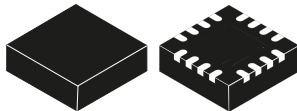


Standalone USB PD controller with integrated CC/CV for AC/DC applications



QFN16 (3x3 mm)

Features

- Type-C and USB PD controller (with autorun)
- Provider role - up to 5 PDO profiles
- Programmable VBUS voltage and current protections
- High-side current sensing
- Integrated CC/CV regulation
- 50 mA V_{CONN} switch (OVP and OCP)
- E-marked cable support for 100 W applications
- Ambient temperature adaptive power and overtemperature protection
- Data role and V_{CONN} swap answer support
- Factory mode configuration over CC pin
- Integrated V_{BUS} discharge control path
- Integrated V_{BUS} switches gate driver (PMOS)
- Short-to- V_{BUS} protections
- $V_{DD} = [4.1 \text{ V}; 22 \text{ V}] - \text{AMR} = 28 \text{ V}$
- Temperature range: $-40 \text{ }^\circ\text{C}$ up to $105 \text{ }^\circ\text{C}$
- ESD = 1.5 kV CDM / 4 kV HBM
- Certified according to:
 - USB Power Delivery specifications (rev 3.0)
 - USB type-C™ (rev 1.4)
 - TID: 2070

Applications

- AC adapters and power supplies for computer, consumer, portable consumer and industrial applications
- Smart plugs and wall adapters

Description

The **STUSB4761** addresses USB type-C and Power Delivery provider devices. Thanks to default parameters stored in an internal non-volatile-memory, the **STUSB4761** implements up to 5 PDOs in order to negotiate autonomously a Power Delivery contract with a sink without any internal or external software (autorun mode). A CC/CV regulation loop allows a fully regulated power management unit (AC/DC) to be implemented with a minimum BOM cost.

| Product status link | |
|---------------------|--|
| STUSB4761 | |
| Product summary | |
| Order code | STUSB4761QTR |
| Description | Standalone USB PD controller (source, autorun) |
| Package | QFN16 (3x3 mm) |
| Marking | 4761 |

1 Functional description

The STUSB4761 is a USB type-C and Power Delivery controller IC optimized for source applications. It integrates a CC/CV regulation loop to drive a power regulation stage.

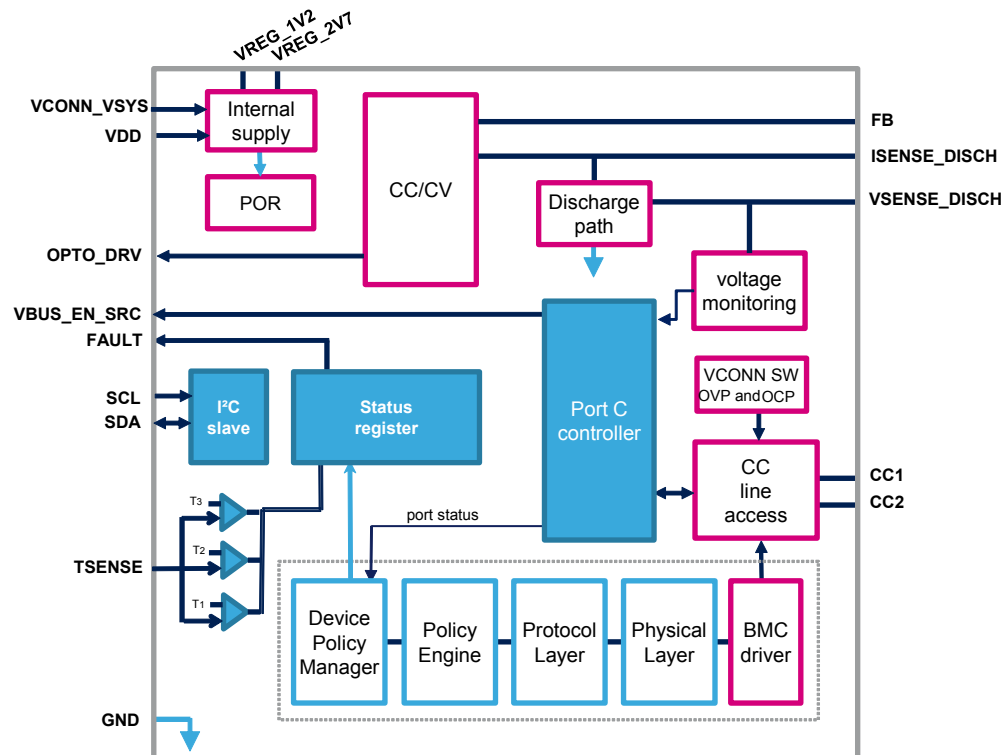
The STUSB4761 offers the benefits of a full hardware USB PD stack allowing a robust, deterministic and safe negotiation in line with USB PD standard. It is ideal for provider applications in which digital or software intelligence is limited or missing.

The STUSB4761 main functions are:

1. Detecting the connection between two ports (attach detection)
2. Establishing a valid source-to-sink connection
3. Determining the attached device mode: sink or accessory
4. Checking cable power capabilities
5. Negotiating a USB PD contract with a PD capable device
6. Configuring the output power path accordingly
7. Regulating voltage and current according to PD contract
8. Monitoring V_{BUS} , managing transitions, handling protections and ensuring user and device safety

In addition, the STUSB4761 offers customizable power data objects (PDO), V_{BUS} under/overvoltage (UVLO / OVLO) protections, an integrated discharge path.

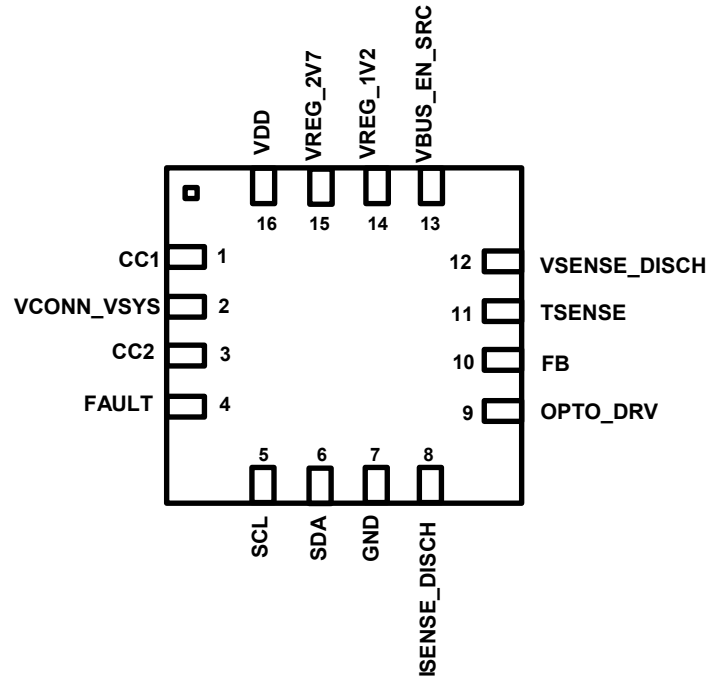
Figure 1. Block diagram



2 Inputs / Outputs

2.1 Pinout

Figure 2. QFN16 (3x3 mm) pinout (top view)



