

TBTCAM (Type-C Multiple Alt Mode) Test Adapter (Intel-Based)

User Manual

(Release Software 1.10, Firmware 1.09)



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Introduction

This user's manual documents the Intel-Based Type-C Multiple Alt. Mode Plug and Thunderbolt Receptacle Test Adapters (TBTCAM-TPA-P and TBTCI-TPA-R). The Plug test adapter, shown in Figures 1, tests Thunderbolt, DisplayPort, and USB Type-C interface cables, hosts and devices against the Thunderbolt, DisplayPort, and USB Type-C Standards and Compliance Specifications. The Receptacle test adapter, shown in Figure 2, tests Thunderbolt devices and cables.

The TPA-P and TPA-R test adapter assemblies allow easy access, via SMP connections or, optionally, via high-performance coaxial cables terminated into 2.92mm connectors, to measure or inject data signals. The test adapters also provide access to USB 3.1 Type-C DP/DN, CC1, CC2, VBUS and Ground, via a Thunderbolt/Mini-DisplayPort connector, probe pins, and a 10-position low-speed connector. A Mating 10-position cable assembly is supplied with the test adapters to provide connection of the LST, LSR, and Ground signals to the Wilder Thunderbolt Generation 2 Microcontroller. A Mini-USB Type-B 2.0 Receptacle is provided for PC User Interface.

NOTE: To avoid damaging the test adapters or optional cables, use the handling techniques described in the Care and Handling section before making any connections or configuring a test setup.

Always use a static-safe workstation when performing tests, as explained in the "Electrostatic Discharge Information" section.

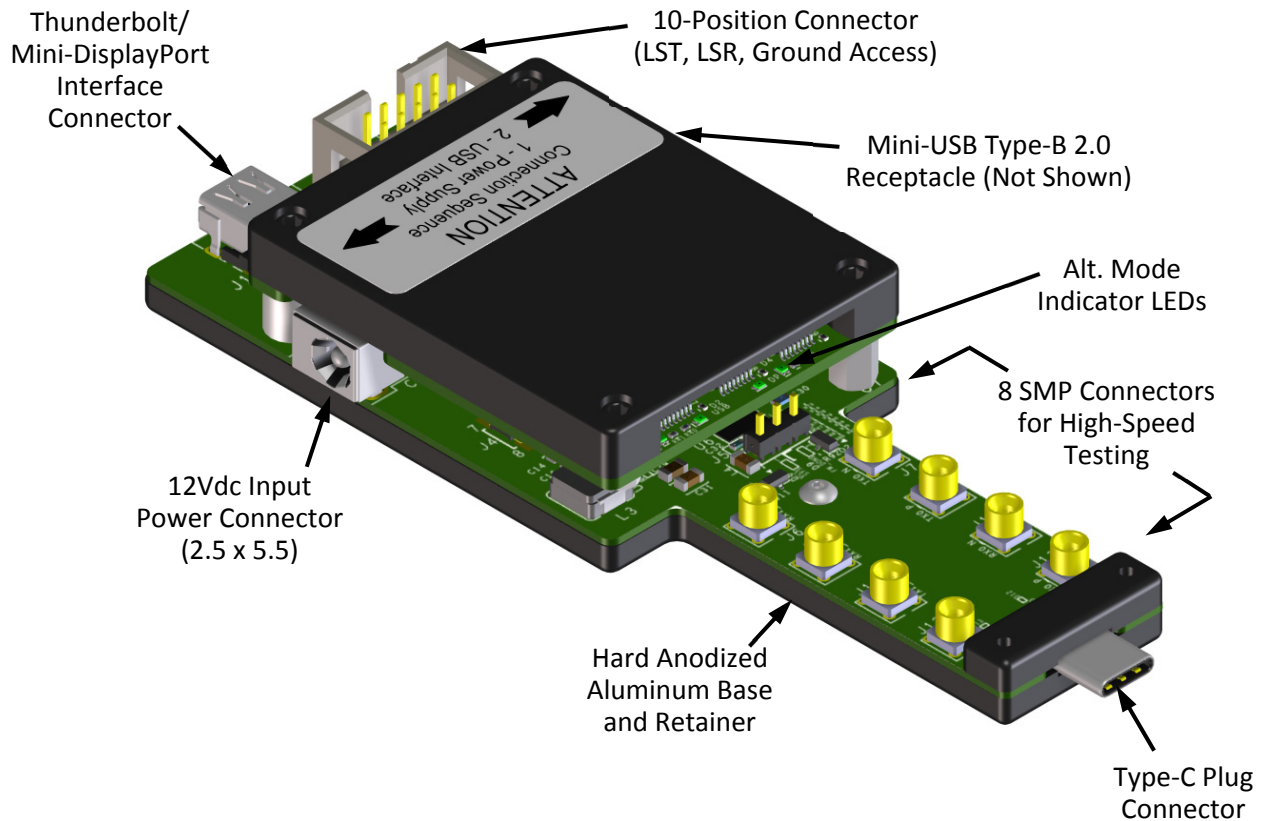


Figure 1. The TBTCAM-TPA-P Test Adapter (Host Plug).

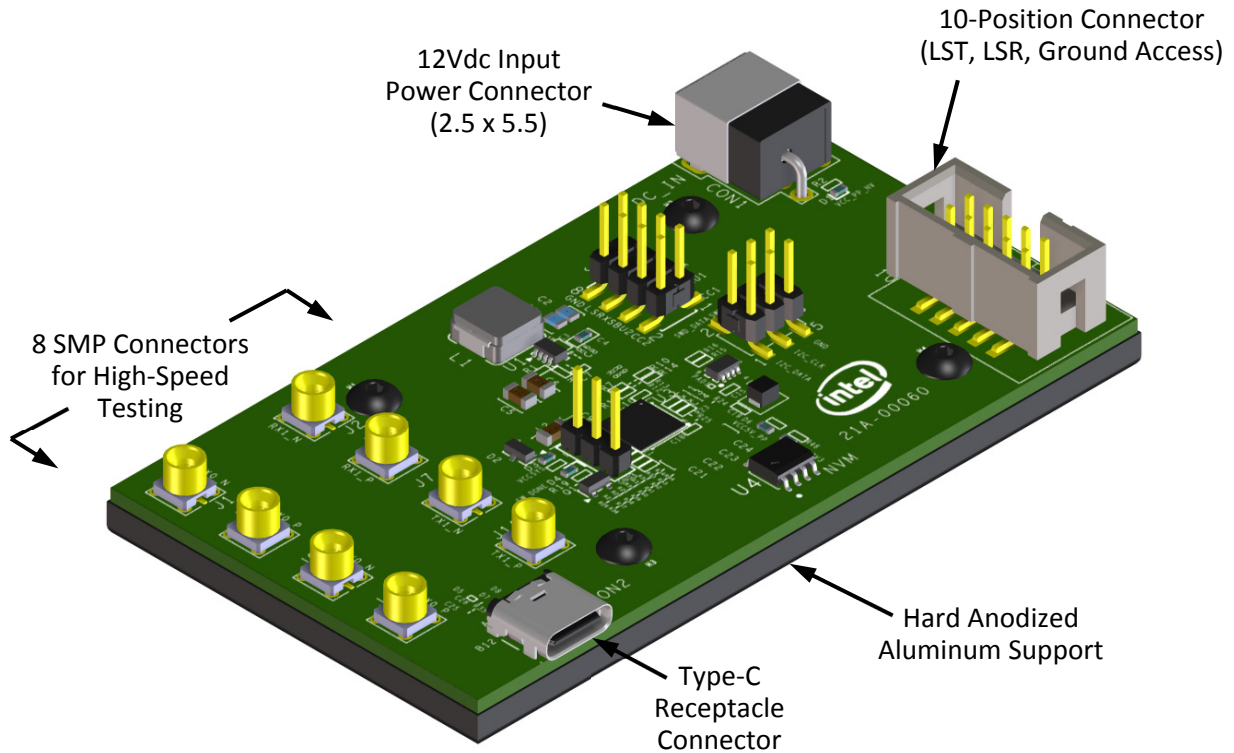


Figure 2. The TBTCI-TPA-R Test Adapter (Device Receptacle).

A 10-position ribbon cable assembly, shown below, is supplied with the test adapters to provide connection of the LST, LSR, and Ground signals to the Wilder Thunderbolt Generation 2 Microcontroller. Also supplied is an Aux Channel Probe Access Module, shown on the following page, to support DisplayPort testing.

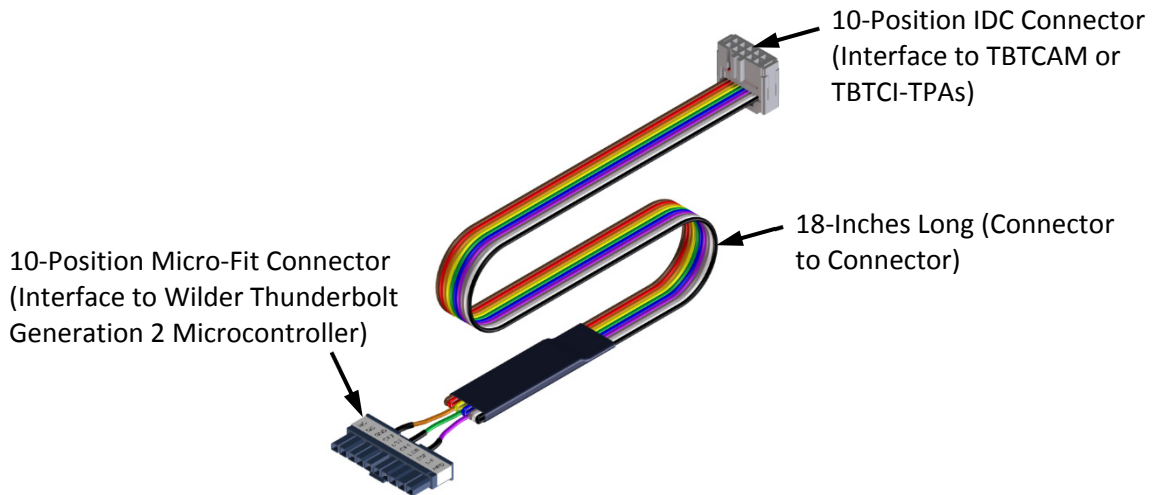


Figure 3. 10-Position Ribbon Cable Assembly (Thunderbolt Testing)

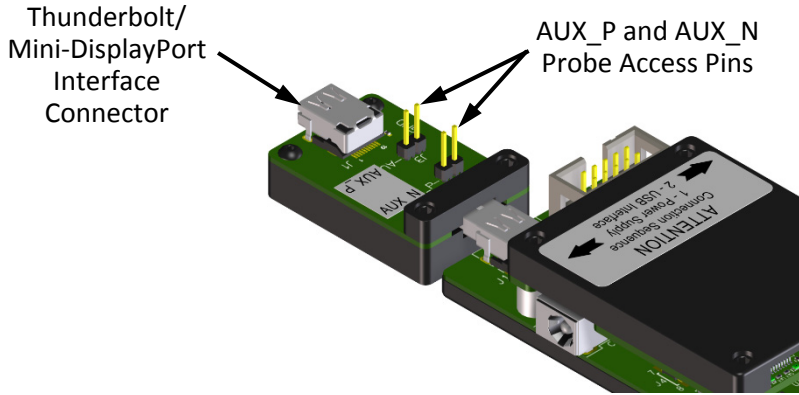


Figure 4. Aux Channel Probe Module (DisplayPort Testing)

