

# NX5P1100

## Logic controlled high-side power switch

Rev. 1 — 21 March 2014

Product data sheet

## 1. General description

The NX5P1100 is an advanced power switch and ESD-protection device for USB OTG applications. It includes under voltage and over voltage lockout, over-current, over-temperature, reverse bias and in-rush current protection circuits. These circuits are designed to isolate a VBUS OTG voltage source from a VBUS interface pin automatically when a fault condition occurs. The device features two power switch terminals, one input (VINT) and one output (VBUS). It has a current limit input (ILIM) for defining the over-current and in-rush current limit. A voltage detect output (VDET) is used to determine when VINT is in the correct voltage range. An open-drain fault output ( $\overline{\text{FAULT}}$ ) indicates when a fault condition has occurred, and an enable input (EN) controls the state of the switch. When EN is set LOW the device enters a low-power mode, disabling all protection circuits except the undervoltage lockout. The low-power mode can be entered at anytime unless the over temperature protection circuit has been triggered.

Designed for operation from 3 V to 5.5 V, it is used in power domain isolation applications to protect from out of range operation. The enable input includes integrated logic level translation making the device compatible with lower voltage processors and controllers.

## 2. Features and benefits

- Wide supply voltage range from 3 V to 5.5 V
- 30 V tolerant on VBUS
- $I_{SW}$  maximum 1 A continuous current
- Very low ON resistance: 100 m $\Omega$  (maximum) at a supply voltage of 4.0 V
- Low-power mode (ground current 20  $\mu$ A typical)
- 1.8 V control logic
- Soft start turn-on slew rate
- Protection circuitry
  - ◆ Over-temperature protection
  - ◆ Over-current protection with low current output mode
  - ◆ Reverse bias current/Back drive protection
  - ◆ Overvoltage lockout
  - ◆ Undervoltage lockout
  - ◆ Analog voltage limited VBUS monitor path
- ESD protection:
  - ◆ HBM ANSI/ESDA/JEDEC JDS-001 Class 2 exceeds 2 kV
  - ◆ CDM AEC standard Q100-011 category C6 exceeds 1 kV
  - ◆ IEC61000-4-2 contact discharge exceeds 8 kV for pins VBUS, D-, D+ and ID
- Specified from -40 °C to +85 °C



### 3. Applications

- USB OTG applications

### 4. Ordering information

Table 1. Ordering information

Type number	Package			Version
	Temperature range	Name	Description	
NX5P1100UK	-40 °C to +85 °C	WLCSP12	wafer level chip-scale package; 12 bumps; 1.36 x 1.66 x 0.51 mm, 0.4 mm pitch (Backside coating included)	NX5P1100

### 5. Marking

Table 2. Marking codes

Type number	Marking code
NX5P1100UK	NX5PB

### 6. Functional diagram

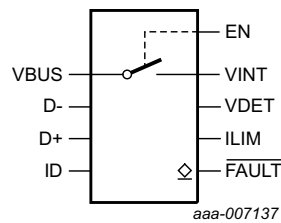


Fig 1. Logic symbol

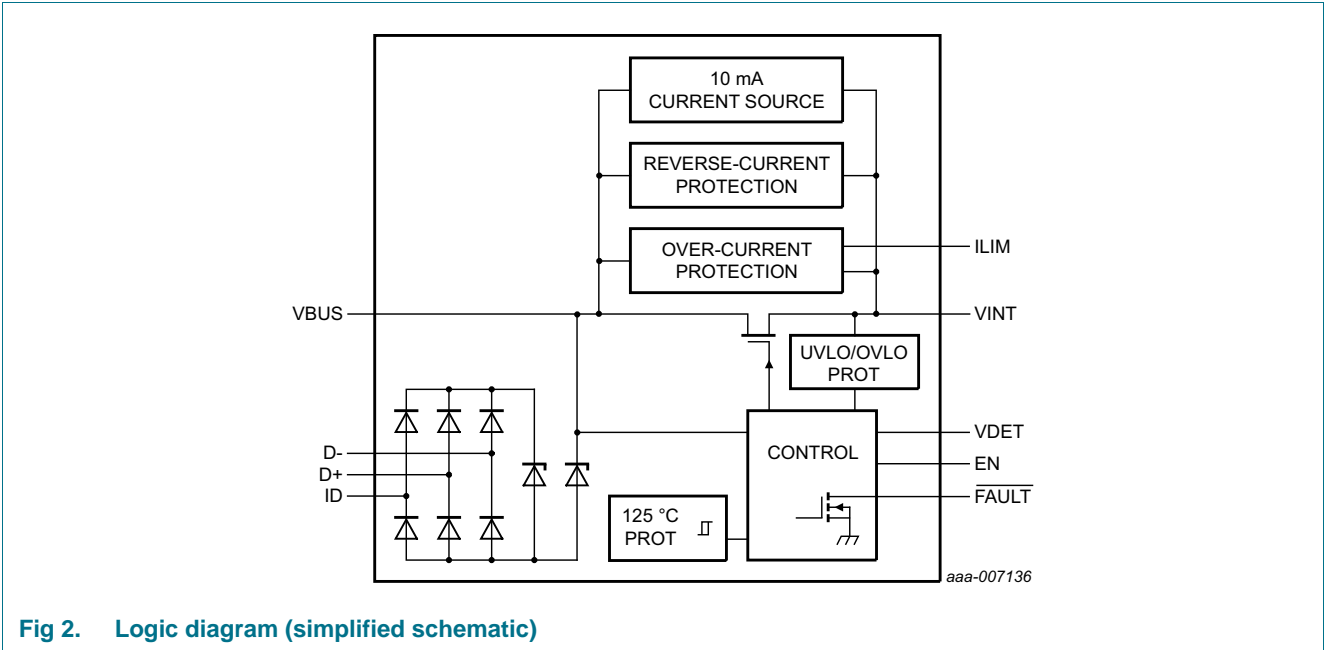


Fig 2. Logic diagram (simplified schematic)

## 7. Pinning information

### 7.1 Pinning

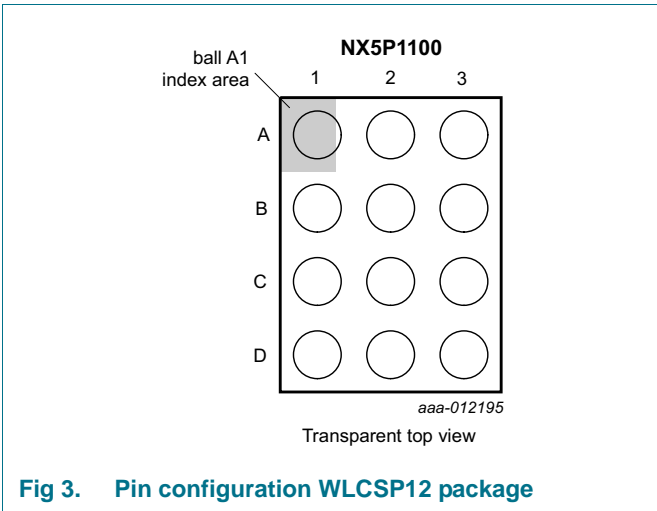


Fig 3. Pin configuration WLCSP12 package

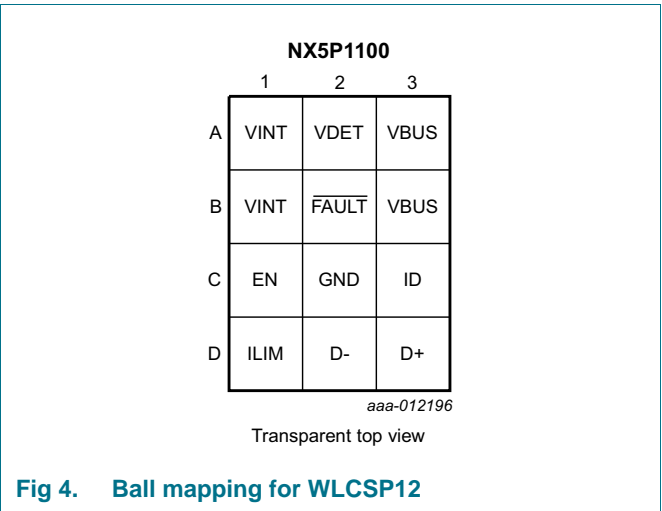


Fig 4. Ball mapping for WLCSP12

### 7.2 Pin description

Table 3. Pin description

Symbol	Pin	Description
VINT	A1, B1	internal circuitry voltage I
VBUS	A3, B3	external connector voltage O
EN	C1	enable input (active HIGH) I
ILIM	D1	current limiter I/O

