NX20P0407
USB Type-C CC and SBU Protection IC
Rev. 1.3 — 22 August 2019   **Product data sheet**

1 General description

The NX20P0407 is a single-chip USB Type-C port protection device that provides 28V short-to-VBUS overvoltage protection to CC1/CC2 and SBU1/SBU2 pins.

USB Type-C allows VBUS voltage to increase up to 20V through Power delivery protocol. CC1/2 and SBU1/2 pins can be shorted to VBUS due to mechanical twisting and sliding of the connector since Type-C connector contact pins are 25% closer to each other than a micro USB connector. Moisture or fine dust may also cause the 20V VBUS pin to be shorted to adjacent pins.

NX20P0407 enables CC and SBU pins to be more robust in even abnormal conditions. NX20P0407 is 28V DC tolerant on CON_CC1, CON_CC2, CON_SBU1 and CON_SBU2 pins in connector side and quickly disconnects switches if the voltage is above overvoltage threshold, protecting CC1, CC2, SBU1 and SBU2 in system side from high voltage.

NX20P0407 integrates IEC 61000-4-2 ESD protection on CON_CC1 and CON_CC2, +15KV air discharge and +8KV contact discharge, which helps to reduce external BOM cost. NX20P0407 CON_CC1/2 pins are designed to be protected from surges up to +/-35V.

2 Features and benefits

- USB Type C CC1/2 and SBU1/2 short protection to VBUS
  - CON_CC1 / CON_CC2 : $28V_{DC}$
  - CON_SBU1 / CON_SBU2 : $28V_{DC}$
- Rd circuit in CON_CC1/CON_CC2 in dead battery
- Low R_{DSon} switch
  - CC switch : 160mΩ
  - SBU switch : 3.6Ω
- Robust ESD immunity for CON_CC1/2
  - IEC 61000-4-2 Contact discharge: 8KV
  - IEC 61000-4-2 Air discharge: 15KV
- +/- 35V surge protection on CON_CC1/2
- Low SYS leakage current : 32µA
- CC1/2 leakage current : < 1µA
- Fast OVP turn off time : 60ns

3   Applications

- Smartphone
- Tablet
- Laptop

4   Ordering information

Table 1. Ordering information

Type number	Topside marking	Package		
		Name	**Description**	**Version**
NX20P0407UK	N07	WLCSP12	Wafer level chip-scale package, 12 bumps; 1.67 mm x 1.27 mm x 0.525 mm body (backside coating included)	SOT1390-7