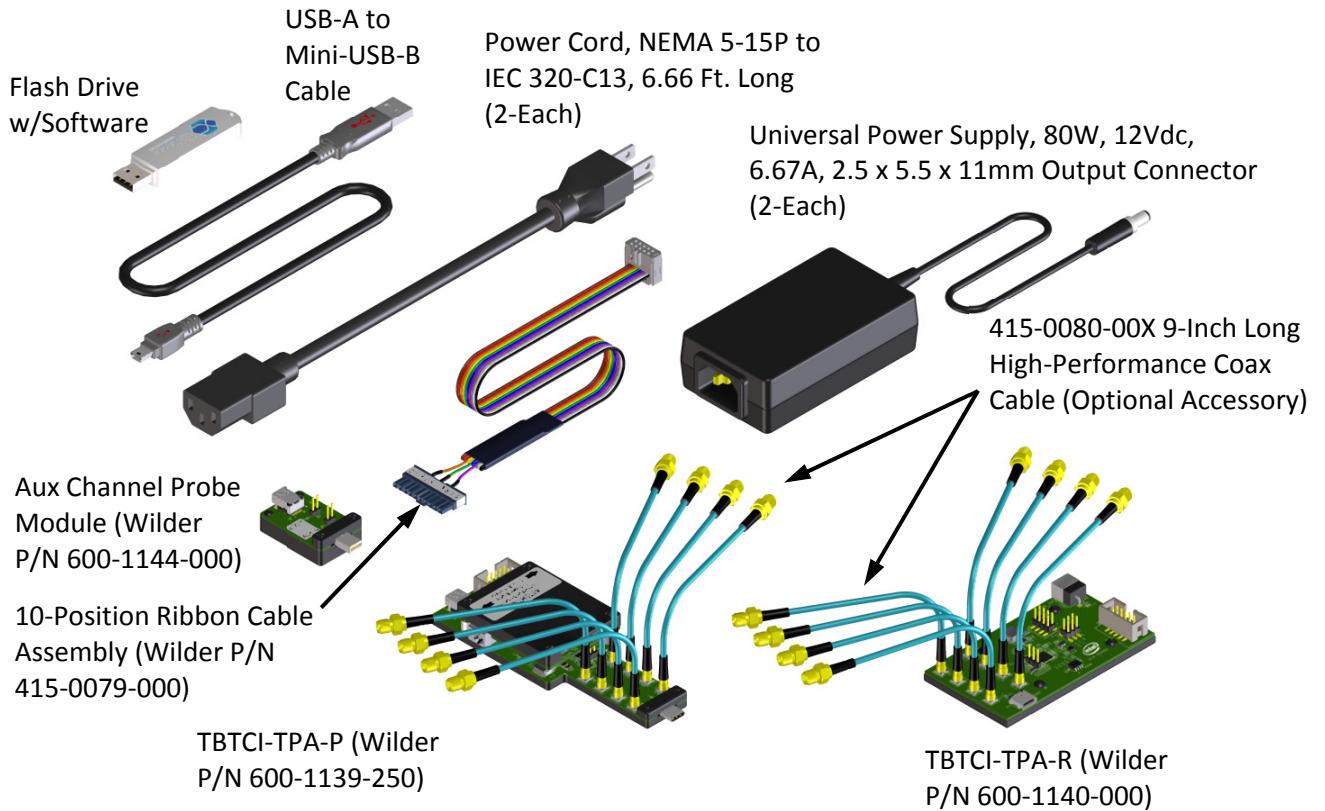


Figure 5. Reference Example of TBTCAM-TPA-PR

The illustration, shown above, is a reference example of the components included in the TBTCAM-TPA-PR product. The optional High-Performance Coaxial Cables shown are 9-inches in length and terminated with female SMP connectors at one end, and 2.92mm female connectors on the opposite end.

The 9-inch long coaxial cables are an optional accessory and are offered as a means to provide a more “mechanically-compliant” interface to test instrumentation than what traditional test instrument cables might provide, while maintaining excellent signal integrity.

Product Inspection

Upon receiving the TBTCAM-TPA from Wilder Technologies, perform the following product inspection:

- Inspect the outer shipping container, foam-lined instrument case, and product for damage. Retain the outer cardboard shipping container until the contents of the shipment have been inspected for completeness and the product has been checked mechanically and electrically. Use the foam-lined instrument-case for secure storage of the Wilder Technologies Type-C Multiple Alt Mode Test Adapter when not in use.
- Locate the shipping list and verify that all items ordered were received.
- In the unlikely event that the product is defective or incomplete, the “Limited Warranty” section discusses how to contact Wilder Technologies for technical assistance and/or how to package the product for return.

The Intel-Based Type-C Multiple Alt Mode Test Adapter Care and Handling Precautions

The Intel-Based Type-C Multiple Alt Mode Test Adapter requires careful handling to avoid damage. If the optional 9-inch long SMP to 2.92mm coaxial cables are to be used, the user should avoid using too small a cable bend radius which can damage the SMP connections mounted to the adapter or the cables themselves. This can occur at any point along the cable. To achieve optimum performance and to prolong the TBTCAM-TPA's life, observe the following handling precautions:

- **CAUTION 1: Avoid Torque Forces (Twisting)**
While individual coaxial cables (optional accessory cables or user-supplied instrument cables) connected to the test adapter have some rotational freedom, twisting the TBTCAM-TPA as a unit, with one end held stationary, may damage or severely degrade performance. Adherence to Caution 5 (below) helps to avoid twisting.
- **CAUTION 2: Avoid Sharp Cable Bends (Optional Accessory Cables or User-Supplied Instrument Cables)**
Never bend coaxial cables into a radius of 26 mm (1-inch) or less. Never bend cables greater than 90°. Single or multiple cable bends must be kept within this limit. Bending cables connected to the TBTCAM-TPA cables less than a 26mm (1-Inch) radius will permanently damage or severely degrade test adapter performance.
- **CAUTION 3: Avoid Cable Tension (Pull Forces on Optional Accessory Cables or User-Supplied Instrument Cables)**
Never apply tension (pull forces) to an individual coaxial cable that is greater than 2.3 kg (5 lbs.). To avoid applying tension, always place accessories and equipment on a surface that allows adjustment to eliminate tension on the TBTCAM-TPA and cables. Use adjustable elevation stands or apparatus to accurately place and support the TBTCAM-TPA.
- **CAUTION 4: Connect the TBTCAM-TPA First**
To prevent twisting, bending, or applying tension to the coaxial cables (Optional Accessory Cables or User-Supplied Instrument Cables) when connecting a TBTCAM-TPA, always attach the TBTCAM-TPA to the device under test (DUT) or cable under test before attaching any SMP connectors. Carefully align the TBTCAM connectors and then gently push the connectors together until fully seated.

If the TBTCAM-TPA must be turned or twisted to make connection to the DUT, avoid using the TBTCAM-TPA housing alone to make this occur. Try to distribute the torque forces along the length of the test setup and connected cabling. If this is not possible, it is recommended to first loosen or disconnect the connections at the TBTCAM-TPA or optional accessory cables. Make the connection to the DUT and then re-attach the test equipment leads.

NOTE: Only grip the test adapter housing when inserting or extracting the TBTCAM-TPA to or from the DUT. Pulling directly on the TBTCI-TPA cables or using them to insert the TBTCAM-TPA may cause damage.

- **CAUTION 5: Carefully Make 2.92mm Connections** (Optional 9-inch SMP to 2.92mm Cables)
To connect the TBTCAM-TPA 2.92mm connectors, follow these steps:

1. Hold the cable stationary by grasping the cable at the black heat-shrink section near the 2.92mm connector.
2. Insert the mating 2.92mm barrel and hand-tighten the free-spinning nut onto the connector while avoiding pulling, bending, or twisting the TBTCAM-TPA coaxial cable (if previously attached to the SMP connectors on the test adapter).
3. The TBTCAM-TPA optional 9-inch cable 2.92mm connectors have flats that accept an open-end 1/4-inch or 6.5mm wrench. When attaching instrument cables to the TBTCAM-TPA, it is recommended that the TBTCAM-TPA 2.92mm connectors be mechanically held and the test leads be tightened to the equipment manufacturer's torque recommendations, normally 5 in-lbs., using a 5/16-inch open-end wrench.

If the test set-up requires repositioning, first loosen or disconnect the 2.92mm connections to avoid twisting, bending, or tension.

NOTE: A drop in signal amplitude by half or 6dB during the testing of a channel may indicate that a cable has been mechanically pulled free of the SMP connections on the test adapter assembly. This could be determined by checking if the optional cable assembly has any play relative to the TPA. This would only occur when the TPA has exceeded the pull force as specified within the mechanical specification. If the cable cannot be re-seated, the test adapter or optional 9-inch accessory cable will need to be returned to the factory for service.

- **CAUTION 6: Independently Support Instrument Cables or Accessories**
Excessive weight from instrument cables and/or accessories connected to the TBTCAM-TPA can cause damage or affect the test adapter performance. Be sure to provide appropriate means to support and stabilize all test set-up components.

General Test Adapter, Cable, and Connector Care and Handling

Observing simple precautions can ensure accurate and reliable measurements.

Handling and Storage

Before each use of the TBTCAM-TPA, ensure that all connectors are clean. Handle all cables carefully and store the TBTCAM-TPA in the foam-lined instrument case when not in use, if possible. Do not set connectors contact-end down. Install the protective end caps onto the optional 9-inch coaxial cables (if used) 2.92mm ends when the TBTCAM-TPA is not in use.

Visual Inspection

Be sure to inspect all cables carefully before making a connection. Inspect all cables for metal particles, scratches, deformed threads, dents, or bent, broken, or misaligned center conductors. Do not use damaged cables. (Applies to the optional 9-inch cables and instrument cables.)

Cleaning

If necessary, clean the connectors using low-pressure (less than 60 PSI) compressed air or nitrogen with an effective oil-vapor filter and condensation trap. Clean the cable threads, if necessary, using a lint-free swab or cleaning cloth moistened with isopropyl alcohol. Always completely dry a connector before use. Do not use abrasives to clean the connectors. Re-inspect connectors, making sure no particles or residue remains.

Making Connections

Before making any connections, review the “Care and Handling Precautions” section. Follow these guidelines when making connections:

- Align cables (instrument or optional 9-inch coaxial) carefully
- Make preliminary connection lightly
- To tighten 2.92mm or SMA connectors, turn connector nut only
- Do not apply bending force to cables (instrument or optional 9-inch coaxial)
- Do not over-tighten preliminary connections
- Do not twist or screw-in cables
- Use an appropriately sized torque wrench (depends on the 2.92mm connector gender), and do not tighten past the “break” point of the torque wrench (normally set to 5 in-lbs.)

Electrostatic Discharge Information

Protection against electrostatic discharge (ESD) is essential while connecting, inspecting, or cleaning the TBTCAM-TPA test adapters and connectors attached to a static-sensitive circuit (such as those found in test sets).

Electrostatic discharge can damage or destroy electronic components. Be sure to perform all work on electronic assemblies at a static-safe work station, using two types of ESD protection:

- Conductive table-mat and wrist-strap combination
- Conductive floor-mat and heel-strap combination

When used together, both of these types provide a significant level of ESD protection. Used alone, the table-mat and wrist-strap combination provide adequate ESD protection. To ensure user safety, the static-safe accessories must provide at least 1 M Ω of isolation from ground. Acceptable ESD accessories may be purchased from a local supplier.

The TBTCAM Test Adapters should always be stored within the provided static-dissipative shield bag and sealed when not in use.

WARNING: These techniques for a static-safe work station should not be used when working on circuitry with a voltage potential greater than 500 volts.

Calibration Through De-Embedding

The Intel-Based Type-C Multiple Alt Mode Test Adapters are fully passive components. Therefore, calibration compensating for the losses must occur within the test instrumentation that drives the Thunderbolt/DisplayPort/USB Type-C receiver or looks at the response of the Thunderbolt/DisplayPort/USB Type-C transmitter.

The TBTCAM-TPA's have Touchstone S4P files for de-embedding the electrical length and losses within the TPA up to the USB Type-C connector interface pads. (Contact Wilder Technologies, support@wilder-tech.com, to obtain copies of the S4P files.) The Touchstone S4P files enable the test engineer to compensate for the following six repeatable, systematic errors that occur when moving the reference plane:

- Signal leakage effects: *Directivity errors*
- Signal leakage effects: *Crosstalk errors*
- Reflection effects: *Source Impedance Mismatching errors*
- Reflection effects: *Load Impedance Mismatching errors*
- Bandwidth effects: *Receiver Transmission in Test Equipment errors*
- Bandwidth effects: *Receiver Reflection-tracking in Test Equipment errors*

These errors are corrected on each port. Refer to the Instrument Manual for instructions on the instrument's specific de-embedding process.

