1. General description

The NX5P3090 is a precision adjustable current-limited power switch for USB PD application. The device includes under voltage lockout, over-temperature protection, and reverse current protection circuits to automatically isolate the switch terminals when a fault condition occurs. The 29 V tolerance on VBUS pin ensures the device is able to work on a USB PD port; a current limit input (ILIM) pin defines the over-current limit threshold; an open-drain fault output (FAULT) indicates when a fault condition has occurred.

The over-current limit threshold can be programmed from 400 mA to 3.3 A, using an external resistor between the ILIM pin and GND pin. In the over current condition, the device will clamp the output current to the value set by ILIM and keep the switch on while assert the FAULT flag. To minimize current surges during turn on, the device has built in soft start which controls the power switch rise time.

Surge protection has been integrated in the device to enhance system robustness. The enable input includes integrated logic level translation making the device compatible with lower voltage processors and controllers.

NX5P3090 is offered in a 12 bump 1.35 x 1.65 mm, 0.4 mm pitch WLCSP package.

2. Features and benefits

- VINT supply voltage range from 2.5 V to 5.5 V
- 29 V tolerance on VBUS and EN pin
- Adjustable current limit from 400 mA to 3.3 A
- Clamped current output in over-current condition
- Very low ON resistance: 34 mΩ (typical)
- Active HIGH EN pin with internal pull down resistor
- All time Reverse Current Protection
- Over Temperature Protection
- Surge protection: IEC61000-4-5 exceeds ±80 V on VBUS
- Safety approvals
  - UL 62368-1, 2nd Edition, File no. 20160526-E470128
  - IEC 62368-1 (ed.2), File no. DK-54536-UL
- ESD protection
  - IEC61000-4-2 contact discharge exceeds 8 kV on VBUS
  - HBM ANSI/ESDA/JEDEC JS-001 Class 2 exceeds 2 kV
  - CDM AEC standard Q100-01 (JESD22-C101E) exceeds 500 V
- Specified from −40 °C to +85 °C ambient temperature
3. Applications

- Notebook and Ultrabook
- USB PD and Type C port/hubs
- Tablet and Smart phone

4. Ordering information

Table 1. Ordering information

<table>
<thead>
<tr>
<th>Type number</th>
<th>Topside marking</th>
<th>Package</th>
<th>Name</th>
<th>Description</th>
<th>Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>NX5P3090UK</td>
<td>X5PT2</td>
<td>WLCSP12</td>
<td></td>
<td>wafer level chip-scale package; 12 bumps; 1.65 x 1.35 x 0.525 mm; 0.4 mm pitch (backside coating included)</td>
<td>SOT1390-5</td>
</tr>
</tbody>
</table>

4.1 Ordering options

Table 2. Ordering options

<table>
<thead>
<tr>
<th>Type number</th>
<th>Orderable part number</th>
<th>Package</th>
<th>Packing method</th>
<th>Minimum order quantity</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>NX5P3090UK</td>
<td>NX5P3090UKZ</td>
<td>WLCSP12</td>
<td>REEL 7&quot; Q1/T1</td>
<td>3000</td>
<td>Tamb = –40 °C to +85 °C</td>
</tr>
</tbody>
</table>

4.1 Ordering options

*SPECIAL MARK CHIPS DP

5. Marking

Table 3. Marking

<table>
<thead>
<tr>
<th>Line</th>
<th>Marking</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>X5PT2</td>
<td>basic type name</td>
</tr>
<tr>
<td>B</td>
<td>mmmmm</td>
<td>wafer lot code (mmmmm)</td>
</tr>
<tr>
<td>C</td>
<td>Z5YWW</td>
<td>manufacturing code</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Z = foundry location</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 = assembly location</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Y = assembly year code</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WW = assembly week code</td>
</tr>
</tbody>
</table>
6. Functional diagram

Fig 1. Logic diagram
7. Pinning information

7.1 Pinning

![Pin configuration](aaa-024125)

![Pin map](aaa-024126)

7.2 Pin description

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Pin</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VBUS</td>
<td>C2, D1, D2</td>
<td>power output; 29 V tolerance</td>
</tr>
<tr>
<td>ILIM</td>
<td>A3</td>
<td>current limiter setting. connects a resistor to GND to set the threshold</td>
</tr>
<tr>
<td>FAULT</td>
<td>A2</td>
<td>fault condition indicator (open-drain output)</td>
</tr>
<tr>
<td>EN</td>
<td>A1</td>
<td>enable input (active HIGH)</td>
</tr>
<tr>
<td>GND</td>
<td>B3, C3, D3</td>
<td>ground (0 V)</td>
</tr>
<tr>
<td>VINT</td>
<td>B1, C1, B2</td>
<td>power input</td>
</tr>
</tbody>
</table>
8. Functional description

8.1 EN Input
When the EN pin is set LOW, the N-channel MOSFET will be disabled, the device will enter low-power mode disabling all protection circuits and setting the FAULT pin high impedance. When EN is set HIGH, all protection circuits will be enabled and then, if no fault conditions exist, the N-channel MOSFET will be turn on. There is a 100 us de-glitch time on EN pin from LOW to HIGH.

