NX20P0408

USB D+/D- protection IC

Rev. 1.1 — 19 August 2019 Product data sheet

1 General description

NX20P0408 is a single chip USB data lines protection solution that provides 28V short-to-VBUS protection to system side D+ and D- pins located near VBUS pins.

USB Type-C allows VBUS voltage to increase up to 20V through Power delivery protocol. D+ and D- 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.

NX20P0408 enables D+/D- to be robust in even abnormal conditions. NX20P0408 is 28V DC tolerant on D+/D- pin in connector side and quickly disconnects switches if the voltage is above overvoltage threshold, protecting D+/D- in system side from high voltage.

2 Features and benefits

- USB Type-C D+/D- short protection to VBUS
  - CON_DP / CON_DN : 28V_{DC}
- Low Rdson switch : 4Ω
- High switch bandwidth = 1.5GHz
- 35V surge protection on CON_DP/CON_DN
- Fast OVP turn off time : 60ns
- Post-stage clamp circuit to clamp voltage until switch is off.

3 Applications

- Smartphone
- Tablet
- Laptop

4 Ordering information

Table 1. Ordering information

Type number	Topside marking	Package		
		Name	Description	Version
NX20P0408UK	N08	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
NX20P0408UK	NX20P0408UKZ	WLCSP12	REEL 7" Q1/T1 DP CHIPS	4000	T_{amb} = -40 °C to +85 °C

5 Functional diagram

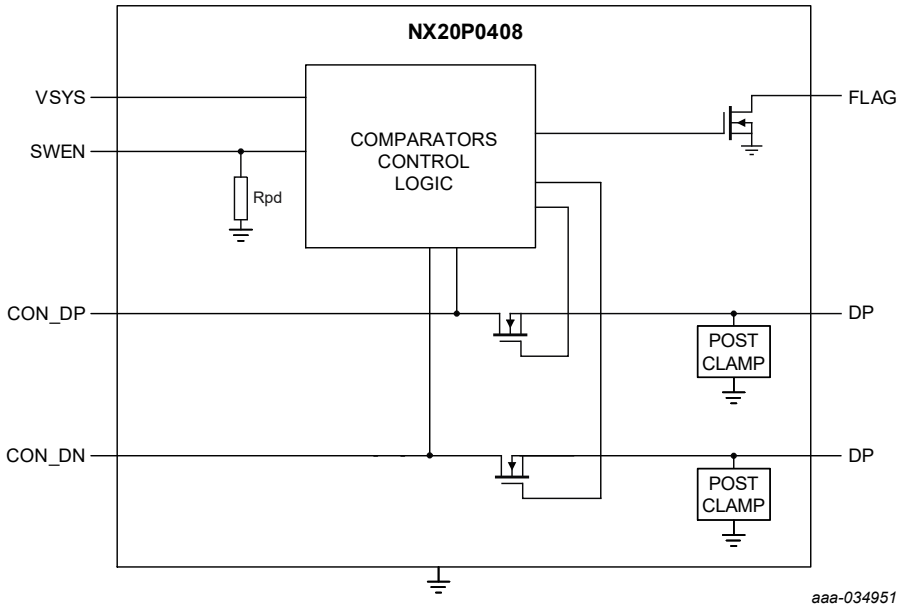


Figure 1. Block diagram

6 Pinning information

6.1 Pinning

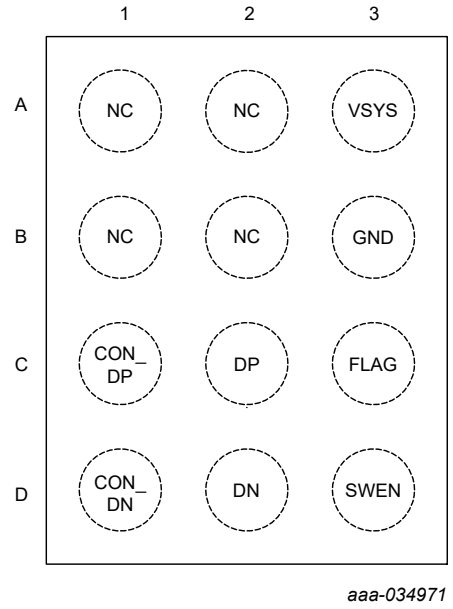


Figure 2. Pin map, bump-side down

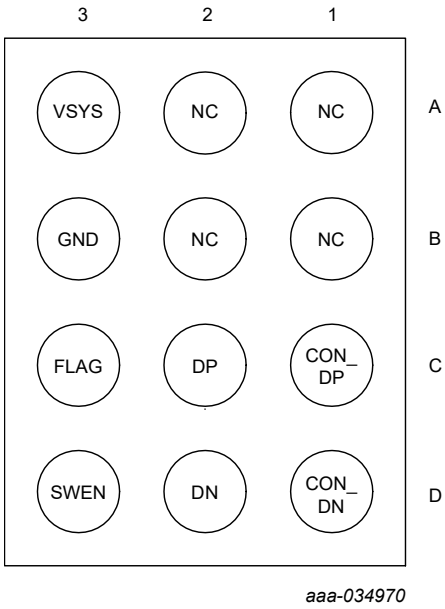


Figure 3. Pin map, bump-side up

6.2 Pin description

Table 3.