NOTE: The reference plane is the boundary, both physically and electrically, between the calibrated and un-calibrated portions of the circuit. Everything outside the reference plane is considered part of the DUT. Any instrument that does not use calibration or de-embedding of the test fixture defines the DUT as the total of externally connected components. If the de-embedding file is not used, all of the TBTCAM-TPA and associated coaxial cables, as well as cables connecting the TPA assembly to the test instrument, would be a part of the DUT.

Non-repeatable errors, such as drift or random errors, can be reduced but not corrected. Drift errors aggregate over time or with environmental changes such as temperature shift. To eliminate drift errors, perform an instrumentation-level calibration.

A random error cannot be corrected through calibration since the error occurred randomly. Random errors are typically associated with either test instrument noise or test repeatability problems. Reduce test instrument noise by increasing source power, lowering the IF bandwidth, or averaging results over multiple sweeps. Reduce test repeatability problems through the use of a torque wrench or, again, by averaging over multiple sweeps.

Mechanical and Environmental Specifications

NOTE: All specifications in this manual are subject to change.

Table 1. General Specifications

| ITEM | DESCRIPTION |
|--|--|
| Usage Environment | Controlled indoor environment |
| Plug Test Adapter Length (w/o optional cables) | 127 mm +/- 2 mm (5.00 inches +/- .08 inches) (Characteristic) |
| Receptacle Test Adapter Length (w/o optional cables) | 89.4 mm +/- 2 mm (3.52 inches +/- .08 inches) (Characteristic) |
| Operating Temperature | 0°C to +55°C (32°F to +131°F) (Characteristic) |
| Storage Temperature | -40°C to +70°C (-40°F to +158°F) (Characteristic) |

TBTCAM-TPA-P Pinout

The TBTCAM-TPA-P test adapter provide 8 SMP connectors (access up to four lanes of differential TX and RX). Aux signals are accessed through a Thunderbolt/Mini-DisplayPort connector. LSTX and LSRX signals are accessed through one 10-position low-speed connector. A USB Mini-USB Type-B is provided for the PC User Interface. Connectors are identified by silkscreen. The following figure refers to pin-description tables for each of the connector types.

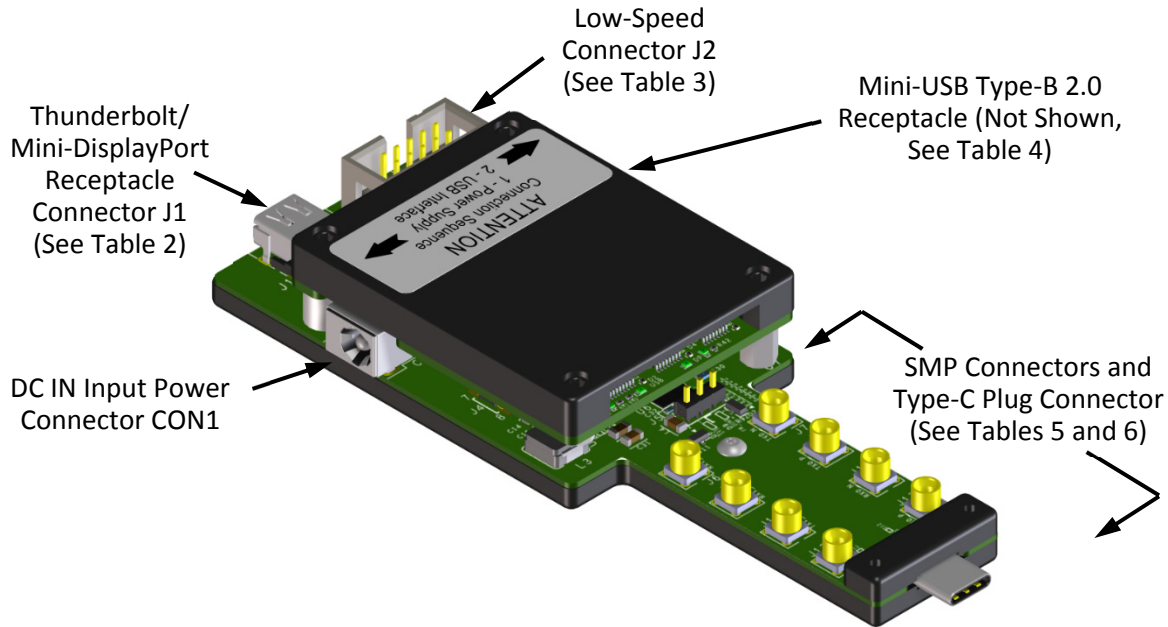


Figure 6. TBTCAM-TPA-P (Plug) Connectors

Table 2. Mini-DisplayPort Receptacle Connector (J1) Pin Assignments (DisplayPort Only)

| Pin Description | Connector Pin Number |
|------------------------|----------------------|
| Ground | 1 |
| Hot Plug Detect | 2 |
| ML Lane 0 (p) – Source | 3 |
| Config1 | 4 |
| ML Lane 0 (n) – Source | 5 |
| Config2 | 6 |
| Ground | 7 |
| Ground | 8 |
| ML Lane 1 (p) – Source | 9 |
| ML Lane 3 (p) – Source | 10 |
| ML Lane 1 (n) – Source | 11 |
| ML Lane 3 (n) – Source | 12 |
| Ground | 13 |
| Ground | 14 |
| ML Lane 2 (p) – Source | 15 |
| AUX CH (p) | 16 |
| ML Lane 2 (n) – Source | 17 |
| AUX CH (n) | 18 |
| Ground | 19 |
| DP_PWR | 20 |

Table 3. Low-Speed Connector (J2) Pin Assignments (Thunderbolt Only)

| Pin Description | Connector Pin Number(s) |
|-----------------|-------------------------|
| No Connect | 1, 2, 3, 5, 7, 9, 10 |
| LSRX | 4 |
| LSTX | 6 |
| Ground | 8 |

Table 4. Mini-USB Type-B 2.0 Receptacle Connector (Mezzanine J2) Pin Assignments (PC User Interface)

| Pin Description | Connector Pin Number(s) |
|-----------------|-------------------------|
| Vbus (5V) | 1 |
| D- | 2 |
| D+ | 3 |
| ID (No Connect) | 4 |
| Ground | 5 |

Table 5. High-Speed SMP Connectors (J6 through J12) Pin Assignments

| Pin Description | Connector Number |
|-----------------|------------------|
| RX1_N | J6 |
| TX0_N | J7 |
| RX1_P | J8 |
| TX0_P | J9 |
| TX1_N | J10 |
| RX0_N | J11 |
| TX1_P | J12 |
| RX0_P | J13 |

Table 6. USB Type-C Connector (Plug) Pin Assignments

| Pin Description | Connector Pin Number |
|---|----------------------|
| GND (Signal Ground) | A1 |
| TX0_P (USB SuperSpeed, Transmit 0 Positive) | A2 |
| TX0_N (USB SuperSpeed, Transmit 0 Negative) | A3 |
| VBUS (Bus Power) | A4 |
| CC1 (Configuration Channel 1) | A5 |
| USB2_P (USB 2.0 Differential Pair Positive) | A6 |
| USB2_N (USB 2.0 Differential Pair Negative) | A7 |
| SBU1 (Side Band Use 1) | A8 |
| VBUS (Bus Power) | A9 |
| RX1_N (USB SuperSpeed, Receive 1 Negative) | A10 |
| RX1_P (USB SuperSpeed, Receive 1 Positive) | A11 |
| GND (Signal Ground) | A12 |
| GND (Signal Ground) | B1 |
| TX1_P (USB SuperSpeed, Transmit 1 Positive) | B2 |
| TX1-N (USB SuperSpeed, Transmit 1 Negative) | B3 |
| VBUS (Bus Power) | B4 |
| CC2 (Configuration Channel 2) | B5 |
| USB2_P (USB 2.0 Differential Pair Positive) | B6 |
| USB2_N (USB 2.0 Differential Pair Negative) | B7 |
| SBU2 (Side Band Use 2) | B8 |
| VBUS (Bus Power) | B9 |
| RX0_N (USB SuperSpeed, Transmit 0 Negative) | B10 |
| RX0_P (USB SuperSpeed, Transmit 0 Positive) | B11 |
| GND (Signal Ground) | B12 |
| CGND (Signal Ground, Case/Shell) | G1, G2, G3, G4 |

TBTCI-TPA-R Cable Pinout

The TBTCI-TPA-R cables provide 8 SMP connectors (access up to four lanes of differential TX and RX), one 10-position low-speed connector where the LSTX and LSRX signals are accessed, and one Type-C receptacle connector. The receptacle test adapter also provides probing access to other signal types via probe pin connectors. Connectors are identified by silkscreen. The following figure refers to pin-description tables for each of the connector types.

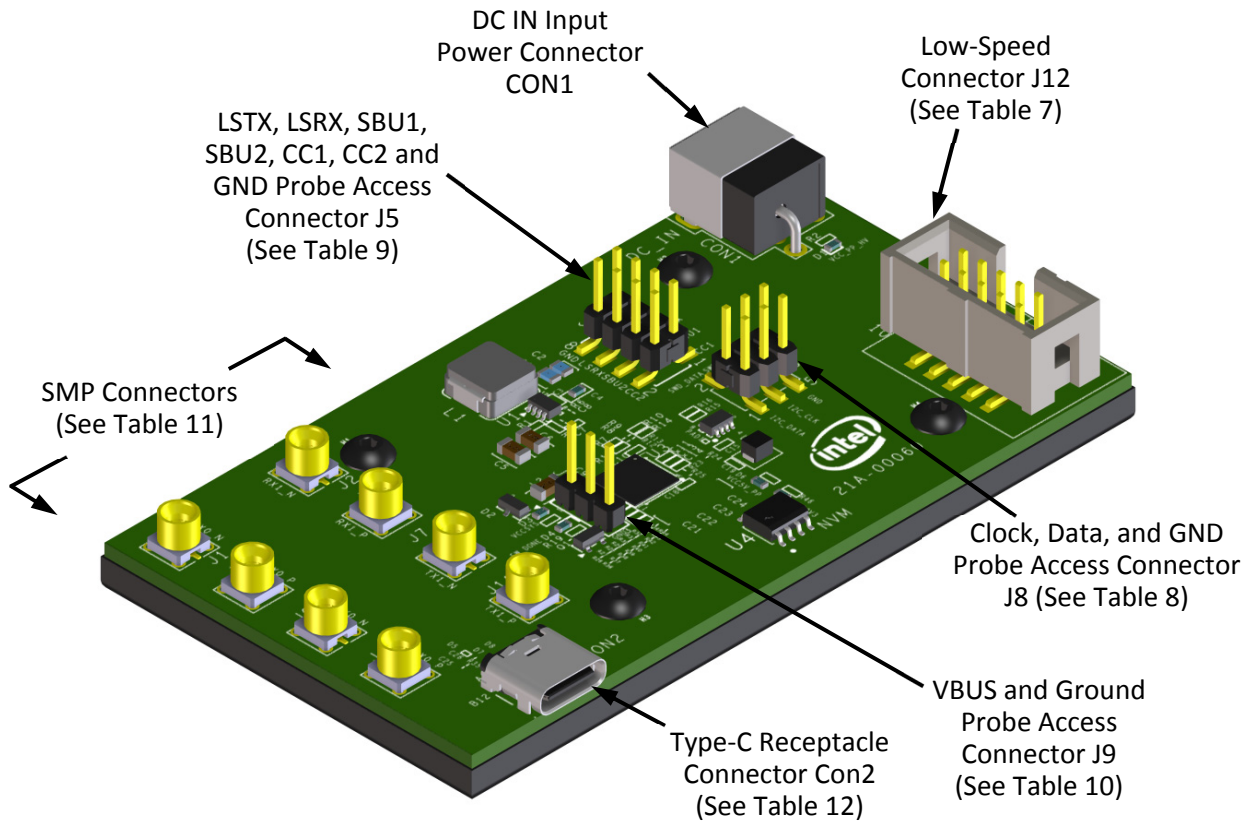


Figure 7. TBTCI-TPA-R (Receptacle) Cable Connectors

Table 7. Low-Speed Connector (J12) Pin Assignments (Thunderbolt Only)

| Pin Description | Connector Pin Number(s) |
|-----------------|-------------------------|
| No Connect | 1, 2, 3, 5, 7, 9, 10 |
| LSRX | 4 |
| LSTX | 6 |
| Ground | 8 |