4.1   Ordering options

Table 2. Ordering options

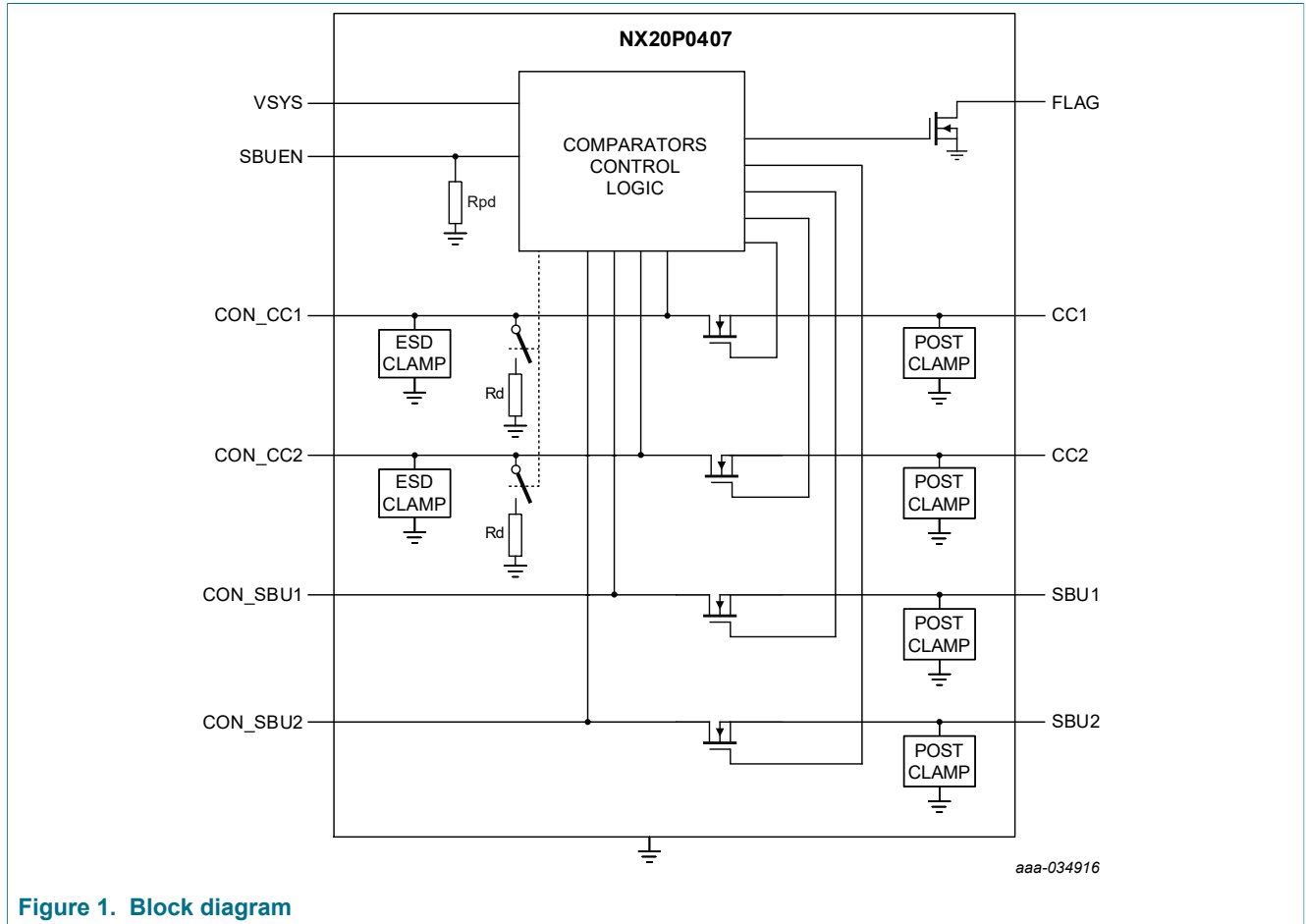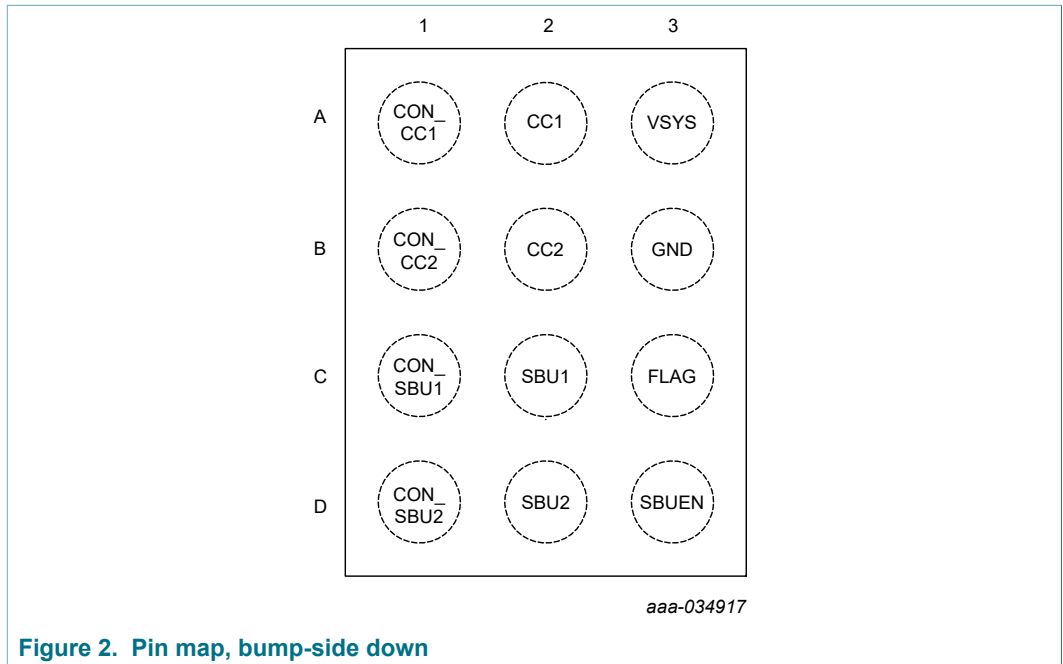| Type number	Orderable part number	Package	Packing method	Minimum order quantity	Temperature
NX20P0407UK	NX20P0407UKAZ	WLCSP12	REEL 7" Q1/T1 DP CHIPS	4000	T_{amb} = -40 °C to +85 °C
	NX20P0407UKZ	WLCSP12	REEL 13" Q1/T1 DP CHIPS	15000	T_{amb} = -40 °C to +85 °C

