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## ABSTRACT

Compliance testing is necessary for USB devices and hosts to verify their operation over a wide set of criteria defined by the USB 2.0 standard. Performing high-speed signal quality testing with the TUSB21XX USB 2.0 redrivers varies by both device and method of testing. This document will detail the various procedures and methods for performing HS signal quality testing and their compatibility among the TUSB21XX redrivers for host, device, and embedded host test modes. Behavior of the output flags high-speed enable (ENA\_HS) and connection-detected (CD) are recorded throughout each stage and mode of testing to assist in debugging device state.

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## 1 Introduction

The TUSB21XX family of devices are USB high-speed signal conditioners intended to compensate for ISI signal losses in a transmission channel. The devices are designed to condition high-speed signals, while leaving low and full-speed signals unconditioned. For this reason, it is important to ensure that the device is enabled in high-speed mode while performing compliance testing. Some cases can arise in which the device does not detect and enable high-speed mode if test procedures are not followed exactly. The TUSB21XX devices include both a high-speed enable (ENA\_HS) and connection-detected (CD) status pin to assist in ensuring proper device state prior to testing. This document details the behavior of these status pins across the testing procedure for each test mode. The expected state of each pin during testing is included in [Table 1-1](#).

**Table 1-1. TUSB21XX HS Signal Quality Test Status Flags**

Test Mode	ENA_HS Status Flag	CD Status Flag
Host	High <sup>1</sup>	Low <sup>2</sup>
Device	High	High
Embedded Host	High	High

1. "High" indicates logic level 1. Voltage value varies based on supply voltage and current. For more information, see the *Electrical Characteristics* section of the device-specific data sheet.
2. "Low" indicates logic level 0. Voltage value will be approximately 0V. For exact values, see the *Electrical Characteristics* section of the device-specific data sheet.

In performing HS signal quality testing, there are three main "modes" or configurations of testing: host mode, device mode, and embedded host mode. Each of these configurations involve a slightly different test procedure and system setup. In host mode, a system sends test packets downstream, where they are received and measured. In device mode, a host system sends a test packet command to a connected device downstream. Upon receiving this command, the device sends test packets upstream, where they can be measured and analyzed. Lastly, in embedded host mode, the use of a device with a specific Vendor ID (VID) and Product ID (PID) is needed. The VID and PID are 16-bit numbers used to identify USB devices. A device with a specific combination is needed to place a controller, or embedded host, in test mode and tell it to continuously send test packets. Embedded host testing supports compliance testing for system design in which the host cannot support the USB-IF High-Speed Electrical Test Tool (HSET), such as an embedded microcontroller. The test mode compatibility across the TUSB21XX devices are detailed in [Table 1-2](#).

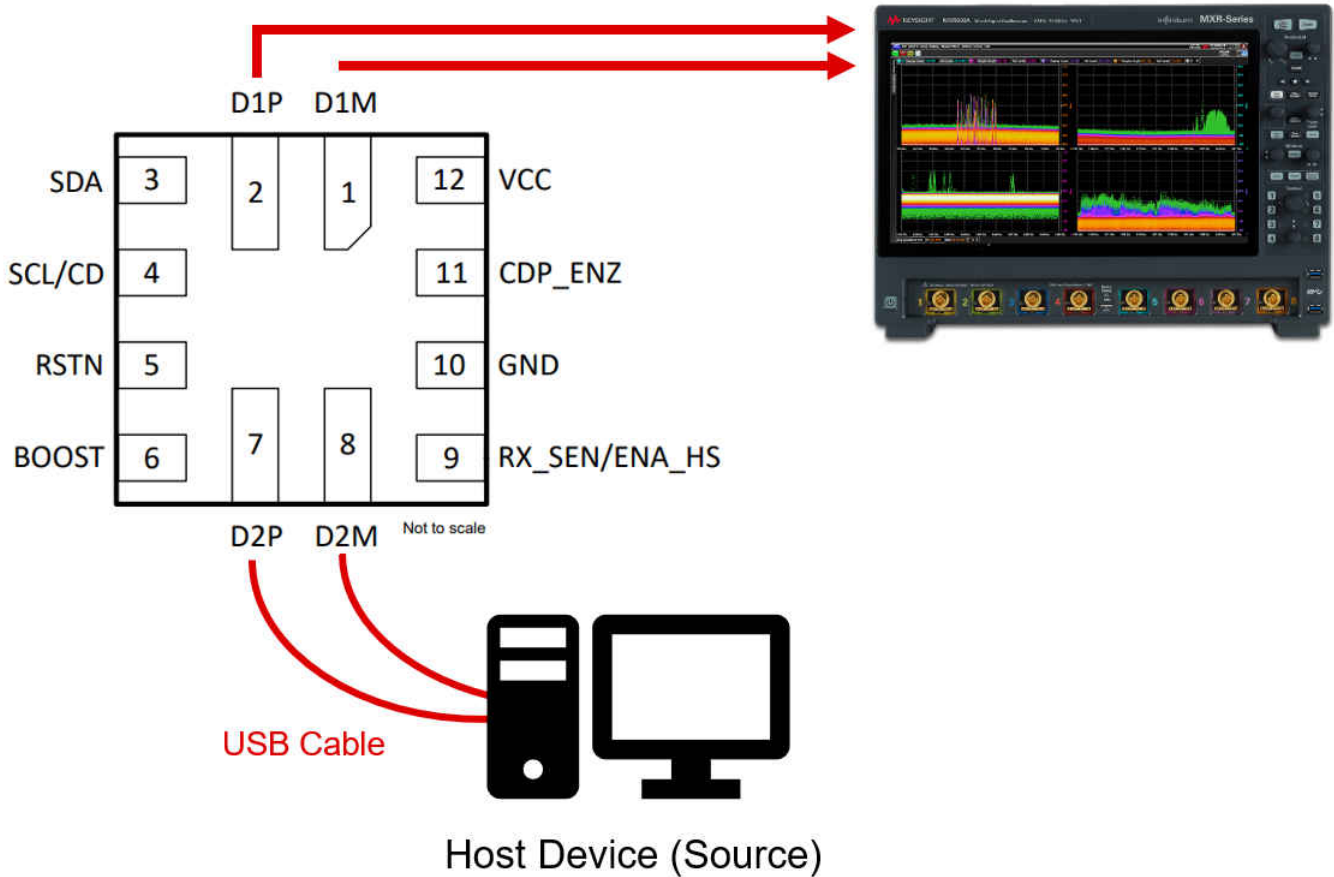
**Table 1-2. TUSB21XX Test Mode Compatibility**

Part Number	Host	Device	Embedded Host
TUSB211	X	X	X
TUSB212	X	X	X
TUSB216	X		
TUSB216I	X	X	X
TUSB217	X		
TUSB217A	X	X	X

## 2 Host Mode Testing

When performing high-speed signal quality testing in the host mode, no enumeration or handshaking is required, but it is crucial that the system is setup in the correct way for the TUSB21XX device to detect and enable high-speed signal conditioning.

A generalized system diagram for host mode testing is shown in [Figure 2-1](#). The host device (a PC in this case) is connected to the input of the TUSB21XX device via a USB cable. The host must be a Windows device able to install and run the USB-IF HSET software. In cases where this is not possible, embedded host mode testing is required ([Section 4](#)). The output of the TUSB21XX is connected directly to an oscilloscope for test packet measurement. Practically, the output will likely be interfaced with the TUSB21XX through a USB receptacle. In this case, a [test fixture](#) is needed to break out the D1P/D1M data lines to the oscilloscope input.



