



High Definition Oscilloscopes

Embargo Date - October 22nd 2012



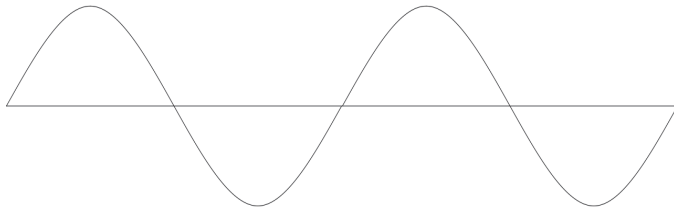
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Oscilloscope Evolution



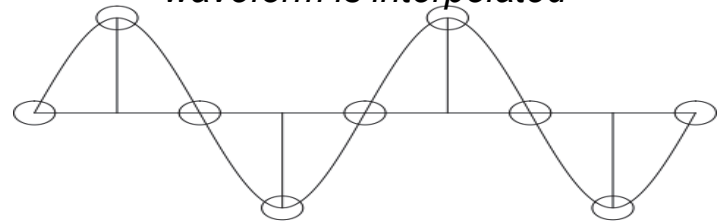
Analog

Input signal displayed directly on screen



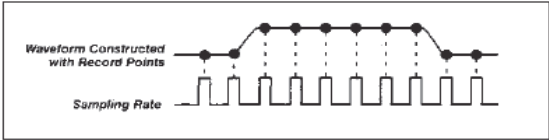
Digital

Input signal is sampled, waveform is interpolated



Digital Oscilloscope Basics



- **Bandwidth**
 - The bandwidth specification tells you the frequency range the oscilloscope accurately measures
 - Typically expressed in *Mega Hertz (MHz)* or *Giga Hertz (GHz)*
- **Sample Rate**
 - On digitizing oscilloscopes, the sample rate indicates how many samples per second the ADC (and therefore the oscilloscope) can acquire

The diagram illustrates the relationship between a continuous waveform and its digital representation. The top part shows a smooth, continuous waveform labeled 'Waveform Constructed with Record Points'. Below it, a series of vertical lines represent the 'Sampling Rate'. Dotted lines connect the peaks of the sampling rate pulses to the corresponding record points on the reconstructed waveform, showing how the discrete samples are used to approximate the original signal.

 - Maximum sample rates are usually given in *Megasamples per second (MS/s)*
 - The faster the oscilloscope can sample, the more accurately it can represent fine details in a fast signal
- **Record Length**
 - The record length of a digitizing oscilloscope indicates how many waveform points the oscilloscope is able to acquire for one waveform record
 - Typically expressed in *Megapoints* per channel (*Mpts/ch*)

ADC Resolution



- Along with bandwidth, sample rate and record length oscilloscopes have a resolution spec
- Oscilloscope resolution is based on the resolution of the ADC used in the acquisition system
- Typical oscilloscopes use 8-bit ADCs to digitize the input signal

What is Resolution?



- Resolution is the ability of a device to reproduce fine detail
- Many popular consumer electronic products have resolution specifications
- Resolution improves over time as next generation products are developed

iPhone

Original display
becomes retina display



4x

Digital Camera

3 Megapixels become
15 Megapixels



5x

Television

Standard definition TV
becomes HDTV



6x

Resolution in Oscilloscopes



- The number of bits in the ADC determines the resolution of the oscilloscope
- Higher resolution in an oscilloscope means it can show finer details and make more accurate measurements
- LeCroy Oscilloscopes with high resolution ADCs are the next generation of oscilloscopes providing 16 times more resolution than traditional 8 bit instruments

LeCroy HRO 6 Zi
8-bit ADC becomes
12-bit ADC



16x

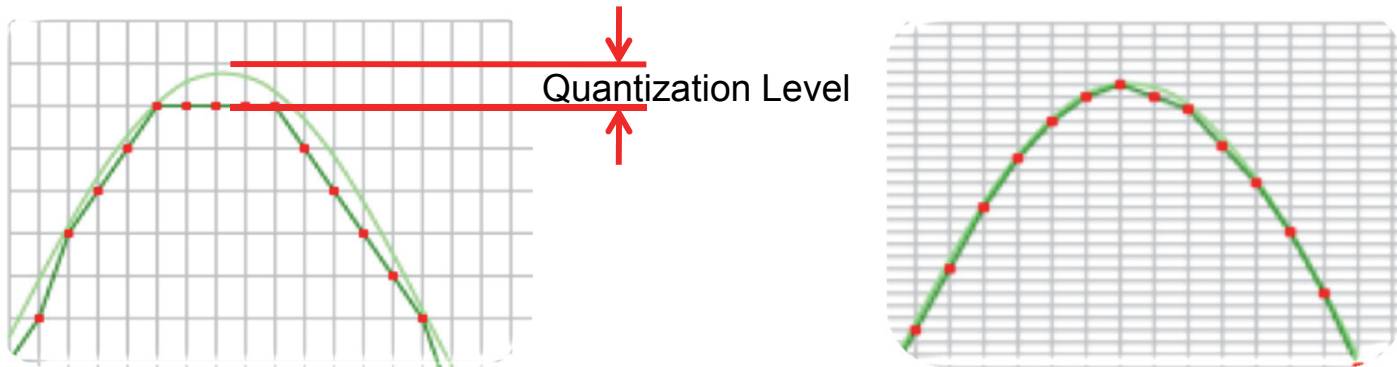
How Does Oscilloscope Resolution Work?



