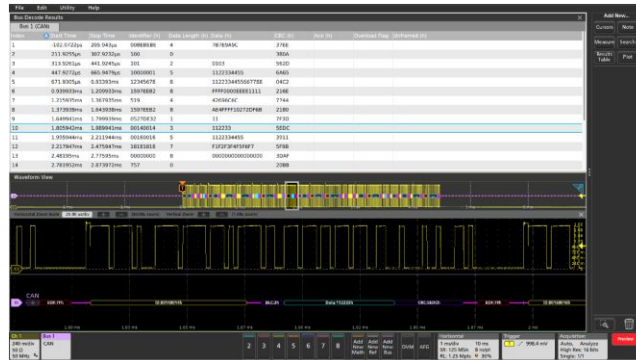# Tektronix®

5 Series MSO Serial Triggering and Analysis Applications

5-SRAUDIO, 5-SRAUTO, 5-SRCOMP, and 5-SREMBD Datasheet

On a serial bus, a single signal often includes address, control, data, and clock information. This can make isolating events of interest difficult. The serial applications for the 5 Series MSO transform the oscilloscopes into a robust tool for debugging serial buses with automatic trigger and decode for I2C, SPI, CAN, LIN, FlexRay, RS-232/422/485, UART, I2S, LJ, RJ, and TDM.

Key features

- Automated Serial Triggering and Decode Options for I2C, SPI, CAN, LIN, FlexRay, RS-232/422/485, UART, I2S, LJ, RJ, and TDM [1]

- Trigger on all the critical elements of a serial bus such as address, data, etc.

- Decode all the critical elements of each message. No more counting 1s and 0s!

- Search through long acquisitions with user-defined criteria to find specific messages

- Event Table shows decoded serial bus activity in a tabular, time-stamped format for quick summary of system activity

Serial Triggering and Analysis Applications

The 5 Series MSO serial applications support automatic trigger and decode for I2C, SPI, CAN, LIN, FlexRay, RS-232/422/485, UART, I2S, LJ, RJ, and TDM buses, making it easier to locate, analyze, and debug events of interest.

Serial triggering

Trigger on packet content such as start of packet, specific addresses, specific data content, unique identifiers, etc. on popular serial interfaces such as I2C, SPI, CAN, LIN, FlexRay, RS-232/422/485, UART, I2S, LJ, RJ, and TDM.

Bus display

The bus display provides a higher-level, combined view of the individual signals (clock, data, chip enable, and so on) that make up your bus, making it easy to identify where packets begin and end and identifying sub-packet components such as address, data, errors, and so on.

Bus decoding

Tired of having to visually inspect the waveform to count clocks, determine if each bit is a 1 or a 0, combine bits into bytes, and determine the hex value?

Let the oscilloscope with a serial application do it for you! Once you've set up a bus, the 5 Series MSO will decode each packet on the bus, and display the value in hex, binary, or ASCII (RS-232/422/485/UART only) in the bus waveform.

Results table

In addition to seeing decoded packet data on the bus waveform itself, you can view all captured packets in a tabular view much like you would see in a software listing. Packets are time stamped and listed consecutively with columns for each component (Address, Data, and so on).

Wave Inspector® search

Serial triggering is very useful for isolating the event of interest, but once you've captured it and need to analyze the surrounding data, what do you do?

In the past, users had to manually scroll through the waveform counting and converting bits and looking for what caused the event. With a serial application, you can enable the 5 Series MSO to automatically search through the acquired data for user-defined criteria including serial packet content. Each occurrence is highlighted by a search mark. Rapid navigation between marks is as simple as pressing the ← and → buttons on the oscilloscope front panel.

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[1]   USB 2.0 and Ethernet support information available in separate datasheets

Characteristics

I²C characteristics

Bus setup options

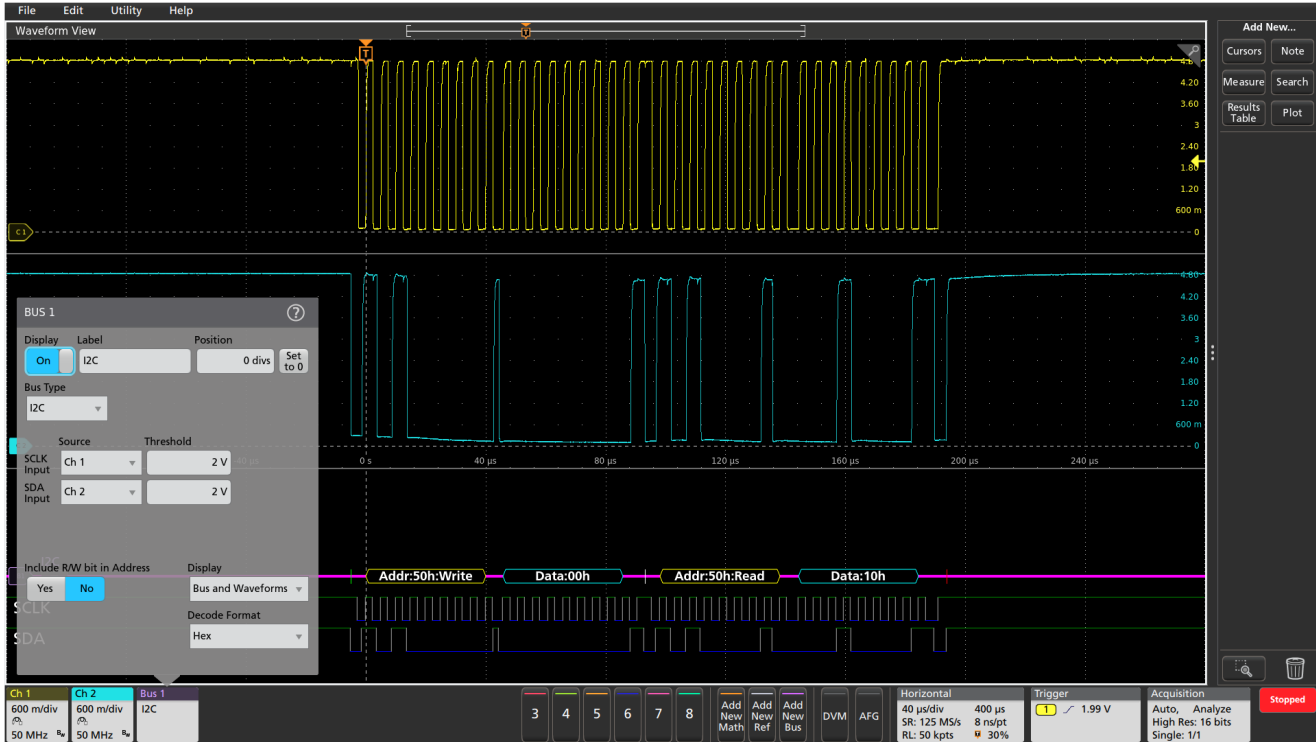| Characteristic	Description
I²C Sources (Clock and Data)	Analog channels Digital channels Active Math channels Active Reference channels
Thresholds	Per-channel thresholds
Recommended Probing	Single-ended
Include R/W in Address	Yes or No
Address/Data Formats Available	Hex Binary

