Tektronix[®]

Serial Triggering and Analysis Application Modules AERO • AUDIO • AUTO • AUTOMAX • COMP • EMBD • FLEX • USB • ENET Datasheet



Key features

- Automated Serial Triggering, Decode, and Search options for I²C, SPI, CAN, CAN FD, LIN, FlexRay, RS-232/422/485/UART, MIL-STD-1553, ARINC 429, I²S/LJ/ RJ/T DM, USB, and Ethernet.
- 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 using user-defined criteria to find specific messages. Search mark table provides a tabular view of the events found during an automated search.
- Export Search Mark table data to .csv file.
- Event table shows decoded serial bus activity in a tabular, timestamped format for quick summary of system activity.
- Export Event table data to .csv file.

Serial triggering and analysis application modules

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 Application modules for the MDO4000C, MDO3000, and MSO/DPO2000B Series transform the oscilloscope into a robust tool for debugging serial buses with automatic trigger, decode, and search for I²C, SPI, CAN, CAN FD, LIN, FlexRay, RS-232/422/485/ UART, MIL-STD-1553, ARINC 429, I²S/LJ/RJ/TDM, USB2, and Ethernet.

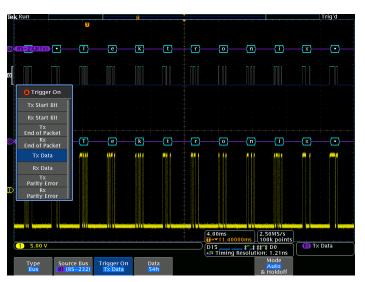


Figure 1: Triggering on a specific transmit data packet going across an RS-232 bus. A complete set of triggers, including triggers for specific serial packet content, ensures you quickly capture your event of interest.

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, CAN FD, LIN, FlexRay, RS-232/422/485/UART, MIL-STD-1553, ARINC 429, and I²S/LJ/RJ/TDM, USB2, and Ethernet.

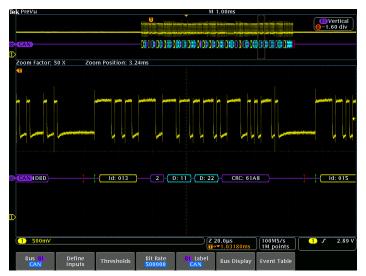
Bus display

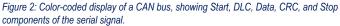
Provides a higher-level, combined view of the individual signals (clock, data, chip enable, etc.) that make up your bus, making it easy to identify where packets begin and end and identifying sub-packet components such as address, data, identifier, CRC, etc.

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? Let the oscilloscope with a Serial Application module do it for you! Once you've set up a bus, the oscilloscope will decode each packet on the bus, and display the value in hex, binary, decimal (LIN, MIL-STD-1553, and FlexRay, USB and Ethernet only), signed decimal (I²S/LJ/RJ/TDM only), or ASCII (RS-232/422/485/UART, USB and Ethernet only) in the bus waveform.







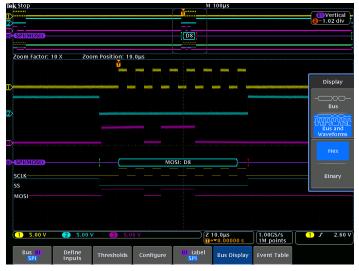


Figure 3: Simultaneously display the bus and digital waveforms. Digital waveforms show how the bus translates the individual signals based on the threshold settings (useful for making analog channels look like just 1s and 0s).

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.).

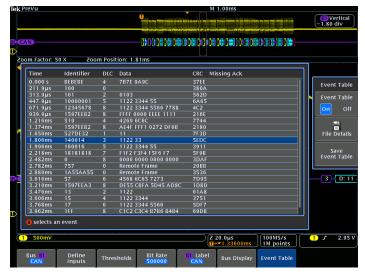


Figure 4: Event table showing decoded Identifier, DLC, DATA, and CRC for every CAN packet in a long acquisition

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 module, you can enable the oscilloscope to automatically search through the acquired data for userdefined criteria including serial packet content. Each occurrence is highlighted by a search mark. Rapid navigation between marks is as simple as pressing the Previous (\leftarrow) and Next (\rightarrow) buttons on the oscilloscope front panel. The Search Mark table provides a tabular view of all events found during an automated search. The search mark data can be exported to a .csv file.

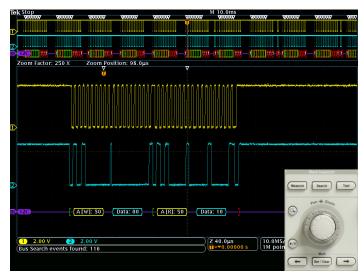


Figure 5: Search $-l^2C$ decode showing results from a Wave Inspector® search for Address value 50. Wave Inspector® controls provide unprecedented efficiency in viewing and navigating waveform data.

Specifications

I²C Characteristics

Bus setup options

Sources	(Clock	and	Data)
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Thresholds Recommended probing Include R/W in address Decode formats available Display modes

Analog channels 1-4				
Digital channels D0-D15				
Per-channel thresholds				
Single ended				
Yes or No				
Hex, Binary				
Mode				
Bus				

Mode	Description
Bus	Bus only
Bus and waveforms	Simultaneous display of bus and logic waveforms
Event table	Decoded packet data in a tabular view

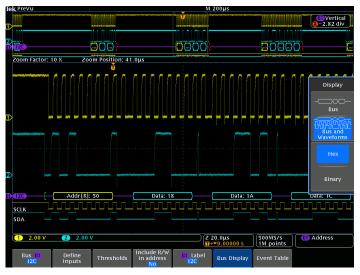


Figure 6: I²C bus setup, showing selection of bus display modes.

Bus trigger and search options

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

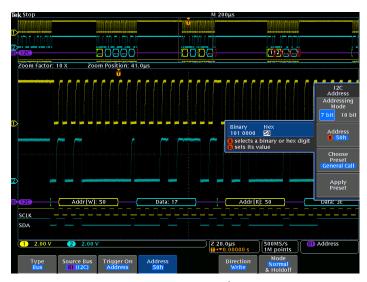


Figure 7: Triggering on a specific address value on the l^2C bus.

