# TUSB546-DCI in a DisplayPort Application

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**ABSTRACT**

The TUSB546-DCI is a linear redriver that supports both USB3.1 Gen1 and DisplayPort 1.4 over a Type-C interface. Even though the TUSB546-DCI is released for the Type-C market, the TUSB546-DCI can also be used as a standalone redriver for DisplayPort applications. This application report describes how to use the TUSB546-DCI in a DisplayPort application. The information in this document can also be applied to the TUSB1046-DCI.

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# 1 Introduction

The TUSB546-DCI is a Type-C linear redriver mux intended for Type-C source applications. The TUSB546-DCI multiplexes between four DP1.4 lanes and USB3.1 to a single Type-C receptacle. In a DisplayPort only application only the TUSB546-DCI's DisplayPort functionality is required. The USB3.1 functionality must be disabled and USB3.1 pins are left unconnected.

Before any video can be sent between source and sink, the DisplayPort source (DPTX) transmitter settings, both voltage swing and pre-emphasis, must be optimized to provide for a robust communication path to the sink (DPRX). These settings are determined during the link training phase. The DisplayPort standard defines a minimum eye opening at the end of channel in which a compliant receiver must operate. A redriver (limited or linear) is needed when the eye opening is no longer compliant. The purpose of a redriver is to compensate for inter-symbol interference (ISI) caused by frequency-dependent channel loss through a lossy medium like FR4 PCB trace. When the channel loss is properly compensated (or equalized), the result is a compliant signal at the receiver. Without system knowledge of a limited redriver presence, a limited redriver can have a negative impact on link training. But a linear redriver, like the TUSB546-DCI, is transparent to link training.

A redriver is considered linear when the output signal amplitude is a linear function of the input signal amplitude. A linear redriver can be thought of PCB trace shortener (electrical signal of long trace will look like shorter trace). An example of shortening PCB trace is shown in Figure 1. The linear feature of the TUSB546-DCI makes it ideal for DisplayPort applications. The DPTX's voltage swing and pre-emphasis levels presence at TUSB546-DCI receiver will be passed through to the DPRX.
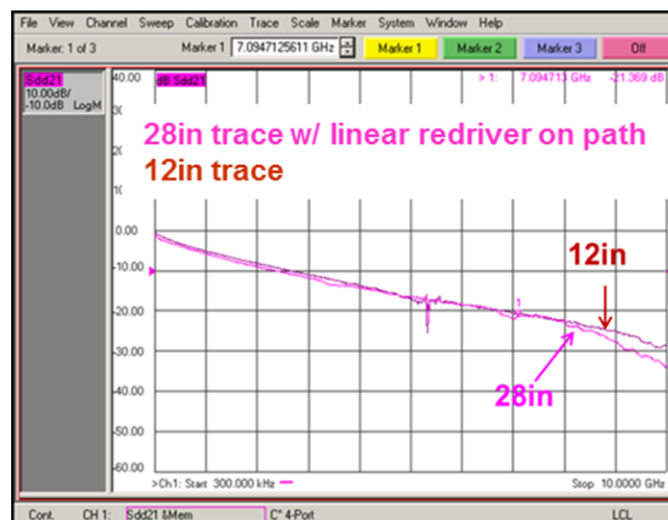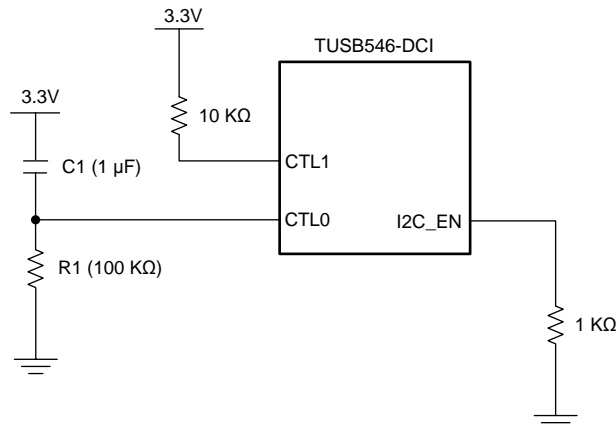