- Available Quantization Levels in an ADC = 2^N bits of Resolution

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

- Quantization levels – 16 times more for 12-bit scopes



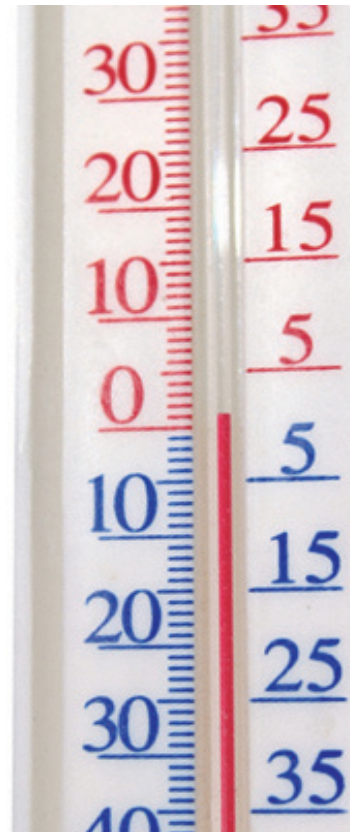
Scope with low resolution

Scope with high resolution

An Example of Quantization Levels



- Temperature increments on a thermometer can represent quantization levels
- Right side levels are every 10 degrees, left side every 1
- Left side has 10 times more quantization levels than the right and provides more precise measurements



Right side:
Temperature is between -5° and $+5^{\circ}$, close to 0°
(In the digital world, with quantization levels, the Temp measured would be in this case $+5^{\circ}$)

Left side:
Temperature is precisely measured as $+1^{\circ}$

HD4096 High Definition Technology

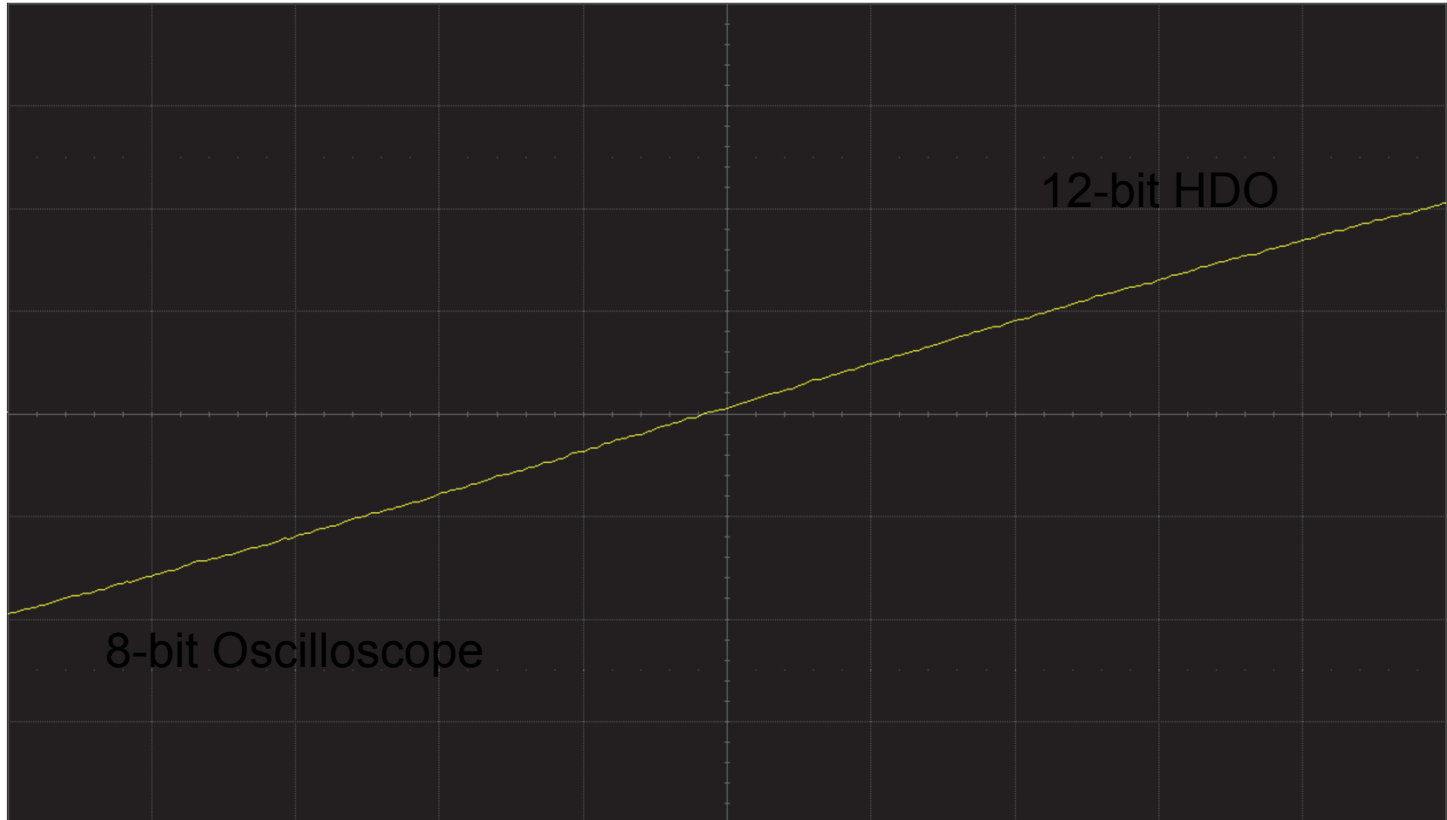


- Combination of
 - High Sample Rate 12-bit ADCs
 - High signal-to-noise input amplifiers
 - Low noise system architecture
- 16 times more resolution than any other oscilloscope on the market
- Capture high frequency signals with 1GHz bandwidth
- Benefits
 - Clean, Crisp Waveforms
 - More Signal Details
 - Precise Waveform Measurements