Bus decode

Characteristic	Description
Maximum Clock/Data Rate	Up to 10 Mb/s (for automated decoding of bus)
Decode Display	Start (green bracket)
	Address (yellow box)
	Missing Ack (red ! symbol)
	Data (cyan box)
	Stop (red bracket)

		rosition.	9.56ms			_	
Time	Repeat Start	Address	Data	Mis	sing Ack		
-9.558ms		[W]50	00				Event Ta
-9.460ms		[R] 50	10				Event Ta
-9.057ms		[R] 50	12				Event Ta
-8.556ms		[R] 50	1416				Event ra
-8.055ms		[R] 50	181A 1C				On
-7.555ms		[R] 50	1E20 2224				
-7.053ms		[R] 50	2628 2A2C				1000
-6.553ms		[R] 50	2E30 3234				
-6.052ms		[R] 50	3638 3A3C				File Deta
-5.551ms		[W]50					
-5.452ms	х	[R] 50	3E				
-5.049ms		[W]102	F3BE				Save
-4.548ms		[W]103	66BB				Event Ta
-4.047ms		[W]152					
-3.949ms		[R] 79	77A7				
-3.546ms		[W]153	BEEB				
-3.356ms	х	[R] 79	BEEB				
-540.7µs		[W]0		х			
-40.20µs		[W]50	00				
57.96µs		[R] 50	10				
460.8µs		[R] 50	12				

Figure 8: Event table for I²C bus with all captured packets time stamped and in a tabular view.

SPI Characteristics

Bus setup options

Characteristic	Description			
Sources (Clock, Slave Select, MOSI, and MISO)	Analog channels 1-4			
	Digital channels D0-D15			
Thresholds	Per-channel thresholds			
Recommended probing	Single ended			
Decode configuration				
Farming	Idle Time (2-wire SPI)			
C C	Slave Select (3-wire or 4-wire SPI)			
Clock	Rising or Falling Edge			
Slave select	Active High or Active Low			
MOSI	Active High or Active Low			
MISO	Active High or Active Low			
Word size	4-32 bits			
Bit order	Most Significant (MS) First			
	Least Significant (LS) First			
Decode formats available	Hex, Binary			
Display modes				
Bus	Bus only			
Bus and waveforms	Simultaneous display of bus and logic waveforms			
Event table	Decoded packet data in a tabular view			



Figure 9: SPI bus setup, showing configuration options for bus sources.

Bus trigger and search options

Characteristic	Description
Trigger and/or Search On	SS Active
	Start of Frame
	MOSI
	MISO
	MOSI and MISO
	Data: maximum of 128 bits (up to four 32-bit words or 32 four-bit words)

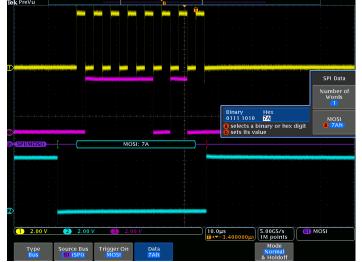


Figure 10: Triggering on a specific MOSI data value on the SPI bus.

Bus decode

Characteristic	Description
Maximum Clock/Data Rate	Up to 50 Mb/s (for automated decoding of bus)
Decode display	Start (green bracket)
	Data (cyan box)
	Stop (red bracket)

PreVu				Ť.			B Vert -1.28 di
SPI(MOSI)	10 X Zoo	m Position: -4	.55ms			(<u>(</u>)	
Time	MOSI			MISO			
-4.549ms	E1			MIJG			
-4.048ms	DS						Event T
-4.048ms	CE						
-3.046ms	CE C4						Event 1
-2.545ms	88						
-2.044ms	AC						On
-1.543ms	AC						
-1.042ms	93						
-541.6µs	86						File De
-40.68µs	7A						The De
460.3µs	6D						
961.1µs	60						Sav
1.462ms	54						Event 1
1.963ms	48						
2.464ms	30						MOSI, ET
2.965ms	32						
3.466ms	28						
3.967ms							
4.468ms							
4.969ms							
a selects an	event						Hartes)-order-10-from
1) 2.00 V	2 2.00 V	3 2.0	0 V		2 2.00µs ∎→▼−3.40000µs	100MS/s 1M points	(B) MOSI
Bus (B1)	Define						

Figure 11: Event table for SPI bus with all captured packets time stamped and in a tabular view.

RS-232/UART/RS-422/RS-485 Characteristics

Bus setup options

RS-232/UART Sources	Analog channels 1-4				
(Transmit and Receive)	Digital channels D0-D15				
RS-422/RS-485 Sources (Transmit and Receive)	Analog channels 1-4				
Thresholds	Per-channel thresholds				
Recommended probing	RS-232/UART: Single ended RS-422/RS-485: Differential				
Polarity	RS-422/RS-485 Inverted (UART, RS-422/RS-485)				
Decode configuration	Paramater	Description			
	Bit rate				
	Pre-defined list of rates	50 b/s - 2.8 Mb/s			
	Custom	50 b/s - 10 Mb/s			
	Data bits	7, 8, or 9			
	Parity	None, Odd, or Even			
	Packets	On or Off			
	End of packet	00h (NUL)			
		0Ah (LF)			
		0Dh (CR)			
		20h (SP)			
		FFh			

Hex, Binary, ASCII

Display modes

Mode	Description
Bus	Bus only
Bus and waveforms	Simultaneous display of bus and logic waveforms
Event table	Decoded packet data in a tabular view



Figure 12: RS-232 bus setup, showing bit rate options for RS-232 bus.

Bus trigger and search options

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

ek PreVu					_	M 4.	00ms				
>				<u> </u>		I	[]]				
RS-232(Tx)		e	k	t		(0)	n		X	-0-	С
Zoom Factor	: 10 X	Zoom Pos	sition: 0.	00 s							
				Ū							
			-	-						TX D	ata
										Numb Byt	es
×					Binary 0111 0010	Hex 72	AS0 r	211		Da	ta
					a selects a l b sets its va	oinary or due	hex digit,	or an ASC	CII characte	er 8 7	2h
							ومترافية والأ		ining participation	n se an parisi	
RS-232(Tx)			r								
(K3-232(TX)											
1 5.00 V							0µs 164.000µs	25.0M		😗 Tx Data	
(<mark>1) 5.00 V</mark> Туре	Source	Rus Tria	gger On	Data		_ Z 401 ∎+▼4	0μs 164.000μs		oints	街 Tx Data	

Figure 13: Triggering on a specific Tx data value on the RS-232 bus.