Table 8. Clock, Data, and Ground Probe Access (J8) Pin Assignments

| Pin Description | Connector Pin Number |
|-----------------|----------------------|
| I2C_DATA | 1 |
| SWD_DATA | 2 |
| I2C_CLK | 3 |
| SWD_CLK | 4 |
| Ground | 5 |
| Ground | 6 |

Table 9. SBU*, LS*, CC* Probe Access Connector (J5) Pin Assignments

| Pin Description | Connector Pin Number |
|-----------------|----------------------|
| CC1 | 1 |
| CC2 | 2 |
| SBU1 | 3 |
| SBU2 | 4 |
| LSTX | 5 |
| LSRX | 6 |
| Ground | 7 |
| Ground | 8 |

Table 10. VBUS and Ground Probe Access Connector (J9) Pin Assignments

| Pin Description | Connector Pin Number(s) |
|-----------------|-------------------------|
| VBUS | 1 |
| No Connect | 2 |
| Ground | 3 |

Table 11. High-Speed SMP Connectors (J1, J2, J3, J4, J6, J7, J10, J11) Pin Assignments

| Pin Description | Connector Number |
|-----------------|------------------|
| TX0_N | J1 |
| RX1_N | J2 |
| TX0_P | J3 |
| RX1_P | J4 |
| RX0_N | J6 |
| TX1_N | J7 |
| RX0_P | J10 |
| TX1_P | J11 |

Table 12. USB Type-C Connector (Receptacle) Pin Assignments

| Pin Description | Connector Pin Number |
|---|----------------------|
| GND (Signal Ground) | A1 |
| TX0_P (USB SuperSpeed, Transmit 0 Positive) | A2 |
| TX0_N (USB SuperSpeed, Transmit 0 Negative) | A3 |
| VBUS (Bus Power) | A4 |
| CC1 (Configuration Channel 1) | A5 |
| USB2_P (USB 2.0 Differential Pair Positive) | A6 |
| USB2_N (USB 2.0 Differential Pair Negative) | A7 |
| SBU1 (Side Band Use 1) | A8 |
| VBUS (Bus Power) | A9 |
| RX1_N (USB SuperSpeed, Receive 1 Negative) | A10 |
| RX1_P (USB SuperSpeed, Receive 1 Positive) | A11 |
| GND (Signal Ground) | A12 |
| GND (Signal Ground) | B1 |
| TX1_P (USB SuperSpeed, Transmit 1 Positive) | B2 |
| TX1-N (USB SuperSpeed, Transmit 1 Negative) | B3 |
| VBUS (Bus Power) | B4 |
| CC2 (Configuration Channel 2) | B5 |
| USB2_P (USB 2.0 Differential Pair Positive) | B6 |
| USB2_N (USB 2.0 Differential Pair Negative) | B7 |
| SBU2 (Side Band Use 2) | B8 |
| VBUS (Bus Power) | B9 |
| RX0_N (USB SuperSpeed, Transmit 0 Negative) | B10 |
| RX0_P (USB SuperSpeed, Transmit 0 Positive) | B11 |
| GND (Signal Ground) | B12 |
| CGND (Signal Ground, Case/Shell) | G1, G2, G3, G4 |

Electrical Specifications

NOTE: All specifications in this manual are subject to change.

Table 13. Electrical Specifications

| SPECIFICATION | MINIMUM | TYPICAL | MAXIMUM | NOTES |
|---|---------|---------|---------|---|
| TX and RX Differential Pair Insertion Loss (GHz) at -3 dB | | 8.4 | | TX0 and RX1 Differential Pairs, Mated Plug and Receptacle TPAs with Connectors and Pads. |
| TX and RX Differential Pair Insertion Loss (GHz) at -3 dB | | 10.5 | | TX1 and RX0 Differential Pairs, Mated Plug and Receptacle TPAs with Connectors and Pads. |
| TX and RX Differential Pair Return Loss (GHz) at -10 dB | | 10.7 | | All TX and RX Differential Pairs, Mated Plug and Receptacle TPAs with Connectors and Pads. |
| Differential Impedance (ohms), 50 ps Rise Time, 10 – 90 percent | >82 | | <88 | All Differential Pairs (High-Speed Only), Receptacle and Plug, excluding the USB Type-C connector. |
| Single-Ended Impedance (ohms), 50 ps Rise Time, 10 – 90 percent | >47.5 | | <52.5 | All Single-Ended Conductors (High-Speed Only), Receptacle and Plug, excluding USB Type-C connector. |
| Current Carrying (A) Per Pin | | | 1.25 | +5V Power (Nominal). |

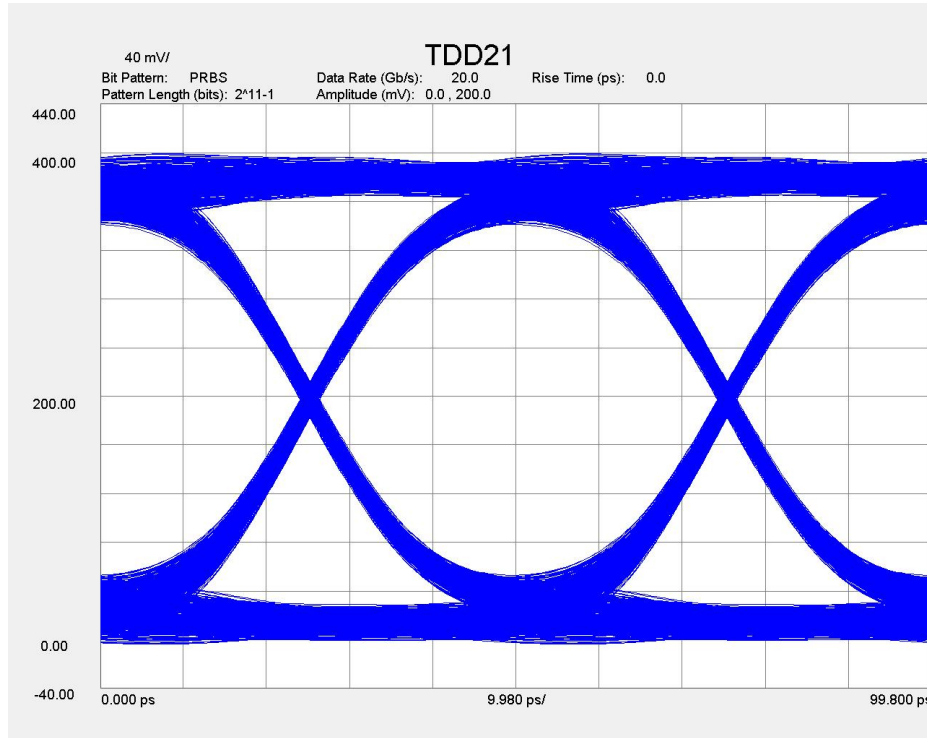


Figure 8. Typical mated pair 20 Gb/s eye diagram.

Parameter Measurement Result

| Name | Result |
|--------------------------|----------|
| Eye Level Zero (mV): | 26.4781 |
| Eye Level One (mV): | 366.6134 |
| Eye Level Mean (mV): | 196.5457 |
| Eye Amplitude (mV): | 340.1353 |
| Eye Height (mV): | 258.8686 |
| Eye Height (dB): | -3.7796 |
| Eye Width: | 46.3740 |
| Eye Opening Factor: | 0.7611 |
| Eye Signal to Noise: | 12.5563 |
| Eye Duty Cycle Dist: | 0.0602 |
| Eye Duty Cycle Dist (%): | 0.1205 |
| Eye Rise Time (10-90): | 30.1177 |
| Eye Fall Time (10-90): | 30.1228 |
| Eye Jitter (PP): | 2.7645 |
| Eye Jitter (RMS): | 0.6101 |

Figure 9. Typical mated pair 20 Gb/s eye data.

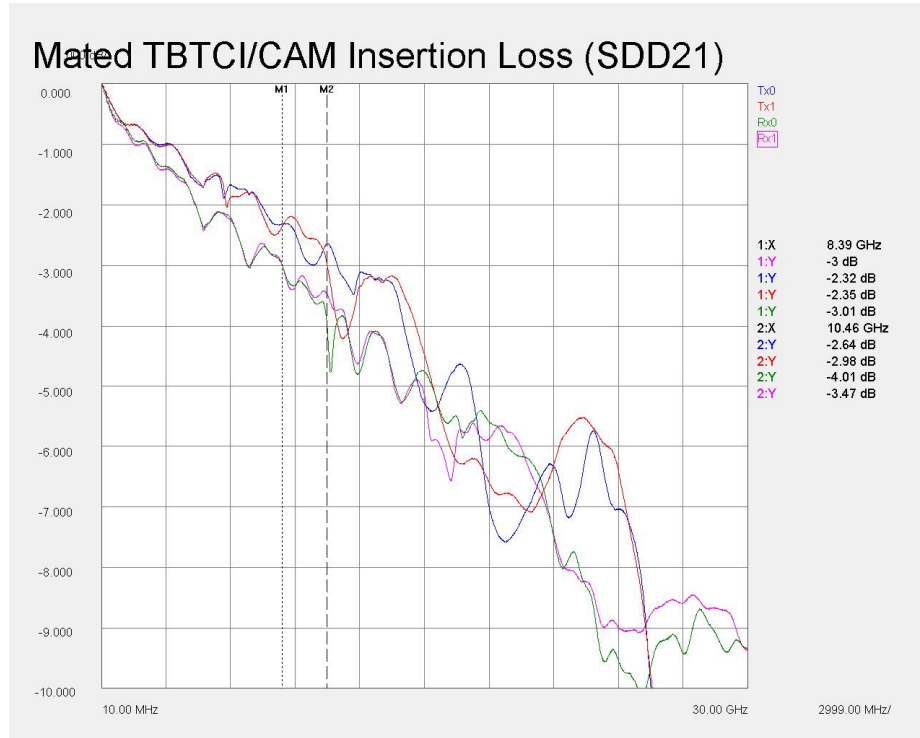


Figure 10. All TX and RX differential mated pairs, balanced insertion loss.

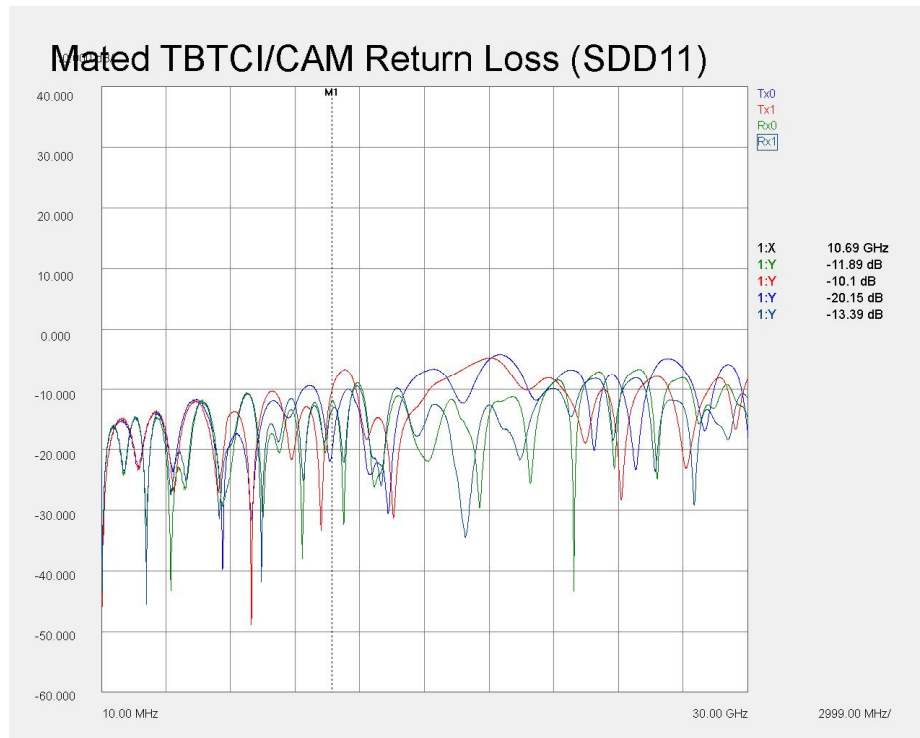


Figure 11. All TX and RX differential mated pairs, balanced return loss.

