TELEDYNE LECROY
Everywhereyoulook™

HRO™ 12-bit
High Resolution Oscilloscopes

Unmatched Signal Fidelity and Excellent Measurement Precision

12-BIT HIGH RESOLUTION OSCILLOSCOPE

Features

- **12-bit ADC resolution up to 15-bit with ERES**
- **400 MHz and 600 MHz models**
- **256 Mpts/Ch**
- **±0.5% F.S. DC gain accuracy**
- **55 dB SNR**
- **1 mV vertical Sensitivity @ full bandwidth**
- **Up to ±400 V offset capability**
- **20 MHz, 100 MHz, 200 MHz, 350 MHz filters for additional noise filtering**

HRO 12-bit

The HRO™ 12-bit features an industry leading 12-bit Analog to Digital Convertor (ADC), deep memory of 256 Mpts/Ch, and superior DC accuracy specifications. These features are in addition to the extensive analysis features of the WaveRunner 6 Zi. Engineers no longer have to compromise high resolution for deep analysis.

ADC Resolution	Number of Steps	Dynamic Range
8	**256**	**48 dB**
12	**4096**	**72 dB**

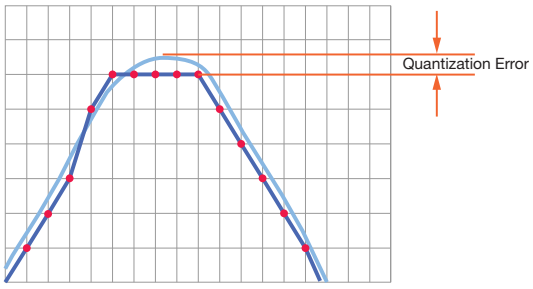
Resolution refers to the number of levels available.
Number of levels = $2^{\text{bits of resolution}}$

Designed for the medical, automotive, power, and electro-mechanical markets, the HRO 12-bit has higher resolution and measurement precision than 8-bit alternatives. Traditional oscilloscopes use 8-bit ADCs to digitize the data, which is not enough for many applications that require viewing signals with both a large and small voltage component. The reduced noise and improved resolution of the 12-bit ADC architecture provides finer measurement accuracy and better waveform clarity. This can be seen with the superb 55 dB signal to noise ratio (SNR) and ±0.5% DC vertical gain accuracy, which is up to four times better than typical 8-bit oscilloscopes.

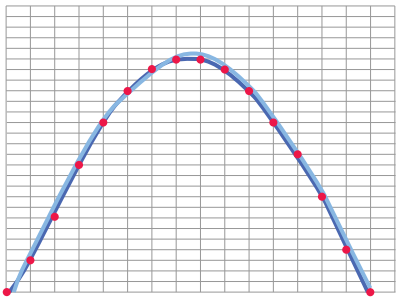
Full Scale	Smallest Voltage Step 8-bits	12-bits
80 V	312.5 mV	19.5 mV
40 V	156.2 mV	9.76 mV
20 V	78.1 mV	4.88 mV
8 V	31.3 mV	1.95 mV
4 V	15.6 mV	976 µV
1.6 V	6.3 mV	390 µV
800 mV	3.1 mV	195 µV
400 mV	1.56 mV	97.6 µV
160 mV	625 µV	39 µV
80 mV	313 µV	19.5 µV
40 mV	156 µV	9.76 µV
16 mV	62.5 µV	3.9 µV
8 mV	31.2 µV	1.95 µV