Bus decode

Characteristic	Description
Maximum Clock/Data Rate	Up to 10 Mb/s (for automated decoding of bus)
Decode display	Data (cyan box)
	Errors (red box)
	- Parity
	- Framing

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D											BVertical -1.48 div
BI <mark>X RS</mark> -	-23 <mark>2(T</mark> x))		e	K		- r		n	— <u>(i)</u> —	—×	-•-•
Zoo	m Factor: 10	0 X	Zoom Po	sition: –1	7.8ms						
	Time	Tx	Eri	rors							_
	-17.32ms -13.99ms	• T									Event Table
	-10.76ms -7.436ms										Event Table
ъШ	–4.212ms –884.4µs										On Off
	2.340ms 5.668ms										B
	8.892ms 12.22ms										File Details
	15.44ms 18.77ms										Save Event Table
(a) selects an	i event									
	5.00 V						Z 40 ∎•▼	0μs 464.000μs	25.0N 1M pc	15/s bints	B) Tx Data
E	Bus B1 RS=232	Define Inputs	Thr	esholds	Configure 9600 - 8 -	e B1 N RS	Label	Bus Displa			

Figure 14: Event table for RS-232 bus with all captured packets time stamped and in a tabular view.

CAN, CAN FD (ISO and non-ISO) Characteristics

Bus setup options

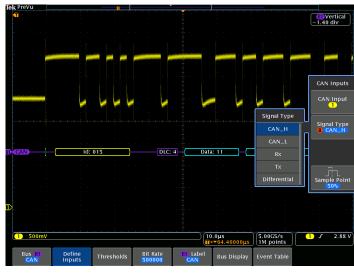


Figure 15: Can bus setup, showing signal type options for CAN bus.

Source for CAN_H, CAN_L,	Analog channels 1-4							
Rx, or Tx probing	Digital channels D0-D15							
Source for differential probing	Analog channels 1-4							
Thresholds	Per-channel thresholds							
Recommended probing	obing TDP1500 differential probe CAN_H, CAN_L, Rx, Tx: Single ended							
	Differential: Differential							
Bit Rate	Parameter	Description						
	Standard: pre-defined list of rates and Custom	10 Kb/s - 1 Mb/s						
	FD: Pre-defined and custom	1 Mb/s - 10 Mb/s (7 M/bs MDO3K)						
Sample Point	Position at 15% to 95% within bit period or unit interval							
Decode formats available	Hex, Binary							
Display modes	Parameter	Description						
	Bus	Bus only						
	Bus and waveforms	Simultaneous display of bus and logic waveforms						
	Event table	Decoded packet data in a tabular view						

Bus trigger and search options

Characteristic	Description
Trigger and/or Search On ¹	Start of Frame
	Type of Frame (Data, Remote, Error, Overload)
	Identifier (Standard or Extended)
	Data (number of bytes 1-8, trigger or search when =, \neq , <, >, <, ≥)
	Identifier and Data
	End of Frame
	Missing Ack
	Bit Stuffing Error
	FD BRS Bit
	FD ESI Bit
	Form Error
	Any Error



Figure 16: Triggering on a specific data value on the CAN bus.

Bus decode

Characteristic	Description
Decode display	Start (green bracket)
	Address (yellow box)
	DLC, CRC (purple box)
	Missing Ack (red ! symbol)
	Data (cyan box)
	Stop (red bracket)
	Bit stuffing errors (red box)

1 FD BRS Bit, FD ESI Bit, Form Error and Any Error are available only when CAN FD is selected as BUS

Image: Second	0(0)))))))))))))))))))))))))))))))))))	Eve
Time Identifier DLC Data CRC Missing Ack -551.1µs BEBEBE 4 787E 9A9C 37EE -339.1µs 100 0 380A -327.1µs 562D -103.1µs 100 2 0103 562D -103.1µs 1000001 -103.1µs 10000001 5 1122 3344 556 6A65		Eve
-551.1µs BEBEBE 4 787E 9A9C 37EE -339.1µs 100 0 380A -237.1µs 1000001 2 0103 562D -103.1µs 10000001 5 1122 3344 556 67788 4C2 388.9µs 1597EE2 8 FFFF 0000 EEE 1111 216E 664.9µs 519 4 4269 6C6C 77744		Eve
-230 Jus 100 0 380A -237.Jus 101 2 0103 562D -103.Jus 10000001 5 1122 3344 55 6A65 120.9µs 12243678 8 1122 3344 556 778 4C2 388.9µs 1507EE2 8 FFF 6000 EEE 1111 216E 664.9µs 519 4 4269 6C6C 7744		Eve
-237. Jus 101 2 0103 562D -103. Jus 100000001 5 1122 3344 55 6A65 120. gus 12345678 8 1122 3344 5566 7788 4C2 388. gus 1597EE2 8 FHF 0000 EEEE 1111 216E 664. gus 519 4 4269 GC6C 77744		
-103. lps 10000001 5 1122 3344 55 6A65 120. 9µs 12345678 8 1122 3344 5566 7788 4C2 388. 9µs 1597EEB2 8 FFFF 0000 EEEE 1111 216E 664. 9µs 519 4 4269 6C6C 7744		
120.9μs 12345678 8 1122 3344 5566 7788 4C2 388.9μs 1597EEB2 8 FFF 0000 EEEE 1111 216E 664.9μs 519 4 4269 6C6C 7744		– 🚪 Eve
388.9μs 1597EEB2 8 FFFF 0000 EEEE 1111 216E 664.9μs 519 4 4269 6C6C 7744		On
822.9µs 1597EEB2 8 AE4F FFF1 0272 DF6B 2180		
1.099ms 527DE32 1 11 7F3D		File
1.255ms 140014 3 1122 33 5EDC		
1.445ms 160016 5 1122 3344 55 3911		
1.667ms 18181818 7 F1F2 F3F4 F5F6 F7 5F9B		- Eve
1.931ms 0 8 0000 0000 0000 3DAF		EVe
2.231ms 757 0 Remote Frame 20BB		
2.329ms 1A55AA55 0 Remote Frame 3536		
2.465ms 57 6 4568 6C65 7273 7D95		
2.659ms 1597EEA3 8 DE55 CBFA 5D45 AD8C 1DBD		
2.925ms 13 2 1122 61A8		
3.055ms 15 4 1122 3344 3751		
3.217ms 17 6 1122 3344 5566 5DF7		
3.411ms 1FF 8 C1C2 C3C4 B7B6 B4B4 69DB		
3.411ms IFF 8 C1C2 C3C4 8786 8484 69DB 6 selects an event 7 710.0µs	100MS/s	Data
1 +▼1.16750n	ns 1M points	

Figure 17: Event table for CAN bus with all captured packets time stamped and in a tabular view.

