

# TPS25810A-Q1 USB Type-C DFP Controller and Power Switch With Digital Cable Compensation

## 1 Features

- Qualified for Automotive Applications
- AEC-Q100 Qualified With the Following Results:
  - Device Temperature Grade T:  $-40^{\circ}\text{C}$  to  $105^{\circ}\text{C}$  Ambient Operating Temperature Range
  - Device HBM ESD Classification Level 2
  - Device CDM ESD Classification Level C4B
- USB Type-C Rev. 1.2 Compliant DFP Controller
- Connector Attach or Detach Detection
- STD, 1.5-A, or 3-A Capability Advertisement on CC
- Super-Speed Polarity Determination
- $V_{\text{BUS}}$  Application and Discharge
- $V_{\text{CONN}}$  Application to Electronically Marked Cable
- Audio and Debug Accessory Identification
- $0.7\text{-}\mu\text{A}$  (typ)  $I_{\text{DDQ}}$  When Port Is Unattached
- Three Input Supply Options
  - IN1: USB Charging Supply
  - IN2:  $V_{\text{CONN}}$  Supply
  - AUX: Device Power Supply
- Power Wake Supports Low Power in System Hibernate (S4) and OFF (S5) Power States
- $34\text{-m}\Omega$  (typ) High-Side MOSFET
- Fixed  $3.4\text{-A}$   $I_{\text{LIM}}$  ( $\pm 7.1\%$ )

- Digital Cable Compensation,  $I_{\text{OUT}} \geq 1.95\text{ A}$
- Package: 20-Pin WQFN ( $3\text{ mm} \times 4\text{ mm}$ ) <sup>(1)</sup>

## 2 Applications

- Automotive Infotainment Systems
- Automotive Back-seat USB Charging

## 3 Description

The TPS25810A-Q1 device is a USB Type-C downstream-facing port (DFP) controller with an integrated 3-A rated USB power switch. The device monitors the Type-C configuration channel (CC) lines to determine when a USB device is attached. If an upstream-facing port (UFP) device is attached, it applies power to  $V_{\text{BUS}}$  and communicate the selectable  $V_{\text{BUS}}$  current-sourcing capability to the UFP via the pass-through CC line. If the UFP is attached using an electronically marked cable, it also applies  $V_{\text{CONN}}$  power to the cable CC pin. The TPS25810A-Q1 can identify and report when Type-C audio or debug accessories are attached.

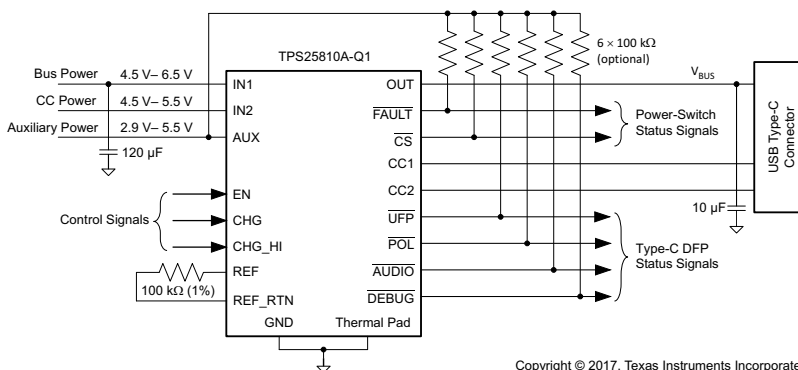
### Device Information<sup>(1)</sup>

| PART NUMBER  | PACKAGE   | BODY SIZE (NOM)   |
|--------------|-----------|-------------------|
| TPS25810A-Q1 | WQFN (20) | 3.00 mm x 4.00 mm |

(1) For all available packages, see the orderable addendum at the end of the data sheet.

(1) CC pins are IEC-61000-4-2 rated

### Simplified Schematic



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## 4 Revision History

| DATE       | REVISION | NOTE            |
|------------|----------|-----------------|
| April 2017 | *        | Initial release |

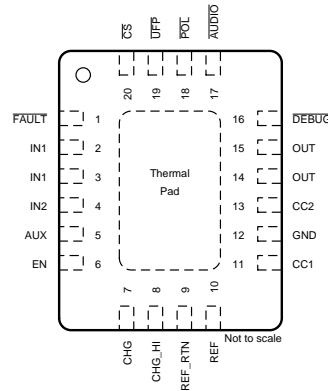
## 5 Description (Continued)

The TPS25810A-Q1 device draws less than 0.7  $\mu$ A (typical) from the AUX pin when no USB load is connected. Additional system power saving is achievable in the S4 and S5 system power states by using the  $\overline{\text{UFP}}$  output to disable the high-power 5-V supply when no UFP is attached. In this mode, the device is capable of running from an auxiliary supply (AUX), which can be a lower-voltage supply (3.3 V), typically powering the system microcontroller in low-power states (S4 and S5).

The TPS25810A-Q1 device integrates a 34-m $\Omega$  power switch with a fixed 3.4-A current limit independent of the Type-C current advertisement level. The  $\overline{\text{FAULT}}$  output signals when the switch is in an overcurrent or overtemperature condition. The  $\overline{\text{CS}}$  output is used for implementing digital cable compensation for load currents greater than 1.95 A. Cable compensation, also known as line drop compensation, is a means of offsetting voltage droop from the USB power supply to the UFP load.

## 6 Pin Configuration and Functions

**TPS25810A-Q1 RVC Package**  
**20-Pin WQFN With Exposed Thermal Pad**  
**Top View**



### Pin Functions

| PIN                       |        | I/O | DESCRIPTION  |
|---------------------------|--------|-----|--|
| NAME                      | NO.    |     |  |
| $\overline{\text{AUDIO}}$ | 17     | O   | Open-drain logic output that asserts when a Type-C audio accessory is identified on the CC lines   |
| AUX                       | 5      | I   | Auxiliary input supply. Connect to an always-alive system rail to use the power-wake feature. Short to IN1 and IN2 if only one supply is used.   |
| CC1                       | 11     | I/O | Analog input/output that connects to the Type-C receptacle CC1 pin   |
| CC2                       | 13     | I/O | Analog input/output that connects to the Type-C receptacle CC2 pin.  |
| CHG                       | 7      | I   | Charge-logic input to select between standard USB (500 mA for a Type-C receptacle supporting only USB 2.0, and 900 mA for Type-C receptacle supporting USB 3.1) or a Type-C current-sourcing capability.                                 |
| CHG_HI                    | 8      | I   | High-charge logic input to select between 1.5-A and 3-A Type-C current sourcing capability. Valid when CHG is set to Type-C current.   |
| $\overline{\text{CS}}$    | 20     | O   | Open-drain output enabling digital cable compensation when load current is greater than 1.95 A, nominal.   |
| $\overline{\text{DEBUG}}$ | 16     | O   | Open-drain logic output that asserts when a Type-C debug accessory is identified on the CC lines   |
| EN                        | 6      | I   | Enable logic input. Turns the device on and off  |
| $\overline{\text{FAULT}}$ | 1      | O   | Fault event indicator. Open-drain logic output that asserts low to indicate a current-limit or thermal-shutdown event due to overtemperature.  |
| GND                       | 12     | —   | Power ground   |
| IN1                       | 2, 3   | I   | $V_{\text{BUS}}$ input supply. Internal power switch connects IN1 to OUT.  |
| IN2                       | 4      | I   | $V_{\text{CONN}}$ input supply. Internal power switch connects IN2 to CC1 or CC2. Short to IN1 if only one supply is used.   |
| OUT                       | 14, 15 | O   | Power switch output  |
| $\overline{\text{POL}}$   | 18     | O   | Polarity open-drain logic output that signals which Type-C CC pin is connected to the CC line. This gives the information needed to multiplex the super-speed lines. Asserted when the CC2 pin is connected to the CC line in the cable. |
| REF                       | 10     | I   | Analog input used to generate the internal current reference. Connect a 1% or better, 100-ppm, 100-k $\Omega$ resistor between this pin and REF_RTN.   |
| REF_RTN                   | 9      | I   | Precision signal-reference return. Connect to the REF pin via a 100-k $\Omega$ , 1% resistor.  |
| $\overline{\text{UFP}}$   | 19     | O   | Open-drain logic output that asserts when a Type-C UFP is identified on the CC lines.  |
| Thermal pad               | —      | —   | Thermal pad on the bottom of the package. The thermal pad is internally connected to GND and is used to heat-sink the device to the circuit board. Connect the thermal pad to the GND plane.   |

## 7 Specifications

### 7.1 Absolute Maximum Ratings

over operating ambient temperature range, voltages are with respect to GND (unless otherwise noted) <sup>(1)</sup>

|  |  | MIN  | MAX                         | UNIT |
|--|--|------|-----------------------------|------|
| Pin voltage, V                                 | AUDIO, AUX, CC1, CC2, CHG, CHG_HI, CS, DEBUG, EN, FAULT, IN1, IN2, OUT, POL, REF, UFP, | -0.3 | 7                           | V    |
|  | REF_RTN  |      | Internally connected to GND | V    |
| Pin positive source current, I <sub>SRC</sub>  | CC1, CC2, OUT, REF   |      | Internally limited          | A    |
| Pin positive sink current, I <sub>SNK</sub>    | OUT (while applying V <sub>BUS</sub> )   |      | 5                           | A    |
|  | CC1, CC2 (while applying V <sub>CONN</sub> )   |      | 1                           | A    |
|  | AUDIO, CS, DEBUG, FAULT, POL, UFP  |      | Internally limited          | mA   |
| Operating junction temperature, T <sub>J</sub> |  | -40  | 180                         | °C   |
| Storage temperature range, T <sub>stg</sub>    |  | -65  | 150                         | °C   |

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

### 7.2 ESD Ratings

|   |   | VALUE   | UNIT |
|---|---|---------|------|
| V <sub>(ESD)</sub> <sup>(1)</sup> Electrostatic discharge | Human-body model (HBM), per per AEC Q100-002 <sup>(2)</sup> | ±2 000  | V    |
|   | Charged-device model (CDM), per per AEC Q100-011            | ±500    |      |
|   | 61000-4-2 contact discharge, CC1 and CC2 <sup>(3)</sup> IEC | ±8 000  |      |
|   | IEC 61000-4-2 air discharge, CC1 and CC2 <sup>(3)</sup>     | ±15 000 |      |

- (1) Electrostatic discharge (ESD) to measure device sensitivity and immunity to damage caused by assembly line electrostatic discharges into the device.  
 (2) AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.  
 (3) Surges per IEC61000-402, 1999 applied between CC1, CC2 and output ground of the TPS25810EVM-745.

### 7.3 Recommended Operating Conditions

Voltages are with respect to GND (unless otherwise noted)

|   |   | MIN  | NOM | MAX                | UNIT |
|---|---|------|-----|--------------------|------|
| V <sub>IN</sub> Supply voltage                                | IN1   | 4.5  |     | 6.5                | V    |
|   | IN2   | 4.5  |     | 5.5                |      |
|   | AUX   | 2.9  |     | 5.5                |      |
| V <sub>I</sub> Input voltage                                  | CHG, CHG_HI, EN                             | 0    |     | 5.5                | V    |
| V <sub>IH</sub> High-level input voltage                      | CHG, CHG_HI, EN                             | 1.17 |     |                    | V    |
| V <sub>IL</sub> Low-level input voltage                       | CHG, CHG_HI, EN                             |      |     | 0.63               | V    |
| V <sub>PU</sub> Pullup voltage                                | Used on AUDIO, CS, DEBUG, FAULT, POL, UFP,  | 0    |     | 5.5                | V    |
| I <sub>SRC</sub> Positive source current                      | OUT   |      |     | 3                  | A    |
|   | CC1 or CC2 when supplying V <sub>CONN</sub> |      |     | 250                | mA   |
| I <sub>SNK</sub> Positive sink current (10 ms moving average) | AUDIO, CS, DEBUG, FAULT, POL, UFP           |      |     | 10                 | mA   |
| I <sub>SNK_PULSE</sub> Positive repetitive pulse sink current | AUDIO, CS, DEBUG, FAULT, POL, UFP           |      |     | Internally limited | mA   |
| R <sub>REF</sub> Reference resistor                           |   | 98   | 100 | 102                | kΩ   |
| T <sub>J</sub> Operating junction temperature                 |   | -40  |     | 125                | °C   |

## 7.4 Thermal Information

| THERMAL METRIC <sup>(1)</sup> |  | TPS25810A-Q1 |      |
|-------------------------------|--|--------------|------|
|                               |  | RVC (WQFN)   |      |
|                               |  | 20 PINS      |      |
| Symbol                        | Description                                  | Value        | Unit |
| $R_{\theta JA}$               | Junction-to-ambient thermal resistance       | 39.3         | °C/W |
| $R_{\theta JC(top)}$          | Junction-to-case (top) thermal resistance    | 43.4         | °C/W |
| $R_{\theta JB}$               | Junction-to-board thermal resistance         | 13           | °C/W |
| $\Psi_{JT}$                   | Junction-to-top characterization parameter   | 0.7          | °C/W |
| $\Psi_{JB}$                   | Junction-to-board characterization parameter | 13           | °C/W |
| $R_{\theta JC(bot)}$          | Junction-to-case (bottom) thermal resistance | 4.2          | °C/W |

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, [SPRA953](#).

## 7.5 Electrical Characteristics

–40°C ≤ T<sub>J</sub> ≤ 125°C, 4.5 V ≤ V<sub>IN1</sub> ≤ 6.5 V, 4.5 V ≤ V<sub>IN2</sub> ≤ 5.5 V, 2.9 V ≤ V<sub>AUX</sub> ≤ 5.5 V; V<sub>EN</sub> = V<sub>CHG</sub> = V<sub>CHG\_HI</sub> = V<sub>AUX</sub>, R<sub>REF</sub> = 100 kΩ. Typical values are at 25°C. All voltages are with respect to GND. I<sub>OUT</sub> and I<sub>OS</sub> defined as positive out of the indicated pin (unless otherwise noted)

| PARAMETER                  |  | TEST CONDITIONS   | MIN  | TYP  | MAX  | UNIT |
|----------------------------|--|---|------|------|------|------|
| <b>OUT – POWER SWITCH</b>  |  |   |      |      |      |      |
| $r_{DS(on)}$               | On-resistance <sup>(1)</sup>                           | T <sub>J</sub> = 25°C, I <sub>OUT</sub> = 3 A   |      | 34   | 37   | mΩ   |
|                            |  | –40°C ≤ T <sub>J</sub> ≤ 85°C, I <sub>OUT</sub> = 3 A   |      | 34   | 46   |      |
|                            |  | –40°C ≤ T <sub>J</sub> ≤ 125°C, I <sub>OUT</sub> = 3 A  |      | 34   | 55   |      |
| $I_{REV}$                  | OUT to IN reverse leakage current                      | V <sub>OUT</sub> = 6.5 V, V <sub>IN1</sub> = V <sub>EN</sub> = 0 V,<br>–40°C ≤ T <sub>J</sub> ≤ 85°C,<br>I <sub>REV</sub> is current out of IN1 pin |      | 0    | 3    | μA   |
| <b>OUT – CURRENT LIMIT</b> |  |   |      |      |      |      |
| $I_{OS}$                   | Short-circuit current limit <sup>(1)</sup>             |   | 3.16 | 3.4  | 3.64 | A    |
|                            |  | R <sub>REF</sub> = 10 Ω   |      |      | 7    |      |
| <b>OUT – DISCHARGE</b>     |  |   |      |      |      |      |
|                            | Discharge resistance                                   | V <sub>OUT</sub> = 4 V, UFP signature removed from CC lines, time < t <sub>w_DCHG</sub>   | 400  | 500  | 600  | Ω    |
|                            | Bleed discharge resistance                             | V <sub>OUT</sub> = 4 V, No UFP signature on CC lines, time > t <sub>w_DCHG</sub>  | 100  | 150  | 250  | kΩ   |
| <b>REF</b>                 |  |   |      |      |      |      |
| V <sub>O</sub>             | Output voltage   |   | 0.78 | 0.8  | 0.82 | V    |
| $I_{OS}$                   | Short circuit current                                  | R <sub>REF</sub> = 10 Ω   | 9.5  |      | 15.3 | μA   |
| <b>FAULT</b>               |  |   |      |      |      |      |
| V <sub>OL</sub>            | Output low voltage                                     | $I_{FAULT} = 1 \text{ mA}$  |      |      | 350  | mV   |
| $I_{OFF}$                  | Off-state leakage                                      | $V_{FAULT} = 5.5 \text{ V}$   |      |      | 1    | μA   |
| <b>CS</b>                  |  |   |      |      |      |      |
| V <sub>OL</sub>            | Output low voltage                                     | $I_{CS} = 1 \text{ mA}$   |      |      | 350  | mV   |
| $I_{OFF}$                  | Off-state leakage                                      | $V_{CS} = 5.5 \text{ V}$  |      |      | 1    | μA   |
| $I_{TH}$                   | OUT sourcing, rising threshold current for load detect |   | 1.8  | 1.95 | 2.1  | A    |
|                            | Hysteresis <sup>(2)</sup>                              |   |      | 125  |      | mA   |

(1) Pulse-testing techniques maintain junction temperature close to ambient temperature; thermal effects must be taken into account separately.

