

# PF8121

## 12-channel power management integrated circuit for high performance applications

Rev. 3.0 — 23 March 2020

Product data sheet

## 1 Overview

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The PF8121 is a power management integrated circuit (PMIC) designed for high performance consumer applications. It features seven high efficiency buck converters and four linear regulators for powering the processor, memory and miscellaneous peripherals.

Built-in one time programmable memory stores key startup configurations, drastically reducing external components typically used to set output voltage and sequence of external regulators. Regulator parameters are adjustable through high-speed I<sup>2</sup>C after start up offering flexibility for different system states.

## 2 Features

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- Up to seven high efficiency buck converters
- Four linear regulators with load switch options
- RTC supply and coin cell charger
- Watchdog timer/monitor
- Voltage and system monitoring circuits
- One time programmable device configuration
- 3.4 MHz I<sup>2</sup>C communication interface
- 56-pin 8 x 8 QFN package



### 3 Simplified application diagram

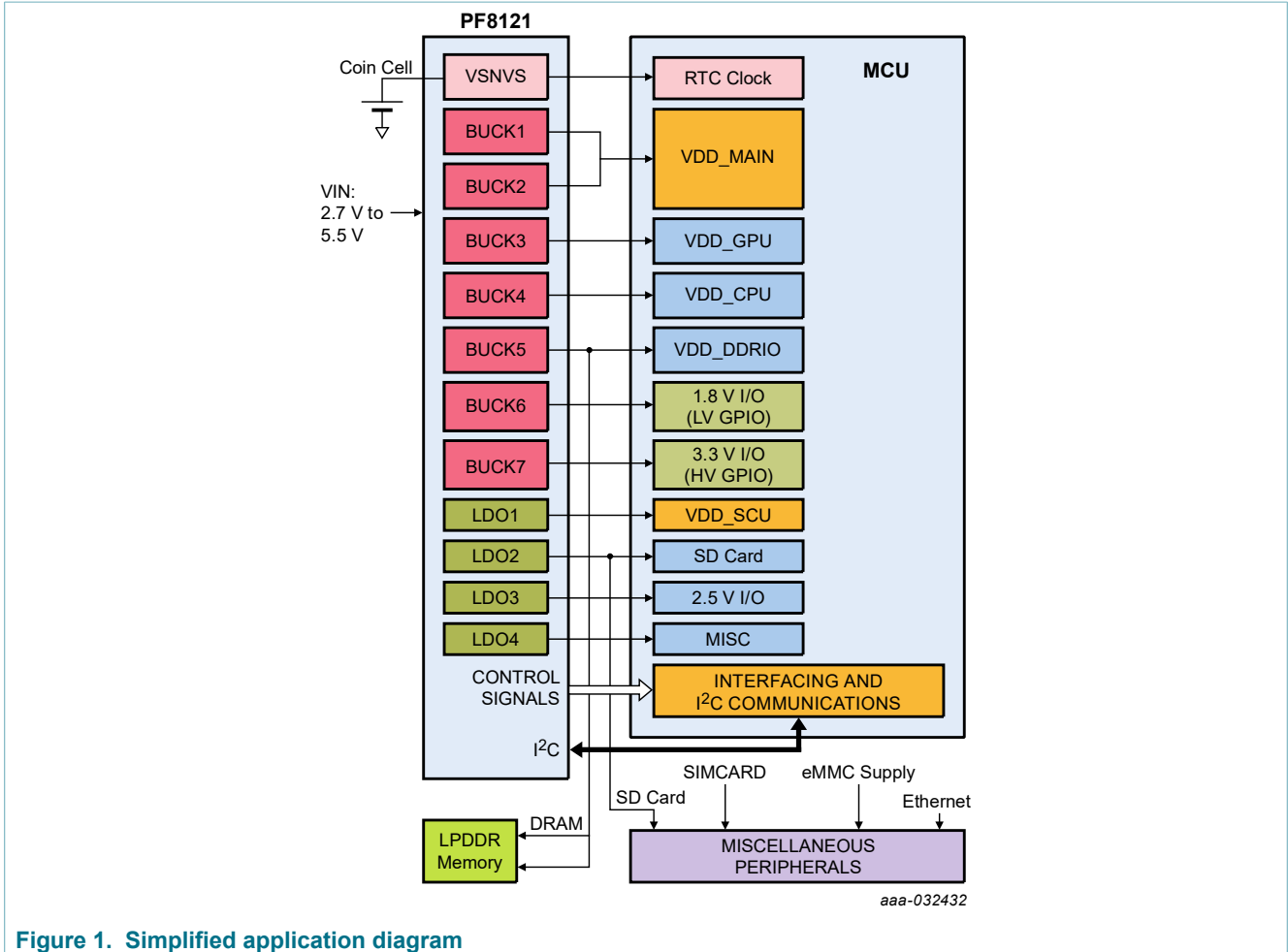


Figure 1. Simplified application diagram

### 4 Ordering information

Table 1. Device options

| Type   | Package |  |           |
|--------|---------|--|-----------|
|        | Name    | Description  | Version   |
| PF8121 | HVQFN56 | HVQFN56, plastic, thermally enhanced very thin quad; flat non-leaded package, 56 terminals; 0.5 mm pitch; 8 mm x 8 mm x 0.85 mm body | SOT684-21 |

Table 2. Ordering information

| Part number <sup>[1]</sup> | Target market | NXP processor | System comments                                 | Safety grade | OTP ID  |
|----------------------------|---------------|---------------|---|--------------|---|
| MC32PF8121A0EP             | Consumer      | i.MX8M Mini   | Not programmed                                  | n/a          | n/a   |
| MC32PF8121EU0EP            | Consumer      | i.MX8M Mini   | LPDDR4 (Vin > 4.0 V, SW7 = 3.3 V, SW4 = 1.8 V)  | n/a          | <a href="http://www.nxp.com/MC32PF8121EU0EP-OTP-Report">http://www.nxp.com/MC32PF8121EU0EP-OTP-Report</a> |
| MC32PF8121F1EP             | Consumer      | i.MX8M Mini   | LPDDR4 memory                                   | n/a          | <a href="http://www.nxp.com/MC32PF8121F1EP-OTP-Report">http://www.nxp.com/MC32PF8121F1EP-OTP-Report</a>   |
| MC32PF8121F2EP             | Consumer      | i.MX8M Mini   | DDR3L (external VTT)                            | n/a          | <a href="http://www.nxp.com/MC32PF8121F2EP-OTP-Report">http://www.nxp.com/MC32PF8121F2EP-OTP-Report</a>   |
| MC32PF8121G5EP             | Consumer      | i.MX8M Mini   | LPDDR4 (Vin > 4.0 V, SW7 = 3.3 V, SW4 = 0.85 V) | n/a          | <a href="http://www.nxp.com/MC32PF8121G5EP-OTP-Report">http://www.nxp.com/MC32PF8121G5EP-OTP-Report</a>   |

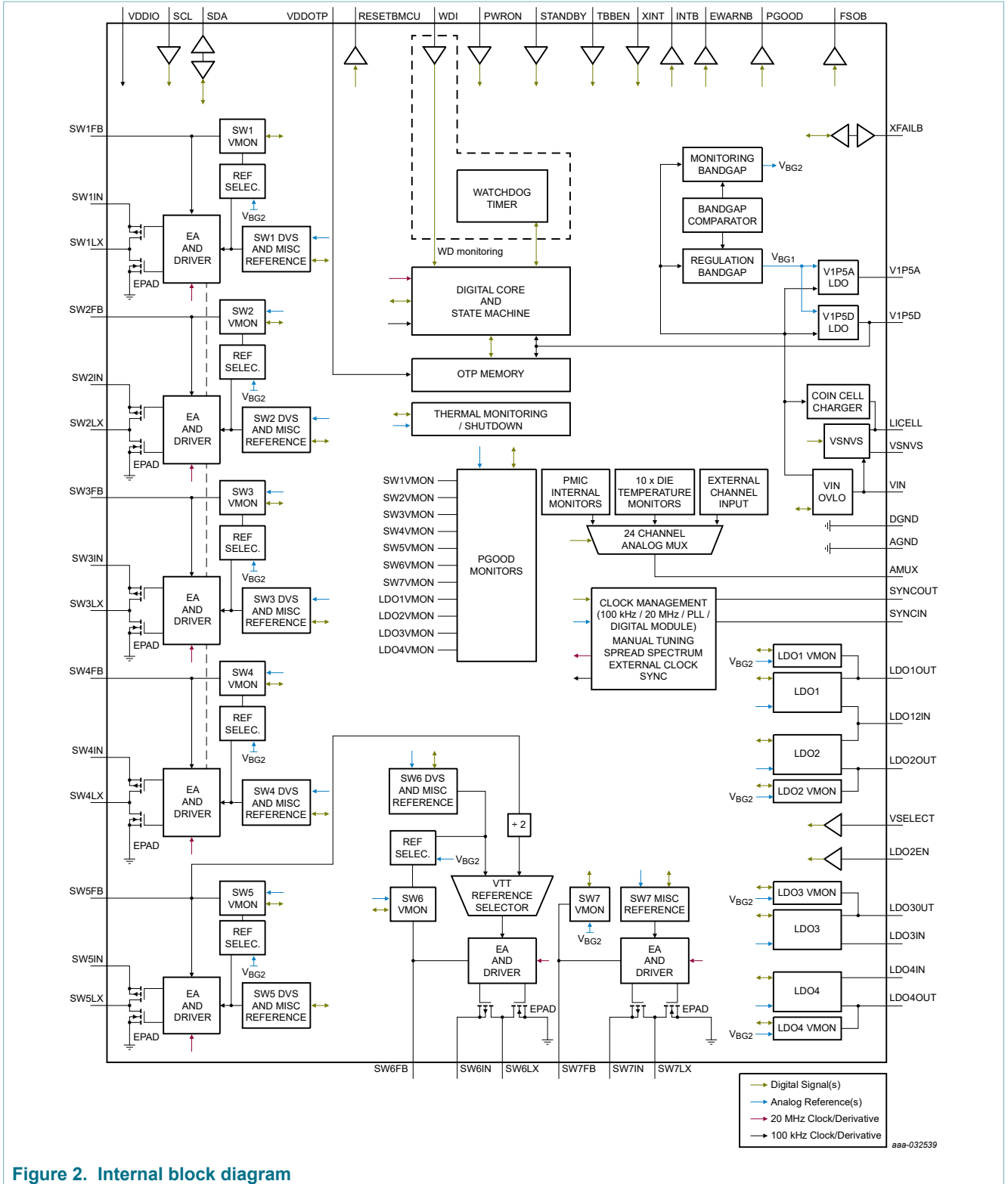
[1] To order parts in tape and reel, add the R2 suffix to the part number.

## 5 Applications

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- IoT devices
- Industrial

## 6 Internal block diagram



## 7 Pinning information

### 7.1 Pinning

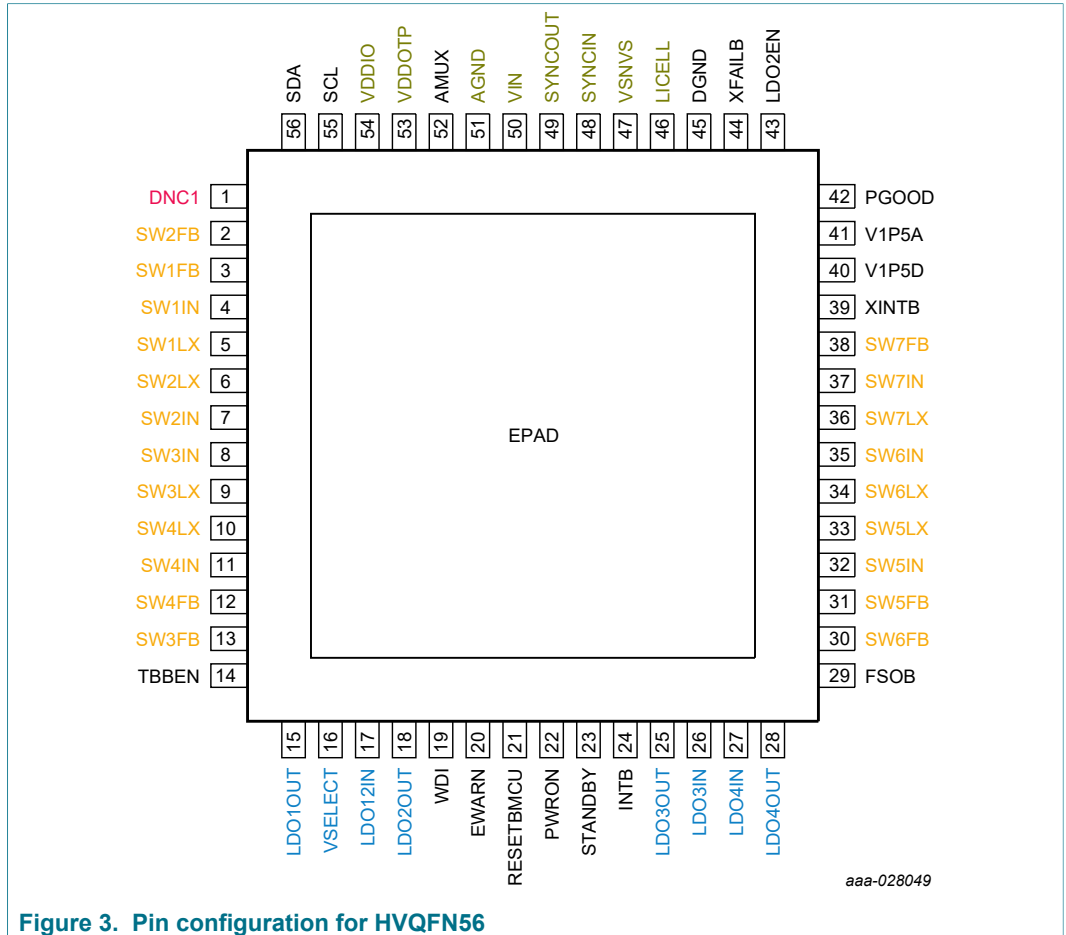


Figure 3. Pin configuration for HVQFN56

### 7.2 Pin description

Table 3. HVQFN56 pin description

| Pin number | Symbol | Application description        | Pin type | Min  | Max | Units |
|------------|--------|--------------------------------|----------|------|-----|-------|
| 1          | DNC1   | Do not connect                 | —        | —    | —   | V     |
| 2          | SW2FB  | Buck 2 output voltage feedback | I        | -0.3 | 6.0 | V     |
| 3          | SW1FB  | Buck 1 output voltage feedback | I        | -0.3 | 6.0 | V     |
| 4          | SW1IN  | Buck 1 input supply            | I        | -0.3 | 6.0 | V     |
| 5          | SW1LX  | Buck 1 switching node          | O        | -0.3 | 6.0 | V     |
| 6          | SW2LX  | Buck 2 switching node          | O        | -0.3 | 6.0 | V     |
| 7          | SW2IN  | Buck 2 input supply            | I        | -0.3 | 6.0 | V     |
| 8          | SW3IN  | Buck 3 input supply            | I        | -0.3 | 6.0 | V     |
| 9          | SW3LX  | Buck 3 switching node          | O        | -0.3 | 6.0 | V     |
| 10         | SW4LX  | Buck 4 switching node          | O        | -0.3 | 6.0 | V     |
| 11         | SW4IN  | Buck 4 input supply            | I        | -0.3 | 6.0 | V     |

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| Pin number | Symbol    | Application description                         | Pin type | Min  | Max | Units |
|------------|-----------|---|----------|------|-----|-------|
| 12         | SW4FB     | Buck 4 output voltage feedback                  | I        | -0.3 | 6.0 | V     |
| 13         | SW3FB     | Buck 3 output voltage feedback                  | I        | -0.3 | 6.0 | V     |
| 14         | TBBEN     | Try Before Buy enable pin                       | I        | -0.3 | 6.0 | V     |
| 15         | LDO1OUT   | LDO1 output                                     | O        | -0.3 | 6.0 | V     |
| 16         | VSELECT   | LDO2 voltage select input                       | I        | -0.3 | 6.0 | V     |
| 17         | LDO12IN   | LDO1 and LDO2 input supply                      | I        | -0.3 | 6.0 | V     |
| 18         | LDO2OUT   | LDO2 output                                     | O        | -0.3 | 6.0 | V     |
| 19         | WDI       | Watchdog Input from MCU                         | I        | -0.3 | 6.0 | V     |
| 20         | EWARN     | Early warning to MCU                            | O        | -0.3 | 6.0 | V     |
| 21         | RESETBMCU | RESETBMCU open-drain output                     | O        | -0.3 | 6.0 | V     |
| 22         | PWRON     | PWRON input                                     | I        | -0.3 | 6.0 | V     |
| 23         | STANDBY   | STANDBY input                                   | I        | -0.3 | 6.0 | V     |
| 24         | INTB      | INTB open-drain output                          | O        | -0.3 | 6.0 | V     |
| 25         | LDO3OUT   | LDO3 output                                     | O        | -0.3 | 6.0 | V     |
| 26         | LDO3IN    | LDO3 input supply                               | I        | -0.3 | 6.0 | V     |
| 27         | LDO4IN    | LDO4 input supply                               | I        | -0.3 | 6.0 | V     |
| 28         | LDO4OUT   | LDO4 output                                     | O        | -0.3 | 6.0 | V     |
| 29         | FSOB      | Fault notification output                       | O        | -0.3 | 6.0 | V     |
| 30         | SW6FB     | Buck 6 output voltage feedback                  | I        | -0.3 | 6.0 | V     |
| 31         | SW5FB     | Buck 5 output voltage feedback                  | I        | -0.3 | 6.0 | V     |
| 32         | SW5IN     | Buck 5 input supply                             | I        | -0.3 | 6.0 | V     |
| 33         | SW5LX     | Buck 5 switching node                           | O        | -0.3 | 6.0 | V     |
| 34         | SW6LX     | Buck 6 switching node                           | O        | -0.3 | 6.0 | V     |
| 35         | SW6IN     | Buck 6 input supply                             | I        | -0.3 | 6.0 | V     |
| 36         | SW7LX     | Buck 7 switching node                           | O        | -0.3 | 6.0 | V     |
| 37         | SW7IN     | Buck 7 input supply                             | I        | -0.3 | 6.0 | V     |
| 38         | SW7FB     | Buck 7 output voltage feedback                  | I        | -0.3 | 6.0 | V     |
| 39         | XINTB     | External interrupt input                        | I        | -0.3 | 6.0 | V     |
| 40         | V1P5D     | 1.6 V digital core supply                       | O        | -0.3 | 2.0 | V     |
| 41         | V1P5A     | 1.6 V analog core supply                        | O        | -0.3 | 2.0 | V     |
| 42         | PGOOD     | PGOOD open-drain output                         | O        | -0.3 | 6.0 | V     |
| 43         | LDO2EN    | LDO2 enable pin                                 | I        | -0.3 | 6.0 | V     |
| 44         | XFAILB    | External Synchronization pin                    | I/O      | -0.3 | 6.0 | V     |
| 45         | DGND      | Digital ground                                  | GND      | -0.3 | 0.3 | V     |
| 46         | LICELL    | Coin cell input                                 | I        | -0.3 | 5.5 | V     |
| 47         | VSNVS     | VSNVS regulator output                          | O        | -0.3 | 6.0 | V     |
| 48         | SYNCIN    | External clock input pin for synchronization    | I        | -0.3 | 6.0 | V     |
| 49         | SYNCOUT   | Clock out pin for external part synchronization | O        | -0.3 | 6.0 | V     |
| 50         | VIN       | Main input voltage to PMIC                      | I        | -0.3 | 6.0 | V     |
| 51         | AGND      | Analog ground                                   | GND      | -0.3 | 0.3 | V     |

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| Pin number | Symbol | Application description   | Pin type | Min  | Max | Units |
|------------|--------|---|----------|------|-----|-------|
| 52         | AMUX   | Analog multiplexer output   | O        | -0.3 | 6.0 | V     |
| 53         | VDDOTP | OTP selection input   | I        | -0.3 | 10  | V     |
| 54         | VDDIO  | I/O supply voltage. Connect to voltage rail between 1.6 V and 3.3 V | I        | -0.3 | 6.0 | V     |
| 55         | SCL    | I <sup>2</sup> C clock signal                                       | I        | -0.3 | 6.0 | V     |
| 56         | SDA    | I <sup>2</sup> C data signal  | I/O      | -0.3 | 6.0 | V     |
| 57         | EPAD   | Exposed pad<br>Connect to ground                                    | GND      | -0.3 | 0.3 | V     |

## 8 Absolute maximum ratings

Table 4. Absolute maximum ratings

| Symbol             | Parameter                                     | Min  | Typ | Max | Unit |
|--------------------|---|------|-----|-----|------|
| VIN                | Main input supply voltage <sup>[1]</sup>      | -0.3 | —   | 6.0 | V    |
| SWxVIN,<br>LDOxVIN | Regulator input supply voltage <sup>[1]</sup> | -0.3 | —   | 6.0 | V    |
| VDDOTP             | OTP programming input supply voltage          | -0.3 | —   | 10  | V    |
| VLICELL            | Coin cell voltage                             | -0.3 | —   | 5.5 | V    |

[1] Pin reliability may be affected if system voltages are above the maximum operating range of 5.5 V for extended periods of time. To minimize system reliability impact, system must not operate above 5.5 V for more than 1800 sec over the lifetime of the device.

## 9 ESD ratings

Table 5. ESD ratings

All ESD specifications are compliant with AEC-Q100 specification.

| Symbol               | Parameter  | Min | Typ | Max  | Unit |
|----------------------|--|-----|-----|------|------|
| V <sub>ESD</sub>     | Human Body Model <sup>[1]</sup>                              | —   | —   | 2000 | V    |
| V <sub>ESD</sub>     | Charge Device Model <sup>[1]</sup><br>QFN package - all pins | —   | —   | 500  | V    |
| I <sub>LATCHUP</sub> | Latch-up current   | —   | —   | 100  | mA   |

[1] ESD testing is performed in accordance with the human body model (HBM) (CZAP = 100 pF, RZAP = 1500 Ω), and the charge device model (CDM), robotic (CZAP = 4.0 pF)

## 10 Thermal characteristics

Table 6. Thermal characteristics

| Symbol            | Parameter                                    | Min | Typ | Max | Unit |
|-------------------|--|-----|-----|-----|------|
| T <sub>A</sub>    | Ambient operating temperature <sup>[1]</sup> | -40 | —   | 85  | °C   |
| T <sub>J</sub>    | Junction temperature                         | -40 | —   | 150 | °C   |
| T <sub>ST</sub>   | Storage temperature range                    | -40 | —   | 150 | °C   |
| T <sub>PPRT</sub> | Peak package reflow temperature              | —   | —   | 260 | °C   |

[1] All parameters are specified up to a junction temperature of 150 °C. All parameters are tested at T<sub>A</sub> from -40°C to 85 °C to allow headroom for self heating during operation. If higher T<sub>A</sub> operation is required, proper thermal and loading consideration must be made to ensure device operation below the maximum T<sub>J</sub> = 150 °C.

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Table 7. QFN56 thermal resistance and package dissipation ratings

| Symbol            | Parameter   | Min | Max | Unit |
|-------------------|---|-----|-----|------|
| R <sub>θJA</sub>  | Junction to Ambient Natural Convection<br>Single Layer Board (1s) [1] [2] | —   | 81  | °C/W |
| R <sub>θJA</sub>  | Junction to Ambient Natural Convection<br>Four Layer Board (2s2p) [1] [2] | —   | 27  | °C/W |
| R <sub>θJA</sub>  | Junction to Ambient Natural Convection<br>Eight Layer Board (2s6p)        | —   | 22  | °C/W |
| R <sub>θJMA</sub> | Junction to Ambient (@200ft/min)<br>Single Layer Board (1s) [1] [3]       | —   | 66  | °C/W |
| R <sub>θJMA</sub> | Junction to Ambient (@200ft/min)<br>Four Layer Board (2s2p) [1] [3]       | —   | 22  | °C/W |
| R <sub>θJB</sub>  | Junction to Board [4]   | —   | 11  | °C/W |
| R <sub>θJC</sub>  | Junction to Case (bottom) [5]   | —   | 0.6 | °C/W |
| Ψ <sub>JT</sub>   | Junction to package (top) [6]   | —   | 1   | °C/W |

[1] Junction temperature is a function of die size, on-chip power dissipation, package thermal resistance, mounting site (board) temperature, ambient temperature, air flow, power dissipation of other components on the board, and board thermal resistance.

[2] Per JEDEC JESD51-2 with natural convection for horizontally oriented board. Board meets JESD51-9 specification for 1s or 2s2p board, respectively.

[3] Per JEDEC JESD51-6 with forced convection for horizontally oriented board. Board meets JESD51-9 specification for 1s or 2s2p board, respectively.

[4] Thermal resistance between the die and the printed circuit board per JEDEC JESD51-8. Board temperature is measured on the top surface of the board near the package.

[5] Thermal resistance between the die and the solder pad on the bottom of the package. Interface resistance is ignored.

[6] Thermal characterization parameter indicating the temperature difference between package top and the junction temperature per JEDEC JESD51-2. When Greek letters are not available, the thermal characterization parameter is written as Psi-JT.

## 11 Operating conditions

Table 8. Operating conditions

| Symbol              | Parameter                  | Min   | Typ | Max | Unit |
|---------------------|----------------------------|-------|-----|-----|------|
| V <sub>IN</sub>     | Main input supply voltage  | UVDET | —   | 5.5 | V    |
| V <sub>LICELL</sub> | LICELL input voltage range | —     | —   | 4.2 | V    |

## 12 General description

### 12.1 Features

The PF8121 is a power management integrated circuit (PMIC) designed to be the primary power management building block for NXP high-end multimedia application processors. It is also capable of providing power solution to the high end i.MX 6 series as well as several non-NXP processors.

- Buck regulators
  - SW1, SW2, SW3, SW4, SW5, SW6: 0.4 V to 1.8 V; 2500 mA; 2 % accuracy
  - SW7; 1.0 V to 4.1 V; 2500 mA; 2 % accuracy
  - Dynamic voltage scaling on SW1, SW2, SW3, SW4, SW5, and SW6
  - SW1, SW2 configurable as a dual phase regulator
  - SW3, SW4 configurable as a dual phase regulator
  - SW5, SW6 configurable as a dual phase regulator
  - SW1, SW2 and SW3 configurable as a triple phase regulator with up to 7.5 A current capability



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- SW1, SW2, SW3 and SW4 configurable as a quad phase regulator with up to 10 A current capability
- VTT termination mode on SW6
- Programmable current limit
- Spread-spectrum and manual tuning of switching frequency
- LDO regulators
  - LDO1, 1.5 V to 5.0 V, 400 mA; 3 % accuracy with optional load switch mode
  - LDO2, 1.5 V to 5.0 V, 400 mA; 3 % accuracy with optional load switch mode and selectable hardware/software control
  - LDO3, 1.5 V to 5.0 V, 400 mA; 3 % accuracy with optional load switch mode
  - LDO4, 1.5 V to 5.0 V, 400 mA; 3 % accuracy with optional load switch mode
- RTC LDO/Switch supply from system supply or coin cell
  - RTC supply VSNVS 1.8 V/3.0 V/3.3 V, 10 mA
  - Battery backed memory including coin cell charger with programmable charge current and voltage
- System features
  - Fast PMIC startup
  - Advanced state machine for seamless processor interface
  - High speed I<sup>2</sup>C interface support (up to 3.4 MHz)
  - PGOOD monitor
  - User programmable standby and off modes
  - Programmable soft start sequence and power down sequence
  - Programmable regulator configuration
  - 24 channel analog multiplexer for smart system monitoring/diagnostic
- OTP (One time programmable) memory for device configuration
- Voltage and system monitoring
  - Independent voltage monitoring with programmable fault protection
  - Advance thermal monitoring and protection
  - External watchdog monitoring and programmable internal watchdog counter
  - I<sup>2</sup>C cyclic redundancy check (CRC)

12.2 Functional block diagram

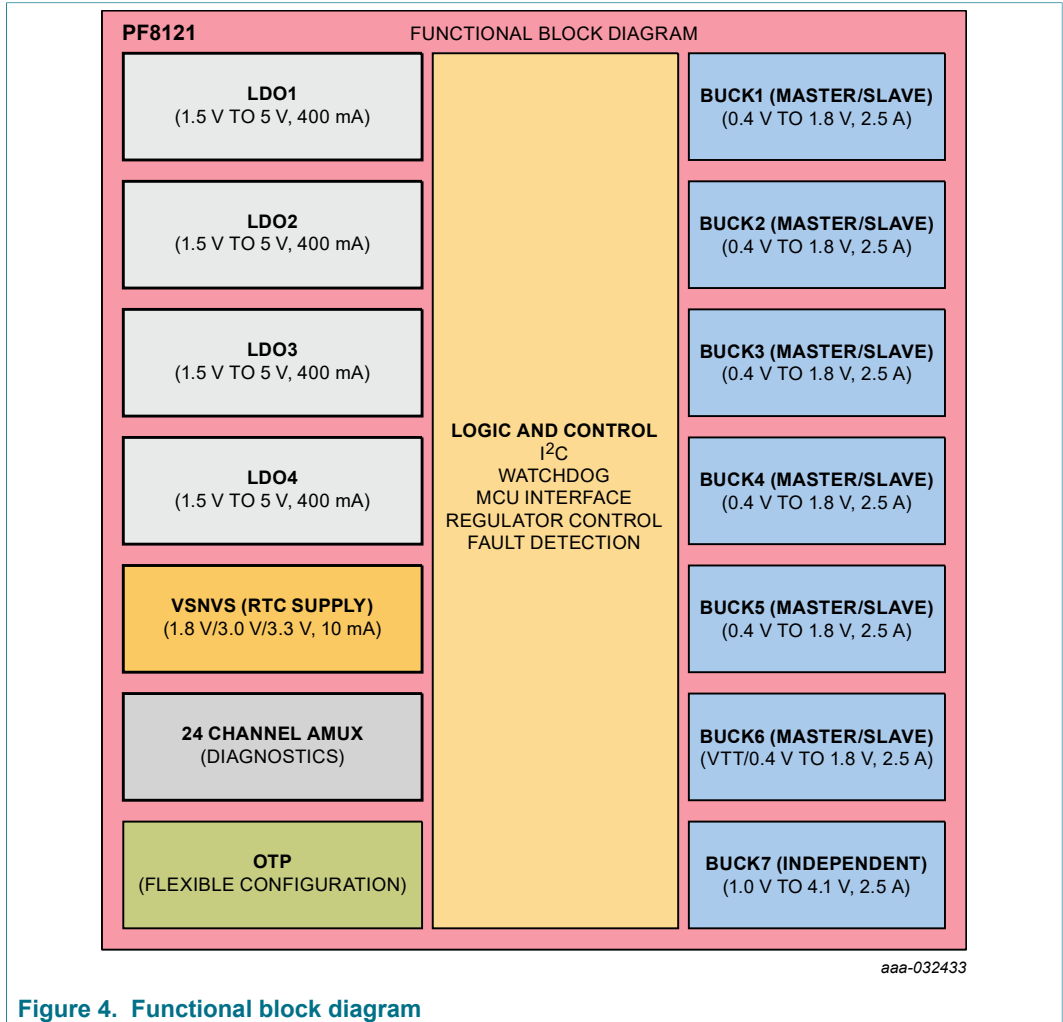


Figure 4. Functional block diagram

12.3 Power tree summary

The following table shows a summary of the voltage regulators in the PF8121.

Table 9. Voltage supply summary

| Regulator | Type            | Input supply | Regulated output range (V) | VOUT programmable step (mV) | IRATED (mA) |
|-----------|-----------------|--------------|----------------------------|-----------------------------|-------------|
| SW1       | Buck            | SW1IN        | 0.4 V to 1.8 V             | 6.25                        | 2500        |
| SW2       | Buck            | SW2IN        | 0.4 V to 1.8 V             | 6.25                        | 2500        |
| SW3       | Buck            | SW3IN        | 0.4 V to 1.8 V             | 6.25                        | 2500        |
| SW4       | Buck            | SW4IN        | 0.4 V to 1.8 V             | 6.25                        | 2500        |
| SW5       | Buck            | SW5IN        | 0.4 V to 1.8 V             | 6.25                        | 2500        |
| SW6       | Buck            | SW6IN        | VTT/0.4 V to 1.8 V         | 6.25                        | 2500        |
| SW7       | Buck            | SW7IN        | 1.0 V to 4.1 V             | —                           | 2500        |
| LDO1      | Linear (P-type) | LDO12IN      | 1.5 V to 5.0 V             | —                           | 400         |

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| Regulator | Type            | Input supply | Regulated output range (V) | VOUT programmable step (mV) | IRATED (mA) |
|-----------|-----------------|--------------|----------------------------|-----------------------------|-------------|
| LDO2      | Linear (P-type) | LDO12IN      | 1.5 V to 5.0 V             | —                           | 400         |
| LDO3      | Linear (P-type) | LDO3IN       | 1.5 V to 5.0 V             | —                           | 400         |
| LDO4      | Linear (P-type) | LDO4IN       | 1.5 V to 5.0 V             | —                           | 400         |
| VSNVS     | LDO/Switch      | VIN/LICELL   | 1.8 V/3.0 V/3.3 V          | —                           | 10          |

### 13 State machine

The PF8121 features a state of the art state machine for seamless processor interface. The state machine handles the IC start up, provides fault monitoring and reporting, and protects the IC and the system during fault conditions.

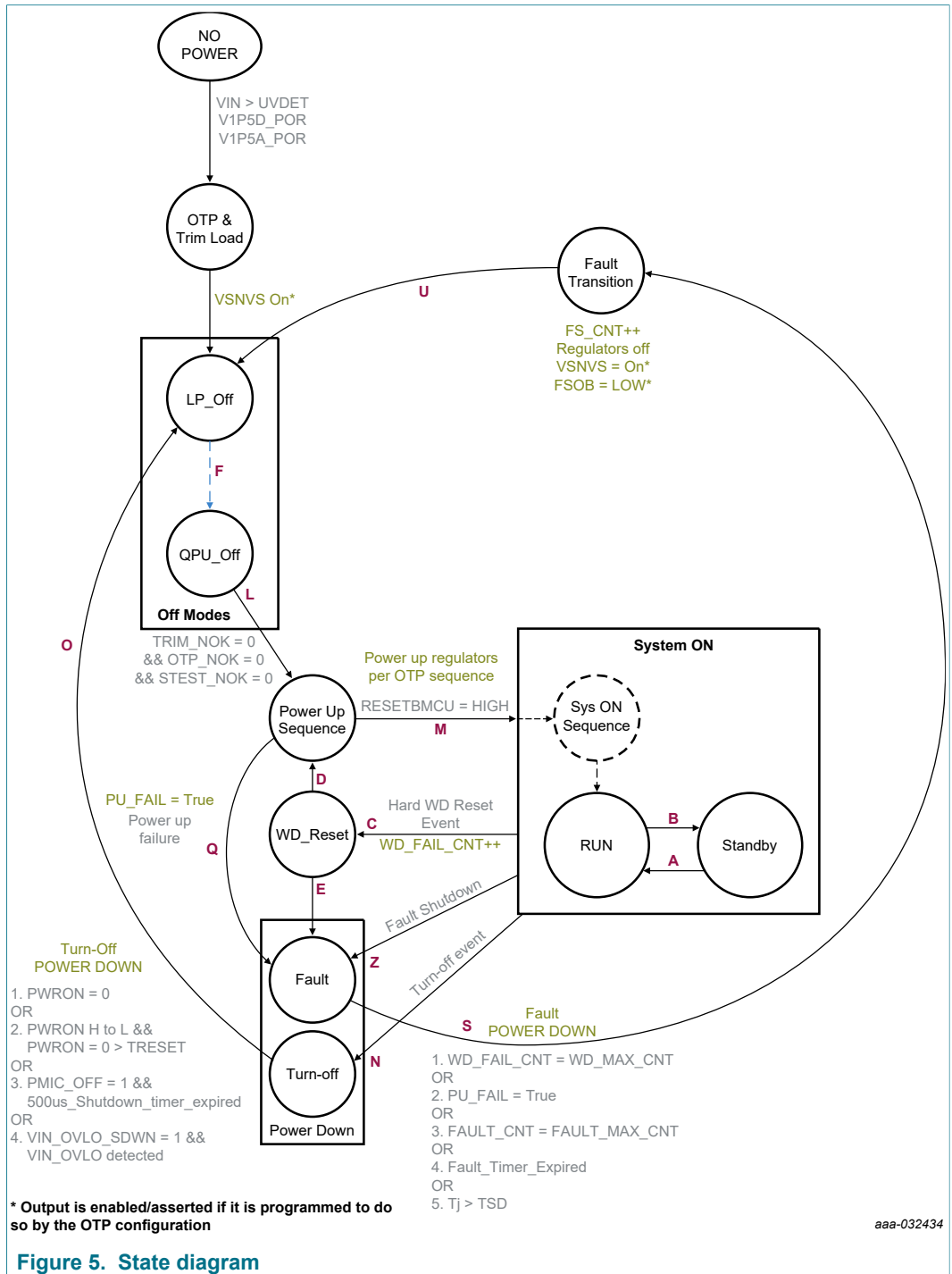


Figure 5. State diagram

Table 10 lists the conditions for the different state machine transitions.

Table 10. State machine transition definition

| Symbol       | Description    | Conditions                           |
|--------------|----------------|--------------------------------------|
| Transition A | Standby to run | 1. STANDBY = 0 && STANDBYINV bit = 0 |
|              |                | 2. STANDBY = 1 && STANDBYINV bit = 1 |

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| Symbol       | Description                    | Conditions  |
|--------------|--------------------------------|---|
| Transition B | Run to standby                 | 1. STANDBY = 1 && STANDBYINV bit = 0  |
|              |                                | 2. STANDBY = 0 && STANDBYINV bit = 1  |
| Transition C | System on to WD reset          | 1. Hard WD Reset event  |
| Transition D | WD reset to system on          | 1. 30 $\mu$ s delay passed && WD_EVENT_CNT < WD_MAX_CNT   |
| Transition E | WD reset to power down (fault) | 1. WD_EVENT_CNT = WD_MAX_CNT  |
| Transition F | LP_Off to QPU_Off              | Transitory Off state: device pass through LP_Off to QPU_Off (no power up event present)<br>1. LPM_OFF = 1<br>&& TBBEN = Low   |
|              |                                | Power up event from LP_Off state<br>2. LPM_OFF = 0<br>&& TBBEN = Low<br>&& (PWRON = 1 && OTP_PWRON_MODE = 0)<br>&& UVDET < VIN < VIN_OVLO (or VIN_OVLO disabled)<br>&& Tj < TSD<br>&& TRIM_NOK = 0 && OTP_NOK = 0 |
|              |                                | Power up event from LP_Off state<br>3. LPM_OFF = 0<br>&& TBBEN = Low<br>&& (PWRON H to L && OTP_PWRON_MODE = 1)<br>&& UVDET < VIN < VIN_OVLO (or VIN_OVLO disabled)<br>&& Tj < TSD && TRIM_NOK = 0 && OTP_NOK = 0 |
|              |                                | Transitory Off state: device pass through LP_Off to QPU_Off (no power up event present)<br>4. TBBEN = High (V1P5D)  |

12-channel power management integrated circuit for high performance applications

| Symbol       | Description                        | Conditions  |
|--------------|------------------------------------|---|
| Transition L | QPU_Off to power up                | Transitory QPU_Off state, power on event occurs from LP_Off state, after self-test is passed, QPU_Off is just a transitory state until power up sequence starts.<br>1. LPM_OFF = 0<br>&& TBBEN = Low<br>&& TRIM_NOK = 0 && OTP_NOK = 0 && STEST_NOK=0 |
|              |                                    | Power up event from QPU_Off state<br>2. LPM_OFF = 1<br>&& (PWRON = 1 && OTP_PWRON_MODE = 0)<br>&& UVDET < VIN < VIN_OVLO (or VIN_OVLO disabled)<br>&& Tj < TSD<br>&& TRIM_NOK = 0 && OTP_NOK = 0 && STEST_NOK=0                                       |
|              |                                    | Power up event from QPU_Off state<br>3. LPM_OFF = 1<br>&& (PWRON H to L && OTP_PWRON_MODE = 1)<br>&& UVDET < VIN < VIN_OVLO (or VIN_OVLO disabled)<br>&& Tj < TSD<br>&& TRIM_NOK = 0 && OTP_NOK = 0 && STEST_NOK=0                                    |
|              |                                    | Power up event from QPU_Off state<br>4. TBBEN = High<br>&& (PWRON = 1 && OTP_PWRON_MODE = 0)<br>&& UVDET < VIN < VIN_OVLO (or VIN_OVLO disabled)<br>&& Tj < TSD<br>&& TRIM_NOK = 0 && OTP_NOK = 0 && STEST_NOK=0                                      |
|              |                                    | Power up event from QPU_Off state<br>5. TBBEN = High<br>&& (PWRON H to L && OTP_PWRON_MODE = 1)<br>&& UVDET < VIN < VIN_OVLO (or VIN_OVLO disabled)<br>&& Tj < TSD<br>&& TRIM_NOK = 0 && OTP_NOK = 0 && STEST_NOK=0                                   |
| Transition M | Power up sequence to system on     | 1. RESETBMCU is released as part of the power up sequence   |
| Transition N | System on to power down (turn off) | Requested turn off event<br>1. OTP_PWRON_MODE = 0 && PWRON = 0  |
|              |                                    | Requested turn off event<br>2. OTP_PWRON_MODE = 1 && (PWRON H to L && PWRON = low for t > TRESET)   |
|              |                                    | Requested turn off event<br>3. PMIC_OFF = 1 && 500µs_Shutdown_Timer_Expired   |
|              |                                    | Protective turn off event (no PMIC fault)<br>4. VIN_OVLO_SDWN=1 && VIN_OVLO detected for longer than VIN_OVLO_DBNC time   |
| Transition Z | System on to power down (fault)    | Turn off event due to PMIC fault<br>1. Fault Timer expired  |
|              |                                    | Turn off event due to PMIC fault<br>2. FAULT_CNT = FAULT_MAX_CNT  |
|              |                                    | Turn off event due to PMIC fault<br>3. Thermal shutdown Tj > TSD  |
| Transition O | Power down (turn off) to LP_Off    | Requested turn off event moves directly to LP_Off<br>1. Power down sequences finished   |

| Symbol       | Description                            | Conditions  |
|--------------|--|---|
| Transition Q | Power up to power down (fault)         | Power up failure<br>1. Failure during power up sequence   |
| Transition S | Power down (fault) to fault transition | Turn off event due to a fault condition moves to fault transition<br>1. Power down sequence is finished             |
| Transition U | Fault transition to LP_Off             | Transitory fault transition<br>Moves automatically to LP_Off state after increasing the FS_CNT system fault counter |

## 13.1 States description

### 13.1.1 OTP/TRIM load

Upon VIN application V1P5D and V1P5A regulators are turned on automatically. Once the V1P5D and V1P5A cross their respective POR thresholds, the fuses (for trim and OTP) are loaded into the mirror registers and into the functional I<sup>2</sup>C registers if configured by the voltage on the VDDOTP pin.

The fuse circuits have a CRC error check routine which reports and protects against register loading errors on the mirror registers. If a register loading error is detected, the corresponding TRIM\_NOK or OTP\_NOK flag is asserted. See [Section 17 "OTP/TBB and default configurations"](#) for details on handling fuse load errors.

If no fuse load errors are present, VSNVS is configured as indicated in the OTP configuration bits, and the state machine moves to the LP\_OFF state.

### 13.1.2 LP\_Off state

The LP\_Off state is a low power off mode selectable by the LPM\_OFF bit during the system on modes. By default, the LPM\_OFF = 0 when VIN crosses the UVDET threshold, therefore the state machine stops at the LP\_Off state until a valid power up event is present. When LPM\_OFF = 1, the state machine transitions automatically to the QPU\_Off state if no power up event has been present and waits in the QPU\_Off until a valid power up event is present.

The selection of the LPM\_OFF bit is based on whether prioritizing low quiescent current (stay in LP\_Off) or quick power up (move to QPU\_Off state).

If a power up event is started in LP\_Off state with LPM\_OFF = 0 and a fuse loading error is detected, the PF8121 ignores the power up event and remains in the LP\_Off state to avoid any potential damage to the system.

To be in LP\_Off state, it is necessary to have VIN present. If a valid LICELL is present, but VIN is below the UVDET, the PF8121 enters the coin cell state.

### 13.1.3 QPU\_Off state

The QPU\_Off state is a higher power consumption off mode, in which all internal circuitry required for a power on is biased and ready to start a power up sequence.

If LPM\_OFF = 1 and no turn on event is present, the device stops at the QPU\_Off state, and waits until a valid turn on event is present.

In this state, if VDDIO supply is provided externally, the device is able to communicate through I<sup>2</sup>C to access and modify the mirror registers in order to operate the device in

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TBB mode or to program the OTP registers as described in [Section 17 "OTP/TBB and default configurations"](#).

By default, the coin cell charger is disabled during the QPU\_Off state when VIN crosses the UVDET threshold, but it may be turned on or off in this state once it is programmed by COINCHG\_OFF during the system-on states.

If a power up event is started and any of the TRIM\_NOK or OTP\_NOK flags are asserted, the device ignores the power up event and remains in the QPU\_Off state. See [Section 17 "OTP/TBB and default configurations"](#) for more details on debugging a fuse loading failure.

Upon a power up event, the default configuration from OTP or hardwire is loaded into their corresponding I<sup>2</sup>C functional register in the transition from QPU\_Off to power up state.

### 13.1.4 Power up sequence

During the power up sequence, the external regulators are turned on in a predefined order as programmed by the default (OTP or hardwire) sequence.

If PGOOD is used as a GPO, it can also be set high as part of the power up sequence in order to allow sequencing of any external supply/device controlled by the PGOOD pin.

The RESETBMCU is also programmed as part of the power up sequence, and it is used as the condition to enter system-on states. The RESETBMCU may be released in the middle of the power up sequence, in this case, the remaining supplies in the power up continues to power up as the device is in the run state. See [Section 14.5.2 "Power up sequencing"](#) for details.

### 13.1.5 System-on states

During the system-on states, the MCU is powered and out of reset and the system is fully operational.

The system on is a virtual state composed by two modes of operations:

- Run state
- Standby state

Register to control the regulators output voltage, regulator enable, interrupt masks, and other miscellaneous functions can be written to or read from the functional I<sup>2</sup>C register map during the system-on states.

#### 13.1.5.1 Run state

If the power up state is successfully completed, the state machine transitions to the run state. In this state, RESETBMCU is released high, and the MCU is expected to boot up and set up specific registers on the PMIC as required during the system boot up process.

The run mode is intended to be used as the normal mode of operation for the system.

Each regulator has specific registers to control its output voltage, operation mode and/or enable/disable state during the run state.

By default, the VSWx\_RUN[7:0] / VLDOx\_RUN[3:0] registers are loaded with the data stored in the OTP\_VSWx[7:0] or OTP\_VLDOx[3:0] bits respectively.



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SW7 uses only one global register to configure the output voltage during run or standby mode. Upon power up the VSW7[4:0] bits are loaded with the values of the OTP\_VSW7[4:0].

Upon power up, if the switching regulator is part of the power up sequence, the SWx\_RUN\_MODE[1:0] bits will be loaded as needed by the system:

- When OTP\_SYNCIN\_EN = 1, default SWx\_RUN\_MODE at power up is always set to PWM (0b01)
- When OTP\_SYNCOUT\_EN = 1, default SWx\_RUN\_MODE at power up is always set to PWM (0b01)
- When OTP\_FSS\_EN = 1, default SWx\_RUN\_MODE at power up shall always set to PWM (0b01)
- If none of the above conditions are met, the default value of the SWx\_RUN\_MODE bits at power up will be set by the OTP\_SW\_MODE bits.

