

TUSB1064-Q1 USB Type-C® DP Alt モード 10Gbps シンクサイド リニア リドライバ クロスポイントスイッチ

1 特長

- USB Type-C® クロスポイントスイッチで、次の仕様をサポート
 - USB 3.2 10Gbps + 2 つの DP 1.4 レーン
 - 4 つの DP 1.4 レーン
- USB 3.2 で最大 10Gbps
- DisplayPort™ 1.4 で最大 8.1Gbps (HBR3)
- VESA® DisplayPort™ Alt モードの UFP_D リドライビング クロスポイントスイッチで、C、D、E のピン割り当てをサポート
- 超低消費電力アーキテクチャ
- 最大 13.3dB のイコライゼーション付きのリニア リドライバ
- DisplayPort™ リンクトレーニングに対して透過的
- GPIO または I²C により設定可能
- ホットプラグ対応
- 車載グレード 2 の温度範囲: -40°C~105°C
- パッケージ: 5mm × 7mm、0.5mm ピッチの VQFN

2 アプリケーション

- 車載用インフォテインメントおよびクラスタ
- 後部座席用エンターテインメント
- 車載ヘッド ユニット

3 概要

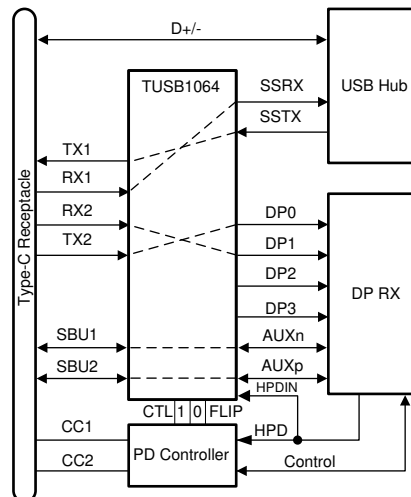
TUSB1064-Q1 は VESA® DisplayPort™ Alt モードの USB-C® リドライビング スイッチで、USB 3.2 で 10Gbps まで、DisplayPort 1.4 で 8.1Gbps までの、上流向きポート (シンク) のデータレートをサポートします。このデバイスは、USB Type-C® 規格の VESA® DisplayPort™ Alt モードで、UFP_D ピンの割り当て C、D、E に使用されます。

TUSB1064-Q1 には、いくつかのレベルの受信リニア イコライゼーションがあり、ケーブルおよび基板配線での損失によるシンボル間干渉 (ISI) を補償できます。TUSB1064-Q1 は単一の 3.3V 電源で動作し、車載グレード 2 の温度範囲に対応しています。

パッケージ情報

| 部品番号 | パッケージ(1) | パッケージ サイズ(2) |
|-------------|----------------|--------------|
| TUSB1064-Q1 | RGF (VQFN, 40) | 7mm × 5mm |

- (1) 供給されているすべてのパッケージについては、[セクション 12](#) を参照してください。
- (2) パッケージ サイズ (長さ × 幅) は公称値であり、該当する場合はピンも含まれます。



概略回路図



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4 Pin Configuration and Functions

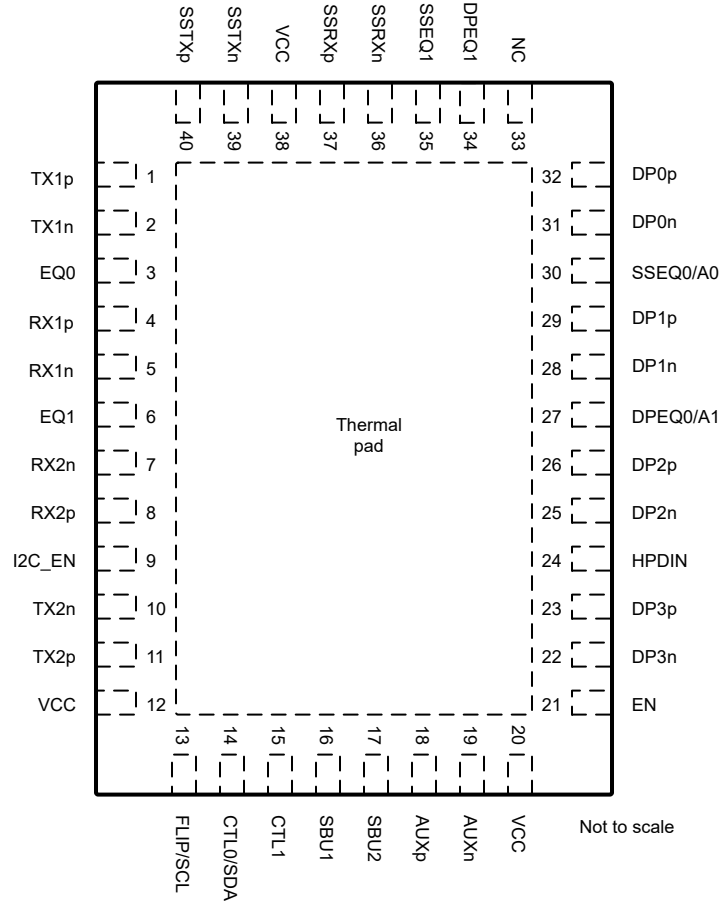


図 4-1. RGF Package, 40-Pin (VQFN) (Top View)

表 4-1. Pin Functions

| PIN | | TYPE ⁽¹⁾ | DESCRIPTION |
|------|-----|---------------------|--|
| NAME | NO. | | |
| DP0p | 32 | Diff O | DP differential positive output for DisplayPort Lane 0. |
| DP0n | 31 | Diff O | DP differential negative output for DisplayPort Lane 0. |
| DP1p | 29 | Diff O | DP differential positive output for DisplayPort Lane 1. |
| DP1n | 28 | Diff O | DP differential negative output for DisplayPort Lane 1. |
| DP2p | 26 | Diff O | DP differential positive output for DisplayPort Lane 2. |
| DP2n | 25 | Diff O | DP differential negative output for DisplayPort Lane 2. |
| DP3p | 23 | Diff O | DP differential positive output for DisplayPort Lane 3. |
| DP3n | 22 | Diff O | DP differential negative output for DisplayPort Lane 3. |
| TX1n | 2 | Diff I/O | Differential negative input for DisplayPort or differential negative output for USB3.2 upstream facing port. |
| TX1p | 1 | Diff I/O | Differential positive input for DisplayPort or differential positive output for USB3.2 upstream facing port. |
| RX1n | 5 | Diff I | Differential negative input for DisplayPort or USB3 upstream facing port. |
| RX1p | 4 | Diff I | Differential positive input for DisplayPort or USB3 upstream facing port. |
| RX2p | 8 | Diff I | Differential positive input for DisplayPort or USB3 upstream facing port. |
| RX2n | 7 | Diff I | Differential negative input for DisplayPort or USB3 upstream facing port. |

表 4-1. Pin Functions (続き)

| PIN | | TYPE ⁽¹⁾ | DESCRIPTION |
|----------|-----|---------------------------|---|
| NAME | NO. | | |
| TX2p | 11 | Diff I/O | Differential positive input for DisplayPort or differential positive output for USB3 upstream Facing port. |
| TX2n | 10 | Diff I/O | Differential negative input for DisplayPort or differential negative output for USB3 upstream Facing port. |
| SSTXp | 40 | Diff I | Differential positive input for USB3 downstream facing port. |
| SSTXn | 39 | Diff I | Differential negative input for USB3 downstream facing port. |
| SSRXp | 37 | Diff O | Differential positive output for USB3 downstream facing port. |
| SSRXn | 36 | Diff O | Differential negative output for USB3 downstream facing port. |
| EQ1 | 6 | 4 Level I | This pin along with EQ0 sets the USB receiver equalizer gain for upstream facing RX1 and RX2 when USB used. Up to 11dB of EQ available. |
| EQ0 | 3 | 4 Level I | This pin along with EQ1 sets the USB receiver equalizer gain for upstream facing RX1 and RX2 when USB used. Up to 11dB of EQ available. |
| EN | 21 | 2 Level I (PD) | Device Enable. For normal operation pull up this pin to 3.3V through a 10k to 50kΩ resistor. |
| HPDIN | 24 | 2 Level I | Hot Plug Detect. This pin is an input for Hot Plug Detect received from DisplayPort sink. When HPDIN is Low for greater than 2ms, all DisplayPort lanes are disabled while the AUX to SBU switch remains closed. |
| I2C_EN | 9 | 4 Level I | I ² C Programming Mode or GPIO Programming Select. I ² C is only disabled when this pin is "0". 0 = GPIO mode (I ² C disabled) R = TI Test Mode (I ² C enabled at 3.3V) F = I ² C enabled at 1.8 V 1 = I ² C enabled at 3.3V. |
| SBU1 | 16 | I/O, CMOS | SBU1. DC couple this pin to the SBU1 pin on the Type-C receptacle. A 2MΩ resistor to GND is also recommended. |
| SBU2 | 17 | I/O, CMOS | SBU2. DC couple this pin to the SBU2 pin on the Type-C receptacle. A 2MΩ resistor to GND is also recommended. |
| AUXp | 18 | I/O, CMOS | AUXp. DisplayPort AUX positive I/O connected to the DisplayPort sink through a AC-coupling capacitor. In addition to AC-coupling capacitor, this pin also requires a 1M resistor to DP_PWR (3.3V). This pin along with AUXN is used by the TUSB1064-Q1 for AUX snooping and is routed to SBU1/2 based on the orientation of the Type-C. |
| AUXn | 19 | I/O, CMOS | AUXn. DisplayPort AUX negative I/O connected to the DisplayPort sink through a AC-coupling capacitor. In addition to AC-coupling capacitor, this pin also requires a 1M resistor to GND. This pin along with AUXP is used by the TUSB1064-Q1 for AUX snooping and is routed to SBU1/2 based on the orientation of the Type-C. |
| DPEQ1 | 34 | 4 Level I | DisplayPort Receiver EQ. The DPEQ1 and DPEQ0 pins select the DisplayPort receiver equalization gain. |
| DPEQ0/A1 | 27 | 4 Level I | DisplayPort Receiver EQ. The DPEQ0 and DPEQ1 pins select the DisplayPort receiver equalization gain. When I2C_EN ≠ "0", the DPEQ0 pin also sets the TUSB1064-Q1 I ² C address. |
| SSEQ1 | 35 | 4 Level I | The SSEQ1 and SSEQ0 pins set the USB receiver equalizer gain for downstream facing SSTXP/N. |
| SSEQ0/A0 | 30 | 4 Level I | The SSEQ0 and SSEQ1 pins set the USB receiver equalizer gain for downstream facing SSTXP/N. When I2C_EN ≠ "0", the SSEQ0 pin also sets the TUSB1064-Q1 I ² C address. If I2C_EN = "F", then the SSEQ0 pin must be set to "F" or "0". |
| FLIP/SCL | 13 | 2 Level I (Failsafe) (PD) | When I2C_EN = "0" this pin is Flip control, otherwise this pin is I ² C clock. When used for the I ² C clock, pull up to the VCC I ² C supply on the I ² C controller through an external resistor. |
| CTL0/SDA | 14 | 2 Level I (Failsafe) (PD) | When I2C_EN = "0" this pin is USB3 switch control, otherwise this pin is I ² C data. When used for I ² C data, pull up to the VCC I ² C supply on the I ² C controller through an external resistor. |

表 4-1. Pin Functions (続き)

| PIN | | TYPE ⁽¹⁾ | DESCRIPTION |
|------|-------------|---------------------------|---|
| NAME | NO. | | |
| CTL1 | 15 | 2 Level I (Failsafe) (PD) | DP Alt mode Switch Control Pin. When I2C_EN = "0", this pin can enable or disable DisplayPort functionality. Otherwise, when I2C_EN ≠ "0", DisplayPort functionality is enabled and disabled through I ² C registers. L = DisplayPort Disabled. H = DisplayPort Enabled. |
| VCC | 12 | P | 3.3V Power Supply |
| VCC | 20 | P | 3.3V Power Supply |
| VCC | 38 | P | 3.3V Power Supply |
| NC | 33 | NC | No connect pin. Leave open. |
| GND | Thermal Pad | G | Ground |

(1) I = input, O = output, Diff = differential, P = power, NC = no connection, G = ground

5 Specifications

5.1 Absolute Maximum Ratings

over operating free-air temperature and voltage range (unless otherwise noted)⁽¹⁾

| | | MIN | MAX | UNIT |
|----------------------|---|------|------|------|
| V _{CC} | Supply voltage range | -0.3 | 4 | V |
| V _{IN_DIFF} | Differential voltage at differential inputs | | ±2.5 | V |
| V _{IN_SE} | Input voltage at differential inputs | -0.5 | 4 | V |
| V _{IN_CMOS} | Input voltage at CMOS inputs | -0.3 | 4 | V |
| T _J | Junction temperature | | 125 | °C |
| T _{STG} | Storage temperature | -65 | 150 | °C |

- (1) Operation outside the *Absolute Maximum Ratings* may cause permanent device damage. Absolute Maximum Ratings do not imply functional operation of the device at these or any other conditions beyond those listed under *Recommended Operating Conditions*. If used outside the Recommended Operating Conditions but within the Absolute Maximum Ratings, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime.

5.2 ESD Ratings

| | | | VALUE | UNIT |
|--------------------|-------------------------|--|-------|------|
| V _(ESD) | Electrostatic discharge | Human body model (HBM), per AEC Q100-002 ⁽¹⁾ , all pins | ±4000 | V |
| | | Charged device model (CDM), per AEC Q100-011, all pins | ±1500 | |

- (1) AEC Q100-002 indicates that HBM stressing must be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

5.3 Recommended Operating Conditions

over operating free-air temperature and voltage range (unless otherwise noted)

| | | MIN | NOM | MAX | UNIT |
|----------------------|---|-----|-----|-----|------|
| V _{CC} | Supply voltage | 3 | 3.3 | 3.6 | V |
| V _{CC_RAMP} | Power supply ramp | 0.1 | | 100 | ms |
| V _{I2C} | Supply that external resistors on SDA and SCL are pulled up too | 1.7 | | 3.6 | V |
| V _{PSN} | Power supply noise on VCC | | | 100 | mV |
| T _A | Ambient temperature | -40 | | 105 | °C |
| T _{PCB} | PCB temperature (1mm away from the device) | -40 | | 112 | °C |

5.4 Thermal Information

| THERMAL METRIC ⁽¹⁾ | | Device | UNIT |
|-------------------------------|--|------------|------|
| | | RGF (VQFN) | |
| | | 40 PINS | |
| R _{θJA} | Junction-to-ambient thermal resistance | 29.3 | °C/W |
| R _{θJC(top)} | Junction-to-case (top) thermal resistance | 18.6 | °C/W |
| R _{θJB} | Junction-to-board thermal resistance | 10.8 | °C/W |
| Ψ _{JT} | Junction-to-top characterization parameter | 0.3 | °C/W |
| Ψ _{JB} | Junction-to-board characterization parameter | 10.7 | °C/W |
| R _{θJC(bot)} | Junction-to-case (bottom) thermal resistance | 3.5 | °C/W |

- (1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application note.

5.5 Electrical Characteristics

over operating free-air temperature and voltage range (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|--|---|---|------|------|-----|------|
| Power | | | | | | |
| P _{CC-ACTIVE-USB} | Average active power in USB-only mode while in U0 | CTL1 = L; CTL0 = H; Link in U0 at 10Gbps; | | 340 | | mW |
| P _{CC-ACTIVE-USB-DP} | Average active power in USB + 2 lane DP mode | CTL1 = H; CTL0 = H; USB in U0 at 10Gbps; DP at 8.1Gbps; | | 670 | | mW |
| P _{CC-ACTIVE-DP} | Average active power in 4 lane DP mode | CTL1 = H; CTL0 = L; Four DP lanes at 8.1Gbps | | 640 | | mW |
| P _{CC-NC-USB} | Average power in USB mode while in disconnect state. | CTL1 = L; CTL0 = H; No USB device detected; | | 2.5 | | mW |
| P _{CC-U2U3} | Average power in USB mode while in U2/U3 state | CTL1 = L; CTL0 = H; Link in U2 or U3; | | 2.5 | | mW |
| P _{CC-SHUTDOWN} | Average power in shutdown mode. | CTL1 = L; CTL0 = L; I2C_EN = "0"; | | 0.7 | | mW |
| 4-State CMOS Inputs(EQ[1:0], SSEQ[1:0], DPEQ[1:0], I2C_EN) | | | | | | |
| I _{IH} | High-level input current | V _{CC} = 3.6V; V _{IN} = 3.6V | 20 | | 80 | μA |
| I _{IL} | Low-level input current | V _{CC} = 3.6V; V _{IN} = 0V | -160 | | -40 | μA |
| 4-Level V _{TH} | Threshold 0 / R | V _{CC} = 3.3V | | 0.59 | | V |
| | Threshold R/ Float | V _{CC} = 3.3V | | 1.65 | | V |
| | Threshold Float / 1 | V _{CC} = 3.3V | | 2.7 | | V |
| R _{PU} | Internal pullup resistance | | | 45 | | kΩ |
| R _{PD} | Internal pulldown resistance | | | 95 | | kΩ |
| 2-State CMOS Input (EN, FLIP, CTL0, CTL1, HPDIN) CTL1, CTL0 and FLIP are Failsafe | | | | | | |
| V _{IH} | High-level input voltage | | 2.2 | | 3.6 | V |
| V _{IL} | Low-level input voltage | | 0 | | 0.8 | V |
| R _{PD} | Internal pull-down resistance for FLIP, CTL0, and EN. | | | 500 | | kΩ |
| R _{PD-CTL1} | Internal pull-down resistance for CTL1 | | | 395 | | kΩ |
| I _{IH-EN} | High-level input current for EN pin | V _{IN} = 3.6V | 4 | | 12 | μA |
| I _{IL-EN} | Low-level input current for EN pin | V _{IN} = GND, V _{CC} = 3.6V | -1 | | 1 | μA |
| I _{IH-FLIP} | High-level input current for FLIP pin | V _{IN} = 3.6V | 4 | | 12 | μA |
| I _{IL-FLIP} | Low-level input current for FLIP pin | V _{IN} = GND, V _{CC} = 3.6V | -1 | | 1 | μA |
| I _{IH-CTL0} | High-level input current for CTL0 pin | V _{IN} = 3.6V | 4 | | 12 | μA |
| I _{IL-CTL0} | Low-level input current for CTL0 pin | V _{IN} = GND, V _{CC} = 3.6V | -1 | | 1 | μA |
| I _{IH-CTL1} | High-level input current for CTL1 pin | V _{IN} = 3.6V | 4 | | 12 | μA |
| I _{IL-CTL1} | Low-level input current for CTL1 pin | V _{IN} = GND, V _{CC} = 3.6V | -1 | | 1 | μA |
| I _{IH-HPDIN} | High-level input current for HPD pin | V _{IN} = 3.6V | 0.5 | | 5 | μA |
| I _{IL-HPDIN} | Low-level input current for HPD pin | V _{IN} = GND, V _{CC} = 3.6V | -1 | | 1 | μA |
| I2C Control Pins SCL, SDA | | | | | | |
| V _{IH} | High-level input voltage | I2C_EN = "1" or "R" (3.3V I2C levels) | 2.2 | | 3.6 | V |
| V _{IL} | Low-level input voltage | I2C_EN = "1" or "R" (3.3V I2C levels) | 0 | | 0.8 | V |
| V _{IH} | High-level input voltage | I2C_EN = "F" (1.8V I2C levels) | 1.2 | | 3.6 | V |
| V _{IL} | Low-level input voltage | I2C_EN = "F" (1.8V I2C levels) | 0 | | 0.4 | V |
| V _{OL} | Low-level output voltage | I2C_EN ! = "0"; I _{OL} = 3mA | 0 | | 0.4 | V |

