

Automotive Ethernet Triggering and Decode

100/1000BASE-T1 Protocol Trigger and Decode for Infiniium Oscilloscopes



Easily Debug and Test Designs That Include Automotive Ethernet Protocols

The Keysight D9020AUTP Automotive Ethernet protocol triggering and decode software provides you with an easy and accurate way to verify and debug your 100/1000BASE-T1 designs.

Automotive Ethernet enables faster data communication to meet the demands of today's vehicles and the connected vehicles of the future. Expertise with low-speed buses is less relevant than you may expect. Unlike with CAN or LIN, you can't glance at a few bits on the screen of an oscilloscope and quickly understand what's happening on the bus. Protocol decoding enables you to correlate a packet error back to the physical bus. Keysight's full suite of automotive Ethernet solutions automate testing and validation across Tx, Rx as well as channel testing for 10M to 10Gbps.

Automotive Ethernet is widely used today in automotive designs. In many designs, these connections and data links provide content-rich points for debug and test. The D9020AUTP Automotive Ethernet protocol triggering and decode software enables you to :

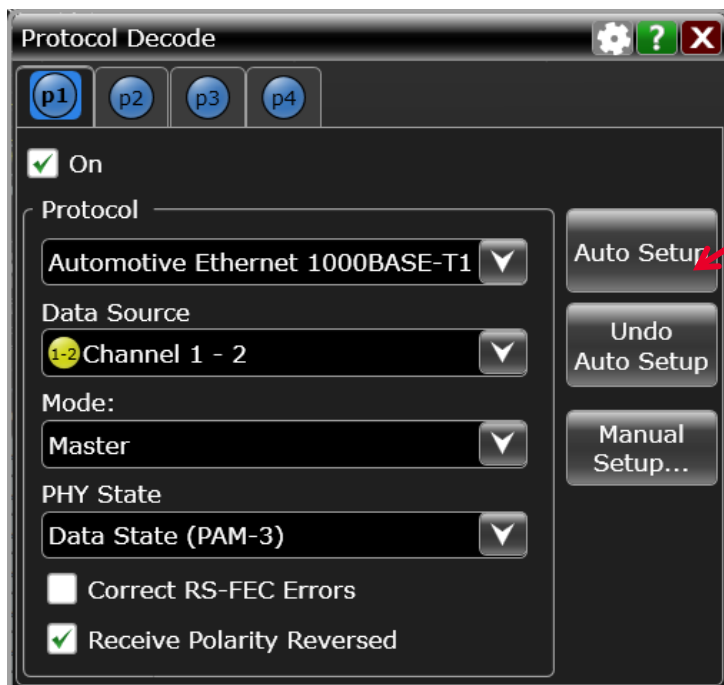
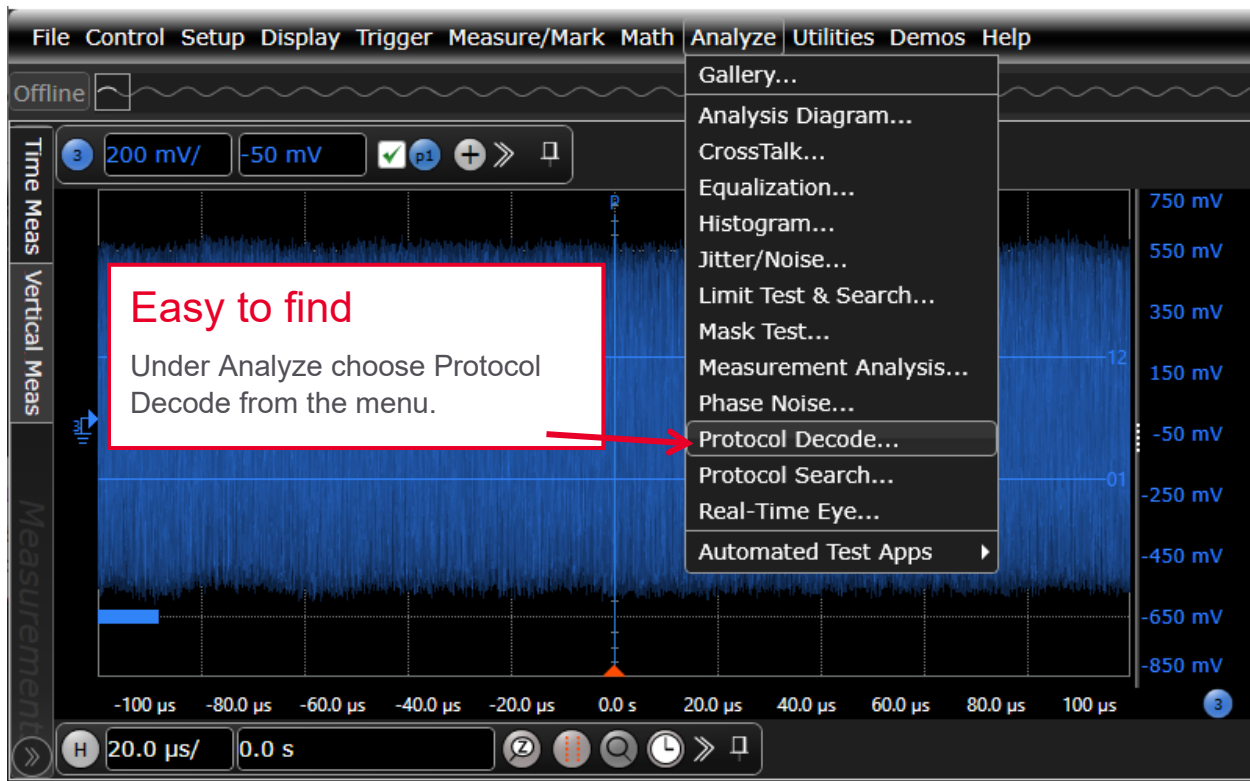
- Set up your scope to show Automotive Ethernet protocol decode in less than 30 seconds
- Get access to a rich set of integrated protocol-level triggers
- Save time and eliminate errors by viewing packets at the protocol level
- Use time-correlated views to quickly troubleshoot protocol problems back to their timing or signal integrity root cause.

