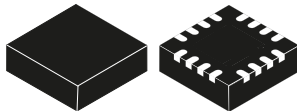# Standalone USB PD controller with integrated CC/CV for AC/DC applications

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 V; 22 V] - AMR = 28 V
- Temperature range: -40 °C up to 105 °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

Product status link
STUSB4761

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

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.

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.
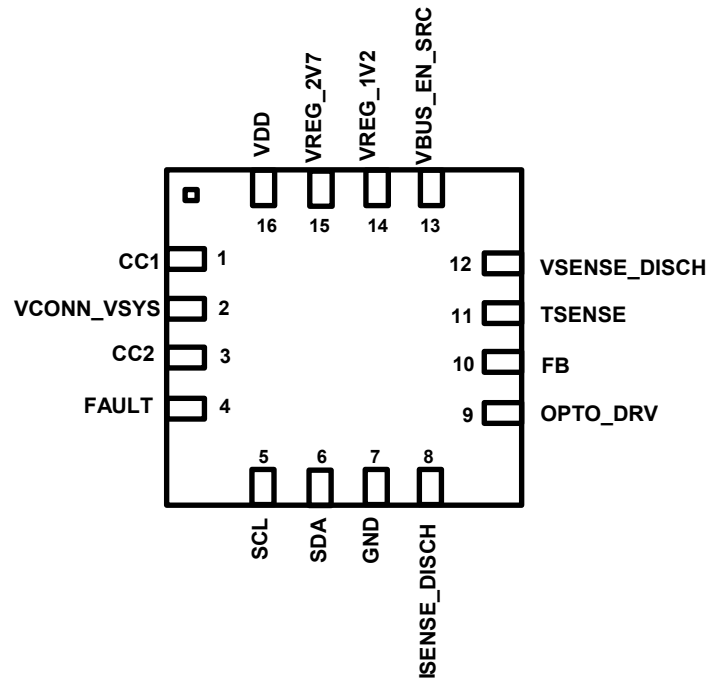
Figure 1. Block diagram
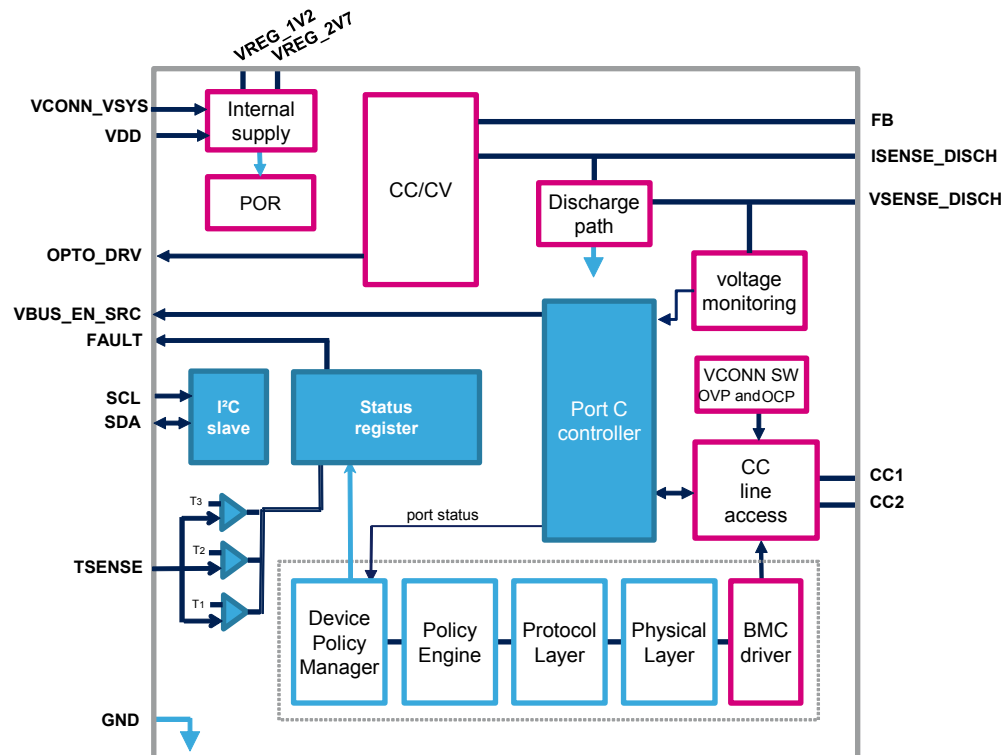
2 Inputs / Outputs

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 µF 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 I²C master - ext. pull-up
6	SDA	DI/OD	I^{2}C data input/output – active low open drain	To I²C 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 µF typ. decoupling capacitor
15	VREG_2V7	PWR	2.7 V internal regulator output	1 µF 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.