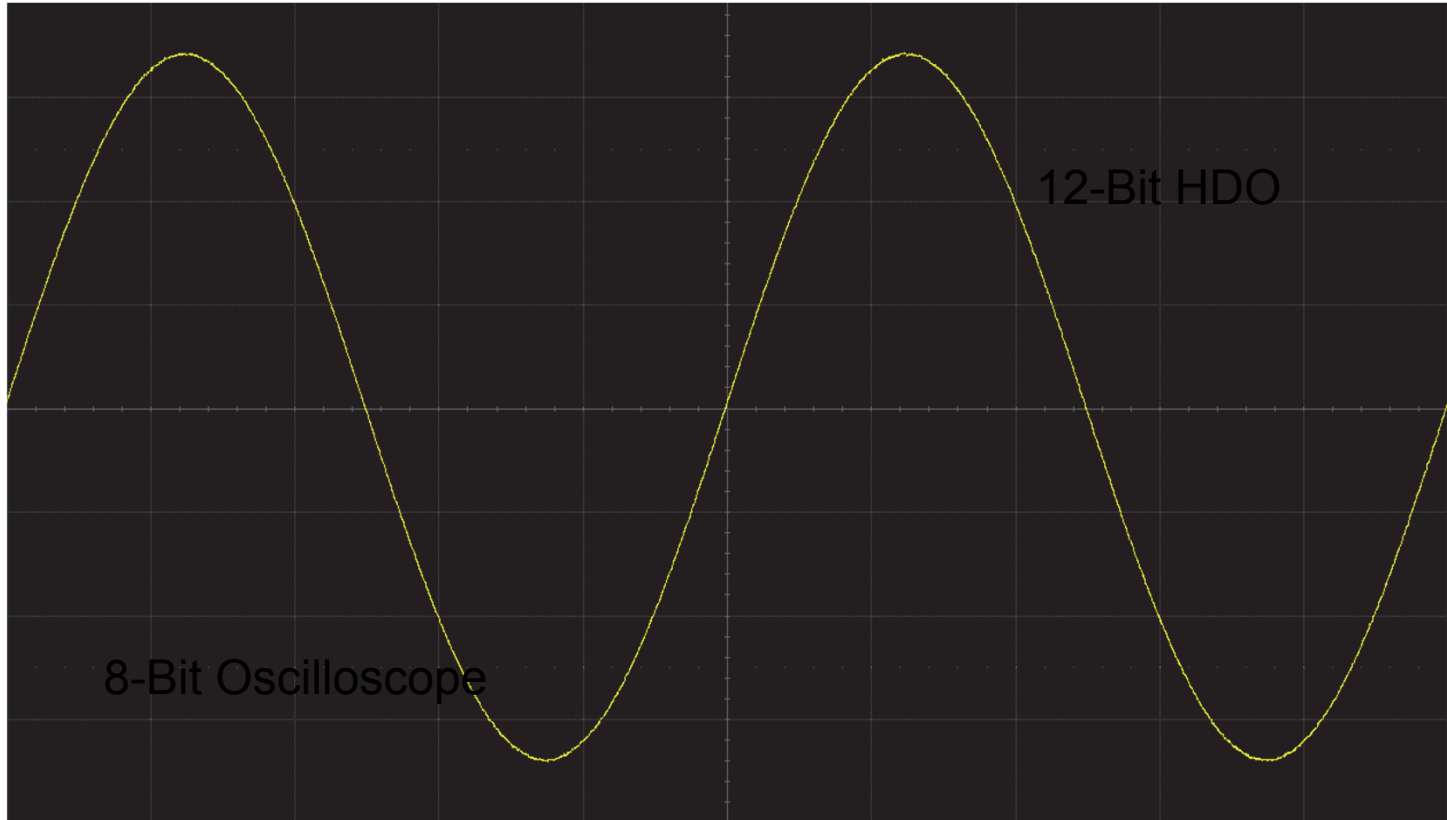
HD4096 Benefits – Clean, Crisp Waveforms



HD4096 Benefits – Clean, Crisp Waveforms



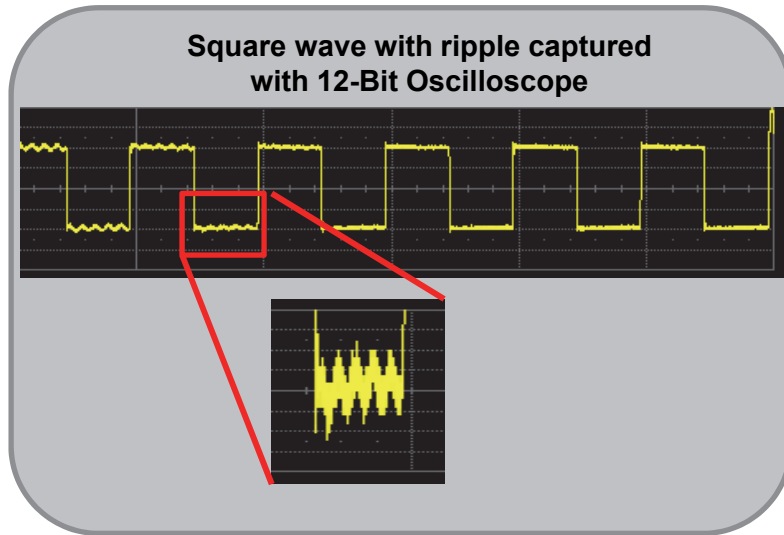
HD4096 Benefits – Clean, Crisp Waveforms