**Figure 2-1. Host Mode Test Setup**

## 2.1 Host Mode Test Procedure

It is important to start the test procedure with all connections to the TUSB21XX device disconnected and no test packets being sent from the host. Doing so will ensure high-speed signal compensation is active throughout the test. The host mode test procedure is as follows:

1. Connect TUSB21XX input to host (test packet source).
2. Toggle RSTN (reset) on TUSB21XX.
3. Connect TUSB21XX output to oscilloscope/measurement tool.
4. Send high-speed test packets via [xHCI Electrical Test Tool](#) (Figure 2-2).

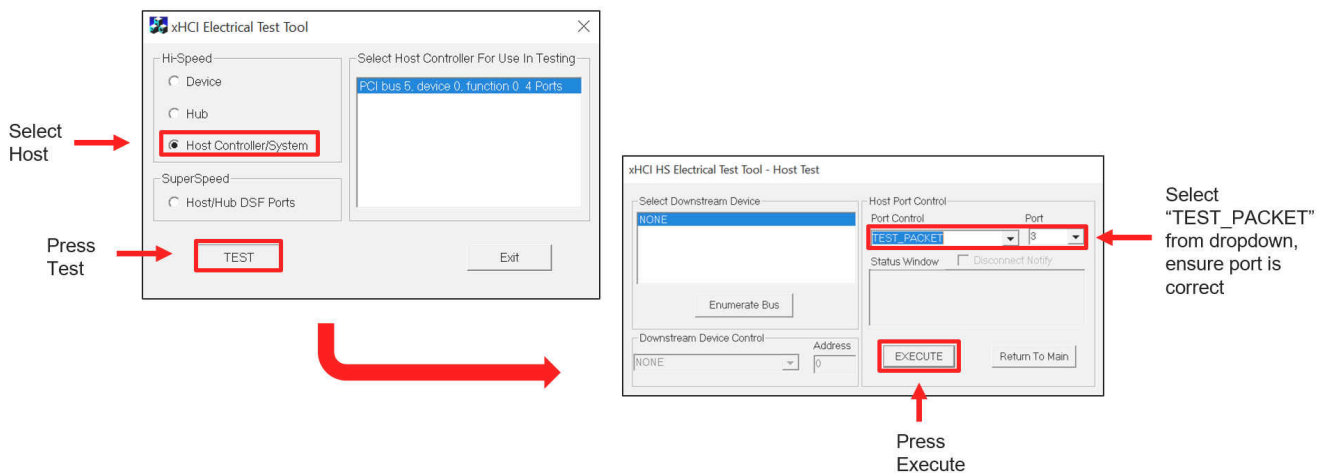


Figure 2-2. Host Mode Testing Software Configuration

Once test packets have been sent via software, the scope output and status flags should be observed as below. The high-speed enable (ENA\_HS) flag switches high during the first test packet and remains that way for the duration of testing (Figure 2-3).

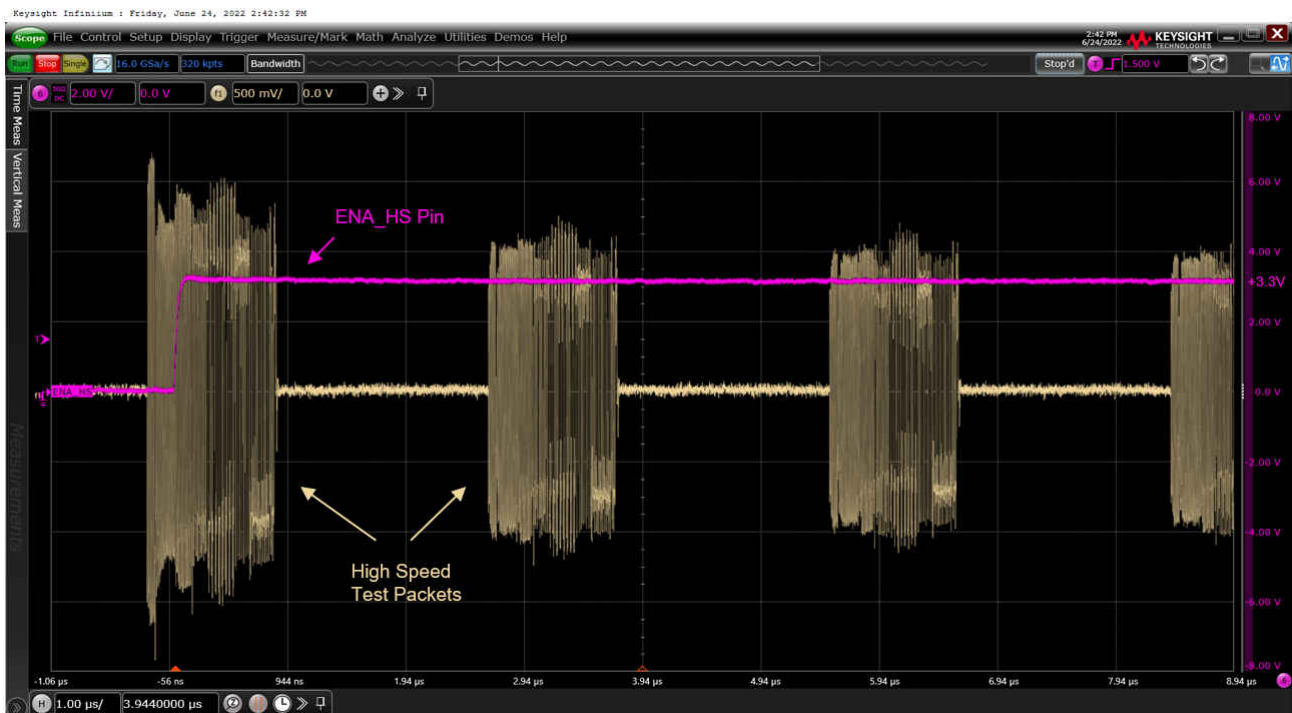


Figure 2-3. Host Mode Enable High-Speed (ENA\_HS) Status Flag

The connection-detected (CD) flag remains low during all steps of testing (Figure 2-4).