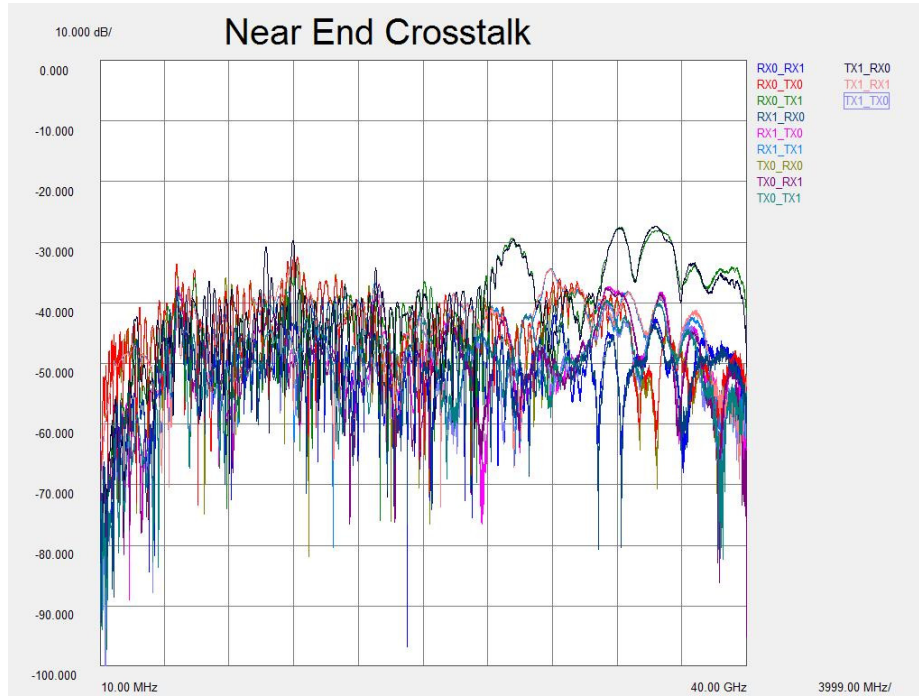


Figure 12. Typical Differential NEXT, with mated Plug and Receptacle TPAs, adjacent differential pairs, all differential pairs terminated at both ends. (Excludes SBU channel.)

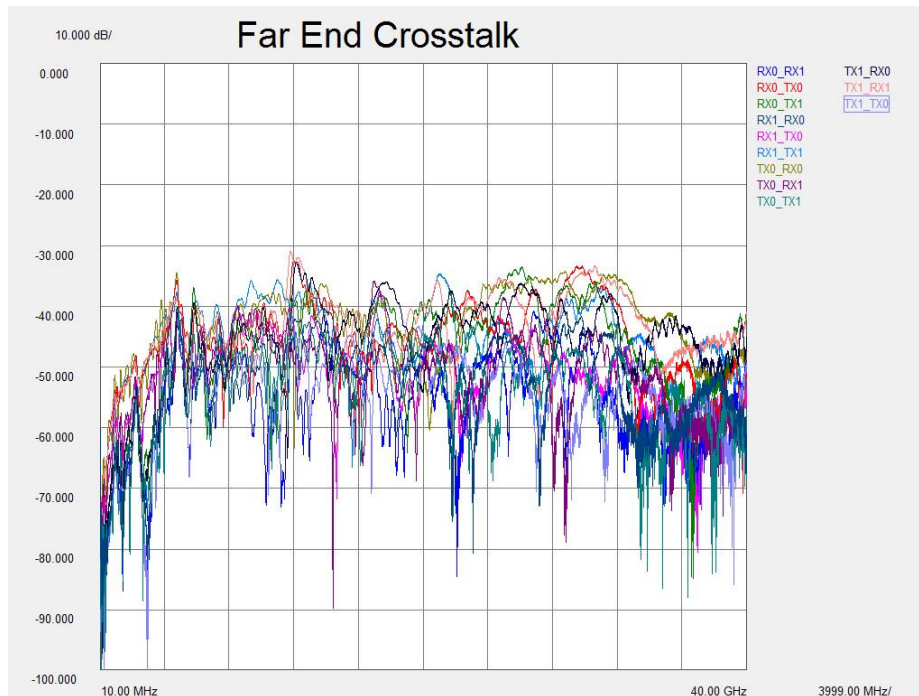


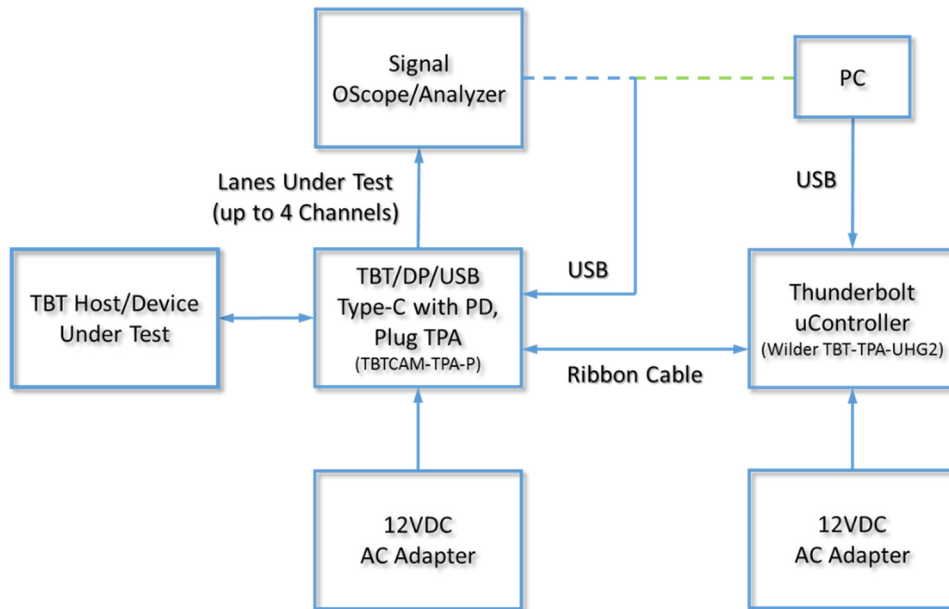
Figure 13. Typical Differential FEXT, with mated Plug and Receptacle TPAs, adjacent differential pairs, both transmit and receive terminated at both ends. (Excludes SBU channel.)

User Models

The Intel-Based Type-C Multiple Alt Mode TPA is capable of performing within the scope of measurements contained in the associated CTS PHYs, limited only by the specifications, environmental, care and handling as stated in this document.

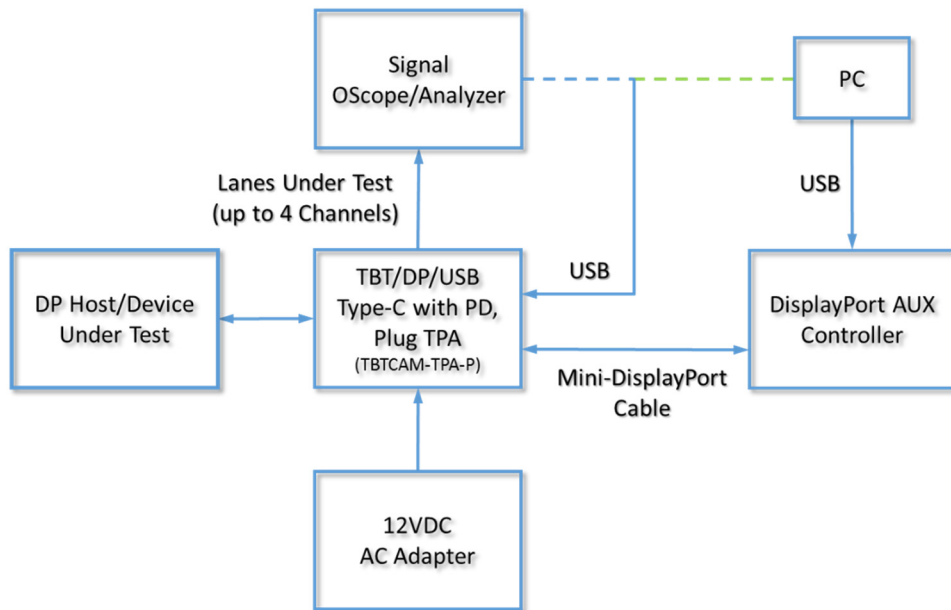
The following examples are suggestions and/or references for possible testing setups.

This first example illustrates a Thunderbolt Type-C Host/Device test using an Intel-Based Type-C Multiple Alt Mode Plug TPA connected to Thunderbolt Gen 2 Microcontroller, connected to a USB Power Delivery Controller.

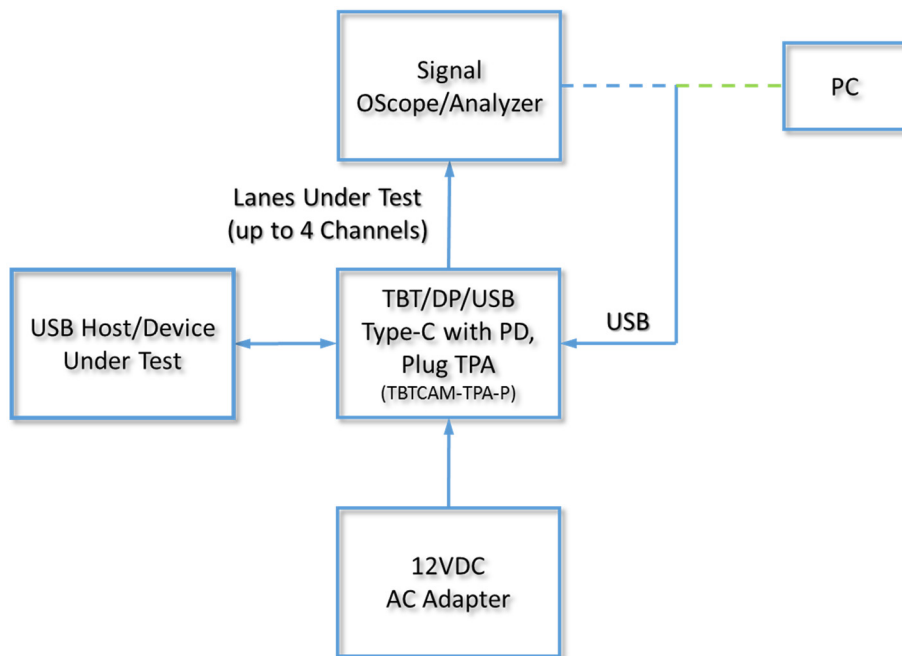


TBTCAM (Type-C Multiple Alt. Mode) Test Adapter User Manual (Intel Based)

This second example illustrates a DisplayPort Type-C Host/Device test using an Intel-Based Type-C Multiple Alt Mode Plug TPA connected to a DisplayPort AUX Controller and a Signal Oscilloscope/Analyzer.

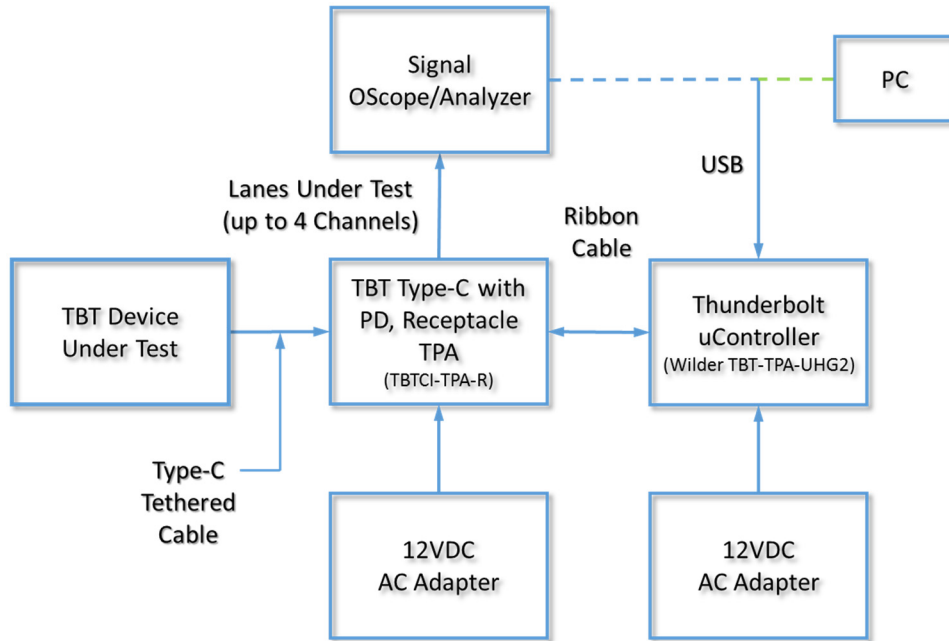


This third example illustrates a USB Type-C Host/Device test using an Intel-Based Type-C Multiple Alt Mode Plug TPA connected to a Signal Oscilloscope/Analyzer.