Display modes

Characteristic	Description
Bus	Bus only
Bus and Waveforms	Simultaneous display of bus and digital waveforms
Results Table	Decoded packet data in a tabular view

Bus trigger and search options

Characteristic	Description
Trigger and/or Search On	Start Repeated Start Stop Missing Ack Address (7 or 10 bit) Data (1-5 bytes) Address and Data

Bus decode

Characteristic	Description
Maximum Clock/Data Rate	Up to 10 Mb/s (automatic selection)
Decode Display	Start (green bar) Address (yellow packet) Data (cyan packet) Missing Ack (! symbol in red box) Stop (red bar)

Color-coded I^{2}C bus display, using hexadecimal display format.
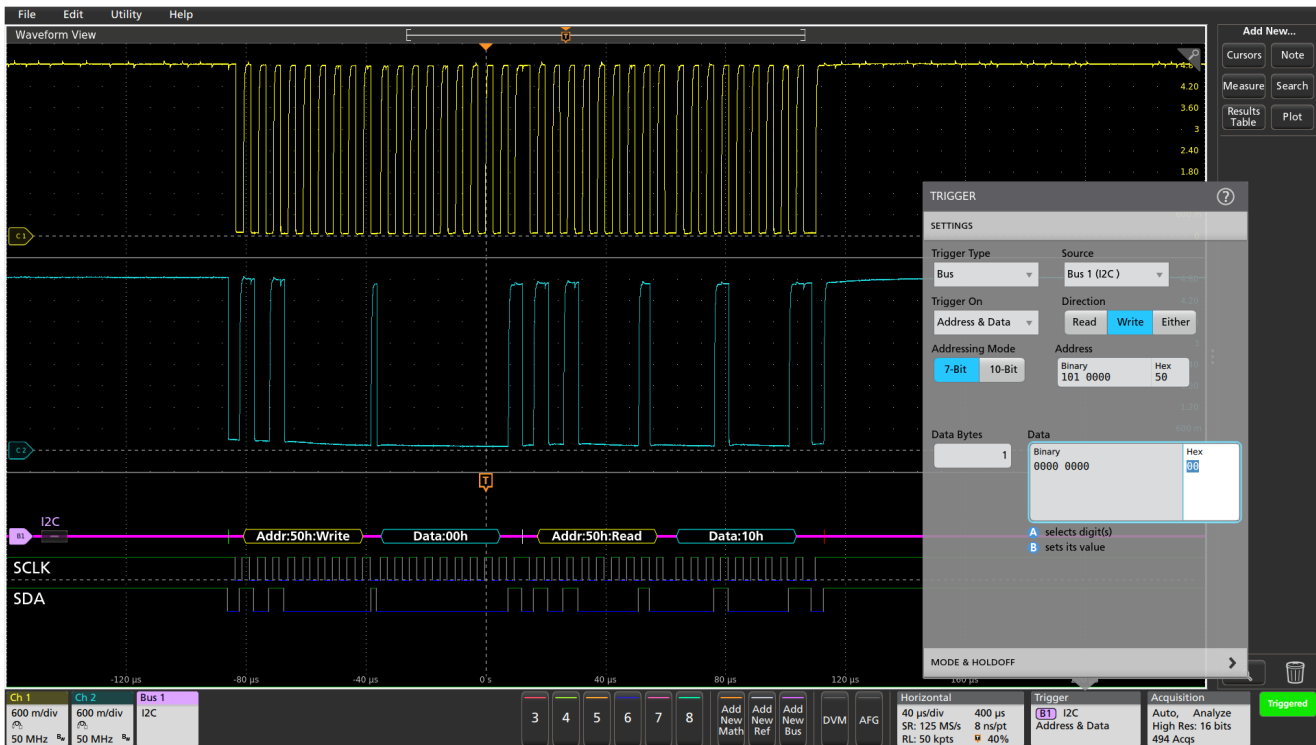
Triggering on a specific address value on the I^{2}C bus.

SPI characteristics

Bus setup options

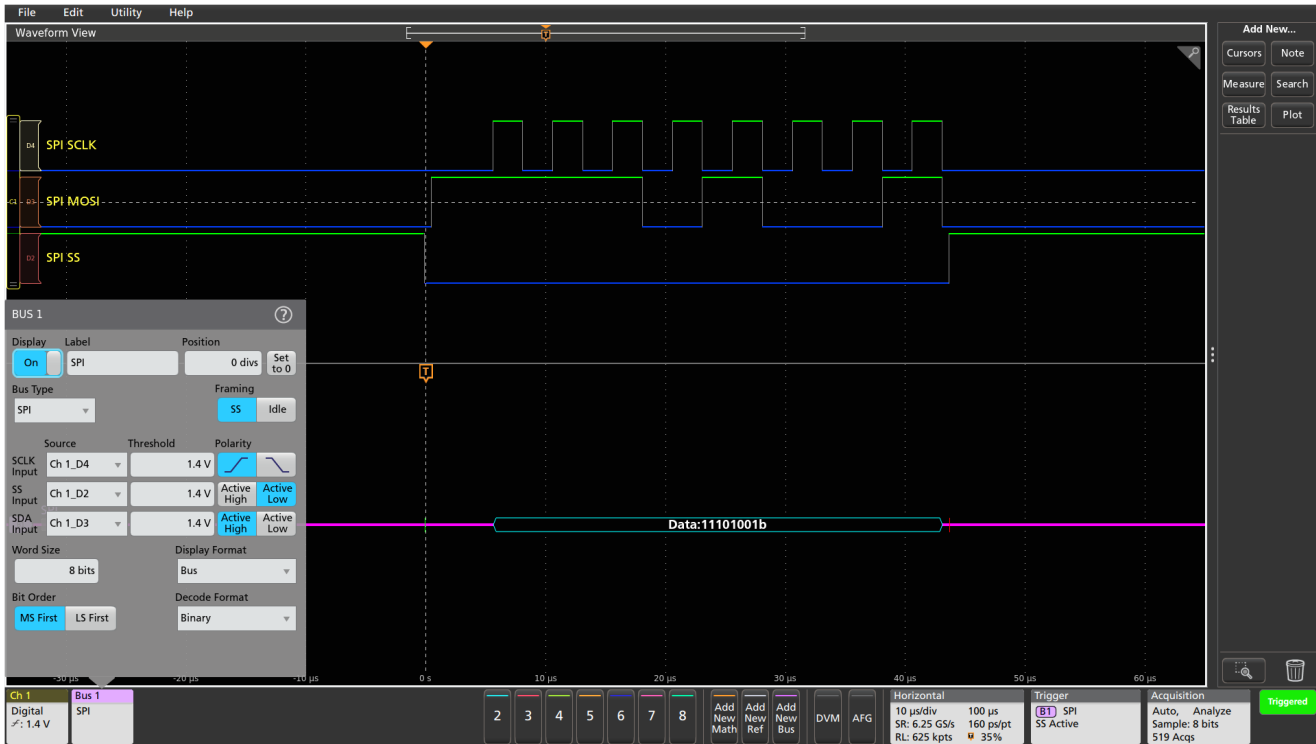| Characteristic	Description
SPI Sources (Clock, Data, and Slave Select)	Analog channels Digital channels Active Math channels Active Reference channels
Thresholds	Per-channel thresholds
Recommended Probing	Single-ended
Decode Configuration: Framing Clock Slave Select Data Word Size Bit Order	Slave Select (3-wire SPI), Idle Time (2-wire SPI) Rising or Falling Edge Active High or Active Low Active High or Active Low 4 - 32 bits Most Significant (MS) First, Least Significant (LS) First
Formats Available	Hex Binary