When OTP\_SW\_MODE = 0, the default value of the SWx\_RUN\_MODE bits are set to 0b11 (autoskip).

When OTP\_SW\_MODE = 1, the default value of the SWx\_RUN\_MODE bits are set to 0b01 (PWM).

If the switching regulator is not part of the power up sequence, the SWx\_RUN\_MODE[1:0] bits are loaded with 0b00 (OFF mode).

Likewise, if the LDO is part of the power up sequence, the LDOx\_RUN\_EN bit is set to 1 (enabled) by default. If the LDO is not selected as part of the power up sequence, the LDOx\_RUN\_EN bit is set to 0 (disabled) by default.

In a typical system, each time the processor boots up (PMIC transitions from off mode to run state), all output voltage configurations are reset to the default OTP configuration, and the MCU should configure the PMIC to its desired usage in the application.

### 13.1.5.2 Standby state

The standby state is intended to be used as a low power (state retention) mode of operation. In this state, the voltage regulators can be preset to a specific low power configuration in order to reduce the power consumption during system's sleep or state retention modes of operations.

The standby state is entered when the STANDBY pin is pulled high or low as defined by the STANDBYINV bit. The STANDBY pin is pulled high/low by the MCU to enter/exit system low power mode. See [Section 14.9.2 "STANDBY"](#) for detailed configuration of the STANDBY pin.

Each regulator has specific registers to control its output voltage, operation mode and/or enable/disable state during the standby state.

By default, the VSWx\_STBY[7:0] / VLDOx\_STBY[3:0] registers are loaded with the data stored in the OTP\_VSWx[7:0] or OTP\_VLDOx[3:0] bits respectively.

Upon power up, if the switching regulator is part of the power up sequence, the SWx\_STBY\_MODE[1:0] bits will be loaded as needed by the system:

- When OTP\_SYNCIN\_EN = 1, default SWx\_STBY\_MODE at power up is always set to PWM (0b01)
- When OTP\_SYNCOUT\_EN = 1, default SWx\_STBY\_MODE at power up is always set to PWM (0b01)

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- When `OTP_FSS_EN = 1`, default `SWx_STBY_MODE` at power up shall always set to PWM (0b01)
- If none of the conditions above are met, the default value of the `SWx_STBY_MODE` bits at power up will be set by the `OTP_SW_MODE` bits.

When `OTP_SW_MODE = 0`, the default value of the `SWx_STBY_MODE` bits are set to 0b11 (autoskip).

When `OTP_SW_MODE = 1`, the default value of the `SWx_STBY_MODE` bits are set to 0b01 (PWM).

If the switching regulator is not part of the power up sequence, the `SWx_STBY_MODE[1:0]` bits are loaded with 0b00 (OFF mode).

Likewise, if the LDO is part of the power up sequence, the `LDOx_RUN_EN` bit is set to 1 (enabled) by default. If the LDO is not selected as part of the power up sequence, the `LDOx_RUN_EN` bit is set to 0 (disabled) by default.

Upon power up, the standby registers are loaded with the same default OTP values as the run mode. The MCU is expected to program the desired standby values during boot up.

If any of the external regulators are disabled in the standby state, the power down sequencer is engaged as described in [Section 14.6.2 "Power down sequencing"](#).

### 13.1.6 WD\_Reset

When a hard watchdog reset is present, the state machine increments the `WD_EVENT_CNT[3:0]` register and compares against the `WD_MAX_CNT[3:0]` register. If `WD_EVENT_CNT[3:0] = WD_MAX_CNT[3:0]`, the state machine detects a cyclic watchdog failure, it powers down the external regulators and proceeds to the fault transition.

If `WD_EVENT_CNT[3:0] < WD_MAX_CNT[3:0]`, the state machine performs a hard WD reset.

A hard WD reset can be generated from either a transition in the WDI pin or a WD event initiated by the internal watchdog counter as described in [Section 15.11.2 "Watchdog reset behaviors"](#).

### 13.1.7 Power down state

During power down state, all regulators except VSNVS are disabled as configured in the power down sequence. The power down sequence is programmable as defined in [Section 14.6.2 "Power down sequencing"](#).

Two types of events may lead to the power down sequence:

- Non faulty turn off events: move directly into LP\_Off state as soon as power down sequence is finalized
- Turn off events due to a PMIC fault: move to the fault transition as soon as the power down sequence is finalized

### 13.1.8 Fault transition

The fault transition is entered if the PF8121 initiates a turn off event due to a PMIC fault.

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If the fault transition is entered, the PF8121 provides four FAIL bits to indicate the source of the failure:

- The PU\_FAIL is set to 1 when the device shuts down due to a power up failure
- The WD\_FAIL is set to 1 when the device shuts down due to a watchdog event counter max out
- The REG\_FAIL is set to 1 when the device shuts down due to a regulator failure (fault counter maxed out or fault timer expired)
- The TSD\_FAIL is set to 1 when the device shuts down due to a thermal shutdown

The value of the FAIL bits is retained as long as VIN > UVDET.

The MCU can read the FAIL bits during the system-on states in order to obtain information about the previous failure and can clear them by writing a 1 to them, provided the state machine is able to power up successfully after such failure.

13.1.9 Coin cell state

When VIN is not present and LICELL pin has a valid voltage, the device is placed into a coin cell state. In such state, only VSNVS remains on (if programmed to do so by the OTP\_VSNVSVOTL[1:0] bits) and is expected to provide power to the SNVS domain on the MCU as long as the LICELL pin has a valid input suitable to supply the configured VSNVS output voltage.

14 General device operation

14.1 UVDET

UVDET works as the main operation threshold for the PF8121. Crossing UVDET on the rising edge is a mandatory condition for OTP fuses to be loaded into the mirror registers and allows the main PF8121 operation.

If VIN is below the UVDET threshold, the device remains in an unpowered state if no valid LICELL is present, or in the LICELL mode if a valid LICELL voltage is present. A 200 mV hysteresis is implemented on the UVDET comparator to set the falling threshold.

Table 11. UVDET threshold

| Symbol | Parameter     | Min | Typ | Max | Unit |
|--------|---------------|-----|-----|-----|------|
| UVDET  | Rising UVDET  | 2.7 | 2.8 | 2.9 | V    |
| UVDET  | Falling UVDET | 2.5 | 2.6 | 2.7 | V    |

14.2 VIN OVLO condition

The VIN\_OVLO circuit monitors the main input supply of the PF8121. When this block is enabled, the PF8121 monitors its input voltage and can be programmed to react to an overvoltage in two ways:

- When the VIN\_OVLO\_SDWN = 0, the VIN\_OVLO event triggers an OVLO interrupt but does not turn off the device
- When the VIN\_OVLO\_SDWN = 1, the VIN\_OVLO event initiates a power down sequence

When the VIN\_OVLO\_EN = 0, the OVLO monitor is disabled and when the VIN\_OVLO\_EN = 1, the OVLO monitor is enabled. The default configuration of the

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VIN\_OVLO\_EN bit is set by the OTP\_VIN\_OVLO\_EN bit in OTP. Likewise, the default value of the VIN\_OVLO\_SDWN bit is set by the OTP\_VIN\_OVLO\_SDWN upon power up.

During a power up transition, if the OTP\_VIN\_OVLO\_SDWN = 0 the device allows the external regulators to come up and the PF8121 announces the VIN\_OVLO condition through an interrupt. If the OTP\_VIN\_OVLO\_SDWN = 1, the device stops the power up sequence and returns to the corresponding off mode.

Debounce on the VIN\_OVLO comparator is programmable to 10 μs, 100 μs or 1.0 ms, by the VIN\_OVLO\_DBNC[1:0] bits. The default value for the VIN\_OVLO debounce is set by the OTP\_VIN\_OVLO\_DBNC[1:0] bits upon power up.

Table 12. VIN\_OVLO debounce configuration

| VIN_OVLO_DBNC[1:0] | VIN OVLO debounce value (μs) |
|--------------------|------------------------------|
| 00                 | 10                           |
| 01                 | 100                          |
| 10                 | 1000                         |
| 11                 | Reserved                     |

Table 13. VIN\_OVLO specifications

| Symbol       | Parameter   | Min  | Typ | Max | Unit |
|--------------|---|------|-----|-----|------|
| VIN_OVLO     | VIN overvoltage lockout rising <sup>[1]</sup>     | 5.55 | 5.8 | 6.0 | V    |
| VIN_OVLO_HYS | VIN overvoltage lockout hysteresis <sup>[1]</sup> | —    | —   | 200 | mV   |

[1] Operating the device above the maximum VIN = 5.5 V for extended periods of time may degrade and cause permanent damage to the device.

14.3 IC startup timing with PWRON pulled up

The PF8121 features a fast internal core power up sequence to fulfill system power up timings of 5.0 ms or less, from power application until MCU is out of reset. Such requirement needs a maximum ramp up time of 1.5 ms for VIN to cross the UVDET threshold in the rising edge.

A maximum core biasing time of 1.5 ms from VIN crossing to UVDET until the beginning of the power up sequence is ensured to allow up to 1.5 ms time frame for the voltage regulators power up sequence.

Timing for the external regulators to start up is programmed by default in the OTP fuses.

The 5.0 ms power up timing requirement is only applicable when the PWRON pin operates in level sensitive mode OTP\_PWRON\_MODE = 0, however turn on timing is expected to be the same for both level or edge sensitive modes after the power on event is present.

In applications using the VSNVS regulator, if VSNVS is required to reach regulation before system regulators come up, the system should use the SEQ[7:0] bits to delay the system regulators to allow enough time for VSNVS to reach regulation before the power up sequence is started.

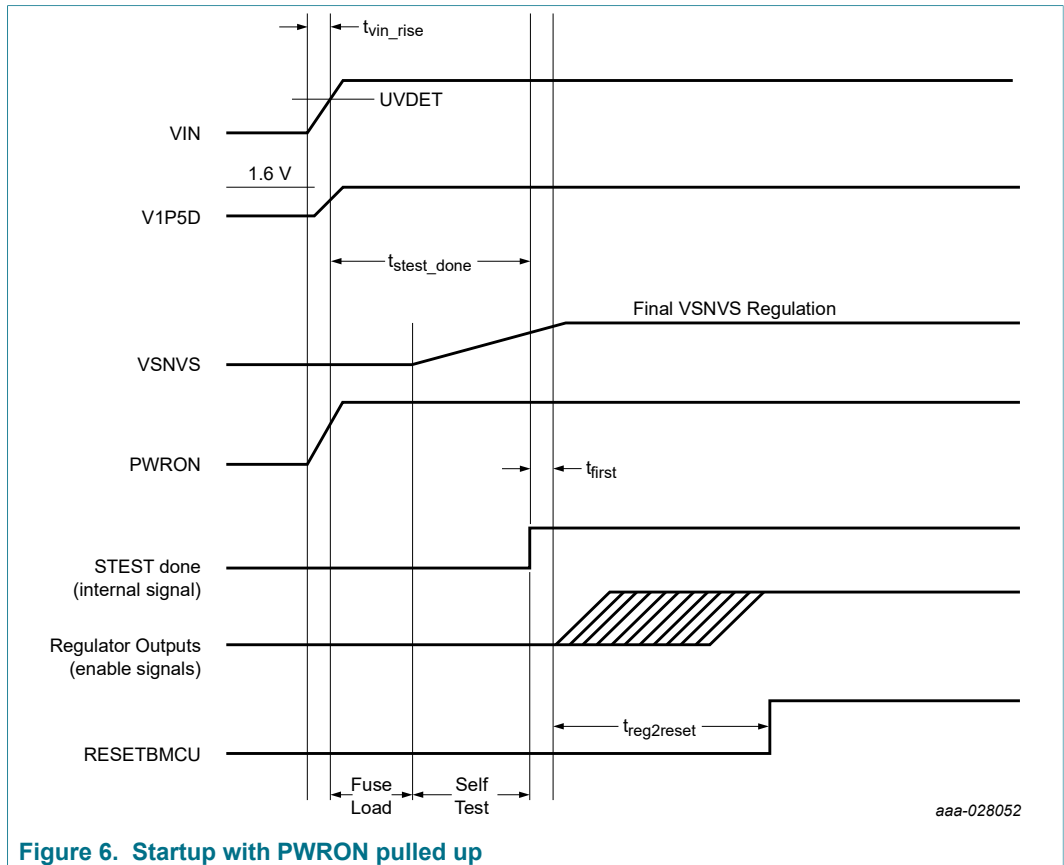


Figure 6. Startup with PWRON pulled up

Table 14. Startup timing requirements (PWRON pulled up)

| Symbol            | Parameter  | Min | Typ | Max  | Unit    |
|-------------------|--|-----|-----|------|---------|
| $t_{vin\_rise}$   | Rise time of VIN from VPWR application to UVDET (system dependent)                       | 10  | —   | 1500 | $\mu s$ |
| $t_{stest\_done}$ | Time from VIN crossing UVDET to STEST_done going high (self-test performed and passed)   | —   | —   | 1.4  | ms      |
| $t_{first}$       | Time from STEST_done to first slot of power up sequence                                  | —   | —   | 100  | $\mu s$ |
| $t_{reg2reset}$   | Time from first regulator enabled to RESETBMCU asserted to guarantee 5.0 ms PMIC boot up | [1] | —   | 1.5  | ms      |

[1] External regulators power up sequence time ( $t_{reg2reset}$ ) is programmed by OTP and may be longer than 1.5 ms. However, 1.5 ms is the maximum allowed time to ensure power up within 5.0 ms.

### 14.4 IC startup timing with PWRON pulled low during VIN application

It is possible that PWRON is held low when VIN is applied. By default, LPM\_OFF bit is reset to 0 upon crossing UVDET, therefore the PF8121 remains in the LP\_Off state as described in Section 13.1.2 "LP\_Off state". In this scenario, quiescent current in the LP\_Off state is kept to a minimum. When PWRON goes high with LPM\_OFF = 0, the PMIC startup is expected to take longer, since it has to enable most of the internal circuits and perform the self-test before starting a power up sequence.

Figure 7 shows startup timing with LPM\_OFF = 0.

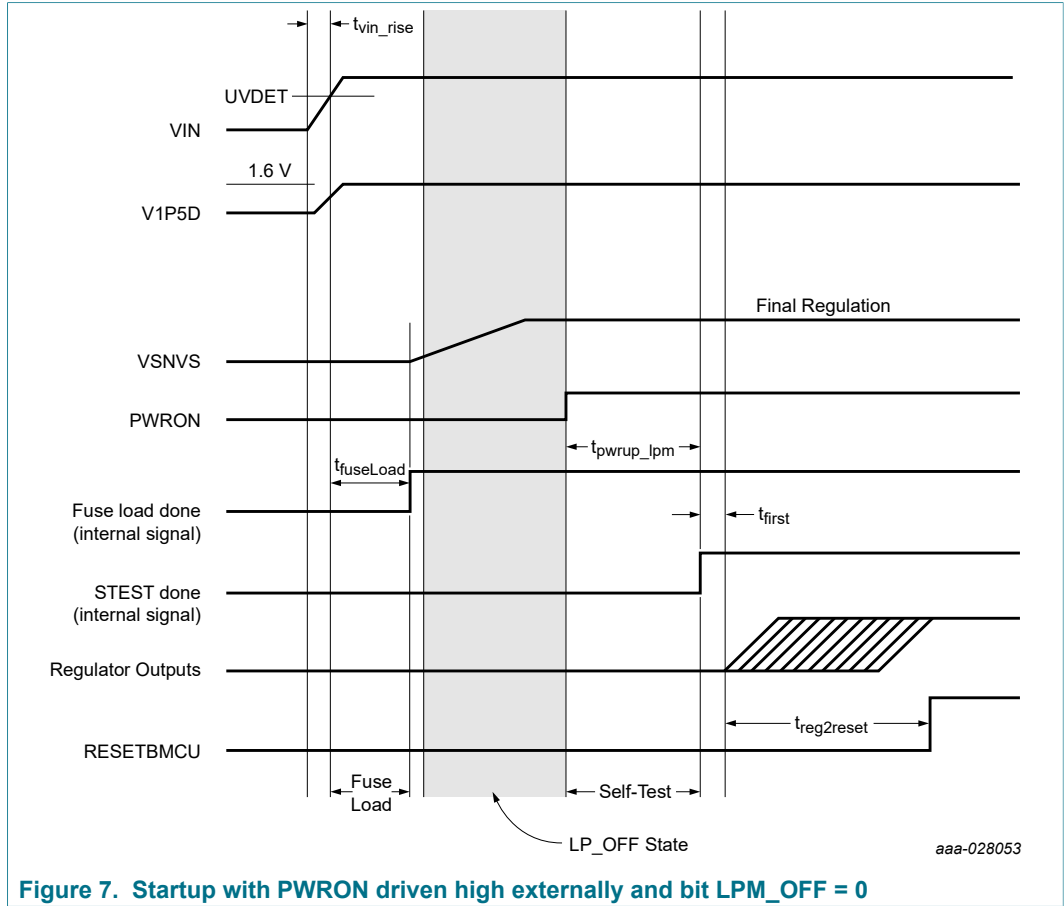


Table 15. Startup with PWRON driven high externally and LPM\_OFF = 0

| Symbol           | Parameter  | Min | Typ | Max  | Unit    |
|------------------|--|-----|-----|------|---------|
| $t_{vin\_rise}$  | Rise time of VIN from VPWR application to UVDET (system dependent)                       | 10  | —   | 1500 | $\mu s$ |
| $t_{fuseload}$   | Time from VIN crossing UVDET to Fuse_Load_done (fuse loaded correctly)                   | —   | —   | 600  | $\mu s$ |
| $t_{pwrup\_lpm}$ | Time from PWRON going high to the STEST_done (self-test performed and passed)            | —   | —   | 700  | $\mu s$ |
| $t_{first}$      | Time from STEST_done to first slot of power up sequence                                  | —   | —   | 100  | $\mu s$ |
| $t_{reg2reset}$  | Time from first regulator enabled to RESETBMCU asserted to guarantee 5.0 ms PMIC boot up | [1] | —   | 1.5  | ms      |

[1] External regulators power up sequence time ( $t_{reg2reset}$ ) is programmed by OTP and may be longer than 1.5 ms.

## 14.5 Power up

### 14.5.1 Power up events

Upon a power cycle ( $VIN > UVDET$ ), the LPM\_OFF bit is reset to 0, therefore the device moves to the LP\_Off state by default. The actual value of the LPM\_OFF bit can be changed during the run mode and is maintained until VIN crosses the UVDET threshold.

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In either one of the off modes, the PF8121 can be enabled by the following power up events:

1. When OTP\_PWRON\_MODE = 0, PWRON pin is pulled high.
2. When OTP\_PWRON\_MODE = 1, PWRON pin experiences a high to low transition and remains low for as long as the PWRON\_DBNC timer.

A power up event is valid only if:

- VIN > UVDET
- VIN < VIN\_OVLO (unless the OVLO is disabled or OTP\_VIN\_OVLO\_SDWN = 0)
- Tj < thermal shutdown threshold
- TRIM\_NOK = 0 && OTP\_NOK = 0

14.5.2 Power up sequencing

The power up sequencer controls the time and order in which the voltage regulators and other controlling I/O are enabled when going from the off mode into the run state.

The OTP\_SEQ\_TBASE[1:0] bits set the default time base for the power up and power down sequencer.

The SEQ\_TBASE[1:0] bits can be modified during the system-on states in order to change the sequencer timing during run/standby transitions as well as the power down sequence.

Table 16. Power up time base register

| OTP bits<br>OTP_SEQ_TBASE[1:0] | Functional bits<br>SEQ_TBASE[1:0] | Sequencer time base<br>(µs) |
|--------------------------------|-----------------------------------|-----------------------------|
| 00                             | 00                                | 30                          |
| 01                             | 01                                | 120                         |
| 10                             | 10                                | 250                         |
| 11                             | 11                                | 500                         |

The power up sequence may include any of the following:

- Switching regulators
- LDO Regulators
- PGOOD pin if programmed as a GPO
- RESETBMCU

The default sequence slot for each one of these signals is programmed via the OTP configuration registers. And they can be modified in the functional I<sup>2</sup>C register map to change the order in which the sequencer behaves during the run/standby transitions as well as the power down sequence.

The \_SEQ[7:0] bits set the regulator/pin sequence from 0 to 254. Sequence code 0x00 indicates that the particular output is not part of the startup sequence and remains in off (in case of a regulator) or remains low/disabled (in case of PGOOD pin used as a GPO).

Table 17. Power up sequence registers

| OTP bits<br>OTP_SWx_SEQ[7:0]/<br>OTP_LDOx_SEQ[7:0]/<br>OTP_PGOOD_SEQ[7:0]/<br>OTP_RESETBMCU_SEQ[7:0] | Functional bits<br>SWx_SEQ[7:0]/<br>LDOx_SEQ[7:0]/<br>PGOOD_SEQ[7:0]/<br>RESETBMCU_SEQ[7:0] | Sequence slot | Startup time<br>( $\mu$ s)                  |
|--|---|---------------|---|
| 00000000   | 00000000  | Off           | Off   |
| 00000001   | 00000001  | 0             | SLOT0<br>(right after PWRON event is valid) |
| 00000010   | 00000010  | 1             | SEQ_TBASE x SLOT1                           |
| .  | .   | .             | .   |
| .  | .   | .             | .   |
| .  | .   | .             | .   |
| 11111111   | 11111111  | 254           | SEQ_TBASE x SLOT254                         |

If RESETBMCU is not programmed in the OTP sequence, it will be enabled by default after the last regulator programmed in the power up sequence.

When the \_SEQ[7:0] bits of all regulators and PGOOD used as a GPIO are set to 0x00 (off) and a power on event is present, the device moves to the run state in slave mode. In this mode, the device is enabled without any voltage regulator or GPO enabled. If the RESETBMCU is not programmed in a power up sequence slot, it is released when the device enters the run state.

The slave mode is a special case of the power up sequence to address the scenario where the PF8121 is working as a slave PMIC, and supplies are meant to be enabled by the MCU during the system operation. In this scenario, if RESETBMCU is used, it is connected to the master RESETBMCU pin.

The PWRUP\_I interrupt bit is asserted at the end of the power up sequence when the time slot of the last regulator in the sequence has ended.

Figure 8 provides an example of the power up/down sequence coming from the off modes.

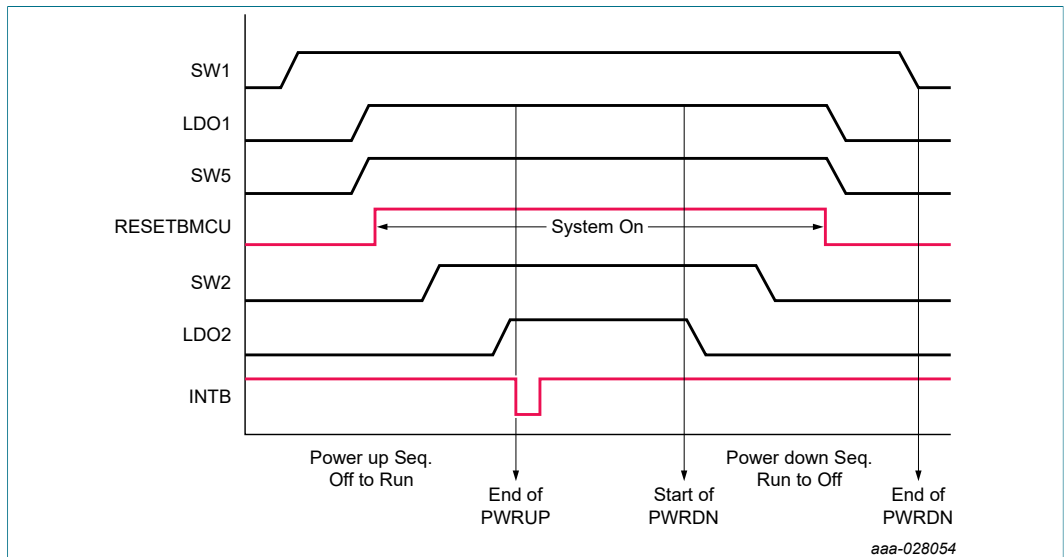


Figure 8. Power up/down sequence between off and system-on states



When transitioning from standby mode to run mode, the power up sequencer is activated only if any of the external regulators is re-enabled during this transition. If none of the regulators toggle from off to on and only voltage changes are being performed when entering or exiting standby mode, the changes for the voltage regulators are made simultaneously rather than going through the power up sequencer.

Figure 9 shows an example of the power up/down sequence when transitioning between run and standby modes.

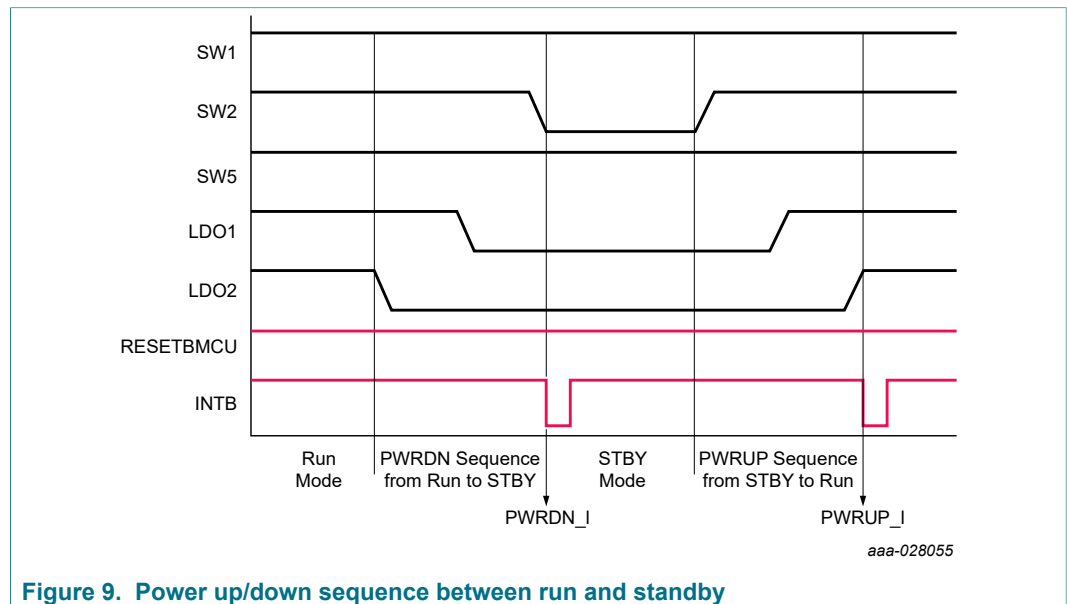


Figure 9. Power up/down sequence between run and standby

The PWRUP\_I interrupt is set while transitioning from standby to run, even if the sequencer is not used. This is used to indicate that the transition is complete and device is ready to perform proper operation.

## 14.6 Power down

### 14.6.1 Turn off events

Turn off events may be requested by the MCU (non-PMIC fault related) or due to a critical failure of the PMIC (hard fault condition).

The following are considered non-PMIC failure turn off events:

1. When OTP\_PWRON\_MODE = 0, the device starts a power down sequence when the PWRON pin is pulled low.
2. When OTP\_PWRON\_MODE = 1, the device starts a power down sequence when the PWRON pin sees a transition from high to low and remains low for longer than TRESET.
3. When bit PMIC\_OFF is set to 1, the device starts a 500 μs shutdown timer. When the shutdown timer is started, the PF8121 sets the SDWN\_I interrupt and asserts the INTB pin provided it is not masked. At this point, the MCU can read the interrupt and decide whether to continue with the turn off event or stop it in case it was sent by mistake.

If the SDWN\_I bit is cleared before the 500 μs shutdown timer is expired, the shutdown request is cancelled and the shutdown timer is reset; otherwise, if the shutdown timer is expired, the PF8121 starts a power down sequence.

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The PMIC\_OFF bit self-clears after SDWN\_I flag is cleared.

4. When VIN\_OVLO\_EN = 1 and VIN\_OVLO\_SDWN = 1, and a VIN\_OVLO event is present.

Turn off events due to a hard fault condition:

1. If an OV, UV or ILIM condition is present long enough for the fault timer to expire.
2. In the event that an OV, UV or ILIM condition appears and clears cyclically, and the FAULT\_CNT[3:0] = FAULT\_MAX\_CNT[3:0].
3. If the watchdog fail counter is overflowed, that is WD\_EVENT\_CNT = WD\_MAX\_CNT.
4. When T<sub>j</sub> crosses the thermal shutdown threshold as the temperature rises.

When the PF8121 experiences a turn off event due to a hard fault condition, the device passes through the fault transition after regulators have been powered down.

### 14.6.2 Power down sequencing

During a power down sequence, output voltage regulators can be turned off in two different modes as defined by the PWRDWN\_MODE bit.

1. When PWRDWN\_MODE = 0, the regulators power down in sequential mode.
2. When PWRDWN\_MODE = 1, the regulators power down by groups.

During transition from run to standby, the power down sequencer is activated in the corresponding mode. If any of the external regulators are turned off in the standby configuration. If external regulators are not turned off during this transition, the power down sequencer is bypassed and the transition happens at once (any associated DVS transitions could still take time).

The PWRDN\_I interrupt is set at the end of the transition from run to standby when the last regulator has reached its final state, even if external regulators are not turned off during this transition.

#### 14.6.2.1 Sequential power down

When the device is set to the sequential power down, it uses the same \_SEQ[7:0] registers as the power up sequence to power down in reverse order.

All regulators with the \_SEQ[7:0] bits set to 0x00, power down immediately and the remaining regulators power down one OTP\_SEQ\_TBASE[1:0] delay after, in reverse order as defined in the \_SEQ[7:0] bits.

If PGOOD pin is used as a GPO, it is de-asserted as part of the power down sequence as indicated by the PGOOD\_SEQ[7:0] bits.

If the MCU requires a different power down sequence, it can change the values of the SEQ\_TBASE[1:0] and the \_SEQ[7:0] bits during the system-on states.

When the state machine pass through any of the off modes, the contents of the SEQ\_TBASE[1:0] and \_SEQ[7:0] bits are reloaded with the corresponding mirror register (OTP) values before it starts the next power up sequence.

#### 14.6.2.2 Group power down

When the device is configured to power down in groups, the regulators are assigned to a specific power down group. All regulators assigned to the same group are disabled at the same time when the corresponding group is due to be disabled.

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Power down groups shut down in decreasing order starting from the lowest hierarchy group with a regulator shutting down (for instance, Group 4 being the lowest hierarchy and Group 1 the highest hierarchy group). If no regulators are set to the lowest hierarchy group, the power down sequence timer starts off the next available group that contains a regulator to power down.

Each regulator has its own `_PDGRP[1:0]` bits to set the power down group it belongs to as shown in [Table 18](#).

**Table 18. Power down regulator group bits**

| OTP_SWx_PDGRP[1:0]<br>OTP_LDOx_PDGRP[1:0]<br>OTP_PGOOD_PDGRP[1:0]<br>OTP_RESETBMCU_PDGRP[1:0] | SWx_PDGRP[1:0]<br>LDOx_PDGRP[1:0]<br>PGOOD_PDGRP[1:0]<br>RESETBMCU_PDGRP[1:0] | Description                  |
|---|---|------------------------------|
| 00  | 00  | Regulator belongs to Group 4 |
| 01  | 01  | Regulator belongs to Group 3 |
| 10  | 10  | Regulator belongs to Group 2 |
| 11  | 11  | Regulator belongs to Group 1 |

If PGOOD pin is used as a GPO, the PGOOD\_PDGRP[1:0] is used to turn off the PGOOD pin in a specific group during the power down sequence. If PGOOD pin is used in power good mode, it is recommended that the OTP\_PGOOD\_PDGRP bits are set to 11 to ensure the group power down sequencer does not detect these bits as part of Group 4.

Each one of power down groups have programmable time delay registers to set the time delay after the regulators in this group have been turned off, and the next group can start to power down.

**Table 19. Power down counter delay**

| OTP bits<br>OTP_GRPx_DLY[1:0] | Functional bits<br>GRPx_DLY[1:0] | Power down delay<br>(µs) |
|-------------------------------|----------------------------------|--------------------------|
| 00                            | 00                               | 120                      |
| 01                            | 01                               | 250                      |
| 10                            | 10                               | 500                      |
| 11                            | 11                               | 1000                     |

If RESETBMCU is required to be asserted first before any of the external regulators from the corresponding group, the RESETBMCU\_DLY provides a selectable delay to disable the regulators after RESETBMCU is asserted.

**Table 20. Programmable delay after RESETBMCU is asserted**

| OTP bits<br>OTP_RESETBMCU_DLY[1:0] | Functional bits<br>RESETBMCU_DLY[1:0] | RESETBMCU delay<br>(µs) |
|------------------------------------|---------------------------------------|-------------------------|
| 00                                 | 00                                    | No delay                |
| 01                                 | 01                                    | 10                      |
| 10                                 | 10                                    | 100                     |
| 11                                 | 11                                    | 500                     |

If RESETBMCU\_DLY is set to 0x00, all regulators in the same power down group as RESETBMCU is disabled at the same time RESETBMCU is asserted.

Figure 10 shows an example of the power down sequence when PWRDWN\_MODE = 1.

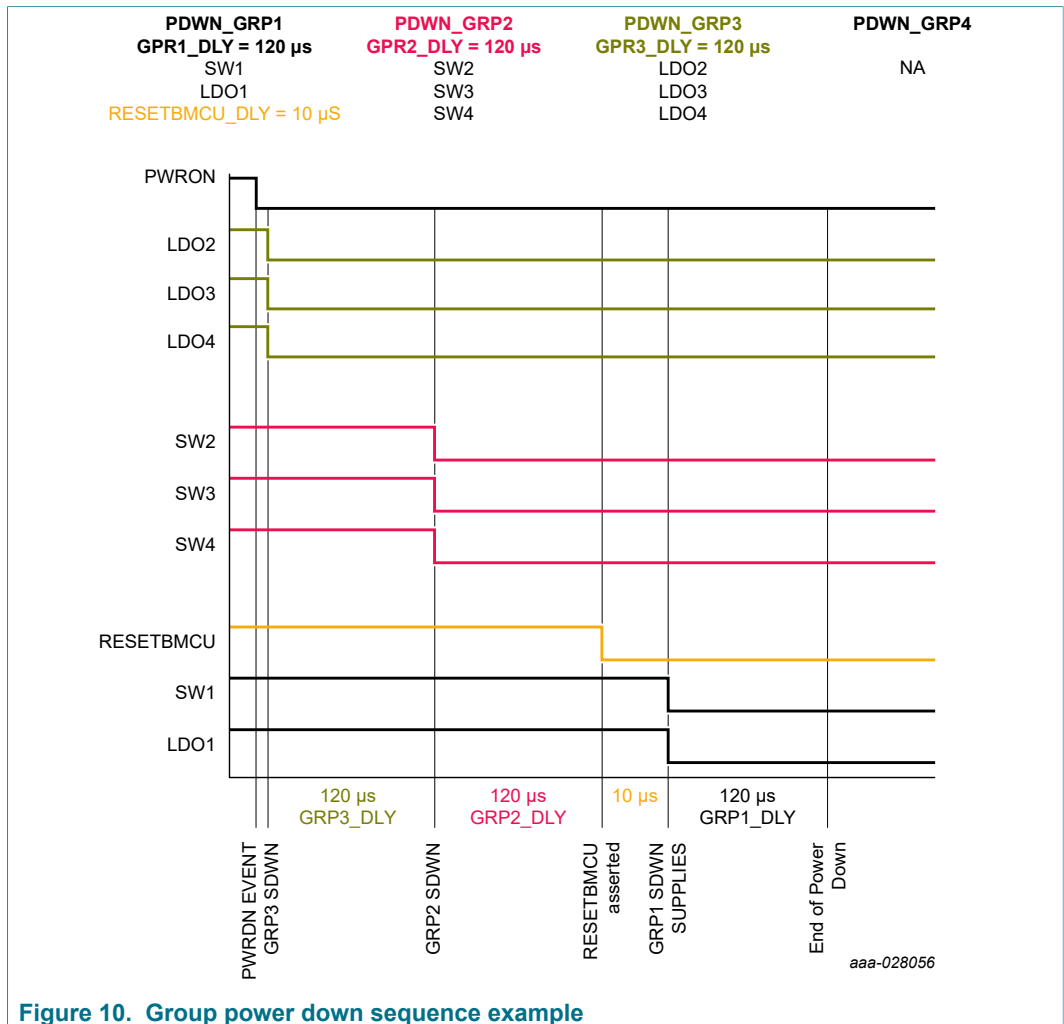


Figure 10. Group power down sequence example

### 14.6.2.3 Power down delay

After a power down sequence is started, the PWRON pin shall be masked until the sequence is finished and the programmable power down delay is reached, then the device can power up again if a power-up event is present. The power down delay time can be programed on OTP via the OTP\_PD\_SEQ\_DLY[1:0] bits.

Table 21. Power down delay selection

| OTP_PD_SEQ_DLY[1:0] | Delay after power down sequence |
|---------------------|---------------------------------|
| 00                  | No delay                        |
| 01                  | 1.5 ms                          |
| 10                  | 5.0 ms                          |
| 11                  | 10 ms                           |

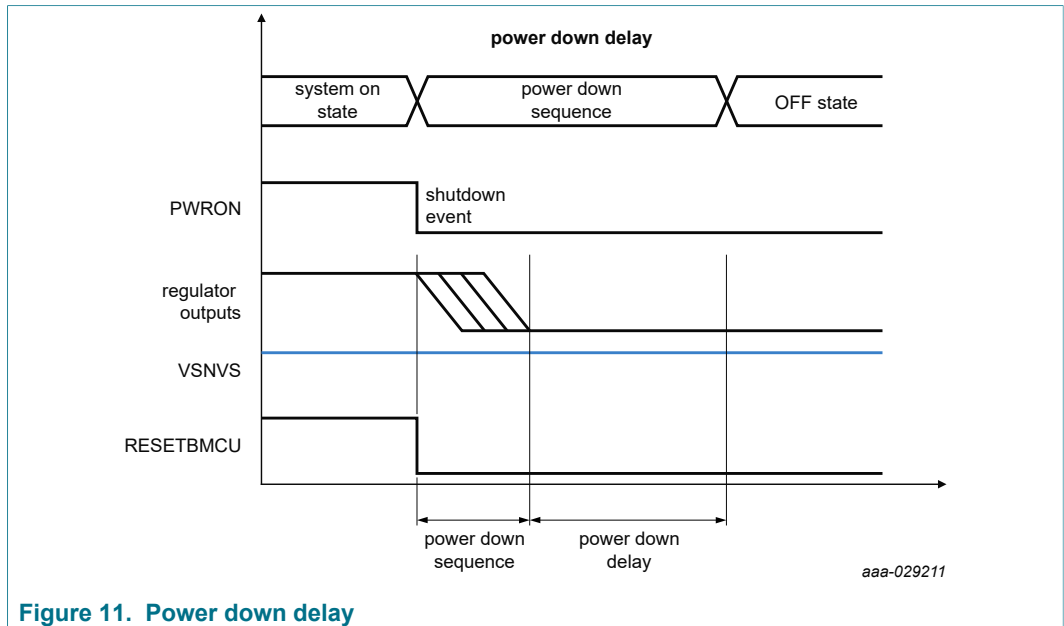


Figure 11. Power down delay

The default value of the OTP\_PD\_SEQ\_DLY[1:0] bits on an unprogrammed OTP device shall be 00.

### 14.7 Fault detection

Three types of faults are monitored per regulator: UV, OV and ILIM. Faults are monitored during power up sequence, run, standby and WD reset states. A fault event is notified to the MCU through the INTB pin if the corresponding fault is not masked.

The fault configuration registers are reset to their default value after the power up sequences, and system must configure them as required during the boot-up process via I<sup>2</sup>C commands.

For each type of fault, there is an I<sup>2</sup>C bit that is used to select whether the regulator is kept enabled or disabled when the corresponding regulator experience a fault event.

SW<sub>x</sub>\_ILIM\_STATE / LDO<sub>x</sub>\_ILIM\_STATE

- 0 = regulator disable upon an ILIM fault event
- 1 = regulator remains on upon an ILIM fault event

SW<sub>x</sub>\_OV\_STATE / LDO<sub>x</sub>\_OV\_STATE

- 0 = regulator disable upon an OV fault event
- 1 = regulator remains on upon an OV fault event

SW<sub>x</sub>\_UV\_STATE / LDO<sub>x</sub>\_UV\_STATE

- 0 = regulator disable upon an UV fault event
- 1 = regulator remains on upon an UV fault event

The following table lists the functional bits associated with enabling/disabling the external regulators when they experience a fault.

Table 22. Regulator control during fault event bits

| Regulator | Bit to disable the regulator during current limit | Bit to disable the regulator during undervoltage | Bit to disable the regulator during overvoltage |
|-----------|---|--|---|
| SW1       | SW1_ILIM_STATE                                    | SW1_UV_STATE                                     | SW1_OV_STATE                                    |
| SW2       | SW2_ILIM_STATE                                    | SW2_UV_STATE                                     | SW2_OV_STATE                                    |
| SW3       | SW3_ILIM_STATE                                    | SW3_UV_STATE                                     | SW3_OV_STATE                                    |
| SW4       | SW4_ILIM_STATE                                    | SW4_UV_STATE                                     | SW4_OV_STATE                                    |
| SW5       | SW5_ILIM_STATE                                    | SW5_UV_STATE                                     | SW5_OV_STATE                                    |
| SW6       | SW6_ILIM_STATE                                    | SW6_UV_STATE                                     | SW6_OV_STATE                                    |
| SW7       | SW7_ILIM_STATE                                    | SW7_UV_STATE                                     | SW7_OV_STATE                                    |
| LDO1      | LDO1_ILIM_STATE                                   | LDO1_UV_STATE                                    | LDO1_OV_STATE                                   |
| LDO2      | LDO2_ILIM_STATE                                   | LDO2_UV_STATE                                    | LDO2_OV_STATE                                   |
| LDO3      | LDO3_ILIM_STATE                                   | LDO3_UV_STATE                                    | LDO3_OV_STATE                                   |
| LDO4      | LDO4_ILIM_STATE                                   | LDO4_UV_STATE                                    | LDO4_OV_STATE                                   |

ILIM faults are debounced for 1.0 ms before they can be detected as a fault condition. If the regulator is programmed to disable upon an ILIM condition, the regulator turns off as soon as the ILIM condition is detected.

OV/UV faults are debounced as programmed by the OV\_DB and UV\_DB registers, before they are detected as a fault condition. If the regulator is programmed to disable upon an OV or UV, the regulator will turn off if the fault persist for longer than 300 μs after the OV/UV fault has been detected.

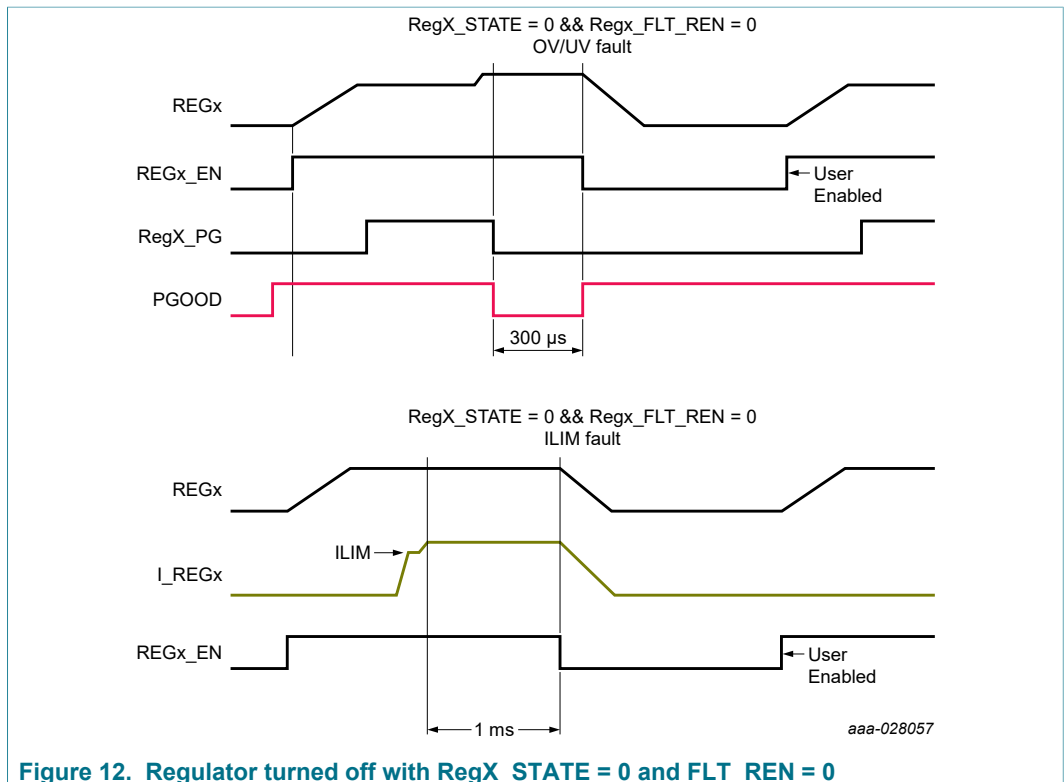


Figure 12. Regulator turned off with RegX\_STATE = 0 and FLT\_REN = 0

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When a regulator is programmed to disable upon an OV, UV, or ILIM fault, a bit is provided to decide whether a regulator can return to its previous configuration or remain disabled when the fault condition is cleared.

SWx\_FLT\_REN / LDOx\_FLT\_REN

- 0 = regulator remains disabled after the fault condition is cleared or no longer present
- 1 = regulator returns to its previous state if fault condition is cleared

If a regulator is programmed to remain disabled after clearing the fault condition, the MCU can turn it back on during the system on states by toggling off and on the corresponding mode/enable bits.

When the bit SWx\_FLT\_REN = 1, if a regulator is programmed to turn off upon an OV, UV or ILIM condition, the regulator returns to its previous state 500 µs after the fault condition is cleared. If the regulator is programmed to turn off upon an ILIM condition, the device may take up to 1.0 ms to debounce the ILIM condition removal, in addition to the 500 µs wait period to re-enable the regulator.

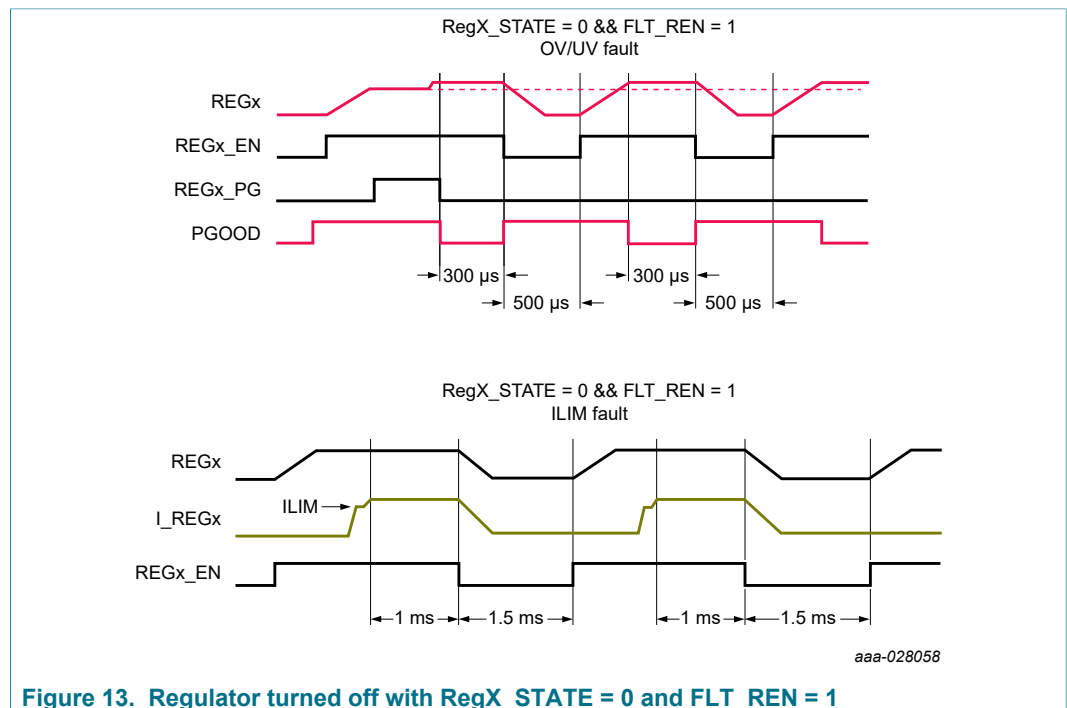


Figure 13. Regulator turned off with RegX\_STATE = 0 and FLT\_REN = 1

When the LDO2 is controlled by hardware using the LDO2EN pin and programmed to turn off upon an OV, UV or ILIM fault, the LDO2\_FLT\_REN bit still controls whether the regulator returns to its previous state or not regardless the state of the LDO2EN pin.