5 Functional diagram
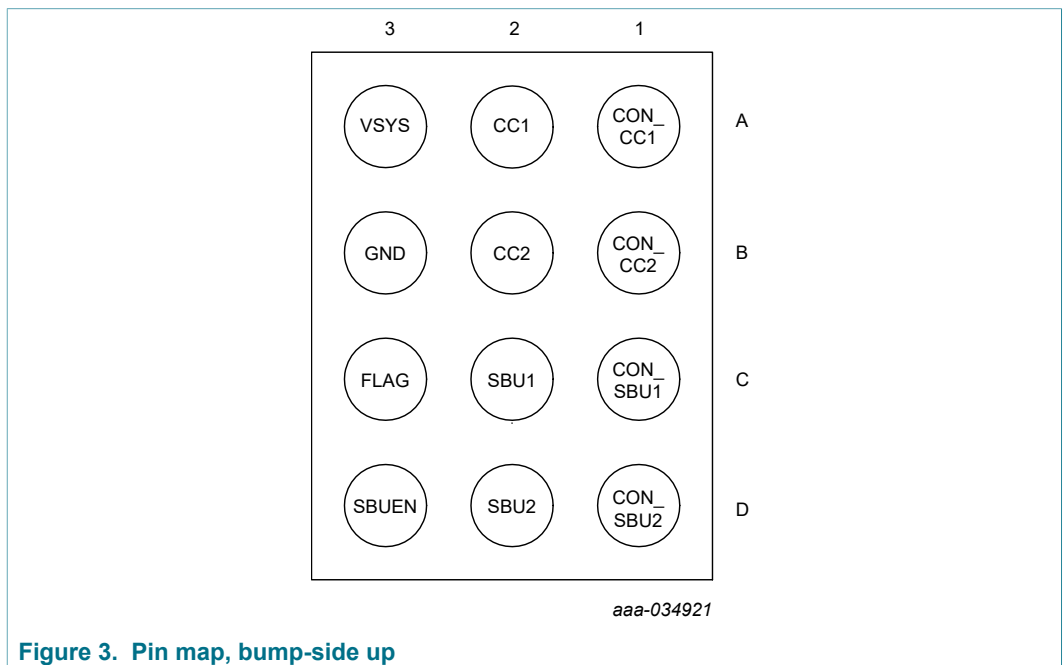

Figure 1. Block diagram

6 Pinning information

6.1 Pinning

Figure 2. Pin map, bump-side down

Figure 3. Pin map, bump-side up

6.2 Pin description

Table 3. Pin description

Symbol	Pin	Type	Description
CON_CC1	A1	P/AIO	Type-C connector side CC1. Connect CC1 of Type-C USB connector.
CON_CC2	B1	P/AIO	Type-C connector side CC2. Connect CC2 of Type-C USB connector.
CON_SBU1	C1	DIO	Type-C connector side SBU1. Connect SBU1 of Type-C USB connector.
CON_SBU2	D1	DIO	Type-C connector side SBU2. Connect SBU2 of Type-C USB connector.
CC1	A2	P/AIO	System side CC1. Connect CC1 of USB CC/PD controller.
CC2	B2	P/AIO	System side CC2. Connect CC2 of USB CC/PD controller.
SBU1	C2	DIO	System side SBU1.
SBU2	D2	DIO	System side SBU2.
SBUEN	D3	DI	SBU switch enable/disable control pin. SBUEN is driven high to enable SBU switch. There is a 460kΩ Internal pull-down resistor.
VSYS	A3	P	Power supply input; connect System voltage and bypass 1µF capacitor to GND.
FLAG	C3	DO	Open-drain output indicating fault condition. Low when Fault condition happens, external pull-up resistor is required.
GND	B3	P	Ground

7 Functional description

NX20P0407 is placed in front of Type-C connector and protects CC and SBU pins in System side from 20V VBUS short, ESD and surge.