LIN Characteristics

Bus setup options

Source	Analog channels 1-4						
	Digital channels D0-D15						
Thresholds	Per-channel thresholds						
Recommended probing	Single ended						
Decode Configuration	Parameter	Description					
	Polarity	Normal or Inverted					
	Bit rate						
	Pre-defined list of rates	1.2 kb/s - 19.2 kb/s					
	Custom	800 b/s - 100 kb/s					
	LIN standard	v1.x, v2.x, or Both					
	Include parity bits with ID	Yes or No					
Decode formats available	Mixed: ID and Parity are shown in Hex, Data and Checksur Hex: all fields Binary: all fields	m are shown in Binary					
Display modes	Mode	Description					
	Bus	Bus only					
	Bus and waveforms	Simultaneous display of bus and logic waveforms					
	Event Table	Decoded packet data in a tabular view					

Tek PreVu			1				
							<u>(G)</u> Vertical –2.58 div
							LIN Configuration Bit Rate 19.2K bps
						LIN Standar	d 🚺 🗕 🔤 🚽
						v1.x	LIN Standard a v2.x
- · ·						v2.x	Include Parity
						Both	Bits with Id Yes No
				-			
	Sync – Id	: 12 P:1	Data: E4h	Data: 2Al	h Data:	86h (Chk: 6A
· · · · · ·							
1 2.00 V					00µs •▼1.854000ms	250MS/s 1M points	1 J 3.40 V
Bus B1 LIN	Define Inputs	Thresholds	Configure v2.x-19200 Id w/o Parity	(B1) Label LIN	Bus Display	Event Table	

Figure 18: LIN bus setup, showing source configuration options for LIN bus.

Bus trigger and search options

Characteristic	Description
Trigger and/or Search On	Sync
	Identifier
	Data (number of bytes 1-8; trigger or search when =, \neq , <, >, <, >, inside range, outside range)
	Identifier and Data
	Wakeup Frame
	Sleep Frame
	Error (Sync, ID Parity, Checksum)



Figure 19: Triggering on a Sync Error on the LIN bus

Bus decode

Characteristic	Description
Maximum bit rate	Up to 1 Mb/s, by LIN definition up to 20 kb/s (for automated decoding of bus)
Decode display	Start (green bracket)
	Sync, Break (purple box)
	Identifier, Parity (yellow box)
	Data (cyan box)
	Checksum, Wakeup (purple box)
	End of frame (red bracket)
	Errors (red box)
	- Sync
	- Parity
	- Checksum
	- Header Time
	- Response Time
	- Frame Time
	- Response and Frame Time

Pre	eVu					M 2	00ms					
				Γ		Ť				G	B1 Ver	ical
											2.58 di	
				-								
LIN					nn	<u>n n</u>	11		-1-			
			u uu									
001	m Factor: 10	X Zo	om Posit	ion: -2	19ms							
	Time	Identifier (dec)	Parity (dec)	Data (hex)		Checksum (hex)	Errors					
	-979.0ms	12	1	F42A	~~	6A	Checksun		10		Event 1	Гаb
		12			86 CCBD AE9F 807F	FE	Спескѕип	1 Error	- 11	_		
	-870.4ms -761.8ms	14	0 2	3FDB 82C5		6F					Event 1	Fab
	-761.8ms -653.1ms	14		82C5 B4F6		12						
	-553.1ms -544.5ms	60	<u>3</u>		77FA FFFF FFFF FFFF	0				Π		
	-544.5ms -463.2ms	Wakeup	0	00FF		0						
	-463.2ms -435.9ms	макеир п		2F45	C2	90	Checksun	Error		П		1
	-435.9ms	1			C3 7499 E245 8C83	2A	Checksun	TEHOP		П		
	-218.7ms	2	3		A82E C6B6 812F	A0	Parity Ern	0.F	- 11		File De	ita
	-109.9ms	3	0		B116 14	C9	Checksun					
	-109.9ms -1.372ms	4	3	1248 3E	8110 14	FB	Sync Erro		-11		Sav	ρ
	-1.372ms 107.3ms	5	3	3F 981D		DC	SYNC Erro	1	- 11		Event 1	
	215.9ms	<u> </u>		6723	£7	6F	Header Ti		- 11			
	215.9ms 324.5ms	7			348E E8	48	Checksun		- 11			-
	324.5ms 433.1ms	8	0	6780	348E E8	4B 10			- 11			
	433.1ms 542.3ms	9			RE98 D8C5 46FF	83	Checksun	Time Error	- 11			
							спескзии	1 Error	- 11			
	650.9ms	10	3		6473 5440 8292	5A						
	759.6ms	11	2	E7		8C						
	868.2ms			E42A	80	6A	Checksun	1 Error				
ΓL	951.9ms	Wakeup										
6	selects an	avant										
	sciects all	event										
	_								1.1			
1	2.00 V						0.0ms 10.00000 s	500kS/s		B1) Er	ror	
							0.00000 \$	1M points				
	us (B1)	Define	T		Configure	B1 Label						
P			Thres		v2.x-19200		Bus Display	Event Table				

Figure 20: Event table for LIN bus with all captured packets time stamped and in a tabular view.

FlexRay Characteristics

Bus setup options				
Source for single-ended	Analog channels 1-4			
probing	Digital channels D0-D15			
Source for differential probing	Analog channels 1-4 High and low thresholds per-channel			
Thresholds				
Recommended probing	Single ended or differential			
Decode Configuration	Parameter	Description		
	Bit rate	2.5 Mb/s, 5 Mb/s, 10 Mb/s, or Custom (1 Mb/s - 100 Mb/s)		
	Channel type	A or B		
	Polarity	BDiff or BP, BM, Tx or Rx		
Decode formats available	Mixed: Identifier, Payload Length and Cycle Count ar Hex: all fields Binary: all fields	e shown in Decimal, Data and CRCs are shown in Hex.		
Display modes	Mode	Description		
	Bus	Bus only		
	Bus and waveforms	Simultaneous display of bus and logic waveforms		
	Event Table	Decoded packet data in a tabular view		

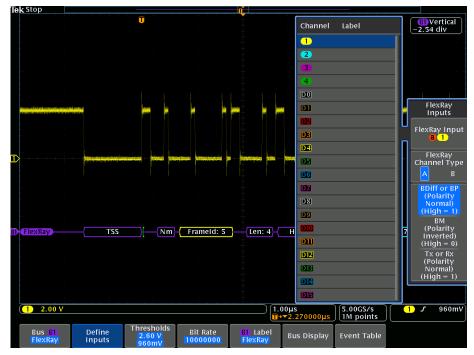


Figure 21: FlexRay bus setup, showing input options for FlexRay bus.

