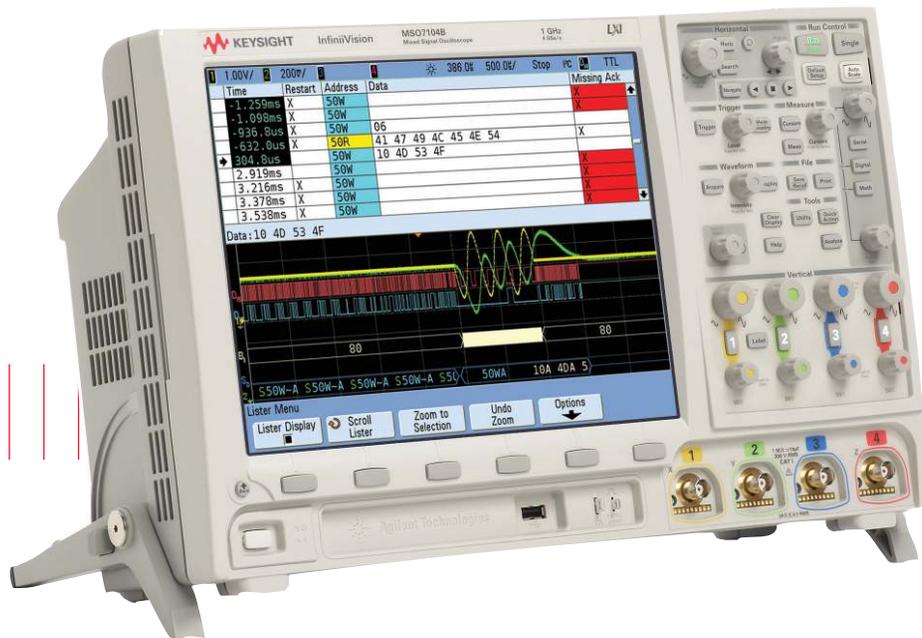# Keysight Technologies

I^2C and SPI Triggering and Hardware-based Decode for Keysight InfiniiVision Series Oscilloscopes (N5423A)

Data Sheet

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Find and debug intermittent serial bus errors and signal integrity problems faster

The Keysight Technologies, Inc. triggering and decode options for the InfiniiVision Series oscilloscopes (5000, 6000, and 7000 series) offer hardware-accelerated decode to help you debug embedded designs with I2C and SPI serial buses hardware-based decoding provides the fastest decode update rates in the industry.

Lower-speed serial bus interfaces such as I2C (inter-integrated circuit) and SPI (serial peripheral interface) are widely used today in mixed-signal embedded designs for chip-to-chip communication between EEPROMs, DACs, ADCs, and other peripheral ICs to microcontrollers, microprocessors, and DSPs. Since these protocols transfer many bits of data serially, it can be very difficult to unravel what's happening in an embedded system with conventional scope triggering.

The Keysight InfiniiVision Series oscilloscopes offer integrated serial triggering and hardware-accelerated protocol decoding solutions that give you the tools you need to efficiently and effectively debug your embedded system designs that have serial buses.

Other oscilloscope solutions with serial bus triggering and protocol decode typically use software post-processing techniques to decode serial packets/frames. Using these software techniques, waveform- and decode-update rates tend to be slow (sometimes seconds per update), especially when you use deep memory, which is often required to capture multiple packetized serial signals. Faster decode update rates enhance the scope's probability of capturing infrequent serial communication errors.

Keysight's InfiniiVision Series mixed signal oscilloscopes (MSOs) are a perfect fit for verifying and debugging embedded designs that include a combination of analog signals, serial traffic, and higher-speed digital control signals found in today's embedded designs. MSOs provide an integrated way to capture and time-correlate multiple analog, serial and digital signals of various speeds with deep memory. Keysight offers MSOs with optional serial bus capabilities in various bandwidth models ranging from 100 MHz up to 1 GHz.

Using an MSO with the N5423A I2C/SPI option, you can capture and decode I2C or SPI data packets and correlate them with other signals in mixed-signal designs, such as digital control signals and analog signals, as shown in Figure 1 and Figure 2.