16 Times More Resolution

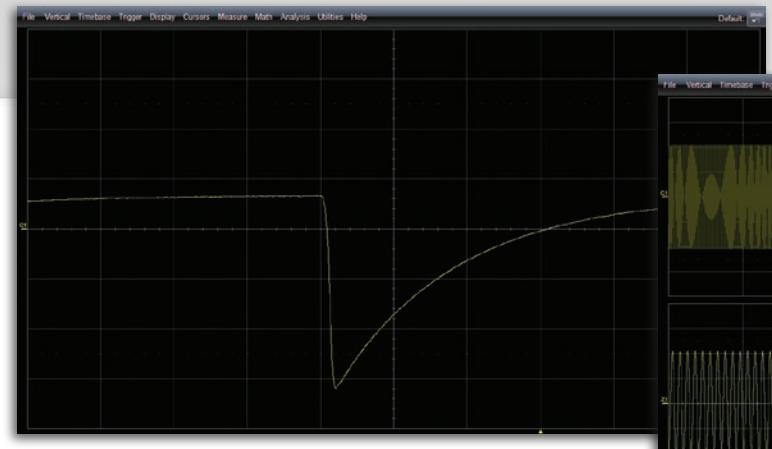
12-bits of vertical resolution provides sixteen times more resolution than 8-bits. The 4096 discrete levels reduce the quantization error and improve the voltage accuracy. The difference in accuracy is shown below. The lower resolution waveform shows a higher level of quantization error, while the higher resolution waveform shows a more accurate representation of the actual waveform.



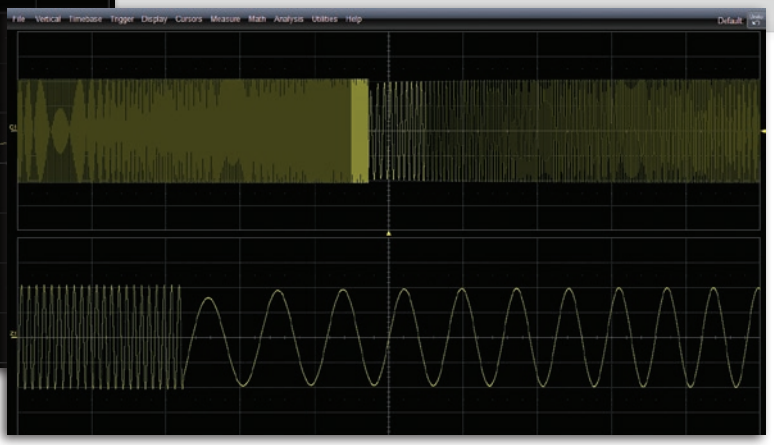
Lower resolution



Higher resolution



Capture a fast transient signal at the highest sample rate for the best resolution.



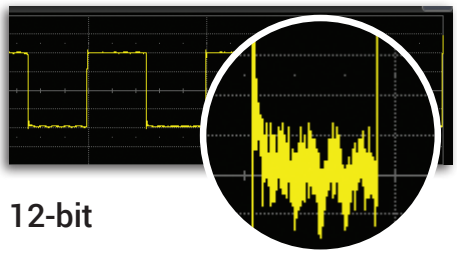
Capture up to 30 seconds of data at sample rates as high as 10 MS/s for trending and searching for events.

256 Mpts/Ch Deep Memory

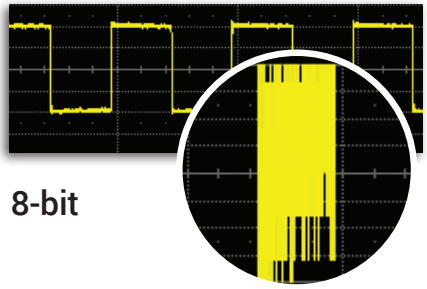
High resolution applications typically require a very long acquisition, capturing up to 30 seconds of data to detect very slow or gradual changes. The 2 GS/s, 256 Mpts/Ch architecture provides the ability to capture a fast transient or a long acquisition.

12-bit High Resolution

A common application for high resolution products is the ability to view a small amplitude signal within a larger voltage signal. The 4096 discrete amplitude levels and 55 dB SNR of the HRO 12-bit can detect much smaller voltage signals with more clarity than an 8-bit oscilloscope.



12-bit



8-bit

HRO 12-bit Analysis Tools

Conventional high resolution products have very limited analysis tools, such as FFT, math, measurements, and triggers. The HRO 12-bit offers a full suite of analysis tools to address the most challenging test needs.