2.2 Pin list

Table 1. Pin function list

| Pin | Name | Type | Description | Typical connection |
|-----|--------------|----------------|---|---|
| 1 | CC1 | 20 V analog IO | Type-C configuration channel 1 | To Type-C receptacle A5 |
| 2 | VCONN_VSYS | PWR | 5 V supply input for active plug | 1 μ F typ. protection capacitor |
| 3 | CC2 | 20 V analog IO | Type-C configuration channel 2 | To Type-C receptacle B5 |
| 4 | FAULT | OD | FAULT flag | To user interface LED |
| 5 | SCL | DI | I ² C clock input | To I ² C master - ext. pull-up |
| 6 | SDA | DI/OD | I ² C data input/output – active low open drain | To I ² C master - ext. pull-up |
| 7 | GND | PWR | Ground | Ground |
| 8 | ISENSE_DISCH | 20 V analog IO | Current sensing and discharge path | From V _{SRC} (system side) |
| 9 | OPTO_DRV | 20 V analog IO | Optocoupler driver | To NMOS gate |
| 10 | FB | Analog IO | Voltage / current regulation feedback input | To compensation network |
| 11 | TSENSE | Analog IO | Temperature sensing input | From NTC |
| 12 | VSENSE_DISCH | 20 V analog IO | V _{BUS} voltage monitoring and discharge path | From V _{BUS} |
| 13 | VBUS_EN_SRC | 20 V analog IO | V _{BUS} source power path enable – active low open drain | To switch pull-up |
| 14 | VREG_1V2 | PWR | 1.2 V internal regulator output | 1 μ F typ. decoupling capacitor |
| 15 | VREG_2V7 | PWR | 2.7 V internal regulator output | 1 μ F typ. decoupling capacitor |
| 16 | VDD | 20V PWR | Main power supply (USB power line) | From V _{SRC} (system side) |

Table 2. Legend

| Type | Description |
|------|-------------------|
| DI | Digital input |
| AI | Analog input |
| IO | Bidirectional pad |
| OD | Open drain output |
| PWR | Power supply |
| GND | Ground |

2.3 Pin description

2.3.1 CC1 / CC2

CC1 and CC2 are the configuration channel pins used for connection and attachment detection, plug orientation determination and system configuration management across USB Type-C cable.

2.3.2 VCONN_VSYS

This power input is connected to a power source that can be a 5 V power supply or a lithium battery. It is used to provide power to the local plug. It is internally connected to power switches that are protected against short-circuit and overvoltage. This does not require any protection on the input side. When a valid source-to-sink connection is determined and the V_{CONN} power switches are enabled, V_{CONN} is provided by the source to the unused CC pin (see Section 3.2 VCONN supply) if power input is above 2.65 V. It is mandatory to supply this pin to allow overall power above 60 W or any power profile with current above 3 A.

2.3.3 FAULT

FAULT signal is asserted when T₃ temperature threshold is reached (see Section 3.4 Ambient temperature adaptive power and protection). FAULT signal is de-asserted when one of the below re-start conditions is met:

1. VDD goes below POR threshold
2. Temperature decreases below T₁

Note: this re-start condition is valid once. In case some errors occur again, condition 1 only becomes valid, allowing T₁ falling threshold output condition to be cleared/enabled again.

2.3.4 I²C interface

An IC interface can be used for non-volatile-memory customization (see Section 3.1 PDO customization)

Table 3. I²C interface pin list

| Name | Description |
|------|--|
| SCL | I ² C clock - need external pull-up |
| SDA | I ² C data - need external pull-up |

2.3.5 GND

Ground.

2.3.6 ISENSE_DISCH

Current sensing and VBUS discharge signal. The shunt resistor must be placed between VDD and ISENSE_DISCH for the correct current measurement. This pin is used to discharge high capacitive VBUS line (on system side). Discharge is enabled automatically during voltage down transitions, hard reset, error_recovery or cable disconnection.

2.3.7 FB

IC internal feedback loop compensation pin.

2.3.8 OPTO_DRV

Control signal used to drive the optocoupler.

2.3.9 TSENSE

Temperature sensing input pin. To be connected to an NTC.

If ambient temperature adaptive power and overtemperature protection is not used, connect 1 kΩ pull-up resistor to 1.2 V in order to disable temperature monitoring feature.

- 2.3.10 VSENSE_DISCH**
 This input pin is used to sense V_{BUS} presence, monitor V_{BUS} output voltage and V_{BUS} discharge on USB Type-C receptacle side.
- 2.3.11 VBUS_EN_SRC**
 This pin enables the outgoing V_{BUS} power when the connection to a sink is established and VDD is in the valid operating range. The open drain output allows a PMOS transistor to be driven directly.
- 2.3.12 VREG1V2**
 This pin is used only for external decoupling of 1.2 V internal regulator.
 Recommended decoupling capacitor: 1 μF typ. (0.5 μF min.; 10 μF max.).
- 2.3.13 VREG2V7**
 This pin is used only for external decoupling of 2.7 V internal regulator.
 Recommended decoupling capacitor: 1 μF typ. (0.5 μF min.; 10 μF max.).
- 2.3.14 VDD**
 This pin is the IC power supply and feedback loop input in CV mode.
 This pin assures that before applying V_{BUS} on type-C connector, voltage is in the range [3.9 V-6 V]. V_{BUS} path is not closed if VDD is not in this range at connection.

3 Features description

3.1 PDO customization

The STUSB4761 implements a default configuration (cf section §4) stored in a non-volatile-memory (NVM) and loaded at every power-ON. This configuration can be customized statically to align PD controller behavior according to final application requirements. Customization applies to various parameters such as: number of PDO, voltage, current, discharge time, protection thresholds, etc..

Parameter customization is possible:

- Either by I²C interface direct access
- Or by using specific commands packaged as ST proprietary unstructured VDM when the STUSB4761 is connected in debug accessory mode (OrientedDebug Accessory.SRC state)

This process is recommended during end product manufacturing or testing. Once parameters have been overridden in non-volatile-memory, it does not immediately apply. The STUSB4761 must be unpowered first and new settings will apply after a power-on reset.

3.2 VCONN supply

The STUSB4761 features a 50 mA V_{CONN} power switch with a fixed overcurrent protection (OCP) of 80 mA typical.

3.3 E-marked cable support

The STUSB4761 can check a type-C cable current capability and clamp to 3 A any PDO that is not compliant with the attached cable current ratings.

By default, passive cables support up to 3 A. If cable can support more than 3 A current, it must be marked electronically (EMCA = Electronically Marked Cables Assembly).

Therefore, the STUSB4761 communicates directly with a type-C e-marked cable. This check is performed after type-C attach and before starting a power negotiation. As a consequence, source power supply exposes any PDO above 3 A only if cable is identified as able to sustain such current, otherwise PDOs are automatically clamped to 3 A so that sink never receives erroneous information versus the application sustainability.

The device, which can sink up to 5 A from a capable source, would be notified 3 A max. in case the cable current capability is not identified properly or not in line with the source capability.