The D9020AUTP Automotive Ethernet protocol triggering and decode software includes a suite of configurable protocol-level trigger conditions specific to Automotive Ethernet. It enables you to save time and eliminate errors by viewing packets at the protocol level.

Decoding at the protocol layer enables you to map errors back to the physical bus, giving you more confidence in your design. The D9020AUTP software helps you debug quickly to get to the root cause and get back to testing the rest of your components.

The software is installed and runs on a Keysight Infiniium oscilloscope. There are a variety of license types and terms available. Please see ordering instructions for more information.





30-second trigger setup

Configure your oscilloscope to display protocol decode in under 30 seconds. Use *Auto Setup* to automatically configure sample rate, memory depth and threshold and trigger levels.

Automotive Ethernet Protocol Triggering and Searching

Get access to a rich set of integrated protocol-level triggers. The application includes a suite of configurable protocol-level trigger conditions specific to Automotive Ethernet. When protocol triggering is selected, the application enables special real-time triggering hardware inside the scope. Hardware-based triggering ensures that the scope never misses a trigger event when armed. It then inspects these protocol frames against specified protocol-level trigger conditions and triggers when the conditions are met. Hardware-based triggering for Automotive Ethernet is available on Infiniium S-Series.

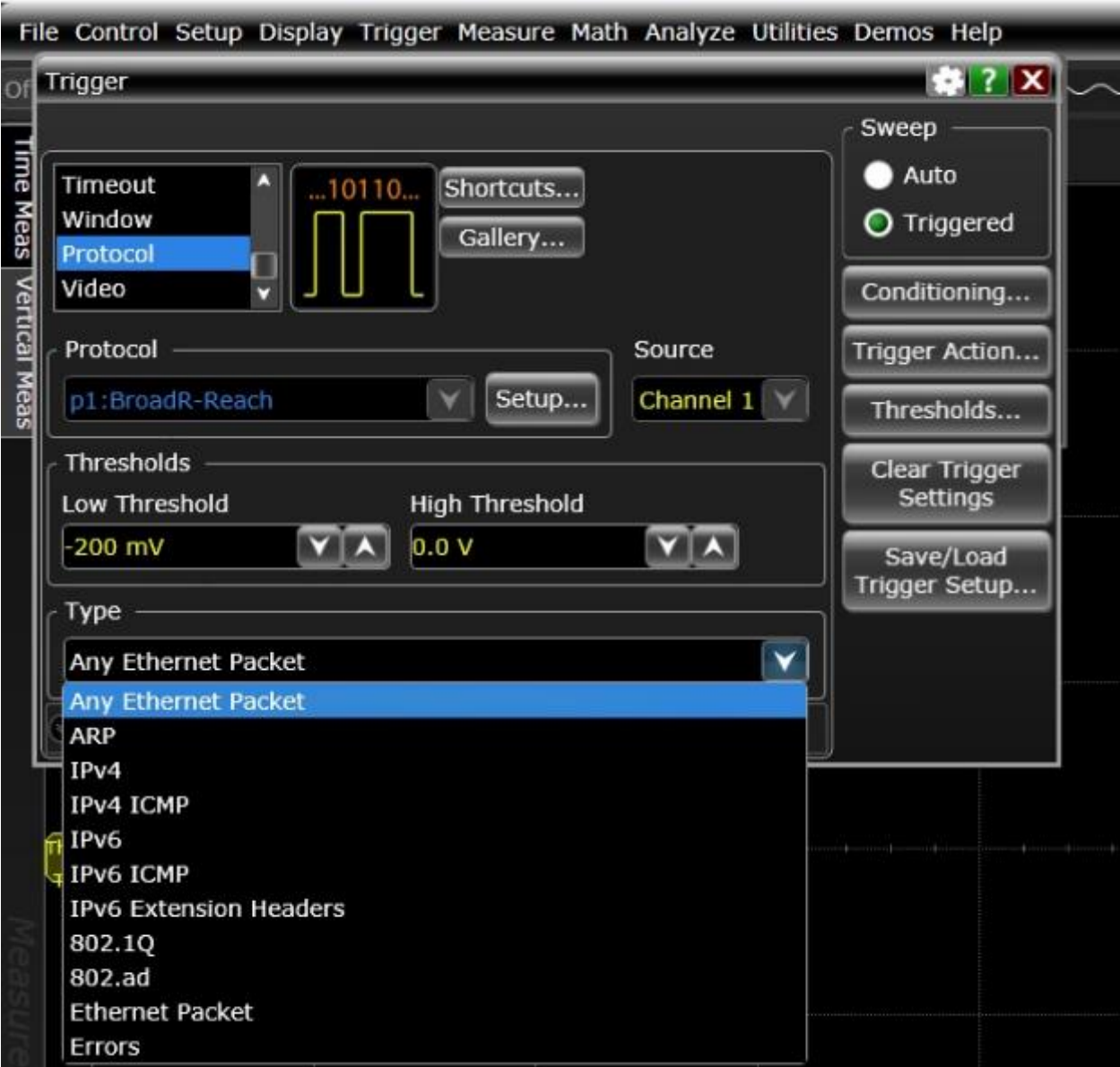
Trigger setup

Keysight's D9020AUTP Automotive Ethernet triggering supports the following trigger options:

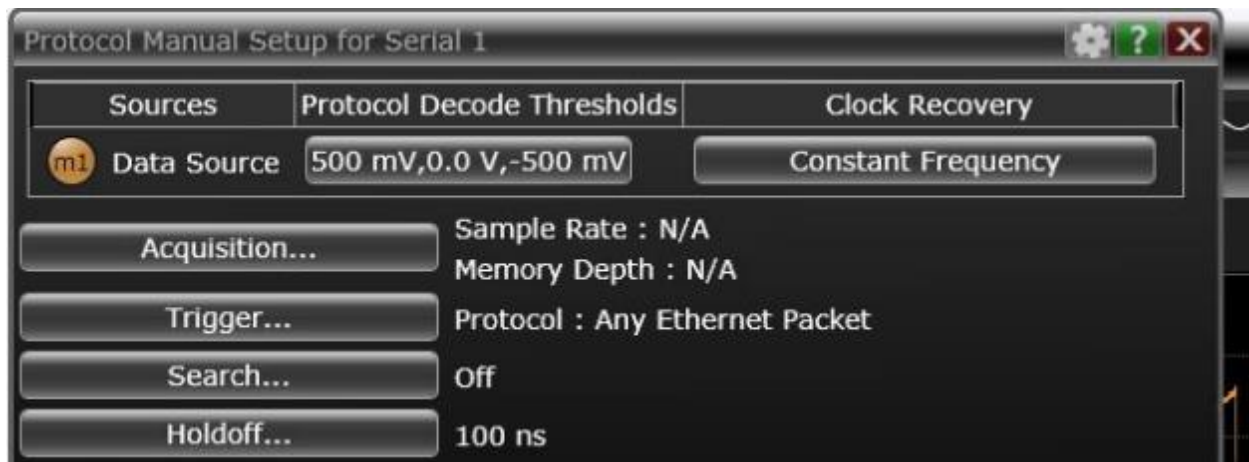
Trigger	Description
Any Ethernet packet	Triggers on any ethernet packet
ARP	Triggers for ARP frames . the user can select following fields for further refining the search: <ul style="list-style-type: none">• Destination MAC• Source MAC• Hardware Type• Protocol Type• Hardware Length• Protocol Length• Operation• Sender MAC Address• Sender IP Address• Target MAC Address• Target IP Address• Payload
IPv4	Triggers on the following: <ul style="list-style-type: none">• Any IPv4 packet• IPV4 TCP• IPV4 UDP• IPV4 Packet The fields within the packets can also be set with a defined value for refined search
IPv4 ICMP	Triggers on different types of IPv4 ICMP (Internet Control Message protocol) types and their fields
IPv6	Triggers on the following:

	<ul style="list-style-type: none"> • Any IPv6 packet • IPV6 TCP • IPV6 UDP • IPV6 Packet <p>The fields within the packets can also be set with a defined value for refined search</p>
IPv6 ICMP	Triggers on different types of IPv6 ICMP (Internet Control Message protocol) types and their fields
IPv6 Extension Headers	Triggers on different types of IPv6 Extension Header types and their fields
802.1Q	<p>Triggers on 802.1Q frames. The user can select following fields for further refining the search:</p> <ul style="list-style-type: none"> • Destination MAC • Source MAC • Priority Code Point(PCP) • Drop Eligible Indicator(DEI) • VLAN Identifier(VID) • TPID • Payload
802.ad	<p>Triggers on 802.ad frames. The user can select following fields for further refining the search:</p> <ul style="list-style-type: none"> • Destination MAC • Source MAC • Priority Code Point(PCP Outer) • Drop Eligible Indicator(DEI Outer) • VLAN Identifier(VID Outer) • TPID (Outer) • Priority Code Point(PCP Inner) • Drop Eligible Indicator(DEI Inner) • VLAN Identifier(VID Inner) • TPID (Inner) • Payload
Ethernet packet	<p>Triggers on the following fields of an Ethernet packet</p> <ul style="list-style-type: none"> • Destination MAC • Source MAC • Length/Type • Payload

Symbol Sequence	Triggers when specified symbol sequence matches
Errors	Triggers if following errors are detected: <ul style="list-style-type: none"> • Bad FCS CRC • Bad IPv4 or TCP or ICMP or UDP Checksum • Bad Ethernet Payload Length > 1500 bytes • Any of the above errors



Example of triggering options



Manual setup

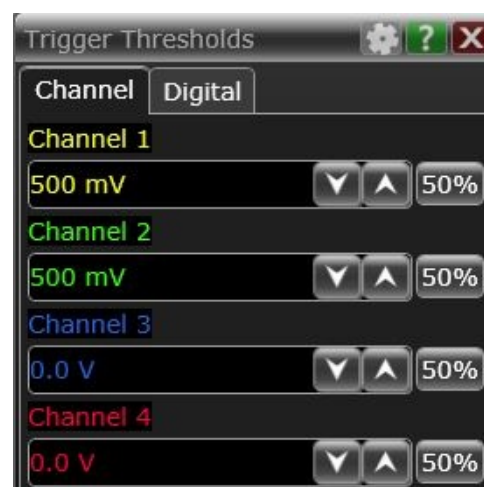
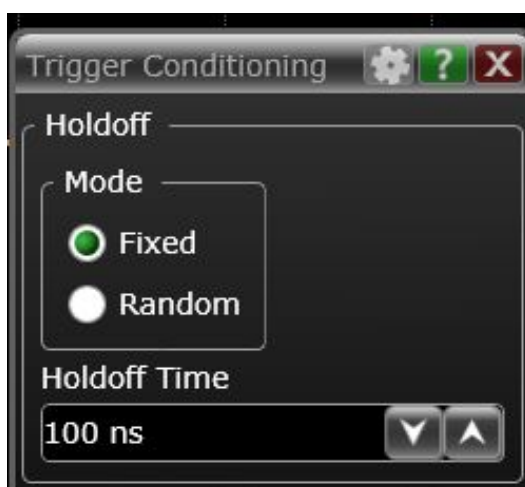
Choose to automate the trigger and decode setup or use the manual setup option. Manual setup enables you to set the Protocol decode and trigger thresholds, acquisition sample rate and depth, and clock recovery method.