Display modes

Characteristic	Description
Bus	Bus only
Bus and Waveforms	Simultaneous display of bus and digital waveforms
Results Table	Decoded packet data in a tabular view

Bus trigger and search options

Characteristic	Description
Trigger and/or Search On	SS Active (3-wire SPI) Start of Frame (2-wire SPI) Data (1-16 bytes)

Bus decode

Characteristic	Description
Maximum Clock/Data Rate	Up to 10 Mb/s (automatic selection)
Decode Display	Start (green bar) Data (cyan packet) Stop (red bar)

SPI bus, captured with digital channels, showing binary display format of the color-coded SPI bus decoding.

Triggering on a specific data value on the SPI bus.

RS-232, RS-422, RS-485, UART characteristics

Bus setup options

Characteristic	Description
Sources, RS-232, UART	Analog channels Digital channels Active Math channels Active Reference channels
Sources, RS-422, RS-485	Analog channels Active Math channels Active Reference channels
Polarity	Normal (RS-232) Inverted (UART, RS-422, RS-485)
Parity	None Odd Even
Recommended Probing, RS-232, UART	Single ended
Recommended Probing, RS-422, RS-485	Differential
Number of Bits	7 - 9
Formats Available	Hex Binary ASCII Packet View

Display modes

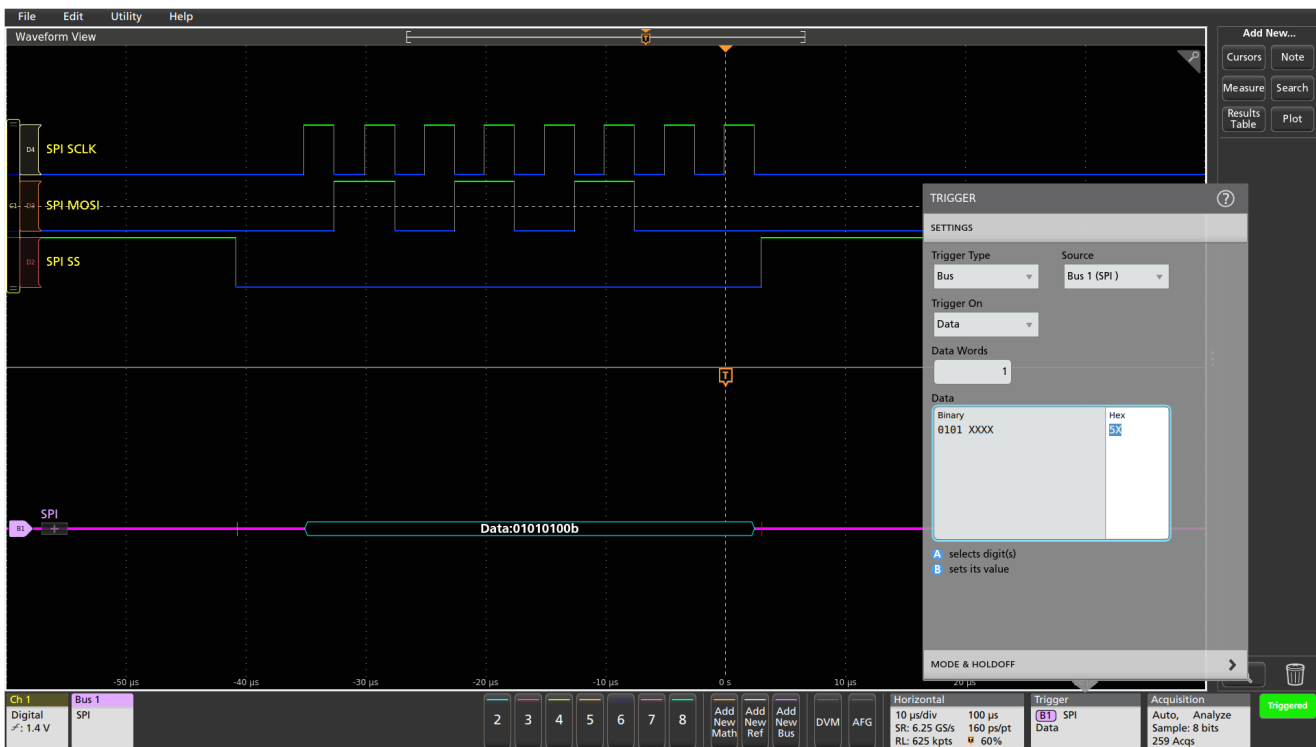| Characteristic	Description
Bus	Bus only
Bus and Waveforms	Simultaneous display of bus and digital waveforms
Results Table	Decoded packet data in a tabular view

Bus trigger and search options

Characteristic	Description
Trigger and/or Search On	Start End of Packet Data (1 - 10 bytes) Parity Error

