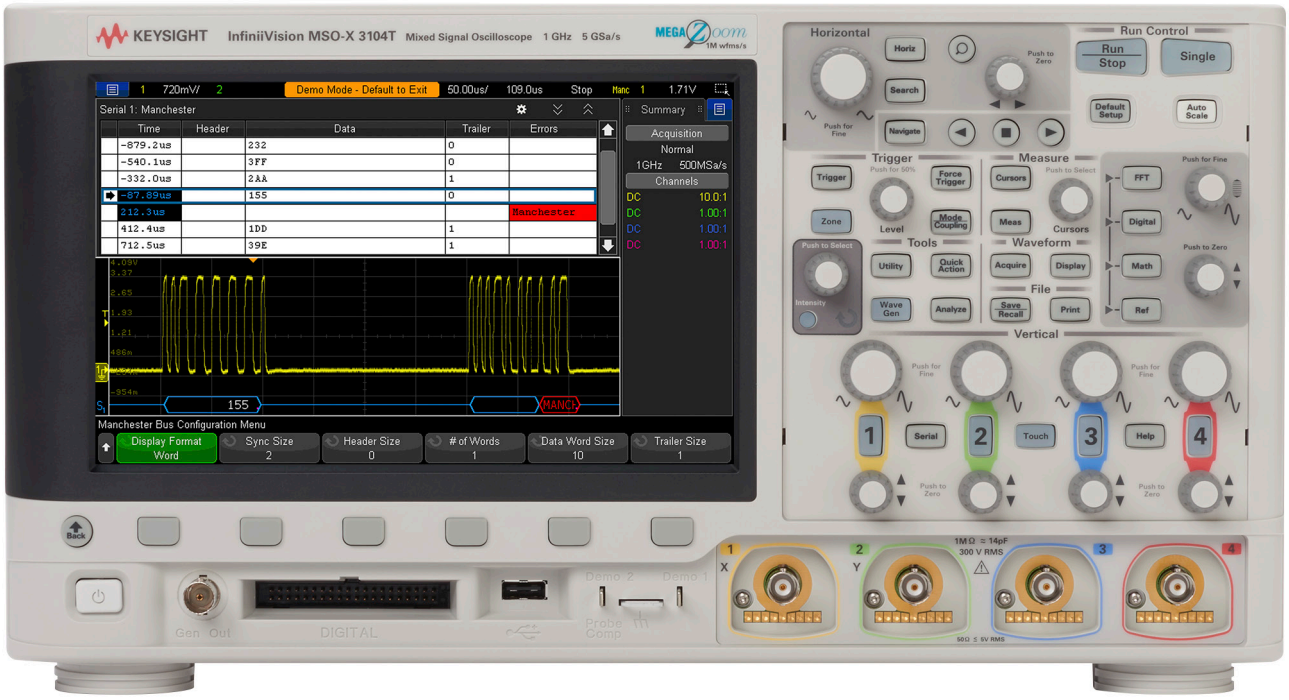
Keysight Technologies

Triggering on and Decoding the PSI5 Sensor Serial Bus

Using Keysight InfiniiVision X-Series Oscilloscopes

Application Note



KEYSIGHT TECHNOLOGIES

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Introduction

The Peripheral Sensor Interface 5 (PSI5) serial bus is used in automotive sensor monitoring applications including airbag systems. The PSI5 bus is based on a 2-wire current-modulated interface with Manchester encoding. This interface supplies power to PSI5 intelligent sensors and sensor-to-ECU data transmission is achieved via current modulation over the same 2-wire interface. Though the most common baud rate for PSI5 is 125 kbps, this bus can operate up to 189 kbps.

Keysight's InfiniiVision X-Series oscilloscopes offer a wide range of licensed application options that allow you to set up the scope to decode and trigger on a wide range complex automotive serial bus communication, including PSI5. Having the ability to synchronize on and decode PSI5 communication will enhance your ability to test, debug, and verify proper bus operation and signal integrity of the physical layer. Triggering on and decoding the PSI5 bus can be accomplished using Keysight's User-definable Manchester/NRZ Trigger and Decode option (DSOXT3NRZ/DSOX4NRZ/DSOX6NRZ).

