Be Sure to Capture the Complete Picture

Technical Brief

Tektronix Digital Real-time (DRT) Sampling Technology

As an engineer or technician, you need the confidence and trust that you're accurately capturing the details of your signal. If an oscilloscope's sample rate isn't fast enough, signal details are lost, resulting in missing data and measurement errors.

Digital real-time oscilloscopes acquire signals in real time, capturing enough samples of the signal needed to faithfully reconstruct a waveform in a single acquisition cycle.
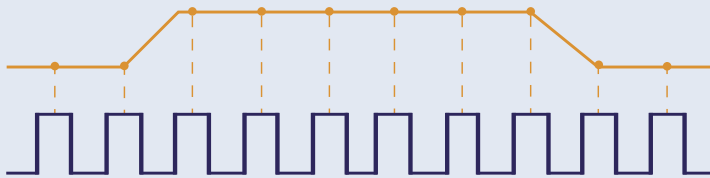
The Solution…

Digital Real-time (DRT) Sampling Technology

Input 1
Waveform Constructed with Record Points

Sampling RateSampling Rate

Tektronix®

Digital Real-time vs. Equivalent-time Sampling Techniques

	Equivalent-time (ET) Sampling	Digital Real-time (DRT) Sampling
Definition	A sampling technique in which a representative waveform is created with a series of samples taken from identical repetitive waveforms	A sampling technique in which all samples are taken in a single cycle of the digitizing system, capturing and displaying the event in the same time frame in which it occurs
Elements	Allows the oscilloscope to accurately capture signals whose frequency components are higher than the oscilloscope's sample rate; however, the input signal **must** be repetitive Requires multiple triggering events, which often results in missing signal information in the case of non-repetitive or single-shot events Most ET-sampling DSOs have actual real-time bandwidths of less than a third of their published analog or repetitive-signal bandwidths If pushed to published bandwidth, displays of single-shot wave-forms can be marred by digital aliasing or other distortions caused by exceeding the oscilloscope's effective real-time bandwidth	Affords true 4X to 10X over-sampling of the signal on all channels simultaneously Input signal need **not** be repetitive Samples are equally spaced in time and acquired in a single trigger event Every single waveform cycle is sampled completely, providing all the detail needed to accurately reconstruct the signal Real-time acquisition up to the instrument's full analog bandwidth for both repetitive and single-shot events

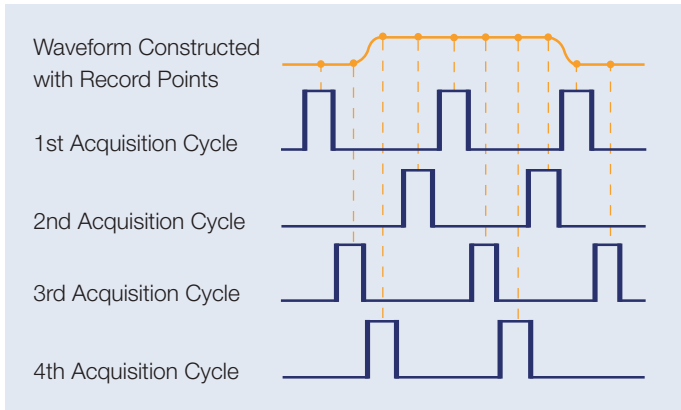## Why is Sample Rate So Important?

Real-world events are dynamic and occur in real time. Shouldn't your oscilloscope be equipped with adequate technology to capture dynamic signals in real time as well?

Transient and changing signals events occur only once, and therefore, must be sampled in the same time frame in which they occur. If your oscilloscope's sample rate isn't fast enough, high-frequency components can "fold down" into a lower frequency, causing aliasing in the display, measurement errors or simply missing waveform events or details.

The faster a digital storage oscilloscope samples an input signal, the greater the resolution and detail realized on the displayed waveform. The Nyquist sampling theory states that a waveform must be sampled at a rate that is at least twice the highest expected frequency in the signal under test. However, this theory only applies to sinusoidal signals. Today's complex waveforms undoubtedly require higher than 2X sample rate multipliers to accurately capture changing or single-shot events.

