AN14356

NX48P0407 application note

Rev. 1.0 — 26 August 2024 **Application note**

Document information

Information	Content
Keywords	NX48P0407, USB Type C, CC1/2 and SBU1/2 Protection
Abstract	The NX48P0407 is a CC and SBU protection IC, which can protect the short-to-VBUS damage on CC and SBU pins of Type-C by ultra-fast response of overvoltage protection detection.

1 Scope and setup of the application note

1.1 Scope

This application note discusses the NX48P0407 functions for general applications and the notes when testing this device.

1.2 General setup of the application note

The setup of this document is made in such a way, that a chapter or paragraph on a selected subject can be read as a stand-alone explanation with a minimum of cross-references to other document parts or the datasheet. This will lead to some repetition of information with in the application note and to descriptions or figures that are similar to the ones published in the NX48P0407 datasheet. In most cases typical values are given to enhance the readability.

- Chapter 2: Introduction and features
- Chapter 3: IC pin overview with a summary of the functions
- Chapter 4: Application diagram
- Chapter 5: System description
- Chapter 6: Debugging an application circuit
- Chapter 7: optional circuits and application tricks
- Chapter 8: PCB design and layout guidelines

1.3 Related documents and tools

More documents and design tools can be found at the product page of NX48P0407 or through the local sales office.

2 Introduction

2.1 Introduction

NX48P0407 is a single chip USB-Type C port protection solution. CC1/CC2 and SBU1/SBU2 pins in the system side are protected from 48 V short to VBUS, which are located next to the VBUS pins.

2.2 Features

The NX48P0407 is a CC and SBU protection IC which can protect the short-to-VBUS damage on CC and SBU pins of Type-C by ultra-fast response of over voltage protection detection. USB Type-C allows VBUS voltage to increase up to 48 V through PD 3.1 protocol. CC1/2 and SBU1/2 pins can be shorted to VBUS of 48 V 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 48 V VBUS pin to be shorted to adjacent pins.

The NX48P0407 integrates IEC 61000-4-2 ESD protection on CON_CC1 and CON_CC2,+/-15 kV air discharge and +/-8 kV contact discharge, which helps to reduce external BOM cost. NX48P0407 CON_CC1/2 and CON_SBU1/2 pins are designed to be protected from surges up to +80 V.

2.2.1 Key features

- Type-C 48 V short-to-VBUS protection
  - CON_CC1/CON_CC2: up to 60 V_{DC}
  - CON_SBU1/CON_SBU2: up to 60 V_{DC}
- Dead-battery mode Rd integrated on CON_CCx
- Low RON for OVP FET paths
  - CC OVP Switch: 250 mΩ
  - SBU OVP Switch: 3.6 Ω

  Robust IEC-61000-4-2 ESD protection
  - Contact discharge +/-8 kV: CON_CCx/CON_SBUx
  - Air discharge +/-15 kV: CON_CCx/CON_SBUx
- Low standby quiescent current of CC path: ~40 µA
- Fast OVP turn off time: 60 ns
- HVQFN16 package
- USB-PD EPR application
- Laptop, notebook, computing PC

3 Pinning information

3.1 Pinning

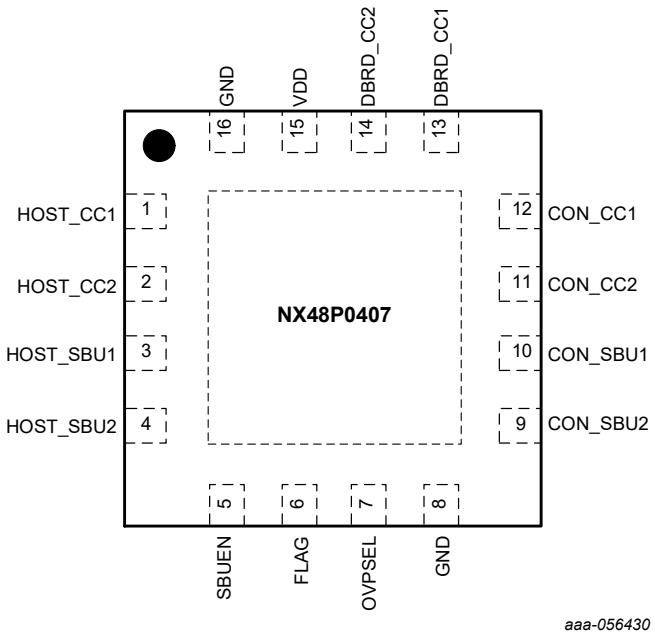


Figure 1. HVQFN16 – top view

3.2 Pin description

Table 1. Pin type definition

Pin type	Description	Pin type	Description	Pin type	Description
PI	Power Input	AO	Analog Output	DIO	Digital Input/ Output
PO	Power output	AIO	Analog Input/Output	AG	Analog Ground
PIO	Power Input/Output	DI	Digital Input	PG	Power Ground
AI	Analog Input	DO	Digital Output		