3.4 Ambient temperature adaptive power and protection

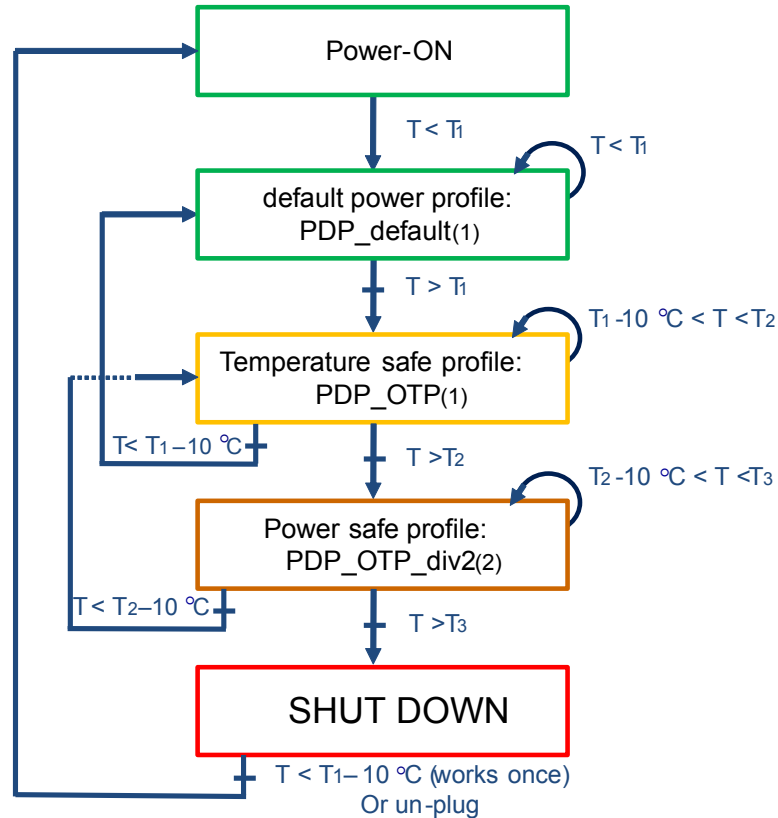
The STUSB4761 embeds the temperature measurement and protection mechanism, used to prevent from ambient overheating conditions. A dedicated pin (TSENSE) is used to sense PCB temperature measured by an external NTC.

The STUSB4761 adjusts its USB PD output power (PDP) depending on temperature.

The temperature protection mechanism has 3 different thresholds, which can be adjusted with an appropriate external resistor value (see [Section 5.4 Reference schematic \(full feature: up to 100 W, temperature adaptive power, LED\)](#)).

Table 4. Ambient temperature adaptive power and protection

| | Rising threshold | Hysteresis | Behavior | Re-start |
|-------|------------------------------|----------------------------|--|--|
| T_a | $< 70\text{ }^\circ\text{C}$ | | Default power profile (PDP_default) | |
| T_1 | $70\text{ }^\circ\text{C}$ | $10\text{ }^\circ\text{C}$ | Temperature safe profile (PDP_OTP) New PDO applied with same voltage but reduced current value. Customer or application dependent | New negotiation with PDP_OTP power profile |
| T_2 | $90\text{ }^\circ\text{C}$ | $10\text{ }^\circ\text{C}$ | Power safe profile (PDP_OTP_div2) For every PDO, the current of the previous profile (PDP_OTP) is divided by 2 | New negotiation with PDP_OTP_div2 power profile |
| T_3 | $110\text{ }^\circ\text{C}$ | $10\text{ }^\circ\text{C}$ | Alert Abort negotiation and disconnect. FAULT signal asserted | V_{BUS} switch open. The application does not re-start unless: 1. VDD goes below POR threshold 2. Temperature decreases below T_1 . In case same error occurs again, condition 1) becomes the only valid re-start condition |

Figure 3. OTP_FSM


3.5 Data role and V_{CONN} SWAP

The STUSB4761, as a source, can advertise itself as a data host or downstream facing port (DFP). In order to respond to unstructured message, the STUSB4761 supports incoming data role swap requests from the sink. When request is acknowledged (if DR_SW_EN = ON), the STUSB4761 becomes UFP.

In the same way, the STUSB4761 supports incoming V_{CONN} swap request from the sink. When the request is acknowledged, the port remains a source and the DFP/UFP roles remain unchanged.

3.6 Voltage and current regulation

3.6.1 Voltage regulation

Input voltage is sensed on VDD pin. Until a PD contract is negotiated, regulation is set to 5 V. In power delivery mode, the regulation aligns V_{BUS} value on negotiated voltage value. Voltage regulation accuracy is 3% worst case.

3.6.2 CC MODE

V_{BUS} current, used for regulation, is measured thanks to a 10 mOhms (default) shunt resistor between VDD and ISENSE_DISCH pins. In case the measured V_{BUS} current reaches the regulation threshold, the STUSB4761 enters constant current (CC) mode: voltage is decreased down to the undervoltage (UVLO) condition defined for the selected contract if current does not decrease enough, which triggers the voltage monitoring alert; in this case, the STUSB4761 goes to error-recovery (see [Section 3.8 Hardware fault management](#)).

PDO current can be adjusted from 300 mA up to 5 A.

- Below 1 A, current regulation is effective about 130 mA or 260 mA (adjustable OCP threshold) above the current set.
- Above 1 A, current regulation is effective when the measured current overcomes by either 12.5% or 25% (adjustable OCP threshold) the current regulation reference

When the STUSB4761 is attached in Type-C mode, current regulation threshold is set to the STUSB4761 R_p value: TYPEC_CURRENT (see [Section 4.1 Parameter overview](#)).

When the STUSB4761 is attached in USB PD mode, current regulation reference is set by default to the current value from the selected source PDO. Other configurations are possible as per table below:

Table 5. Reference regulation current

| | |
|------------------------------|--|
| 1 (DEFAULT) | Current from the STUSB4761 PDO selected by the sink: I_SRC_PDO[RDO object position field] |
| 2 | Operating current of sink request: RDO[operating current field] |
| 3 | Maximum operating current of sink request: RDO[max. operating current field] |

Table 6. OCP threshold

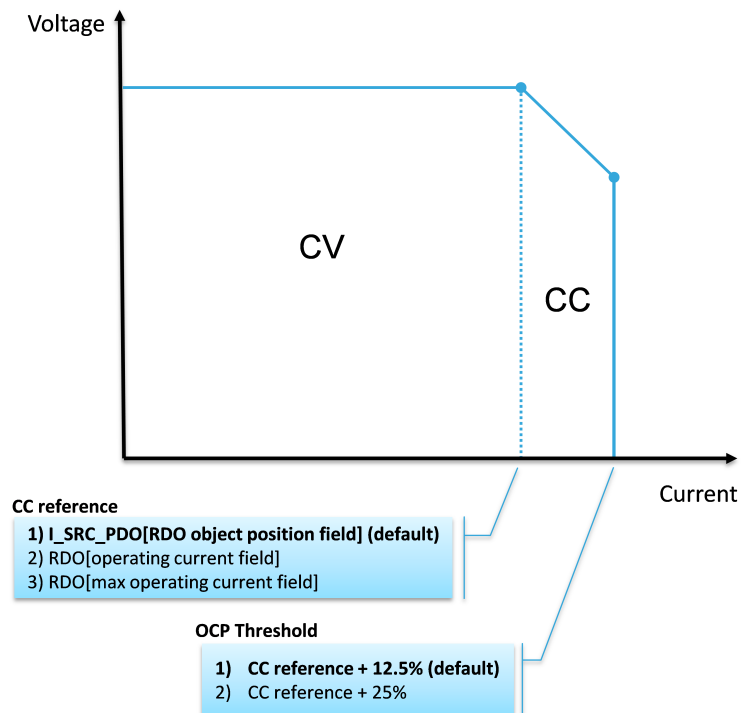
| | |
|------------------------------|---|
| 1 (DEFAULT) | 12.5% above reference regulation current ⁽¹⁾ |
| 2 | 25% above reference regulation current ⁽²⁾ |

