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VESA DisplayPort Interoperability Guideline

Version 1.1

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Purpose

The purpose of this document is to set a guideline for enabling interoperability between DisplayPort Devices and DVI/HDMI Devices through cable adaptors.

Summary

This is an implementation guideline document of Source Devices and Sink Devices that support both DisplayPort and single-link DVI/HDMI operation modes (“Dual-mode Devices”). A cable adaptor converting the DisplayPort connector of a Dual-mode Device to either a DVI or HDMI connector, and the discovery mechanism of the cable adaptor are defined in this document

Furthermore, an implementation guideline of a cable adaptor with a built-in active protocol converter between a DisplayPort Device and a dual-link DVI Device is covered.

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Acknowledgements

This document would not have been possible without the efforts of VESA Display Systems Standards Committee's DisplayPort Task Group. In particular, the following individuals and their companies contributed significant time and knowledge to this version of the guideline.

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Revision History

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Changes from Ver.1.0 are as follows:

- Figure 5-1, “A Source-side Cable Adaptor Plugged to a Dual-mode Source Device”, updated
  - +3.3V termination on Main Link changed to “Vbias_RX” which must be +2.0V or less
  - +3.3V pull-up on AUX/DDC changed to “DDC_Pullup” which must be +2.0V or less
- DDC buffer ID of a Source-side HDMI Cable Adaptor incorporated as the means of distinguishing it from a Source-side DVI cable Adaptor.
- It is recommended for a Source-side Cable Adaptor to be designed so as to draw power only when the HPD signal from a Sink Device is asserted.
- Figure 5-2, “A Sink-side Cable Adaptor Plugged to a Dual-mode Sink Device”, updated
  - +3.3V termination on Main Link changed to DMSINK_TERM which is +3.3V+/-5% in DVI/HDMI mode and +2.0V or less in DisplayPort mode
- It is clarified that AUX+ be pulled down and AUX- be pulled up to +2.5 ~ +3.3V both via 100kΩ resistors on a Source Device (including a Dual-mode Source Device) and that AUX+ be pulled up to +2.5 ~ +3.3V and AUX- be pulled down both via 1MΩ resistors on a Sink Device (including a Dual-mode Sink Device).
- Sections are added to describe the distinction method of a Source-side HDMI cable adaptor from a DVI cable adaptor (Section 5.4.2) and a Sink-side HDMI cable adaptor from a DVI cable adaptor (Section 5.4.4). A Dual-mode Source Device must check an ID of a Source-side HDMI cable adaptor for the distinction while a Dual-mode Sink Device must use the voltage level of Pin 14.
- Section is added to describe the DP_PWR User detection method by a Sink Device with a permanently tethered cable (Section 5.4.5).

1 Overview

The DisplayPort Interoperability Guideline is designed to provide guidance for products that implement both DisplayPort 1.1a and either the DVI 1.0 or HDMI specification. Appropriate references to specific technical requirements within each specification are provided in this guideline document.

There is industry interest in establishing a means for achieving interoperability between DisplayPort Devices and DVI 1.0/HDMI compatible Devices. For example, it is desirable to have the ability to connect a cable between a DisplayPort Source Device and a DVI 1.0/HDMI Sink Device (or vice versa) and have the devices interoperate. This interoperability cannot currently be accomplished at the specification level, but can be accomplished at the product level for products that compliantly support both DisplayPort 1.1a and either the DVI 1.0 or HDMI specification.

This document describes the following:

- Implementation guideline for Source and Sink Devices that support both DisplayPort 1.1a and DVI 1.0/HDMI modes of operation ("Dual-mode Devices").
- Functional definition of a cable adaptor that has a DisplayPort connector on one end and either a DVI or HDMI Type A/Type C connector on the other.
- Mechanism through which a Dual-mode Device discovers the presence/absence of the cable adaptor.

When a Source-side cable adaptor is plugged into it, a Dual-mode Source Device configures itself for outputting either DVI.1.0 or HDMI compliant signals through the cable adaptor. When a Sink-side cable adaptor is plugged into it, a Dual-mode Sink Device configures itself for receiving signals that are either DVI 1.0 or HDMI compliant through the cable adaptor.

The discovery mechanism ensures that a Dual-mode Device only sends or receives either DVI 1.0 signals or HDMI signals when a valid cable adaptor is present.

The Dual-mode Devices are limited to supporting single-link DVI 1.0/HDMI specifications. For interoperability between a DisplayPort Device and a dual-link DVI 1.0 Device, a cable adaptor with a built-in active protocol converter is required. The implementation guideline for the cable adaptor with such an active protocol converter is covered in Section 7 of this document.

1.1 Glossary/Acronyms

Terminology	Definition
AUX CH	A half-duplex, bi-directional channel between DisplayPort transmitter and DisplayPort receiver. Consists of 1 differential pair transporting self-clocked data. The DisplayPort AUX CH supports a bandwidth of 1Mbps over DisplayPort link. A DisplayPort Source is the master (also referred to as AUX CH Requester) that initiates an AUX CH transaction. A DisplayPort Sink is the slave (also referred to as AUX CH Replier) that replies to the AUX CH transaction initiated by the Requester.
Box-to-box connection	A DisplayPort link between two boxes detachable by an end user. A DisplayPort cable-connector assembly for the box-to-box connection must implement four Main Link lanes.
Branch Device	A device that contains both Source and Sink functions.
CEC	Consumer Electronics Control
DDC	Display Data Channel
DisplayPort receiver	Circuitry that receives the incoming DisplayPort Main Link data. Also contains the transceiver circuit for AUX CH. Located in a Sink Device and the upstream port of a Branch Device.
DisplayPort transmitter	Circuitry that transmits the DisplayPort Main Link data. Also contains the transceiver circuit for AUX CH. Located in a Source Device and in the downstream port of Branch Device.
Dual-mode Device	A Source or Sink Device that supports DisplayPort and DVI (and/or HDMI) operating modes.
DVI 1.0	Digital Visual Interface version 1.0 specification.
EMI	Electro-Magnetic Interference
HPD	Hot Plug Detect
HDMI	High-bandwidth Digital Multimedia Interface
ID	IDentification
Main Link	A uni-directional channel for isochronous stream transport from a DisplayPort Source to a DisplayPort Sink. Consists of 1, 2, or 4 lanes, or differential pairs. Supports two bit rates: 2.7Gbps per lane (referred to as a “high bit rate”) and 1.62Gbps per lane (referred to as a “low bit rate” or “reduced bit rate”).
Sink Device	A device that contains A/V stream sinks for display and/or sound.
Source Device	A device that contains a stream source and originates an isochronous A/V stream.

1.2 References

Document	Version/revision	Date
VESA DisplayPort	Version 1.1a	January 11, 2008
DVI Specification	Revision 1.0	April 2, 1999
HDMI Specification	Revision 1.3a	November 10, 2006

2 Symbol for Dual-mode Devices

It is recommended that Dual-mode Devices include an icon or label next to the DisplayPort connector indicating that the device also supports DVI 1.0 or HDMI in addition to DisplayPort.

A “++” symbol in conjunction with the DisplayPort logo as shown in Figure 2.1 is the preferred icon to indicate the Dual-mode device capability.

A Dual-mode Device must pass the DisplayPort compliance tests in order to use the DisplayPort logo.

Figure 2-1: A Dual-mode Device Indication Symbol

3 DisplayPort Cable Adaptor Types

A cable adaptor may be designed in varying form factors. This section shows a few examples. It is emphasized that the cable adaptor must have a DisplayPort plug connector on one end and either a DVI or HDMI (Type A or Type C) receptacle connector on the other end.

One exception is a cable adaptor for a Dual-mode Sink Device with a permanently tethered cable for which a cable adaptor with DisplayPort receptacle connector is used. For a Sink-side DVI cable adaptor with a DisplayPort receptacle connector, the other end may be either a DVI plug or receptacle connector. For a Sink-side HDMI cable adaptor, the other end must be an HDMI receptacle connector regardless of whether it has a DisplayPort plug or receptacle connector.

3.1 Pig Tail (Cable Adaptor with a Short Cable)

Figure 3-1 shows a conceptual view of a pigtail design cable adaptor with a DVI receptacle connector.