This application note provides an overview of the structure of the PSI5 protocol/bit timing, followed by step-by-step instructions on how to set up an InfiniiVision oscilloscope to decode then trigger on a PSI5 serial bus.

PSI5 Protocol and Timing Overview

PS15 serial communication is based on Manchester encoding where transitions near the mid-point of bit periods determine the polarity of the transmitted and/or received bit. A rising transition/edge in the middle of a bit period corresponds to a logic “0” while a falling transition during the middle of a bit period corresponds to logic “1” as shown in the waveform timing diagram of Figure 1. Transitions at or near bit boundaries are ignored.

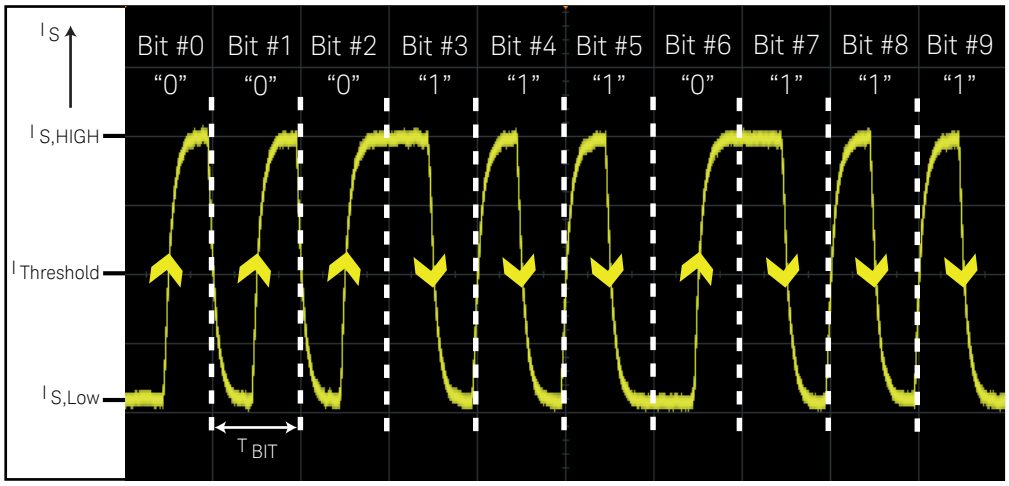

Figure 1. Bit polarities based on Manchester encoding.

PSI5 Protocol and Timing Overview (Continued)

PSI5 data frames consists of three primary fields/regions including a 2-bit start field (polarity always “0”), a 10- to 28-bit payload/data field, which can be further segmented into optional and mandatory sub-fields, and a 1- or 3-bit Parity/CRC field. This is shown in Figure 2 with additional explanations in Table 1.