(2) These parameters are provided for reference only and do not constitute part of TI's published specifications for purposes of TI's product warranty.

**Electrical Characteristics (continued)**

$-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ ,  $4.5\text{ V} \leq V_{\text{IN}1} \leq 6.5\text{ V}$ ,  $4.5\text{ V} \leq V_{\text{IN}2} \leq 5.5\text{ V}$ ,  $2.9\text{ V} \leq V_{\text{AUX}} \leq 5.5\text{ V}$ ;  $V_{\text{EN}} = V_{\text{CHG}} = V_{\text{CHG\_HI}} = V_{\text{AUX}}$ ,  $R_{\text{REF}} = 100\text{ k}\Omega$ . Typical values are at  $25^{\circ}\text{C}$ . All voltages are with respect to GND.  $I_{\text{OUT}}$  and  $I_{\text{OS}}$  defined as positive out of the indicated pin (unless otherwise noted)

| PARAMETER  |  | TEST CONDITIONS  | MIN  | TYP   | MAX  | UNIT               |
|--|--|--|------|-------|------|--------------------|
| <b>CC1, CC2 – V<sub>CONN</sub> POWER SWITCH</b>                                  |  |  |      |       |      |                    |
| $r_{\text{DS(on)}}$  | On-resistance  | $T_J = 25^{\circ}\text{C}$ , $I_{\text{OUT}} = 250\text{ mA}$  |      | 365   | 420  | m $\Omega$         |
|  |  | $-40^{\circ}\text{C} \leq T_J \leq 85^{\circ}\text{C}$ , $I_{\text{OUT}} = 250\text{ mA}$  |      | 365   | 530  |                    |
|  |  | $-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ , $I_{\text{OUT}} = 250\text{ mA}$   |      | 365   | 600  |                    |
| <b>CC1, CC2 – V<sub>CONN</sub> POWER SWITCH – CURRENT LIMIT</b>                  |  |  |      |       |      |                    |
| $I_{\text{OS}}$  | Short-circuit current limit <sup>(1)</sup>   |  | 300  | 355   | 410  | mA                 |
|  |  | $R_{\text{REF}} = 10\ \Omega$  |      |       | 800  |                    |
| <b>CC1, CC2 – CONNECT MANAGEMENT – DANGLING ELECTRONICALLY MARKED CABLE MODE</b> |  |  |      |       |      |                    |
| $I_{\text{SRC}}$   | Sourcing current on the pass-through CC Line   | $0\text{ V} \leq V_{\text{CCx}} \leq 1.5\text{ V}$   | 64   | 80    | 96   | $\mu\text{A}$      |
|  | Sourcing current on the Ra CC line   | $0\text{ V} \leq V_{\text{CCx}} \leq 1.5\text{ V}$   | 64   | 80    | 96   |                    |
| <b>CC1, CC2 – CONNECT MANAGEMENT – ACCESSORY MODE</b>                            |  |  |      |       |      |                    |
| $I_{\text{SRC}}$   | CCx sourcing current (CC2 – audio, CC1-debug)  | $0\text{ V} \leq V_{\text{CCx}} \leq 1.5\text{ V}$   | 64   | 80    | 96   | $\mu\text{A}$      |
|  | CCx sourcing current (CC1 – audio, CC2-debug) <sup>(2)</sup>                             | $0\text{ V} \leq V_{\text{CCx}} \leq 1.5\text{ V}$   |      | 0     |      |                    |
| <b>CC1, CC2 – CONNECT MANAGEMENT – UFP MODE</b>                                  |  |  |      |       |      |                    |
| $I_{\text{SRC}}$   | Sourcing current with either IN1 or IN2 in UVLO  | $0\text{ V} \leq V_{\text{CCx}} \leq 1.5\text{ V}$<br>$V_{\text{IN}1} < V_{\text{TH\_UVLO\_IN}1}$ or $V_{\text{IN}2} < V_{\text{TH\_UVLO\_IN}2}$ | 64   | 80    | 96   | $\mu\text{A}$      |
| $I_{\text{SRC}}$   | Sourcing current   | $V_{\text{CHG}} = 0\text{ V}$ and $V_{\text{CHG\_HI}} = 0\text{ V}$<br>$0\text{ V} \leq V_{\text{CCx}} \leq 1.5\text{ V}$                        | 75   | 80    | 85   | $\mu\text{A}$      |
|  |  | $V_{\text{CHG}} = V_{\text{AUX}}$ and $V_{\text{CHG\_HI}} = 0\text{ V}$<br>$0\text{ V} \leq V_{\text{CCx}} \leq 1.5\text{ V}$                    | 170  | 180   | 190  |                    |
|  |  | $V_{\text{CHG}} = V_{\text{AUX}}$ and $V_{\text{CHG\_HI}} = V_{\text{AUX}}$<br>$0\text{ V} \leq V_{\text{CCx}} \leq 2.45\text{ V}$               | 312  | 330   | 348  |                    |
| <b>UFP, POL, AUDIO, DEBUG</b>  |  |  |      |       |      |                    |
| $V_{\text{OL}}$  | Output low voltage   | $I_{\text{SNK\_PIN}} = 1\text{ mA}$  |      |       | 250  | mV                 |
| $I_{\text{OFF}}$   | Off-state leakage  | $V_{\text{PIN}} = 5.5\text{ V}$  |      |       | 1    | $\mu\text{A}$      |
| <b>EN, CHG, CHG_HI – LOGIC INPUTS</b>  |  |  |      |       |      |                    |
| $V_{\text{TH}}$  | Rising threshold voltage   |  |      | 0.925 | 1.15 | V                  |
| $V_{\text{TH}}$  | Falling threshold voltage  |  | 0.65 | 0.875 |      | V                  |
|  | Hysteresis <sup>(2)</sup>  |  |      | 50    |      | mV                 |
| $I_{\text{IN}}$  | Input current  | $V_{\text{EN}} = 0\text{ V}$ or $6.5\text{ V}$   | -0.5 |       | 0.5  | $\mu\text{A}$      |
| <b>OVERTEMPERATURE SHUTDOWN</b>  |  |  |      |       |      |                    |
| $T_{\text{TH\_OTS}2}$  | Rising threshold temperature for device shutdown   |  | 155  |       |      | $^{\circ}\text{C}$ |
|  | Hysteresis <sup>(2)</sup>  |  |      | 20    |      | $^{\circ}\text{C}$ |
| $T_{\text{TH\_OTS}1}$  | Rising threshold temperature for OUT/ V <sub>CONN</sub> switch shutdown in current limit |  | 135  |       |      | $^{\circ}\text{C}$ |
|  | Hysteresis <sup>(2)</sup>  |  |      | 20    |      | $^{\circ}\text{C}$ |
| <b>IN1</b>   |  |  |      |       |      |                    |
| $V_{\text{TH\_UVLO\_IN}1}$   | Rising threshold voltage for UVLO  |  | 3.9  | 4.1   | 4.3  | V                  |
|  | Hysteresis <sup>(2)</sup>  |  |      | 100   |      | mV                 |
| $I_{\text{IN}1(\text{DIS})}$   | Disabled supply current  | $V_{\text{EN}} = 0\text{ V}$ , $-40^{\circ}\text{C} \leq T_J \leq 85^{\circ}\text{C}$  |      |       | 1    | $\mu\text{A}$      |
| $I_{\text{IN}1(\text{CC\_OPEN})}$  | Enabled supply current with CC lines open  | $-40^{\circ}\text{C} \leq T_J \leq 85^{\circ}\text{C}$   |      |       | 1    | $\mu\text{A}$      |

## Electrical Characteristics (continued)

$-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ ,  $4.5\text{ V} \leq V_{\text{IN}1} \leq 6.5\text{ V}$ ,  $4.5\text{ V} \leq V_{\text{IN}2} \leq 5.5\text{ V}$ ,  $2.9\text{ V} \leq V_{\text{AUX}} \leq 5.5\text{ V}$ ;  $V_{\text{EN}} = V_{\text{CHG}} = V_{\text{CHG\_HI}} = V_{\text{AUX}}$ ,  $R_{\text{REF}} = 100\text{ k}\Omega$ . Typical values are at  $25^{\circ}\text{C}$ . All voltages are with respect to GND.  $I_{\text{OUT}}$  and  $I_{\text{OS}}$  defined as positive out of the indicated pin (unless otherwise noted)

| PARAMETER                         |  | TEST CONDITIONS   | MIN  | TYP  | MAX  | UNIT          |
|-----------------------------------|--|---|------|------|------|---------------|
| $I_{\text{IN}1(\text{Ra})}$       | Enabled supply current with accessory or dangling electronically marked cable signature on CC lines                                    |   |      |      | 2    | $\mu\text{A}$ |
| $I_{\text{IN}1(\text{Rd})}$       | Enabled supply current with UFP attached   | $V_{\text{CHG}} = 0\text{ V}$ , or $V_{\text{CHG}} = V_{\text{AUX}}$ and $V_{\text{CHG\_HI}} = 0\text{ V}$                  |      | 75   | 100  | $\mu\text{A}$ |
|                                   |  |   |      | 85   | 110  |               |
| <b>IN2</b>                        |  |   |      |      |      |               |
| $V_{\text{TH\_UVLO\_IN}2}$        | Rising threshold voltage for UVLO  |   | 3.9  | 4.1  | 4.3  | V             |
|                                   | Hysteresis <sup>(2)</sup>  |   |      | 100  |      | mV            |
| $I_{\text{IN}2(\text{DIS})}$      | Disabled supply current  | $V_{\text{EN}} = 0\text{ V}$ , $-40^{\circ}\text{C} \leq T_J \leq 85^{\circ}\text{C}$                                       |      |      | 1    | $\mu\text{A}$ |
| $I_{\text{IN}2(\text{CC\_OPEN})}$ | Enabled supply current with CC lines open  | $-40^{\circ}\text{C} \leq T_J \leq 85^{\circ}\text{C}$  |      |      | 1    | $\mu\text{A}$ |
| $I_{\text{IN}2(\text{Ra})}$       | Enabled supply current with accessory or dangling electronically marked cable signature on CC lines                                    |   |      |      | 2    | $\mu\text{A}$ |
| $I_{\text{IN}2(\text{Rd})}$       | Enabled supply current with UFP signature on CC lines (Includes IN current that provides the CC output current to the UFP Rd resistor) | $V_{\text{CHG}} = 0\text{ V}$ , $0\text{ V} \leq V_{\text{CCx}} \leq 1.5\text{ V}$  |      | 98   | 110  | $\mu\text{A}$ |
|                                   |  | $V_{\text{CHG}} = V_{\text{IN}}$ and $V_{\text{CHG\_HI}} = 0\text{ V}$ , $0\text{ V} \leq V_{\text{CCx}} \leq 1.5\text{ V}$ |      | 198  | 215  |               |
|                                   |  | $0\text{ V} \leq V_{\text{CCx}} \leq 2.45\text{ V}$   |      | 348  | 373  |               |
| <b>AUX</b>                        |  |   |      |      |      |               |
| $V_{\text{TH\_UVLO\_AUX}}$        | Rising threshold voltage for UVLO  |   | 2.65 | 2.75 | 2.85 | V             |
|                                   | Hysteresis <sup>(2)</sup>  |   |      | 100  |      | mV            |
| $I_{\text{AUX}(\text{DIS})}$      | Disabled supply current  | $V_{\text{EN}} = 0\text{ V}$ , $-40^{\circ}\text{C} \leq T_J \leq 85^{\circ}\text{C}$                                       |      |      | 1    | $\mu\text{A}$ |
| $I_{\text{AUX}(\text{CC\_OPEN})}$ | Enabled internal supply current with CC lines open   | $-40^{\circ}\text{C} \leq T_J \leq 85^{\circ}\text{C}$  |      | 0.7  | 3    | $\mu\text{A}$ |
| $I_{\text{AUX}(\text{Ra})}$       | Enabled supply current with accessory or dangling active cable signature on CC lines   |   |      | 140  | 185  | $\mu\text{A}$ |
| $I_{\text{AUX}(\text{Rd\_noIN})}$ | Enabled supply current with UFP termination on CC lines and with either IN1 or IN2 in UVLO   | $V_{\text{IN}1} < V_{\text{TH\_UVLO\_IN}1}$ or $V_{\text{IN}2} < V_{\text{TH\_UVLO\_IN}2}$                                  |      | 145  | 190  | $\mu\text{A}$ |
| $I_{\text{AUX}(\text{Rd})}$       | Enabled supply current with UFP termination on CC lines  |   |      | 55   | 82   | $\mu\text{A}$ |

## 7.6 Switching Characteristics

$-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ ,  $4.5\text{ V} \leq V_{\text{IN}1} \leq 6.5\text{ V}$ ,  $4.5\text{ V} \leq V_{\text{IN}2} \leq 5.5\text{ V}$ ,  $2.9\text{ V} \leq V_{\text{AUX}} \leq 5.5\text{ V}$ ;  $V_{\text{EN}} = V_{\text{CHG}} = V_{\text{CHG\_HI}} = V_{\text{AUX}}$ ,  $R_{\text{REF}} = 100\text{ k}\Omega$ . Typical values are at  $25^{\circ}\text{C}$ . All voltages are with respect to GND.  $I_{\text{OUT}}$  and  $I_{\text{OS}}$  defined as positive out of the indicated pin (unless otherwise noted)

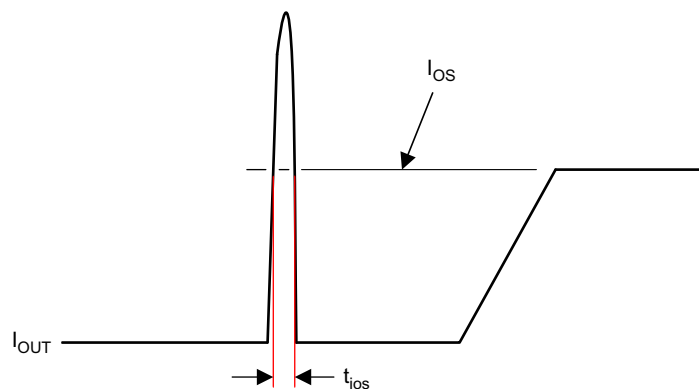
| PARAMETER                  |  | TEST CONDITIONS   | MIN  | TYP  | MAX  | UNIT          |
|----------------------------|--|---|------|------|------|---------------|
| <b>OUT – POWER SWITCH</b>  |  |   |      |      |      |               |
| $t_r$                      | Output-voltage rise time                     | $V_{\text{IN}1} = 5\text{ V}$ , $C_L = 1\text{ }\mu\text{F}$ , $R_L = 100\text{ }\Omega$  | 1.2  | 1.8  | 2.5  | ms            |
| $t_f$                      | Output-voltage fall time                     | (measured from 10% to 90% of final value)   | 0.35 | 0.55 | 0.75 | ms            |
| $t_{\text{on}}$            | Output-voltage turnon time                   | $V_{\text{IN}1} = 5\text{ V}$ , $C_L = 1\text{ }\mu\text{F}$ , $R_L = 100\text{ }\Omega$  | 2.5  | 3.5  | 5    | ms            |
| $t_{\text{off}}$           | Output-voltage turnoff time                  |   | 2    | 3    | 4.5  | ms            |
| <b>OUT – CURRENT LIMIT</b> |  |   |      |      |      |               |
| $t_{\text{ios}}$           | Current-limit response time to short circuit | $V_{\text{IN}1} - V_{\text{OUT}} = 1\text{ V}$ , $R_L = 10\text{ m}\Omega$ , see Figure 1 |      | 1.5  | 4    | $\mu\text{s}$ |