5.5 Electrical Characteristics (続き)

over operating free-air temperature and voltage range (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|--|------|------|-----|------------|
| I_{OL} | Low-level output current | I2C_EN ! = "0"; $V_{OL} = 0.4V$ | 20 | | | mA |
| I_{i_I2C} | Input current on SDA pin | $0.1 \times V_{I2C} < \text{Input voltage} < 3.3V$ | -10 | | 10 | μA |
| C_{i_I2C} | Input capacitance | | | | 10 | pF |
| USB Differential Receiver (RX1P/N, RX2P/N, SSTXP/N) | | | | | | |
| $V_{RX-DIFF-PP}$ | Input differential peak-peak voltage swing linear dynamic range | AC-coupled differential peak-to-peak signal measured post CTLE through a reference channel | | 1200 | | mVppd |
| $V_{RX-DC-CM}$ | Common-mode voltage bias in the receiver (DC) | | | 0 | | V |
| $R_{RX-DIFF-DC}$ | Differential input impedance (DC) | Present after a USB3 device is detected on TXP/TXN | 72 | | 120 | Ω |
| $R_{RX-CM-DC}$ | Receiver DC common mode impedance | Present after a USB3 device is detected on TXP/TXN | 18 | | 30 | Ω |
| $Z_{RX-HIGH-IMP-DC-POS}$ | Common-mode input impedance with termination disabled (DC) | Present when no USB3 device is detected on TXP/TXN. Measured over the range of 0V to 500mV with respect to GND. | 25 | | | k Ω |
| $V_{SIGNAL-DET-DIFF-PP}$ | Input differential peak-to-peak signal detect assert level | At 10Gbps, No loss and bit rate PRBS7 pattern | | 95 | | mVppd |
| $V_{RX-IDLE-DET-DIFF-PP}$ | Input differential peak-to-peak signal detect de-assert level | At 10 Gbps, No loss and bit rate PRBS7 pattern | | 70 | | mVppd |
| $V_{RX-LFPS-DET-DIFF-PP}$ | Low-frequency periodic signaling (LFPS) detect threshold | $25^{\circ}C \leq T_A \leq 105^{\circ}C$; Below the minimum is squelched. Tested at 25MHz and 300mVppd VIN. | 100 | | 300 | mVppd |
| $RL_{RX-DIFF}$ | Differential return loss | 50MHz to 1.25GHz at 90 Ω ; Lowest EQ setting; FLIP = L; | | -23 | | dB |
| $RL_{RX-DIFF}$ | Differential return loss | 5GHz at 90 Ω ; Lowest EQ setting; FLIP = L; | | -12 | | dB |
| RL_{RX-CM} | Common-mode return loss | 50MHz to 5GHz at 90 Ω ; Lowest EQ setting; FLIP = L; | | -8 | | dB |
| EQ_{SSP} | Receiver equalization for RX1/2 receivers at maximum setting | At 5GHz; FLIP = L; | | 13.3 | | dB |
| EQ_{SSP} | Receiver equalization for SSTX receiver at maximum setting | At 5GHz; FLIP = L; | | 10.5 | | dB |
| USB Differential Transmitter (TX1P/N, TX2P/N, SSRXP/N) | | | | | | |
| $V_{TX-DIFF-PP}$ | Transmitter dynamic differential voltage swing range. | | | 1300 | | mVppd |
| $V_{TX-RCV-DETECT}$ | Amount of voltage change allowed during Receiver Detection | At 3.3V | | | 600 | mV |
| $V_{TX-CM-IDLE-DELTA}$ | Transmitter idle common-mode voltage change while in U2/U3 and not actively transmitting LFPS | Measured at the connector side of the AC-coupling capacitor with 50 Ω load | -600 | | 600 | mV |
| $V_{TX-DC-CM}$ | Common-mode voltage bias in the transmitter (DC) | In U0; | 1.5 | | 2.1 | V |
| $V_{TX-CM-AC-PP-ACTIVE}$ | TX AC common-mode voltage active | At 3.3V; Maximum mismatch from Txp+Txn for both time and amplitude | | | 100 | mVpp |
| $V_{TX-IDLE-DIFF-AC-PP}$ | AC electrical idle differential peak-to-peak output voltage | At package pins after high-pass filter (HPF) to remove DC component; HPF = 1/LPF; No AC or DC signals are applied at RX terminals; | 0 | | 10 | mV |

5.5 Electrical Characteristics (続き)

over operating free-air temperature and voltage range (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|--|---|---|-------|------|-----|-------|
| V _{TX-IDLE-DIFF-DC} | DC electrical idle differential output voltage | At package pins after low-pass filter (LPF) to remove AC component; LPF = 1/HPF; No AC or DC signals are applied at RX terminals; | 0 | | 10 | mV |
| V _{TX-CM-DC-ACTIVE-IDLE-DELTA} | Absolute DC common-mode voltage between U1 and U0 | At package pin | | | 200 | mV |
| R _{TX-DIFF} | Differential impedance of the driver | | 75 | | 120 | Ω |
| R _{TX-CM} | Common-mode impedance of the driver | Measured with respect to AC ground over 0V to 500mV | 18 | | 30 | Ω |
| C _{AC-COUPLING} | External AC-coupling capacitor | | 75 | | 265 | nF |
| I _{TX-SHORT} | TX short-circuit current | TX+/- shorted to GND | | | 67 | mA |
| RL _{TX-DIFF} | Differential return loss (SDD22) | 50MHz to 1.25GHz at 90Ω; Lowest EQ setting; FLIP = L; | | -25 | | dB |
| RL _{TX-DIFF-5G} | Differential return loss (SDD22) | 5GHz at 90Ω; Lowest EQ setting; FLIP = L; | | -12 | | dB |
| RL _{TX-CM} | Common-mode return loss (SCC22) | 50MHz to 5GHz at 90Ω; Lowest EQ setting; FLIP = L; | | -9 | | dB |
| AC Electrical Characteristics | | | | | | |
| Crosstalk | Differential crosstalk between TX and RX signal pairs | At 5GHz; FLIP = L; | | -39 | | dB |
| G _{LF} | Low-frequency voltage gain. | At 100MHz, 600mVpp V _{ID} | -0.25 | 0.6 | 1.5 | dB |
| G _{LF_LFPS_TX1/2} | Low-frequency voltage gain for SSTX → TX1/TX2 path | At 10MHz to 50MHz sine wave; 1.0Vpp V _{ID} ; EQ = 0; FLIP = 0 and 1; | -0.5 | 0.8 | 1.6 | dB |
| CP _{1 dB-LF} | Low-frequency -1dB compression point | At 100MHz, 200mVpp < V _{ID} < 2000mVpp | | 1000 | | mVpp |
| CP _{1 dB-HF} | High-frequency -1dB compression point | At 5GHz, 200mVpp < V _{ID} < 2000mVpp | | 770 | | mVpp |
| D _{J_8.1G} | TX output deterministic jitter | 200mVpp < V _{ID} < 2000mVpp, PRBS7, 8.1Gbps, 10dB pre-channel and 1dB post-channel, Optimal EQ setting | | 0.03 | | Upp |
| D _{J_10G} | TX output deterministic jitter | 200mVpp < V _{ID} < 2000mVpp, PRBS7, 10Gbps, 10dB pre-channel and 1dB post-channel, Optimal EQ setting | | 0.07 | | Upp |
| DisplayPort Receiver (TX1P/N, TX2P/N, RX1P/N, RX2P/N) | | | | | | |
| V _{ID_PP} | Peak-to-peak input differential dynamic voltage range | | | 1400 | | mVppd |
| V _{IC} | Input common-mode voltage | | | 0 | | V |
| C _{AC} | External AC-coupling capacitor | | 75 | | 265 | nF |
| EQ _{DP} | Receiver equalizer at maximum setting | At 4.05GHz; | | 13.7 | | dB |
| d _R | Data rate | HBR3 | | | 8.1 | Gbps |
| R _{tx} | Input termination resistance | | 80 | 100 | 120 | Ω |
| DisplayPort Transmitter (DP[3:0]P/N) | | | | | | |
| V _{TX-DIFFPP} | VOD dynamic range | | | 1300 | | mVppd |
| I _{TX-SHORT} | TX short-circuit current | TX+/- shorted to GND | | | 67 | mA |
| V _{DPTX-DC-CM} | Common-mode voltage bias in the transmitter (DC) | | 1.5 | | 2.2 | V |
| R _{DPTX} | Differential impedance of the driver | | 75 | | 120 | Ω |
| AUXP/N and SBU1/2 | | | | | | |

5.5 Electrical Characteristics (続き)

over operating free-air temperature and voltage range (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|--------------------------|--|---|-----|-----|-----|------|
| R _{ON} | Output ON resistance | V _{CC} = 3.3V; V _{IN} = 0V to 0.4V for AUXP; V _{IN} = 2.7V to 3.6V for AUXN | | 5 | 10 | Ω |
| R _{ON-MISMATCH} | ΔON resistance mismatch within pair | V _{CC} = 3.3V; V _{IN} = 0V to 0.4V for AUXP; V _{IN} = 2.7V to 3.6V for AUXN | | | 1.5 | Ω |
| R _{ON_FLAT} | ON resistance flatness (RON _{max} –RON _{min}) measured at identical VCC and temperature | V _{CC} = 3.3V; V _{IN} = 0V to 0.4V for AUXP; V _{IN} = 2.7V to 3.6V for AUXN | | | 2 | Ω |
| V _{AUXP_DC_CM} | AUX channel DC common-mode voltage for AUXP and SBU2. | V _{CC} = 3.3V | 0 | | 0.4 | V |
| V _{AUXN_DC_CM} | AUX channel DC common-mode voltage for AUXN and SBU1 | V _{CC} = 3.3V | 2.7 | | 3.6 | V |
| C _{AUX_ON} | ON-state capacitance | V _{CC} = 3.3V; CTL1 = 1; V _{IN} = 0V or 3.3V | | 4 | 7 | pF |
| C _{AUX_OFF} | OFF-state capacitance | V _{CC} = 3.3V; CTL1 = 0; V _{IN} = 0V or 3.3V | | 3 | 6 | pF |

5.6 Timing Requirements

| | | MIN | NOM | MAX | UNIT |
|----------------------------------|---|-----|-----|-----|------|
| USB3 | | | | | |
| t _{IDLEEntry} | Delay from U0 to electrical idle | | 10 | | ns |
| t _{IDLEExit_U1} | U1 exit time: break in electrical idle to the transmission of LFPS | | 6 | | ns |
| t _{IDLEExit_U2U3} | U2/U3 exit time: break in electrical idle to transmission of LFPS | | 10 | | μs |
| t _{RXDET_INTVL} | RX detect interval while in disconnect | | | 12 | ms |
| t _{IDLEExit_DISCONNECT} | Disconnect exit time | | 10 | | μs |
| t _{Exit_SHTDN} | Shutdown exit time (CTL0 = V _{CC} /2 to U2/U3) | | 1 | | ms |
| t _{DIFF_DLY} | Differential propagation delay (20% to 80% of differential voltage measured 1.7 inch from the output pin) | | | 300 | ps |
| t _{PWRUPACTIVE} | Time when V _{cc} reaches 70% to device active | | | 1 | ms |
| t _R , t _F | Output rise/fall time | | 40 | | ps |
| t _{RF-MM} | Output rise/fall time mismatch (20% to 80% of differential voltage measured 1.7 inch from the output pin) | | | 5 | ps |

5.7 Switching Characteristics

over operating free-air temperature range (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|--|--------------------------|-----------------|-----|-----|------|------|
| AUXp/n and SBU1/2 | | | | | | |
| T _{AUX_PD} | Switch propagation delay | CTL1 = H | | | 1400 | ps |
| T _{AUX_SW_OFF} | Switching on time | CTL1 = H to L | | | 7500 | ns |
| T _{AUX_SW_ON} | Switching off time | CTL1 = L to H | | | 3000 | ns |
| T _{AUX_INT_RA} | Intra-pair output skew | CTL1 = H | | | 400 | ps |
| USB and DisplayPort mode transition requirement (GPIO mode) | | | | | | |

5.7 Switching Characteristics (続き)

over operating free-air temperature range (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|-------------------------------------|---|--|-------|-----|-----|---------------|
| $T_{GP_USB_4DP}$ | Min overlap of CTL0 and CTL1 when transitioning from USB 3.1 only mode to 4-Lane DisplayPort mode or vice versa | | 4 | | | μs |
| $T_{HPDIN_D_EBOUNCE}$ | HPDIN debounce time when transitioning from H to L | Less than minimum is ignored by device | 1.5 | | 4 | ms |
| I²C (SDA and SCL) | | | | | | |
| f_{SCL} | I ² C clock frequency | | | | 1 | MHz |
| t_{BUF} | Bus free time between START and STOP conditions | | 0.5 | | | μs |
| t_{HDSTA} | Hold time after repeated START condition. After this period, the first clock pulse is generated | | 0.26 | | | μs |
| t_{LOW} | Low period of the I ² C clock | | 0.5 | | | μs |
| t_{HIGH} | High period of the I ² C clock | | 0.26 | | | μs |
| t_{SUSTA} | Setup time for a repeated START condition | | 0.26 | | | μs |
| t_{HDDAT} | Data hold time | | 0.004 | | | μs |
| t_{SUDAT} | Data setup time | | 50 | | | ns |
| t_R | Rise time of both SDA and SCL signals | | | | 120 | ns |
| t_F | Device output fall time for SDA | 30pF load | 0.7 | | 5 | ns |
| t_{SUSTO} | Setup time for STOP condition | | 0.26 | | | μs |
| C_b | Capacitive load for each bus line | | | | 100 | pF |

