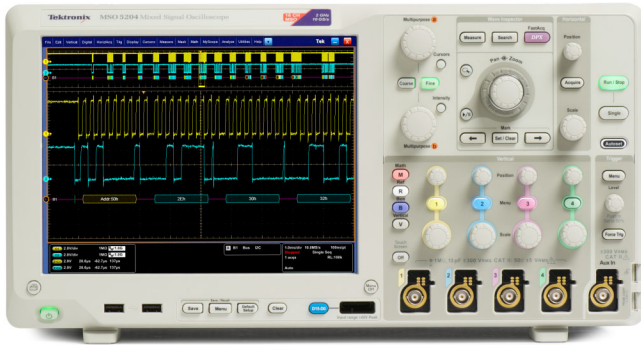# Serial Triggering and Analysis Applications
SR-AERO, SR-AUTO, SR-COMP, and SR-EMBD Datasheet

Features & Benefits

- Automated Serial Triggering and Decode Options for I2C, SPI, CAN, LIN, FlexRay, MIL-STD-1553, and RS-232/422/485/UART*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

*1 USB, Ethernet, and MIPI® D-PHY support information available in separate data sheets.

Tektronix®

Triggering on a specific address on an I2C bus. A complete set of triggers, including triggers for specific address and data packet content, ensures you quickly capture your event of interest.

Color-coded display of I2C bus, showing Start, Address, Data, and Stop components of the serial signal.

Serial Triggering and Analysis Applications

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 MSO/DPO5000, DPO7000C, and DPO/DSA/MSO70000C/D Series transform the oscilloscopes into a robust tool for debugging serial buses with automatic trigger and decode for I2C, SPI, CAN, LIN, FlexRay, MIL-STD-1553, and RS-232/422/485/UART.
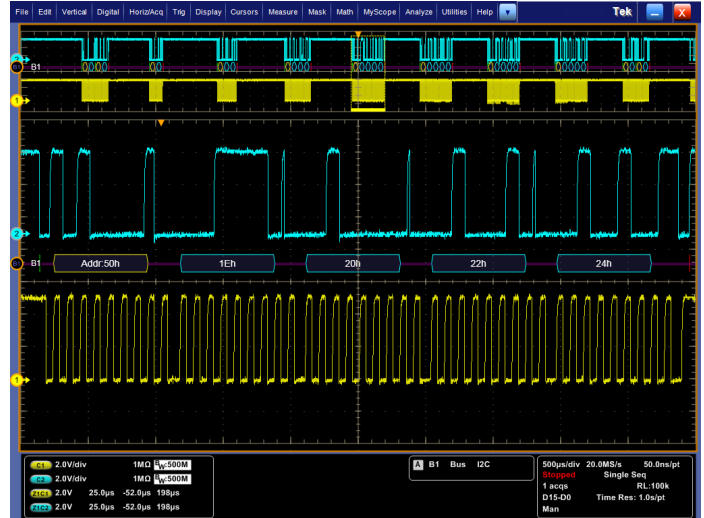
Serial Triggering

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, MIL-STD-1553, and RS-232/422/485/UART.
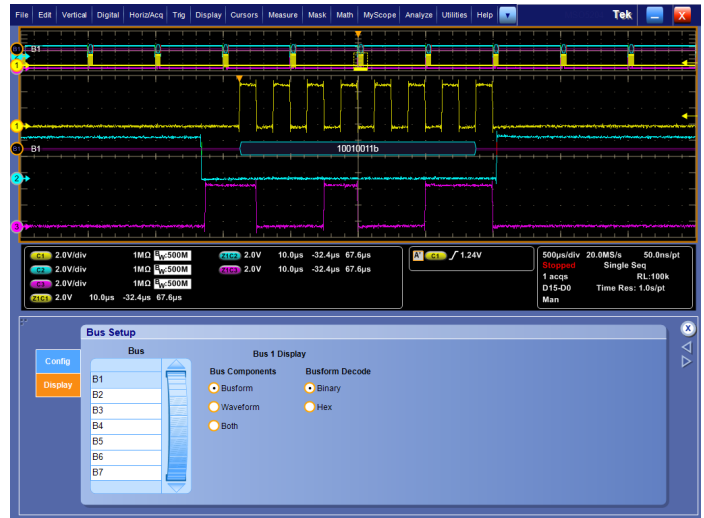
Bus Display

Provides a higher-level, combined view of the individual signals (clock, data, chip enable, etc.) that make up your bus, making it easy to identify where packets begin and end and identifying subpacket components such as address, data, errors, etc.