Bus trigger and search options

Characteristic	Description
Trigger and/or Search On	Start of Frame
	Indicator Bits (Normal, Null, Payload, Sync, Startup)
	Identifier (trigger when =, \neq , <, >, \leq , \geq , inside range, outside range)
	Cycle Count (trigger when =, \neq , <, >, ≤, ≥, inside range, outside range)
	Header Fields (Indicator Bits, Identifier, Payload Length, Header CRC, and Cycle Count)
	Data (number of bits 1-16; byte offset 'don't care' – 253; trigger when =, ≠, <, >, ≤, ≥, inside range, outside range)
	Identifier and Data
	End of Frame (Static, Dynamic (DTS), All)
	Error (Header CRC, Trailer CRC, Null Frame (static or dynamic), Sync Frame, Startup Frame)
Characteristic	Description
Maximum bit rate	Up to 10 Mb/s (for automated decoding of bus)
Table continued	L

Bus decode

Table continued...

Characteristic	Description
Decode display	TSS (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

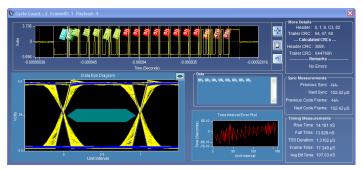


Figure 22: PC-based, eye-diagram analysis software builds an eye-diagram from the entire acquisition and plots it against TP1 mask called out by the FlexRay standard, available with MDO4000C instruments.

Decoded packet data in a tabular view

I²S/LJ/RJ/TDM Characteristics

Event Table

Bus setup options				
Sources (Clock, Word, Data)	Analog channels 1-4			
	Digital channels D0-D15			
Thresholds	Per-channel thresholds			
Recommended probing	Single ended			
Decode Configuration	Parameter	Description		
	Word size	4-32 bits		
	Clock	Rising or falling edge		
	Word Select polarity	Normal or inverted		
	Data High	1 or 0		
	Bit order	Most Significant (MS) First		
		Least Significant (LS) First		
Decode formats available	ailable Signed Decimal, Hex, Binary			
Display modes	Mode	Description		
	Bus	Bus only		
	Bus and waveforms	Simultaneous display of bus and logic waveforms		

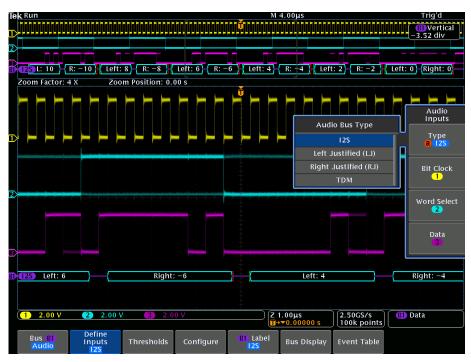
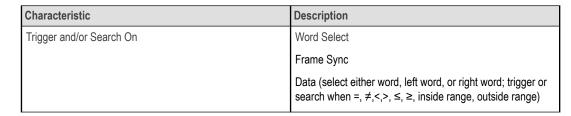


Figure 23: I²S bus setup, showing input configuration options for I²S bus.



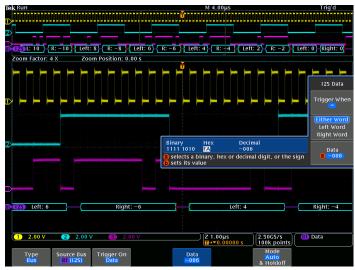


Figure 24: Triggering on a specific data value on the I²S bus.

Bus trigger and search options

Bus decode

Characteristic	Description	
Maximum Clock/Data Rate	Up to 12.5 Mb/s (for automated decoding of I ² S/LJ/RJ bus	
	Up to 25 Mb/s (for automated decoding of TDM bus)	
Decode display	Start (green bracket)	
	Data (cyan box)	
	Stop (red bracket	

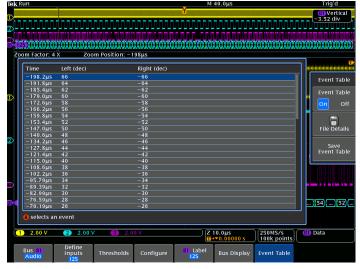


Figure 25: Start (green bracket) Data (cyan box) Stop (red bracket).

MIL-STD-1553 Characteristics

Bus setup options					
Sources					
	Reference waveforms 1-4				
	Math waveform				
Thresholds	High and low threshold per source Single ended or differential (only one single-ended signal required)				
Recommended probing					
Decode Configuration	Parameter	Description			
	Bit rate	1 Mb/s per the standard			
	Response Time	2 µs – 100 µs			
	Polarity	Normal or Inverted			
Decode formats available	Mixed1: Hex (data), Decimal (addresses and count), Binary (bits)				
	Mixed2: ASCII (data), Decimal (addresses and count), Binary (bits)				
	Block Hex				
	Hex and Binary				
	Binary				

Display modes

Mode	Description	
Bus	Bus only	
Bus and waveforms	Simultaneous display of bus and logic waveforms	
Event Table	Decoded packet data in a tabular view	



Figure 26: MIL-STD-1553 bus setup, showing threshold entry fields.

Bus trigger and search options

Characteristic	Description		
Trigger and/or Search On	Sync		
	Word Type ² (Command, Status, Data)		
	Command Word ² (set RT Address (=, \neq , <, >, <, >, inside range, outside range), T/R, Sub-address/Mode, Data Word Count/Mode Code, and Parity individually)		
	Status Word ² (set RT Address (=, \neq , <, >, <, >, inside range, outside range), 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 value)		
	Error (Sync, Parity, Manchester, Non-contiguous data)		
	Idle Time (minimum time selectable from 4 μ s to 100 μ s; maximum time selectable from 12 μ s to 100 μ s; trigger on < minimum, > maximum, inside range, outside range)		

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.

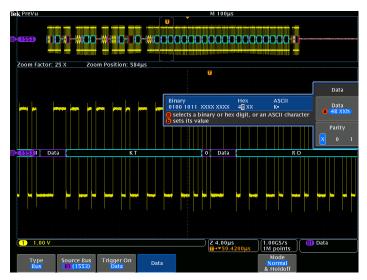


Figure 27: Triggering on a specific data value on the MIL-STD-1553 bus.