**Switching Characteristics (continued)**

$-40^{\circ}\text{C} \leq T_J \leq 125^{\circ}\text{C}$ ,  $4.5\text{ V} \leq V_{\text{IN1}} \leq 6.5\text{ V}$ ,  $4.5\text{ V} \leq V_{\text{IN2}} \leq 5.5\text{ V}$ ,  $2.9\text{ V} \leq V_{\text{AUX}} \leq 5.5\text{ V}$ ;  $V_{\text{EN}} = V_{\text{CHG}} = V_{\text{CHG\_HI}} = V_{\text{AUX}}$ ,  $R_{\text{REF}} = 100\text{ k}\Omega$ . Typical values are at  $25^{\circ}\text{C}$ . All voltages are with respect to GND.  $I_{\text{OUT}}$  and  $I_{\text{OS}}$  defined as positive out of the indicated pin (unless otherwise noted)

| PARAMETER   | TEST CONDITIONS  | MIN  | TYP  | MAX  | UNIT |      |               |
|---|--|--|------|------|------|------|---------------|
| <b>FAULT</b>  |  |  |      |      |      |      |               |
| $t_{\text{DEGA}}$   | Asserting deglitch time due to overcurrent                                     | 5.5  | 8.2  | 10.7 | ms   |      |               |
| $t_{\text{DEGA(OC)}}$   | Asserting deglitch time due to overtemperature in current limit <sup>(1)</sup> |  | 0    |      | ms   |      |               |
| $t_{\text{DEGA(OT)}}$   | Deasserting deglitch time  | 5.5  | 8.2  | 10.7 | ms   |      |               |
| <b>CS</b>   |  |  |      |      |      |      |               |
| $t_{\text{DEGA}}$   | Asserting deglitch time  | 5.5  | 8.2  | 10.7 | ms   |      |               |
| $t_{\text{DEGD}}$   | Deasserting deglitch time  | 5.5  | 8.2  | 10.7 | ms   |      |               |
| <b>OUT – DISCHARGE</b>  |  |  |      |      |      |      |               |
|   | $R_{\text{DCHG}}$ discharge time   | $V_{\text{OUT}} = 1\text{ V}$ , time $I_{\text{SNK\_OUT}} > 1\text{ mA}$ after UFP signature removed from CC lines                 |      | 39   | 65   | 96   | ms            |
| <b>CC1, CC2 - <math>V_{\text{CONN}}</math> POWER SWITCH</b>                 |  |  |      |      |      |      |               |
| $t_r$   | Output-voltage rise time   | $V_{\text{IN2}} = 5\text{ V}$ , $C_L = 1\text{ }\mu\text{F}$ , $R_L = 100\text{ }\Omega$ (measured from 10% to 90% of final value) |      | 0.15 | 0.25 | 0.35 | ms            |
| $t_f$   | Output-voltage fall time   |  |      | 0.18 | 0.22 | 0.26 | ms            |
| $t_{\text{on}}$   | Output-voltage turnon time   | $V_{\text{IN2}} = 5\text{ V}$ , $C_L = 1\text{ }\mu\text{F}$ , $R_L = 100\text{ }\Omega$   |      | 1    | 1.5  | 2    | ms            |
| $t_{\text{off}}$  | Output-voltage turnoff time  |  |      | 0.3  | 0.4  | 0.55 | ms            |
| <b>CC1, CC2 – <math>V_{\text{CONN}}</math> POWER SWITCH – CURRENT LIMIT</b> |  |  |      |      |      |      |               |
| $t_{\text{res}}$  | Current-limit response time to short circuit                                   | $V_{\text{IN2}} - V_{\text{CONN}} = 1\text{ V}$ , $R = 10\text{ m}\Omega$ , see <a href="#">Figure 1</a>                           |      | 1    | 3    |      | $\mu\text{s}$ |
| <b>UFP, POL, AUDIO, DEBUG</b>   |  |  |      |      |      |      |               |
| $t_{\text{DEGR}}$   | Asserting deglitch time  | 100  | 150  | 200  | ms   |      |               |
| $t_{\text{DEGF}}$   | Deasserting deglitch time  | 7.9  | 12.5 | 17.7 | ms   |      |               |

(1) These parameters are provided for reference only and do not constitute part of TI's published specifications for purposes of TI's product warranty.



**Figure 1. Output Short-Circuit Timing Diagram**



## 7.7 Typical Characteristics

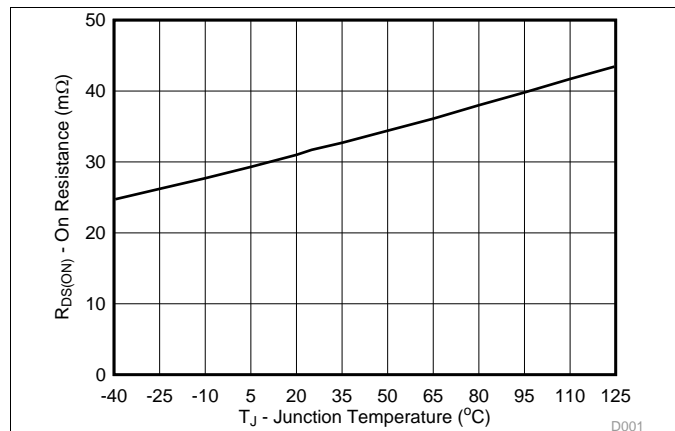


Figure 2.  $V_{BUS}$  Current-Limiting Switch On-Resistance vs Temperature

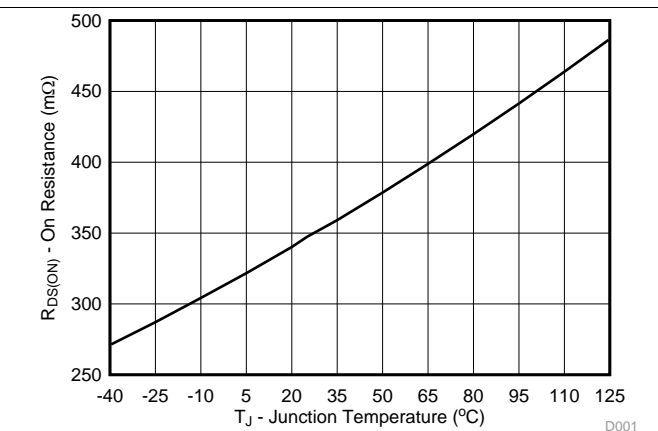


Figure 3.  $V_{CONN}$  Current-Limiting Switch On-Resistance vs Temperature

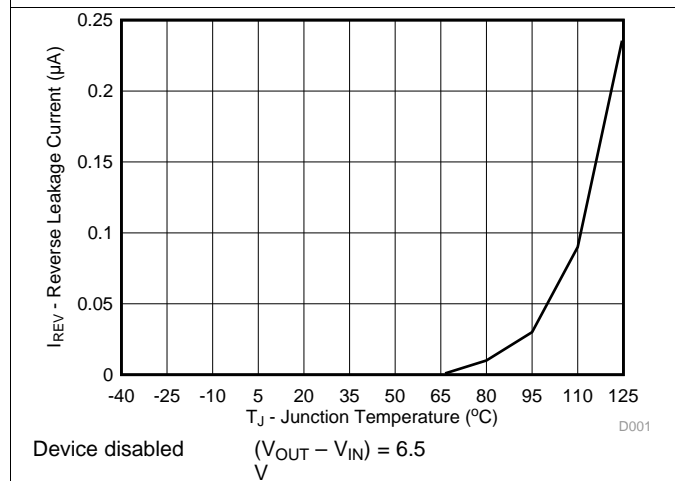


Figure 4. OUT Reverse Leakage Current vs Temperature

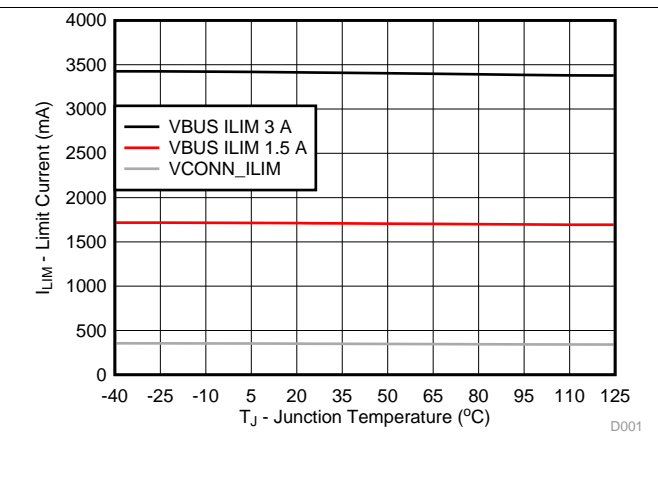


Figure 5.  $I_{LIM}$  for  $V_{BUS}$  and  $V_{CONN}$  vs Temperature

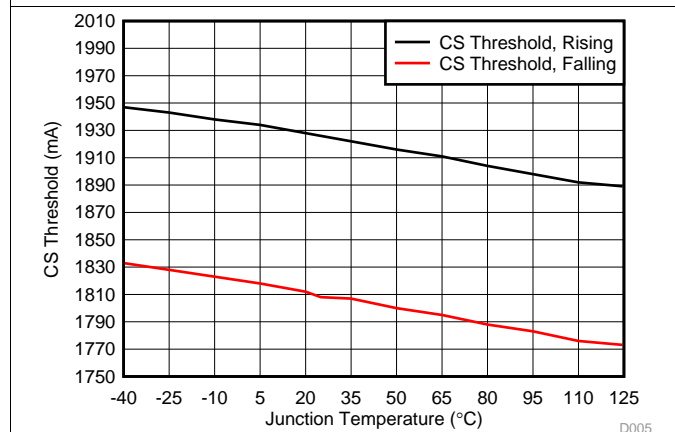


Figure 6.  $\overline{CS}$  Threshold vs Temperature

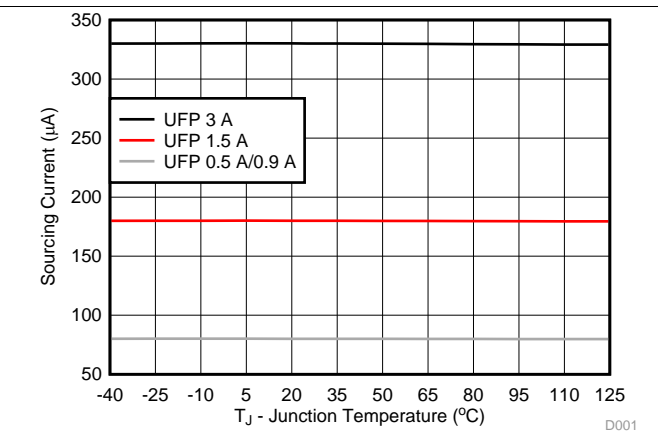


Figure 7. CC Sourcing Current to UFP vs Temperature

Typical Characteristics (continued)

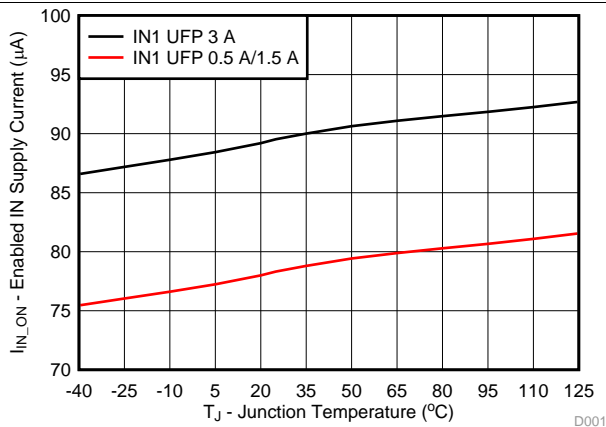


Figure 8. IN1 Current With UFP vs Temperature

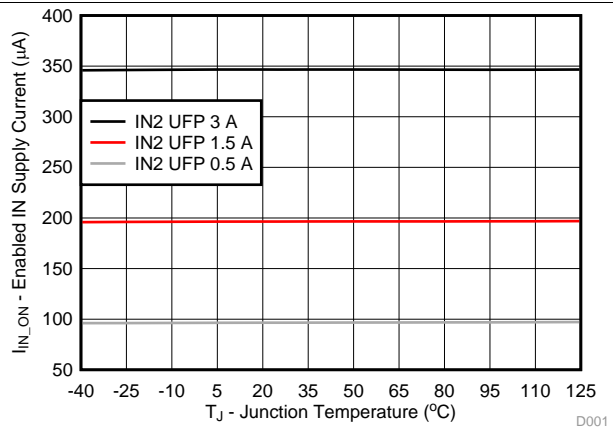


Figure 9. IN2 Current With UFP vs Temperature

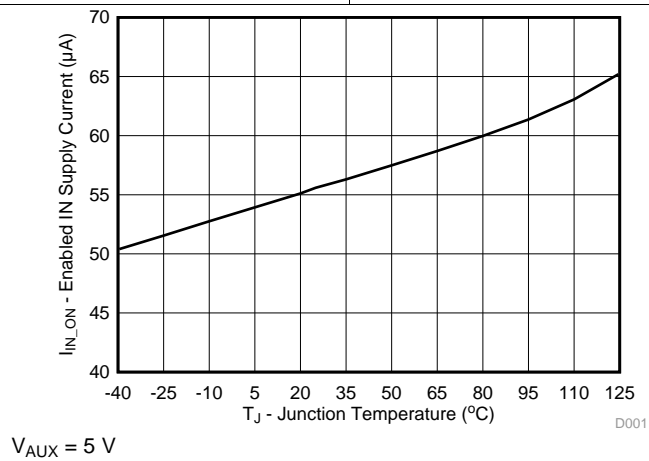


Figure 10. AUX Current With UFP vs Temperature

## 8 Detailed Description

### 8.1 Overview

The TPS25810A-Q1 device is a highly integrated USB Type-C™ downstream-facing port (DFP) controller, developed with a built-in power switch for the new USB Type-C connector and cable. The device provides all of the functionality needed to support a USB Type-C DFP in a system where USB power delivery (PD) source capabilities (for example,  $V_{BUS} > 5\text{ V}$ ) are not implemented. It is designed to be compliant with the Type-C specification, revision 1.2.

#### 8.1.1 USB Type-C Basic

For a detailed description of the Type-C specification, see the USB-IF [Web site](#) to download the latest released version. Some of the basic concepts of the Type-C specification that pertain to understanding the operation of the TPS25810A-Q1 (DFP device) are described as follows.

USB Type-C removes the need for different plug and receptacle types for host and device functionality. The Type-C receptacle replaces both Type-A and Type-B receptacles because the Type-C cable is pluggable in either direction between host and device. A host-to-device logical relationship is maintained via the configuration channel (CC). Optionally, hosts and devices can be either providers or consumers of power when USB PD communication is used to swap roles.

All USB Type-C ports operate in one of the following three data modes:

- Host mode: the port can only be host (provider of power).
- Device mode: the port can only be device (consumer of power).
- Dual-role mode: the port can be either host or device.

Port types:

- DFP (downstream facing port): Host
- UFP (upstream facing port): Device
- DRP (dual-role port): Host or device

Valid DFP-to-UFP connections:

- [Table 1](#) describes valid DFP-to-UFP connections.
- Host-to-host and device-to-device have no functions.

**Table 1. DFP-to-UFP Connections**

|                  | HOST-MODE PORT | DEVICE-MODE PORT | DUAL-ROLE PORT       |
|------------------|----------------|------------------|----------------------|
| Host-mode port   | No function    | Works            | Works                |
| Device-mode port | Works          | No function      | Works                |
| Dual-role port   | Works          | Works            | Works <sup>(1)</sup> |

(1) This may be automatic or manually driven.

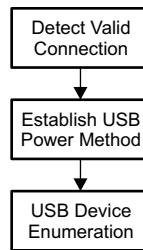
#### 8.1.2 Configuration Channel

The function of the configuration channel (CC) is to detect connections and configure the interface across the USB Type-C cables and connectors.