NX20P0407 has Rd clamp circuit on both CON_CC1 and CON_CC2 when VSYS is below UVLO threshold, i.e., dead battery condition. It allows Type-C adapter to detect sink through CC and start providing 5V VBUS. Main charger regulates system voltage from the VBUS. Once VSYS comes up, NX20P0407 enables switches and disconnects the Rd clamp circuit from CON_CC1 and CON_CC2.
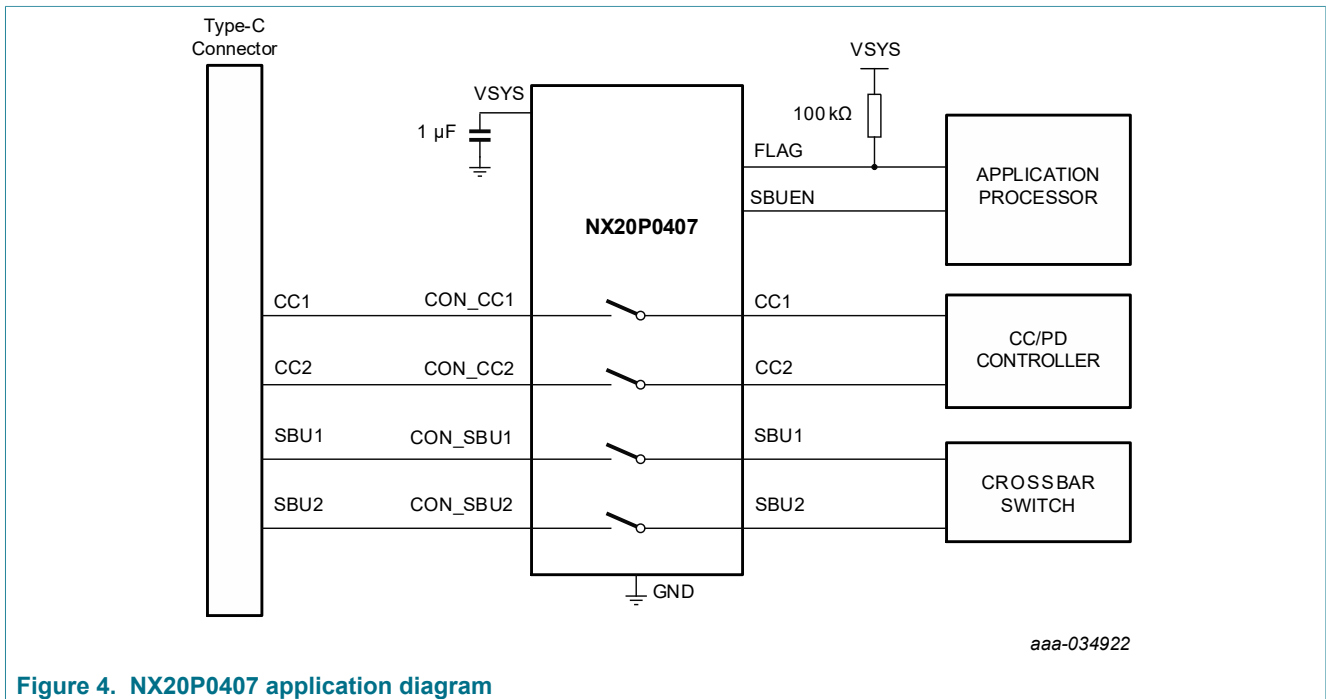

Figure 4. NX20P0407 application diagram

7.1 Power status

When VSYS is below $V_{SYSUVLO}$, NX20P0407 stays in shutdown mode. Bias circuit, switches and all comparators are disabled, but Rd clamp circuits on CON_CC1 and CON_CC2 are enabled. It allows the Type-C adapter to detect Rd and to supply 5V through VBUS pin in dead battery condition.

NX20P0407 enters standby mode when VSYS exceeds $V_{SYSUVLO}$. CC switch turns on automatically and SBU switch is controlled by SBUEN. After CC switch is fully turned ON, the Rd clamp circuit is disabled.

5V VCONN power supply on CC1 or CC2 should be supplied after VSYS is valid.

Table 4. Power states

Power states	VSYS	Flag	SBUEN	Rd circuit	CC Switch	SBU Switch
Dead battery	< $V_{SYSUVLO}$	Hi-Z	x	ON	OFF	OFF
Power ON_A	> $V_{SYSUVLO}$	Hi-Z	Low	OFF	ON	OFF
Power ON_B	> $V_{SYSUVLO}$	Hi-Z	High	OFF	ON	ON

7.2 Overvoltage protection

NX20P0407 has short circuit protection of CON_CC1/2 and CON_SBU1/2 up to 28V. CC switch overvoltage threshold is V_{OVPCC} to guarantee VCONN power supply passes to VCONN load, which is maximum 5.5V by USB Type-C spec. SBU switch overvoltage threshold is V_{OVPSBU} to securely turn the switch off and prevent high voltage to SBU in system side.

Once overvoltage on any channel is detected, the switch is quickly turned off within t_{OVP_RES}, to prevent overvoltage to system side. FLAG pin goes low in t_{FLAG_RES} to inform system of the fault condition. If the voltage of the channel triggered OVP comes down below overvoltage threshold for t_{OVP_DEB}, the switch is turned back on and FLAG pin gets Hi-Z.