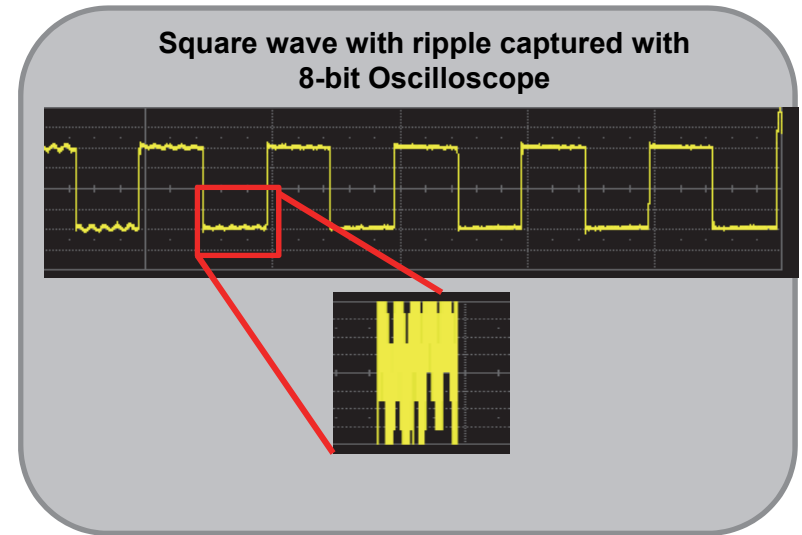
HD4096 Benefits – See More Signal Details



- Details of a waveform are visible due to extra vertical bits, details are not lost in quantization noise



Ripple clearly seen above the noise

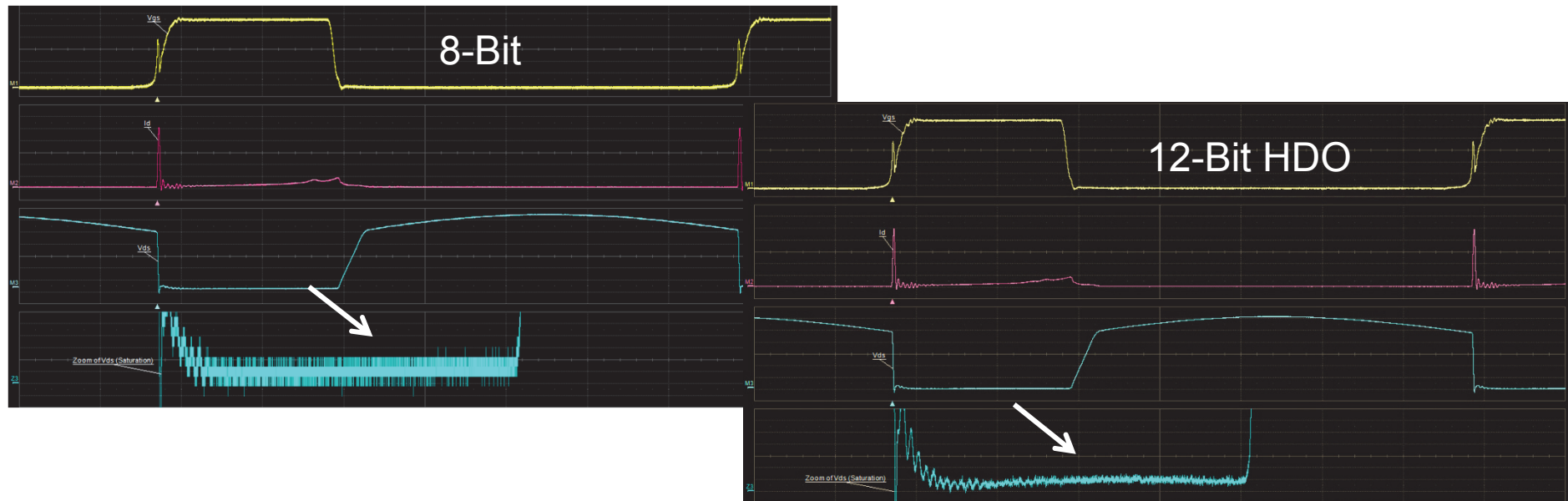


Ripple hidden in noise of the signal

HD4096 Benefits – See More Signal Details



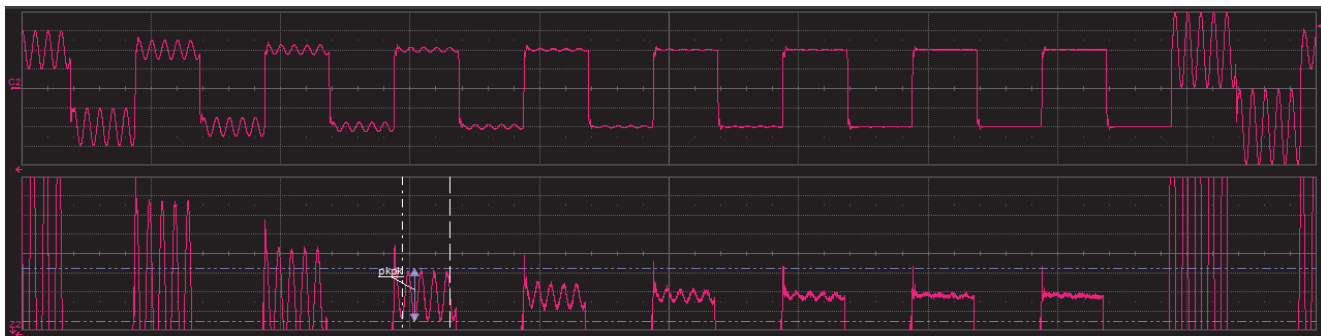
- MOSFET signals in switched-mode power supply application
- User needs to view V_{DS} Saturation Voltage
- 8-bit oscilloscope shows fuzzy saturation voltage trace with no detail
- 12-bit HDO shows clean saturation voltage trace with plenty of detail