Functionally, the configuration channel serves the following purposes:

- Detect connection to the USB ports
- Resolve cable orientation and twist connections to establish USB data-bus routing
- Establish DFP and UFP roles between two connected ports
- Discover and configure power: USB Type-C current modes or USB power delivery
- Discover and configure optional alternate and accessory modes
- Enhance flexibility and ease of use

Typical flow of DFP-to-UFP configuration is shown in [Figure 11](#):

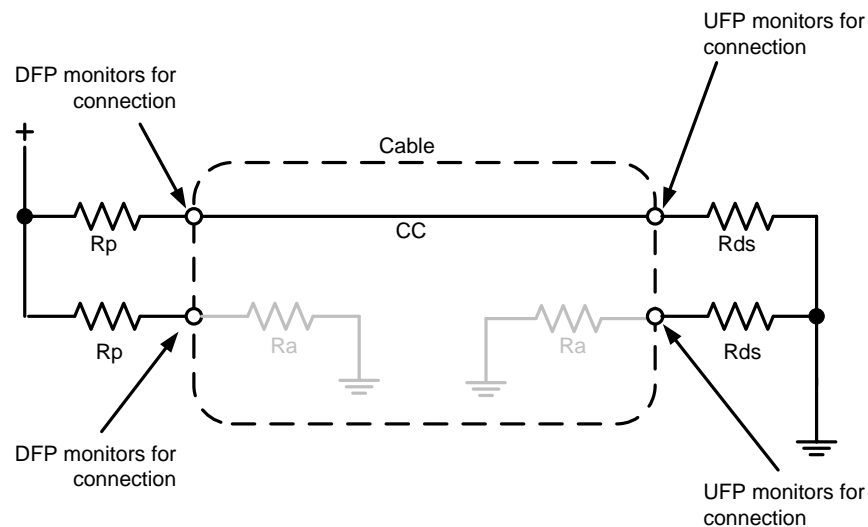


**Figure 11. Flow of DFP-to-UFP Configuration**

### 8.1.3 Detecting a Connection

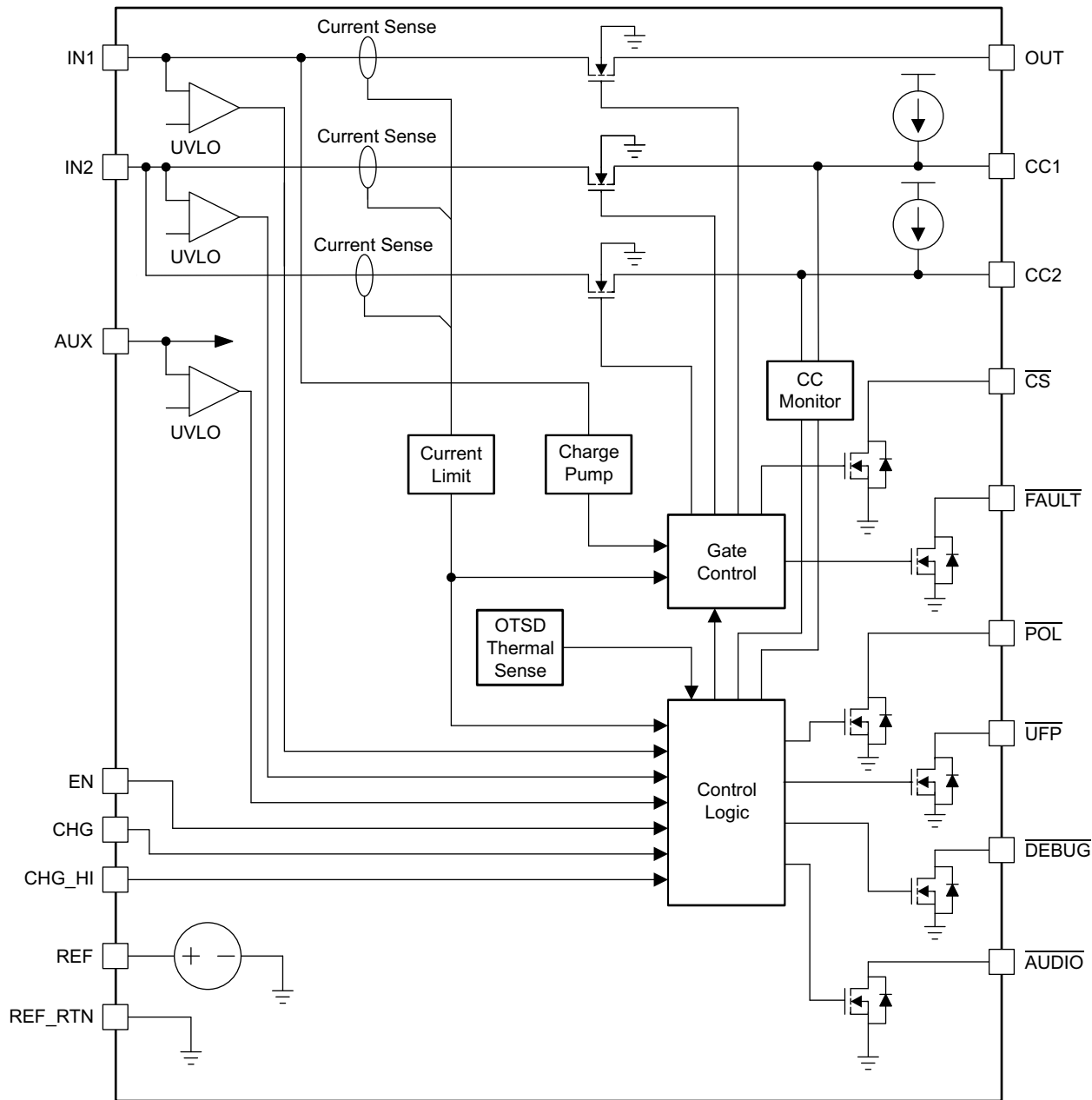
DFPs and DRPs fulfill the role of detecting a valid connection over USB Type-C. [Figure 12](#) shows a DFP-to-UFP connection made with Type-C cable. As shown in [Figure 12](#), the detection concept is based on being able to detect terminations in the product that has been attached. A pullup and pulldown termination model is used. A pullup termination can be replaced by a current source.

- In the DFP-to-UFP connection, the DFP monitors both CC pins for a voltage lower than the unterminated voltage.
- A UFP advertises  $R_d$  on both of its CC pins (CC1 and CC2).
- A powered cable advertises  $R_a$  on only one of the CC pins of the plug.  $R_a$  is used to inform the source to apply  $V_{CONN}$ .
- An analog audio device advertises  $R_a$  on both CC pins of the plug, which identifies it as an analog audio device.  $V_{CONN}$  is not applied on either CC pin in this case.



**Figure 12. DFP-to-UFP Connection**

## 8.2 Functional Block Diagram



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## 8.3 Feature Description

The TPS25810A-Q1 device is a DFP Type-C port controller with integrated power switches for  $V_{CONN}$  and  $V_{BUS}$ . It does not support BC 1.2 charging modes inherently, because it does not interact with USB D+ and D- data lines. The TPS25810A-Q1 device can be used in conjunction with a BC 1.2 controller like the TPS2514A-Q1 device to support BC1.2 and Type-C charging modes in a single Type-C DFP port. See the [TPS25810 EVM User's Guide](#) and [Application and Implementation](#) section of this data sheet for more details. The TPS25810A-Q1 device can be used in a USB 2.0 only or in a USB 3.1 port implementation. When used in a USB 3.1 port, the  $\overline{POL}$  pin can control an external super-speed MUX to handle the Type-C flippable feature.

## Feature Description (continued)

### 8.3.1 Configuration Channel Pins CC1 and CC2

Each device has two pins, CC1 and CC2, that serve to detect an attachment to the port and to resolve cable orientation. These pins are also used to establish the current broadcast to a valid UFP, configure  $V_{CONN}$ , and detect attachment of a debug or audio-adaptor accessory.

Table 2 lists the response to various attachments to its port.

**Table 2. TPS25810A-Q1 Response**

| TPS25810A-Q1 TYPE-C PORT          | CC1  | CC2  | TPS25810A-Q1 RESPONSE <sup>(1)</sup> |                          |                  |                  |                    |                    |
|-----------------------------------|------|------|--------------------------------------|--------------------------|------------------|------------------|--------------------|--------------------|
|                                   |      |      | OUT                                  | $V_{CONN}$ on CC1 or CC2 | $\overline{POL}$ | $\overline{UFP}$ | $\overline{AUDIO}$ | $\overline{DEBUG}$ |
| Nothing attached                  | OPEN | OPEN | OPEN                                 | NO                       | Hi-Z             | Hi-Z             | Hi-Z               | Hi-Z               |
| UFP connected                     | Rd   | OPEN | IN1                                  | NO                       | Hi-Z             | LOW              | Hi-Z               | Hi-Z               |
|                                   | OPEN | Rd   | IN1                                  | NO                       | LOW              | LOW              | Hi-Z               | Hi-Z               |
| Powered cable, no UFP connected   | OPEN | Ra   | OPEN                                 | NO                       | Hi-Z             | Hi-Z             | Hi-Z               | Hi-Z               |
|                                   | Ra   | OPEN | OPEN                                 | NO                       | Hi-Z             | Hi-Z             | Hi-Z               | Hi-Z               |
| Powered cable, UFP connected      | Rd   | Ra   | IN1                                  | CC2                      | Hi-Z             | LOW              | Hi-Z               | Hi-Z               |
|                                   | Ra   | Rd   | IN1                                  | CC1                      | LOW              | LOW              | Hi-Z               | Hi-Z               |
| Debug accessory connected         | Rd   | Rd   | OPEN                                 | NO                       | Hi-Z             | Hi-Z             | Hi-Z               | LOW                |
| Audio-adaptor accessory connected | Ra   | Ra   | OPEN                                 | NO                       | Hi-Z             | Hi-Z             | LOW                | Hi-Z               |

(1)  $\overline{POL}$ ,  $\overline{UFP}$ ,  $\overline{AUDIO}$ , and  $\overline{DEBUG}$  are open-drain outputs; pull high with 100 k $\Omega$  to AUX when used. Tie to GND or leave open when not used.

### 8.3.2 Current Capability Advertisement and Overload Protection

The TPS25810A-Q1 device supports all three Type-C current advertisements as defined by the USB Type-C standard. Current broadcast to a connected UFP is controlled by the CHG and CHG\_HI pins. For each broadcast level, the device protects itself from a UFP that draws current in excess of the USB Type-C current advertisement of that port by setting the current limit as shown in Table 3.

**Table 3. USB Type-C Current Advertisement**

| CHG | CHG_HI | CC CAPABILITY BROADCAST | CURRENT LIMIT (TYP) | $\overline{CS}$ THRESHOLD (TYP) |
|-----|--------|-------------------------|---------------------|---------------------------------|
| 0   | 0      | STD                     | 3.4 A               | 1.95 A                          |
| 0   | 1      | STD                     | 3.4 A               | 1.95 A                          |
| 1   | 0      | 1.5 A                   | 3.4 A               | 1.95 A                          |
| 1   | 1      | 3 A                     | 3.4 A               | 1.95 A                          |

Under OUT overload conditions, an internal OUT current-limit regulator limits the output current to the selected  $I_{LIM}$  based on CHG and CHG\_HI selection. In applications where  $V_{CONN}$  is supplied via CC1 or CC2, separate fixed current-limit regulators protect these pins from overload at the level indicated in the [Electrical Characteristics](#) table. When an overload condition is present, the device maintains a constant output current, with the output voltage determined by  $(I_{OS} \times R_{LOAD})$ . Two possible overload conditions can occur. The first overload condition occurs when either: 1) input voltage is first applied, enable is true, and a short circuit is present (load which draws  $I_{OUT} > I_{OS}$ ), or 2) input voltage is present and the TPS25810A-Q1 device is enabled into a short circuit. The output voltage is held near zero potential with respect to ground and the TPS25810A-Q1 device ramps the output current to  $I_{OS}$ . Both limit the current to  $I_{OS}$  until the overload condition is removed or the device begins to thermal cycle. This is demonstrated in [Figure 23](#) where the device was enabled into a short, and subsequently cycles current off and on as the thermal protection engages.

The second condition is when an overload occurs while the device is enabled and fully turned on. The device responds to the overload condition within time  $t_{ios}$  (see [Figure 1](#)) when the specified overload (per [Electrical Characteristics](#)) is applied. The response speed and shape vary with the overload level, input circuit, and rate of application. The current-limit response can be either simply settling to  $I_{OS}$  or turnoff and controlled return to  $I_{OS}$ . Similar to the previous case, the TPS25810A-Q1 device limits the current to  $I_{OS}$  until the overload condition is removed or the device begins to thermal cycle.

The TPS25810A-Q1 device thermal cycles if an overload condition is present long enough to activate thermal limiting in any of the above cases. This is due to the relatively large power dissipation  $[(V_{IN} - V_{OUT}) \times I_{OS}]$  driving the junction temperature up. The device turns off when the junction temperature exceeds 135°C (minimum) while in current limit. The device remains off until the junction temperature cools 20°C and then restarts. The current-limit profile is shown in [Figure 13](#).

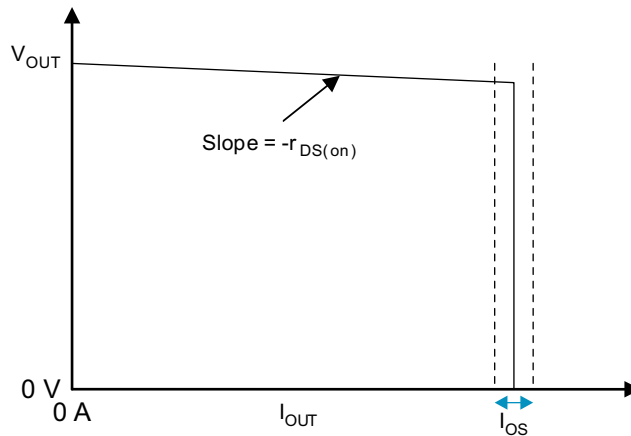


Figure 13. Current-Limit Profile

### 8.3.3 Undervoltage Lockout (UVLO)

The undervoltage lockout (UVLO) circuit disables the power switch until the input voltage reaches the UVLO turnon threshold. Built-in hysteresis prevents unwanted on-off cycling due to input voltage droop during turnon.

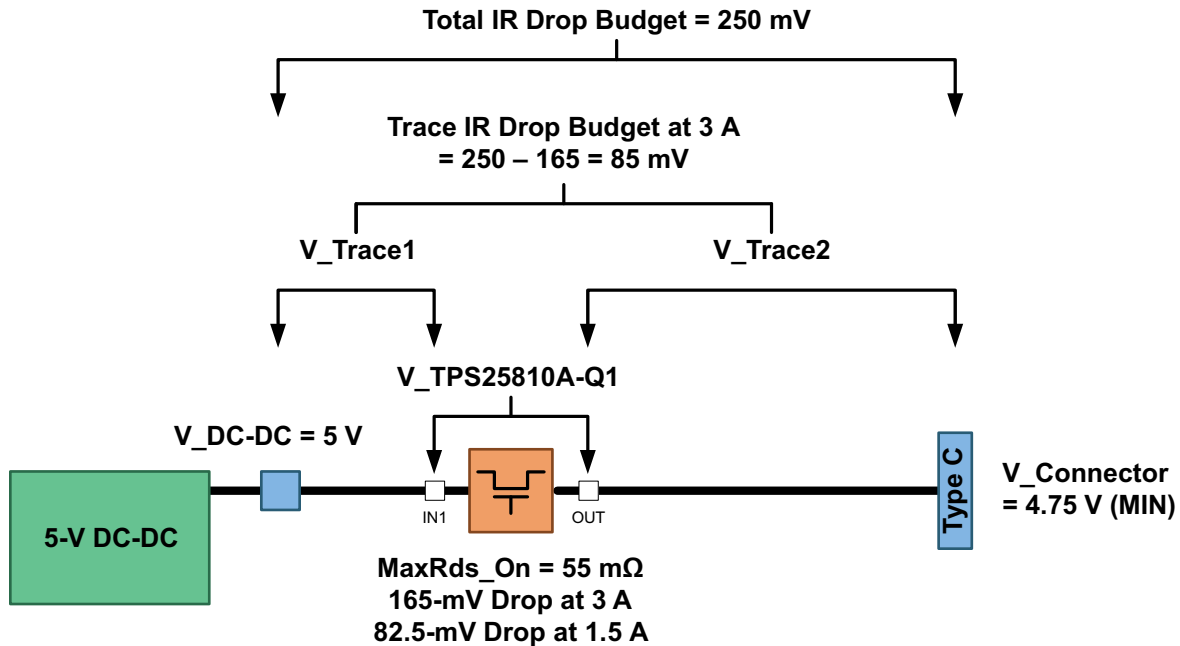
#### 8.3.3.1 Device Power Pins (IN1, IN2, AUX, OUT, and GND)

The device has multiple input power pins: IN1, IN2 and AUX. IN1 is connected to OUT by the internal power FET and serves as the supply for the Type-C charging current. IN2 is the supply for  $V_{CONN}$  and ties directly between the  $V_{CONN}$  power switch on its input and CC1 or CC2 on its output. AUX, the auxiliary input supply, provides power to the device. See the [Functional Block Diagram](#).