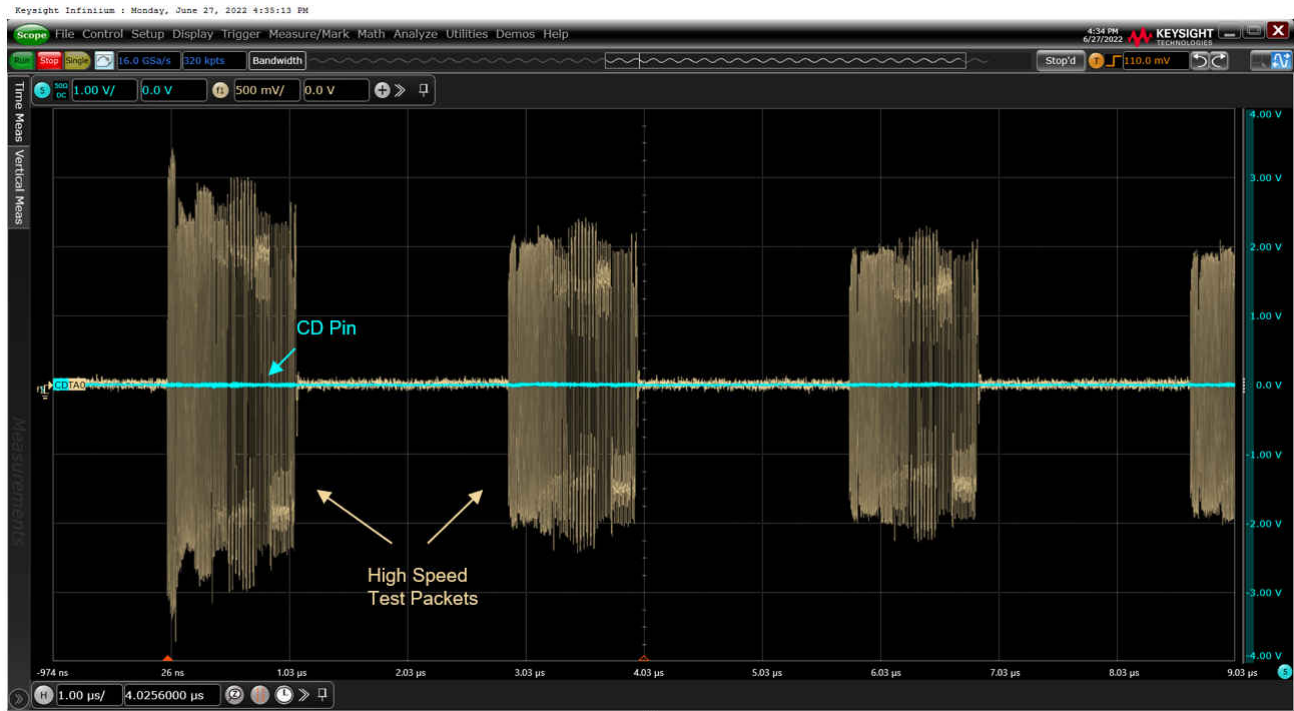


Figure 2-4. Host Mode Connection-Detected (CD) Status Flag

### 3 Device Mode Testing

In device mode testing, enumeration of the USB device sending high-speed test packets is required. In order to support this enumeration, observe the device test packets, and provide bus power for the device. The use of a relay or switching board is necessary. The board allows the enumeration and test packet command to travel from the host to the device, while also allowing the test packets to be observed without any reflections or interference from upstream. Relay boards are included in any typical [USB 2.0 approved test fixture](#).

A basic system diagram for device mode testing is shown in [Figure 3-1](#). A host device, the source of the test packet command, is connected to the "init" port of a test fixture relay board. As with host mode testing, the test host must be a Windows device capable of running the USB-IF HSET software. The "test" port of the relay board is connected to the TUSB21XX's input via a short USB cable. An oscilloscope is connected to the DP/DM data lines on the relay board via SMA cables. Finally, the USB device is connected on the output of the TUSB21XX device.

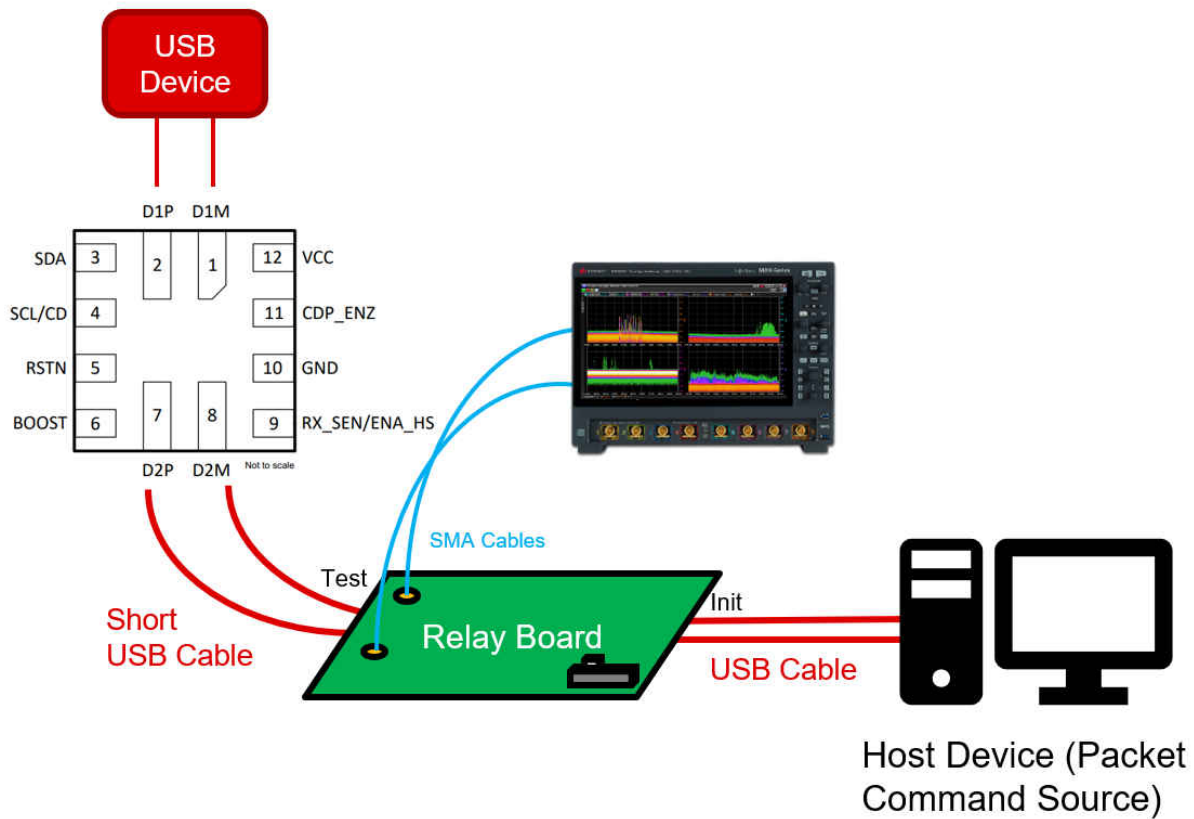
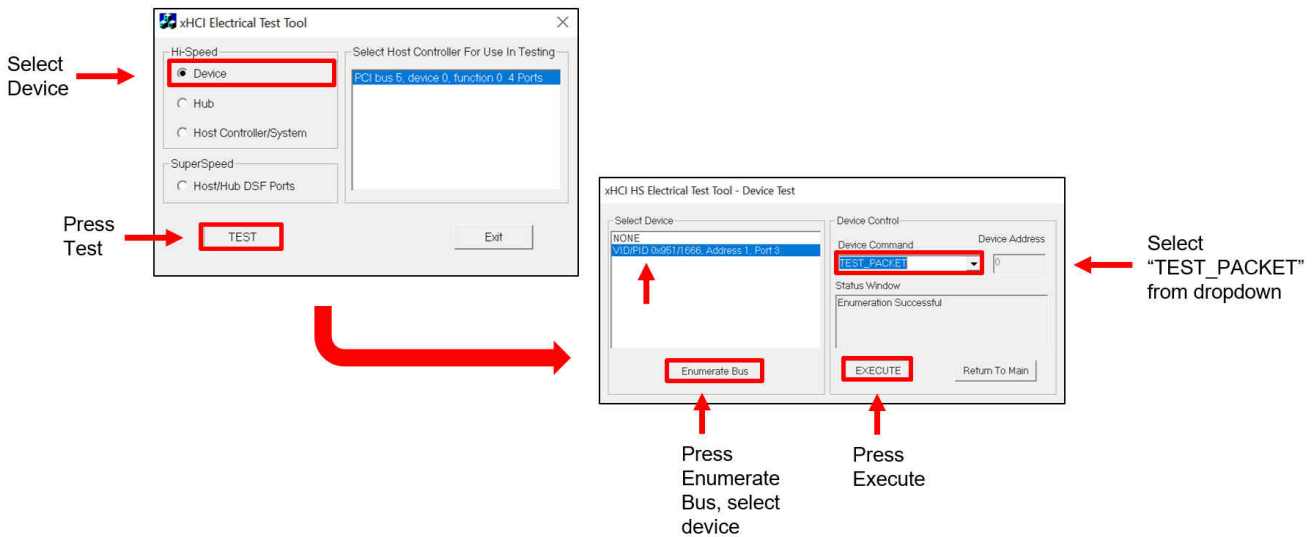


Figure 3-1. Device Mode Test Setup

### 3.1 Device Mode Test Procedure

As with host mode testing, it is crucial to begin the test procedure with all cabling and devices disconnected, including the USB device that is receiving the test packet command. Using the steps shown in the following test procedure correctly ensures that proper enumeration and activation of high-speed conditioning occurs:

1. Connect TUSB21XX input to host via relay/switching board.
2. Connect relay board to oscilloscope.
3. Toggle RSTN (reset) on TUSB21XX.
4. Connect device to TUSB21XX output.
5. Set relay board to "init" position.
6. Send high-speed test packet command via [xHCI Electrical Test Tool](#) (Figure 3-2).
7. Set relay board to "test" position.