HD4096 Benefits – Precise Waveform Measurements



8-Bit Oscilloscope



12-Bit HDO

- 12-bit ADC will provide more accurate measurement results
- Measurements in 8-bit oscilloscope include quantization noise
- 12-bit HDO with 16x more quantization levels more accurately characterizes the waveform
- Peak-to-Peak measurement of fourth oscillation with 8-bit and 12-bit ADC results
 - 8 bit = 165 mV
 - 12 bit = 134 mV

High Definition Oscilloscopes



- 12-bit ADC resolution, up to 15 bit with enhanced resolution
- 200 MHz, 350 MHz, 500 MHz, 1 GHz bandwidths
- Long Memory – up to 250 Mpts/Ch
- 12.1” Multi-touch screen display
- WaveScan – Advanced Search and Find
- LabNotebook Documentation and Report Generation
- History Mode – Waveform Playback
- Spectrum Analyzer Mode
- Power Analysis Software
- Serial Data Trigger and Decode



HDO4000 and HDO6000



- In order to bring the benefits of HD4096 technology to the greatest number of users two High Definition Oscilloscope series have been created
- **HDO4000** is the high resolution solution for Easy Measure and Fast Debug
- **HDO6000** is the next generation Oscilloscope for Easy Measure, Fast Debug and Advanced Analysis

Side by Side – Specifications



■ **HDO4000 Banner specs:**

- 200 MHz – 1 GHz
- 12 bit resolution
- 2.5 GS/s, 12.5 Mpts/ch
 - 50 Mpts max
- 12.1” Multi-touch Display
- Spectrum Analyzer – Optional
- 1.6 GHz Celeron with 2 GB RAM

■ **HDO6000 Banner specs:**

- 350 MHz – 1 GHz
- 12 bit resolution
- 2.5 GS/s, **50 Mpts/ch**
 - **250 Mpts max**
- 12.1” Multi-touch Display
- Spectrum Analyzer – **Standard**
- **2.5 GHz i5 with 4 GB RAM**

Side by Side – Debug and Analysis Tools



	HDO4000	HDO6000
# of Math Traces	2	8
# of Measurement Parameters	8 on screen with stats, trends and histicons	8 on screen with stats, trends, histicons, tracks and histograms
Standard Tools	WaveScan, LabNotebook, Sequence, History	Spectrum, TriggerScan, WaveScan, LabNotebook, Sequence, History
Option Packages	Spectrum, Power, Serial Trigger and Decode	Power, JitKit, Serial Data Mask, Disk Drive Measurement, Serial Trigger and Decode, Advanced Customization, EMC, Digital Filtering,

Multi-Touch Display Interface for Easy Operation

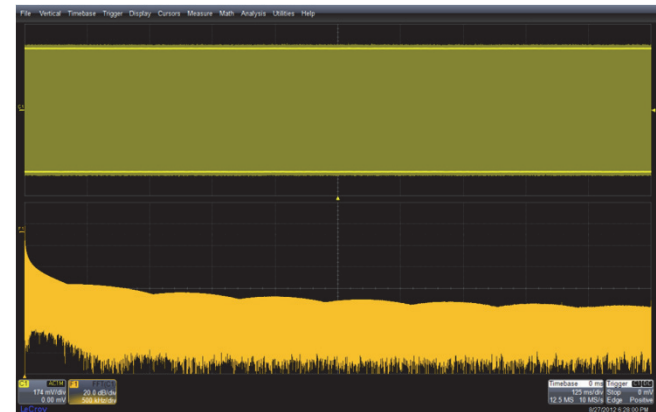
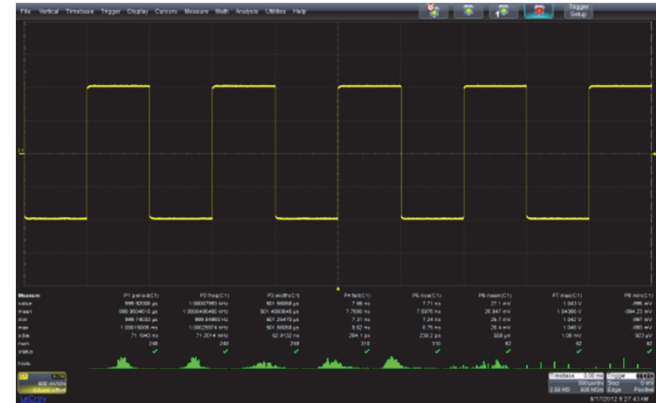


- HDO4000 is the only instrument in its class with a touch-screen
- Intuitive Touch-Screen interface easily controls
 - Channels
 - Trigger
 - Math Traces
 - Measurements
- Advanced Multi-Touch Display
 - Pinch-to-zoom
 - Swipe-to-pan

Math and Measure Tools



- HD4096 technology improves precision and reduces inaccuracies in math and measurements
- Variety of math functions for waveform debug
 - Display 2 simultaneous math traces
 - Each trace supports dual math functions
- Large set of measurement parameters to quantify waveform characteristics
 - Display 8 measurements at the same time
 - Statistics provide mean, min, max, standard deviation and count information
- Histograms provide thumbnail preview of the statistical distribution of each measurement