5.8 Typical Characteristics

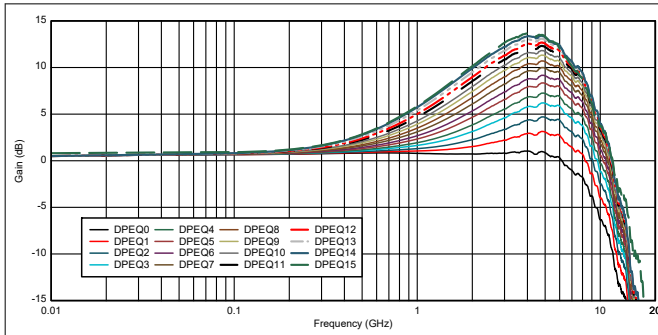


図 5-1. DisplayPort EQ Settings Curves

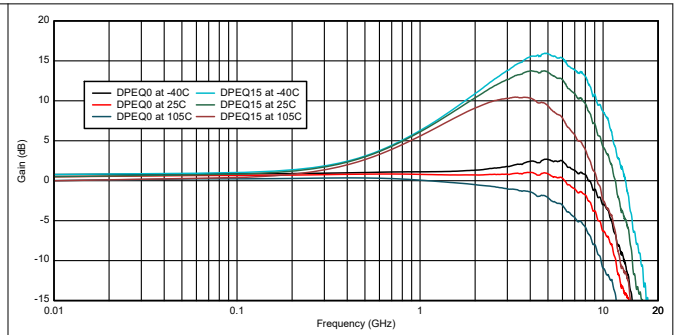


図 5-2. DisplayPort EQ DPEQ0 and DPEQ15 Across Temperatures

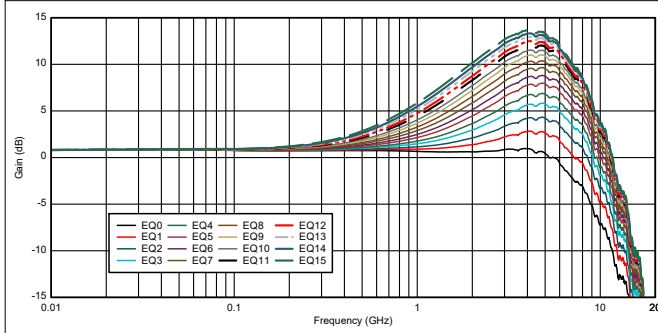


図 5-3. USB3 RX1 EQ Settings Curves

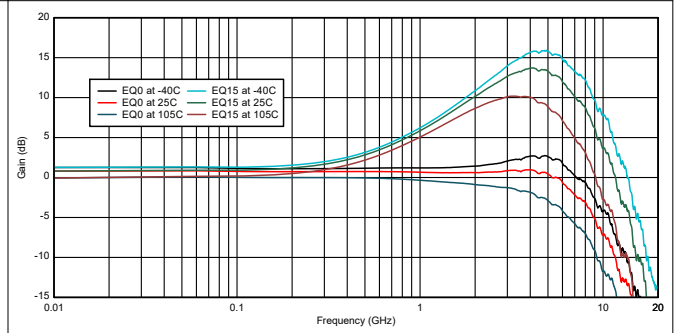


図 5-4. USB3 RX1 EQ0 and EQ15 Across Temperatures

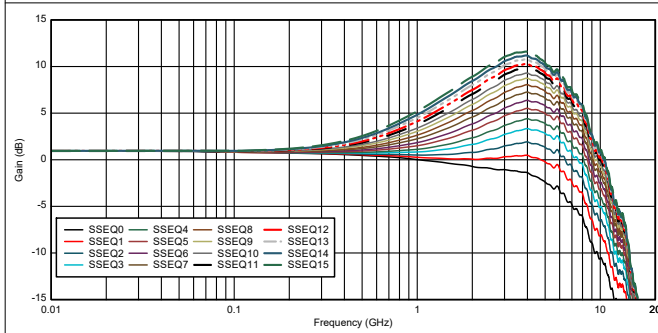


図 5-5. USB3 SSTX EQ Settings Curves

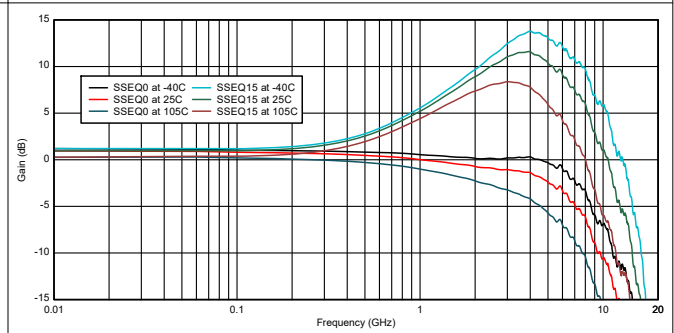


図 5-6. USB3 SSTX SSEQ0 and SSEQ15 Across Temperatures

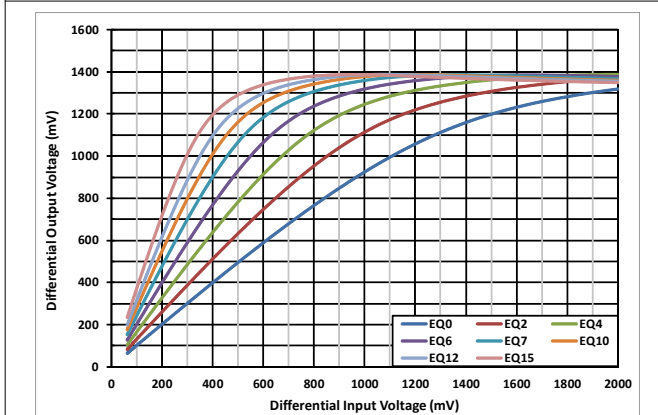


図 5-7. DisplayPort Linearity Curves at 4.05GHz

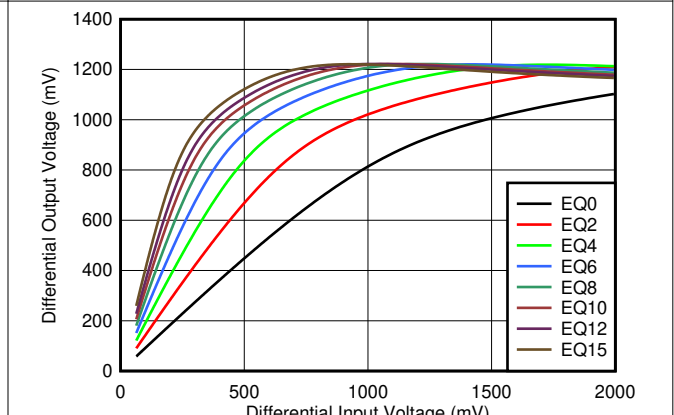
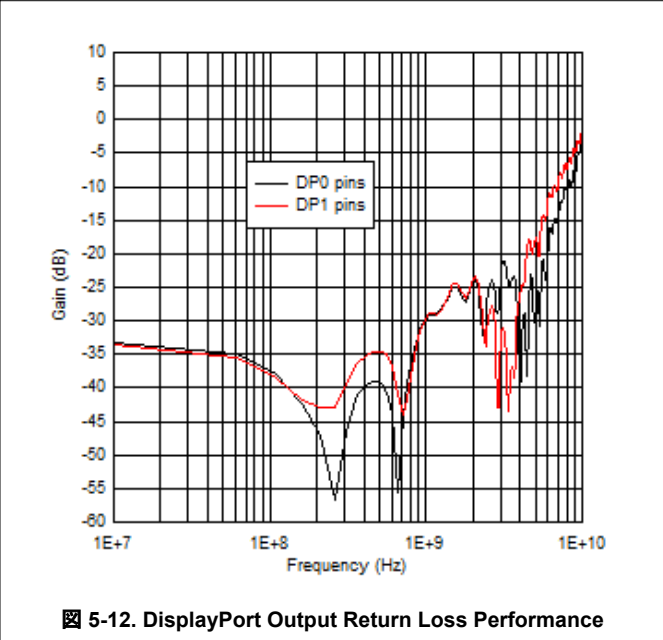
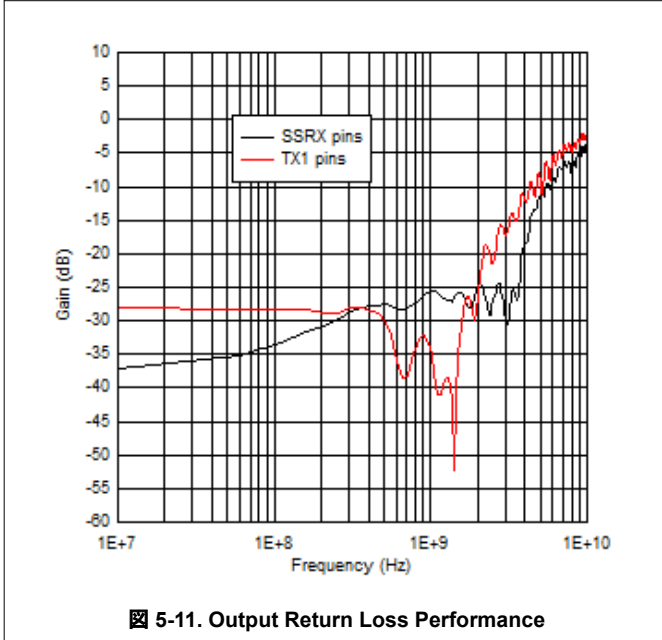
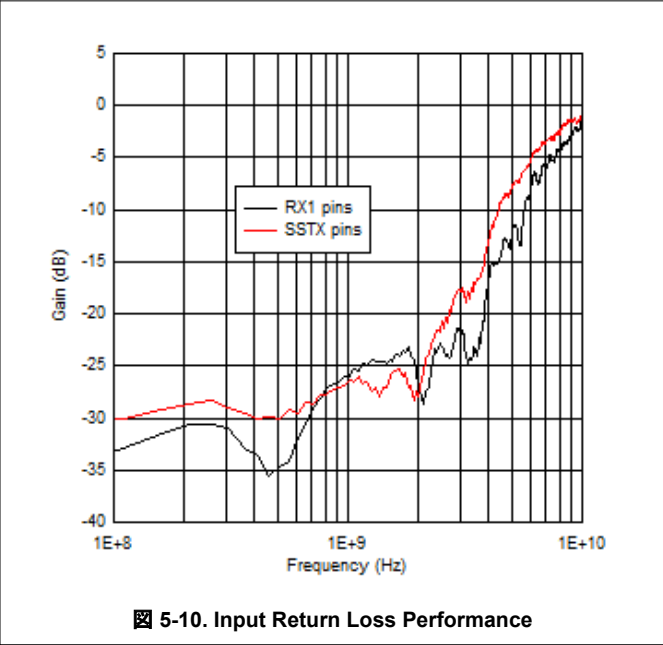
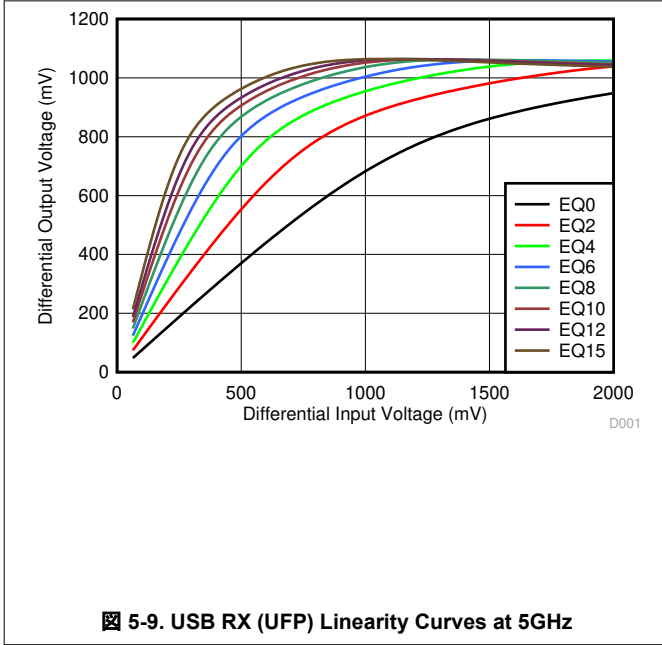
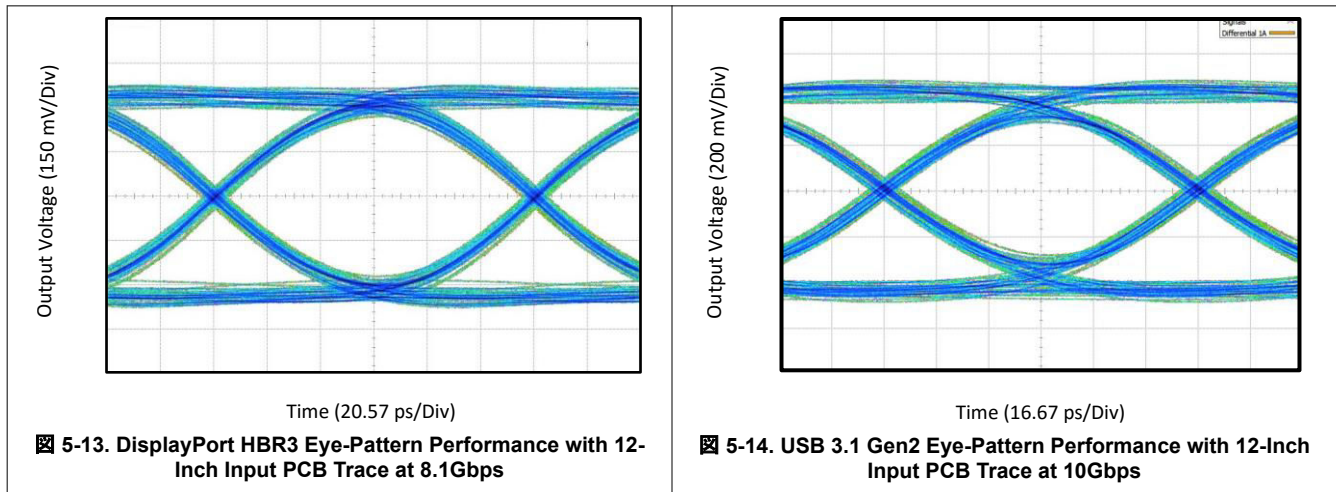


図 5-8. USB TX (DFP) Linearity Curves at 5GHz

5.8 Typical Characteristics (continued)



5.8 Typical Characteristics (continued)



6 Parameter Measurement Information

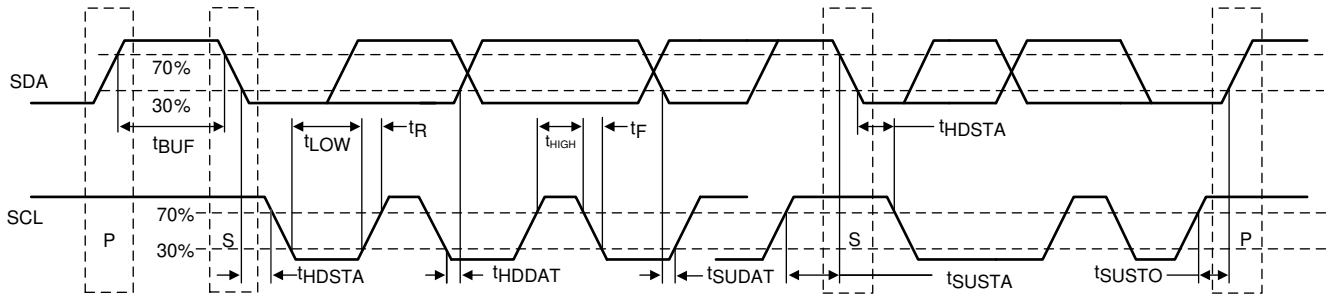


図 6-1. I²C Timing Diagram Definitions

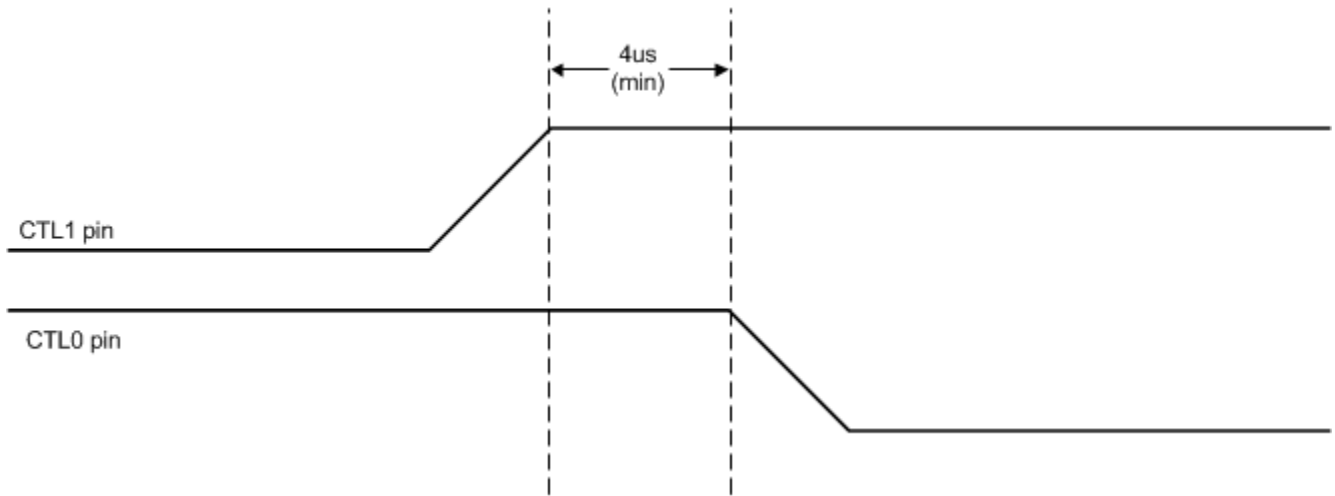


図 6-2. USB3.1 to 4-Lane DisplayPort in GPIO Mode

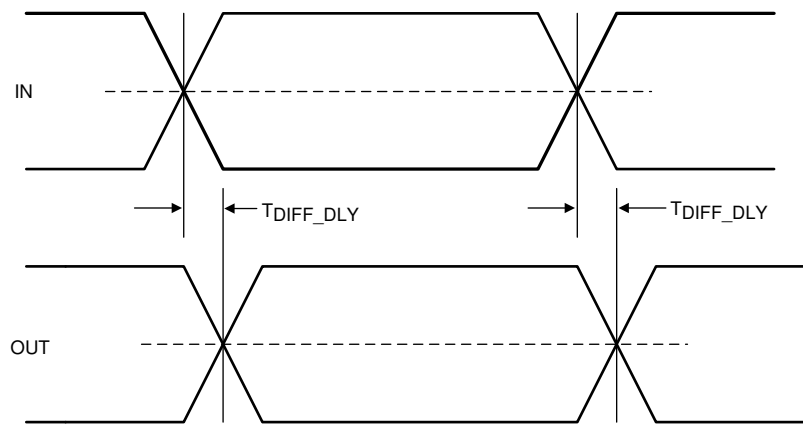


図 6-3. Propagation Delay

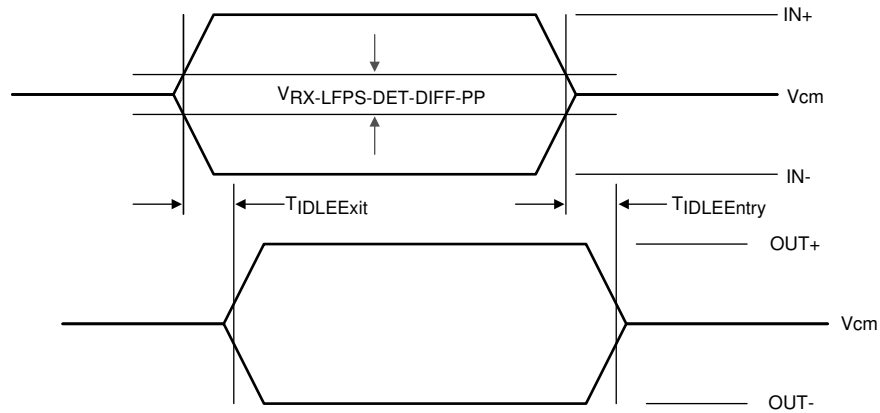


図 6-4. Electrical Idle Mode Exit and Entry Delay

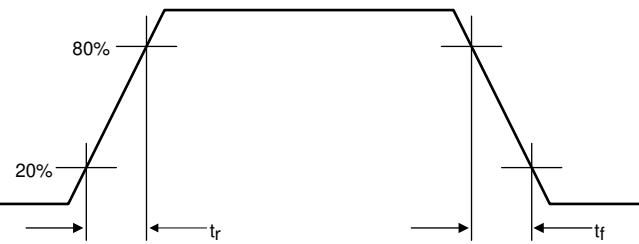


図 6-5. Output Rise and Fall Times

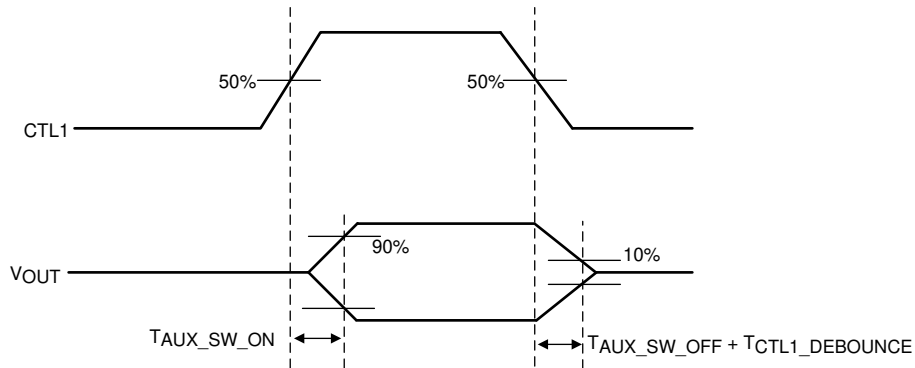


図 6-6. AUX and SBU Switch ON and OFF Timing Diagram

7 Detailed Description

7.1 Overview

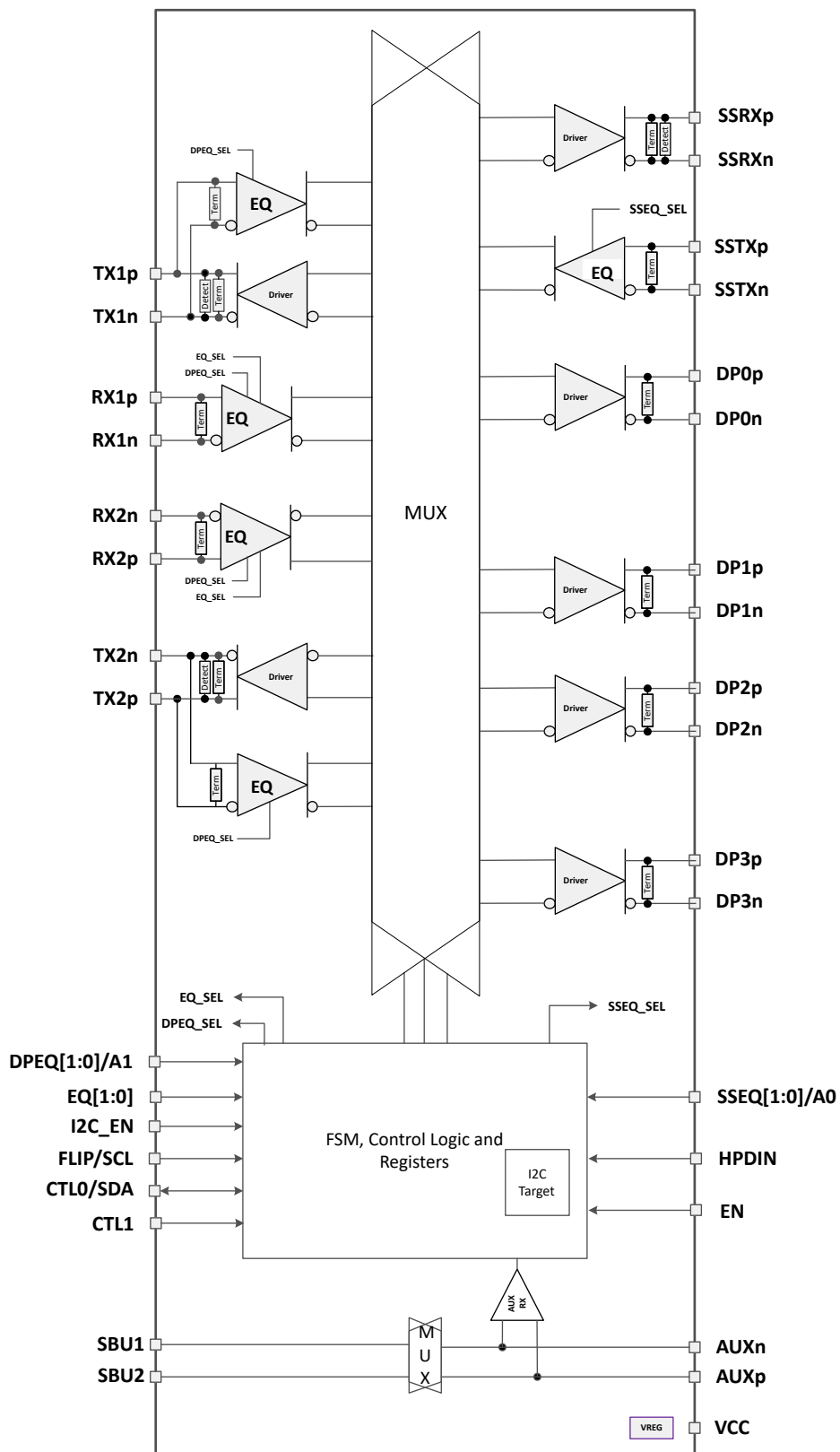
The TUSB1064-Q1 is a VESA USB Type-C Alt Mode redriving switch that supports data rates up to 8.1Gbps for upstream facing port. This device uses 5th generation USB redriver technology. The device is used for UFP pin assignments C and D from the VESA DisplayPort Alt Mode on USB Type-C Standard.