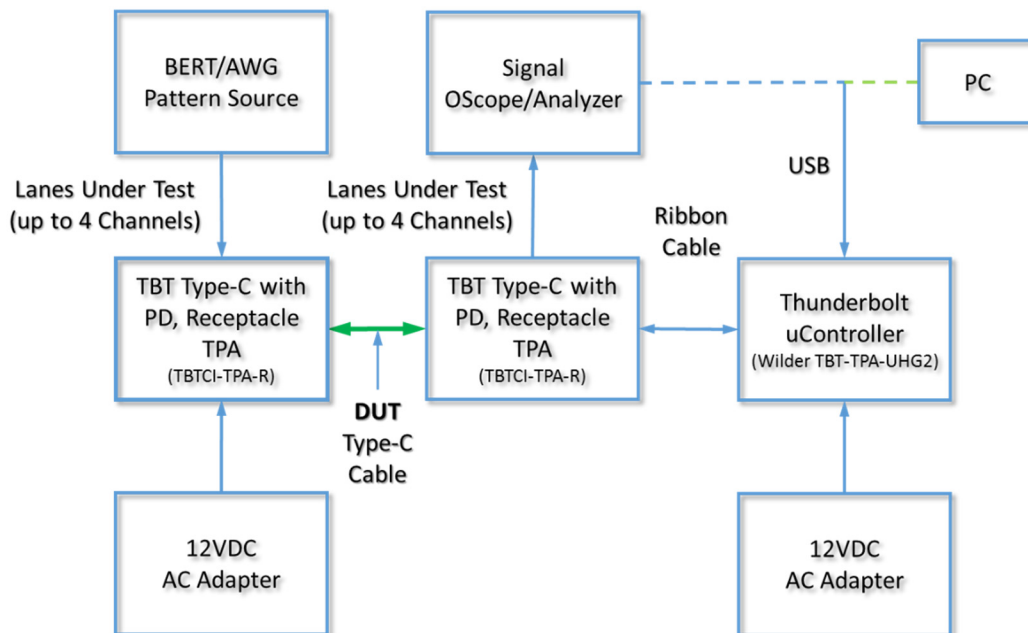


TBTCAM (Type-C Multiple Alt. Mode) Test Adapter User Manual (Intel Based)

This fourth example illustrates a Thunderbolt Type-C Device test using an Intel-Based Type-C Receptacle TPA connected to a Thunderbolt Gen 2 Microcontroller, connected to a Signal Oscilloscope/Analyzer.



This fifth example illustrates a Thunderbolt Type-C Cable test using two Intel-Based Type-C Receptacle TPAs connected to a Thunderbolt Gen 2 Microcontroller, connected to a BERTS/AWG Pattern Source and a Signal Oscilloscope/Analyzer.



TBTCAM User Interface Software

Introduction

The included User Interface (UI) and Application Program Interface (API) Software (SW) runs on a PC and operates the Wilder Technologies TBTCAM Plug Assembly via a USB connection from a PC. The UI provides Screens that allow interaction with the TBTCAM Plug Hardware. The SW will run on most PCs with Windows 7, 8, and 10. A powered USB port is required.

The UI make calls to an API which directly operates the Hardware. The API is provided in a DLL file. Its calls are separately documented in this document.

This Manual is for UI Software Version 1.10, API Version 1.10 and Firmware Version 1.09. The Firmware is Field Upgradable.

TBTCAM LED Status Indicators

The TBTCAM LED Status Indicators can be viewed through the rectangular opening on the upper mezzanine board assembly.

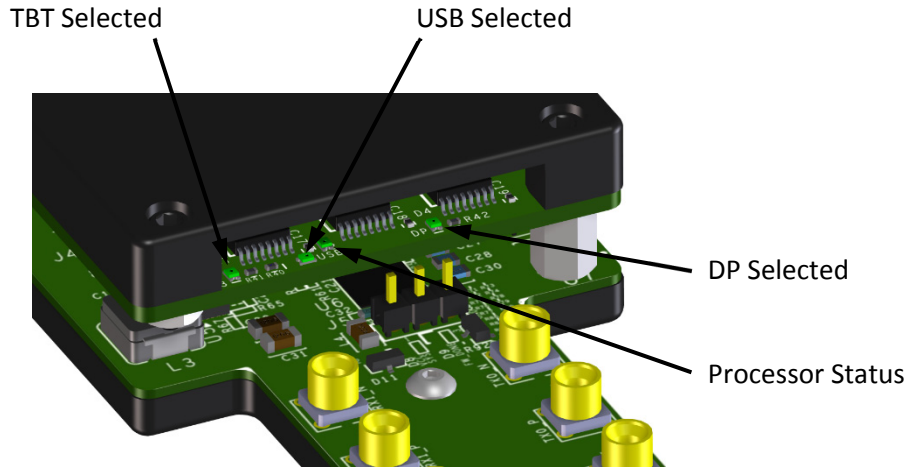


Figure 21. TBTCAM-TPA-P LED Status Indicators

| LED Indicator | Reference Designator | LED States |
|------------------|----------------------|---|
| Processor Status | D1 | Blinks when processor is running |
| USB | D2 | On when USB configuration is selected |
| TBT | D3 | On when Thunderbolt configuration is selected |
| DP | D4 | On when DisplayPort configuration is selected |

TBTCAM Supported USB Type-C Functions

The TBTCAM can be selected to operate in one of three different Modes. The Modes are implemented by the TI Type-C controller configuration ROMs.

| Mode (Alt-Mode) | Data Role | Power Role | CC Current Advertised Power | PD Message Advertised Power |
|-----------------|-----------|------------|-----------------------------|-----------------------------|
| USB Native | DFP | Source | 5V @ 3A | 5V @ 3A |
| Thunderbolt | DFP | Source | 5V @ 3A | 5V @ 3A; 12V @ 3A |
| DisplayPort | UFP | Sink | | |

The TBTCAM Type-C controller has two selectable Data Roles:

| DUT Type | Result |
|---------------|--|
| Device / Sink | Type-C Controller is Enabled and its Data Role is as configured by the Configuration ROM. |
| Host / Source | Type-C Controller is Turned Off. It does not act as a Host or Device. However certain Hosts can be Lane Flipped (see below). |

The TBTCAM can Lane Flip the Super Speed Lanes in certain configurations:

| TBTCAM Mode (Alt-Mode) | Lane Flip Capability |
|------------------------|------------------------------------|
| USB Native | Host or Device can be Lane Flipped |
| Thunderbolt | Host or Device can be Lane Flipped |
| DisplayPort | Host only can be Lane Flipped |

The TBTCAM must be connected directly to the Type-C DUT.

One of three Port Lane Flip Configurations may be selected:

| Port Configuration | CC State at the TBTCAM Type-C Plug | SS Lane |
|------------------------|--|---------|
| Disconnected | CC1 and CC2 are disconnected | |
| Upside-Up (Un-Flipped) | CC1 is connected and CC2 is disconnected | 0 |
| Upside-Down (Flipped) | CC2 is connected and CC1 is disconnected | 1 |

The connected CC1 line creates a path for current to be supplied to the DUT which then should Flip or Un-Flip. Note that because the TBTCAM can be connected to the DUT physically, Flipped or Un-Flipped, the Configurations in the table may also be Flipped.

All selections are made via the API or User Interface Software.

TBTCAM Software File List

These files are included in the Flash Drive.

| | |
|-----------------------------|---|
| Wilder_TBTCAM.exe | The Wilder TBTCAM UI Executable |
| Wilder_Type_C_Cap_A_API.dll | The Wilder TBTCAM API Dynamic Link Library |
| 910-0051-000 Rev B.pdf | TBTCAM Type-C Multiple Alt Mode User Manual |

Installation

The SW will run on Windows 7, 8, and 10. Microsoft .NET Version 4.5 or greater is required. Some Windows 7 computers do not have this version. It may be downloaded from the Microsoft web site. If .NET is earlier than 4.5 there may be a message reporting that .NET is too old or an Error Message that includes the text "IAsyncState".

Copy the software distribution files to a folder on the PC from which the TBTCAM UI Software and API DLL will be run. The .exe and .dll files should remain in this folder, but all other files can be moved.

Run the `Wilder_TBTCAM.exe` program. The start screen should report that its version is **1.10** or later. The Log Box should report that the API version is **1.10** or later.

TBTCAM UI PC Program Operation

The UI Screen comes up when `Wilder_TBTCAM.exe` is run. Version information and several buttons will appear. Information, Status and Errors will appear in the Log Box. Errors are listed under each UI function description. Status and Errors are more thoroughly described in the API section.

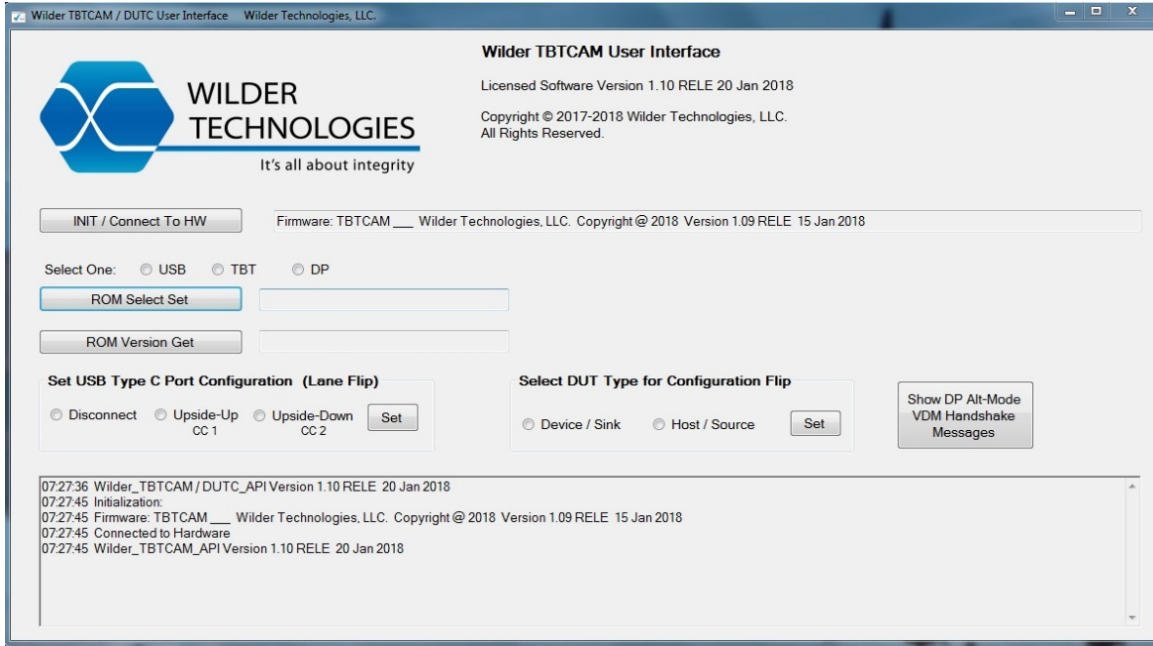


Figure 22. TBTCAM UI Screen

TBTCAM UI / API Connection to TBTCAM Hardware

To operate both the UI and Hardware (HW) together, the UI SW (via the API) must connect to the TBTCAM Hardware.