If LDO2 controlled by LDO2EN pin is instructed to remain disabled by the LDO2\_FLT\_REN bit, it recovers hardware control by modifying the LDO2\_EN bits in the I<sup>2</sup>C register maps. See [Section 14.9.10 "LDO2EN"](#) for details on hardware control of LDO2 regulator.

To avoid fault cycling, a global fault counter is provided. Each time any of the external regulators encounter a fault event, the PF8121 compares the value of the FAULT\_CNT[3:0] against the FAULT\_MAX\_CNT, and if it not equal, it increments the FAULT\_CNT[3:0] and proceeds with the fault protection mechanism.

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The processor is expected to read the counter value and reset it when the faults have been cleared and the device returns to a normal operation. If the processor does not reset the fault counter and it equals the FAULT\_MAX\_CNT[3:0] value, the state machine initiates a power down sequence.

The default value of the FAULT\_MAX\_CNT[3:0] is loaded from the OTP\_FAULT\_MAX\_CNT[3:0] bits during the power up sequence.

When the FAULT\_MAX\_CNT[3:0] is set to 0x00, the system disables the turn-off events due to a Fault Counter maxing out.

When a regulator experiences a fault event, a fault timer is started. While this timer is in progress, the expectation is that the processor takes actions to clear the fault. For example, it could reduce its load in the event of a current limit fault, or turn off the regulator in the event of an overvoltage fault.

If the fault clears before the timer expires, the state machine resumes the normal operation, and the fault timer gets reset. If the fault does not clear before the timer expires, a power down sequence is initiated to turn off the voltage regulators.

The default value of the fault timer is set by the OTP\_TIMER\_FAULT[3:0], however the duration of the fault timer can be changed during the system on states by modifying the TIMER\_FAULT[3:0] bits in the I<sup>2</sup>C registers.

**Table 23. Fault timer register configuration**

| OTP bits<br>OTP_TIMER_FAULT [3:0] | Functional bits<br>TIMER_FAULT [3:0] | Timer value<br>(ms) |
|-----------------------------------|--------------------------------------|---------------------|
| 0000                              | 0000                                 | 1                   |
| 0001                              | 0001                                 | 2                   |
| 0010                              | 0010                                 | 4                   |
| 0011                              | 0011                                 | 8                   |
| 0100                              | 0100                                 | 16                  |
| 0101                              | 0101                                 | 32                  |
| 0110                              | 0110                                 | 64                  |
| 0111                              | 0111                                 | 128                 |
| 1000                              | 1000                                 | 256                 |
| 1001                              | 1001                                 | 512                 |
| 1010                              | 1010                                 | 1024                |
| 1011                              | 1011                                 | 2056                |
| 1100                              | 1100                                 | Reserved            |
| 1101                              | 1101                                 | Reserved            |
| 1110                              | 1110                                 | Reserved            |
| 1111                              | 1111                                 | Disabled            |

Each voltage regulator has a dedicated I<sup>2</sup>C bit that is used to bypass the fault detection mechanism for each specific fault.

SW<sub>x</sub>\_ILIM\_BYPASS / LDO<sub>x</sub>\_ILIM\_BYPASS

- 0 = ILIM protection enabled
- 1 = ILIM fault bypassed

SW<sub>x</sub>\_OV\_BYPASS / LDO<sub>x</sub>\_OV\_BYPASS



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- 0 = OV protection enabled
- 1 = OV fault bypassed

SWx\_UV\_BYPASS / LDOx\_UV\_BYPASS

- 0 = UV protection enabled
- 1 = UV fault bypassed

**Table 24. Fault bypass bits**

| Regulator | Bit to bypass a current limit | Bit to bypass an undervoltage | Bit to bypass an overvoltage |
|-----------|-------------------------------|-------------------------------|------------------------------|
| SW1       | SW1_ILIM_BYPASS               | SW1_UV_BYPASS                 | SW1_OV_BYPASS                |
| SW2       | SW2_ILIM_BYPASS               | SW2_UV_BYPASS                 | SW2_OV_BYPASS                |
| SW5       | SW5_ILIM_BYPASS               | SW5_UV_BYPASS                 | SW5_OV_BYPASS                |
| SW6       | SW6_ILIM_BYPASS               | SW6_UV_BYPASS                 | SW6_OV_BYPASS                |
| SW7       | SW7_ILIM_BYPASS               | SW7_UV_BYPASS                 | SW7_OV_BYPASS                |
| LDO1      | LDO1_ILIM_BYPASS              | LDO1_UV_BYPASS                | LDO1_OV_BYPASS               |
| LDO2      | LDO2_ILIM_BYPASS              | LDO2_UV_BYPASS                | LDO2_OV_BYPASS               |
| LDO3      | LDO3_ILIM_BYPASS              | LDO3_UV_BYPASS                | LDO3_OV_BYPASS               |

The default value of the OV\_BYPASS, UV\_BYPASS and ILIM\_BYPASS bits upon power up can be configured by their corresponding OTP bits.

Bypassing the fault detection prevents the specific fault from starting any of the protective mechanism:

- Increment the counter
- Start the Fault timer
- Disable the regulator if the corresponding \_STATE bit is 0
- OV / UV condition asserting the PGOOD pin low

When a fault is bypassed, the corresponding interrupt bit is still set and the INTB pin is asserted, provided the interrupt has not been masked.

**14.7.1 Fault monitoring during power up state**

An OTP bit is provided to select whether the output of the switching regulators is verified during the power up sequence and used as a gating condition to release the RESETBMCU or not.

- When OTP\_PG\_CHECK = 0, the output voltage of the regulators is not checked during the power up sequence and power good indication is not required to de-assert the RESETBMCU. In this scenario, the OV/UV monitors are masked until RESETBMCU is released; after this event, all regulators may start checking for faults after their corresponding blanking period.
- When OTP\_PG\_CHECK = 1, the output voltage of the regulators is verified during the power up sequence and a power good condition is required to release the RESETBMCU.

When OTP\_PG\_CHECK = 1, OV and UV faults during the power up sequence are reported based on the internal PG (Power Good) signals of the corresponding external regulator. The PGOOD pin can be used as an external indicator of an OV/UV failure when the RESETBMCU is ready to be de-asserted and it has been configured in the

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PGOOD mode. See [Section 14.9.8 "PGOOD"](#) for details on PGOOD pin operation and configuration.

Regardless of the PGOOD pin configured as a power good indicator or not, the PF8121 masks the detection of an OV/UV failure until RESETBMCU is ready to be released, at this point the device checks for any OV/UV condition for the regulators turned on so far. If all regulators powered up before or in the same sequence slot than RESETBMCU are in regulation, RESETBMCU is de-asserted and the power up sequence can continue as shown in [Figure 14](#).

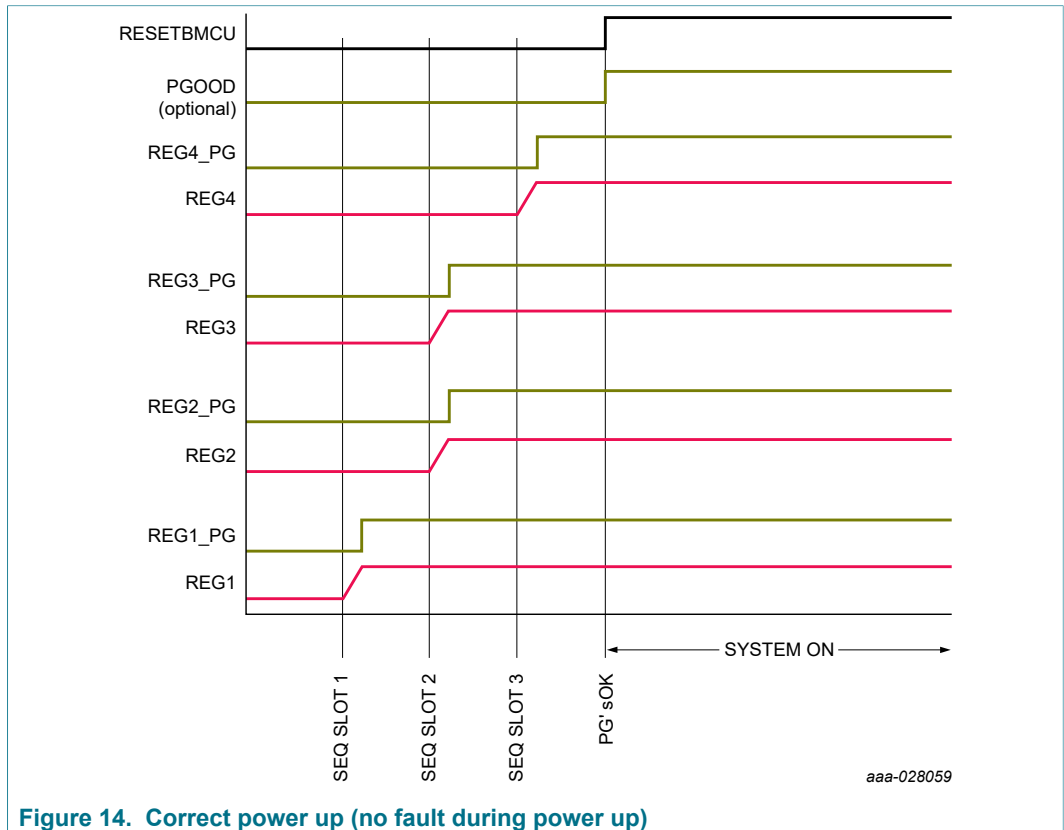


Figure 14. Correct power up (no fault during power up)

If any of the regulators are powered up before RESETBMCU is out of regulator, RESETBMCU is not de-asserted and the power up sequence is stopped for up to 2.0 ms. If the fault is cleared and all internal PG signals are asserted within the 2.0 ms timer, RESETBMCU is de-asserted and the power up sequence continues where it stopped as shown in [Figure 15](#).

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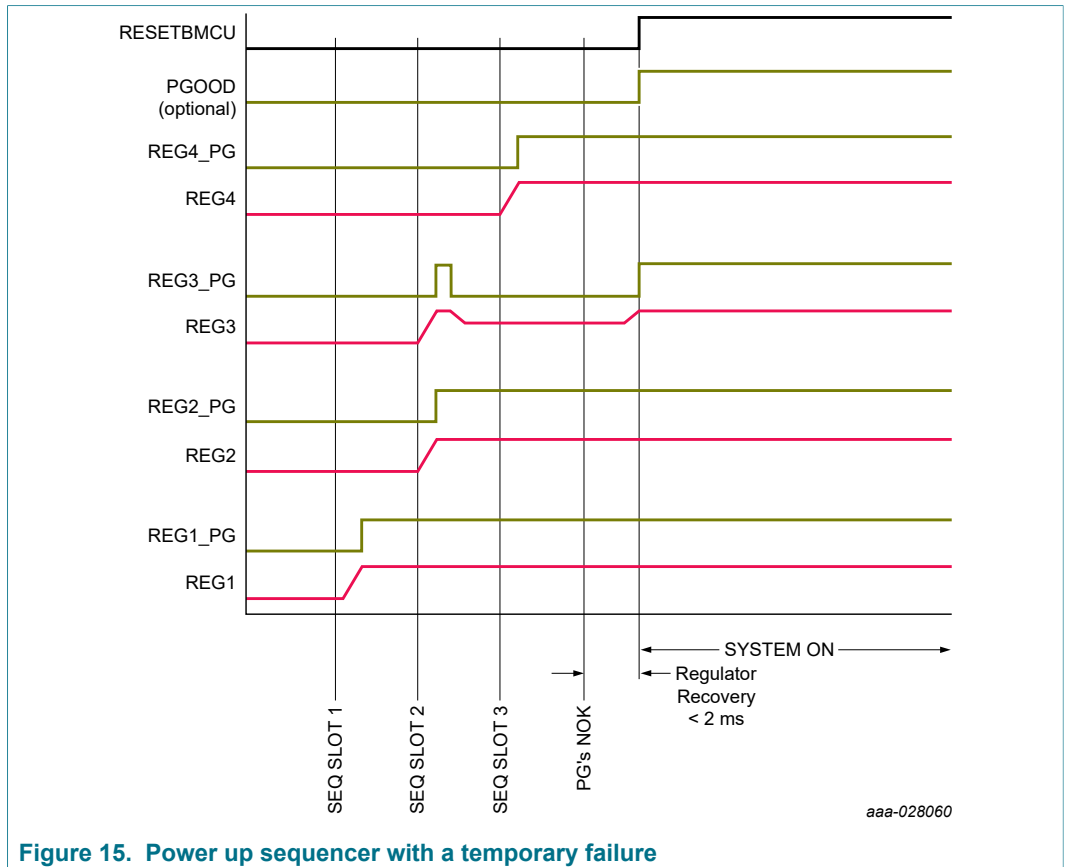


Figure 15. Power up sequencer with a temporary failure

If the faulty condition is not cleared within the 2.0 ms timer, the power up sequence is aborted and the PF8121 turn off all voltage regulators enabled so far as shown in [Figure 16](#).



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- When the mask bit is 0, INTB pin is pulled low as long as the corresponding latch bit is set.
- The sense bit XXXX\_S: if available, the sense bit provides the actual status of the signal triggering the interrupt.

The INTB pin is a reflection of an “OR” logic of all the interrupt status bits which control the pin.

Interrupts are stored in two levels on the interrupts registers. At first level, the SYS\_INT register provides information about the Interrupt register that originated the interrupt event.

The corresponding SYS\_INT bits will be set as long as the INTB pin is programmed to assert with any of the interrupt bits of the respective interrupt registers.

- STATUS1\_I: this bit is set when the interrupt is generated within the INT STATUS1 register
- STATUS2\_I: this bit is set when the interrupt is generated within the INT STATUS2 register
- MODE\_I: this bit is set when the interrupt is generated within the SW MODE INT register
- ILIM\_I: this bit is set when the interrupt is generated within any of the SW ILIM INT or LDO ILIM INT registers
- UV\_I: this bit is set when the interrupt is generated within any of the SW UV INT or LDO UV INT registers
- OV\_I: this bit is set when the interrupt is generated within any of the SW OV INT or LDO OV INT registers
- PWRON\_I: this bit is set when the interrupt is generated within the PWRON INT register
- EWARN\_I: is set when an early warning event occurs to indicate an imminent shutdown

The SYS\_INT bits are set when the INTB pin is asserted by any of the second level interrupt bits that have not been masked in their corresponding mask registers. When the second level interrupt bit is cleared, the corresponding first level interrupt bit on the SYS\_INT register will be cleared automatically.

The INTB pin will remain asserted if any of the first level interrupt bit is set, and it will be de-asserted only when all the unmasked second level interrupts are cleared and thus all the first level interrupts are cleared as well.

At second level, the remaining registers provide the exact source for the interrupt event.

[Table 25](#) shows a summary of the interrupt latch, mask and sense pins available on the PF8121.

**Table 25. Interrupt registers**

| Register name | BIT7   | BIT6        | BIT5        | BIT4        | BIT3        | BIT2        | BIT1       | BIT0       |
|---------------|--------|-------------|-------------|-------------|-------------|-------------|------------|------------|
| INT STATUS1   | SDWN_I | FREQ_RDY_I  | CRC_I       | PWRUP_I     | PWRDN_I     | XINTB_I     | FSOB_I     | VIN_OVLO_I |
| INT MASK1     | SDWN_M | FREQ_RDY_M  | CRC_M       | PWRUP_M     | PWRDN_M     | XINTB_M     | FSOB_M     | VIN_OVLO_M |
| INT SENSE1    | —      | —           | —           | —           | —           | XINTB_S     | FSOB_S     | VIN_OVLO_S |
| THERM INT     | WDI_I  | FSYNC_FLT_I | THERM_155_I | THERM_140_I | THERM_125_I | THERM_110_I | THERM_95_I | THERM_80_I |
| THERM MASK    | WDI_M  | FSYNC_FLT_M | THERM_155_M | THERM_140_M | THERM_125_M | THERM_110_M | THERM_95_M | THERM_80_M |
| THERM SENSE   | WDI_S  | FSYNC_FLT_S | THERM_155_S | THERM_140_S | THERM_125_S | THERM_110_S | THERM_95_S | THERM_80_S |
| SW MODE INT   | —      | SW7_MODE_I  | SW6_MODE_I  | SW5_MODE_I  | SW4_MODE_I  | SW3_MODE_I  | SW2_MODE_I | SW1_MODE_I |
| SW MODE MASK  | —      | SW7_MODE_M  | SW6_MODE_M  | SW5_MODE_M  | SW4_MODE_M  | SW3_MODE_M  | SW2_MODE_M | SW1_MODE_M |

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| Register name  | BIT7    | BIT6       | BIT5       | BIT4       | BIT3        | BIT2        | BIT1        | BIT0         |
|----------------|---------|------------|------------|------------|-------------|-------------|-------------|--------------|
| SW_ILIM_INT    | —       | SW7_ILIM_I | SW6_ILIM_I | SW5_ILIM_I | SW4_ILIM_I  | SW3_ILIM_I  | SW2_ILIM_I  | SW1_ILIM_I   |
| SW_ILIM_MASK   | —       | SW7_ILIM_M | SW6_ILIM_M | SW5_ILIM_M | SW4_ILIM_M  | SW3_ILIM_M  | SW2_ILIM_M  | SW1_ILIM_M   |
| SW_ILIM_SENSE  | —       | SW7_ILIM_S | SW6_ILIM_S | SW5_ILIM_S | SW4_ILIM_S  | SW3_ILIM_S  | SW2_ILIM_S  | SW1_ILIM_S   |
| LDO_ILIM_INT   | —       | —          | —          | —          | LDO4_ILIM_I | LDO3_ILIM_I | LDO2_ILIM_I | LDO1_ILIM_I  |
| LDO_ILIM_MASK  | —       | —          | —          | —          | LDO4_ILIM_M | LDO3_ILIM_M | LDO2_ILIM_M | LDO1_ILIM_M  |
| LDO_ILIM_SENSE | —       | —          | —          | —          | LDO4_ILIM_S | LDO3_ILIM_S | LDO2_ILIM_S | LDO1_ILIM_S  |
| SW_UV_INT      | —       | SW7_UV_I   | SW6_UV_I   | SW5_UV_I   | SW4_UV_I    | SW3_UV_I    | SW2_UV_I    | SW1_UV_I     |
| SW_UV_MASK     | —       | SW7_UV_M   | SW6_UV_M   | SW5_UV_M   | SW4_UV_M    | SW3_UV_M    | SW2_UV_M    | SW1_UV_M     |
| SW_UV_SENSE    | —       | SW7_UV_S   | SW6_UV_S   | SW5_UV_S   | SW4_UV_S    | SW3_UV_S    | SW2_UV_S    | SW1_UV_S     |
| SW_OV_INT      | —       | SW7_OV_I   | SW6_OV_I   | SW5_OV_I   | SW4_OV_I    | SW3_OV_I    | SW2_OV_I    | SW1_OV_I     |
| SW_OV_MASK     | —       | SW7_OV_M   | SW6_OV_M   | SW5_OV_M   | SW4_OV_M    | SW3_OV_M    | SW2_OV_M    | SW1_OV_M     |
| SW_OV_SENSE    | —       | SW7_OV_S   | SW6_OV_S   | SW5_OV_S   | SW4_OV_S    | SW3_OV_S    | SW2_OV_S    | SW1_OV_S     |
| LDO_UV_INT     | —       | —          | —          | —          | LDO4_UV_I   | LDO3_UV_I   | LDO2_UV_I   | LDO1_UV_I    |
| LDO_UV_MASK    | —       | —          | —          | —          | LDO4_UV_M   | LDO3_UV_M   | LDO2_UV_M   | LDO1_UV_M    |
| LDO_UV_SENSE   | —       | —          | —          | —          | LDO4_UV_S   | LDO3_UV_S   | LDO2_UV_S   | LDO1_UV_S    |
| LDO_OV_INT     | —       | —          | —          | —          | LDO4_OV_I   | LDO3_OV_I   | LDO2_OV_I   | LDO1_OV_I    |
| LDO_OV_MASK    | —       | —          | —          | —          | LDO4_OV_M   | LDO3_OV_M   | LDO2_OV_M   | LDO1_OV_M    |
| LDO_OV_SENSE   | —       | —          | —          | —          | LDO4_OV_S   | LDO3_OV_S   | LDO2_OV_S   | LDO1_OV_S    |
| PWRON_INT      | BGMON_I | PWRON_8S_I | PWRON_4S_I | PRON_3S_I  | PWRON_2S_I  | PWRON_1S_I  | PWRON_REL_I | PWRON_PUSH_I |
| PWRON_MASK     | BGMON_M | PWRON_8S_M | PWRON_4S_M | PRON_3S_M  | PWRON_2S_M  | PWRON_1S_M  | PWRON_REL_M | PWRON_PUSH_M |
| PWRON_SENSE    | BGMON_S | —          | —          | —          | —           | —           | —           | PWRON_S      |
| SYS_INT        | EWARN_I | PWRON_I    | OV_I       | UV_I       | ILIM_I      | MODE_I      | STATUS2_I   | STATUS1_I    |

### 14.9 I/O interface pins

The PF8121 PMIC is fully programmable via the I<sup>2</sup>C interface. Additional communication between MCU, PF8121 and other companion PMIC is provided by direct logic interfacing including INTB, RESETBMCU, PGOOD, among other pins.

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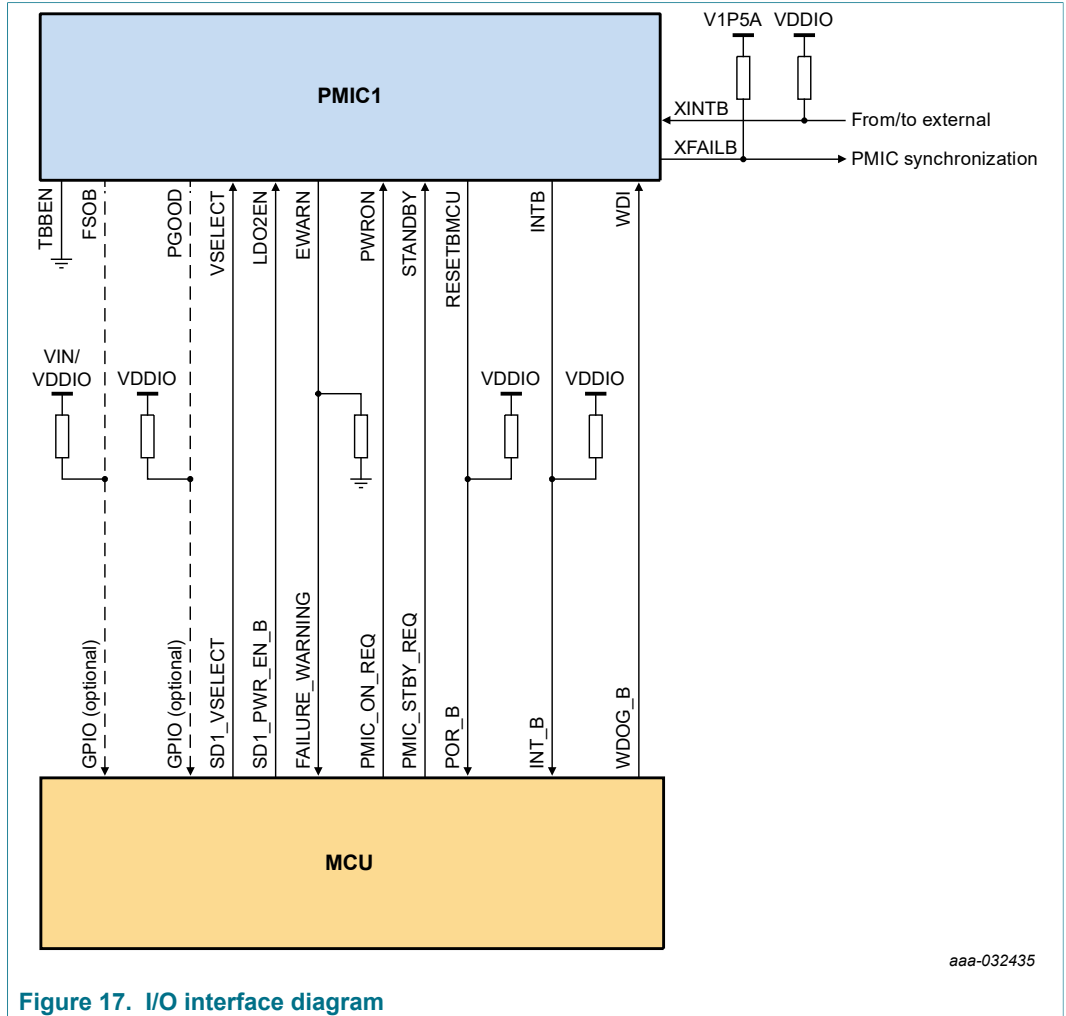


Figure 17. I/O interface diagram

Table 26. I/O electrical specifications

| Symbol                    | Parameter  | Min       | Typ | Max       | Unit |
|---------------------------|--|-----------|-----|-----------|------|
| PWRON_V <sub>IL</sub>     | PWRON low input voltage                            | —         | —   | 0.4       | V    |
| PWRON_V <sub>IH</sub>     | PWRON high input voltage                           | 1.4       | —   | 5.5       | V    |
| STANDBY_V <sub>IL</sub>   | STANDBY low input voltage                          | —         | —   | 0.4       | V    |
| STANDBY_V <sub>IH</sub>   | STANDBY high input voltage                         | 1.4       | —   | 5.5       | V    |
| RESETBMCU_V <sub>OL</sub> | RESETBMCU low output voltage<br>10 mA load current | 0         | —   | 0.4       | V    |
| INTB_V <sub>OL</sub>      | INTB low output voltage<br>10 mA load current      | 0         | —   | 0.4       | V    |
| XINTB_V <sub>IL</sub>     | XINTB low input voltage                            | —         | —   | 0.3*VDDIO | V    |
| XINTB_V <sub>IH</sub>     | XINTB high input voltage                           | 0.7*VDDIO | —   | 5.5       | V    |
| R <sub>XINTB_PU</sub>     | XINTB internal pullup resistance                   | 0.475     | 1.0 | —         | MΩ   |
| WDI_V <sub>IL</sub>       | WDI low input voltage                              | —         | —   | 0.3*VDDIO | V    |
| WDI_V <sub>IH</sub>       | WDI high input voltage                             | 0.7*VDDIO | —   | 5.5       | V    |
| R <sub>WDI_PD</sub>       | WDI internal pull down resistance                  | 0.475     | 1.0 | —         | MΩ   |

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| Symbol                   | Parameter  | Min         | Typ | Max       | Unit |
|--------------------------|--|-------------|-----|-----------|------|
| EWARN_ V <sub>OH</sub>   | EWARN high output voltage<br>2.0 mA load current | VDDIO - 0.5 | —   | VDDIO     | V    |
| PGOOD_ V <sub>OL</sub>   | PGOOD low output voltage<br>10 mA load current   | 0           | —   | 0.4       | V    |
| VSELECT_ V <sub>IL</sub> | VSELECT low input voltage                        | —           | —   | 0.3*VDDIO | V    |
| VSELECT_ V <sub>IH</sub> | VSELECT high input voltage                       | 0.7*VDDIO   | —   | 5.5       | V    |
| R <sub>VSELECT_PD</sub>  | VSELECT internal pull down resistance            | 0.475       | 1.0 | —         | MΩ   |
| LDO2EN_ V <sub>IL</sub>  | LDO2EN low input voltage                         | —           | —   | 0.3*VDDIO | V    |
| LDO2EN_ V <sub>IH</sub>  | LDO2EN high input voltage                        | 0.7*VDDIO   | —   | 5.5       | V    |
| R <sub>LDO2EN_PD</sub>   | LDO2EN internal pull down resistance             | 0.475       | 1.0 | —         | MΩ   |
| TBBEN_ V <sub>IL</sub>   | TBBEN low input voltage                          | —           | —   | 0.4       | V    |
| TBBEN_ V <sub>IH</sub>   | TBBEN high input voltage                         | 1.4         | —   | 5.5       | V    |
| R <sub>TBBEN_PD</sub>    | TBBEN internal pull down resistance              | 0.475       | 1.0 | —         | MΩ   |
| XFAILB_ V <sub>IL</sub>  | XFAILB low input voltage                         | —           | —   | 0.4       | V    |
| XFAILB_ V <sub>IH</sub>  | XFAILB high input voltage                        | 1.4         | —   | 5.5       | V    |
| XFAILB_ V <sub>OH</sub>  | XFAILB high output voltage<br>Pulled-up to V1P5A | V1P5A - 0.5 | —   | —         | V    |
| XFAILB_ V <sub>OL</sub>  | XFAILB low output voltage<br>10 mA load current  | 0           | —   | 0.4       | V    |
| FSOB_ V <sub>OL</sub>    | FSOB low output voltage<br>-10 mA                | 0           | —   | 0.4       | V    |
| SCL_ V <sub>IL</sub>     | SCL low input voltage                            | —           | —   | 0.3*VDDIO | V    |
| SCL_ V <sub>IH</sub>     | SCL high input voltage                           | 0.7*VDDIO   | —   | VDDIO     | V    |
| SDA_ V <sub>IL</sub>     | SDA low input voltage                            | —           | —   | 0.3*VDDIO | V    |
| SDA_ V <sub>IH</sub>     | SDA high input voltage                           | 0.7*VDDIO   | —   | VDDIO     | V    |
| SDA_ V <sub>OL</sub>     | SDA low output voltage<br>-20 mA load current    | 0           | —   | 0.4       | V    |

### 14.9.1 PWRON

PWRON is an input signal to the IC that acts as a power up event signal in the PF8121.

The PWRON pin has two modes of operations as programmed by the OTP\_PWRON\_MODE bit.

When OTP\_PWRON\_MODE = 0 the PWRON pin operates in level sensitive mode. In this mode, the device is in the corresponding off mode when the PWRON pin is pulled low. Pulling the PWRON pin high is a necessary condition to generate a power on event.

PWRON may be pulled up to VSNVS or VIN with an external 100 kΩ resistor if device is intended to come up automatically with VIN application. See [Section 14.5 "Power up"](#) for details on power up requirements.

When OTP\_PWRON\_MODE = 1, the PWRON pin operates in edge sensitive mode. In this mode, PWRON is used as an input from a push button connected to the PMIC.

When the switch is not pressed, the PWRON pin is pulled up to VIN externally through a 100 kΩ resistor. When the switch is pressed, the PWRON pin should be shorted to



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ground. The PWRON\_S bit is high whenever the PWRON pin is at logic 0 and is low whenever the PWRON pin is at logic 1.

The PWRON pin has a programmable debounce on the rising and falling edges as shown below.

**Table 27. PWRON debounce configuration in edge detection mode**

| Bits            | Value | Falling edge debounce (ms) | Rising edge debounce (ms) |
|-----------------|-------|----------------------------|---------------------------|
| PWRON_DBNC[1:0] | 00    | 32                         | 32                        |
| PWRON_DBNC[1:0] | 01    | 32                         | 32                        |
| PWRON_DBNC[1:0] | 10    | 125                        | 32                        |
| PWRON_DBNC[1:0] | 11    | 750                        | 32                        |

The default value for the power on debounce is set by the OTP\_PWRON\_DBNC[1:0] bits.

Pressing the PWRON switch for longer than the debounce time starts a power on event as well as generate interrupts which the processor may use to initiate PMIC state transitions.

During the system-on states, when the PWRON button is pushed (logic 0) for longer than the debounce setting, the PWRON\_PUSH\_I interrupt is generated. When the PWRON button is released (logic 1) for longer than the debounce setting, the PWRON\_REL\_I interrupt is generated.

The PWRON\_1S\_I, PWRON\_2S\_I, PWRON\_3S\_I, PWRON\_4S\_I and PWRON\_8S\_I interrupts are generated when the PWRON pin is held low for longer than 1, 2, 3, 4 and 8 seconds respectively.

If PWRON\_RST\_EN = 1, pressing the PWRON for longer than the delay programmed by TRESET[1:0] forces a PMIC reset. A PMIC reset initiates a power down sequence, wait for 30 μs to allow all supplies to discharge and then it powers back up with the default OTP configuration.

If PWRON\_RST\_EN = 0, the device starts a turn off event after push button is pressed for longer than TRESET[1:0].

**Table 28. TRESET configuration**

| TRESET[1:0] | Time to reset |
|-------------|---------------|
| 00          | 2 s           |
| 01          | 4 s           |
| 10          | 8 s           |
| 11          | 16 s          |

The default value of the TRESET delay is programmable through the OTP\_TRESET[1:0] bits.

**14.9.2 STANDBY**

STANDBY is an input signal to the IC, when this pin is asserted, the device enters the standby mode and when de-asserted, the part exits standby mode.

STANDBY can be configured as active high or active low using the STANDBYINV bit.

Table 29. Standby pin polarity control

| STANDBY (pin) | STANDBYINV (I <sup>2</sup> C bit) | STANDBY control     |
|---------------|-----------------------------------|---------------------|
| 0             | 0                                 | Not in standby mode |
| 0             | 1                                 | In standby mode     |
| 1             | 0                                 | In standby mode     |
| 1             | 1                                 | Not in standby mode |

### 14.9.3 RESETBMCU

RESETBMCU is an open-drain, active low output used to bring the processor (and peripherals) in and out of reset.

The time slot RESETBMCU is de-asserted during the power up sequence is programmed by the OTP\_RESETBMCU\_SEQ[7:0] bits, and it is a condition to enter the system-on states.

During the system-on states, the RESETBMCU is de-asserted (pulled high), and it is asserted (pulled low) as indicated in the power down sequence, when a system power down or reset is initiated.

In the application, RESETBMCU can be pulled up to VDDIO or VSNVS by a 100 kΩ external resistor.

### 14.9.4 INTB

INTB is an open-drain, active low output. This pin is asserted (pulled low) when any interrupt occurs, provided that the interrupt is not masked.

INTB is de-asserted after the corresponding interrupt latch is cleared by software, which requires writing a “1” to the interrupt bit.

An INTB\_TEST bit is provided to allow a manual test of the INTB pin. When INTB\_TEST is set to 1, the interrupt pin asserts for 100 μs and then de-asserts to its normal state. The INTB\_TEST bit self-clears to 0 automatically after the test pulse is generated.

In the application, INTB can be pulled up to VDDIO with an external 100 kΩ resistor.

### 14.9.5 XINTB

XINTB is an input pin used to receive an external interrupt and trigger an interrupt event on the PF8121. It is meant to interact with the INTB pin of a companion PMIC, in order to simplify MCU interaction to identify the source of the interrupt.

A high to low transition on the XINTB pin sets the XINTB\_I interrupt bit and causes the INTB to be asserted, provided the interrupt is not masked.

The XINTB\_S bit follows the actual status of the XINTB pin even when the XINTB\_I has been cleared or the interrupt has been masked.

This pin is internally pulled up to VDDIO with a 1.0 MΩ resistors; therefore, it can be left unconnected when the XINTB is not used.

### 14.9.6 WDI

WDI is an input pin to the PF8121 and is intended to operate as an external watchdog monitor.

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When the WDI pin is connected to the watchdog output of the processor, this pin is used to detect a pulse to indicate a watchdog event is requested by the processor. When the WDI pin is asserted, the device starts a watchdog event to place the PMIC outputs in a default known state.

The WDI pin is monitored during the system on states. In the off modes and during the power up sequence, the WDI pin is masked until RESETBMCU is de-asserted.

The WDI can be configured to assert on the rising or the falling edge using the OTP\_WDI\_INV bit.

- When OTP\_WDI\_INV = 0, the device starts a WD event on the falling edge of the WDI.
- When OTP\_WDI\_INV = 1, the device starts a WD event on the rising edge of the WDI.

A 10 µs debounce filter is implemented on either rising or falling edge detection to prevent false WDI signals to start a watchdog event.

The OTP\_WDI\_MODE bit allows the WDI pin to react in two different ways:

- When OTP\_WDI\_MODE = 1, a WDI asserted performs a hard WD reset.
- When OTP\_WDI\_MODE = 0, a WDI asserted performs a soft WD reset.

The WDI\_STBY\_ACTIVE bit allows the WDI pin to generate a watchdog event during the standby state.

- When WDI\_STBY\_ACTIVE = 0, asserting the WDI will not generate a watchdog event during the standby state.
- When WDI\_STBY\_ACTIVE = 1, asserting the WDI will start a watchdog event during the standby state.

The OTP\_WDI\_STBY\_ACTIVE is used to configure whether the WDI is active in the standby state or not by default upon power up.

See [Section 15.11 "Watchdog event management"](#) for details on watchdog event.

14.9.7 EWARN

EWARN is an active high output, used to notify that an imminent power failure is about to occur. It should be pulled down to GND by a 100 kΩ resistor.

When a power down is initiated due to a fault, the EWARN pin is asserted before the device starts powering down as defined by the EWARN\_TIME[1:0] bits in order to allow the system to prepare for the imminent shutdown.

The following faults cause the EWARN pin to be asserted:

- Fault timer expired
- FAULT\_CNT = FAULT\_MAX\_CNT
- Thermal Shutdown  $t_j > TSD$
- VIN\_OVLO event when VIN\_OVLO\_SDWN=1

Table 30. EWARN time configuration

| OTP_EWARN_TIME[1:0] | EWARN delay time |
|---------------------|------------------|
| 00                  | 100 µs           |
| 01                  | 5.0 ms           |
| 10                  | 20 ms            |
| 11                  | 50 ms            |

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When the EWARN pin is asserted, an interrupt will be generated and the EWARN\_I bit will be set to announce to the system of an imminent shutdown event.

In the Off modes, EWARN remains de-asserted (pulled low).

In the event of a power loss (VIN removed), the EWARN pin is asserted upon crossing the  $V_{\text{WARNTH}}$  threshold to notify to the processor that VIN may be lost and allow some time to prepare for the power loss.

**Table 31. Early warning threshold**

| Symbol              | Parameter               | Min | Typ | Max | Unit |
|---------------------|-------------------------|-----|-----|-----|------|
| $V_{\text{WARNTH}}$ | Early warning threshold | 2.7 | 2.8 | 2.9 | V    |

### 14.9.8 PGOOD

PGOOD is an open drain output programmable as a Power Good indicator pin or GPO. In the application, PGOOD can be pulled up to VDDIO with a 100 k $\Omega$  resistor.

When `OTP_PG_ACTIVE = 0`, the PGOOD pin is used as a general purpose output.

As a GPO, during the run state, the state of the pin is controlled by the `RUN_PG_GPO` bit in the functional I<sup>2</sup>C registers:

- When `RUN_PG_GPO = 1`, the PGOOD pin is high
- When `RUN_PG_GPO = 0`, the PGOOD pin is low

During the standby state, the state of the pin is controlled by the `STBY_PG_GPO` bit in the functional I<sup>2</sup>C registers:

- When `STBY_PG_GPO = 1`, the PGOOD pin is high
- When `STBY_PG_GPO = 0`, the PGOOD pin is low

When used as a GPO, the PGOOD pin can be enabled high as part of the power up sequence as programmed by the `OTP_SEQ_TBASE[1:0]` and the `OTP_PGOOD_SEQ[7:0]` bits. If enabled as part of the power up sequence, both the `RUN_PG_GPO` and `STBY_PG_GPO` bits are loaded with 1, otherwise they are loaded with 0 upon power up.

When `OTP_PG_ACTIVE = 1`, the PGOOD pin is in Power good (PG) mode and it acts as a PGOOD indicator for the selected output voltages in the PF8121.

There is an individual PG monitor for every regulator. Each monitor provide an internal PG signal that can be selected to control the status of the PGOOD pin upon an OV or UV condition when the corresponding `SWxPG_EN / LDOxPG_EN` bits are set. The status of the PGOOD pin is a logic AND function of the internal PG signals of the selected monitors.

- When the `PG_EN = 1`, the corresponding regulator becomes part of the AND function that controls the PGOOD pin.
- When the `PG_EN = 0`, the corresponding regulator does not control the status of the PGOOD pin.

The PGOOD pin is pulled low when any of the selected regulator outputs falls above or below the programmed OV/UV thresholds and a corresponding OV/UV interrupt is generated. If the faulty condition is removed, the corresponding `OV_S/UV_S` bit goes low to indicate the output is back in regulation, however, the interrupt remains latched until it is cleared.

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The actual condition causing the interrupt (OV, UV) can be read in the fault interrupt registers. For more details on handling interrupts, see [Section 14.8 "Interrupt management"](#).

When a particular regulator is disabled (via OTP, or I<sup>2</sup>C, or by change in state of PMIC such as going to standby mode), it no longer controls the PGOOD pin.

In the Off mode and during the power up sequence, the PGOOD pin is held low until RESETBMCU is ready to be released, at this point, the PG monitors are unmasked and the PGOOD pin is released high if all the internal PG monitors are in regulation. In the event that one or more outputs are not in regulation by the time RESETBMCU is ready to de-assert, the PGOOD pin is held low and the PF8121 performs the corresponding fault protection mechanism as described in [Section 14.7.1 "Fault monitoring during power up state"](#).

**14.9.9 VSELECT**

VSELECT is an input pin used to select the output voltage of LDO2 when bit VSELECT\_EN = 1.

- When VSELECT pin is low, the LDO2 output is programmed to 3.3 V.
- When VSELECT pin is high, the LDO2 output is programmed to 1.8 V.

When VSELECT\_EN = 0, the output of LDO2 is given by the VLDO2\_RUN[3:0] bits.

When the PF8121 is in the standby mode, the output voltage of LDO2 follows the configuration as selected by the VLDO2\_STBY[3:0] bits, regardless of the value of VSELECT\_EN bit.

The default value of the VSELECT\_EN bit is programmed by the OTP\_VSELECT\_EN bit in the OTP fuses.

A read only bit is provided to monitor the actual state of the VSELECT pin. When the VSELECT pin is low, the VSELECT\_S bit is 0 and when the VSELECT pin is high, the VSELECT\_S bit is set to 1.

**14.9.10 LDO2EN**

LDO2EN is an input pin used to enable or disable LDO2 when the bit LDO2HW\_EN = 1.

When LDO2HW\_EN = 1, the status of LDO2 output can also be controlled by the LDO2\_RUN\_EN bit in the run mode or the LDO2\_STBY\_EN bit in the standby mode.

**Table 32. LDO control in run or standby mode**

| LDO2EN pin  | LDO2HW_EN bit | LDO2_RUN_EN LDO2_STBY_EN | LDO2 output |
|-------------|---------------|--------------------------|-------------|
| Do not care | 0             | 0                        | Disabled    |
| Do not care | 0             | 1                        | Enabled     |
| Do not care | 1             | 0                        | Disabled    |
| Low         | 1             | 1                        | Disabled    |
| High        | 1             | 1                        | Enabled     |

The default controlling mode for LDO2 is programmed by the OTP\_LDO2HW\_EN bit in the OTP fuses.

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A read only bit is provided to monitor the actual state of the LDO2EN pin. When the LDO2EN pin is low, the LDO2EN\_S bit is 0 and when the LDO2EN pin is high, the LDO2EN\_S bit is set to 1.

**14.9.11 FSOB (fault status output)**

The FSOB pin is a configurable, active low, open drain output used as a fault notification output during a specific failure event.

The FSOB pin is externally pulled up to VIN or VDDIO with a 470 kΩ resistor and it is de-asserted high in normal operation.

The FSOB pin is intended to operate in fault status mode.

In the fault status mode, the FSOB is de-asserted by default, and can be asserted as programmed by the FSOB fault selection bits.

A bit is provided to enable the FSOB to be asserted when a regulator fault (OV, UV, ILIM) is present.

- If FSOB\_SOFTFAULT = 0, the FSOB pin is not asserted by any OV, UV, or ILIM fault.
- If FSOB\_SOFTFAULT = 1, an OV, UV, or ILIM fault on any of the regulators causes the FSOB pin to assert and remain asserted regardless of it being corrected or not, and also asserts the FSOB\_SFAULT\_NOK flag.

A bit is provided to enable the FSOB to be asserted when a WD reset occurs due to a WDI event.

- If FSOB\_WDI = 0, the FSOB pin is not asserted by a WDI event.
- If FSOB\_WDI = 1, a WDI event causes the FSOB pin to assert and the FSOB\_WDI\_NOK flag to be set.

A bit is provided to enable the FSOB to be asserted when a WD reset occurs due to an internal WD counter fault is present.

- If FSOB\_WDC = 0, the FSOB pin is not asserted by a WD reset started by the internal WD counter.
- If FSOB\_WDC = 1, a WD reset is started by the internal WD counter causing the FSOB pin to be asserted and the FSOB\_WDC\_NOK flag to be set.

A bit is provided to enable the FSOB to be asserted when a hard fault shutdown has occurred.

- If FSOB\_HARDFAULT = 0, the FSOB pin is not asserted by a hard fault.
- If FSOB\_HARDFAULT = 1, any of the hard fault shutdown events cause the FSOB pin to be asserted and the FSOB\_HFAULT\_NOK flag to be set.

Any of the following events are considered a hard fault shutdown:

- Fault timer expired
- FAULT\_CNT = FAULT\_MAX\_CNT (regulator fault counter max out)
- WD\_EVENT\_CNT = WD\_MAX\_CNT (watchdog event counter max out)
- Power up failure
- Thermal shutdown

The FSOB pin is released when all the FSOB fault flags are cleared or VIN falls below the UVDET threshold.

If the secure I<sup>2</sup>C write mechanism is enabled, all FSOB flags require a secure write to be cleared (write 1 to clear).

### 14.9.12 TBBEN

The TBBEN is an input pin provided to allow the user to program the mirror registers in order to operate the device with a custom configuration as well as programming the default values on the OTP fuses.

- When TBBEN pin is pulled low to ground, the device is operating in normal mode.
- When TBBEN pin is pulled high to V1P5D device enables the TBB configuration mode.

See [Section 17 "OTP/TBB and default configurations"](#) for details on TBB and OTP operation.

When TBBEN pin is pulled high to V1P5D the following conditions apply:

- The device uses a fixed I<sup>2</sup>C device address (0x08)
- Disable the watchdog operation, including WDI monitoring and internal watchdog timer
- Disable the CRC and I<sup>2</sup>C secure write mechanism while no power up event is present (TBB/OTP programming mode).

Disabling the watchdog operation may be required for in-line MCU programming where output voltages are required but watchdog operation should be completely disabled.

### 14.9.13 XFAILB

XFAILB is a bidirectional pin with an open drain output used to synchronize the power up and power down sequences of two or more PMIC's. It should be pulled up externally to V1P5A supply.

The OTP\_XFAILB\_EN bit is used to enable or disable the XFAILB mode of operation.

- When OTP\_XFAILB\_EN = 0, the XFAILB mode is disabled and any events on this pin are ignored
- When OTP\_XFAILB\_EN = 1, the XFAILB mode is enabled

When the XFAILB mode is enabled, and the PF8121 has a turn off event generated by an internal fault, the XFAILB pin is asserted low 20  $\mu$ s before starting the power down sequence.