The TUSB1064-Q1 provides several levels of receive equalization to compensate for cable and board trace loss which if not equalized causes inter-symbol interference (ISI) when USB 3.2 or DisplayPort 1.4 signals travel across a PCB or cable. This device requires a 3.3V power supply. The device comes in an automotive grade 2 temperature range.

For a sink application, the TUSB1064-Q1 enables the system to pass both transmitter compliance and receiver jitter tolerance tests for USB 3.2 up to 10Gbps and DisplayPort version 1.4 HBR3. The redriver recovers incoming data by applying equalization that compensates for channel loss, and drives out signals with a high differential voltage. Each channel has a receiver equalizer with selectable gain settings. Set the equalization based on the amount of insertion loss in the channels connected to the TUSB1064-Q1 . Independent equalization control for each channel can be set using EQ[1:0], SSEQ[1:0], and DPEQ[1:0] pins.

The TUSB1064-Q1 advanced state machine makes the device transparent to hosts and devices. After power up, the TUSB1064-Q1 periodically performs receiver detection on the TX pairs. If the TUSB1064-Q1 detects a USB 3.2 receiver, the RX termination is enabled, and the TUSB1064-Q1 is ready to re-drive.

7.2 Functional Block Diagram



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7.3 Feature Description

7.3.1 USB 3.2

The TUSB1064-Q1 supports USB 3.2 datarates up to 10Gbps. The TUSB1064-Q1 supports all the USB defined power states (U0, U1, U2, and U3). The TUSB1064-Q1 is a linear redriver, therefore the device cannot decode USB3.2 physical layer traffic. The TUSB1064-Q1 monitors the actual physical layer conditions like receiver termination, electrical idle, LFPS, and SuperSpeed signaling rate to determine the USB power state of the USB 3.2 interface.

The TUSB1064-Q1 features an intelligent low-frequency periodic signaling (LFPS) detector. The LFPS detector automatically senses the low-frequency signals and disables receiver equalization functionality. When not receiving LFPS, the TUSB1064-Q1 enables receiver equalization based on the EQ[1:0] and SSEQ[1:0] pins or values programmed into EQ1_SEL, EQ2_SEL, and SSEQ_SEL registers.

7.3.2 DisplayPort

The TUSB1064-Q1 supports up to four DisplayPort lanes at datarates up to 8.1Gbps (HBR3). When configured in DisplayPort mode, the TUSB1064-Q1 monitors the native AUX traffic as the device traverses between DisplayPort source and DisplayPort sink. For the purposes of reducing power, the TUSB1064-Q1 manages the number of active DisplayPort lanes based on the content of the AUX transactions. The TUSB1064-Q1 snoops native AUX writes to DPCD registers 0x00101 (LANE_COUNT_SET) and 0x00600 (SET_POWER_STATE) of the DisplayPort sink. The TUSB1064-Q1 disables or enables lanes based on value written to LANE_COUNT_SET. The TUSB1064-Q1 disables all lanes when SET_POWER_STATE is in the D3. Otherwise, active lanes are based on value of LANE_COUNT_SET.

DisplayPort AUX snooping is enabled by default but can be disabled by changing the AUX_SNOOP_DISABLE register. After AUX snoop is disabled, management of TUSB1064-Q1 DisplayPort lanes are controlled through various configuration registers.

注

AUX snooping feature is only supported when TUSB1064-Q1 is configured for I²C mode. When TUSB1064-Q1 is configured for GPIO mode, the AUX snoop feature is disabled and all four DP lanes are enabled if HPDIN is asserted high.

When the TUSB1064-Q1 AUX snoop feature is enabled, the syncs defined by the DisplayPort standard must be received for AUX snoop feature to function properly. AUX writes to the DPCD address 0x00600 and 0x00101 of the panel can result in SET_POWER_STATE and LANE_COUNT_SET fields at TUSB1064-Q1 offset 0x12 to get set to the appropriate value. If these fields do not get set correctly, then incoming AUX may not be compliant. If this is the case, then it is best to disable AUX snoop by setting the AUX_SNOOP_DISABLE field at offset 0x13.

7.3.3 4-Level Inputs

The TUSB1064-Q1 has (I2C_EN, EQ[1:0], DPEQ[1:0], and SSEQ[1:0]) 4-level inputs pins that are used to control the equalization gain and place TUSB1064-Q1 into different modes of operation. These 4-level inputs use a resistor divider to help set the four valid levels and provide a wider range of control settings. There is an internal 35kΩ pullup and a 95kΩ pulldown. These resistors, together with the external resistor connection combine to achieve the desired voltage level.

表 7-1. 4-Level Control Pin Settings

| LEVEL | SETTINGS |
|-------|-------------------------------|
| 0 | Tie 1kΩ 5% to GND |
| R | Tie 20kΩ 5% to GND |
| F | Float (leave pin open) |
| 1 | Tie 1kΩ 5% to V _{CC} |

注

All 4-level inputs are latched after the rising edge of internal reset. After $t_{cf_g_hd}$, the internal pullup and pulldown resistors are isolated to save power.

7.3.4 Receiver Linear Equalization

The purpose of receiver equalization is to compensate for channel insertion loss and the resulting inter-symbol interference in the system before the input or after the output of the TUSB1064-Q1. The receiver overcomes these losses by attenuating the low-frequency components of the signals with respect to the high-frequency components. Select the proper gain setting to match the channel insertion loss. Two 4-level input pins enable up to 16 possible equalization settings. The USB3.2 upstream path, USB3.2 downstream path, and DisplayPort each have two 4-level inputs. The TUSB1064-Q1 also provides the flexibility of adjusting settings through I²C registers.

7.4 Device Functional Modes

7.4.1 Device Configuration in GPIO Mode

The TUSB1064-Q1 is in GPIO configuration when I2C_EN = "0". The TUSB1064-Q1 supports the following configurations: USB only, 2 DisplayPort lanes + USB, or 4 DisplayPort lanes (no USB). The CTL1 pin controls whether DisplayPort is enabled. The combination of CTL1 and CTL0 selects between USB only, 2 lanes of DisplayPort, or 4-lanes of DisplayPort as detailed in 表 7-2. The AUXp or AUXn to SBU1 or SBU2 mapping is controlled based on 表 7-3.

After power up (V_{CC} from 0V to 3.3V), the TUSB1064-Q1 defaults to USB mode. The USB PD controller upon detecting no device attached to Type-C port must take TUSB1064-Q1 out of USB mode by transitioning the CTL0 pin from L to H and back to L.

表 7-2. GPIO Configuration Control

| CTL1 PIN | CTL0 PIN | FLIP PIN | CONFIGURATION | VESA DisplayPort ALT MODE UFP_D CONFIGURATION |
|----------|----------|----------|--------------------------------------|---|
| L | L | L | Power Down | — |
| L | L | H | Power Down | — |
| L | H | L | One Port USB – No Flip | — |
| L | H | H | One Port USB – With Flip | — |
| H | L | L | 4 Lane DP – No Flip | C |
| H | L | H | 4 Lane DP – With Flip | C |
| H | H | L | One Port USB + 2 Lane DP – No Flip | D |
| H | H | H | One Port USB + 2 Lane DP – With Flip | D |

表 7-3. GPIO AUXp or AUXn to SBU1 or SBU2 Mapping

| CTL1 PIN | FLIP PIN | MAPPING |
|----------|----------|----------------------------|
| H | L | SBU1 → AUXn SBU2 → AUXp |
| H | H | SBU2 → AUXn SBU1 → AUXp |
| L > 2ms | X | Open |

表 7-4 details the TUSB1064-Q1 MUX routing. This table is valid for both I²C and GPIO configuration modes.

表 7-4. INPUT to OUTPUT Mapping

| CTL1 PIN | CTL0 PIN | FLIP PIN | FROM | TO |
|----------|----------|----------|-----------|------------|
| | | | INPUT PIN | OUTPUT PIN |
| L | L | L | NA | NA |
| L | L | H | NA | NA |
| L | H | L | RX1p | SSRXp |
| | | | RX1n | SSRXn |
| | | | SSTXp | TX1p |
| | | | SSTXn | TX1n |
| L | H | H | RX2p | SSRXp |
| | | | RX2n | SSRXn |
| | | | SSTXp | TX2p |
| | | | SSTXn | TX2n |
| H | L | L | TX2p | DP0p |
| | | | TX2n | DP0n |
| | | | RX2p | DP1p |
| | | | RX2n | DP1n |
| | | | RX1p | DP2p |
| | | | RX1n | DP2n |
| | | | TX1p | DP3p |
| | | | TX1n | DP3n |
| H | L | H | TX1p | DP0p |
| | | | TX1n | DP0n |
| | | | RX1p | DP1p |
| | | | RX1n | DP1n |
| | | | RX2p | DP2p |
| | | | RX2n | DP2n |
| | | | TX2p | DP3p |
| | | | TX2n | DP3n |
| H | H | L | RX1p | SSRXp |
| | | | RX1n | SSRXn |
| | | | SSTXp | TX1p |
| | | | SSTXn | TX1n |
| | | | TX2p | DP0p |
| | | | TX2n | DP0n |
| | | | RX2p | DP1p |
| | | | RX2n | DP1n |
| H | H | H | RX2p | SSRXp |
| | | | RX2n | SSRXn |
| | | | SSTXp | TX2p |
| | | | SSTXn | TX2n |
| | | | TX1p | DP0p |
| | | | TX1n | DP0n |
| | | | RX1p | DP1p |
| | | | RX1n | DP1n |

7.4.2 Device Configuration In I²C Mode

The TUSB1064-Q1 is in I²C mode when I2C_EN is not equal to 0. The same configurations defined in GPIO mode are also available in I²C mode. The TUSB1064-Q1 USB and DisplayPort configuration is controlled based on 表 7-5. The AUXp or AUXn to SBU1 or SBU2 mapping control is based on 表 7-6.

表 7-5. I²C Configuration Control

| REGISTERS | | | CONFIGURATION | VESA DisplayPort ALT MODE UFP_D CONFIGURATION |
|-----------|---------|---------|-------------------------------------|--|
| CTLSEL1 | CTLSEL0 | FLIPSEL | | |
| 0 | 0 | 0 | Power Down | — |
| 0 | 0 | 1 | Power Down | — |
| 0 | 1 | 0 | One Port USB – No Flip | — |
| 0 | 1 | 1 | One Port USB – With Flip | — |
| 1 | 0 | 0 | 4 Lane DP – No Flip | C |
| 1 | 0 | 1 | 4 Lane DP – With Flip | C |
| 1 | 1 | 0 | One Port USB + 2 Lane DP – No Flip | D |
| 1 | 1 | 1 | One Port USB+ 2 Lane DP – With Flip | D |

表 7-6. I²C AUXp or AUXn to SBU1 or SBU2 Mapping

| REGISTERS | | | MAPPING |
|-------------|---------|---------|----------------------------|
| AUX_SBU_OVR | CTLSEL1 | FLIPSEL | |
| 00 | 1 | 0 | SBU1 → AUXn SBU2 → AUXp |
| 00 | 1 | 1 | SBU2 → AUXn SBU1 → AUXp |
| 00 | 0 | X | Open |
| 01 | X | X | SBU1 → AUXn SBU2 → AUXp |
| 10 | X | X | SBU2 → AUXn SBU1 → AUXp |
| 11 | X | X | Open |

7.4.3 DisplayPort Mode

The TUSB1064-Q1 supports up to four DisplayPort lanes at data rates up to 8.1Gbps. The TUSB1064-Q1 can be enabled for DisplayPort through the GPIO control pin CTL1 or through the I²C register CTLSEL1. When I2C_EN is "0", DisplayPort is controlled based on 表 7-2. When not in GPIO mode, DisplayPort functionality is controlled through I²C registers. Data transfer through the DisplayPort lanes is further controlled by the HPDIN pin. DisplayPort must be enabled using CTL1 pin or CTLSEL1 register and also HPDIN must be pulled high for the DisplayPort data transfer to be enabled through the DisplayPort lanes.

注

When operating in 4-lane DP mode (CTLSEL[1:0] = 2h) with AUX snoop disabled (AUX_SNOOP_DISABLE = 1), all four DP lanes must be enabled (DP0_DISABLE = DP1_DISABLE = DP2_DISABLE = DP3_DISABLE = "0").

With AUX snoop disabled (AUX_SNOOP_DISABLE = 1) and CTLESEL[1:0] = 2h, the individual DP lane disable/enable for DP0 and DP3 are swapped and DP1 and DP2 are swapped. DP0_DISABLE controls DP3, DP3_DISABLE controls DP0, DP1_DISABLE controls DP2, and DP2_DISABLE controls DP1.

7.4.4 Linear EQ Configuration

Each of the TUSB1064-Q1 receiver lanes has individual controls for receiver equalization. The receiver equalization gain value can be controlled either through I²C registers or through GPIOs. 表 7-7 details the gain value for each available combination when TUSB1064-Q1 is in GPIO mode. These same options are also available in I²C mode by updating registers DP0EQ_SEL, DP1EQ_SEL, DP2EQ_SEL, DP3EQ_SEL, EQ1_SEL, EQ2_SEL, and SSEQ_SEL. Each of the 4-bit EQ configuration registers is mapped to the configuration pins as follows: x_SEL = {x1[1:0],x0[1:0]} where xn[1:0] are the EQ configuration pins with pin levels mapped to 2-bit values as: 0 = 00, R = 01, F = 10, 1 = 11.

表 7-7. TUSB1064-Q1 Receiver Equalization GPIO Control

| EQUALIZATION SETTING # | USB3.2 UPSTREAM FACING PORTS | | | USB 3.2 DOWNSTREAM FACING PORT | | | ALL DISPLAYPORT LANES | | |
|------------------------|------------------------------|---------------|----------------------|--------------------------------|-----------------|----------------------|-----------------------|-----------------|-------------------------|
| | EQ1 PIN LEVEL | EQ0 PIN LEVEL | EQ GAIN AT 5GHz (dB) | SSEQ1 PIN LEVEL | SSEQ0 PIN LEVEL | EQ GAIN AT 5GHz (dB) | DPEQ1 PIN LEVEL | DPEQ0 PIN LEVEL | EQ GAIN AT 4.05GHz (dB) |
| 0 | 0 | 0 | 0.4 | 0 | 0 | -2.4 | 0 | 0 | 1.0 |
| 1 | 0 | R | 2.6 | 0 | R | -0.2 | 0 | R | 3.0 |
| 2 | 0 | F | 4.2 | 0 | F | 1.3 | 0 | F | 4.4 |
| 3 | 0 | 1 | 5.7 | 0 | 1 | 2.8 | 0 | 1 | 5.8 |
| 4 | R | 0 | 6.7 | R | 0 | 3.8 | R | 0 | 6.8 |
| 5 | R | R | 7.9 | R | R | 4.9 | R | R | 8.0 |
| 6 | R | F | 8.7 | R | F | 5.8 | R | F | 8.8 |
| 7 | R | 1 | 9.5 | R | 1 | 6.6 | R | 1 | 9.6 |
| 8 | F | 0 | 10.2 | F | 0 | 7.3 | F | 0 | 10.4 |
| 9 | F | R | 10.9 | F | R | 7.9 | F | R | 11.0 |
| 10 | F | F | 11.4 | F | F | 8.4 | F | F | 11.6 |
| 11 | F | 1 | 11.9 | F | 1 | 8.9 | F | 1 | 12.1 |
| 12 | 1 | 0 | 12.2 | 1 | 0 | 9.3 | 1 | 0 | 12.5 |
| 13 | 1 | R | 12.6 | 1 | R | 9.7 | 1 | R | 13.0 |
| 14 | 1 | F | 12.9 | 1 | F | 10.0 | 1 | F | 13.4 |
| 15 | 1 | 1 | 13.3 | 1 | 1 | 10.5 | 1 | 1 | 13.7 |

7.4.5 USB3 Modes

The TUSB1064-Q1 monitors the physical layer conditions like receiver termination, electrical idle, LFPS, and SuperSpeed signaling rate to determine the state of the USB3.1 interface. Depending on the state of the USB 3.2 interface, the TUSB1064-Q1 can be in one of four primary modes of operation when USB 3.2 is enabled (CTL0 = H or CTLSEL0 = 1b1): Disconnect, U2/U3, U1, and U0.

The Disconnect mode is the state in which TUSB1064-Q1 has not detected far-end termination on upstream facing port (UFP) or downstream facing port (DFP). The disconnect mode is the lowest power mode of each of the four modes. The TUSB1064-Q1 remains in this mode until far-end receiver termination has been detected on both UFP and DFP. The TUSB1064-Q1 immediately exits this mode and enters U0 after far-end termination is detected.

When in U0 mode, the TUSB1064-Q1 redrives all traffic received on UFP and DFP. U0 is the highest power mode of all USB3.1 modes. The TUSB1064-Q1 remains in U0 mode until electrical idle occurs on both UFP and DFP. Upon detecting electrical idle, the TUSB1064-Q1 immediately transitions to U1.

The U1 mode is the intermediate mode between U0 mode and U2/U3 mode. In U1 mode, the TUSB1064-Q1 UFP and DFP receiver termination remains enabled. The UFP and DFP transmitter DC common mode is maintained. The power consumption in U1 is similar to power consumption of U0.