- Connect the HW to the 12 Volt power supply. This must be done first.
- Connect the HW to a PC Powered USB Port.
- Select the [INIT / Connect to HW] Button on the UI Screen. (The API `Init()` is called.)
- If successful, the Text Box to the right of the Connect Button updates to indicate connection to the HW and reports the Firmware Version. Verify that the version text is similar to:

```
"Firmware: TBTCAM __ Wilder Technologies, LLC.
Copyright © 2018 Version 1.09 RELE 15 Jan 2018"
```

The USB Configuration ROM is select by default when the TBTCAM HW is powered up.

These errors may be reported:

| | |
|----------------------|---|
| HANDLE_NOT_OBTAINED | The TBTCAM HW is not connected to the PC |
| NO_HID_DEVICES_FOUND | The USB HID driver is not installed on the PC |

If the UI Software session is exited the TBTCAM Hardware will retain its state.

TBTCAM TI Type-C Configuration ROM Select

The UI ROM is selected by Default when the TBTCAM HW is powered up.

To change the ROM (and therefore the Type-C Controller configuration):

Select one of the Radio Buttons [USB], [TBT], or [DP]

Select the [ROM Select Set] Button.

The selected ROM will be connected to the Type-C Controller and the Controller will be rebooted. This may take up to 500ms.

The API `ROM_Select_Set ()` is called.

These errors may be reported:

| | |
|----------------------|--|
| INIT_FAILURE | Initialization/Connection not performed or failed |
| TBTCAM_POWER_MISSING | The 12 Volt Power is not connected |
| TBTCAM_I2C_FAILURE | The two TBTCAM circuit boards may be separated |
| TBTCAM_ROM_INVALID | The Configuration ROM is missing or has a Bad Checksum |

Select the [ROM Version Get] Button to obtain the version of the Configuration ROM.

Set USB Type-C Port Configuration (Lane Flip)

To change the Type-C Port Configuration (and Lane Flip) select one of the Radio Buttons [Disconnect], [Upside-Up], or [Upside-Down]

Select the [Set] Button.

The state of the CC lines is changed.

The API `USB_Port_Config_Set ()` is called.

These errors may be reported:

| | |
|----------------------|---|
| INIT_FAILURE | Initialization/Connection not performed or failed |
| TBTCAM_POWER_MISSING | The 12 Volt Power is not connected |
| TBTCAM_I2C_FAILURE | The two TBTCAM circuit boards may be separated |

Select DUT Type for Configuration Flip

To choose the DUT Type for Configuration Flip, select one of the Radio Buttons [Device / Sink], or [Host / Source].

Select the [Set] Button.

The Type-C Controller is Enabled with the selected Configuration ROM or Disabled.

The API `USB_Data_Role_Set ()` is called.

These errors may be reported:

| | |
|----------------------|---|
| INIT_FAILURE | Initialization/Connection not performed or failed |
| TBTCAM_POWER_MISSING | The 12 Volt Power is not connected |
| TBTCAM_I2C_FAILURE | The two TBTCAM circuit boards may be separated |

DisplayPort Handshake Messages

To see the content of a few DisplayPort Alt-Mode VDM handshake messages select the [Show DP Alt-Mode VDM Handshake Messages] Button.

The following is displayed on the Log Box:

DP Alt Mode VDM Handshake Message Content:

DP Status Tx: No Connection
DP Status Rx: No Connection
DP Status Tx: 0x0000 (Outgoing DP Status Message)
DP Status Rx: 0x0000 (Most Recent DP Status Message Received)
DP Configure: 0x0000 (DP Configure Message)
DP Discover: 0x0000 (DP Discovered Capabilities)

The content is only valid after a DP Alt-Mode handshake has started and it may change as the handshake is completed or failed.

The content is decoded in “VESA DisplayPort Alt Mode on USB Type-C Standard” Version 1.0b.

`u_DP_Status_Tx`: Current Outgoing DP Status message contents (Table 5-3)

`u_DP_Status_Rx`: Most recently received DP Status message contents (Table 5-3)

`u_DP_Configure`: DP Configure message when sent (DFP_U) or received (UFP_U) (Table 5-5)

`u_DP_Discover`: DP Discover Mode response when received (DFP_U) or sent (UFP_U) (Table 5-2)

The API `DP_Selected_Messages_Request ()` is called.

TBTCAM Application Program Interface (API)

The API (for Version 1.09 Release) is in a single Object coded in C# using .NET. It is provided as a Windows DLL file. The functions in the API communicate with the TBTCAM Firmware and Hardware via USB. The USB functionality and High Level Driver are inside the DLL. Windows will install a basic Human Interface Device (HUD) Driver.

| | |
|-----------------|-----------------------------|
| File Name | Wilder_Type_C_Cap_A_API.dll |
| namespace | Wilder_Type_C_Cap_A_API |
| class | Wilder_Type_C_Cap_A_API |
| Windows Version | 7, 8, 10 |
| .NET Version | 4.5 or later |

To access the object and its public members, add a reference to the DLL and put this in the source code:

```
using WTAA = Wilder_Type_C_Cap_A_API.Wilder_Type_C_Cap_A_API;
```

Then create an object instance:

```
WTAA t_WTAA = new WTAA();
```

The Functions prefixed with `async` must be called with `await`. For example:

```
WTAA.WTA_Result t_WTA_Result = await t_WTAA.Init();
```

Most Functions return `WTAA.WTA_Result`. These are enumerated on the following page.

TBTCAM API Result Code Enumeration

```
public enum WTA_Result
```

| | | |
|---------------------------|---|---|
| Good | 0 | The API call has completed successfully. |
| INIT_FAILURE | 1 | The API function was called before <code>Init()</code> was called or <code>Init()</code> was not able to connect to the Hardware. |
| SETTING_INVALID | 2 | Setting or Other API parameter have invalid values or not recognized. |
| HW_CONNECTION_FAILURE | 3 | <code>Init()</code> was unable to connect the PC USB to the TBTCAM HW. The most common cause is a disconnected USB cable. |
| RETURN_PACKET_FAILURE | 4 | The API function contacted the TBTCAM HW but did not get a return. May be caused by USB cable disconnected after a successful <code>Init()</code> . |
| TBTCAM_ROM_SELECT_FAILURE | 5 | The ROM Selection Multiplexors on the Mezzanine are not operating correctly. This is a HW Fault. |
| TBTCAM_POWER_MISSING | 6 | The TBTCAM has no Power. It is powered via CON1 / DC IN. (The processor is powered from USB). |
| TBTCAM_I2C_FAILURE | 7 | I2C communication between the Mezzanine and the TBTCAM is not operating. May be caused by improper connection between the Mezzanine Board and the TBTCAM Board. Otherwise it is a HW Fault. |
| TBTCAM_ROM_INVALID | 8 | The ROM attached to the TI Controller was determined by the TI USB PD Controller to be missing, inaccessible or has Invalid content. Recovery requires a Valid ROM to be selected followed by Power Cycle on the TBTCAM Board. |

TBTCAM API Function Calls

```
public async Task<WTA_Result> Init();
```

Initializes the API and Connects the PC to the TBTCAM HW. The Connection (and operation) is via USB from the PC to the micro-controller on the TBTCAM. This *must* be called before any other function is called. The Firmware and API Version text strings can be acquired. See below.

```
public void Disconnect();
```

Disconnects The USB. Ends the API session.

```
public string Firmware_Version_Get();
```

Returns the Version string of the Firmware on the TBTCAM Firmware.

```
public string API_Version_Get();
```

Returns the Version string of the API/DLL itself.

```
public async Task<WTA_Result> TI_Version_Request()
```

```
public string TI_Version_Get();
```

Request and then Get the TI USB PD Controller Binary Coded Decimal version number, bootloader/application code version. Represented as VVVV.MM.RR with leading 0's removed. See Texas Instruments SLVUAN1 (July 2016) page 7, Register 0x0F.

ROM Select API Function Calls

```
public enum WTA_ROM_Select_Setting
```

| | | |
|---------|---|--|
| Unknown | 0 | Used only by ROM_Select_Get() |
| USB | 1 | Select the USB Configuration ROM |
| TBT | 2 | Select the Thunderbolt Configuration ROM |
| DP | 3 | Select the DisplayPort Configuration ROM |

```
public async Task<WTA_Result>
    ROM_Select_Set(WTA_ROM_Select_Setting t_WTA_Setting);
```

Selects a Configuration ROM
 The TBTCAM Power is Checked.
 The specified Configuration ROM is connected to the TI controller.
 The TI controller is Reset. This may take 500 milliseconds.
 After a ROM is selected the CC1 is connected and the CC2 is disconnected so that an Upside-Up Type-C connection can be made. (See the Lane Flip explanation below.)

```
public async Task<WTA_ROM_Select_Setting> ROM_Select_Get();
```

Returns the Current Configuration Setting. The TBTCAM HW is queried for this information.

USB Type-C Device and Host Lane Flip Operation in USB Mode (USB ROM).

USB Type-C Port Role API Function Calls.

```
public enum WTA_USB_Data_Role_Setting
```

| | | |
|---------------|---|---|
| As_Configured | 1 | Set TBTCAM to use the TI Controller as Configured by the Configuration ROM. If the TI is configured as a Host and the DUT is a Device OR if the TI is configured as a Device and the DUT is a Host, then the Lanes can be Flipped. (This the default operation of the TBTCAM for the selected ROM.) |
| DISABLED | 3 | Set TBTCAM to Disable the TI. This is used when the TI Controller ROM configures as a Host. A Host DUT may then be Connected and Lane Flipped. |

```
public async Task<WTA_Result> USB_Data_Role_Set
(WTA_USB_Data_Role_Setting e_Data_Role_Setting)
```

Set the TI Controller Data Role so that USB_Port_Config_Set can be used to Lane Flip a Device or a Host.

USB Type-C Port Connection Configuration API Function Calls.

```
Public enum WTA_USB_Config_Setting
```

| | | |
|-------------|---|---|
| Unknown | 0 | used only by USB_Port_Config_Sense() |
| DISCONNECT | 1 | Set Port Disconnected (CC1 and CC2 open) |
| UPSIDE_UP | 2 | Set Port Connected Upside-up (CC1 pulled to Gnd via 5.1K; CC2 open) |
| UPSIDE_DOWN | 3 | Set Port Connected Upside-down (CC2 pulled to Gnd via 5.1K; CC1 open) |

```
public async Task<WTA_Result>
    USB_Port_Config_Set(WTA_USB_Config_Setting e_Config_Setting);
```

Set the USB Type-C Port Connection Configuration

USB_Data_Role_Set() must be called before this function is called.

DisplayPort Alt-Mode VDM Handshake Messages

```
public async Task<WTA_Result> DP_Handshake_Messages_Request ()  
  
public string DP_Selected_Messages_Get(  
    out UInt32 u_DP_Status_Tx_Out, out UInt32 u_DP_Status_Rx_Out,  
    out UInt32 u_DP_Configure_Out, out UInt32 u_DP_Discover );
```

Request and then Get the Content of some VDM Handshake Messages exchanged during a DisplayPort Alt-Mode handshake. The content is only valid after a DP Alt-Mode handshake has started and it may change as the handshake is completed or failed.

The content is decoded in “VESA DisplayPort Alt Mode on USB Type-C Standard” Version 1.0b.

u_DP_Status_Tx: Current Outgoing DP Status message contents (Table 5-3)

u_DP_Status_Rx: Most recently received DP Status message contents (Table 5-3)

u_DP_Configure: DP Configure message when sent (DFP_U) or received (UFP_U) (Table 5-5)

u_DP_Discover: DP Discover Mode response when received (DFP_U) or sent (UFP_U) (Table 5-2)

Wilder Technologies, LLC – Limited Warranty

Wilder Technologies, LLC warrants that each Test Adapter, 1) is free from defects in materials and workmanship and, 2) conforms to Wilder Technologies specifications for a period of 12 months, with the exceptions of the HDMI A2 (HDMI v2.0), HDMI D2 (HDMI v2.0), SFP28, QSFP28, DPC, USBC, TBTCI, and TBTCAM Test Adapters, whereby are warranted for a period of 6 months, all other aspects of the Wilder Technologies, LLC warranty apply.

See Consumable and Fragile Material Warranty for exceptions to the 6 and 12-month warranty

The warranty period for a Test Adapter is a specified, fixed period commencing on the date of ship from Wilder Technologies, LLC. If you did not purchase your Test Adapter directly from Wilder Technologies, LLC, the serial number and a valid proof of purchase will be required to establish your purchase date. If you do not have a valid proof of purchase, the warranty period will be measured from the date of ship from Wilder Technologies, LLC.