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?
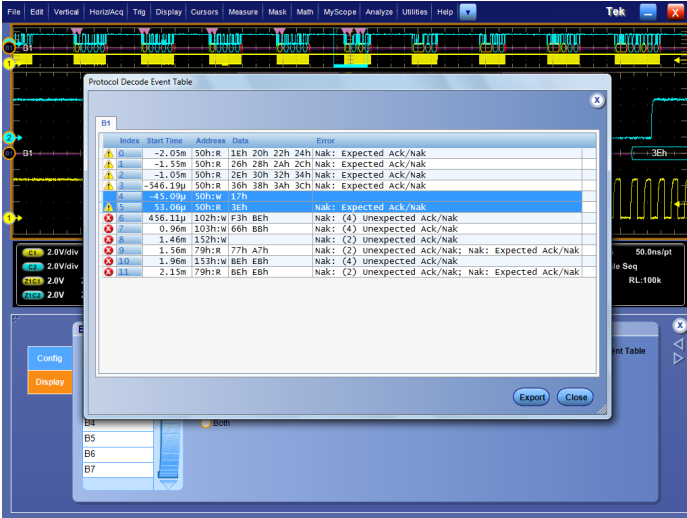

Decoded display of SPI bus, automatically displaying bus content in any of several digital formats.

Let the oscilloscope with a serial application do it for you! Once you've set up a bus, the MSO/DPO5000, DPO7000C, and DPO/DSA/MSO70000C/D Series 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.

Event Table display of bus content, with time stamp information for each packet.

Serial Search display showing every occurrence of the specified serial event.

Event 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, etc.).

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 MSO/DPO5000, DPO7000C, or DPO/DSA/MSO70000C/D Series oscilloscope 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 **Previous** (←) and **Next** (→) buttons on the oscilloscope front panel.
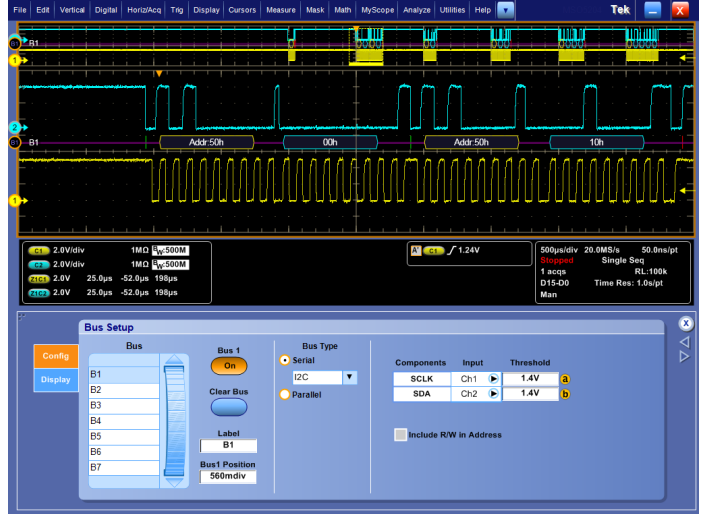
Characteristics