And with Keysight's 7000B Series oscilloscope, you can also easily search and navigate within the protocol lister display to find and mark particular events of interest with direct time-correlation to the waveform display.
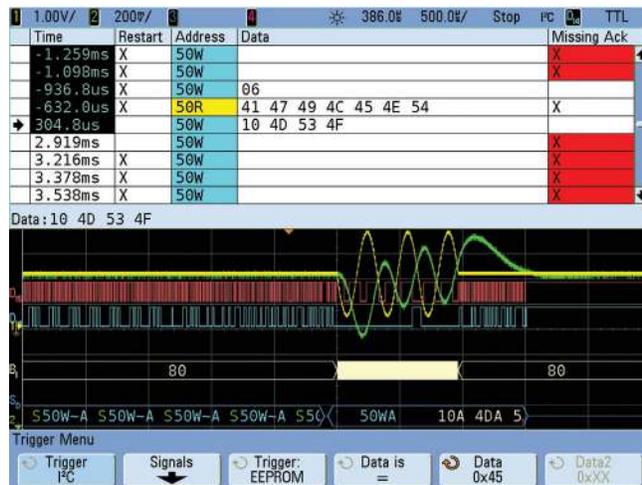

Figure 1. On-screen serial decode of I2C data packet shown with time-correlated analog and digital waveforms captured by an MSO7104B

Figure 2. On-screen serial decode of SPI signals with time-correlated analog and digital waveforms capture by an MSO7104B.

Segmented Memory acquisition captures and stores serial bus data packets

The Segmented Memory acquisition option (Option LMT) for Keysight's InfiniiVision Series oscilloscopes can optimize your scope's acquisition memory, allowing you to capture more I²C and SPI packets of data while using less memory. Segmented memory acquisition optimizes the number of serial packets that can be captured consecutively by selectively ignoring (not digitizing) unimportant idle. And with a minimum 250 picoseconds time-tagging resolution, you will know the precise time between each captured word.

Figure 3 shows an example of capturing consecutive occurrences of a particular I²C word with the scope set up to trigger on a Write operation to address 50 HEX. Using this trigger condition with the segmented memory acquisition mode turned on, the scope easily captures 500 consecutive occurrences of this word for a total acquisition time of over 12 seconds. After acquiring these 500 I²C Write commands, we can then scroll through all words individually to look for any anomalies or errors.

Figure 3. Segmented memory acquisition captures up to 2000 consecutive packets of data with precise time-tagging.

I²C Specifications/Characteristics (N5423A or Option LSS)

I²C source (clock and data)	Analog channels 1, 2, 3, or 4 Digital channels D0 to D15
Max clock/data rate	Up to 3.4 Mbps (automatic)
Triggering[1]	Start condition Stop condition Missing acknowledge Address with no acknowledge Restart EEPROM data read Frame (Start:Addr7:Read:Ack:Data) Frame (Start:Addr7:Write:Ack:Data) Frame (Start:Addr7:Read:Ack:Data:Ack:Data2) Frame (Start:Addr7:Write:Ack:Data:Ack:Data2) 10-bit write
Color-coded, hardware-accelerated decode[2]	Data (HEX digits in white) Read address (HEX digits in yellow) Write address (HEX digits in light-blue) Restart addresses (prefixed with "S" in green) Acknowledges (suffixes "A" or "~A" in the same color as the data or address preceding it) Idle bus (high bus trace in white) Active bus (bi-level bus trace in dark-blue) Unknown/error bus (bi-level bus trace in red)

1. Standard I²C triggering in all Keysight 6000 Series oscilloscopes
2. Optional I²C decoding in all 4-channel and 4+16-channel 6000 Series oscilloscopes

SPI Specifications/Characteristics (N5423A or Option LSS)

SPI source (clock, data, chip select)	Analog channels 1, 2, 3, or 4 Digital channels D0 to D15
Max clock/data rate	Up to 25 Mbps (automatic)
Triggering[1]	4- to 32-bit data pattern during a user-specified framing period Framing period can be a positive or negative chip select (CS or ~CS) or clock idle time (timeout)
Color-coded, hardware-accelerated decode[2]	Data (hex digital in white) Unknown/error bus (bi-level bus trace in red) Number of clocks/packet ("XX CLKS" in light-blue) Idle bus (outside of a packet = white) Active bus (bi-level bus trace in dark-blue)

1. Standard SPI triggering in all Keysight 6000 Series oscilloscopes
2. Optional SPI decoding in all 4-channel and 4+16-channel 6000 series oscilloscopes

Ordering information

The N5423A (I²C and SPI) is compatible with Keysight's
InfiniiVision Series' 4-channel DSO and 4+16 channels MSO
models, including the 5000, 6000, and 7000 Series scopes. This
option is available as a factory-installed option if ordered as
Option-LSS along with a specific oscilloscope model, or existing
InfiniiVision Series oscilloscope users can order this option as an
afterpurchase product upgrade (N5423A).