1. If current > 1 A (otherwise +130 mA if current < 1 A)

2. If current > 1 A (otherwise +260 mA if current < 1 A)

In the other cases, the current regulation threshold is set to 300 mA:

- At Power-On reset exit
- When no sink device is attached

Figure 4. Current regulation

Table 7. Reference regulation current

| PDO voltage | Accuracy@ 27 °C | Typical temperature drift | |
|-------------|-------------------|---------------------------|-----------------|
| | | -40 °C to 27 °C | 27 °C to 105 °C |
| 5 | [-20 mA; +100 mA] | -80 mA | + 80 mA |
| 9 | [-10 mA; +130 mA] | | |
| 12 | [+20 mA; +160 mA] | | |
| 15 | [+40 mA; +180 mA] | | |
| 20 | [+80 mA; +220 mA] | | |

Table 8. Example

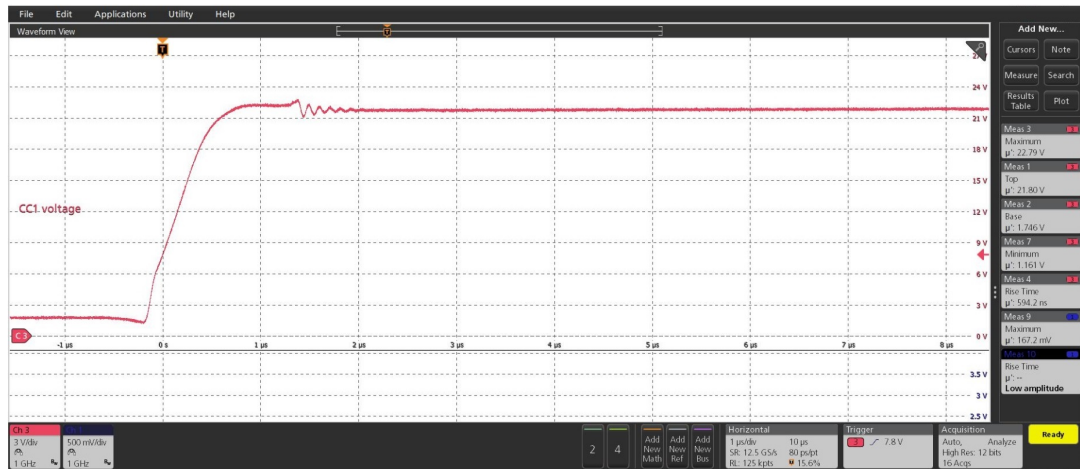
| PDO setting | OCP_Threshold setting | CC regulation window@ 27 °C | CC regulation window@ [-40 °C; 105 °C] |
|--------------|-----------------------|-----------------------------|--|
| 15 V; 0.75 A | 12.5% - +130 mA | [0.92 A; 1.06 A] | [0.84 A; 1.14 A] |
| | 25% - +260 mA | [1.05 A; 1.19 A] | [0.97 A; 1.27 A] |
| 15 V; 2 A | 12.5% | [2.29 A; 2.43 A] | [2.21 A; 2.51 A] |
| | 25% | [2.54 A; 2.68 A] | [2.46 A; 2.76 A] |

3.7 High voltage protection

The STUSB4761 can be safely used in systems or connected to systems that handle high voltage on the V_{BUS} power path. The device integrates an internal circuitry on the CC pins that tolerates high voltages and ensures protection up to 22 V in case of unexpected short-circuits with the V_{BUS}.

Short to 22 V is guaranteed as per figure below.

Figure 5. Short-to-VBUS



3.8 Hardware fault management

Table 9. Hardware fault management

| Parameter | Fault type | Behavior |
|-------------------------|---|--|
| Ambient temperature | Thermal protection | See Section 3.4 Ambient temperature adaptive power and protection |
| VDD | Overvoltage | Goes to ErrorRecovery (ER). |
| | Undervoltage | V _{BUS} path not asserted. Force detach (remove termination). Re-init connection |
| VBUS | Overvoltage | Goes to ErrorRecovery (ER). |
| | Undervoltage (3.125 ms blanking time) | De-assert V _{BUS} path. Force detach (remove termination). Re-init connection |
| | VBUS not valid during attach | |
| CC pin and VCONN switch | <ol style="list-style-type: none"> Short to V_{BUS} (up to 22 V) Overvoltage (6 V) Undervoltage (2.65 V) Reverse voltage Overcurrent (80 mA) Overheating ESD | <ol style="list-style-type: none"> Power switch opened. ErrorRecovery Power switch opened. ErrorRecovery Power switch opened Power switch opened Current limit Power switch opened. ErrorRecovery Discharge event |

3.9 Debug accessory detection

This mode is to be selected in order to access the STUSB4761 configuration via ST proprietary unstructured VDM (see Section 3.1 PDO customization).

4 User-defined start-up configuration

4.1 Parameter overview

The non-volatile-memory allows customer to customize the STUSB4761 default parameters. The default configuration can be overridden either through the I²C interface or via CC pin (see [Section 3.1 PDO customization](#)). The list of customizable parameters is described in the table below:

Table 10. Parameter overview

| Parameter | Description | Value | Comments |
|--------------------|---|------------------------------------|--|
| TYPEC_CURRENT (Rp) | Source current advertised on CC pin | USB default | |
| | | 1.5 A | |
| | | 3 A | |
| SRC_PDO_NUMB | Number of PDO | From 2 to 5 | To be ranked by increasing voltage value |
| V_SRC_PDO(i) | Default voltage value for SRC_PDO(i) $1 \leq i \leq \text{SRC_PDO_NUMB}$ | 5 V | Fixed value for SRC_PDO1 |
| | | V_SRC_PDO_FLEX1 | Flexible voltage value to be assigned to any SRC_PDO: $5 \text{ V} < V_{\text{SRC_PDO}} \leq 20 \text{ V}$ by steps of 50 mV |
| | | V_SRC_PDO_FLEX2 | Flexible voltage value to be assigned to any SRC_PDO: $5 \text{ V} < V_{\text{SRC_PDO}} \leq 20 \text{ V}$ by steps of 50 mV |
| I_SRC_PDO(i) | Default current value for every SRC_PDO(i) $(1 \leq i \leq \text{SRC_PDO_NUMB})$ | Flexible current I_SRC_PDO_FLEX | Flexible value to be assigned to any SRC_PDO: $300 \text{ mA} < I_{\text{SRC_PDO_FLEX}} \leq 5 \text{ A}$ by steps of 10 mA |
| | | Pre-defined current | <ul style="list-style-type: none"> • 0.50 A • 0.75 A • 1.00 A • 1.25 A • 1.50 A • 1.75 A • 2.00 A • 2.25 A • 2.50 A • 2.75 A • 3.00 A • 3.50 A • 4.00 A • 4.50 A • 5.00 A |
| I_SRC_PDO_otp(i) | Current value, for every SRC_PDO(i), in overtemperature condition ($T > T_1$) | I_SRC_PDO_FLEX | Flexible value to be assigned to any SRC_PDO: $10 \text{ mA} < I_{\text{SRC_PDO_FLEX}} < 5 \text{ A}$ by steps of 10 mA |