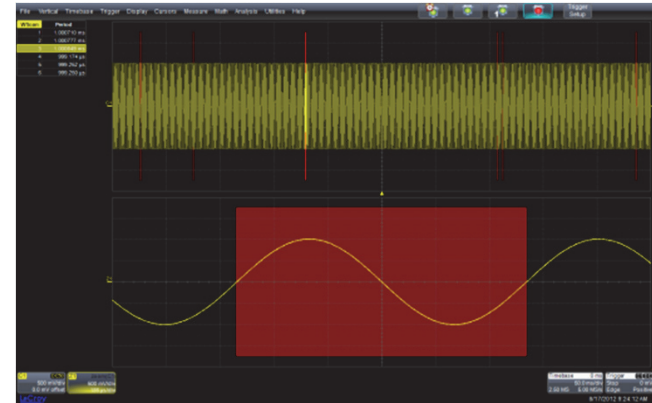


Powerful Debug Tools



- **WaveScan** - Advanced Search and Find
 - Automatically analyzes waveforms for runts, glitches, or other signal abnormalities
 - Search captured waveforms or scan live waveforms

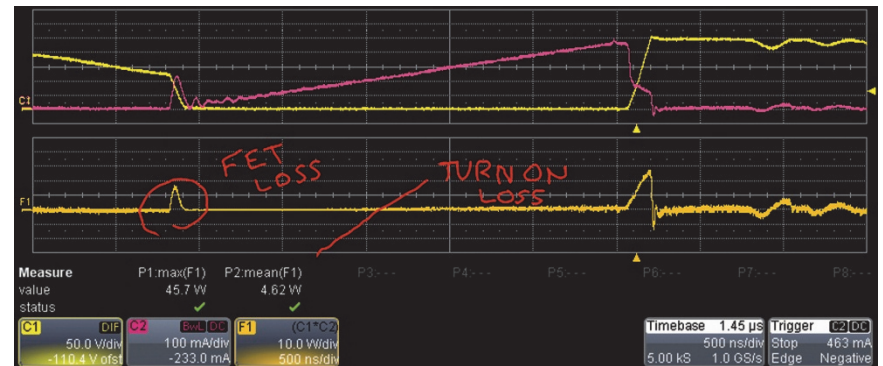
- **History Mode** - Waveform Playback
 - Scroll back in time to isolate anomalies
 - Always active, one button press quickly shows all waveforms in the history buffer



LabNotebook Documentation and Report Generation Tool



- Save and document all waveforms, settings and screen images at once
- Annotate screen images using touch-screen
- Create custom reports to document measurements and test results
- Flashback function returns the oscilloscope to that state it was in when the entry was saved
 - Measure and analyze recalled waveforms as if they were recently captured



Sequence Mode



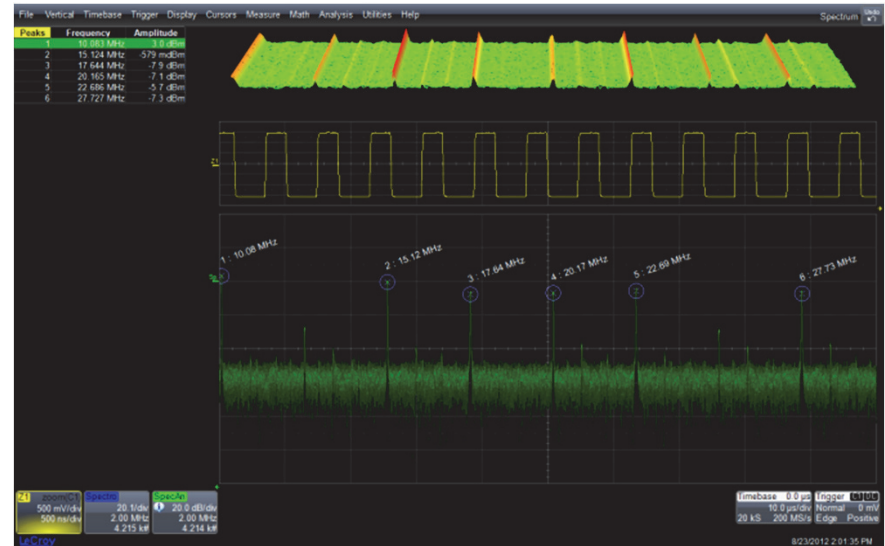
- Segments memory and creates a single waveform
- Each segment is triggered, captured and stored when the pre-determined number of triggers is reached
- Ideal for capturing fast pulses in quick succession or events spaced over long periods
- All triggers are times stamped and displayed for the user