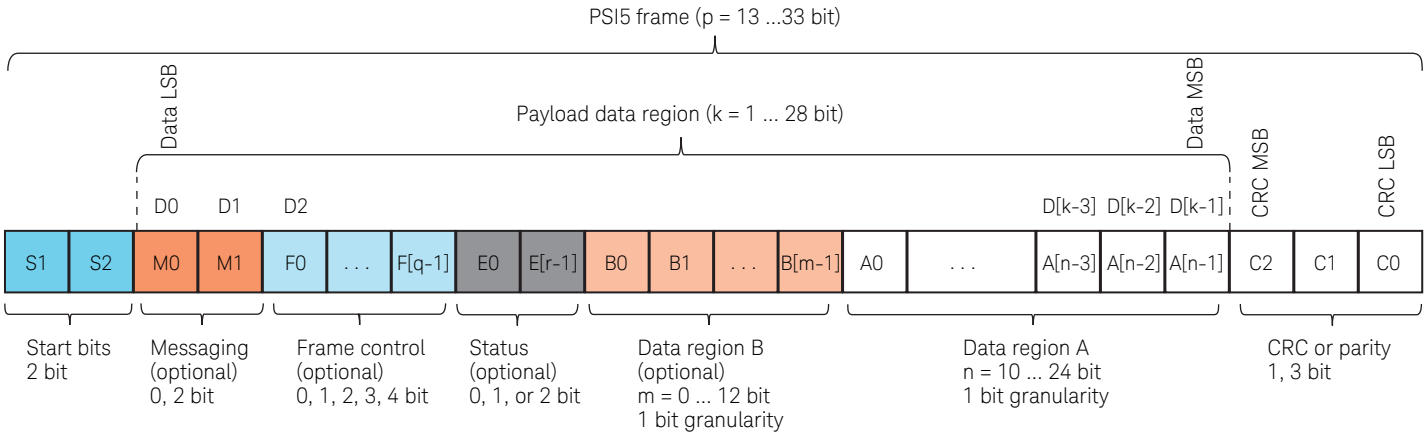

Figure 2. PSI5 data frame structure (based on PSI5 Technical Specification, v2.2).

Table 1. PSI5 frame region/field definitions

	Bits	Function	Number of bits	Comments
	S1, S2	Start bits	2	“0” polarity (mandatory)
Optional payload	M0, M1	Messaging	0, 2	Serial messaging channel (optional)
	F0 ... F[q-1]	Frame control	0, 1, 2, 3, 4	Indicates type of frame or data content. or identifies sensor (optional)
	E0 ... E[r-1]	Status	0, 1, 2	Error flag (optional)
	B0 ... B[m-1]	Payload data	0, 1, 2, ..., 12	Data region B (optional)
	A0 ... A[n-1}	Payload data	10, ..., 24	Data region A (mandatory)
	C2, C1, C0	Parity bit or CRC	1, 3	Mandatory

Decoding PSI5

Now learn how to set up an InfiniiVision X-Series oscilloscope to decode a stream of PSI5 signals/frames that consists of two start bits, a 10-bit data field, and a single parity bit. Begin by probing the PSI5 bus with a high-sensitively current probe such as Keysight's N2821A. Then properly scale (Amps/div) and trigger on a repetitive PSI5 signal while initially using the default edge trigger mode so the scope displays one or more frames on screen. Note that triggering on specific PSI5 frames must be established after properly setting up decode on the scope. Next, select the **Manchester** protocol decode mode in the scope's **Serial** menu as shown in Figure 3. Progress from left to right within this menu to define decoding based on the PSI5 protocol.