Pin description			
Symbol	**Pin**	**Type**	**Description**
CON_DP	C1	DIO	Type-C connector side DP. Connect DP of Type-C USB connector.
CON_DN	D1	DIO	Type-C connector side DN. Connect DN of Type-C USB connector.
DP	C2	DIO	System side DP.
DN	D2	DIO	System side DN.
SWEN	D3	DI	USB switch enable/disable control pin. SWEN is driven HIGH to enable USB switch. There is a 460kΩ internal pull-down resistor, 460kΩ.
VSYS	A3	P	Power supply input, connect System voltage and bypass 1uF capacitor to GND.
FLAG	C3	DO	Open-drain output indicating fault condition. LOW when Fault condition happen. External pull-up resistor is required.
GND	B3	P	Ground
NC	A1, A2, B1, B2		No connection. Leave them open.

7 Functional description

NX20P0408 is placed in front of the Type-C connector and protects D+ and D- pins in system side from 20V VBUS short, ESD and surge.

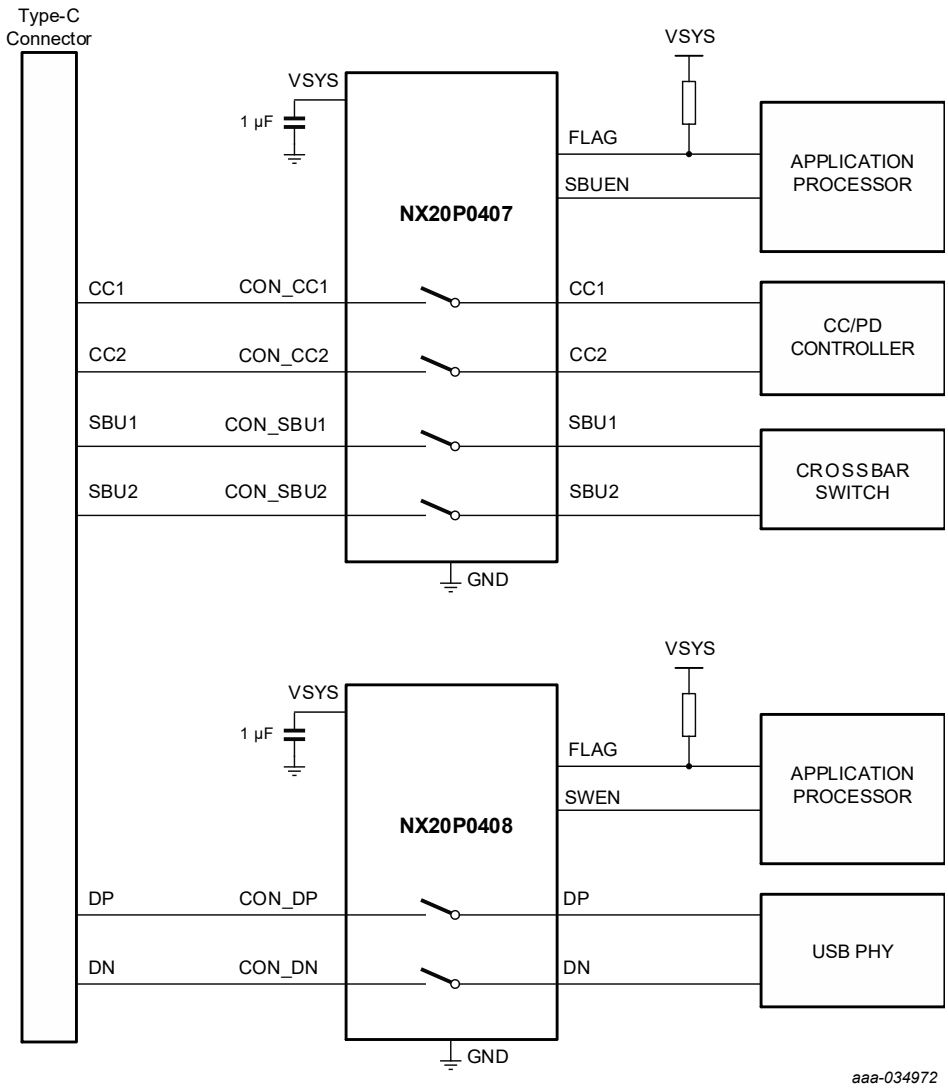


Figure 4. NX20P0408 application diagram

7.1 Power status

When VSYS is below $V_{SYSUVLO}$, NX20P0408 stays in shutdown mode, where bias, switches and all comparators are disabled.