Bus decode

Characteristic	Description
Maximum Clock/Data Rate	Up to 10 Mb/s
Bit Rate Selection	300 b/s 1,200 b/s 2,400 b/s 9,600 b/s 19,200 b/s 38,400 b/s 115,200 b/s 921,600 b/s Custom (50 b/s - 10 Mb/s)
Decode Display	Start (green packet) Data (cyan packet) Parity (purple packet) Parity Error (red packet)
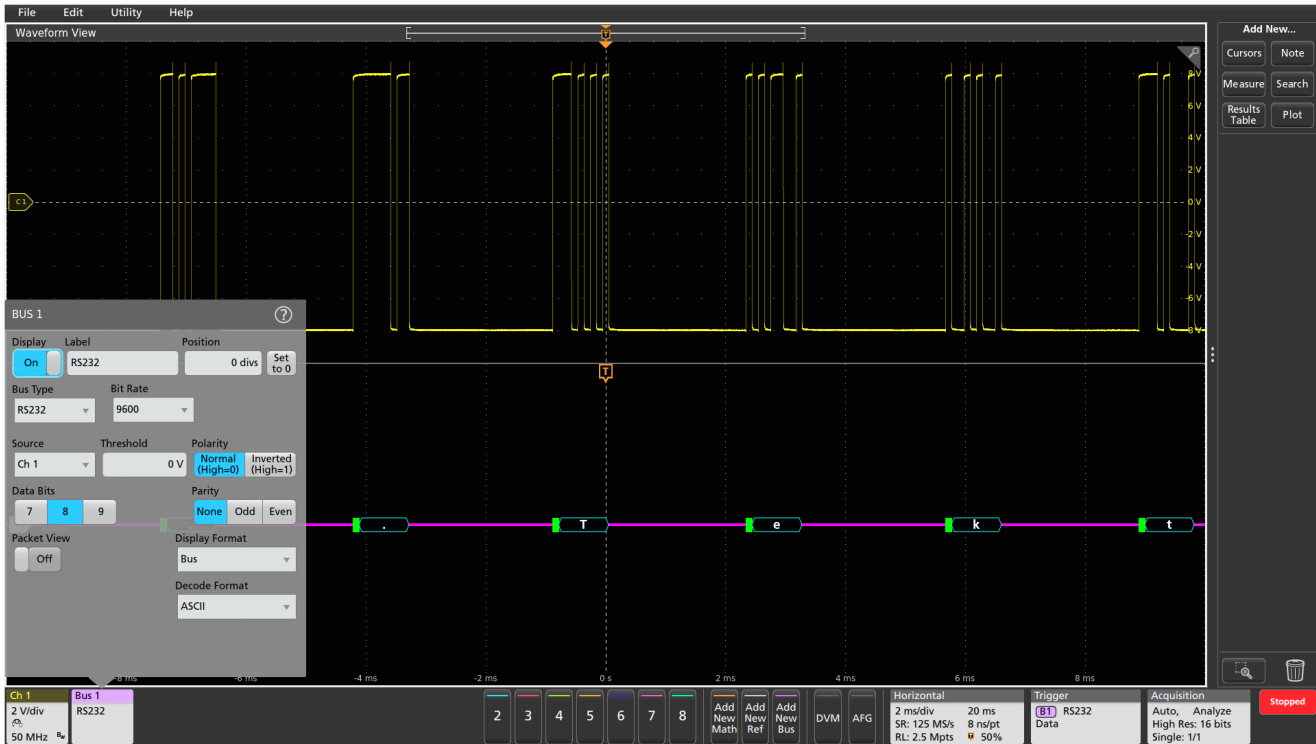
RS-232 bus setup and ASCII display, showing assignment of source signal, digital threshold, and polarity.

RS-232 bus shown in Packet View format, with the Wave Inspector search automatically searching for the data string "Tek".

CAN characteristics

Bus setup options

Characteristic	Description
Source for CAN_H, CAN_L, Rx, or Tx (single-ended probing)	Analog channels Digital channels Active Math channels Active Reference channels
Source for Diff (differential probing)	Analog channels Active Math channels Active Reference channels
Thresholds	Per-channel thresholds
Recommended Probing: CAN_H, CAN_L, Rx, Tx Diff	Single-ended Differential
Bit Rate Selection: Predefined list of rates Custom	10 kb/s - 1 Mb/s 1 kb/s - 1 Mb/s
Sample Point	0% - 100% of bit period of unit interval
Formats Available	Hex Binary

Display modes

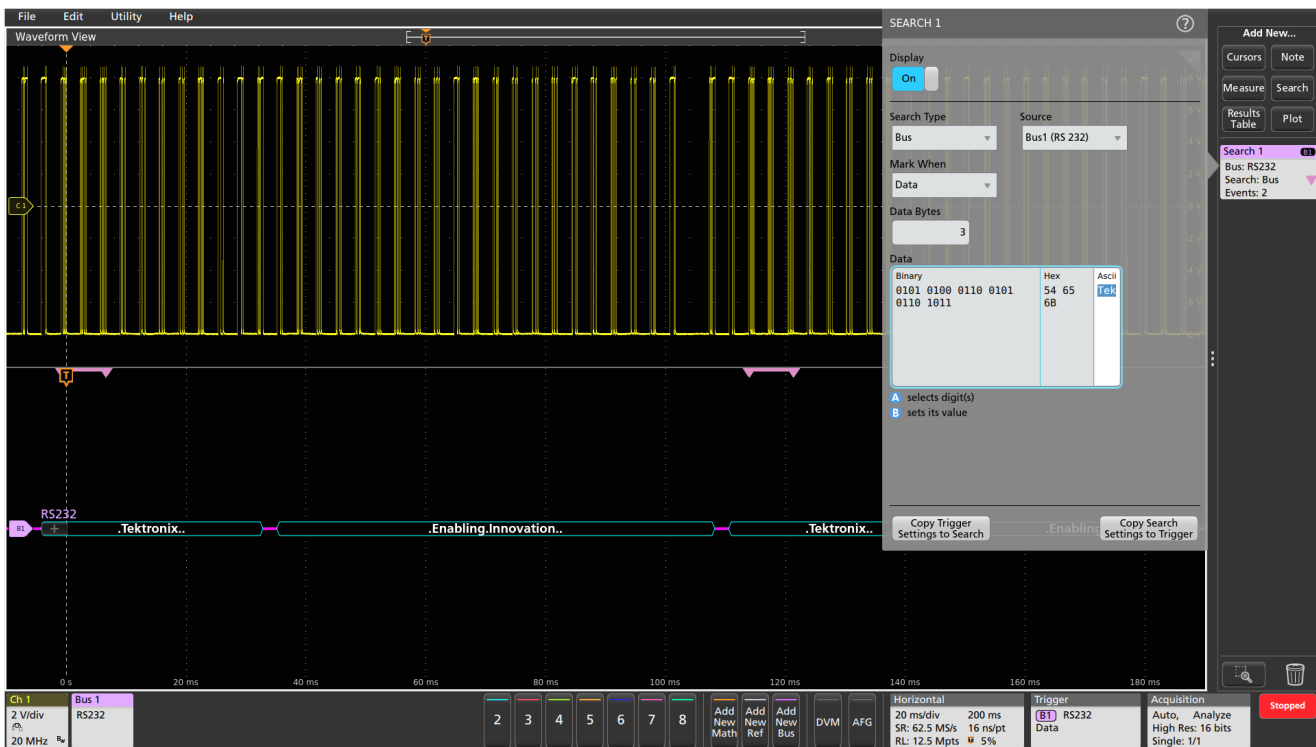| Characteristic	Description
Bus	Bus only
Bus and Waveforms	Simultaneous display of bus and digital waveforms
Results Table	Decoded packet data in a tabular view