I²C Characteristics

Bus Setup Options

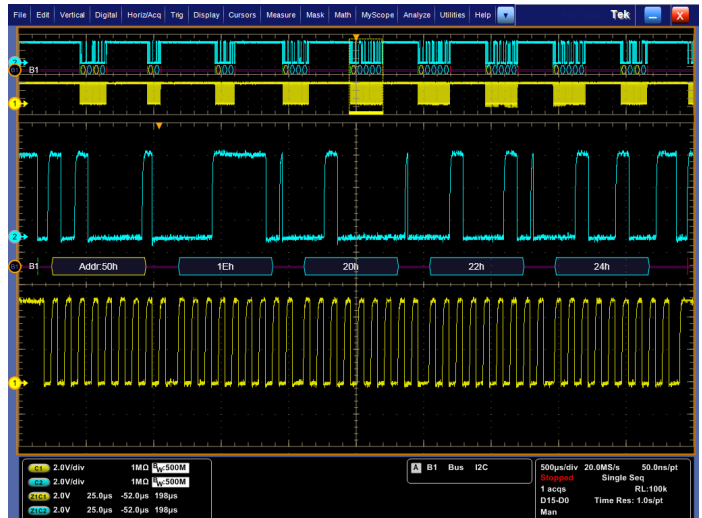| Characteristic	Description
I²C Sources (Clock and Data)	Analog channels 1-4 Math channels 1-4 Digital channels D0 - D15 (MSO models only)
Thresholds	Per-channel thresholds
Recommended Probing	Single ended
Include R/W in Address	Yes or No
Address/Data Formats Available	Hex Binary
Display Modes	
Bus	Bus only
Bus and Waveforms	Simultaneous display of bus and digital waveforms
Event Table	Decoded packet data in a tabular view

Bus Trigger and Search Options

Characteristic	Description
Trigger and/or Search On	Start Stop Repeated Start 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) Missing Ack (! symbol) Data (cyan packet) Stop (red bar)

I²C bus setup, showing assignment of source signals and digital thresholds.

Color-coded I²C bus display, using hexadecimal display format.

Triggering on a specific address value on the I²C bus.

SPI Characteristics

Bus Setup Options

Characteristic	Description
SPI Sources (Clock, Data, and Slave Select)	Analog channels 1-4 Math channels 1-4 Digital channels D0 - D15 (MSO models only)
Thresholds	Per-channel thresholds
Recommended Probing	Single ended
Decode Configuration	
Framing	Idle Time (2-wire SPI) Slave Select (3-wire SPI)
Clock	Rising or Falling Edge
Slave Select	Active High or Active Low
Data	Active High or Active Low
Word Size	4 - 32 bits
Bit Order	Most Significant (MS) First Least Significant (LS) First
Formats Available	Hex Binary

Display Modes

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

Bus Trigger and Search Options

Characteristic	Description
Trigger and/or Search On	SS Data (1 - 16 bytes)

