



**THE DATASHEET OF  
PCF2127T/2Y**





# PCF2127

Accurate RTC with integrated quartz crystal for industrial applications

Rev. 8 — 19 December 2014

Product data sheet

## 1. General description

The PCF2127 is a CMOS<sup>1</sup> Real Time Clock (RTC) and calendar with an integrated Temperature Compensated Crystal (Xtal) Oscillator (TCXO) and a 32.768 kHz quartz crystal optimized for very high accuracy and very low power consumption. The PCF2127 has 512 bytes of general-purpose static RAM, a selectable I<sup>2</sup>C-bus or SPI-bus, a backup battery switch-over circuit, a programmable watchdog function, a timestamp function, and many other features.

For a selection of NXP Real-Time Clocks, see [Table 94 on page 89](#)

## 2. Features and benefits

- UL Recognized Component
- Operating temperature range from  $-40\text{ }^{\circ}\text{C}$  to  $+85\text{ }^{\circ}\text{C}$
- Temperature Compensated Crystal Oscillator (TCXO) with integrated capacitors
- Typical accuracy:
  - ◆ PCF2127AT:  $\pm 3$  ppm from  $-15\text{ }^{\circ}\text{C}$  to  $+60\text{ }^{\circ}\text{C}$
  - ◆ PCF2127T:  $\pm 3$  ppm from  $-30\text{ }^{\circ}\text{C}$  to  $+80\text{ }^{\circ}\text{C}$
- Integration of a 32.768 kHz quartz crystal and oscillator in the same package
- Provides year, month, day, weekday, hours, minutes, seconds, and leap year correction
- 512 bytes of general-purpose static RAM
- Timestamp function
  - ◆ with interrupt capability
  - ◆ detection of two different events on one multilevel input pin (for example, for tamper detection)
- Two line bidirectional 400 kHz Fast-mode I<sup>2</sup>C-bus interface
- 3 line SPI-bus with separate data input and output (maximum speed 6.5 Mbit/s)
- Battery backup input pin and switch-over circuitry
- Battery backed output voltage
- Battery low detection function
- Extra power fail detection function with input and output pins
- Power-On Reset Override (PORO)
- Oscillator stop detection function
- Interrupt output (open-drain)

1. The definition of the abbreviations and acronyms used in this data sheet can be found in [Section 21](#).



- Programmable 1 second or 1 minute interrupt
- Programmable watchdog timer with interrupt
- Programmable alarm function with interrupt capability
- Programmable square wave output pin
- Programmable countdown timer with interrupt
- Clock operating voltage: 1.8 V to 4.2 V
- Low supply current: typical 0.70  $\mu$ A at  $V_{DD} = 3.3$  V

### 3. Applications

- Electronic metering for electricity, water, and gas
- Precision timekeeping
- Access to accurate time of the day
- GPS equipment to reduce time to first fix
- Applications that require an accurate process timing
- Products with long automated unattended operation time

### 4. Ordering information

Table 1. Ordering information

| Type number | Package |  |          |
|-------------|---------|--|----------|
|             | Name    | Description  | Version  |
| PCF2127AT   | SO20    | plastic small outline package; 20 leads; body width 7.5 mm | SOT163-1 |
| PCF2127T    | SO16    | plastic small outline package; 16 leads; body width 7.5 mm | SOT162-1 |

#### 4.1 Ordering options

Table 2. Ordering options

| Product type number | Orderable part number | Sales item (12NC) | Delivery form                    | IC revision |
|---------------------|-----------------------|-------------------|----------------------------------|-------------|
| PCF2127AT/2         | PCF2127AT/2Y          | 935299867518      | tape and reel, 13 inch, dry pack | 2           |
| PCF2127T/2          | PCF2127T/2Y           | 935299866518      | tape and reel, 13 inch, dry pack | 2           |

### 5. Marking

Table 3. Marking codes

| Product type number | Marking code |
|---------------------|--------------|
| PCF2127AT/2         | PCF2127AT    |
| PCF2127T/2          | PCF2127T     |