A power down event caused by the following conditions will assert the XFAILB pin:

- Fault timer expired
- FAULT\_CNT = FAULT\_MAX\_CNT (regulator fault counter max out)
- WD\_EVENT\_CNT = WD\_MAX\_CNT (watchdog event counter max out)
- Power up failure
- Thermal shutdown
- Hard WD event

The XFAILB pin is forced low during the off mode.

During the system-on states, if the XFAILB pin is externally pulled low, it will detect an XFAIL event after a 20  $\mu$ s debounce. When an XFAIL event is detected, the XFAILB pin is asserted low internally and the device starts a power down sequence.

If a PWRON event is present, the device starts a turn on event and proceeds to release the XFAILB pin when its ready to start the power up sequence state. If the XFAILB pin is pulled down externally during the power up event, the PF8121 will stop the power up sequence until the pin is no longer pulled down externally. This will help both PMIC's to synchronize the power up sequence allowing it to continue only when both PMIC's are ready to initiate the power up sequence.

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A hard WD event will set the XFAILB pin 20  $\mu$ s before it starts its power down sequence. After all regulators outputs have been turned off, the device will release the XFAILB pin internally after a 30  $\mu$ s delay, proceed to load the default OTP configuration and wait for the XFAILB pin to be released externally before it can restart the power up sequence.

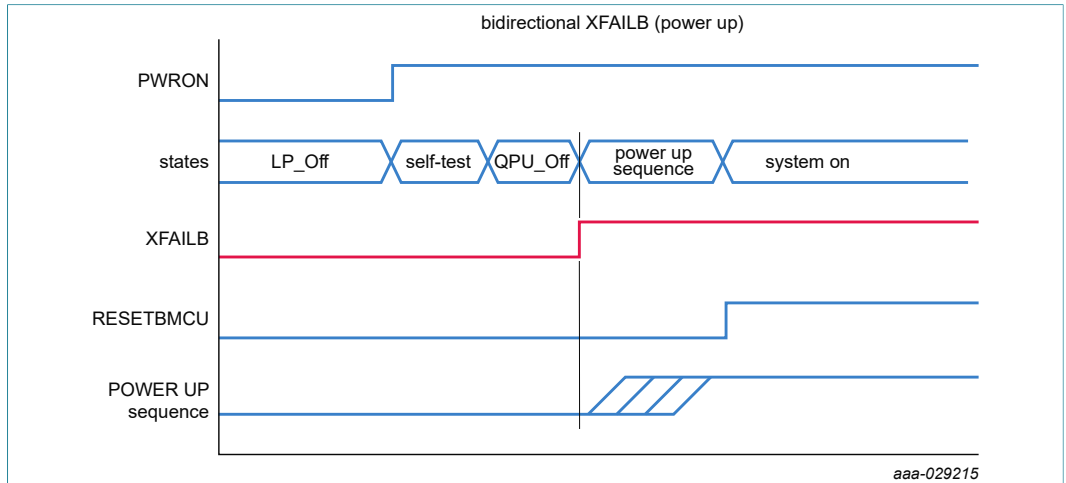


Figure 18. XFAILB behavior during a power up sequence

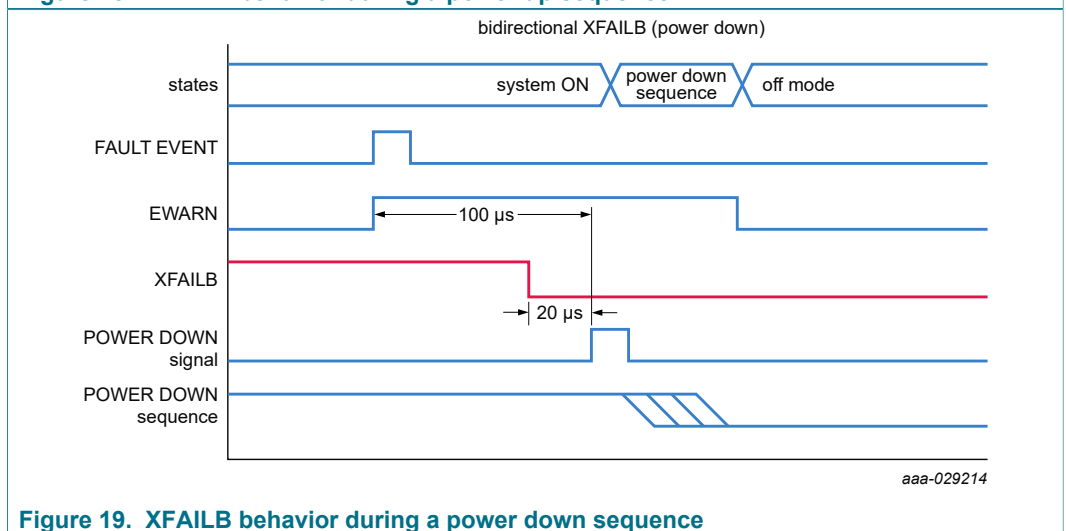


Figure 19. XFAILB behavior during a power down sequence



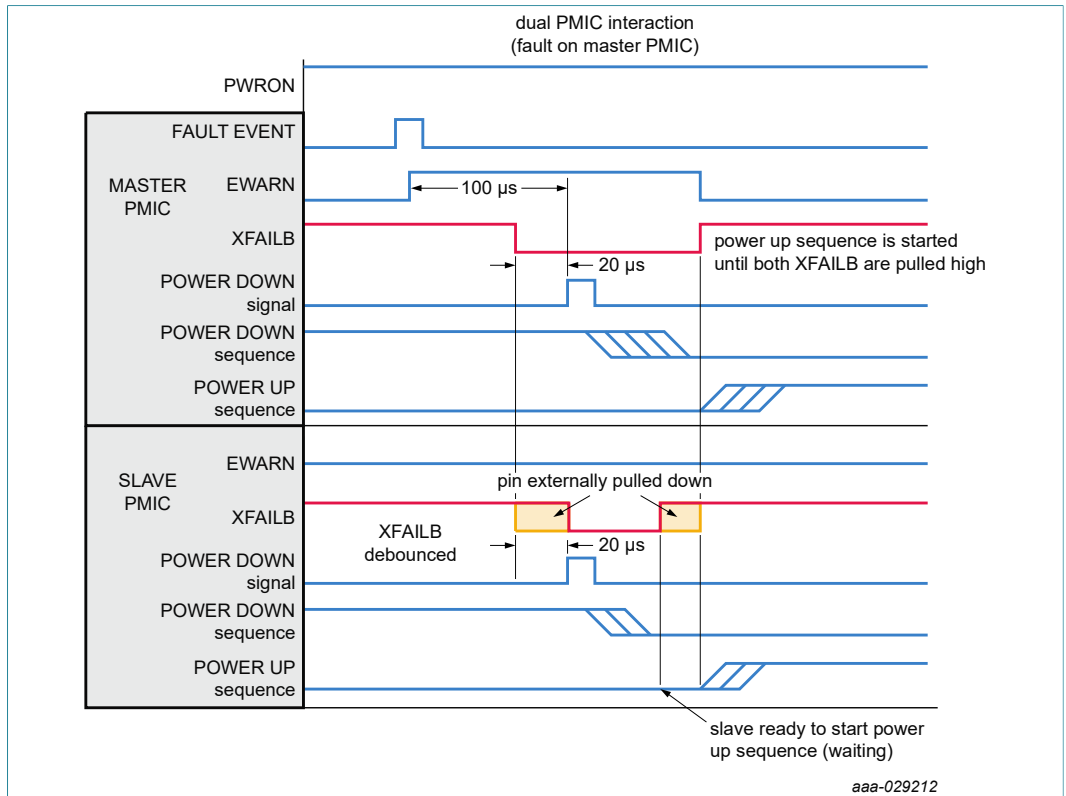


Figure 20. Behavior during an external XFAILB event

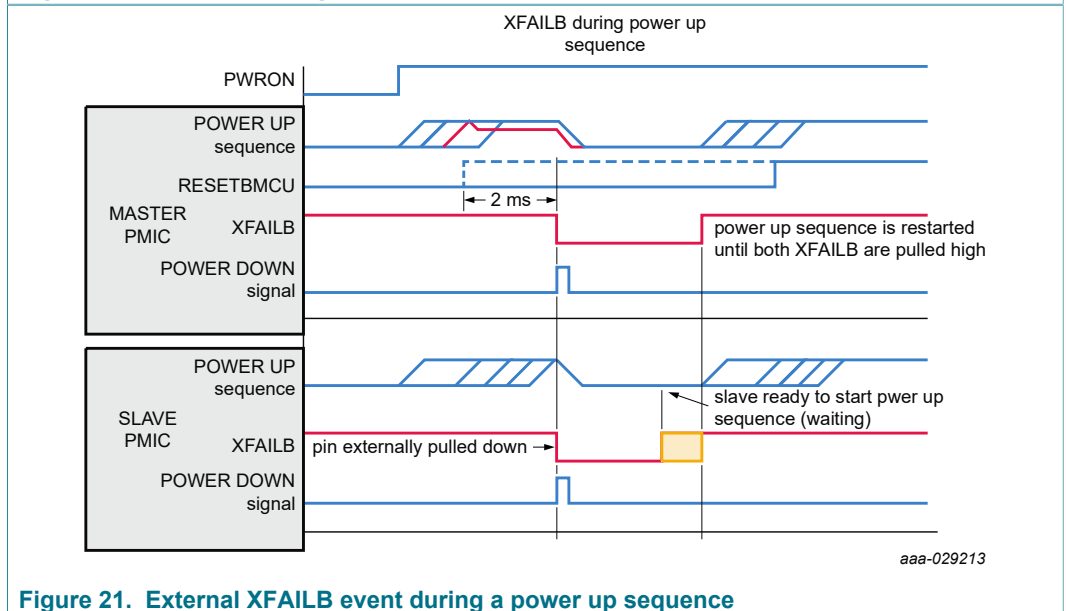


Figure 21. External XFAILB event during a power up sequence

### 14.9.14 SDA and SCL (I<sup>2</sup>C bus)

Communication with the PF8121 is done through I<sup>2</sup>C and it supports high-speed operation mode with up to 3.4 MHz operation. SDA and SCL are pulled up to VDDIO with 2.2 kΩ resistors. It is recommended to use 1.5 kΩ if 3.4 MHz I<sup>2</sup>C speed is required.

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The PF8121 is designed to operate as a slave device during I<sup>2</sup>C communication. The default I<sup>2</sup>C device address is set by the OTP\_I2C\_ADD[2:0].

Table 33. I<sup>2</sup>C address configuration

| OTP_I2C_ADD[2:0] | Device address |
|------------------|----------------|
| 000              | 0x08           |
| 001              | 0x09           |
| 010              | 0x0A           |
| 011              | 0x0B           |
| 100              | 0x0C           |
| 101              | 0x0D           |
| 110              | 0x0E           |
| 111              | 0x0F           |

See [http://www.nxp.com/documents/user\\_manual/UM10204.pdf](http://www.nxp.com/documents/user_manual/UM10204.pdf) for detailed information on the digital I<sup>2</sup>C communication protocol implementation.

During an I<sup>2</sup>C transaction, the communication will latch after the 8th bit is sent. If the data sent is not a multiple of 8 bit, any word with less than 8 bits will be ignored. If only 7 bits are sent, no data is written and the logic will not provide an ACK bit to the MCU.

From an IC level, a wrong I<sup>2</sup>C command can create a system level safety issue. For example, though the MCU may have intended to set a given regulator's output to 1.0 V, it may be erroneously registered as 1.1 V due to noise in the bus.

To prevent a wrong I<sup>2</sup>C configuration, various protective mechanisms are implemented.

14.9.14.1 I<sup>2</sup>C CRC verification

When this feature is enabled, a selectable CRC verification is performed on each I<sup>2</sup>C transaction.

- When OTP\_I2C\_CRC\_EN = 0, the CRC verification mechanism is disabled.
- When OTP\_I2C\_CRC\_EN = 1, the CRC verification mechanism is enabled.

After each I<sup>2</sup>C transaction, the device calculates the corresponding CRC byte to ensure the configuration command has not been corrupted.

When a CRC fault is detected, the PF8121 ignores the erroneous configuration command and triggers a CRC\_I interrupt asserting the INTB pin, provided the interrupt is not masked.

The PF8121 implements a CRC-8-SAE, per the SAE J1850 specification.

- Polynomial = 0x1D
- Initial value = 0xFF

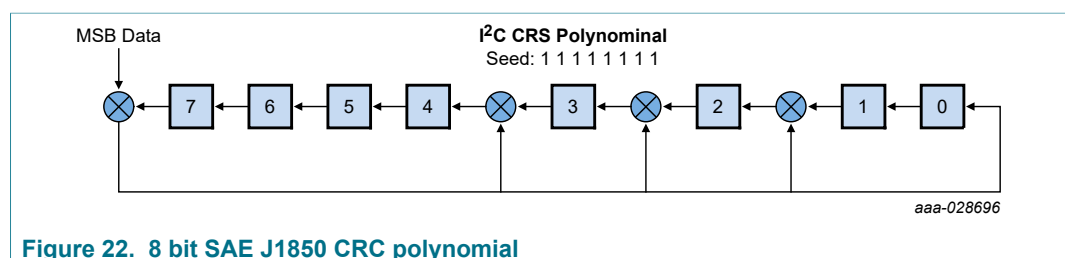


Figure 22. 8 bit SAE J1850 CRC polynomial

## 15 Functional blocks

### 15.1 Analog core and internal voltage references

All regulators use the main bandgap as the reference for the output voltage generations, this bandgap is also used as reference for the internal analog core and digital core supplies. The performance of the regulators is directly dependent on the performance of the bandgap.

No external DC loading is allowed on V1P5A and V1P5D. V1P5D is kept powered as long as there is a valid supply and/or valid coin cell and it may be used as a reference voltage for the VDDOTP and TBBEN pins during system power on.

A second bandgap is provided as the reference for all the monitoring circuits. This architecture allows the PF8121 to provide a reliable way to detect not only single point, but also latent faults.

**Table 34. Internal supplies electrical characteristics**

| Symbol            | Parameter              | Min  | Typ  | Max  | Unit |
|-------------------|------------------------|------|------|------|------|
| V <sub>1P5D</sub> | V1P5D output voltage   | 1.50 | 1.60 | 1.65 | V    |
| C <sub>1P5D</sub> | V1P5D output capacitor | —    | 1.0  | —    | μF   |
| V <sub>1P5A</sub> | V1P5A output voltage   | 1.50 | 1.60 | 1.65 | V    |
| C <sub>1P5A</sub> | V1P5A output capacitor | —    | 1.0  | —    | μF   |

### 15.2 Coin cell charger

A coin cell or super capacitor may be connected to the LICELL pin, the PF8121 features a simple constant current charger available at the LICELL pin.

The COINCHG\_EN bit is used to enable or disable the coin cell charger during the system-on states (run and standby) via I<sup>2</sup>C.

- When COINCHG\_EN = 0 the coin cell charger is disabled in run or standby modes.
- When COINCHG\_EN = 1 the coin cell charger is enabled in run or standby modes.

The COINCHG\_EN bit is reset to 0, when VIN crosses the UVDET threshold.

During the run mode, the coin cell charger utilizes a 60 μA charging current. If enabled during standby mode, the coin cell charger utilizes only a 10 μA charging current to be able to maintain low power consumption while still being able to maintain the backup battery voltage charged at all time.

The COINCHG\_OFF bit is used to enable or disable the coin cell charger during the QPU\_Off state via I<sup>2</sup>C. In this mode, the charger utilizes a 10 μA charging current.

- When COINCHG\_OFF = 0 the coin cell charger is disabled in QPU\_Off state.
- When COINCHG\_OFF = 1 the coin cell charger is enabled in QPU\_Off state.

If the system requires to allow charging of the coin cell during the QPU\_Off, the system should enable the COINCHG\_OFF bit during the run mode and the charger turns on during the QPU\_Off state, if programmed to stay in this state after power down. The COINCHG\_OFF bit is reset to 0, when VIN crosses the UVDET threshold.

The VCOIN[3:0] bits set the target charging voltage for the LICELL pin as shown in the table below. The OTP\_VCOIN[3:0] bits are used to set the default voltage for the coin cell battery charger.

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Table 35. Coin cell charger voltage level

| VCOIN[3:0] | Target LICELL voltage (V) |
|------------|---------------------------|
| 0000       | 1.8                       |
| 0001       | 2.0                       |
| 0010       | 2.1                       |
| 0011       | 2.2                       |
| 0100       | 2.3                       |
| 0101       | 2.4                       |
| 0110       | 2.5                       |
| 0111       | 2.6                       |
| 1000       | 2.7                       |
| 1001       | 2.8                       |
| 1010       | 2.9                       |
| 1011       | 3.0                       |
| 1100       | 3.1                       |
| 1101       | 3.2                       |
| 1110       | 3.3                       |
| 1111       | 3.6                       |

Table 36. Coin cell electrical characteristics

All parameters specified for  $T_A = -40\text{ }^\circ\text{C}$  to  $85\text{ }^\circ\text{C}$ ,  $V_{IN} = 5.0\text{ V}$ , All output voltage settings, typical external components, unless otherwise noted. Typical values are specified for  $T_A = 25\text{ }^\circ\text{C}$ ,  $V_{IN} = 5.0\text{ V}$ , typical external components, unless otherwise noted.

| Symbol          | Parameter   | Min  | Typ | Max | Unit          |
|-----------------|---|------|-----|-----|---------------|
| $V_{IN}$        | Input voltage range   | 2.5  | —   | 5.5 | V             |
| $V_{COINACC}$   | Voltage accuracy (2.6 V to 3.6 V)   | -3.0 | —   | 3.0 | %             |
| $V_{COINACC}$   | Voltage accuracy (1.8 V to 2.5 V)   | -4.0 | —   | 4.0 | %             |
| $V_{COINHDR}$   | Input voltage headroom<br>Minimum $V_{IN}$ headroom to guarantee $V_{COIN}$ regulation at $I_{COINHI}$    | 300  | —   | —   | mV            |
| $V_{COINHYS}$   | Charging hysteresis   | 60   | 100 | 200 | mV            |
| $I_{COINACC}$   | Current accuracy  | -30  | —   | 30  | %             |
| $I_{COINHI}$    | Coin cell charger current in run mode   | —    | 60  | —   | $\mu\text{A}$ |
| $I_{COINLO}$    | Coin cell charger current in standby and QPU_Off  | —    | 10  | —   | $\mu\text{A}$ |
| $I_{QCOINCH}$   | Quiescent current when coin cell is charging  | 0    | 10  | 20  | $\mu\text{A}$ |
| $V_{COINRLHYS}$ | Reverse leakage comparator hysteresis   | 50   | 100 | 170 | mV            |
| $V_{COINRLTR}$  | Reverse leakage comparator trip voltage at rising edge<br>( $V_{IN} - V_{COIN}$ ) at every VCOIN setting  | 100  | 200 | 300 | mV            |
| $V_{COINRLTF}$  | Reverse leakage comparator trip voltage at falling edge<br>( $V_{IN} - V_{COIN}$ ) at every VCOIN setting | 0    | 100 | 250 | mV            |

### 15.3 VSNVS LDO/switch

VSNVS is a 10 mA LDO/switch provided to power the RTC domain in the processor.

Three scenarios may be possible during  $V_{IN}$  application:

1. Coin cell was applied for the first time before  $V_{IN}$  power up.

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2. Coin cell is not present upon VIN power up.
3. Coin cell has been present after a previous power cycle.

If coin cell is first applied without VIN present, VSNVS remains disabled until VIN > UVDET and the VSNVS gets loaded with the OTP fuse configuration.

When VIN is applied and no coin cell is present, VSNVS is initially disabled and it is only enabled to its regulation point after OTP fuses are loaded.

If coin cell has been present after a previous power cycle, the VSNVS configuration is reloaded from the OTP registers when the VIN crosses the UVDET threshold. This way, if the VSNVS was modified via the I<sup>2</sup>C configuration bit, it will always be reset to the default value after a VIN power cycle.

When VIN < V<sub>WARNTH</sub>, a best of supply circuit decides whether VSNVS is powered by VIN or LICELL.

- When VIN is rising and VIN > UVDET, VSNVS is powered by VIN. When operating from VIN, it can regulate the output to 1.8 V, 3.0 V or 3.3 V. If the configured output voltage is higher than the input source, the VSNVS operates in dropout mode to track the input voltage.
- When operating from LICELL, it regulates the output when the output voltage is selected at 1.8 V. VSNVS operates as a switch from LICELL when the output voltage setting is selected to 3.0 V or 3.3 V.

The following table shows the expected operation of the VSNVS block for different voltage settings and different input voltage conditions.

**Table 37. VSNVS operation description**

| OTP_VSNVSVOLT[1:0] | VSNVS output voltage (V) | VIN                           | Expected VSNVS output  |
|--------------------|--------------------------|-------------------------------|--|
| 00                 | Disabled                 | Do not care                   | VSNVS is disabled on OTP   |
| 01                 | 1.8                      | < V <sub>WARNTH</sub> falling | Regulate to 1.8 V from the highest of VIN or LICELL <sup>[1]</sup> |
| 01                 | 1.8                      | > UVDET rising                | Regulate to 1.8 V from VIN   |
| 10                 | 3.0                      | < V <sub>WARNTH</sub> falling | Switch mode from the highest of VIN or LICELL                      |
| 10                 | 3.0                      | > UVDET rising                | Regulate to 3.0 from VIN <sup>[1]</sup>                            |
| 11                 | 3.3                      | < V <sub>WARNTH</sub> falling | Switch mode from the highest of VIN or LICELL                      |
| 11                 | 3.3                      | > UVDET rising                | Regulate to 3.3 from VIN <sup>[1]</sup>                            |

[1] Regulator is in drop off mode, if input is not enough to regulate to set point.

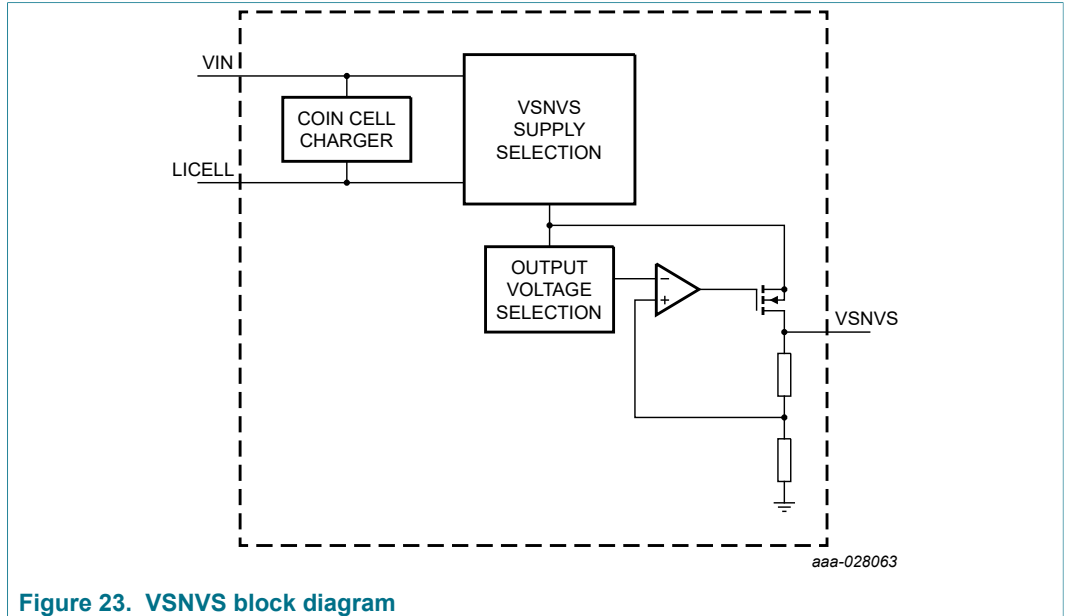


Figure 23. VSNVS block diagram

The VSNVS output keeps regulation through all states, including the system-on, off modes, power down sequence, watchdog reset, and fault transition as long as it has a valid input (VIN or LICELL), and the output has been configured by the OTP\_VSNVSVOLT[1:0] registers.

Table 38. VSNVS output voltage configuration

| OTP_VSNVSVOLT[1:0] | VSNVSVOLT[1:0] | VSNVS output voltage (V) |
|--------------------|----------------|--------------------------|
| 00                 | 00             | Off                      |
| 01                 | 01             | 1.8                      |
| 10                 | 10             | 3.0                      |
| 11                 | 11             | 3.3                      |

For system debugging purposes, the VSNVS output may be changed during the system-on states by changing the VSNVSVOLT[1:0] bits in the functional I<sup>2</sup>C registers.

Table 39. VSNVS electrical characteristics

All parameters are specified at  $T_A = -40\text{ }^\circ\text{C}$  to  $85\text{ }^\circ\text{C}$ , unless otherwise noted. Typical values are characterized at  $V_{IN} = 5.0\text{ V}$ , and  $T_A = 25\text{ }^\circ\text{C}$ , unless otherwise noted.

| Symbol             | Parameter  | Min   | Typ | Max | Unit          |
|--------------------|--|-------|-----|-----|---------------|
| $V_{IN\_SNVS}$     | Operating voltage range from VIN   | 2.5   | —   | 5.5 | V             |
| $V_{LICELL\_SNVS}$ | Operating voltage range from LICELL  | 1.728 | —   | 5.5 | V             |
| $I_{SNVS}$         | VSNVS load current range   | 0     | —   | 10  | mA            |
| $V_{SNVS\_ACC}$    | VSNVS output voltage accuracy in LDO mode  | -5.0  | —   | 5.0 | %             |
| $V_{SNVS\_RDSON}$  | VSNVS LDO on resistance<br>VSNVSVOLT[1:0] = 10 or 11   | —     | —   | 20  | $\Omega$      |
| $V_{SNVS\_IQ}$     | VSNVS quiescent current in LDO mode  | —     | 5.0 | —   | $\mu\text{A}$ |
| $V_{SNVS\_HDR}$    | VSNVS LDO headroom voltage<br>Minimum voltage above setting<br>VSNVSVOLT[1:0] = 10 or 11 to guarantee<br>regulation with 5 % tolerance | 200   | —   | —   | mV            |

| Symbol                      | Parameter   | Min  | Typ | Max  | Unit |
|-----------------------------|---|------|-----|------|------|
| V <sub>SNVS_HDR</sub>       | VSNVS LDO headroom voltage<br>Minimum voltage above setting<br>VSNVSVOLT[1:0] = 01 to guarantee regulation with 5 % tolerance | 500  | —   | —    | mV   |
| V <sub>SNVS_OS</sub>        | VSNVS startup overshoot   | —    | —   | 200  | mV   |
| V <sub>SNVS_TRANS</sub>     | VSNVS load transient  | -100 | —   | 100  | mV   |
| V <sub>SNVS_SW_R</sub>      | VSNVS switch mode resistance<br>VSNVSVOLT[1:0] = 10 or 11   | —    | —   | 20   | Ω    |
| V <sub>SNVS_LICELL_IQ</sub> | VSNVS quiescent current in switch mode<br>VSNVSVOLT[1:0] = 10 or 11   | —    | 1.0 | —    | μA   |
| V <sub>SNVS_ILIM</sub>      | VSNVS current limit   | 20   | —   | 70   | mA   |
| V <sub>SNVS_TON</sub>       | VSNVS turn on time<br>Block enabled to VSNVS at 90 % of final value   | —    | —   | 1.35 | ms   |

### 15.4 Type 1 buck regulators (SW1 to SW6)

The PF8121 features six low-voltage regulators with input supply range from 2.5 V to 5.5 V and output voltage range from 0.4 V to 1.8 V in 6.25 mV steps. Each voltage regulator is capable to supply 2.5 A and features a programmable soft-start and DVS ramp for system power optimization.

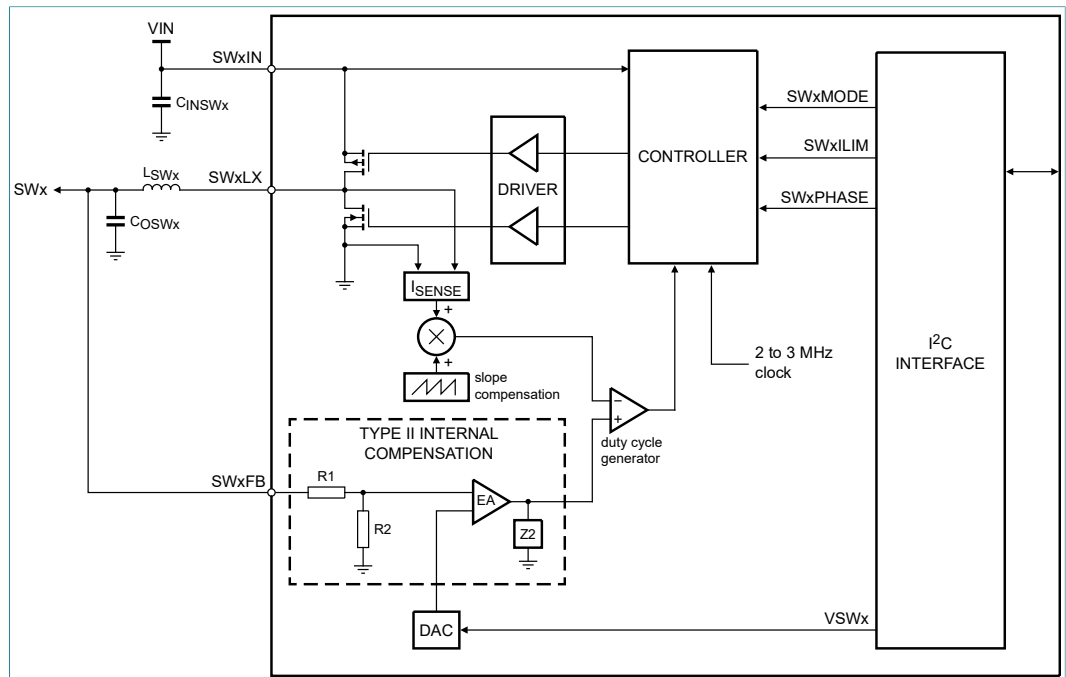


Figure 24. Buck regulator block diagram

The OTP\_SWxDVS\_RAMP bit sets the default step/time ratio for the power up ramp during the power up/down sequence as well as the DVS slope during the system on.

The power down ramp and DVS rate of the Type 1 buck regulators can be modified during the system-on states by changing the SWxDVS\_RAMP bit on the I<sup>2</sup>C register map.

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**Table 40. DVS ramp speed configuration**

| SWxDVS_RAMP bit | DVS ramp speed |
|-----------------|----------------|
| 0               | Slow DVS ramp  |
| 1               | Fast DVS ramp  |

The DVS ramp rate is based on the internal clock configuration as shown in [Table 41](#).

**Table 41. Ramp rates**

All ramp rates are typical values.

Clock frequency tolerance = ± 6 %.

| CLK_FREQ[3:0] | Clock frequency (MHz) | Regulators frequency (MHz) | SWxDVS_RAMP = 0 DVS_Up (mV/μs) | SWxDVS_RAMP = 0 DVS_Down (mV/μs) | SWxDVS_RAMP = 1 DVS_Up (mV/μs) | SWxDVS_RAMP = 1 DVS_Down (mV/μs) |
|---------------|-----------------------|----------------------------|--------------------------------|----------------------------------|--------------------------------|----------------------------------|
| 0000          | 20                    | 2.5                        | 7.813                          | 5.208                            | 15.625                         | 10.417                           |
| 0001          | 21                    | 2.625                      | 8.203                          | 5.469                            | 16.406                         | 10.938                           |
| 0010          | 22                    | 2.75                       | 8.594                          | 5.729                            | 17.188                         | 11.458                           |
| 0011          | 23                    | 2.875                      | 8.984                          | 5.990                            | 17.969                         | 11.979                           |
| 0100          | 24                    | 3                          | 9.375                          | 6.250                            | 18.750                         | 12.500                           |
| 1001          | 16                    | 2                          | 6.250                          | 4.167                            | 12.500                         | 8.333                            |
| 1010          | 17                    | 2.125                      | 6.641                          | 4.427                            | 13.281                         | 8.854                            |
| 1011          | 18                    | 2.25                       | 7.031                          | 4.688                            | 14.063                         | 9.375                            |
| 1100          | 19                    | 2.375                      | 7.422                          | 4.948                            | 14.844                         | 9.896                            |

Type 1 Buck regulators use 8 bits to set the output voltage.

- The VSWx\_RUN[7:0] set the output voltage during the run mode.
- The VSWx\_STBY[7:0] set the output voltage during the standby mode.

The default output voltage configuration for the run and the standby modes is loaded from the OTP\_VSWx[7:0] registers upon power up.

**Table 42. Output voltage configuration**

| Set point  | VSWx_RUN[7:0]<br>VSWx_STBY[7:0] | V <sub>SWxFB</sub> (V) |
|------------|---------------------------------|------------------------|
| 0          | 00000000                        | 0.40000                |
| 1          | 00000001                        | 0.40625                |
| 2          | 00000010                        | 0.41250                |
| 3          | 00000011                        | 0.41875                |
| ·          | ·                               | ·                      |
| ·          | ·                               | ·                      |
| 175        | 10101111                        | 1.49375                |
| 176        | 10110000                        | 1.50000                |
| 177        | 10110001                        | 1.80000                |
| 178 to 255 | 10110010 to 11111111            | Reserved               |

DVS operation is available for all voltage settings between 0.4 V to 1.5 V. However, the SWx regulator is not intended to perform DVS transitions to or from the 1.8 V configuration. In the event a voltage change is requested between any of the low voltage settings and 1.8 V, the switching regulator is automatically disabled first and then re-enabled at the selected voltage level to avoid an uncontrolled transition to the new voltage setting.



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Each regulator is provided with two bits to set its mode of operation.

- The SWx\_RUN\_MODE[1:0] bits allow the user to change the mode of operation of the SWx regulators during the run state. If the regulator was programmed as part of the power up sequence, the SWx\_RUN\_MODE[1:0] bits are loaded with 0b11 (autoskip) by default. Otherwise, it is loaded with 0b00 (disabled).
- The SWx\_STBY\_MODE[1:0] bits allow the user to change the mode of operation of the SWx regulators during the standby state. If the regulator was programmed as part of the power up sequence, the SWx\_STBY\_MODE[1:0] bits are loaded with 0b11 (autoskip) by default. Otherwise, it is loaded with 0b00 (disabled).

**Table 43. SW regulator mode configuration**

| SWx_MODE[1:0] | Mode of operation |
|---------------|-------------------|
| 00            | OFF               |
| 01            | PWM mode          |
| 10            | PFM mode          |
| 11            | Autoskip mode     |

The SWx\_MODE\_I interrupt asserts the INTB pin when any of the Type 1 regulators have changed the mode of operation, provided the corresponding interrupt is not masked.

To avoid potential detection of an OV/UV fault during SWx ramp up, it is recommended to power up the regulator in PWM or autoskip mode.

The type 1 buck regulators use 2 bits SWxILIM[1:0], to program the current limit detection.

**Table 44. SWx current limit selection**

| SWxILIM[1:0] | Typical current limit |
|--------------|-----------------------|
| 00           | 2.1 A                 |
| 01           | 2.6 A                 |
| 10           | 3.0 A                 |
| 11           | 4.5 A                 |

During single phase operation, all buck regulators use 3 bits (SWxPHASE[2:0]) to control the phase shift of the switching frequency. Upon power up, the switching phase of all regulators is defaulted to 0 degrees and can be modified during the system-on states.

**Table 45. SWx phase configuration**

| SWx_PHASE[2:0] | Phase shift [degrees] |
|----------------|-----------------------|
| 000            | 45                    |
| 001            | 90                    |
| 010            | 135                   |
| 011            | 180                   |
| 100            | 225                   |
| 101            | 270                   |
| 110            | 315                   |
| 111            | 0 (default)           |

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Each one of the buck regulator provide 2 OTP bits to configure the value of the inductor used in the corresponding block. The OTP\_SWx\_LSELECT[1:0] allow to choose the inductor as shown in [Table 46](#).

**Table 46. SWx inductor selection bits**

| OTP_SWx_LSELECT[1:0] | Inductor value |
|----------------------|----------------|
| 00                   | 1.0 μH         |
| 01                   | 0.47 μH        |
| 10                   | 1.5 μH         |
| 11                   | Reserved       |

**15.4.1 SW6 VTT operation**

SW6 features a selectable VTT mode to create VTT termination for DDR memories.

When SW6\_VTTEN = 1, the VTT mode is enabled. In this mode, SW6 reference voltage is internally connected to SW5FB output through a divider by 2.

During the VTT mode the DVS operation on SW6 is disabled and SW6 output is given by  $V_{SW5FB} / 2$ . In this mode, the minimum output voltage configuration for SW5 should be 800 mV to ensure the SW6 is still within the regulation range at its output.

During the power up sequence, the SW6 (VTT) may be turned on in the same or at a later slot than SW5, as required by the system. When SW6 and SW5 are enabled in the same slot, SW6 will always track the  $V_{SW5}/2$ . When SW6 is enabled after SW5, it will ramp up gradually to a predefined voltage and once this voltage is reached, it will start tracking  $V_{SW5}/2$ . The user may adjust the value at which the SW6 should start tracking the voltage on the SW5 regulator by setting the OTP\_VSW6 register accordingly.

During normal operation, if the SW5 is disabled via the I<sup>2</sup>C command, SW6 will track the output of SW5 and both regulators will be discharged together and pulled down internally. When SW5 is enabled back via the I<sup>2</sup>C commands, the SW5 output will ramp-up to the corresponding voltage while SW6 is always  $V_{SW5}/2$ .

When only SW6 is disabled, the PMIC uses the OTP\_VTT\_PDOWN bit to program whether the SW6 regulator is disabled with the output in high impedance or discharged internally.

- When OTP\_VTT\_PDOWN = 0, the output is disabled in high impedance mode.
- When OTP\_VTT\_PDOWN = 1, the output is disabled with the internal pull down enabled.

When SW6 is requested to enable back again, the SW6 will ramp-up to the voltage set on the VSW6\_RUN or VSW6\_STBY registers. Once it reaches the final DVS value, it will change its reference to start tracking SW5 output again. Note that VSW6\_RUN(STBY) must be set to  $V_{SW5\_RUN(STBY)}/2$  or the closest code by the MCU to ensure proper operation.

When operating in VTT mode, the minimum output voltage configuration for SW5 should be 800 mV to ensure the SW6 is still within the regulation range at its output.

**15.4.2 Multiphase operation**

Regulators SW1, SW2, SW3 and SW4 can be configured in quad phase mode. In this mode, SW1 registers control the output voltage and other configurations. Likewise, SW1FB pin becomes the main feedback node for the resulting voltage rail, however all

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four FB pins should be connected together. In quad phase operation, each phase can be independently set via the corresponding SWxPHASE[1:0] bits.

Regulators SW1, SW2 and SW3 can be configured in triple phase mode. In this mode, SW1 registers control the output voltage and other configurations. Likewise, SW1FB pin becomes the main feedback node for the resulting voltage rail, however all three FB pins should be connected together. In triple phase operation, each phase can be independently set via the corresponding SWxPHASE[1:0] bits.

When SW1 to SW3 are configured in triple phase, the SW4 operates in single phase.

Regulators SW1 and SW2 can be configured in dual phase mode. In this mode, SW1 registers control the output voltage and other configurations. Likewise, SW1FB pin becomes the main feedback node for the resulting voltage rail, however the two FB pins should be connected together. In dual phase operation, each phase can be independently set via the corresponding SWxPHASE[1:0] bits.

The OTP\_SW1CONFIG[1:0] bits are used to select the dual phase configuration for SW1/SW2, as well as triple or quad phase configuration.

**Table 47. OTP\_SW1CONFIG register description**

| OTP_SW1CONFIG[1:0] | Description                                |
|--------------------|--|
| 00                 | SW1 and SW2 operate in single phase mode   |
| 01                 | SW1/SW2 operate in dual phase mode         |
| 10                 | SW1/SW2/SW3/SW4 operate in quad phase mode |
| 11                 | SW1/SW2/SW3 operate in triple phase mode   |

Regulators SW3 and SW4 can be configured in dual phase mode. In this mode, SW4 registers control the output voltage and other configurations. Likewise, SW4FB pin becomes the main feedback node for the resulting voltage rail, however the two FB pins should be connected together.

In dual phase operation, each phase can be independently set via the corresponding SWxPHASE[1:0] bits.

The OTP\_SW4CONFIG[1:0] bits are used to select the dual phase operation of SW3/SW4.

**Table 48. OTP SW4CONFIG register description**

| OTP_SW4CONFIG[1:0] | Description                              |
|--------------------|--|
| 00                 | SW3 and SW4 operate in single phase mode |
| 01                 | SW3/SW4 operate in dual phase mode       |
| 10                 | Reserved                                 |
| 11                 | Reserved                                 |

Configuring regulators SW1 through SW4 in quad phase or triple phase operation overrides the configuration of the OTP\_SW4CONFIG[1:0] bits.

Regulators SW5 and SW6 can be configured in dual phase mode. In this mode, SW5 registers control the output voltage and other configurations. Likewise, SW5FB pin becomes the main feedback node for the resulting voltage rail, however the two FB pins should be connected together.

In dual phase operation, each phase can be independently set via the corresponding SWxPHASE[1:0] bits.

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The OTP\_SW5CONFIG[1:0] bits are used to select single or dual phase configuration for SW5/SW6.