Each of the four switches for CC1/2 and SBU1/2 has its own OVP comparator and is controlled by its comparator independently. If CC1 voltage exceeds OVP threshold, the CC1 switch is turned off, but the other switches stay ON.
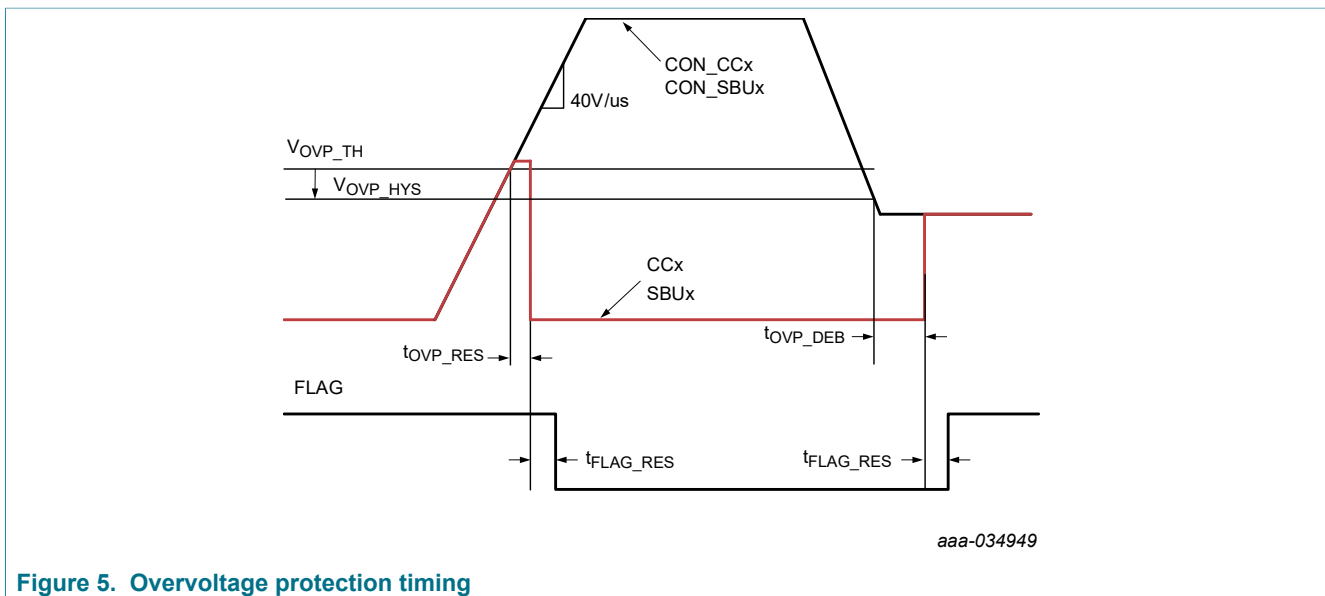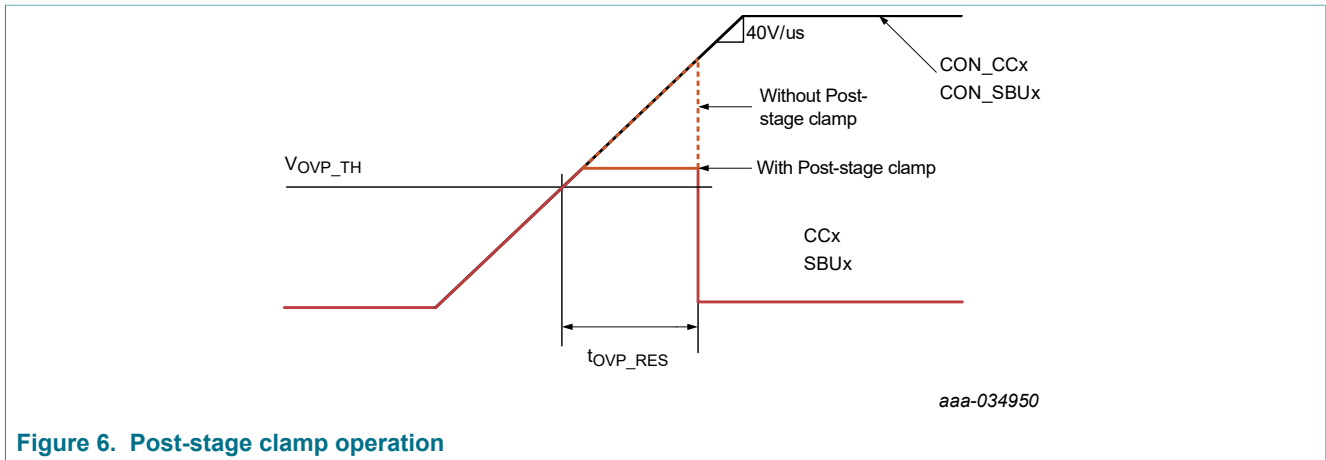

Figure 5. Overvoltage protection timing

7.3 Post-stage clamp circuit

NX20P0407 has a post-stage clamp circuit to clamp extra voltage on CC1, CC2, SBU1 and SBU2 in system side. When shorting with VBUS, the voltage on CON_CCx and SBU_CCx is rapidly increased. Even though NX20P0407 features super fast response time for overvoltage condition, the overvoltage may pass through to CCx / SBUx for the response time, t_{OVP_RES}. NX20P0407 post-stage clamp circuit provides secondary protection to clamp the voltage on CCx/ SBUx in system side, to prevent exceeding 7V Clamping voltage.