Model	Description
N5423A (or Option LSS)	I²C/SPI serial decode option (4 and 4+16 channel models only)
N5457A (or Option 232)	RS-232/UART triggering and decode (4 and 4+16 channel models only)
N5424A (or Option AMS)	CAN/LIN automotive triggering and decode (4 and 4+16 channel models only)
N5454A (or option SGM)	Segmented Memory

Note that additional options and accessories are available for Keysight InfiniiVision Series oscilloscopes. Refer to the appropriate 5000, 6000, or
7000 Series data sheet for ordering information about these additional options and accessories, as well as ordering information for specific
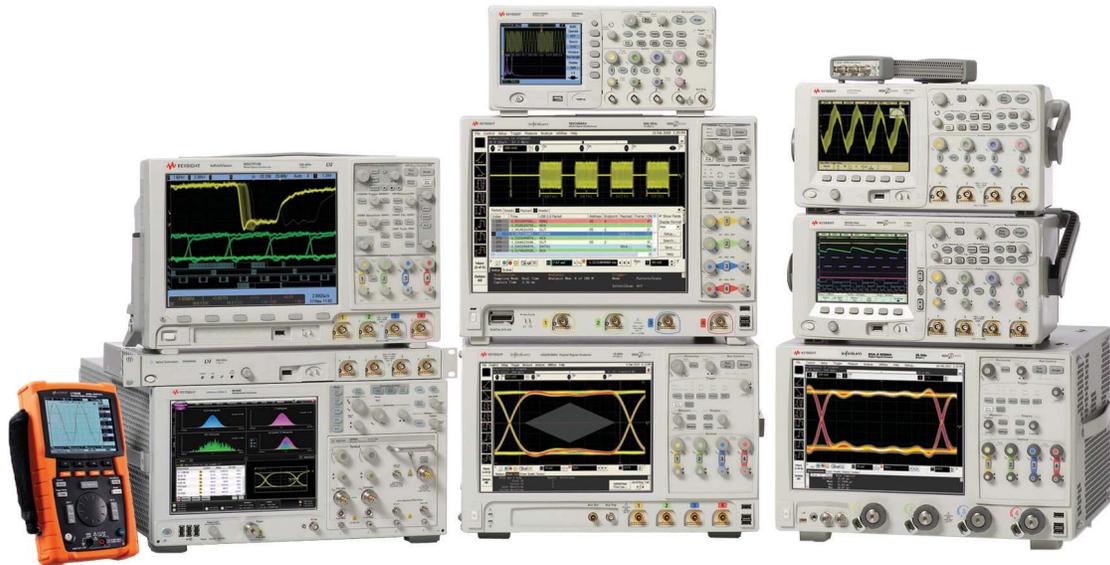oscilloscope models.

Related Literature

Publication title	Publication type	Publicationnumber
Keysight 7000B Series InfiniiVision Oscilloscopes	Data sheet	5990-4769EN
Keysight 6000 Series InfiniiVision Oscilloscopes	Data sheet	5989-4087EN
Keysight 5000 Series InfiniiVision Oscilloscopes	Data sheet	5989-6110EN
Keysight InfiniiVision Series Oscilloscope Probes and Accessories	Data sheet	5989-8153EN
RS-232/UART triggering and hardware-based decode for Keysight Keysight InfiniiVision Series Oscilloscopes (N5457A)	Data sheet	5989-7832EN
Segmented Memory Acquisition for Keysight InfiniiVision Oscilloscopes (N5454A)	Data sheet	5989-7833EN
Evaluating Oscilloscope Segmented Memory for Serial Bus Applications	Application note	5990-5817EN
Using a Keysight InfiniiVision MSO to Debug an Automotive CAN Bus	Application note	5989-5049EN
Evaluating Oscilloscopes for Best Waveform Update Rates	Application note	5989-7885EN
Evaluating Oscilloscopes to Debug Mixed-Signal Designs	Application note	5989-3702EN
Evaluating Oscilloscope Bandwidths for your Applications	Application note	5989-5733EN
Evaluating Oscilloscope Sample Rates vs. Sampling Fidelity	Application note	5989-5732EN
Evaluating Oscilloscope Vertical Noise Characteristics	Application note	5989-3020EN

Product Web site

For the most up-to-date and complete application and product information, please visit our product Web site at: www.keysight.com/find/scopes

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