Sampling rate performance also become critical when using multiple channels to ensure that timing accuracy is maintained across all captured channels along with preserving the real-time bandwidth. Some products trade-off maximum sampling rate when using multiple channels often reducing performance by 50%. This can impact measurements results and waveform analysis.

| | | Waveform Constructed with Record Points |
| 1st Acquisition Cycle |
| 2nd Acquisition Cycle |
| 3rd Acquisition Cycle |
| 4th Acquisition Cycle |

Equivalent-time sampling oscilloscopes construct a picture of a repetitive signal by capturing a little bit of information from a series of acquisition cycles

	Sampling Techniques	
Specification	Equivalent-time (ET)	Digital Real-time (DRT)
Bandwidth	100 MHz	100 MHz
Sample Rate (Single-shot or Real-time)	200 MS/s	1 GS/s
Sample Rate (Equivalent-time)	25 GS/s	N/A
Sample Rate*/Bandwidth =	2X	10X

*Single-shot or real-time sample rate for non-repetitive events.

The Limitation of Equivalent-time (ET) Sampling Technology

Would you use a digital camera if it required you to take a series of pictures before producing a clear image? Most people would probably find this unacceptable. The same holds true for a digital storage oscilloscope's ability to take snapshots that accurately reproduce non-repetitive or single-shot waveforms in a single acquisition cycle.

One persistent limitation of many conventional digital storage oscilloscopes (DSO) has been their inability to perform to published bandwidths when acquiring non-repetitive waveforms and single-shot events. This limitation is an artifact of the equivalent-time (ET) sampling architecture that requires multiple acquisition cycles in order to display a meaningful waveform. ET sampling techniques work well for repetitive waveforms, but often fall short when reconstructing non-repetitive or single-shot events.

How Do I Avoid Products with Equivalent-time (ET) Sampling Technology?

When evaluating the purchase of your next digital storage oscilloscope, make sure the maximum specified single-shot sample rate is at least 4X, and preferably 10X, greater than the instrument's published bandwidth.
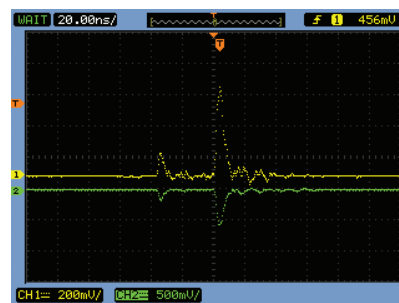
Benefits of Digital Real-time Sampling Technology

Single-shot Events

Digital real-time (DRT) sampling on all channels ensure the full bandwidth performance is pre-served along with maximum waveform details.
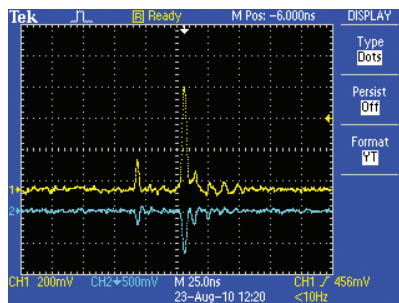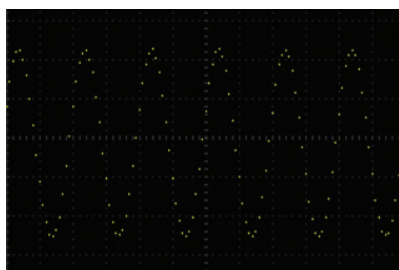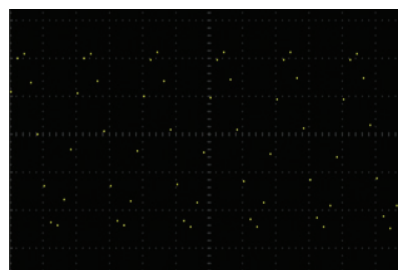

2 channels at 2 GS/s max sampling rate.