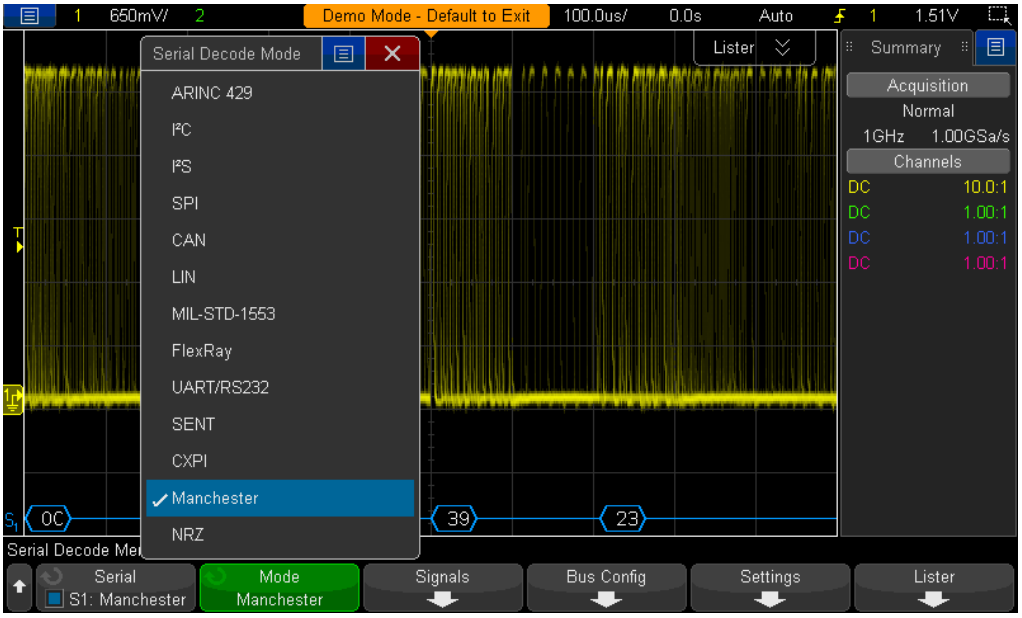

Figure 3. Scaling the waveform and then selecting to decode based on User-definable Manchester.

Select the **Signals** sub-menu and define the following parameters as shown in Figure 4:

- Source = 1 (assuming you're probing the bus with channel-1 to capture the PSI5 signal)
- Threshold = ~50% of waveform swing
- Baud Rate = 125 kb/s
- Baud Rate Tolerance = 20%

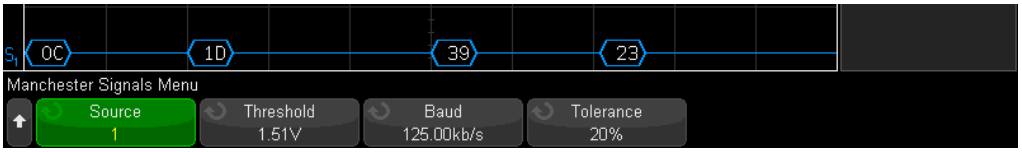

Figure 4. Defining the input channel source, threshold, baud rate, and baud rate tolerance in the Signals menu.

Decoding PSI5 (Continued)

Since the serial decoding on the InfiniiVision oscilloscope is based on hardware technology, the decoding threshold level is the same as the trigger level. So if you set up the scope to trigger on either rising or falling edge transitions with the trigger level near 50% of the peak-to-peak swing of the waveform, you should achieve a valid threshold level for decoding.

After establishing settings in the **Signals** sub-menu, press the **Back** key to return to the main **Manchester** decode menu. Select the **Bus Config** sub-menu and define the following parameters as shown in Figure 5:

- Display Format = Word
- Sync Size = 2 (number of start bits)
- Header Size = 0
- Number of Words = 1 (single data word within payload/data field)
- Data Word Size = 10
- Trailer Size = 1 (1 parity bit)

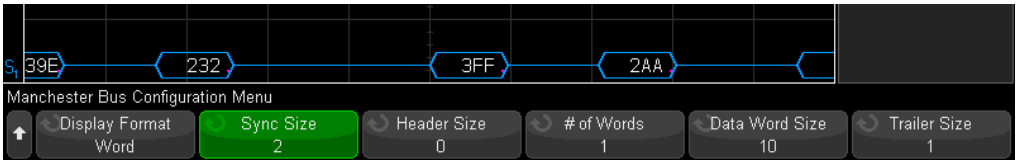

Figure 5. Defining the fields/regions of each PSI5 frame.

Note that if we were attempting to decode PSI5 frames that contain any of the optional fields/ regions, we could specify the “Header Size” as another unique field for decoding.

After establishing settings in the **Bus Config** sub-menu, press the **Back** key once again to return to the main **Manchester** decode menu. Select the **Settings** sub-menu and define the following parameters as shown in Figure 6:

- Start Edge # = 1 (1st edge after 2 start bits)
- Polarity = falling edge: 1 (falling edge in the middle of bit time = 1, rising edge in the middle of a bit time = 0)
- Bit Order = LSB (data field bit order)
- Idle Bits = 1.5 (minimum number of bits/gap between frames)
- Decode Base = Hex

Figure 6. Defining parameters within the Settings menu.

Note that bit order applies to the entire frame. This means if your PSI5 frames include a 3-bit CRC field, then this field will be decoded in reverse order.