Figure 3-1: A Pigtail-Type Cable Adaptor with a DVI Receptacle Connector

3.2 Coupler

A cable adaptor may also be implemented in a molded form factor such as a coupler. Figure 3-2 shows a conceptual view of coupler based cable adaptors with DVI receptacle connectors.

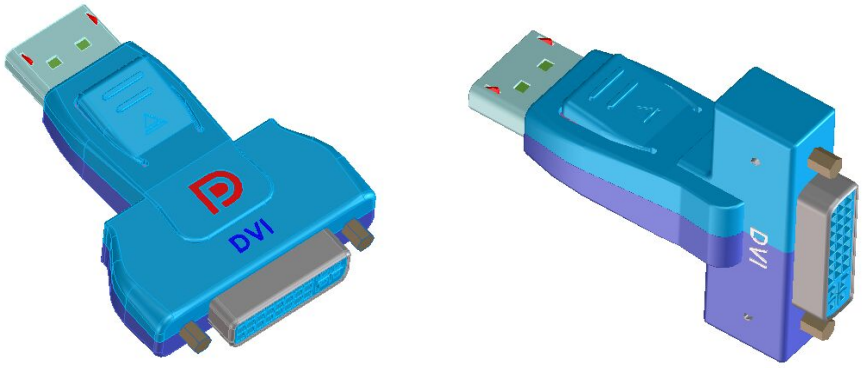

Figure 3-2: Coupler-Type Cable Adaptors with DVI Receptacle Connectors

3.3 A Sink-side Cable Adaptor for a Dual-mode Sink with a Tethered Cable

An example of a Sink-side cable adaptor for a Dual-mode Sink device with a permanently tethered cable is shown in Figure 3-3.

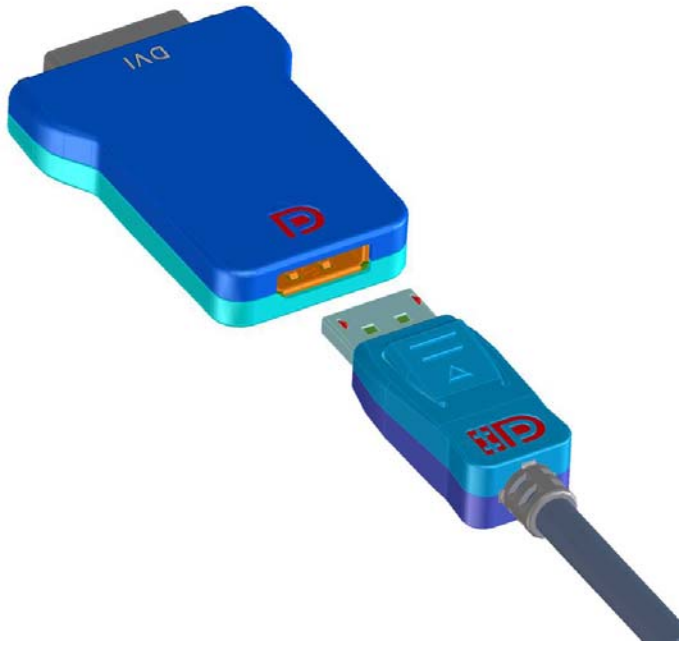

Figure 3-3: A Sink-side Cable Adaptor for Dual-mode Sink with a Tethered Cable

4 Cable Adaptor Mechanical Definitions

As noted in Section 3, it is emphasized that a cable adaptor must have a DVI or HDMI (Type A or Type C) receptacle connector. One exception is a Sink-side DVI cable adaptor for a Dual-mode Sink Device with a permanently tethered cable. For this Sink-side DVI cable adaptor, the DVI connector may be either a receptacle or plug connector. An HDMI cable adaptor must always have an HDMI receptacle connector.

4.1 Mechanical Drawings – DisplayPort Connector

Refer to DisplayPort Version. 1.1a for the definition and drawings for the DisplayPort connector.

4.2 Mechanical Drawings – DVI 1.0 Connector

Refer to the DVI 1.0 Specification for the definition and drawings for the DVI 1.0 connector.

4.3 Mechanical Drawings – HDMI Connector

Refer to the HDMI Specification Version 1.3a for the definition and drawings for the HDMI Type A/Type C connectors.

5 Electrical and Protocol Definitions

This section describes the electrical definitions of the cable adaptors and the pin-mapping/cable adaptor discovery mechanism of the Dual-mode Devices.

With Dual-mode/DisplayPort-only Source/Sink Devices and Source-/Sink-side cable adaptors, there are numerous connection scenarios. Those connection scenarios, including reverse plug conditions, are examined in Section 6.

An un-powered Dual-mode Device/cable adaptor may be connected to a powered Device. Implementations of the Dual-mode Device and the cable adaptor must incorporate the protection against accidental power-up in such conditions.

5.1 Cable Adaptor Electrical Components and Pin Mapping

A Source-side cable adaptor is covered in Section 5.1.1 and a Sink-side cable adaptor is covered in Section 5.1.2

5.1.1 Source-side Cable Adaptor Electrical Components and Pin Mapping

Figure 5-1 shows a Source-side cable adaptor plugged to a Dual-mode Source Device.

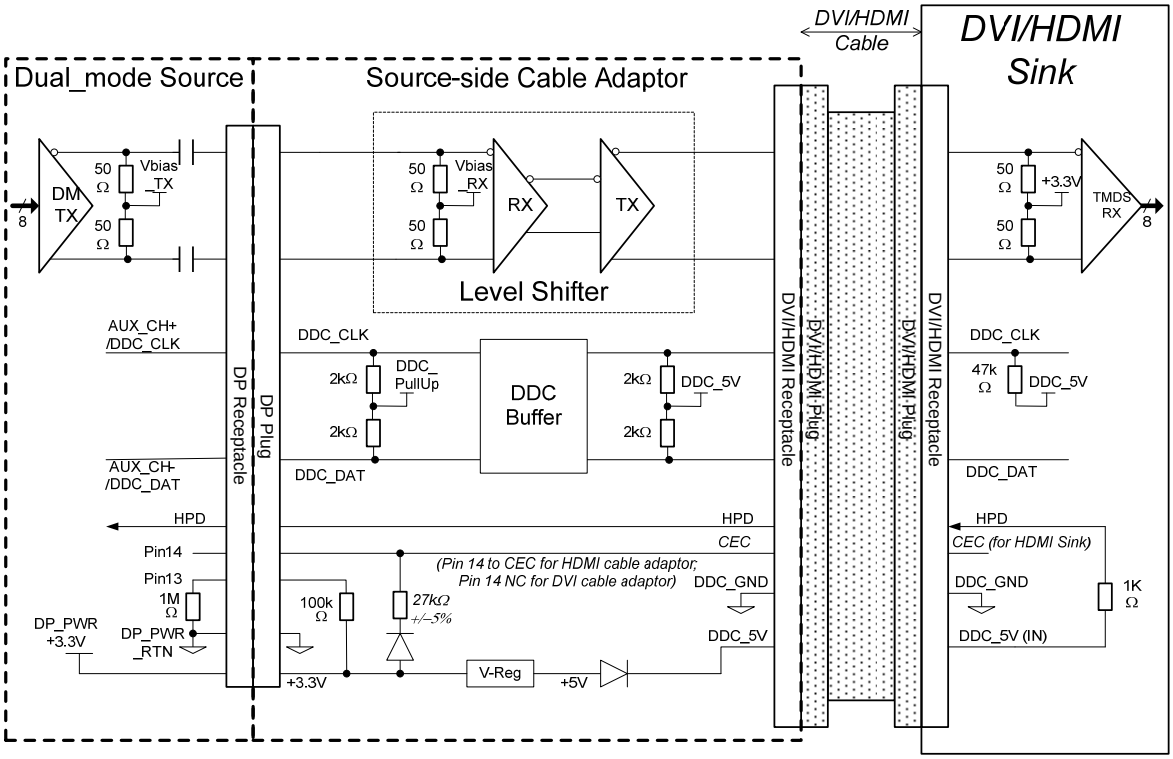

Figure 5-1: A Source-side Cable Adaptor Plugged to a Dual-mode Source Device

DDC_Pullup voltage must be +3.3V+/-10%.

The 27kΩ pull-up resistor and a diode on Pin 14 is for an HDMI cable adaptor only. Pin 14 must be a “no connect” inside a DVI cable adaptor. A Dual-mode Source Device that supports an HDMI mode may have a 5MΩ (or larger) pull-down resistor on Pin 14 to detect the presence of the pull-up

on Pin 14 inside the cable adaptor. It should be noted that other HDMI devices may be momentarily pulling down Pin 14 as part of CEC protocol.