Table 3. Pin description ...continued

Symbol	Pin	Description
VDET	A2	VBUS voltage level indicator O
$\overline{\text{FAULT}}$	B2	fault condition indicator (open-drain; active LOW)
GND	C2	ground (0 V)
D-	D2	ESD-protection I/O
D+	D3	ESD-protection I/O
ID	C3	ESD-protection I/O

## 8. Functional description

Table 4. Function table<sup>[1]</sup>

EN	VINT	VBUS	$\overline{\text{FAULT}}$	Operation mode
X	0 V	Z	L	no supply
X	0 V	< 30 V	Z	disabled; switch open
X	< 3.2 V	Z	L	undervoltage lockout; switch open
H	> 5.5 V	Z	L	overvoltage lockout; switch open
H	3.2 V to 5.5 V	Z	L	over-temperature; switch open
L	3.2 V to 5.5 V	Z	Z	disabled; switch open
H	3.2 V to 5.5 V	VBUS = VINT	Z	enabled; switch closed; active
H	3.2 V to 5.5 V	0 V to VINT	L	over-current; switch open; constant current on VBUS
H	3.2 V to 5.5 V	0 V to VINT	L	when ILIM is connected to GND, VBUS is supplied with 10 mA current source
H	3.2 V to 5.5 V	$\text{VINT} + 30 \text{ mV} < \text{VBUS} < \text{VINT} + 0.45 \text{ V} (> 4 \text{ ms})$	L	reverse bias current/back drive; switch open
H	3.2 V to 5.5 V	$\text{VBUS} > \text{VINT} + 0.45 \text{ V}$	L	reverse bias current/back drive; switch open

[1] H = HIGH voltage level; L = LOW voltage level, Z = high-impedance OFF-state, X = Don't care.

Table 5. Function table VDET versus VBUS

VBUS	VDET	Operation mode
$3 \text{ V} < \text{VBUS} < 30 \text{ V}$	$1.5 < \text{VDET} < 5.5 \text{ V}$	VDET detects VBUS voltage; See <a href="#">Figure 22</a> .

### 8.1 EN input

A LOW on EN disables the N-channel MOSFET and the device enters low-power mode. In low-power mode, all protection circuits are disabled except for the undervoltage lockout circuit. A HIGH on EN, enables the protection circuits and then enables the N-channel MOSFET.

### 8.2 $\overline{\text{FAULT}}$ output

The  $\overline{\text{FAULT}}$  output is an open-drain output that requires an external pull-up resistor. If any of the UVLO, OVLO, RCP, OCP or OTP circuits are activated the  $\overline{\text{FAULT}}$  output is set LOW. A LOW indicates that a fault has occurred. The  $\overline{\text{FAULT}}$  output returns to the high impedance state automatically once the fault condition is removed.

### 8.3 VDET output

VDET is an analog output that allows a controller to monitor the voltage level on VBUS.

### 8.4 Undervoltage lockout (UVLO)

When  $V_{INT} < 3.2$  V, the UVLO circuit is triggered. It disables the N-channel MOSFET sets the  $\overline{FAULT}$  output LOW and the device enters low-power mode. Once  $V_{INT} > 3.2$  V, the EN pin controls the state of the N-channel MOSFET. The UVLO circuit remains active in low-power mode.

### 8.5 Overvoltage lockout (OVLO)

When EN is HIGH and  $V_{INT} > 5.75$  V, the OVLO circuit is triggered. It disables the N-channel MOSFET and sets the FAULT output LOW. The OVLO circuit is disabled in low-power mode and does not influence the FAULT output state. If the OVLO circuit is triggered, setting the EN pin LOW returns the device to low-power mode.

### 8.6 Over-current protection (OCP)

If either of these two conditions occur for longer than 8 ms, the OCP circuit is triggered.

1. Current through the N-channel MOSFET exceeds  $I_{trig}$ .
2.  $VBUS < V_{INT} - 200$  mV.

During the 8 ms trigger delay, the maximum current is clamped at  $I_{ocp}$ . The OCP disables the N-channel MOSFET; supplies VBUS from the 10 mA current source ( $I_O$ ), and sets  $\overline{FAULT}$  LOW. When  $V_{INT} > V_{BUS} > V_{INT} - 200$  mV for 20  $\mu$ s, the OCP circuit is disabled. EN controls the state of the N-channel MOSFET, the 10 mA current source is disconnected and  $\overline{FAULT}$  is set high impedance. If the OCP circuit is active, setting the EN pin LOW returns the device to low-power mode. (see [Figure 23](#), [Figure 24](#), [Figure 25](#), [Figure 26](#))

### 8.7 ILIM

The OCP trigger value  $I_{trig}$ , is set using an external resistor  $R_{ILIM}$  connected to the ILIM pin (see [Figure 6](#)). When EN is HIGH and ILIM is grounded, VBUS is supplied by the 10 mA current source and  $\overline{FAULT}$  is set LOW.

### 8.8 Over-temperature protection (OTP)

When EN is HIGH, if the device temperature exceeds 125 °C, the OTP circuit is triggered. It disables the N-channel MOSFET and sets  $\overline{FAULT}$  LOW. Any transition on EN has no effect. Once the device temperature decreases to below 115 °C the device returns to the defined state. The OTP circuit is disabled in low-power mode. If the OTP circuit is active, setting the EN pin LOW does not return the device to low-power mode.

**8.9 Reverse bias current/back drive protection**

If either of these two conditions occur, the RCP circuit is triggered.

1.  $(V_{INT} + 30 \text{ mV}) < V_{BUS} < (V_{INT} + 0.45 \text{ V})$  for longer than 4 ms.
2.  $V_{BUS} > (V_{INT} + 0.45 \text{ V})$

It disables the N-channel MOSFET and sets  $\overline{\text{FAULT}}$  LOW. Once  $V_{BUS} < V_{INT}$  for longer than 4 ms the device returns to the defined state. If the RCP circuit is active, setting the EN pin LOW returns the device to low-power mode.

**8.10 In-rush current protection**

The N-channel MOSFET can be enabled via the EN pin or via a recovering fault condition. When enabled, the in-rush current protection circuit limits the current while  $V_{BUS}$  increases to  $V_{INT} - 200 \text{ mV}$ . The resistor connected to  $I_{LIM}$  determines the current limit. The in-rush current protection circuit is disabled in low-power mode.

**9. Application diagram**

The NX5P1100 typically connects a voltage source on  $V_{INT}$  to the  $V_{BUS}$  of a USB connector supporting USB3 OTG in a portable, battery operated device. The external resistor  $R_{ILIM}$  sets the maximum current limit threshold. The  $\overline{\text{FAULT}}$  signal requires an external pull-up resistor.