Triggering on PSI5

Though the scope should now be decoding this PSI5 serial bus, it's not yet triggering on anything specific, other than random edge transitions. To set up a unique PSI5 trigger condition, select the **Trigger** menu, and then select to trigger on **Manchester**.

You can also turn on the protocol "Lister" display by selecting the **Lister** tab at the top of the scope's waveform display as shown in Figure 7. InfiniiVision scopes have the ability to display protocol decoding in two different formats. A time-correlated decode trace always appears below waveforms showing the contents of each frame. The "Lister" display can be turned on to show decoding in a tabular format in the top half of the scope's display.

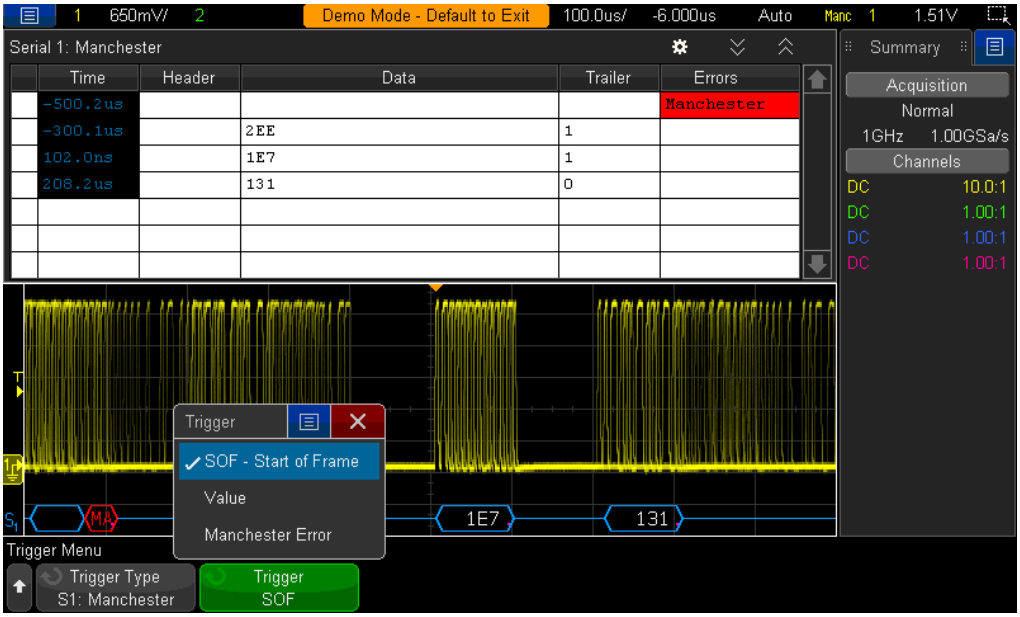

Figure 7. Triggering on the start of any PSI5 frame.

The default Manchester trigger condition is start-of-frame (SOF). However, you also have the ability to establish a more specific trigger condition by specifying a serial bit pattern value in binary format (entered in order of bit received by the scope), or trigger on Manchester errors. In this example there is the occurrence of an occasional Manchester error as shown in the lister display. A Manchester error is defined as the non-occurrence of an edge in the middle of any bit period within the tolerance setting. Now we set up the scope to trigger on this Manchester error to uncover the specific timing problem.

Triggering on PSI5 (Continued)

Figure 8 illustrates the scope triggering on the Manchester error while decoding in a binary bit display/decoding format. The orange triangle above the waveform (near right side of the display) marks the trigger point, which is at the end of the bit time following the Manchester error. With timebase set at 8 µs/div (same as a PSI5 bus bit time), we should observe a rising or falling edge very close to the mid-point between each vertical display graticules (8 µs between vertical graticules). We can see the transition that should have occurred in the middle of the 7th bit was interrupted early (prior to the middle of the bit period). This interruption produced a falling edge outside of the tolerance setting. The scope immediately detects this error at the end of that bit time, triggers on the error, and displays the “MANCH” error message highlighted in red.