**Figure 1. PCB Trace Shortener Feature of a Linear Redriver**

# 2 USB 3.1 Default

Because of USB Type-C requirements, the TUSB546-DCI will power-up in USB 3.1 mode. For a DisplayPort application, the TUSB546-DCI must be taken out of USB 3.1 mode and into four Lane DisplayPort mode. If the TUSB546-DCI is configured for I2C mode (I2C_EN pin != 0), then software must program bits 1:0 of address 0x0A (General Registers) to a 2'b10. If the TUSB546-DCI is configured GPIO mode (I2C_EN pin = 0), then the CTL0 pin must transition high and then back low. One method to create the toggle on CTL0 pin is illustrated in Figure 2. The value chosen for C1 and R1 should result in a discharge rate in which CTL0's VIH level is held for at least 16 ms.

The TUSB546-DCI USB3.1 signals are not used in a DisplayPort application. The following pins can be left unconnected: SSTXP/N, SSRXP/N, SSEQ1, EQ0 and EQ1. SSEQ0/A0 can be left unconnected if TUSB546-DCI is configured for GPIO mode. If TUSB546-DCI is configured for I2C, then this pin selects the TUSB546-DCI's 7-bit I2C slave address.
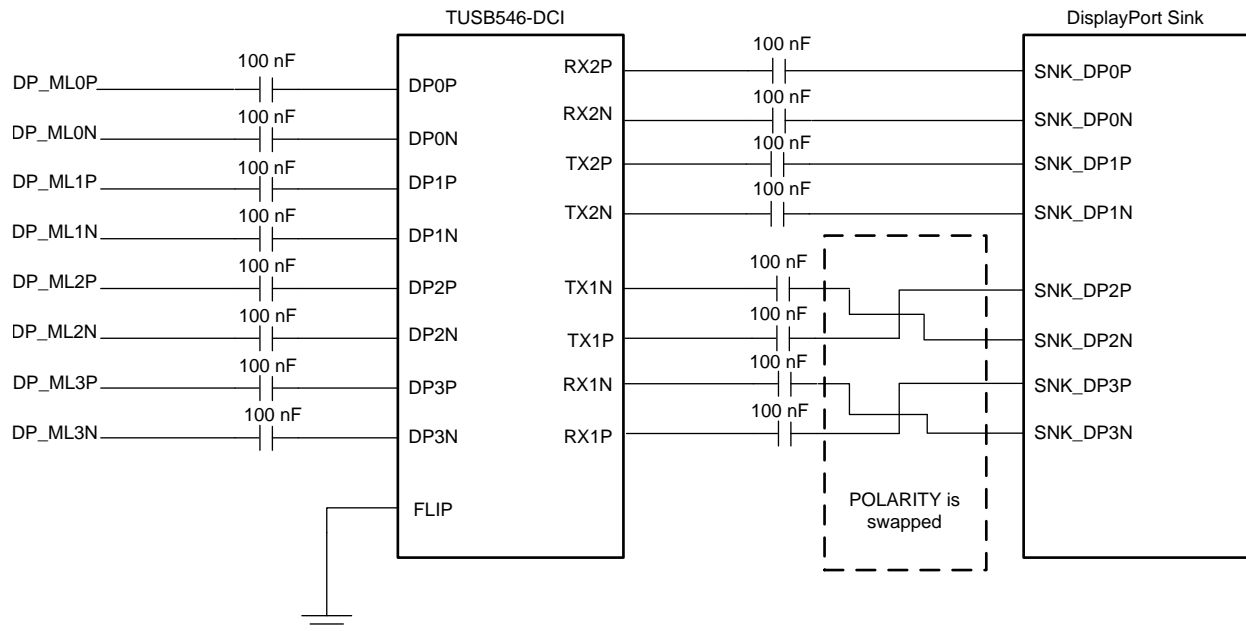
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**Figure 2. Method to Enable DisplayPort Mode When in GPIO Mode**

## 3 Polarity Inversion

The USB Type-C receptacle has symmetrical placement of the differential pairs. The TUSB546-DCI pin-out is targeted for easy routing to the Type-C receptacle. Because of this, the TUSB546-DCI's pin-out will produce an undesired polarity swap on RX1 and TX1 pins in DisplayPort applications. This polarity swap must be handled on the PCB. Figure 3 shows the DisplayPort input to output routing along with the polarity swap on TX1 and RX1. This figure assumes that FLIP orientation is set to zero.