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Figure 6. Post-stage clamp operation

7.4 Flag

Flag pin is an open drain output to indicate device fault condition to application processor. If Fault condition is detected, Flag output is latched to low until the fault condition is cleared.

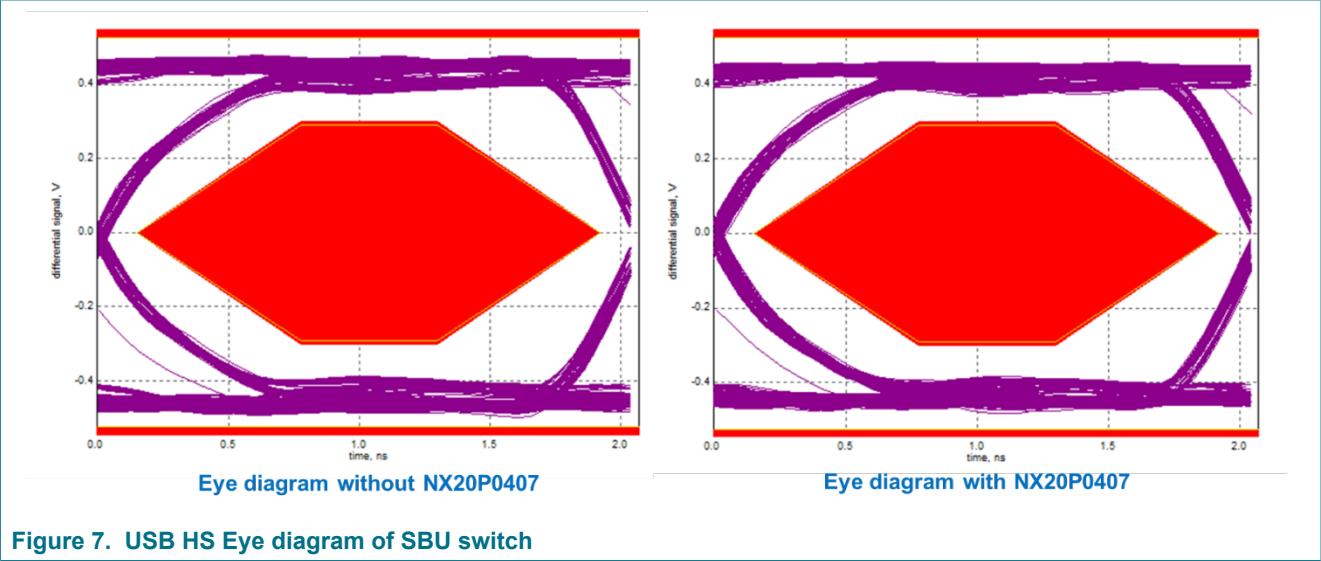Table 5 shows NX20P0407 fault conditions and its behavior.

Table 5. Fault conditions and behavior

Fault	Condition	SBUEN	Flag	CC Switch	SBU Switch
Thermal Protection	$Tj > T_{OTP}$	Low	Low	ON	OFF
Thermal Protection	$Tj > T_{OTP}$	High	Low	ON	ON
CC OVP	$V_{CON\_CCx} > V_{OVPCC}$	Low	Low	OFF	OFF
CC OVP	$V_{CON\_CCx} > V_{OVPCC}$	High	Low	OFF	ON
SBU OVP	$V_{CON\_SBUx} > V_{OVPSBU}$	Low	Hi-Z	ON	OFF
SBU OVP	$V_{CON\_SBUx} > V_{OVPSBU}$	High	Low	ON	OFF

7.5 CC and SBU Switch

NX20P0407 has two pairs of switches: CC switches and SBU switches. CC switches are always ON when SYS power is valid and there is no fault condition. The switches are capable of +/- 1.2A current with R_{ON_CC} switch resistance. SBU switches are controlled by SBUEN when SYS power is valid. The switch bandwidth is 1.5GHz so that it can be used to protect USB D+/D- from overvoltage if SBU is not used.