NX20P0408 enters standby mode when VSYS exceed $V_{SYSUVLO}$. USB switch is controlled by SWEN.

Table 4. Power state

Power state	VSYS	Flag	SWEN	USB Switch
Dead battery	< $V_{SYSUVLO}$	Hi-Z	x	OFF
Power ON_A	> $V_{SYSUVLO}$	Hi-Z	LOW	OFF
Power ON_B	> $V_{SYSUVLO}$	Hi-Z	HIGH	ON

7.2 Overvoltage protection

NX20P0408 has short circuit protection of CON_DP and CON_DN up to 28V. USB switch overvoltage threshold is V_{OVP} to secure turn the switch off and prevent high voltage to USB phy 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 DP and DN has its own OVP comparator and is controlled by its comparator independently. If DP voltage exceeds OVP threshold, the DP switch is turned off, but the other switches stay ON.

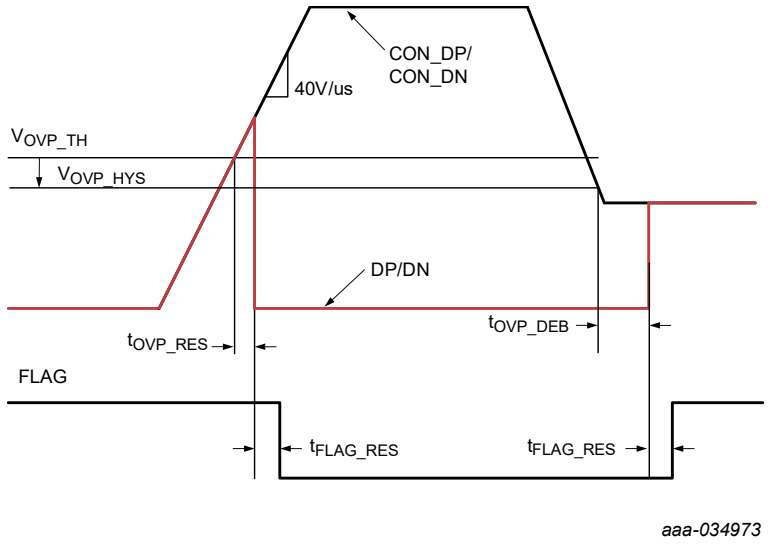


Figure 5. Overvoltage protection timing

7.3 Post-stage clamp circuit

NX20P0408 has a post-stage clamp circuit to clamp extra voltage on DP and DN in system side. When shorting with VBUS, the voltage on CON_DP and CON_DN is

rapidly increased. Even though NX20P0408 features super fast response for overvoltage condition, the overvoltage may pass through to DP/DN for the response time, 70ns. NX20P0408 post-stage clamp circuit is second protection to clamp the voltage on DP/DN in system side not to exceed Clamping voltage, 7V.

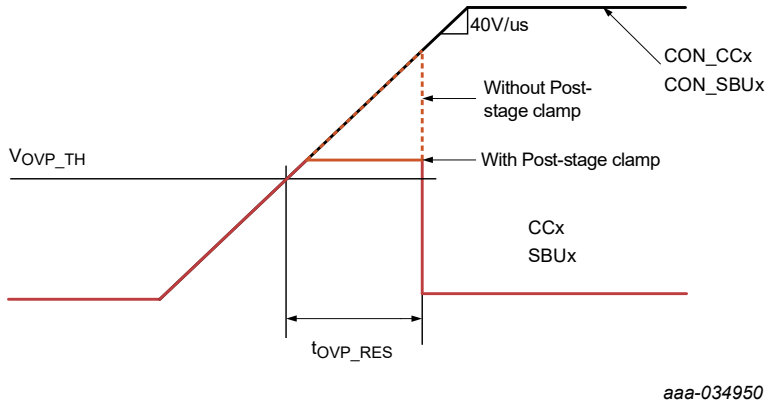


Figure 6. Post-stage clamp operation

7.4 Flag

The 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 NX20P0408 fault conditions and its behavior.