Most Complete Serial Data Test Solutions

18/36 Ch. Mixed-Signal Solutions

Spectrum Analysis

16 Multiple Grids

Pass Fail Testing

Power Analysis

JitKit Clock Jitter Analysis

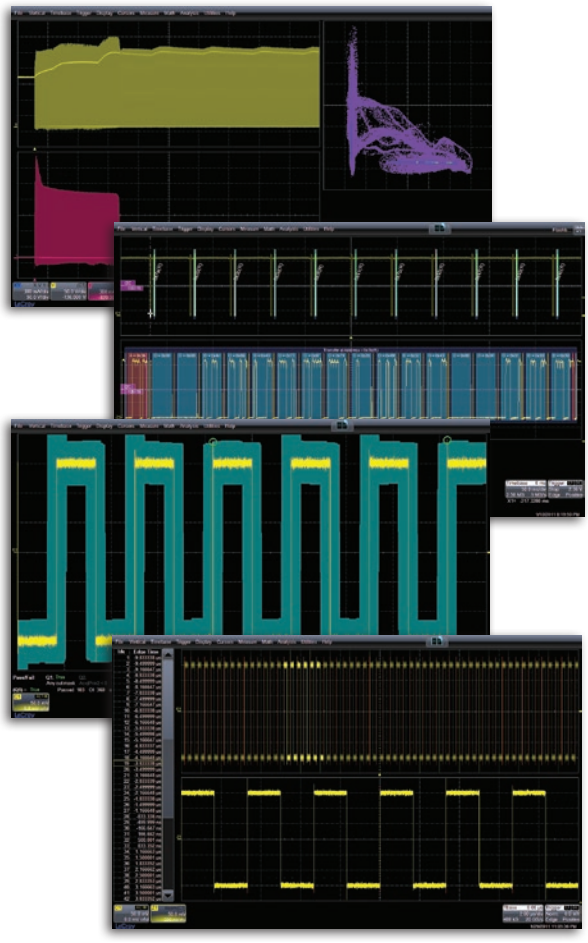
History Mode

Measurement Trigger

WaveScan

Full Customization with XDEV

TriggerScan – Rare Event Capture



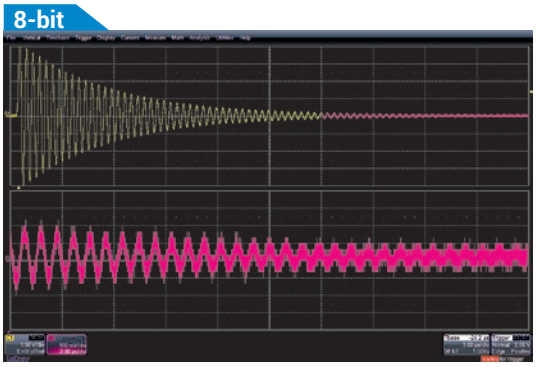
8-BIT VS. 12-BIT EXAMPLES

See All Your Signal Details with Unmatched Accuracy and up to 15-bit Resolution

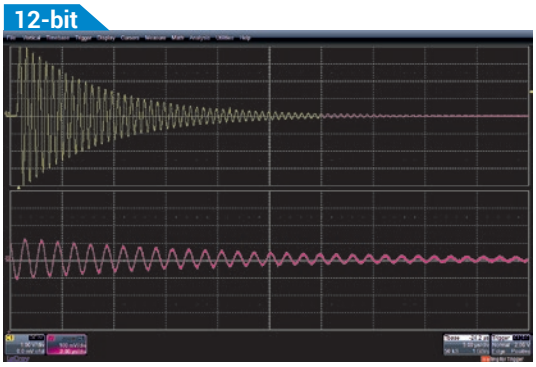
Detecting a small voltage signal on a large signal

- A common application is to measure small signal details in a large voltage signal.
- The damped sine wave starts at a high amplitude and ends at zero.
- The zoomed waveforms clearly show the benefit of the higher resolution oscilloscope where the shape of the sine wave is visible until the very end.