Table 2. Pin description

Pin name	Pin number	Type	Description
HOST_CC1	1	P/AIO	System side CC1. Connect CC1 of USB CC/PD controller.
HOST_CC2	2	P/AIO	System side CC2. Connect CC2 of USB CC/PD controller.
HOST_SBU1	3	A/DIO	System side SBU1.
HOST_SBU2	4	A/DIO	System side SBU2.
SBUEN	5	DI	SBU switch enable/disable control pin. SBUEN is driven HIGH to enable SBU switch. (1.8 MΩ Internal pull-down resistor)

Table 2. Pin description...*continued*

Pin name	Pin number	Type	Description
FLAG	6	DO	Open-drain output indicating fault condition. Low when Fault condition happens, external pull-up resistor is required.
OVPSEL	7	DI	For SBU OVP SEL of options
GND	8	AG	Ground
CON_SBU2	9	A/DIO	Type-C connector side SBU2. Connect SBU2 of Type-C USB connector.
CON_SBU1	10	A/DIO	Type-C connector side SBU1. Connect SBU2 of Type-C USB connector.
CON_CC2	11	P/AIO	Type-C connector side CC2. Connect CC2 of Type-C USB connector.
CON_CC1	12	P/AIO	Type-C connector side CC1. Connect CC2 of Type-C USB connector.
DBRD_CC1	13	AG	Dead-Battery Mode RD of CC1.
DBRD_CC2	14	AG	Dead-Battery Mode RD of CC2.
VDD	15	PI	Power supply input; connect System voltage and bypass 1µF capacitor to GND.
GND	16	AG	Ground.

4 Application diagram

NX48P0407 is placed in front of Type-C connector and protects CC and SBU pins in System side from 48 V VBUS short, ESD and surge.

NX48P0407 has DBRD circuit on both CON_CC1 and CON_CC2 when VDD is below UVLO threshold, i.e., dead battery condition. It allows Type-C adapter to detect sink through CC and start providing 5 V VBUS. Main charger regulates system voltage from the VBUS. Once VDD comes up, NX48P0407 enables switches and disconnects the DBRD circuit from CON_CC1 and CON_CC2.