The Source-side cable adaptor should have the following electrical components:

- An active level shifting circuit on Main Link
- A buffer for DDC signals
    - For a Source-side HDMI cable adaptor, this DDC buffer must store the ID shown in 0 below at I^2C Device Address 80h/81h
    - The DDC buffer for a Source-side DVI cable adaptor must not have this ID.
- Pull-up resistors for DDC Clock and DDC Data
- A pull-up resistor for Pin 13 of DisplayPort plug connector for cable adaptor detection
- A pull-up resistor and a diode for Pin 14 of DisplayPort plug connector (for HDMI cable adaptor only)
- A voltage regulator to generate DDC_5V and Vbias_RX from DP_PWR
- A DisplayPort 1.1a plug connector
- A DVI 1.0 or HDMI (Type A or Type C) receptacle connector

Table 5-1: DDC Buffer ID of a Source-side HDMI Cable Adaptor

Offset	0	1	2	3	4	5	6	7	8	9	Ah	Bh	Ch	Dh	Eh	Fh
Data	44h	50h	2Dh	48h	44h	4Dh	49h	20h	41h	44h	41h	50h	54h	4Fh	52h	04h

It is recommended that the Source-side cable adaptor is designed so as to draw power only when the HPD signal from a Sink Device is asserted high to minimize unnecessary power when a cable is not plugged to the cable adaptor.

When a Source-side cable adaptor is discovered, the Dual-mode Source Device re-configures the DisplayPort connector pins in DVI/HDMI mode as shown below,

Dual-mode Source Device Pin Mapping

DisplayPort Pins	DVI 1.0/HDMI Mode
Main Link Lane 0	Channel 2
Main Link Lane 1	Channel 1
Main Link Lane 2	Channel 0
Main Link Lane 3	Channel Clock
AUX CH+	DDC Clock
AUX CH-	DDC Data
DP_PWR (+3.3V)	DP_PWR
Hot Plug Detect	Hot Plug Detect
Pin 13	Cable Adaptor Detect (Optional)
Pin 14	CEC (HDMI cable adaptor only)

Monitoring of the voltage level on Pin 13 by a Dual-mode Source Device is optional. Instead of monitoring the voltage level, a Dual-mode Source Device may attempt an AUX CH read transaction and, if the transaction fails, a DDC transaction to discover the presence/absence of a cable adaptor.

For a DDC transaction, a Dual-mode Device must isolate the AC-coupling capacitors of the AUX CH signal lines from the DDC signals lines, regardless of whether Pin 13 voltage level is monitored or not. Figure 5-3 and Figure 5-4 show an example of how this isolation can be realized.

As for the DP_PWR voltage, a Dual-mode Source Device must set it to +3.3V+/-10%. A cable adaptor generates DDC_5V from this DP_PWR as shown in Figure 5-1.

5.1.2 Sink-side Cable Adaptor Electrical Components and Pin Mapping

Figure 5-2 shows a Sink-side cable adaptor plugged to a Dual-mode Sink Device.

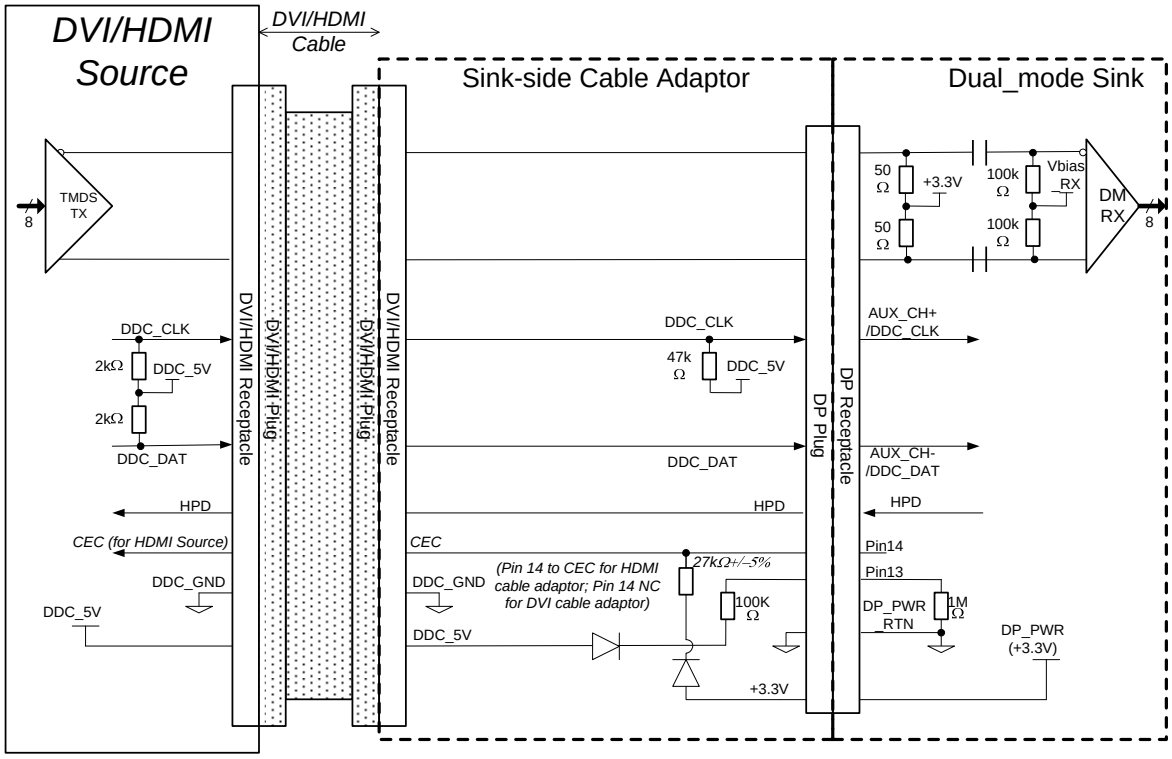

Figure 5-2: A Sink-side Cable Adaptor Plugged to a Dual-mode Sink Device

DMSINK_TERM of a Dual-mode Sink Device must be +3.3V+/-5% in DVI/HDMI mode and +2.0V or less in DisplayPort mode.

The 27kΩ pull-up resistor and a diode on Pin 14 is for an HDMI cable adaptor only. Pin 14 must be a “no connect” inside a DVI cable adaptor. A Dual-mode Source Device that supports HDMI mode may have a 5MΩ (or larger) pull-down resistor on Pin 14 to detect the presence of the pull-up on Pin 14 inside the cable adaptor. It should be noted that other HDMI devices may be momentarily pulling down Pin 14 as part of CEC protocol.

A Dual-mode Sink Device asserts HPD signal only when it is locally powered instead of when DDC_5V is present. The Dual-mode Sink Device EDID is readable only when the Sink Device is powered.

The Sink-side cable adaptor should have the following electrical components:

- A pull-up resistor for DDC Clock
- A Diode and a pull-up resistor for Pin 13 of DisplayPort plug connector for cable adaptor detection
- A pull-up resistor and a diode for Pin 14 of DisplayPort connector (for HDMI cable adaptor only)
- A DisplayPort 1.1a plug connector
- A DVI 1.0 or HDMI (Type A or Type C) receptacle connector

A Sink-side cable adaptor for a Dual-mode Sink Device with a permanently tethered cable will have a DisplayPort receptacle connector instead of a DisplayPort plug connector and may have a DVI plug connector.

When a Sink-side cable adaptor is discovered, the Dual-mode Sink Device re-configures the DisplayPort connector pins in DVI/HDMI mode as shown below.

Dual-mode Sink Device Pin Mapping

DisplayPort Pins	DVI 1.0/HDMI Mode
Main Link Lane 0	Channel Clock
Main Link Lane 1	Channel 0
Main Link Lane 2	Channel 1
Main Link Lane 3	Channel 2
AUX CH+	DDC Clock
AUX CH-	DDC Data
DP_PWR	DP_PWR
Hot Plug Detect	Hot Plug Detect
Pin 13	Cable Adaptor Detect
Pin 14	CEC (HDMI cable adaptor only)

The DP_PWR output of a Dual-mode Sink Device is not used in the cable adaptor. DDC5V pin of the DVI 1.0/HDMI receptacle connector is connected to Pin 13 via a diode and a 100 kΩ resistor to pull up the pin as shown in Figure 5-2.