8-bit



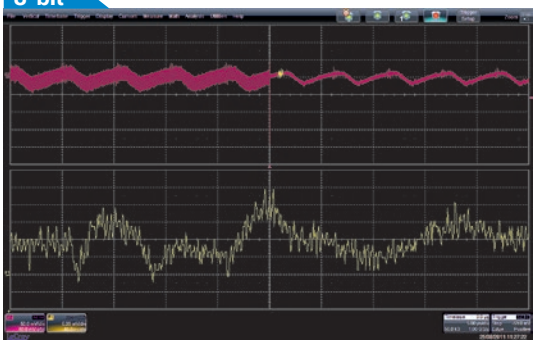
12-bit



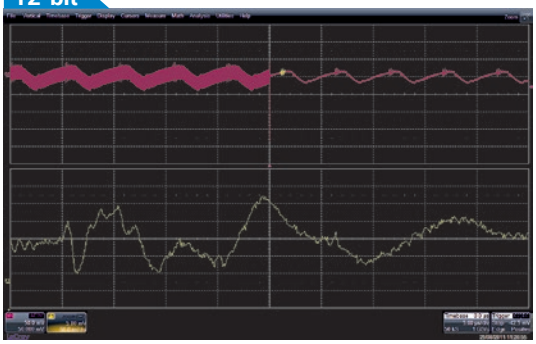
Switched Mode Power Supplies

- Switched mode power supplies are widely used due to their high efficiency, low cost and small size.
- The images show the output of an example power supply subjected to a small load step.
- The 8-bit scope displays the step in the output but only the 12-bit scope shows the high frequency oscillation in detail.

8-bit



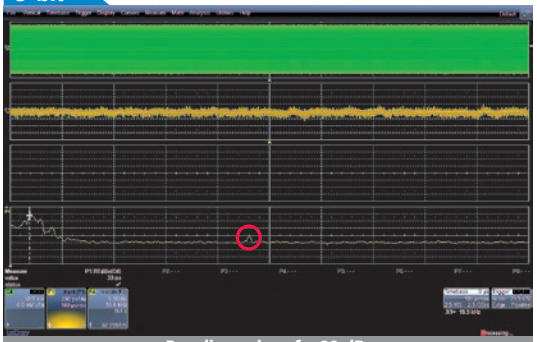
12-bit



Phase Noise Measurement

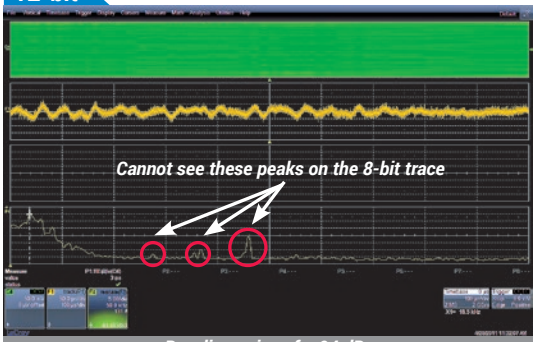
- Details of important components are completely missing on the left 8-bit screenshot.
- Notice how low the floor is on the 12-bit trace compared to the 8-bit.