2 channels at 1 GS/s max sampling rate.

Real-time Bandwidth

Real-time bandwidth is best achieved when the sampling rate is the same across all channels. Lower sampling rates can also effect what is seen on the display.
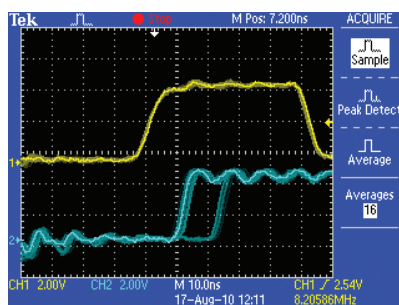

100 MHz sine wave captured at 2 GS/s.

100 MHz sine wave captured at 1 GS/s.

Non-repetitive Events

Instruments that require equivalent time (ET) sampling can create distorted representation of actual signals and lack the capture rate to track changing signals.

DRT Sampling Technology[1].
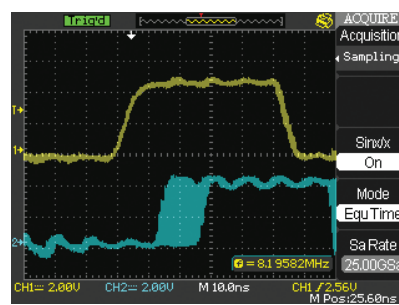
ET Sampling Technology[2].

*1 Tektronix TDS2024C digital storage oscilloscope.
*2

TPS2000B Series Digital Storage Oscilloscopes

The DRT Advantage

### Powerful Productivity from Bench to Field

Specification	TPS2012B	TPS2014B	TPS2024B
Channels (Isolated)	2	4	4
Bandwidth (MHz)	100	100	200
Sample Rate (GS/s) (Real-time)	1.0	1.0	2.0
Record Length	2.5 K points on all models		
Display (1/4 VGA LCD)	Color on all models		
CompactFlash Mass Storage	Integrated in all models		
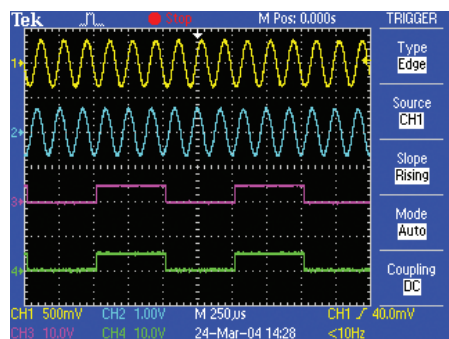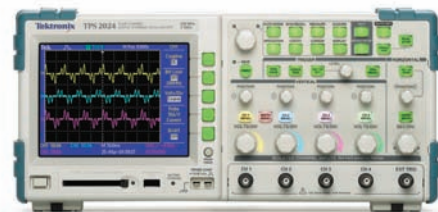
Make floating and differential measurements, accurately and quickly with four Isolated Channel inputs and isolated external trigger[*3].
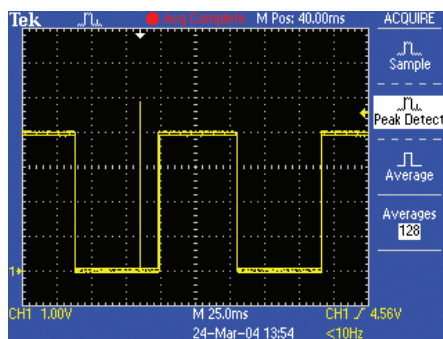
Capture elusive glitches–the first time–with DRT sampling technology.
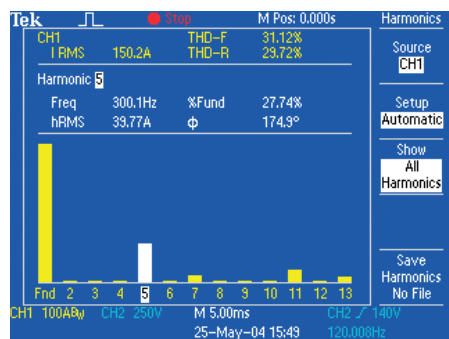
Conduct harmonic distortion measurements with TPS2PWR1 power measurement software.

