USB Type-C ENGINEERING CHANGE NOTICE

Title: Liquid Corrosion Mitigation
Applied to: USB Type-C Specification Release 2.2, October 2022

Brief description of the functional changes proposed:
This ECR deprecates analog audio accessory and uses the same method for entering a liquid corrosion mitigation state on a port and provide a CC-state indication to its port partner that liquid corrosion mitigation is being done.

Benefits as a result of the proposed changes:
Provides a distinct port state for when a product is taking steps to mitigate against corrosion from moisture detected in its port.

An assessment of the impact to the existing revision and systems that currently conform to the USB specification:
Few hosts support analog audio accessory. Those that might could be confused when connected to a device supporting corrosion mitigation, but no detrimental behavior should be seen. This should be a corner case of a corner case so likely zero to very low ppm of this condition. Note, any compliant host that supports analog audio accessory today is also required to support digital audio accessories, so there should be no impact to users.

An analysis of the hardware implications:
New hosts/devices that support corrosion mitigation will add ability to pull down on CC pins with resistance < RA. No impact to compliant sources as they should already support the behavior when seeing an attached device in mitigation. There are some power bricks that incorrectly implemented the AudioAccessory state without supporting an actual audio accessory. Ports that don't support audio accessories should have stayed in attachwait.src. If these bricks implemented the exit from AudioAccessory by only monitoring a single CC pin for the removal of RA and are connected to a cable with an RA (e-Marked), these bricks have a 50% chance (depending on orientation) of remaining in the AudioAccessory state when the device supporting the new CorrosionMitigation state is disconnected at the device end. The source port may be monitoring for a disconnect on the CC pin that is connected to the cable RA and not the device CorrosionMitigation RA. For these, the source should exit the state when the cable is unplugged from the source end. Some information may need to be provided to the user by article or in a screen message to aid in performing the correct steps to exit the legacy AudioAccessory state.

An analysis of the software implications:
Policy software would need to be added to support liquid corrosion mitigation.

An analysis of the compliance testing implications:

Actual Changes Requested

(a) Section 1.5

Redline changes:

1.5 Terms and Abbreviations

Term	Description
Accessory Mode	A reconfiguration of the connector based on the presence of Rd/Rd ~~or Ra/Ra~~ on CC1/CC2, respectively.
Audio Adapter Accessory Mode	The Accessory Mode defined by the presence of Ra/Ra on CC1/CC2, respectively. ~~See Appendix A.~~This mode is deprecated and replaced by Liquid Corrosion Mitigation Mode.
Liquid Corrosion Mitigation Mode	The ~~Accessory~~ m~~M~~ode defined by the presence of Ra/Ra on CC1/CC2, respectively. See Appendix A.

(b) Table 3-5

Redline changes:

Table 3-5 USB Type-C Receptacle Interface Pin Assignments for USB 2.0-only Support

Pin	Signal Name	Description	Mating Sequence	Pin	Signal Name	Description	Mating Sequence
A1	GND	Ground return	First	B12	GND	Ground return	First
A2				B11			
A3				B10			
A4	VBUS	Bus Power	First	B9	VBUS	Bus Power	First
A5	CC1	Configuration Channel	Second	B8	SBU2	Sideband Use (SBU)	Second
A6	Dp1	Positive half of the *USB 2.0* differential pair – Position 1	Second	B7	Dn2	Negative half of the *USB 2.0* differential pair – Position 2	Second
A7	Dn1	Negative half of the *USB 2.0* differential pair – Position 1	Second	B6	Dp2	Positive half of the *USB 2.0* differential pair – Position 2	Second
A8	SBU1	Sideband Use (SBU)	Second	B5	CC2	Configuration Channel	Second
A9	VBUS	Bus Power	First	B4	VBUS	Bus Power	First
A10				B3			
A11				B2			
A12	GND	Ground return	First	B1	GND	Ground return	First

Notes:

1. Unused contact locations shall be electrically isolated from power, ground or signaling (i.e., not connected).
2. Contacts B6 and B7 should not be present in the USB Type-C plug. The receptacle side shall support the *USB 2.0* differential pair present on Dp1/Dn1 or Dp2/Dn2. The plug orientation determines which pair is active. In one implementation, Dp1 and Dp2 may be shorted on the host/device as close to the receptacle as possible to minimize stub length; Dn1 and Dn2 may also be shorted. The maximum shorting trace length should not exceed 3.5 mm.
3. Contacts A8 and B8 (SBU1 and SBU2) shall be not connected unless required for a specified purpose ~~(e.g., Audio Adapter Accessory Mode)~~.
4. All VBUS pins shall be connected together within the USB Type-C plug and shall be connected together at the USB Type-C receptacle connector when the receptacle is in its mounted condition (e.g., all VBUS pins bussed together on the PCB).
5. All Ground return pins shall be connected together within the USB Type-C plug and shall be connected together at the USB Type-C receptacle connector when the receptacle is in its mounted condition (e.g., all ground return pins bussed together on the PCB).
6. If the contact dimensions shown in Figure 3-1 ALTERNATE SECTION A-A are used then the VBUS contacts (A4, A9, B4 and B9) mate second, and signal contacts (A5, A6, A7, A8, B5, B6, B7 and B8) mate third.

(c) Section 4.3

Redline changes:

4.3 Sideband Use (SBU)

The Sideband Use pins (SBU1 and SBU2) are limited to the uses as defined by this specification and additional functionality defined in the *USB4 Specification*. See Appendix E ~~and Appendix A~~ for use of the SBU pins in Alternate Modes ~~and Audio Adapter Accessory Mode~~.

The SBU pins on a port shall either be open circuit or have a weak pull-down to ground no stronger than zSBUTermination when in *USB 3.2* or *USB 2.0*.

These pins are pre-wired in the standard USB Full-Featured Type-C cable as individual single-ended wires (SBU_A and SBU_B). Note that SBU1 and SBU2 are cross-connected in the cable.

When operating in *USB4*, these pins are used as the *USB4* Sideband Channel with SBU1 mapping to SBTX and SBU2 mapping to SBRX. SBTX and SBRX functional requirements are as defined in the *USB4 Specification*. When a port determines that the locally-inserted plug is flipped (i.e. CC1 is open, CC2 is terminated), the *USB4 Specification* (reference Sideband Channel Lane Reversal) dictates that the port flip the SBTX and SBRX mappings to SBU1 and SBU2 in order to assure proper sideband transmit-to-receive end-to-end operation.

(d) Section 4.5.1.2.1

Redline changes:

4.5.1.2.1 Detecting a Valid Source-to-Sink Connection

The general concept for setting up a valid connection between a Source and Sink is based on being able to detect terminations residing in the product being attached.

To aid in defining the functional behavior of CC, a pull-up (Rp) and pull-down (Rd) termination model is used – actual implementation in hosts and devices may vary, for example, the pull-up termination could be replaced by a current source. Figure 4-5 and Figure 4-6 illustrates two models, the first based on a pull-up resistor in the Source and the second replacing this with a current source.

Figure 4-5 Pull-Up/Pull-Down CC Model

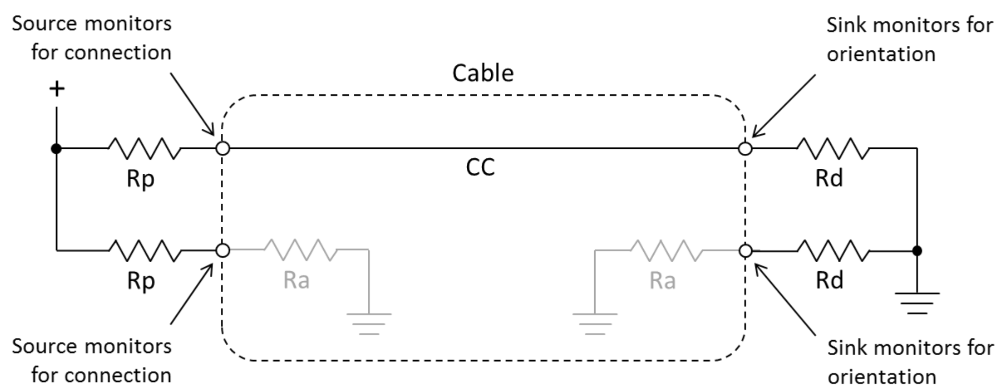
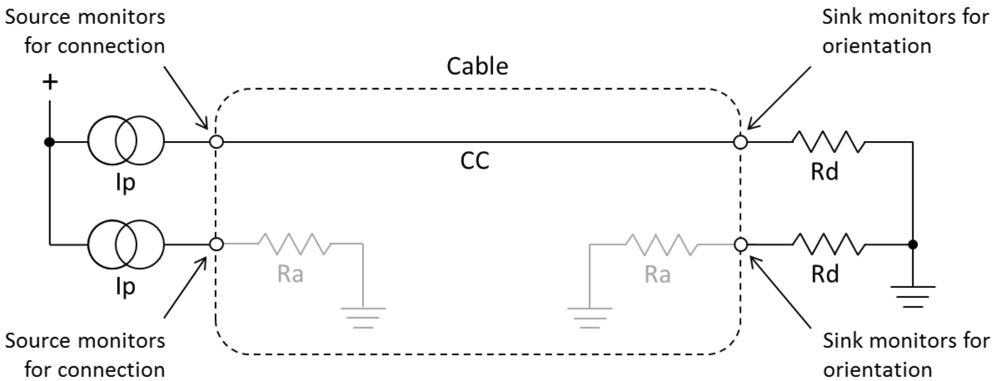


Figure 4-6 Current Source/Pull-Down CC Model



Initially, a Source exposes independent Rp terminations on its CC1 and CC2 pins, and a Sink exposes independent Rd terminations on its CC1 and CC2 pins, the Source-to-Sink combination of this circuit configuration represents a valid connection. To detect this, the Source monitors CC1 and CC2 for a voltage lower than its unterminated voltage – the choice of Rp is a function of the pull-up termination voltage and the Source's detection circuit. This indicates that either a Sink, a powered cable, or a Sink connected via a powered cable has been attached.

Prior to application of VCONN, a powered cable exposes Ra on its VCONN pin. Ra represents the load on VCONN plus any resistive elements to ground. In some cable plugs it might be a pure resistance and in others it may be simply the load.

The Source has to be able to differentiate between the presence of Rd and Ra to know whether there is a Sink attached and where to apply VCONN. The Source is not required to source VCONN unless Ra is detected.

Two special termination combinations on the CC pins as seen by a Source are defined for ~~directly attached Accessory~~ specific m~~M~~odes: Ra/Ra for ~~Audio Adapter Accessory~~Liquid Corrosion Mitigation Mode (Appendix A) and Rd/Rd for Debug Accessory Mode (Appendix B).

The Source uses de-bounce timers to reliably detect states on the CC pins to de-bounce the connection (tCCDebounce), and hide *USB PD* BMC communications (tPDDebounce).

Table 4-10 summarizes the port state from the Source's perspective.