Bus Decode

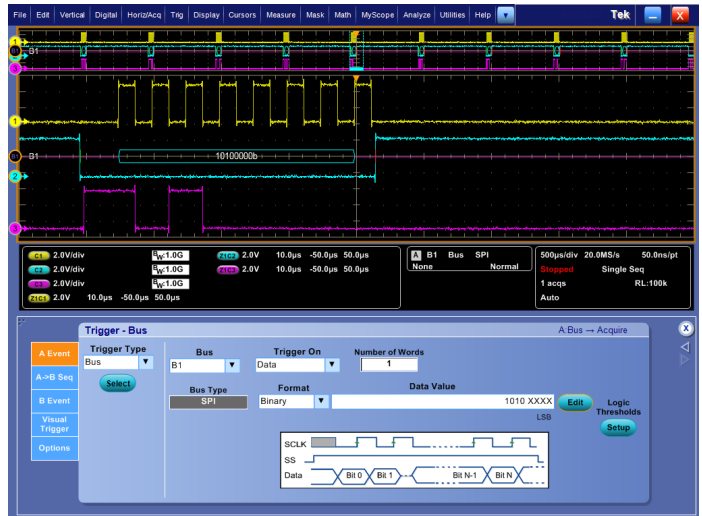| Characteristic	Description
Maximum Clock/Data Rate	Up to 10 Mb/s (automatic selection)
Decode Display	Start (green bar) Data (cyan packet) Stop (red bar)
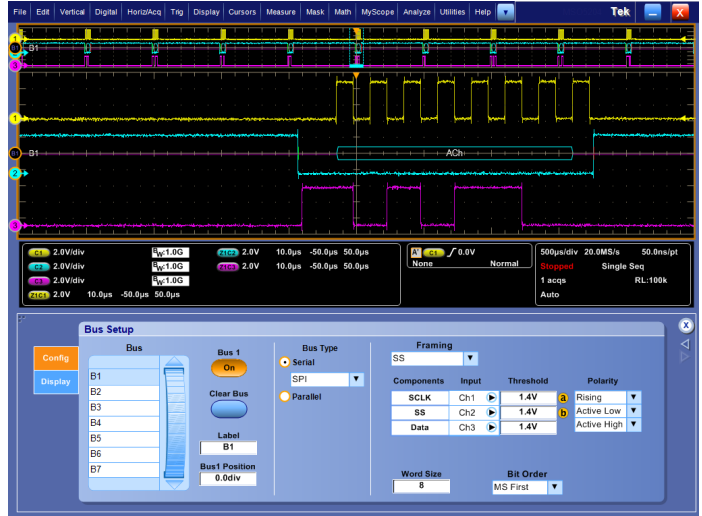
SPI bus setup, showing assignment of source signals and digital thresholds.
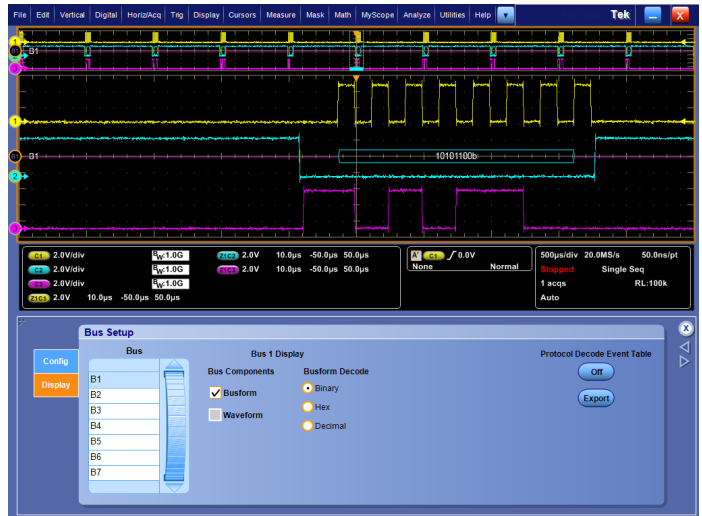
Color-coded SPI bus display, showing binary display format.

Triggering on a specific data value on the SPI bus.

CAN Characteristics

Bus Setup Options

Characteristic	Description
Source for CAN_H, CAN_L, Rx, or Tx Probing	Analog channels 1-4
	Math channels 1-4
	Digital channels D0 - D15 (MSO models only)
Source for Differential Probing	Analog channels 1-4
	Math channels 1-4
Thresholds	Per-channel thresholds
Recommended Probing	
CAN_H, CAN_L, Rx, Tx	Single ended
Differential	Differential
Bit Rate	
Predefined list of rates	10 Kb/s - 1 Mb/s
Custom	10 Kb/s - 1 Mb/s
Sample Point	50% of bit period or unit interval
Formats Available	Hex
	Binary
Display Modes	
Bus	Bus only
Bus and Waveforms	Simultaneous display of bus and digital waveforms
Event Table	Decoded packet data in a tabular view