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**Figure 3. TX1 and RX1 Polarity Swap (FLIP = 0)**

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# 4    AUX Implementation

The TUSB546-DCI will snoop AUX transactions in order to enable and disable DisplayPort lanes to save power. It does this by monitoring the AUX traffic passing over the AUXP/N pins. If the TUSB546-DCI is configured for GPIO mode, AUX snoop feature is enabled when CAD_SNK pin is low and disabled when CAD_SNK pin is high. If TUSB546-DCI is configured for I2C Mode, then AUX snoop feature control is based on the state of bit 7 in register 13h. System AUX signals must be connected to TUSB546-DCI AUXP/N pins anytime the AUX snoop feature is enabled.

If system designer desires to handle power saving through an alternative method, the snoop feature can be disabled. If TUSB546-DCI snoop feature is disabled, then the DisplayPort AUXP/N signals can bypass the TUSB546-DCI. When bypassing the TUSB546-DCI AUXP/N pins, the AUXN pin should be pulled up to 3.3V through 100K resistor and the AUXP pin should be pulled down to GND through a 100K resistor as depicted in Figure 4.

**Table 1. AUX Snoop Enable Control**

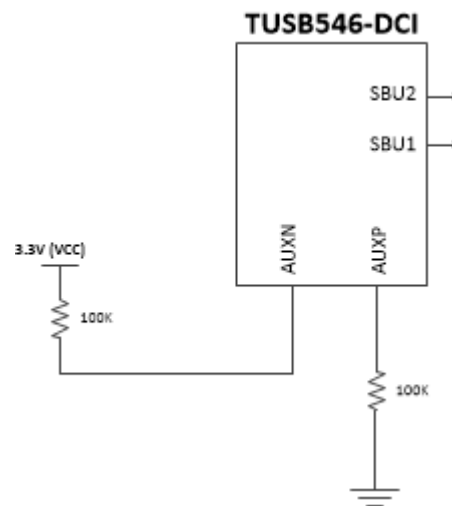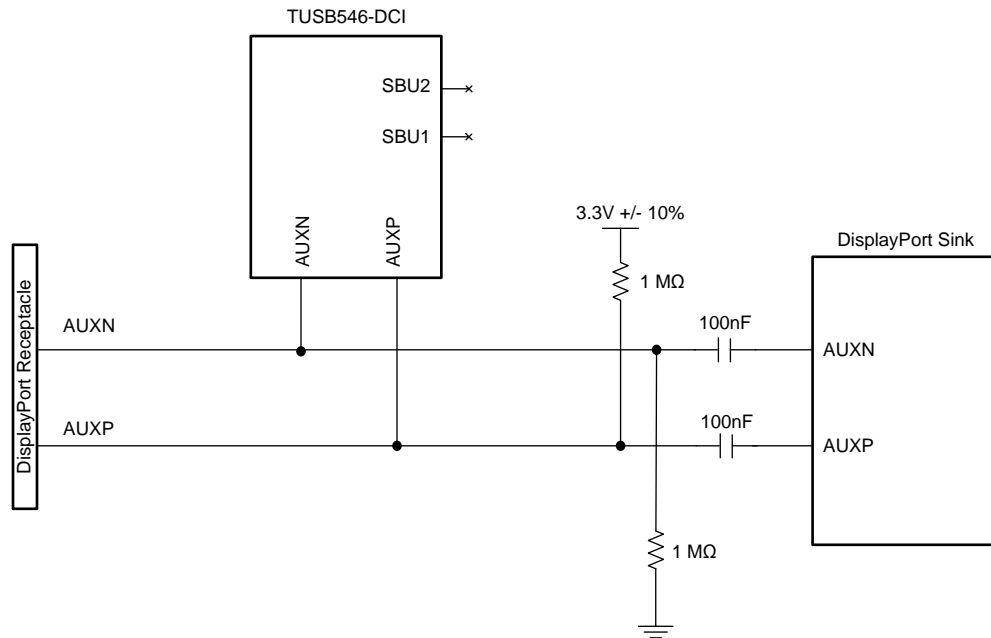| GPIO or I2C Mode | AUX Snoop Enabled | AUX Snoop Disabled |
|---|---|---|
| GPIO Mode (pin I2C_EN = 0) | CAD_SNK (pin 29) = Low | CAD_SNK (pin 29) = HIGH.<br>All four DisplayPort lanes are enabled. |
| I2C Mode (pin I2C_EN != 0) | Clear bit 7 Reg13h | Set bit 7 Reg13h |