Holdoff mode and time

The Holdoff Time control sets the amount of time that the oscilloscope waits before re-arming the trigger circuitry. With a fixed mode as an example, if you have a burst of pulses and want to trigger on the first pulse in the burst, you can set the holdoff time to be slightly longer than the burst width.

Trigger thresholds

Set specific thresholds for your system and the signals you are looking for.

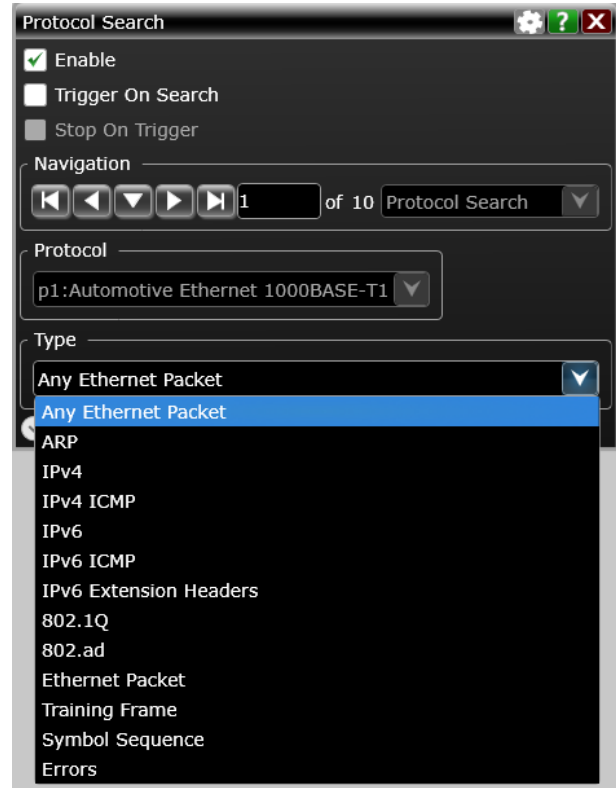


Post-acquisition searching

When data is being captured and decoded, you can search the decoded data for any Ethernet packet, selected packets, symbols or errors. The software-based packet's "Trigger On Search" causes an automatic decode after each hardware trigger (acquisition). If the packet search specification is found in the captured data, the data is displayed; otherwise, the data is not displayed.

Then, another run (acquisition) is initiated, and the process repeats. If "Stop On Trigger" is also enabled, the first time the packet search specification is found, the oscilloscope stops capturing data and does not initiate another run.

The decoder also provides insight into FEC (forward error correction) status, indicating correctable FEC errors.



Blue row in the packet listing is time correlated to the tracking marker in the waveform

Protocol window

Index	Time	FEC	IEEE 802.3	Source Port	Source MAC	Index	Time	Data
5	-209.7840564 µs		IPv4 TCP	63441	40-74-E0-90-...	337215	-123.8396548 µs	FA
6	-197.9655161 µs		IPv4 TCP	63441	40-74-E0-90-...	337216	-123.8329876 µs	AC
7	-186.4936310 µs		IPv4 TCP	63441	40-74-E0-90-...	337217	-123.8263200 µs	Hdr(Data_Blk)
8	-175.0084350 µs		IPv4 TCP	63441	40-74-E0-90-...	337218	-123.8249864 µs	5
9	-163.1832276 µs		IPv4 TCP	63441	40-74-E0-90-...	337219	-123.8183181 µs	1F
10	-151.6846756 µs		IPv4 TCP	63441	40-74-E0-90-...	337220	-123.8116495 µs	FB
11	-139.8728050 µs		IPv4 TCP	63441	40-74-E0-90-...	337221	-123.8049806 µs	38
12	-128.4089233 µs		IPv4 TCP	63441	40-74-E0-90-...	337222	-123.7983126 µs	E1
13	-116.5970616 µs		IPv4 TCP	63441	40-74-E0-90-...	337223	-123.7916459 µs	97
14	-105.1118546 µs		IPv4 TCP	63441	40-74-E0-90-...	337224	-123.7849791 µs	E0
15	-93.6332996 µs		IPv4 TCP	63441	40-74-E0-90-...	337225	-123.7783119 µs	53
16	-81.8161014 µs		IPv4 TCP	63441	40-74-E0-90-...	337226	-123.7716444 µs	56
17	-70.3442127 µs		IPv4 TCP	63441	40-74-E0-90-...	337227	-123.7649767 µs	BD
18	-58.5323503 µs		IPv4 TCP	63441	40-74-E0-90-...	337228	-123.7583090 µs	OAM_Symbol
19	-47.0404609 µs		IPv4 TCP	63441	40-74-E0-90-...	337229	-123.7569755 µs	0
20	-35.5619207 µs		IPv4 TCP	63441	40-74-E0-90-...	337230	-123.7489743 µs	FEC_Parity
						337231	-123.7476408 µs	84

Symbols can also be searched

Automotive Ethernet decode with precise time-correlation between waveforms and listings

The Keysight Automotive Ethernet protocol viewer includes correlation between the waveforms and the selected packet. The selected packet, which appears as a highlighted blue row in the listing, is time-correlated with the blue line in the waveform display. Move the blue tracking marker in time through waveforms and the blue bar will automatically track in the packets window. Or, scroll through the packet viewer and highlight a specific packet. The time-correlation tracking marker will move to the associated point in the waveform.