6. Block diagram

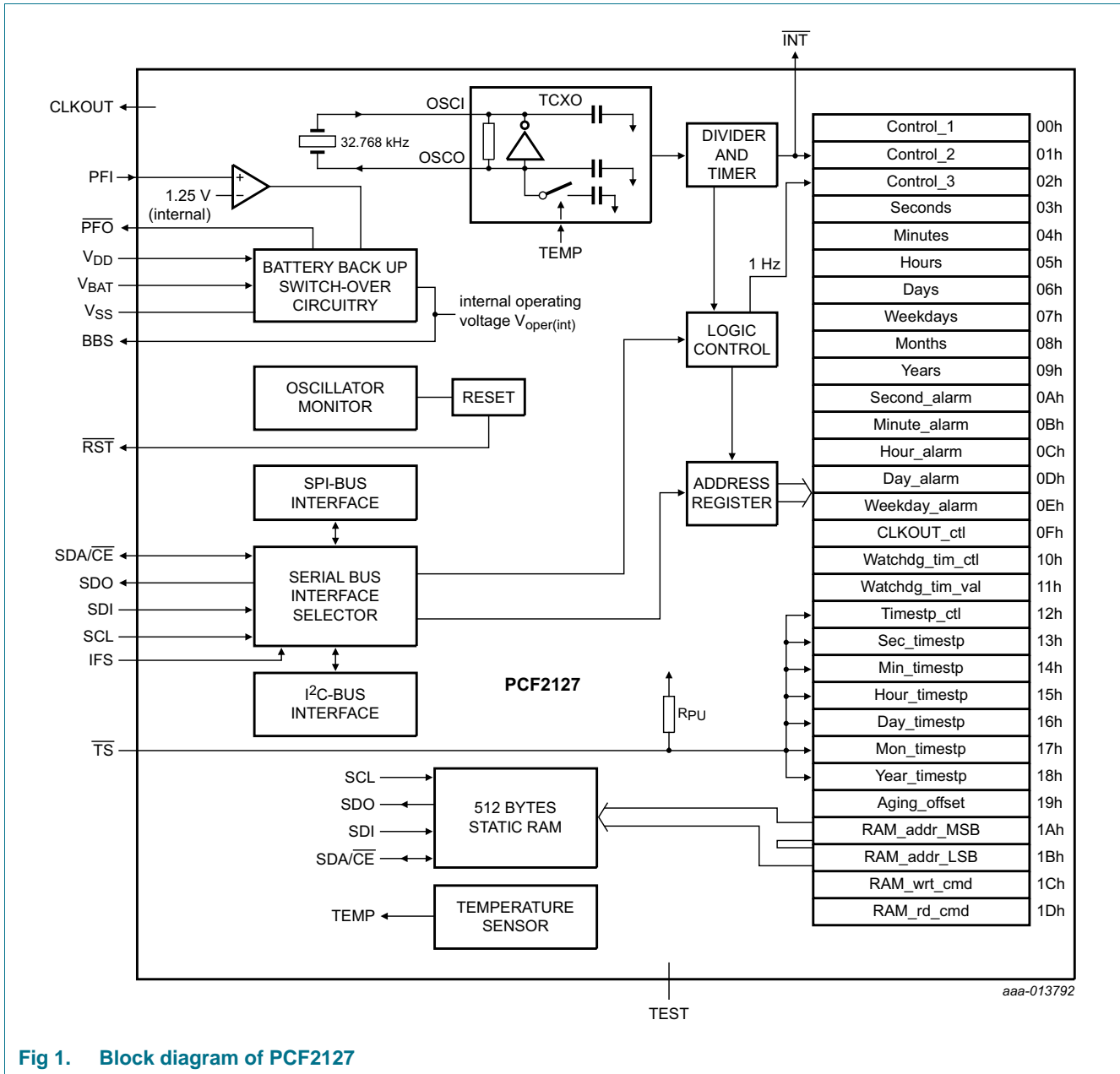
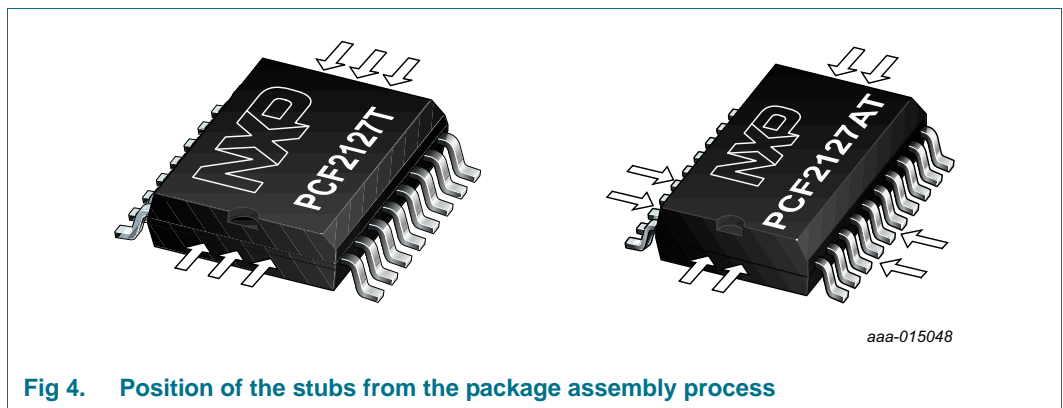
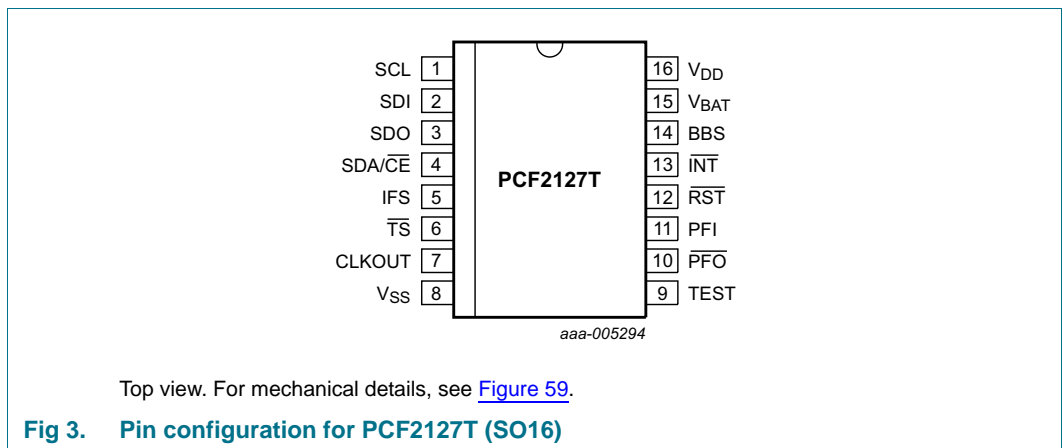
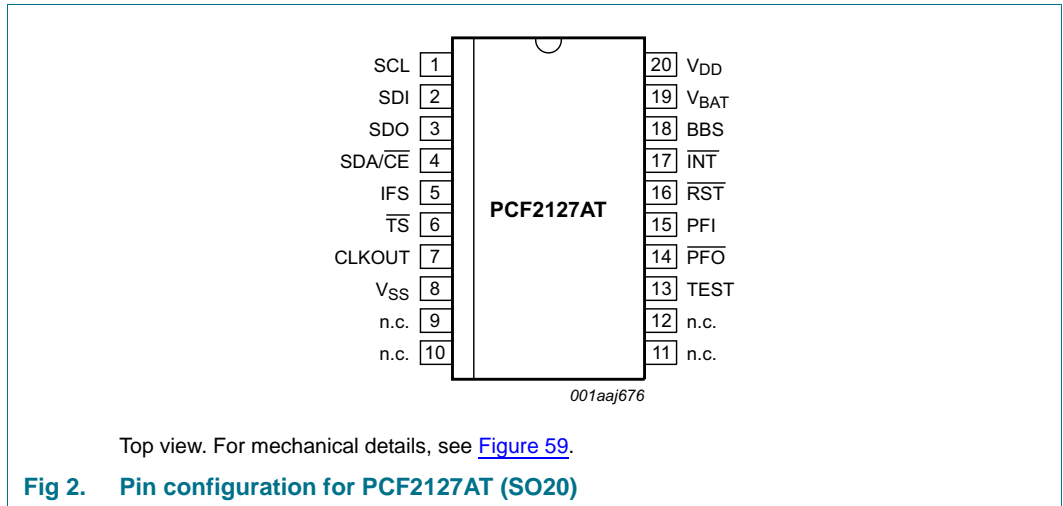