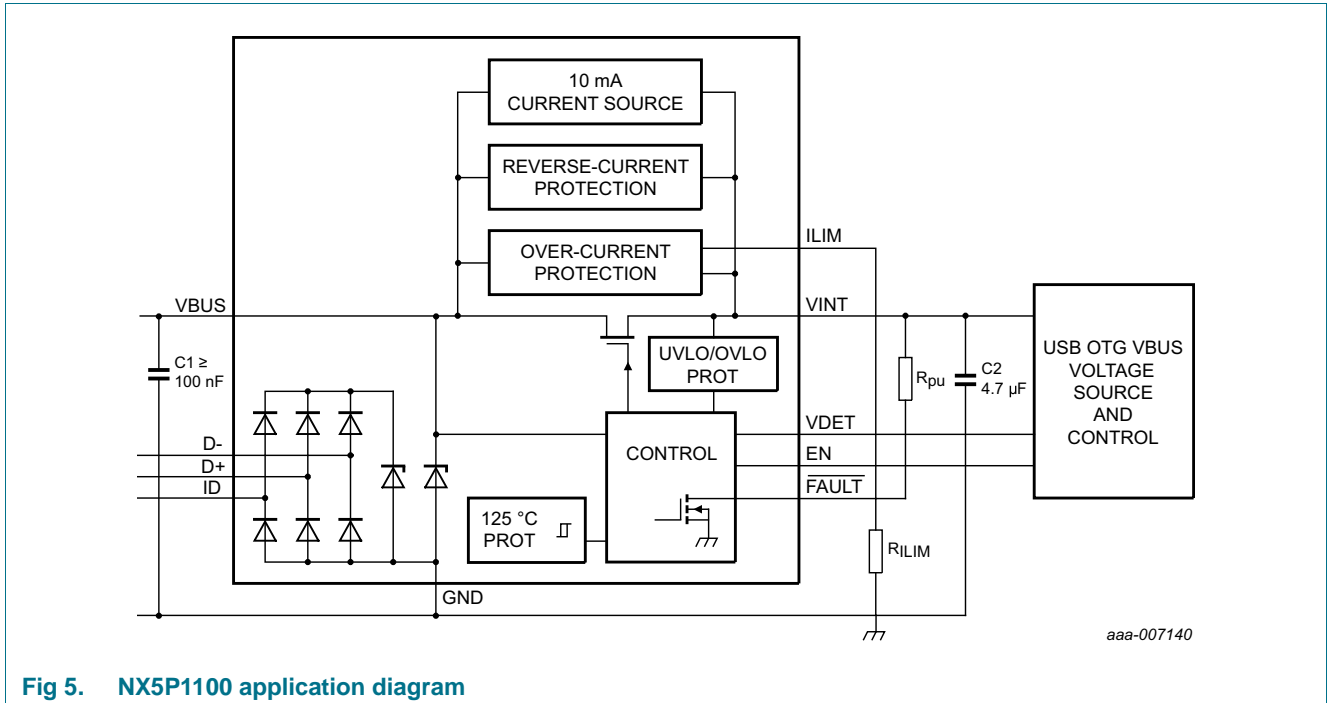


Fig 5. NX5P1100 application diagram

## 10. Limiting values

**Table 6. Limiting values**

In accordance with the Absolute Maximum Rating System (IEC 60134). Voltages are referenced to GND (ground = 0 V).

Symbol	Parameter	Conditions	Min	Max	Unit
V <sub>I</sub>	input voltage	VBUS <sup>[1]</sup>	-0.5	+32	V
		VINT <sup>[1]</sup>	-0.5	+6.0	V
		EN, ILIM <sup>[2]</sup>	-0.5	VINT + 0.5	V
		D-, D+, ID <sup>[1]</sup>	-0.5	+6.0	V
V <sub>O</sub>	output voltage	FAULT	-0.5	+6.0	V
I <sub>IK</sub>	input clamping current	EN: V <sub>I</sub> < -0.5 V	-50	-	mA
I <sub>SK</sub>	switch clamping current	VBUS; VINT; V <sub>I</sub> < -0.5 V	-50	-	mA
I <sub>SW</sub>	switch current	T <sub>amb</sub> = 85 °C	-	±1000	mA
T <sub>j(max)</sub>	maximum junction temperature		-40	+125	°C
T <sub>stg</sub>	storage temperature		-65	+150	°C
P <sub>tot</sub>	total power dissipation	<sup>[3]</sup>	-	100	mW

[1] The minimum and maximum switch voltage ratings may be exceeded if the switch clamping current rating is observed.

[2] The minimum input voltage rating may be exceeded if the input current rating is observed.

[3] The (absolute) maximum power dissipation depends on the junction temperature T<sub>j</sub>. Higher power dissipation is allowed at lower ambient temperatures. The conditions to determine the specified values are T<sub>amb</sub> = 85 °C and the use of a two layer PCB.

## 11. Recommended operating conditions

**Table 7. Recommended operating conditions**

Symbol	Parameter	Conditions	Min	Max	Unit
V <sub>I</sub>	input voltage	VINT	3.0	5.5	V
		EN, ILIM	0	VINT	V
V <sub>O</sub>	output voltage	VBUS; EN = LOW	0	30	V
V <sub>I/O</sub>	input/output voltage	D-, D+, ID	0	5.5	V
T <sub>amb</sub>	ambient temperature		-40	+85	°C

## 12. Thermal characteristics

**Table 8. Thermal characteristics**

Symbol	Parameter	Conditions	Typ	Unit
R <sub>th(j-a)</sub>	thermal resistance from junction to ambient		<sup>[1]</sup> 73	K/W

[1] R<sub>th(j-a)</sub> is dependent upon board layout. To minimize R<sub>th(j-a)</sub>, ensure that all pins have a solid connection to larger copper layer areas. In multi-layer PCBs, the second layer should be used to create a large heat spreader area below the device. Avoid using solder-stop varnish under the device.

### 13. Static characteristics

**Table 9. Static characteristics**

$V_{I(VINT)} = 4.0\text{ V to }5.5\text{ V}$ ; unless otherwise specified; Voltages are referenced to GND (ground = 0 V).