Spectrum Analysis Software



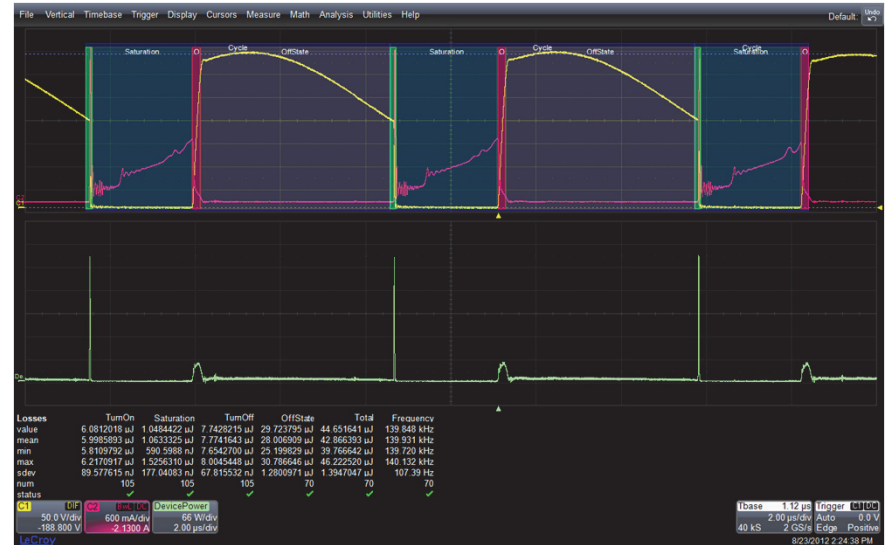
- Spectrum analyzer style interface for easy viewing and measuring in the frequency domain.
 - Quickly adjust center frequency, frequency span and resolution bandwidth
- Automatically find and label peaks in the spectrum
- Use markers for frequency and magnitude measurements across the entire spectrum
- Interactive table to quickly navigate between peaks and measure between markers
- Spectrogram display shows how the spectrum changes over time



Power Analysis Software Option



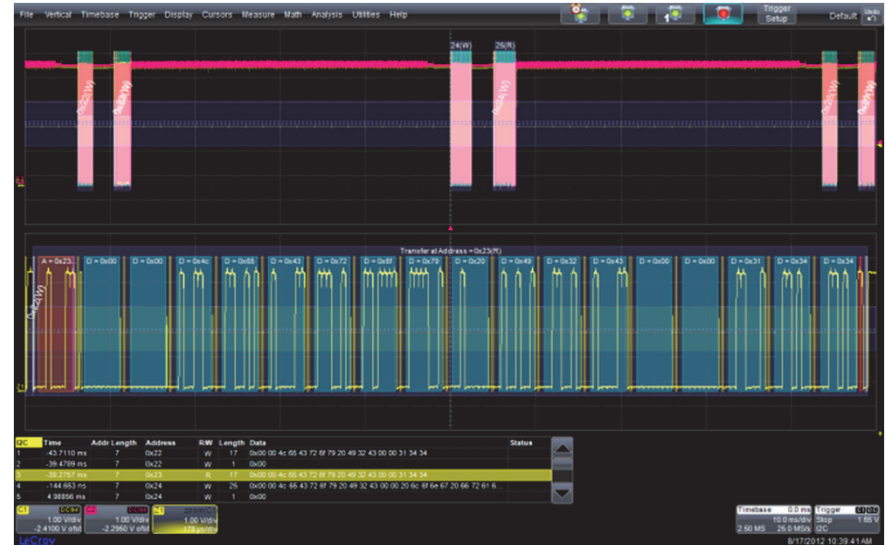
- Measure and analyze operating characteristics of power conversion devices and circuits
- Automatic detection and measuring of turn-on, turn-off and conduction losses
- Identify areas of power loss with color coded waveform overlay
- Streamlined user interface to guide user through various stages of analysis
- Operating modes for:
 - Power switching device measurements
 - Control loop modulation analysis
 - Line power harmonics



Serial Trigger and Decode Options



- Color coded overlay of decoded data directly on top of physical layer signal
- Trigger on protocol specific information to isolate events
- Up to 4 decodes simultaneously – can be a combination of any protocol at any speed
- Decode table provides a quick overview of decode and can be clicked to zoom to specific packet
- Wide variety of different protocols supported
 - I²C, SPI, UART/RS232
 - CAN, LIN, FlexRay, SENT
 - Audio (I²S, LJ, RJ, TDM)
 - DigRF3G, DigRFv4, DPHY
 - ARINC429, MIL-STD 1553
 - USB 1.0/1.1/2.0, USB-HSIC



Banner Specifications



HDO6034 HDO6054 HDO6104

	HDO6034	HDO6054	HDO6104
Bandwidth	350 MHz	500 MHz	1 GHz
Channels	4	4	4
ADC Resolution	12 bit	12 bit	12 bit
Sample Rate (All Channels)	2.5 GS/s	2.5 GS/s	2.5 GS/s
Memory	50 Mpts/ch	50 Mpts/ch	50 Mpts/ch
Max Memory	250 Mpts	250 Mpts	250 Mpts
Display	12.1" touch-screen display	12.1" touch-screen display	12.1" touch-screen display

HDO4022 HDO4024 HDO4032 HDO4034 HDO4054 HDO4104

	HDO4022	HDO4024	HDO4032	HDO4034	HDO4054	HDO4104
Bandwidth	200 MHz	200 MHz	350 MHz	350 MHz	500 MHz	1 GHz
Channels	2	4	2	4	4	4
ADC Resolution	12 bit	12 bit	12 bit	12 bit	12 bit	12 bit
Sample Rate (All Channels)	2.5 GS/s	2.5 GS/s	2.5 GS/s	2.5 GS/s	2.5 GS/s	2.5 GS/s
Memory	12.5 Mpts/ch	12.5 Mpts/ch	12.5 Mpts/ch	12.5 Mpts/ch	12.5 Mpts/ch	12.5 Mpts/ch
Max Memory (per ch / intlv'd)	25 Mpts / 50 Mpts	25 Mpts / 50 Mpts	25 Mpts / 50 Mpts	25 Mpts / 50 Mpts	25 Mpts / 50 Mpts	25 Mpts / 50 Mpts
Display	12.1" touch-screen display	12.1" touch-screen display	12.1" touch-screen display	12.1" touch-screen display	12.1" touch-screen display	12.1" touch-screen display