In the simplest implementation where multiple supplies are not available, IN1, IN2, and AUX can be tied together. However, in mobile systems (battery powered) where system power savings is paramount, IN1 and IN2 can be powered by the high-power dc-dc supply (>3-A capability), and AUX can be connected to the low-power supply that typically powers the system microcontroller when the system is in the hibernate or sleep power state. Unlike IN1 and IN2, AUX can operate directly from a 3.3-V supply commonly used to power the microcontroller when the system is put in low-power mode. Ceramic bypass capacitors close to the device from the INx and AUX pins to GND are recommended to alleviate bus transients.

The recommended operating voltage range for IN1 and IN2 is 4.5 V to 5.5 V, whereas AUX can be operated from 2.9 V to 5.5 V. However IN1, the high-power supply, can operate up to 6.5 V. This higher input voltage affords a larger IR loss budget in systems where a long cable harness is used, and results in high IR losses with 3-A charging current. Increasing IN1 beyond 5.5 V enables longer cable and board trace lengths between the device and the Type-C receptacle while meeting the USB specification for  $V_{BUS} \geq 4.75$  V at the connector.

[Figure 14](#) illustrates the point. In this example IN1 is at 5 V, which restricts the IR loss budget from the dc-dc converter to the connector to 250 mV.


**Figure 14. Total IR Loss Budget**

### 8.3.3.2 FAULT Response

The  $\overline{\text{FAULT}}$  pin is an open-drain output asserted low when the device OUT current exceeds its programmed value and the overtemperature threshold ( $T_{\text{TH\_OTSD1}}$ ) is crossed. See the [Electrical Characteristics](#) for overcurrent and overtemperature values. The FAULT signal remains asserted until the fault condition is removed and the device resumes normal operation. An internal deglitch circuit eliminates false overcurrent-fault reporting.

Connect  $\overline{\text{FAULT}}$  with a pullup resistor to AUX.  $\overline{\text{FAULT}}$  can be left open or tied to GND when not used.

### 8.3.3.3 Thermal Shutdown

The device has two internal overtemperature shutdown thresholds,  $T_{\text{TH\_OTSD1}}$  and  $T_{\text{TH\_OTSD2}}$ , to protect the internal FET from damage and assist with overall safety of the system.  $T_{\text{TH\_OTSD2}}$  is greater than  $T_{\text{TH\_OTSD1}}$ .  $\overline{\text{FAULT}}$  is asserted low to signal a fault condition when the device temperature exceeds  $T_{\text{TH\_OTSD1}}$  and the current-limit switch is disabled. However, when  $T_{\text{TH\_OTSD2}}$  is exceeded, all open-drain outputs are left open and the device is disabled such that minimum power is dissipated. The device attempts to power up when the die temperature decreases by 20°C.

### 8.3.3.4 REF

A 100-kΩ (1% or better recommended) resistor is connected from this pin to REF\_RTN. The REF pin sets the reference current required to bias the internal circuitry of the device. The overload current-limit tolerance and CC currents depend upon the accuracy of this resistor. Using a ±1% or better low-temperature-coefficient resistor yields the best current-limit accuracy and overall device performance.

### 8.3.3.5 Audio Accessory Detection

The USB Type-C specification defines an audio-adaptor decode state which allows implementation of an analog USB Type-C to 3.5-mm headset adapter. An audio accessory device is detected when both CC1 and CC2 pins detect  $V_{\text{Ra}}$  voltage (when pulled to ground by an  $R_a$  resistor). The open-drain AUDIO pin is asserted low to indicate the detection of such a device.

**Table 4. Audio Accessory Detection**

| CC1   | CC2   | $\overline{\text{AUDIO}}$ | STATE                             |
|-------|-------|---------------------------|-----------------------------------|
| $R_a$ | $R_a$ | Asserted (pulled low)     | Audio-adaptor accessory connected |



Platforms supporting the audio accessory function can be triggered by the  $\overline{\text{AUDIO}}$  pin to enable accessory mode circuits to support the audio function. When the Ra pulldown is removed from the CC2 pin,  $\overline{\text{AUDIO}}$  is deasserted or pulled high. The TPS25810A-Q1 device monitors the CC2 pin for audio device detach. When this function is not needed (for example in a data-less port),  $\overline{\text{AUDIO}}$  can be tied to GND or left open.

### 8.3.3.6 Debug Accessory Detection

The Type-C spec supports an optional debug-accessory mode, used for debug only and not to be used for communicating with commercial products. When the TPS25810A-Q1 device detects  $V_{Rd}$  voltage on both CC1 and CC2 pins (when pulled to ground by an Rd resistor), it asserts  $\overline{\text{DEBUG}}$  low. With  $\overline{\text{DEBUG}}$  asserted, the system can enter debug mode for factory testing or a similar functional mode.  $\overline{\text{DEBUG}}$  deasserts or pulls high when Rd is removed from CC1. The CC1 pin is monitored for debug-accessory detach.

If the debug-accessory mode is not used, tie  $\overline{\text{DEBUG}}$  to GND or leave it open.

**Table 5. Debug Accessory Detection**

| CC1 | CC2 | $\overline{\text{POL}}$ | STATE                     |
|-----|-----|-------------------------|---------------------------|
| Rd  | Rd  | Asserted (pulled low)   | Debug accessory connected |

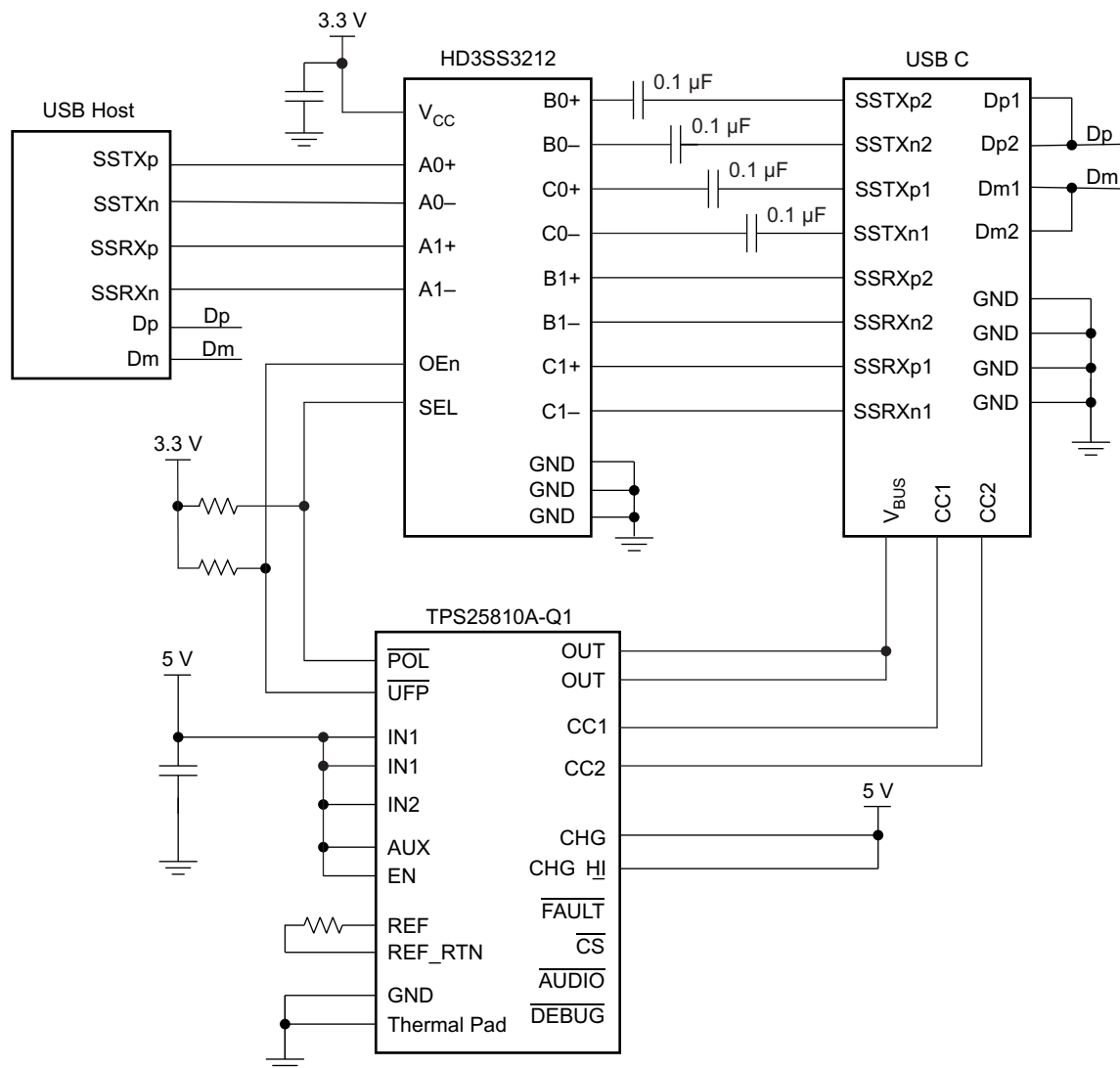
### 8.3.3.7 Plug Polarity Detection

Reversible Type-C plug orientation is reported by the  $\overline{\text{POL}}$  pin when a UFP is connected. However, when no UFP is attached  $\overline{\text{POL}}$  remains deasserted, irrespective of cable plug orientation. Table 6 describes the  $\overline{\text{POL}}$  state based on which of the device CC pins detects  $V_{Rd}$  from an attached UFP pulldown.

**Table 6. Plug Polarity Detection**

| CC1  | CC2  | $\overline{\text{POL}}$ | STATE                                       |
|------|------|-------------------------|---|
| Rd   | Open | Hi-Z                    | UFP connected                               |
| Open | Rd   | Asserted (pulled low)   | UFP connected with reverse plug orientation |

Figure 15 shows an example implementation which uses the  $\overline{\text{POL}}$  terminal to control the SEL terminal on the HD3SS3212 device. The HD3SS3212 device provides switching on the differential channels between Port B and Port C to Port A, depending on cable orientation. For details on the HD3SS3212 device, see [HD3SS3212x Two-Channel Differential 2:1/1:2 USB3.1 Mux/Demux](#).



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**Figure 15. Example Implementation**

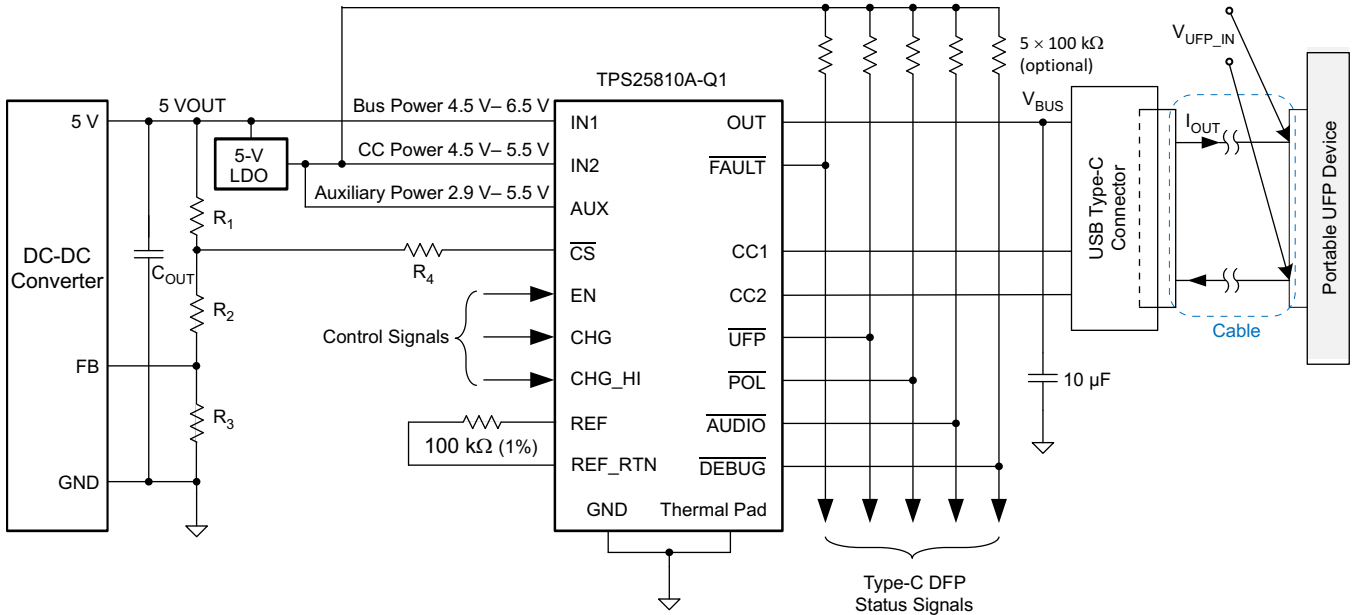
### 8.3.3.8 Device Enable Control

The logic enable pin (EN) controls the power switch and device supply current. The supply current is reduced to less than 1  $\mu\text{A}$  when a logic low is present on EN. The EN pin provides a convenient way to turn on or turn off the device while it is powered. The enable input threshold has built-in hysteresis. When this pin is pulled high, the device is turned on or enabled. When the device is disabled (EN pulled low) the internal FETs tied to IN1 and IN2 are disconnected, all open-drain outputs are left open (Hi-Z), and the monitor block for CC1 and CC2 is turned off. The EN terminal should not be left floating.

### 8.3.3.9 Cable Compensation ( $\overline{\text{CS}}$ )

The TPS25810A-Q1 device monitors the current to a UFP, and if the load current exceeds 1.95 A (typ), the  $\overline{\text{CS}}$  pin asserts. This can be useful for implementing a digital droop-compensation scheme by altering the feedback resistor ratio of the IN1 power source.

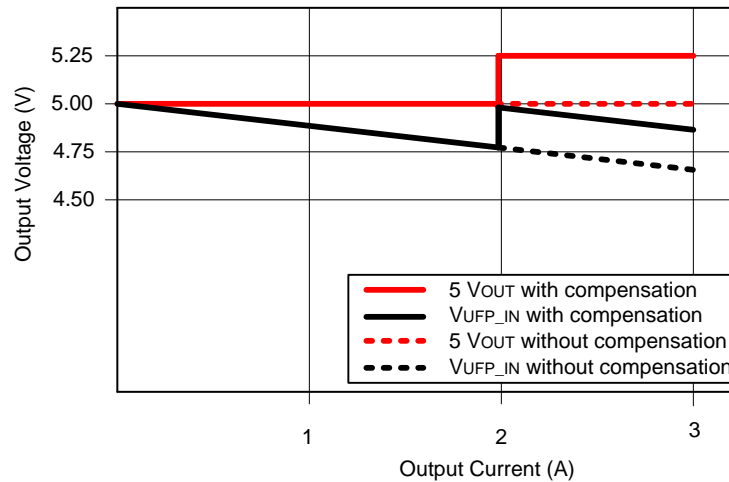
Figure 16 shows a USB charging design using the TPS25810A-Q1 device. The 5-V (typical) nominal output of the USB power supply, designated  $5 V_{OUT}$  herein, is often a dc-dc converter in automotive applications.  $V_{UFP\_IN}$  refers to the voltage across the inside contacts of the USB connector of a UFP device. Official USB specifications should be consulted for the most up-to-date requirements. For illustration purposes, it is assumed the minimum and maximum voltages allowed for  $V_{UFP\_IN}$  are 4 V and 5.25 V, respectively. In general, when  $V_{UFP\_IN}$  is 5 V, the UFP draws optimum current and requires the minimum amount of time to recharge its battery.