8-bit



Baseline noise of – 82 dBc

12-bit



Baseline noise of – 94 dBc

SPECIFICATIONS

Vertical System

	HRO 64Zi	HRO 66Zi
Analog Bandwidth @ 50 Ω (-3 dB)	400 MHz	600 MHz
Analog Bandwidth @ 1 MΩ (-3 dB)	400 MHz (typical)	500 MHz (typical)
Rise Time (10–90%, 50 Ω)	875 ps (typical)	625 ps (typical)
Rise Time (20–80%, 50 Ω)	650 ps (typical)	435 ps (typical)
Input Channels	4	
Bandwidth Limiters	20 MHz, 100 MHz, 200 MHz	20 MHz, 100 MHz, 200 MHz, 350 MHz
Input Impedance	50 Ω ±2% or 1 MΩ || 17pF, 10 MΩ || 9.5 pF with supplied Probe	
Input Coupling	1 MΩ: AC, DC, GND; 50 Ω: DC, GND	
Maximum Input Voltage	50 Ω: 5 V_{rms} ±10 V peak 1 MΩ: 400 V max. (DC + peak AC < 10 kHz)	
Channel-Channel Isolation	> 300:1	
Vertical Resolution	12-bits; up to 15-bits with enhanced resolution (ERES)	
Sensitivity	50 Ω: 1 mV/div–1 V/div, fully variable 1 MΩ: 1 mV/div–10 V/div, fully variable	
DC Vertical Gain Accuracy (Gain Component of DC Accuracy)	±(0.5%) F.S, offset at 0 V	
Offset Range	**50 Ω:** ±1.6 V @ 1 mV– 4.95 mV ±4 V @ 5 mV–9.9 mV ±8 V @ 10 mV–19.8 mV ±10 V @ 20 mV–1 V **1 MΩ:** ±1.6 V @ 1 mV–4.95 mV ±4 V @ 5 mV–9.9 mV ±8 V @ 10 mV–19.8 mV ±16 V @ 20 mV–100 mV ±80 V @ 102 mV–198 mV ±160 V @ 200 mV–1 V ±400 V @ 1.02 V–10 V	
DC Vertical Offset Accuracy	±(1% of offset setting + 0.2% F.S. + 0.02% max offset + 1 mV)	

Horizontal System

Timebases	Internal timebase common to 4 input channels; an external clock may be applied at the auxiliary input	
Time/Division Range	Real-Time: 20 ps/div–1000 s/div; RIS mode: 20 ps/div–10 ns/div; Roll mode: up to 1000 s/div (roll mode is user selectable at ≥ 100 ms/div and ≤ 5 MS/s	
Clock Accuracy	≤ 1.5 ppm +(aging of 1.0 ppm/yr from last calibration)	
Trigger and Interpolator Jitter	≤ 6 ps_{rms} (typical) < 1.0 ps_{rms} (typical, software assisted)	≤ 5.5 ps_{rms} (typical) < 1.0 ps_{rms} (typical, software assisted)
Channel-Channel Deskew Range	±9 x time/div. setting, 100 ms max., each channel	
External Timebase Reference (Input)	10 MHz ±25 ppm via LBUS BNC adapter	
External Timebase Reference (Output)	10 MHz 3.5 dBm ±1 dBm, synchronized to reference being used by user (internal or external reference) via LBUS BNC adaptor	
External Clock	DC to 100 MHz; (50 Ω/1 MΩ), Ext. BNC input, Minimum rise time and amplitude requirements apply at low frequencies	