5.2 DDC and AUX CH Signal Routing

Source and Sink Devices that support both DisplayPort 1.1a and DVI 1.0/HDMI should route the AUX CH and DDC signals as shown in Figure 5-3 and Figure 5-4. A pair of switches is placed on the AUX CH lines in these Dual-mode Source and Sink Devices to control the mapping of the DDC signals. The switches are OFF when a cable adaptor is attached as Pin 13 of DisplayPort connector is pulled up, and are ON when a cable adaptor is not attached as the Pin 13 is pulled down as can be seen in Figure 5-1 and Figure 5-2.

Though it is not shown in Figure 5-3 below, AUX+ must be pulled down to ground via 100kΩ resistor and AUX- pulled up to +3.3V via 100kΩ resistor for Source Device and powered Source Device detection purposes, respectively as in the main DisplayPort Specification.

As stated in Section 5.1.1, monitoring of Pin 13 voltage level is optional for a Dual-mode Source Device.

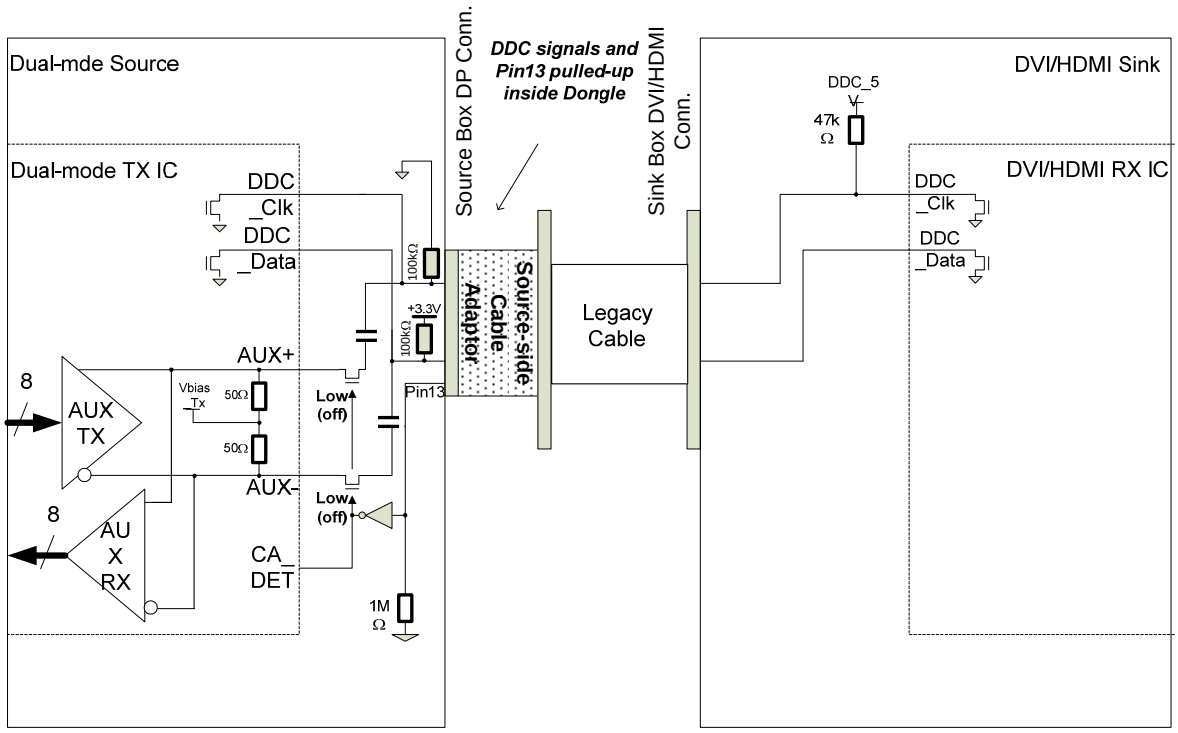

Figure 5-3: DisplayPort to DVI 1.0/HDMI Sink Device DDC Mapping

As is the case with any DisplayPort Sink Devices, Dual-mode Sink Devices must have AC coupling capacitors on the AUX/DDC lines as shown in Figure 5-4. Furthermore, a Dual-mode Sink Device, just like any other DisplayPort Sink Device must have AUX+ weakly pulled up to +2.5 ~ +3.3V and AUX- weakly pulled down both via 1MΩ resistors.

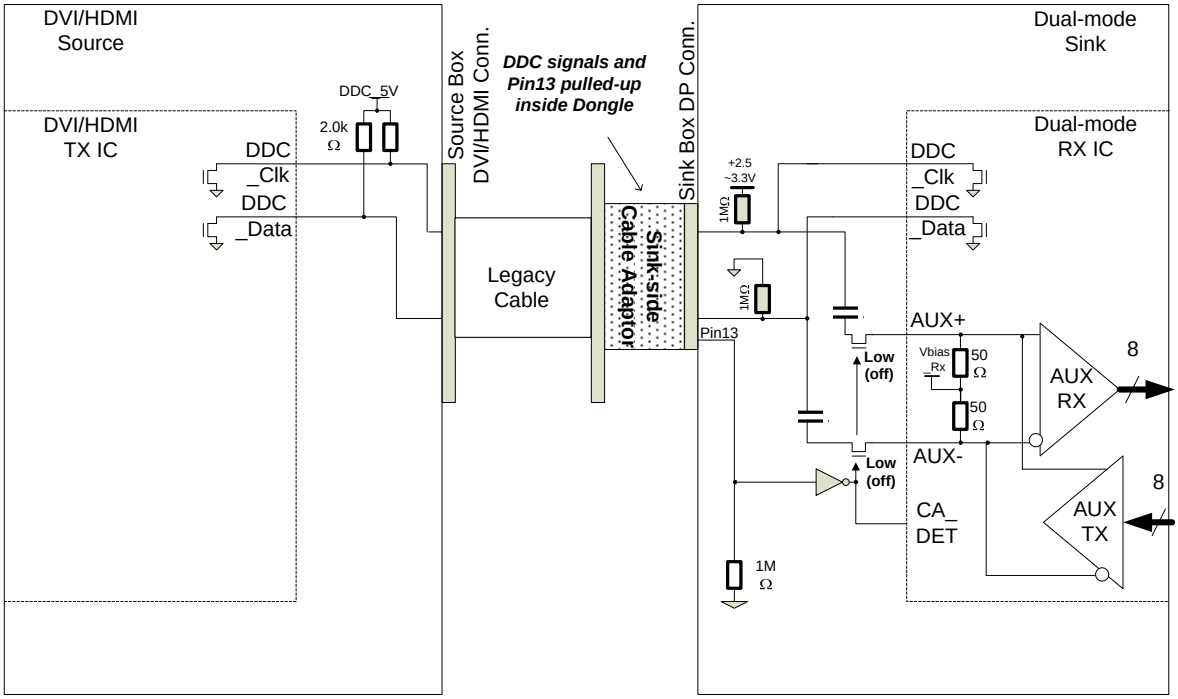

Figure 5-4: DisplayPort to DVI 1.0/HDMI Sink Device DDC Mapping

5.3 CEC Mapping for HDMI Cable Adaptor

Source and Sink Devices that support both DisplayPort 1.1a and HDMI must map the CEC signal to Pin 14 of a DisplayPort connector. Pin 14 may be weakly pulled down in the Dual-mode Device via a 5MΩ (or larger) resistor that supports both DisplayPort 1.1a and HDMI, and is pulled up to +3.3V via 27kΩ resistor and diode in the HDMI cable adaptor.

Within a DVI cable adaptor, Pin 14 must not be connected.

5.4 Cable Adaptor Discovery Mechanism

The presence/absence of a cable adaptor is discovered by the Dual-mode Source and Sink Devices using the procedure described in this section.

5.4.1 Cable Adaptor Discovery by a Dual-mode Source Device

A Dual-mode Source Device is recommended to power up with both DDC and AUX CH disabled. After initialization, the Source Device is recommended to detect CA_DET (Cable Adaptor Detection) voltage level.