Table 4-10 Source Perspective

CC1	CC2	State	Position
Open	**Open**	Nothing attached	N/A
Rd	**Open**	Sink attached	①
Open	**Rd**		②
Open	**Ra**	Powered cable without Sink attached or Liquid Corrosion Mitigation Mode attached (Appendix A)	①
Ra	**Open**		②
Rd	**Ra**	Powered cable with Sink, VCONN-Powered Accessory (VPA), or VCONN-Powered USB Device (VPD) attached	①
Ra	**Rd**		②
Rd	**Rd**	Debug Accessory Mode attached (Appendix B)	N/A
Ra	**Ra**	~~Audio Adapter Accessory~~Liquid Corrosion Mitigation Mode attached (Appendix A)	N/A

Once the Sink is powered, the Sink monitors CC1 and CC2 for a voltage greater than its local ground. The CC pin that is at a higher voltage (i.e. pulled up by Rp in the Source) indicates the orientation of the plug.

Table 4-11 summarizes the typical behaviors for simple Sources (Hosts) and Sinks (Devices) for each state in Table 4-10.

Table 4-11 Source (Host) and Sink (Device) Behaviors by State

State	Source Behavior	Sink Behavior
Nothing attached	• Sense CC pins for attach • Do not apply VBUS or VCONN	• Sense VBUS for attach
Sink attached	• Sense CC for orientation • Sense CC for detach • Apply VBUS and VCONN	• Sense CC pins for orientation • Sense loss of VBUS for detach
Powered cable without Sink attached	• Sense CC pins for attach • Do not apply VBUS or VCONN	• Sense VBUS for attach
Powered cable with Sink, VCONN-Powered Accessory, or VCONN-Powered USB Device attached	• Sense CC for orientation • Sense CC for detach • Apply VBUS and VCONN • Detect VPD and remove VBUS	• If accessories or VPDs are supported, see Source Behavior with exception that VBUS is not applied., otherwise, N/A.
Debug Accessory Mode attached	• Sense CC pins for detach • Reconfigure for debug	• Sense VBUS for detach • Reconfigure for debug
~~Audio Adapter Accessory~~Liquid Corrosion Mitigation Mode attached	• Sense CC pins for detach • ~~Reconfigure for analog audio~~Do not apply VBUS or VCONN.	• ~~If accessories are supported, see Source Behavior~~N/A ~~, otherwise, N/A~~

Figure 4-3 shows how the inserted plug orientation is detected at the Source's receptacle by noting on which of the two CC pins in the receptacle an Rd termination is sensed. Now that the Source (Host) has recognized that a Sink (Device) is attached and the plug orientation is determined, it configures the TX/RX data bus routing to the receptacle.

The Source (Host) then turns on VBUS. For the CC pin that does not connect Source-to-Sink through the cable, the Source supplies VCONN and may remove the termination. With the Sink (Device) now powered, it configures the USB data path. This completes the Host-to-Device connection.

The Source monitors the CC wire for the loss of pull-down termination to detect detach. If the Sink is removed, the Source port removes any voltage applied to VBUS and VCONN, resets its interface configuration and resumes looking for a new Sink attach.

Once a valid Source-to-Sink connection is established, alternatives to traditional USB power (VBUS as defined by either *USB 2.0* or *USB 3.2* specifications) may be available depending on the capabilities of the host and device. These include USB Type-C Current, USB Power Delivery, and *USB Battery Charging 1.2*.

In the case where *USB PD* PR_Swap is used to swap the Source and Sink of VBUS, the supplier of VCONN remains unchanged during and after the VBUS power swap. The new Source monitors the CC wire and the new Sink monitors VBUS to detect detach. When a detach event is detected, any voltages applied to VBUS and VCONN are removed, each port resets its interface configuration and resumes looking for an attach event.

In the case where *USB PD* DR_Swap is used to swap the data roles (DFP and UFP), the source of VBUS and VCONN do not change after the data role swap.

In the case where *USB PD* VCONN_Swap is used to swap the VCONN source, the VBUS Source/Sink and DFP/UFP roles are maintained during and after the VCONN swap.

The last step in the normal USB Type-C connect process is for the USB device to be attached and enumerated per standard *USB 2.0* and *USB 3.2* processes.

(d) Section 4.5.2

Redline changes:

4.5.2 CC Functional and Behavioral Requirements

4.5.2.1 Connection State Diagrams

This section provides reference connection state diagrams for CC-based behaviors.

Refer to Section 4.5.2.2 for the specific state transition requirements related to each state shown in the diagrams.

Refer to Section 4.5.2.4 for a description of which states are mandatory for each port type, and a list of states where *USB PD* communication is permitted.

Figure 4-12 illustrates a connection state diagram for a Source (Host/Hub DFP).

Figure 4-12 Connection State Diagram: Source

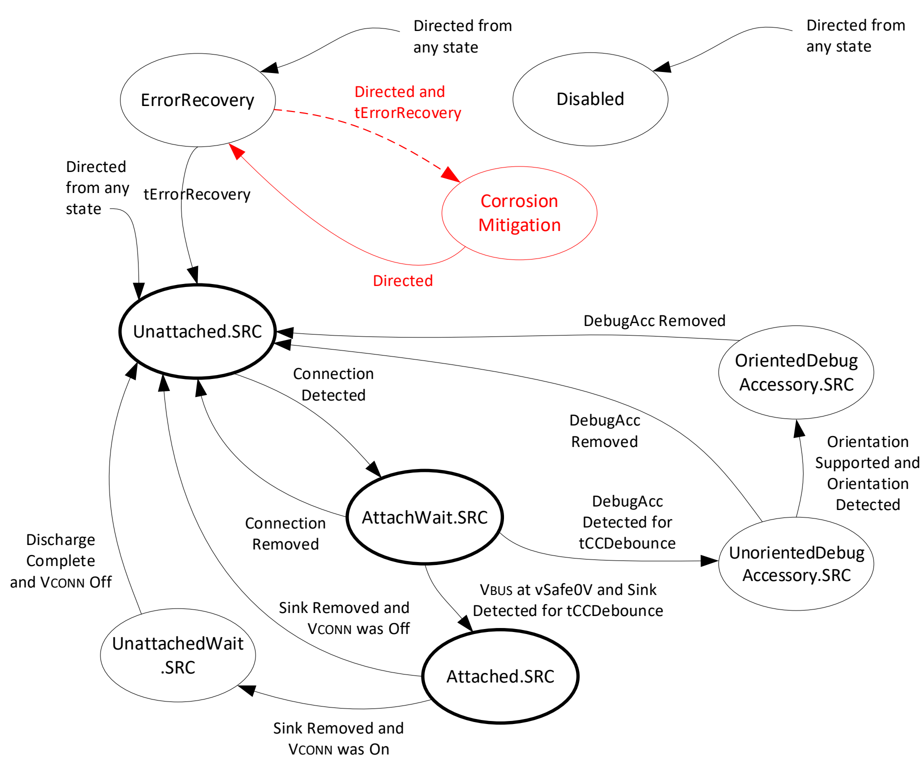


Figure 4-13 illustrates a connection state diagram for a simple Sink (Device/Hub UFP).

Figure 4-13 Connection State Diagram: Sink

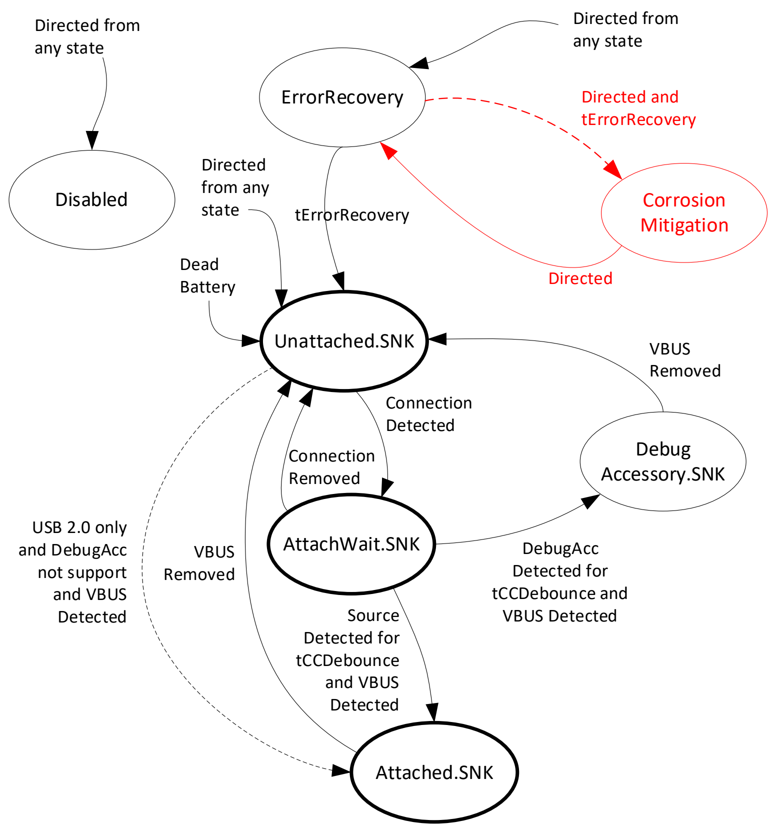


Figure 4-14 illustrates a connection state diagram for a Sink that supports Accessory Modes.