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Figure 16. TPS25810A-Q1 Charging System Schematic

In a practical system, there are voltage drops from the dc-dc output,  $5 V_{OUT}$ , to  $V_{UFP\_IN}$  which include the on-resistance of the TPS25810A-Q1 device power switch, USB cabling and connector contact resistances. Under rated UFP load current, these drops can be several hundred millivolts, decreasing  $V_{UFP\_IN}$  below the optimal 5-V level. In addition, as  $V_{UFP\_IN}$  decreases below 5 V, most modern UFPs decrease their load current to prevent possible overload conditions and to maintain  $V_{UFP\_IN}$  above 4 V. Lower-than-optimum load current increases the time required to recharge the UFP battery. For example, in Figure 16, assuming that the loss resistance is 113 mΩ (includes 79 mΩ of USB cable resistance and 34 mΩ of power switch resistance) and  $5 V_{OUT}$  is 5 V, the input voltage of UFP ( $V_{UFP\_IN}$ ) is about 4.66 V at 3 A. The TPS25810A-Q1 device provides the CS pin to report high-charging-current conditions and increase the  $5 V_{OUT}$  voltage as shown in Figure 17



**Figure 17. TPS25810A-Q1 CS Function**

Equation 1 through Equation 4 refer to Figure 16

The power supply output voltage is calculated in Equation 1.

$$5V_{OUT} = \frac{(R_1 + R_2 + R_3) \times V_{FB}}{R_3} \quad (1)$$

5 V<sub>OUT</sub> and V<sub>FB</sub> are known. If R<sub>3</sub> is given and R<sub>1</sub> is fixed, R<sub>2</sub> can be calculated. The 5 V<sub>OUT</sub> voltage change with compensation is shown in Equation 2 and Equation 3.

$$\Delta V = \frac{(R_2 + R_3) \times R_1 \times V_{FB}}{R_3 \times R_4} \quad (2)$$

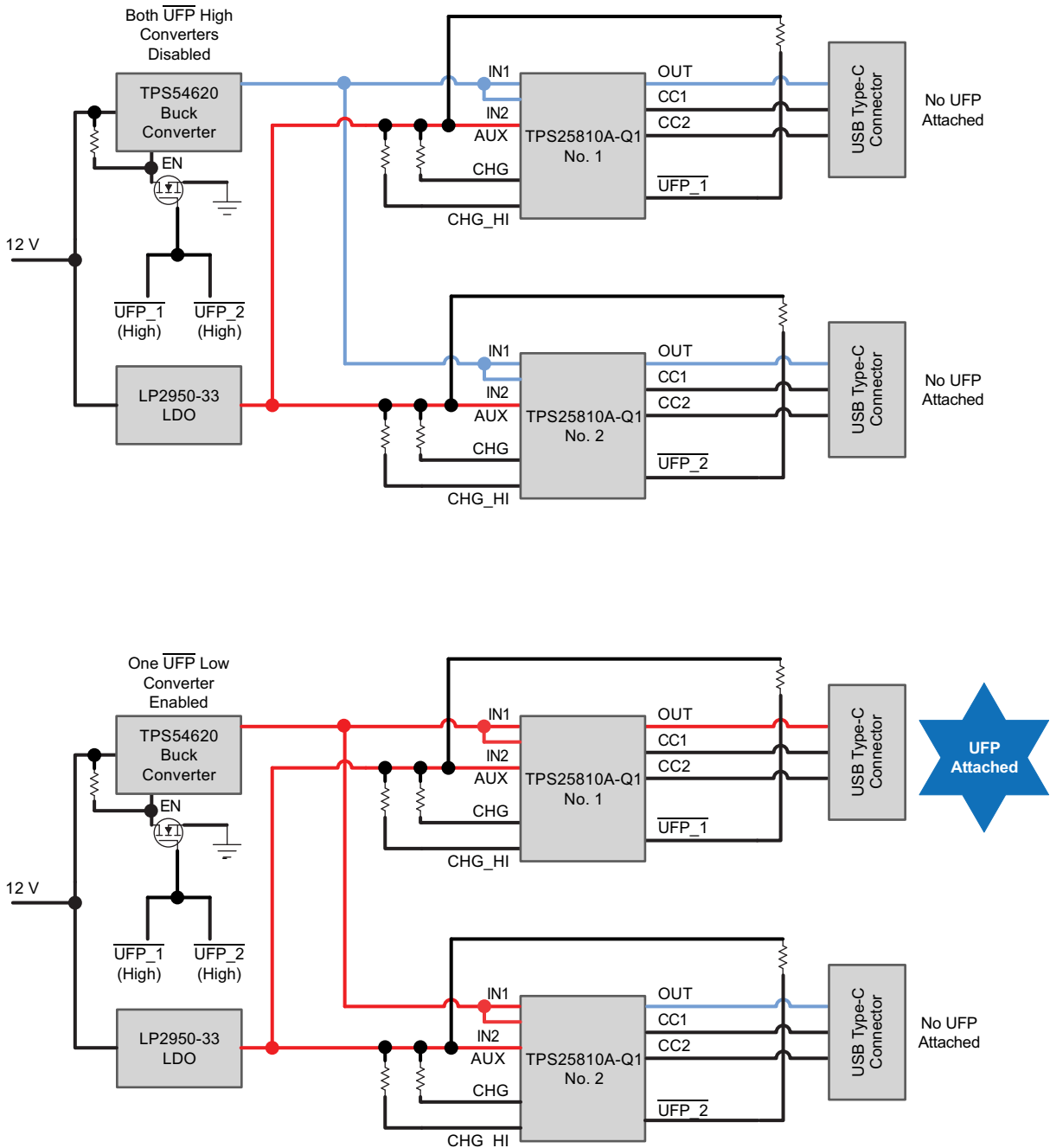
$$\Delta V = \left( \frac{5V_{OUT}}{V_{FB}} - \frac{R_1}{R_3} \right) \frac{R_1 \times V_{FB}}{R_4} \quad (3)$$

If R<sub>1</sub> is less than R<sub>3</sub>, then Equation 3 can be simplified as Equation 4.

$$\Delta V \approx \frac{5V_{OUT} \times R_1}{R_4} \quad (4)$$

### 8.3.3.10 Power Wake

The power-wake feature offers the mobile-systems designer a way to save on system power when no UFP is attached to the Type-C port. See Figure 18. To enable power wake, the UFP pins from any combination of two TPS25810A-Q1 devices are tied together (each with its own 100-kΩ pullup) to the enable pin of a 5-V, 6-A dc-dc buck converter. When no UFP is detected on both Type-C ports, the EN pin of the dc-dc converter is pulled high, thereby disabling it. Because the TPS25810A-Q1 device is powered by an always-on 3.3-V LDO, turning off the supply to IN1 and IN2 does not affect its operation in the detach state. Anytime a UFP is detected on either port, the corresponding UFP pin is pulled low, enabling the dc-dc converter to provide charging current to the attached UFP. Turning off the high-power dc-dc converter when ports are unattached saves on system power. This method can save a significant amount of power, because the TPS25810A-Q1 device requires only 0.7 μA (typical) via the AUX pin when no UFP device is connected.



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Figure 18. Power-Wake Implementation

### 8.4 Device Functional Modes

The TPS25810A-Q1 device is a Type-C controller with integrated power switches that supports all Type-C functions in a downstream facing port. The device manages current advertisement and protection for a connected UFP and active cable. Each device starts its operation by monitoring the AUX bus. When  $V_{AUX}$  exceeds the undervoltage-lockout threshold, the device samples the EN pin. A high level on this pin enables the device, and normal operation begins. Having successfully completed its start-up sequence, the device now

## Device Functional Modes (continued)

actively monitors its CC1 and CC2 pins for attachment to a UFP. When a UFP is detected on either the CC1 or CC2 pin, the internal MOSFET starts to turn on after the required deglitch time is met. The internal MOSFET starts conducting and allows current to flow from IN1 to OUT. If Ra is detected on the other CC pin (not connected to the UFP),  $V_{\text{CONN}}$  is applied to allow current to flow from IN2 to the CC pin connected to Ra. For a complete listing of various device operational modes, see [Table 2](#).

## 9 Application and Implementation

### NOTE

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. Customers should validate and test their design implementation to confirm system functionality.

### 9.1 Application Information

The TPS25810A-Q1 device is a Type-C DFP controller that supports all Type-C DFP required functions. It applies power to  $V_{BUS}$  when a UFP attach is detected and removes power when it detects the UFP is detached. The device exposes its identity via its CC pin, advertising its current capability based on the CHG and CHG\_HI pin settings. The TPS25810A-Q1 device also limits its advertised current internally and provides robust protection to a fault on the system  $V_{BUS}$  power rail.

After a connection is established, either device is capable of providing  $V_{CONN}$  to power circuits in the cable plug on the CC pin that is not connected to the CC wire in the cable.  $V_{CONN}$  is internally current-limited and has its own supply pin, IN2. Apart from providing charging current to a UFP, the TPS25810A-Q1 device also supports audio and debug accessory modes.

The following design procedure can be used to implement a full-featured Type-C DFP.

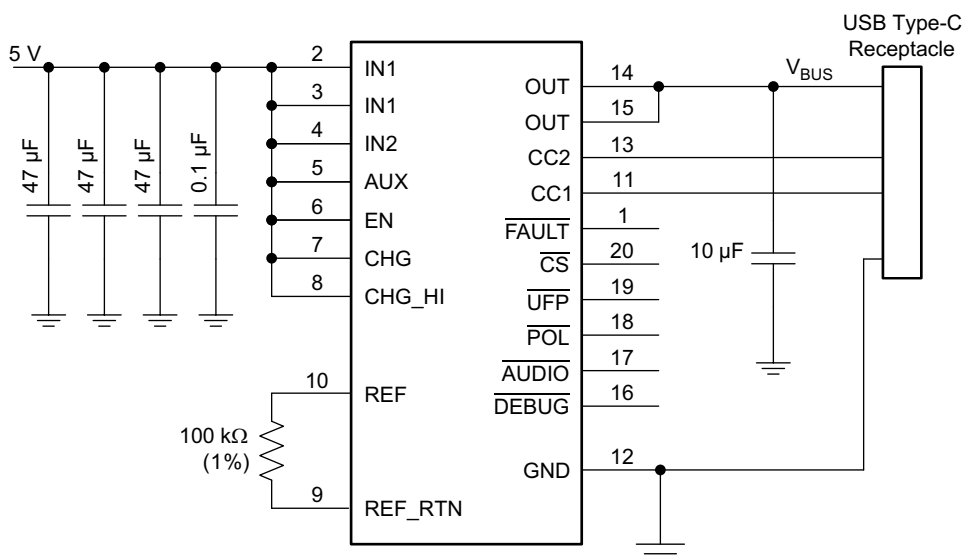
### NOTE

BC 1.2 is not supported in the TPS25810A-Q1 device. To support BC 1.2 with Type-C charging modes in a single Type-C connector, a dedicated charging port (DCP) controller something like a TPS2514A-Q1 device must be used.

### 9.2 Typical Applications

#### 9.2.1 Type-C DFP Port Implementation Without BC 1.2 Support

Figure 19 shows a minimal Type-C DFP implementation capable of supporting 5-V and 3-A charging.



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Figure 19. Type-C DFP Port Implementation Without BC 1.2 Support

## Typical Applications (continued)

### 9.2.1.1 Design Requirements

#### 9.2.1.1.1 Input and Output Capacitance

Input and output capacitance improves the performance of the device. The actual capacitance should be optimized for the particular application. For all applications, a 0.1- $\mu\text{F}$  or greater ceramic bypass capacitor between INx and GND is recommended as close to the device as possible for local noise decoupling.

All protection circuits, including those of the TPS25810A-Q1 device, have the potential for input voltage overshoots and output voltage undershoots. Input voltage overshoots can be caused by either of two effects. The first cause is an abrupt application of input voltage in conjunction with input power-bus inductance and input capacitance when the INx pin is high-impedance (before turnon). Theoretically, the peak voltage is 2 times the applied voltage. The second cause is due to the abrupt reduction of output short-circuit current when the device turns off and energy stored in the input inductance drives the input voltage high. Input voltage droops may also occur with large load steps and as the output is shorted. Applications with large input inductance (for instance, connecting the evaluation board to the bench power supply through long cables) may require large input capacitance to prevent the voltage overshoot from exceeding the absolute maximum voltage of the device.

The fast current-limit speed of the TPS25810A-Q1 device to hard output short circuits isolates the input bus from faults. However, ceramic input capacitance in the range of 1  $\mu\text{F}$  to 22  $\mu\text{F}$  adjacent to the input aids in both response time and limiting the transient seen on the input power bus. Momentary input transients to 6.5 V are permitted. Output voltage undershoot is caused by the inductance of the output power bus just after a short has occurred and the device has abruptly reduced the OUT current. Energy stored in the inductance drives the OUT voltage down, and potentially negative, as it discharges. An application with large output inductance (such as from a cable) benefits from the use of a high-value output capacitor to control voltage undershoot.

When implementing a USB-standard application, 120- $\mu\text{F}$  minimum output capacitance is required. Typically, a 150- $\mu\text{F}$  electrolytic capacitor is used, which is sufficient to control voltage undershoots. Because in Type-C applications, DFP is a cold socket when no UFP is attached, the output capacitance should be placed at the INx pin versus the OUT pin, as is done in USB Type-A ports. It is also recommended to put a 10- $\mu\text{F}$  ceramic capacitor on the OUT pin for better voltage bypass.

#### 9.2.1.2 Detailed Design Procedure

The TPS25810A-Q1 device supports up to three different input voltages, based on the application. In the simplest implementation, all input pins are tied to a single voltage source set to 5 V, as shown in [Figure 19](#). However, it is recommended to set a slightly higher (100 mV to 200 mV) input voltage, when possible, to compensate for IR loss from the source to the Type-C connector.