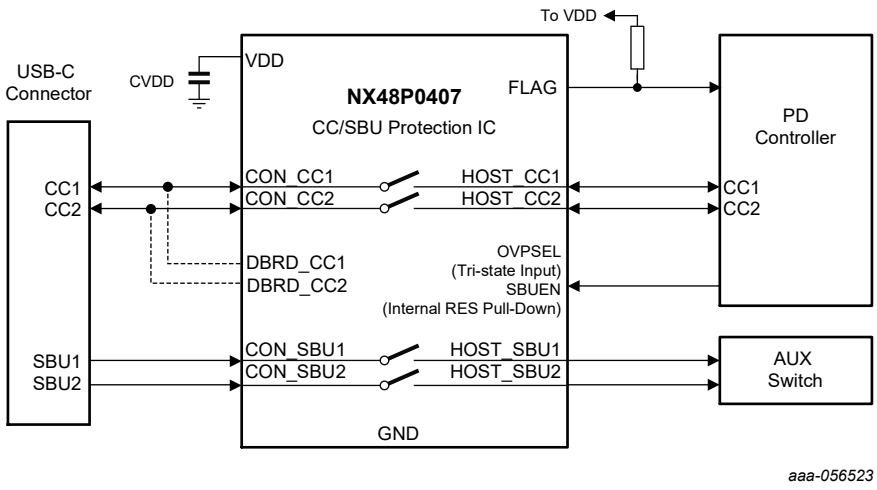


Figure 2. Application diagram

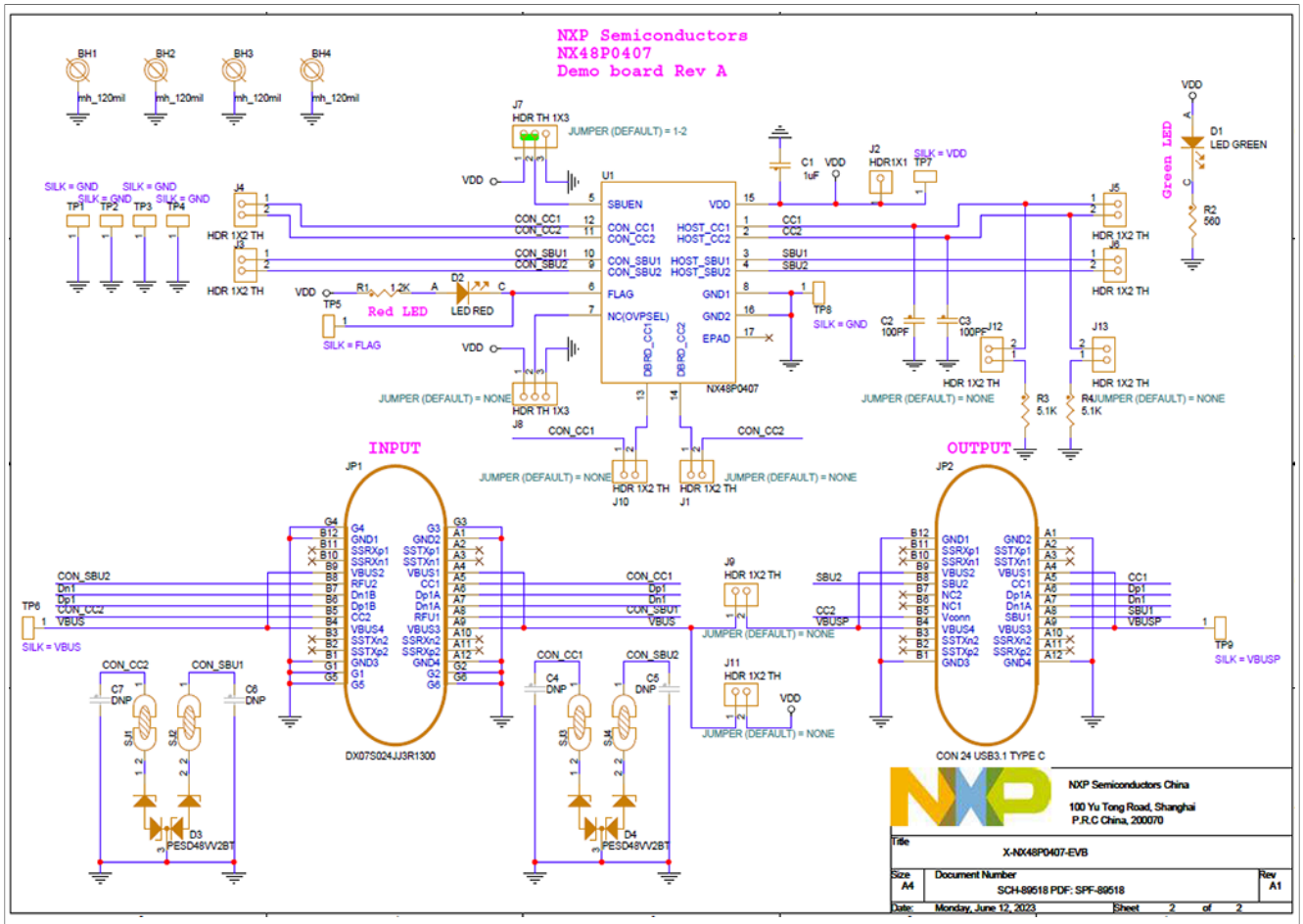


Figure 3. NX48P0407 application schematic

5 System description

5.1 Power state table

When VDD is below VDDUVLO, NX48P0407 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 5 V through VBUS pin in dead battery condition.

NX48P0407 enters standby mode when VDD exceeds VDDUVLO. CC switch automatically turns on and SBU switch is controlled by SBUEN. After CC switch is fully turned ON, the Rd clamp circuit is disabled. 5 V VCONN power supply on HOST_CC1 or _HOST_CC2 should be supplied after VDD is valid.

Table 3. Power states

Power states	VDD	FLAG	SBUEN	Dead Battery-Rd	CC Switch	SBU Switch
Dead-Battery Mode	< VDDUVLO	Hi-Z	X	ON	OFF	OFF
Power ON_CC	> VDDUVLO	Hi-Z	Low	OFF	ON	OFF
Power ON_CC/ SBU	> VDDUVLO	Hi-Z	High	OFF	ON	ON

5.2 Protection

5.2.1 Overvoltage protection

NX48P0407 has short circuit protection of CON_CC1/2 and CON_SBU1/2 when they are shorted by 48 V. CC switch overvoltage threshold is V_{OVP_CC} to guarantee VCONN power supply passes to VCONN load, which is maximum 5.5 V by USB Type-C spec. SBU switch overvoltage threshold is V_{OVP_SBU} 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. Refer to Figure 5.