- If below V_{IL}, the cable adaptor is plugged

- Configures itself either as DVI or HDMI Source, and enables DDC, while keeping AUX CH disabled.
- A Dual-mode Source Device that supports both DisplayPort and HDMI may check the voltage level of Pin 14 which is to carry CEC signal.

- If above V_{IH}, the cable adaptor is not plugged
  - Configures itself as DP Source and enables AUX CH, while keeping DDC disabled.

A Dual-mode Source Device continues to monitor Pin 13 voltage level to detect either detachment or attachment of the cable adaptor.

Optionally, a Dual-mode Source Device may attempt an AUX CH transaction, and if it fails, a DDC transaction to detect the presence/absence of the cable adaptor, instead of monitoring CA_DET voltage level.

5.4.2 Distinction of a Source-side HDMI Cable Adaptor

A Dual-mode Source Device should distinguish a Source-side HDMI cable adaptor from a DVI cable adaptor by checking the DDC buffer ID as described in 0.

5.4.3 Cable Adaptor Discovery by a Dual-mode Sink Device

A Dual-mode Sink Device is recommended to power up with both DDC and AUX CH disabled and HPD signal driven low. After initialization, the Sink Device is recommended to detect CA_DET (Cable Adaptor Detection) voltage level while keeping HPD signal low.

- If below V_{IL}, the cable adaptor is plugged
  - Configures itself either as DVI or HDMI Sink and enables DDC, while keeping AUX CH disabled.
  - Sink Device that supports both DisplayPort and HDMI may check the voltage level of Pin 14 which is to carry CEC signal.
- If above V_{IH}, the cable adaptor is not plugged
  - Configures itself as DisplayPort Sink and enables AUX CH, while keeping DDC disabled.

The Dual-mode Sink Device asserts its HPD signal only after the presence/absence of a Sink-side cable adaptor is discovered. The Sink Device continues to monitor the CA_DET voltage levels to detect the detachment or attachment of the cable adaptor.

5.4.4 Distinction of a Sink-side HDMI Cable Adaptor

A Dual-mode Sink Device must distinguish a Sink-side HDMI cable adaptor from a DVI cable adaptor by checking the voltage level of Pin 14. It should be noted that Pin 14 may be momentarily pulled low by another HDMI Device.

5.4.5 Detection of a DP_PWR User by a Dual-mode Sink Device with a Permanently Tethered Cable

A DisplayPort Sink Device with a permanently tethered cable must first detect the presence of a DP_PWR User before enabling DP_PWR output. The DP_PWR User has a short (smaller than 100Ω) between Pin 13 and Pin 14 of DisplayPort connector.

A Sink Device with a permanently tethered cable may continuously send a probe power to Pin 14 and looks for "H" voltage level on Pin 13. When the H level is detected, that means one of the following:

- A DP_PWR User is connected
- A Sink-side HDMI/DVI cable adaptor is connected

The Sink Device then withdraws a probe power from Pin 14 and checks if Pin 14 and Pin 13 will become L level.

Table 5-2: DP_PWR User Detection by a Sink with a Permanently Tethered Cable

Pin 13	Pin 14	DP_PWR User Present?	Following Action by a Sink Device with a permanently tethered cable
H	H	No. A Sink-side HDMI cable adaptor plugged.	Keep DP_PWR output disabled.
H	L	No. A Sink-side DVI cable adaptor plugged	Keep DP_PWR output disabled.
L	H	No.	Keep DP_PWR output disabled.
L	L	Yes.	o Latch DP_PWR USER Present status o Enable DP_PWR output. o Start monitoring AUX+ and AUX- for detection of Source and powered Source. o Clear DP_PWR_USER Present status when Source and powered Source are detected absent.

Pin 14 of the DisplayPort connector may be used to carry HDMI CEC signal. Therefore, the Sink Device with a permanently tethered cable must apply the probe voltage through a weak current source so as not disturb a CEC operation that may be on-going.

5.5 AC/DC-Coupling Conversion of High Speed Differential Signals

DisplayPort is an AC-coupled link while DVI 1.0 and HDMI are a DC-coupled link. Therefore, a conversion between AC-coupling and DC-coupling through level shifting is needed for a Dual-mode Device to interoperate with DVI 1.0/HDMI Devices.

5.5.1 Conversion for a Dual-mode Source and a Source-side Cable Adaptor

As can be seen in Figure 5-1, the conversion is done by an active level shifter circuit in the Source-side cable adaptor.

5.5.2 Conversion for a Dual-mode Sink and a Sink-side Cable Adaptor

As can be seen in Figure 5-2, level shifting is done inside the Dual-mode Sink Device. No level shifting is done within the Sink-side cable adaptor.

5.6 High-Speed Differential Pair Electrical Specification of Cable Adaptor

This section describes the high-speed differential pair electrical specification of the cable adaptor. In developing a Dual-mode Source Device, a system implementer must take the loss within the cable adaptor into consideration to make sure that the eye opening specification of either DVI 1.0 or HDMI Specification is met at the DVI or HDMI receptacle connector of the cable adaptor. Similarly, a developer of a Dual-mode Sink Device must take into account the loss within the cable adaptor.

The use of a cable adaptor with a Source or Sink Device will in effect transpose the test points in the DVI 1.0/HDMI specification to the end of the cable adaptor.

For a cable adaptor connected to a Source Device, the opposite end of the cable adaptor to the Source Device (either a DVI or HDMI receptacle connector) is considered the TP2 test point and will be compliant with either the DVI 1.0 or HDMI specification at this point.

Similarly, for a cable adaptor connected to a Sink Device, the opposite end of the cable adaptor to the Sink Device (either DVI or HDMI receptacle connector) is considered the TP3 test point and will be compliant with either the DVI 1.0 or HDMI specification at this point.

The jitter and EYE Height specification in the following sections must be measured using the methods described in the DVI 1.0 and HDMI specifications.

5.6.1 Entry EYE Mask at a DisplayPort Plug – a Source-side Cable Adaptor

The EYE opening of differential signals at a DisplayPort plug connector when it enters the cable adaptor must meet the following specification:

- Clock Jitter <= 0.21 UI
- Data Jitter <= 0.26 UI
- EYE Height >= 300 mVdiff_pp, <= 1200 mVdiff_pp

5.6.2 Exit Eye Mask at a DVI/HDMI Receptacle - a Source-side Cable Adaptor

The EYE opening of differential signals at either a DVI or HDMI receptacle connector when it exits the cable adaptor must be equal to or larger than the eye masks at TP2 in DVI 1.0 specification or and that of TP1 in HDMI specification, respectively. Namely,

- Clock Jitter <= 0.25 UI
- Data Jitter <= 0.30 UI
- EYE Height >= 800 mVdiff_pp, <=1200 mVdiff_pp

5.6.3 Entry Eye Mask at a DVI/HDMI Receptacle – a Sink-side Cable Adaptor

The EYE opening of differential signals at either a DVI or HDMI receptacle connector when it enters the Sink-side cable adaptor is expected to be equal to or larger than the eye masks at TP3 defined in DVI 1.0 specification or that at TP2 in HDMI specification. Namely,

- Clock Jitter <= 0.30 UI
- Data Jitter <= 0.50 UI
- EYE Height >= 150 mVdiff_pp, <=1200 mVdiff_pp

5.6.4 Exit Eye Mask at a DisplayPort Plug – a Sink-side Cable Adaptor

The EYE opening of differential signals at a DisplayPort plug connector when it exits the cable adaptor must meet the following specification:

- Clock Jitter < = 0.32 UI
- Data Jitter <= 0.52 UI
- EYE Height >= 120 mVdiff_pp, <=1200 mVdiff_pp

5.6.5 Exit Eye Mask at a DisplayPort Receptacle – a Sink-side Cable Adaptor for a Sink Device with a Tethered Cable

The entry EYE opening of differential signals at a DVI plug connector of a Sink-side cable adaptor for a Dual-mode Sink Device with a permanently tethered cable is expected to meet the TP2 specification in DVI 1.0 specification.