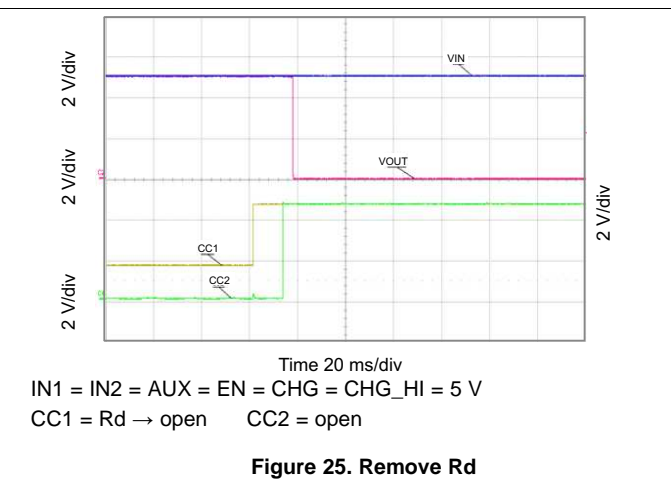
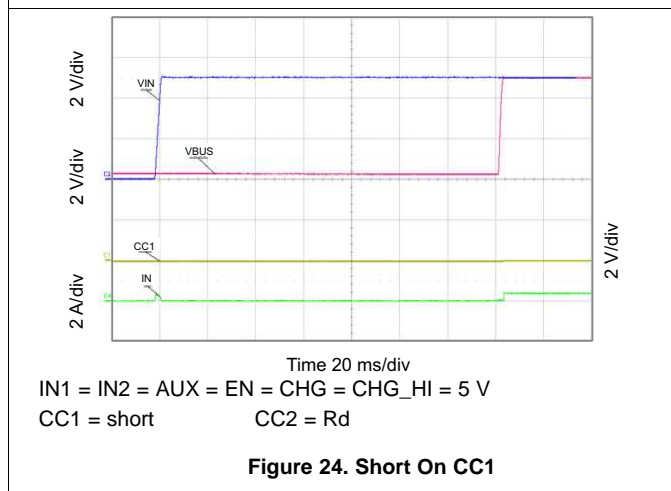
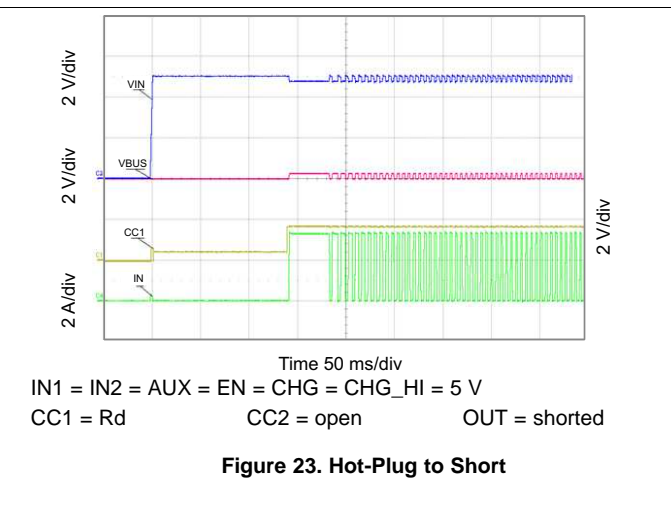
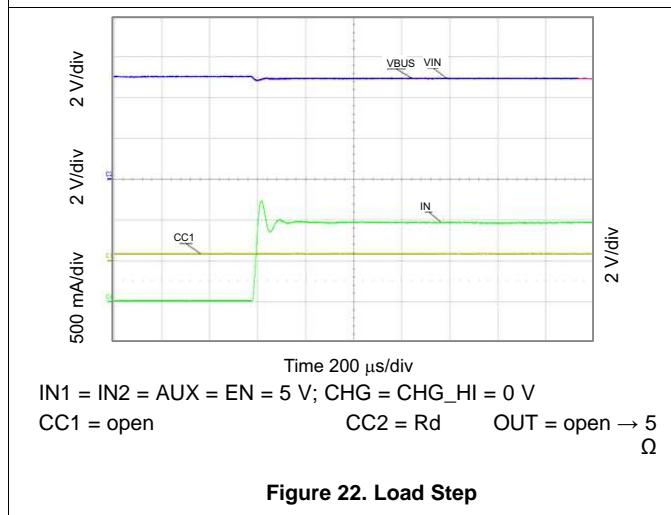
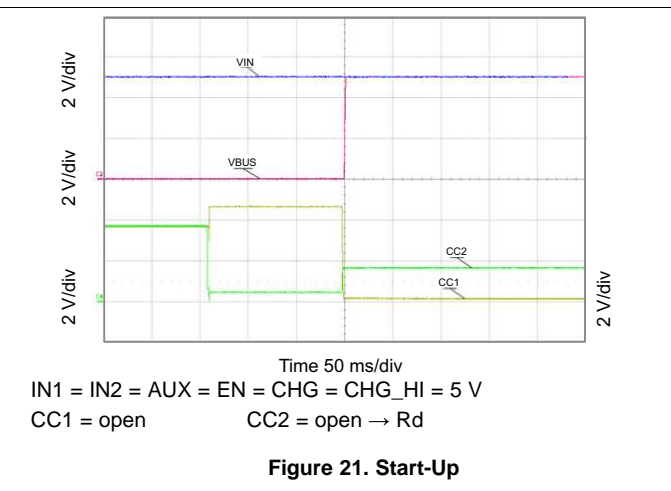
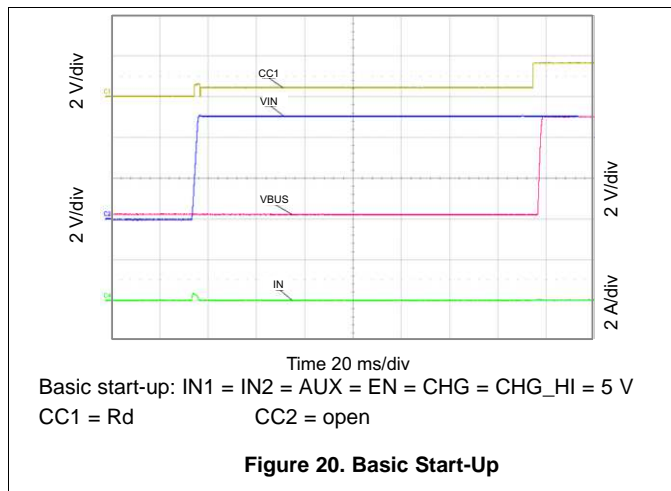
Other design considerations are listed as follows:

- Place at least 120  $\mu\text{F}$  of bypass capacitance close to the INx pins rather than the OUT pin, as Type-C is a cold-socket connector.
- A 10- $\mu\text{F}$  bypass capacitor is recommended to be placed near a Type-C receptacle  $V_{\text{BUS}}$  pin to handle load transients.
- Depending on the maximum current-level advertisement supported by the Type-C port in the system, set the CHG and CHG\_HI levels accordingly. Advertisement of 3 A is shown in [Figure 19](#).
- The EN, CHG, and CHG\_HI pins can be tied directly to GND or  $V_{\text{AUX}}$  without a pullup resistor.
  - CHG and CHG\_HI can also be dynamically controlled by a microcontroller to change the current advertisement level to the UFP.
- When an open-drain output of the TPS25810A-Q1 device is not used, it can be left open or tied to GND.
- Use a 1% 100-k $\Omega$  resistor to connect between the REF and REF\_RTN pins, placing it close to the device pin and keeping it isolated from switching noise on the board.

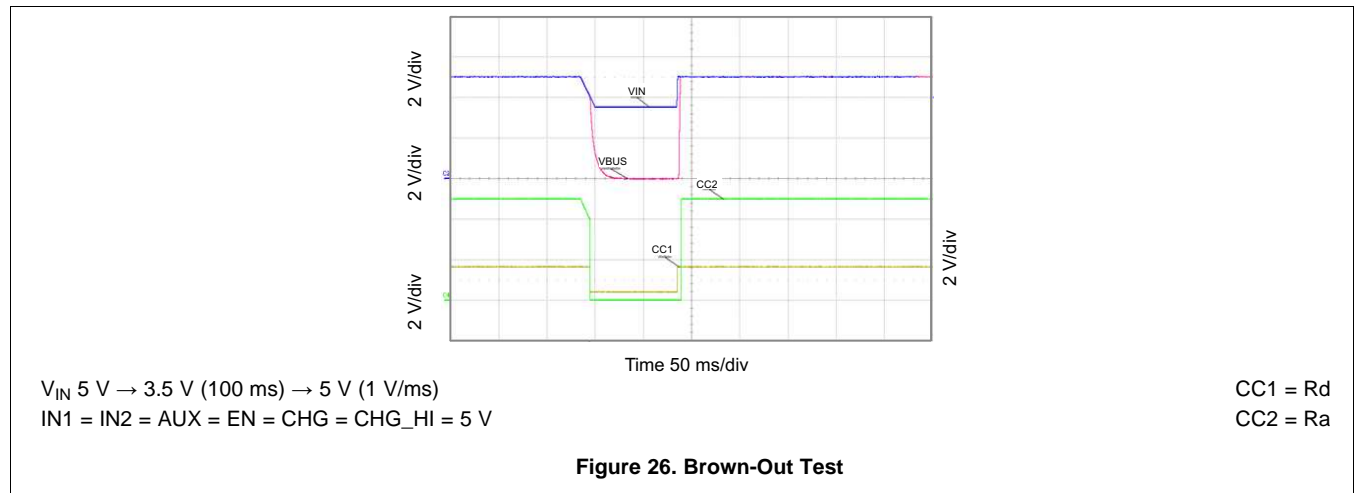


Typical Applications (continued)

9.2.1.3 Application Curves



**Typical Applications (continued)**

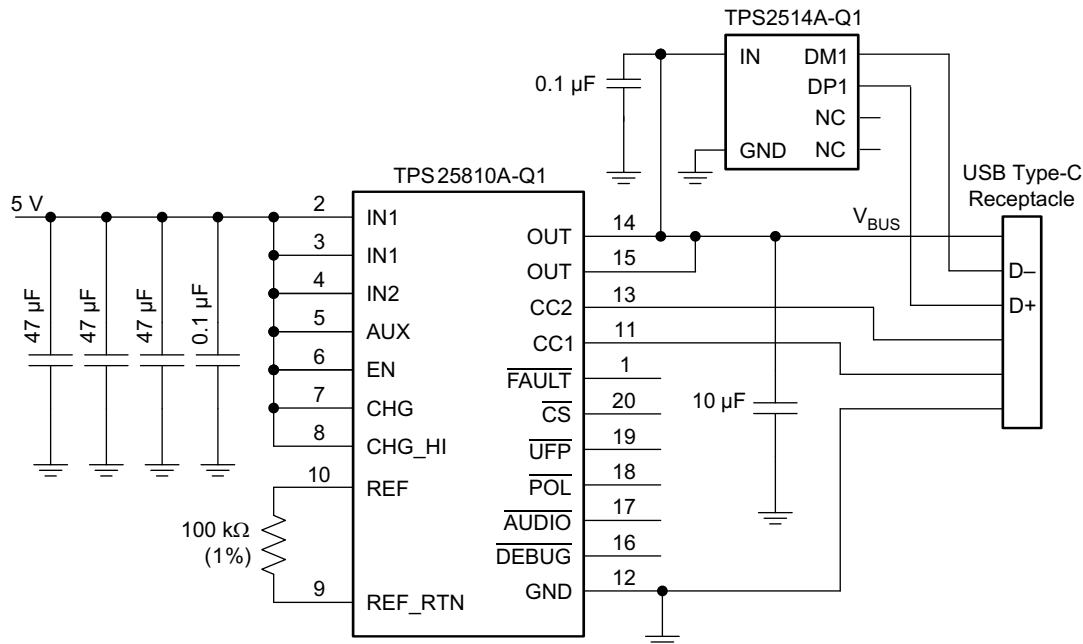


## Typical Applications (continued)

### 9.2.2 Type-C DFP Port Implementation With BC 1.2 (DCP Mode) Support

Figure 27 shows a Type-C DFP implementation capable of supporting 5-V, 3-A charging in a Type-C port that is also able to support charging of legacy devices when used with a Type-C  $\mu$ B cable assembly for charging phones and handheld devices equipped with a  $\mu$ B connector.

This implementation requires the use of a TPS2514A-Q1 device, a USB dedicated charging-port (DCP) controller with auto-detect feature to charge not only BC 1.2-compliant handheld devices but also popular phones and tablets that incorporate their own propriety charging algorithm. See [TPS2513A-Q1](#), [TPS2514A-Q1 USB Dedicated Charging Port Controller](#) for more details.



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Figure 27. Type-C DFP Port Implementation With BC 1.2 (DCP Mode) Support

#### 9.2.2.1 Design Requirements

See [Design Requirements](#) for the design requirements.

#### 9.2.2.2 Detailed Design Procedure

See [Detailed Design Procedure](#) for the detailed design procedure.

#### 9.2.2.3 Application Curves

See [Application Curves](#) for the application curves.

## 10 Power Supply Recommendations

The device has three power supply inputs. IN1, which is directly connected to OUT via the power MOSFET, is tied to the  $V_{BUS}$  pin in the Type-C receptacle. IN2 has a current-limiting switch and is multiplexed either to the CC1 or CC2 pin in the Type-C receptacle, depending on cable plug polarity. AUX is the device supply. In most applications, all three supplies are tied together. In a special implementation like power wake, IN1 and IN2 are tied to a single supply, whereas AUX is powered by a supply that is always ON and can be as low as 2.9 V.

USB Specification Revisions 2.0 and 3.1 require  $V_{BUS}$  voltage at the connector to be between 4.75 V and 5.5 V. Depending on layout and routing from the supply to the connector, the voltage drop on  $V_{BUS}$  must be tightly controlled. Locate the input supply close to the device. For all applications, a 10- $\mu$ F or greater ceramic bypass capacitor between OUT and GND is recommended, located as close to the Type-C connector of the device as possible for local noise decoupling. The power supply should be rated higher than the current limit setting to avoid voltage droops during overcurrent and short-circuit conditions.

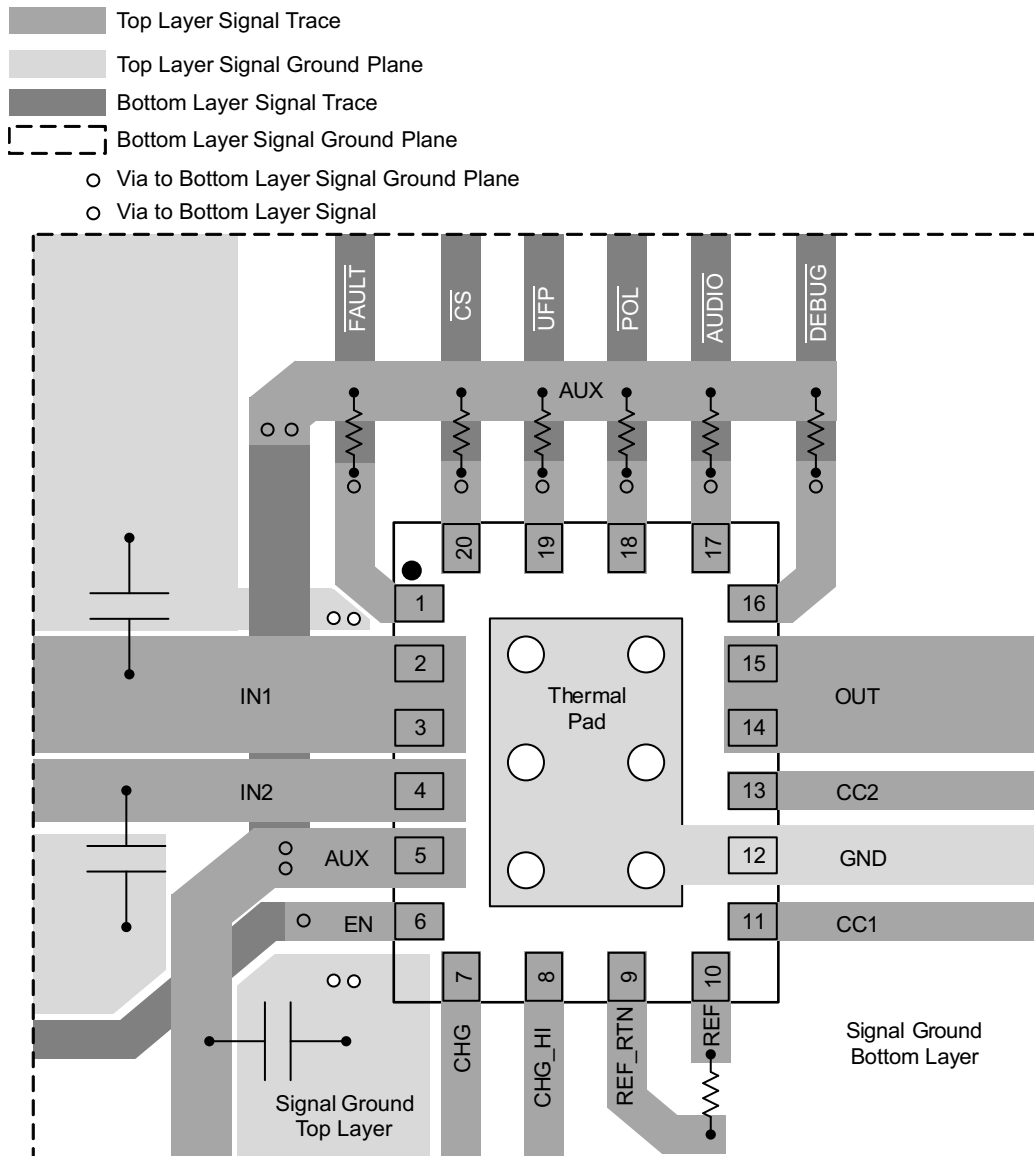
## 11 Layout

### 11.1 Layout Guidelines

Layout best practices as they apply to the TPS25810A-Q1 device are listed as follows.