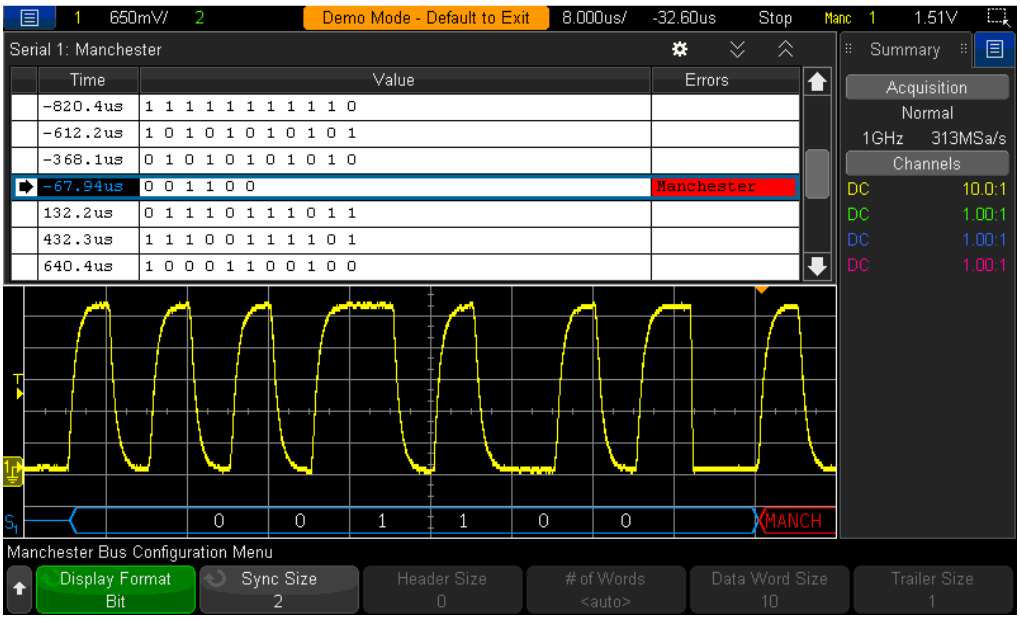

Figure 8. Using Manchester error triggering to uncover a bit timing problem.

Summary

Using Keysight's User-definable Manchester/NRZ Serial Trigger and Decode option on an InfiniiVision X-Series oscilloscope (except 2000X) allows you to quickly test and debug the PSI5 automotive sensor bus. Keysight also offers licensed options commonly used for automotive measurement applications including CAN, CAN FD, LIN, FlexRay, SENT, I^2C, SPI, etc. To learn more about testing automotive serial buses, refer to documents in **Related Literature** section at the end of this application note. To view short videos focused on automotive measurement applications, go to **www.keysight.com/find/scopes-auto**.

Related Literature

Publication title	Publication number
InfiniiVision 3000T X-Series Oscilloscopes - Data Sheet	5992-0140EN
InfiniiVision 4000 X-Series Oscilloscopes - Data Sheet	5991-1103EN
InfiniiVision 6000 X-Series Oscilloscopes - Data Sheet	5991-4087EN
Serial Bus Options for InfiniiVision X-Series Oscilloscopes - Data Sheet	5990-6677EN
N2820A/21A High-Sensitivity, High Dynamic Range Current Probes - Data Sheet	5991-1711EN
Oscilloscope Measurement Tools to Help Debug Automotive Serial Buses Faster - Application Note	5991-0512EN
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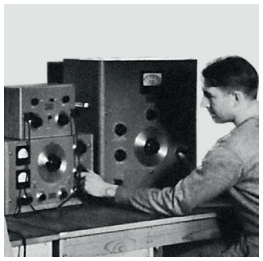
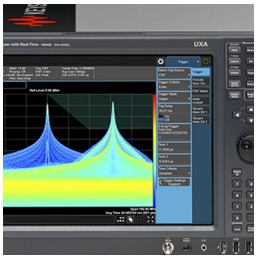


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