Figure 4-14 Connection State Diagram: Sink with Accessory Support

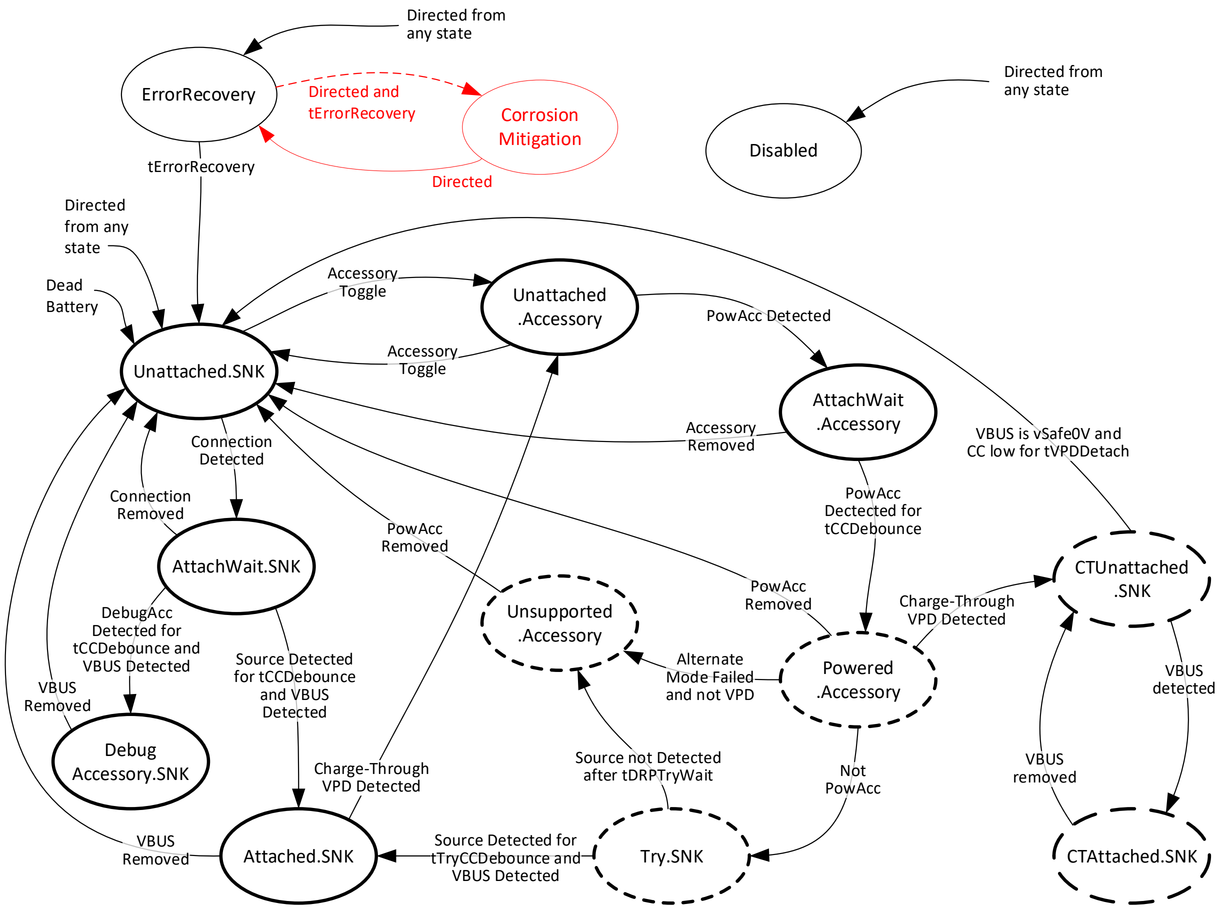


Figure 4-15 illustrates a connection state diagram for a simple DRP (Dual-Role-Power) port.

Figure 4-15 Connection State Diagram: DRP

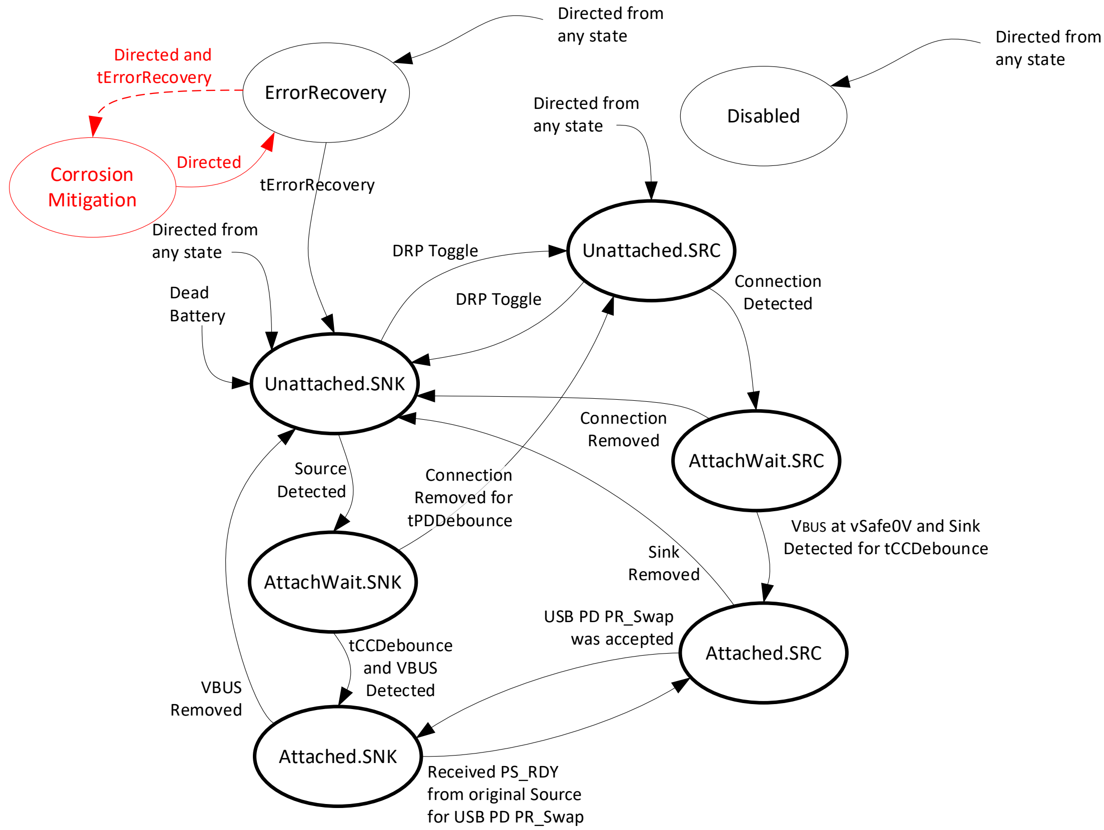


Figure 4-16 illustrates a connection state diagram for a DRP that supports Try.SRC and Accessory Modes.

Figure 4-16 Connection State Diagram: DRP with Accessory and Try.SRC Support

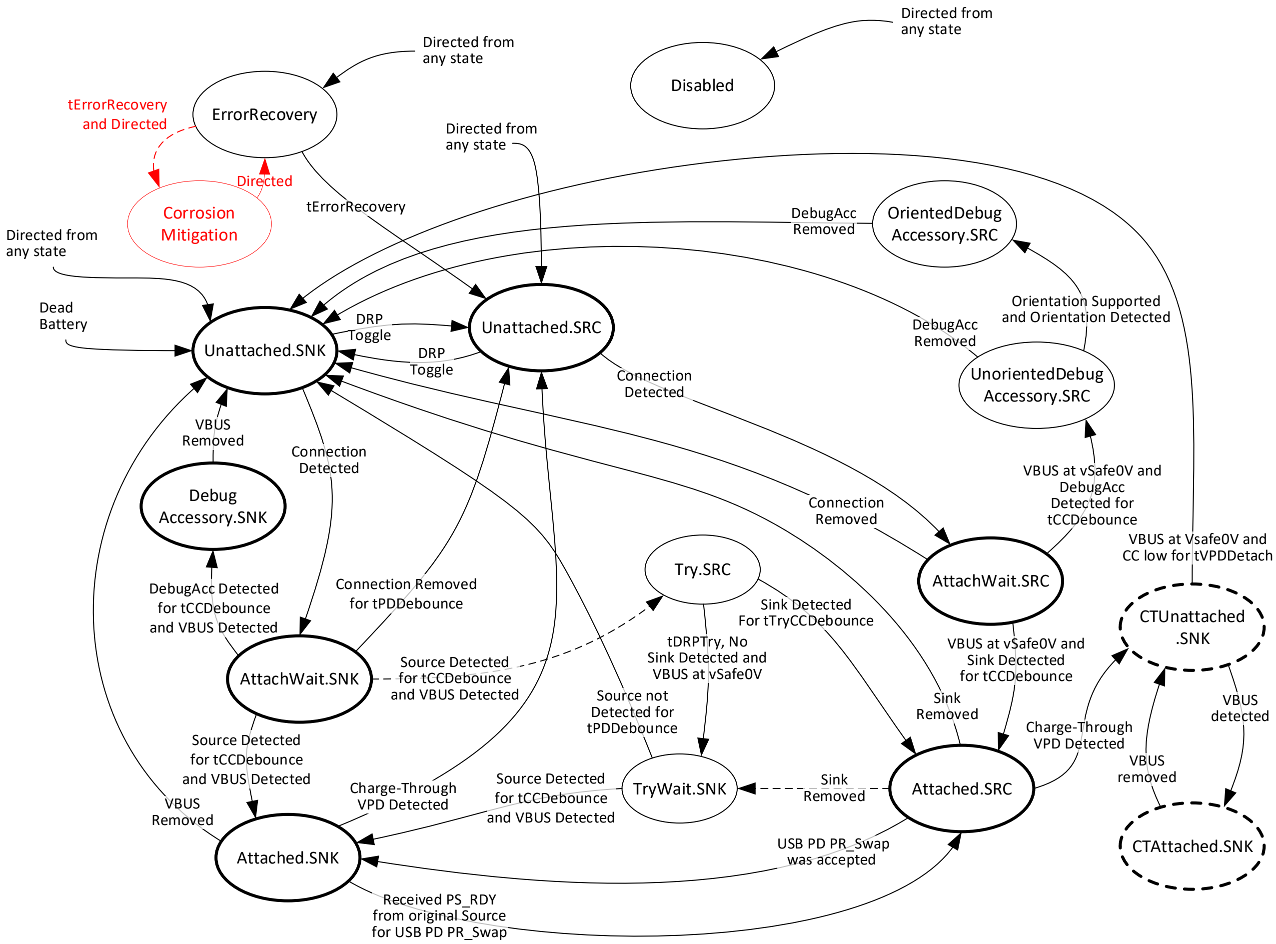


Figure 4-17 illustrates a connection state diagram for a DRP that supports Try.SNK and Accessory Modes.