Table 49. OTP\_SW5CONFIG register description

| OTP_SW5CONFIG[1:0] | Description                              |
|--------------------|--|
| 00                 | SW5 and SW6 operate in single phase mode |
| 01                 | SW5/SW6 operate in dual phase mode       |
| 10                 | Reserved                                 |
| 11                 | Reserved                                 |

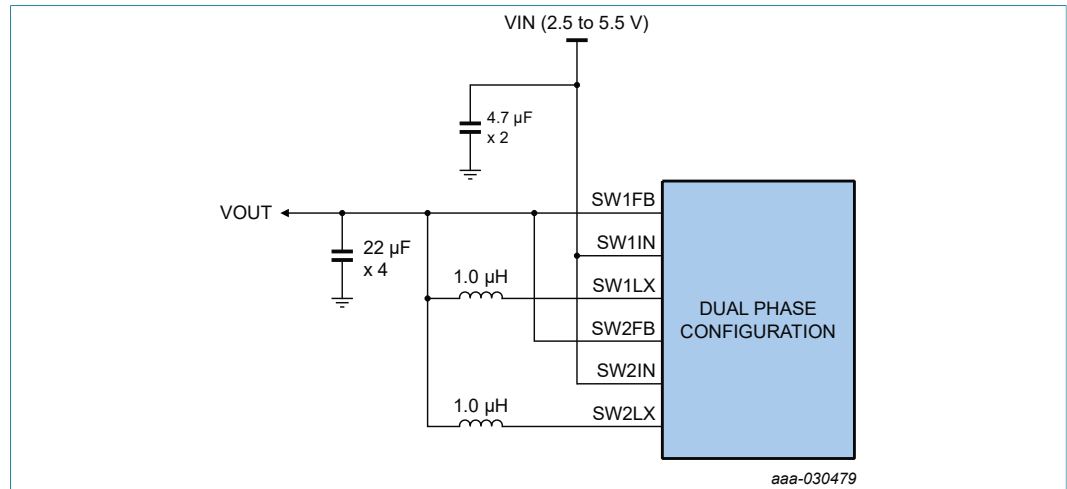


Figure 25. Dual phase configuration

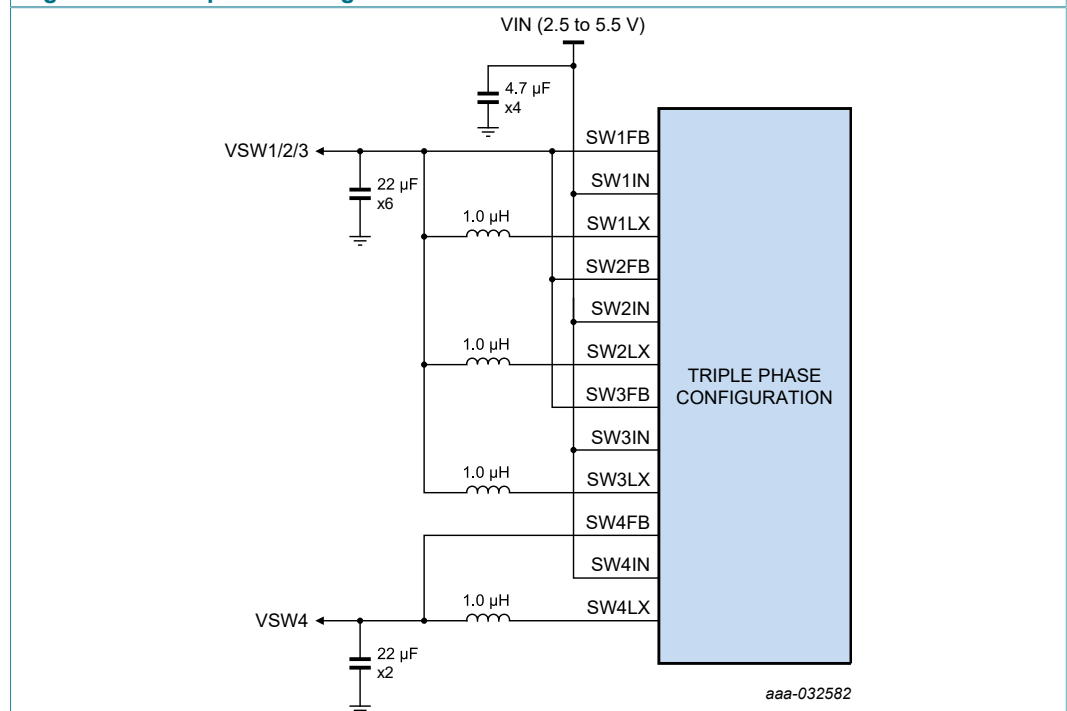


Figure 26. Triple phase configuration

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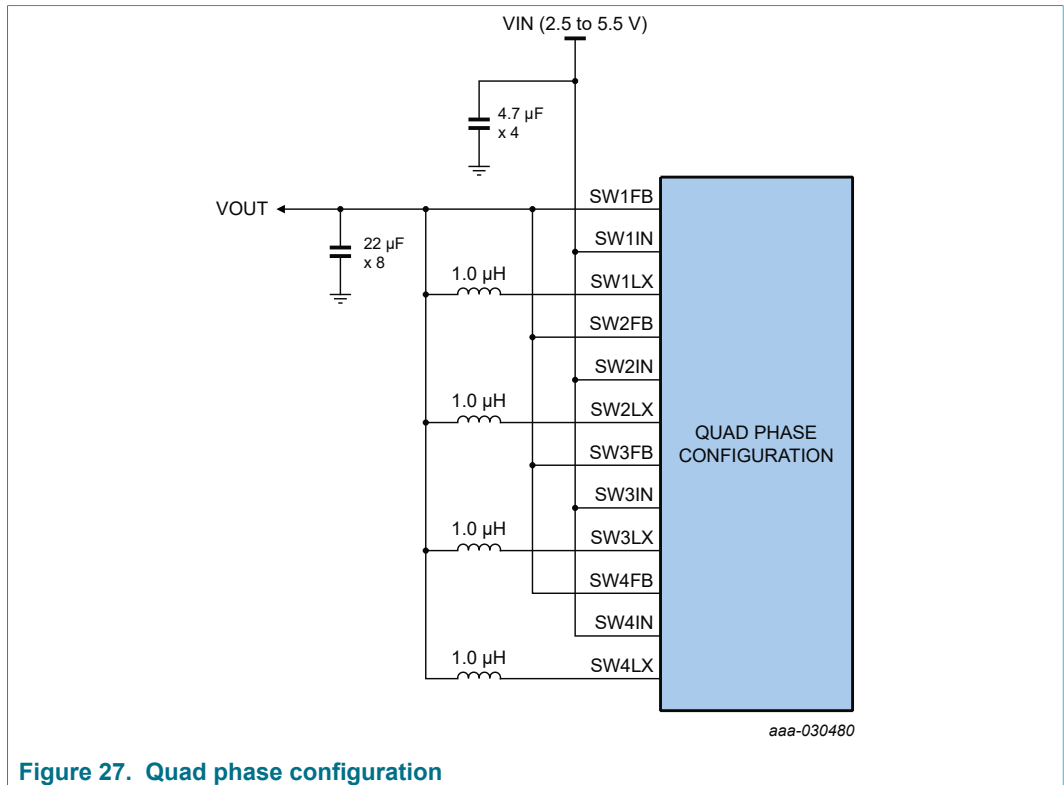


Figure 27. Quad phase configuration

15.4.3 Electrical characteristics

Table 50. Type 1 buck regulator electrical characteristics

All parameters are specified at  $T_A = -40$  to  $85$  °C,  $V_{SWxIN} = UVDET$  to  $5.5$  V,  $V_{SWxFB} = 1.0$  V,  $I_{SWx} = 500$  mA, typical external component values,  $f_{SW} = 2.25$  MHz, unless otherwise noted. Typical values are characterized at  $V_{SWxIN} = 5.0$  V,  $V_{SWxFB} = 1.0$  V,  $I_{SWx} = 500$  mA, and  $T_A = 25$  °C, unless otherwise noted.

| Symbol          | Parameter <sup>[1][2]</sup>   | Min   | Typ | Max | Unit |
|-----------------|---|-------|-----|-----|------|
| $V_{SWxIN}$     | Operating functional input voltage  | UVDET | —   | 5.5 | V    |
| $V_{SWxACC}$    | Output voltage accuracy<br>PWM mode<br>$0.4\text{ V} \leq V_{SWxFB} \leq 0.8\text{ V}$<br>$0 \leq I_{SWx} \leq 2.5\text{ A}$  | -10   | —   | 10  | mV   |
| $V_{SWxACC}$    | Output voltage accuracy<br>PWM mode<br>$0.8\text{ V} < V_{SWxFB} \leq 1.5\text{ V}$<br>$0 \leq I_{SWx} \leq 2.5\text{ A}$     | -2.0  | —   | 2.0 | %    |
| $V_{SWxACC}$    | Output voltage accuracy<br>PWM mode<br>$V_{SWxFB} = 1.8\text{ V}$<br>$0 \leq I_{SWx} \leq 2.5\text{ A}$                       | -2.0  | —   | 2.0 | %    |
| $V_{SWxACC}PFM$ | Output voltage accuracy<br>PFM mode<br>$0.4\text{ V} \leq V_{SWxFB} \leq 1.5\text{ V}$<br>$0 \leq I_{SWx} \leq 100\text{ mA}$ | -36   | —   | 36  | mV   |
| $V_{SWxACC}PFM$ | Output voltage accuracy<br>PFM mode<br>$V_{SWxFB} = 1.8\text{ V}$<br>$0 \leq I_{SWx} \leq 100\text{ mA}$                      | -57   | —   | 57  | mV   |
| $t_{PFMtoPWM}$  | PFM to PWM transition time  | 30    | —   | —   | μs   |
| $I_{SWx}$       | Max load current in single phase  | 2500  | —   | —   | mA   |
| $I_{SWx\_DP}$   | Max load current in dual phase  | 5000  | —   | —   | mA   |
| $I_{SWx\_TP}$   | Max load current in triple phase  | 7500  | —   | —   | mA   |

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| Symbol                  | Parameter <sup>[1][2]</sup>   | Min              | Typ  | Max   | Unit |
|-------------------------|---|------------------|------|-------|------|
| I <sub>SWx_QP</sub>     | Max load current in quad phase  | 10000            | —    | —     | mA   |
| I <sub>SWxLIM</sub>     | Current limiter - inductor peak current detection<br>SWxLIM[1:0] = 00   | 1.6              | 2.1  | 2.5   | A    |
| I <sub>SWxLIM</sub>     | Current limiter - inductor peak current detection<br>SWxLIM[1:0] = 01   | 2.0              | 2.6  | 3.1   | A    |
| I <sub>SWxLIM</sub>     | Current limiter - inductor peak current detection<br>SWxLIM[1:0] = 10   | 2.4              | 3.0  | 3.7   | A    |
| I <sub>SWxLIM</sub>     | Current limiter - inductor peak current detection<br>SWxLIM[1:0] = 11   | 3.6              | 4.5  | 5.45  | A    |
| I <sub>SWxNLIM</sub>    | Negative current limit in single phase mode   | 0.6              | 1.0  | 1.4   | A    |
| I <sub>SWxxLIM_DP</sub> | Current limit in dual phase operation<br>SWxLIM = 00 (master)   | 3.2              | 4.2  | 5.0   | A    |
| I <sub>SWxxLIM_DP</sub> | Current limit in dual phase operation<br>SWxLIM = 01 (master)   | 4.0              | 5.2  | 6.2   | A    |
| I <sub>SWxxLIM_DP</sub> | Current limit in dual phase operation<br>SWxLIM = 10 (master)   | 4.8              | 6.0  | 7.4   | A    |
| I <sub>SWxxLIM_DP</sub> | Current limit in dual phase operation<br>SWxLIM = 11 (master)   | 7.2              | 9.0  | 10.9  | A    |
| I <sub>SWxxLIM_TP</sub> | Current limit in triple phase operation<br>SW1LIM[1:0] = 00   | 4.8              | 6.3  | 7.5   | A    |
| I <sub>SWxxLIM_TP</sub> | Current limit in triple phase operation<br>SW1LIM[1:0] = 01   | 6.0              | 7.8  | 9.3   | A    |
| I <sub>SWxxLIM_TP</sub> | Current limit in triple phase operation<br>SW1LIM[1:0] = 10   | 7.2              | 9.0  | 11.1  | A    |
| I <sub>SWxxLIM_TP</sub> | Current limit in triple phase operation<br>SW1LIM[1:0] = 11   | 10.8             | 13.5 | 16.35 | A    |
| I <sub>SWxxLIM_QP</sub> | Current limit in quad phase operation<br>SW1LIM = 00  | 7.2              | 8.4  | 10    | A    |
| I <sub>SWxxLIM_QP</sub> | Current limit in quad phase operation<br>SW1LIM = 01  | 8.0              | 10.4 | 12.4  | A    |
| I <sub>SWxxLIM_QP</sub> | Current limit in quad phase operation<br>SW1LIM = 10  | 9.6              | 12.0 | 14.8  | A    |
| I <sub>SWxxLIM_QP</sub> | Current limit in quad phase operation<br>SW1LIM = 11  | 14.4             | 18.0 | 21.8  | A    |
| V <sub>SWxOSH</sub>     | Startup overshoot<br>SWxDVS RAMP = 6.25 mV/μs<br>VSWxIN = 5.5 V, VSWxFB= 1.0 V  | -25              | 25   | 50    | mV   |
| t <sub>ONSWx</sub>      | Turn on time<br>From enable to 90 % of end value<br>SWxDVS RAMP = 0 (6.25 mV/μs)<br>VSWxIN = 5.5 V, VSWxFB= 1.0 V         | —                | 160  | —     | μs   |
| t <sub>ONSWxMAX</sub>   | Maximum turn on time<br>From enable to 90 % of end value<br>SWxDVS RAMP = 0 (6.25 mV/μs)<br>VSWxIN = 5.5 V, VSWxFB= 1.5 V | —                | —    | 310   | μs   |
| t <sub>ONSWx_MIN</sub>  | Minimum turn on time<br>From enable to 90 % of end value<br>SWxDVS RAMP = 1 (12.5 mV/μs)<br>VSWxIN = 5.5 V, VSWxFB= 0.4 V | 34.2             | —    | —     | μs   |
| η <sub>SWx</sub>        | Efficiency (PFM mode, 1.0 V, 1.0 mA)  | —                | 80   | —     | %    |
| η <sub>SWx</sub>        | Efficiency (PFM mode, 1.0 V, 50 mA)   | —                | 81   | —     | %    |
| η <sub>SWx</sub>        | Efficiency ( PFM Mode, 1.0 V, 100 mA)   | —                | 82   | —     | %    |
| η <sub>SWx</sub>        | Efficiency (PWM mode, 1.0 V, 500 mA)  | <sup>[3]</sup> — | 83   | —     | %    |
| η <sub>SWx</sub>        | Efficiency (PWM mode, 1.0 V, 1000 mA)   | <sup>[3]</sup> — | 82   | —     | %    |
| η <sub>SWx</sub>        | Efficiency (PWM mode, 1.0 V, 2000 mA)   | <sup>[3]</sup> — | 79   | —     | %    |
| F <sub>SWx</sub>        | PWM switching frequency range<br>Frequency set by CLK_FREQ[3:0]   | 1.9              | 2.5  | 3.15  | MHz  |
| T <sub>OFFminSWx</sub>  | Minimum off time  | —                | 27   | —     | ns   |
| T <sub>DBSWx</sub>      | Deadband time   | —                | 3.0  | —     | ns   |

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| Symbol               | Parameter <sup>[1][2]</sup>   | Min  | Typ | Max                | Unit |
|----------------------|---|------|-----|--------------------|------|
| T <sub>slew</sub>    | Slewing time (10 % to 90 %)   | —    | —   | 5.0                | ns   |
| D <sub>VSWx</sub>    | Output ripple in PWM mode   | —    | —   | 1.0                | %    |
| V <sub>SWxLOTR</sub> | Transient load regulation (overshoot/undershoot)<br>at 0.8 V < V <sub>SWxFB</sub> ≤ 1.2 V<br>I <sub>Load</sub> = 200 mA to 1.0 A, di/dt = 2.0 A/μs (single phase)<br>I <sub>Load</sub> = 400 mA to 2.0 A, di/dt = 4.0 A/μs (dual phase)<br>I <sub>Load</sub> = 600 mA to 3.0 A, di/dt = 6.0 A/μs (triple phase)<br>I <sub>Load</sub> = 800 mA to 4.0 A, di/dt = 8.0 A/μs (quad phase)<br>Output capacitance = 44 μF per phase | -25  | —   | +25                | mV   |
| V <sub>SWxLOTR</sub> | Transient load regulation (overshoot/undershoot)<br>at 1.25 < V <sub>SWxFB</sub> < 1.8 V<br>I <sub>Load</sub> = 200 mA to 1.0 A, di/dt = 2.0 A/μs (single phase)<br>I <sub>Load</sub> = 400 mA to 2.0 A, di/dt = 4.0 A/μs (dual phase)<br>I <sub>Load</sub> = 600 mA to 3.0 A, di/dt = 6.0 A/μs (triple phase)<br>I <sub>Load</sub> = 800 mA to 4.0 A, di/dt = 8.0 A/μs (quad phase)<br>Output capacitance = 44 μF per phase  | -3.0 | —   | +3.0               | %    |
| I <sub>RCS</sub>     | DCM (skip mode) reverse current sense threshold<br>Current flowing from PGND to SWxLX   | -200 | —   | 200                | mA   |
| I <sub>SWxQ</sub>    | Quiescent current<br>PFM mode   | —    | 14  | —                  | μA   |
| I <sub>SWxQ</sub>    | Quiescent current<br>Auto skip mode   | —    | 160 | 250                | μA   |
| I <sub>SWxQ_DP</sub> | Quiescent current in dual phase pulse skip mode   | —    | 200 | 320                | μA   |
| I <sub>SWxQ_TP</sub> | Quiescent current in triple phase pulse skip mode   | —    | 220 | 390                | μA   |
| I <sub>SWxQ_QP</sub> | Quiescent current in quad phase pulse skip mode   | —    | 240 | 480                | μA   |
| R <sub>ONSWxHS</sub> | SWx high-side P-MOSFET R <sub>DS(on)</sub>  | —    | —   | 135 <sup>[4]</sup> | mΩ   |
| R <sub>ONSWxLS</sub> | SWx low-side N-MOSFET R <sub>DS(on)</sub>   | —    | —   | 80 <sup>[4]</sup>  | mΩ   |
| R <sub>SWxDIS</sub>  | Discharge resistance<br>Regulator disabled and ramp down completed  | 20   | 70  | 120                | Ω    |

- [1] For VSWx configurations greater than 1.35 V, full parametric operation is guaranteed for 2.7 V < SWxVIN < 5.5 V. Below 2.7 V, the SWx regulators are fully functional with degraded operation due to headroom limitation.
- [2] For VSWx = 1.8 V, output capacitance should be kept at or below the maximum recommended value. Likewise, it is recommended to use the slow turn-on/off ramp rate to ensure the output is discharged completely when it is disabled.
- [3] PWM efficiency is applicable per single phase operation. For multiphase operation, multiply the load current by the number of phases to achieve the same efficiency percentage in PWM operation.
- [4] Max R<sub>DS(on)</sub> does not include bondwire resistance. Consider +50 % tolerance to account for bondwire and pin loss.

Table 51. Recommended external components

| Symbol           | Parameter  | Min  | Typ | Max | Unit |
|------------------|--|------|-----|-----|------|
| L                | Output inductor<br>Maximum inductor DC resistance 50 mΩ <sup>[1]</sup><br>Minimum saturation current at full load: 3.0 A | 0.47 | 1.0 | 1.5 | μH   |
| C <sub>out</sub> | Output capacitor<br>Use 2 x 22 μF, 6.3 V X7T ceramic capacitor to reduce output capacitance ESR.                         | —    | 44  | —   | μF   |
| C <sub>in</sub>  | Input capacitor<br>4.7 μF, 10 V X7R ceramic capacitor  | —    | 4.7 | —   | μF   |

- [1] Keep inductor DCR as low as possible to improve regulator efficiency.

### 15.5 Type 2 buck regulator (SW7)

The PF8121 also features one single phase low-voltage buck regulator (SW7) with an input voltage range between 2.5 V and 5.5 V and an output voltage range from 1.0 V to 4.1 V.

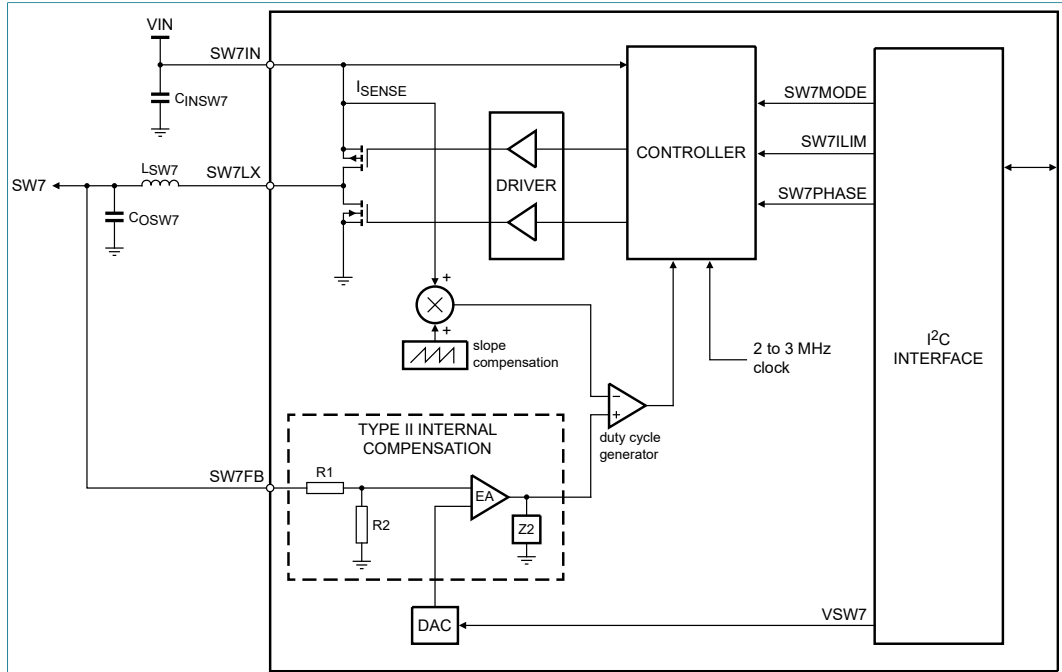


Figure 28. Type 2 buck regulator block diagram

Buck regulator SW7 uses 5 bits to set the output voltage. The VSW7[4:0] sets the output voltage during the run and the standby mode.

The SW7 is designed to have a fixed voltage for entire system operation. In the event a system requires this regulator to change its output voltage during the system-on states, when the SW7 is commanded to change its voltage via the I<sup>2</sup>C command, the output will be discharged first and then enabled back to the new voltage level as stated in the VSW7[4:0] bits.

The default output voltage configuration for the run and the standby modes is loaded from the OTP\_VSW7[4:0] registers upon power up.

Table 52. SW7 output voltage configuration

| Set point | VSW7[4:0] | V <sub>SW7FB</sub> (V) |
|-----------|-----------|------------------------|
| 0         | 0 0000    | 1.00                   |
| 1         | 0 0001    | 1.10                   |
| 2         | 0 0010    | 1.20                   |
| 3         | 0 0011    | 1.25                   |
| 4         | 0 0100    | 1.30                   |
| 5         | 0 0101    | 1.35                   |
| 6         | 0 0110    | 1.50                   |
| 7         | 0 0111    | 1.60                   |
| 8         | 0 1000    | 1.80                   |
| 9         | 0 1001    | 1.85                   |
| 10        | 0 1010    | 2.00                   |
| 11        | 0 1011    | 2.10                   |
| 12        | 0 1100    | 2.15                   |



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| Set point | VSW7[4:0] | V <sub>SW7FB</sub> (V) |
|-----------|-----------|------------------------|
| 13        | 0 1101    | 2.25                   |
| 14        | 0 1110    | 2.30                   |
| 15        | 0 1111    | 2.40                   |
| 16        | 1 0000    | 2.50                   |
| 17        | 1 0001    | 2.80                   |
| 18        | 1 0010    | 3.15                   |
| 19        | 1 0011    | 3.20                   |
| 20        | 1 0100    | 3.25                   |
| 21        | 1 0101    | 3.30                   |
| 22        | 1 0110    | 3.35                   |
| 23        | 1 0111    | 3.40                   |
| 24        | 1 1000    | 3.50                   |
| 25        | 1 1001    | 3.80                   |
| 26        | 1 1010    | 4.00                   |
| 27        | 1 1011    | 4.10                   |
| 28        | 1 1100    | 4.10                   |
| 29        | 1 1101    | 4.10                   |
| 30        | 1 1110    | 4.10                   |
| 31        | 1 1111    | 4.10                   |

Regulator SW7 is provided with two bits to set its mode of operation.

- The SW7\_RUN\_MODE[1:0] bits allow the user to change the mode of operation of the SW7 regulators during the run state. If the regulator was programmed as part of the power up sequence, the SW7\_RUN\_MODE[1:0] bits are loaded with 0b11 (autoskip) by default. Otherwise, it is loaded with 0b00 (disabled).
- The SW7\_STBY\_MODE[1:0] bits allow the user to change the mode of operation of the SW7 regulators during the standby state. If the regulator was programmed as part of the power up sequence, the SW7\_STBY\_MODE[1:0] bits are loaded with 0b11 (autoskip) by default. Otherwise it is loaded with 0b00 (disabled).

**Table 53. SW7 regulator mode configuration**

| SW7_MODE[1:0] | Mode of operation |
|---------------|-------------------|
| 00            | OFF               |
| 01            | PWM mode          |
| 10            | PFM mode          |
| 11            | Autoskip mode     |

The SW7\_MODE\_I interrupt asserts the INTB pin when the SW7 regulator has changed the mode of operation, provided the corresponding interrupt is not masked.

When the device toggles from run to standby mode, the SW7 output voltage remains the same, unless the regulator is enabled/disabled by the corresponding SW7\_RUN\_MODE[1:0] or SW7\_STBY\_MODE[1:0] bits.

The SW7ILIM [1:0] bits are used to program the current limit detection level of SW7.

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Table 54. SW7 current limit selection

| SW7ILIM[1:0] | Typical current limit |
|--------------|-----------------------|
| 00           | 2.1 A                 |
| 01           | 2.6 A                 |
| 10           | 3.0 A                 |
| 11           | 4.5 A                 |

Regulator SW7 use 3 bits (SWxPHASE[2:0]) to control the phase shift of the switching frequency. Upon power up, the switching phase is defaulted to 0 degrees and can be modified during the system-on states.

Table 55. SW7 phase configuration

| SW7_PHASE[2:0] | Phase shift [degrees] |
|----------------|-----------------------|
| 000            | 45                    |
| 001            | 90                    |
| 010            | 135                   |
| 011            | 180                   |
| 100            | 225                   |
| 101            | 270                   |
| 110            | 315                   |
| 111            | 0                     |

SW7 buck regulator provide 2 OTP bits to configure the value of the inductor used in the power stage. The OTP\_SW7\_LSELECT[1:0] allow to choose the inductor as shown in the following table.

Table 56. SW7 inductor selection bits

| OTP_SW7_LSELECT[1:0] | Inductor value |
|----------------------|----------------|
| 00                   | 1.0 $\mu$ H    |
| 01                   | 0.47 $\mu$ H   |
| 10                   | 1.5 $\mu$ H    |
| 11                   | Reserved       |

15.5.1 Electrical characteristics

Table 57. Type 2 buck regulator electrical characteristics

All parameters are specified at  $T_A = -40$  to  $85$  °C,  $V_{IN} = V_{SW7IN} = UVDET$  to  $5.5$  V,  $V_{SW7FB} = 1.8$  V,  $I_{SW7} = 500$  mA, typical external component values,  $f_{SW} = 2.25$  MHz, unless otherwise noted. Typical values are characterized at  $V_{SW7IN} = 5.0$  V,  $V_{SW7FB} = 1.8$  V,  $I_{SW7} = 500$  mA, and  $T_A = 25$  °C, unless otherwise noted.

| Symbol            | Parameter  | Min                | Typ | Max | Unit |
|-------------------|--|--------------------|-----|-----|------|
| $V_{SW7IN}^{[1]}$ | Operating input voltage range<br>$1.2$ V < $V_{SW7FB} \leq 1.85$ V, DCR $\leq 40$ m $\Omega$ | UVDET              | —   | 5.5 | V    |
| $V_{SW7IN}^{[1]}$ | Operating input voltage range<br>$1.85$ V < $V_{SW7FB} < 4.1$ V, DCR $\leq 40$ m $\Omega$    | $V_{SW7FB} + 0.65$ | —   | 5.5 | V    |
| $V_{SW7ACC}$      | Output voltage accuracy<br>PWM mode<br>$0 \leq I_{SW7} \leq 2.5$ A                           | -2.0               | —   | 2.0 | %    |
| $V_{SW7ACC}$      | Output voltage accuracy<br>PFM mode<br>$0 \leq I_{SW7} \leq \Delta I/2$                      | -4.0               | —   | 4.0 | %    |

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| Symbol                | Parameter   | Min  | Typ | Max                | Unit |
|-----------------------|---|------|-----|--------------------|------|
| t <sub>PFMtoPWM</sub> | PFM to PWM transition time  | 10   | —   | —                  | μs   |
| I <sub>SW7</sub>      | Maximum output load   | 2500 | —   | —                  | mA   |
| I <sub>SW7LIM</sub>   | Current limiter - inductor peak current detection<br>SW7LIM = 00  | 1.6  | 2.1 | 2.5                | A    |
| I <sub>SW7LIM</sub>   | Current limiter - inductor peak current detection<br>SW7LIM = 01  | 2.0  | 2.6 | 3.1                | A    |
| I <sub>SW7LIM</sub>   | Current limiter - inductor peak current detection<br>SW7LIM = 10  | 2.4  | 3.0 | 3.7                | A    |
| I <sub>SW7LIM</sub>   | Current limiter - inductor peak current detection<br>SW7LIM = 11  | 3.6  | 4.5 | 5.45               | A    |
| I <sub>SW7NILIM</sub> | Negative current limit - inductor valley current detection  | 0.7  | 1.0 | 1.3                | A    |
| t <sub>SW7RAMP</sub>  | Soft-start ramp time during power up and power down<br>V <sub>SW7FB</sub> = 1.8 V   | 90   | —   | 200                | μs   |
| t <sub>ONSW7</sub>    | Turn on time<br>From regulator enabled to 90 % of end value<br>V <sub>SW7FB</sub> = 1.8 V   | 100  | 180 | 300                | μs   |
| V <sub>SW7OSH</sub>   | Startup overshoot   | -50  | —   | 50                 | mV   |
| η <sub>SW7</sub>      | Efficiency<br>PFM mode, 3.3 V, 1.0 mA, T <sub>J</sub> = 125 °C  | —    | 85  | —                  | %    |
| η <sub>SW7</sub>      | Efficiency<br>PFM mode, 3.3 V, 50 mA, T <sub>J</sub> = 125 °C   | —    | 88  | —                  | %    |
| η <sub>SW7</sub>      | Efficiency<br>PFM mode, 3.3 V, 100 mA, T <sub>J</sub> = 125 °C  | —    | 90  | —                  | %    |
| η <sub>SW7</sub>      | Efficiency<br>PWM mode, 3.3 V, 400 mA, T <sub>J</sub> = 125 °C  | —    | 91  | —                  | %    |
| η <sub>SW7</sub>      | Efficiency<br>PWM mode, 3.3 V, 1000 mA, T <sub>J</sub> = 125 °C   | —    | 92  | —                  | %    |
| η <sub>SW7</sub>      | Efficiency<br>PWM mode, 3.3 V, 2000 mA, T <sub>J</sub> = 125 °C   | —    | 90  | —                  | %    |
| F <sub>SWx</sub>      | PWM switching frequency range<br>Frequency set by CLK_FREQ[3:0]   | 1.9  | 2.5 | 3.15               | MHz  |
| T <sub>ONminSW7</sub> | Minimum on time   | —    | 50  | —                  | ns   |
| T <sub>DBSW7</sub>    | Deadband time   | —    | 3.0 | —                  | ns   |
| T <sub>slew</sub>     | Slewing time<br>10 % to 90 %<br>V <sub>SW7IN</sub> = 5.5 V  | —    | —   | 5.0                | ns   |
| ΔV <sub>SW7</sub>     | Output ripple<br>Output cap ESR ~ 10 mΩ, 2 × 22 μF  | -1.0 | —   | 1.0                | %    |
| V <sub>SW7LOTR</sub>  | Transient load regulation (overshoot/undershoot)<br>Transient load = 200 mA to 1.0 A step<br>di/dt = 2.0 A/ms<br>C <sub>out</sub> = 20 μF effective<br>V <sub>SW7FB</sub> = 1.8 V | -50  | —   | 50                 | mV   |
| I <sub>RCS</sub>      | DCM (skip mode) reverse current sense threshold   | —    | 10  | —                  | mA   |
| I <sub>SW7Q</sub>     | Quiescent current<br>PFM mode   | —    | 18  | —                  | μA   |
| I <sub>SW7Q</sub>     | Quiescent current<br>Auto skip mode   | —    | 150 | 250                | μA   |
| R <sub>ONSW7HS</sub>  | SW7 high-side P-MOSFET R <sub>DS(on)</sub>  | —    | —   | 135 <sup>[2]</sup> | mΩ   |
| R <sub>ONSW7LS</sub>  | SW7 low-side N-MOSFET R <sub>DS(on)</sub>   | —    | —   | 80 <sup>[2]</sup>  | mΩ   |
| R <sub>SW7DIS</sub>   | SW7 discharge resistance (normal operation)   | —    | 100 | 200                | Ω    |
| R <sub>SW7TBB</sub>   | SW7 discharge resistance during TBB mode<br>TBBEN = 1 and QPU_OFF state   | 1.0  | 2   | —                  | kΩ   |

[1] V<sub>SW7IN</sub> must be connected to VIN to ensure proper operation.

[2] Max R<sub>DS(on)</sub> does not include bondwire resistance. Consider +50 % tolerance to account for bondwire and pin losses.

Table 58. Recommended external components

| Symbol           | Parameter   | Min  | Typ | Max | Unit |
|------------------|---|------|-----|-----|------|
| L                | Output inductor<br>Maximum inductor DC resistance 50 mΩ [1]<br>Minimum saturation current at full load: 3.0 A | 0.47 | 1.0 | 1.5 | μH   |
| C <sub>out</sub> | Output capacitor<br>Use 2 x 22 μF, 6.3 V X7T ceramic capacitor to reduce output capacitance ESR               | —    | 44  | —   | μF   |
| C <sub>in</sub>  | Input capacitor<br>4.7 μF, 10 V X7R ceramic capacitor   | —    | 4.7 | —   | μF   |

[1] Keep inductor DCR as low as possible to improve regulator efficiency.

### 15.6 Linear regulators

The PF8121 has four low drop-out (LDO) regulators with the following features:

- 400 mA current capability
- Input voltage range from 2.5 V to 5.5 V
- Programmable output voltage between 1.5 V and 5.0 V
- Soft-start ramp control during power up (enable)
- Discharge mechanism during power down (disable)
- OTP programmable Load switch mode

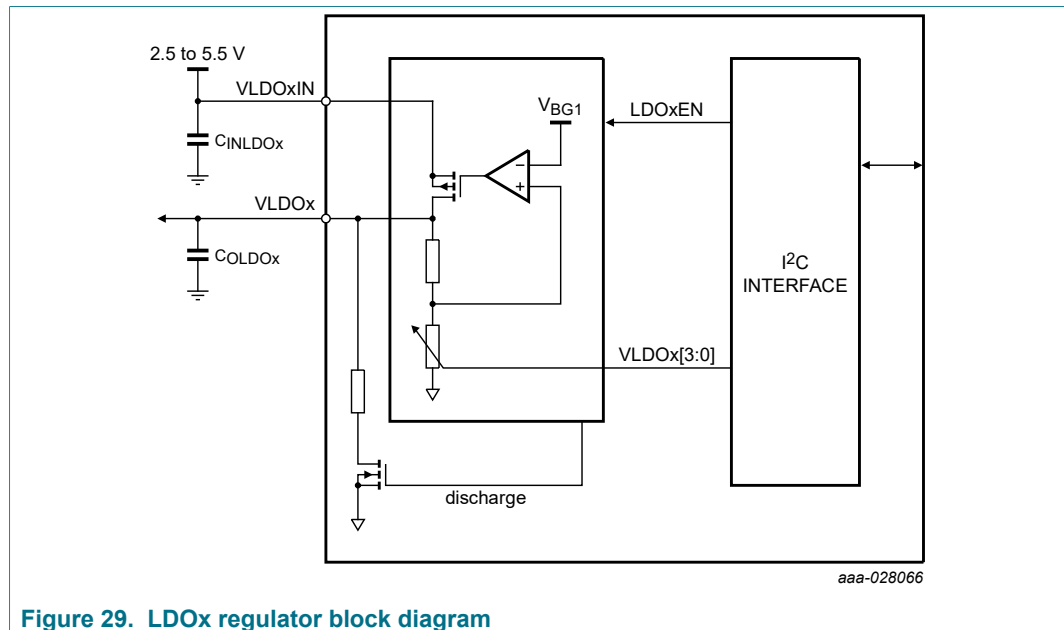


Figure 29. LDOx regulator block diagram

LDO1 and LDO2 share the same input supply; LDO12IN while LDO3 and LDO4 have their own dedicated input supply pin, LDO3IN and LDO4IN respectively.

The four LDOs are provided with one bit to enable or disable its output during the system-on states.

- When LDOx\_RUN\_EN = 0, the LDO is disabled during the run mode. If the regulator is part of the power up sequence, this bit is set during the power up sequence. Otherwise it is defaulted to 0.

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- When LDOx\_STBY\_EN = 0, the LDO is disabled during the standby mode. If the regulator is part of the power up sequence, this bit is set during the power up sequence. Otherwise it is defaulted to 0.

The mode of operation of the LDOx is selected on OTP via the OTP\_LDOxLS bit.

Table 59. LDO operation description

| LDOx_RUN_EN / LDOx_STBY_EN | OTP_LDOxLS | LDO operation mode (Run or standby mode) |
|----------------------------|------------|--|
| 0                          | X          | Disabled with output pull down active    |
| 1                          | 0          | Enabled in normal mode                   |
| 1                          | 1          | Enabled in load switch configuration     |

The LDOs use four bits to set the output voltage.

- The VLDOx\_RUN[3:0] sets the output voltage during the run mode.
- The VLDOx\_STBY[3:0] sets the output voltage during standby mode.

The default output voltage configuration for the run and the standby mode is loaded from the OTP\_VLDOx[3:0] registers on power up.

Table 60. LDO output voltage configuration

| Set point | VLDOx_RUN[3:0]<br>VLDOx_STBY[3 :0] | VLDOx output (V) |
|-----------|------------------------------------|------------------|
| 0         | 0000                               | 1.5              |
| 1         | 0001                               | 1.6              |
| 2         | 0010                               | 1.8              |
| 3         | 0011                               | 1.85             |
| 4         | 0100                               | 2.15             |
| 5         | 0101                               | 2.5              |
| 6         | 0110                               | 2.8              |
| 7         | 0111                               | 3.0              |
| 8         | 1000                               | 3.1              |
| 9         | 1001                               | 3.15             |
| 10        | 1010                               | 3.2              |
| 11        | 1011                               | 3.3              |
| 12        | 1100                               | 3.35             |
| 13        | 1101                               | 1.65             |
| 14        | 1110                               | 1.7              |
| 15        | 1111                               | 5.0              |

LDO2 can be controlled by hardware using the VSELECT and LDO2EN pins. When controlling the LDO2 by hardware, the output voltage can be selectable by the VSELECT pin as well as enable/disable by the LDO2EN pin.

### 15.6.1 LDO load switch operation

When the OTP\_LDOxLS bit is set to 1, the corresponding LDO operates as a load switch, allowing a pass-through from the LDOxVIN to the corresponding LDOxVOUT output through a maximum 130 mΩ resistance. In this mode of operation, the input must be kept inside the LDO operating input voltage range (2.5 V to 5.5 V)

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When the LDO regulator is set in Load switch mode, the LDOxEN bit is used to enable or disable the switch.

## 15.6.2 LDO regulator electrical characteristics

Table 61. LDO regulator electrical characteristics

All parameters are specified at  $T_A = -40$  to  $85$  °C,  $V_{LDOxIN} = 2.5$  V to  $5.5$  V,  $V_{LDOx} = 1.8$  V,  $I_{LDOx} = 100$  mA, typical external component values, unless otherwise noted. Typical values are characterized at  $V_{LDOxIN} = 5.5$  V,  $V_{LDOx} = 1.8$  V,  $I_{LDOx} = 100$  mA, and  $T_A = 25$  °C, unless otherwise noted.

| Symbol         | Parameter   | Min                  | Typ | Max                | Units |
|----------------|---|----------------------|-----|--------------------|-------|
| $V_{LDOxIN}$   | LDOx operating input voltage range<br>$1.5 \text{ V} \leq V_{LDOx} < 2.25 \text{ V}$  | 2.5                  | —   | 5.5                | V     |
| $V_{LDOxIN}$   | LDOx operating input voltage range<br>$2.25 \text{ V} < V_{LDOx} < 5.0 \text{ V}$   | $V_{LDOxNOM} + 0.25$ | —   | 5.5                | V     |
| $I_{LDOx}$     | Maximum load current  | 400                  | —   | —                  | mA    |
| $V_{LDOxTOL}$  | Output voltage tolerance<br>$1.5 \text{ V} \leq V_{LDOx} \leq 5.0 \text{ V}$<br>$0 \text{ mA} < I_{LDOx} \leq 400 \text{ mA}$   | -3.0                 | —   | 3.0                | %     |
| $V_{LDOxLOR}$  | Load regulation   | —                    | 0.1 | 0.20               | mV/mA |
| $V_{LDOxLIR}$  | Line regulation   | —                    | —   | 20                 | mV/mA |
| $I_{LDOxLIM}$  | Current limit<br>$I_{LDOx}$ when VLDOx is forced to $V_{LDOxNOM}/2$   | 450                  | 850 | 1400               | mA    |
| $I_{LDOxQ}$    | Quiescent current (measured at $T_A = 25$ °C)   | —                    | 7.0 | 10                 | µA    |
| $R_{DS(on)}$   | Drop-out/load switch on resistance<br>$V_{LDOxINx} = 3.3 \text{ V}$ (at $T_J = 125$ °C)   | —                    | —   | 150 <sup>[1]</sup> | mΩ    |
| $PSRR_{VLDOx}$ | DC PSRR<br>$I_{LDOx} = 150 \text{ mA}$<br>$VLDOx[3:0] = 0000$ to $1111$<br>$V_{LDOxINx} = V_{LDOxINMIN}$  | 48                   | —   | —                  | dB    |
| $TR_{VLDOx}$   | Turn on rise time (soft-start ramp)<br>10 % to 90 % of end value<br>$V_{LDOx} = 3.3 \text{ V}$<br>$I_{LDOx} = 0.0 \text{ mA}$   | —                    | 220 | 360                | µs    |
| $t_{ONLDOx}$   | Turn on time<br>Enable to 90 % of end value<br>$V_{LDOx} = 5.0 \text{ V}$<br>$I_{LDOx} = 0.0 \text{ mA}$  | —                    | —   | 400                | µs    |
| $t_{OFFLDOx}$  | Turn off time<br>Disable to 10 % of initial value<br>$V_{LDOx} = 5.0 \text{ V}$<br>$I_{LDOx} = 0.0 \text{ mA}$  | —                    | —   | 3500               | µs    |
| $V_{LDOxOSHT}$ | Startup overshoot<br>$V_{LDOxINx} = V_{LDOxINxMIN}$<br>$V_{LDOx} = 5.0 \text{ V}$<br>$I_{LDOx} = 0.0 \text{ mA}$  | —                    | 1.0 | 2.0                | %     |
| $V_{LDOxLOTR}$ | Transient load response<br>$I_{LDOx} = 10 \text{ mA}$ to $200 \text{ mA}$ in $2.0 \mu\text{s}$<br>Peak of overshoot or undershoot of LDOx with respect to final value | -6.0                 | —   | 6.0                | %     |
| $T_{onLDOxLS}$ | Load switch mode turn on rise time  | —                    | 150 | 300                | µs    |

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| Symbol                 | Parameter   | Min | Typ | Max  | Units      |
|------------------------|---|-----|-----|------|------------|
| $R_{\text{dischLDOx}}$ | Output discharge resistance when LDO is disabled<br>LDO and Switch mode   | 50  | 100 | 300  | $\Omega$   |
| $I_{\text{LSxLIM}}$    | Load switch mode current limit when enabled<br>LSxLIM_EN = 1              | 450 | 850 | 1400 | mA         |
| $R_{\text{LDOxTBB}}$   | LDOx pull down resistance during TBB mode<br>TBBEN = 1 & in QPU_OFF state | 1.0 | 2.0 | —    | k $\Omega$ |

[1] Max  $R_{\text{DS(on)}}$  does not include bondwire resistance. Consider 40 % tolerance to account for bondwire and pin losses.

## 15.7 Voltage monitoring

### 15.7.1 OV/UV configuration

The PF8121 provides OV and UV monitoring capability for the following voltage regulators:

- SW1 to SW7
- LDO1 to LDO4

A programmable UV threshold is selected via the OTP\_SWxUV\_TH[1:0] and OTP\_LDOxUV\_TH[1:0] bits. UV threshold selection represents a percentage of the nominal voltage programmed on each regulator.

**Table 62. UV threshold configuration register**

| OTP_SWxUV_TH[1:0]<br>OTP_LDOxUV_TH[1:0] | UV threshold level |
|---|--------------------|
| 00                                      | 95 %               |
| 01                                      | 93 %               |
| 10                                      | 91 %               |
| 11                                      | 89 %               |

A programmable OV threshold is selected via the OTP\_SWxOV\_TH[1:0] and OTP\_LDOxOV\_TH[1:0] bits. OV threshold selection represents a percentage of the nominal voltage programmed on each regulator.

**Table 63. OV threshold configuration register**

| OTP_SWxOV_TH<br>OTP_LDOxOV_TH | OV threshold level |
|-------------------------------|--------------------|
| 00                            | 105 %              |
| 01                            | 107 %              |
| 10                            | 109 %              |
| 11                            | 111 %              |

Two functional bits are provided to program the UV debounce time for all the voltage regulators.

**Table 64. UV debounce timer configuration**

| UV_DB[1:0] | UV debounce Time |
|------------|------------------|
| 00         | 5 $\mu\text{s}$  |
| 01         | 15 $\mu\text{s}$ |

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| UV_DB[1:0] | OV debounce Time |
|------------|------------------|
| 10         | 25 $\mu$ s       |
| 11         | 40 $\mu$ s       |

The default value of the UV\_DB[1:0] upon a full register reset is 0b10

Two functional bits to program the OV debounce time for all the voltage regulators.

**Table 65. OV debounce timer configuration**

| OV_DB[1:0] | OV debounce Time |
|------------|------------------|
| 00         | 25 $\mu$ s       |
| 01         | 50 $\mu$ s       |
| 10         | 80 $\mu$ s       |
| 11         | 125 $\mu$ s      |

The default value of the OV\_DB[1:0] upon a full register reset is 0b00

The VMON\_EN bits enable or disable the OV/UV monitor for each one of the external regulators (SWxVMON\_EN, LDOxVMON\_EN).

- When the VMON\_EN bit of a specific regulator is 1, the voltage monitor for that specific regulator is enabled.
- When the VMON\_EN bit of a specific regulator is 0, the voltage monitor for that specific regulator is disabled.

By default, the VMON\_EN bits are set to 1 on power up.

When the I2C\_SECURE\_EN = 1, a secure write must be performed to set or clear the VMON\_EN bits to enable or disable the voltage monitoring for a specific regulator.

On enabling a regulator, the UV/OV monitor is masked until the corresponding regulator reaches the point of regulation. If a voltage monitor is disabled, the UV\_S and OV\_S indicators from that monitor are reset to 0.

### 15.7.2 Output voltage monitoring with dedicated bandgap reference

For the type 2 buck regulator and LDOs, the OV/UV monitors operate from a dedicated bandgap reference for voltage monitoring.

For the type 1 buck regulators, the OV/UV monitor operate from the same reference as the regulator. To ensure the integrity of the type 1 buck regulators, a comparison between the regulator bandgap and the monitoring bandgap is performed. A 4 % to 12 % difference between the two bandgaps is an indicator of a potential regulation or monitoring fault and is considered as a critical issue. Therefore, the device prevents the switching regulators from powering up.

If a drift between the two bandgaps is detected during system-on states:

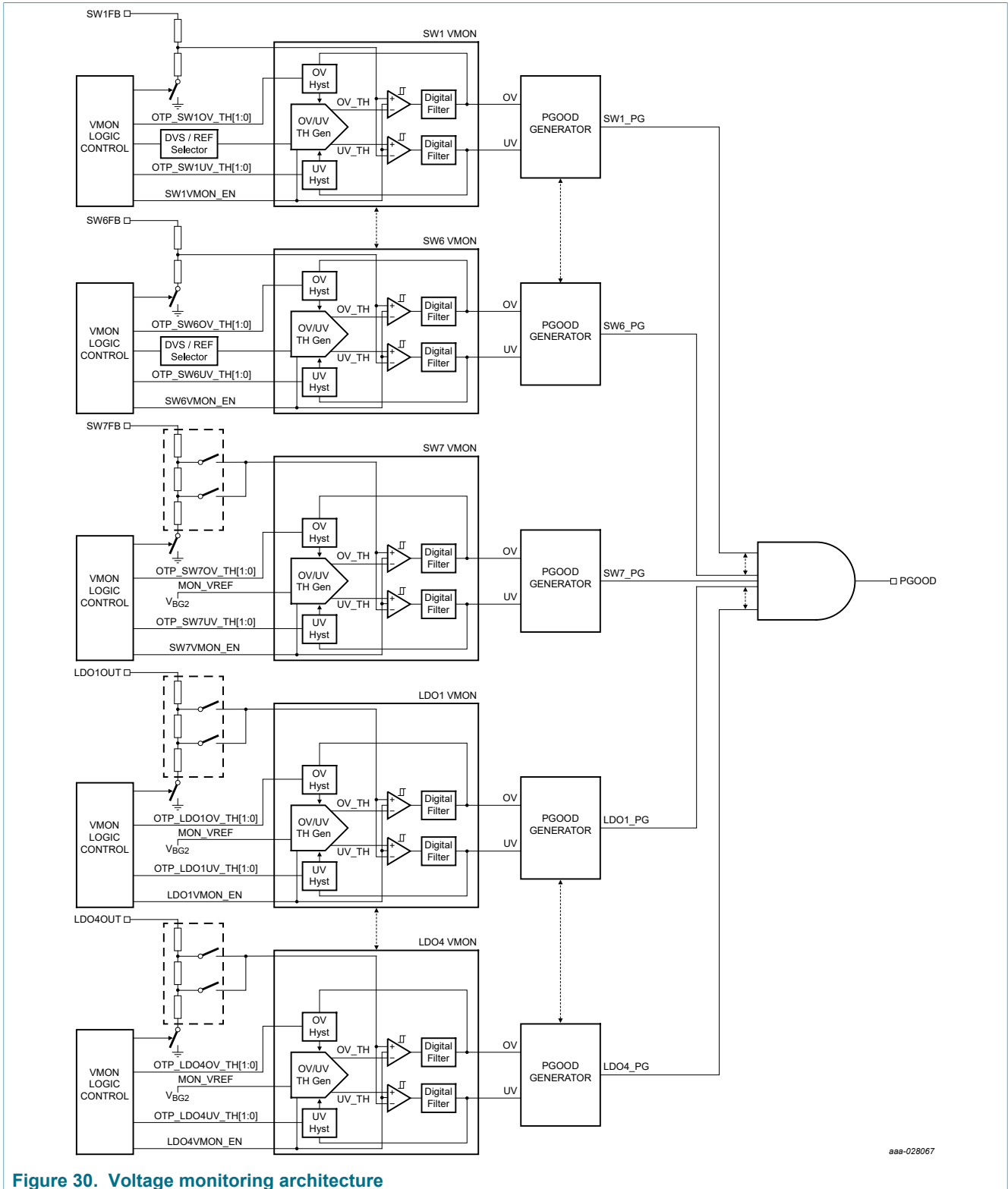
- with OTP\_BGMON\_BYPASS = 0, the power stage of the voltage regulators will be shutdown
- with OTP\_BGMON\_BYPASS = 1, the bandgap monitor only sends an interrupt to the system to announce the bandgap failure

The BGMON\_I is asserted when a bandgap failure occurs, provided it is not masked.

The BGMON\_S bit is set to 0 when the bandgaps are within range, and set to 1 when the bandgaps are out of range.



Figure 30 shows the PF8121 voltage monitoring architecture.