Table 5. Fault conditions and behavior

Fault	Condition	SWEN	Flag	USB Switch
Thermal Warning	$Tj > T_{OTP}$	LOW	LOW	OFF
Thermal Warning	$Tj > T_{OTP}$	HIGH	LOW	ON
OVP	$V_{CON\_Dx} > V_{OVP}$	LOW	Hi-Z	OFF
OVP	$V_{CON\_Dx} > V_{OVP}$	HIGH	LOW	OFF

7.5 Switch

NX20P0408 has a pair of USB switches controlled by SWEN when SYS power is valid. The switch bandwidth is 1.5GHz so that it can be used to protect USB D+/D- from overvoltage.

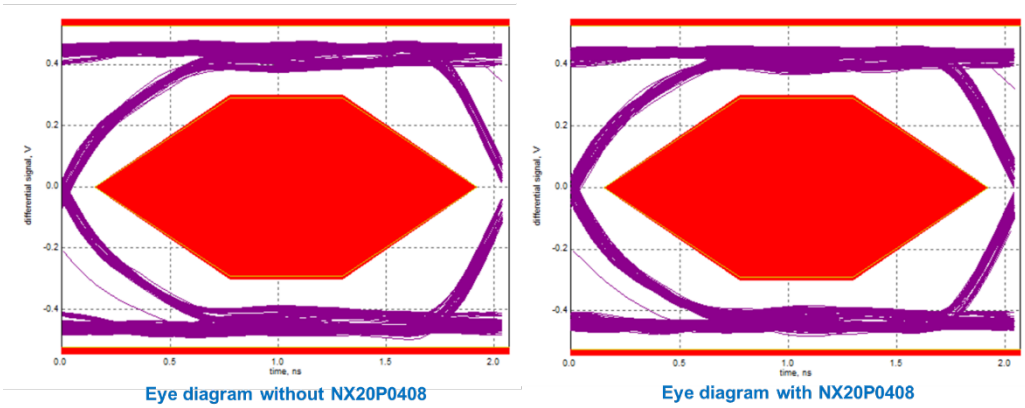


Figure 7. USB high speed eye diagram of USB switch

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_DP, CON_DN	-0.5	28	V
		DP, DN	-0.5	6	V
V_I	input voltage	VSYS	-0.5	6	V
V_O	output voltage	FLAG	-0.5	6	V
I_O	output current	CON_DP, CON_DN, DP, DN	-100	+100	mA
T_j	junction temperature		-40	+135	°C
V_{ESD}	electrostatic discharge voltage	HBM (JESD22-001)	-2	+2	kV
		CDM (JESD22-C101E)	-500	+500	V

9 Recommended operating conditions

Table 7. Recommended operating conditions

Symbol	Parameter	Conditions	Min	Max	Unit
V_{IO}	input/output voltage	DP, DN, CON_DP, CON_DN	0	4.5	V
V_I	input voltage	SWEN	0	5.5	V
		VSYS	2.5	5.5	V
V_O	output voltage	FLAG	0	5.5	V
T_{amb}	ambient temperature		-40	85	°C

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, SWEN = 0V		32	55.5	µA
		V_{SYS} = 3.6V, SWEN = 3.6V		105	170	µA
I_{Leak}	Leakage current for DP/DN pins	V_{SYS} = 3.6V, $V_{DP/DN}$ = 3.6V, CON_DP/DN floating			1	µA
USB switcher						
R_{on}	On resistance	V_{SYS} = 3.6V, SWEN = HIGH, DP/DN= 3.6V	-	3.6	5.4	Ω
R_{on_Flat}	On resistance flatness	Sweep DP/DN voltage between 0V and 3.6V		30	150	mΩ
V_{OVP}	OVP threshold on CON_DP/DN	V_{SYS} = 3.6V, SWEN = HIGH, rising	4.6	4.8	5.0	V
V_{OVP_hys}	OVP threshold hysteresis			100		mV
C_{on}	Equivalent on capacitance	Capacitance between Dx / CON_Dx and GND when Powered up. $V_{DP/DN}$ = 0V to 1.2V, f = 240MHz		4.5		pF
BW	3dB Bandwidth	Single ended, 50Ω termination, $V_{DP/DN}$ = 0.1V to 1.2V		1500		MHz
XTALK	Crosstalk	Swing 1Vpp at 10MHz, measure the other channels with 50mΩ termination		-84		dB

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{CLAMP}	Clamp voltage on system side	Hot plug voltage CON_Dx = 22V. load 150nF cap and 40Ω in series to GND on DP/DN		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
SWEN						
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
T_{OTP_hys}	Over temperature Flag hysteresis		-	10	-	°C