SPECIFICATIONS

	HRO 64Zi	HRO 66Zi
Acquisition System		
Single-Shot Sample Rate/Ch	2 GS/s on 4 Ch	
Random Interleaved Sampling (RIS)	100 GS/s, user selectable for repetitive signals (20 ps/div to 10 ns/div)	
Maximum Trigger Rate	500,000 waveforms/second (in Sequence Mode, up to 4 channels)	
Intersegment Time	2 µs	
Max. Acquisition Memory Points/Ch	L-128 Option: 128M XL-256 Option: 256M	
Standard Memory (4 Ch / 2 Ch / 1 Ch) (Number of Segments)	64M (30,000)	
Memory Options (4 Ch / 2 Ch / 1 Ch) (Number of Segments)	L-128 Option: 128M (60,000) XL-256 Option: 256M (65,000)	
Acquisition Processing		
Averaging	Summed averaging to 1 million sweeps; continuous averaging to 1 million sweeps	
Enhanced Resolution (ERES)	From 12.5- to 15-bits vertical resolution	
Envelope (Extrema)	Envelope, floor, or roof for up to 1 million sweeps	
Interpolation	Linear or Sin x/x	
Triggering System		
Modes	Normal, Auto, Single, and Stop	
Sources	Any input channel, Ext, Ext/10, or line; slope and level unique to each source (except line trigger)	
Coupling Mode	DC, AC, HFRej, LFRej	
Pre-trigger Delay	0–100% of memory size (adjustable in 1% increments or 100 ns)	
Post-trigger Delay	0–10,000 divisions in real time mode, limited at slower time/div settings or in roll mode	
Hold-off by Time or Events	From 2 ns up to 20 s or from 1 to 99,999,999 events	
Internal Trigger Range	±4.1 div from center (typical)	
Trigger Sensitivity with Edge Trigger (Ch 1–4)	2 div @ < 400 MHz 1.5 div @ < 200 MHz 0.9 div @ < 10 MHz (DC, AC, and LFRej coupling)	2 div @ < 600 MHz 1.5 div @ < 300 MHz 1 div @ < 200 MHz 0.9 div @ < 10 MHz (DC, AC, and LFRej coupling)
External Trigger Sensitivity, (Edge Trigger)	2 div @ < 600 MHz 1.5 div @ < 300 MHz 1 div @ < 200 MHz 0.9 div @ < 10 MHz (DC, AC, and LFRej coupling)	
Max. Trigger Frequency, SMART Trigger	400 MHz @ ≥ 10 mV/div 1.9 ns (minimum triggerable width 1.9 ns)	600 MHz @ ≥ 10 mV/div 1.2 ns (minimum triggerable width 1.2 ns)
External Trigger Input Range	Ext (±0.4 V); Ext/10 (±4 V)	
Basic Triggers		
Edge	Triggers when signal meets slope (positive, negative, or either) and level condition	
Window	Triggers when signal exits a window defined by adjustable thresholds	
TV-Composite Video	Triggers NTSC or PAL with selectable line and field; HDTV (720p, 1080i, 1080p) with selectable frame rate (50 or 60 Hz) and Line; or CUSTOM with selectable Fields (1–8), Lines (up to 2000), Frame Rates (25, 30, 50, or 60 Hz), Interlacing (1:1, 2:1, 4:1, 8:1), or Synch Pulse Slope (Positive or Negative)	
SMART Triggers		
State or Edge Qualified	Triggers on any input source only if a defined state or edge occurred on another input source. Delay between sources is selectable by time or events	
Qualified First	In Sequence acquisition mode, triggers repeatably on event B only if a defined pattern, state, or edge (event A) is satisfied in the first segment of the acquisition. Holdoff between sources is selectable by time or events	
Dropout	Triggers if signal drops out for longer than selected time between 1 ns and 20 s	
Pattern	Logic combination (AND, NAND, OR, NOR) of 5 inputs (4 channels and external trigger input. Each source can be high, low, or don't care. The High and Low level can be selected independently. Triggers at start or end of the pattern	