8.2 Under-voltage lock-out
Independently of the logic level on the EN pin, the under-voltage lockout (UVLO) circuit disables the N-channel MOSFET and enters low power mode until the input voltage reaches the UVLO turn-on threshold level VUVLO.

8.3 ILIM
The over-current protection circuit's (OCP) trigger value Iocp can be set using an external resistor RILIM connected between ILIM pin and GND pin. When EN is HIGH and the ILIM pin is pulled to ground, the N-channel MOSFET will be disabled and the FAULT output set LOW. The detailed IOCP setting is given in Section 8.4.

8.4 Over-current protection (OCP)
The device offers over current protection when enabled, three possible over-current conditions can occur. These conditions are:

- Over-current at start-up, ISW > Iocp when enabling the N-channel MOSFET.
- Over-current after enabled, ISW > Iocp when the N-channel MOSFET is already ON.
- Short circuit after enabled, ISW > 10 A (typical).

In the over current condition, because the device clamps the output current rather than completely shut down the switch, the power dissipation on the device might be increased which could lead to over temperature protection (see Section 8.7).

8.4.1 Over-current at start-up
If the device senses a VBUS short to GND or over-current while enabling the N-channel MOSFET, OCP is triggered. It limits the output current to Iocp and after the de-glitch time sets the FAULT output LOW.

Table 5. Function table[1]

<table>
<thead>
<tr>
<th>EN</th>
<th>VINT</th>
<th>VBUS</th>
<th>FAULT</th>
<th>Switch</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>&lt;2.5V</td>
<td>X</td>
<td>Z</td>
<td>under voltage lockout, switch open</td>
</tr>
<tr>
<td>L</td>
<td>2.5V to 5.5V</td>
<td>X</td>
<td>Z</td>
<td>disabled; switch open</td>
</tr>
<tr>
<td>H</td>
<td>2.5V to 5.5V</td>
<td>VBUS=VINT</td>
<td>Z</td>
<td>enabled; switch closed</td>
</tr>
<tr>
<td>H</td>
<td>2.5V to 5.5V</td>
<td>0V to VINT</td>
<td>L</td>
<td>over-current, clamped current output, switch closed</td>
</tr>
<tr>
<td>H</td>
<td>2.5V to 5.5V</td>
<td>VBUS&gt;VINT+40mV (&gt;4ms)</td>
<td>L</td>
<td>reverse current; switch open</td>
</tr>
<tr>
<td>H</td>
<td>2.5V to 5.5V</td>
<td>Z</td>
<td>L</td>
<td>Over-temperature; switch open</td>
</tr>
</tbody>
</table>

[1] H = HIGH voltage level; L = LOW voltage level.
8.4.2 Over-current when enabled
If the device senses $I_{SW} > I_{ocp}$ after enabled, OCP is triggered. It limits the output current to $I_{ocp}$ and after the de-glitch time sets the FAULT output LOW. Limiting the output current reduces $V_{OUT}$.

8.4.3 Short circuit when enabled
If the device senses $I_{SW} > 10$ A after enabled, a short circuit is detected. The device disables the N-channel MOSFET immediately. It then re-enables the N-channel MOSFET and limit the output current to $I_{ocp}$, and after the de-glitch time the FAULT output is set LOW.

8.5 Reverse-Current protection (RCP)
When the VBUS pin voltage exceeds the input voltage by 40 mV (typical) the device will protect itself from damage by switching off the MOSFET after 4 ms de-glitch time.

When the VBUS pin voltage exceeds the VINT voltage by 100 mV, the device will shutdown the FET immediately without any de-glitch time.

FAULT pin will be set LOW in the reverse-current protection condition.

In the RCP state, when the VBUS voltage drops below VINT voltage, the device will exit the RCP state in 128 us and resume normal operation.

Before normal turn on, the device will always check the RCP condition first, if higher voltage is detected on VBUS pin, it will never turn on the power MOSFET even EN pin is pulled HIGH.