Bus decode

Description		
Up to 1 Mb/s (for automated decoding of bus)		
Start (green bracket)		
Sync ³ (purple box) with Word Type identified		
Address (yellow box)		
R/T (purple box)		
Word Count (purple box)		
Status Bits (purple box)		
Data (cyan box)		
Parity (purple box)		
Stop (red bracket)		
Errors (red box)		

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

Tek F B)	558 H)::::-::::::::::::::::::::::::::::::::		Vertical 0.00 div
Zo	om Factor: 2 Time -351.9µs -331.9µs	5 X Z Type C/S Data	Coom Position: 235µs Payload RT/IMG Error B011 (22-00000010001) 00h 13h 9.996µs	Event Table
BD	-303.9µs -267.9µs -247.9µs -191.9µs -163.9µs -143.9µs -59.91µs -39.90µs	C/S Cmd Data Cmd Cmd Data Cmd Data Data	E000 (22-0000000000) 18.00µs F822 (31-K-L-2) 00h 07h 00h 08h 18.00µs SC23 (17-L-1-3) 9.994µs 5800 (17-K-R-0) SX00 (17-K-R-0) 18.00µs Data Obh 00h 00h 01h 012h 18.00µs Data SA2 (10-K-29-2) 7.00µs Data T KL RT. PO RTLAN D. O RE 7.00 µs 7.00 µs	Event Table On Off File Details
	368.1µs		G O N . 9.994µs 3000 (10-000-0000-000)	Event Table
			Thresholds DT	B) Data
	Bus (81) MIL-1553	Define Inputs	Thresholds RT BI Label 1.224 V 12:0µs BI Label 1.48 V 4.00µs 1553 Bus Display Event Table	

Figure 28: Event table for MIL-STD-1553 bus with all captured packets time stamped and in a tabular view.

ARINC 429 Characteristics

Bus setup options					
Sources	Analog channels 1-4				
	Reference waveforms 1-4 Math waveform High and low threshold per source				
Thresholds					
Decode configuration	Parameter	Description			
	Bit rate	100 kb/s (High speed), 12.5-14.5 kb/s (Low speed)			
	Polarity	Normal or Inverted			
Decode formats available	Hex, Binary, Mixed (table listing; Label octal, Data hex)				
Display modes	Mode	Description			
	Bus	Bus only			
	Bus and waveforms	Simultaneous display of bus and logic waveforms			
	Event Table	Decoded packet data in a tabular view			

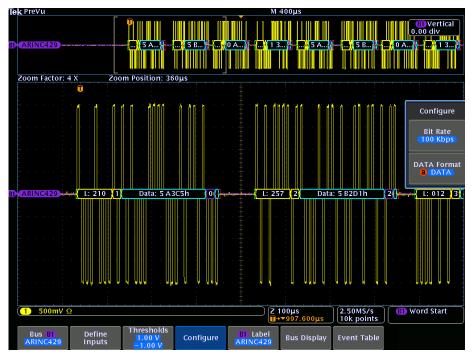


Figure 29: ARINC 429 bus setup, showing configuration entry of bit rate and data format.

Bus trigger and search options

Characteristic	Description
Trigger and/or Search On	Word Start, Word End, Label, Data Field (Data, SDI+Data, SDI+Data+SSM), Label+Data, Gap Error, Parity Error, Word Error, Any Error Data qualifiers include: (=, ≠, <, >, ≤, ≥, inside range, outside range)



Figure 30: Triggering on a specific data value on the ARINC 429 bus.

Characteristic	Description
Maximum Clock/Data Rate	Up to 100 kb/s (1 Mbps custom)
Decode Display	Start (green bracket)
	Label (yellow box)
	SDI (yellow box)
	Data (cyan box)
	SSM (purple box)
	Parity (cyan box)
	Stop (red bracket)
	Errors (red box)
	Word end (red bracket)

Tek P	reVu							VI 400µs				
	RINC429	Ĩ	5 A)				1 3)	5 A)				B Vertical 0.00 div 1 3
	Time	Label (oct)	SDI	Data (hex)	SSM	Errors						
	-308.0µs	210	1	5A3C5	0							Event Table
	92.40µs	257	2	5B2D1	2							Event Table
	452.4µs	012	3	0ABCD								
	832.4µs	102	0	137F0	3							On Off
	1.203ms 1.603ms	210 257	1 2	5A3C5 5B2D1	0							
	1.963ms	012	2 3	0ABCD	<u> </u>							
	2.343ms	102	0	137F0	3							File Details
B												Save Event Table
	a selects ar	ı event										N. V
) 500mV Ω							Z 100µs ∎→▼997.	600µs	2.50MS/s 10k points	B	Data
	Bus B1 RINC429	Define Inputs		hresholds 1.00 V -1.00 V	Config	ure	(B1) Label ARINC429	Bus	Display	Event Table		

Figure 31: Event table for ARINC 429 bus with all captured packets time stamped and in a tabular view.

USB Characteristics

Bus setup options	USB 2.0 Compatibility	
	Low-speed and Full-speed: All MDO4000C or MDO3000	Series models
	High-speed: Models with 1 GHz analog channel bandwidt	h
Sources	Single-ended: Analog channels 1-4	
	Digital channels D0-D15	
	Differential: Analog channels 1-4, Math channel, Reference	ce channels 1-4
Recommended probing	Low-speed and Full-speed: Single-ended or differential High-speed: Differential	
Thresholds presents	Low-speed and Full-speed: Single-ended (D+: 1.4 V; D-: - High-speed: Differential (High: 100 mV; Low: -100 mV) High-speed: Differential (High: 100 mV; Low: -100 mV)	1.4 V), differential (High: 1.4 V; Low: -1.4 V)
Decode formats available	Mixed1: Frame and Address are shown in Decimal, Data Mixed2: Frame and Address are shown in Decimal, Data Hex: all fields Binary: all fields	
Display modes	Mode	Description
	Bus	Bus only
	Bus and waveforms	Simultaneous display of bus and logic waveforms
	Event Table	Decoded packet data in a tabular view

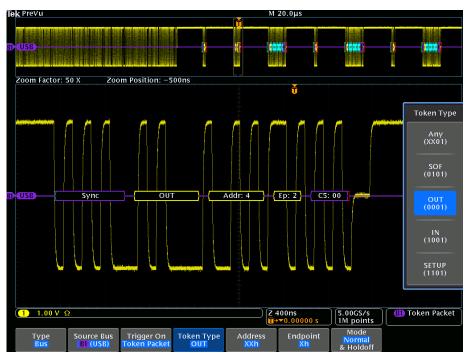


Figure 32: Triggering on a specific PID on a USB FS bus.

Bus decode

Characteristic	Description
USB 2.0 Data Rates	Low-speed: 1.5 Mb/s
	Full-speed: 12 Mb/s
	High-speed: 480 Mb/s
Decode Display	Start (green bracket)
	PID (yellow box)
	Data (cyan box)
	CRC (purple box)
	Stop (red bracket)



Figure 33: High-speed USB decoded display, automatically displaying bus content.