SPECIFICATIONS

	HRO 64Zi & HRO 66Zi
SMART Triggers with Exclusion Technology	
Glitch	Triggers on positive or negative glitches with widths selectable as low as 200 ps (depending on oscilloscope bandwidth) to 20 s, or on intermittent faults
Width (Signal or Pattern)	Triggers on positive or negative glitches with widths selectable as low as 200 ps (depending on oscilloscope bandwidth) to 20 s, or on intermittent faults
Interval (Signal or Pattern)	Triggers on intervals selectable between 1 ns and 20 s
Timeout (State/Edge Qualified)	Triggers on any source if a given state (or transition edge) has occurred on another source. Delay between sources is 1 ns to 20 s, or 1 to 99,999,999 events
Runt	Trigger on positive or negative runts defined by two voltage limits and two time limits. Select between 1 ns and 20 ns
Slew Rate	Trigger on edge rates. Select limits for dV, dt, and slope. Select edge limits between 1 ns and 20 ns
Exclusion Triggering	Trigger on intermittent faults by specifying the expected behavior and triggering when that condition is not met
Measurement Trigger	
	Trigger on measurement values, Edge, Serial Pattern, Bus Pattern, Non-monotonic
Cascade (Sequence) Triggering	
Capability	Arm on "A" event, then Trigger on "B" event. Or Arm on "A" event, then Qualify on "B" event, and Trigger on "C" event. Or Arm on "A" event, then Qualify on "B" then "C" event, and Trigger on "D" event
Types	A, B, C, or D event: Edge, Glitch, Width, Window, Dropout, Interval, Runt, Slew Rate, or Pattern (analog), Measurement Trigger
Holdoff	Holdoff between A and B, B and C, C or D, or any is selectable by time or number of events
Reset	Reset between A and B, B and C, C and D, or any combination is selectable in time or number of events
Color Waveform Display	
Type	Color 12.1" widescreen flat panel TFT-Active Matrix with high resolution touch screen
Resolution	WXGA; 1280 x 800 pixels
Number of Traces	Display a maximum of 8 traces. Simultaneously display channel, zoom, memory and math traces
Grid Styles	Auto, Single, Dual, Quad, Octal, X-Y, Single+X-Y, Dual+X-Y
Waveform Representation	Sample dots joined, or sample dots only
Processor/CPU	
Type	Intel® E5300 Pentium Dual Core 2.6 GHz or greater
Processor Memory	4 GB standard
Operating System	Microsoft Windows® 7 Professional for Embedded Systems, 64-bit
Real Time Clock	Date and time displayed with waveform in hardcopy files. SNTP support to synchronize to precision internal clocks
Power Requirements	
Voltage	100–240 VAC ±10% at 45–66 Hz; 100–120 VAC ±10% at 380–420 Hz; Automatic AC Voltage Selection; Installation Category: 300 V CAT II
Power Consumption (Nominal)	325 W / 325 VA
Max Power Consumption	425 W / 425 VA (with all PC peripherals, active probes connected to 4 channels, and MSO active)
Environmental	
Temperature (Operating)	+5 °C to +40 °C
Temperature (Non-Operating)	–20 °C to +60 °C
Humidity (Operating)	5% to 80% relative humidity (non-condensing) up to +31 °C Upper limit derates to 50% relative humidity (Non-condensing) at +40 °C
Humidity (Non-Operating)	5% to 95% relative humidity (non-condensing) as tested per MIL-PRF-28800F
Altitude (Operating)	Up to 10,000 ft. (3,048 m) at or below +25 °C
Random Vibration (Operating)	0.31 g_{rms} 5 Hz to 500 Hz, 15 minutes in each of three orthogonal axes
Random Vibration (Non-Operating)	2.4 g_{rms} 5 Hz to 500 Hz, 15 minutes in each of three orthogonal axes
Functional Shock	30 g_{peak}, half sine, 11 ms pulse, 3 shocks (positive and negative) in each of three orthogonal axes, 18 shocks total
Physical Dimensions	
Dimensions (HWD)	11.6929" H x 16.4567" W x 8.937" D (297 x 418 x 227 mm)
Weight	25.4 lbs. (11.52 kg)
Shipping Weight	36 lbs. (16.36 kg)
Certifications	
	CE Compliant, UL and cUL listed; Conforms to EN 61326-1, EN 61010-1, UL 61010-1 2nd edition, and CSA C22.2 No. 61010-1-04