| Parameter | Description | Value | Comments |
|----------------------------|---|--------------------------------------|--|
| I_SRC_PDO_otp(i) | Current value, for every SRC_PDO(i), in overtemperature condition ($T > T_1$) | Pre-defined current | <ul style="list-style-type: none"> • 0.50 A • 0.75 A • 1.00 A • 1.25 A • 1.50 A • 1.75 A • 2.00 A • 2.25 A • 2.50 A • 2.75 A • 3.00 A • 3.50 A • 4.00 A • 4.50 A • 5.00 A |
| VCONN_ENABLE | V _{CONN} pin connection | No | V _{CONN} not supported, connected to GND |
| | | Yes | V _{CONN} supported, connected to POWER |
| DR_SW_EN | Data role swap enable | Off | Data role swap not supported |
| | | On | Data role swap accepted |
| VDM_CUSTOM_DIS | Enable the STUSB4761 customization via CC pins | Off | Factory customization via CC pin is available |
| | | On | Factory customization via CC pin is not possible |
| CC_ref_current | Constant current mode reference | I_SRC_PDO[RDO object position field] | Current from STUSB4761 PDO selected by the sink |
| | | RDO[operating current field] | Operating current of sink request |
| | | RDO[max operating current field] | Maximum operating current of sink request |
| OCP_Threshold | OCP threshold value (see Section 3.6.2 CC MODE) | + 12.5% | +12.5% (or +130 mA) above reference regulation current (CC_ref_current) |
| | | + 25% | +25% (or +260 mA) above reference regulation current (CC_ref_current) |
| V_UVLO | Undervoltage lockout | From 5% to 20% | By increments of 5% |
| V_OVLO | Overvoltage lockout | From 5% to 20% | By increments of 5% |
| SHUNT_RESISTOR | Current regulation gain adjustment based on shunt value | 10 mΩ | |
| | | 15 mΩ | |
| | | 25 mΩ | |
| UNCONSTRAINED_POWER | Unconstrained power bit from fixed supply PDO | Off | No external source of power |
| | | On | An external source of power is available and is sufficient to adequately power the system while charging external devices |

| Parameter | Description | Value | Comments |
|------------------|--|-------|--|
| USB_COMM_CAPABLE | USB communications capable bit from fixed supply PDO | No | Application does not support USB 2.0 or 3.x data |
| | | Yes | Application supports USB 2.0 or 3.x data |

4.2 Factory settings

Table 11. Factory settings

| PARAMETER | VALUE |
|---------------------|--------------------------------------|
| TYPEC_CURRENT | 3 A |
| SRC_PDO_NUMB | 5 |
| DR_SW_EN | ON |
| VCONN_ENABLE | NO |
| VDM_CUSTOM_DIS | OFF |
| CC_ref_current | I_SRC_PDO[RDO object position field] |
| OCP_Threshold | +12.5% |
| SHUNT_RESISTOR | 10 mOhms |
| UNCONSTRAINED_POWER | ON |
| USB_COMM_CAPABLE | NO |

Table 12. Factory settings continued

| PDO # | Type | PD power ⁽¹⁾ (default) | PD power ⁽¹⁾ (OTP) | Voltage UVLO ⁽²⁾ | Voltage OVLO ⁽²⁾ |
|----------|-----------|--------------------------------------|----------------------------------|--------------------------------|--------------------------------|
| SRC_PDO1 | Fixed PDO | 5 V; 3.00 A | 2.00 A | -5% | +10% |
| SRC_PDO2 | Fixed PDO | 9 V; 3.00 A | 2.00 A | -5% | +10% |
| SRC_PDO3 | Fixed PDO | 12 V; 3.00 A | 2.00 A | -5% | +10% |
| SRC_PDO4 | Fixed PDO | 15 V; 3.00 A | 2.00 A | -5% | +10% |
| SRC_PDO5 | Fixed PDO | 20 V; 2.25 A | 2.00 A | -5% | +10% |

1. PD power (PDP): The output power of a source, as specified by the manufacturer and expressed in fixed supply PDOs.
2. UVLO / OVLO accuracy: +/- 2% across temperature range.

5 Applications

The following sections are not part of ST product specifications. They are intended to give a generic application overview to be used by the customer as a starting point for further implementation and customization. ST does not warrant compliance with customer specifications. Full system implementation and validation are under customer responsibility.