Bus trigger and search options

Characteristic	Description
Trigger and/or Search On	Low-speed: Trigger/Search on Sync, Reset, Suspend, Resume, End of Packet, Token (Address) Packet, Data Packet, Handshake Packet, Special Packet, Error.
	Token Packet – Any token type, SOF, OUT, IN, SETUP; Address can be further specified to trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular value, or inside or outside of a range. Frame number can be specified for SOF token using Binary, Hex, Unsigned Decimal, and Don't Care digits.
	Data Packet – Any data type, DATA0, DATA1; Data can be further specified to trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular data value, or inside or outside of a range.
	Handshake Packet – Any handshake type, ACK, NAK, STALL.
	Special Packet – Any special type, Reserved.
	Error – PID Check, CRC5, CRC16, Bit Stuffing.

Table continued...

Characteristic	Description
	Full-speed: Trigger/Search on Sync, Reset, Suspend, Resume, End of Packet, Token (Address) Packet, Data Packet,
	Handshake Packet, Special Packet, Error.
	Token Packet – Any token type, SOF, OUT, IN, SETUP; Address can be further specified to trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular value, or inside or outside of a range. Frame number can be specified for SOF token using Binary, Hex, Unsigned Decimal, and Don't Care digits.
	Data Packet – Any data type, DATA0, DATA1; Data can be further specified to trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular data value, or inside or outside of a range.
	Handshake Packet – Any handshake type, ACK, NAK, STALL.
	Special Packet – Any special type, PRE, Reserved.
	Error – PID Check, CRC5, CRC16, Bit Stuffing.
Table continued	

Characteristic	Description
	High-speed: Trigger/Search on Sync, Reset, Suspend, Resume, End of Packet, Token (Address) Packet, Data Packet, Handshake Packet, Special Packet, Error.
	Token Packet – Any token type, SOF, OUT, IN, SETUP; Address can be further specified to trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular value, or inside or outside of a range. Frame number can be specified for SOF token using Binary, Hex, Unsigned Decimal, and Don't Care digits.
	Data Packet – Any data type, DATA0, DATA1, DATA2, MDATA; Data can be further specified to trigger on \leq , \leq , \geq , \geq , \neq a particular data value, or inside or outside of a range.
	Handshake Packet – Any handshake type, ACK, NAK, STALL, NYET.
	Special Packet – Any special type, ERR, SPLIT, PING, Reserved. SPLIT packet components that can be specified include:
	Hub Address
	Start/Complete – Don't Care, Start (SSPLIT), Complete
	(CSPLIT)
	Port Address
	Start and End bits - Don't Care, Control/Bulk/Interrupt
	(Full-speed Device, Low-speed Device),
	Isochronous (Data is Middle, Data is End, Data is Start,
	Data is All)
	Endpoint Type – Don't Care, Control, Isochronous, Bulk,
	Interrupt
	Error – PID Check, CRC5, CRC16

Ethernet Characteristics

Bus setup options	Ethernet compatibility 10BASE-T, 100BASE-TX On MDO4000C Series only
Sources	Single-ended: Analog channels 1-4 Differential: Analog channels 1-4, Math channel, Reference channels 1-4
Recommended probing	10BASE-T: Single-ended or differential 100BASE-TX: Differential
Thresholds presents	10BASE-T: Single-ended (D+: 1.25 V; D-: 1.25 V); Differential (High: 1.25 V; Low: -1.25 V) 100BASE-TX: Single-ended (D+: 500 mV; D-: 500 mV); Differential (High: 500 mV; Low: -500 mV)
Decode formats available	Mixed1: Data is shown in Hex, all other fields are shown in either Decimal or Hex Mixed2: Data is shown in ASCII, all other fields are shown in either Decimal or Hex Hex: all fields Binary: all fields

Display modes

Mode	Description				
Bus	Bus only				
Bus and waveforms	Simultaneous display of bus and logic waveforms				
Event Table	Decoded packet data in a tabular view				

Tek	PreVu				M 20.0µs				
B1 E	thernet								H Vertical 0.00 div
Zo	om Factor: 1	00 X Zoom P	osition: –4.00ns						
	Time	Destination (hex)	Source (hex)	Length (hex)	Data (hex)	FCS/CRC (hex)	Errors	קור	
	-4.200ns		080011FF01CA		IP: 4,5,0,54,0,2,0	C6E367E9		-111	Event Table
B	10.24µs	002290ED45C5	080011FF01CA	88	40.1CMP.9989 134.62.74.162 134.62.74.1 0800 17A2 06A3 0000 6B08 6EAF 0000 4001 9989 863E 4AA2 863E 4A01 0000 17A2 06A3 0000 6B06 6EAF 0000 0000 0000 0000 0000 0000 0000 00	56789CDC			Event Table On Off File Details Save Event Table
	a selects an	i event							
(500mV Ω				Z 200ns 		0GS/s points	B :	Start of Frame
	Bus (B1) Ethernet	Define Inputs Th 100BASE-TX	nresholds Yes	Pv4 No	(B1) Label Ethernet Bus Dis	splay Eve	nt Table		

Figure 34: DPO4ENET 100BASE-TX decoded Event Table showing all packet information.

Characteristic	Description	
Ethernet Data Rates	10BASE-T: 10 Mb/s	
	100BASE-TX: 100 Mb/s	
Decode Display	Start (green bracket)	
	MAC Address (yellow box)	
	Data (cyan box)	
	IPv4 Header (white box)	
	TCP Header (brown box)	
	CRC (purple box)	
	Stop (red bracket)	
	Error (red box)	
Internet Protocol Support	IPv4	
Transport Layer Protocol Support	ТСР	

Bus decode

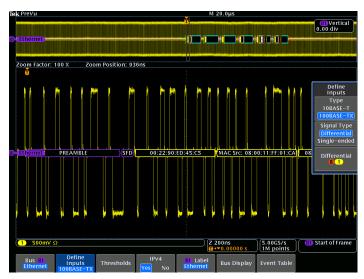


Figure 35: Color-coded DPO4ENET display of 100BASE-TX.