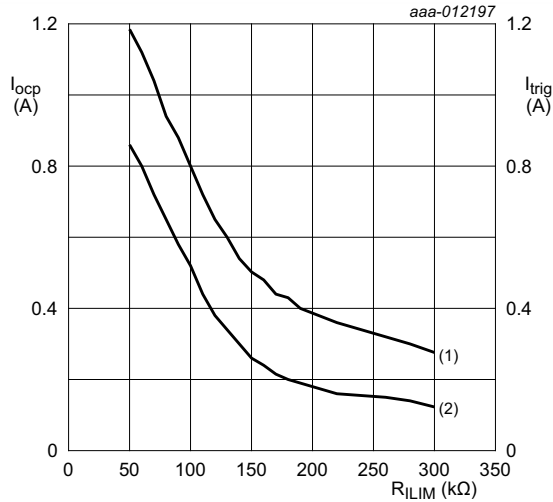
Symbol	Parameter	Conditions	$T_{amb} = 25\text{ °C}$			$T_{amb} = -40\text{ °C to }+85\text{ °C}$		Unit
			Min	Typ <sup>[1]</sup>	Max	Min	Max	
$V_{IH}$	HIGH-level input voltage	EN input	1.2	-	-	1.2	-	V
$V_{IL}$	LOW-level input voltage	EN input	-	-	0.4	-	0.4	V
$V_O$	output voltage	VDET; $I_{VDET} = -2\text{ mA}$ ; $3\text{ V} < V_{BUS} < 30\text{ V}$	1.5	-	5.5	1.5	5.5	V
$V_{OL}$	LOW-level output voltage	FAULT, $I_O = 8\text{ mA}$	-	-	0.5	-	0.5	V
$I_O$	output current	Current source; EN = HIGH	-	10	-	8	15	mA
$I_{trig}$	trigger current	OCP trigger; EN = HIGH; see <a href="#">Figure 6</a>	-	-	-	-	-	mA
$I_{ocp}$	overcurrent protection current	EN = HIGH; see <a href="#">Figure 6</a>	-	$I_{trig}+250$	-	$I_{trig}+150$	$I_{trig}+350$	mA
$R_{pu}$	pull-up resistance	FAULT	20	-	200	-	-	k $\Omega$
$V_{pu}$	pull-up voltage	FAULT	-	-	VINT	-	VINT	V
$R_{ILIM}$	current limit resistance	ILIM	40	-	300	40	300	k $\Omega$
$I_{GND}$	ground current	VBUS open; EN = LOW; see <a href="#">Figure 7</a> and <a href="#">Figure 8</a>	-	20	-	-	40	$\mu\text{A}$
		VBUS open; EN = HIGH; see <a href="#">Figure 7</a> and <a href="#">Figure 8</a>	-	220	-	-	360	$\mu\text{A}$
$I_{OFF}$	power-off leakage current	VBUS = 0 V to 30 V; <sup>[2]</sup> VINT = 0 V; see <a href="#">Figure 9</a>	-	2	-	-	22	$\mu\text{A}$
$I_{S(OFF)}$	OFF-state leakage current	VBUS = 0 V to 30 V; <sup>[2]</sup> see <a href="#">Figure 10</a> and <a href="#">Figure 11</a>	-	2	-	-	22	$\mu\text{A}$
$V_{UVLO}$	undervoltage lockout voltage		3.0	3.2	3.4	3.0	3.4	V
$V_{OVLO}$	overvoltage lockout voltage		5.5	5.75	6.0	5.5	6.0	V
$V_{hys(OVLO)}$	overvoltage lockout hysteresis voltage		-	150	-	-	-	mV
$C_{I/O}$	input/output capacitance	D-, D+, ID	-	3	-	-	-	pF
$C_I$	input capacitance	EN	-	2	-	-	-	pF
$C_{S(ON)}$	ON-state capacitance		-	0.2	-	-	1	nF

[1] Typical values are measured at  $T_{amb} = 25\text{ °C}$  and  $V_{I(VINT)} = 5.0\text{ V}$  unless otherwise specified.

[2] Typical value is measured at  $T_{amb} = 25\text{ °C}$  and  $V_{I(VBUS)} = 5.0\text{ V}$ .

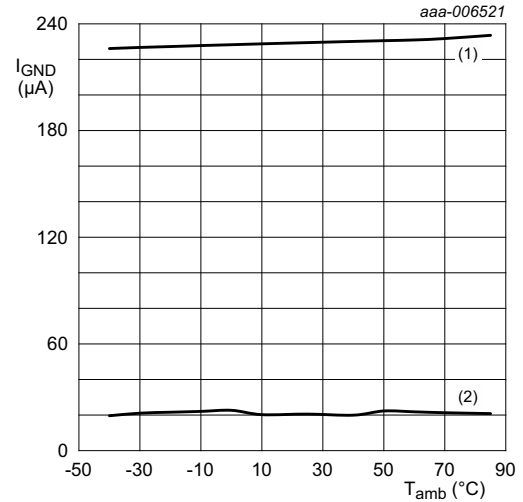


13.1 Graphs



$V_{I(VINT)} = 5\text{ V}; T_{amb} = 25\text{ }^\circ\text{C}$ .  
 (1)  $I_{occ}$   
 (2)  $I_{trig}$

Fig 6. Typical OCP trigger current and overcurrent protection current versus the external resistor value.



(1) Enabled  
 (2) Disabled

Fig 7. Typical ground current versus temperature

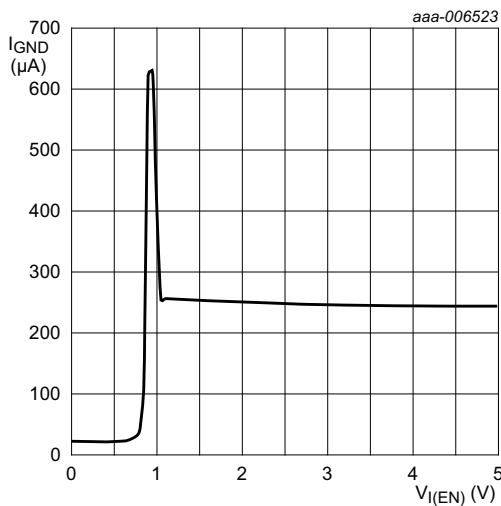
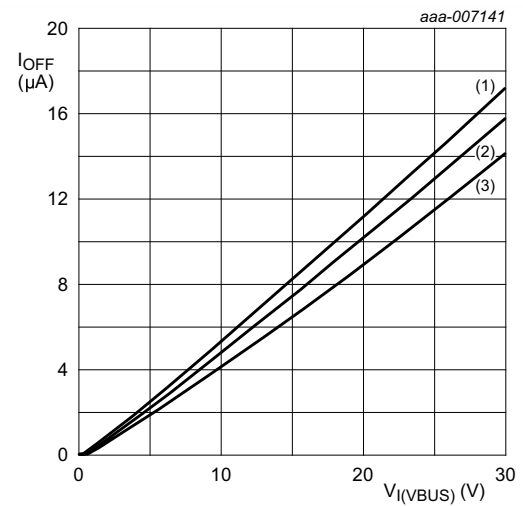
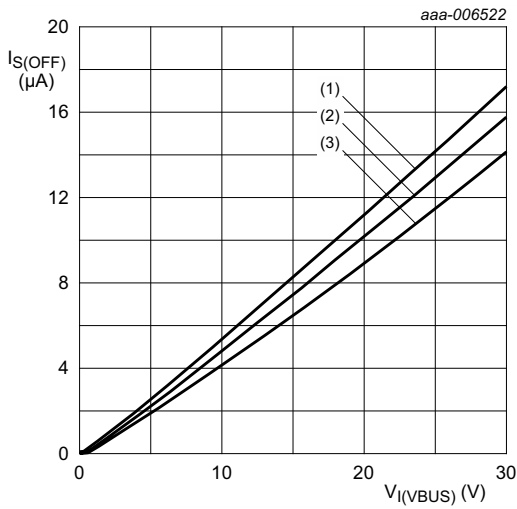


Fig 8. Typical ground current versus input voltage



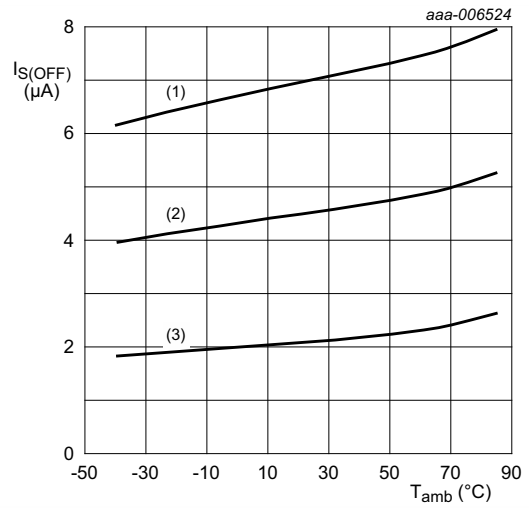
(1)  $T_{amb} = 85\text{ }^\circ\text{C}$   
 (2)  $T_{amb} = 25\text{ }^\circ\text{C}$   
 (3)  $T_{amb} = -40\text{ }^\circ\text{C}$