Fig 1. Block diagram of PCF2127

## 7. Pinning information

### 7.1 Pinning



After lead forming and cutting, there remain stubs from the package assembly process. These stubs are present at the edge of the package as illustrated in [Figure 4](#). The stubs are at an electrical potential. To avoid malfunction of the PCF2127, it has to be ensured that they are not shorted with another electrical potential (e.g. by condensation).

## 7.2 Pin description

**Table 4. Pin description of PCF2127**

*Input or input/output pins must always be at a defined level ( $V_{SS}$  or  $V_{DD}$ ) unless otherwise specified.*

| Symbol               | Pin       |          | Description  |
|----------------------|-----------|----------|--|
|                      | PCF2127AT | PCF2127T |  |
| SCL                  | 1         | 1        | combined serial clock input for both I <sup>2</sup> C-bus and SPI-bus  |
| SDI                  | 2         | 2        | serial data input for SPI-bus<br>connect to pin $V_{SS}$ if I <sup>2</sup> C-bus is selected                                       |
| SDO                  | 3         | 3        | serial data output for SPI-bus, push-pull  |
| SDA/ $\overline{CE}$ | 4         | 4        | combined serial data input and output for the I <sup>2</sup> C-bus and chip enable input (active LOW) for the SPI-bus              |
| IFS                  | 5         | 5        | interface selector input<br>connect to pin $V_{SS}$ to select the SPI-bus<br>connect to pin BBS to select the I <sup>2</sup> C-bus |
| $\overline{TS}$      | 6         | 6        | timestamp input (active LOW) with 200 k $\Omega$ internal pull-up resistor ( $R_{PU}$ )  |
| CLKOUT               | 7         | 7        | clock output (open-drain)  |
| $V_{SS}$             | 8         | 8        | ground supply voltage  |
| n.c.                 | 9 to 12   | -        | not connected; do not connect; do not use as feed through  |
| TEST                 | 13        | 9        | do not connect; do not use as feed through   |
| $\overline{PFO}$     | 14        | 10       | power fail output (open-drain; active LOW)   |
| PFI                  | 15        | 11       | power fail input   |
| $\overline{RST}$     | 16        | 12       | reset output (open-drain; active LOW)  |
| $\overline{INT}$     | 17        | 13       | interrupt output (open-drain; active LOW)  |
| BBS                  | 18        | 14       | output voltage (battery backed)  |
| $V_{BAT}$            | 19        | 15       | battery supply voltage (backup)<br>connect to $V_{SS}$ if battery switch-over is not used  |
| $V_{DD}$             | 20        | 16       | supply voltage   |

## 8. Functional description

The PCF2127 is a Real Time Clock (RTC) and calendar with an on-chip Temperature Compensated Crystal (Xtal) Oscillator (TCXO) and a 32.768 kHz quartz crystal integrated into the same package (see [Section 8.3.3](#)).

Address and data are transferred by a selectable 400 kHz Fast-mode I<sup>2</sup>C-bus or a 3 line SPI-bus with separate data input and output (see [Section 9](#)). The maximum speed of the SPI-bus is 6.5 Mbit/s.

The PCF2127 has a backup battery input pin and backup battery switch-over circuit which monitors the main power supply. The backup battery switch-over circuit automatically switches to the backup battery when a power failure condition is detected (see [Section 8.6.1](#)). Accurate timekeeping is maintained even when the main power supply is interrupted.

A battery low detection circuit monitors the status of the battery (see [Section 8.6.2](#)). When the battery voltage drops below a certain threshold value, a flag is set to indicate that the battery must be replaced soon. This ensures the integrity of the data during periods of battery backup.

### 8.1 Register overview

The PCF2127 contains an auto-incrementing address register: the built-in address register will increment automatically after each read or write of a data byte up to the register 1Bh. After register 1Bh, the auto-incrementing will wrap around to address 00h (see [Figure 5](#)).

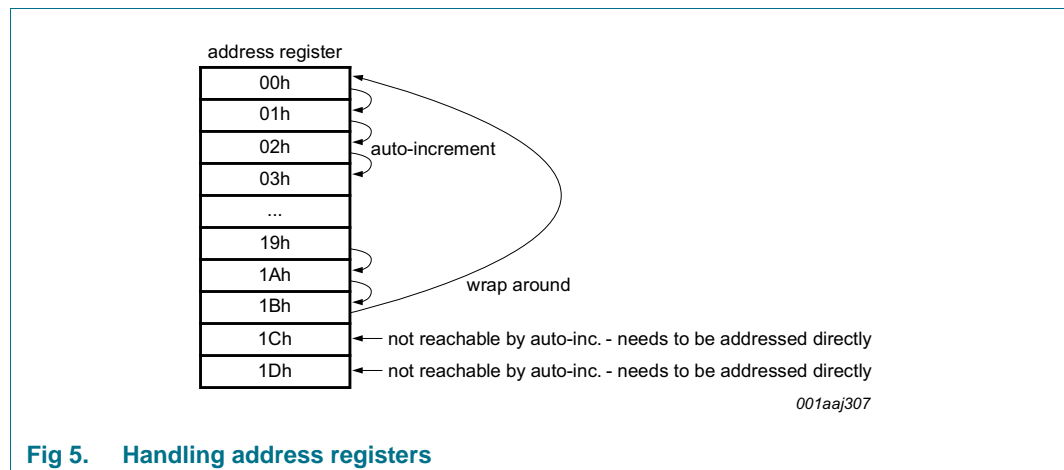


Fig 5. Handling address registers

- The first three registers (memory address 00h, 01h, and 02h) are used as control registers (see [Section 8.2](#)).
- The memory addresses 03h through to 09h are used as counters for the clock function (seconds up to years). The date is automatically adjusted for months with fewer than 31 days, including corrections for leap years. The clock can operate in 12-hour mode with an AM/PM indication or in 24-hour mode (see [Section 8.9](#)).
- The registers at addresses 0Ah through 0Eh define the alarm function. It can be selected that an interrupt is generated when an alarm event occurs (see [Section 8.10](#)).