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.

5.2.2 Post-clamping protection

NX48P0407 has a post-clamping protection to clamp extra voltage on HOST_CC1/CC2, HOST_SBU1/SBU2 in system side. When shorting with VBUS, the voltage on CON_CCx and SBU_CCx is rapidly increased. Even though NX48P0407 features ultra-fast response time for overvoltage condition, the overvoltage may pass through to HOST_CCx / HOST_SBUx during the response time, t_{OVP_RES}. NX48P0407 post-clamping circuit provides secondary protection to clamp the voltage on HOST_CCx and HOST_SBUx in system side, to prevent exceeding 7V in HOST_CCx and 7 V or 4.5 V in HOST_SBUx by OVPSEL settings.

5.2.3 Undervoltage protection

When VDD voltage exceeds UVLO threshold, NX48P0407 behaves in normal, dead-battery mode. Rd will be removed with a delay time after CC OVP switch turns on. Otherwise, NX48P0407 will be operating in dead-battery mode and present dead-battery mode Rd on CON_CC1 and CON_CC2 pin.

5.2.4 Overtemperature protection

When NX48P0407 operates in normal power on mode, OTP detection circuit is active for monitoring if device temperature exceeds 140 °C. Once OTP occurs, the CC OVP switch will always turn on while FLAG will be asserted to Low and it turns to Hi-Z until temperature goes back to 120 °C.

5.2.5 IEC-61000-4-2 contact ESD protection

NX48P0407 integrates IEC-61000-4-2 ESDs on CON_CCx and CON_SBUx up to contact +/-8 kV in CC channels and +/- 8 kV in SBU channels as well, and Air +/- 15 kV to help to reduce the external BOM in USB-C CC/SBU signal path design.

5.2.6 IEC-61000-4-5 surge protection

NX48P0407 integrates IEC-61000-4-5 TVSs on CON_CCx and CON_SBUx up to +80 V to help to reduce the external BOM in USB-C CC/SBU signal path design.

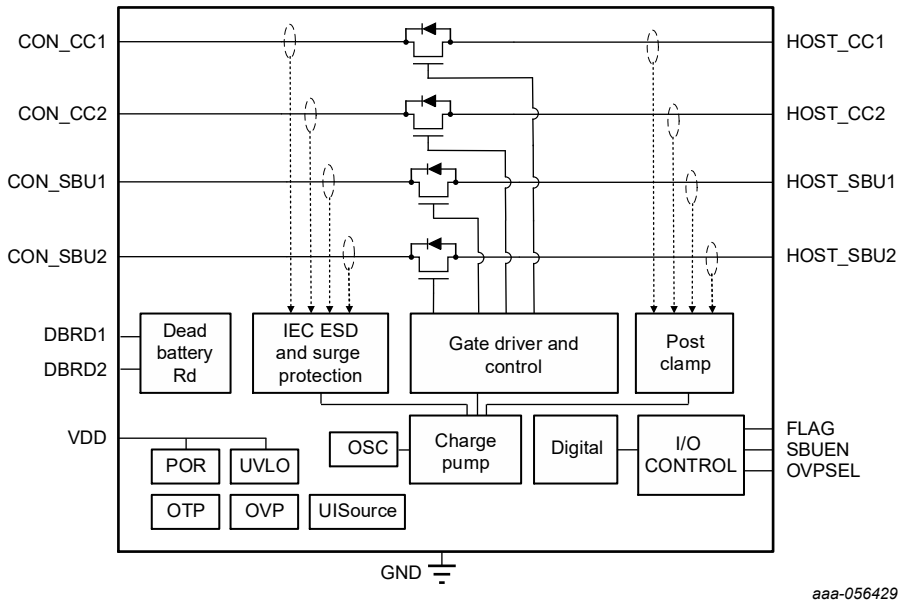


Figure 4. NX48P0407 block diagram

6 Debugging an application circuit

6.1 FLAG Function

6.1.1 FLAG signal

FLAG pin is open-drain configuration. When there is no any protection event like OVP or OTP, it behaves as Hi-Z state. If FLAG is not used in system, leave it floating or connected to GND. When OVP or OTP occurs, FLAG asserts “LOW” state after the delay of t_{FLAG_RES}.

6.1.2 FLAG and switch condition during protections

NX48P0407 performs different kinds of behavior during OTP and OVP in CC or SBU channel. Please refer to Table 4 for the operation.