**Figure 3-2. Device Mode Testing Software Configuration**

Initially, both ENA\_HS and CD status flags are low. Immediately after device connection (Step 4), DP/DM pull-up resistors are detected and the CD status flag switches high (Figure 3-3). Shortly later, after device enumeration, ENA\_HS switches high (Figure 3-4). If this does not occur, ensure that the device being used is USB 2.0 high-speed compatible and that the host is able to enumerate the device (the host controller is not mounted by any software).

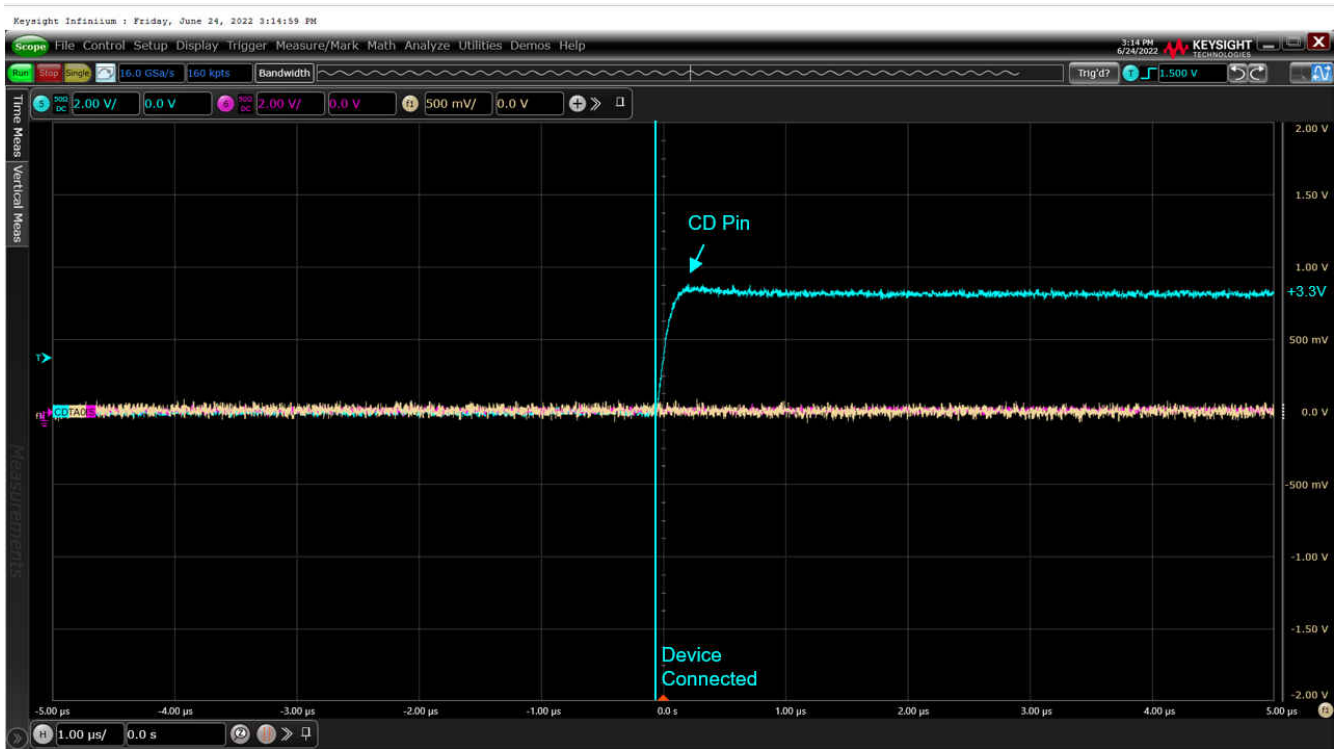


Figure 3-3. Device Connected - CD Status Flag

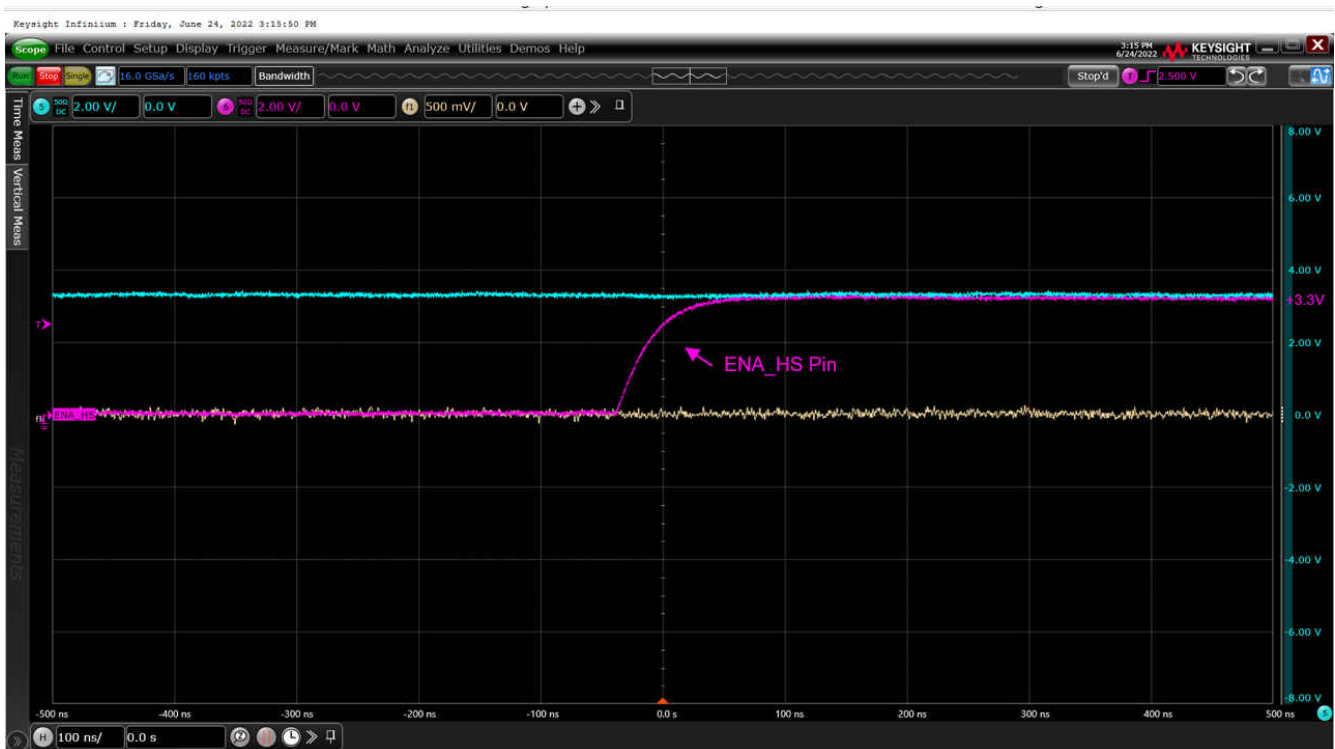


Figure 3-4. Device Connected - ENA\_HS Status Flag



After sending the test packet command in software (Step 6) and setting the relay board to the "test" position (Step 7), test packets immediately begin to appear on the oscilloscope input (Figure 3-5). These will continue until the device is disconnected, at which point both CD and ENA\_HS fall low (Figure 3-6).