Next to the disconnect mode, the U2/U3 mode is next lowest power state. While in this mode, the TUSB1064-Q1 periodically performs far-end receiver detection. Anytime the far-end receiver termination is not detected on either UFP or DFP, the TUSB1064-Q1 leaves the U2/U3 mode and transitions to the Disconnect mode. The device also monitors for a valid LFPS. Upon detection of a valid LFPS, the TUSB1064-Q1 immediately transitions to the U0 mode. In U2/U3 mode, the TUSB1064-Q1 receiver terminations remain enabled but the TX DC common mode voltage is not maintained.

7.4.6 Operation Timing – Power Up

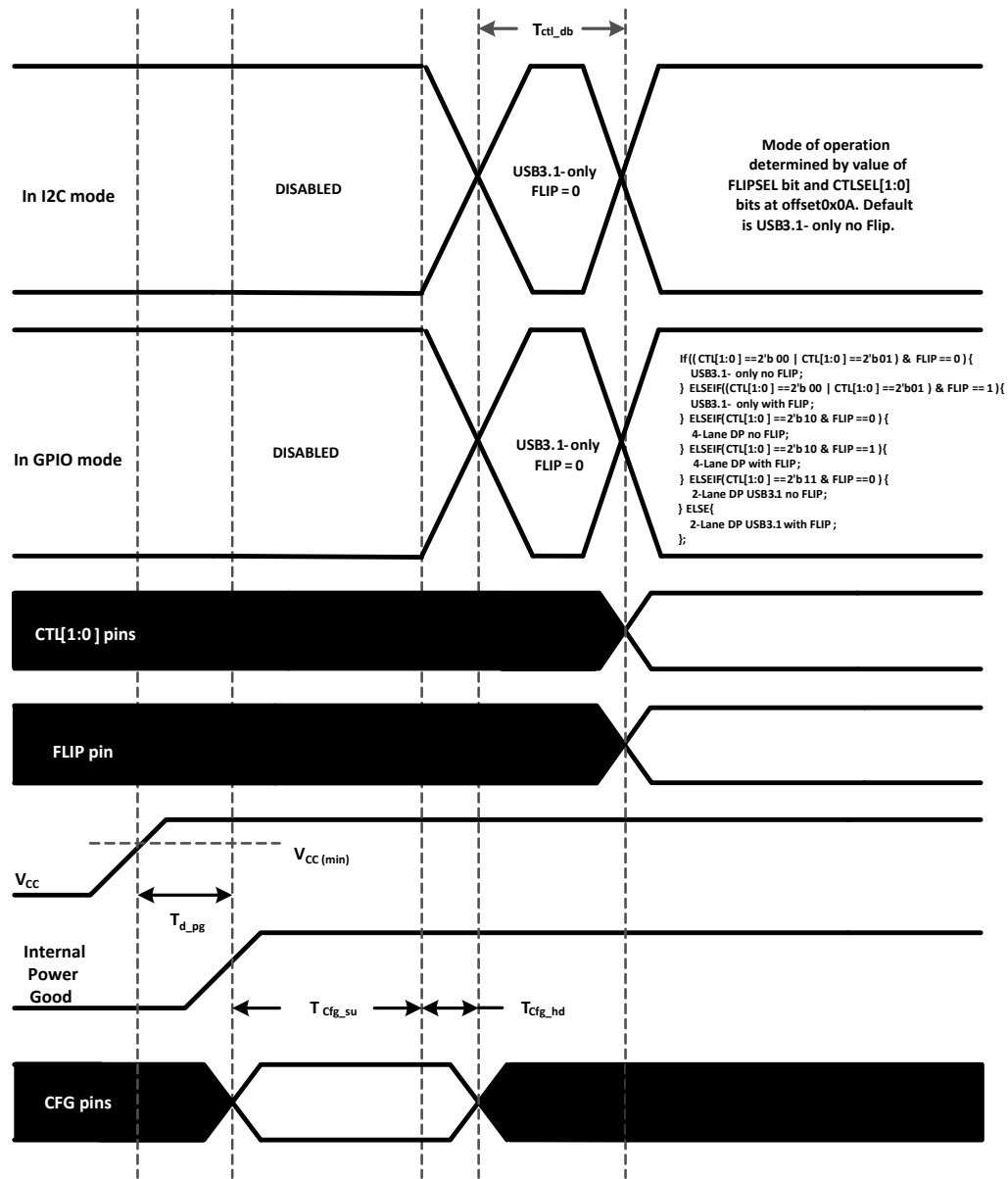


図 7-1. Power-Up Timing

表 7-8. Power-Up Timing ⁽¹⁾ ⁽²⁾

| PARAMETER | | MIN | MAX | UNIT |
|-----------------|---|-----|-----|---------|
| t_{d_pg} | V_{CC} (minimum) to Internal Power Good asserted high | | 500 | μ s |
| t_{cfg_su} | CFG ⁽¹⁾ pins setup ⁽²⁾ | 50 | | μ s |
| t_{cfg_hd} | CFG ⁽¹⁾ pins hold | 10 | | μ s |
| t_{CTL_DB} | CTL[1:0] and FLIP pin debounce | | 16 | ms |
| t_{VCC_RAMP} | VCC supply ramp requirement | 0.1 | 50 | ms |

(1) Following pins comprise CFG pins: I2C_EN, EQ[1:0], SSEQ[1:0], and DPEQ[1:0].
 (2) Recommend CFG pins are stable when V_{CC} is at minimum value.

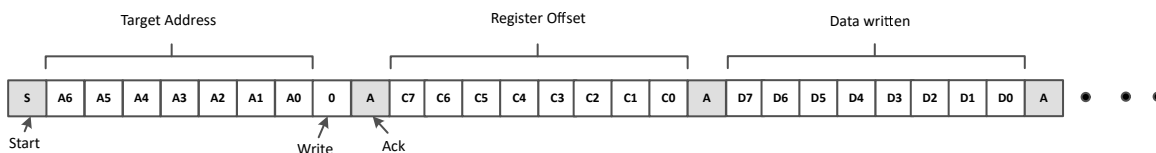
7.5 Programming

For further programmability, the TUSB1064-Q1 can be controlled using I²C. The SCL and SDA pins are used for I²C clock and I²C data, respectively.

表 7-9. TUSB1064-Q1 I²C Target Address

| DPEQ0/A1 PIN LEVEL | SSEQ0/A0 PIN LEVEL | BIT 7 (MSB) | BIT 6 | BIT 5 | BIT 4 | BIT 3 | BIT 2 | BIT 1 | BIT 0 (W/R) |
|-----------------------|-----------------------|-------------|-------|-------|-------|-------|-------|-------|-------------|
| 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0/1 |
| 0 | R | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0/1 |
| 0 | F | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0/1 |
| 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0/1 |
| R | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0/1 |
| R | R | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0/1 |
| R | F | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0/1 |
| R | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0/1 |
| F | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0/1 |
| F | R | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0/1 |
| F | F | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0/1 |
| F | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0/1 |
| 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0/1 |
| 1 | R | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0/1 |
| 1 | F | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0/1 |
| 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0/1 |

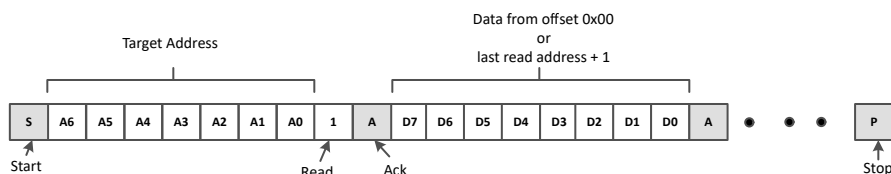
7.5.1 TUSB1064-Q1 I²C Target Behavior



7-2. I²C Write with Data

Use the following procedure to write data to TUSB1064-Q1 I²C registers (refer to 7-2):

1. The controller initiates a write operation by generating a start condition (S), followed by the TUSB1064-Q1 7-bit address and a zero-value W/R bit to indicate a write cycle.
2. The TUSB1064-Q1 acknowledges the address cycle.
3. The controller presents the register offset within TUSB1064-Q1 to be written, consisting of one byte of data, MSB-first.
4. The TUSB1064-Q1 acknowledges the sub-address cycle.
5. The controller presents the first byte of data to be written to the I²C register.
6. The TUSB1064-Q1 acknowledges the byte transfer.
7. The controller can continue presenting additional bytes of data to be written, with each byte transfer completing with an acknowledge from the TUSB1064-Q1 .
8. The controller terminates the write operation by generating a stop condition (P).



7-3. I²C Read Without Repeated Start

Use the following procedure to read the TUSB1064-Q1 I²C registers without a repeated Start (refer to 7-3).

1. The controller initiates a read operation by generating a start condition (S), followed by the TUSB1064-Q1 7-bit address and a zero-value W/R bit to indicate a read cycle.
2. The TUSB1064-Q1 acknowledges the 7-bit address cycle.
3. Following the acknowledge the controller continues sending clock.
4. The TUSB1064-Q1 transmit the contents of the memory registers MSB-first starting at register 00h or last read register offset+1. If a write to the I²C register occurred prior to the read, then the TUSB1064-Q1 shall start at the register offset specified in the write.
5. The TUSB1064-Q1 waits for either an acknowledge (ACK) or a not-acknowledge (NACK) from the controller after each byte transfer; the I²C controller acknowledges reception of each data byte transfer.
6. If an ACK is received, the TUSB1064-Q1 transmits the next byte of data as long as controller provides the clock. If a NAK is received, the TUSB1064-Q1 stops providing data and waits for a stop condition (P).
7. The controller terminates the write operation by generating a stop condition (P).

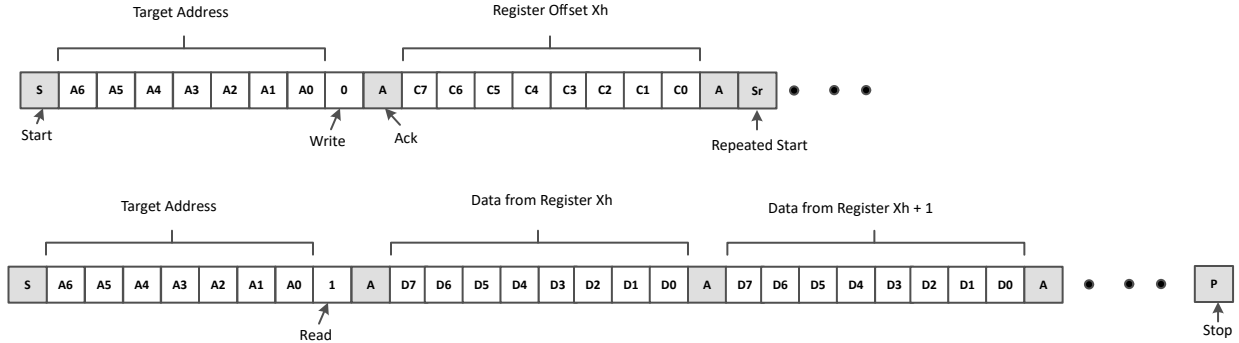


図 7-4. I²C Read with Repeated Start

Use the following procedure to read the TUSB1064-Q1 I²C registers with a repeated Start (refer 図 7-4).

1. The controller initiates a read operation by generating a start condition (S), followed by the TUSB1064-Q1 7-bit address and a zero-value W/R bit to indicate a write cycle.
2. The TUSB1064-Q1 acknowledges the 7-bit address cycle.
3. The controller presents the register offset within TUSB1064-Q1 to be written, consisting of one byte of data, MSB-first.
4. The TUSB1064-Q1 acknowledges the register offset cycle.
5. The controller presents a repeated start condition (Sr).
6. The controller initiates a read operation by generating a start condition (S), followed by the TUSB1064-Q1 7-bit address and a one-value W/R bit to indicate a read cycle.
7. The TUSB1064-Q1 acknowledges the 7-bit address cycle.
8. The TUSB1064-Q1 transmit the contents of the memory registers MSB-first starting at the register offset.
9. The TUSB1064-Q1 shall wait for either an acknowledge (ACK) or a not-acknowledge (NACK) from the controller after each byte transfer; the I²C controller acknowledges reception of each data byte transfer.
10. If an ACK is received, the TUSB1064-Q1 transmits the next byte of data as long as controller provides the clock. If a NAK is received, the TUSB1064-Q1 stops providing data and waits for a stop condition (P).
11. The controller terminates the read operation by generating a stop condition (P).

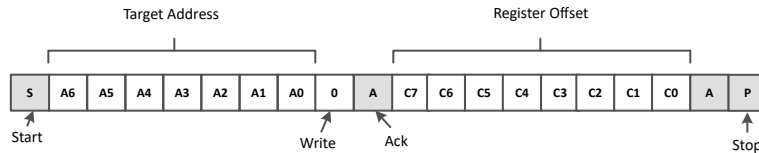


図 7-5. I²C Write Without Data

Use the following procedure to set a starting sub-address for I²C reads (refer to 図 7-5).

1. The controller initiates a write operation by generating a start condition (S), followed by the TUSB1064-Q1 7-bit address and a zero-value W/R bit to indicate a write cycle.
2. The TUSB1064-Q1 acknowledges the address cycle.
3. The controller presents the register offset within TUSB1064-Q1 to be written, consisting of one byte of data, MSB-first.
4. The TUSB1064-Q1 acknowledges the register offset cycle.
5. The controller terminates the write operation by generating a stop condition (P).

注

After initial power up, if no register offset is included for the read procedure (refer to [図 7-3](#)), then reads start at register offset 00h and continue byte by byte through the registers until the I²C controller terminates the read operation. During a read operation, the TUSB1064-Q1 auto-increments the I²C internal register address of the last byte transferred independent of whether or not an ACK was received from the I²C controller.

Software must only access (read or write) addresses detailed in this document. Accessing reserved or undocumented addresses can result in TUSB1064-Q1 entering an undefined state.

8 Application and Implementation

注

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

8.1 Application Information

The TUSB1064-Q1 is a linear redriver designed specifically to compensation for intersymbol interference (ISI) jitter caused by signal attenuation through a passive medium like PCB traces and cables. Because the TUSB1064-Q1 has four independent DisplayPort 1.4 inputs, one upstream facing USB 3.2 Gen 2 input, and two downstream facing USB 3.2 Gen 2 inputs, the TUSB1064-Q1 can be optimized to correct ISI on all those seven inputs through 16 different equalization choices. Placing the TUSB1064-Q1 between a USB3.2 Host/DisplayPort 1.4 GPU and a USB3.2 Type-C receptacle can correct signal integrity issues resulting in a more robust system.

8.2 Typical Application

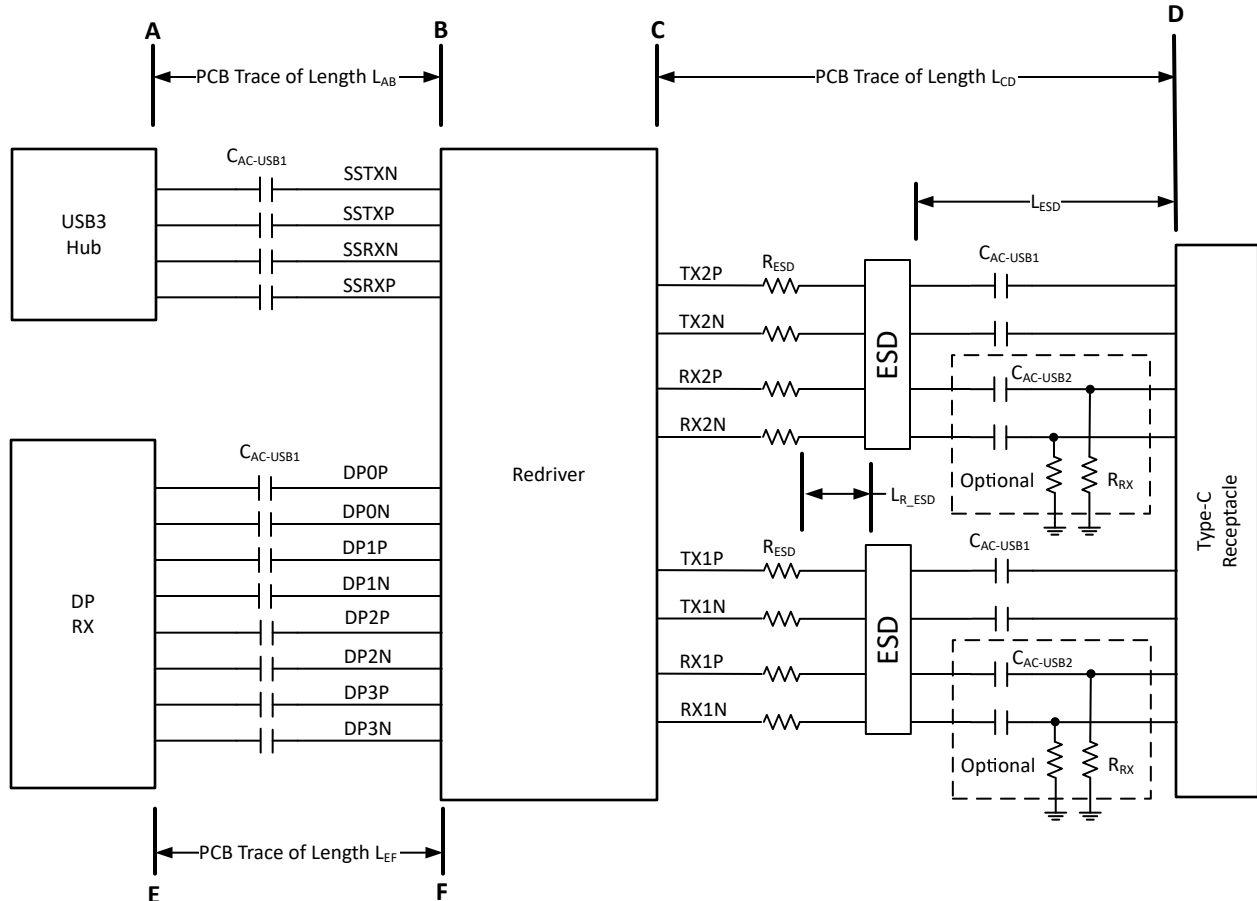


図 8-1. TUSB1064-Q1 in a DP Alt Sink Application

8.2.1 Design Requirements

For this design example, use the parameters provided in 表 8-1.