Bus Trigger and Search Options

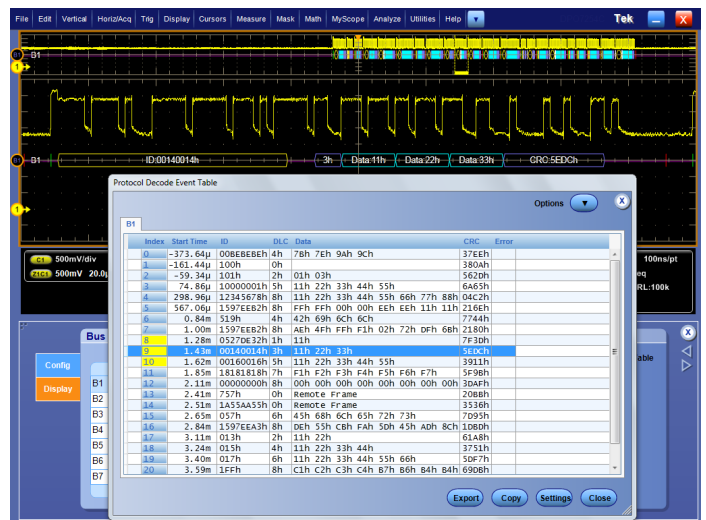| Characteristic	Description
Trigger and/or Search On	Start of Frame
	Type of Frame (Data, Remote, Error, Overload)
	Identifier (Standard or Extended)
	Data (number of bytes 1-8, trigger or search when =, !=, <, >, <=, >=)
	Identifier and Data
	EOF
	Missing Ack
	Bit Stuff Error

Bus Decode

Characteristic	Description
Maximum Clock/Data Rate	Up to 1 Mb/s (for automated decoding of bus)
Decode Display	Start (green bar)
	Identifier (yellow packet)
	DLC, CRC (blue packet)
	Missing Ack (red ! symbol)
	Data (cyan packet)
	Stop (red bar)
	Errors (red packet)

CAN bus setup, showing assignment of source, threshold, and bit rate.

Triggering on a specific ID and data value on the CAN bus.

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

LIN Characteristics

Bus Setup Options

Characteristic	Description
LIN Source	Analog channels 1-4
	Math channels 1-4
	Digital channels D0 - D15 (MSO models only)
Thresholds	Per-channel thresholds
Recommended Probing	Single ended
Polarity	Normal
	Inverted
Bit Rate	
Predefined list of rates	1.2 Kb/s - 19.2 Kb/s
Custom	800 b/s - 100 Kb/s
Sample Point	50% of bit period or unit interval
LIN Standard	V 1.x
	V 2.x
	Both
Include Parity Bits with ID	Yes
	No
Formats Available	Decimal: ID and Parity; Hex: Data and Checksum
	Binary
Display Modes	
Bus	Bus only
Bus and Waveforms	Simultaneous display of bus and digital waveforms
Event Table	Decoded packet data in a tabular view

Bus Trigger and Search Options

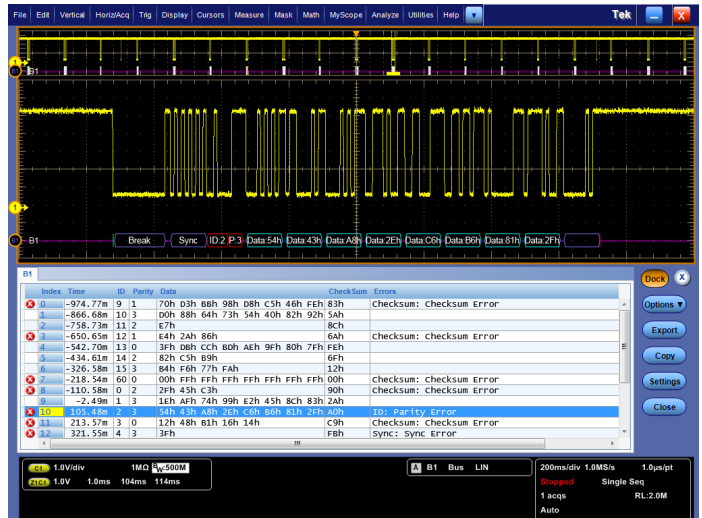| Characteristic	Description
Trigger and/or Search On	Sync
	Identifier
	Data (number of bytes 1-8, trigger or search when =, !=, <, >, <=, >=, Inside Range, Outside Range)
	ID and Data
	Wakeup Frame
	Sleep Frame
	Error (Sync, ID Parity, Checksum)
Bit Rate	800 b/s - 19.2 Kb/s