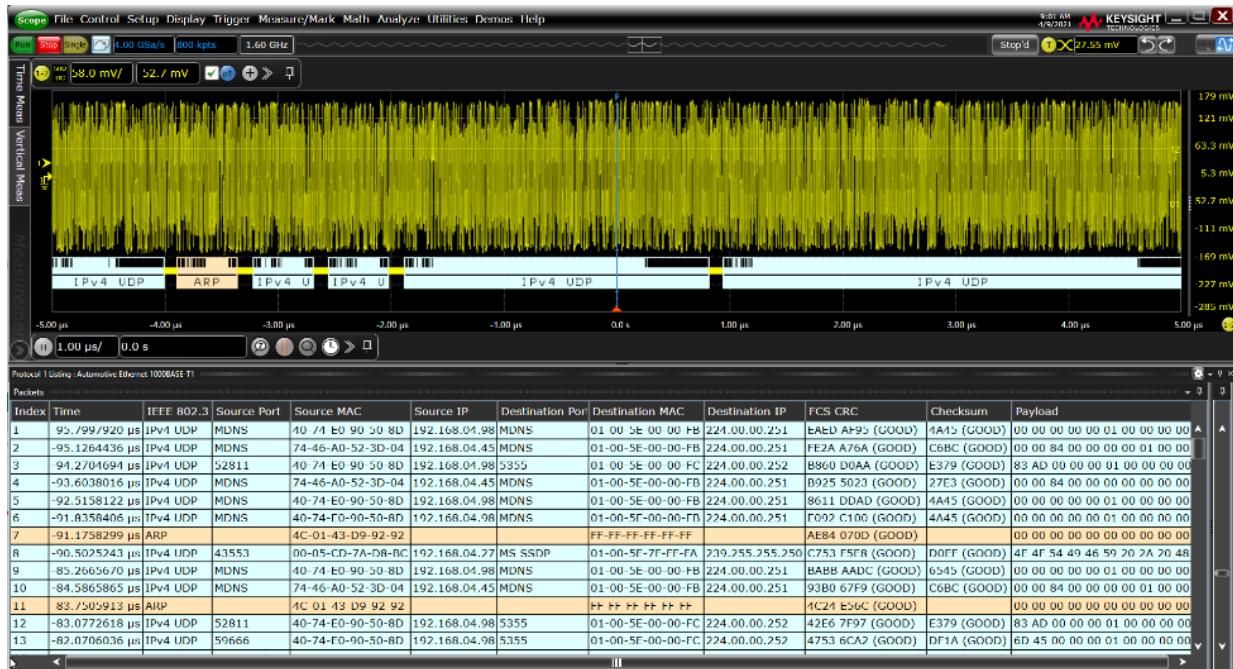
Decode embedded in waveform area

Utilize the oscilloscope waveform area to display decode information. For Automotive Ethernet, minor ticks indicate clock transitions and major ticks show the beginning and end of each word in the serial packet.

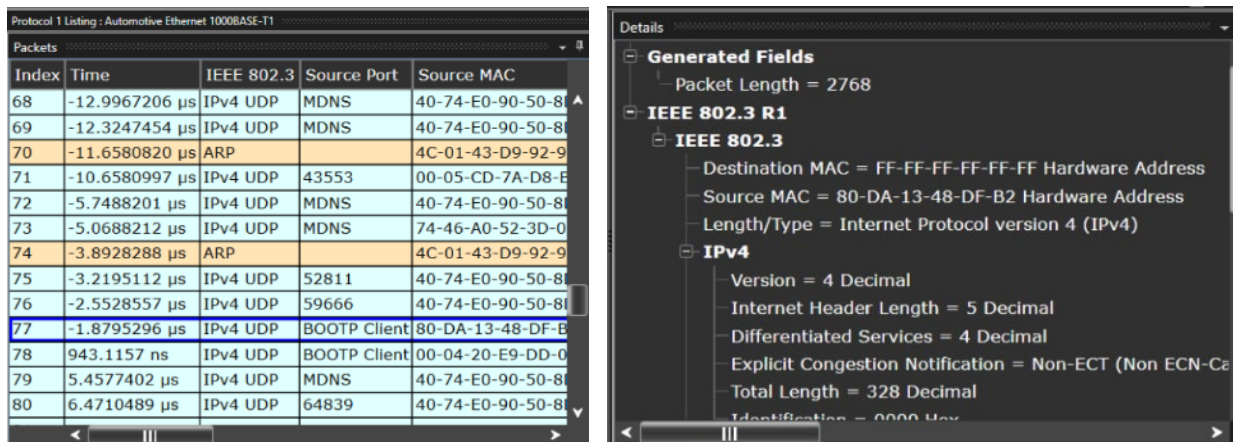


Protocol listing window

Quickly move between physical and Automotive Ethernet protocol layer information using the time correlated tracing marker. Display protocol content using embedded decode in the waveform area, or, see protocol events in a compact listing format using the industry's first scope-based multi-tab protocol viewer. The entries in the Packets listing are color-coded with the waveform so you can easily see which sections of the protocol decode correspond to which packet. This is also convenient when you zoom out because you can easily match the color code even when you are not zoomed in enough to see the decode listings in the display. There can be up to five areas (or panes) within in the Protocol Listing window: packets, symbols, details, payload, and header.



Display as many protocol packets as you want to see. The protocol viewer shows index number, time stamp, and data content for each serial packet. Listing content can be saved to a .csv or .txt file for off-line analysis or documentation. Use search capability to quickly navigate through an acquisition.