表 8-1. Design Parameters

| PARAMETER ⁽¹⁾ | VALUE |
|--|---|
| Redriver to USB3 Hub maximum PCB trace length, X_{AB} | 6 inches |
| Redriver to DP RX maximum PCB trace length, X_{EF} | 6 inches |
| Redriver to Type-C connector maximum PCB trace length, X_{CD} | 2 inches |
| Maximum distance of ESD component from the USB receptacle, L_{ESD} | 1.0 inches |
| Maximum distance of series resistor (R_{ESD}) from ESD component, L_{R_ESD} | 0.25 inches |
| $C_{AC-USB1}$ AC-coupling capacitor (75nF to 265nF) | 100nF or 220nF |
| $C_{AC-USB2}$ AC-coupling capacitor (297nF to 363nF) | Options: <ul style="list-style-type: none"> • RX1 and RX2 are DC-coupled to USB receptacle • 330nF AC-couple with R_{RX} resistor |
| Optional R_{RX} resistor (220k Ω \pm 5%) | 220k Ω \pm 5% |
| Optional R_{ESD} (0 Ω to 2.2 Ω) | 1 Ω |
| VCC supply (3V to 3.6V) | 3.3V |
| I2C Mode or GPIO Mode | I2C Mode. (I2C_EN pin != "0") |
| 1.8V or 3.3V I2C Interface | 3.3V I2C. Pullup the I2C_EN pin to 3.3V with a 1K ohm resistor. CTL1, EQ[1:0], SSEQ[1:0], and DPEQ[1:0] pin unconnected. |
| EQ setting for DisplayPort Lanes | EQ Setting # 5 (Register 0x0A[4] = 1'b1, 0x10 = 0x55; 0x11 = 0x55) |
| EQ setting for Downstream USB Data Path | EQ Setting # 6 (Register 0x0A[4] = 1'b1, 0x20 = 0x66) |
| EQ setting for Upstream USB Data Path | EQ Setting # 6 (Register 0x0A[4] = 1'b1, 0x21 = 0x08) |

(1) Maximum trace length assumes an insertion loss of 0.2dB/inch/GHz. If insertion loss is more than 0.2dB/inch/GHz, then maximum trace length must be reduced accordingly.

8.2.2 Detailed Design Procedure

A typical usage of the TUSB1064-Q1 device is shown in 図 8-2. The device can be controlled either through its GPIO pins or through its I²C interface. In the example shown below, a Type-C PD controller is used to configure the device through the I²C interface. In I²C mode, the equalization settings for each receiver can be independently controlled through I²C registers. For this reason, the configuration pin CTL1 and all of the equalization pins (EQ[1:0], SSEQ[1:0], and DPEQ[1:0]) can be left unconnected. If these pins are left unconnected, the TUSB1064-Q1 7-bit I²C target address is 0x12 because both DPEQ/A1 and SSEQ0/A0 are at pin level "F". If a different I²C target address is desired, set the DPEQ/A1 and SSEQ0/A0 pins to a level which produces the desired I²C target address.

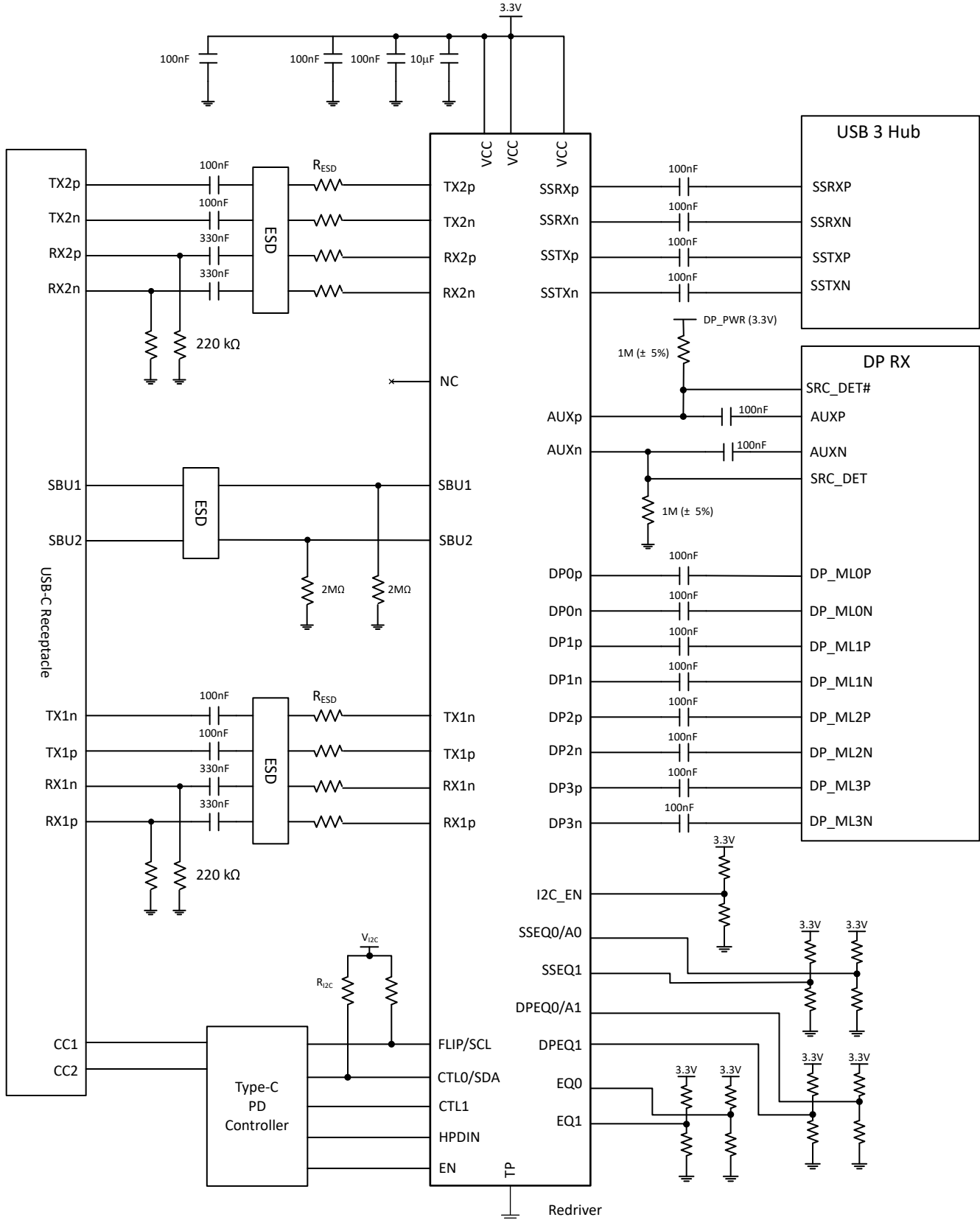


图 8-2. Application Circuit

8.2.2.1 ESD Protection

It may be necessary to incorporate an ESD component to protect the TUSB1064-Q1 from electrostatic discharge (ESD). TI recommends following the ESD protection recommendations listed in 表 8-2. A clamp voltage greater than value specified in 表 8-2 may require a R_{ESD} on each differential pin. Place the ESD component near the USB connector.

表 8-2. ESD Diodes Recommended Characteristics

| PARAMETER | RECOMMENDATION |
|--|---|
| Breakdown voltage | $\geq 3.5V$ |
| I/O line capacitance | Data rates $\leq 5Gbps$: $\leq 0.50pF$ |
| | Data rates $> 5Gbps$: $\leq 0.35pF$ |
| Delta capacitance between any P and N I/O pins | $\leq 0.07pF$ |
| Clamping voltage at 8A I_{PP} IO to GND ⁽¹⁾ | $\leq 4.5V$ |
| Typical dynamic resistance | $\leq 30m\Omega$ |

(1) According to IEC 61000-4-5 (8/20 μs current waveform)

表 8-3. Recommended ESD Protection Component

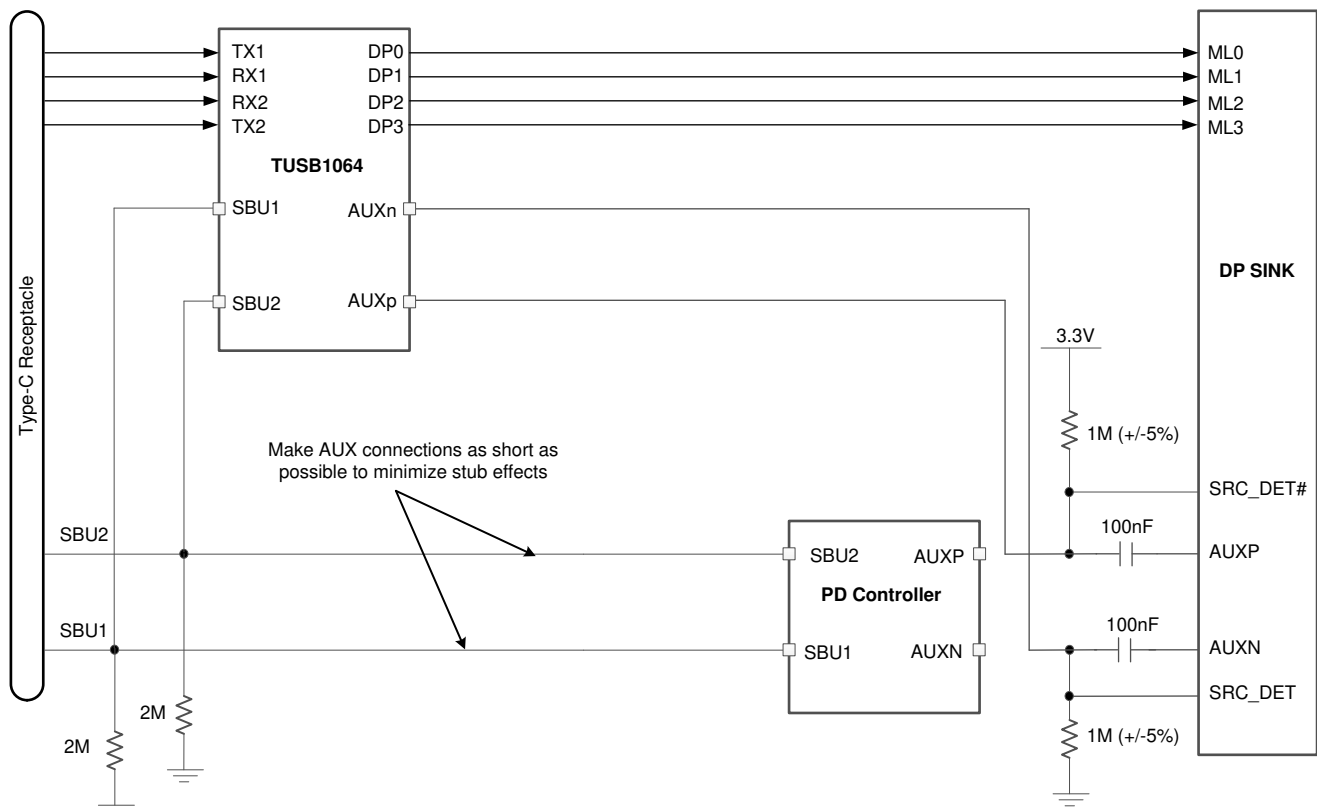
| MANUFACTURER | PART NUMBER | R_{ESD} TO SUPPORT IEC 61000-4-2 CONTACT $\pm 8kV$ |
|-------------------|----------------|--|
| Nexperia | PUSB3FR4 | 1 Ω |
| Nexperia | PESD2V8Y1BSF | 1 Ω |
| Texas Instruments | TPD1E04U04DPLR | 2 Ω |
| Texas Instruments | TPD4E02B04DQAR | 2 Ω |

8.2.2.2 Support for DisplayPort UFP_D Pin Assignment E

The TUSB1064-Q1 device can be used in a system that handles DisplayPort UFP_D Pin Assignment E use-case if special measures are taken as described below. With UFP_D Pin Assignment E, the polarity of both the main link and AUX signals are inverted on the Type-C receptacle pins relative to Pin Assignment C. Moreover, on the Type-C receptacle, the location of Lane 0 is swapped with Lane 1 and that of Lane 2 is swapped with Lane 3 relative to Pin Assignment C. For correct reception of the DisplayPort video signal, the system must comprehend the above-described signaling variation.

The use of the TUSB1064-Q1 device in a system that handles Pin Assignment E depends on whether AUX-to-SBU switching of the DisplayPort AUX signal is performed internally by the TUSB1064-Q1 or by external devices such as a PD controller. It also depends on the configuration mode used: I²C Mode or GPIO Mode. In all those scenarios, the TUSB1064-Q1 passes the polarity of the Main Link signals as received. The DisplayPort sink must handle the polarity inversion of those signals. Moreover, the DisplayPort sink must handle the lane swapping with the following lane-to-pin mapping as received by the TUSB1064-Q1 device: Lane 0 → DP1, Lane 1 → DP0, Lane 2 → DP3, and Lane 3 → DP2.

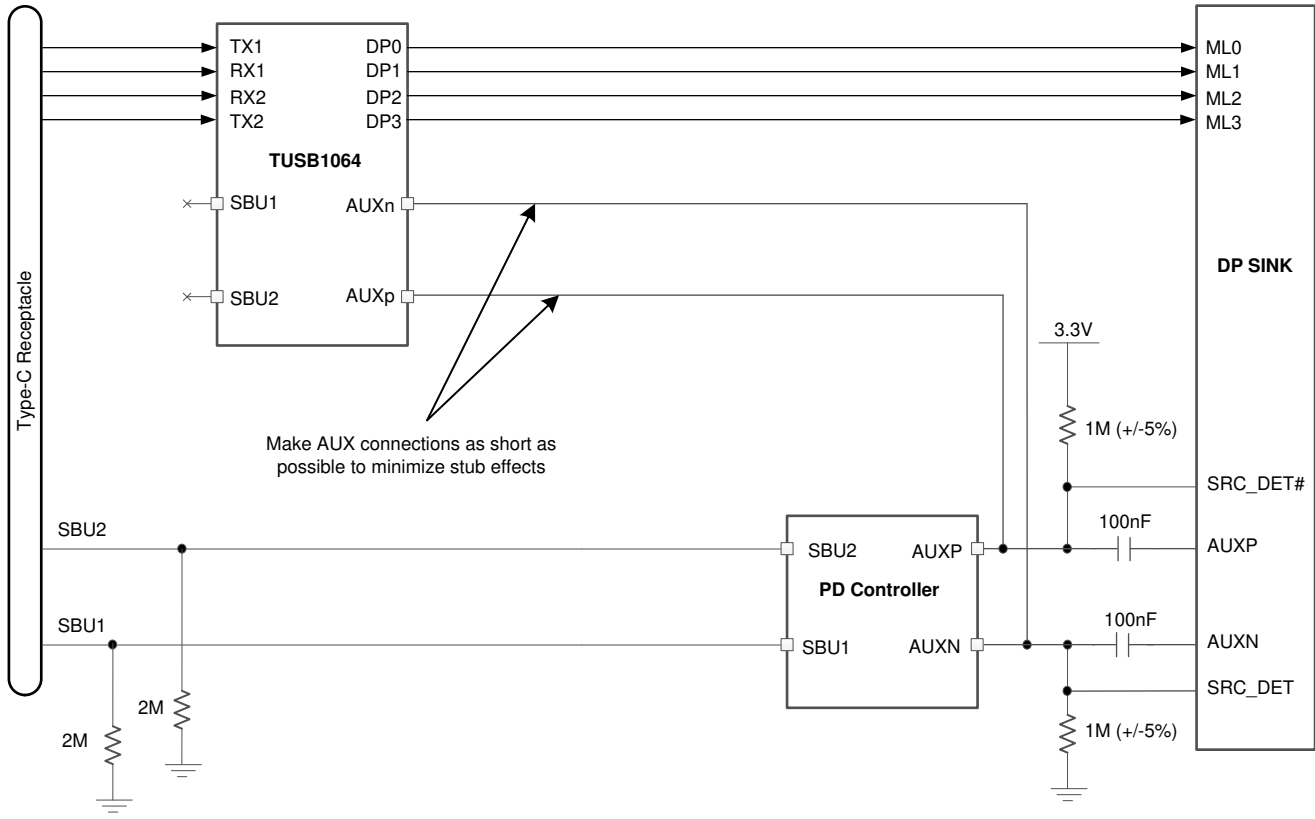
The use-case with the AUX-to-SBU switching performed internally by the TUSB1064-Q1 device is shown in [Figure 8-3](#). If the TUSB1064-Q1 device configuration is through the I²C Mode, AUX snooping must be disabled by setting AUX_SNOOP_DISABLE register 0x13[7] = 1'b1, and manual AUX-to-SBU switching must be performed through the AUX_SBU_OVR register 0x13[5:4]: AUX_SBU_OVR = 2'b01 for normal USB Type-C plug orientation, or AUX_SBU_OVR = 2'b10 for flipped USB Type-C plug orientation when Pin Assignment E signals are received. If the TUSB1064-Q1 device configuration is through the GPIO Mode, all four DisplayPort lanes are automatically activated. The DisplayPort sink device must handle the polarity inversion of both the AUX and Main Link signals as well as main link lane swapping.



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Figure 8-3. DisplayPort AUX Connections for UFP_D Pin Assignment E with Internal AUX Switching

The use-case with the AUX-to-SBU switching performed by an external device is shown in [Figure 8-4](#). In this case, it is assumed that the PD controller is capable of correcting the polarity inversion of the AUX signal and the TUSB1064-Q1 is provided with the corrected polarity of the AUX signal through its AUXp/AUXn pins. If the TUSB1064-Q1 device configuration is through the I²C Mode, disable AUX snooping by setting AUX_SNOOP_DISABLE register 0x13[7] = 1'b1. The DisplayPort sink device must handle the polarity inversion of the Main Link signals as well as the Main Link lane swapping.



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Figure 8-4. DisplayPort AUX Connections for UFP_D Pin Assignment E with External AUX Switching

8.2.3 Application Curve

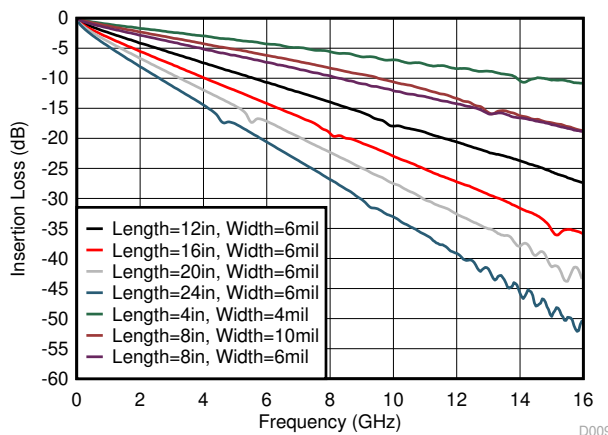


Figure 8-5. Insertion Loss of FR4 PCB Traces

8.3 System Examples

8.3.1 USB 3.1 Only

The TUSB1064-Q1 is in USB3.1 only when the CTL1 pin is low and CTL0 pin is high.