8.6 FAULT output
The FAULT output is an open-drain output that requires an external pull-up resistor. If any of the protection circuits is activated, the FAULT output will set LOW to indicate a fault has occurred. The FAULT output will return to the high impedance state automatically once the fault condition is removed. An internal delay (de-glitch) circuit for the over-current protection (8 ms typical) and reverse-current protection (4 ms typical) is used when entering fault conditions. This ensures that FAULT is not accidentally asserted.

Over-temperature condition will not be de-glitched, the FAULT signal will be asserted immediately.

8.7 Over-temperature protection
When EN is HIGH, the device junction temperature exceeds 140 °C, the over-temperature protection (OTP) circuit will disable the N-channel MOSFET and indicate a fault condition by setting the FAULT pin LOW. Any transition on the EN pin will have no effect. Once the device temperature decreases below 115 °C the device will return to the defined state.
9. Application diagram

0.1 μF ceramic capacitor (CINT) is required for local decoupling. Higher capacitor values CINT further reduce the voltage drop at the input. When driving inductive loads, a larger capacitance CINT prevents voltage spikes from exceeding absolute maximum voltage of VIN. The CBUS capacitor should be placed as closer as possible to VBUS pin.

Fig 4. 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).

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>V_I</td>
<td>input voltage</td>
<td>VBUS, EN</td>
<td>-0.5</td>
<td>+29</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>VINT</td>
<td>-0.5</td>
<td>+6</td>
<td>V</td>
</tr>
<tr>
<td>V_O</td>
<td>output voltage</td>
<td>FAULT</td>
<td>-0.5</td>
<td>+6</td>
<td>V</td>
</tr>
<tr>
<td>I_K</td>
<td>input clamping current</td>
<td>input EN: V_I(EN) &lt; -0.5 V</td>
<td>-50</td>
<td>-</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>input ILIM: V_I(ILIM) &lt; -0.5 V</td>
<td>-50</td>
<td>-</td>
<td>mA</td>
</tr>
<tr>
<td>I_O(source)</td>
<td>input source current</td>
<td>input IIIIM</td>
<td>-</td>
<td>1</td>
<td>mA</td>
</tr>
<tr>
<td>I_O(K)</td>
<td>output clamping current</td>
<td>V_O &lt; 0 V</td>
<td>-50</td>
<td>-</td>
<td>mA</td>
</tr>
<tr>
<td>I_S(K)</td>
<td>switch clamping current</td>
<td>input VIN: V_I(VIN) &lt; -0.5 V</td>
<td>-50</td>
<td>-</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>output VOUT: V_O(VOUT) &lt; -0.5 V</td>
<td>-50</td>
<td>-</td>
<td>mA</td>
</tr>
<tr>
<td>I_SW</td>
<td>switch current</td>
<td>V_SW &gt; -0.5 V</td>
<td>-</td>
<td>3.6</td>
<td>A</td>
</tr>
<tr>
<td>T_T(max)</td>
<td>maximum junction temperature</td>
<td></td>
<td>-40</td>
<td>+150</td>
<td>°C</td>
</tr>
<tr>
<td>T_stg</td>
<td>storage temperature</td>
<td></td>
<td>-65</td>
<td>+150</td>
<td>°C</td>
</tr>
<tr>
<td>P_tot</td>
<td>total power dissipation</td>
<td></td>
<td>-</td>
<td>910</td>
<td>mW</td>
</tr>
</tbody>
</table>

[1] The minimum input voltage rating may be exceeded if the input current rating is observed.
[2] The minimum and maximum switch voltage ratings may be exceeded if the switch clamping current rating is observed.
[4] The (absolute) maximum power dissipation depends on the junction temperature T_j. Higher power dissipation is allowed in conjunction with lower ambient temperatures. The conditions to determine the specified values are T_amb = 25 °C and the use of a two layer PCB.

11. Recommended operating conditions

Table 7. Recommended operating conditions

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>V_I</td>
<td>input voltage</td>
<td>VINT</td>
<td>2.5</td>
<td>5.5</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EN: VBUS (OFF state)</td>
<td>0</td>
<td>20</td>
<td>V</td>
</tr>
<tr>
<td>V_O</td>
<td>Output voltage</td>
<td>VBUS</td>
<td>0</td>
<td>5</td>
<td>V</td>
</tr>
<tr>
<td>I_SW</td>
<td>switch current</td>
<td>T_I = -40 °C to +85 °C</td>
<td>0</td>
<td>3</td>
<td>A</td>
</tr>
<tr>
<td>I_O(sink)</td>
<td>output sink current</td>
<td>output FAULT</td>
<td>-10</td>
<td>-</td>
<td>mA</td>
</tr>
<tr>
<td>R_ILIM</td>
<td>current limit resistance</td>
<td>input ILIM</td>
<td>16</td>
<td>140</td>
<td>kΩ</td>
</tr>
<tr>
<td>C_dec</td>
<td>decoupling capacitance</td>
<td>VIN to GND</td>
<td>0.1</td>
<td>-</td>
<td>µF</td>
</tr>
<tr>
<td>T_amb</td>
<td>ambient temperature</td>
<td></td>
<td>-40</td>
<td>+85</td>
<td>°C</td>
</tr>
</tbody>
</table>