Details tab breaks the packets into easy-to-read text fields.

Packets					Symbols			Payload
Index	Time	IEEE 802.3	Source Port	Source	Index	Time	Data	
74	-3.8928288 µs	ARP		4C-00-11	19468	17.9962409 µs	2C	0000: 4E 4F 54 49 46 59 20 2A NOTIFY.*
75	-3.2195112 µs	IPv4 UDP	52811	40-74-46-00	19469	18.0029079 µs	EC	0008: 20 48 54 54 50 2F 31 2E .HTTP/1.
76	-2.5528557 µs	IPv4 UDP	59666	40-74-46-00	19470	18.0095751 µs	Data_Blk_Hdr	0010: 31 0D 0A 48 4F 53 54 3A 1..HOST:
77	-1.8795296 µs	IPv4 UDP	BOOTP Client	80-D4-91-00	19471	18.0109085 µs	2C	0018: 20 32 33 39 2E 32 35 35 .239.255
78	943.1157 ns	IPv4 UDP	BOOTP Client	00-04-5D-00	19472	18.0175747 µs	CC	0020: 2E 32 35 35 2E 32 35 30 :255.250
79	5.4577402 µs	IPv4 UDP	MDNS	40-74-46-00	19473	18.0242409 µs	34	0028: 3A 31 39 30 30 0D 0A 43 :1900..C
80	6.4710489 µs	IPv4 UDP	64839	40-74-46-00	19474	18.0309072 µs	B4	0030: 41 43 48 45 2D 43 4F 4E ACHE-CON
81	7.1510260 µs	IPv4 UDP	58018	40-74-46-00	19475	18.0375740 µs	8C	0038: 54 52 4F 4C 3A 20 6D 61 TROL:ma
								0040: 78 2D 61 67 65 3D 31 38 x-age.18
								0048: 30 0D 0A 4C 4F 43 41 54 0..LOCAT
								0050: 49 4F 4E 3A 20 68 74 74 ION:.htt
								0058: 70 3A 2F 2F 31 39 32 2E p://192.

Payload tab shows data carried by the packet in byte-by-byte.

The screenshot shows the Wireshark interface with the following views:

- Packet List:** Shows a list of packets with columns for Index, Time, IEEE 802.3, Source Port, Source, Index, Time, Data, and Payload. Packet 77 is selected.
- Packet Details:** Shows the structure of the selected packet (Index 77) in a data book format. Fields include:
 - Destination MAC [47:16]
 - Source MAC [15:0]
 - Source MAC [31:0]
 - Length/Type, Version, Int. HL, Diff. Seq.
 - Total Length, Identification
 - Fragment Offset, Time To Live, Protocol
 - Header Checksum, Source IP [31:16]
 - Source IP [15:0], Destination IP [31:16]
 - Destination Port, Source Port, Length
 - Checksum, Payload [2399:2384]
 - Payload [2383:2352]
- Packet Bytes:** Shows the raw byte sequence of the packet, with a hex view and ASCII view.

Header tab shows packets in a data book format. Hovering at any field reveals additional detail.



PAM-3 clock recovery

The Keysight D9020AUTP extends to analysis of PAM-3 signals. A wizard walks you quickly through the steps required to setup measurements for a PAM encoded signal, to select methods for clock recovery, and then the measurements you wish to have performed on your PAM signal. The software is able to accurately set the individual threshold levels of your PAM signal and render each individual eye. You can choose different, software-based clock methods that include first and second order phase-locked loop or constant frequency clock recovery.

Other measurements supported include;

- Eye measurements including Eye center, eye width, eye height, eye skew, eye level
- Level measurements including Level mean, level RMS, level thickness, level skew
- Rise/fall times (for all edges at once),
- Noise measurements (levels can be specified, graphed)
- Jitter measurements (levels can be specified, graphed)
- BER (cumulative or per acquisition)
- SER (cumulative or per acquisition)
- PBRS13Q (J4u, Jrms, EOJ)
- Clock recovery rate
- Pattern length

Deeper analysis with de-embedding and equalization

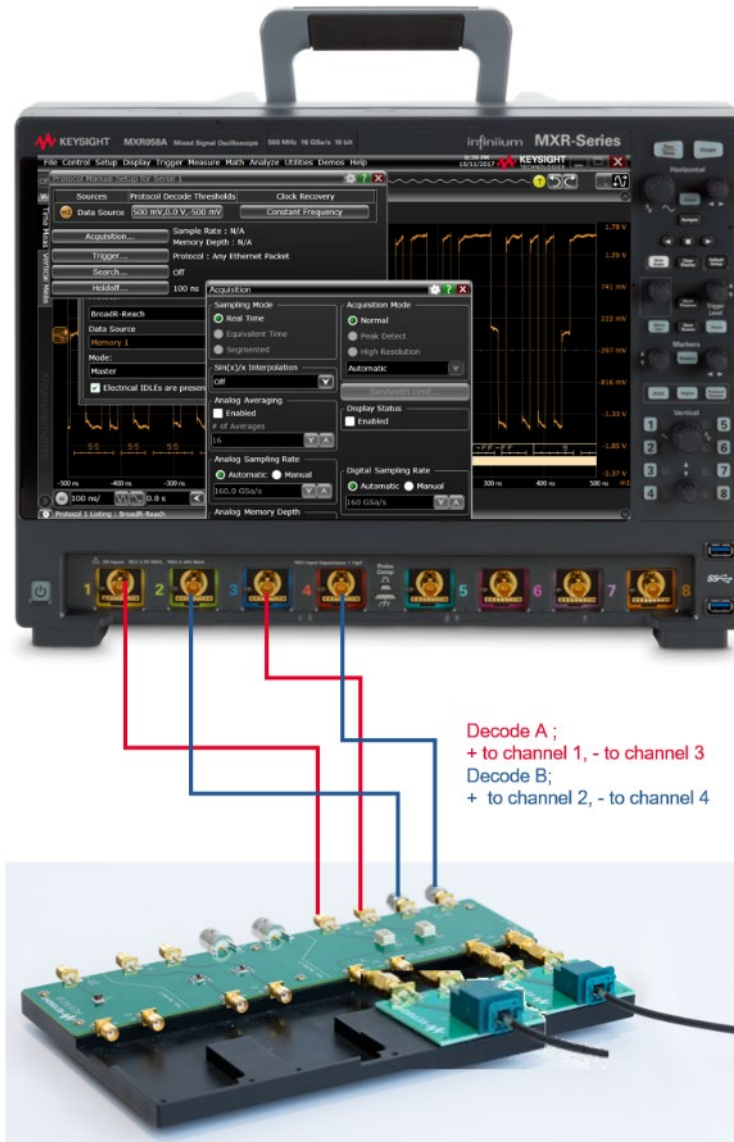
There are additional tools of optional Infiniium software that support more advanced analysis of signals, providing even more insight into your designs. Using the Infiniium signal processing interface tools for real-time oscilloscopes, you can (for example), cascade S-parameter models and/or equalizers to model your transmission line, or backplane, and receiver. The optional D9020ASIA includes InfiniiSim and Serial Data Equalization Software, which adds powerful software equalization capability to accurate modelling of Feed-Forward (FFE), Decision Feedback (DFE), and Continuous-Time Linear Equalization (CTLE). The D9020ASIA also includes Cross Talk Analysis.