15.7.3 Electrical characteristics

Table 66. VMON Electrical characteristics

All parameters are specified at  $T_A = -40\text{ }^\circ\text{C}$  to  $85\text{ }^\circ\text{C}$ , unless otherwise noted. Typical values are characterized at  $V_{IN} = 5.0\text{ V}$ ,  $V_{xFB} = 1.5\text{ V}$  (Type 1 Buck Regulator),  $3.3\text{ V}$  (Type 2 Buck regulator, LDO Regulator), and  $T_A = 25\text{ }^\circ\text{C}$ , unless otherwise noted.

| Symbol                  | Parameter   | Min | Typ | Max | Unit          |
|-------------------------|---|-----|-----|-----|---------------|
| $I_{QON}$               | Block quiescent current, when block is enabled<br>One block per regulator   | —   | 10  | 13  | $\mu\text{A}$ |
| $I_{OFF}$               | Block leakage current when disabled   | —   | —   | 500 | nA            |
| $t_{ON\_MON}$           | Voltage monitor settling time after enabled   | —   | —   | 30  | $\mu\text{s}$ |
| $V_{xFBUVHysteresis}$   | Power good (UV) hysteresis<br>Voltage difference between UV rising and falling thresholds   | 0.5 | —   | 1.0 | %             |
| $V_{UV\_Tol}$           | Undervoltage falling threshold accuracy<br>With respect to target feedback voltage tolerance<br>For type 2 switching regulator and LDO regulator<br>For type 1 switching regulator when $V_{SWxFB} > 0.75\text{ V}$ | -2  | —   | 2   | %             |
| $V_{UV\_Tol}$           | Under voltage falling threshold accuracy<br>With respect to target feedback voltage<br>For type 1 switching regulator when $V_{SWxFB} \leq 0.75\text{ V}$   | -3  | —   | 3   | %             |
| $t_{UV\_DB}$            | Power good (UV) debounce time $UV\_DV = 00$   | 2.5 | 5.0 | 7.5 | $\mu\text{s}$ |
|                         | Power good (UV) debounce time $UV\_DV = 01$   | 10  | 15  | 20  | $\mu\text{s}$ |
|                         | Power good (UV) debounce time $UV\_DV = 10$   | 20  | 30  | 40  | $\mu\text{s}$ |
|                         | Power good (UV) debounce time $UV\_DV = 11$   | 25  | 40  | 55  | $\mu\text{s}$ |
| $V_{OV\_Tol}$           | Overvoltage rising threshold accuracy<br>With respect to target feedback voltage tolerance<br>For type 2 switching regulator and LDO regulators<br>For type 1 switching regulator when $V_{SWxFB} > 0.75\text{ V}$  | -2  | —   | 2   | %             |
| $V_{OV\_Tol}$           | Overvoltage rising threshold<br>With respect to target feedback voltage tolerance<br>For type 1 switching regulator when $V_{SWxFB} \leq 0.75\text{ V}$   | -3  | —   | 3   | %             |
| $V_{xFB OV Hysteresis}$ | Overvoltage (OV) hysteresis<br>Voltage difference between OV rising and falling thresholds  | 0.5 | —   | 1.0 | %             |
| $t_{OV\_DB}$            | Power good (OV) debounce time $OV\_DV = 00$   | 20  | 30  | 40  | $\mu\text{s}$ |
|                         | Power good (OV) debounce time $OV\_DV = 01$   | 35  | 50  | 65  | $\mu\text{s}$ |
|                         | Power good (OV) debounce time $OV\_DV = 10$   | 55  | 80  | 105 | $\mu\text{s}$ |
|                         | Power good (OV) debounce time $OV\_DV = 11$   | 90  | 135 | 160 | $\mu\text{s}$ |

15.8 Clock management

The clock management provides a top-level management control scheme of internal clock and external synchronization intended to be primarily used for the switching regulators. The clock management incorporates various sub-blocks:

- Low power 100 kHz clock
- Internal high frequency clock with programmable frequency

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- Phase Locked Loop (PLL)

A digital clock management interface is in charge of supporting interaction among these blocks.

The clock management provides clocking signals for the internal state machine, the switching frequencies for the seven buck converters as well as the multiples of those switching frequencies in order to enable phase shifting for multiple phase operation.

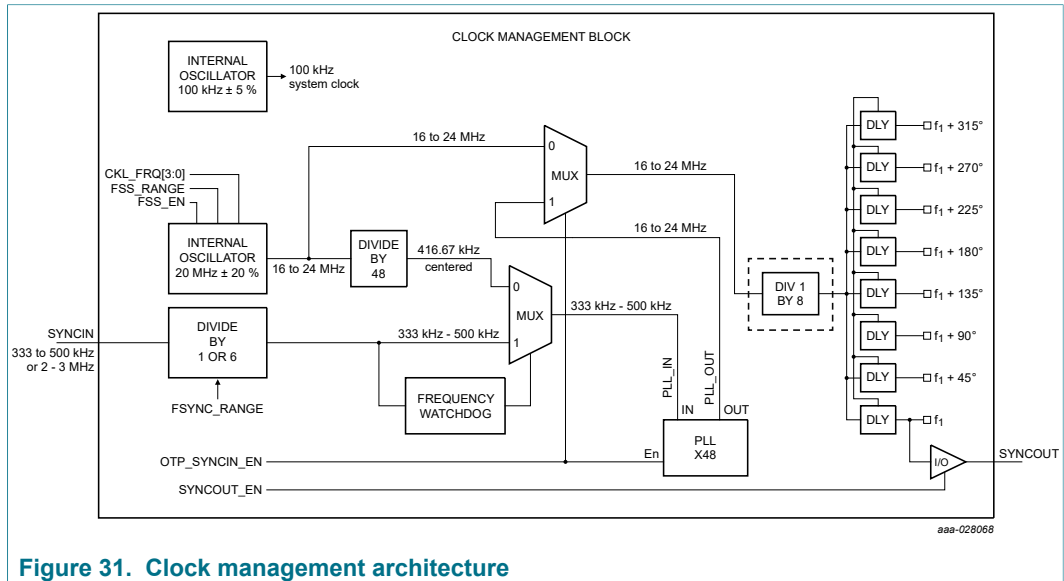


Figure 31. Clock management architecture

### 15.8.1 Low frequency clock

A low power 100 kHz clock is provided for overall logic and digital control. Internal logic and debounce timers are based on this 100 kHz clock.

### 15.8.2 High frequency clock

The PF8121 features a high frequency clock with nominal frequency of 20 MHz. Clock frequency is programmable over a range of  $\pm 20\%$  via the CLK\_FREQ[3:0] control bits.

### 15.8.3 Manual frequency tuning

The PF8121 features a manual frequency tuning to set the switching frequency of the high frequency clock. The CLK\_FREQ [3:0] bits allow a manual frequency tuning of the high frequency clock from 16 MHz to 24 MHz.

If a frequency change of two or more steps is requested by a single I<sup>2</sup>C command, the device performs a gradual frequency change passing through all steps in between with a 5.2  $\mu$ s time between each frequency step. When the frequency reaches the programmed value, the FREQ\_RDY\_I asserts the INTB pin, provided it is not masked.

When the internal clock is used as the main frequency for the power generation, an internal frequency divider by 8 is used to generate the switching frequency for all the buck regulators. Adjusting the frequency of the high frequency clock allows for manual tuning of the switching frequencies for the buck regulators from 2.0 MHz to 3.0 MHz.

**Table 67. Manual frequency tuning configuration**

| CLK_FREQ[3:0] | High speed clock frequency (MHz) | Switching regulators frequency (MHz) |
|---------------|----------------------------------|--------------------------------------|
| 0000          | 20                               | 2.500                                |
| 0001          | 21                               | 2.625                                |
| 0010          | 22                               | 2.750                                |
| 0011          | 23                               | 2.875                                |
| 0100          | 24                               | 3.000                                |
| 0101          | Not used                         | Not used                             |
| 0110          | Not used                         | Not used                             |
| 0111          | Not used                         | Not used                             |
| 1000          | Not used                         | Not used                             |
| 1001          | 16                               | 2.000                                |
| 1010          | 17                               | 2.125                                |
| 1011          | 18                               | 2.250                                |
| 1100          | 19                               | 2.375                                |
| 1101          | Not used                         | Not used                             |
| 1110          | Not used                         | Not used                             |
| 1111          | Not used                         | Not used                             |

The default switching frequency is set by the OTP\_CLK\_FREQ[3:0] bits.

Manual tuning cannot be applied when frequency spread-spectrum or external clock synchronization is used. However, during external clock synchronization, it is recommended to program the CLK\_FREQ[3:0] bits to match the external frequency as close as possible.

### 15.8.4 Spread-spectrum

The internal clock provides a programmable frequency spread spectrum with two ranges for narrow spread and wide spread to help manage EMC in the automotive applications.

- When the FSS\_EN = 1, the frequency spread-spectrum is enabled.
- When the FSS\_EN = 0, the frequency spread-spectrum is disabled.

The default state of the FSS\_EN bit upon a power up can be configured via the OTP\_FSS\_EN bit.

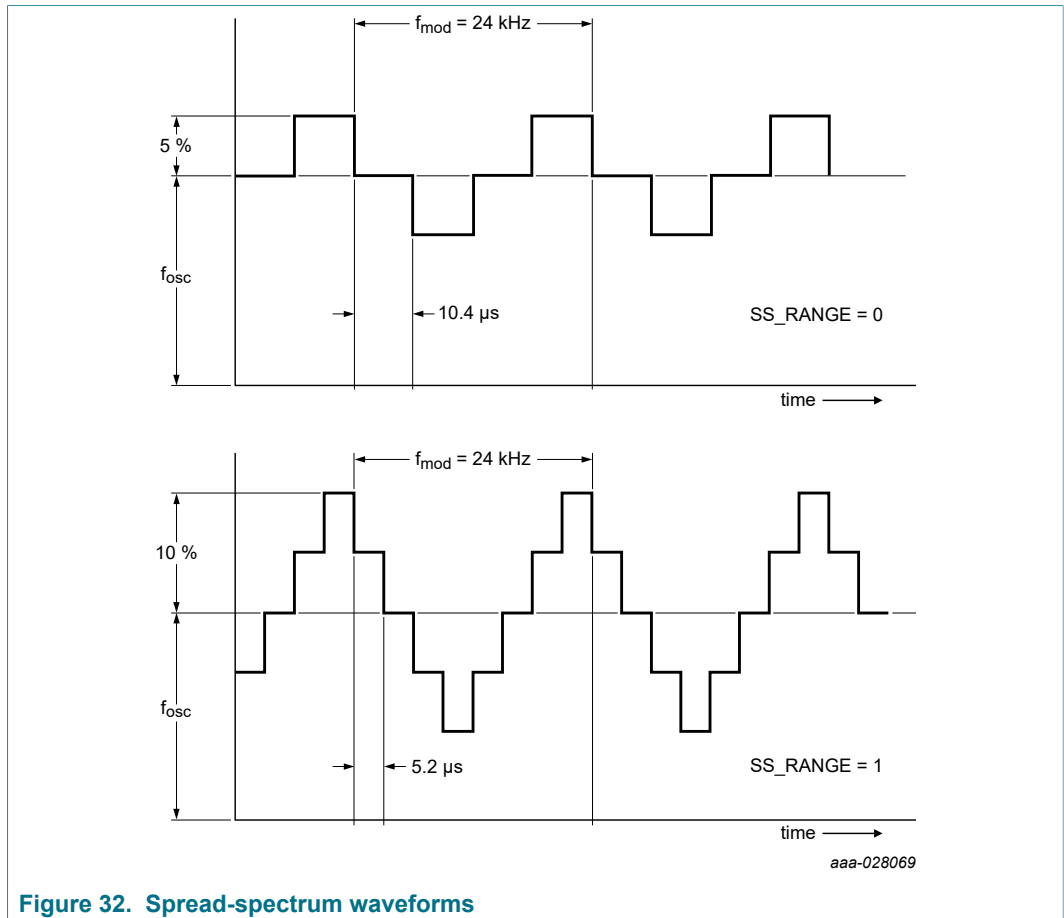
The FSS\_RANGE bit is provided to select the clock frequency range.

- When FSS\_RANGE = 0, the maximum clock frequency range is  $\pm 5\%$ .
- When FSS\_RANGE = 1, the maximum clock frequency range is  $\pm 10\%$ .

The default value of the FSS\_RANGE bit upon a power up can be configured via the OTP\_FSS\_RANGE bit.

The frequency spread-spectrum is performed at a 24 kHz modulation frequency when the internal high frequency clock is used to generate the switching frequency for the switching regulators. When the external clock synchronization is enabled, the spread-spectrum is disabled.

[Figure 32](#) shows implementation of spread-spectrum for the two settings.



If the frequency spread-spectrum is enabled, the switching regulators should be set in PWM mode to ensure clock synchronization at all time.

If the external clock synchronization is enabled, (SYNCIN\_EN = 1), the spread spectrum is disabled regardless of the value of the FSS\_EN bit.

### 15.8.5 Clock Synchronization

An external clock can be fed via the SYNCIN pin to synchronize the switching regulators to this external clock.

When the OTP\_SYNCIN\_EN = 0, the external clock synchronization is disabled. In this case, the PLL is disabled, and the device always uses the internal high frequency clock to generate the main frequency for the switching regulators.

When the OTP\_SYNCIN\_EN = 1, the external clock synchronization is enabled. In this case, the internal PLL is always enabled and it uses either the internal high frequency clock or the SYNCIN pin as its source to generate the main frequency for the switching regulators.

If the SYNCIN function is not used, the pin should be grounded. If the external clock is meant to start up after the PMIC has started, the SYNCIN pin must be maintained low until the external clock is applied.

The SYNCIN pin is prepared to detect clock signals with a 1.8 V or 3.3 V amplitude and within the frequency range set by the FSYNC\_RANGE bit.

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- When the FSYNC\_RANGE = 0, the input frequency range at SYNCIN pin should be between 2000 kHz and 3000 kHz.
- When the FSYNC\_RANGE = 1, the input frequency range at SYNCIN pin should be between 333 kHz and 500 kHz.

The OTP\_FSYNC\_RANGE bit is used to select the default frequency range accepted in the SYNCIN pin.

The external clock duty cycle at the SYNCIN pin should be between 40 % and 60 %. An input frequency in the SYNCIN pin outside the range defined by the FSYNC\_RANGE bit is detected as invalid. If the external clock is not present or invalid, the device automatically switches to the internal clock and sets the FSYNC\_FLT\_I interrupt, which in turn asserts the INTB pin provided it is not masked.

The FSYNC\_FLT\_S bit is set to 1 as long as the input frequency is not present or invalid, and it is cleared to 0 when the SYNCIN has a valid input frequency.

The device switches back to the external switching frequency only when both, the FSYNC\_FLT\_I interrupt has been cleared and the SYNCIN pin sees a valid frequency.

When the external clock is selected, the switching regulators should be set in PWM mode to ensure clock synchronization at all time.

The SYNCOUT pin is used to synchronize an external device to the PF8121.

The SYNCOUT pin outputs the main frequency used for the switching regulators in the range of 2.0 MHz to 3.0 MHz. The SYNCOUT\_EN bit can be used to enable or disable the SYNCOUT feature via I<sup>2</sup>C during the system-on states.

- When SYNCOUT\_EN = 0, the SYNCOUT feature is disabled and the pin is internally pulled to ground.
- When SYNCOUT\_EN = 1, the SYNCOUT pin toggles at the base frequency used by the switching regulators.

The SYNCOUT function can be enabled or disabled by default by using the OTP\_SYNCOUT\_EN bit.

**Table 68. Clock management specifications**

All parameters are specified at T<sub>A</sub> = -40 to 85 °C, unless otherwise noted. Typical values are characterized at V<sub>IN</sub> = 5.0 V and T<sub>A</sub> = 25 °C, unless otherwise noted.

| Symbol                      | Parameter  | Min  | Typ  | Max | Unit |
|-----------------------------|--|------|------|-----|------|
| <b>Low frequency clock</b>  |  |      |      |     |      |
| I <sub>Q100KHz</sub>        | 100 kHz clock quiescent current  | —    | —    | 3.0 | µA   |
| f <sub>100KHzACC</sub>      | 100 kHz clock accuracy   | -5.0 | —    | 5.0 | %    |
| <b>High frequency clock</b> |  |      |      |     |      |
| f <sub>20MHz</sub>          | High frequency clock nominal frequency<br>via CLK_FREQ[3:0] = 0000   | —    | 20   | —   | MHz  |
| f <sub>20mzACC</sub>        | High frequency clock accuracy  | -6.0 | —    | 6.0 | %    |
| t <sub>20MHzStep</sub>      | Clock step transition time<br>Minimum time to transition from one frequency<br>step to the next in manual tuning mode      | —    | 5.2  | —   | µs   |
| FSS <sub>RANGE</sub>        | Spread-spectrum range<br>FSS_RANGE= 0<br>via CLK_FREQ[3:0]<br>Spread-spectrum is done around center frequency<br>of 20 MHz | —    | ±5.0 | —   | %    |

| Symbol                       | Parameter   | Min         | Typ | Max       | Unit |
|------------------------------|---|-------------|-----|-----------|------|
| FSS <sub>RANGE</sub>         | Spread-spectrum range<br>FSS_RANGE= 1<br>via CLK_FREQ[3:0]<br>Spread-spectrum is done around center frequency of 20 MHz | —           | ±10 | —         | %    |
| FSS <sub>mod</sub>           | Spread spectrum frequency modulation  | —           | 24  | —         | kHz  |
| <b>Clock synchronization</b> |   |             |     |           |      |
| f <sub>SYNCIN</sub>          | SYNCIN input frequency range<br>FSYNC_RANGE = 0   | 2000        | —   | 3000      | kHz  |
| f <sub>SYNCIN</sub>          | SYNCIN input frequency range<br>FSYNC_RANGE = 1   | 333         | —   | 500       | kHz  |
| f <sub>SYNCOUT</sub>         | SYNCOUT output frequency range<br>via CLK_FREQ[3:0]   | 2000        | —   | 3000      | kHz  |
| V <sub>SYNCINLO</sub>        | Input frequency low voltage threshold   | —           | —   | 0.3*VDDIO | V    |
| V <sub>SYNCINHI</sub>        | Input frequency high voltage threshold  | 0.7*VDDIO   | —   | —         | V    |
| R <sub>PD_SYNCIN</sub>       | SYNCIN internal pull down resistance  | 0.475       | 1.0 | —         | MΩ   |
| V <sub>SYNCOUTLO</sub>       | Output frequency low voltage threshold  | 0           | —   | 0.4       | V    |
| V <sub>SYNCOUTH</sub>        | Output frequency high voltage threshold   | VDDIO – 0.5 | —   | —         | V    |

### 15.9 Thermal monitors

The PF8121 features ten temperature sensors spread around the die. These sensors are located at the following locations:

|                    |                        |
|--------------------|------------------------|
| 1. Center of die   | 6. Vicinity of SW5     |
| 2. Vicinity of SW1 | 7. Vicinity of SW6     |
| 3. Vicinity of SW2 | 8. Vicinity of SW7     |
| 4. Vicinity of SW3 | 9. Vicinity of LDO1-2  |
| 5. Vicinity of SW4 | 10. Vicinity of LDO3-4 |

The temperature sensor at the center of the die is used to generate the thermal interrupts and thermal shutdown.

The output of all temperature sensors are internally connected to the Analog MUX, allowing the user to read the raw voltage equivalent to the temperature on each sensor. The processor can read outputs of the other temperature sensors and take appropriate action (such as reduce loading, or turning off regulator) if the temperature exceeds desired limits at any point in the die.

[Figure 33](#) shows a high level block diagram of the thermal monitoring architecture in PF8121.

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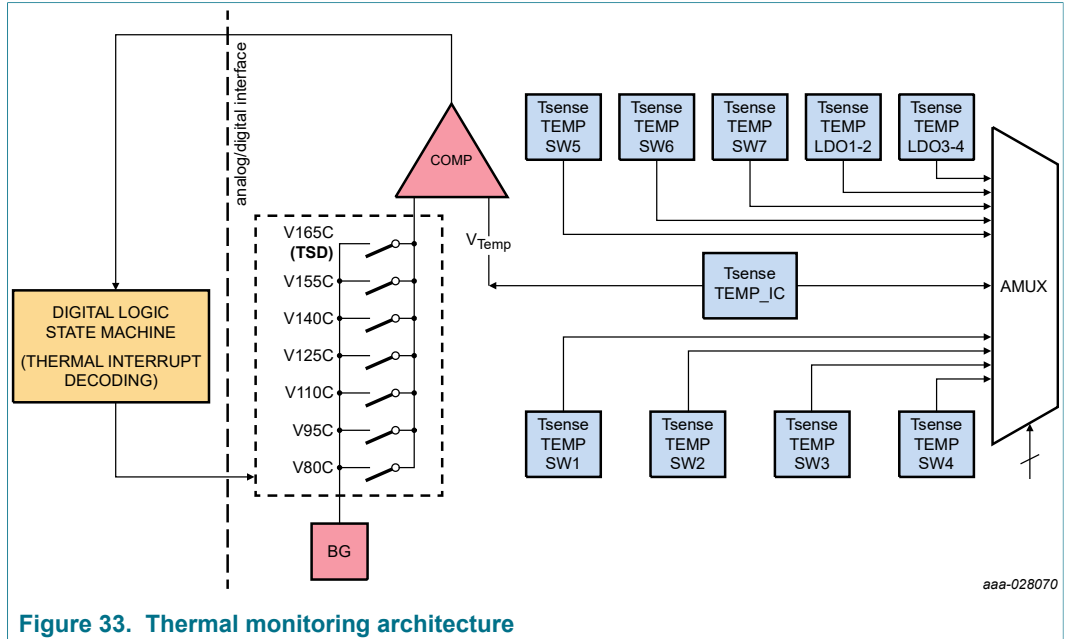


Figure 33. Thermal monitoring architecture

Table 69. Thermal monitor specifications

| Symbol                 | Parameter <sup>[1]</sup>                                     | Min   | Typ   | Max | Unit  |
|------------------------|--|-------|-------|-----|-------|
| V <sub>IN</sub>        | Operating voltage range of thermal circuit                   | UVDET | —     | 5.5 | V     |
| TCOF                   | Thermal sensor coefficient                                   | —     | -3.5  | —   | mV/°C |
| V <sub>TSROOM</sub>    | Thermal sensor voltage<br>24 °C                              | —     | 1.414 | —   | V     |
| T <sub>SEN_RANGE</sub> | Thermal sensor temperature range                             | -40   | —     | 175 | °C    |
| V <sub>TEMP_MAX</sub>  | Thermal sensor output voltage range                          | 0     | —     | 1.8 | V     |
| T <sub>80C</sub>       | 80 °C temperature threshold                                  | 70    | 80    | 90  | °C    |
| T <sub>95C</sub>       | 95 °C temperature threshold                                  | 85    | 95    | 105 | °C    |
| T <sub>110C</sub>      | 110 °C temperature threshold                                 | 100   | 110   | 120 | °C    |
| T <sub>125C</sub>      | 125 °C temperature threshold                                 | 115   | 125   | 135 | °C    |
| T <sub>140C</sub>      | 140 °C temperature threshold                                 | 130   | 140   | 150 | °C    |
| T <sub>155C</sub>      | 155 °C temperature threshold                                 | 145   | 155   | 165 | °C    |
| T <sub>SD</sub>        | Thermal shutdown threshold                                   | 155   | 165   | 175 | °C    |
| T <sub>WARN_HYS</sub>  | Thermal threshold hysteresis                                 | —     | 5.0   | —   | °C    |
| T <sub>SD_HYS</sub>    | Thermal shutdown hysteresis                                  | —     | 10    | —   | °C    |
| t <sub>temp_db</sub>   | Debounce timer for temperature thresholds<br>(bidirectional) | —     | 10    | —   | µs    |
| t <sub>interval</sub>  | Sampling interval time<br>When TMP_MON_AON = 1               | —     | 3.0   | —   | ms    |
| t <sub>window</sub>    | Sampling window<br>When TMP_MON_AON = 1                      | —     | 450   | —   | µs    |

[1] Sensor temperature is calculated with the following formula:  $T [°C] = (V_{TSENSE} - 1.498 V) / TCOF$ , where  $V_{TSENSE}$  is the thermal sensor voltage measured on the corresponding AMUX channel.



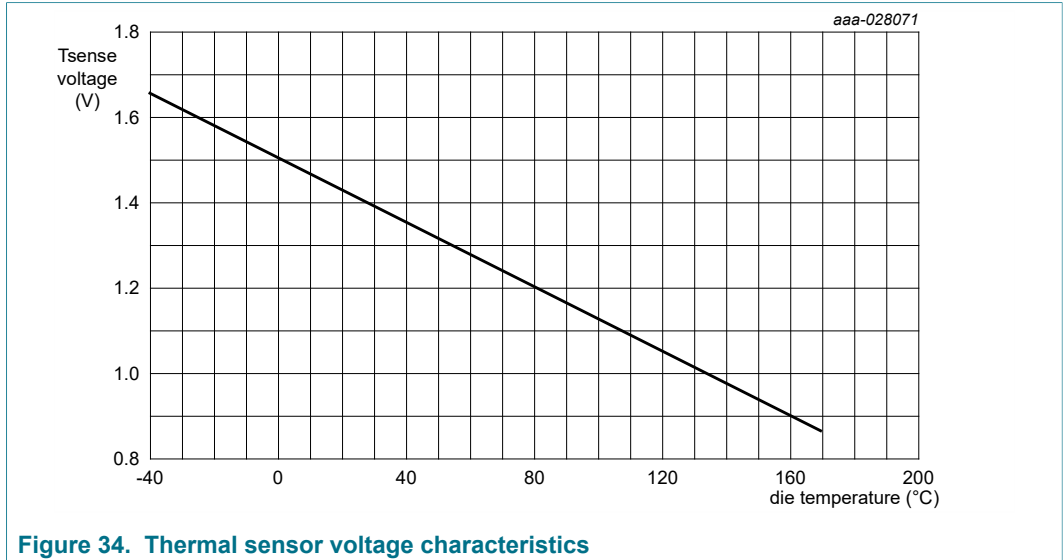


Figure 34. Thermal sensor voltage characteristics

As the temperature crosses the thermal thresholds, the corresponding interrupts are set to notify the system. The processor may take appropriate action to bring down the temperature (either by turning off external regulators, reducing load, or turning on a fan).

A 5 °C hysteresis is implemented on a falling temperature in order to release the corresponding THERM\_x\_S signal. When the shutdown threshold is crossed, the PF8121 initiates a thermal shutdown and it prevents from turning back on until the 15 °C thermal shutdown hysteresis is crossed as the device cools down.

The temperature monitor can be enabled or disabled via I<sup>2</sup>C with the TMP\_MON\_EN bit.

- When TMP\_MON\_EN = 0, the temperature monitor circuit is disabled.
- When TMP\_MON\_EN = 1, the temperature monitor circuit is enabled.

In the run state, the temperature sensor can operate in always on or sampling modes.

- When the TMP\_MON\_AON = 1, the device is always on during the run mode.
- When the TMP\_MON\_AON = 0, the device operates in sampling mode to reduce current consumption in the system. In sampling mode, the thermal monitor is turned on during 450 µs at a 3.0 ms sampling interval.

In the standby mode, the thermal monitor operates only in sampling mode as long as the TMP\_MON\_EN = 1

Table 70. Thermal monitor bit description

| Bit(s)                                | Description   |
|---------------------------------------|---|
| THERM_80_I, THERM_80_S, THERM_80_M    | Interrupt, sense and mask bits for 80 °C threshold    |
| THERM_95_I, THERM_95_S, THERM_95_M    | Interrupt, sense and mask bits for 95 °C threshold    |
| THERM_110_I, THERM_110_S, THERM_110_M | Interrupt, sense and mask bits for 110 °C threshold   |
| THERM_125_I, THERM_125_S, THERM_125_M | Interrupt, sense and mask bits for 125 °C threshold   |
| THERM_140_I, THERM_140_S, THERM_140_M | Interrupt, sense and mask bits for 140 °C threshold   |
| THERM_155_I, THERM_155_S, THERM_155_M | Interrupt, sense and mask bits for 155 °C threshold   |
| TMP_MON_EN                            | Disables temperature monitoring circuits when cleared |

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| Bit(s)      | Description  |
|-------------|--|
| TMP_MON_AON | When set, the temperature monitoring circuit is always ON.<br>When cleared, the temperature monitor operates in sampling mode. |

### 15.10 Analog multiplexer

A 24 channel Analog Multiplexer (AMUX) is provided to allow access to various internal voltages within the PMIC. The selected voltage is buffered and made available on the AMUX output pin during the system-on states.

When the AMUX\_EN bit is 0, the AMUX block is disabled and the output remains pulled down to ground.

When the AMUX\_EN bit is 1, the AMUX block is enabled and the system may select the channel to be read by using the AMUX\_SEL[4:0] bits.

**Table 71. AMUX channel selection**

| AMUX_EN | AMUX_SEL[4:0] | AMUX selection                              | Internal signal dividing ratio                 |
|---------|---------------|---|--|
| 0       | X XXXX        | AMUX disabled and pin pulled-down to ground | N/A  |
| 1       | 0 0000        | AMUX disabled in high impedance mode        | N/A  |
| 1       | 0 0001        | VIN   | 4  |
| 1       | 0 0010        | VSNVS                                       | 3.5  |
| 1       | 0 0011        | LICELL                                      | 3  |
| 1       | 0 0100        | SW1_FB                                      | 1.25 (1.8 V setting)<br>1 (all other settings) |
| 1       | 0 0101        | SW2_FB                                      | 1.25 (1.8 V setting)<br>1 (All other settings) |
| 1       | 0 0110        | SW3_FB                                      | 1.25 (1.8 V setting)<br>1 (all other settings) |
| 1       | 0 0111        | SW4_FB                                      | 1.25 (1.8 V setting)<br>1 (all other settings) |
| 1       | 0 1000        | SW5_FB                                      | 1.25 (1.8 V setting)<br>1 (all other settings) |
| 1       | 0 1001        | SW6_FB                                      | 1.25 (1.8 V setting)<br>1 (all other settings) |
| 1       | 0 1010        | SW7_FB                                      | 10/3.5 = 2.86                                  |
| 1       | 0 1011        | LDO1  | 10/3 = 3.33                                    |
| 1       | 0 1100        | LDO2  | 10/3 = 3.33                                    |
| 1       | 0 1101        | LDO3  | 10/3 = 3.33                                    |
| 1       | 0 1110        | LDO4  | 10/3 = 3.33                                    |
| 1       | 0 1111        | TEMP_IC                                     | 1  |
| 1       | 1 0000        | TEMP_SW1                                    | 1  |
| 1       | 1 0001        | TEMP_SW2                                    | 1  |
| 1       | 1 0010        | TEMP_SW3                                    | 1  |
| 1       | 1 0011        | TEMP_SW4                                    | 1  |

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| AMUX_EN | AMUX_SEL[4:0]    | AMUX selection | Internal signal dividing ratio |
|---------|------------------|----------------|--------------------------------|
| 1       | 1 0100           | TEMP_SW5       | 1                              |
| 1       | 1 0101           | TEMP_SW6       | 1                              |
| 1       | 1 0110           | TEMP_SW7       | 1                              |
| 1       | 1 0111           | TEMP_LDO1_2    | 1                              |
| 1       | 1 1000           | TEMP_LDO3_4    | 1                              |
| 1       | 1 1001 to 1 1111 | Reserved       | N/A                            |

All selectable input signals are conditioned internally to fall within an operating output range from 0.3 V to 1.65 V, However, the AMUX pin is clamped to a maximum 2.5 V.

Table 72. AMUX specifications

| Symbol                    | Parameter  | Min   | Typ  | Max   | Unit |
|---------------------------|--|-------|------|-------|------|
| V <sub>IN</sub>           | Operational voltage  | UVDET | —    | 5.5   | V    |
| I <sub>REF</sub>          | Current reference range  | 0.95  | 1.0  | 1.05  | µA   |
| V <sub>OFFSET</sub>       | AMUX output voltage offset (input to output)   | -6.25 | —    | 6.25  | mV   |
| I <sub>QAMUX</sub>        | AMUX quiescent current   | —     | 110  | —     | µA   |
| t <sub>AMUX_ON</sub>      | AMUX settling time (off to channel transition)<br>Max step size of 1.8 V; output cap 150 pF      | —     | —    | 50    | µs   |
| t <sub>AMUX_CHG</sub>     | AMUX settling time (channel to channel transition)<br>Max step size of 1.8 V; output cap 150 pF  | —     | —    | 50    | µs   |
| V <sub>CLAMP</sub>        | AMUX clamping voltage  | 1.8   | 2.5  | 3.1   | V    |
| RA <sub>DIV_CH1</sub>     | Channel 1 Internal divider ratio<br>Input source = V <sub>IN</sub>                               | 3.97  | 4.0  | 4.05  | —    |
| RA <sub>DIV_CH2</sub>     | Channel 2 internal divider ratio<br>Input source = V <sub>SNVS</sub>                             | 3.48  | 3.5  | 3.54  | —    |
| RA <sub>DIV_CH3</sub>     | Channel 3 internal divider ratio<br>Input source = LICELL  | 2.98  | 3.0  | 3.04  | —    |
| RA <sub>DIV_CH4_9</sub>   | Channel 4 to 9 internal divider ratio<br>Input source = Type 1 regulators at 1.8 V configuration | 1.241 | 1.25 | 1.267 | —    |
| RA <sub>DIV_CH10</sub>    | Channel 10 internal divider ratio<br>Input source = Type 2 regulator                             | 2.85  | 2.86 | 2.91  | —    |
| RA <sub>DIV_CH10_14</sub> | Channel 11 to 14 internal divider ratio<br>Input source = LDO regulators                         | 3.32  | 3.35 | 3.39  | —    |

### 15.11 Watchdog event management

A watchdog event may be started in two ways:

- The WDI pin toggles low due to a watchdog failure on the MCU
- The internal watchdog expiration counter reach the maximum value the WD timer is allowed to expire

A watchdog event initiated by the WDI pin may perform a hard WD reset or a soft WD reset as defined by the WDI\_MODE bit. A watchdog event initiated by the internal watchdog always performs a hard WD reset.

15.11.1 Internal watchdog timer

The internal WD timer counts up and it expires when it reaches the value in the WD\_DURATION[3:0] register. When the WD timer starts counting, the WD\_CLEAR flag is set to 1. Clearing the WD\_CLEAR flag within the valid window is interpreted as a successful watchdog refresh and the WD timer gets reset. The MCU must write a 1 to clear the WD\_CLEAR flag.

The WD timer is reset when device goes into any of the off modes and does not start counting until RESETBMCU is deasserted in the next power up sequence.

The OTP\_WD\_DURATION[3:0] selects the initial configuration for the watchdog window duration between 1.0 ms and 32768 ms (typical values).

The watchdog window duration can change during the system-on states by modifying the WD\_DURATION[3:0] bits on the functional register map. If the WD\_DURATION[3:0] bits get changed during the system-on states, the WD timer is reset.

Table 73. Watchdog duration register

| WD_DURATION[3:0] | Watchdog timer duration (ms) |
|------------------|------------------------------|
| 0000             | 1                            |
| 0001             | 2                            |
| 0010             | 4                            |
| 0011             | 8                            |
| 0100             | 16                           |
| 0101             | 32                           |
| 0110             | 64                           |
| 0111             | 128                          |
| 1000             | 256                          |
| 1001             | 512                          |
| 1010             | 1024                         |
| 1011             | 2048                         |
| 1100             | 4096                         |
| 1101             | 8192                         |
| 1110             | 16384                        |
| 1111             | 32768                        |

The WD\_EXPIRE\_CNT[2:0] counter is used to ensure no cyclic watchdog condition occurs. When the WD\_CLEAR flag is cleared successfully before the WD timer expires, the WD\_EXPIRE\_CNT[2:0] is decreased by 1. Every time the WD timer is not successfully refreshed, it gets reset and starts a new count and the WD\_EXPIRE\_CNT[2:0] is increased by 2.

If WD\_EXPIRE\_CNT[2:0] = WD\_MAX\_EXPIRE[2:0], a WD event is initiated. The default maximum amount of time the watchdog can expire before starting a WD Reset, is set by the OTP\_WD\_MAX\_EXPIRE[2:0]. Writing a value less than or equal to 0x02 on the OTP\_WD\_MAX\_EXPIRE causes the watchdog event to be initiated, as soon as the WD Timer expires for the first time.

The OTP\_WDWINDOW bit selects whether the watchdog is singled ended or window mode.

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- When `OTP_WDWINDOW = 0`, the `WD_CLEAR` flag can be cleared within 100 % of the watchdog timer.
- When `OTP_WDWINDOW = 1`, the `WD_CLEAR` flag can only be cleared within the second half of the programmed watchdog timer. Clearing the `WD_CLEAR` flag within the first half of the watchdog window is interpreted as a failure to refresh the watchdog.

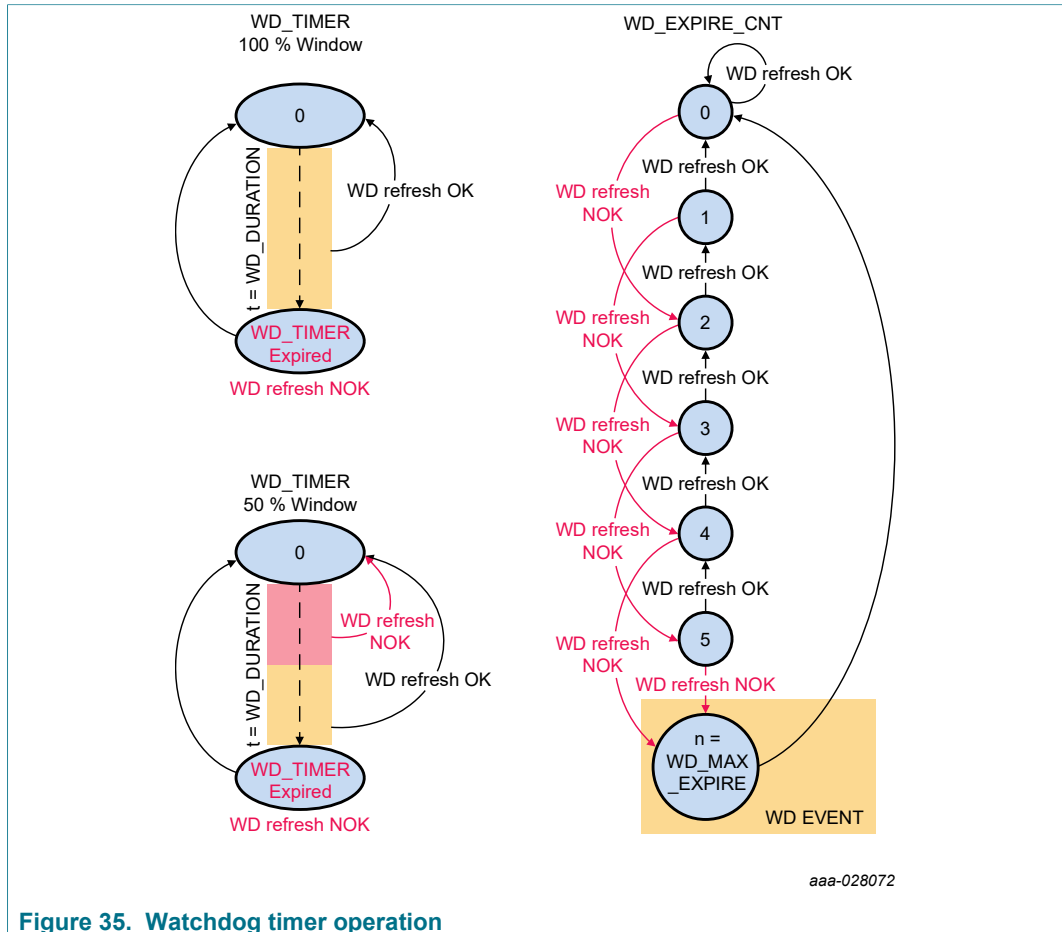


Figure 35. Watchdog timer operation

The watchdog function can be enabled or disabled by writing the `WD_EN` bit on the `I2C` register map. When the `I2C_SECURE_EN = 1`, a secure write must be performed to change the `WD_EN` bit.

- When `WD_EN = 0` the internal watchdog timer operation is disabled.
- When `WD_EN = 1` the internal watchdog timer operation is enabled.

The `OTP_WD_EN` bit is used to select the default status of the watchdog counter upon power up.

The watchdog function can be programmed to be enabled or disabled during the standby state by writing the `WD_STBY_EN` bit on the `I2C` register map. When the `I2C_SECURE_EN = 1`, a secure write must be performed to modify the `WD_STBY_EN` bit.

- When `WD_STBY_EN = 0` the internal watchdog timer operation during standby is disabled.
- When `WD_STBY_EN = 1` the internal watchdog timer operation during standby is enabled.

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The OTP\_WD\_STBY\_EN bit selects whether the watchdog is active in standby mode by default or not.

## 15.11.2 Watchdog reset behaviors

When a watchdog event is started, a watchdog (WD) reset is performed. There are two types of watchdog reset:

- Soft WD reset
- Hard WD reset

A soft WD reset is used as a safe way for the MCU to force the PMIC to return to a known default configuration without forcing a POR Reset on the MCU. During a soft WH reset, the RESETBMCU remains deasserted all the time.

Upon a soft WD reset, a partial OTP register re-load is performed on the registers as shown in [Table 74](#).

Table 74. Soft WD register reset

| Bit name                       | Register        | Bits |
|--------------------------------|-----------------|------|
| <b>Configuration registers</b> |                 |      |
| STANDBYINV                     | CTRL2           | 2    |
| RUN_PG_GPO                     | CTRL2           | 1    |
| STBY_PG_GPO                    | CRTL2           | 0    |
| RESETBMCU_SEQ[7:0]             | RESETBMCU PWRUP | 7:0  |
| PGOOD_SEQ[7:0]                 | PGOOD PWRUP     | 7:0  |
| WD_EN                          | CTRL1           | 3    |
| WD_DURATION[3:0]               | WD CONFIG       | 3:0  |
| WD_STBY_EN                     | CTRL1           | 2    |
| WDI_STBY_ACTIVE                | CTRL1           | 1    |
| <b>SW registers</b>            |                 |      |
| SWx_WDBYPASS                   | SWx CONFIG1     | 1    |
| SWx_PG_EN                      | SWx CONFIG1     | 0    |
| SWxDVS_RAMP                    | SWx CONFIG2     | 5    |
| SWxILIM[1:0]                   | SWx CONFIG2     | 4:3  |
| SWxPHASE[2:0]                  | SWx CONFIG2     | 2:0  |
| SWx_SEQ[7:0]                   | SWx PWRUP       | 7:0  |
| SWx_PDGRP[1:0]                 | SWx MODE        | 5:4  |
| SWx_STBY_MODE [1:0]            | SWx MODE        | 3:2  |
| SWx RUN_MODE [1:0]             | SWx MODE        | 1:0  |
| VSWx_RUN [7:0]                 | SWx RUN VOLT    | 7:0  |
| VSWx_STBY [7:0]                | SWx STBY VOLT   | 7:0  |
| VSW7 [4:0]                     | SW7 VOLT        | 4:0  |
| SW6_VTTEN                      | SW6_CONFIG2     | 6    |
| <b>LDO registers</b>           |                 |      |
| LDOx_WDBYPASS                  | LDOx CONFIG1    | 1    |
| LDOx_PG_EN                     | LDOx CONFIG1    | 0    |

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| Bit name        | Register       | Bits |
|-----------------|----------------|------|
| LDOx_PDGRP[1:0] | LDOx CONFIG2   | 6:5  |
| LDO2HW_EN       | LDO2 CONFIG2   | 4    |
| VSELECT_EN      | LDO2 CONFIG2   | 3    |
| LDOxLS          | LDOx CONFIG2   | 2    |
| LDOx_RUN_EN     | LDOx CONFIG2   | 1    |
| LDOx_STBY_EN    | LDOx CONFIG2   | 0    |
| LDOx_SEQ [7:0]  | LDOx PWRUP     | 7:0  |
| VLDOx_RUN[3:0]  | LDOx RUN VOLT  | 3:0  |
| VLDOx_STBY[3:0] | LDOx STBY VOLT | 3:0  |

A soft WD reset may require all or some regulators to be reset to their default OTP configuration. In the event a regulator is required to keep its current configuration during a soft WD reset, a watchdog bypass bit is provided for each regulator (SWx\_WDBYPASS / LDOx\_WDBYPASS).

- When the WDBYPASS = 0, the watchdog bypass is disabled and the output of the corresponding regulator is returned to its default OTP value during the soft WD reset.
- When the WDBYPASS = 1, the watchdog bypass is enabled and the output of the corresponding regulator is not affected by the soft WD reset, keeping its current configuration.

During a soft WD reset, only regulators that are activated in the power up sequence go back to their default voltage configuration if their corresponding WDBYPASS = 0.

Switching regulators returning to their default voltages configuration, will gradually reach the new output voltage using its DVS configuration. LDO regulators returning to their default configuration, will change to the default output voltage configuration instantaneously. Regulators with WDBYPASS = 0 and which are not activated during the power up sequence will turn off immediately.

After all output voltages, have transitioned to their corresponding default values, the device waits for at least 30  $\mu$ s before returning to the run state and announces it has finalized the soft WD reset by asserting the INTB pin, provided the WDI\_I interrupt is not masked.

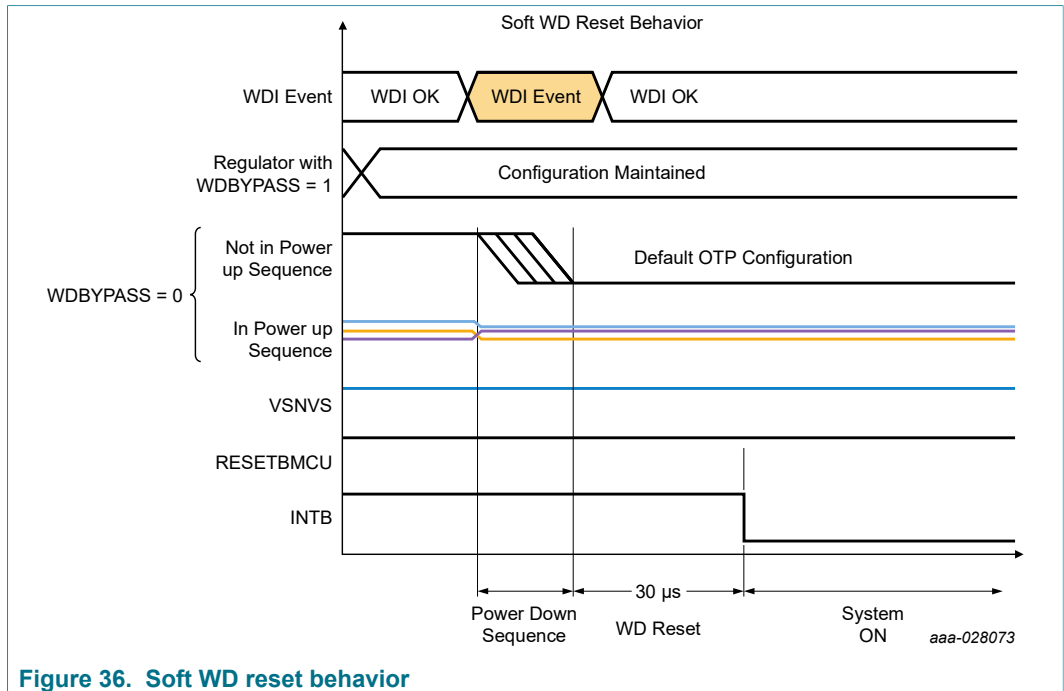


Figure 36. Soft WD reset behavior

A hard WD reset is used to force a system power-on reset when the MCU has become unresponsive. In this scenario, a full OTP register reset is performed.

During a hard WD reset, the device turn off all regulators and deassert RESETBMCU as indicated by the power down sequence. If PGOOD is programmed as a GPO and configured as part of the power up sequence, it will also be disabled accordingly.

After all regulator's outputs have gone through the power down sequence and the power down delay is finished, the device waits for 30 µs before reloading the default OTP configuration and gets ready to start a power up sequence if the XFAILB pin is not held low externally.