ORDERING INFORMATION

Product Description	Product Code
HRO 12-bit Oscilloscopes	
400 MHz, 2 GS/s, 4 Ch, 64 Mpts/Ch 12-bit DSO with 12.1" WXGA Color Display	WaveRunner HRO 64Zi
600 MHz, 2 GS/s, 4 Ch, 64 Mpts/Ch 12-bit DSO with 12.1" WXGA Color Display	WaveRunner HRO 66Zi
Memory Options	
64 Mpts/Ch Standard Memory. Includes 4 GB of RAM	WR6Zi-HRO-STD
128 Mpts/Ch Memory. Includes 4 GB of RAM.	WR6Zi-HRO-L-128
256 Mpts/Ch Memory. A Includes 4 GB of RAM	WR6Zi-HRO-XL-256
Oscilloscope Synchronization	
8 Channel Simultaneous Acquisition-Capture Between two HRO 6 Zi Oscilloscopes	WR6Zi-8CH-Synch
Serial Trigger and Decode	
8b/10b Trigger and Decode Option	WR6Zi-80B-8B10B TD
ARINC 429 Bus Symbolic Decode Option	WR6Zi-ARINCbus DSymbolic
Audiobus Trigger and Decode for I²S, Option LJ, RJ, and TDM	WR6Zi-Audiobus TD
Audiobus Trigger, Decode, and Graph Option for I²S, LJ, RJ, and TDM	WR6Zi-Audiobus TDG
CANbus TD Trigger and Decode Option	WR6Zi-CANbus TD
CANbus TDM Trigger, Decode and Measure/Graph Option	WR6Zi-CANbus TDM
Decode Annotation and Protocol Analyzer Synchronization Software Option	WR6Zi-ProtoSync
Digital Filter Software Package	WR6ZI-DFP
DigRF 3G Decode Option	WR6Zi-DigRF3Gbus D
DigRF v4 Decode Option	WR6Zi-DigRFv4bus D
ENET Decode Option	WR6Zi-ENETbus D
FlexRay Trigger and Decode Option	WR6Zi-FlexRaybus TD
FlexRay Trigger, Decode, and Physical Layer Test Option	WR6Zi-FlexRaybus TDP
I²C, SPI and UART Trigger and Decode Option	WR6Zi-EMB
LIN Trigger and Decode Option	WR6Zi-LINbus TD
Manchester Decode Option	WR6Zi-Manchesterbus D
MIL-STD-1553 Trigger and Decode Option	WR6Zi-1553 TD

Product Description	Product Code
Serial Trigger and Decode (cont'd)	
MIPI D-PHY Decode Option	WR6Zi-DPHYbus D
MIPI D-PHY Decode and Physical Layer Test Option	WR6Zi-DPHYbus DP
MIPI M-PHY Decode Option	WR6Zi-MPHYbus D
MIPI M-PHY Decode and Physical Layer Option	WR6Zi-MPHYbus DP
MS-500-36 with I²C, SPI and UART Trigger and Decode Option	WR6Zi-MSO-EMB
NRZ Decode Option	WR6Zi-NRZbus D
PROTObus MAG Serial Debug Toolkit	WR6Zi-PROTObus MAG
SENT Bus Decode Option	WR6ZI-SENTBUS D
UART and RS-232 Trigger and Decode Option	WR6Zi-UART-RS232bus TD
USB 1.x/2.0 Trigger/Decode Option	WR6Zi-USB2bus TD
USB2-HSIC Decode Option	WR6Zi-USB20HSICbus D
Vehicle Bus Analyzer Package - Includes CANBus TDM, FlexRay TDP, LINBus TD, and ProtoBus MAG	WR6Zi-VBA
Mixed Signal Solutions	
250 MHz, 1 GS/s, 18 Ch, 10 Mpts/Ch Mixed Signal Oscilloscope Option	MS-250
500 MHz, 2 GS/s, 18 Ch, 50 Mpts/Ch Mixed Signal Oscilloscope Option	MS-500
250 MHz, 1 GS/s, 36 Ch, 25 Mpts/Ch (500 MHz, 18 Ch, 2 GS/s, 50 Mpts/Ch Interleaved) Mixed Signal Oscilloscope Option	MS-500-36
Power Analysis Software	
Power Analyzer Option	WR6Zi-PWR
Jitter Analysis Software	
Clock Jitter Analysis with Four Views Software Option	WR6Zi-JITKIT
Other Software Options	
Advanced Customization Option	WR6Zi-XDEV
Spectrum Analyzer Software Option	WR6Zi-SPECTRUM
EMC Pulse Parameter Software Option	WR6Zi-EMC
Electrical Telecom Mask Test Software Option	WR6Zi-ET-PMT
Warranty and Service	
3-year warranty; calibration recommended annually. Optional service programs include extended warranty, upgrades, and calibration services	

TELEDYNE LECROY
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1-800-5-LeCroy
www.teledynelecroy.com

Local sales offices are located throughout the world.
Visit our website to find the most convenient location.