If, during the warranty period, the Test Adapter is not in good working order, Wilder Technologies, LLC will, at its option, repair or replace it at no additional charge, except as is set forth below. In some cases, the replacement Test Adapter may not be new and may have been previously installed. Regardless of the Test Adapter's production status, Wilder Technologies, LLC appropriate warranty terms apply.

Consumable and Fragile Material Warranty

Wilder Technologies, LLC warrants that consumable materials and all fragile materials supplied by Wilder Technologies, LLC either as part of an instrument or system, or supplied separately, will be free from defects in material and workmanship at the time of shipment.

Extent of Warranty

The warranty does not cover the repair or exchange of a Test Adapter resulting from misuse, accident, modification, unsuitable physical or operating environment, improper maintenance by you, or failure caused by a product for which Wilder Technologies, LLC is not responsible. The warranty is voided by removal or alteration of Test Adapter or parts identification labels. The initial three months are unconditional; the remaining months excludes plugs, receptacles, SMA and 2.92mm connectors. Connectors are wear items and excluded from the warranty after the initial three months.

These warranties are your exclusive warranties and replace all other warranties or conditions, express or implied, including but not limited to, the implied warranties or conditions of merchantability and fitness for a particular purpose. These warranties give you specific legal rights and you may also have other rights which vary from jurisdiction to jurisdiction. Some jurisdictions do not allow the exclusion or limitation of express or implied warranties, so the above exclusion or limitation may not apply to you. In that event, such warranties are limited in duration to the warranty period. No warranties apply after that period.

Items Not Covered by Warranty

Wilder Technologies, LLC does not warrant uninterrupted or error-free operation of a Test Adapter.

Any technical or other support provided for a Test Adapter under warranty, such as assistance via telephone with "how-to" questions and those regarding Test Adapter set-up and installation, will be provided **WITHOUT WARRANTIES OF ANY KIND**.

Warranty Service

Warranty service may be obtained from Wilder Technologies, LLC by returning a Wilder Technologies, LLC Returns Material Authorization and the Test Adapter to Wilder Technologies, LLC during the warranty period. To obtain RMA number, contact support@wilder-tech.com.

You may be required to present proof of purchase or other similar proof of warranty entitlement. You are responsible for any associated transportation charges, duties and insurance between you and Wilder Technologies, LLC. In all instances, you must ship Test Adapters in Wilder Technologies, LLC approved packaging. Information on packaging guidelines can be found at: www.wilder-tech.com. Wilder Technologies, LLC will ship repaired or replacement Test Adapter Delivery Duty Prepaid (DDP) and will pay for return shipment. You will receive title to the repaired or replacement Test Adapter and you will be the importer of record.

Wilder Technologies, LLC – Terms & Conditions of Sale

- Other Documents:** This Agreement may NOT be altered, supplemented, or amended by the use of any other document(s) unless otherwise agreed to in a written agreement signed by both you and Wilder Technologies, LLC. If you do not receive an invoice or acknowledgement in the mail, via e-mail, or with your Product, information about your purchase may be obtained at support@wilder-tech.com or by contacting your sales representative.
- Payment Terms, Orders, Quotes, Interest:** Terms of payment are within Wilder Technologies, LLC's sole discretion, and unless otherwise agreed to by Wilder Technologies, LLC, payment must be received by Wilder Technologies, LLC prior to Wilder Technologies, LLC's acceptance of an order. Payment for the products will be made by credit card, wire transfer, or some other prearranged payment method unless credit terms have been agreed to by Wilder Technologies, LLC. Invoices are due and payable within the time period noted on your invoice, measured from the date of the invoice. Wilder Technologies, LLC may invoice parts of an order separately. Your order is subject to cancellation by Wilder Technologies, LLC, in Wilder Technologies, LLC's sole discretion. Unless you and Wilder Technologies, LLC have agreed to a different discount, Wilder Technologies, LLC's standard pricing policy for Wilder Technologies, LLC-branded systems, which includes hardware, software and services in one discounted price, allocates the discount off list price applicable to the service portion of the system to be equal to the overall calculated percentage discount off list price on the entire system. Wilder Technologies, LLC is not responsible for pricing, typographical, or other errors in any offer by Wilder Technologies, LLC and reserves the right to cancel any orders resulting from such errors.
- Shipping Charges; Taxes; Title; Risk of Loss:** Shipping, handling, duties and tariffs are additional unless otherwise expressly indicated at the time of sale. Title to products passes from Wilder Technologies, LLC to Customer on shipment from Wilder Technologies, LLC's facility. Loss or damage that occurs during shipping by a carrier selected by Wilder Technologies, LLC is Wilder Technologies, LLC's responsibility. Loss or damage that occurs during shipping by a carrier selected by you is your responsibility. You must notify Wilder Technologies, LLC within 7 days of the date of your invoice or acknowledgement if you believe any part of your purchase is missing, wrong or damaged. Unless you provide Wilder Technologies, LLC with a valid and correct tax exemption certificate applicable to your purchase of Product and the Product ship-to location, you are responsible for sales and other taxes associated with the order. **Shipping dates are estimates only.**
- WARRANTY:** WILDER TECHNOLOGIES, LLC, warrants that the item(s) manufactured under the Buyer's contract shall be free from defects in materials and workmanship furnished by WILDER TECHNOLOGIES, LLC, and shall conform to the applicable drawings and specifications. WILDER TECHNOLOGIES, LLC'S liability herein, for breach of warranty, contract or negligence in manufacturing, shall be limited to repair or replacement. Repair or replacement of defective items will be applicable only if the Buyer notifies WILDER TECHNOLOGIES, LLC, by written notice within 30-days of delivery. All claims shall be addressed to: support@wilder-tech.com or WILDER TECHNOLOGIES, LLC, 6101A East 18th Street, Vancouver, Washington 98661 U.S.A.; ATTENTION: Customer Service Manager. WILDER TECHNOLOGIES, LLC, reserves the right to inspect at the Buyer's plant all items claimed to be defective or nonconforming prior to authorizing their return. WILDER TECHNOLOGIES, LLC, assumes no liability for the results of the use of its components in conjunction with other electric, electronic or mechanical components, circuits and/or systems. The foregoing constitutes the sole and exclusive remedy of the Buyer and the exclusive liability of WILDER TECHNOLOGIES, LLC, and is IN LIEU OF ANY AND ALL OTHER WARRANTIES, STATUTORY, IMPLIED OR EXPRESSED AS TO MERCHANTABILITY, FITNESS FOR THE PURPOSE SOLD, DESCRIPTION, QUALITY, and PRODUCTIVENESS OR ANY OTHER MATTER. Without limiting the foregoing, in no event shall WILDER TECHNOLOGIES, LLC, be liable for loss of use, profit or other collateral, or for special and/or consequential damages.
- RETURNED GOODS:** WILDER TECHNOLOGIES, LLC, will accept only those goods for return that have been authorized for return. All goods authorized for return shall be assigned a Returned Material Authorization (RMA) Number. The RMA Number shall be clearly marked on the shipping container(s) and all documentation accompanying the goods authorized for return. The RMA Number shall be assigned by WILDER TECHNOLOGIES, LLC pursuant to the conditions set forth in Paragraph 4, WARRANTY.
- UNITED STATES GOVERNMENT CONTRACTS:** In the event this offer is accepted under Government contract, WILDER TECHNOLOGIES, LLC, agrees to accept clauses required by Government regulations and to waive WILDER TECHNOLOGIES, LLC conditions inconsistent therewith. WILDER TECHNOLOGIES, LLC, certifies that it is a regular manufacturer or dealer of the goods and/or services offered herein and that the prices offered do not exceed those charged to any customer for like quantities, services or materials under the same conditions.

Compliance with Environmental Legislation

Wilder Technologies, LLC, is dedicated to complying with the requirements of all applicable environmental legislation and regulations, including appropriate recycling and/or disposal of our products.



WEEE Compliance Statement

The European Union adopted Directive 2002/96/EC on Waste Electrical and Electronic Equipment (WEEE), with requirements that went into effect August 13, 2005. WEEE is intended to reduce the disposal of waste from electrical and electronic equipment by establishing guidelines for prevention, reuse, recycling and recovery.

Wilder Technologies has practices and processes in place to conform to the requirements in this important Directive.

In support of our environmental goals, effective January 1st, 2009 Wilder Technologies, LLC has partnered with EG Metals Inc. – Metal and Electronics Recycling of Hillsboro, Oregon, www.egmetalrecycling.com, to recycle our obsolete and electronic waste in accordance with the European Union Directive 2002/96/EC on waste electrical and electronic equipment ("WEEE Directive").

As a service to our customers, Wilder Technologies is also available for managing the proper recycling and/or disposal of all Wilder Technologies products that have reached the end of their useful life. For further information and return instructions, contact support@wilder-tech.com.



Compliance to RoHS 2 Substance Restrictions

Wilder Technologies, LLC certifies that the parts described in this document are compliant to the substance restrictions of Directive 2011/65/EU of the European Parliament, and of the Council of 8 June, 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS 2 Directive), prohibiting the use in homogeneous materials in excess of the listed maximum concentration value, except in cases where use is allowed by applicable exemptions listed in Annex III and Annex IV of the Directive.

Compliance with RoHS 2 has been verified through internal controls at design and production sites, including establishment of processes for specifying and controlling materials and segregation of non-compliant parts, receipt of supplier declarations of compliance and/or analytical test.

Glossary of Terms

| TERMINOLOGY | DEFINITION |
|----------------------------|--|
| Alt Mode (Alternate Mode) | Operation defined by a vendor or standards organization that is associated with a SVID assigned by the USB-IF. Entry and exit into and from an Alternate Mode is controlled by <i>USB PD r2.0 v1.1</i> Structured VDM Enter Mode and Exit Mode commands. |
| API | Application Program Interface |
| Captive Cable (Tethered) | Cable that is terminated on one end with a USB Type-C plug and has a vendor-specific means with which to connect (hard-wired or custom detachable) on the opposite end. |
| CC | Configuration Channel |
| DFP | Downward Facing Port |
| DLL | Dynamic Link Library (an API is usually inside) |
| DP | DisplayPort |
| DUT | Device Under Test |
| Far-End Crosstalk or FEXT | Crosstalk that is propagated in a disturbed channel in the same direction as the propagation of a signal in the aggressor channel. The terminals of the aggressor channel and the victim channel are usually close to each other. |
| Informative | The designation of a test that is not required for compliance but is considered important from a characterization standpoint. It is provided for informational purposes only. |
| Initiator | Port that initiates a <i>USB PD r2.0 v1.1</i> Vendor-Defined Message. It is independent of the port's PD role (e.g., Provider, Consumer, Provider/Consumer, or Consumer/Provider). |
| Insertion loss | The ratio, expressed in dB, of incident power to delivered power. |
| MOI | Method of implementation. |
| Near-End Crosstalk or NEXT | Crosstalk that is propagated in a disturbed channel in the opposite direction as the propagation of a signal in the aggressor channel. The terminals of the aggressor channel and the victim channel are usually close to each other. |
| Normative | The designation of a test that is required for compliance. |
| Passive Cable | Cable that does not incorporate any electronics to condition the data path signals. May or may not be electronically marked. |
| Physical Link | Two differential signal pairs, one pair in each direction, that connect two physical phys. |
| Responder | Port that responds to the Initiator of a <i>USB PD r2.0 v1.1</i> Vendor-Defined Message. Independent of the port's PD role (e.g., Provider, Consumer, Provider/Consumer, or Consumer/Provider). |
| Return Loss | The ratio, expressed in dB, of incident power to reflected power. |
| SBU | Sideband Use. |
| TBT | Thunderbolt |
| UPF | Upward Facing Port |
| USB Type-C | Generic reference to a USB Type-C Plug, USB Type-C Port, USB Type-C Receptacle, or USB Type-C Cable Assembly, as specified in <i>USB Type-C r1.1</i> . |
| VCONN-Powered | VCONN is a 5V, 1W power supply used to power the IC within an electronically marked Type-C cable. The DFP will supply the VCONN power upon start-up |
| VDM | Vendor Defined Messages (subset of PD messages on the CC lines) |

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