Figure 4-17 Connection State Diagram: DRP with Accessory and Try.SNK Support

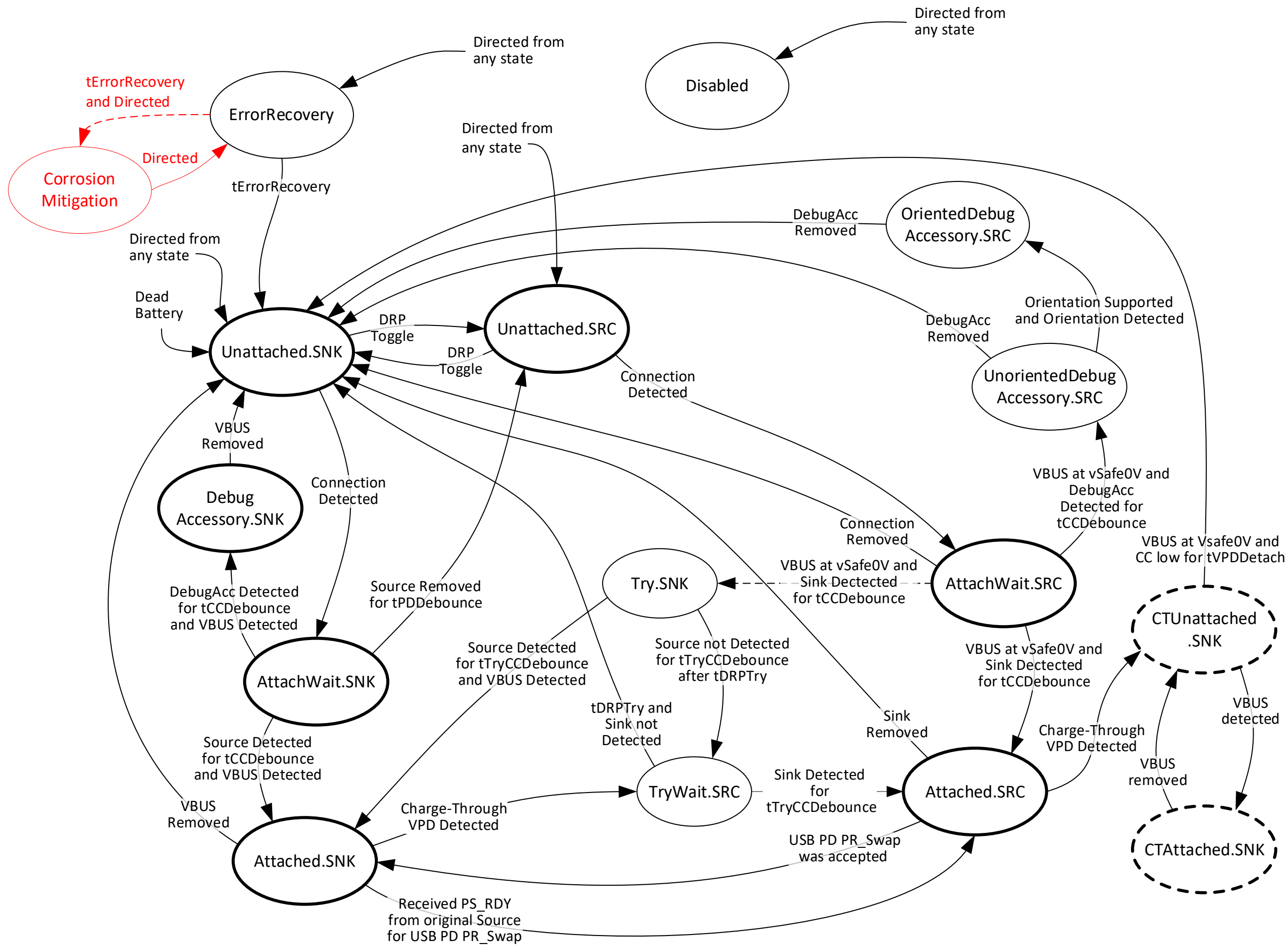
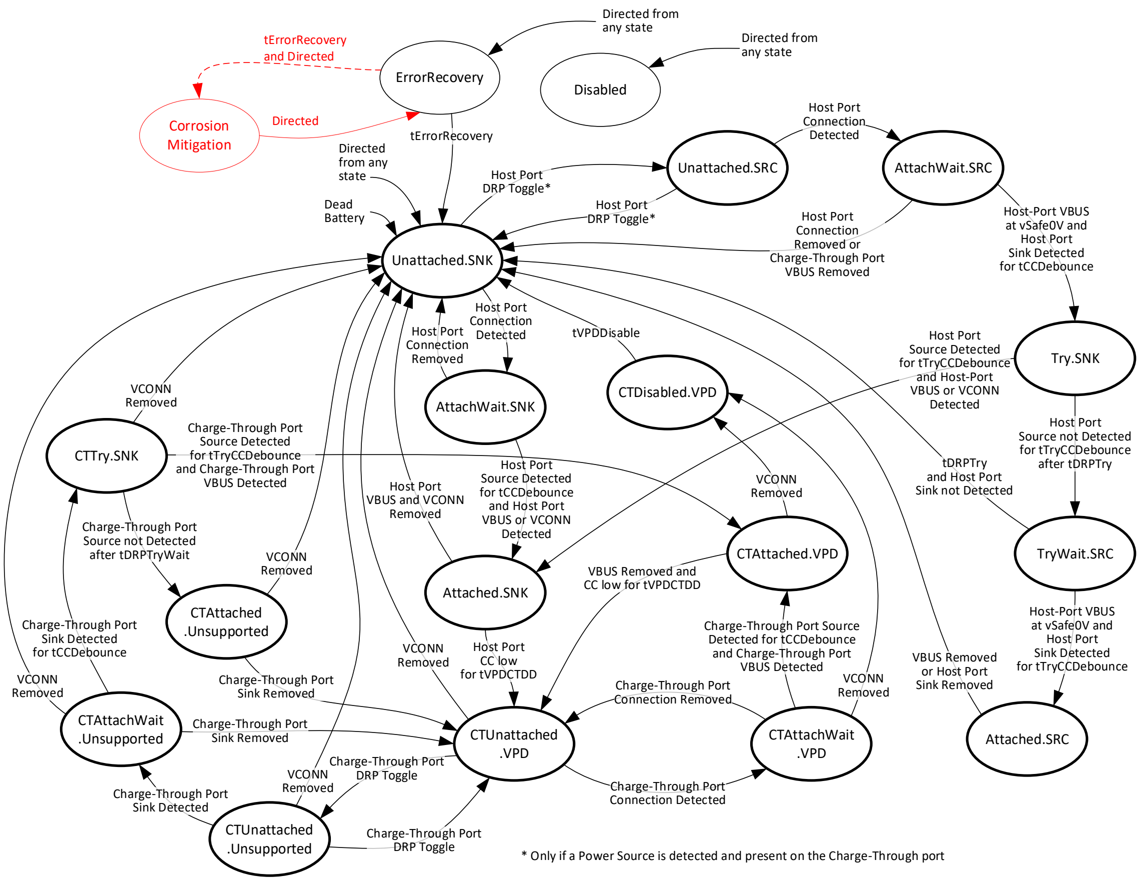


Figure 4-18 illustrates a connection state diagram for a Charge-Through VCONN-Powered USB Device.

Figure 4-18 Connection State Diagram: Charge-Through VPD



4.5.2.2 Connection State Machine Requirements

4.5.2.2.1 Disabled State

4.5.2.2.2 ErrorRecovery State

This state appears in Figure 4-12, Figure 4-13, Figure 4-14, Figure 4-15, Figure 4-16 and Figure 4-17.

The ErrorRecovery state is where the port removes the terminations from the CC1 and CC2 pins for tErrorRecovery followed by transitioning to the appropriate Unattached.SNK or Unattached.SRC state based on port type. This is the equivalent of forcing a detach event and looking for a new attach. The port may alternately transition from ErrorRecovery to CorrosionMitigation if directed.

Ports that support *USB Power Delivery* shall support the ErrorRecovery state.

Ports that support the ErrorRecovery state shall transition to the ErrorRecovery state from any other state when directed.

A port that does not support *USB Power Delivery* may choose not to support the ErrorRecovery state. If the ErrorRecovery state is not supported, the port shall be directed to the Disabled state if supported. If the Disabled state is not supported, the port shall be directed to either the Unattached.SNK or Unattached.SRC states.

4.5.2.2.2.1 ErrorRecovery State Requirements

The port shall not drive VBUS or VCONN, and shall present a high-impedance to ground (above zOPEN) on its CC1 and CC2 pins.

4.5.2.2.2.2 Exiting from ErrorRecovery State

A Sink shall transition to Unattached.SNK after tErrorRecovery or shall transition to CorrosionMitigation after tErrorRecovery if directed.

A Source shall transition to Unattached.SRC after tErrorRecovery or shall transition to CorrosionMitigation after tErrorRecovery if directed.

A DRP (Figure 4-15) and a DRP with Accessory and Try.SNK Support (Figure 4-17) shall transition to Unattached.SNK after tErrorRecovery or shall transition to CorrosionMitigation after tErrorRecovery if directed.

A DRP with Accessory and Try.SRC Support (Figure 4-16) shall transition to Unattached.SRC after tErrorRecovery or shall transition to CorrosionMitigation after tErrorRecovery if directed.

4.5.2.2.3 Unattached.SNK State

4.5.2.2.4 AttachWait.SNK State

4.5.2.2.5 Attached.SNK State

4.5.2.2.6 UnattachedWait.SRC State

4.5.2.2.7 Unattached.SRC State

4.5.2.2.8 AttachWait.SRC State

This state appears in Figure 4-12, Figure 4-15, Figure 4-16, Figure 4-17 and Figure 4-18.

The AttachWait.SRC state is used to ensure that the state of both of the CC1 and CC2 pins is stable after a Sink is connected.

When in the AttachWait.SRC state, the Charge-Through VCONN-Powered USB Device ensures that the state of Host-side port's CC pin is stable after a Sink is connected.

4.5.2.2.8.1 AttachWait.SRC Requirements

The requirements for this state are identical to Unattached.SRC.

4.5.2.2.8.2 Exiting from AttachWait.SRC State

The port shall transition to Attached.SRC when VBUS is at vSafe0V and the SRC.Rd state is detected on exactly one of the CC1 or CC2 pins for at least tCCDebounce.

The Charge-Through VCONN-Powered USB Device shall transition to Try.SNK when the host-side VBUS is at vSafe0V and the SRC.Rd state is on the Host-side port's CC pin for at least tCCDebounce.

~~If the port supports Audio Adapter Accessory ModeLiquid Corrosion Mitigation Mode, it shall transition to AudioAccessory CorrosionMitigation when the SRC.Ra state is detected on both the CC1 and CC2 pins for at least tCCDebounce.~~

If the port supports Debug Accessory Mode, it shall transition to UnorientedDebugAccessory.SRC when VBUS is at vSafe0V and the SRC.Rd state is detected on both the CC1 and CC2 pins for at least tCCDebounce.

A Source shall transition to Unattached.SRC and a DRP to Unattached.SNK when the SRC.Open state is detected on both the CC1 and CC2 pins. The Source shall detect the SRC.Open state within tSRCDisconnect, but should detect it as quickly as possible.

A Source shall transition to Unattached.SRC and a DRP to Unattached.SNK when the SRC.Open state is detected on either the CC1 or CC2 pin and the other CC pin is SRC.Ra. The Source shall detect the SRC.Open state within tSRCDisconnect, but should detect it as quickly as possible.

A Charge-Through VCONN-Powered USB Device shall transition to Unattached.SNK when the SRC.Open state is detected on the Host-side port's CC or if Charge-Through VBUS falls below vSinkDisconnect. The Charge-Through VCONN-Powered USB Device shall detect the SRC.Open state within tSRCDisconnect, but should detect it as quickly as possible.

A DRP that strongly prefers the Sink role may optionally transition to Try.SNK instead of Attached.SRC when VBUS is at vSafe0V and the SRC.Rd state is detected on exactly one of the CC1 or CC2 pins for at least tCCDebounce.

4.5.2.2.9 Attached.SRC State

4.5.2.2.10 Try.SRC State

4.5.2.2.11 TryWait.SNK State

4.5.2.2.12 Try.SNK State

4.5.2.2.13 TryWait.SRC State

4.5.2.2.14 Unattached.Accessory State

This state appears in Figure 4-14.

The Unattached.Accessory state allows accessory-supporting Sinks to connect to ~~audio or~~ VCONN-Powered Accessories.

This state is functionally equivalent to the Unattached.SRC state in a DRP, except that Attached.SRC is not supported.

4.5.2.2.14.1 Unattached.Accessory Requirements

The port shall not drive VBUS or VCONN.

The port shall source current on both the CC1 and CC2 pins independently.

The port shall provide an Rp as specified in Table 4-26.