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Eye diagram without NX20P0407

Eye diagram with NX20P0407

Figure 7. USB HS Eye diagram of SBU switch

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8   Limiting values

Table 6. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134).

Symbol	Parameter	Conditions	Min	Max	Unit
V_{IO}	input/output voltage	CON_CC1, CON_CC2, CON_SBU1, CON_SBU2	-0.5	28	V
		CC1, CC2, SBU1, SBU2	-0.5	6	V
V_I	input voltage	SBUEN, VSYS	-0.5	6	V
V_O	output voltage	FLAG	-0.5	6	V
I_O	output current	CON_CC1, CON_CC2, CC1, CC2; $T_j < 105°C$	-1.25	1.25	A
		CON_SBU1, CON_SBU2, SBU1, SBU2	-100	100	mA
T_j	junction temperature		-40	135	°C
V_{ESD}	electrostatic discharge voltage	IEC 61000-4-2 Contact discharge; CON_CC1, CON_CC2	-8	+8	kV
		IEC 61000-4-2 Air discharge; CON_CC1, CON_CC2	+15	+15	kV
		HBM (JESD22-001); all other pins	-2	+2	kV
		CDM (JESD22-C101E); all other pins	-500	+500	V

9   Recommended operating conditions

Table 7. Recommended operating conditions

Symbol	Parameter	Conditions	Min	Max	Unit
V_{IO}	input/output voltage	CC1, CC2, CON_CC1, CON_CC	0	5.5	V
		SBU1, SBU2, CON_SBU1, CON_SBU2	0	4.5	V
V_I	input voltage	SBUEN	0	5.5	V
		VSYS	2.5	5.5	V
V_O	output voltage	FLAG	0	5.5	V
$I_{IO(CC)}$	CC input/output current	CON_CC1, CON_CC2, CC1, CC2; $V_{CC} - V_{CON\_CC} \leq 300mV$	-1.2	+1.2	A
T_{amb}	ambient temperature		-40	85	°C

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10 Thermal characteristics

Table 8. Thermal characteristics

Symbol	Parameter	Conditions		Typ	Unit
$R_{th(j-a)}$	thermal resistance from junction to ambient		[1] [2]	110	°C/W

[1] The overall $R_{th(j-a)}$ can vary depending on the board layout. To minimize the effective $R_{th(j-a)}$, all pins must have a solid connection to larger Cu layer areas e.g. to the power and ground layer. In multi-layer PCB applications, the second layer should be used to create a large heat spreader area right below the device. If this layer is either ground or power, it should be connected with several vias to the top layer connecting to the device ground or supply. Try not to use any solder-stop varnish under the chip.
[2] This $R_{th(j-a)}$ is calculated based on JEDEX2S2P board. The actual Rth(j-a) value may vary in applications using different layer stacks and layouts.

11 Electrical characteristics

11.1 Static characteristics

Table 9. Static characteristics

At recommended input voltages and T_{amb} = -40 °C to +85 °C; voltages are referenced to GND (ground = 0 V); unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Supply current / Leakage current						
$V_{SYSUVLO}$	VSYS Under Voltage Lockout	Falling, 100mV hysteresis	2.14	2.27	2.40	V
I_{SYS}	Standby current	V_{SYS} = 3.6V, SBUEN = 0V CCx = 5.1kΩ		32	55.5	µA
		V_{SYS} = 3.6V, SBUEN = 3.6V CCx = 5.1kΩ		107	170	µA
I_{CC_Leak}	Leakage current for CC pins	V_{SYS} = 3.6V, V_{CCx} = 3.0V, CON_CCx floating, V_{SYS} > V_{CCx} + 0.6V			1	µA
	Leakage current for CC pins	V_{SYS} = 3.6V, V_{CCx} = 3.6V, CON_CCx floating, V_{SYS} < V_{CCx} + 0.6V			5	µA
I_{SBU_Leak}	Leakage current for SBU pins	V_{SYS} = 3.6V, V_{SBUx} = 3.6V, CON_SBUx floating			1	µA
CC switcher						
R_{on_CC}	On resistance	V_{SYS} = 3.6V, V_{CCx} = 5.5V	-	160	250	mΩ
$R_{on\_CC\_Flat}$	On resistance flatness	Sweep CCx voltage between 0V and 3.6V		2	10	mΩ
V_{CLAMPH}	CON_CCx clamping voltage	External 330µA	0.9		2.13	V
V_{CLAMPM}	CON_CCx clamping voltage	External 180µA	0.5		1.2	V
V_{CLAMPD}	CON_CCx clamping voltage	External 80µA	0.3		1.2	V
V_{OVPCC}	OVP threshold on CON_CCx	V_{SYS} = 3.6V, rising	5.6	5.8	6.0	V