- The register at address 0Fh defines the temperature measurement period and the clock out mode. The temperature measurement can be selected from every 4 minutes (default) down to every 30 seconds (see [Table 14](#)). CLKOUT frequencies of 32.768 kHz (default) down to 1 Hz for use as system clock, microcontroller clock, and so on, can be chosen (see [Table 15](#)).
- The registers at addresses 10h and 11h are used for the watchdog and countdown timer functions. The watchdog timer has four selectable source clocks allowing for timer periods from less than 1 ms to greater than 4 hours (see [Table 58](#)). Either the watchdog timer or the countdown timer can be enabled (see [Section 8.11](#)). For the watchdog timer, it is possible to select whether an interrupt or a pulse on the reset pin is generated when the watchdog times out. For the countdown timer, it is only possible that an interrupt is generated at the end of the countdown.
- The registers at addresses 12h to 18h are used for the timestamp function. When the trigger event happens, the actual time is saved in the timestamp registers (see [Section 8.12](#)).
- The register at address 19h is used for the correction of the crystal aging effect (see [Section 8.4.1](#)).
- The registers at addresses 1Ah and 1Bh define the RAM address. The register at address 1Ch (RAM\_wrt\_cmd) is the RAM write command; register 1Dh (RAM\_rd\_cmd) is the RAM read command. Data is transferred to or from the RAM by the serial interface (see [Section 8.5](#)).
- The registers Seconds, Minutes, Hours, Days, Months, and Years are all coded in Binary Coded Decimal (BCD) format to simplify application use. Other registers are either bit-wise or standard binary.

When one of the RTC registers is written or read, the content of all counters is temporarily frozen. This prevents a faulty writing or reading of the clock and calendar during a carry condition (see [Section 8.9.8](#)).

**Table 5. Register overview**

Bit positions labeled as - are not implemented and return 0 when read. Bits labeled as T must always be written with logic 0. Bits labeled as power-on and unchanged by subsequent resets.

| Address                        | Register name    | Bit                    |                        |      |                                      |           |             |      |         | Reset value |        |
|--------------------------------|------------------|------------------------|------------------------|------|--------------------------------------|-----------|-------------|------|---------|-------------|--------|
|                                |                  | 7                      | 6                      | 5    | 4                                    | 3         | 2           | 1    | 0       |             |        |
| <b>Control registers</b>       |                  |                        |                        |      |                                      |           |             |      |         |             |        |
| 00h                            | Control_1        | EXT_TEST               | T                      | STOP | TSF1                                 | POR_OVRD  | 12_24       | MI   | SI      | 0000 10     |        |
| 01h                            | Control_2        | MSF                    | WDTF                   | TSF2 | AF                                   | CDTF      | TSIE        | AIE  | CDTIE   | 0000 00     |        |
| 02h                            | Control_3        | PWRMNG[2:0]            |                        | BTSE | BF                                   | BLF       | BIE         | BLIE | 0000 00 |             |        |
| <b>Time and date registers</b> |                  |                        |                        |      |                                      |           |             |      |         |             |        |
| 03h                            | Seconds          | OSF                    | SECONDS (0 to 59)      |      | 1XXX X                               |           |             |      |         |             |        |
| 04h                            | Minutes          | -                      | MINUTES (0 to 59)      |      | -XXX X                               |           |             |      |         |             |        |
| 05h                            | Hours            | -                      | -                      | AMPM | HOURS (1 to 12) in 12-hour mode      |           | - - XX X    |      |         |             |        |
| 06h                            | Days             | -                      | -                      | -    | HOURS (0 to 23) in 24-hour mode      |           | - - XX X    |      |         |             |        |
| 07h                            | Weekdays         | -                      | -                      | -    | DAYS (1 to 31)                       |           | - - - - - X |      |         |             |        |
| 08h                            | Months           | -                      | -                      | -    | WEEKDAYS (0 to 6)                    |           | - - - X X   |      |         |             |        |
| 09h                            | Years            | -                      | -                      | -    | MONTHS (1 to 12)                     |           | XXXX X      |      |         |             |        |
| 09h                            | Years            | -                      | -                      | -    | YEARS (0 to 99)                      |           | XXXX X      |      |         |             |        |
| <b>Alarm registers</b>         |                  |                        |                        |      |                                      |           |             |      |         |             |        |
| 0Ah                            | Second_alarm     | AE_S                   | SECOND_ALARM (0 to 59) |      | 1XXX X                               |           |             |      |         |             |        |
| 0Bh                            | Minute_alarm     | AE_M                   | MINUTE_ALARM (0 to 59) |      | 1XXX X                               |           |             |      |         |             |        |
| 0Ch                            | Hour_alarm       | AE_H                   | -                      | AMPM | HOUR_ALARM (1 to 12) in 12-hour mode |           | 1 - XX X    |      |         |             |        |
| 0Dh                            | Day_alarm        | AE_D                   | -                      | -    | HOUR_ALARM (0 to 23) in 24-hour mode |           | 1 - XX X    |      |         |             |        |
| 0Eh                            | Weekday_alarm    | AE_W                   | -                      | -    | DAY_ALARM (1 to 31)                  |           | 1 - XX X    |      |         |             |        |
| 0Eh                            | Weekday_alarm    | AE_W                   | -                      | -    | WEEKDAY_ALARM (0 to 6)               |           | 1 - - - - > |      |         |             |        |
| <b>CLKOUT control register</b> |                  |                        |                        |      |                                      |           |             |      |         |             |        |
| 0Fh                            | CLKOUT_ctl       | TCR[1:0]               | OTPR                   | -    | COF[2:0]                             | 00X - - C |             |      |         |             |        |
| <b>watchdog registers</b>      |                  |                        |                        |      |                                      |           |             |      |         |             |        |
| 10h                            | Watchdog_tim_ctl | WD_CD[1:0]             | TI_TP                  | -    | TF[1:0]                              | 000 - - - |             |      |         |             |        |
| 11h                            | Watchdog_tim_val | WATCHDGDG_TIM_VAL[7:0] |                        |      |                                      |           |             |      |         |             | XXXX X |
| <b>Timestamp registers</b>     |                  |                        |                        |      |                                      |           |             |      |         |             |        |
| 12h                            | Timestamp_ctl    | TSM                    | TSOFF                  | -    | 1_O_16_TIMESTP[4:0]                  |           | 00 - X X    |      |         |             |        |