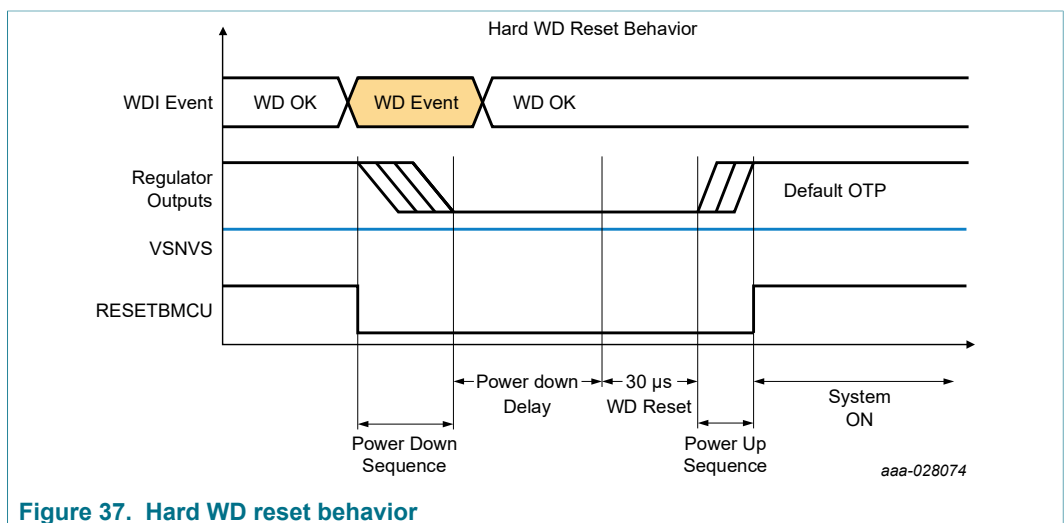


Figure 37. Hard WD reset behavior

After a WD reset, the PMIC may enter the standby state depending on the status of STANDBY pin.



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Every time a WD event occurs, the WD\_EVENT\_CNT[3:0] nibble is incremented. To prevent continuous failures, if the WD\_EVENT\_CNT[3:0] = WD\_MAX\_CNT[3:0] the state machine proceeds to the fault transition. The MCU is expected to clear the WD\_EVENT\_CNT[3:0] when it is able to do so in order to keep proper operation. Upon power up, the WD\_MAX\_CNT[3:0] is loaded with the values on the OTP\_WD\_MAX\_CNT[3:0] bits.

Every time the device passes through the off states, the WD\_EVENT\_CNT[3:0] is reset to 0x00, to ensure the counter has a fresh start after a device power down.

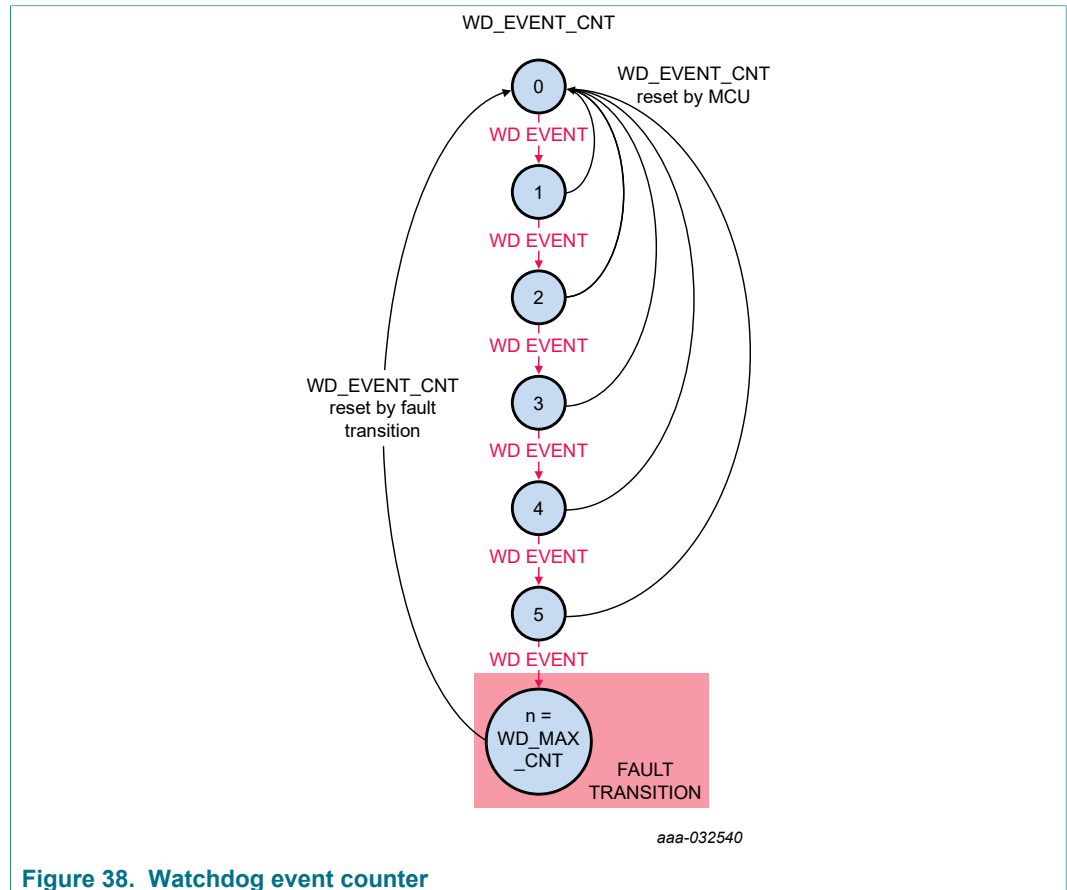


Figure 38. Watchdog event counter

## 16 I<sup>2</sup>C register map

The PF8121 provides a complete set of registers for control and diagnostics of the PMIC operation. The configuration of the device is done at two different levels.

At first level, the OTP Mirror registers provide the default hardware and software configuration for the PMIC upon power up. These are one time programmable and should be defined during the system development phase, and are not meant to be modified during the application. See [Section 17 "OTP/TBB and default configurations"](#) for more details on the OTP configuration feature.

At a second level, the PF8121 provides a set of functional registers intended for system configuration and diagnostics during the system operation. These registers are accessible during the system-on states and can be modified at any time by the System Control Unit.

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The device ID register provides general information about the PMIC.

- DEVICE\_FAM[3:0]: indicates the PF8x00 family of devices  
0100 (fixed)
- DEVICE\_ID[3:0]: provides the device type identifier  
0010 = PF8121

Registers 0x02 and 0x03 provide a customizable program ID registers to identify the specific OTP configuration programmed in the part.

- EMREV (Address 0x02): contains the MSB bits PROG\_ID[8:11]
- PROG\_ID (Address 0x03): contains the LSB bit PROG\_ID[7:0]

16.1 PF8121 functional register map

| RESET SIGNALS |  | R/W types |                          |
|---------------|--|-----------|--------------------------|
| UVDET         | Reset when VIN crosses UVDET threshold   | R         | Read only                |
| OFF_OTP       | Bits are loaded with OTP values (mirror register)  | R/W       | Read and Write           |
| OFF_TOGGLE    | Reset when device goes to OFF mode   | RW1C      | Read, Write a 1 to clear |
| SC            | Self-clear after write   | R/SW      | Read/Secure Write        |
| NO_VSNVS      | Reset when BOS has no valid input<br>VIN < UVDET and coin cell < 1.8 V (VSNVS not present) | R/TW      | Read/Write on TBB only   |

| AD DR | Register name    | R/W  | BIT7                | BIT6        | BIT5        | BIT4        | BIT3                 | BIT2         | BIT1         | BIT0            |  |
|-------|------------------|------|---------------------|-------------|-------------|-------------|----------------------|--------------|--------------|-----------------|--|
| 00    | DEVICE ID        | R    | DEVICE_FAM[3:0]     |             |             |             | DEVICE_ID[3:0]       |              |              |                 |  |
| 01    | REV ID           | R    | FULL_LAYER_REV[3:0] |             |             |             | METAL_LAYER_REV[3:0] |              |              |                 |  |
| 02    | EMREV            | R    | PROG_ID[11-8]       |             |             |             | —                    | EMREV[2:0]   |              |                 |  |
| 03    | PROG ID          | R    | PROG_ID[7:0]        |             |             |             |                      |              |              |                 |  |
| 04    | INT STATUS1      | RW1C | SDWN_I              | FREQ_RDY_I  | CRC_I       | PWRUP_I     | PWRDN_I              | XINTB_I      | FSOB_I       | VIN_OVLO_I      |  |
| 05    | INT MASK1        | R/W  | SDWN_M              | FREQ_RDY_M  | CRC_M       | PWRUP_M     | PWRDN_M              | XINTB_M      | FSOB_M       | VIN_OVLO_M      |  |
| 06    | INT SENSE1       | R    | —                   | —           | —           | —           | —                    | XINTB_S      | FSOB_S       | VIN_OVLO_S      |  |
| 07    | THERM INT        | RW1C | WDI_I               | FSYNC_FLT_I | THERM_155_I | THERM_140_I | THERM_125_I          | THERM_110_I  | THERM_95_I   | THERM_80_I      |  |
| 08    | THERM MASK       | R/W  | WDI_M               | FSYNC_FLT_M | THERM_155_M | THERM_140_M | THERM_125_M          | THERM_110_M  | THERM_95_M   | THERM_80_M      |  |
| 09    | THERM SENSE      | R    | WDI_S               | FSYNC_FLT_S | THERM_155_S | THERM_140_S | THERM_125_S          | THERM_110_S  | THERM_95_S   | THERM_80_S      |  |
| 0A    | SW MODE INT      | RW1C | —                   | SW7_MODE_I  | SW6_MODE_I  | SW5_MODE_I  | SW4_MODE_I           | SW3_MODE_I   | SW2_MODE_I   | SW1_MODE_I      |  |
| 0B    | SW MODE MASK     | R/W  | —                   | SW7_MODE_M  | SW6_MODE_M  | SW5_MODE_M  | SW4_MODE_M           | SW3_MODE_M   | SW2_MODE_M   | SW1_MODE_M      |  |
| 12    | SW ILIM INT      | RW1C | —                   | SW7_ILIM_I  | SW6_ILIM_I  | SW5_ILIM_I  | SW4_ILIM_I           | SW3_ILIM_I   | SW2_ILIM_I   | SW1_ILIM_I      |  |
| 13    | SW ILIM MASK     | R/W  | —                   | SW7_ILIM_M  | SW6_ILIM_M  | SW5_ILIM_M  | SW4_ILIM_M           | SW3_ILIM_M   | SW2_ILIM_M   | SW1_ILIM_M      |  |
| 14    | SW ILIM SENSE    | R    | —                   | SW7_ILIM_S  | SW6_ILIM_S  | SW5_ILIM_S  | SW4_ILIM_S           | SW3_ILIM_S   | SW2_ILIM_S   | SW1_ILIM_S      |  |
| 15    | LDO ILIM INT     | RW1C | —                   | —           | —           | —           | LDO4_ILIM_I          | LDO3_ILIM_I  | LDO2_ILIM_I  | LDO1_ILIM_I     |  |
| 16    | LDO ILIM MASK    | R/W  | —                   | —           | —           | —           | LDO4_ILIM_M          | LDO3_ILIM_M  | LDO2_ILIM_M  | LDO1_ILIM_M     |  |
| 17    | LDO ILIM SENSE   | R    | —                   | —           | —           | —           | LDO4_ILIM_S          | LDO3_ILIM_S  | LDO2_ILIM_S  | LDO1_ILIM_S     |  |
| 18    | SW UV INT        | RW1C | —                   | SW7_UV_I    | SW6_UV_I    | SW5_UV_I    | SW4_UV_I             | SW3_UV_I     | SW2_UV_I     | SW1_UV_I        |  |
| 19    | SW UV MASK       | R/W  | —                   | SW7_UV_M    | SW6_UV_M    | SW5_UV_M    | SW4_UV_M             | SW3_UV_M     | SW2_UV_M     | SW1_UV_M        |  |
| 1A    | SW UV SENSE      | R    | —                   | SW7_UV_S    | SW6_UV_S    | SW5_UV_S    | SW4_UV_S             | SW3_UV_S     | SW2_UV_S     | SW1_UV_S        |  |
| 1B    | SW OV INT        | RW1C | —                   | SW7_OV_I    | SW6_OV_I    | SW5_OV_I    | SW4_OV_I             | SW3_OV_I     | SW2_OV_I     | SW1_OV_I        |  |
| 1C    | SW OV MASK       | R/W  | —                   | SW7_OV_M    | SW6_OV_M    | SW5_OV_M    | SW4_OV_M             | SW3_OV_M     | SW2_OV_M     | SW1_OV_M        |  |
| 1D    | SW OV SENSE      | R    | —                   | SW7_OV_S    | SW6_OV_S    | SW5_OV_S    | SW4_OV_S             | SW3_OV_S     | SW2_OV_S     | SW1_OV_S        |  |
| 1E    | LDO UV INT       | RW1C | —                   | —           | —           | —           | LDO4_UV_I            | LDO3_UV_I    | LDO2_UV_I    | LDO1_UV_I       |  |
| 1F    | LDO UV MASK      | R/W  | —                   | —           | —           | —           | LDO4_UV_M            | LDO3_UV_M    | LDO2_UV_M    | LDO1_UV_M       |  |
| 20    | LDO UV SENSE     | R    | —                   | —           | —           | —           | LDO4_UV_S            | LDO3_UV_S    | LDO2_UV_S    | LDO1_UV_S       |  |
| 21    | LDO OV INT       | RW1C | —                   | —           | —           | —           | LDO4_OV_I            | LDO3_OV_I    | LDO2_OV_I    | LDO1_OV_I       |  |
| 22    | LDO OV MASK      | R/W  | —                   | —           | —           | —           | LDO4_OV_M            | LDO3_OV_M    | LDO2_OV_M    | LDO1_OV_M       |  |
| 23    | LDO OV SENSE     | R    | —                   | —           | —           | —           | LDO4_OV_S            | LDO3_OV_S    | LDO2_OV_S    | LDO1_OV_S       |  |
| 24    | PWRON INT        | RW1C | BGMON_I             | PWRON_8S_I  | PWRON_4S_I  | PRON_3S_I   | PWRON_2S_I           | PWRON_1S_I   | PWRON_REL_I  | PWRON_PUSH_I    |  |
| 25    | PWRON MASK       | R/W  | BGMON_M             | PWRON_8S_M  | PWRON_4S_M  | PRON_3S_M   | PWRON_2S_M           | PWRON_1S_M   | PWRON_REL_M  | PWRON_PUSH_M    |  |
| 26    | PWRON SENSE      | R    | BGMON_S             | —s          | —           | —           | —                    | —            | —            | PWRON_S         |  |
| 27    | SYS INT          | R    | EWARN_I             | PWRON_I     | OV_I        | UV_I        | ILIM_I               | MODE_I       | STATUS2_I    | STATUS1_I       |  |
| 29    | HARD FAULT FLAGS | RW1C | —                   | —           | —           | —           | PU_FAIL              | WD_FAIL      | REG_FAIL     | TSD_FAIL        |  |
| 2A    | FSOB FLAGS       | R/SW | —                   | —           | —           | —           | FSOB_SFFAULT_NOK     | FSOB_WDI_NOK | FSOB_WDC_NOK | FSOB_HFAULT_NOK |  |
| 2B    | FSOB SELECT      | R/W  | —                   | —           | —           | —           | FSOB_SOFTFAULT       | FSOB_WDI     | FSOB_WDC     | FSOB_HARDFAULT  |  |
| 30    | TEST FLAGS       | R/TW | —                   | —           | —           | LDO2EN_S    | VSELECT_S            | —            | TRIM_NOK     | OTP_NOK         |  |

12-channel power management integrated circuit for high performance applications

| AD DR | Register name  | R/W   | BIT7               | BIT6               | BIT5             | BIT4               | BIT3                | BIT2               | BIT1              | BIT0        |  |
|-------|----------------|-------|--------------------|--------------------|------------------|--------------------|---------------------|--------------------|-------------------|-------------|--|
| 35    | VMONEN1        | R/SW  | —                  | SW7VMON_EN         | SW6VMON_EN       | SW5VMON_EN         | SW4VMON_EN          | SW3VMON_EN         | SW2VMON_EN        | SW1VMON_EN  |  |
| 36    | VMONEN2        | R/SW  | —                  | —                  | —                | —                  | LDO4VMON_EN         | LDO3VMON_EN        | LDO2VMON_EN       | LDO1VMON_EN |  |
| 37    | CTRL1          | R/SW  | VIN_OVLO_EN        | VIN_OVLO_SDWN      | WDL_MODE         | TMP_MON_EN         | WD_EN               | WD_STBY_EN         | WDL_STBY_ACTIVE   | —           |  |
| 38    | CTRL2          | R/W   | VIN_OVLO_DBNC[1:0] |                    | —                | TMP_MON_AON        | LPM_OFF             | STANDBYINV         | RUN_PG_GPO        | STBY_PG_GPO |  |
| 39    | CTRL3          | R/W   | OV_DB[1:0]         |                    | UV_DB[1:0]       |                    | —                   | —                  | PMIC_OFF          | INTB_TEST   |  |
| 3A    | PWRUP CTRL     | R/W   | —                  | PWRDWN_MODE        | PGOOD_PDGRP[1:0] |                    | RESETMCU_PDGRP[1:0] |                    | SEQ_TBASE[1:0]    |             |  |
|       |                |       |                    |                    |                  |                    |                     |                    |                   |             |  |
| 3C    | RESETMCU PWRUP | R/W   | RESETMCU_SEQ[7:0]  |                    |                  |                    |                     |                    |                   |             |  |
| 3D    | PGOOD PWRUP    | R/W   | PGOOD_SEQ[7:0]     |                    |                  |                    |                     |                    |                   |             |  |
| 3E    | PWRDN DLY1     | R/W   | GRP4_DLY[1:0]      |                    | GRP3_DLY[1:0]    |                    | GRP2_DLY[1:0]       |                    | GRP1_DLY[1:0]     |             |  |
| 3F    | PWRDN DLY2     | R/W   | —                  | —                  | —                | —                  | —                   | —                  | RESETMCU_DLY[1:0] |             |  |
| 40    | FREQ CTRL      | R/W   | SYNCOUT_EN         | FSYNC_RANGE        | FSS_EN           | FSS_RANGE          | CLK_FREQ[3:0]       |                    |                   |             |  |
| 41    | COINCELL CTRL  | R/W   | —                  | —                  | COINCHG_EN       | COINCHG_OFF        | VCOIN[3:0]          |                    |                   |             |  |
| 42    | PWRON          | R/W   | —                  | —                  | —                | PWRON_DBNC [1:0]   |                     | PWRON_RST_EN       | TRESET[1:0]       |             |  |
| 43    | WD CONFIG      | R/W   | —                  | —                  | —                | —                  | WD_DURATION[3:0]    |                    |                   |             |  |
| 44    | WD CLEAR       | R/W1C | —                  | —                  | —                | —                  | —                   | —                  | —                 | WD_CLEAR    |  |
| 45    | WD EXPIRE      | R/W   | —                  | WD_MAX_EXPIRE[2:0] |                  |                    | —                   | WD_EXPIRE_CNT[2:0] |                   |             |  |
| 46    | WD COUNTER     | R/W   | WD_MAX_CNT [3:0]   |                    |                  | WD_EVENT_CNT [3:0] |                     |                    |                   |             |  |
| 47    | FAULT COUNTER  | R/W   | FAULT_MAX_CNT[3:0] |                    |                  | FAULT_CNT [3:0]    |                     |                    |                   |             |  |
|       |                |       |                    |                    |                  |                    |                     |                    |                   |             |  |
| 49    | FAULT TIMERS   | R/W   | —                  | —                  | —                | —                  | TIMER_FAULT[3:0]    |                    |                   |             |  |
| 4A    | AMUX           | R/W   | —                  | —                  | AMUX_EN          | AMUX_SEL [4:0]     |                     |                    |                   |             |  |
|       |                |       |                    |                    |                  |                    |                     |                    |                   |             |  |
| 4D    | SW1 CONFIG1    | R/W   | SW1_UV_BYPASS      | SW1_OV_BYPASS      | SW1_ILIM_BYPASS  | SW1_UV_STATE       | SW1_OV_STATE        | SW1_ILIM_STATE     | SW1_WDBYPASS      | SW1_PG_EN   |  |
| 4E    | SW1 CONFIG2    | R/W   | SW1_FLT_REN        | —                  | SW1DVS_RAMP      | SW1ILIM[1:0]       |                     | SW1PHASE[2:0]      |                   |             |  |
| 4F    | SW1 PWRUP      | R/W   | —                  |                    |                  |                    | SW1_SEQ[7:0]        |                    |                   |             |  |
| 50    | SW1 MODE       | R/W   | —                  | —                  | SW1_PDGRP[1:0]   | SW1_STBY_MODE[1:0] |                     | SW1_RUN_MODE[1:0]  |                   |             |  |
| 51    | SW1 RUN VOLT   | R/W   | VSW1_RUN[7:0]      |                    |                  |                    |                     |                    |                   |             |  |
| 52    | SW1 STBY VOLT  | R/W   | VSW1_STBY[7:0]     |                    |                  |                    |                     |                    |                   |             |  |
|       |                |       |                    |                    |                  |                    |                     |                    |                   |             |  |
| 55    | SW2 CONFIG1    | R/W   | SW2_UV_BYPASS      | SW2_OV_BYPASS      | SW2_ILIM_BYPASS  | SW2_UV_STATE       | SW2_OV_STATE        | SW2_ILIM_STATE     | SW2_WDBYPASS      | SW2_PG_EN   |  |
| 56    | SW2 CONFIG2    | R/W   | SW2_FLT_REN        | —                  | SW2DVS_RAMP      | SW2ILIM[1:0]       |                     | SW2PHASE[2:0]      |                   |             |  |
| 57    | SW2 PWRUP      | R/W   | —                  |                    |                  |                    | SW2_SEQ[7:0]        |                    |                   |             |  |
| 58    | SW2 MODE1      | R/W   | —                  | —                  | SW2_PDGRP[1:0]   | SW2_STBY_MODE[1:0] |                     | SW2_RUN_MODE[1:0]  |                   |             |  |
| 59    | SW2 RUN VOLT   | R/W   | VSW2_RUN[7:0]      |                    |                  |                    |                     |                    |                   |             |  |
| 5A    | SW2 STBY VOLT  | R/W   | VSW2_STBY[7:0]     |                    |                  |                    |                     |                    |                   |             |  |
|       |                |       |                    |                    |                  |                    |                     |                    |                   |             |  |
| 5D    | SW3 CONFIG1    | R/W   | SW3_UV_BYPASS      | SW3_OV_BYPASS      | SW3_ILIM_BYPASS  | SW3_UV_STATE       | SW3_OV_STATE        | SW3_ILIM_STATE     | SW3_WDBYPASS      | SW3_PG_EN   |  |
| 5E    | SW3 CONFIG2    | R/W   | SW3_FLT_REN        | —                  | SW3DVS_RAMP      | SW3ILIM[1:0]       |                     | SW3PHASE[2:0]      |                   |             |  |
| 5F    | SW3 PWRUP      | R/W   | —                  |                    |                  |                    | SW3_SEQ[7:0]        |                    |                   |             |  |
| 60    | SW3 MODE1      | R/W   | —                  | —                  | SW3_PDGRP[1:0]   | SW3_STBY_MODE[1:0] |                     | SW3_RUN_MODE[1:0]  |                   |             |  |
| 61    | SW3 RUN VOLT   | R/W   | VSW3_RUN[7:0]      |                    |                  |                    |                     |                    |                   |             |  |
| 62    | SW3 STBY VOLT  | R/W   | VSW3_STBY[7:0]     |                    |                  |                    |                     |                    |                   |             |  |
|       |                |       |                    |                    |                  |                    |                     |                    |                   |             |  |
| 65    | SW4 CONFIG1    | R/W   | SW4_UV_BYPASS      | SW4_OV_BYPASS      | SW4_ILIM_BYPASS  | SW4_UV_STATE       | SW4_OV_STATE        | SW4_ILIM_STATE     | SW4_WDBYPASS      | SW4_PG_EN   |  |
| 66    | SW4 CONFIG2    | R/W   | SW4_FLT_REN        | —                  | SW4DVS_RAMP      | SW4ILIM[1:0]       |                     | SW4PHASE[2:0]      |                   |             |  |
| 67    | SW4 PWRUP      | R/W   | —                  |                    |                  |                    | SW4_SEQ[7:0]        |                    |                   |             |  |
| 68    | SW4 MODE1      | R/W   | —                  | —                  | SW4_PDGRP[1:0]   | SW4_STBY_MODE[1:0] |                     | SW4_RUN_MODE[1:0]  |                   |             |  |
| 69    | SW4 RUN VOLT   | R/W   | VSW4_RUN[7:0]      |                    |                  |                    |                     |                    |                   |             |  |
| 6A    | SW4 STBY VOLT  | R/W   | VSW4_STBY[7:0]     |                    |                  |                    |                     |                    |                   |             |  |
|       |                |       |                    |                    |                  |                    |                     |                    |                   |             |  |
| 6D    | SW5 CONFIG1    | R/W   | SW5_UV_BYPASS      | SW5_OV_BYPASS      | SW5_ILIM_BYPASS  | SW5_UV_STATE       | SW5_OV_STATE        | SW5_ILIM_STATE     | SW5_WDBYPASS      | SW5_PG_EN   |  |
| 6E    | SW5 CONFIG2    | R/W   | SW5_FLT_REN        | —                  | SW5DVS_RAMP      | SW5ILIM[1:0]       |                     | SW5PHASE[2:0]      |                   |             |  |
| 6F    | SW5 PWRUP      | R/W   | SW5_SEQ[7:0]       |                    |                  |                    |                     |                    |                   |             |  |
| 70    | SW5 MODE1      | R/W   | —                  | —                  | SW5_PDGRP[1:0]   | SW5_STBY_MODE[1:0] |                     | SW5_RUN_MODE[1:0]  |                   |             |  |

12-channel power management integrated circuit for high performance applications

| AD DR | Register name  | R/W  | BIT7           | BIT6            | BIT5             | BIT4               | BIT3            | BIT2            | BIT1              | BIT0         |
|-------|----------------|------|----------------|-----------------|------------------|--------------------|-----------------|-----------------|-------------------|--------------|
| 71    | SW5 RUN VOLT   | R/W  | VSW5_RUN[7:0]  |                 |                  |                    |                 |                 |                   |              |
| 72    | SW5 STBY VOLT  | R/W  | VSW5_STBY[7:0] |                 |                  |                    |                 |                 |                   |              |
| 75    | SW6 CONFIG1    | R/W  | SW6_UV_BYPASS  | SW6_OV_BYPASS   | SW6_ILIM_BYPASS  | SW6_UV_STATE       | SW6_OV_STATE    | SW6_ILIM_STATE  | SW6_WDBYPASS      | SW6_PG_EN    |
| 76    | SW6 CONFIG2    | R/W  | SW6_FLT_REN    | SW6_VTTEN       | SW6DVS_RAMP      | SW6ILIM[1:0]       |                 |                 | SW6PHASE[2:0]     |              |
| 77    | SW6 PWRUP      | R/W  | SW6_SEQ[7:0]   |                 |                  |                    |                 |                 |                   |              |
| 78    | SW6 MODE1      | R/W  | —              | —               | SW6_PDGRP[1:0]   | SW6_STBY_MODE[1:0] |                 |                 | SW6_RUN_MODE[1:0] |              |
| 79    | SW6 RUN VOLT   | R/W  | VSW6_RUN[7:0]  |                 |                  |                    |                 |                 |                   |              |
| 7A    | SW6 STBY VOLT  | R/W  | VSW6_STBY[7:0] |                 |                  |                    |                 |                 |                   |              |
| 7D    | SW7 CONFIG1    | R/W  | SW7_UV_BYPASS  | SW7_OV_BYPASS   | SW7_ILIM_BYPASS  | SW7_UV_STATE       | SW7_OV_STATE    | SW7_ILIM_STATE  | SW7_WDBYPASS      | SW7_PG_EN    |
| 7E    | SW7 CONFIG2    | R/W  | SW7_FLT_REN    | —               | —                | SW7ILIM[1:0]       |                 |                 | SW7PHASE[2:0]     |              |
| 7F    | SW7 PWRUP      | R/W  | SW7_SEQ[7:0]   |                 |                  |                    |                 |                 |                   |              |
| 80    | SW7 MODE1      | R/W  | —              | —               | SW7_PDGRP[1:0]   | SW7_STBY_MODE[1:0] |                 |                 | SW7_RUN_MODE[1:0] |              |
| 81    | SW7 RUN VOLT   | R/W  | —              | —               | —                | VSW7[4:0]          |                 |                 |                   |              |
| 85    | LDO1 CONFIG1   | R/W  | LDO1_UV_BYPASS | LDO1_OV_BYPASS  | LDO1_ILIM_BYPASS | LDO1_UV_STATE      | LDO1_OV_STATE   | LDO1_ILIM_STATE | LDO1_WDBYPASS     | LDO1_PG_EN   |
| 86    | LDO1 CONFIG2   | R/W  | LDO1_FLT_REN   | LDO1_PDGRP[1:0] |                  | —                  | —               | —               | LDO1_RUN_EN       | LDO1_STBY_EN |
| 87    | LDO1 PWRUP     | R/W  | LDO1_SEQ[7:0]  |                 |                  |                    |                 |                 |                   |              |
| 88    | LDO1 RUN VOLT  | R/W  | —              | —               | —                | —                  | VLDO1_RUN[3:0]  |                 |                   |              |
| 89    | LDO1 STBY VOLT | R/W  | —              | —               | —                | —                  | VLDO1_STBY[3:0] |                 |                   |              |
| 8B    | LDO2 CONFIG1   | R/W  | LDO2_UV_BYPASS | LDO2_OV_BYPASS  | LDO2_ILIM_BYPASS | LDO2_UV_STATE      | LDO2_OV_STATE   | LDO2_ILIM_STATE | LDO2_WDBYPASS     | LDO2_PG_EN   |
| 8C    | LDO2 CONFIG2   | R/W  | LDO2_FLT_REN   | LDO2_PDGRP[1:0] |                  | LDO2HW_EN          | VSELECT_EN      | —               | LDO2_RUN_EN       | LDO2_STBY_EN |
| 8D    | LDO2 PWRUP     | R/W  | LDO2_SEQ[7:0]  |                 |                  |                    |                 |                 |                   |              |
| 8E    | LDO2 RUN VOLT  | R/W  | —              | —               | —                | —                  | VLDO2_RUN[3:0]  |                 |                   |              |
| 8F    | LDO2 STBY VOLT | R/W  | —              | —               | —                | —                  | VLDO2_STBY[3:0] |                 |                   |              |
| 91    | LDO3 CONFIG1   | R/W  | LDO3_UV_BYPASS | LDO3_OV_BYPASS  | LDO3_ILIM_BYPASS | LDO3_UV_STATE      | LDO3_OV_STATE   | LDO3_ILIM_STATE | LDO3_WDBYPASS     | LDO3_PG_EN   |
| 92    | LDO3 CONFIG2   | R/W  | LDO3_FLT_REN   | LDO3_PDGRP[1:0] |                  | —                  | —               | —               | LDO3_RUN_EN       | LDO3_STBY_EN |
| 93    | LDO3 PWRUP     | R/W  | LDO3_SEQ[7:0]  |                 |                  |                    |                 |                 |                   |              |
| 94    | LDO3 RUN VOLT  | R/W  | —              | —               | —                | —                  | VLDO3_RUN[3:0]  |                 |                   |              |
| 95    | LDO3 STBY VOLT | R/W  | —              | —               | —                | —                  | VLDO3_STBY[3:0] |                 |                   |              |
| 97    | LDO4 CONFIG1   | R/W  | LDO4_UV_BYPASS | LDO4_OV_BYPASS  | LDO4_ILIM_BYPASS | LDO4_UV_STATE      | LDO4_OV_STATE   | LDO4_ILIM_STATE | LDO4_WDBYPASS     | LDO4_PG_EN   |
| 98    | LDO4 CONFIG2   | R/W  | LDO4_FLT_REN   | LDO4_PDGRP[1:0] |                  | —                  | —               | —               | LDO4_RUN_EN       | LDO4_STBY_EN |
| 99    | LDO4 PWRUP     | R/W  | LDO4_SEQ[7:0]  |                 |                  |                    |                 |                 |                   |              |
| 9A    | LDO4 RUN VOLT  | R/W  | —              | —               | —                | —                  | VLDO4_RUN[3:0]  |                 |                   |              |
| 9B    | LDO4 STBY VOLT | R/W  | —              | —               | —                | —                  | VLDO4_STBY[3:0] |                 |                   |              |
| 9D    | VSNVS CONFIG1  | R/W  | —              | —               | —                | —                  | —               | —               | VSNVSVOLT [1:0]   |              |
| 9F    | PAGE SELECT    | R/TW | —              | —               | —                | —                  | —               | PAGE[2:0]       |                   |              |

16.2 PF8121 OTP mirror register map (page 1)

| Reset types |  |
|-------------|--|
| OFF_OTP     | Register loads the OTP mirror register values during power up                            |
| OTP         | Register available in OTP bank only, reset from fuses when VIN crosses UVDET threshold   |
| VSNVS       | Reset when BOS has no valid input. VIN < UVDET and coin cell < 1.8 V (VSNVS not present) |

| AD DR | Register name       | BIT7                   | BIT6            | BIT5                 | BIT4                | BIT3                     | BIT2                   | BIT1                   | BIT0               |
|-------|---------------------|------------------------|-----------------|----------------------|---------------------|--------------------------|------------------------|------------------------|--------------------|
| A0    | OTP FSOB SELECT     | —                      | —               | —                    | —                   | OTP_FSOB_SOFTFAULT       | OTP_FSOB_WDI           | OTP_FSOB_WDC           | OTP_FSOB_HARDFAULT |
| A1    | OTP I2C             | —                      | —               | —                    | —                   | OTP_I2C_CRC_EN           | OTP_I2C_ADD[2:0]       |                        |                    |
| A2    | OTP CTRL1           | —                      | —               | OTP_EWARN_TIME[1:0]  | —                   | —                        | OTP_STANDBYINV         | OTP_PG_ACTIVE          | OTP_PG_CHECK       |
| A3    | OTP CTRL2           | OTP_FSS_EN             | OTP_FSS_RANGE   | —                    | OTP_XFAILB_EN       | OTP_VIN_OVLO_SDWN        | OTP_VIN_OVLO_EN        | OTP_VIN_OVLO_DBNQ[1:0] |                    |
| A4    | OTP CTRL3           | OTP_VTT_PDOWN          | OTP_SW6_VTEN    | OTP_SW5CONFIG[1:0]   |                     | OTP_SW4CONFIG[1:0]       |                        | OTP_SW1CONFIG[1:0]     |                    |
| A5    | OTP FREQ CTRL       | OTP_SW_MODE            | OTP_SYNCIN_EN   | OTP_SYNCOUT_EN       | OTP_FSYNC_RANGE     | OTP_CLK_FREQ[3:0]        |                        |                        |                    |
| A6    | OTP COINCELL CTRL   | —                      | —               | —                    | —                   | OTP_VCOIN[3:0]           |                        |                        |                    |
| A7    | OTP PWRON           | —                      | —               | OTP_PWRON_MODE       | OTP_PWRON_DBNQ[1:0] |                          | OTP_PWRON_RST_EN       | OTP_TRESET[1:0]        |                    |
| A8    | OTP WD CONFIG       | —                      | —               | OTP_WDI_MODE         | OTP_WDI_INV         | OTP_WD_EN                | OTP_WD_STBY_EN         | OTP_WDI_STBY_ACTIVE    | OTP_WDWINDOW       |
| A9    | OTP WD EXPIRE       | —                      | —               | —                    | —                   | —                        | OTP_WD_MAX_EXPIRE[2:0] |                        |                    |
| AA    | OTP WD COUNTER      | OTP_WD_DURATION[3:0]   |                 |                      |                     | OTP_WD_MAX_CNT [3:0]     |                        |                        |                    |
| AB    | OTP FAULT COUNTERS  | —                      | —               | —                    | —                   | OTP_FAULT_MAX_CNT[3:0]   |                        |                        |                    |
| AC    | OTP FAULT TIMERS    | —                      | —               | —                    | —                   | OTP_TIMER_FAULT[3:0]     |                        |                        |                    |
| AD    | OTP PWRDN DLY1      | OTP_GRP4_DLY[1:0]      |                 | OTP_GRP3_DLY[1:0]    |                     | OTP_GRP2_DLY[1:0]        |                        | OTP_GRP1_DLY[1:0]      |                    |
| AE    | OTP PWRDN DLY2      | OTP_PD_SEQ_DLY[1:0]    |                 | —                    | —                   | —                        | —                      | OTP_RESETBMCU_DLY[1:0] |                    |
| AF    | OTP PWRUP CTRL      | —                      | OTP_PWRDWN_MODE | OTP_PGOOD_PDGRP[1:0] |                     | OTP_RESETBMCU_PDGRP[1:0] |                        | OTP_SEQ_TBASE[1:0]     |                    |
| B0    | OTP RESETBMCU PWRUP | OTP_RESETBMCU_SEQ[7:0] |                 |                      |                     |                          |                        |                        |                    |
| B1    | OTP PGOOD PWRUP     | OTP_PGOOD_SEQ[7:0]     |                 |                      |                     |                          |                        |                        |                    |
| B2    | OTP SW1 VOLT        | OTP_VSW1[7:0]          |                 |                      |                     |                          |                        |                        |                    |
| B3    | OTP SW1 PWRUP       | OTP_SW1_SEQ[7:0]       |                 |                      |                     |                          |                        |                        |                    |
| B4    | OTP SW1 CONFIG1     | OTP_SW1UV_TH[1:0]      |                 | OTP_SW1OV_TH[1:0]    |                     | OTP_SW1_PDGRP[1:0]       |                        | OTP_SW1ILIM[1:0]       |                    |
| B5    | OTP SW1 CONFIG2     | OTP_SW1_LSELECT[1:0]   |                 | OTP_SW1PHASE[2:0]    |                     |                          | OTP_SW1DVS_RAMP        | OTP_SW1_PG_EN          | OTP_SW1_WDBYPASS   |
| B6    | OTP SW2 VOLT        | OTP_VSW2[7:0]          |                 |                      |                     |                          |                        |                        |                    |
| B7    | OTP SW2 PWRUP       | OTP_SW2_SEQ[7:0]       |                 |                      |                     |                          |                        |                        |                    |
| B8    | OTP SW2 CONFIG1     | OTP_SW2UV_TH[1:0]      |                 | OTP_SW2OV_TH[1:0]    |                     | OTP_SW2_PDGRP[1:0]       |                        | OTP_SW2ILIM[1:0]       |                    |
| B9    | OTP SW2 CONFIG2     | OTP_SW2_LSELECT[1:0]   |                 | OTP_SW2PHASE[2:0]    |                     |                          | OTP_SW2DVS_RAMP        | OTP_SW2_PG_EN          | OTP_SW2_WDBYPASS   |
| BA    | OTP SW3 VOLT        | OTP_VSW3[7:0]          |                 |                      |                     |                          |                        |                        |                    |
| BB    | OTP SW3 PWRUP       | OTP_SW3_SEQ[7:0]       |                 |                      |                     |                          |                        |                        |                    |

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| AD DR | Register name    | BIT7                 | BIT6             | BIT5               | BIT4             | BIT3               | BIT2              | BIT1              | BIT0              |
|-------|------------------|----------------------|------------------|--------------------|------------------|--------------------|-------------------|-------------------|-------------------|
| BC    | OTP SW3 CONFIG1  | OTP_SW3UV_TH[1:0]    |                  | OTP_SW3OV_TH[1:0]  |                  | OTP_SW3_PDGRP[1:0] |                   | OTP_SW3ILIM[1:0]  |                   |
| BD    | OTP SW3 CONFIG2  | OTP_SW3_LSELECT[1:0] |                  | OTP_SW3PHASE[2:0]  |                  | OTP_SW3DVS_RAMP    |                   | OTP_SW3_PG_EN     | OTP_SW3_WDBYPASS  |
| BE    | OTP SW4 VOLT     | OTP_VSW4[7:0]        |                  |                    |                  |                    |                   |                   |                   |
| BF    | OTP SW4 PWRUP    | OTP_SW4_SEQ[7:0]     |                  |                    |                  |                    |                   |                   |                   |
| C0    | OTP SW4 CONFIG1  | OTP_SW4UV_TH[1:0]    |                  | OTP_SW4OV_TH[1:0]  |                  | OTP_SW4_PDGRP[1:0] |                   | OTP_SW4ILIM[1:0]  |                   |
| C1    | OTP SW4 CONFIG2  | OTP_SW4_LSELECT[1:0] |                  | OTP_SW4PHASE[2:0]  |                  | OTP_SW4DVS_RAMP    |                   | OTP_SW4_PG_EN     | OTP_SW4_WDBYPASS  |
| C2    | OTP SW5 VOLT     | OTP_VSW5[7:0]        |                  |                    |                  |                    |                   |                   |                   |
| C3    | OTP SW5 PWRUP    | OTP_SW5_SEQ[7:0]     |                  |                    |                  |                    |                   |                   |                   |
| C4    | OTP SW5 CONFIG1  | OTP_SW5UV_TH[1:0]    |                  | OTP_SW5OV_TH[1:0]  |                  | OTP_SW5_PDGRP[1:0] |                   | OTP_SW5ILIM[1:0]  |                   |
| C5    | OTP SW5 CONFIG2  | OTP_SW5_LSELECT[1:0] |                  | OTP_SW5PHASE[2:0]  |                  | OTP_SW5DVS_RAMP    |                   | OTP_SW5_PG_EN     | OTP_SW5_WDBYPASS  |
| C6    | OTP SW6 VOLT     | OTP_VSW6[7:0]        |                  |                    |                  |                    |                   |                   |                   |
| C7    | OTP SW6 PWRUP    | OTP_SW6_SEQ[7:0]     |                  |                    |                  |                    |                   |                   |                   |
| C8    | OTP SW6 CONFIG1  | OTP_SW6UV_TH[1:0]    |                  | OTP_SW6OV_TH[1:0]  |                  | OTP_SW6_PDGRP[1:0] |                   | OTP_SW6ILIM[1:0]  |                   |
| C9    | OTP SW6 CONFIG2  | OTP_SW6_LSELECT[1:0] |                  | OTP_SW6PHASE[2:0]  |                  | OTP_SW6DVS_RAMP    |                   | OTP_SW6_PG_EN     | OTP_SW6_WDBYPASS  |
| CA    | OTP SW7 VOLT     | —                    | —                | —                  | OTP_VSW7[4:0]    |                    |                   |                   |                   |
| CB    | OTP SW7 PWRUP    | OTP_SW7_SEQ[7:0]     |                  |                    |                  |                    |                   |                   |                   |
| CC    | OTP SW7 CONFIG1  | OTP_SW7UV_TH[1:0]    |                  | OTP_SW7OV_TH[1:0]  |                  | OTP_SW7_PDGRP[1:0] |                   | OTP_SW7ILIM[1:0]  |                   |
| CD    | OTP SW7 CONFIG2  | OTP_SW7_LSELECT[1:0] |                  | OTP_SW7PHASE[2:0]  |                  | —                  | OTP_SW7_PG_EN     |                   | OTP_SW7_WDBYPASS  |
| CE    | OTP LDO1 VOLT    | OTP_LDO1UV_TH[1:0]   |                  | OTP_LDO1OV_TH[1:0] |                  | OTP_VLDO1[3:0]     |                   |                   |                   |
| CF    | OTP LDO1 PWRUP   | OTP_LDO1_SEQ[7:0]    |                  |                    |                  |                    |                   |                   |                   |
| D0    | OTP LDO1 CONFIG  | OTP_LDO1_PDGRP[1:0]  |                  | —                  | —                | —                  | OTP_LDO1_PG_EN    | OTP_LDO1_WDBYPASS | OTP_LDO1LS        |
| D1    | OTP LDO2 VOLT    | OTP_LDO2UV_TH[1:0]   |                  | OTP_LDO2OV_TH[1:0] |                  | OTP_VLDO2[3:0]     |                   |                   |                   |
| D2    | OTP LDO2 PWRUP   | OTP_LDO2_SEQ[7:0]    |                  |                    |                  |                    |                   |                   |                   |
| D3    | OTP LDO2 CONFIG  | OTP_LDO2_PDGRP[1:0]  |                  | OTP_VSELECT_EN     | OTP_LDO2HW_EN    | —                  | OTP_LDO2_PG_EN    | OTP_LDO2_WDBYPASS | OTP_LDO2LS        |
| D4    | OTP LDO3 VOLT    | OTP_LDO3UV_TH[1:0]   |                  | OTP_LDO3OV_TH[1:0] |                  | OTP_VLDO3[3:0]     |                   |                   |                   |
| D5    | OTP LDO3 PWRUP   | OTP_LDO3_SEQ[7:0]    |                  |                    |                  |                    |                   |                   |                   |
| D6    | OTP LDO3 CONFIG  | OTP_LDO3_PDGRP[1:0]  |                  | —                  | —                | —                  | OTP_LDO3_PG_EN    | OTP_LDO3_WDBYPASS | OTP_LDO3LS        |
| D7    | OTP LDO4 VOLT    | OTP_LDO4UV_TH[1:0]   |                  | OTP_LDO4OV_TH[1:0] |                  | OTP_VLDO4[3:0]     |                   |                   |                   |
| D8    | OTP LDO4 PWRUP   | OTP_LDO4_SEQ[7:0]    |                  |                    |                  |                    |                   |                   |                   |
| D9    | OTP LDO4 CONFIG  | OTP_LDO4_PDGRP[1:0]  |                  | —                  | —                | —                  | OTP_LDO4_PG_EN    | OTP_LDO4_WDBYPASS | OTP_LDO4LS        |
| DA    | OTP VSNVS CONFIG | —                    | —                | —                  | —                | —                  | —                 | VSNVSVOLT [1:0]   |                   |
| DB    | OTP_OV_BYPASS1   | —                    | OTP_SW7_OVBYPASS | OTP_SW6_OVBYPASS   | OTP_SW5_OVBYPASS | OTP_SW4_OVBYPASS   | OTP_SW3_OVBYPASS  | OTP_SW2_OVBYPASS  | OTP_SW1_OVBYPASS  |
| DC    | OTP_OV_BYPASS2   | —                    | —                | —                  | —                | OTP_LDO4_OVBYPASS  | OTP_LDO3_OVBYPASS | OTP_LDO2_OVBYPASS | OTP_LDO1_OVBYPASS |

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| AD DR | Register name    | BIT7 | BIT6               | BIT5               | BIT4               | BIT3                | BIT2                | BIT1                | BIT0                |
|-------|------------------|------|--------------------|--------------------|--------------------|---------------------|---------------------|---------------------|---------------------|
| DD    | OTP_UV_BYPASS1   | —    | OTP_SW7_UVBYPASS   | OTP_SW6_UVBYPASS   | OTP_SW5_UVBYPASS   | OTP_SW4_UVBYPASS    | OTP_SW3_UVBYPASS    | OTP_SW2_UVBYPASS    | OTP_SW1_UVBYPASS    |
| DE    | OTP_UV_BYPASS2   | —    | —                  | —                  | —                  | OTP_LDO4_UVBYPASS   | OTP_LDO3_UVBYPASS   | OTP_LDO2_UVBYPASS   | OTP_LDO1_UVBYPASS   |
| DF    | OTP_ILIM_BYPASS1 | —    | OTP_SW7_ILIMBYPASS | OTP_SW6_ILIMBYPASS | OTP_SW5_ILIMBYPASS | OTP_SW4_ILIMBYPASS  | OTP_SW3_ILIMBYPASS  | OTP_SW2_ILIMBYPASS  | OTP_SW1_ILIMBYPASS  |
| E0    | OTP_ILIM_BYPASS2 | —    | —                  | —                  | —                  | OTP_LDO4_ILIMBYPASS | OTP_LDO3_ILIMBYPASS | OTP_LDO2_ILIMBYPASS | OTP_LDO1_ILIMBYPASS |
| E3    | OTP_DEBUG1       | —    | —                  | —                  | —                  | —                   | —                   | —                   | BGMOM_BYPASS        |

## 17 OTP/TBB and default configurations

The PF8121 supports OTP fuse bank configuration and a predefined hardware configurations to select the default power up configuration via the VDDOTP pin.

The default power up configuration is loaded into the functional I<sup>2</sup>C registers based on the voltage on VDDOTP pin on register loading.

When OTP configuration is selected, the register loading occurs in two stages:

- In the first stage, the fuses are loaded in the OTP Mirror registers every time VIN crosses the UVDET threshold in the rising edge.
- At the second stage, data from the mirror registers are loaded into the functional I<sup>2</sup>C registers for device operation.