Table 4. NX48P0407 protection condition and behaviors of FLAG and switch configuration

Protection	Condition	SBUEN	FLAG	CC OVP switch	SBU OVP switch
Overtemperature	Tj > TOTP	LOW	LOW	ON	OFF
Overtemperature	Tj > TOTP	HIGH	LOW	ON	ON
Overvoltage on CON_CCx	VCON_CCX > VOVPCC	LOW	LOW	OFF	OFF
Overvoltage on CON_CCx	VCON_CCX > VOVPCC	HIGH	LOW	OFF	ON
Overvoltage on CON_SBUx	VCON_SBUX > VOVPSBU	LOW	Hi-Z	ON	OFF
Overvoltage on CON_SBUx	VCON_SBUX > VOVPSBU	HIGH	LOW	ON	OFF

6.2 SBUEN function

When SBUEN=High, SBU OVP path is turned on, otherwise, the path is OFF. SBUEN has internal pull down of 1.8 MΩ. SBUEN is also capable of 1.2/1.8/3.3 V control signal by PD Controller, MCU or other CPUs.

6.3 OVPSEL function

NX48P0407 can reverse several OVP thresholds of SBU path for different kinds of signaling. Please refer to Table 5.

Table 5. NX48P0407 protection condition and behaviors of FLAG and switch configuration

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
SBU OVP Switch						
VOVP_SBU	OVP Threshold on CON_SBUx	VDD = 3.3 V, VCON_SBUx rising, SBUEN=High, OVPSEL=VDD	3.50	3.65	3.80	V
		VDD = 3.3 V, VCON_SBUx rising, SBUEN=High, OVPSEL=GND	3.65	3.85	4.05	V

Table 5. NX48P0407 protection condition and behaviors of FLAG and switch configuration*...continued*

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
		VDD = 3.3 V, VCON_SBUx rising, SBUEN=High, OVPSEL=floating	4.15	4.35	4.55	V
VCLAMP_HOST_SBUx	Clamp voltage on system side	Hot plug voltage on CON_SBUx =48 V with load of 150nF cap and 40 Ω in series to GND on HOST_ SBUx with 40 V/us, for OVPSEL=Floating		7		V
		Hot plug voltage on CON_SBUx =48 V with load of 150nF cap and 40 Ω in series to GND on HOST_ SBUx with 40 V/us, for OVPSEL=VDD or GND		4.5		V

7 Optional circuit and application tricks

7.1 Overvoltage protection

NX48P0407 has short circuit protection of CON_CC1/2 and CON_SBU1/2 up to 48 V. CC switch overvoltage threshold is maximum 6 V. SBU switch overvoltage threshold determined of OVPSEL setting.