**Figure 4. AUXP/N Connections When AUX Bypassed**

## 4.1    Sink Application

The AUXP/N from DisplayPort receptacle should be routed directly to TUSB546-DCI and then to DisplayPort sink through 100 nF AC capacitor. The TUSB546-DCI SBU1 and SBU2 pins should be left unconnected. The Figure 5 illustrates the AUX implementation for a DisplayPort sink application when AUX snoop is enabled.
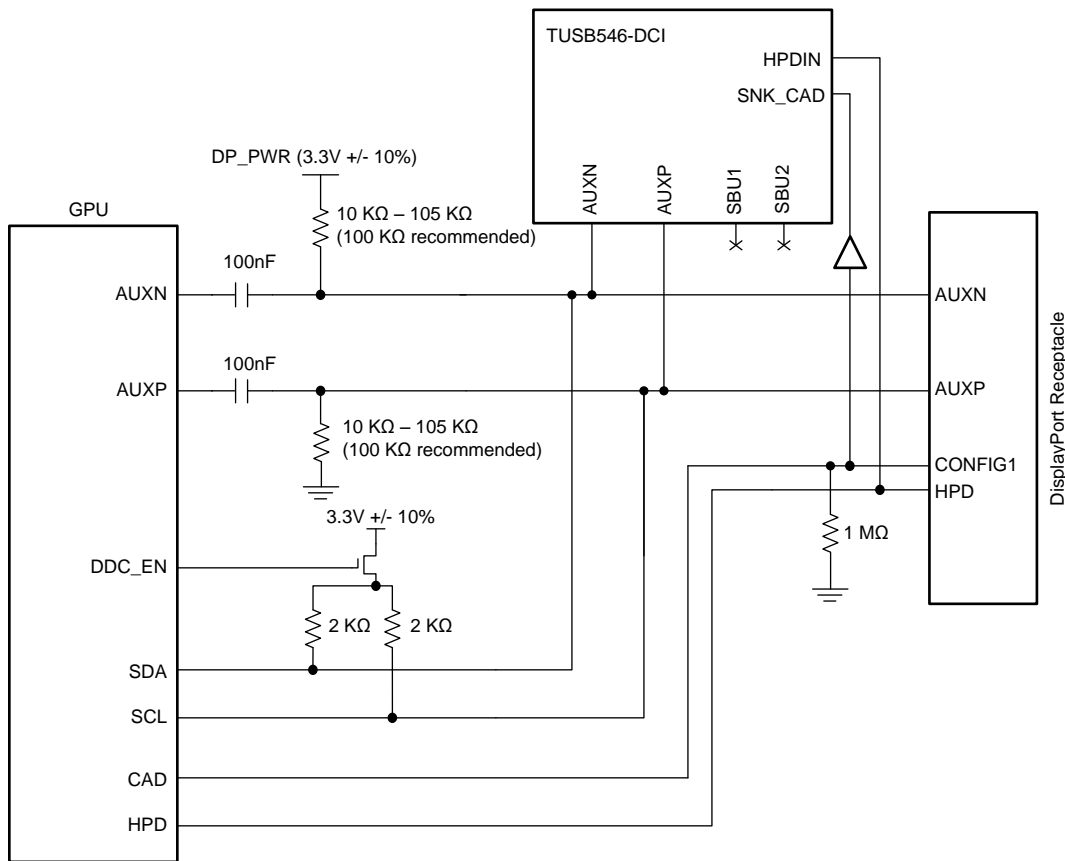
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**Figure 5. AUX Implementation in DisplayPort Sink Application**