Automotive Ethernet Specifications and Characteristics

Automotive Ethernet source (clock and data)	Analog channels 1, 2, 3, or 4 Memory can also be used
Max clock/data rate	Any waveform memory up to 3.4 Mbps (automatic)
Auto setup	Automatically configures scope settings for proper Automotive Ethernet decode and protocol triggering
Triggering	<ul style="list-style-type: none">• MAC destination addresses• MAC source addresses• MAC length/type• ARP header• IPv4 header/payload• IPv6 header/payload• UDP header• TCP header/payload• Frame check sequence – FCS• Cyclic redundancy check - CRC• Errors• 802.1Q (VLAN)• 802.AD



The Automotive Ethernet 100/1000BASE-T1 protocols generate a full duplex connection using a differential pair of wires for data transmission. If your wire pair signal is transmitting in opposite directions simultaneously, it cannot be decoded. To separate the signals, you can use the AE6941A Automotive Ethernet test fixture. The set-up below shows how the test fixture is used in the test system.¹



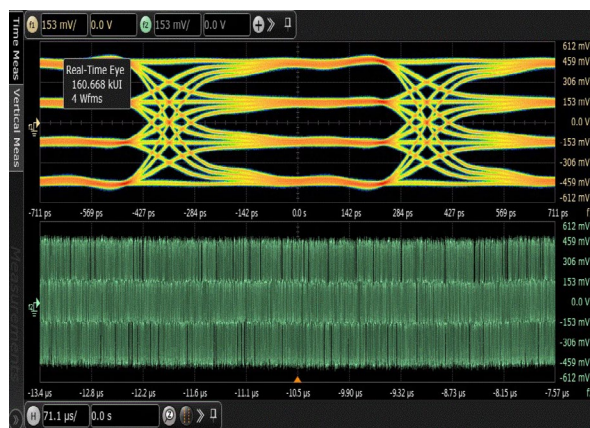
¹ The AE6941A works for 100BASE-T1 and limited 1000BASE-T1 cases. For recommendations for other 1000BASE-T1 devices please see page 15.

Ordering Information

Optional and Recommended Software

Model number	Description	
AE6910T/AE6920T	Automotive Ethernet Tx compliance	Optional, offers transmit compliance 10M-10G
D9020ASIA [†]	Signal Integrity Software	Optional, provides equalization capability, includes Equalization, InfiniiSim and Crosstalk/Power Integrity packages

[†] D9020ASIA includes InfiniiSim Serial Data Equalization Software, which adds powerful software equalization capability. You can leverage CTLE and FFE/LFE and will allow you to simulate more than one element to de-embed or embed.



Optional software that adds additional insight includes automotive Ethernet compliance AE6910T/AE6920T and D9020ASIA.

Recommended Hardware

The protocol triggering and decode software is compatible with Keysight Infiniium Series oscilloscopes with operating software as listed in the table below. For oscilloscopes with earlier revisions, free upgrade software is available here: www.keysight.com/find/scope-apps-sw

Standard	Data rate	Minimum bandwidth	Minimum channels	Firmware revision	Oscilloscope models
802.3bw	100 Mb/s	1 GHz	2	11.15 for MXR	Infiniium S-Series, MXR Series, V-Series
802.3bp	1000Mb/s	2 GHz	2	6.70 for S- and V-Series ¹	

¹ Infiniium S and V-Series supports decode only

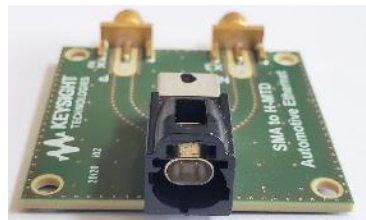
Recommended Accessories

The recommended configuration is to use SMA cables, adapters with the fixture boards from Keysight.