4.5.2.2.14.2 Exiting from Unattached.Accessory State

~~A port that supports Audio Adapter Accessory Mode shall transition to AttachWait.Accessory when the state of both CC pins is SRC.Ra.~~

A port that supports VCONN-Powered Accessories also shall transition to AttachWait.Accessory when the state of either CC1 or CC2 pin is SRC.Ra and the other CC pin is SRC.Rd.

The maximum time the local port shall take to transition from Unattached.Accessory to the AttachWait.Accessory state when ~~an Audio Adapter Accessory or~~a VCONN-Powered Accessory is present is tOnePortToggleConnect.

Otherwise, the port shall transition to Unattached.SNK within tDRPTransition after dcSRC.DRP · tDRP, or if directed.

4.5.2.2.15 AttachWait.Accessory State

This state appears in Figure 4-14.

The AttachWait.Accessory state is used to ensure that the state of both of the CC1 and CC2 pins is stable after a cable is plugged in.

4.5.2.2.15.1 AttachWait.Accessory Requirements

The requirements for this state are identical to Unattached.Accessory.

4.5.2.2.15.2 Exiting from AttachWait.Accessory State

If the port supports Audio Adapter Accessory Mode, it shall transition to AudioAccessory when the state of both the CC1 and CC2 pins is SRC.Ra for at least tCCDebounce.

The port shall transition to Unattached.SNK when the state of either the CC1 or CC2 pin is SRC.Open for at least tCCDebounce.

If the port supports VCONN-Powered Accessories, it shall transition to PoweredAccessory state if the state of either the CC1 or CC2 pin is SRC.Rd and the other CC pin is SRC.Ra concurrently for at least tCCDebounce.

4.5.2.2.16 ~~AudioAccessory~~ CorrosionMitigation State

This state appears in Figure 4-12, Figure 4-13, Figure 4-14, Figure 4-15, Figure 4-16, ~~and~~ Figure 4-17 and Figure 4-18.

The ~~AudioAccessory~~ CorrosionMitigation state is used for the ~~Audio Adapter Accessory Mode~~Corrosion Mitigation Mode specified in Appendix A.

4.5.2.2.16.1 ~~AudioAccessory~~ CorrosionMitigation Requirements

The port shall reconfigure its pins as detailed in Appendix A.

The port shall not drive VBUS or VCONN. ~~A port that sinks current from the audio accessory over VBUS shall not draw more than 500 mA.~~

The port shall ~~provide~~ pull low with a resistance on both CC1 and CC2 less than or equal to the Maximum Impedance of~~an~~ Ra ~~Rp~~ as specified in ~~Table 4-26~~Table 4-28. The port should pull low with a resistance stronger than Ra.

Alternatively, the port shall pull low with this resistance on only one of the CC1 or CC2 pins and have the other pin Open (present an impedance to ground above zOPEN). When using this single pull low, the Sink shall monitor the voltage on the Open CC pin and shall swap the resistance and Open from one CC pin to the other when SNK.Rp is detected.

~~The port shall source current on at least one of the CC1 or CC2 pins and monitor to detect when the state is no longer SRC.Ra. If the port sources and monitors only one of CC1 or CC2, then it shall ensure that the termination on the unmonitored CC pin does not affect the monitored signal when the port is connected to an Audio Accessory that may short both CC1 and CC2 pins together.~~

4.5.2.2.16.2 Exiting from ~~AudioAccessory~~ CorrosionMitigation State

~~If the port is a Sink, the port shall transition to Unattached.SNK when the state of the monitored CC1 or CC2 pin(s) is SRC.Open for at least tCCDebounce.~~

~~If the port is a Source or DRP, the port shall transition to Unattached.SRC when the state of the monitored CC1 or CC2 pin(s) is SRC.Open for at least tCCDebounce~~The port shall transition to ErrorRecovery when directed.

(e) Section 4.5.2.6

Redline changes:

4.5.2.6 Connection States Summary

Table 4-18 defines the mandatory and optional states for each type of port.

Table 4-18 Mandatory and Optional States

	SOURCE	SINK	DRP	USB PD Communication
Disabled	Optional	Optional	Optional	Not Permitted
ErrorRecovery	Mandatory[10]	Mandatory[10]	Mandatory[10]	Not Permitted
Unattached.SNK	N/A	Mandatory	Mandatory	Not Permitted
AttachWait.SNK	N/A	Mandatory[1]	Mandatory	Not Permitted
Attached.SNK	N/A	Mandatory	Mandatory	Permitted
UnattachedWait.SRC	Mandatory or N/A[7]	N/A	N/A	Not Permitted
Unattached.SRC	Mandatory	N/A	Mandatory	Not Permitted
AttachWait.SRC	Mandatory	N/A	Mandatory	Not Permitted
Attached.SRC	Mandatory	N/A	Mandatory	Permitted
Try.SRC[4]	N/A	N/A	Optional	Not Permitted
TryWait.SNK[2]	N/A	N/A	Optional	Not Permitted
Try.SNK[4, 8]	N/A	N/A	Optional	Not Permitted
TryWait.SRC[5, 8]	N/A	N/A	Optional	Not Permitted
~~AudioAccessory~~CorrosionMitigation	Optional	Optional	Optional	Not Permitted
UnorientedDebugAccessory.SRC	Optional[6]	N/A	Optional[6]	Not Permitted
OrientedDebugAccessory.SRC	Optional[6]	N/A	Optional[6]	Permitted
DebugAccessory.SNK	N/A	Optional	Optional	Permitted
Unattached.Accessory	N/A	Optional	N/A	Not Permitted
AttachWait.Accessory	N/A	Optional	N/A	Not Permitted
PoweredAccessory	N/A	Optional	N/A	Permitted
Unsupported.Accessory[3]	N/A	Optional	N/A	Not Permitted
CTUnattached.VPD	N/A	N/A	Optional	SOP' Permitted
CTAttachWait.VPD[8]	N/A	N/A	Optional	SOP' Permitted
CTAttached.VPD[8]	N/A	N/A	Optional	Not Permitted
CTDisabled.VPD[8]	N/A	N/A	Optional	Not Permitted
CTUnattached.SNK	N/A	N/A	Optional	SOP' Permitted
CTAttached.SNK[9]	N/A	N/A	Optional	Permitted
CTUnattached.Unsupported[8]	N/A	N/A	Optional	SOP' Permitted
CTAttachWait.Unsupported[8]	N/A	N/A	Optional	SOP' Permitted
CTTry.SNK[8]	N/A	N/A	Optional	SOP' Permitted
CTAttached.Unsupported[8]	N/A	N/A	Optional	SOP' Permitted
PowerDefault.SNK	N/A	Mandatory	Mandatory	Permitted
Power1.5.SNK	N/A	Optional	Optional	Permitted

	SOURCE	SINK	DRP	USB PD Communication
Power3.0.SNK	N/A	Optional	Optional	Permitted

Notes:

1. Optional for UFP applications that are USB 2.0-only, consume USB Default Power and do not support USB PD or accessories.
2. TryWait.SNK is mandatory when Try.SRC is supported.
3. Unsupported.Accessory is mandatory when PoweredAccessory is supported.
4. Try.SRC and Try.SNK shall not be supported at the same time, although an unattached device may dynamically choose between Try.SRC and Try.SNK state machines based on external factors.
5. TryWait.SRC is mandatory when Try.SNK is supported.
6. UnorientedDebugAccessory.SRC is required for any Source or DRP that supports Debug Accessory Mode. OrientedDebugAccessory.SRC is only required if orientation detection is necessary in Debug Accessory Mode.
7. Mandatory for a DFP that was providing VCONN in the previous Attached.SRC state. N/A for a DFP that was not providing VCONN in the previous Attached.SRC state.
8. CTAttachWait.VPD, CTAttached.VPD, CTDisabled.VPD, Try.SNK, TryWait.SRC, CTUnattached.Unsupported, CTAttachWait.Unsupported, CTAttached.Unsupported, and CTTry.SNK are mandatory when CTUnattached.VPD is supported.
9. CTAttached.SNK is mandatory when CTUnattached.SNK is supported.
10. Optional for non-*USB4* and non-*USB PD* implementations.

(f) Appendix A

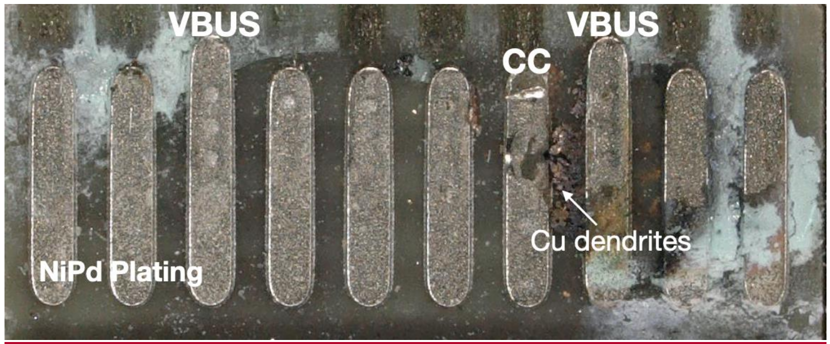
Redline changes:

A Liquid ~~Audio Adapter Accessory~~Corrosion Mitigation Mode

A.1 Overview

Ingress of every day liquids with electrolytes (sweat, soda, tap water, salt water, pool water, etc.) ~~Analog audio headsets are supported by multiplexing four analog audio signals onto~~into the ~~pins on the~~ USB Type-C® connector can easily corrode the connector pins when exposed to the liquid with electrical bias in the connector (VBUS, CC, etc.). The liquid forms a bridge between pins and when the voltage difference between the pins is high enough (above a few hundred millivolts), the exposed metal will dissolve into free ions and these ions will migrate from one pin to another. When these dissolved ions move and form oxides, they can lead to open or high impedance due to surface residue or partial metal pin material loss or they can lead to shorts due to various mechanisms like dendrite growth or metal-based particle depositions on plastic surface.~~when in the Audio Adapter Accessory Mode. The four analog audio signals are the same as those used by a traditional 3.5 mm headset jack. This makes it possible to use existing analog headsets with a 3.5 mm to USB Type-C adapter. The audio adapter architecture allows for an audio peripheral to provide up to 500 mA back to the system for charging.~~

Figure A-1 Electrolytic Liquid Corrosion Example.