Easily correlate measurements between bench, lab and field with eight hours of battery power and beyond.

- 2 or 4 IsolatedChannel™ inputs and isolated external trigger input

- 8 hours of continuous battery operation with two batteries installed, hot-swappable for virtually unlimited freedom from an AC power source

- Optional power application software offers the broadest range of power measurements at its price point

- OpenChoice® software and integrated CompactFlash mass storage to quickly store, document and analyze measurement results

- Traditional oscilloscope user interface with backlit menu buttons/display and brightness/contrast controls for ease of operation in a variety of challenging environments[*4]

*3 Make floating, or differential measurements up to 30 V_{RMS} floating on four channels simultaneously when the TPS2000B Series is paired with its standard TPP0201 passive probe.
For floating or differential measurements up to 600 V_{RMS} CAT II (or 300 V_{RMS} CAT III) floating, use the optional P5122 passive, high-voltage probe.

*4 Do not operate TPS2000B Series oscilloscopes where conductive pollutants may be present, or in wet or damp conditions.

TDS2000C Series Digital Storage Oscilloscopes

## The DRT Advantage

Performance you need at a price you can afford

Specifications	TDS2001C	TDS2002C	TDS2004C	TDS2012C	TDS2014C	TDS2022C	TDS2024C
Channels	2	2	4	2	4	2	4
Bandwidth (MHz)	50	70	70	100	100	200	200
Sample Rate (GS/s) (Real-time) all channels	0.5	1.0	1.0	2.0	2.0	2.0	2.0
Record Length	2.5 K points on all models						
Display (1/4 VGA LCD)	Color on all models						
USB Flash Drive Storage	Standard on all models						
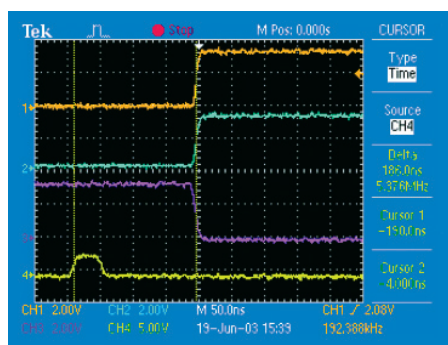
Capture signals with far greater precision than a conventional DSO with DRT sampling technology.
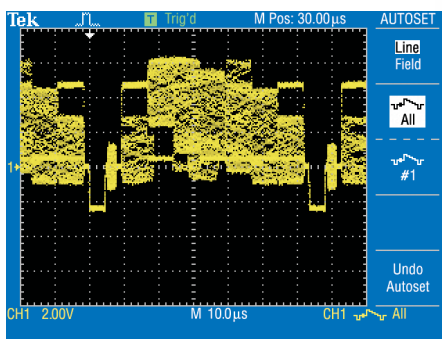
Advanced triggers make even complex characterization and debugging fast and easy.
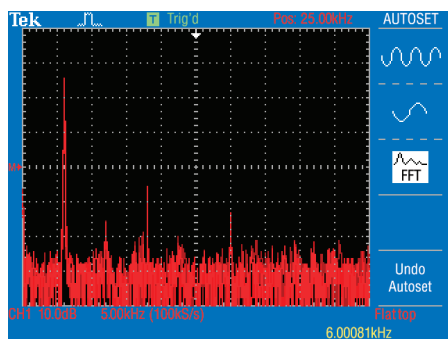
Fast Fourier Transform (FFT) makes it easy to precisely analyze, characterize and troubleshoot circuits in the frequency domain.
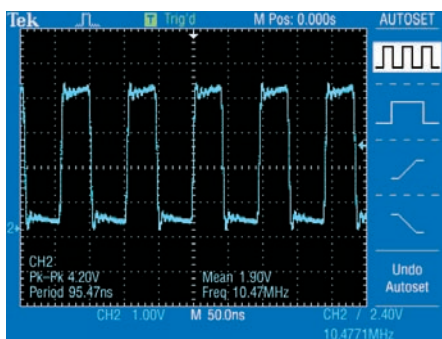
Autoset menu simplifies setup and operation.
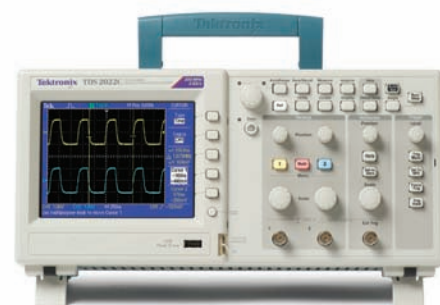
- Up to 16 automatic measurements to speed measurement tasks
- FFT standard on all models
- Quick, easy setup and operation with traditional, analog-style knobs, multiple-language user interface, autoset menu, built-in context-sensitive help, and probe check wizard
- OpenChoice software including National Instrument's LabVIEW Signal Express Tek Edition for easy documentation and analysis of measurement results