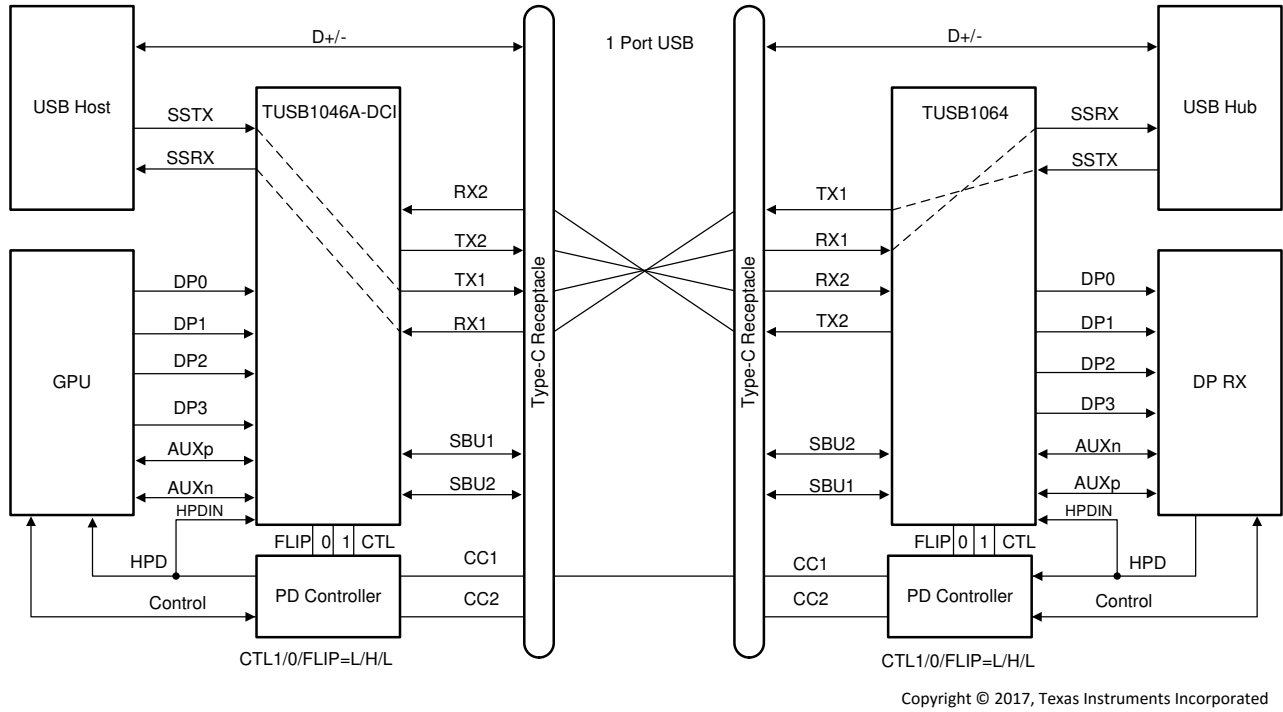


図 8-6. USB3.1 Only – No Flip (CTL1 = L, CTL0 = H, FLIP = L)

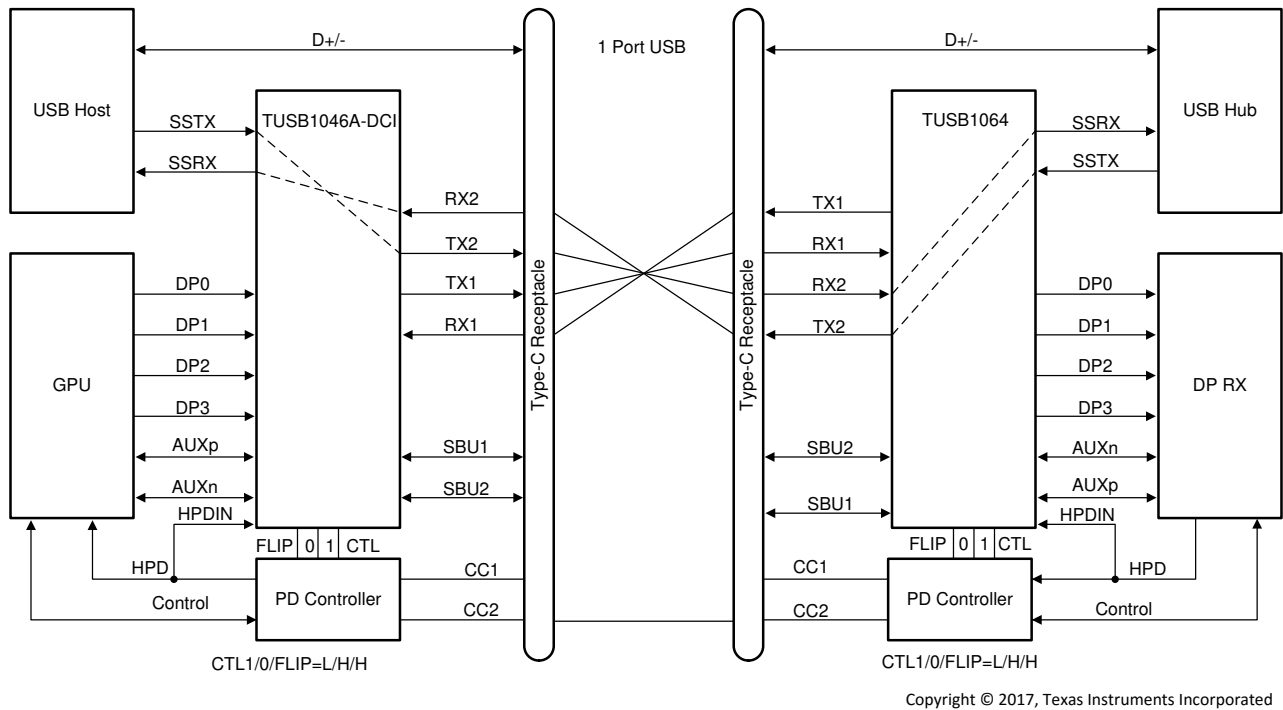
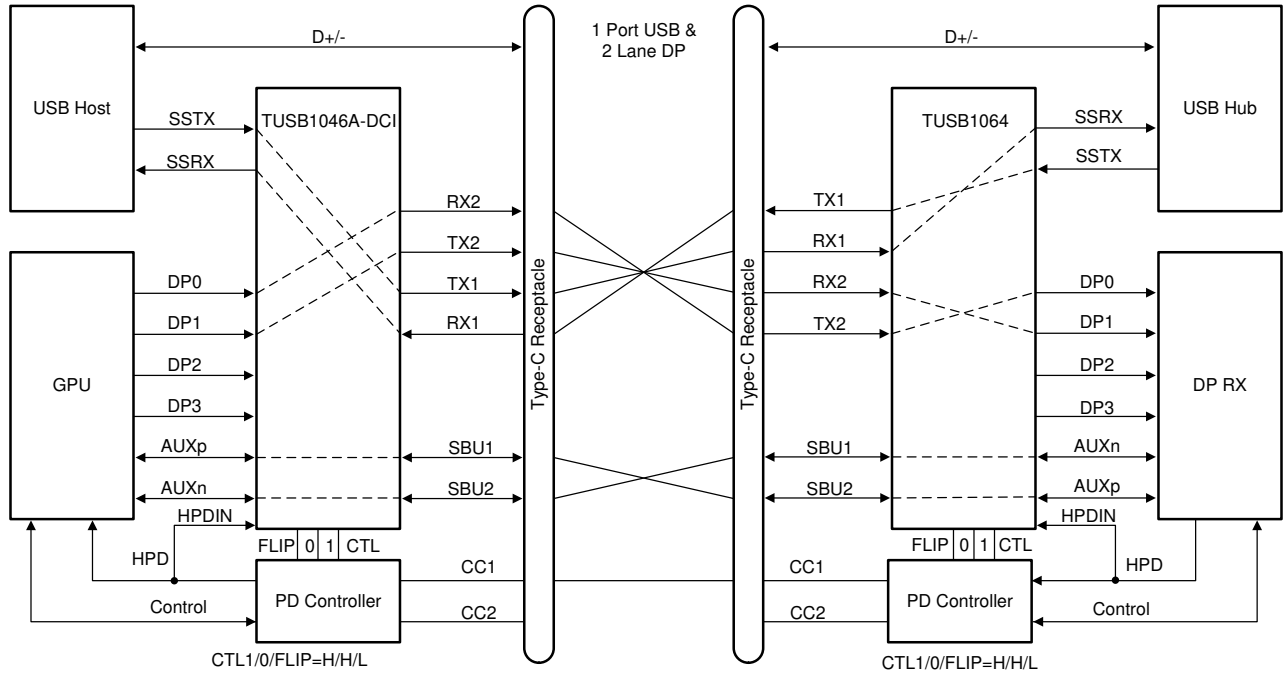


図 8-7. USB3.1 Only – With Flip (CTL1 = L, CTL0 = H, FLIP = H)

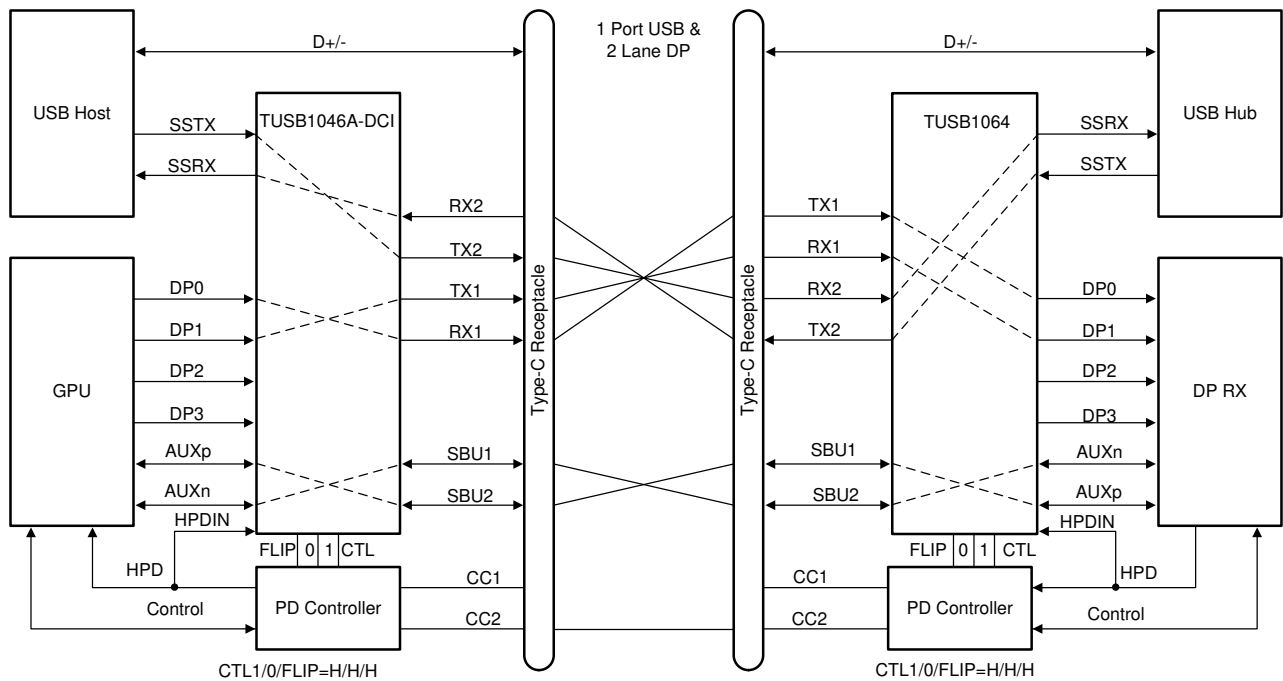
8.3.2 USB 3.1 and 2 Lanes of DisplayPort

The TUSB1064-Q1 operates in USB3.1 and 2 Lanes of DisplayPort mode when the CTL1 pin is high and CTL0 pin is high.



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☒ 8-8. USB3.1 + 2 Lane DP – No Flip (CTL1 = H, CTL0 = H, FLIP = L)

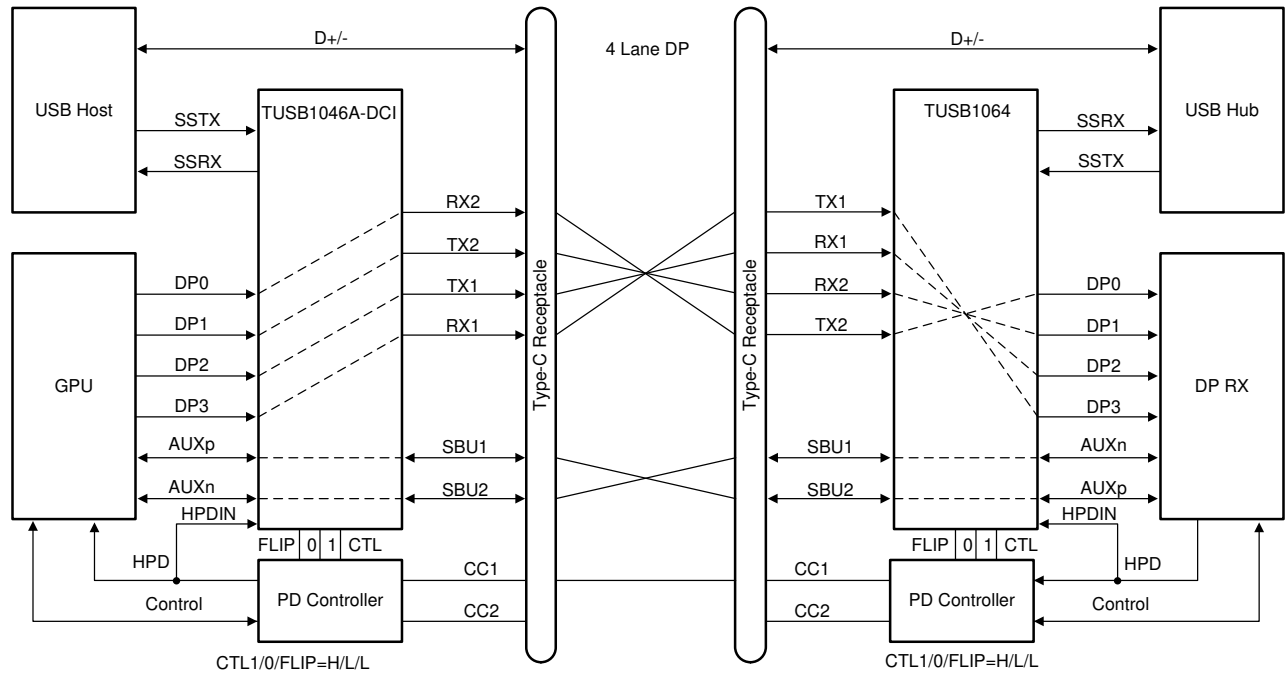


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☒ 8-9. USB 3.1 + 2 Lane DP – Flip (CTL1 = H, CTL0 = H, FLIP = H)

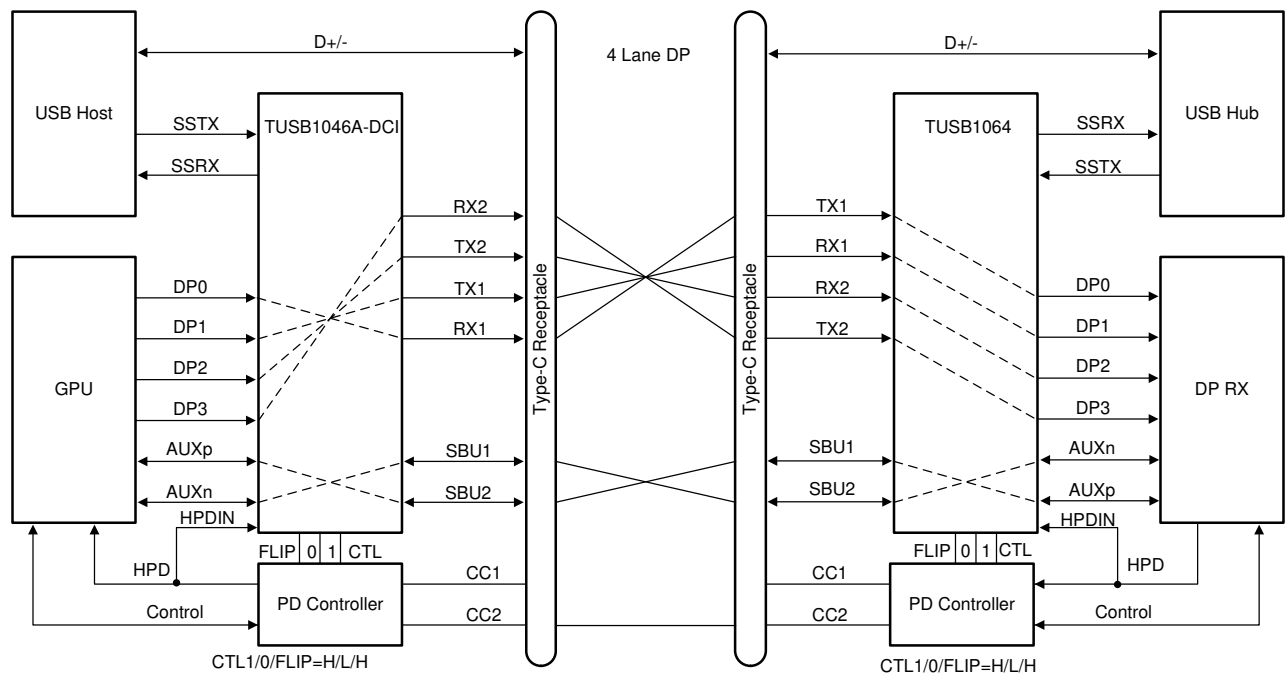
8.3.3 DisplayPort Only

The TUSB1064-Q1 operates in four lanes of DisplayPort-only mode when the CTL1 pin is high and CTL0 pin is low.



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図 8-10. 4-Lane DP – No Flip (CTL1 = H, CTL0 = L, FLIP = L)



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図 8-11. 4-Lane DP – With Flip (CTL1 = H, CTL0 = L, FLIP = H)

8.4 Power Supply Recommendations

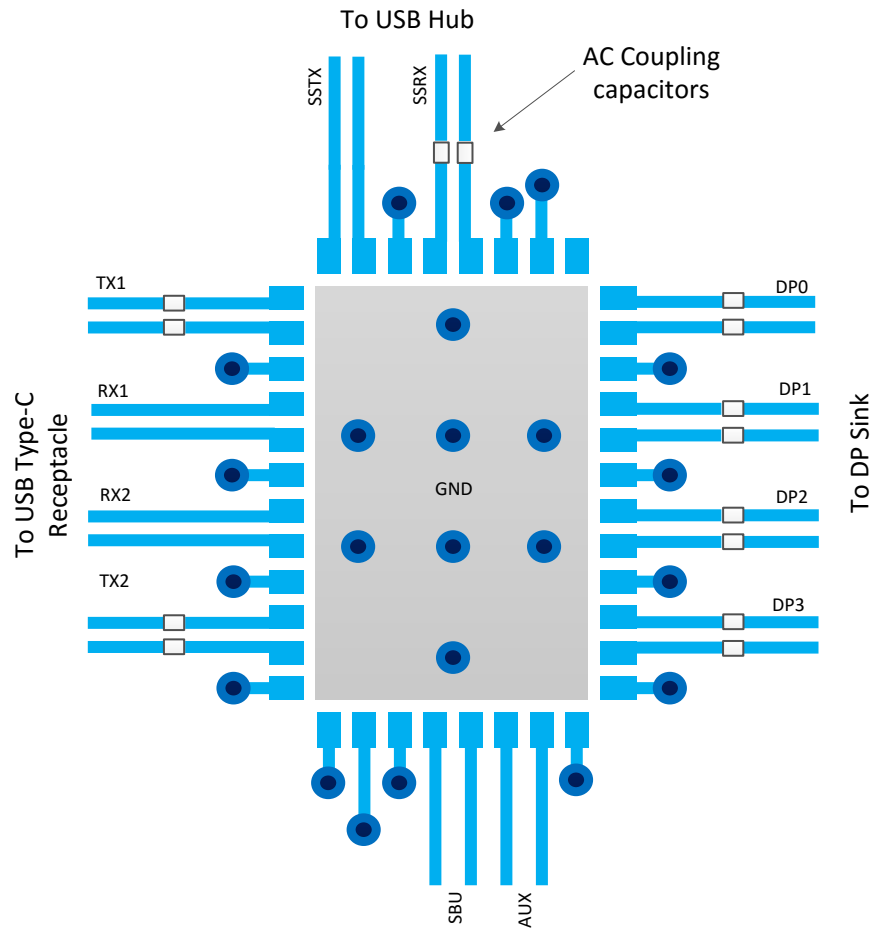
The TUSB1064-Q1 is designed to operate with a 3.3V power supply. Do not use levels above those listed in *Recommended Operating Conditions*. If using a higher voltage system power supply, a voltage regulator can be used to step down to 3.3V. Use decoupling capacitors to reduce noise and improve power supply integrity. Connect a 0.1 μ F capacitor between each power pin and ground.