## 4.2 Source Application

The AUX implementation for a source is similar to the sink implementation. The AUXP/N signals are routed to TUSB546-DCI AUXP/N signals through a 100nF AC coupling capacitor. The SBU1/2 pins should be left unconnected. The AUXP should have a 100kΩ pull-down resistor and AUXN should have a 100K ohm pull-up resistor. These 100KΩ resistors must be on the TUSB546-DCI side of the 100 nF capacitors.

The source application may have the added complexity of supporting dual mode DisplayPort (DP++). When supporting DP++, the TUSB546-DCI configured in GPIO mode (I2C_EN = 0) the SNK_CAD pin must be connected to the CONFIG1 pin on DisplayPort receptacle through a buffer like the SN74AHC1G125. The buffer is required because the internal pulldown on CAD_SNK pin is too strong to register a valid VIH when a Dual mode adapter is plugged into the DisplayPort receptacle. If using TUSB546-DCI in I2C mode, then system software must disable AUX snooping whenever the CONFIG1 pin is high.

Figure 6 illustrates an example AUX implementation of DisplayPort source application when TUSB546-DCI is configured for GPIO mode (I2C_EN = 0).

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**Figure 6. AUX Implementation in DisplayPort Source Application**

## 5 HPD Implementation

The TUSB546-DCI uses the HPDIN to enable and disable DisplayPort functionality to save power. The HPD signal should be routed to either pin 23 or pin 32 based on the TUSB546-DCI GPIO/I2C Mode.

**Table 2. HPD Connection Options**

| GPIO or I2C Mode | HPD |
|---|---|
| GPIO Mode (pin I2C_EN = 0) | Pin 32 |
| I2C Mode (pin I2C_EN != 0) | Pin 23 |