- Clock Jitter <= 0.25 UI
- Data Jitter <= 0.30 UI
- EYE Height >= 800 mVdiff_pp, <=1200 mVdiff_pp

Upon this entry EYE opening, the exit EYE of the Sink-side cable adaptor must meet the following specification:

- Clock Jitter <= 0.27 UI
- Data Jitter <= 0.32 UI
- EYE Height >= 640 mVdiff_pp, <= 1200 mVdiff_pp

5.6.6 Guideline for EMI Management

Because of the complex nature of EMI, it is difficult to specify a component level EMI requirement for the cable adaptor assembly. However, designers need to pay particular attention to receptacle and cable plug shielding to ensure a low impedance ground return path. The following are a few guidelines for EMI management:

- For cable adaptors with a cable section (for example, a pigtail-type cable adaptor shown in Figure 3-1 on p. 12), the quality of the raw cable should be ensured. The intra-pair skew of the clock pair has a significant impact on the cable EMI performance and it should be minimized. The cable external braid should be terminated to the cable plug shell as close to 360˚ as possible. Without appropriate shielding termination, even a perfect cable with zero intra-pair skew can compromise EMI.
- The mating interface between the receptacle and cable plug should have four or more grounding fingers, or springs, to provide a continuous return path from the cable plug to system ground. Note that some commercially available HDMI receptacles omit this feature.
- The receptacle connector should be well grounded to the system through grounding fingers, screws, or any other means to mitigate EMI.

5.7 Parasitic Capacitance of DDC Lines of a Sink-side Cable Adaptor and a Dual-mode Sink Device

The parasitic capacitance of the DDC lines within a Dual-mode Sink Device must be kept to 30pF or less. That of a Sink-side cable adaptor must be kept to 20pF or less.

A DDC buffer is required inside a Source-side cable adaptor. The parasitic capacitance of the DDC lines between the buffer and a DVI/HDMI connector must be kept to 50pF or less.

6 Operations in Various Connection Scenarios

This chapter examines the operations in various connection scenarios. Even if the cable adaptor is connected to the wrong Device, there will be no resulting damage.

6.1 A Dual-mode Source with a Source-side Cable Adaptor

As described in Section 5.1.1 a Dual-mode Source Device configures itself as a DVI 1.0/HDMI Source Device.

6.2 A Dual-mode Sink with a Sink-side Cable Adaptor

As described in Section 5.1.2, a Dual-mode Sink Device configures itself as a DVI 1.0/HDMI Sink.

6.3 A Dual-mode Source to a Dual-mode Sink

There are two connection scenarios:

- A Dual-mode Source connected to a Dual-mode Sink without cable adaptors
- A Dual-mode Source connected to a Dual-mode Sink with two cable adaptors

6.3.1 Dual-mode Source/Sink without Cable Adaptors

Cable adaptors are not detected on either end and the link operates in a DisplayPort mode.

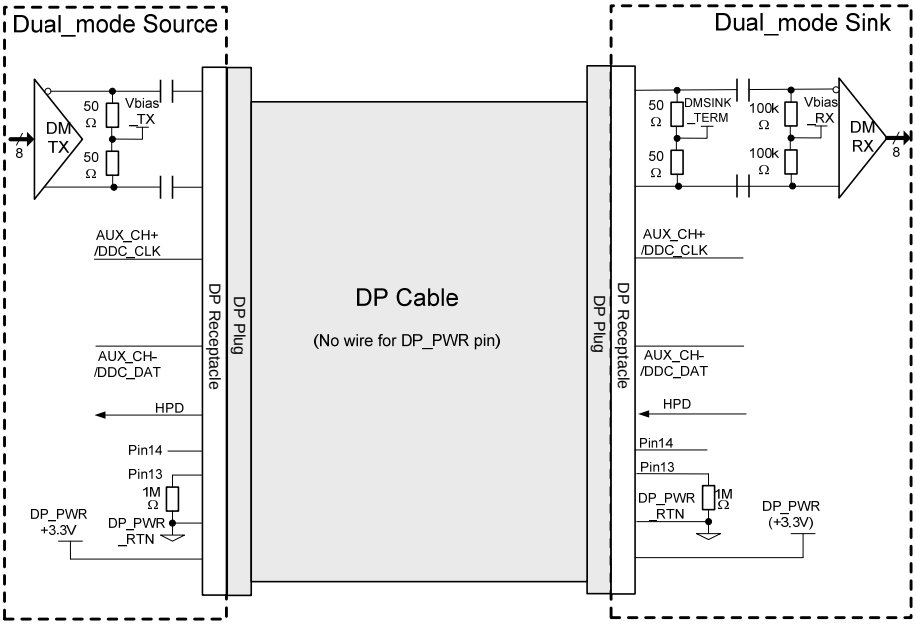

Figure 6-1: Dual-mode Source and Sink without Cable Adaptors

6.3.2 Dual-mode Source/Sink with Cable Adaptors

Cable adaptors are detected on both ends and the link operates in a DVI/HDMI mode.

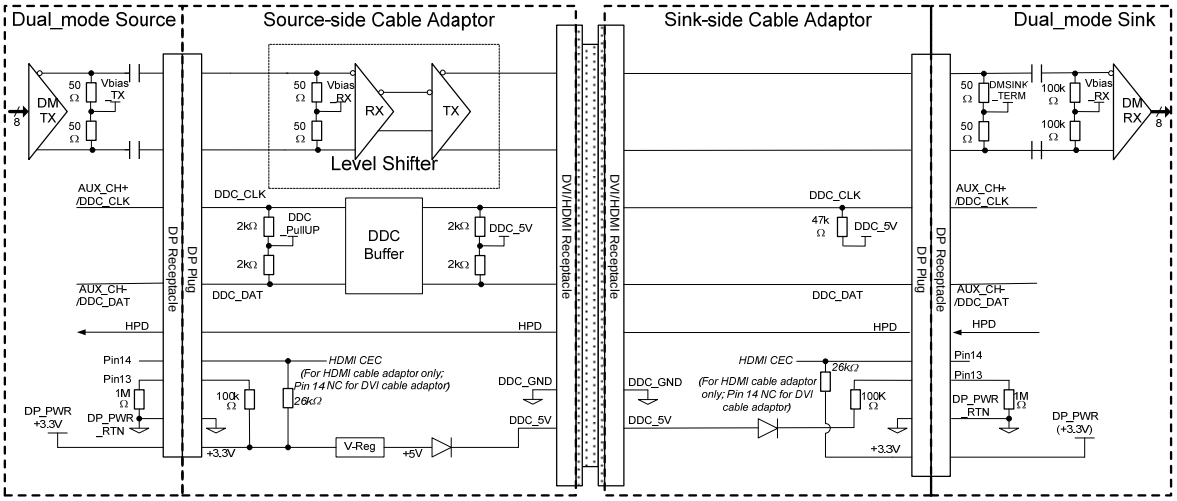

Figure 6-2: Dual-mode Source and Sink via Cable Adaptors

Note: The termination voltage of the level shifter may be different from +3.3V. If the termination voltage, Vbias_Rx is different from +3.3V, the cable adaptor must generate the Vbias_Rx.

6.4 A Dual-mode Source to a DP-only Sink

Cable adaptors are not detected on either end and the link operates in DisplayPort mode.

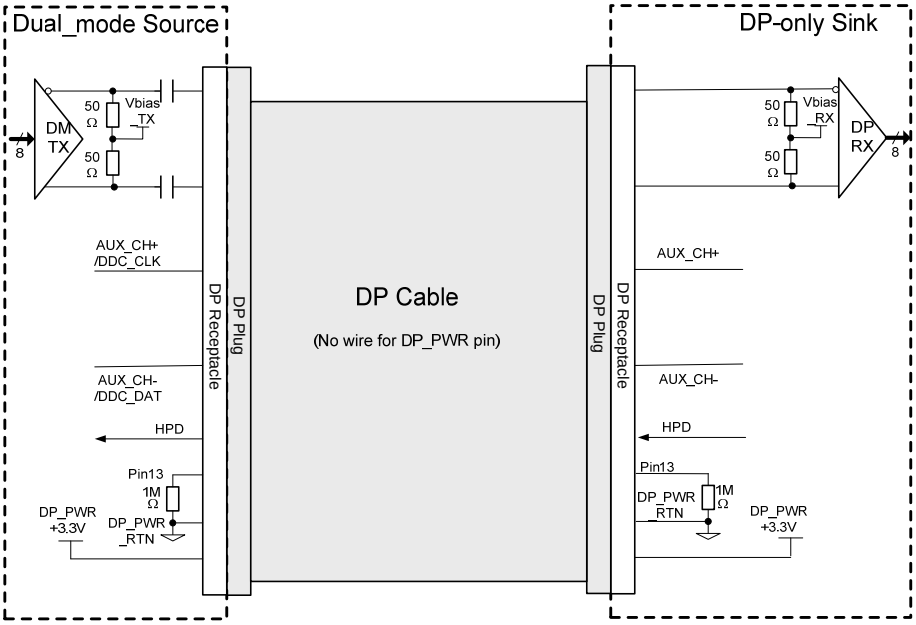

Figure 6-3: A Dual-mode Source to a DisplayPort-only Sink

6.5 A DP-only Source to a Dual-mode Sink

Cable adaptors are not detected on either end and the link operates in a DisplayPort mode.