When VDDOTP = GND, the mirror registers hold the default configuration to be used on a power-on event. The mirror registers can be modified during the TBB mode in order to test a custom power up configuration and/or burn the configuration into the OTP fuses to generate a customized default power up configuration.

When VDDOTP = V1P5D, the I<sup>2</sup>C functional register will always be loaded from the hardware configuration every time a default loading is required. Therefore, no TBB operation is possible in this configuration.

In the event of a TRIM/OTP loading failure or a self-test failure, the corresponding fault flag is set and any PWRUP event is ignored until the flags are cleared by writing a 1 during the QPU\_OFF state.

The TRIM\_NOK, OTP\_NOK flags can only be written when the TBBEN is set high (in TBB Mode). In normal operation, the TRIM\_NOK, OTP\_NOK flags can only be read, but not cleared.

### 17.1 TBB (Try Before Buy) operation

The PF8121 allows temporary configuration (TBB) to debug or test a customized power up configuration in the system. In order to access the TBB mode, the TBBEN pin should be set high .

In this mode of operation, the device ignores the default value of the LPM\_OFF bit and moves into the QPU\_Off.

In the TBB mode, the following conditions are valid:

- I<sup>2</sup>C communication uses standard communication with no CRC and secure write disabled.
- Default I<sup>2</sup>C address is 0x08 regardless of the address configured by OTP.
- Watchdog monitoring is disabled (including WDI and internal watchdog timer).



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- The PF8121 can communicate through I<sup>2</sup>C as long as V<sub>DDIO</sub> is provided to the PMIC externally.

The PAGE[2:0] bits are provided to grant access to the mirror registers and other OTP dedicated bits. When device is in the TBB mode, it can access the mirror registers in the extended register Page 1. With the TBBEN pin pulled low, access to the extended register pages is not allowed.

The mirror registers are preloaded with the values from the OTP configuration. These may be modified to set the proper power up configuration during TBB operation.

If a power up event is present with the TBBEN pin set high, device will power up with the proper configuration but limited functionality.

Limited functionality includes:

- Default I<sup>2</sup>C address = 0x08
- CRC and secure write disabled
- Watchdog operation/monitoring disable

In order to allow TBB operation with full functionality, the TBBEN pin must be low when the power up event occurs.

The PF8121 can operate normally using the TBB configuration, as long as VIN does not go below the UVDET threshold. If VIN is lost (VIN < UVDET) the mirror register will be reset and TBB configuration must be performed again.

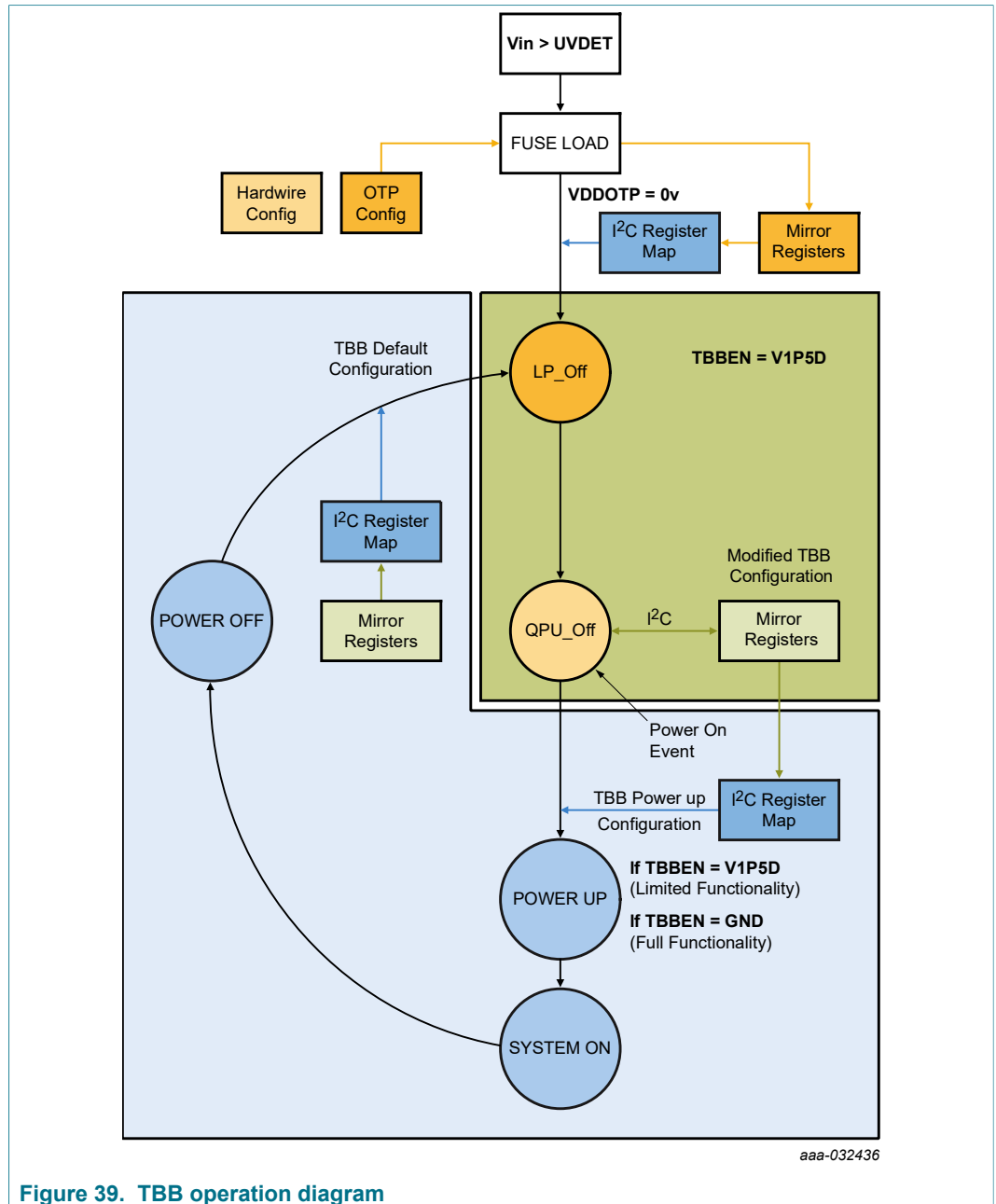


Figure 39. TBB operation diagram

### 17.2 OTP fuse programming

A permanent OTP configuration is possible by burning the OTP fuses. OTP fuse burning is performed in the TBBEN mode during the QPU\_Off state. Contact your NXP representative for detailed information on OTP fuse programming.

### 17.3 Default hardwire configuration

If VDDOTP = V1P5D, the device loads the configuration from the default hardwire configuration directly into the corresponding I<sup>2</sup>C functional registers every time the registers need to be reloaded.

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When using the hardwire configuration, the TRIM values are still loaded from the OTP fuses. In the event of a TRIM loading failure, the corresponding fault flag is set to 1.

When the hardwire configuration is used, the PF8121 does not allow TBB mode operation. When TBBEN = V1P5D, the device enters a debug mode. In this mode of operation, the device ignores the default value of the LPM\_OFF bit and moves into the QPU\_Off.

During hardwire configuration, the OTP\_NOK flag is always set to 0.

When any of the TRIM\_NOK, OTP\_NOK flag is set, any PWRUP event is ignored until the flags are cleared by writing a 0. These flags can only be written when the system is in the debug mode, (TBBEN = V1P5D). In normal operation, the TRIM\_NOK, OTP\_NOK flags are read only.

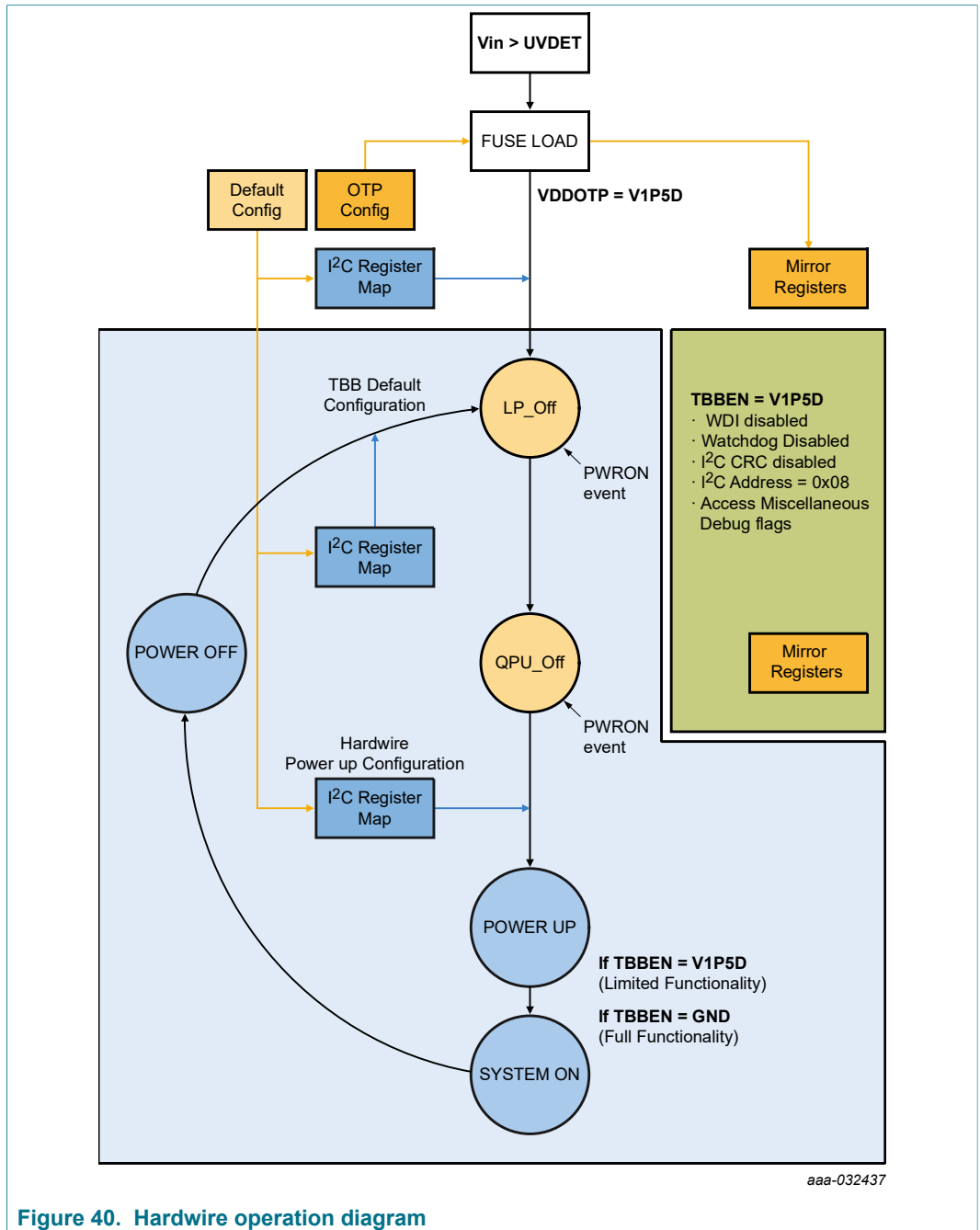


Figure 40. Hardware operation diagram

For simplicity, the default hardware configuration in PF8121 is organized based on the OTP register map as shown in Table 75.

Table 75. Default hardware configuration

| ADDR | Register name   | BIT7 | BIT6 | BIT5 | BIT4 | BIT3 | BIT2 | BIT1 | BIT0 | Configuration   |
|------|-----------------|------|------|------|------|------|------|------|------|---|
| A0   | OTP FSOB SELECT | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | FSOB pin not used   |
| A1   | OTP I2C         | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | I2C CRC disabled   I2C address = 0x08   |
| A2   | OTP CTRL1       | 0    | 0    | 0    | 0    | 0    | 0    | 1    | 0    | 100 μs EWARN   STANDBY active high   PGOOD indicator   PG not Check on power up   |
| A3   | OTP CTRL2       | 0    | 0    | 0    | 0    | 0    | 1    | 0    | 1    | FSS disabled   FSS Range = 5 %   XFAILB Disabled   VIN_OVLO shutdown disabled   VIN_OVLO enabled   VIN_OVLO debounce = 100 μs |
| A4   | OTP CTRL3       | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 1    | VTT Hi-Z off   Single phase: SW6, SW5, SW4, SW3   Dual phase: SW1/SW2   |

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| ADDR | Register name       | BIT7 | BIT6 | BIT5 | BIT4 | BIT3 | BIT2 | BIT1 | BIT0 | Configuration  |
|------|---------------------|------|------|------|------|------|------|------|------|--|
| A5   | OTP_FREQ_CTRL       | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | SWx in APS   SYNCIN = Disabled   SYNCOUT disabled   SYNCIN range = 2 MHz – 3 MHz   CLK Frequency = 2.5 MHz   |
| A6   | OTP_COINCELL_CTRL   | 0    | 0    | 0    | 0    | 1    | 0    | 1    | 1    | VCOIN = 3.0 V  |
| A7   | OTP_PWRON           | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | PWRON = Level sensitive  |
| A8   | OTP_WD_CONFIG       | 0    | 0    | 0    | 1    | 0    | 0    | 0    | 0    | WDI generates soft WD reset   WDI detect on rising edge   WD timer disabled   WD Timer in standby disabled   WDI detect in standby disabled   WD windows = 100 % |
| A9   | OTP_WD_EXPIRE       | 0    | 0    | 0    | 0    | 0    | 1    | 1    | 1    | Max WD expire count = 8  |
| AA   | OTP_WD_COUNTER      | 1    | 0    | 1    | 0    | 1    | 1    | 1    | 1    | WD duration = 1024 ms   Max WD count = 16  |
| AB   | OTP_FAULT_COUNTERS  | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 1    | Regulator fault max counter = 16   |
| AC   | OTP_FAULT_TIMERS    | 0    | 0    | 0    | 0    | 1    | 1    | 1    | 1    | Regulator fault timer = Disabled   |
| AD   | OTP_PWRDN_DLY1      | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | GRP4 delay = 125 µs   GRP 3 delay = 125 µs   GRP 2 delay = 125 µs   GRP 1 delay = 125 µs   |
| AE   | OTP_PWRDN_DLY2      | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 1    | No power down delay   RESETBMCU delay = 10 µs  |
| AF   | OTP_PWRUP_CTRL      | 0    | 0    | 0    | 0    | 0    | 0    | 1    | 0    | PD mirror sequence   RESETBMCU PD Group2   TBASE = 250 µs  |
| B0   | OTP_RESETBMCU_PWRUP | 0    | 0    | 0    | 0    | 0    | 1    | 1    | 1    | RESETBMCU SEQ = Slot 6   |
| B1   | OTP_PGOOD_PWRUP     | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | PGOOD SEQ = OFF  |
| B2   | OTP_SW1_VOLT        | 0    | 1    | 1    | 0    | 0    | 0    | 0    | 0    | Voltage = 1.0 V  |
| B3   | OTP_SW1_PWRUP       | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 1    | SEQ = Slot 0   |
| B4   | OTP_SW1_CONFIG1     | 0    | 1    | 0    | 1    | 0    | 0    | 1    | 1    | UV mon = 7 %   OV mon = 7 %   SW PD Group4   ILIM typ 4.5 A  |
| B5   | OTP_SW1_CONFIG2     | 0    | 0    | 1    | 1    | 1    | 1    | 1    | 0    | L = 1 µH   Phase = 0°   DVS Ramp = 12.5 mV/µs   PG = EN   WDBYPASS = Disable   |
| B6   | OTP_SW2_VOLT        | 0    | 1    | 1    | 0    | 0    | 0    | 0    | 0    | Voltage = 1.0 V  |
| B7   | OTP_SW2_PWRUP       | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 1    | SEQ = Slot 0   |
| B8   | OTP_SW2_CONFIG1     | 0    | 1    | 0    | 1    | 0    | 0    | 1    | 1    | UV mon = 7 %   OV mon = 7 %   SW PD Group4   ILIM typ 4.5 A  |
| B9   | OTP_SW2_CONFIG2     | 0    | 0    | 0    | 1    | 1    | 1    | 1    | 0    | L = 1 µH   Phase = 180°   DVS Ramp = 12.5 mV/µs   PG = EN   WDBYPASS = Disable   |
| BA   | OTP_SW3_VOLT        | 0    | 1    | 1    | 1    | 0    | 0    | 0    | 0    | Voltage = 1.1 V  |
| BB   | OTP_SW3_PWRUP       | 0    | 0    | 0    | 0    | 0    | 1    | 0    | 1    | SEQ = Slot 4   |
| BC   | OTP_SW3_CONFIG1     | 0    | 1    | 0    | 1    | 0    | 0    | 1    | 1    | UV mon = 7 %   OV mon = 7 %   SW PD Group4   ILIM min 4.5 A  |
| BD   | OTP_SW3_CONFIG2     | 0    | 0    | 1    | 1    | 1    | 1    | 1    | 0    | L = 1 µH   Phase = 0°   DVS Ramp = 12.5 mV/µs   PG = EN   WDBYPASS = Disable   |
| BE   | OTP_SW4_VOLT        | 0    | 1    | 1    | 1    | 0    | 0    | 0    | 0    | Voltage = 1.1 V  |
| BF   | OTP_SW4_PWRUP       | 0    | 0    | 0    | 0    | 0    | 1    | 0    | 1    | SEQ = Slot 4   |
| C0   | OTP_SW4_CONFIG1     | 0    | 1    | 0    | 1    | 0    | 0    | 1    | 1    | UV mon = 7 %   OV mon = 7 %   SW PD Group4   ILIM min 4.5 A  |
| C1   | OTP_SW4_CONFIG2     | 0    | 0    | 1    | 1    | 1    | 1    | 1    | 0    | L = 1 µH   Phase = 0°   DVS Ramp = 12.5 mV/µs   PG = EN   WDBYPASS = Disable   |
| C2   | OTP_SW5_VOLT        | 0    | 1    | 1    | 1    | 0    | 0    | 0    | 0    | Voltage = 1.1 V  |
| C3   | OTP_SW5_PWRUP       | 0    | 0    | 0    | 0    | 0    | 0    | 1    | 1    | SEQ = Slot 2 (TBASE x 2 = 500 µs)  |
| C4   | OTP_SW5_CONFIG1     | 0    | 1    | 0    | 1    | 0    | 0    | 1    | 1    | UV mon = 7 %   OV mon = 7 %   SW PD Group4   ILIM min 4.5 A  |
| C5   | OTP_SW5_CONFIG2     | 0    | 0    | 1    | 1    | 1    | 1    | 1    | 0    | L = 1 µH   Phase = 0°   DVS Ramp = 12.5 mV/µs   PG = EN   WDBYPASS = Disable   |
| C6   | OTP_SW6_VOLT        | 1    | 0    | 1    | 1    | 0    | 0    | 0    | 1    | Voltage = 1.8 V  |
| C7   | OTP_SW6_PWRUP       | 0    | 0    | 0    | 0    | 0    | 0    | 1    | 1    | SEQ = Slot 2 (TBASE x 2 = 500 µs)  |
| C8   | OTP_SW6_CONFIG1     | 0    | 1    | 0    | 1    | 0    | 0    | 1    | 1    | UV mon = 7 %   OV mon = 7 %   SW PD Group4   ILIM min 4.5 A  |
| C9   | OTP_SW6_CONFIG2     | 0    | 0    | 1    | 1    | 1    | 1    | 1    | 0    | L = 1 µH   Phase = 0°   DVS Ramp = 12.5 mV/µs   PG = EN   WDBYPASS = Disable   |
| CA   | OTP_SW7_VOLT        | 0    | 0    | 0    | 1    | 0    | 1    | 0    | 1    | Voltage = 3.3 V  |
| CB   | OTP_SW7_PWRUP       | 0    | 0    | 0    | 0    | 0    | 0    | 1    | 1    | SEQ = Slot 2 (TBASE x 2 = 500 µs)  |
| CC   | OTP_SW7_CONFIG1     | 0    | 1    | 0    | 1    | 0    | 0    | 1    | 1    | UV mon = 7 %   OV mon = 7 %   SW PD Group4   ILIM min 4.5 A  |
| CD   | OTP_SW7_CONFIG2     | 0    | 0    | 1    | 1    | 1    | 0    | 1    | 0    | L = 1 µH   Phase = 0°   PG = EN   WDBYPASS = Disable   |
| CE   | OTP_LDO1_VOLT       | 0    | 1    | 0    | 1    | 0    | 0    | 0    | 1    | Voltage = 1.8 V  |
| CF   | OTP_LDO1_PWRUP      | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 1    | SEQ = Slot 0   |
| D0   | OTP_LDO1_CONFIG     | 0    | 0    | 0    | 0    | 0    | 1    | 0    | 0    | LDO PD Group 4   PG = EN   WDBYPASS = Disable   LDO Mode   |
| D1   | OTP_LDO2_VOLT       | 0    | 1    | 0    | 1    | 1    | 0    | 1    | 1    | Voltage = 3.3 V  |

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| ADDR | Register name    | BIT7 | BIT6 | BIT5 | BIT4 | BIT3 | BIT2 | BIT1 | BIT0 | Configuration   |
|------|------------------|------|------|------|------|------|------|------|------|---|
| D2   | OTP LDO2 PWRUP   | 0    | 0    | 0    | 0    | 0    | 0    | 1    | 1    | SEQ = Slot 2 (TBASE x 2 = 500 μs)   |
| D3   | OTP LDO2 CONFIG  | 0    | 0    | 1    | 1    | 0    | 1    | 0    | 0    | LDO PD Group 4   VSELECT = EN   LDO2HW = EN   PG = EN   WDBYPASS = Disable   LDO Mode |
| D4   | OTP LDO3 VOLT    | 0    | 1    | 0    | 1    | 1    | 0    | 1    | 1    | Voltage = 3.3 V   |
| D5   | OTP LDO3 PWRUP   | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | SEQ = OFF   |
| D6   | OTP LDO3 CONFIG  | 0    | 0    | 0    | 0    | 0    | 1    | 0    | 0    | LDO PD Group 4   PG = EN   WDBYPASS = Disable   LDO Mode                              |
| D7   | OTP LDO4 VOLT    | 0    | 1    | 0    | 1    | 1    | 0    | 1    | 1    | Voltage = 3.3 V   |
| D8   | OTP LDO4 PWRUP   | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | SEQ = OFF   |
| D9   | OTP LDO4 CONFIG  | 0    | 0    | 0    | 0    | 0    | 1    | 0    | 0    | LDO PD Group 4   PG = EN   WDBYPASS = Disable   LDO Mode                              |
| DA   | OTP VSNVS CONFIG | 0    | 0    | 0    | 0    | 0    | 0    | 1    | 0    | Voltage = 3.0 V   |
| DB   | OTP OV BYPASS1   | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | OV bypass disabled on all SW regulators   |
| DC   | OTP OV BYPASS2   | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | OV bypass disabled on all LDO regulators  |
| DD   | OTP UV BYPASS1   | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | UV bypass disabled on all SW regulators   |
| DE   | OTP UV BYPASS2   | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | UV bypass disabled on all LDO regulators  |
| DF   | OTP ILIM BYPASS1 | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | ILIM bypass disabled on all SW regulators   |
| E0   | OTP ILIM BYPASS2 | 0    | 0    | 0    | 0    | 0    | 0    | 0    | 0    | ILIM bypass disabled on all LDO regulators  |
| E1   | OTP PROG IDH     | 0    | 0    | 0    | 0    | 1    | 1    | 1    | 1    | Prog ID = 0xFFFF  |
| E2   | OTP PROG IDL     | 1    | 1    | 1    | 1    | 1    | 1    | 1    | 1    | Prog ID = 0xFFFF  |

### 18 IC level quiescent current requirements

**Table 76. Quiescent current requirements**

All parameters are specified at  $T_A = -40$  to  $85$  °C, unless otherwise noted. Typical values are characterized at  $V_{IN} = 5.0$  V and  $T_A = 25$  °C, unless otherwise noted.

| Symbol       | Parameter   | Min | Typ | Max  | Unit |
|--------------|---|-----|-----|------|------|
| $I_{LCELL}$  | Coin cell mode<br>VIN < UVDET<br>VSNVS = 3.0 V or 3.3 V   | —   | 1.0 | 3.0  | μA   |
| $I_{LCELL}$  | Coin cell mode<br>VIN < UVDET<br>VSNVS = 1.8 V  | —   | 5.0 | 7.0  | μA   |
| $I_{LPOFF}$  | LP_Off state<br>LPM_OFF = 0<br>VIN > UVDET<br>VSNVS = ON  | —   | 40  | 150  | μA   |
| $I_{QPUOFF}$ | QPU_Off<br>LPM_OFF = 1<br>System ready to power on  | —   | 750 | 1000 | μA   |
| $I_{SYSON}$  | System on core current<br>Run or standby and all regulators disabled<br>Coin cell charger disabled<br>AMUX disabled | —   | 750 | 1000 | μA   |

19 Typical applications

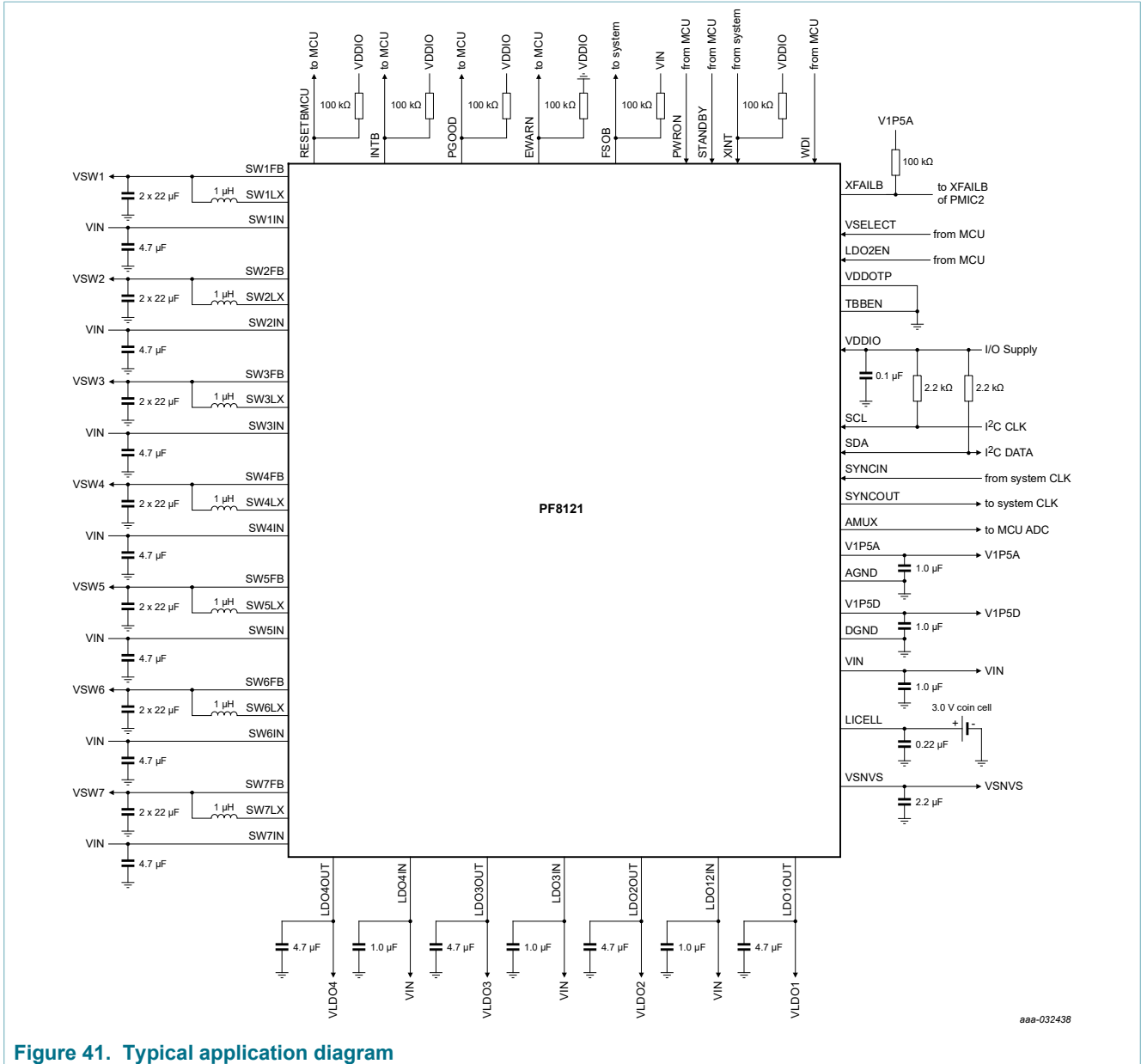


Figure 41. Typical application diagram

20 Package information

20.1 Package outline for E-type HVQFN56

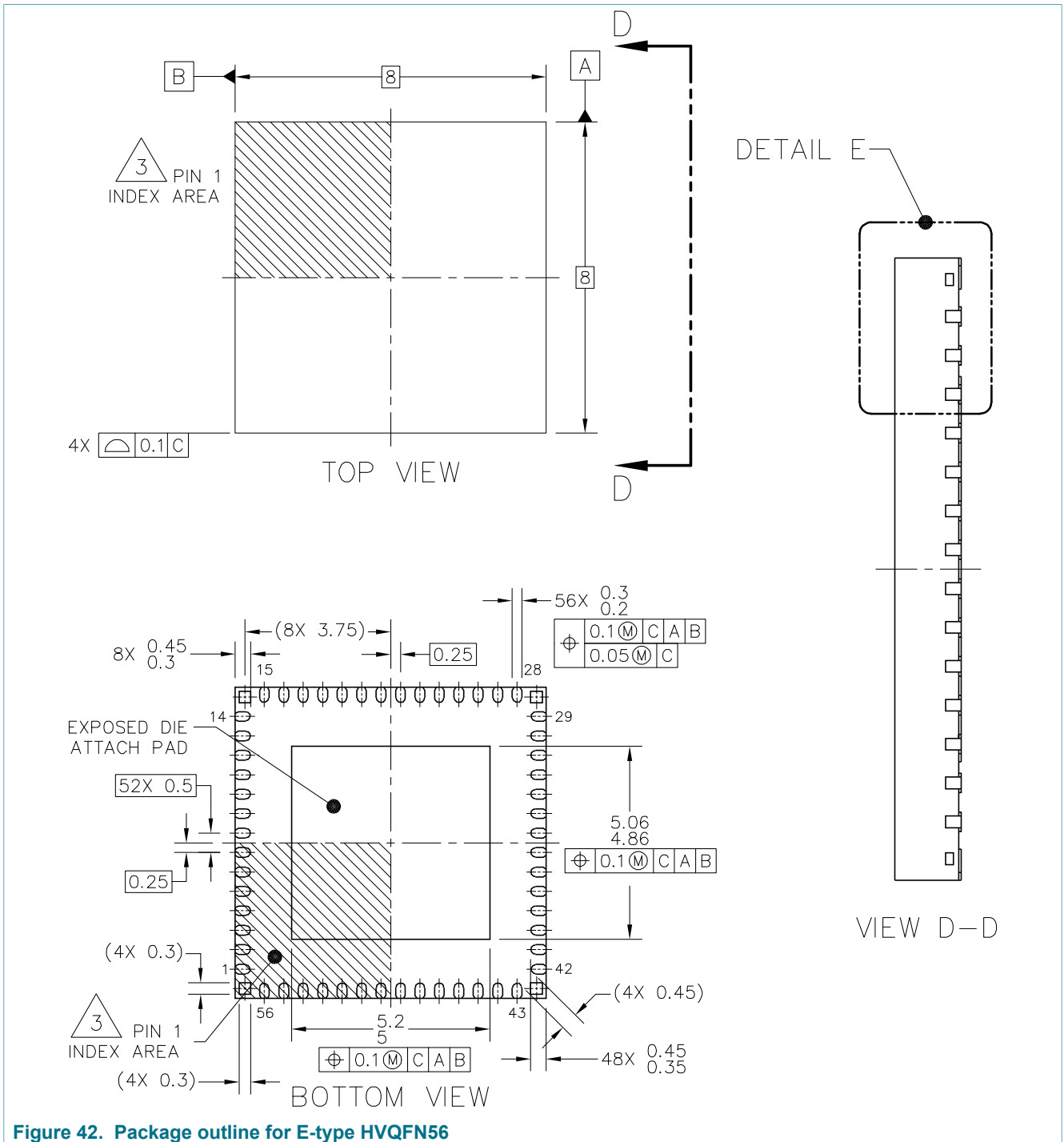


Figure 42. Package outline for E-type HVQFN56



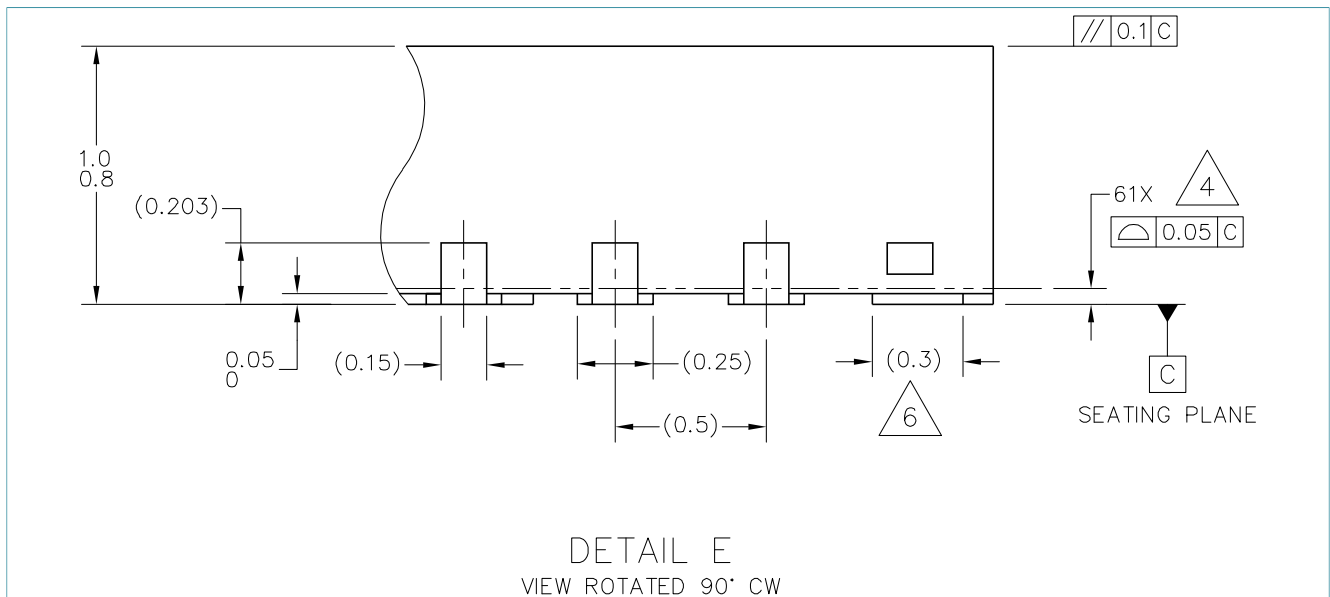


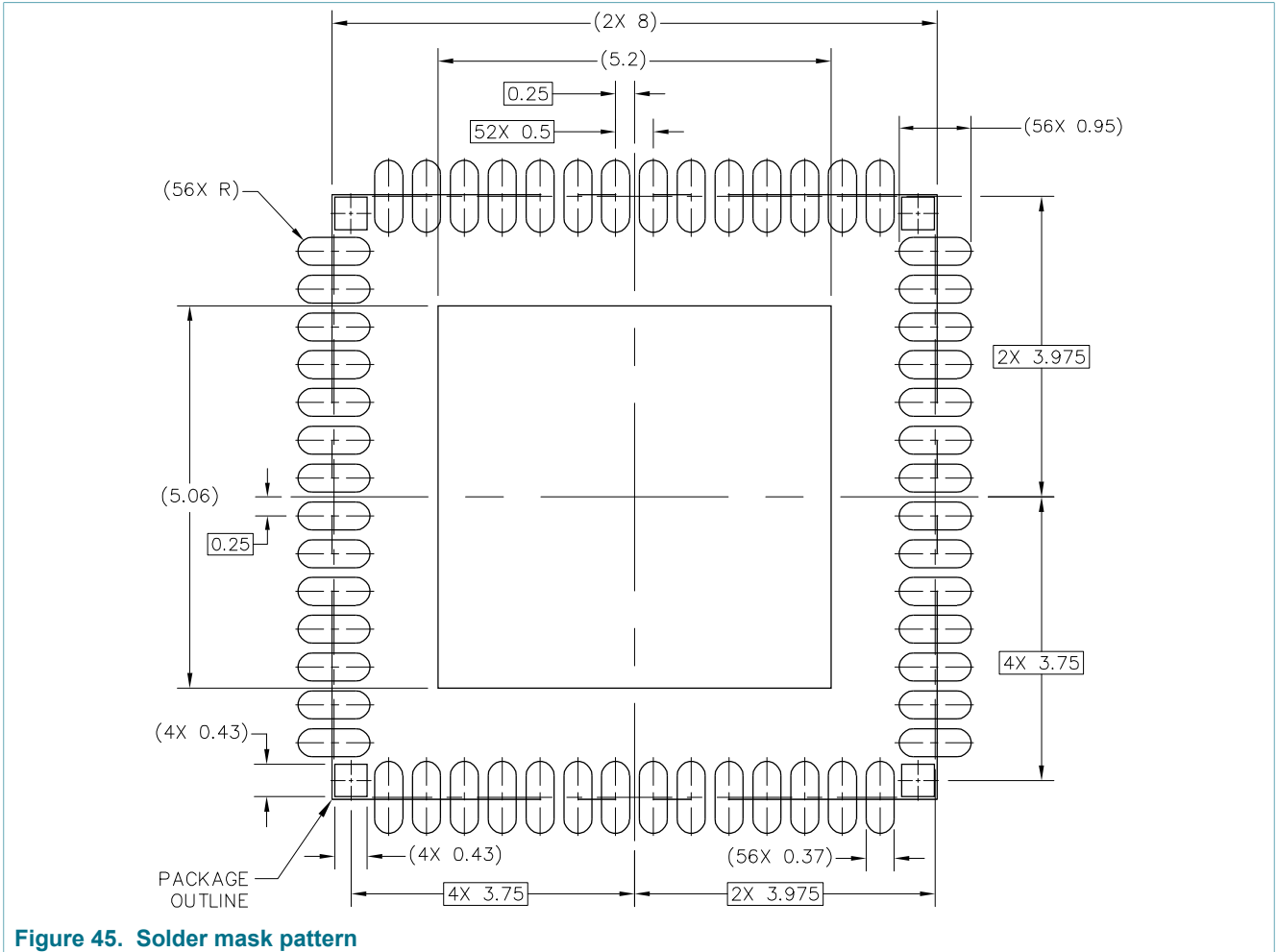
Figure 43. Package outline detail for E-type HVQFN56

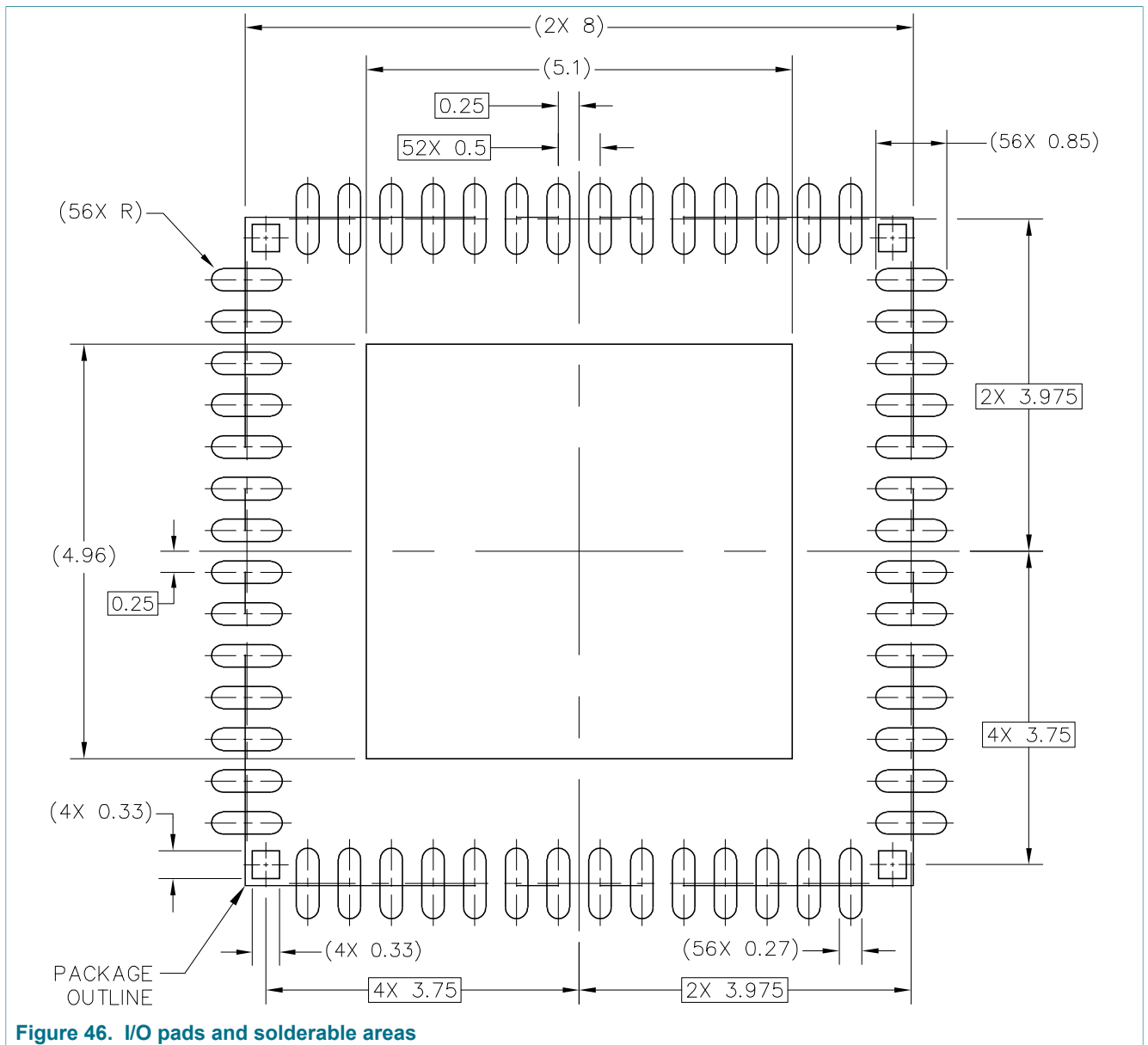
NOTES:

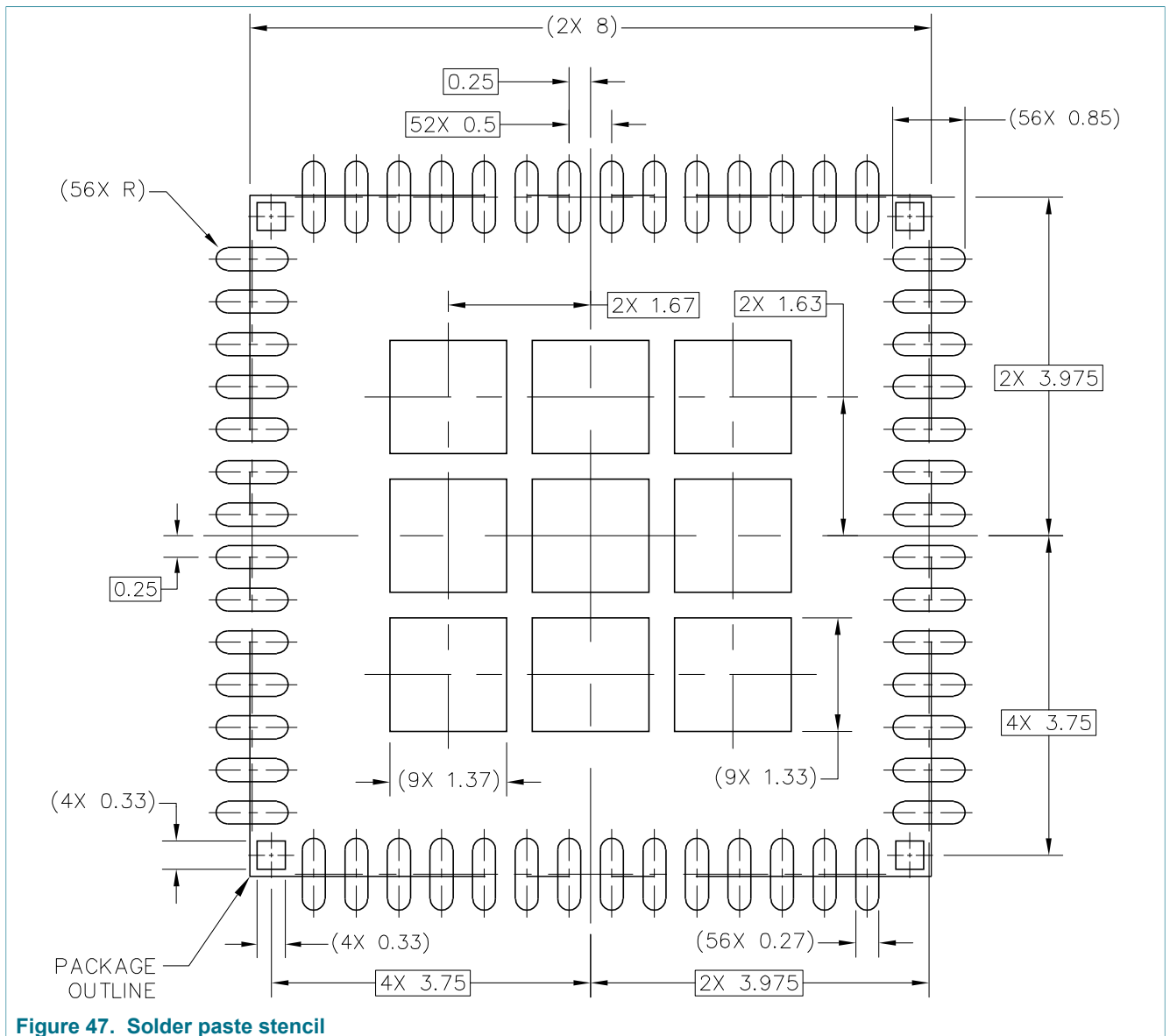
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994.
3. PIN 1 FEATURE SHAPE, SIZE AND LOCATION MAY VARY.
4. COPLANARITY APPLIES TO LEADS, DIE ATTACH FLAG AND CORNER NON-FUNCTIONAL PADS.
5. MIN. METAL GAP SHOULD BE 0.25 MM.
6. ANCHORING PADS.

Figure 44. Package outline notes for E-type HVQFN56

20.2 PCB design guidelines for E-type HVQFN56







## 21 Revision history

**Table 77. Revision history**

| Document ID   | Release date   | Data sheet status      | Change notice  | Supersedes   |
|---------------|--|------------------------|----------------|--------------|
| PF8121 v.3.0  | 20200323   | Product data sheet     | CIN 202003030I | PF8121 v.2.0 |
| Modifications | • <a href="#">Table 2</a> : corrected comments / nomenclature for MC32PF8121EUEP part (replaced BUCK7 by SW7, and BUCK3 by SW4) and added MC32PF8121G5EP part number |                        |                |              |
| PF8121 v.2.0  | 20190429   | Product data sheet     | —              | PF8121 v.1.0 |
| Modifications | • Global: changed document status from Preliminary to Product  |                        |                |              |
| PF8121 v.1.0  | 20190419   | Preliminary data sheet | —              | —            |

## 22 Legal information

### 22.1 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.                                     |

[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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## 12-channel power management integrated circuit for high performance applications

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