## 6 Example Software

TUSB546-DCI in I2C mode must be configured for DisplayPort only. The Aardvark script below shows how to configure TUSB546-DCI for DisplayPort only mode. This script uses an arbitrary equalization value for each lane's receiver. Each receiver has 16 possible equalization settings. The actual value used should be based on the channel insertion loss for each DisplayPort lane. This scripts slave address is set to 0x0F which corresponds to both DPEQ0/A1 and SSEQ0/A0 pins being at a '1' level. This slave address should be changed to match DPEQ0/A1 and SSEQ0/A0 pins value in your system.

```
<aardvark>
    <configure i2c="1" spi="1" gpio="0" tpower="0" pullups="0"/>
    <i2c_bitrate khz="400"/>

===DP only and EQ override set====
<i2c_write addr="0x0F" count="1" radix="16"> 0A 12 </i2c_write> />
```

```
===DP Lanes 0 and 1 EQ setting.  16 possible settings.====
===Lane 0 EQ:  0 Setting   =====
===Lane 1 EQ:  1 Setting   =====
<i2c_write addr="0x0F" count="1" radix="16"> 10 10 </i2c_write> />

===DP Lanes 2 and 3 EQ Settings.  16 possible settings.====
===Lane 2 EQ:  0 Setting   =====
===Lane 3 EQ:  1 Setting   =====
<i2c_write addr="0x0F" count="1" radix="16"> 11 10 </i2c_write> />


</aardvark>
```
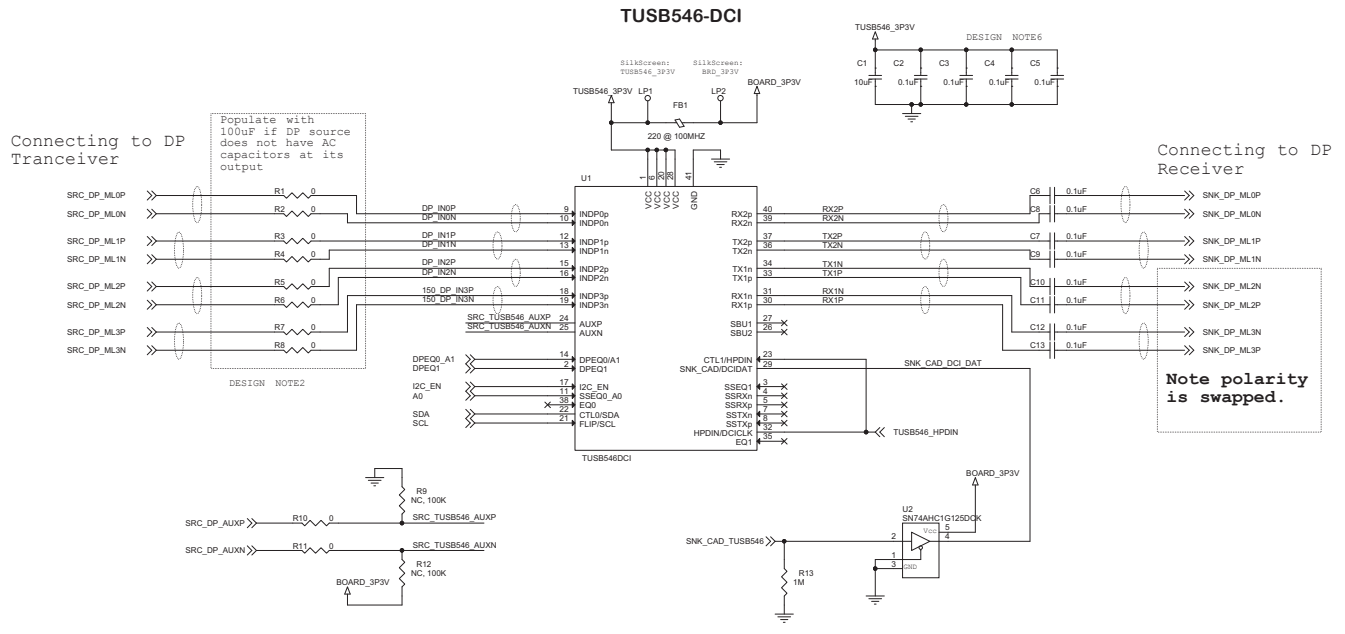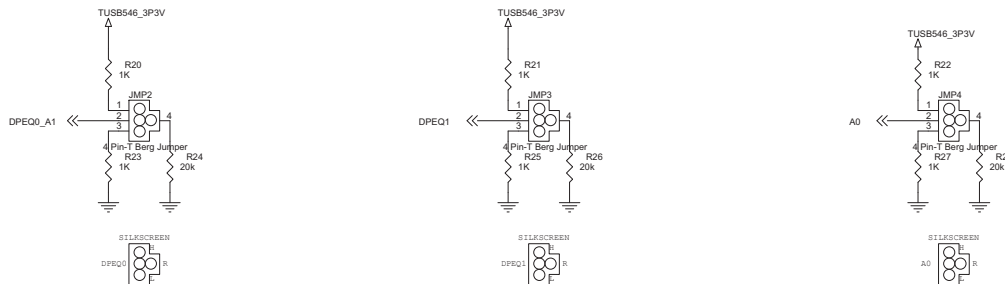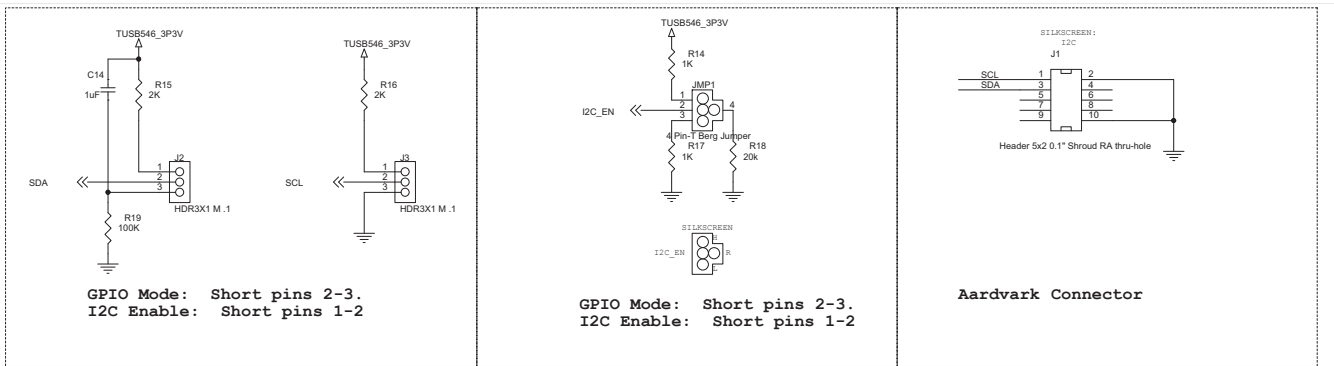
# *Schematics*