2.3.3 FAULT

FAULT signal is asserted when T_3 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 T_1

Note: *this re-start condition is valid once. In case some errors occur again, condition 1 only becomes valid, allowing T_1 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	I²C clock - need external pull-up
SDA	I²C 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 to100 W, temperature adaptive power, LED)).

Table 4. Ambient temperature adaptive power and protection

	Rising threshold	Hysteresis	Behavior	Re-start
T_a	< 70 °C		Default power profile (PDP_default)	
T_1	70 °C	10 °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 °C	10 °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 °C	10 °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
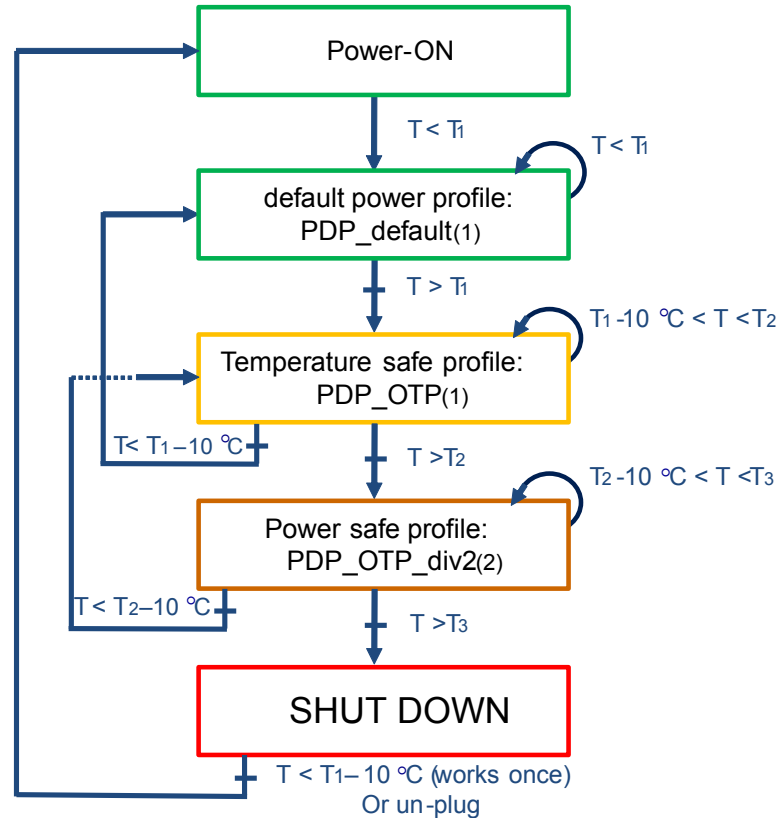
3.5 Data role and V$_{CONN}$ SWAP