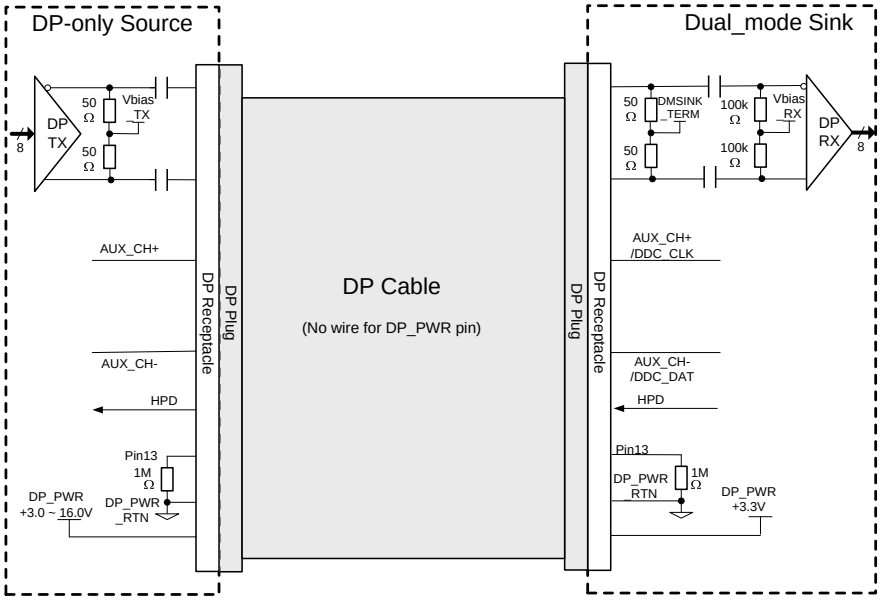

Figure 6-4: A Sink-side Cable Adaptor Plugged to a Dual-mode Source

6.6 A Dual-mode Source with a Sink-side Cable Adaptor (Reverse Plug)

There will be neither interoperation nor damage.

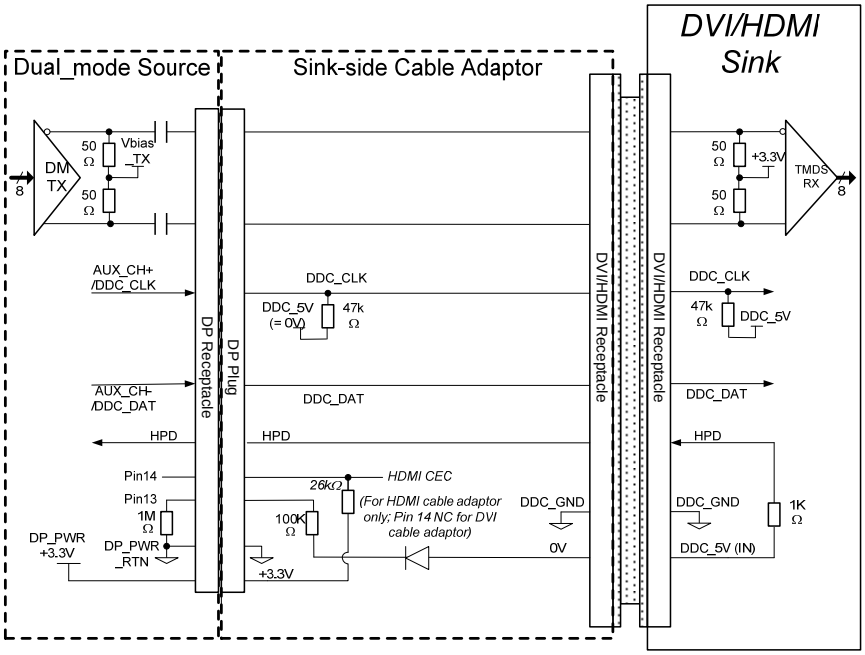

Figure 6-5: A Sink-side Cable Adaptor Plugged to a Dual-mode Source

6.7 A Dual-mode Sink with a Source-side Cable Adaptor (Reverse Plug)

There will be neither interoperation nor damage.

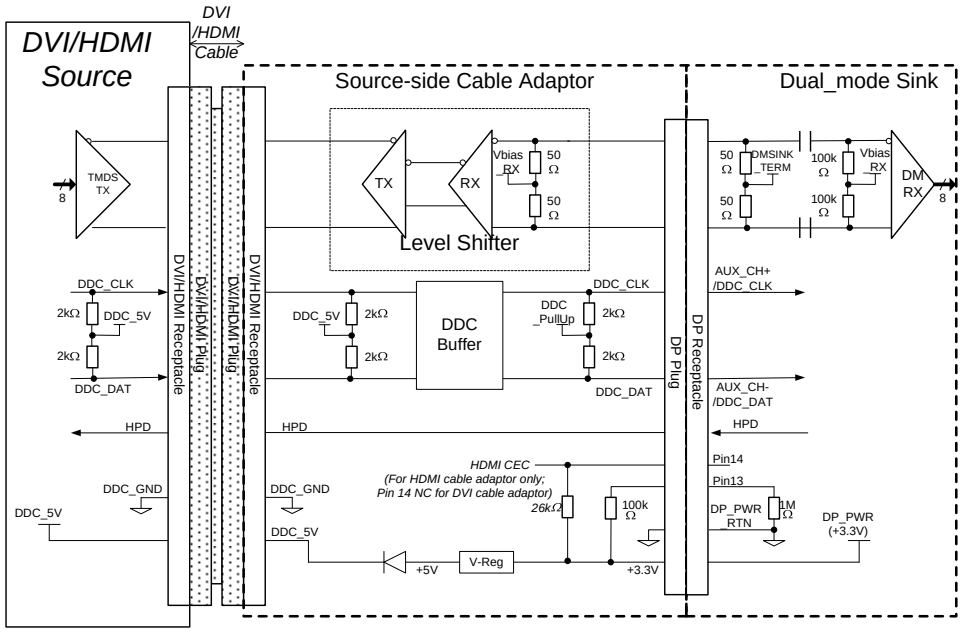

Figure 6-6: A Source-side Cable Adaptor Plugged to a Dual-mode Sink

6.8 Reverse Plugs on Both Ends

There will be neither interoperation nor damage.

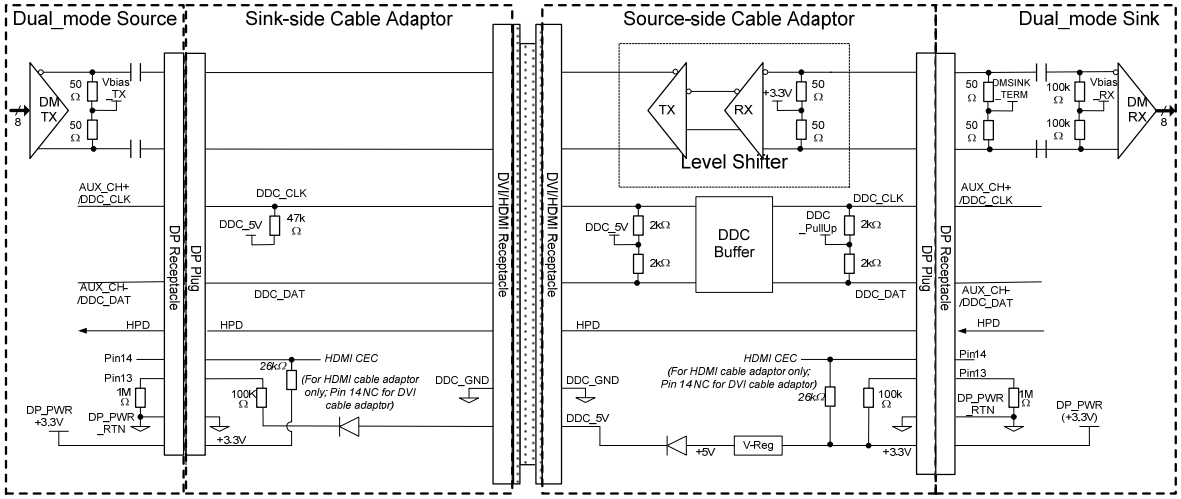

Figure 6-7: Reverse Plugs on Both Ends

7 Interoperation with a Dual-link DVI via an Active Protocol Converter

A Dual-mode Device is limited to supporting single-link DVI 1.0/HDMI specifications when it configures itself as a DVI 1.0/HDMI Device. For interoperability between a DisplayPort Device and a dual-link DVI 1.0 Device, a cable adaptor with a built-in active protocol converter is required.