Fig 9. Typical power-off leakage current versus input voltage on pin VBUS



- (1) T<sub>amb</sub> = 85 °C
- (2) T<sub>amb</sub> = 25 °C
- (3) T<sub>amb</sub> = -40 °C

Fig 10. Typical OFF-state leakage current versus input voltage on pin VBUS



- (1) V<sub>I(VBUS)</sub> = 15.0 V
- (2) V<sub>I(VBUS)</sub> = 10.0 V
- (3) V<sub>I(VBUS)</sub> = 5.0 V

Fig 11. Typical OFF-state leakage current versus temperature

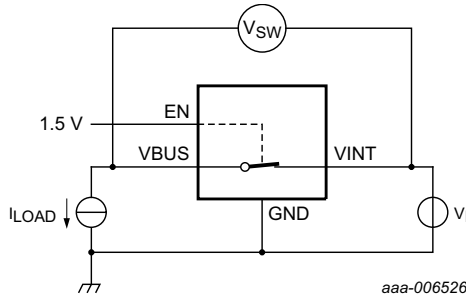
### 13.2 ON resistance

Table 10. ON resistance

At recommended operating conditions; voltages are referenced to GND (ground = 0 V)

Symbol	Parameter	Conditions	T <sub>amb</sub> = 25 °C			T <sub>amb</sub> = -40 °C to +85 °C		Unit
			Min	Typ	Max	Min	Max	
R <sub>ON</sub>	ON resistance	switch enabled; I <sub>LOAD</sub> = 200 mA; see <a href="#">Figure 12</a> , <a href="#">Figure 13</a> and <a href="#">Figure 14</a> V <sub>I(VINT)</sub> = 4.0 V to 5.5 V	-	60	-	-	100	mΩ

### 13.3 ON resistance test circuit and waveforms



$$R_{ON} = V_{SW} / I_{LOAD}$$

Fig 12. Test circuit for measuring ON resistance

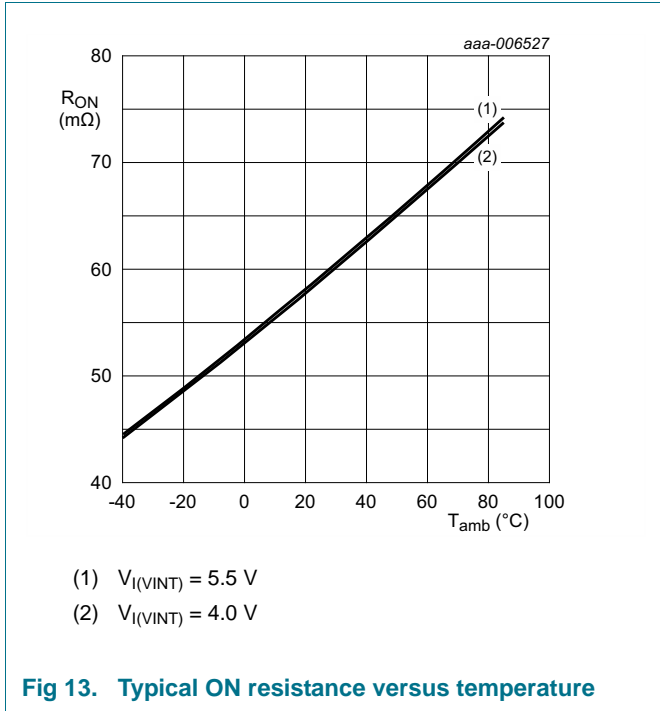


Fig 13. Typical ON resistance versus temperature

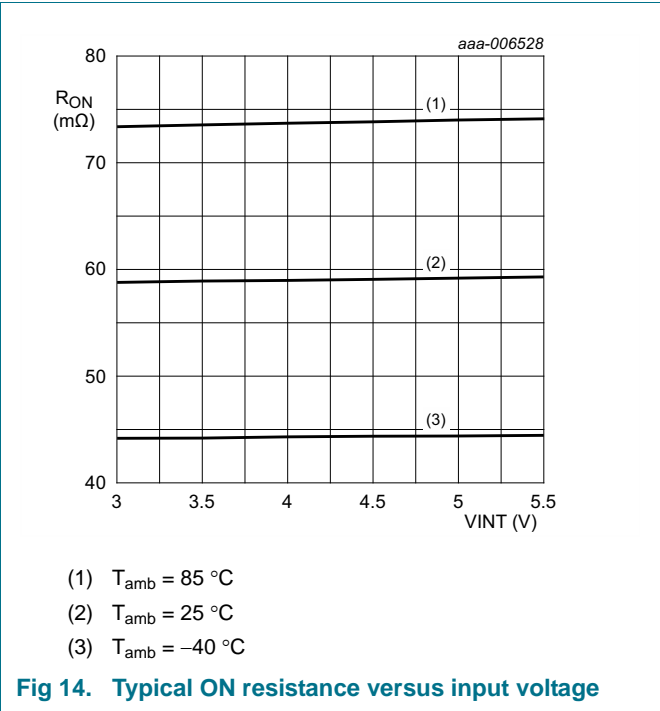


Fig 14. Typical ON resistance versus input voltage

## 14. Dynamic characteristics

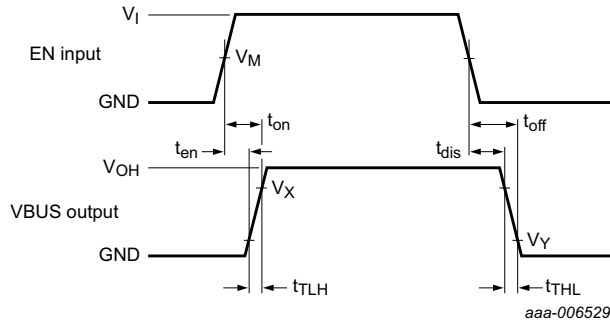
Table 11. Dynamic characteristics

At recommended operating conditions; voltages are referenced to GND (ground = 0 V); for test circuit, see Figure 16.  $V_{I(VINT)} = 4.0 \text{ V to } 5.5 \text{ V}$ .

Symbol	Parameter	Conditions	$T_{amb} = 25 \text{ }^\circ\text{C}$			$T_{amb} = -40 \text{ }^\circ\text{C to } +85 \text{ }^\circ\text{C}$		Unit
			Min	Typ	Max	Min	Max	
$t_{en}$	enable time	EN to VBUS; see Figure 15	-	0.18	-	0.14	-	ms
$t_{dis}$	disable time	EN to VBUS; see Figure 15	-	1.5	-	-	-	ms
$t_{on}$	turn-on time	EN to VBUS; see Figure 15	-	0.63	-	0.52	-	ms
$t_{off}$	turn-off time	EN to VBUS; see Figure 15	-	34.5	-	-	-	ms
$t_{TLH}$	LOW to HIGH output transition time	VBUS; see Figure 15	-	0.39	-	0.16	-	ms
$t_{THL}$	HIGH to LOW output transition time	VBUS; see Figure 15	-	33	-	-	-	ms
$t_{degl}$	deglitch time	VINT; while enabled; see Figure 23	-	8	-	-	-	ms

[1] Guarantee by design.