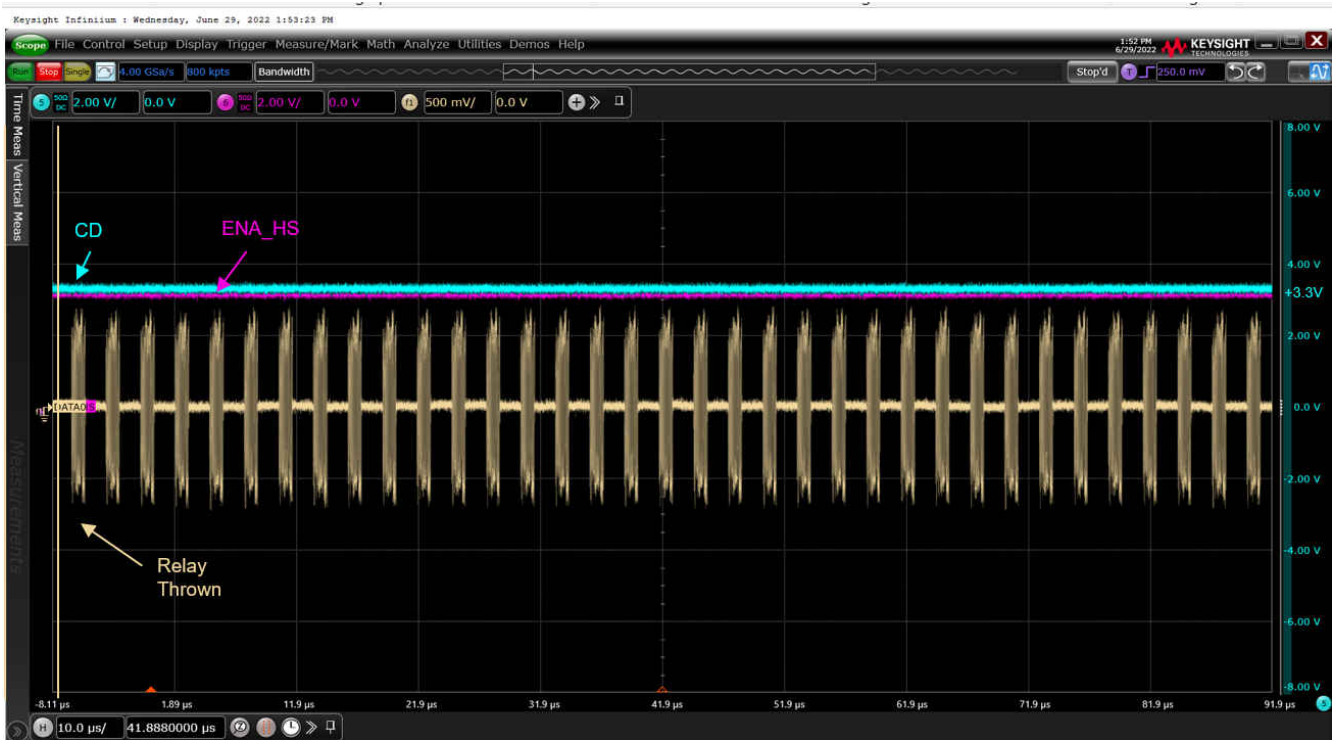


Figure 3-5. Device Mode Test Packets

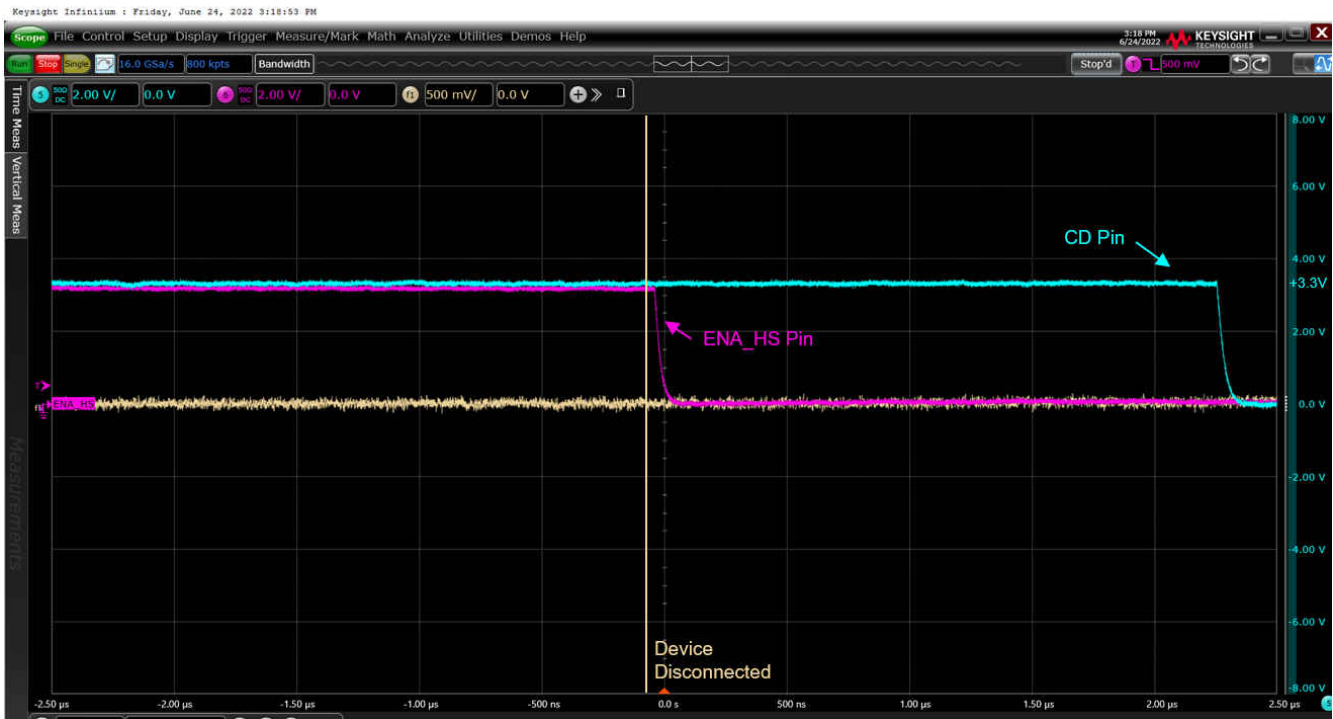


Figure 3-6. Device Disconnect - CD and ENA\_HS Status Flags

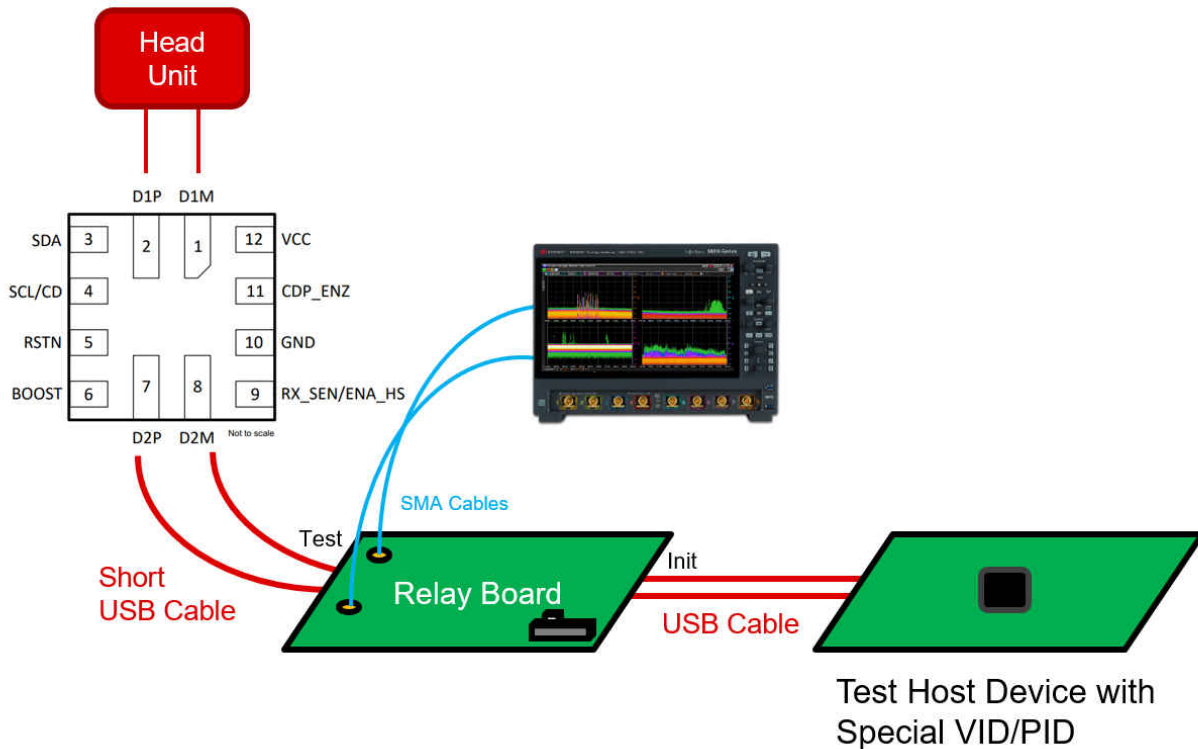
## 4 Embedded Host Mode Testing

When performing testing in embedded host mode, a specialized PID/VID device is required in addition to a relay or switching board as used in device mode testing. The device must present a specific PID/VID combination which upon enumeration will set the embedded host into test mode. The desired VID for embedded testing is 0x1A0A. The PIDs are arranged by test type and are summarized in [Table 4-1](#). For high-speed signal quality testing, the desired PID is 0x0104 (TEST\_PACKET).

**Table 4-1. USB High Speed PID Definitions**

PID	Test Type
0x0101	TEST_SE0_NAK
0x0102	TEST_J
0x0103	TEST_K
0x0104	TEST_PACKET
0x0105	RESERVED
0x0106	HS_HOST_PORT_SUSPEND_RESUME
0x0107	SINGLE_STEP_GET_DEV_DESC
0x0108	SINGLE_STEP_SET_FEATURE
0x0200	TTST_CONFIG
0x0201	Unknown Device Not Supporting HNP
0x0202	Unknown Device Supporting HNP

An example system setup is shown in [Figure 4-1](#). The VID/PID device is connected to the "init" port of a test fixture relay board. The "test" port of the relay board is connected to the TUSB21XX's input via a short cable. An oscilloscope is connected via SMA cables to the DP/DM data lines on the relay board. Lastly, the head unit or "embedded host" is connected to the output of the TUSB21XX through some means of connection, such as cabling or trace routing within a PCB.



**Figure 4-1. Embedded Host Mode Test Setup**

## 4.1 Embedded Host Mode Test Procedure

Begin the test procedure with all necessary devices disconnected and powered down. Ensure the VID/PID device is set to the desired test type. For high-speed signal quality testing, a PID of 0x0104 is desired (TEST\_PACKET).

1. Power relay board and set it to the "init" position
2. Connect the "test" port of the relay board to the TUSB21XX's input
3. Connect oscilloscope to relay board
4. Connect head unit/embedded host to the TUSB21XX's output and power it on
5. Toggle RSTN (reset) on TUSB21XX
6. Connect VID/PID test host device to the "init" port of the relay board
7. Set relay board to "test" position

As with all prior modes of testing, both CD and ENA\_HS are low initially. Upon connection of the VID/PID test host device (Step 6), the CD flag switches high (Figure 4-2). Shortly following this, after successful enumeration by the embedded host, ENA\_HS also switches high (Figure 4-3). If this does not occur, ensure that the VID/PID device is active and presenting the correct VID/PID combination. For some system setups, the embedded host must be powered on prior to the VID/PID device to properly enumerate it. Also ensure the relay board is set to the "init" position to support handshaking.