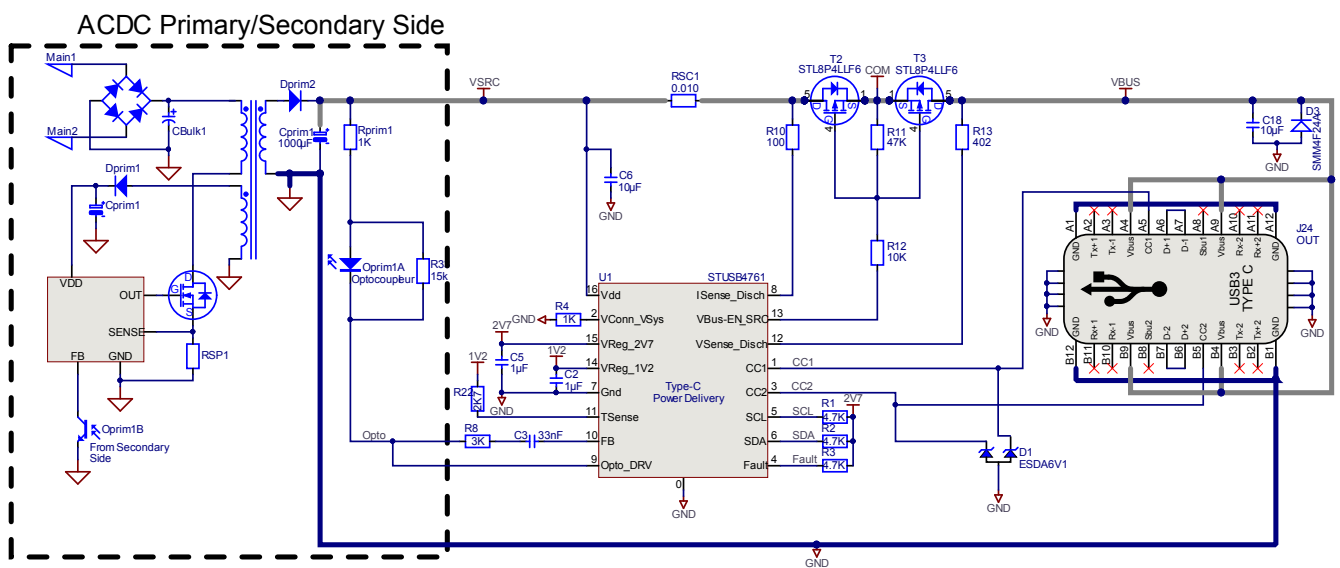
5.1 General information

5.1.1 Power supply

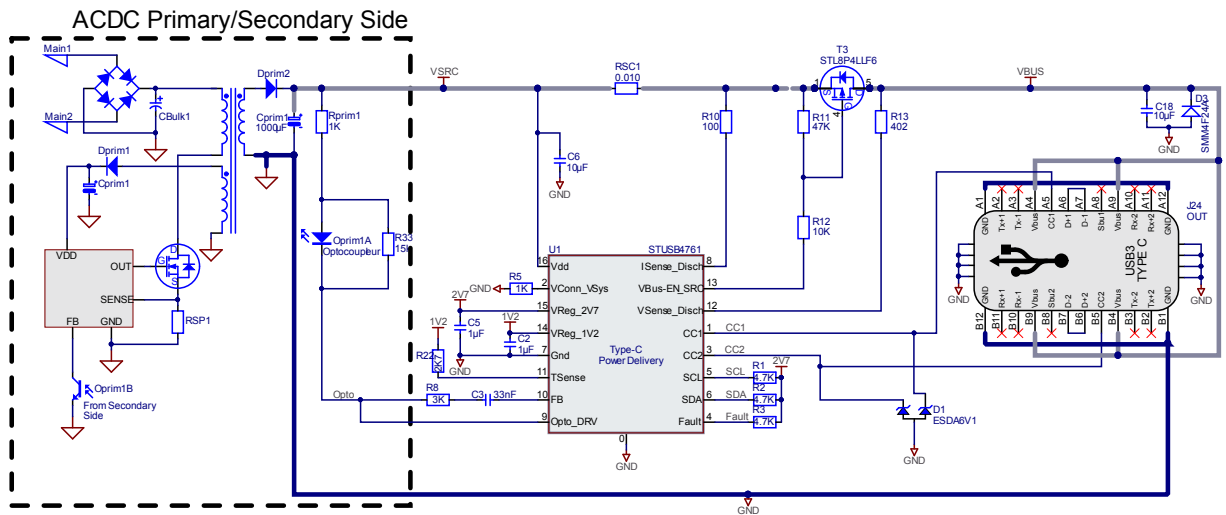
The STUSB4761 is supplied through the VDD pin. For application supporting more than 3 A (60 to 100 W AC adapters typically), at the exception of captive cable implementations, VCONN support is mandatory and therefore, VCONN input pin must be supplied by a 3.3 V-5 V / 50 mA power.

5.2 Typical application (up to 60 W- 3 A max.)

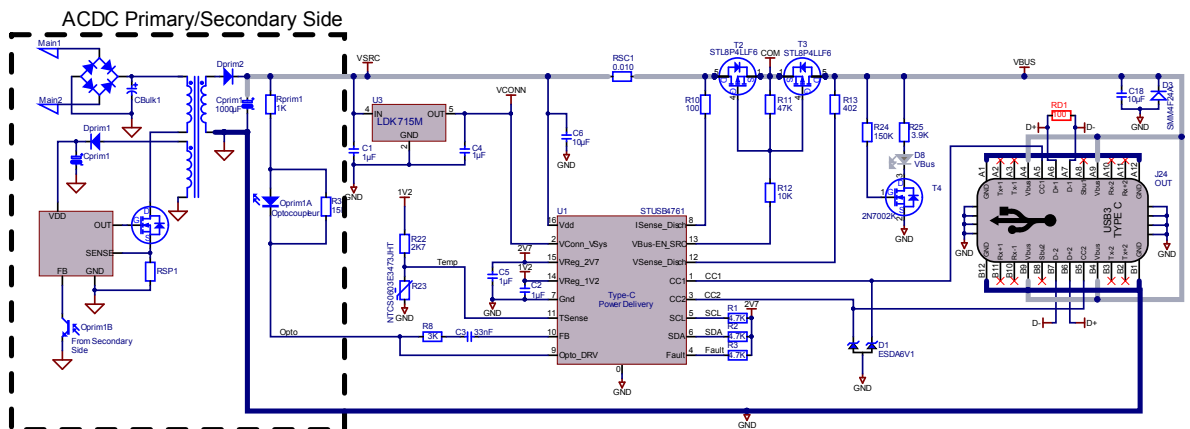
Figure 6. Typical implementation



5.3 Minimal implementation (up to 60 W-3 A max., no temperature protection, no LED)

Figure 7. Minimal implementation


5.4 Reference schematic (full feature: up to 100 W, temperature adaptive power, LED)

Figure 8. Reference schematic


Temperature threshold settings for: T1 = 70 °C; T2 = 90 °C; T3 = 110 °C

- VReg_1V2 = 1.148 V
- R22 = 2.7 kOhms (1% accuracy)
- R23 = 47 kOhms (ref = NTCS0603E3473JHT)

Table 13. Voltage and temperature thresholds

| | STUSB4761 voltage thresholds (typ.) | | Temperature (typ.) | |
|-----------------------|--|---------|-----------------------|---------|
| | Rising | Falling | Rising | Falling |
| Tsense_T ₁ | 0.873 V | 0.933 V | 70 °C | 60 °C |
| Tsense_T ₂ | 0.713 V | 0.791 V | 90 °C | 80 °C |
| Tsense_T ₃ | 0.548 V | 0.630 V | 110 °C | 100 °C |

6 Electrical characteristics

6.1 Absolute maximum ratings

Table 14. Absolute maximum ratings

| Symbol | Parameter | Value | Unit |
|---|---------------------------------------|------------|------|
| V _{DD} | Supply voltage | 28 | V |
| V _{CONN_VSYS} | V _{CONN} voltage | 6 | V |
| V _{CC1} , V _{CC2} | High voltage on CC pins | 22 | V |
| V _{VBUS_EN_SRC} V _{VSENSE_DISCH} V _{ISENSE_DISCH} V _{OPTO_DRV} | High voltage on V _{BUS} pins | 28 | V |
| V _{SDA} , SCL V _{TSENSE} V _{FAULT} V _{FB} | Operating voltage on I/O pins | -0.3 to 6 | V |
| T _{STG} | Storage temperature | -55 to 150 | °C |
| T _J | Maximum junction temperature | 145 | °C |
| ESD | HBM | 4 | kV |
| | CDM | 1.5 | |

6.2 Operating conditions

Table 15. Operating conditions

| Symbol | Parameter | Value | Unit |
|---|-------------------------------|------------|------|
| V _{DD} | Supply voltage | 4.1 to 22 | V |
| V _{CONN_VSYS} | V _{CONN} voltage | 3.0 to 5.5 | V |
| V _{CC1} , V _{CC2} | CC pins ⁽¹⁾ | 0 to 5.5 | V |
| V _{VBUS_EN_SRC} V _{VSENSE_DISCH} V _{ISENSE_DISCH} V _{OPTO_DRV} | High voltage pins | 0 to 22 | V |
| V _{SDA} , SCL V _{TSENSE} V _{FAULT} V _{FB} | Operating voltage on I/O pins | 0 to 4.5 | V |
| T _A | Operating temperature | -40 to 105 | °C |

1. Transient voltage on CC1 and CC2 pins are allowed to go down to -0.3 during BMC communication from connected devices. All voltages are referenced to GND.