[1] Current-limit threshold resistor range from ILIM to GND.
12. Thermal characteristics

Table 8. Thermal characteristics

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Typ</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_{th(j-a)}$</td>
<td>thermal resistance from junction to ambient</td>
<td></td>
<td>109 K/W</td>
<td></td>
</tr>
</tbody>
</table>

$R_{th(j-a)}$ is dependent upon board layout. To minimize $R_{th(j-a)}$, ensure 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

At recommended operating conditions; $V_{i(VINT)} = V_{i(EN)}$, $R_{FAULT} = 10 \text{k}\Omega$ unless otherwise specified; Voltages are referenced to GND (ground = 0 V). See Figure 10

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ[1]</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{IH}$</td>
<td>HIGH-level input voltage</td>
<td>EN input; $V_{i(VINT)} = 2.5 \text{ V to 5.5 \text{ V}}$</td>
<td>1.2</td>
<td>-</td>
<td>-</td>
<td>V</td>
</tr>
<tr>
<td>$V_{IL}$</td>
<td>LOW-level input voltage</td>
<td>EN input; $V_{i(VINT)} = 2.5 \text{ V to 5.5 \text{ V}}$</td>
<td>-</td>
<td>-</td>
<td>0.4</td>
<td>V</td>
</tr>
<tr>
<td>$I_{I}$</td>
<td>input leakage current</td>
<td>EN input; $V_{i(VINT)} = 5.0 \text{ V}$</td>
<td>-</td>
<td>-</td>
<td>7.5</td>
<td>(\mu\text{A})</td>
</tr>
<tr>
<td>$I_{(VIN)}$</td>
<td>supply current</td>
<td>VBUS open; $V_{i(VINT)} = 5.0 \text{ V}$</td>
<td>-</td>
<td>0.9</td>
<td>5</td>
<td>(\mu\text{A})</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EN = GND (low power mode);</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$EN = V_{i(VIN)}; R_{ILIM} = 33 \text{k}\Omega$</td>
<td>-</td>
<td>196</td>
<td>280</td>
<td>(\mu\text{A})</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$EN = V_{i(VIN)}; R_{ILIM} = 16 \text{k}\Omega$</td>
<td>-</td>
<td>210</td>
<td>290</td>
<td>(\mu\text{A})</td>
</tr>
<tr>
<td>$I_{S(OFF)}$</td>
<td>VBUS OFF-State leakage current</td>
<td>$V_{i(VINT)} = 5.0 \text{ V}; V_{i(VBUS)} = 0 \text{ V}; EN = LOW$</td>
<td>-</td>
<td>1</td>
<td>10</td>
<td>(\mu\text{A})</td>
</tr>
<tr>
<td>$I_{S(ON)}$</td>
<td>VINT OFF-state leakage current</td>
<td>$V_{i(VBUS)} = 5.0 \text{ V}; V_{i(VINT)} = 0 \text{ V}; EN = LOW$</td>
<td>-</td>
<td>1</td>
<td>10</td>
<td>(\mu\text{A})</td>
</tr>
<tr>
<td>$I_{Rpd}$</td>
<td>EN pin Pull-down resistance</td>
<td>$V_{i(VINT)} = 5 \text{ V}$</td>
<td>-</td>
<td>1</td>
<td></td>
<td>M(\Omega)</td>
</tr>
<tr>
<td>$V_{trip}$</td>
<td>trip level voltage</td>
<td>RCP; $V_{i(VINT)} = 2.5 \text{ V to 5.5 \text{ V}}$</td>
<td>-</td>
<td>40</td>
<td>-</td>
<td>mV</td>
</tr>
<tr>
<td>$V_{UVLO}$</td>
<td>under voltage lockout voltage</td>
<td>VINT pin</td>
<td>-</td>
<td>2.27</td>
<td>2.45</td>
<td>V</td>
</tr>
<tr>
<td>$V_{hys(UVLO)}$</td>
<td>under voltage lockout hysteresis voltage</td>
<td></td>
<td>-</td>
<td>100</td>
<td>-</td>
<td>mV</td>
</tr>
<tr>
<td>$V_{OL}$</td>
<td>LOW-level output voltage</td>
<td>FAULT; $I_{O} = 8 \text{ mA}$</td>
<td>-</td>
<td>-</td>
<td>0.5</td>
<td>V</td>
</tr>
<tr>
<td>$C_{I}$</td>
<td>EN pin</td>
<td></td>
<td>-</td>
<td>13.5</td>
<td>-</td>
<td>pF</td>
</tr>
</tbody>
</table>