Bus trigger and search options

Characteristic	Description
Trigger and/or Search On	Start of Frame Type of Frame (Data, Remote, Error, Overload) Identifier (Standard or Extended) Data (number of bytes 1-8, trigger or search when =,!=, <, >, <=, >=) Identifier and Data EOF Missing Ack Bit Stuff Error

Bus decode

Characteristic	Description
Maximum Clock/Data Rate	Up to 1 Mb/s (automatic selection)
Decode Display	Start of Frame (green bar) Identifier (yellow packet) Data Length Control (purple packet) Data (cyan packet) CRC (purple packet) End of Frame (red bar) Errors (red packet)

Bus Decode Results

Bus 1 (CAN)

Index	Start Time	Stop Time	Identifier (h)	Data Length (h)	Data (h)	CRC (h)	Ack (h)	Overload Flag	Unframed (h)
1	-102.0722ps	205.943µs	00BEBEBE	4	7B7E9A9C	37EE			
2	211.9255µs	307.9232µs	100	0		380A			
3	313.9261µs	441.9245µs	101	2	0103	562D			
4	447.9272µs	665.9479µs	10000001	5	1122334455	6A65			
5	671.9305µs	0.93393ms	12345678	8	1122334455667788	04C2			
6	0.939933ms	1.209933ms	1597EEB2	8	FFFF0000EEEE1111	216E			
7	1.215935ms	1.367935ms	519	4	42696C6C	7744			
8	1.373938ms	1.643938ms	1597EEB2	8	AE4FFFF10272DF6B	2180			
9	1.649941ms	1.799939ms	0527DE32	1	11	7F3D			
10	1.805942ms	1.989941ms	00140014	3	112233	5EDC			
11	1.995944ms	2.211944ms	00160016	5	1122334455	3911			
12	2.217947ms	2.475947ms	18181818	7	F1F2F3F4F5F6F7	5F9B			
13	2.48195ms	2.77595ms	00000000	8	0000000000000000	3DAF			
14	2.781952ms	2.873972ms	757	0		20BB			

Protocol Decode Results Table provides a time-stamped, tabular view of all captured packets on the CAN bus.

Triggering on a specific extended Identifier value on the CAN bus.

LIN characteristics

Bus setup options

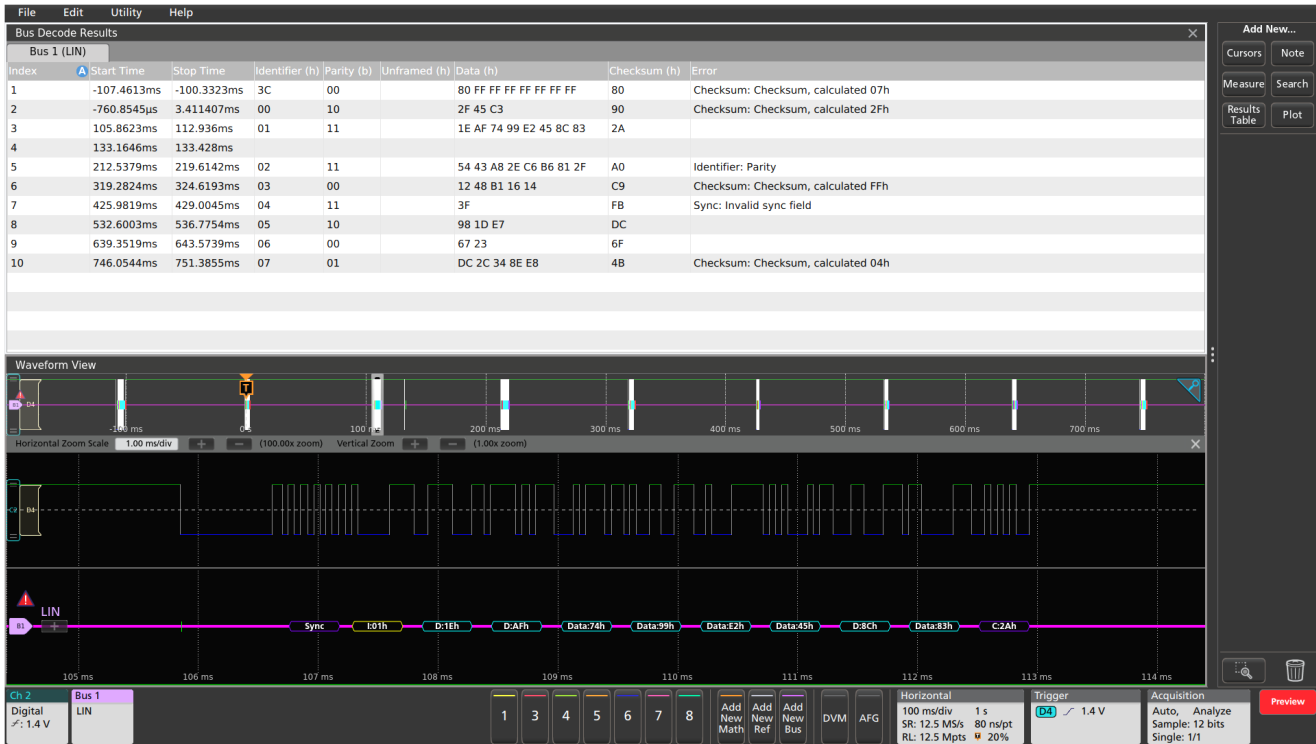| Characteristic	Description
LIN Source	Analog channels Digital channels Active Math channels Active Reference channels
Thresholds	Per-channel thresholds
Recommended Probing	Single-ended
Polarity	Normal Inverted
Bit Rate Selection: Predefined list of rates Custom	1.2 kb/s - 19.2 kb/s 1 kb/s - 100 kb/s
Sample Point	0% - 100% of bit period of unit interval
LIN Standard	V 1.x V 2.x Both
Include Parity Bits with ID	Yes No
Formats Available	Hex Binary