**Table 5. Register overview ...continued**

Bit positions labeled as - are not implemented and return 0 when read. Bits labeled as T must always be written with logic 0. Bits labeled as power-on and unchanged by subsequent resets.

| Address                      | Register name | Bit |   |      |  |   |         |   |   | Reset value                   |        |
|------------------------------|---------------|-----|---|------|--|---|---------|---|---|-------------------------------|--------|
|                              |               | 7   | 6 | 5    | 4  | 3 | 2       | 1 | 0 |                               |        |
| 13h                          | Sec_timestp   | -   |   |      | SECOND_TIMESTP (0 to 59)   |   |         |   |   | - XXX X                       |        |
| 14h                          | Min_timestp   | -   |   |      | MINUTE_TIMESTP (0 to 59)   |   |         |   |   | - XXX X                       |        |
| 15h                          | Hour_timestp  | -   | - | AMPM | HOUR_TIMESTP (1 to 12) in 12-hour mode<br>HOUR_TIMESTP (0 to 23) in 24-hour mode |   |         |   |   | -- XX X<br>-- XX X<br>-- XX X |        |
| 16h                          | Day_timestp   | -   | - |      | DAY_TIMESTP (1 to 31)  |   |         |   |   | -- XX X                       |        |
| 17h                          | Mon_timestp   | -   | - | -    | MONTH_TIMESTP (1 to 12)  |   |         |   |   | --- X X                       |        |
| 18h                          | Year_timestp  |     |   |      | YEAR_TIMESTP (0 to 99)   |   |         |   |   | XXXX X                        |        |
| <b>Aging offset register</b> |               |     |   |      |  |   |         |   |   |                               |        |
| 19h                          | Aging_offset  | -   | - | -    | -  | - | AO[3:0] |   |   | ---- 10                       |        |
| <b>RAM registers</b>         |               |     |   |      |  |   |         |   |   |                               |        |
| 1Ah                          | RAM_addr_MSB  | -   | - | -    | -  | - | -       | - | - | RA8                           | -----  |
| 1Bh                          | RAM_addr_LSB  |     |   |      | RA[7:0]  |   |         |   |   | 0000 00                       |        |
| 1Ch                          | RAM_wrt_cmd   | X   | X | X    | X  | X | X       | X | X | X                             | XXXX X |
| 1Dh                          | RAM_rd_cmd    | X   | X | X    | X  | X | X       | X | X | X                             | XXXX X |

## 8.2 Control registers

The first 3 registers of the PCF2127, with the addresses 00h, 01h, and 02h, are used as control registers.

### 8.2.1 Register Control\_1

**Table 6. Control\_1 - control and status register 1 (address 00h) bit allocation**

Bits labeled as T must always be written with logic 0.

| Bit         | 7        | 6 | 5    | 4    | 3        | 2     | 1  | 0  |
|-------------|----------|---|------|------|----------|-------|----|----|
| Symbol      | EXT_TEST | T | STOP | TSF1 | POR_OVRD | 12_24 | MI | SI |
| Reset value | 0        | 0 | 0    | 0    | 1        | 0     | 0  | 0  |

**Table 7. Control\_1 - control and status register 1 (address 00h) bit description**

Bits labeled as T must always be written with logic 0.

| Bit | Symbol   | Value | Description  | Reference  |
|-----|----------|-------|--|--|
| 7   | EXT_TEST | 0     | normal mode  | <a href="#">Section 8.14</a>   |
|     |          | 1     | external clock test mode   |  |
| 6   | T        | 0     | unused   | -  |
| 5   | STOP     | 0     | RTC source clock runs  | <a href="#">Section 8.15</a>   |
|     |          | 1     | RTC clock is stopped;<br>RTC divider chain flip-flops are asynchronously set logic 0;<br>CLKOUT at 32.768 kHz, 16.384 kHz, or 8.192 kHz is still available |  |
| 4   | TSF1     | 0     | no timestamp interrupt generated   | <a href="#">Section 8.12.1</a>   |
|     |          | 1     | flag set when $\overline{TS}$ input is driven to an intermediate level between power supply and ground;<br>flag must be cleared to clear interrupt         |  |
| 3   | POR_OVRD | 0     | Power-On Reset Override (PORO) facility disabled;<br><b>set logic 0 for normal operation</b>   | <a href="#">Section 8.8.2</a>  |
|     |          | 1     | Power-On Reset Override (PORO) sequence reception enabled  |  |
| 2   | 12_24    | 0     | 24-hour mode selected  | <a href="#">Table 33,</a><br><a href="#">Table 49,</a><br><a href="#">Table 74</a> |
|     |          | 1     | 12-hour mode selected  |  |
| 1   | MI       | 0     | minute interrupt disabled  | <a href="#">Section 8.13.1</a>   |
|     |          | 1     | minute interrupt enabled   |  |
| 0   | SI       | 0     | second interrupt disabled  |  |
|     |          | 1     | second interrupt enabled   |  |

