase <math>A_t \rightarrow B_f</math></p>
Number of Measurements	Display 5 measurements at the same time.
Measurement Range	Screen region, cursor region
Statistic Mode	Extremum, difference
Measurement Statistic	average, max, min, standard deviation, number of measurements
Frequency Counter	Hardware 6 bits frequency counter (channels are selectable)



## Math Operation

Waveform Operation	A+B, A-B, A×B, A÷B, FFT, Digital Filter, logic operation, editable advanced operation
FFT Window	Rectangle, Hanning, Hamming, Blackman
FFT Display	Split, Full Screen
FFT Vertical Scale	Vrms, dB
Logic Operation	AND, OR, NOT, XOR
Math Function	Intg, Diff, Lg, Ln, Exp, Abs, Square, Sqrt, Sine, Cosine, Tangent

## Decoding

Number of Buses	2
Decoding Type	Parallel (standard), RS232/UART (option), I2C (option), SPI (option), CAN (option), FlexRay (option)
Parallel	Combine the sample data of the source channel waveforms as a parallel multi-channel bus and display the data as a single bus value
RS232/UART	Display the input signal(s) of the TX source channel or/and RX source channel as bus
I2C	Display the input signal of the SDA source channel as bus
SPI	Display the input signal(s) of the MISO source channel or/and MOSI source channel as bus
CAN	Display the input signal of the source channel (Rx, Tx, CAN_H, CAN_L or differential) as bus
FlexRay	Display the input signal of the source channel (BP, BM or RX/TX) as bus

## Display

Display Type	9 inches (229 mm) TFT LCD display
Display Resolution	800 horizontal ×RGB×480 vertical pixel
Display Color	160,000 color
Persistence Time	Min, 50 ms, 100 ms, 200 ms, 500 ms, 1 s, 2 s, 5 s, 10 s, 20 s, Infinite
Display Type	Dots, Vectors
Real-time Clock	Time and date (user adjustable)

## I/O

Standard Ports	Dual USB HOST, USB DEVICE, LAN, VGA Output, 10 MHz Input/Output, Aux Output (TrigOut, Fast, PassFail, GND)
Printer Compatibility	PictBridge

## General Specifications

<b>Probe Compensation Output</b>		
Output Voltage <sup>[1]</sup>	About 3 V, peak-peak	
Frequency <sup>[1]</sup>	1 kHz	
<b>Power</b>		
Power Voltage	100 to 127 V, 45 to 440Hz 100 to 240 V, 45 to 65Hz	
Power	Maximum 120 W	
Fuse	3 A, T Degree, 250 V	
<b>Environment</b>		
Temperature Range	Operating: 0°C to +50°C	
	Non-operating: -40°C to +70°C	
Cooling Method	Fan	
Humidity Range	0°C to +30°C: ≤95% relative humidity	
	+30°C to +40°C: ≤75% relative humidity	
	+40°C to +50°C: ≤45% relative humidity	
Altitude	Operating: under 3,000 meters	
	Non-operating: under 15,000 meters	
<b>Physical Characteristics</b>		
Size <sup>[3]</sup>	Width×Height×Depth = 440.0 mm× 218.0 mm×130.0 mm	
Weight	Package Excluded	4.8 kg ± 0.2 kg
	Package Included	7.1 kg ± 1.0 kg
<b>Adjustment Interval</b>		
The recommended calibration interval is one year.		
<b>Regulatory Information</b>		
Electromagnetic Compatibility	2004/108/EC Execution standard EN 61326-1:2006 EN 61326-2-1:2006	
Safety	UL 61010-1:2004; CAN/CSA-C22.2 NO. 61010-1-2004; EN 61010-1:2001; IEC 61010-1:2001	

**Note<sup>[1]</sup>:** Typical value.

**Note<sup>[2]</sup>:** Maximum value. Interweave, sine signal with 10 ns horizontal time base, 4 divs input amplitude and 10 MHz frequency, edge trigger.

**Note<sup>[3]</sup>:** Supporting legs and handle folded, knob height included, front panel cover excluded.