**Figure 7. TUSB546-DCI Schematic**

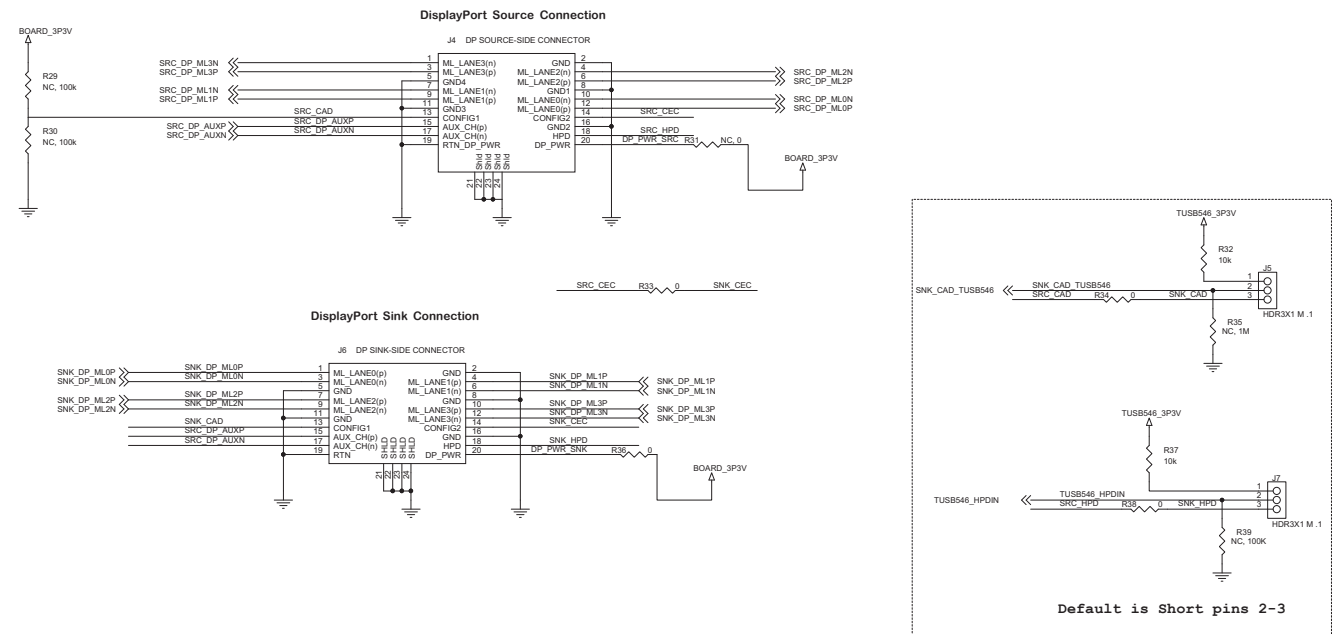**Figure 8. TUSB546-DCI Configuration Control**



**Figure 9. DisplayPort Connectors**

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