Display modes

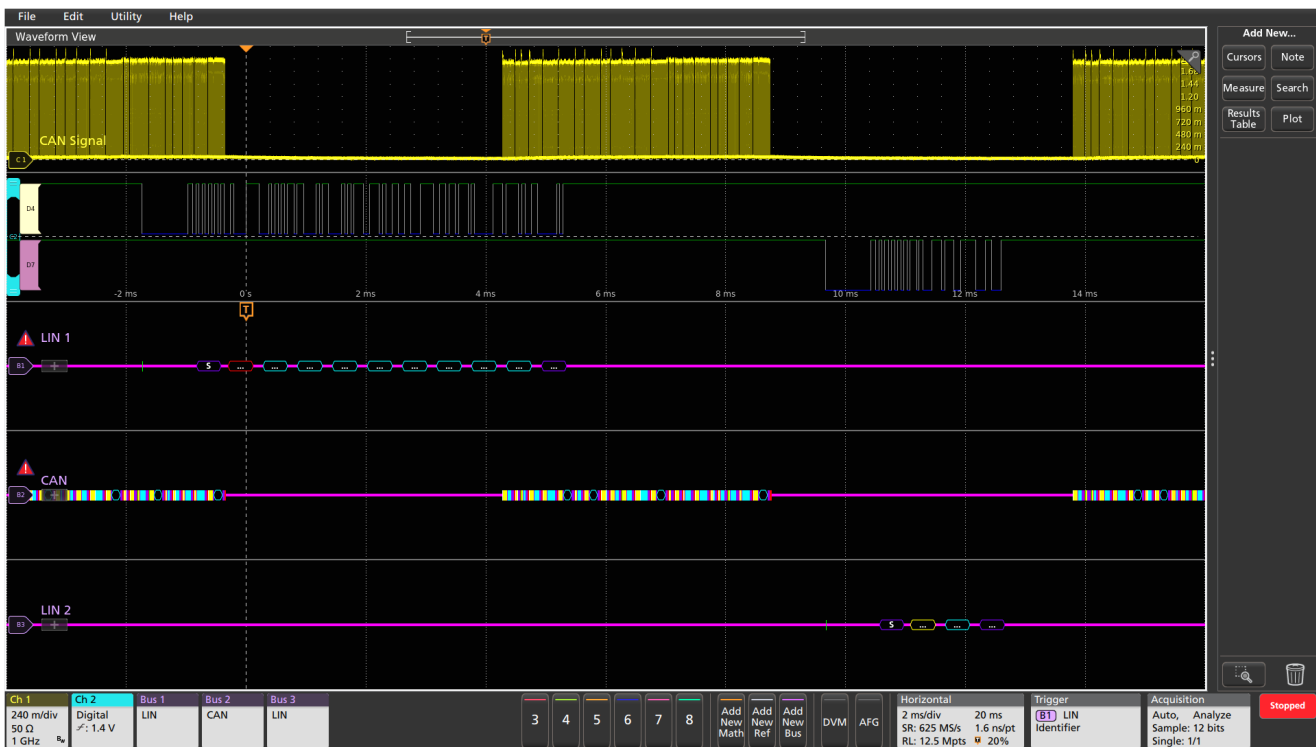| Characteristic	Description
Bus	Bus only
Bus and Waveforms	Simultaneous display of bus and digital waveforms
Results Table	Decoded packet data in a tabular view

Bus trigger and search options

Characteristic	Description
Trigger and/or Search On	Sync Identifier Data (number of bytes 1-8, trigger or search when =, ≠, <, >, ≤, ≥, Inside Range, Outside Range) ID and Data Wakeup Frame Sleep Frame Error (Sync, ID Parity, Checksum)

Bus decode

Characteristic	Description
Maximum Clock/Data Rate	Up to 100 kb/s, by LIN definition up to 20 kb/s (for automated decoding of bus)
Decode Display	Start of Frame (green bar) Sync Identifier (yellow packet) Data (cyan packet) CRC (purple packet) Errors (red packet)

Index	Start Time	Stop Time	Identifier (h)	Parity (b)	Unframed (h)	Data (h)	Checksum (h)	Error
1	-107.4613ms	-100.3323ms	3C	00		80 FF FF FF FF FF FF FF	80	Checksum: Checksum, calculated 07h
2	-760.8545µs	3.411407ms	00	10		2F 45 C3	90	Checksum: Checksum, calculated 2Fh
3	105.8623ms	112.936ms	01	11		1E AF 74 99 E2 45 8C 83	2A	
4	133.1646ms	133.428ms						
5	212.5379ms	219.6142ms	02	11		54 43 A8 2E C6 B6 81 2F	A0	Identifier: Parity
6	319.2824ms	324.6193ms	03	00		12 48 B1 16 14	C9	Checksum: Checksum, calculated FFh
7	425.9819ms	429.0045ms	04	11		3F	FB	Sync: Invalid sync field
8	532.6003ms	536.7754ms	05	10		98 1D E7	DC	
9	639.3519ms	643.5739ms	06	00		67 23	6F	
10	746.0544ms	751.3855ms	07	01		DC 2C 34 8E E8	4B	Checksum: Checksum, calculated 04h

Protocol Decode Results Table provides a time-stamped, tabular view of all captured LIN packets.

Display of multiple LIN and CAN buses, showing timing between the buses.

FlexRay characteristics

Bus setup options

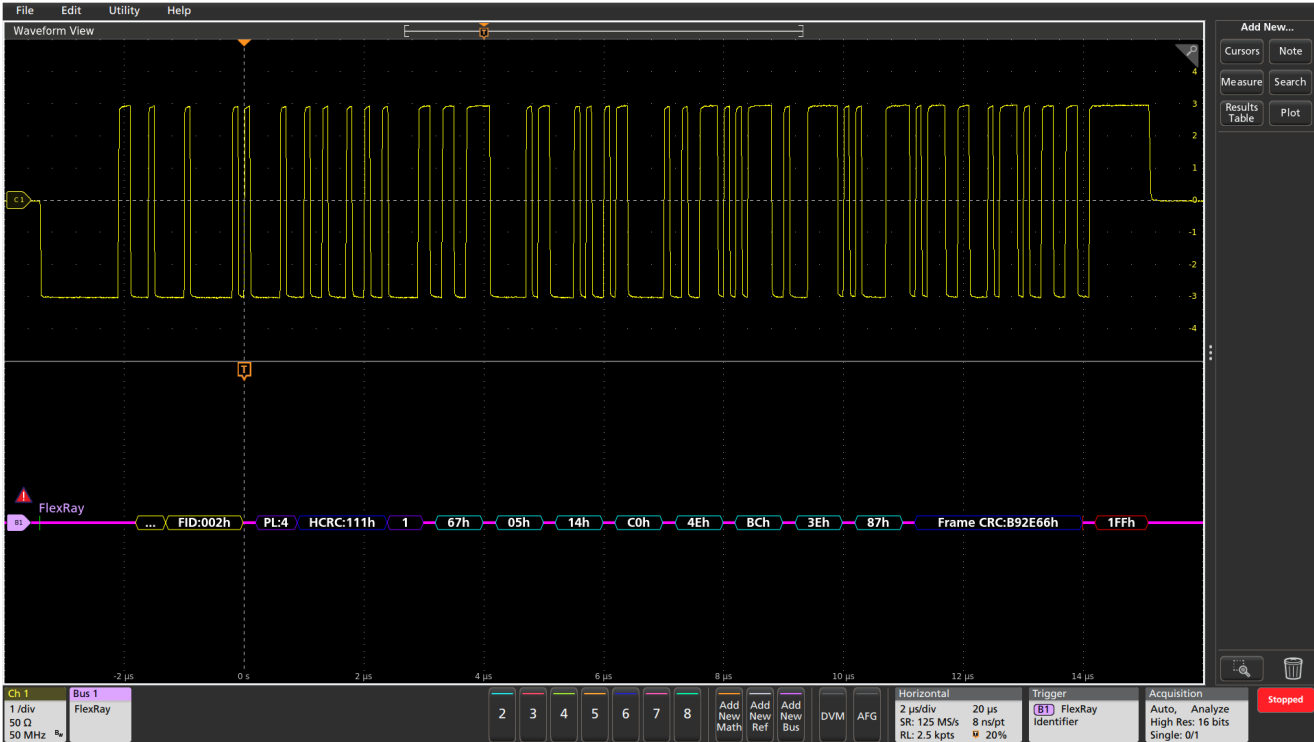| Characteristic	Description
Source for Differential Probing (Bdiff)	Analog channels Active Math channels Active Reference channels
Source for Single-ended Probing (BP, BM)	Analog channels Digital channels Active Math channels Active Reference channels
Source for Single-ended Probing (Tx, Rx)	Analog channels Digital channels Active Math channels Active Reference channels
Thresholds: Bdiff BP, BM (analog channels) BP, BM (digital channels) Tx, Rx	High and Low thresholds High and Low thresholds Single threshold Single threshold
Recommended Probing: Bdiff, BP, BM Tx, Rx	Differential Single-ended
Channel Type	A B
Bit Rate Selection: Predefined list of rates Custom	2.5 Mb/s, 5 Mb/s, 10 Mb/s 1 Mb/s - 10 Mb/s
Formats Available	Hex Binary Mixed Hex (Decimal: ID, Len, and Count; Hex: Data and CRCs)