Display modes

Mode	Description
Bus	Bus only
Bus and waveforms	Simultaneous display of bus and logic waveforms
Event table	Decoded packet data in a tabular view

reVu				M 20.0µs			
hernet) om Factor: 1		osition: –4.00ns				HO)	B Vertic 0.00 div
Time	Destination (hex)	Source (hex)	Length (hex)	Data (hex)	FCS/CRC (hex)	Errors]
-4.200ns		080011FF01CA	800	IP: 4.5.0.54.0.2.0 40.1CMP.9989 40.1CMP.9989 40.1CMP.9989 134.02.74.102 134.02.74.102 134.02.74.102 15800.174.1 15800.174.102 16800.174.1 15800.174.102 16800.174.1 15800.174.102 16800.1674.000.0000 15800.0000.0000 16800.0000.0000.0000 0000.0000.0000 16800.0000.0000.0000 0000.0000.0000 16800.0005.0000.0000 0000.0000.0000 16800.0005.4000.0000 0000.0000.0000 16800.0005.4000.0000 0000.0000.0000 16800.0005.4000.0000 0000.0000.0000 16800.0000.0000.0000 0000.0000.0000 16800.0000.0000.0000 0000.0000.0000 16800.0000.0000.0000 0000.0000.0000 16800.0000.0000.0000 0000.0000.0000	C6E367E9 58789CDC		Event Tal
a selects a				(Z 200ns) (5.0	0GS/s	B) Start of Frar
Bus (B1)	Define	nresholds Yes	Pv4 No	B1 Label Ethernet Bus Di	0 s 1 1 M	nt Table	Jan Start Of Ha

Figure 36: DPO4ENET 100BASE-TX decoded Event Table showing all packet information.

Bus trigger options

Option	Description		
Trigger and/or Search On	10BASE-T:		
	Start Frame Delimiter		
	MAC Addresses: Trigger on Source and Destination 48-bit address values		
	MAC Q-tag Control Information: Trigger on Q-tag 32-bit value		
	MAC Length/Type: Trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular 16-bit value, or inside or outside of a range		
	MAC Client Data: Trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular 16- bit value, or inside or outside of a range. Selectable number of bytes to trigger on from 1-16. Byte offset options of Don't Care, 0-1499		
	IP Header: Trigger on IP header 8-bit value, Source Address, Destination Address		
	TCP Header: Trigger on Destination Port, Source Port, Sequence Number, and Ack Number		
	TCP/IPv4 Client Data: Trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular data value, or inside or outside of a range. Selectable number of bytes to trigger on from 1-16. Byte offset options of Don't Care, 0-1499		
	End of Packet		
	FCS (CRC) Error		
	100BASE-TX:		
	Start Frame Delimiter		
	MAC Addresses: Trigger on Source and Destination 48-bit address values		
	MAC Q-tag Control Information: Trigger on Q-tag 32-bit value		
	MAC Length/Type: Trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular 16-bit value, or inside or outside of a range		
	MAC Client Data: Trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular data value, or inside or outside of a range. Selectable number of bytes to trigger on from 1-16. Byte offset options of Don't Care, 0-1499		
	IP Header: Trigger on IP header 8-bit value, Source Address, Destination Address		
	TCP Header: Trigger on Destination Port, Source Port, Sequence Number, and Ack Number		
	TCP/IPv4 Client Data: Trigger on \leq , $<$, $=$, $>$, \geq , \neq a particular data value, or inside or outside of a range. Selectable number of bytes to trigger on from 1-16. Byte offset options of Don't Care, 0-1499		
	End of Packet		
	FCS (CRC) Error		
	ldle		

èk Stop		۸ [<mark>أ</mark>]	/I 20.0µs		
D Ethernet	10.00				
Zoom Factor: 20 X Zoom Position: 100ns					
		•			
		0 0000 0000		Hex 08:00:11:1D:2B	MAC Address
men meneriseren mei men ministen em		1 0010 1011 a binary or h value			08:00:11: 1D:2B:47h
Ethernel MAC Source Addr: 08:00:11:1D:2B:	47	МАС Тур	e: 0800h (4	(5)-(00)-(Total Length: 84]-{
	1 KW KA AAW	I REFERENCE	VERENEN MI	IN BREEFEERE	
(1) 1.00 V Ω			1.00µs →▼0.00000 s	5.00GS/s 1M points	B Addresses
Type Source Bus Q- (VLAN) Bus B1 (Ethernet) Tagging Yes No	igger On <mark>ddresses</mark>	Destination XX:XX:XX: XX:XX:XXh	Source 08:00:11: 1D:2B:47h	Mode Normal & Holdoff	

Figure 37: DPO4ENET triggering on a specific 10BASE-T MAC source address.

Ordering information

Current/discontinued products

Table 1: Current products

Serial Bus	MDO4000C Series Module	MDO3000 Series Module	MSO/DPO2000B Series Module
I ² C, SPI ⁴	DPO4EMBD	MDO3EMBD	DPO2EMBD
RS-232 / 422 / 485 / UART	DPO4COMP	MD03COMP	DPO2COMP
CAN/CAN FD, LIN	DPO4AUTO	MDO3AUTO	DPO2AUTO ⁵
FlexRay		MDO3FLEX	
CAN/CAN FD, LIN, FlexRay	DPO4AUTOMAX ⁶		
I ² S/LJ/RJ/TDM ⁷	DPO4AUDIO	MDO3AUDIO	
MIL-STD-1553, ARINC 429	DPO4AERO	MDO3AERO	
USB ⁸	DPO4USB	MDO3USB	
Ethernet ⁹	DPO4ENET		

Table 2: Discontinued products

Serial Bus	MSO/DPO4000B and MDO4000/B Series Module	MSO/DPO4000 Series Module	MSO/DPO3000 Series Module	MSO/DPO2000 Series Module
I ² C, SPI ⁴	DPO4EMBD	DPO4EMBD	DPO3EMBD	DPO2EMBD
RS-232 / 422 / 485 / UART	DPO4COMP	DPO4COMP	DPO3COMP	DPO2COMP
CAN, LIN	DPO4AUTO	DPO4AUTO	DPO3AUTO	DPO2AUTO
FlexRay			DPO3FLEX	
CAN, LIN, FlexRay	DPO4AUTOMAX ⁶	DPO4AUTOMAX ⁶		
I ² S/LJ/RJ/TDM ⁷	DPO4AUDIO	DPO4AUDIO	DPO3AUDIO	
MIL-STD-1553	DPO4AERO	DPO4AERO	DP03AER0	
USB ⁸	DPO4USB	DPO4USB		
Ethernet ⁹	DPO4ENET			

Recommended probes

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

⁴ SPI support is limited to 2-wire SPI only on models that have only 2 analog channels and no digital channels.

⁵ CAN FD is not available on MSO/DPO2000 Series.

⁶ DPO4AUTOMAX includes a PC-based software package for FlexRay eye diagram analysis.

⁷ Not available on models that have only 2 analog channels and no digital channels.

⁸ USB LS/FS triggering and decode available on all models in all indicated product families. HS decode available only on 1 GHz models. HS triggering only available on 1 GHz models in MSO/DPO4000B and MDO4000/B/C Series.

⁹ 100BASE-TX requires \geq 350 MHz model.



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