8.5 Layout

8.5.1 Layout Guidelines

1. Route RXP/N and TXP/N pairs with controlled 90 Ω differential impedance ($\pm 15\%$).
2. Keep away from other high speed signals.
3. Keep intra-pair routing to within 2 mils.
4. Place length matching near the location of mismatch.
5. Separate each pair by at least 3 times the signal trace width.
6. Keep the use of bends in differential traces to a minimum. When bends are used, make sure to keep the number of left and right bends as equal as possible and the angle of the bend ≥ 135 degrees. This minimizes any length mismatch causes by the bends and therefore minimizes the impact bends have on EMI.
7. Route all differential pairs on the same of layer.
8. Keep the number of vias to a minimum. TI recommends to keep the via count to 2 or less.
9. Keep traces on layers adjacent to ground plane.
10. Do NOT route differential pairs over any plane split.
11. Note that adding test points can cause impedance discontinuity, and therefore negatively impact signal performance. If test points are used, place the points in series and symmetrically. The points must not be placed in a manner that causes a stub on the differential pair.

8.5.2 Layout Example



8-12. Layout Example

9 Register Maps

表 9-1. Register Legend

| ACCESS TAG | NAME | MEANING |
|------------|-----------|--|
| R | Read | The field can be read by software |
| W | Write | The field can be written by software |
| S | Set | The field can be set by a write of one. Writes of zeros to the field have no effect. |
| C | Clear | The field can be cleared by a write of one. Write of zero to the field have no effect. |
| U | Update | Hardware can autonomously update this field. |
| NA | No Access | Not accessible or not applicable |

9.1 General Register (address = 0x0A) [reset = 00000001]

図 9-1. General Registers

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|----------|---|----------|-------------|-------------------|---------|--------------|---|
| Reserved | | Reserved | EQ_OVERRIDE | HPDIN_OVRRI DE | FLIPSEL | CTLSEL[1:0]. | |
| R | | R | R/W | R/W | R/W | R/W | |

LEGEND: R/W = Read/Write; R = Read only; -n = value after reset

表 9-2. General Registers

| Bit | Field | Type | Reset | Description |
|-----|--------------|------|-------|--|
| 7:5 | Reserved. | R | 00 | Reserved. |
| 4 | EQ_OVERRIDE | R/W | 0 | Setting this field allows software to use EQ settings from registers instead of value sample from pins. 0: EQ settings based on sampled state of the EQ pins (SSEQ[1:0], EQ[1:0], and DPEQ[1:0]). 1: EQ settings based on programmed value of each of the EQ registers |
| 3 | DP_EN_CTRL | R/W | 0 | Controls whether DisplayPort functionality is controlled by CTLSEL1 register or CTL1 pin. 0: DisplayPort enable/disable is based on CTLSEL1 register. 1: DisplayPort enable/disable is based on state of CTL1 pin. |
| 2 | FLIPSEL | R/W | 0 | FLIPSEL. Refer to 表 7-5 and 表 7-6 for this field functionality. |
| 1:0 | CTLSEL[1:0]. | R/W | 01 | 00: Disabled. All RX and TX for USB3 and DisplayPort are disabled. 01: USB3.1 only enabled. (Default) 10: Four DisplayPort lanes enabled. 11: Two DisplayPort lanes and one USB3.1 |

9.2 DisplayPort Control/Status Registers (address = 0x10) [reset = 00000000]

図 9-2. DisplayPort Control/Status Registers (0x10)

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|-----------|---|---|---|-----------|---|---|---|
| DP1EQ_SEL | | | | DP3EQ_SEL | | | |
| R/W/U | | | | R/W/U | | | |

LEGEND: R/W = Read/Write; R = Read only; -n = value after reset

表 9-3. DisplayPort Control/Status Registers (0x10)

| Bit | Field | Type | Reset | Description |
|-----|-----------|-------|-------|---|
| 7:4 | DP1EQ_SEL | R/W/U | 0000 | Field selects EQ level for DP lane 1. When EQ_OVERRIDE = 1'b0, this field reflects the sampled state of DPEQ[1:0] pins. When EQ_OVERRIDE = 1'b1, software can change the EQ setting for DP lane 1 based on value written to this field. |
| 3:0 | DP3EQ_SEL | R/W/U | 0000 | Field selects EQ level for DP lane 3. When EQ_OVERRIDE = 1'b0, this field reflects the sampled state of DPEQ[1:0] pins. When EQ_OVERRIDE = 1'b1, software can change the EQ setting for DP lane 3 based on value written to this field. |

9.3 DisplayPort Control/Status Registers (address = 0x11) [reset = 00000000]

図 9-3. DisplayPort Control/Status Registers (0x11)

| | | | | | | | |
|-----------|---|---|---|-----------|---|---|---|
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| DP0EQ_SEL | | | | DP2EQ_SEL | | | |
| R/W/U | | | | R/W/U | | | |

LEGEND: R/W = Read/Write; R = Read only; -n = value after reset

表 9-4. DisplayPort Control/Status Registers (0x11)

| Bit | Field | Type | Reset | Description |
|-----|-----------|-------|-------|---|
| 7:4 | DP0EQ_SEL | R/W/U | 0000 | Field selects EQ level for DP lane 0. When EQ_OVERRIDE = 1'b0, this field reflects the sampled state of DPEQ[1:0] pins. When EQ_OVERRIDE = 1'b1, software can change the EQ setting for DP lane 0 based on value written to this field. |
| 3:0 | DP2EQ_SEL | R/W/U | 0000 | Field selects EQ level for DP lane 2. When EQ_OVERRIDE = 1'b0, this field reflects the sampled state of DPEQ[1:0] pins. When EQ_OVERRIDE = 1'b1, software can change the EQ setting for DP lane 2 based on value written to this field. |

9.4 DisplayPort Control/Status Registers (address = 0x12) [reset = 00000000]

図 9-4. DisplayPort Control/Status Registers (0x12)

| | | | | | | | |
|----------|-----------------|---|----------------|---|---|---|---|
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Reserved | SET_POWER_STATE | | LANE_COUNT_SET | | | | |
| R | RU | | RU | | | | |

LEGEND: R/W = Read/Write; R = Read only; -n = value after reset

表 9-5. DisplayPort Control/Status Registers (0x12)

| Bit | Field | Type | Reset | Description |
|-----|-----------------|------|-------|---|
| 7 | Reserved | R | 0 | Reserved |
| 6:5 | SET_POWER_STATE | R/U | 00 | This field represents the snooped value of the AUX write to DPCD address 0x00600. When AUX_SNOOP_DISABLE = 1'b0, the TUSB1064-Q1 enables or disables the DP lanes based on the snooped value. When AUX_SNOOP_DISABLE = 1'b1, then DP lane enable/disable are determined by state of DPx_DISABLE registers, where x = 0, 1, 2, or 3. This field is reset to 2'b00 by hardware when CTLSEL1 changes from a 1'b1 to a 1'b0. |
| 4:0 | LANE_COUNT_SET | R/U | 00000 | This field represents the snooped value of AUX write to DPCD address 0x00101 register. When AUX_SNOOP_DISABLE = 1'b0, the TUSB1064-Q1 enables DP lanes specified by the snooped value. Unused DP lanes are disabled to save power. When AUX_SNOOP_DISABLE = 1'b1, then DP lanes enable/disable are determined by DPx_DISABLE registers, where x = 0, 1, 2, or 3. This field is reset to 0x0 by hardware when CTLSEL1 changes from a 1'b1 to a 1'b0. |

9.5 DisplayPort Control/Status Registers (address = 0x13) [reset = 00000000]

図 9-5. DisplayPort Control/Status Registers (0x13)

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|-------------------|----------|-------------|---|-------------|-------------|-------------|-------------|
| AUX_SNOOP_DISABLE | Reserved | AUX_SBU_OVR | | DP3_DISABLE | DP2_DISABLE | DP1_DISABLE | DP0_DISABLE |
| R/W | R | R/W | | R/W | R/W | R/W | R/W |

LEGEND: R/W = Read/Write; R = Read only; -n = value after reset

表 9-6. DisplayPort Control/Status Registers (0x13)

| Bit | Field | Type | Reset | Description |
|-----|-------------------|------|-------|---|
| 7 | AUX_SNOOP_DISABLE | R/W | 0 | 0: AUX snoop enabled. (Default) 1: AUX snoop disabled. |
| 6 | Reserved | R | 0 | Reserved |
| 5:4 | AUX_SBU_OVR | R/W | 00 | This field overrides the AUXp or AUXn to SBU1 or SBU2 connect and disconnect based on CTL1 and FLIP. Changing this field to 2'b01 or 2'b10 allows traffic to pass through AUX to SBU regardless of the state of CTLSEL1 and FLIPSEL register 00: AUX to SBU connect/disconnect determined by CTLSEL1 and FLIPSEL (Default) 01: AUXn -> SBU1 and AUXp -> SBU2 connection always enabled. 10: AUXn -> SBU2 and AUXp -> SBU1 connection always enabled. 11: AUX to SBU open. |
| 3 | DP3_DISABLE | R/W | 0 | When AUX_SNOOP_DISABLE = 1'b1, this field can be used to enable or disable DP lane 3. When AUX_SNOOP_DISABLE = 1'b0, changes to this field have no effect on lane 3 functionality. 0: DP Lane 3 Enabled (default) 1: DP Lane 3 Disabled. |
| 2 | DP2_DISABLE | R/W | 0 | When AUX_SNOOP_DISABLE = 1'b1, this field can be used to enable or disable DP lane 2. When AUX_SNOOP_DISABLE = 1'b0, changes to this field have no effect on lane 2 functionality. 0: DP Lane 2 Enabled (default) 1: DP Lane 2 Disabled. |
| 1 | DP1_DISABLE | R/W | 0 | When AUX_SNOOP_DISABLE = 1'b1, this field can be used to enable or disable DP lane 1. When AUX_SNOOP_DISABLE = 1'b0, changes to this field have no effect on lane 1 functionality. 0: DP Lane 1 Enabled (default) 1: DP Lane 1 Disabled. |
| 0 | DP0_DISABLE | R/W | 0 | DISABLE. When AUX_SNOOP_DISABLE = 1'b1, this field can be used to enable or disable DP lane 0. When AUX_SNOOP_DISABLE = 1'b0, changes to this field have no effect on lane 0 functionality. 0: DP Lane 0 Enabled (default) 1: DP Lane 0 Disabled. |

9.6 USB3.1 Control/Status Registers (address = 0x20) [reset = 00000000]

図 9-6. USB3.1 Control/Status Registers (0x20)

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---------|---|---|---|---------|---|---|---|
| EQ2_SEL | | | | EQ1_SEL | | | |
| R/W/U | | | | R/W/U | | | |

LEGEND: R/W = Read/Write; R = Read only; -n = value after reset

表 9-7. USB3.1 Control/Status Registers (0x20)

| Bit | Field | Type | Reset | Description |
|-----|---------|-------|-------|---|
| 7:4 | EQ2_SEL | R/W/U | 0000 | Field selects EQ level for USB3.1 RX2 receiver. When EQ_OVERRIDE = 1'b0, this field reflects the sampled state of EQ[1:0] pins. When EQ_OVERRIDE = 1'b1, software can change the EQ setting for USB3.1 RX2 receiver based on value written to this field. |
| 3:0 | EQ1_SEL | R/W/U | 0000 | Field selects EQ level for USB3.1 RX1 receiver. When EQ_OVERRIDE = 1'b0, this field reflects the sampled state of EQ[1:0] pins. When EQ_OVERRIDE = 1'b1, software can change the EQ setting for USB3.1 RX1 receiver based on value written to this field. |

9.7 USB3.1 Control/Status Registers (address = 0x21) [reset = 00000000]

図 9-7. USB3.1 Control/Status Registers (0x21)

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|----------|---|---|---|----------|---|---|---|
| Reserved | | | | SSEQ_SEL | | | |
| R | | | | R/W/U | | | |

LEGEND: R/W = Read/Write; R = Read only; -n = value after reset

表 9-8. USB3.1 Control/Status Registers (0x21)

| Bit | Field | Type | Reset | Description |
|-----|----------|-------|-------|---|
| 7:4 | Reserved | R | 0000 | Reserved |
| 3:0 | SSEQ_SEL | R/W/U | 0000 | Field selects EQ for USB3.1 SSTXP/N receiver. When EQ_OVERRIDE = 1'b0, this field reflects the sampled state of SSEQ[1:0] pins. When EQ_OVERRIDE = 1'b1, software can change the EQ setting for USB3.1 SSTXP/N receiver based on value written to this field. |

9.8 USB3.1 Control/Status Registers (address = 0x22) [reset = 00000000]

図 9-8. USB3.1 Control/Status Registers (0x22)

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|-----------|---------|------------------------|------------------------|--------------------|---|----------------------|---|
| CM_ACTIVE | LFPS_EQ | U2U3_LFPS_D EBOUNCE | DISABLE_U2U 3_RXDET | DFP_RXDET_INTERVAL | | USB3_COMPLIANCE_CTRL | |
| R/U | R/W | R/W | R/W | R/W | | R/W | |

LEGEND: R/W = Read/Write; R = Read only; -n = value after reset

表 9-9. USB3.1 Control/Status Registers (0x22)

| Bit | Field | Type | Reset | Description |
|-----|----------------------|------|-------|--|
| 7 | CM_ACTIVE | R/U | 0 | 0: Device not in USB 3.1 compliance mode. (Default) 1: Device in USB 3.1 compliance mode |
| 6 | LFPS_EQ | R/W | 0 | Controls whether settings of EQ based on EQ1_SEL, EQ2_SEL and SSEQ_SEL applies to received LFPS signal. 0 – EQ set to zero when receiving LFPS (default) 1 – EQ set to EQ1_SEL, EQ2_SEL, and SSEQ_SEL when receiving LFPS. |
| 5 | U2U3_LFPS_DEBOUNCE | R/W | 0 | 0: No debounce of LFPS before U2/U3 exit. (Default) 1: 200µs debounce of LFPS before U2/U3 exit. |
| 4 | DISABLE_U2U3_RXDET | R/W | 0 | 0: Rx.Detect in U2/U3 enabled. (Default) 1: Rx.Detect in U2/U3 disabled. |
| 3:2 | DFP_RXDET_INTERVAL | R/W | 00 | This field controls the Rx.Detect interval for the Downstream facing port (TX1P/N and TX2P/N). 00: 8ms 01: 12ms (default) 10: Reserved 11: Reserved |
| 1:0 | USB3_COMPLIANCE_CTRL | R/W | 00 | 00: FSM determined compliance mode. (Default) 01: Compliance Mode enabled in DFP direction (SSTX -> TX1/ TX2) 10: Compliance Mode enabled in UFP direction (RX1/RX2 -> SSRX) 11: Compliance Mode Disabled. |

10 Device and Documentation Support

10.1 ドキュメントの更新通知を受け取る方法

ドキュメントの更新についての通知を受け取るには、www.tij.co.jp のデバイス製品フォルダを開いてください。[通知] をクリックして登録すると、変更されたすべての製品情報に関するダイジェストを毎週受け取ることができます。変更の詳細については、改訂されたドキュメントに含まれている改訂履歴をご覧ください。

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10.5 用語集

[テキサス・インスツルメンツ用語集](#) この用語集には、用語や略語の一覧および定義が記載されています。

11 Revision History

| DATE | REVISION | NOTES |
|----------------|----------|-----------------|
| September 2024 | * | Initial Release |

12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

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PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead finish/ Ball material (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|------------------|---------------|--------------|-----------------|------|-------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| TUSB1064RGFRQ1 | ACTIVE | VQFN | RGF | 40 | 3000 | RoHS & Green | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | TSB6421 | Samples |
| TUSB1064RGFTQ1 | ACTIVE | VQFN | RGF | 40 | 3000 | RoHS & Green | NIPDAU | Level-2-260C-1 YEAR | -40 to 125 | TSB6421 | Samples |

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(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

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OTHER QUALIFIED VERSIONS OF TUSB1064-Q1 :

- Catalog : [TUSB1064](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

GENERIC PACKAGE VIEW

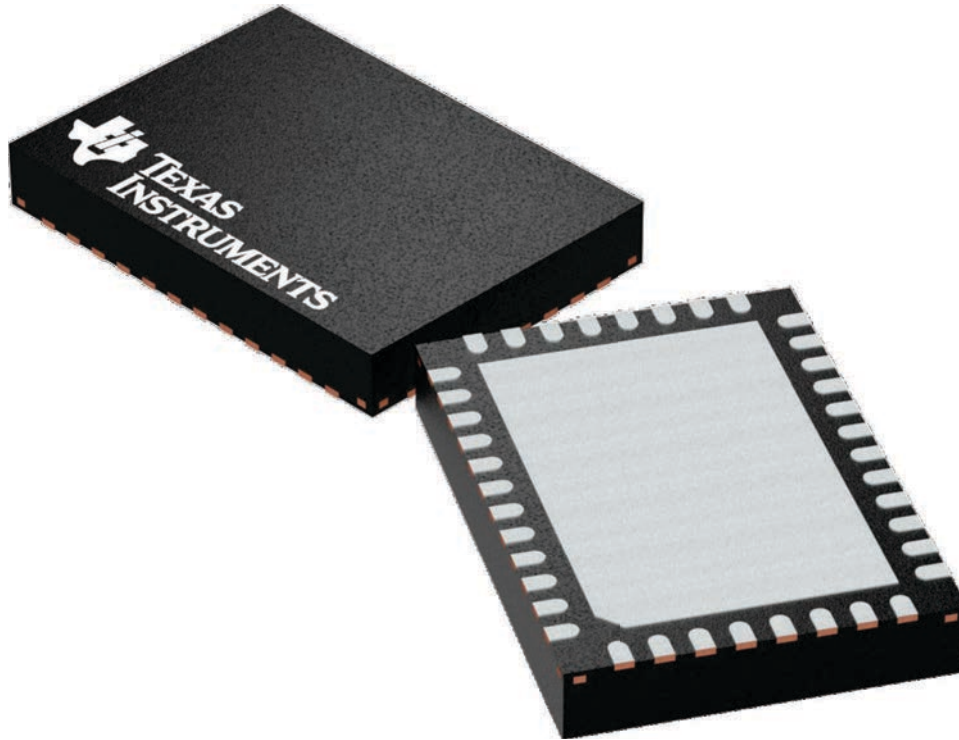
RGF 40

VQFN - 1 mm max height

5 x 7, 0.5 mm pitch

PLASTIC QUAD FLAT PACK- NO LEAD

This image is a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.



4225115/A

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