## 8.2.2 Register Control\_2

**Table 8. Control\_2 - control and status register 2 (address 01h) bit allocation**

| Bit         | 7   | 6    | 5    | 4  | 3    | 2    | 1   | 0     |
|-------------|-----|------|------|----|------|------|-----|-------|
| Symbol      | MSF | WDTF | TSF2 | AF | CDTF | TSIE | AIE | CDTIE |
| Reset value | 0   | 0    | 0    | 0  | 0    | 0    | 0   | 0     |

**Table 9. Control\_2 - control and status register 2 (address 01h) bit description**

| Bit | Symbol | Value | Description   | Reference                      |
|-----|--------|-------|---|--------------------------------|
| 7   | MSF    | 0     | no minute or second interrupt generated   | <a href="#">Section 8.13</a>   |
|     |        | 1     | flag set when minute or second interrupt generated;<br>flag must be cleared to clear interrupt              |                                |
| 6   | WDTF   | 0     | no watchdog timer interrupt or reset generated  | <a href="#">Section 8.13.4</a> |
|     |        | 1     | flag set when watchdog timer interrupt or reset generated;<br>flag cannot be cleared by command (read-only) |                                |
| 5   | TSF2   | 0     | no timestamp interrupt generated  | <a href="#">Section 8.12.1</a> |
|     |        | 1     | flag set when $\overline{\text{TS}}$ input is driven to ground;<br>flag must be cleared to clear interrupt  |                                |
| 4   | AF     | 0     | no alarm interrupt generated  | <a href="#">Section 8.10.6</a> |
|     |        | 1     | flag set when alarm triggered;<br>flag must be cleared to clear interrupt                                   |                                |
| 3   | CDTF   | 0     | no countdown timer interrupt generated  | <a href="#">Section 8.11.4</a> |
|     |        | 1     | flag set when countdown timer interrupt generated;<br>flag must be cleared to clear interrupt               |                                |
| 2   | TSIE   | 0     | no interrupt generated from timestamp flag  | <a href="#">Section 8.13.6</a> |
|     |        | 1     | interrupt generated when timestamp flag set   |                                |
| 1   | AIE    | 0     | no interrupt generated from the alarm flag  | <a href="#">Section 8.13.5</a> |
|     |        | 1     | interrupt generated when alarm flag set   |                                |
| 0   | CDTIE  | 0     | no interrupt generated from countdown timer flag  | <a href="#">Section 8.13.2</a> |
|     |        | 1     | interrupt generated when countdown timer flag set   |                                |

### 8.2.3 Register Control\_3

**Table 10. Control\_3 - control and status register 3 (address 02h) bit allocation**

| Bit         | 7           | 6 | 5 | 4    | 3  | 2   | 1   | 0    |
|-------------|-------------|---|---|------|----|-----|-----|------|
| Symbol      | PWRMNG[2:0] |   |   | BTSE | BF | BLF | BIE | BLIE |
| Reset value | 0           | 0 | 0 | 0    | 0  | 0   | 0   | 0    |

**Table 11. Control\_3 - control and status register 3 (address 02h) bit description**

| Bit    | Symbol      | Value                        | Description   | Reference  |
|--------|-------------|------------------------------|---|--|
| 7 to 5 | PWRMNG[2:0] | see <a href="#">Table 25</a> | control of the battery switch-over, battery low detection, and extra power fail detection functions | <a href="#">Section 8.6</a>  |
| 4      | BTSE        | 0                            | no timestamp when battery switch-over occurs  | <a href="#">Section 8.12.4</a>   |
|        |             | 1                            | time-stamped when battery switch-over occurs  |  |
| 3      | BF          | 0                            | no battery switch-over interrupt generated  | <a href="#">Section 8.6.1</a><br>and<br><a href="#">Section 8.12.4</a> |
|        |             | 1                            | flag set when battery switch-over occurs;<br>flag must be cleared to clear interrupt                |  |
| 2      | BLF         | 0                            | battery status ok;<br>no battery low interrupt generated  | <a href="#">Section 8.6.2</a>  |
|        |             | 1                            | battery status low;<br>flag cannot be cleared by command  |  |
| 1      | BIE         | 0                            | no interrupt generated from the battery flag (BF)   | <a href="#">Section 8.13.7</a>   |
|        |             | 1                            | interrupt generated when BF is set  |  |
| 0      | BLIE        | 0                            | no interrupt generated from battery low flag (BLF)  | <a href="#">Section 8.13.8</a>   |
|        |             | 1                            | interrupt generated when BLF is set   |  |

### 8.3 Register CLKOUT\_ctl

**Table 12. CLKOUT\_ctl - CLKOUT control register (address 0Fh) bit allocation**

Bit positions labeled as - are not implemented and return 0 when read. Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit         | 7        | 6 | 5    | 4 | 3 | 2        | 1 | 0 |
|-------------|----------|---|------|---|---|----------|---|---|
| Symbol      | TCR[1:0] |   | OTPR | - | - | COF[2:0] |   |   |
| Reset value | 0        | 0 | X    | - | - | 0        | 0 | 0 |

**Table 13. CLKOUT\_ctl - CLKOUT control register (address 0Fh) bit description**

Bit positions labeled as - are not implemented and return 0 when read. Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit    | Symbol   | Value                        | Description                    |
|--------|----------|------------------------------|--------------------------------|
| 7 to 6 | TCR[1:0] | see <a href="#">Table 14</a> | temperature measurement period |
| 5      | OTPR     | 0                            | no OTP refresh                 |
|        |          | 1                            | OTP refresh performed          |
| 4 to 3 | -        | -                            | unused                         |
| 2 to 0 | COF[2:0] | see <a href="#">Table 15</a> | CLKOUT frequency selection     |

**8.3.1 Temperature compensated crystal oscillator**

The frequency of tuning fork quartz crystal oscillators is temperature-dependent. In the PCF2127, the frequency deviation caused by temperature variation is corrected by adjusting the load capacitance of the crystal oscillator.