When in a connected state, VBUS ~~can be~~is 4.75V – 50.4V and CC/VCONN ~~can be~~is 0.2V – 5.5V. Likewise, in an unconnected state, a Source or DRP will pull the CC pin to 3V – 5.5V. This results in always-present voltage bias that will corrode pins when exposed to electrolytic liquids~~liquids with the exception of an unconnected Sink.~~

The Liquid Corrosion Mitigation Mode is an optional normative mode that eliminates or reduces the rate of corrosion by removing or forcing the bias voltages in the connector to a voltage as close to 0V as possible.~~An analog audio adapter could be a very basic USB Type-C adapter that only has a 3.5 mm jack, or it could be an analog audio adapter with a 3.5 mm jack and a USB Type-C receptacle to enable charge-through. The analog audio headset shall not use a USB Type-C plug to replace the 3.5 mm plug.~~

~~A USB host that implements support for USB Type-C Analog Audio Adapter Accessory mode shall also support USB Type-C Digital Audio (TCDA) with nominally equivalent functionality and performance. A USB device that implements support for USB Type-C Analog Audio Adapter Accessory mode should also support TCDA with nominally equivalent audio functionality and performance.~~

A.2 Detail

~~An analog audio adapter shall use a captive cable with a USB Type-C plug or include an integrated USB Type-C plug.~~

~~The analog audio adapter shall identify itself by presenting a resistance to GND of ≤ Ra on both A5 (CC) and B5 (VCONN) of the USB Type-C plug. If pins A5 and B5 are shorted together, the effective resistance to GND shall be less than Ra/2.~~

~~A DFP that supports analog audio adapters shall detect the presence of an analog audio adapter by detecting a resistance to GND of less than Ra on both A5 (CC) and B5 (VCONN).~~

~~Table A-1 shows the pin assignments at the USB Type-C plug that shall be used to support analog audio.~~

~~Table A-1 USB Type-C Analog Audio Pin Assignments~~

~~Plug Pin~~	~~USB Name~~	~~Analog Audio Function~~	~~Location on 3.5 mm Jack~~	~~Notes~~
~~A5~~	~~CC~~			~~Connected to digital GND with resistance ≤ Ra.~~ ~~System uses for presence detect.~~
~~B5~~	~~VCONN~~			~~Connected to digital GND with resistance ≤ Ra.~~ ~~System uses for presence detect.~~
~~A6/B6~~	~~Dp~~	~~Right~~	~~Ring 1~~	~~Analog audio right channel~~ ~~A6 and B6 shall be shorted together in the adapter.~~
~~A7/B7~~	~~Dn~~	~~Left~~	~~Tip~~	~~Analog audio left channel~~ ~~A7 and B7 shall be shorted together in the adapter.~~
~~A8~~	~~SBU1~~	~~Mic/AGND~~	~~Ring 2~~	~~Analog audio microphone (OMTP & YD/T) or Audio GND (CTIA).~~
~~B8~~	~~SBU2~~	~~AGND/Mic~~	~~Sleeve~~	~~Audio GND (OMTP & YD/T or analog audio microphone (CTIA).~~
~~A1/A12 B1/B12~~	~~GND~~			~~Digital GND (DGND) used as the ground reference and current return for CC1, CC2, and VBUS.~~
~~A4/A9 B4/B9~~	~~VBUS~~			~~Not connected unless the audio adapter uses this connection to provide 5 V @ 500 mA for charging the system's battery.~~
~~Others~~				~~Other pins shall not be connected.~~

~~The analog audio signaling presented by the headset on the 3.5 mm jack is expected to comply with at least one of the following:~~

- ~~The traditional American headset jack pin assignment, with the jack sleeve used for the microphone signal, supported by CTIA-The Wireless Association~~
- ~~"Local Connectivity: Wired Analogue Audio" from the Open Mobile Terminal Forum (OMTP) forum~~
- ~~"Technical Requirements and Test Methods for Wired Headset Interface of Mobile Communication Terminal" (YT/D 1885-2009) from the China Communications Standards Association~~

~~When in the Audio Adapter Accessory Mode, the system shall not provide VCONN power on either CC1 or CC2. Failure to do this may result in VCONN being shorted to GND when an analog audio peripheral is present.~~

~~The system shall connect A6/B6, A7/B7, A8 and B8 to an appropriate audio codec upon entry into the Audio Adapter Accessory Mode. The connections for A8 (SBU1) and B8 (SBU2) pins are dependent on the adapter's orientation. Depending on the orientation, the microphone and analog ground pins may be swapped. These pins are already reversed between the two major standards for headset jacks and support for this is built into the headset connection of many codecs or can be implemented using an autonomous audio headset switch. The system shall work correctly with either configuration.~~

~~A.3 Electrical Requirements~~

~~The maximum ratings for pin voltages are referenced to GND (pins A1, A12, B1, and B12). The non-GND pins on the plug shall be isolated from GND on the USB Type-C connector and shall be isolated from the USB plug shell. To minimize the possibility of ground loops between systems, AGND shall~~

~~be connected to GND only within the system containing the USB Type-C receptacle. Both the system and audio device implementations shall be able to tolerate the Right, Left, Mic, and AGND signals being shorted to GND. The current provided by the amplifier driving the Right and Left signals shall not exceed ±150 mA per audio channel, even when driving a 0 Ω load.~~

~~Table A-2 shows allowable voltage ranges on the pins in the USB Type-C plug that shall be met.~~

~~Table A-2 USB Type-C Analog Audio Pin Electrical Parameter Ratings~~

~~Plug Pin~~	~~USB Name~~	~~Analog Audio Function~~	~~Min~~	~~Max~~	~~Units~~	~~Notes~~
~~A6/B6~~	~~Dp~~	~~Right~~	~~-3.0~~	~~3.0~~	~~V~~	~~A6 and B6 shall be shorted together in the analog audio adapter~~
~~A7/B7~~	~~Dn~~	~~Left~~	~~-3.0~~	~~3.0~~	~~V~~	~~A7 and B7 shall be shorted together in the analog audio adapter~~
~~A8~~	~~SBU1~~	~~Mic/AGND~~	~~-0.4~~	~~3.3~~	~~V~~	
~~B8~~	~~SBU2~~	~~AGND/Mic~~	~~-0.4~~	~~3.3~~	~~V~~	

If a liquid detection scheme is employed by a device with a USB Type-C port, the port state can be directed to the CorrosionMitigation state by first going through ErrorRecovery. In the CorrosionMitigation state, the port shall pull low with a resistance on both CC1 and CC2 less than or equal to the Maximum Impedance of Ra as specified in Table 4-28. The port should pull low with a resistance stronger than Ra to pull the voltage as low as possible. The lower the voltage, the lower the rate of corrosion. Figure A-2 and Figure A-3 show the Corrosion Mitigation pull-down resistance for ~~a Sink or DRP~~any port in the CorrosionMitigation state when connected to a Source. Alternatively, for solutions with the ability to only pull one pin low at a time, this resistance can be applied to only one of the CC pins while the other CC pin is kept open. Figure A-4 shows the pull-down resistance and open with this method. When this alternative approach is used, the voltage on the open CC pin shall be monitored to detect the presence of a pull-up from an attached Source (CC is SNK.Rp) due to a plug event with a cable or device in the opposite orientation. When the pull-up is detected, the Sink shall swap the pull-down and open between the CC pins.

Figure A-2 Corrosion Mitigation in Pull-Up/Pull-Down CC Model

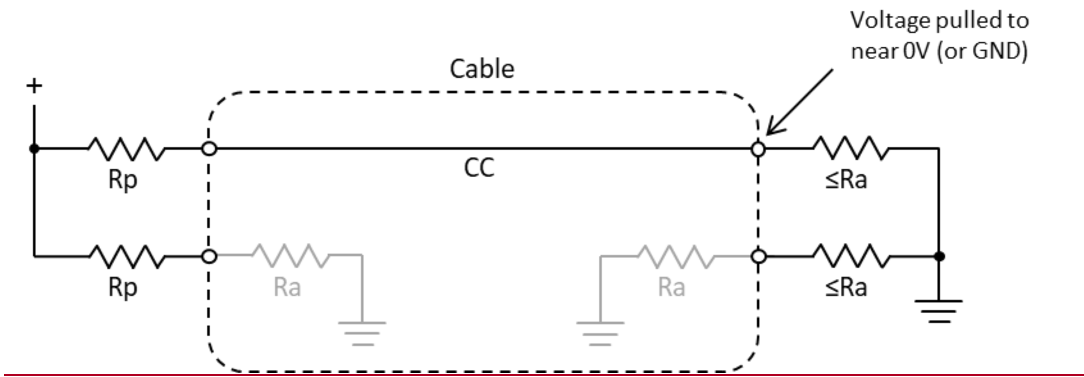


Figure A-3 Corrosion Mitigation in Current Source/Pull-Down CC Model

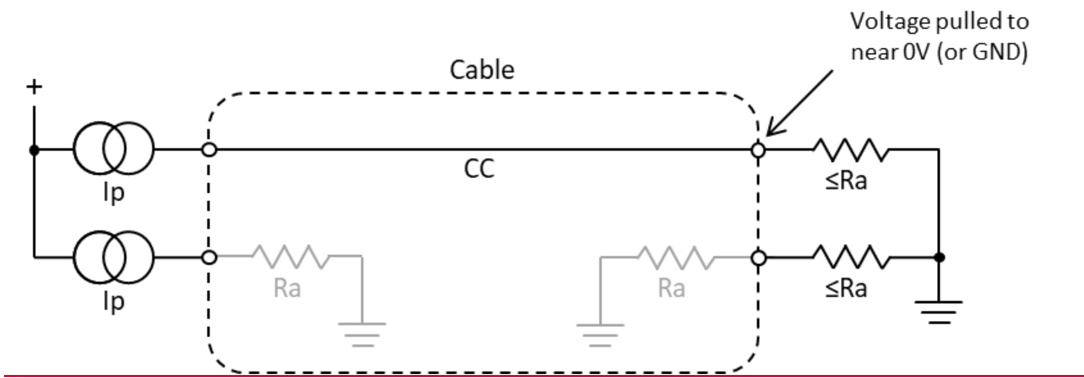
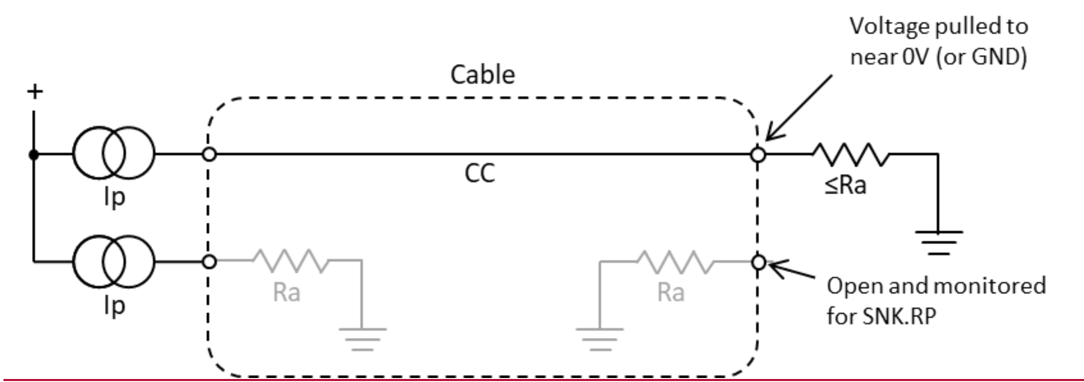


Figure A-4 Corrosion Mitigation in Current Source/Pull-Down CC Model with Alternate Mitigation.