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

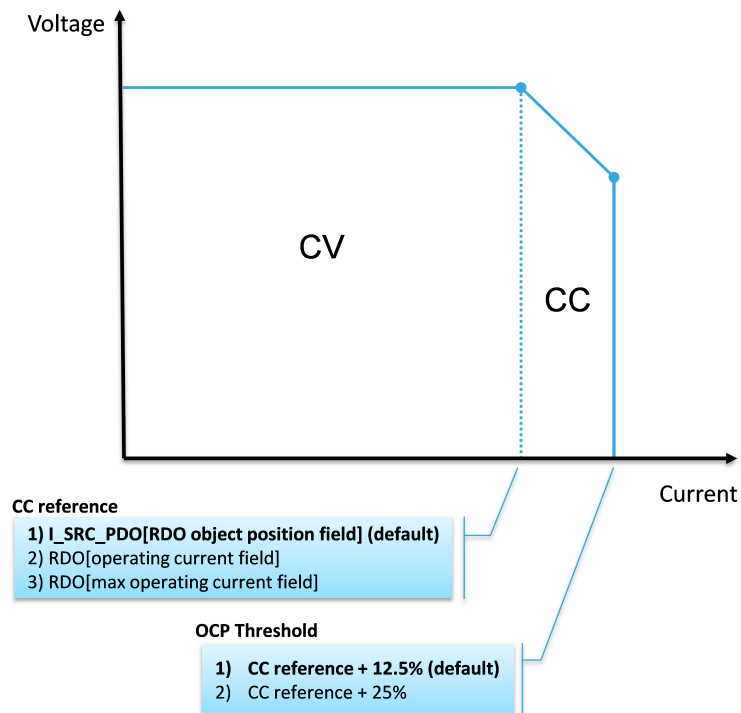| 1 (DEFAULT)	Current from the STUSB4761 PDO selected by the sink: I_SRC_PDO[RDO object position field]
2	Operating current of sink request: RDO[operating current field]
3	Maximum operating current of sink request: RDO[max. operating current field]

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**

CC reference
1) **I_SRC_PDO[RDO object position field] (default)**
2) RDO[operating current field]
3) RDO[max operating current field]

OCP Threshold
1) **CC reference + 12.5% (default)**
2) CC reference + 25%

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
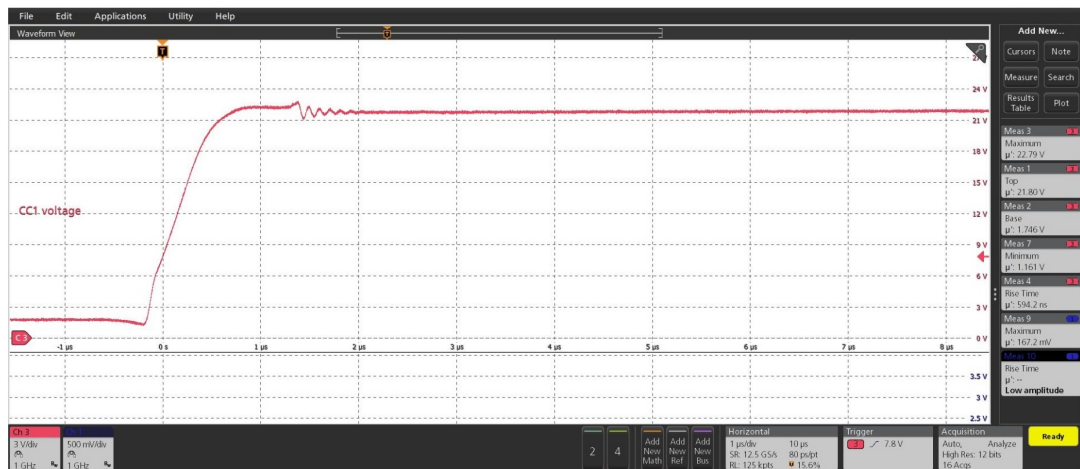
3.8 Hardware fault management

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 VBUS path. Force detach (remove termination). Re-init connection
	VBUS not valid during attach	
CC pin and VCONN switch	1. Short to V_{BUS} (up to 22 V) 2. Overvoltage (6 V) 3. Undervoltage (2.65 V) 4. Reverse voltage 5. Overcurrent (80 mA) 6. Overheating 7. ESD	1. Power switch opened. ErrorRecovery 2. Power switch opened. ErrorRecovery 3. Power switch opened 4. Power switch opened 5. Current limit 6. Power switch opened. ErrorRecovery 7. 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) $1 \leq i \leq$ 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 V < V_SRC_PDO ≤ 20 V by steps of 50 mV
		V_SRC_PDO_FLEX2	Flexible voltage value to be assigned to any SRC_PDO: 5 V < V_SRC_PDO ≤ 20 V by steps of 50 mV
I_SRC_PDO(i)	Default current value for every SRC_PDO(i) $(1 \leq i \leq$ SRC_PDO_NUMB)	Flexible current I_SRC_PDO_FLEX	Flexible value to be assigned to any SRC_PDO: 300 mA < I_SRC_PDO_FLEX ≤ 5 A by steps of 10 mA
		Pre-defined current	• 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 mA < I_SRC_PDO_FLEX < 5 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	• 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 3 A or more (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 (<60 W)