14.1 Waveforms, graphs and test circuit

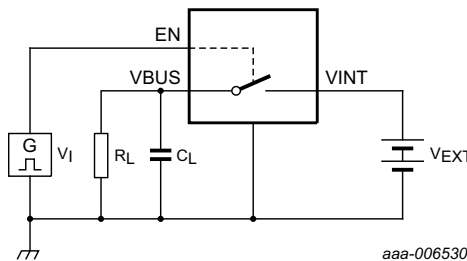


Measurement points are given in [Table 12](#).  
 Logic level:  $V_{OH}$  is the typical output voltage that occurs with the output load.

Fig 15. Switching times

Table 12. Measurement points

Supply voltage	EN Input	Output	
$V_{I(VINT)}$	$V_M$	$V_X$	$V_Y$
4.0 V to 5.5 V	$0.5 \times V_I$	$0.9 \times V_{OH}$	$0.1 \times V_{OH}$

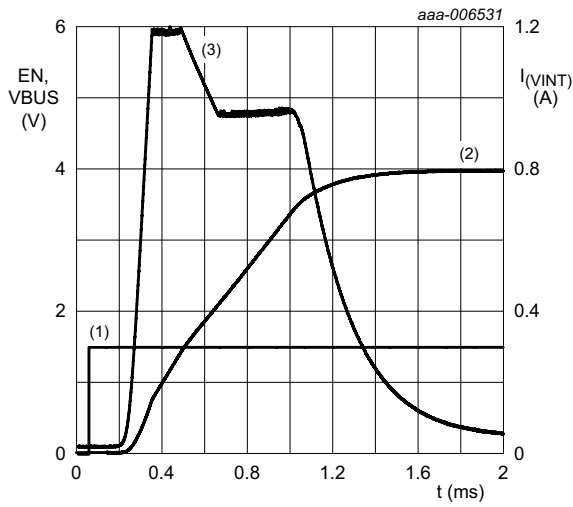


Test data is given in [Table 13](#).  
 Definitions test circuit:  
 $R_L$  = Load resistance.  
 $C_L$  = Load capacitance including jig and probe capacitance.  
 $V_{EXT}$  = External voltage for measuring switching times.

Fig 16. Test circuit for measuring switching times

Table 13. Test data

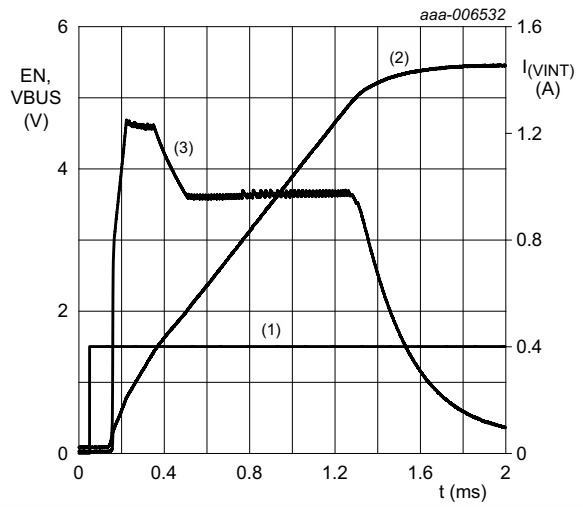
Supply voltage	Input	Load	
$V_{EXT}$	$V_I$	$C_L$	$R_L$
4.0 V to 5.5 V	1.5 V	100 $\mu$ F	150 $\Omega$



EN = 1.5 V; VINT = 4 V;  $R_L = 150 \Omega$ ;  $C_L = 220 \mu\text{F}$ ;  $R_{LIM} = 50 \text{ k}\Omega$ ;  $T_{amb} = 25 \text{ }^\circ\text{C}$ .

- (1) EN
- (2) VBUS
- (3)  $I_{I(VINT)}$

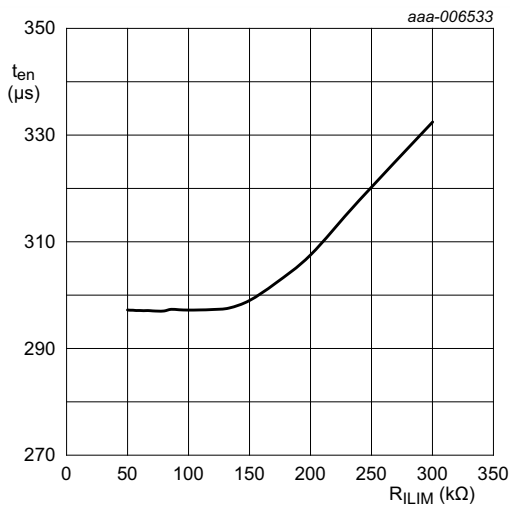
Fig 17. Typical enable time and in-rush current



EN = 1.5 V; VINT = 5.5 V;  $R_L = 150 \Omega$ ;  $C_L = 220 \mu\text{F}$ ;  $R_{LIM} = 50 \text{ k}\Omega$ ;  $T_{amb} = 25 \text{ }^\circ\text{C}$ .

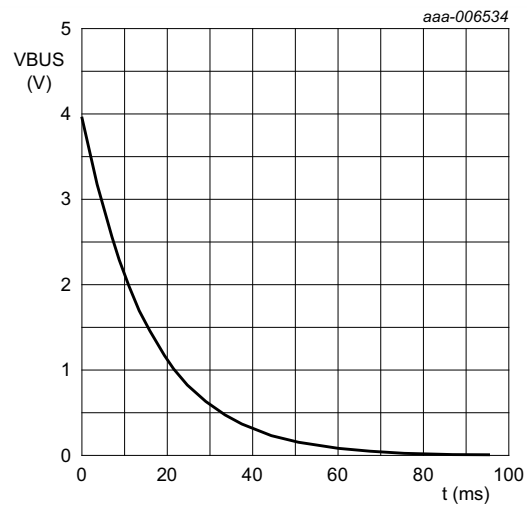
- (1) EN
- (2) VBUS
- (3)  $I_{I(VINT)}$

Fig 18. Typical enable time and in-rush current



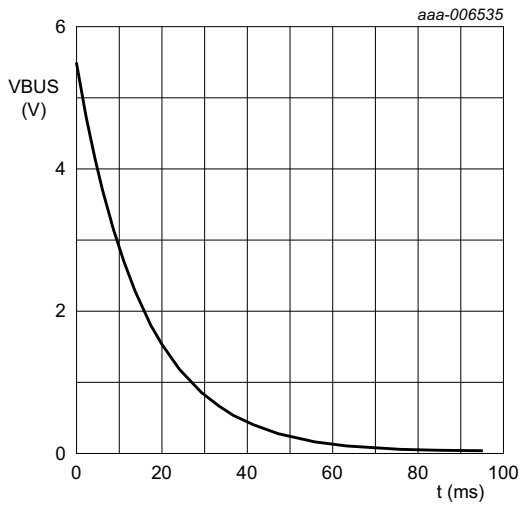
EN = 1.5 V; VINT = 4 V;  $R_L = 150 \Omega$ ;  $C_L = 100 \mu\text{F}$ ;  $T_{amb} = 25 \text{ }^\circ\text{C}$ .