The load capacitance is changed by switching between two load capacitance values using a modulation signal with a programmable duty cycle. In order to compensate the spread of the quartz parameters every chip is factory calibrated.

The frequency accuracy can be evaluated by measuring the frequency of the square wave signal available at the output pin CLKOUT. However, the selection of  $f_{CLKOUT} = 32.768$  kHz (default value) leads to inaccurate measurements. Accurate frequency measurement occurs when  $f_{CLKOUT} = 16.384$  kHz or lower is selected (see [Table 15](#)).

**8.3.1.1 Temperature measurement**

The PCF2127 has a temperature sensor circuit used to perform the temperature compensation of the frequency. The temperature is measured immediately after power-on and then periodically with a period set by the temperature conversion rate TCR[1:0] in the register CLKOUT\_ctl.

**Table 14. Temperature measurement period**

| TCR[1:0] | Temperature measurement period |
|----------|--------------------------------|
| 00       | <a href="#">[1]</a> 4 min      |
| 01       | 2 min                          |
| 10       | 1 min                          |
| 11       | 30 seconds                     |

[1] Default value.

**8.3.2 OTP refresh**

Each IC is calibrated during production and testing of the device. The calibration parameters are stored on EPROM cells called One Time Programmable (OTP) cells. It is recommended to process an OTP refresh once after the power is up and the oscillator is operating stable. The OTP refresh takes less than 100 ms to complete.

To perform an OTP refresh, bit OTPR has to be cleared (set to logic 0) and then set to logic 1 again.

**8.3.3 Clock output**

A programmable square wave is available at pin CLKOUT. Operation is controlled by the COF[2:0] control bits in register CLKOUT\_ctl. Frequencies of 32.768 kHz (default) down to 1 Hz can be generated for use as system clock, microcontroller clock, charge pump input, or for calibrating the oscillator.

CLKOUT is an open-drain output and enabled at power-on. When disabled, the output is high-impedance.

Table 15. CLKOUT frequency selection

| COF[2:0]              | CLKOUT frequency (Hz) | Typical duty cycle <sup>[1]</sup> |
|-----------------------|-----------------------|-----------------------------------|
| 000 <sup>[2][3]</sup> | 32768                 | 60 : 40 to 40 : 60                |
| 001                   | 16384                 | 50 : 50                           |
| 010                   | 8192                  | 50 : 50                           |
| 011                   | 4096                  | 50 : 50                           |
| 100                   | 2048                  | 50 : 50                           |
| 101                   | 1024                  | 50 : 50                           |
| 110                   | 1                     | 50 : 50                           |
| 111                   | CLKOUT = high-Z       | -                                 |

[1] Duty cycle definition: % HIGH-level time : % LOW-level time.

[2] Default value.

[3] The specified accuracy of the RTC can be only achieved with CLKOUT frequencies not equal to 32.768 kHz or if CLKOUT is disabled.

The duty cycle of the selected clock is not controlled, however, due to the nature of the clock generation all but the 32.768 kHz frequencies are 50 : 50.

## 8.4 Register Aging\_offset

Table 16. Aging\_offset - crystal aging offset register (address 19h) bit allocation

Bit positions labeled as - are not implemented and return 0 when read.

| Bit         | 7 | 6 | 5 | 4 | 3       | 2 | 1 | 0 |
|-------------|---|---|---|---|---------|---|---|---|
| Symbol      | - | - | - | - | AO[3:0] |   |   |   |
| Reset value | - | - | - | - | 1       | 0 | 0 | 0 |

Table 17. Aging\_offset - crystal aging offset register (address 19h) bit description

Bit positions labeled as - are not implemented and return 0 when read.

| Bit    | Symbol  | Value                        | Description        |
|--------|---------|------------------------------|--------------------|
| 7 to 4 | -       | -                            | unused             |
| 3 to 0 | AO[3:0] | see <a href="#">Table 18</a> | aging offset value |

### 8.4.1 Crystal aging correction

The PCF2127 has an offset register Aging\_offset to correct the crystal aging effects<sup>2</sup>.

The accuracy of the frequency of a quartz crystal depends on its aging. The aging offset adds an adjustment, positive or negative, in the temperature compensation circuit which allows correcting the aging effect.

At 25 °C, the aging offset bits allow a frequency correction of typically 1 ppm per AO[3:0] value, from -7 ppm to +8 ppm.

2. For further information, refer to the application note [Ref. 3 "AN11266"](#).

Table 18. Frequency correction at 25 °C, typical

| AO[3:0] |        | ppm              |
|---------|--------|------------------|
| Decimal | Binary |                  |
| 0       | 0000   | +8               |
| 1       | 0001   | +7               |
| 2       | 0010   | +6               |
| 3       | 0011   | +5               |
| 4       | 0100   | +4               |
| 5       | 0101   | +3               |
| 6       | 0110   | +2               |
| 7       | 0111   | +1               |
| 8       | 1000   | <sup>[1]</sup> 0 |
| 9       | 1001   | -1               |
| 10      | 1010   | -2               |
| 11      | 1011   | -3               |
| 12      | 1100   | -4               |
| 13      | 1101   | -5               |
| 14      | 1110   | -6               |
| 15      | 1111   | -7               |

[1] Default value.

## 8.5 General purpose 512 bytes static RAM

The PCF2127 contains a general purpose 512 bytes static RAM. This integrated SRAM is battery backed and can therefore be used to store data which is essential for the application to survive a power outage.

9 bits, RA[8:0], define the RAM address pointer in registers RAM\_addr\_MSB and RAM\_addr\_LSB. The register address pointer increments after each read or write automatically up to 1Bh and then wraps around to address 00h (see [Figure 5 on page 6](#)).

Data is transferred to or from the RAM by the interface. To write to the RAM, the register RAM\_wrt\_cmd, to read from the RAM the register RAM\_rd\_cmd must be addressed explicitly.