TDS3000C Series Digital Phosphor Oscilloscopes

The DRT Advantage

More Powerful. More Portable. Still Affordable.

Specifications	TDS3012C	TDS3014C	TDS3032C	TDS3034C	TDS3052C	TDS3054C
Channels	2	4	2	4	2	4
Bandwidth (MHz)	100	100	300	300	500	500
Sample Rate (GS/s) (Real-time)	1.25	1.25	2.5	2.5	5	5
Record Length	10 K points on all models					
Display (1/4 VGA LCD)	Color on all models					
USB Flash Drive Storage	Standard on all models					
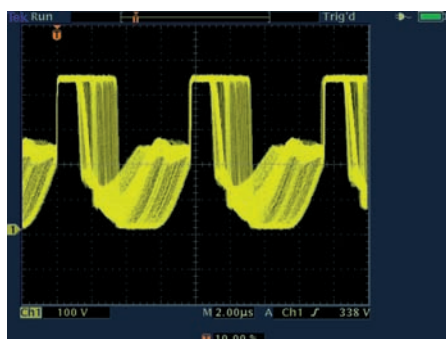
High waveform capture rate combined with intensity grading reveals modulation effects on a power supply control loop.
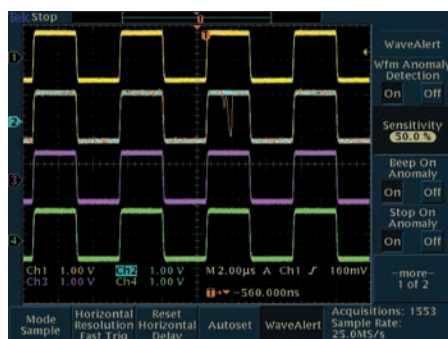
WaveAlert® waveform anomaly detection alerts you to any waveform that deviates from the "normal" input.

TDS3AAM advanced analysis module delivers advanced waveform math.
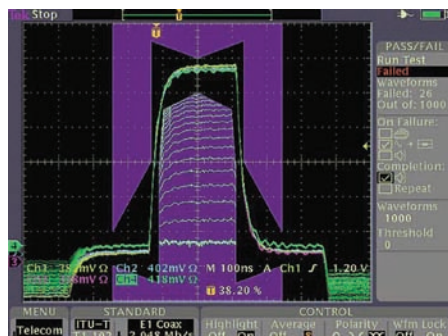
TDS3TMT telecommunications mask testing module provides breakthrough test speeds for telecommunications line card testing.

- Continuous waveform capture rate up to 3,600 wfms/s to reveal dynamic signals and elusive events in real time
- Three-dimensional waveform intensity grading
- Anti-aliasing
- Ultra portable with 3 hours of continuous operation at 7.0 lbs
- Wide array of application-specific modules

For Further Information
Tektronix maintains a comprehensive, constantly expanding collection of application notes, technical briefs and other resources to help engineers working on the cutting edge of technology. Please visit **www.tektronix.com**

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