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 (green bar)
	Sync, Break (blue packet)
	Identifier, Parity (yellow packet)
	Data (cyan packet)
	Checksum, Wakeup (blue packet)
	End of Frame (red bar)
	Errors (red packet)
	- Sync
	- Parity
	- Checksum
	- Header Time
	- Response Time
	- Frame Time
	- Response and Frame Time

LIN bus setup, showing assignment of source, thresholds, standard, and bit rate.

LIN bus trigger setup, capturing a specified data value.

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

FlexRay Characteristics

Bus Setup Options

Characteristic	Description
Source for Differential Probing (Bdiff)	Analog channels 1-4 Math channels 1-4
Source for Single-ended Probing (BP, BM)	Analog channels 1-4 Math channels 1-4 Digital channels D0 - D15 (MSO models only)
Source for Single-ended Probing (Tx, Rx)	Analog channels 1-4 Math channels 1-4 Digital channels D0 - D15 (MSO models only)
Thresholds	
Bdiff	High and Low thresholds
BP, BM (analog and math channels)	High and Low thresholds
BP, BM (digital channels)	Single threshold
Tx, Rx	Single threshold
Recommended Probing	
Bdiff, BP, BM	Differential
Rx, Tx	Single ended
Channel Type	A or B
Bit Rate	
Predefined list of rates	2.5 Mb/s, 5 Mb/s, 10 Mb/s
Custom	1 Mb/s - 10 Mb/s
Formats Available	Hex Binary Mixed (Decimal: ID, Len, and Count; Hex: CRCs and Data)

Display Modes

| Bus	Bus only
Bus and Waveforms	Simultaneous display of bus and digital waveforms
Event 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) - Null - Normal - Sync - Payload - Startup - Unknown - Null Sync - Payload Sync - Null Startup - Payload Startup - CRC Cycle Count (yellow box) Data (cyan box) CRC, DTS, CID (purple box) Stop (red bracket) - TSS - Header CRC - Trailer CRC - Null Frame - Sync Frame - Startup Frame - BSS - FSS

FlexRay bus setup, showing assignment of source, threshold, and bit rate.
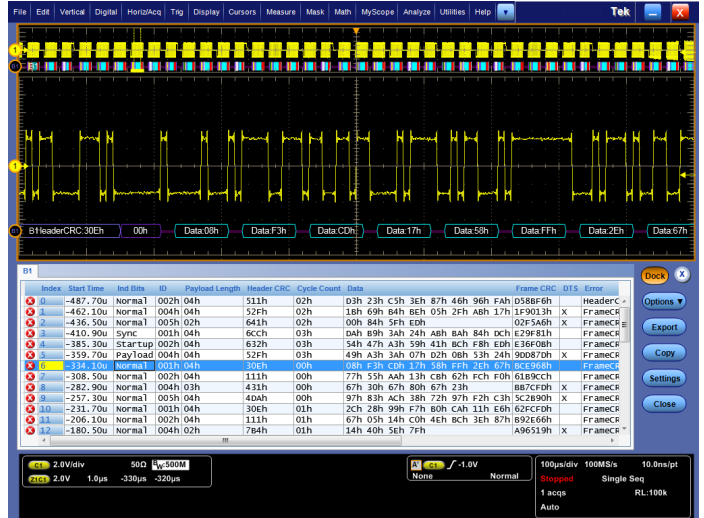
Protocol Decode Event Table provides a time-stamped, tabular view of all captured packets on the FlexRay bus.

Triggering on a specific Identifier value on the FlexRay bus.