Figure 6. Typical application (<60 W)
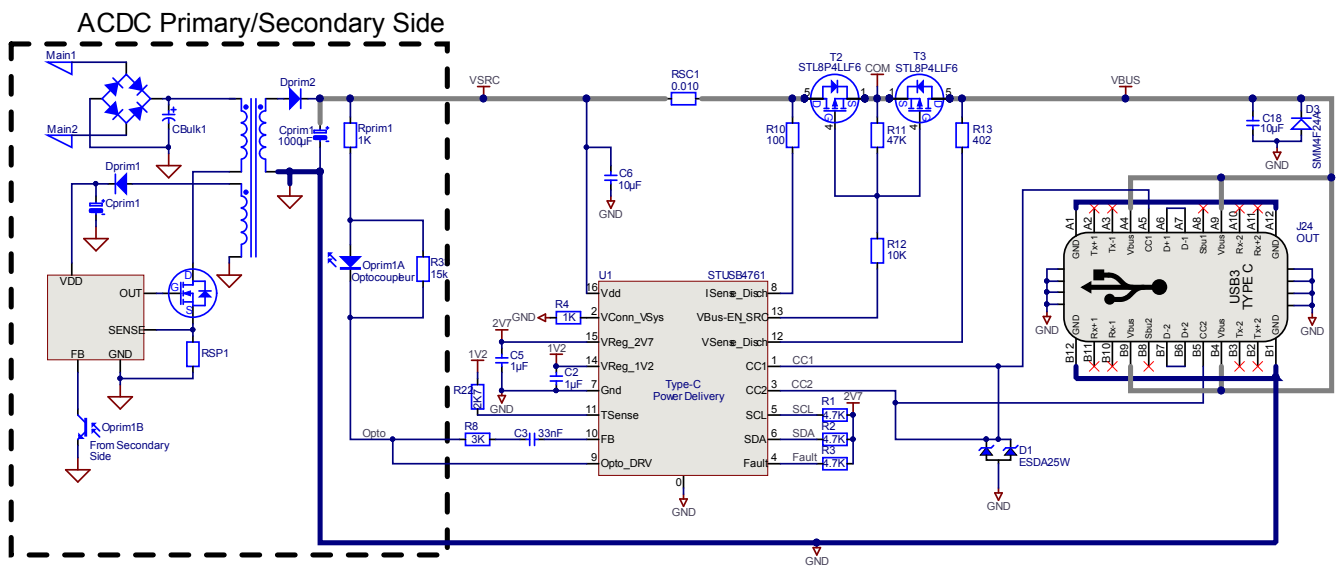
5.3 Minimal implementation (up to 60 W, no temperature protection, no LED)

Figure 7. Minimal implementation
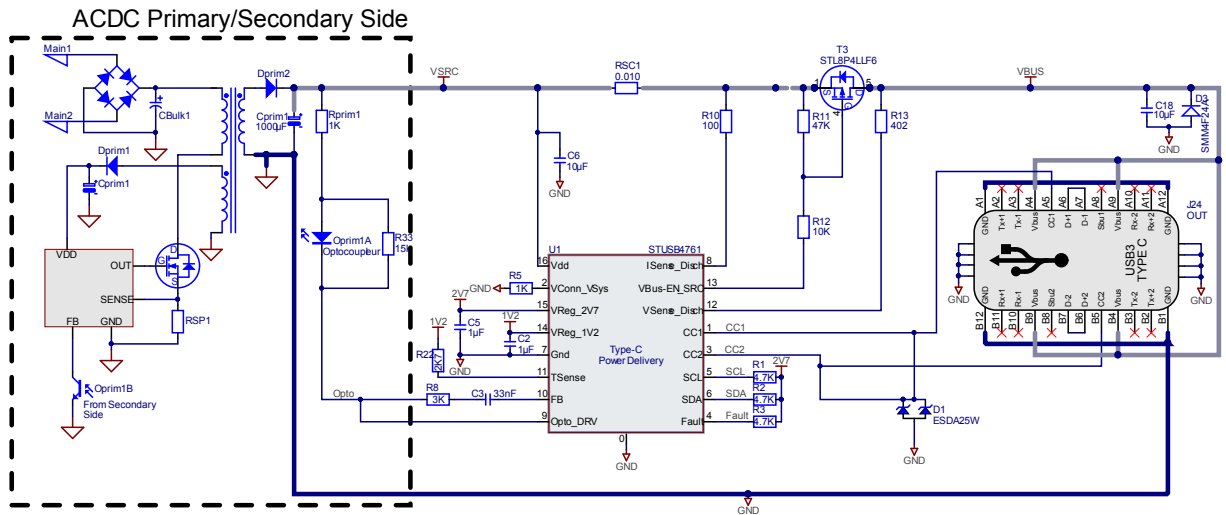
5.4 Reference schematic (full feature: up to100 W, temperature adaptive power, LED)