This section describes the implementation guideline for the cable adaptors with the active protocol converter. When these cable adaptors are attached to DisplayPort Devices, those Devices operate in a DisplayPort mode, even if they are Dual-mode Devices.

7.1 A DisplayPort-to-Dual-link DVI Cable Adaptor

This adaptor is used for connecting a DisplayPort Source Device to a dual-link DVI Sink Device as shown in Figure 7-1. The following conversions take place in this adaptor.

- DisplayPort Main Link signals to TMDS signals
- AUX CH signals to DDC signals, following the I^2C-to-AUX CH mapping specification in DisplayPort Version 1.1a.

These conversions take place both at electrical and protocol levels.

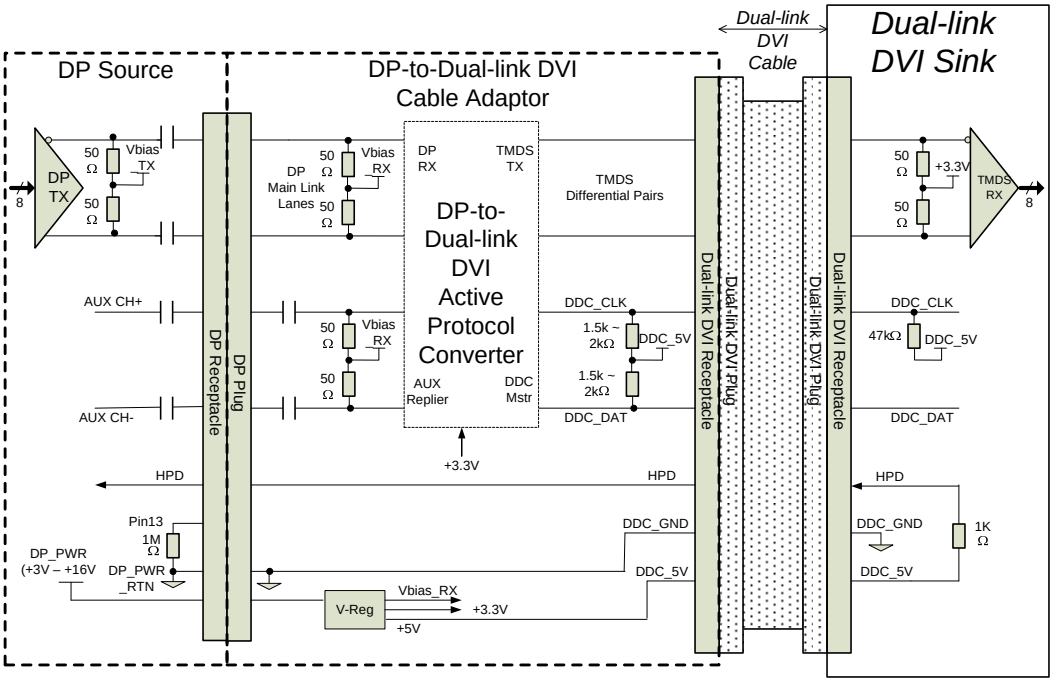

Figure 7-1: A DisplayPort-to-Dual-link DVI Cable Adaptor

The cable adaptor may receive the power from the DP_PWR output pin of the DisplayPort Source Device. If the total power consumption exceeds 1.5 W, however, the cable adaptor must have other means of getting the power.

7.2 Dual-link DVI to DisplayPort Cable Adaptor

This adaptor is used for connecting a dual-link DVI Source Device to a DisplayPort Sink Device as shown in Figure 7-2. The following conversions take place in this adaptor.

- TMDS signals to DisplayPort Main Link signals
- DDC signals to AUX CH signals, following the I^2C-to-AUX CH mapping specification in DisplayPort Version 1.1a.

These conversions take place both at electrical and protocol levels.

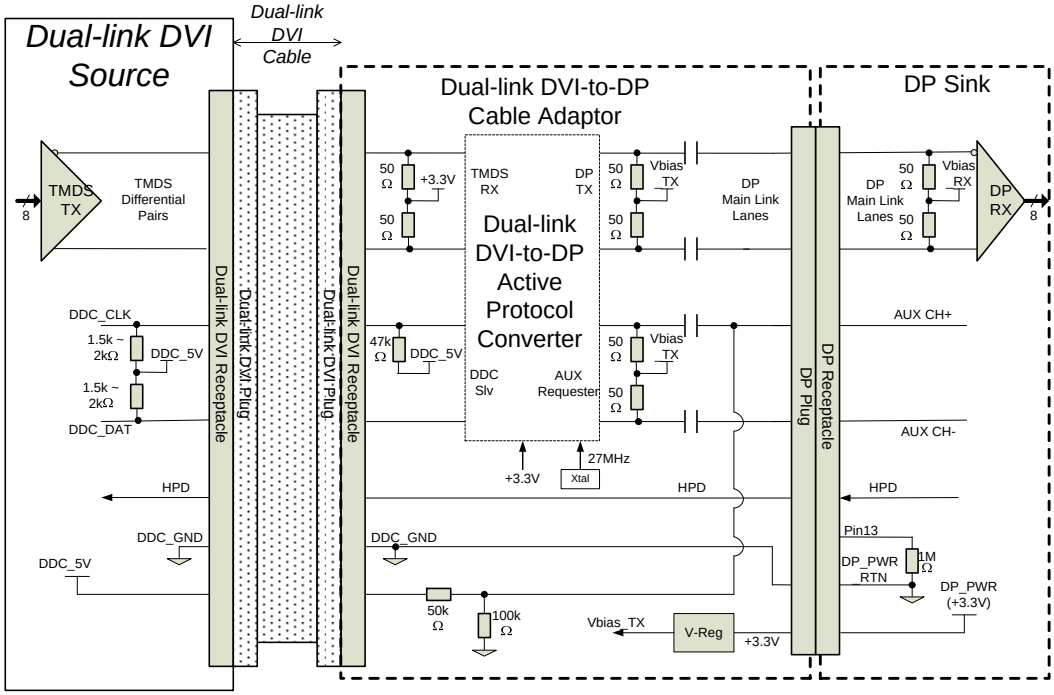

Figure 7-2: A Dual-link DVI to DisplayPort Cable Adaptor

The cable adaptor may receive the power from the DP_PWR output pin of the DisplayPort Sink Device. If the total power consumption exceeds 1.5 W, however, the cable adaptor must have other means of getting the power.

7.3 Dual-link DVI Cable Adaptor for Devices with a Tethered Cable

Some DisplayPort Devices may have a permanently tethered cable with the wire for DP_PWR populated. The dual-link DVI cable adaptor for those devices must have a DisplayPort receptacle connector.

The dual-link DVI cable adaptor for a DisplayPort Device with a permanently tethered cable may receive the power from the DP_PWR output supplied by the DisplayPort Sink Device through the tethered cable. In order to indicate that it is the DP_PWR consumer, not the DP_PWR provider, this cable adaptor must short Pin 13 and Pin 14. When the power consumption of the adaptor exceeds 1.5 W, the cable adaptor must have other means of receiving the power.

8 Appendix A: Main Contribution History

Table 8-1: Main Contributors to Version 1.0

Quinn Carter	AMD	
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Joe Giannuzi	Dell	
Alan Kobayashi	Genesis Microchip	Task Group Editor
Larry Prather	Genesis Microchip	
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Lakshmi K. Uppala	Intel	
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Doron Lapidot	Tyco Electronics	