Datasheet

MIL-STD-1553 Characteristics

Bus Setup Options

Characteristic	Description
Source	Analog channels 1-4 Math channels 1-4
Thresholds	High and Low thresholds
Recommended Probing	Differential or Single-ended (only one single-ended signal required)
Polarity	Normal or Inverted
Bit Rate	1 Mb/s, per the standard
Formats Available	Hex Binary Mixed: Hex (data), Decimal (addresses and count)

Display Modes	
Bus	Bus only
Bus and Waveforms	Simultaneous display of bus and digital waveforms
Event Table	Decoded packet data in a tabular view

Bus Trigger and Search Options

Characteristic	Description
Trigger and/or Search On	Sync Command Word*2 (set RT Address (=, !=, <, >, <=, >=), T/R, Sub-address/Mode, Data Word Count/Mode Code, and Parity individually) Status Word*2 (set RT Address (=, !=, <, >, <=, >=), Message Error, Instrumentation, Service Request Bit, Broadcast Command Received, Busy, Subsystem Flag, Dynamic Bus Control Acceptance (DBCA), Terminal Flag, and Parity individually) Data Word (user-specified 16-bit data and parity values) Idle Time (minimum time selectable from 2 µs to 100 µs; maximum time selectable from 2 µs to 100 µs; trigger on < minimum, > maximum, inside range, outside range) Error (Sync, Parity, Manchester, Noncontiguous Data)

Bus Decode

Characteristic	Description
Maximum Clock/Data Rate	Up to 1 Mb/s (for automated decoding of bus)
Decode Display	Start (green bar) Sync*3 (purple box) with Word Type (Command, Status, Data) identified Address (yellow box) R/T (purple box) Word Count (purple box) Status Bits (purple box) Data (cyan box) Parity (purple box) Stop (red bar) Errors (red box)

*2 Trigger selection of Command Word will trigger on Command and ambiguous Command/Status words.
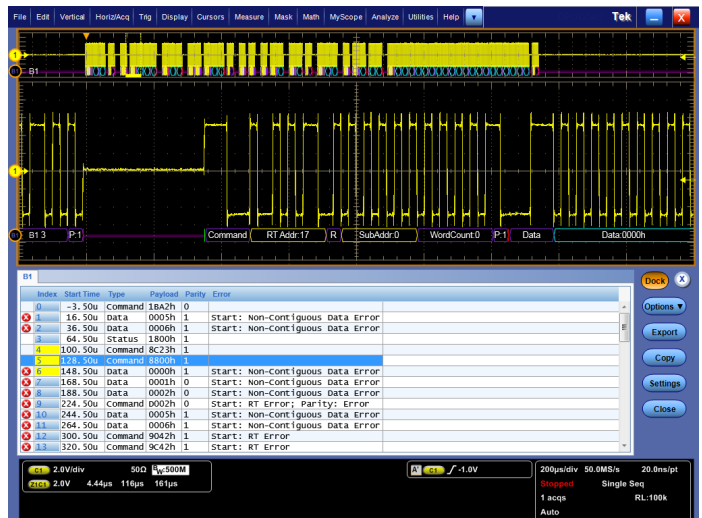Trigger selection of Status Word will trigger on Status and ambiguous Command/Status words.

*3 Ambiguous Command and Status words will be labeled with C/S and a generic bit decode will be displayed.

MIL-1553 bus setup, showing dual threshold settings.

Triggering on a specific data value on the MIL-STD-1553 bus.

Protocol Decode Event Table for MIL-STD-1553 bus with all captured packets time stamped and in a tabular view.

RS-232/422/485/UART Characteristics

Bus Setup Options

Characteristic	Description
Sources	
RS-232	Analog channels 1-4
UART	Math channels 1-4
	Digital channels D0 - D15 (MSO models only)
RS-422	Analog channels 1-4
RS-485	Math channels 1-4
Polarity	Normal (RS-232)
	Inverted (UART, RS-422/RS-485)
Recommended Probing	RS-232/UART: Single ended
	RS-422/RS-485: Differential
Number of Bits	7 - 9
Address/Data Formats Available	Hex
	Binary
	ASCII
	Packet View
Display Modes	
Bus	Bus only
Bus and Waveforms	Simultaneous display of bus and digital waveforms
Event 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 - 5 bytes)
	Parity Error

Bus Decode

Characteristic	Description
Maximum Bit Rate	Up to 10 Mb/s (automatic selection)
Bit Rate Selections	50 b/s
	300 b/s
	1200 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
	10,000,000 b/s
	Custom (50 b/s - 10 Mb/s)
Decode Display	Data (cyan packet)
	Errors (red packet)

RS-232 bus setup, showing assignment of source signal, digital threshold, and polarity.