Display modes

Characteristic	Description
Bus	Bus only
Bus and Waveforms	Simultaneous display of bus and digital waveforms
Results Table	Decoded packet data in a tabular view

Bus trigger and search options

Characteristic	Description
Trigger and/or Search On	Start of Frame Indicator Bits (Normal, Payload, Null, Sync, Startup) Cycle Count (when =, ≠, <, >, ≤, ≥) Header Fields (Indicator Bits, Identifier, Payload Length, Header CRC, and Cycle Count) Identifier (when =, ≠, <, >, ≤, ≥) Data (when =, ≠, <, >, ≤, ≥) Identifier and Data End Of Frame (Static, Dynamic) Error (Header CRC, Trailer CRC, NULL Frame in Static, NULL Frame in Dynamic, Sync Frame in Dynamic, Start Frame No Sync)

Bus decode

Characteristic	Description
Maximum Clock/Data Rate	Up to 10 Mb/s (for automated decoding of bus)
Decode Display	TTS (purple box) Start (green bracket) Frame ID (yellow box) Payload Length (purple box) Headers (purple box) Cycle Count (yellow box) Data (cyan box) CRC, DTS, CID (purple box) Stop (red bracket)

Decoded FlexRay bus, with the acquisition triggered on a specified identifier value.

Decoded FlexRay bus, with all data values in a specific range marked with pink brackets.

Audio characteristics

Bus setup options

Characteristic	Description
Audio Sources (Bit Clock, Word Select, Data)	Analog channels Digital channels Active Math channels Active Reference channels
Thresholds	Per-channel thresholds
Bit Clock Polarity	Rising Edge Falling Edge
Word Select Polarity	Normal Invert
Data Polarity	Active High Active Low
Word Size	4 - 32 bits
Formats Available	Hex Binary

Display modes

| Characteristic	Description
Bus	Bus only
Bus and Waveforms	Simultaneous display of bus and digital waveforms
Results Table	Decoded packet data in a tabular view

Bus trigger and search options

Characteristic	Description
Trigger and/or Search On	Word Select (I^2S, LJ, RJ only) Frame Sync (TDM only) Data (when =, ≠, <, >, ≤, ≥, Inside Range, Outside Range; Left, Right, or Either Word)