6.3 Electrical and timing characteristics

Unless otherwise specified: $V_{DD} = 5\text{ V}$, $T_A = +25\text{ }^\circ\text{C}$, all voltages are referenced to GND.

Table 16. Electrical and timing characteristics

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|--|---|--|------|-------|------|---------------|
| $I_{DD(SRC)}$ | Current consumption | Device attached (connected, PD communication, CCCV regulating @20 V) $-40\text{ }^\circ\text{C} < T_A < +105\text{ }^\circ\text{C}$ | 720 | 900 | 1080 | μA |
| I_{STDBY} | Standby current consumption | Device idle (not connected, no communication, CCCV regulating @5V) $-40\text{ }^\circ\text{C} < T_A < +105\text{ }^\circ\text{C}$ | 450 | 550 | 650 | μA |
| T_{LOAD} | I ² C registers loading time from NVM | At power-up or after a reset | | | 30 | ms |
| V_{CONN} power switches | | | | | | |
| R_{VCONN} | V _{CONN} power path resistance | $I_{VCONN} = 0.050\text{ A}$ $-40\text{ }^\circ\text{C} < T_A < +105\text{ }^\circ\text{C}$ | | 5 | 7.1 | Ω |
| I_{OCP} | Overcurrent protection | $V_{CONN_VSY} = 3.3\text{ V}$ | 70 | 80 | 90 | mA |
| V_{OVP} | Overvoltage protection on CC output pins | | 5.8 | 6.0 | 6.2 | V |
| V_{UVP} | Undervoltage protection on V _{CONN_VSYS} input pin | Rising (typical hysteresis = 22.5 mV) | 2.6 | 2.65 | 2.7 | V |
| TSENSE detection threshold | | | | | | |
| $V_{th}(T_1)$ | Temperature safe profile threshold | Rising Temperature | | 0.873 | | V |
| | | Falling Temperature | | 0.933 | | |
| $V_{th}(T_2)$ | Power safe profile threshold | Rising Temperature | | 0.713 | | V |
| | | Falling Temperature | | 0.791 | | |
| $V_{th}(T_3)$ | Alert threshold | Rising Temperature | | 0.548 | | V |
| | | Falling Temperature | | 0.630 | | |
| Digital input/output (SCL, SDA) | | | | | | |
| V_{IH} | High level input voltage | | 1.2 | | | V |
| V_{IL} | Low level input voltage | | | | 0.35 | V |
| V_{OL} | Low level output voltage | $I_{oh} = 3\text{ mA}$ | | | 0.4 | V |
| 20 V open-drain outputs (VBUS_EN_SRC) | | | | | | |
| V_{OL} | Low level output voltage | $I_{oh} = 3\text{ mA}$ | | | 0.4 | V |
| Discharge pins (VSENSE_DISCH, ISENSE_DISCH) | | | | | | |
| $I_{max}(VSENSE_DISCH)$ | Maximum discharge current | | | | 0.05 | A |
| $I_{max}(ISENSE_DISCH)$ | | | | | 0.50 | A |

6.4 Thermal information

Table 17. Thermal information

| Symbol | Parameter | Value | Unit |
|-----------------|--|-------|-----------------------------|
| $R_{\theta JA}$ | Junction-to-ambient thermal resistance | 78 | $^{\circ}\text{C}/\text{W}$ |
| $R_{\theta JC}$ | Junction-to-case thermal resistance | 30 | $^{\circ}\text{C}/\text{W}$ |

7 Package information

In order to meet environmental requirements, ST offers these devices in different grades of **ECOPACK** packages, depending on their level of environmental compliance. ECOPACK specifications, grade definitions and product status are available at: www.st.com. ECOPACK is an ST trademark.