Figure 5. NX48P0407 CON_CC OVP test

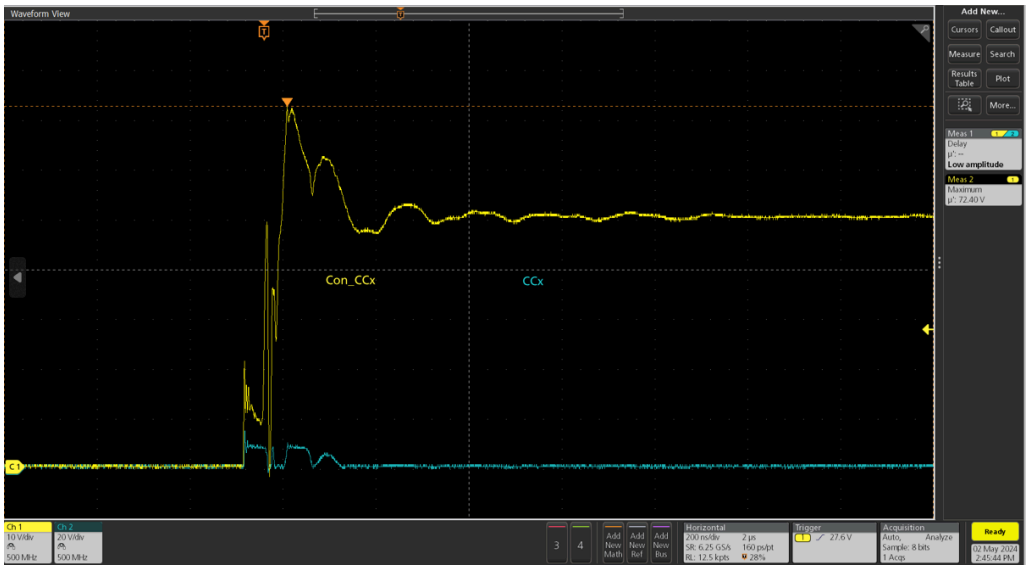


Figure 6. NX48P0407 CON_CC Hot_plug test

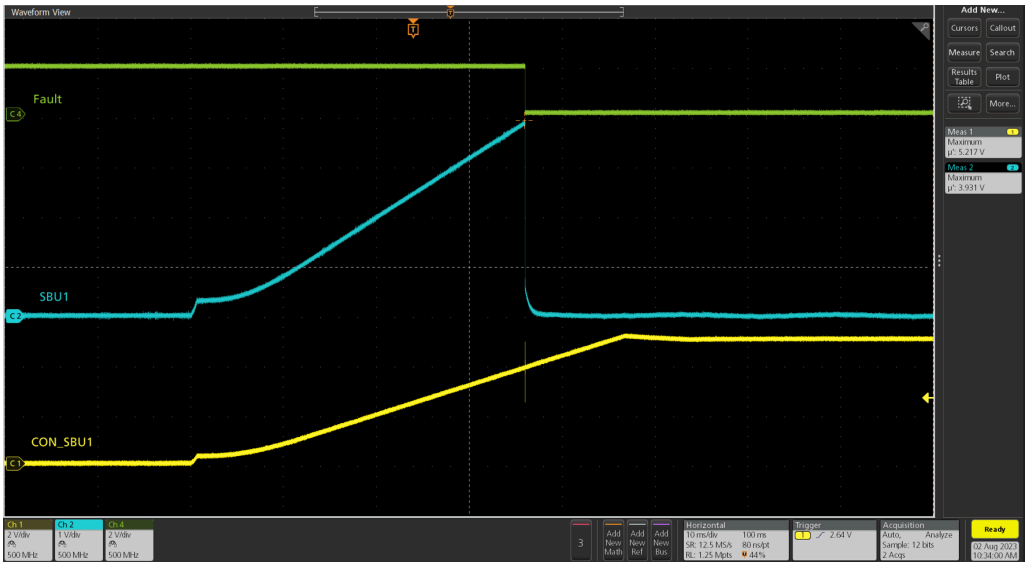


Figure 7. NX48P0407 CON_SBU test (OVPSEL=LOW)

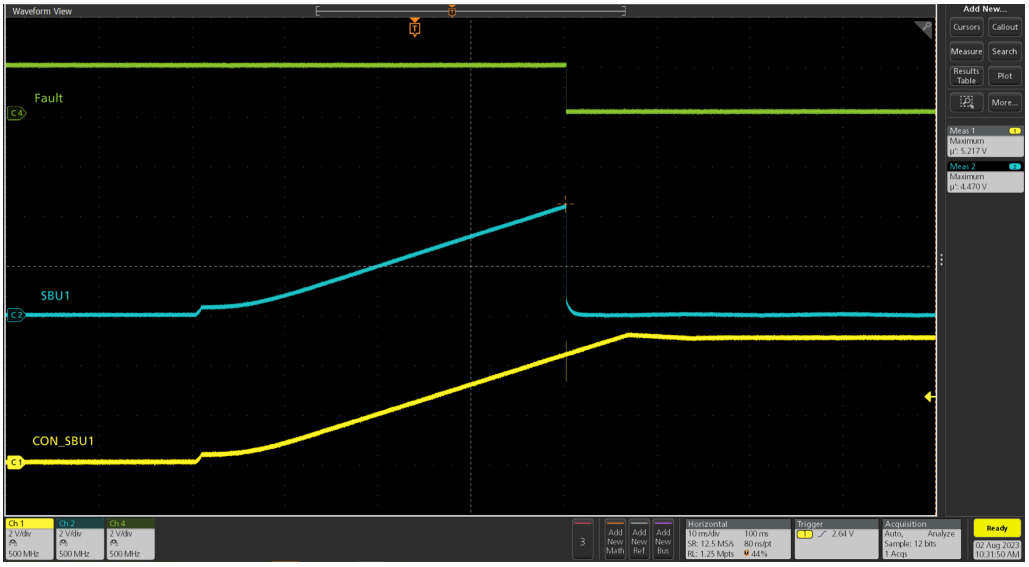


Figure 8. NX48P0407 CON_SBU test (OVPSEL=Floating)