Bus decode

Characteristic	Description
Maximum Clock/Data Rate	Up to 10 Mb/s (for automated decoding of bus)
Decode Display	Left Channel Data (I^2S, LJ, RJ) (yellow box) Right Channel Data (I^2S, LJ, RJ) (cyan box) Channel 1 Data (TDM) (yellow box) Channel 2 - N Data (TDM) (cyan box)
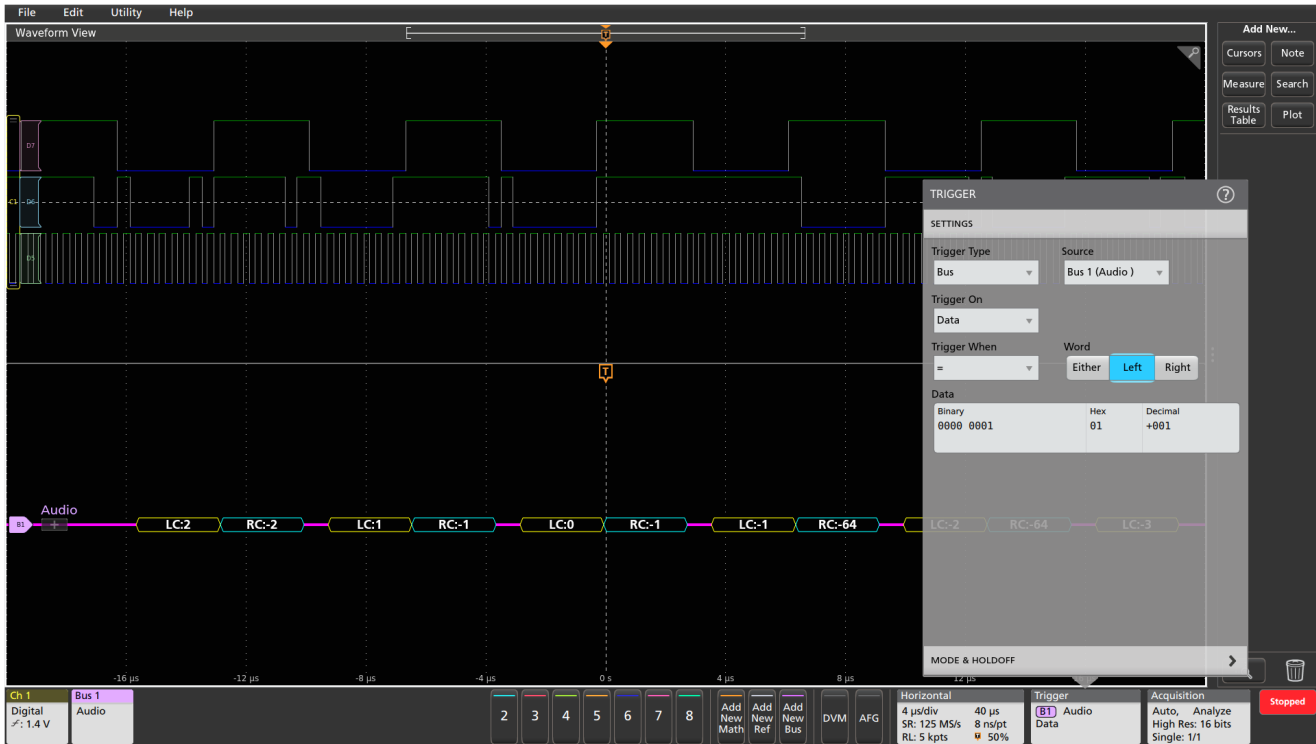
Decoded I²S bus, with data values displayed in signed decimal format, and the MSO triggered on a specific data value.
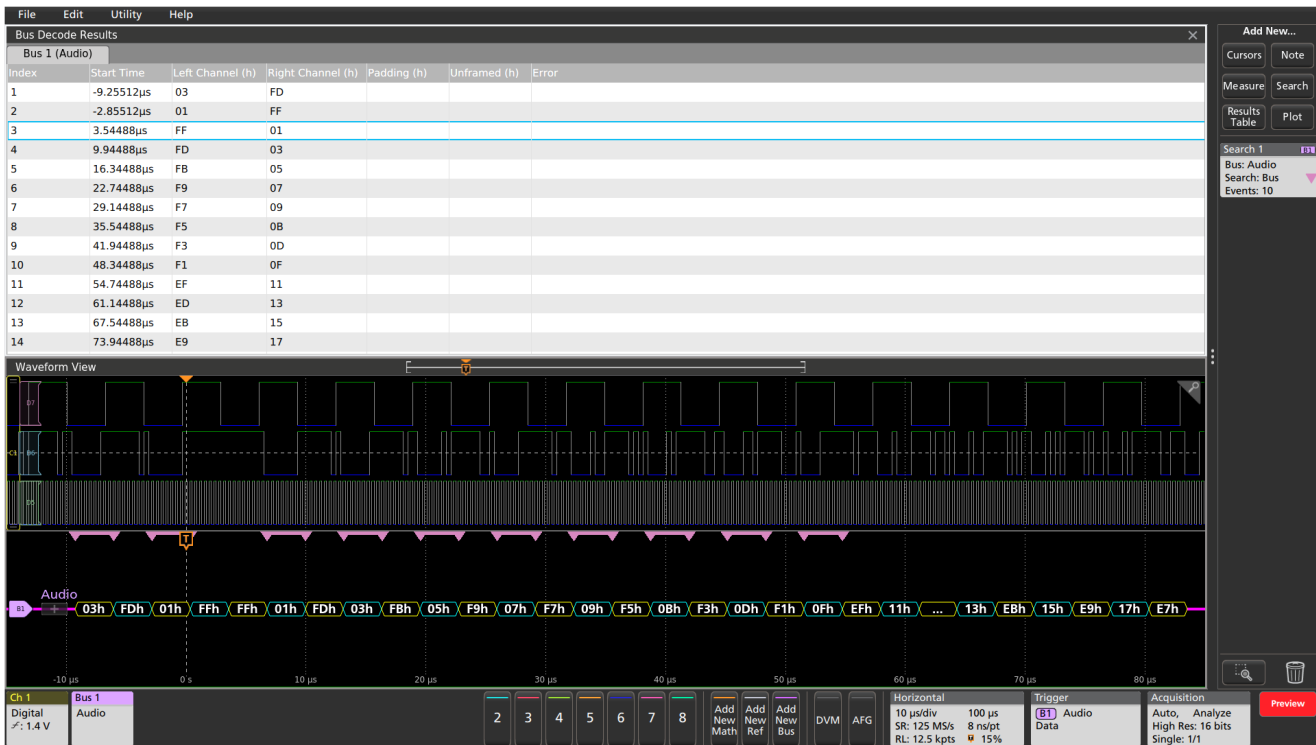
Decoded I²S bus, with data values displayed in hex and Results Table format, and the Wave Inspector automatic search marking all occurrences of the data values equal to 0X hex.

Ordering information

To add to an instrument at purchase

Serial bus	5 Series MSO Option [2]	Description
I ^{2}C, SPI	5-SREMBD	Embedded Serial Triggering and Analysis (I^{2}C, SPI). Enables triggering on packet-level information on I^{2}C and SPI buses as well as analytical tools such as digital views of the signal, bus views, packet decoding, search tools, and packet decode tables with time stamp information.
CAN, LIN, FlexRay	5-SRAUTO	Automotive Serial Triggering and Analysis (CAN, LIN, FlexRay). Enables triggering on packet-level information on CAN/LIN/FlexRay buses as well as analytical tools such as digital views of the signal, bus views, packet decoding, search tools, and packet decode tables with time stamp information.
RS-232/422/485, UART	5-SRCOMP	Computer Serial Triggering and Analysis (RS-232, RS-422, RS-485, UART). Enables triggering on packet-level information on RS-232/422/485 and UART buses as well as analytical tools such as digital views of the signal, bus views, packet decoding, search tools, and packet decode tables with time stamp information.
I^{2}S, LJ, RJ, TDM	5-SRAUDIO	Audio Serial Triggering and Analysis (I^{2}S, LJ, RJ, TDM). Enables triggering on packet-level information on serial audio buses as well as analytical tools such as digital views of the signal, bus views, packet decoding, search tools, and packet decode tables with time stamp information.

To upgrade an existing 5 Series MSO

Serial bus [3]	Order
I^{2}C, SPI	SUP5-SREMBD
CAN, LIN, FlexRay	SUP5-SRAUTO
RS-232/422/485, UART	SUP5-SRCOMP
I^{2}S, LJ, RJ, TDM	SUP5-SRAUDIO

Recommended probes

Please refer to www.tek.com/probes for further information on the recommended models of probes and any necessary probe adapters.

CE Marking Not Applicable.

Tektronix is registered to ISO 9001 and ISO 14001 by SRI Quality System Registrar.

Product(s) complies with IEEE Standard 488.1-1987, RS-232-C, and with Tektronix Standard Codes and Formats.

Product Area Assessed: The planning, design/development and manufacture of electronic Test and Measurement instruments.

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[2]   USB 2.0 and Ethernet options also available.

[3]   Software is supplied with the 5 Series MSO instrument firmware. User documentation is part of the oscilloscope documentation.

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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.tek.com.

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