Figure 8. Reference schematic
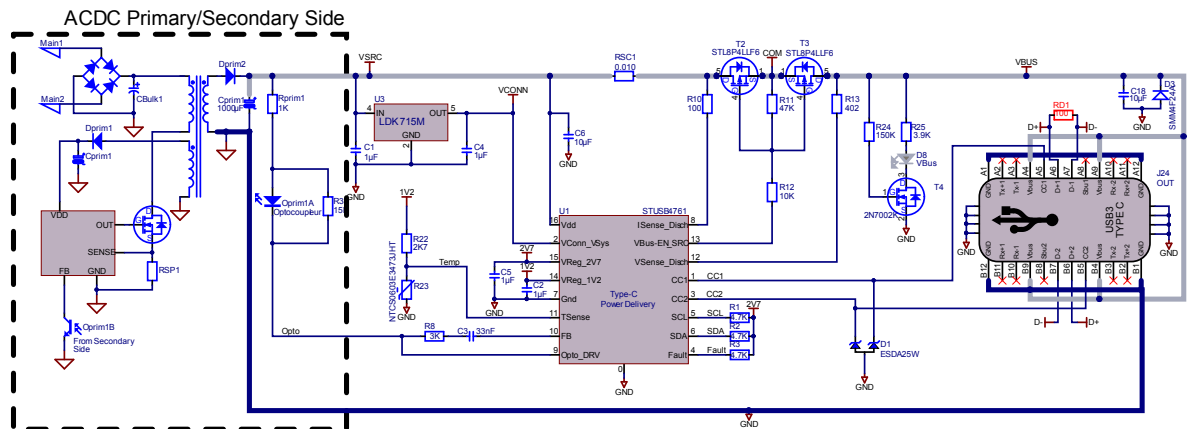
Temperature threshold settings for: T1 = 70 °C; T2 = 90 °C; T3 = 110 °C