[1] Typical values are measured at $T_{aamb} = 25 ^\circ \text{C}$.
13.1 Graphs

**Fig 5.** OFF state supply current versus temperature

\[ V_{\text{EN}} = \text{GND}; V_{\text{VIN}} = 5.0 \text{ V} \]

**Fig 6.** ON state supply current versus temperature

\[ V_{\text{EN}} = V_{\text{VIN}}; V_{\text{VIN}} = 5.0 \text{ V} \]

(1) \( R_{\text{ILIM}} = 33 \text{ K}\Omega \)

(2) \( R_{\text{ILIM}} = 16 \text{ K}\Omega \)
**NXP Semiconductors**

**NX5P3090**

USB PD and type C current-limited power switch

---

**Fig 7. VBUS off state leakage versus temperature**

\[ V_{\text{EN}} = \text{GND}; \ V_{\text{VBUS}} = 0 \ \text{V}; \ R_{\text{ILIM}} = 16 \ \text{K}\Omega \]

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

---

**Fig 8. VINT off state leakage versus temperature**

\[ V_{\text{EN}} = \text{GND}; \ V_{\text{VINT}} = 0 \ \text{V}; \ R_{\text{ILIM}} = 16 \ \text{K}\Omega \]

1. \( T_{\text{amb}} = -40 \ ^\circ\text{C} \)
2. \( T_{\text{amb}} = +25 \ ^\circ\text{C} \)
3. \( T_{\text{amb}} = +85 \ ^\circ\text{C} \)
13.2 Thermal shutdown

Table 10. Thermal shutdown

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$T_{\text{th(ots)}}$</td>
<td>over temperature shutdown threshold temperature</td>
<td>$V_{\text{I(VINT)}} = 2.5$ to $5.5$ V</td>
<td>-</td>
<td>140</td>
<td>-</td>
<td>°C</td>
</tr>
<tr>
<td>$T_{\text{th(otp)hys}}$</td>
<td>hysteresis of over temperature protection threshold temperature</td>
<td>$V_{\text{I(VINT)}} = 2.5$ to $5.5$ V</td>
<td>-</td>
<td>25</td>
<td>-</td>
<td>°C</td>
</tr>
</tbody>
</table>

$R_{ILIM} = 20$ kΩ; $V_{\text{I(VINT)}} = 0$ V

(1) Surge current
(2) Surge voltage on VBUS
### 13.3 ON resistance

**Table 11.**  
ON resistance  
$V_{I(VIN)} = V_{I(EN)}$, $R_{FAULT} = 10 \, k\Omega$ unless otherwise specified; Voltages are referenced to GND (ground = 0 V). See Figure 10

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_{ON}$</td>
<td>ON resistance</td>
<td>$V_{I(VIN)} = 2.5$ to 5.5 V; see Figure 11</td>
<td>-</td>
<td>34</td>
<td>37</td>
<td>mΩ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$T_{amb} = 25 , ^\circ C$</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$T_{amb} = -40 , ^\circ C$ to $+85 , ^\circ C$</td>
<td>-</td>
<td>-</td>
<td>46</td>
<td>mΩ</td>
</tr>
</tbody>
</table>

### 13.4 ON resistance graphs

**Fig 11.** Typical ON resistance versus temperature

**Fig 12.** Typical ON resistance versus enable time
13.5 Current limit

Table 12. Current limit

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ[1]</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iocp</td>
<td>over current protection current</td>
<td>(V_{\text{VINT}} = 2.5) to 5.5 V; (T_{\text{amb}} = -40) (^\circ) C to +85 (^\circ) C;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(R_{\text{SLIM}} = 140) k(\Omega)</td>
<td>330</td>
<td>421</td>
<td>465</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(R_{\text{SLIM}} = 100) k(\Omega)</td>
<td>480</td>
<td>581</td>
<td>625</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(R_{\text{SLIM}} = 54) k(\Omega)</td>
<td>915</td>
<td>1057</td>
<td>1107</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(R_{\text{SLIM}} = 33) k(\Omega)</td>
<td>1505</td>
<td>1723</td>
<td>1780</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(R_{\text{SLIM}} = 24.5) k(\Omega)</td>
<td>2085</td>
<td>2330</td>
<td>2398</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(R_{\text{SLIM}} = 20) k(\Omega)</td>
<td>2567</td>
<td>2848</td>
<td>2920</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(R_{\text{SLIM}} = 16) k(\Omega)</td>
<td>3186</td>
<td>3490</td>
<td>3585</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(R_{\text{SLIM}}) shorted to (\text{VINT})</td>
<td>125</td>
<td>180</td>
<td>220</td>
<td>mA</td>
</tr>
</tbody>
</table>