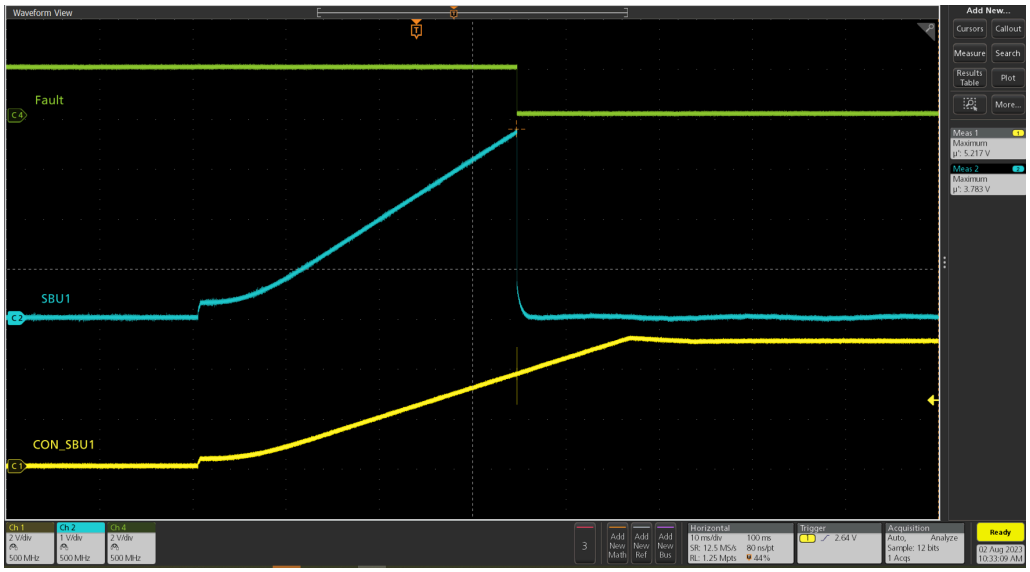


Figure 9. NX48P0407 CON_SBU test (OVPSEL=High)

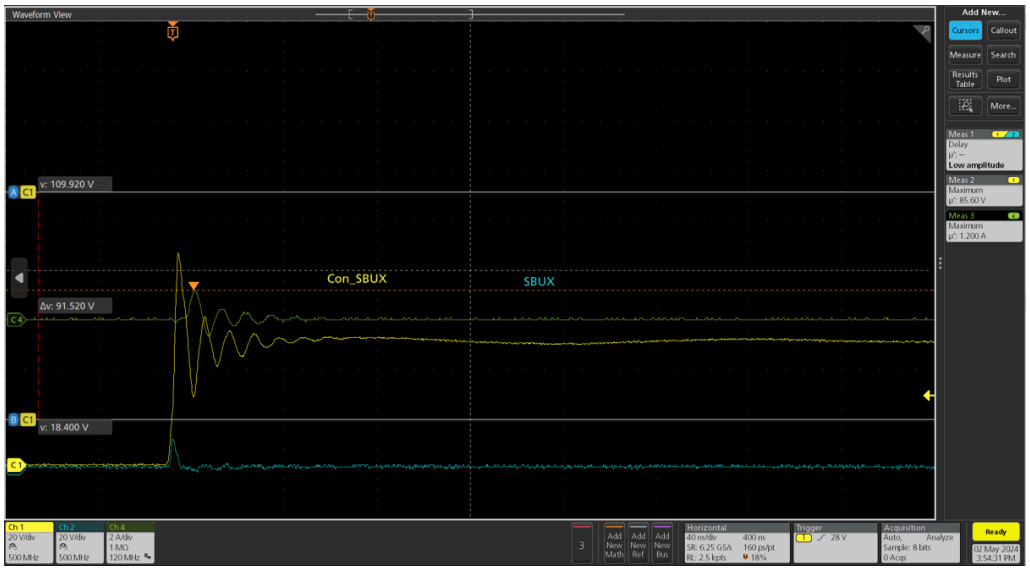


Figure 10. NX48P0407 CON_SBU Hot_plug test

7.2 Hot-plug protection of 48 V touch

NX48P0407 can pass the 48 V hot-plug testing, with the system parameters of hot-plug condition below:

- Source capacitance from 10 μF to 3500 μF
- Source resistance to GND with minimum of 72.5 kΩ.
- USB-C resistance of VBUS path from 100 mΩ to 500 mΩ.
- USB-C resistance of GND path from 50 mΩ to 250 mΩ,
- CON_CCx capacitance for USB-PD Spec from 0 pF to 600 pF