Color-coded RS-232 bus display, showing ASCII display format.
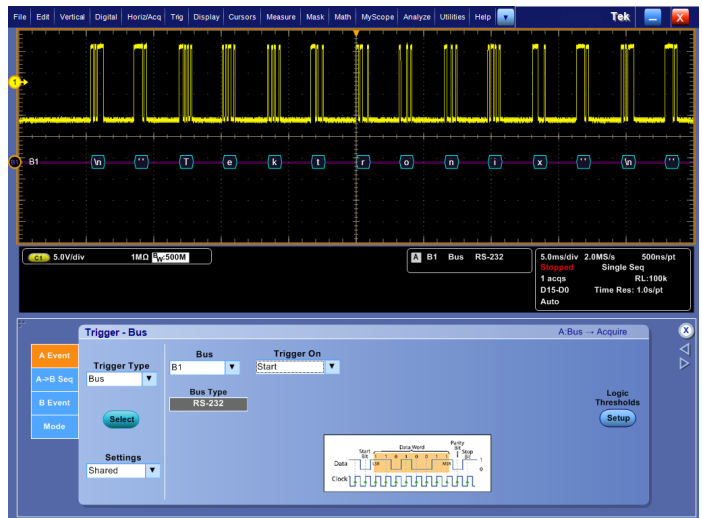
Triggering on a start of packet on the RS-232 bus.

Ordering Information

Optional Applications

Serial Bus	MSO/DPO5000, DPO7000C, and DPO/DSA/MSO70000C/D Series Option[4]	Description
I2C, SPI	SR-EMBD	Embedded Serial Triggering and Analysis (I2C, SPI). Enables triggering on packet-level information on I2C 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.
MIL-STD-1553	SR-AERO	Aerospace Serial Triggering and Analysis (MIL-STD-1553). Enables triggering on packet-level information on MIL-STD-1553 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	SR-AUTO	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	SR-COMP	Computer Serial Triggering and Analysis (RS-232/422/485/UART). Enables triggering on packet-level information on RS-232/422/485/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.

[4] USB, Ethernet, and MIPI® D-PHY options also available.

Note: Serial Triggering and Analysis application software does not operate on earlier versions of the DPO7000, DPO/DSA70000, or DPO/DSA70000B Series oscilloscopes.

To upgrade an existing[5] MSO/DPO5000, DPO7000C, or DPO/DSA/MSO70000C/D Series

Serial Bus	Order
I2C, SPI	DPO-UP Option SR-EMBD
CAN, LIN, FlexRay	DPO-UP Option SR-AUTO
MIL-STD-1553	DPO-UP Option SR-AERO
RS-232/422/485/UART	DPO-UP Option SR-COMP

Note: Software is supplied on the internal hard drive of the MSO/DPO5000, DPO7000C, and DPO/DSA/MSO70000C/D Series oscilloscopes. User documentation (online or user manual) is part of the oscilloscope documentation.

To order a floating license for an existing[5] MSO/DPO5000, DPO7000C, or DPO/DSA/MSO70000C/D Series

Serial Bus	Order
I2C, SPI	DPOFL-SR-EMBD
CAN, LIN, FlexRay	DPOFL-SR-AUTO
MIL-STD-1553	DPOFL-SR-AERO
RS-232/422/485/UART	DPOFL-SR-COMP

[5] Also update oscilloscope firmware to latest version, available for free download from www.tektronix.com.

Recommended Probes

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

CE

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

Datasheet

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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