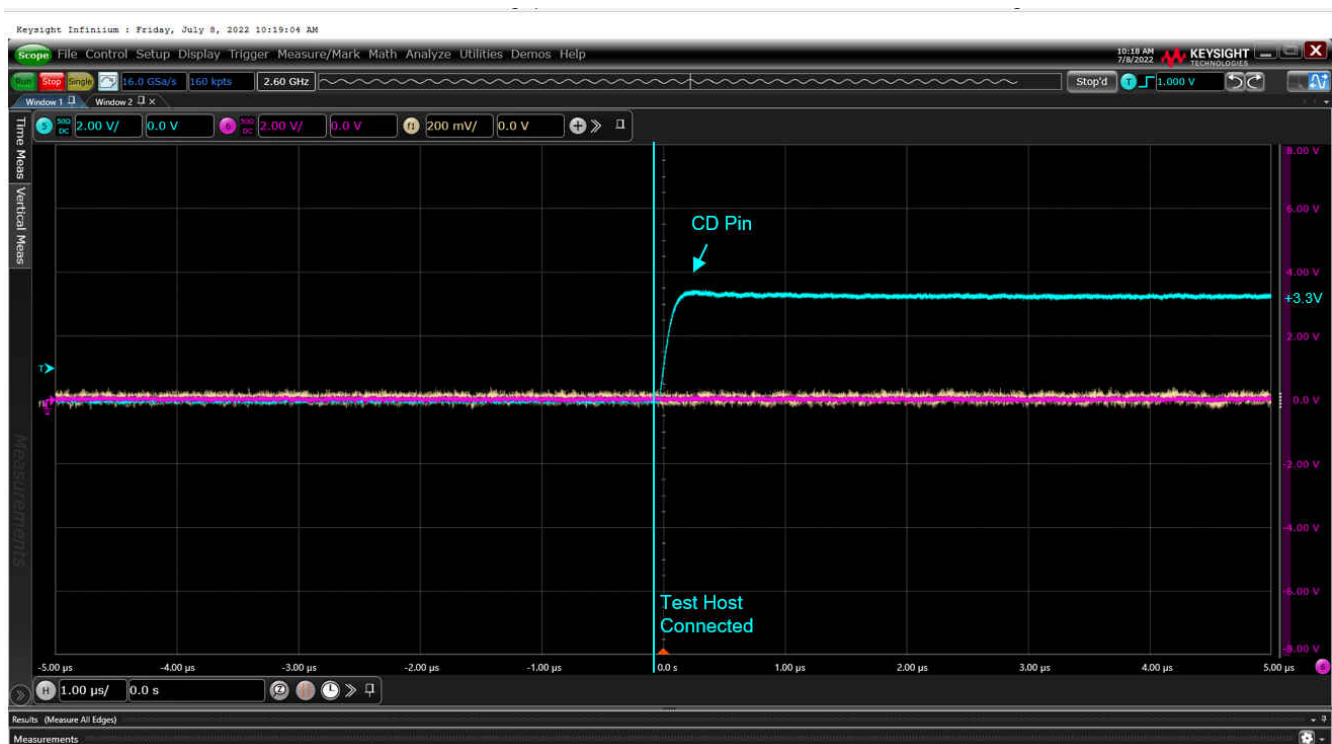


Figure 4-2. VID/PID Device Connected - CD Status Flag

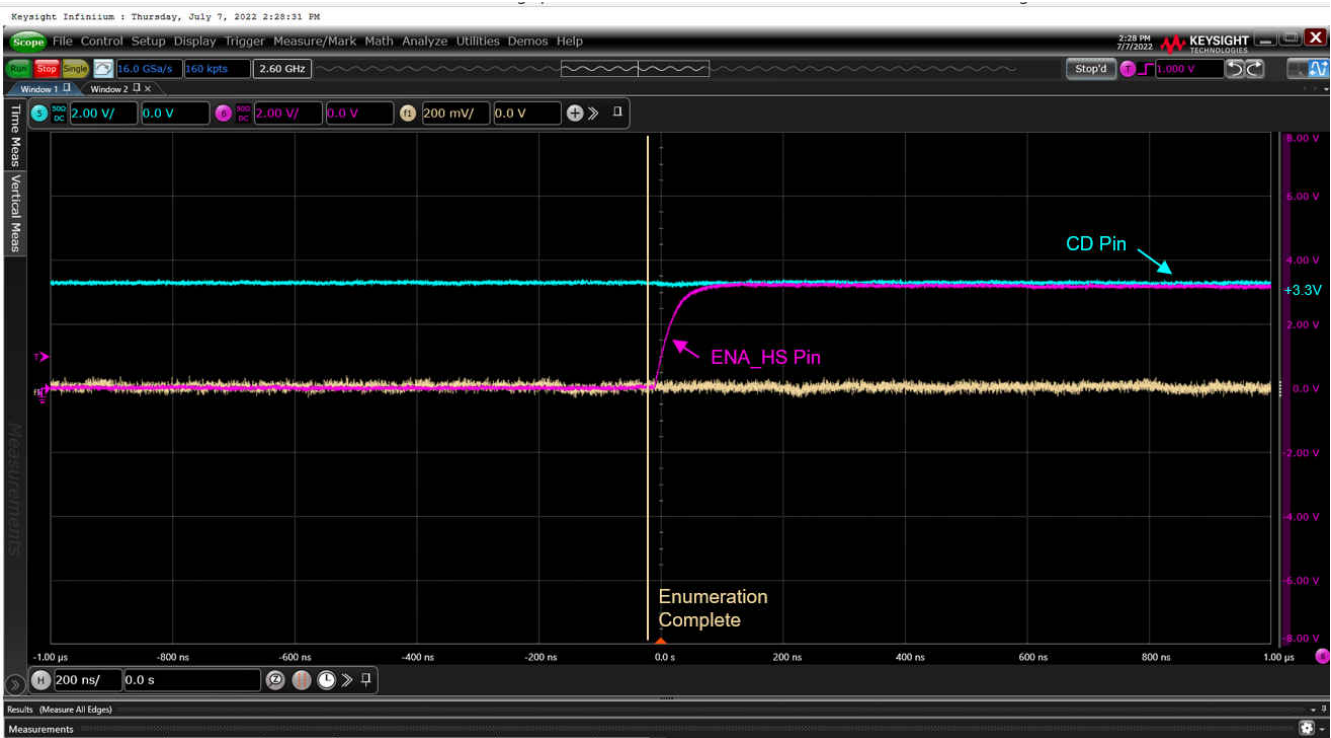


Figure 4-3. VID/PID Device Connected - ENA\_HS Status Flag

After enumeration has completed, the embedded host immediately begins sending test packets. Once the relay is set to the "test" position (Step 7), test packets will appear on the oscilloscope input (Figure 4-4).

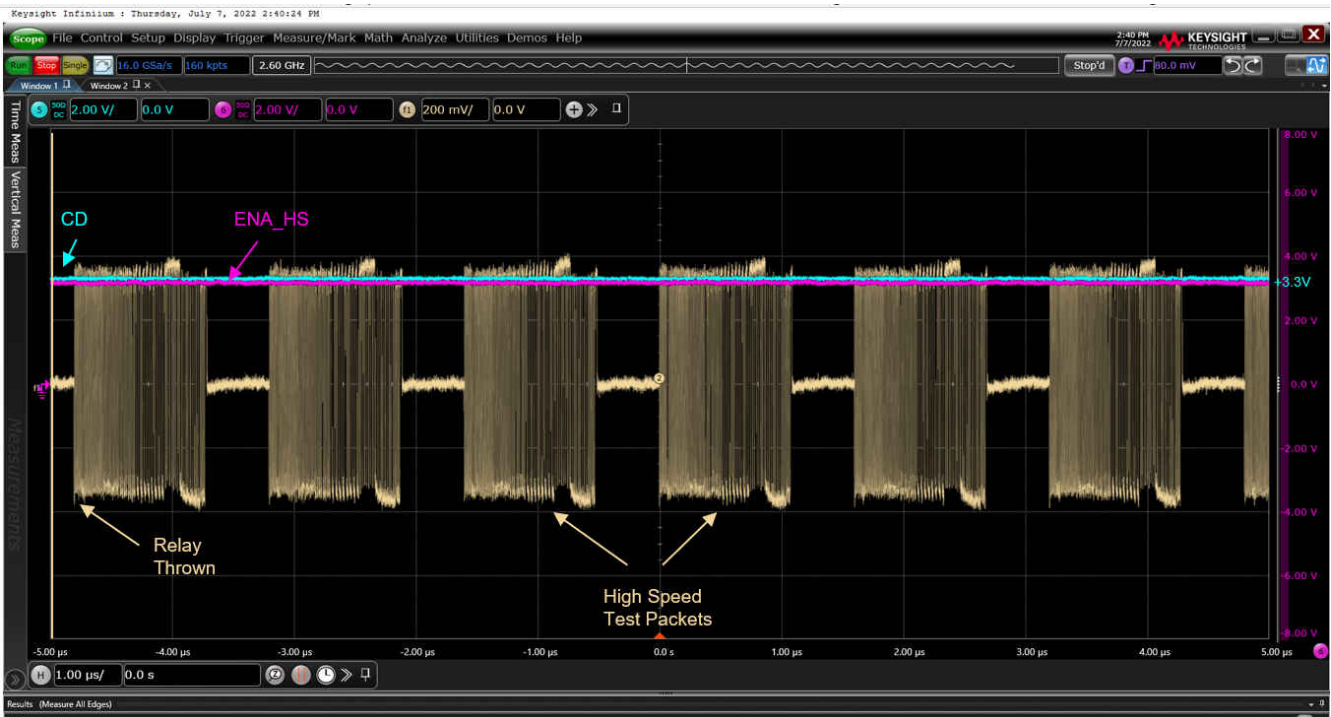


Figure 4-4. Embedded Host Mode Test Packets

The test packets will continue to be sent by the embedded host until it is powered off. ENA\_HS switches low after the relay board is switched back to the "init" position (Figure 4-5).