Fig 19. Typical enable time versus current limit resistance ( $R_{LIM}$ )



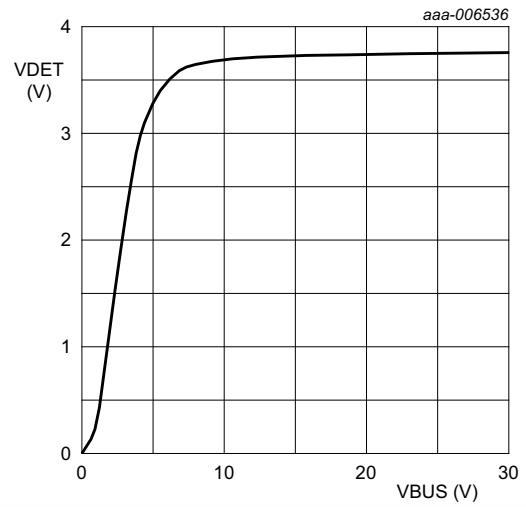
EN = 1.5 V; VINT = 4 V;  $R_L = 150 \Omega$ ;  $C_L = 100 \mu\text{F}$ ;  $R_{LIM} = 50 \text{ k}\Omega$ ;  $T_{amb} = 25 \text{ }^\circ\text{C}$ .

Fig 20. Typical disable time



EN = 1.5 V; VINT = 5.5 V;  $R_L = 150 \Omega$ ;  $C_L = 100 \mu\text{F}$ ;  $R_{LIM} = 50 \text{k}\Omega$ ;  $T_{amb} = 25 \text{ }^\circ\text{C}$ .

Fig 21. Typical disable time



VINT = 5.5 V;  $T_{amb} = 25 \text{ }^\circ\text{C}$ .

Fig 22. Typical VDET versus VBUS

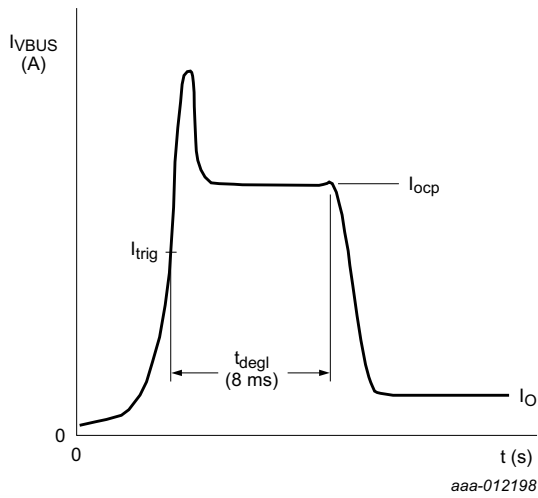
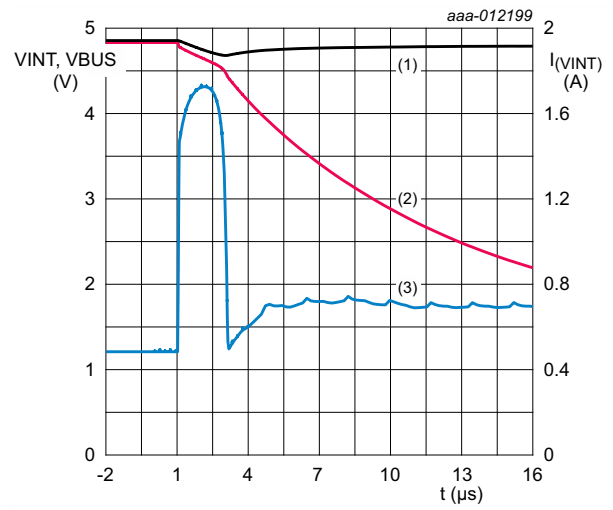
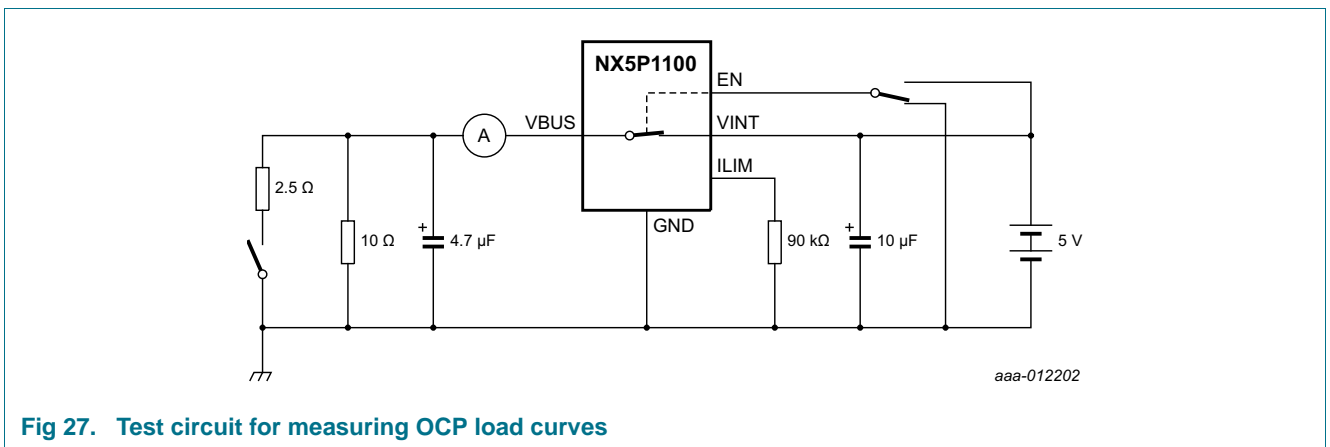
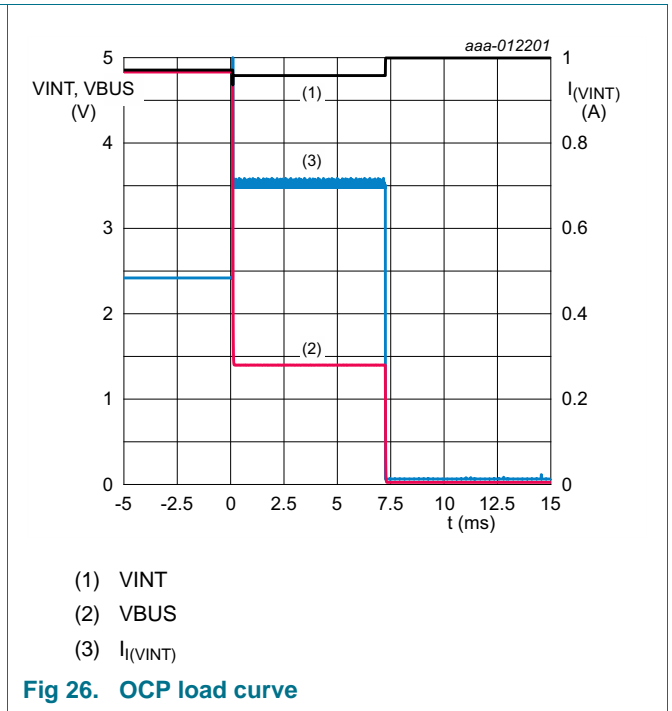
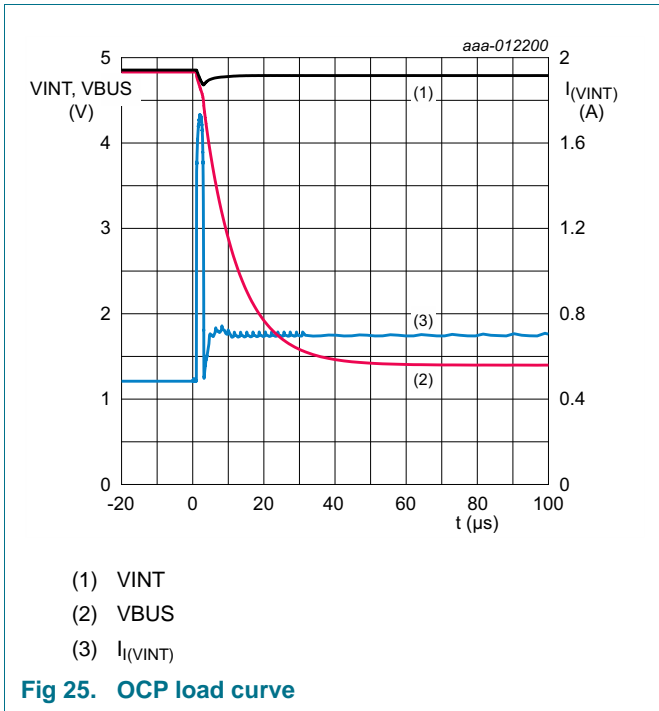