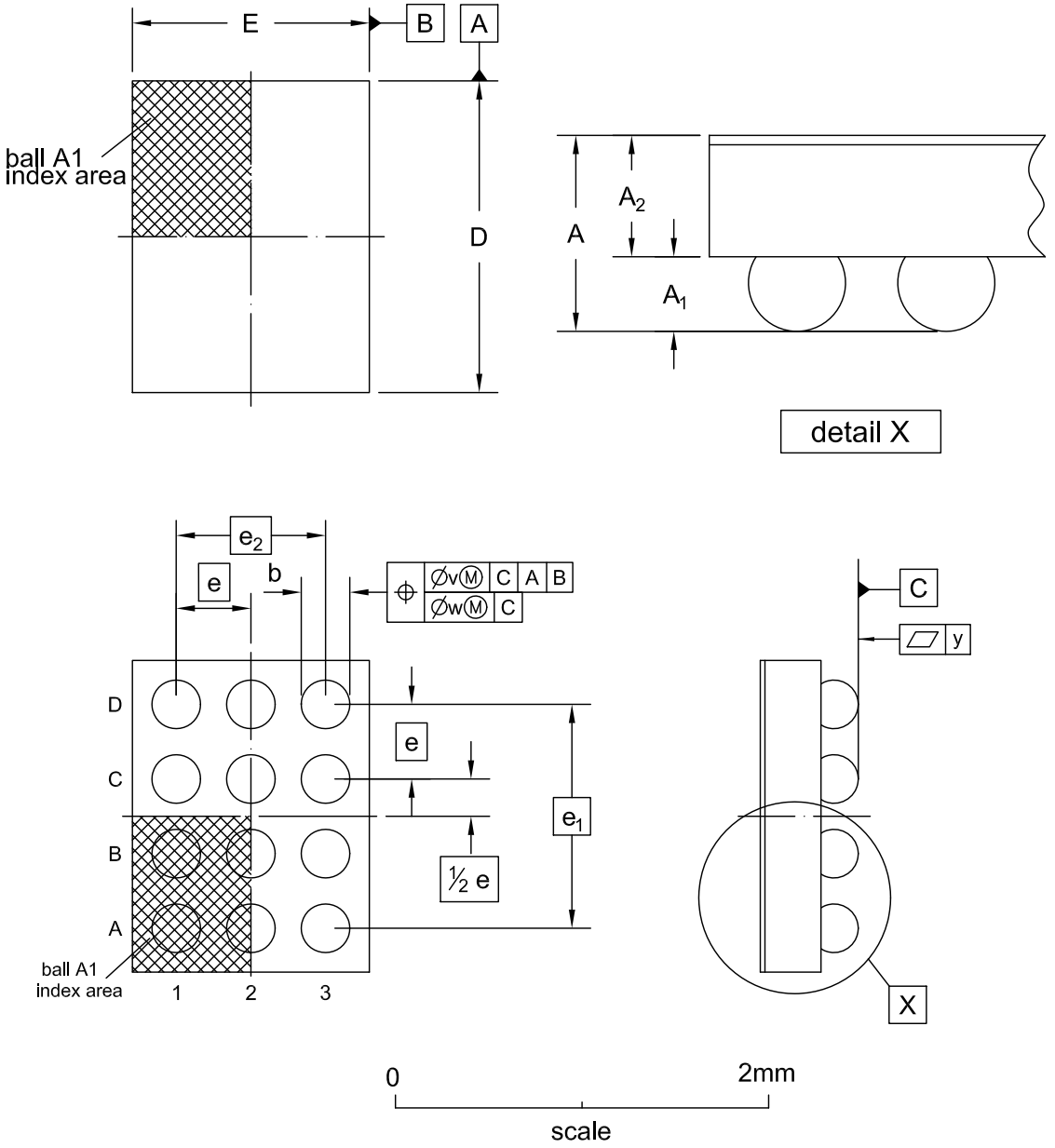
11.2 Dynamic characteristics

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

12 Package outline



DIMENSIONS (mm are the original dimensions)

UNIT		A	A_1	A_2	b	D	E	e	e_1	e_2	v	w	y
mm	MAX.	0.565	0.23	0.350	0.29	1.70	1.30						
	NOM.	0.525	0.20	0.325	0.26	1.67	1.27	0.4	1.2	0.8	0.05	0.02	0.03
	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
NX20P0408 v.1.1	20190819	Product data sheet	-	NX20P0408 v.1.0

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.
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[2] The term 'short data sheet' is explained in section "Definitions".
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