- 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 V, T_A = +25 °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 °C < T_A < +105 °C	720	900	1080	µA
I_{STDBY}	Standby current consumption	Device idle (not connected, no communication, CCCV regulating @5V) -40 °C < TA < +105 °C	450	550	650	µA
T_{LOAD}	I²C 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 A -40 °C < T_A < +105 °C		5	7.1	Ω
I_{OCP}	Overcurrent protection	VCONN_VSYS = 3.3 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 VCONN_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 mA			0.4	V
20 V open-drain ouputs (VBUS_EN_SRC)						
V_{OL}	Low level output voltage	I_{oh} = 3 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	°C/W
$R_{\theta JC}$	Junction-to-case thermal resistance	30	°C/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
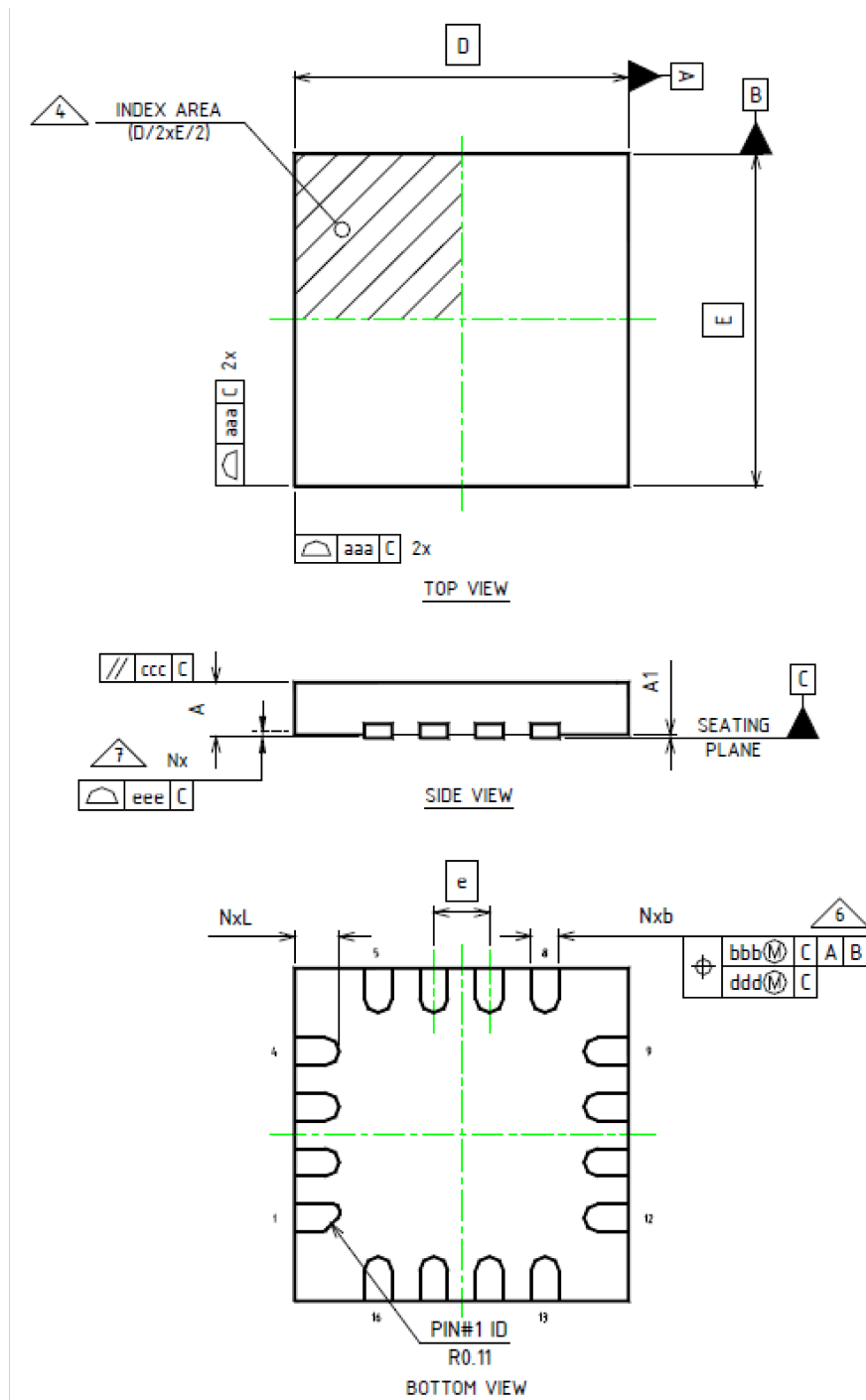
Table 18. QFN 16 (3x3 mm) mechanical data

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.

Contents

List of tables

List of figures

IMPORTANT NOTICE – PLEASE READ CAREFULLY

STMicroelectronics NV and its subsidiaries ("ST") reserve the right to make changes, corrections, enhancements, modifications, and improvements to ST products and/or to this document at any time without notice. Purchasers should obtain the latest relevant information on ST products before placing orders. ST products are sold pursuant to ST's terms and conditions of sale in place at the time of order acknowledgement.

Purchasers are solely responsible for the choice, selection, and use of ST products and ST assumes no liability for application assistance or the design of Purchasers' products.

No license, express or implied, to any intellectual property right is granted by ST herein.

Resale of ST products with provisions different from the information set forth herein shall void any warranty granted by ST for such product.

ST and the ST logo are trademarks of ST. For additional information about ST trademarks, please refer to www.st.com/trademarks. All other product or service names are the property of their respective owners.

Information in this document supersedes and replaces information previously supplied in any prior versions of this document.