Fig 23. OCP level definitions



- (1) VINT
- (2) VBUS
- (3)  $I_{(VINT)}$

Fig 24. OCP load curve



15. Package outline

WLCSP12: wafer level chip-scale package;  
12 bumps; 1.36 x 1.66 x 0.51 mm, 0.4 mm pitch (Backside coating included)

NX5P1100

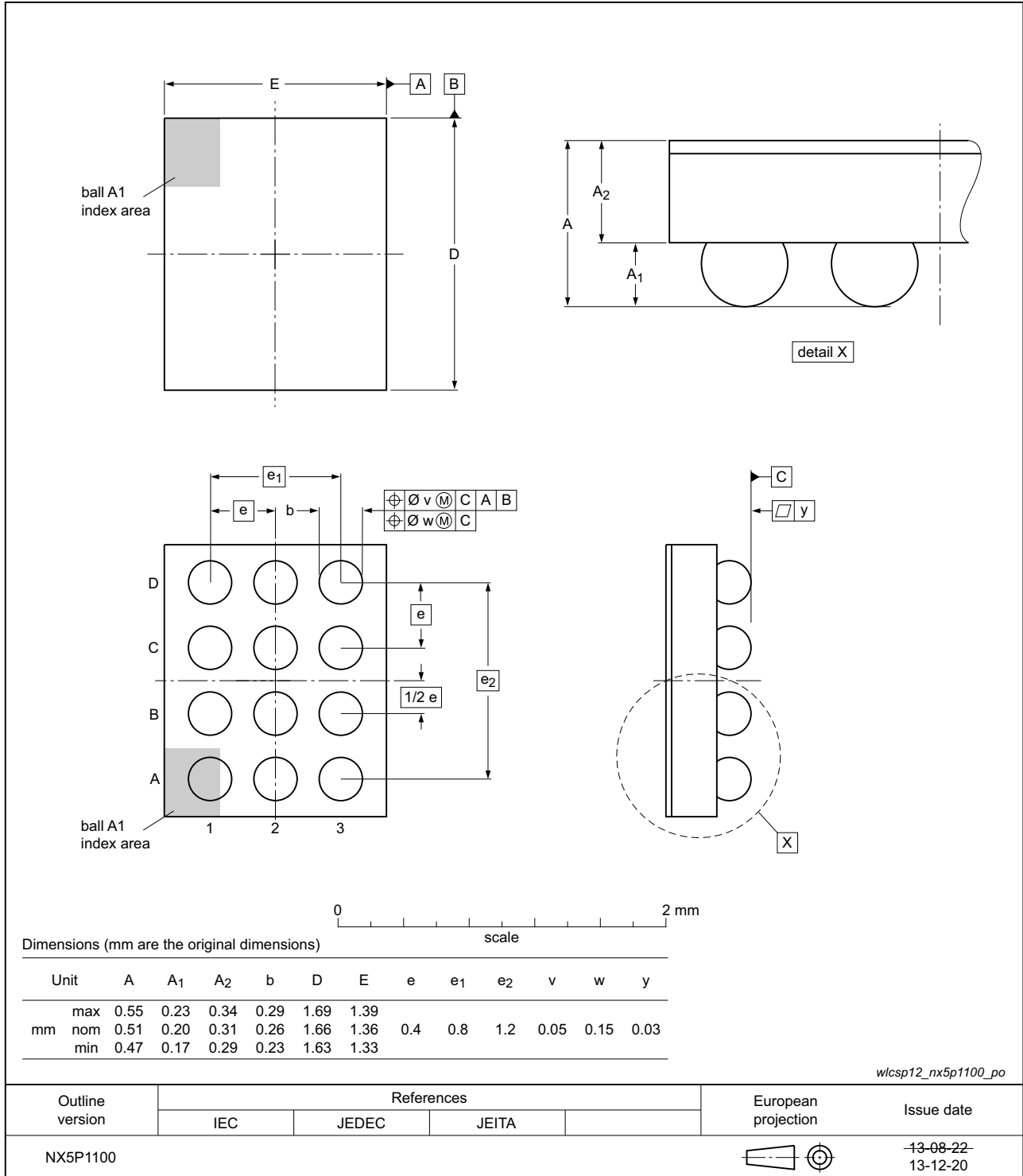


Fig 28. Package outline NX5P1100 (WLCSP12)



## 16. Abbreviations

Table 14. Abbreviations

Acronym	Description
CDM	Charged Device Model
DUT	Device Under Test
ESD	ElectroStatic Discharge
HBM	Human Body Model
MOSFET	Metal-Oxide Semiconductor Field Effect Transistor
OCP	OverCurrent Protection
OTP	OverTemperature Protection
RCP	Reverse Current Protection
USB OTG	Universal Serial Bus On-The-Go
UVLO	Undervoltage lockout
VBUS	USB Power Supply
OVLO	Overvoltage lockout

## 17. Revision history

Table 15. Revision history

Document ID	Release date	Data sheet status	Change notice	Supersedes
NX5P1100 v.1	20140321	Product data sheet	-	-

## 18. Legal information

### 18.1 Data sheet status

Document status <sup>[1][2]</sup>	Product status <sup>[3]</sup>	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.

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

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**20. Contents**

**1 General description . . . . . 1**

**2 Features and benefits . . . . . 1**

**3 Applications . . . . . 2**

**4 Ordering information . . . . . 2**

**5 Marking . . . . . 2**

**6 Functional diagram . . . . . 2**

**7 Pinning information . . . . . 3**

7.1 Pinning . . . . . 3

7.2 Pin description . . . . . 3

**8 Functional description . . . . . 4**

8.1 EN input . . . . . 4

8.2 FAULT output . . . . . 4

8.3 VDET output . . . . . 5

8.4 Undervoltage lockout (UVLO) . . . . . 5

8.5 Overvoltage lockout (OVLO) . . . . . 5

8.6 Over-current protection (OCP) . . . . . 5

8.7 ILIM . . . . . 5

8.8 Over-temperature protection (OTP) . . . . . 5

8.9 Reverse bias current/back drive protection . . . . . 6

8.10 In-rush current protection . . . . . 6

**9 Application diagram . . . . . 6**

**10 Limiting values . . . . . 7**

**11 Recommended operating conditions . . . . . 7**

**12 Thermal characteristics . . . . . 7**

**13 Static characteristics . . . . . 8**

13.1 Graphs . . . . . 9

13.2 ON resistance . . . . . 10

13.3 ON resistance test circuit and waveforms . . . . . 10

**14 Dynamic characteristics . . . . . 11**

14.1 Waveforms, graphs and test circuit . . . . . 12

**15 Package outline . . . . . 16**

**16 Abbreviations . . . . . 17**

**17 Revision history . . . . . 17**

**18 Legal information . . . . . 18**

18.1 Data sheet status . . . . . 18

18.2 Definitions . . . . . 18

18.3 Disclaimers . . . . . 18

18.4 Trademarks . . . . . 19

**19 Contact information . . . . . 19**

**20 Contents . . . . . 20**

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Date of release: 21 March 2014  
 Document identifier: NX5P1100

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