Description	Keysight Model Number(s)	Comments
Fixture	AE6941A Automotive Ethernet test fixture	Required for 100BASE-T1 ¹
<i>Order either SMA cables and adapters</i>	Adapter fixtures	AE6942A SMA to Molex/Mini-50 adapter AE6943A SMA to MATEnet adapter AE6960A SMA to H-MTD adapter
	SMA cables	AE6900T-104 (8121-3118)
	SMA to BNC	AE6900T-102 (54855-67604)
		Qty 4



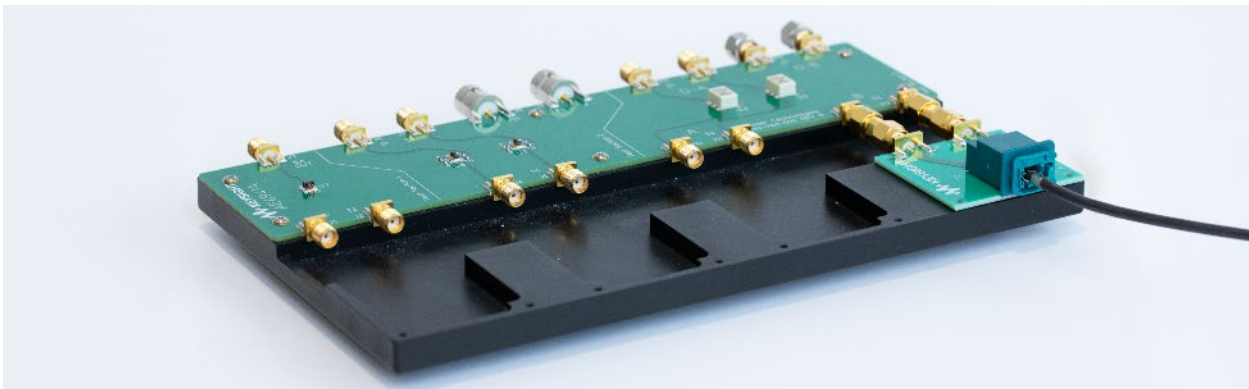
AE6942A SMA to Molex/Mini-50



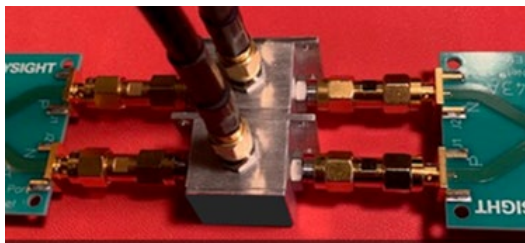
AE6960A SMA to H-MTD.



AE6943A SMA to MATEnet



The AE6941A works as a signal separation solution for 100BASE-T1 and limited 1000BASE-T1 cases.



Directional coupler



Dual Directional coupler

For 1000BASE-T1 cases that require enhanced performance of directional coupler, Keysight recommends the MiniCircuits ZEDC-10-2B.

¹ Certain 1000BASE-T1 devices may require a signal separation solution with enhanced performance. In these cases Keysight recommends the MiniCircuits ZEDC-10-2B.

Software License Types for D9020AUTP

Keysight offers a variety of flexible licensing options to fit your needs and budget. Choose your license term, license type, and KeysightCare software support subscription. Licenses are available either as node-locked, transportable, USB portable or floating and can be purchased with 6, 12, 24, or 36 months of support.

License Terms

- **Perpetual** – Can be used indefinitely
- **Subscription** – Can be used through the term of the license only (6, 12, 24, or 36 months)

License Types

- **Node-locked** – Can be used on one specified instrument/computer
- **Transportable** – Can be used on one instrument/computer at a time but may be transferred to another using Keysight Software Manager (internet connection required)
- **USB Portable** – Can be used on one instrument/computer at a time but may be transferred to another using a certified USB dongle (available for additional purchase with Keysight part number E8900-D10)
- **Floating (single site)** – Networked instruments/computers can access a license from a server one at a time. Multiple licenses can be purchased for concurrent usage. Three types of floating license are available: **Single Site**: 1-mile radius from the server; **Single Region**¹: Americas; Europe; Asia; **Worldwide** (export restriction identified in End User License Agreement (EULA)).

KeysightCare Software Support Subscriptions

Perpetual licenses are sold with 12- (default), 24-, 36-, or 60-month software support subscription. Support subscriptions can be renewed for a fee after that.

Time-based licenses include a software support subscription through the term of the license.

KeysightCare Software Support Subscription provides peace of mind amid evolving technologies.

- Ensure your software is always current with the latest enhancements and measurement standards.
- Gain additional insight into your problems with live access to our team of technical experts.
- Stay on schedule with fast turnaround times and priority escalations when you need support.

¹ Americas (North, Central, and South America, Canada); Europe (European Continent, Middle Eastern Europe, Africa, India); Asia (North and South Asia Pacific Countries, China, Taiwan, Japan)

Selecting your license

Step 1. Choose your software product (e.g. D9020AUTP).

Step 2. Choose your license term: perpetual or subscription.

Step 3. Choose your license type: node-locked, transportable, USB portable, or floating.

Step 4. Depending on the license term, choose your support duration.

Software configuration Examples

If you selected:	Your quote will look like:	
	Part Number	Description
D9020AUTP node-locked perpetual license with a 12-month support subscription	D9020AUTP	High-Speed Automotive Decode and Trigger Software
	R-B5P-001-A	Node-locked perpetual license
	R-B6P-001-L	KeysightCare software support subscription, node-locked–12 months
D9020AUTP transportable 6-month subscription license	Part Number	Description
	D9020AUTP	High-Speed Automotive Decode and Trigger Software
	R-B4P-001-F	6-months, node-locked KeysightCare software support subscription

Keysight Automotive Ethernet solutions visit www.keysight.com/find/automotive-ethernet

Learn more at: www.keysight.com

For more information on Keysight Technologies' products, applications or services, please contact your local Keysight office. The complete list is available at: www.keysight.com/find/contactus