- For all applications, a 10- $\mu$ F ceramic capacitor is recommended near the Type-C receptacle and another 120- $\mu$ F ceramic capacitor close to the IN1 pin.
  - The optimum placement of the 120- $\mu$ F capacitor is closest to the IN1 and GND pins of the device.
  - Care must be taken to minimize the loop area formed by the bypass capacitor connection, the IN1 pin, and the GND pin of the device. See [Figure 28](#) for a PCB layout example.
- High-current-carrying power-path connections to the device should be as short as possible and should be sized to carry at least twice the full-load current.
  - Have the input and output traces as short as possible. The most common cause of voltage loss failure in USB power delivery is the resistance associated with the  $V_{BUS}$  trace. Trace length, maximum current being supplied for normal operation, and total resistance associated with the  $V_{BUS}$  trace must be taken into account while budgeting for voltage loss.
  - For example, a power-carrying trace that supplies 3 A, at a distance of 20 inches, 0.1-in. wide, with 2-oz. copper on the outer layer has a total resistance of approximately 0.046  $\Omega$  and voltage loss of 0.14 V. The same trace at 0.05 in. wide has a total resistance of approximately 0.09  $\Omega$  and voltage loss of 0.28 V.
  - Make power traces as wide as possible.
- The resistor attached to the REF pin of the device has several requirements:
  - It is recommended to use a 1% 100-k $\Omega$  low-temperature-coefficient resistor.
  - It should be connected to the REF and REF\_RTN pins (pins 9 and pin 10, respectively).
  - The REF\_RTN pin should be isolated from the GND plane. See [Figure 28](#).
  - The trace routing between the REF and REF\_RTN pins of the device should be as short as possible to reduce parasitic effects on current-limit and current-advertisement accuracy. These traces should not have any coupling to switching signals on the board.
- Locate all TPS25810A-Q1 pullup resistors for open-drain outputs close to their connection pin. Pullup resistors should be 100 k $\Omega$ .
  - When a particular open-drain output is not used or needed in the system, leave the associated pin open or tied to GND.
- Keep the CC lines close to the same length.
- Thermal considerations:
  - When properly mounted, the thermal-pad package provides significantly greater cooling ability than an ordinary package. To operate at rated power, the thermal pad must be soldered to the board GND plane directly under the device. The thermal pad is at GND potential and can be connected using multiple vias to inner-layer GND. Other planes, such as the bottom side of the circuit board, can be used to increase heat sinking in higher-current applications. See [PowerPad™ Thermally Enhanced Package](#) and [PowerPAD™ Made Easy](#) for more information on using this thermal pad package.
  - Obtaining acceptable performance with alternate layout schemes is possible; however, the layout example in the following section has been shown to produce good results and is intended as a guideline.
- ESD considerations:
  - The TPS25810A-Q1 device has built-in ESD protection for CC1 and CC2. Keep trace length to a minimum from the Type-C receptacle to the TPS25810A-Q1 device on CC1 and CC2.
  - A 10- $\mu$ F output capacitor should be placed near the Type-C receptacle.
  - See the [TPS25810EVM-745](#) evaluation module for an example of a double-layer board that passes IEC61000-4-2 testing.
  - Do not create stubs or test points on the CC lines. Keep the traces short if possible, and use minimal vias along the traces [1–2 inches (2.54 cm–5.08 cm) or less].
  - See [ESD Protection Layout Guide](#) for additional information.
  - Have a dedicated ground plane layer, if possible, to avoid differential voltage buildup.

### 11.2 Layout Example



**Figure 28. Layout Example**

## 12 Device and Documentation Support

### 12.1 Device Support

#### 12.1.1 Third-Party Products Disclaimer

TI'S PUBLICATION OF INFORMATION REGARDING THIRD-PARTY PRODUCTS OR SERVICES DOES NOT CONSTITUTE AN ENDORSEMENT REGARDING THE SUITABILITY OF SUCH PRODUCTS OR SERVICES OR A WARRANTY, REPRESENTATION OR ENDORSEMENT OF SUCH PRODUCTS OR SERVICES, EITHER ALONE OR IN COMBINATION WITH ANY TI PRODUCT OR SERVICE.

### 12.2 Documentation Support

#### 12.2.1 Related Documentation

[PowerPad™ Thermally Enhanced Package](#)

[PowerPAD™ Made Easy](#)

[TPS25810EVM-745 User's Guide](#)

[Protecting the TPS25810 from High Voltage DFPs](#)

#### 12.2.2 Related Links

The following table lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to order now.

### 12.3 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

### 12.4 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

**TI E2E™ Online Community** *TI's Engineer-to-Engineer (E2E) Community*. Created to foster collaboration among engineers. At [e2e.ti.com](http://e2e.ti.com), you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

**Design Support** *TI's Design Support* Quickly find helpful E2E forums along with design support tools and contact information for technical support.

### 12.5 Trademarks

E2E is a trademark of Texas Instruments.

USB Type-C is a trademark of USB Implementers Forum, Inc..

All other trademarks are the property of their respective owners.

### 12.6 Electrostatic Discharge Caution



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

### 12.7 Glossary

[SLYZ022](#) — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

### 13 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 without revision of this document. For browser-based versions of this data sheet, see the left-hand navigation pane.



**PACKAGING INFORMATION**

| Orderable Device  | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2) | Lead finish/<br>Ball material<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples |
|-------------------|---------------|--------------|--------------------|------|----------------|-----------------|--------------------------------------|----------------------|--------------|-------------------------|---------|
| TPS25810ATWRVCRQ1 | ACTIVE        | WQFN         | RVC                | 20   | 3000           | RoHS & Green    | SN                                   | Level-2-260C-1 YEAR  | -40 to 125   | 25810AQ                 | Samples |

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSOLETE:** TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(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.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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## TAPE AND REEL INFORMATION



### QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



\*All dimensions are nominal

| Device            | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|-------------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TPS25810ATWRVCRQ1 | WQFN         | RVC             | 20   | 3000 | 330.0              | 12.4               | 3.3     | 4.3     | 1.1     | 8.0     | 12.0   | Q1            |

TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

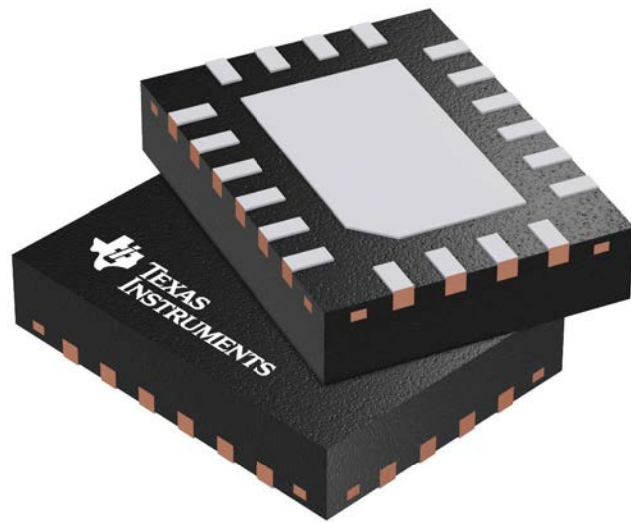
| Device            | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|-------------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TPS25810ATWRVCRQ1 | WQFN         | RVC             | 20   | 3000 | 367.0       | 367.0      | 38.0        |

## GENERIC PACKAGE VIEW

RVC 20

WQFN - 0.8 mm max height

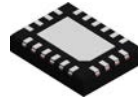
PLASTIC QUAD FLATPACK - NO LEAD



Images above are just a representation of the package family, actual package may vary.  
Refer to the product data sheet for package details.

4209819/B

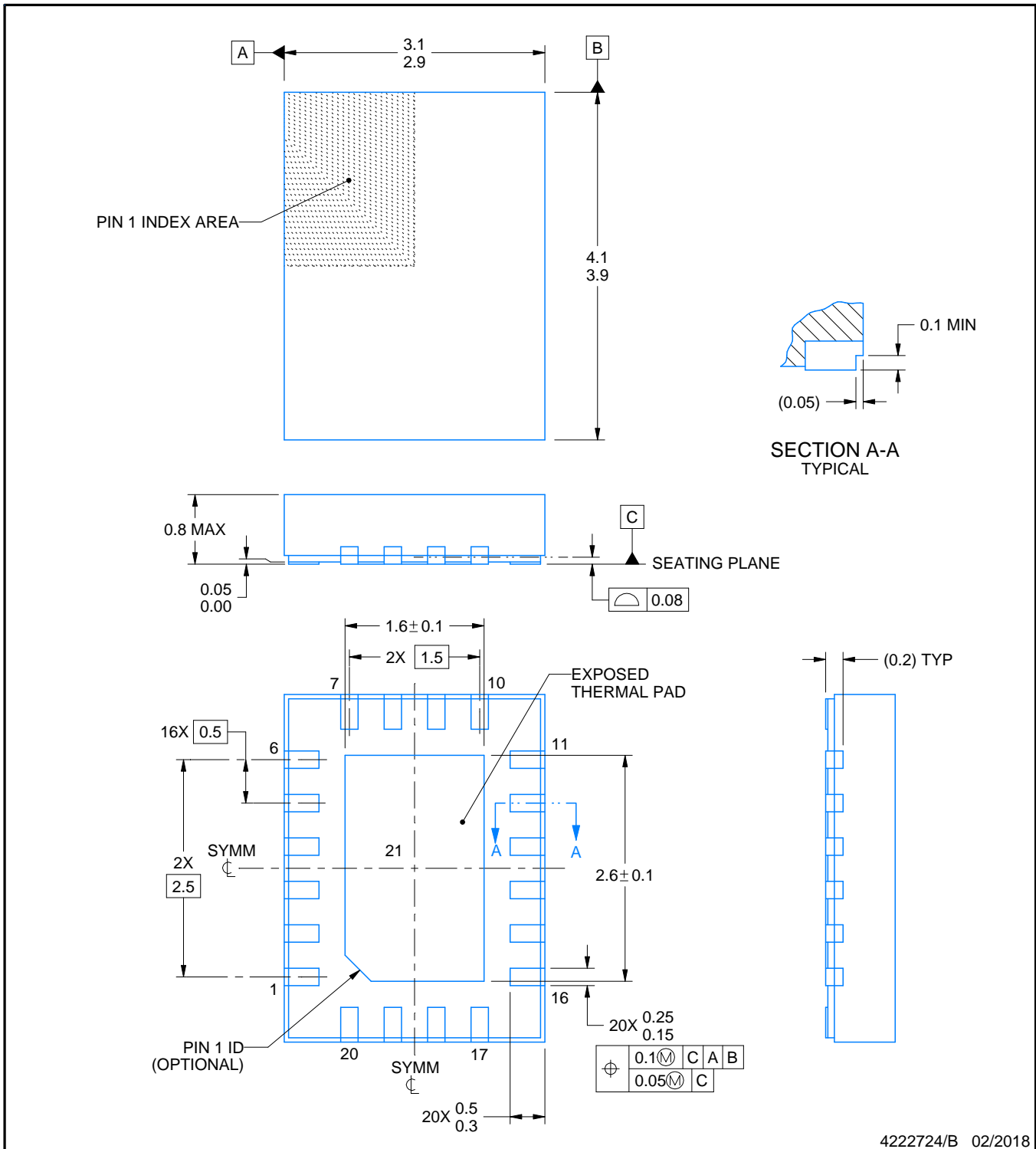
# RVC0020B



# PACKAGE OUTLINE

## WQFN - 0.8 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



**NOTES:**

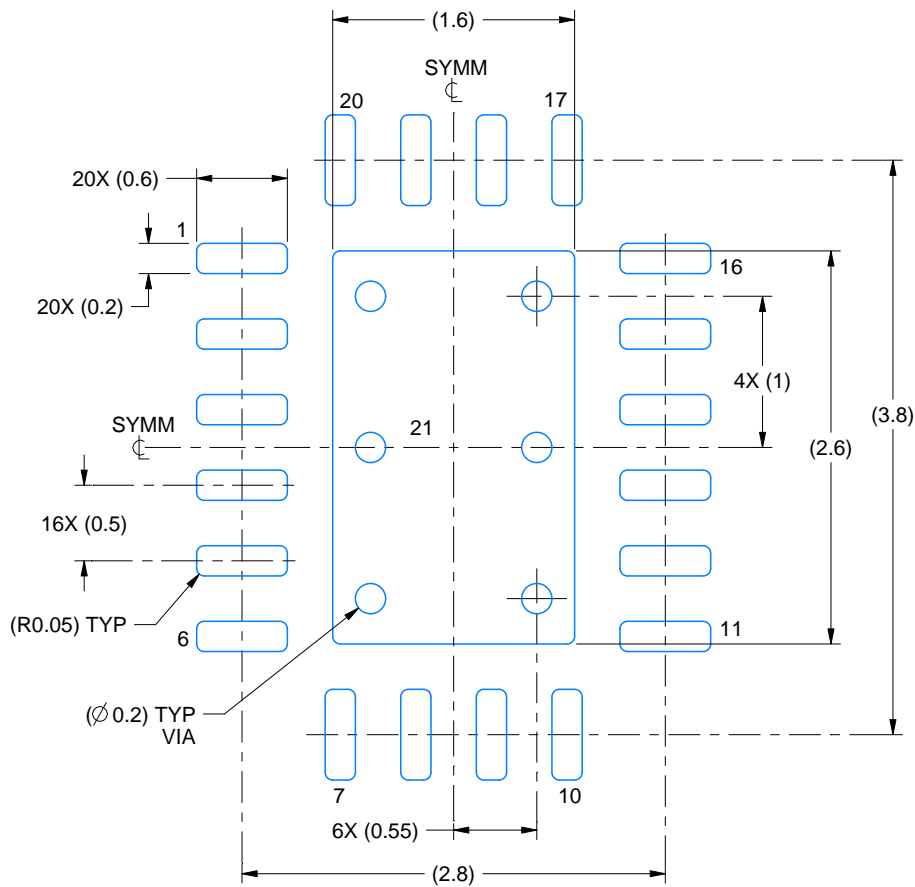
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

# EXAMPLE BOARD LAYOUT

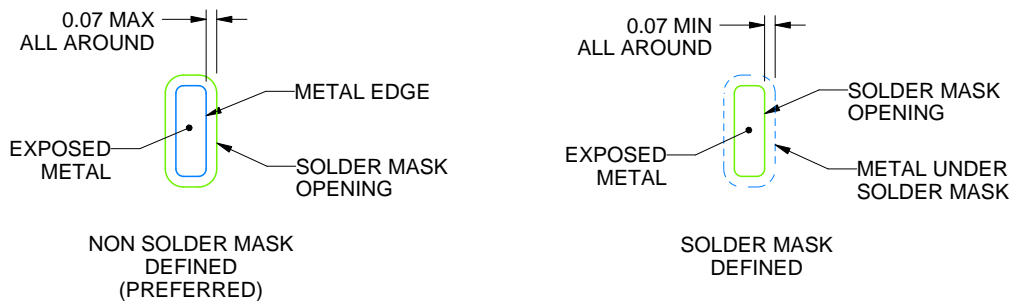
RVC0020B

WQFN - 0.8 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:20X



SOLDER MASK DETAILS

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NOTES: (continued)

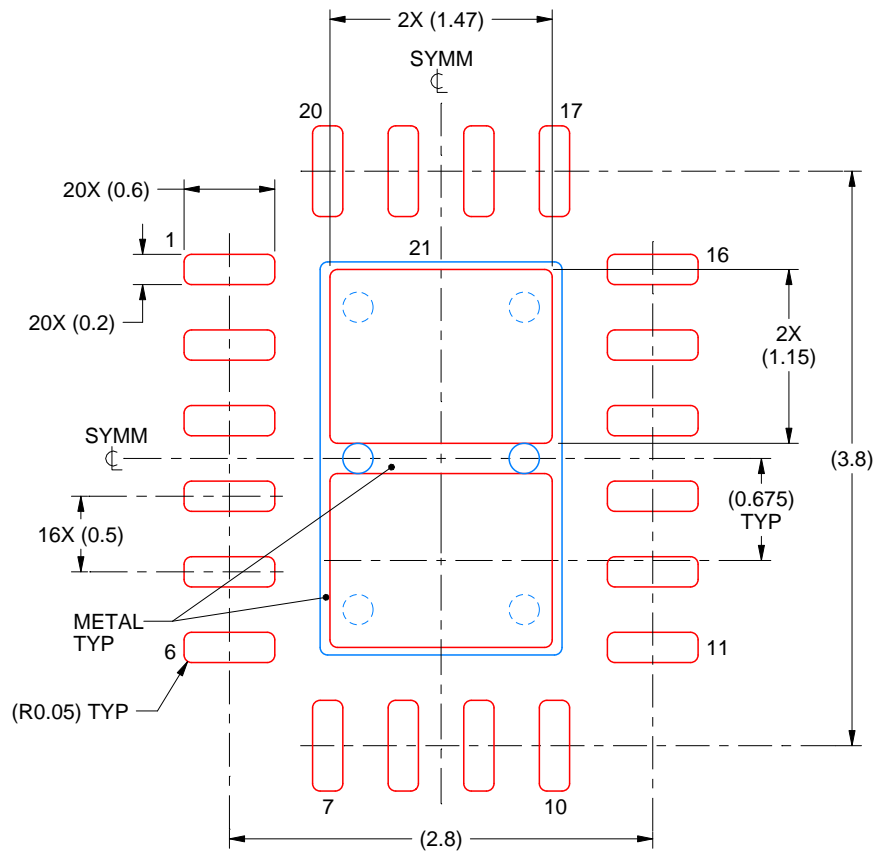
4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/slua271](http://www.ti.com/lit/slua271)).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

# EXAMPLE STENCIL DESIGN

RVC0020B

WQFN - 0.8 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



**SOLDER PASTE EXAMPLE**  
BASED ON 0.1 mm THICK STENCIL

EXPOSED PAD  
81.3% PRINTED SOLDER COVERAGE BY AREA  
SCALE:20X

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NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

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