[1] Typical values are measured at \(T_{\text{amb}} = 25\) \(^\circ\) C. 1% tolerance resistor is recommend for \(R_{\text{SLIM}}\).

\[
I_{\text{ocp}} \text{ can be calculated with below equation, } x = R_{\text{SLIM}} (k\Omega):
I_{\text{OCP(MAX)}} = 49495x^{-0.948}
\]
\[
I_{\text{OCP(TYP)}} = 52775x^{-0.979}
\]
\[
I_{\text{OCP(MIN)}} = 57949x^{-1.042}
\]

13.6 Current limit graphs

Fig 13. Typical over current protection current versus external resistor value \(R_{\text{SLIM}}\)
14. Dynamic characteristics

Table 13. Dynamic characteristics
At recommended operating conditions; \( V_{(VINT)} = V_{(EN)}; R_{FAULT} = 10 \, k\Omega \) unless otherwise specified; voltages are referenced to GND (ground = 0 V).

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min</th>
<th>Typ[1]</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>( t_{TLH} )</td>
<td>LOW to HIGH output transition time</td>
<td>( V_{OUT}; C_L = 1 , \mu F; R_L = 100 , \Omega ); see Figure 14 and Figure 15</td>
<td>2.5</td>
<td>2.5</td>
<td>-</td>
<td>ms</td>
</tr>
<tr>
<td>( t_{THL} )</td>
<td>HIGH to LOW output transition time</td>
<td>( V_{OUT}; C_L = 1 , \mu F; R_L = 100 , \Omega ); see Figure 14 and Figure 15</td>
<td>1.4</td>
<td>1.4</td>
<td>-</td>
<td>ms</td>
</tr>
<tr>
<td>( t_{en} )</td>
<td>enable time</td>
<td>( EN ) to ( V_{OUT}; C_L = 1 , \mu F; R_L = 100 , \Omega ); see Figure 14 and Figure 15</td>
<td>-</td>
<td>1.5</td>
<td>-</td>
<td>ms</td>
</tr>
<tr>
<td>( t_{dis} )</td>
<td>disable time</td>
<td>( EN ) to ( V_{OUT}; C_L = 1 , \mu F; R_L = 100 , \Omega ); see Figure 14 and Figure 15</td>
<td>-</td>
<td>13</td>
<td>-</td>
<td>( \mu )S</td>
</tr>
<tr>
<td>( t_{degl} )</td>
<td>deglitch time</td>
<td>( FAULT ) in OCP; ( V_{(VINT)} = 5 , V )</td>
<td>-</td>
<td>8</td>
<td>-</td>
<td>ms</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( RCP ); ( FAULT ) in RCP; ( V_{(VINT)} = 5 , V )</td>
<td>-</td>
<td>4</td>
<td>-</td>
<td>ms</td>
</tr>
</tbody>
</table>

[1] Typical values are measured at \( T_{\text{amb}} = 25 \, ^\circ \text{C} \).

14.1 Waveform and test circuits

![Switching times and rise and fall times](aaa-024134)

Measurement points are given in Table 14.
Logic level: \( V_{OH} \) is the typical output voltage that occurs with the output load.

Fig 14. Switching times and typical rise and fall times

Table 14. Measurement points

<table>
<thead>
<tr>
<th>Supply voltage</th>
<th>EN Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V_{(VIN)} )</td>
<td>( V_M )</td>
<td>( V_X )</td>
</tr>
<tr>
<td>5.0 V</td>
<td>( 0.5 \times V_{(EN)} )</td>
<td>( 0.9 \times V_{OH} )</td>
</tr>
</tbody>
</table>

NX5P3090
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Test data is given in Table 15.
Definitions test circuit:
- \( R_L \) = Load resistance.
- \( C_L \) = Load capacitance including jig and probe capacitance.
- \( V_{\text{EXT}} \) = External voltage for measuring switching times.