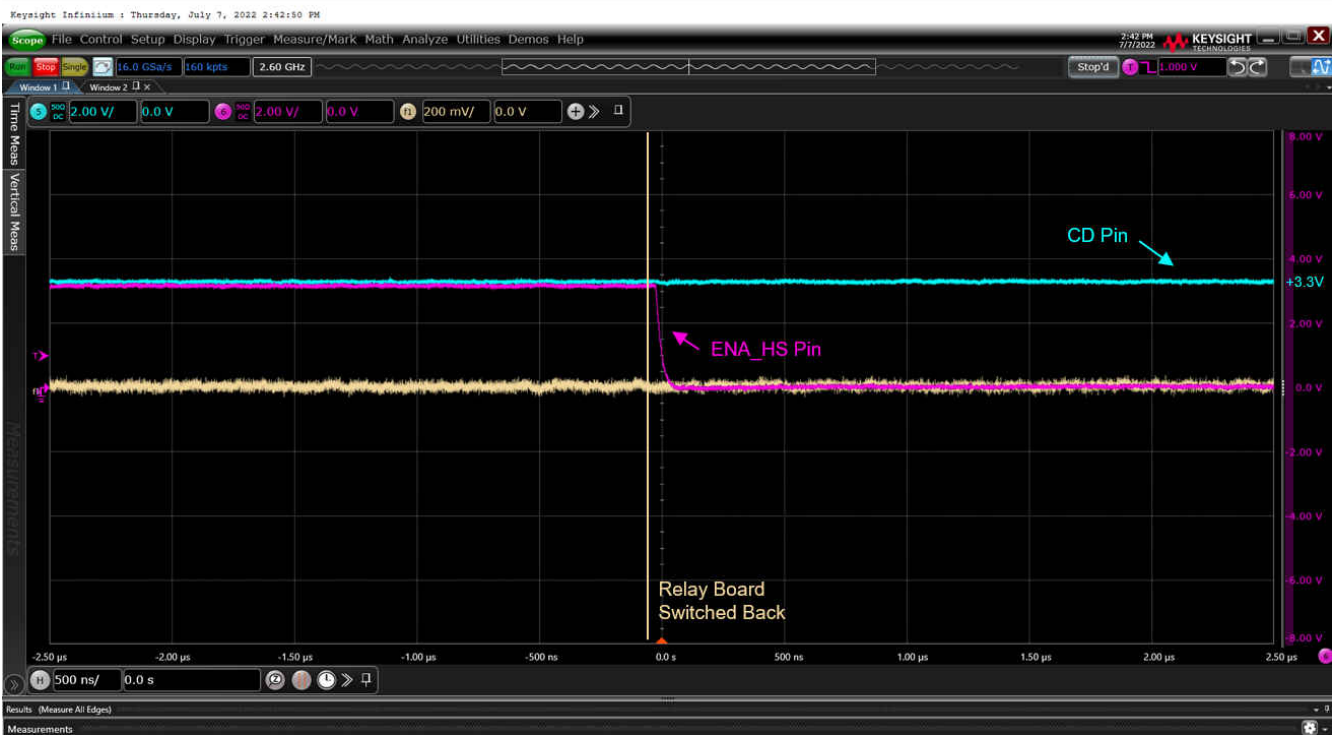


Figure 4-5. Relay Board Switch - ENA\_HS Status Flag

Finally, after disconnecting the VID/PID device, CD switches low (Figure 4-6).

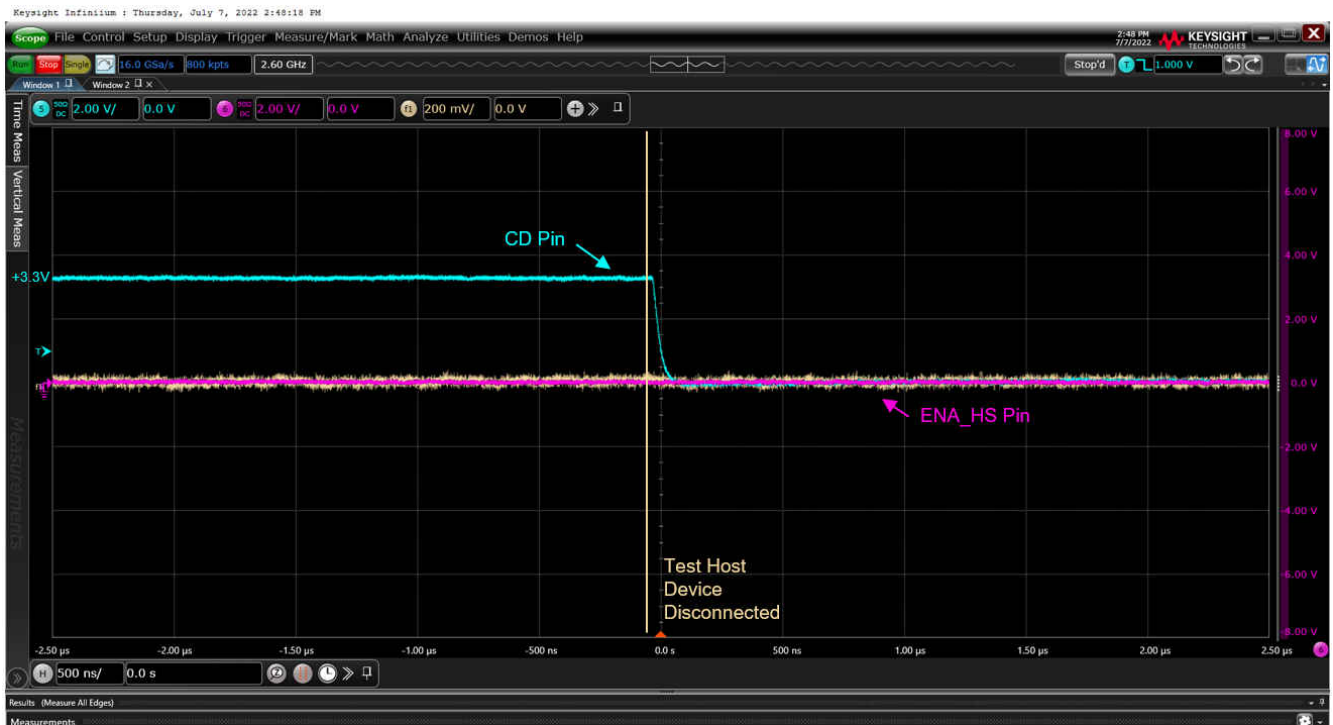


Figure 4-6. VID/PID Device Disconnect - CD Status Flag

## 5 Additional Compliance Resources

- [USB 2.0 Specification](#)
- [USB 2.0 Electrical Compliance Test Specifications](#)
- [USB-IF Embedded Host High-Speed Electrical Test Procedure](#)
- [USB-IF Testing Applications](#)
- [USB 2.0 Approved Test Fixtures](#)

## 6 References

- Texas Instruments: [TUSB216I USB 2.0 High-Speed Signal Conditioner With BC 1.2 Controller Data Sheet](#)
- Texas Instruments: [TUSB217A USB 2.0 High-Speed Signal Conditioner With DCP and CDP Controllers Data Sheet](#)
- Texas Instruments: [TUSB211 USB 2.0 High Speed Signal Conditioner Data Sheet](#)
- Texas Instruments: [TUSB212 USB 2.0 High Speed Signal Conditioner Data Sheet](#)
- Texas Instruments: [TUSB216 USB 2.0 High-Speed Signal Conditioner With BC 1.2 Controller Data Sheet](#)
- Texas Instruments: [TUSB217-Q1 USB High Speed Signal Conditioner Data Sheet](#)
- Texas Instruments: [TUSB2XX Implementation Guide](#)

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