When a Source or DRP connects to a ~~Sink~~port in the CorrosionMitigation state, it will move to the AttachWait.SRC state (two Ra detected), stay in the Unattached.SRC state (Source with single Ra detected), or continue DRP toggling (DRP with single Ra detected) ~~and stay in this state~~ until the CorrosionMitigation state is exited by the Port Partner. In these states, VBUS and VCONN are at 0V, and the CC pin will be pulled low by the attached resistance ~~on the Sink side of the cable~~of the Port Partner. All other pins should be open or pulled low. This will hold all voltages in the port low enough to stop or greatly reduce the rate of corrosion. Once a liquid condition is no longer detected, the port should be directed to exit the CorrosionMitigation state.

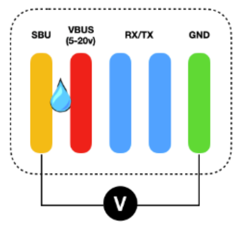
A.3 Liquid Detection Methods

Multiple methods exist to detect liquid in a port. Three possible methods are described, but this is not an exhaustive list. Other methods may be developed and used.

Leakage Measurement Method

Liquid may be detected by measuring the effect of leakage through the liquid between pins. The voltage on a pin can be measured to determine if there is a connection through this liquid to another pin. Figure A-4 shows an example of this measurement using one of the SBU pins. When the port is dry, the measurement pin should be biased to a known level based on the bias circuitry chosen. When the port is wet, DC voltages or signals may couple on the measurement pin which can be read by comparator or ADC. To use the method, various liquids should be characterized with the planned connector (metal, plating, spacing, etc.). Note, this method has low complexity, but may have only moderate sensitivity (accuracy of detection) to liquids resulting in some missed detections based on the amount of and type of liquid. This method may also have a high rate of missed detects due to the variation of the voltages to which the leakage may be connected (namely VBUS and CC). This method may also produce higher levels of false detections (other contaminants, high levels of coupling, etc.).

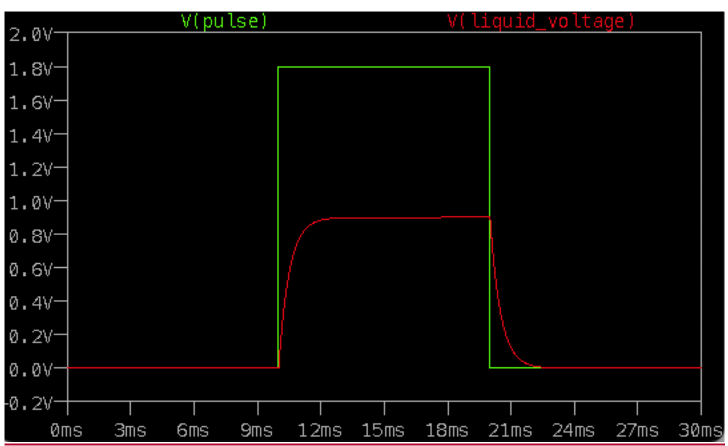
Figure A-4 Liquid Detection by Leakage Measurement



Pulsed Measurement Method

Liquid may be detected by measuring the effect of driving a pulse onto the measurement pin through a series resistance. The rise and fall behavior of the pin can be measured with a timer and comparator to determine the time it takes to cross a certain threshold. Figure A-5 shows an example of this measurement. When the port is dry, the pin voltage will pass the threshold quickly. When the port is wet, loading from the liquid and adjacent pins will cause a slower voltage rise or fall. Like the leakage measurement method, to use the pulsed measurement method, various liquids should be characterized with the planned connector (metal, plating, spacing, etc.). Note, this method is slightly more complex, but can also have only moderate sensitivity to liquids. Some missed detections based on the amount of and type of liquid may still occur. This method may also miss detections due to other pulsed signals within the port like DRP toggling. This method may also produce false detections but at a reduced rate from the leakage measurement method.

Figure A-5 Liquid Detection by Pulsed Measurement



Impedance Measurement Method

Liquid may be detected by measuring the impedance of a measurement pin. This can be done by various methods. One example method is an I-V measurement that measures both the amplitude and phase shift from a known "dry" condition. Wet or Dry conditions can be determined by the measurement impedance characteristics of the port with the liquid. Like the previous measurement methods, to use the pulsed measurement method, various liquids should be characterized with the planned connector (metal, plating, spacing, etc.). Note, this method is much more complex, but has higher sensitivity and lower false detections. Figure A-6 through Figure A-9 show examples of this measurement on various liquids taken with a Keysight E4990A impedance analyzer sweeping from 20Hz to 1MHz. Table A-1 shows the conditions for the measurements shown.

Table A-1 Example Measurement Test Conditions.

Equipment	**Model**	**Description**
Connector	JAE DX07S024JJ2R1300	USB Type-C receptacle, 24 pin SMD
Liquid dispense	Various	0.5-10µL micropipette
Equipment	Keysight E4990A	Impedance Analyzer
Artificial Sweat	1700-0020	Pickering Laboratories Artificial Eccrine Perspiration Stabilized