7.1 QFN 16 (3x3 mm), pitch 0.50 package information

Figure 9. QFN 16 (3x3 mm) package outline

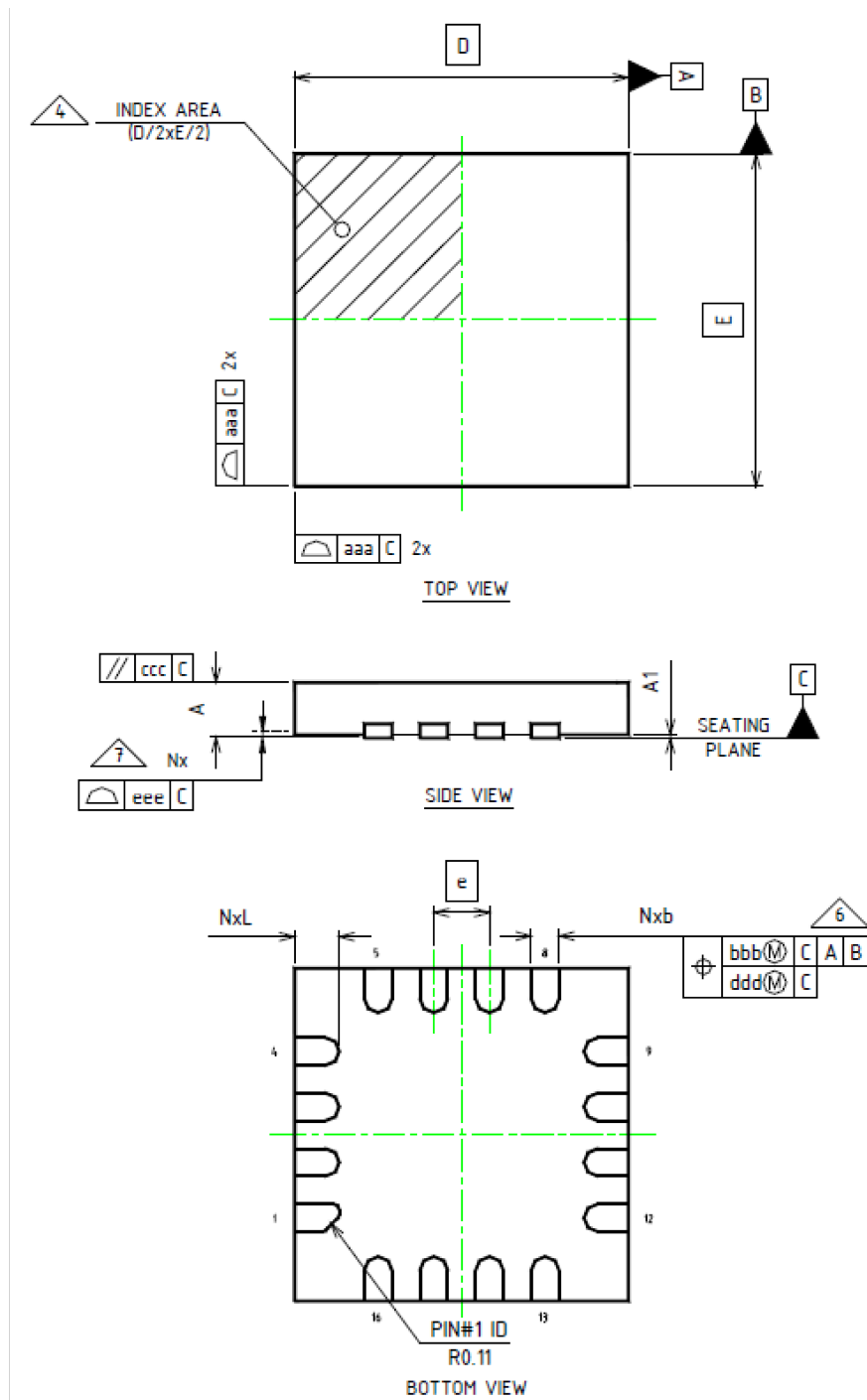


Table 18. QFN 16 (3x3 mm) mechanical data

| Symbol | mm | | |
|--------|----------|------|------|
| | Min. | Typ. | Max. |
| A | 0.5 | | 0.65 |
| A1 | 0 | | 0.05 |
| b | 0.18 | 0.25 | 0.30 |
| D | 3.00 bsc | | |
| E | 3.00 bsc | | |
| e | | 0.50 | |
| L | 0.40 | 0.50 | 0.60 |
| aaa | | | 0.15 |
| bbb | | | 0.10 |
| ccc | | | 0.10 |
| ddd | | | 0.05 |
| eee | | | 0.08 |
| n | | 16 | |
| nD | | 4 | |
| nE | | 4 | |

Note:

1. *N is the total number of terminals*
2. *nD and nE refer to the number of terminals on D and E side respectively*
3. *Dimensions b applies to metallized terminal and is measured between 0.15 mm and 0.30 mm from the terminal tip. If the terminal has the optional radius on the other end of the terminal, the dimension b should not be measured on that radius area*

Revision history

Table 19. Document revision history

| Date | Version | Changes |
|-------------|---------|---|
| 19-Nov-2019 | 1 | Initial release. |
| 20-May-2021 | 2 | Updated Table 18. QFN 16 (3x3 mm) mechanical data. |
| 08-Sep-2021 | 3 | <p>Updated Section 2.3.2 VCONN_VSYS, Section 5.1.1 Power supply, Section 5.2 Typical application (up to 60 W- 3 A max.), Section 5.3 Minimal implementation (up to 60 W-3 A max., no temperature protection, no LED).</p> <p>Updated Figure 6. Typical implementation, Figure 7. Minimal implementation and Figure 8. Reference schematic.</p> |

Contents

| | | |
|----------|---|----------|
| 1 | Functional description | 2 |
| 2 | Inputs / Outputs | 3 |
| 2.1 | Pinout | 3 |
| 2.2 | Pin list | 4 |
| 2.3 | Pin description | 5 |
| 2.3.1 | CC1 / CC2 | 5 |
| 2.3.2 | VCONN_VSYS | 5 |
| 2.3.3 | FAULT | 5 |
| 2.3.4 | I ² C interface | 5 |
| 2.3.5 | GND | 5 |
| 2.3.6 | ISENSE_DISCH | 5 |
| 2.3.7 | FB | 5 |
| 2.3.8 | OPTO_DRV | 5 |
| 2.3.9 | TSENSE | 5 |
| 2.3.10 | VSENSE_DISCH | 6 |
| 2.3.11 | VBUS_EN_SRC | 6 |
| 2.3.12 | VREG1V2 | 6 |
| 2.3.13 | VREG2V7 | 6 |
| 2.3.14 | VDD | 6 |
| 3 | Features description | 7 |
| 3.1 | PDO customization | 7 |
| 3.2 | VCONN supply | 7 |
| 3.3 | E-marked cable support | 7 |
| 3.4 | Ambient temperature adaptive power and protection | 7 |
| 3.5 | Data role and V _{CONN} SWAP | 9 |
| 3.6 | Voltage and current regulation | 9 |
| 3.6.1 | Voltage regulation | 9 |
| 3.6.2 | CC MODE | 9 |
| 3.7 | High voltage protection | 10 |
| 3.8 | Hardware fault management | 11 |

| | | |
|----------|--|-----------|
| 3.9 | Debug accessory detection | 11 |
| 4 | User-defined start-up configuration | 12 |
| 4.1 | Parameter overview | 12 |
| 4.2 | Factory settings | 14 |
| 5 | Applications | 15 |
| 5.1 | General information | 15 |
| 5.1.1 | Power supply | 15 |
| 5.2 | Typical application (up to 60 W- 3 A max.) | 15 |
| 5.3 | Minimal implementation (up to 60 W-3 A max., no temperature protection, no LED) | 16 |
| 5.4 | Reference schematic (full feature: up to 100 W, temperature adaptive power, LED) | 16 |
| 6 | Electrical characteristics | 18 |
| 6.1 | Absolute maximum ratings | 18 |
| 6.2 | Operating conditions | 19 |
| 6.3 | Electrical and timing characteristics | 20 |
| 6.4 | Thermal information | 21 |
| 7 | Package information | 22 |
| 7.1 | QFN16_3x3_mm_package information | 22 |
| | Revision history | 24 |

List of tables

| | | |
|------------------|---|----|
| Table 1. | Pin function list | 4 |
| Table 2. | Legend | 4 |
| Table 3. | I ² C interface pin list | 5 |
| Table 4. | Ambient temperature adaptive power and protection | 8 |
| Table 5. | Reference regulation current | 9 |
| Table 6. | OCP threshold | 9 |
| Table 7. | Reference regulation current | 10 |
| Table 8. | Example | 10 |
| Table 9. | Hardware fault management | 11 |
| Table 10. | Parameter overview | 12 |
| Table 11. | Factory settings | 14 |
| Table 12. | Factory settings continued | 14 |
| Table 13. | Voltage and temperature thresholds | 17 |
| Table 14. | Absolute maximum ratings | 18 |
| Table 15. | Operating conditions | 19 |
| Table 16. | Electrical and timing characteristics | 20 |
| Table 17. | Thermal information | 21 |
| Table 18. | QFN 16 (3x3 mm) mechanical data | 23 |
| Table 19. | Document revision history | 24 |

List of figures

| | | |
|------------------|--|----|
| Figure 1. | Block diagram | 2 |
| Figure 2. | QFN16 (3x3 mm) pinout (top view) | 3 |
| Figure 3. | OTP_FSM | 8 |
| Figure 4. | Current regulation | 10 |
| Figure 5. | Short-to-VBUS | 11 |
| Figure 6. | Typical implementation | 15 |
| Figure 7. | Minimal implementation | 16 |
| Figure 8. | Reference schematic | 16 |
| Figure 9. | QFN 16 (3x3 mm) package outline | 22 |

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