**Fig 15. Test circuit for measuring switching times**

**Table 15. Test data**

<table>
<thead>
<tr>
<th>Supply voltage ( V_{\text{EXT}} )</th>
<th>( V_{\text{EN}} )</th>
<th>Load ( C_L )</th>
<th>( R_L )</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.0 V</td>
<td>0 to ( V_{\text{VIN}} )</td>
<td>1 ( \mu )F</td>
<td>100 ( \Omega )</td>
</tr>
</tbody>
</table>

\( V_{\text{VIN}} \) = 5 V; \( R_L \) = 5.1 \( \Omega \); \( C_L \) = 1 \( \mu \)F;

(1) \( V_{\text{BUS}} \) (2) \( I_{\text{VIN}} \) (3) \( V_{\text{EN}} \)

**Fig 16. Typical 1 \( \mu \)F load enable time and inrush current**
**USB PD and type C current-limited power switch**

**Fig 17. Typical 100 µF load enable time and inrush current**

\[ V_{(VIN)} = 5 \text{ V}; R_L = 5.1 \, \Omega; C_L = 100 \, \mu\text{F}; \]

(1) \( V_O(BUS) \)
(2) \( I_{(VIN)} \)
(3) \( V_{(EN)} \)

**Fig 18. Typical 1 µF load turn off**

\[ V_{(VINT)} = 5 \text{ V}; R_L = 5.1 \, \Omega; C_L = 1 \, \mu\text{F}; \]

(1) \( V_O(BUS) \)
(2) \( I_{(VIN)} \)
(3) \( V_{(EN)} \)
**USB PD and type C current-limited power switch**

**Fig 19. Typical 100 μF load turn off**

\[ V_{\text{VIN}} = 5 \text{ V}; R_L = 5.1 \Omega; C_L = 100 \mu \text{F} \]

1. \( V_{\text{O(BUS)}} \)
2. \( I_{\text{(VIN)}} \)
3. \( V_{\text{I(EN)}} \)

**Fig 20. Reverse-current protection response**

\[ V_{\text{I(VINT)}} = 4 \text{ V} \]

1. \( V_{\text{O(BUS)}} \)
2. \( V_{\text{I(VINT)}} \)
3. \( I_{\text{(VIN)}} \)
4. \( \text{FAULT} \)
Fig 21. Reverse-current protection recovery

Fig 22. Device into current limit after enabled
$V_{(VIN)} = 5 \text{ V}; R_{LIM} = 33 \text{ kΩ}.$

(1) $V_{O(VBUS)}$
(2) $V_{I(VINT)}$
(3) $I_{(VIN)}$
(4) FAULT

Fig 23. Device start up with VBUS short to GND
15. Package outline

**WLCSP12: wafer level chip-scale package;**
12 bumps; 1.65 x 1.35 x 0.525 mm (Backside coating included)

**Fig 24.** Package outline WLCSP12
16. Packing information

16.1 Packing method

Fig 25. Reel dry pack for SMD: guard band; embossed tape
Table 16. Dimensions and quantities

<table>
<thead>
<tr>
<th>Reel dimensions (d \times w) (mm)</th>
<th>SPQ/PQ (pcs)</th>
<th>Reels per box</th>
<th>Outer box dimensions (l \times w \times h) (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>180 × 8</td>
<td>3000</td>
<td>1</td>
<td>209 × 206 × 34</td>
</tr>
</tbody>
</table>

[1] \(d\) = reel diameter; \(w\) = tape width.  
View ordering and availability details at [NXP order portal](https://www.nxp.com), or contact your local NXP representative.

16.2 Product orientation

Fig 26. Product orientation in carrier tape

Fig 27. Carrier tape dimensions

Table 17. Carrier tape dimensions  
*In accordance with IEC 60286-3.*

<table>
<thead>
<tr>
<th>(A_0) (mm)</th>
<th>(B_0) (mm)</th>
<th>(K_0) (mm)</th>
<th>(T) (mm)</th>
<th>(P_1) (mm)</th>
<th>(W) (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.61 ± 0.05</td>
<td>1.78 ± 0.05</td>
<td>0.73 ± 0.05</td>
<td>0.25 ± 0.02</td>
<td>4.0 ± 0.1</td>
<td>(8 \div 0.3 - 0.1)</td>
</tr>
</tbody>
</table>
16.4 Reel dimensions

Fig 28. Schematic view of reel

Table 18. Reel dimensions

<table>
<thead>
<tr>
<th>A [nom] (mm)</th>
<th>W2 [max] (mm)</th>
<th>B [min] (mm)</th>
<th>C [min] (mm)</th>
<th>D [min] (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>180</td>
<td>14.4</td>
<td>1.5</td>
<td>12.8</td>
<td>20.2</td>
</tr>
</tbody>
</table>

In accordance with IEC 60286-3.
16.5 Barcode label

Table 19. Barcode label dimensions

<table>
<thead>
<tr>
<th>Box barcode label</th>
<th>Reel barcode label</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I \times W (mm)</strong></td>
<td><strong>I \times W (mm)</strong></td>
</tr>
<tr>
<td>100 \times 75</td>
<td>100 \times 75</td>
</tr>
</tbody>
</table>
17. Soldering of WLCSP packages

17.1 Introduction to soldering WLCSP packages

This text provides a very brief insight into a complex technology. A more in-depth account of soldering WLCSP (Wafer Level Chip-Size Packages) can be found in application note AN10439 “Wafer Level Chip Scale Package” and in application note AN10365 “Surface mount reflow soldering description”.