HDO4000 Competitive Landscape – 500 MHz and below



	R & S RTM1000	Tektronix DPO4000B	Agilent DSO7000B	Teledyne LeCroy WaveSurfer MXs-B	Teledyne LeCroy HDO4000
Bandwidth	500 MHz	350 – 500 MHz	100 - 500 MHz	200 - 600 MHz	200 – 500 MHz
Channels	2,4	4	2,4	2,4	2,4
ADC Resolution	8 Bit	8 Bit	8 Bit	8 Bit	12 Bit
Max Sample Rate (per Ch)	2.5 GS/s	2.5 GS/s	2 GS/s	5 GS/s	2.5 GS/s
Sample Rate (Intlv'd)	5 GS/s	2.5 GS/s	4 GS/s	10 GS/s	2.5 GS/s
Std Memory (per ch/intlv'd)	4 Mpts / 8 Mpts	20 Mpts / 20 Mpts	4 Mpts / 8 Mpts	16 Mpts / 32 Mpts	12.5 Mpts / 25 Mpts
Max Memory (per ch/intlv'd)	4 Mpts / 8 Mpts	20 Mpts / 20 Mpts	4 Mpts / 8 Mpts	16 Mpts / 32 Mpts	25 Mpts / 50 Mpts
Touch Screen	No	No	No	Yes	Yes
Display	8.4"	10.4"	12.1"	10.4"	12.1"
List Price (EUR)				€8,600 - €11,850	€9,200 - €14,000

- Only the HDO4000 offers 12-bit resolution
- No sacrifice in Sample Rate to support 12-bit resolution – 2.5 GS/s per channel
- Very small price premium for benefit of 12-bit performance

HDO4000 Competitive Landscape – 1 GHz



	Tektronix DPO4000B	Agilent DSO7000B	Teledyne LeCroy WaveSurfer MXs-B	Teledyne LeCroy HDO4000
Bandwidth	1 GHz	1 GHz	1 GHz	1 GHz
Channels	4	4	4	4
ADC Resolution	8 Bit	8 Bit	8 Bit	12 Bit
Max Sample Rate (per Ch)	5 GS/s	2 GS/s	5 GS/s	2.5 GS/s
Sample Rate (Intlv'd)	5 GS/s	4 GS/s	10 GS/s	2.5 GS/s
Std Memory (per ch/intlv'd)	20 Mpts / 20 Mpts	4 Mpts / 8 Mpts	16 Mpts / 32 Mpts	12.5 Mpts / 25 Mpts
Max Memory (per ch/intlv'd)	20 Mpts / 20 Mpts	4 Mpts / 8 Mpts	16 Mpts / 32 Mpts	25 Mpts / 50 Mpts
Touch Screen	No	No	Yes	Yes
Display	10.4"	12.1"	10.4"	12.1"
List Price (EUR)			€13,960	€16,300

- Only the HDO4000 offers 12-bit resolution
- 2.5 GS/s is adequate at 1 GHz but some users may desire ≥ 5 GS/s
 - WaveSurfer is the sample rate leader with up to 10 GS/s
- Very small price premium for benefit of 12-bit performance

HDO6000 Competitive Landscape



350 MHz - 1 GHz	R & S RTO1000	Tektronix DPO5000	Tektronix DPO7000	Agilent DSO9000	Teledyne LeCroy WaveRunner 6Zi	Teledyne LeCroy HDO6000
Bandwidth	1 GHz	350 MHz - 1 GHz	500 MHz - 1 GHz	600 MHz - 1 GHz	400 MHz - 1 GHz	350 MHz - 1 GHz
Channels	2,4	4	4	4	4	4
ADC Resolution	8 Bit	8 Bit	8 Bit	8 Bit	8 Bit	12 Bit
Max Sample Rate (per Ch)	10 GS/s	5 GS/s	5 GS/s	10 GS/s	10 GS/s	2.5 GS/s
Sample Rate (Intlv'd)	10 GS/s	5 GS/s (10GS/s@1GHz)	10 GS/s	20 GS/s	20 GS/s	2.5 GS/s
Std Memory (per ch/intlv'd)	20 Mpts / 20 Mpts	12.5 Mpts / 25 Mpts	12.5 Mpts / 25 Mpts	10 Mpts / 20 Mpts	16 Mpts / 32 Mpts	50 Mpts / 50 Mpts
Max Memory (per ch/intlv'd)	100 Mpts / 100 Mpts	125 Mpts / 125 Mpts	50 Mpts / 125 Mpts	500 Mpts / 1000 Mpts	64 Mpts / 128 Mpts	250 Mpts / 250 Mpts
Display	10.4"	10.4"	12.1"	12.1"	12.1"	12.1"
List Price (EUR)					€14,000 - €18,265	€14,280 - €19,580

- Only the HDO6000 offers 12-bit resolution
- 2.5 GS/s is adequate at 1 GHz but some users may desire ≥ 5 GS/s
 - WaveRunner is a sample rate leader with up to 20 GS/s
- Very small price premium over competitors for benefit of 12-bit performance

High Definition Oscilloscopes



- 12-bit ADC resolution, up to 15 bit with Enhanced Resolution
- 200 MHz, 350 MHz, 500 MHz, 1 GHz Bandwidths
- Long Memory – up to 250 Mpts/Ch
- 12.1” Multi-touch screen Display
- WaveScan – Advanced Search and Find
- LabNotebook Documentation and Report Generation
- History Mode – Waveform Playback
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