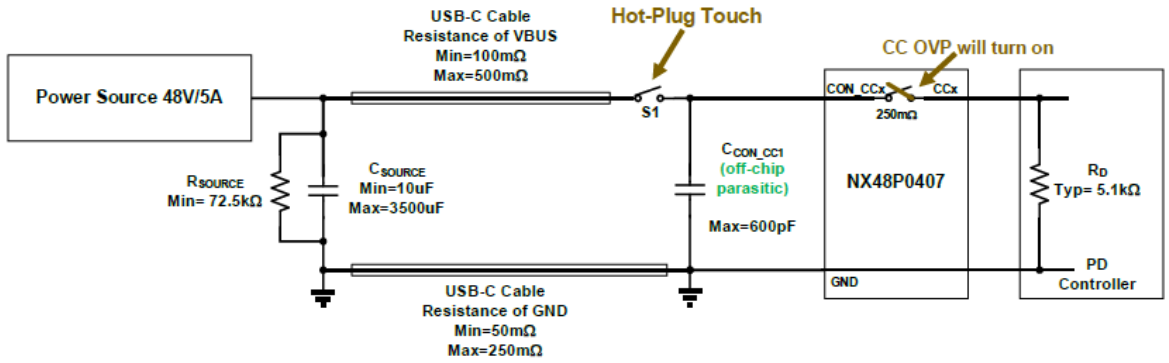


Figure 11. VBUS hot-plug system setup

8 PCB design and layout guidelines

8.1 Recommend capacitances

1. The capacitances of VDD should be as close as possible to NX48P0407.
2. The recommended capacitance value for VDD is 1 µF.

8.2 Recommend layout guide for no HDI PCB

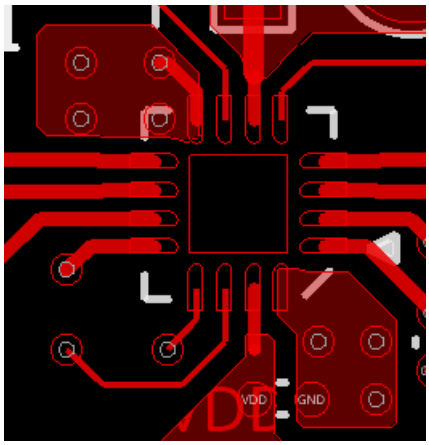
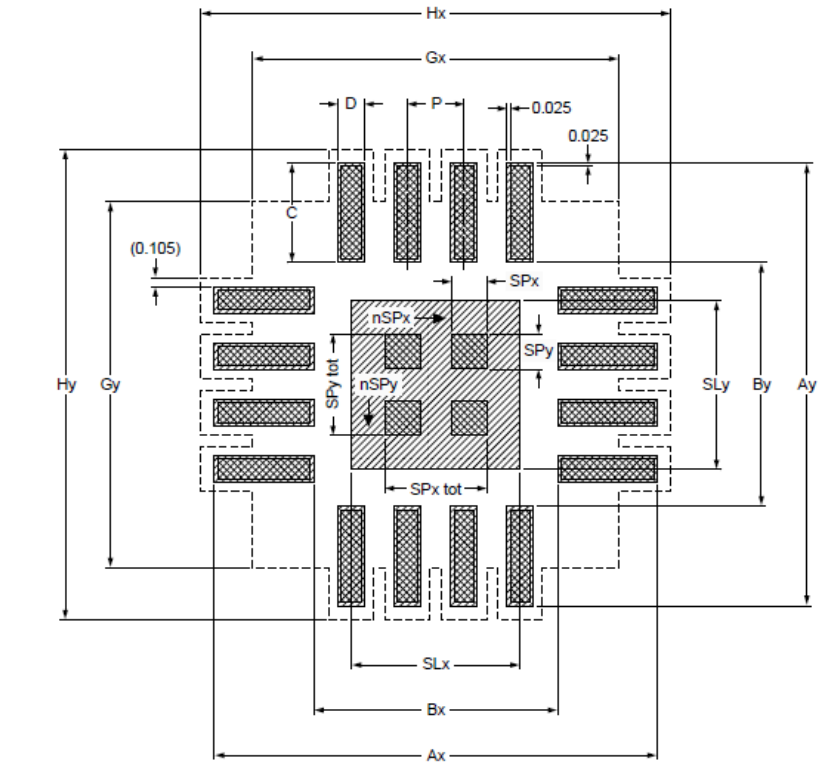


Figure 12. Recommended layout

8.3 Soldering

Footprint information for reflow soldering



nSPx	nSPy
2	2

Dimensions in mm

P	Ax	Ay	Bx	By	C	D	SLx	SLy	SPx tot	SPy tot	SPx	SPy	Gx	Gy	Hx	Hy
0.50	4.00	4.00	2.20	2.20	0.90	0.24	1.50	1.50	0.90	0.90	0.30	0.30	3.30	3.30	4.25	4.25

Figure 13. Reflow soldering footprint

9 Revision history

Table 6. Revision history

Document ID	Release date	Description
AN14356 v.1.0	26 August 2024	• Initial version

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