Figure A-6 Example Measurement of a Dry Port

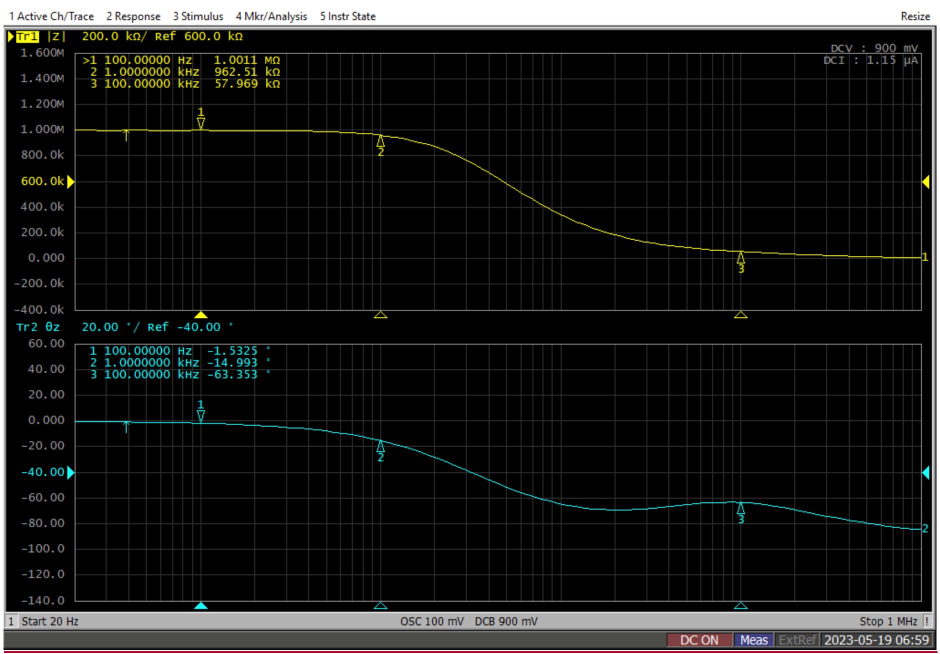


Figure A-7 Example Measurement of a Port with Reverse Osmosis Water

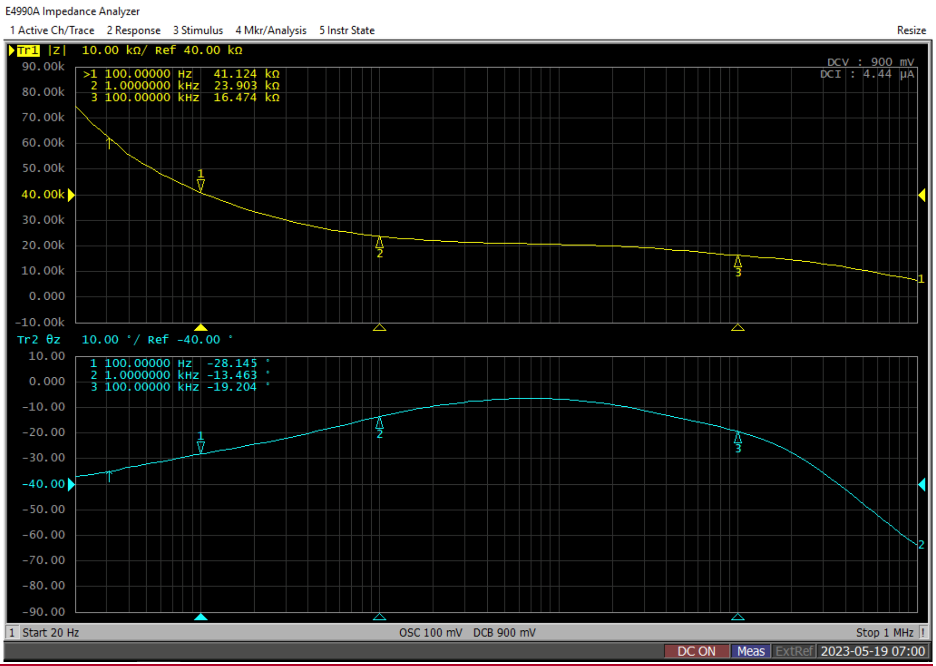


Figure A-8 Example Measurement of a Port with Tap Water

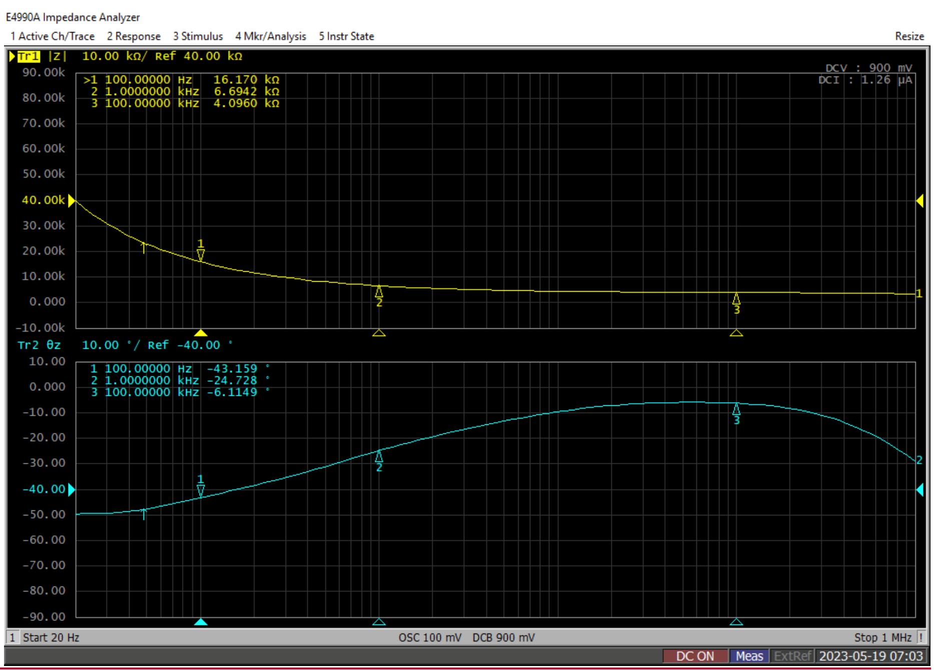


Figure A-8 Example Measurement of a Port with Artificial Sweat

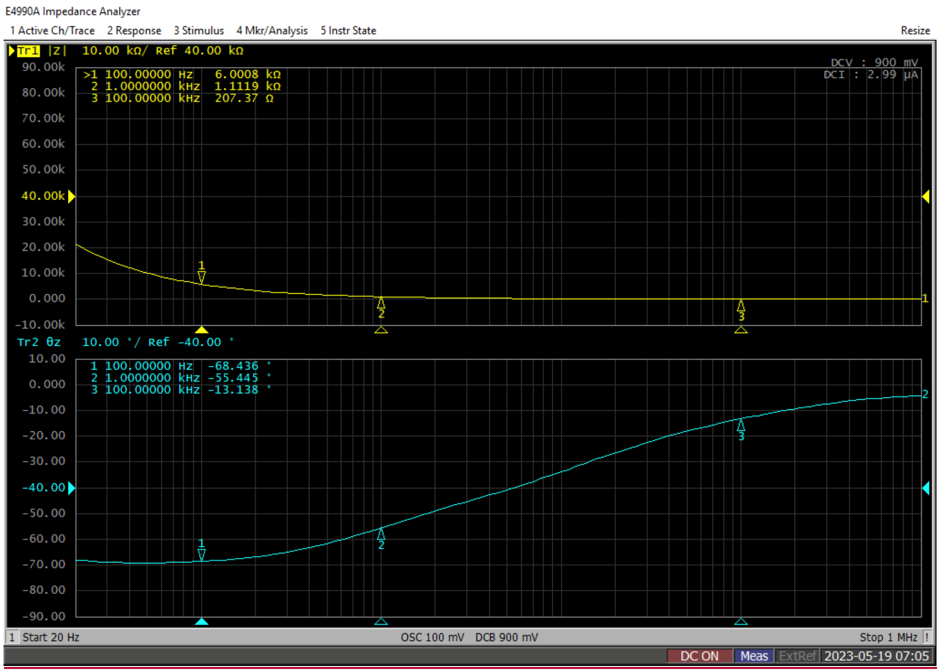
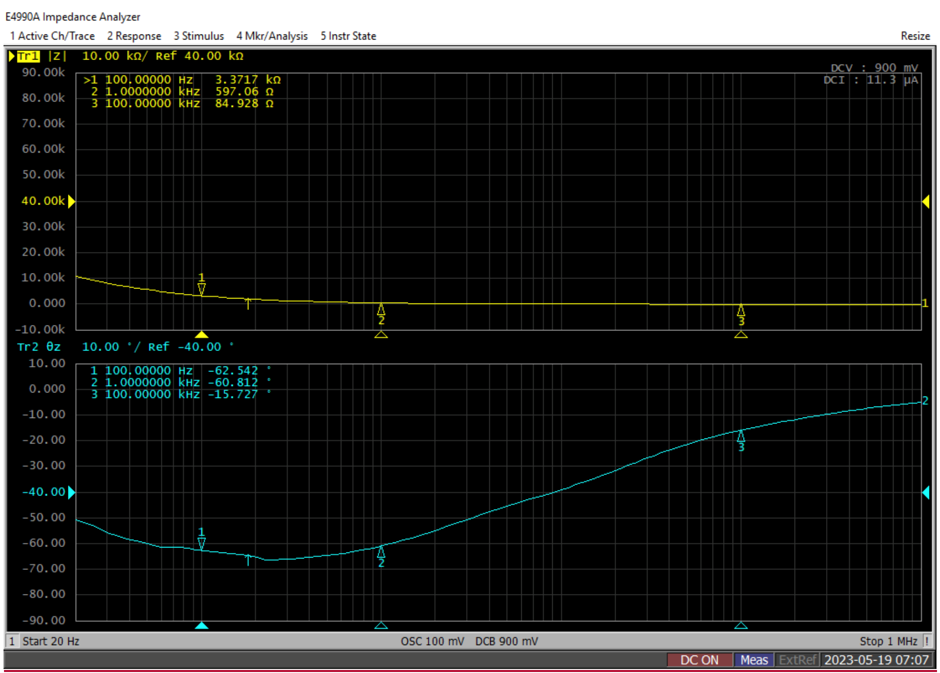


Figure A-8 Example Measurement of a Port with Ocean Water



A.4 Liquid Detection Pins in the Connector

Liquid may be detected by utilizing unused pin(s) in the connector or by adding dedicated pin(s)/pad(s) into the connector.

Key options and design areas that need attention.

1. When adding pin(s)/pad(s) to the connector, requirements found in Section 3.2.1 shall still be met.

2. This specification does not define standard locations for liquid detection pin(s)/pad(s). Figure A-9 shows a reference area within a receptacle where dedicated liquid detection (LD) pin(s)/pad(s) may be added. This region is between the normative pin mating area and the EMC pad. Utilizing this area for liquid detection pin(s)/pad(s) avoids interfering with either the normative plug pins or the EMC springs. It is recommended that the connector designer define the liquid detection pin(s)/pad(s) tolerances such that these pin(s)/pad(s) stay in the liquid detect zone in worse case tolerance.

3. Figure A-10 shows a reference receptacle with a liquid detection pad along the full width of the receptacle pins. Note, the reference receptacle shown is a PCB tongue with the ground mating locations on the metal frame encapsulating the edge.

4. Figure A-11 shows a reference receptacle with dedicated liquid detection pins between each VBUS and the adjacent CC and SBU pins. In this example, the liquid detection pins have been placed where typical corrosion damage is observed and where the connector is functionally most sensitive to shorts (impedance reduction) due to corrosion. Figure A-12 shows a view of an example surface mount footprint with the added pins. This can be applied to a vertical-mount, right-angle mount, or mid-mound receptacle.

5. Placement of the liquid detection pad or pins can affect the signal performance of the high-speed signaling path. The resulting shape and spacing of the high-speed pins should be analyzed to ensure it meets the signaling requirements of the high-speed protocol being used in the design. Interference of the high-speed signals from the liquid detection pin(s)/pad(s) due to the liquid detection method should also be analyzed.

Figure A-9 Example Liquid Detect pin(s)/pad(s) location area.

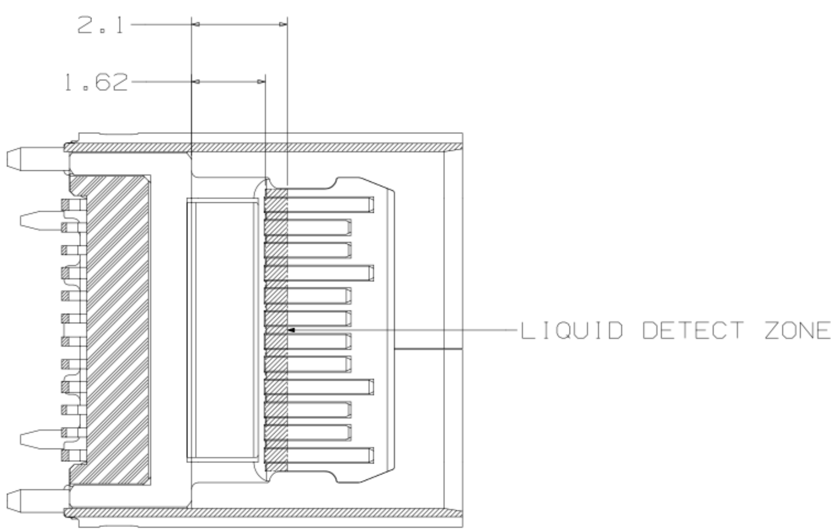


Figure A-10 Example Liquid Detect pad along all connector pins.

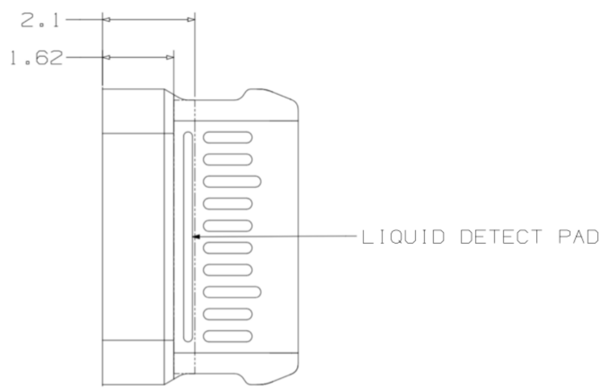


Figure A-11 Example Liquid Detect pins adjacent to VBUS/CC/SBU.

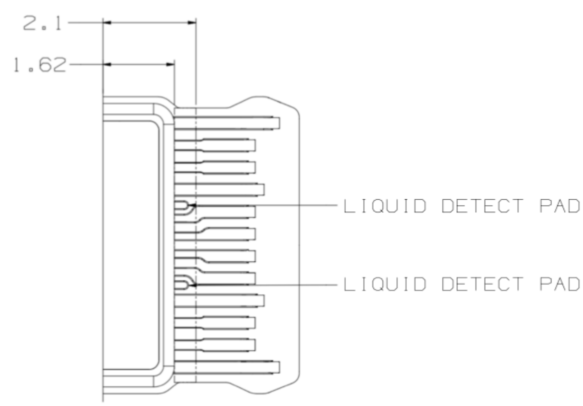
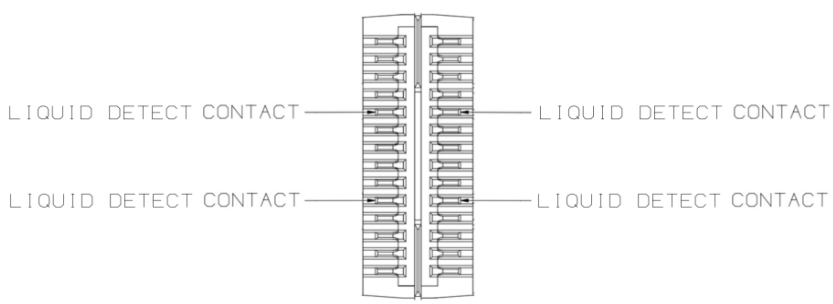


Figure A-12 Example Liquid Detect connector surface mount view.



(g) Appendix C.1

Redline changes:

C USB Type-C Digital Audio

C.1 Overview

One of the goals of USB Type-C® is to help reduce the number of I/O connectors on a host platform. One connector type that could be eliminated is the legacy 3.5 mm audio device jack. ~~While USB Type-C does include definition of an analog audio adapter accessory (see Appendix A), that solution requires a separate adapter that can be readily lost and the host implementation in support of analog audio is technically challenging. To best serve the user experience, a~~A ~~simplified~~ USB Type-C digital audio solution based on native USB protocol is a simple solution and is~~r/more~~ interoperable with both the host platform and audio device being connected directly without the need for adapters and operates seamlessly through existing USB topologies (e.g., through hubs and docks).

This appendix is for the optional normative definition of digital audio support on USB Type-C-based products. Any USB Audio Class product, having either a USB Type-C plug or receptacle, and whether it is a host system, typically an audio source, and an audio device, typically an audio sink, shall meet the requirements of this appendix in addition to all other applicable USB specification requirements.