Wave soldering is not suitable for this package.

All NXP WLCSP packages are lead-free.

17.2 Board mounting

Board mounting of a WLCSP requires several steps:

1. Solder paste printing on the PCB
2. Component placement with a pick and place machine
3. The reflow soldering itself

17.3 Reflow soldering

Key characteristics in reflow soldering are:

- Lead-free versus SnPb soldering; note that a lead-free reflow process usually leads to higher minimum peak temperatures (see Figure 30) than a SnPb process, thus reducing the process window
- Solder paste printing issues, such as smearing, release, and adjusting the process window for a mix of large and small components on one board
- Reflow temperature profile; this profile includes preheat, reflow (in which the board is heated to the peak temperature), and cooling down. It is imperative that the peak temperature is high enough for the solder to make reliable solder joints (a solder paste characteristic) while being low enough that the packages and/or boards are not damaged. The peak temperature of the package depends on package thickness and volume and is classified in accordance with Table 20.

Moisture sensitivity precautions, as indicated on the packing, must be respected at all times.

Studies have shown that small packages reach higher temperatures during reflow soldering, see Figure 30.
17.3.1 Stand off

The stand off between the substrate and the chip is determined by:

- The amount of printed solder on the substrate
- The size of the solder land on the substrate
- The bump height on the chip

The higher the stand off, the better the stresses are released due to TEC (Thermal Expansion Coefficient) differences between substrate and chip.

17.3.2 Quality of solder joint

A flip-chip joint is considered to be a good joint when the entire solder land has been wetted by the solder from the bump. The surface of the joint should be smooth and the shape symmetrical. The soldered joints on a chip should be uniform. Voids in the bumps after reflow can occur during the reflow process in bumps with high ratio of bump diameter to bump height, i.e. low bumps with large diameter. No failures have been found to be related to these voids. Solder joint inspection after reflow can be done with X-ray to monitor defects such as bridging, open circuits and voids.

17.3.3 Rework

In general, rework is not recommended. By rework we mean the process of removing the chip from the substrate and replacing it with a new chip. If a chip is removed from the substrate, most solder balls of the chip will be damaged. In that case it is recommended not to re-use the chip again.
Device removal can be done when the substrate is heated until it is certain that all solder joints are molten. The chip can then be carefully removed from the substrate without damaging the tracks and solder lands on the substrate. Removing the device must be done using plastic tweezers, because metal tweezers can damage the silicon. The surface of the substrate should be carefully cleaned and all solder and flux residues and/or underfill removed. When a new chip is placed on the substrate, use the flux process instead of solder on the solder lands. Apply flux on the bumps at the chip side as well as on the solder pads on the substrate. Place and align the new chip while viewing with a microscope. To reflow the solder, use the solder profile shown in application note AN10365 “Surface mount reflow soldering description”.

17.3.4 Cleaning

Cleaning can be done after reflow soldering.
## 18. Abbreviations

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>ESD</td>
<td>ElectroStatic Discharge</td>
</tr>
<tr>
<td>CDM</td>
<td>Charged Device Model</td>
</tr>
<tr>
<td>HBM</td>
<td>Human Body Model</td>
</tr>
<tr>
<td>USB</td>
<td>Universal Serial Bus</td>
</tr>
<tr>
<td>VOIP</td>
<td>Voice over Internet Protocol</td>
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## 19. Revision history

### Table 22. Revision history

<table>
<thead>
<tr>
<th>Document ID</th>
<th>Release date</th>
<th>Data sheet status</th>
<th>Change notice</th>
<th>Supersedes</th>
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<td>20160801</td>
<td>Product data sheet</td>
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20. Legal information

20.1 Data sheet status

<table>
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<tr>
<th>Document status[n]</th>
<th>Product status[v]</th>
<th>Definition</th>
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<td>Objective [short] data sheet</td>
<td>Development</td>
<td>This document contains data from the objective specification for product development.</td>
</tr>
<tr>
<td>Preliminary [short] data sheet</td>
<td>Qualification</td>
<td>This document contains data from the preliminary specification.</td>
</tr>
<tr>
<td>Product [short] data sheet</td>
<td>Production</td>
<td>This document contains the product specification.</td>
</tr>
</tbody>
</table>

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