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Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{OVPCC_hys}	OVP threshold hysteresis			100		mV
C_{on_cc}	Equivalent on capacitance	Capacitance between CCx/CON_CCx and GND when Powered up. V_{CCx} = 0V to 1.2V, f = 240MHz		25		pF
BW_{CC}	3dB Bandwidth	Single ended, 50Ω termination, V_{CCx} = 0.1V to 1.2V		250		MHz
V_{CLAMP}	Clamp voltage on system side	Hot plug voltage CON_CCx = 22V. load 150nF cap and 40Ω in series to GND on CCx 40V/us		7		V
SBU switcher						
R_{on_SBU}	On resistance	V_{SYS} = 3.6V, SBUEN = High, SBUx = 3.6V	-	3.6	5.4	Ω
$R_{on\_SBU\_Flat}$	On resistance flatness	Sweep SBUx voltage between 0V and 3.6V		30	150	mΩ
V_{OVPSBU}	OVP threshold on CON_SBUx	V_{SYS} = 3.6V, SBUEN = High, rising	4.6	4.8	5.0	V
V_{OVPSBU_hys}	OVP threshold hysteresis			100		mV
C_{on_SBU}	Equivalent on capacitance	Capacitance between SBUx/CON_SBUx and GND when Powered up. V_{SBUx} = 0V to 1.2V, f = 240MHz		4.5		pF
BW_{SBU}	3dB Bandwidth	Single ended, 50Ω termination, V_{SBUx} = 0.1V to 1.2V		1500		MHz
XTALK	Crosstalk	Swing 1Vpp at 10MHz, measure the other channels with 50mΩ termination		-84		dB
V_{CLAMP}	Clamp voltage on system side	Hot plug voltage CON_SBUx = 22V. load 150nF cap and 40Ω in series to GND on SBUx		7		V
FLAG						
V_{OL}	Output low voltage	I_{OL} = 5mA			0.3	V
I_{OH}	High level leakage current	V_{FLAG} = 5.5V			1	µA
SBUEN						
V_{IH}	Valid input high		1.5			V
V_{IL}	Valid input low				0.4	V
R_{PD}	Pull down resistor		350	450	600	kΩ
Over Temperature flag						
T_{OTP}	Over temperature Flag			125		°C

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Symbol	Parameter	Conditions	Min	Typ	Max	Unit
T_{OTP_hys}	Over temperature Flag hysteresis		-	10	-	°C

11.2 Dynamic characteristics

Table 10. Dynamic characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Switch Dynamic Characteristics						
t_{pwrup}	Power up time from Valid power source of VSYS			2.5	5	ms
$t_{OVP\_res\_CC}$	OVP response time	Time from OVP trip voltage asserted to OVP FET turn-off	-	60		ns
$t_{OVP\_res\_SBU}$	OVP response time	Time from OVP trip voltage asserted to OVP FET turn-off	-	60		ns
t_{OVP_deb}	Minimum time to exit OVP shutdown, CON_CCx or CON_SBUx voltage should be lower than OVP voltage for this time		-	20		ms
t_{SBU_ON}	SBU switch enable time from SBUEN to high			40	80	us
t_{OTP_deb}	Minimum time to exit over temperature flag	[1]	-	20		ms
t_{FLAG_RES}	Time to FLAG assertion from OVP detected.			5		us
t_{OTP_flag}	Time to Flag from over temperature	[1]		20		us

[1]   Guaranteed by Design

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12 Package outline

detail X

DIMENSIONS (mm are the original dimensions)

UNIT		A	A₁	A₂	b	D	E	e	e₁	e₂	v	w	y
mm	MAX.	0.565	0.23	0.350	0.29	1.70	1.30	0.4	1.2	0.8	0.05	0.02	0.03
	NOM.	0.525	0.20	0.325	0.26	1.67	1.27						
	MIN.	0.485	0.17	0.300	0.23	1.64	1.24						

NOTE: Backside coating 25 um

Figure 8. Package outline SOT1390-7 (WLCSP12)

13 Revision history

Table 11. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
NX20P0407 v.1.3	20190822	Product data sheet	-	NX20P0407 v.1.2

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14 Legal information

14.1 Data sheet status

Document status[1][2]	Product status[3]	Definition
Objective [short] data sheet	Development	This document contains data from the objective specification for product development.
Preliminary [short] data sheet	Qualification	This document contains data from the preliminary specification.
Product [short] data sheet	Production	This document contains the product specification.

[1]   Please consult the most recently issued document before initiating or completing a design.
[2]   The term 'short data sheet' is explained in section "Definitions".
[3]   The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the Internet at URL http://www.nxp.com.

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