### 8.5.1 Register RAM\_addr\_MSB

**Table 19. RAM\_addr\_MSB - RAM address MSB register (address 1Ah) bit allocation**

Bit positions labeled as - are not implemented and return 0 when read.

| Bit         | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0   |
|-------------|---|---|---|---|---|---|---|-----|
| Symbol      | - | - | - | - | - | - | - | RA8 |
| Reset value | - | - | - | - | - | - | - | 0   |

**Table 20. RAM\_addr\_MSB - RAM address MSB register (address 1Ah) bit description**

Bit positions labeled as - are not implemented and return 0 when read.

| Bit    | Symbol | Description                            |
|--------|--------|--|
| 7 to 1 | -      | unused                                 |
| 0      | RA8    | RAM address, MSB (9 <sup>th</sup> bit) |

### 8.5.2 Register RAM\_addr\_LSB

**Table 21. RAM\_addr\_LSB - RAM address LSB register (address 1Bh) bit allocation**

| Bit         | 7       | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|-------------|---------|---|---|---|---|---|---|---|
| Symbol      | RA[7:0] |   |   |   |   |   |   |   |
| Reset value | 0       | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Table 22. RAM\_addr\_LSB - RAM address LSB register (address 1Bh) bit description**

| Bit    | Symbol  | Description   |
|--------|---------|---|
| 7 to 0 | RA[7:0] | RAM address, LSB (1 <sup>st</sup> to 8 <sup>th</sup> bit) |

### 8.5.3 Register RAM\_wrt\_cmd

**Table 23. RAM\_wrt\_cmd - RAM write command register (address 1Ch) bit description**

| Bit    | Symbol | Description                 |
|--------|--------|-----------------------------|
| 7 to 0 | -      | data to be written into RAM |

### 8.5.4 Register RAM\_rd\_cmd

**Table 24. RAM\_rd\_cmd - RAM read command register (address 1Dh) bit description**

| Bit    | Symbol | Description              |
|--------|--------|--------------------------|
| 7 to 0 | -      | data to be read from RAM |

## 8.5.5 Operation examples

### 8.5.5.1 Writing to the RAM

1. Set RAM address:
  - Select register RAM\_addr\_MSB (send address 1Ah).
  - Set value for bit RA8 (data byte of register 1Ah).  
Note: register address will be incremented automatically to 1Bh.
  - Set value for array RA[7:0] (data byte of register 1Bh).
2. Send RAM write command:
  - Select register RAM\_wrt\_cmd (send address 1Ch).
3. Write data into the RAM:
  - Write n data byte into RAM.

For details, see [Figure 46 on page 69](#).

### 8.5.5.2 Reading from the RAM

1. Set RAM address:
  - Select register RAM\_addr\_MSB (send address 1Ah).
  - Set value for bit RA8 (data byte of register 1Ah).  
Note: register address will be incremented automatically to 1Bh.
  - Set value for array RA[7:0] (data byte of register 1Bh).
2. Send RAM read command:
  - Select register RAM\_rd\_cmd (send address 1Dh).
3. Read from the RAM:
  - Read n data byte from the RAM.

For details, see [Figure 47 on page 70](#).

## 8.6 Power management functions

The PCF2127 has two power supplies:

$V_{DD}$  — the main power supply

$V_{BAT}$  — the battery backup supply

Internally, the PCF2127 is operating with the internal operating voltage  $V_{oper(int)}$  which is also available as  $V_{BBS}$  on the battery backed output voltage pin, BBS. Depending on the condition of the main power supply and the selected power management function,  $V_{oper(int)}$  is either on the potential of  $V_{DD}$  or  $V_{BAT}$  (see [Section 8.6.4](#)).

Three power management functions are implemented:

**Battery switch-over function.** monitoring the main power supply  $V_{DD}$  and switching to  $V_{BAT}$  in case a power fail condition is detected (see [Section 8.6.1](#)).

**Battery low detection function.** monitoring the status of the battery,  $V_{BAT}$  (see [Section 8.6.2](#)).

**Extra power fail detection function.** monitoring the voltage at the power fail input pin, PFI (see [Section 8.6.3](#)).

The power management functions are controlled by the control bits PWRMNG[2:0] (see [Table 25](#)) in register Control\_3 (see [Table 11](#)):

**Table 25. Power management control bit description**

| PWRMNG[2:0] | Function   |
|-------------|--|
| 000         | [1] battery switch-over function is enabled in standard mode;<br>battery low detection function is enabled;<br>extra power fail detection function is enabled                        |
| 001         | battery switch-over function is enabled in standard mode;<br>battery low detection function is disabled;<br>extra power fail detection function is enabled                           |
| 010         | battery switch-over function is enabled in standard mode;<br>battery low detection function is disabled;<br>extra power fail detection function is disabled                          |
| 011         | battery switch-over function is enabled in direct switching mode;<br>battery low detection function is enabled;<br>extra power fail detection function is enabled                    |
| 100         | battery switch-over function is enabled in direct switching mode;<br>battery low detection function is disabled;<br>extra power fail detection function is enabled                   |
| 101         | battery switch-over function is enabled in direct switching mode;<br>battery low detection function is disabled;<br>extra power fail detection function is disabled                  |
| 110         | [2] battery switch-over function is disabled - only one power supply ( $V_{DD}$ );<br>battery low detection function is disabled;<br>extra power fail detection function is enabled  |
| 111         | [2] battery switch-over function is disabled - only one power supply ( $V_{DD}$ );<br>battery low detection function is disabled;<br>extra power fail detection function is disabled |

[1] Default value.

[2] When the battery switch-over function is disabled, the PCF2127 works only with the power supply  $V_{DD}$ .  $V_{BAT}$  must be put to ground and the battery low detection function is disabled.

### 8.6.1 Battery switch-over function

The PCF2127 has a backup battery switch-over circuit which monitors the main power supply  $V_{DD}$ . When a power failure condition is detected, it automatically switches to the backup battery.

One of two operation modes can be selected:

**Standard mode** — the power failure condition happens when:

$$V_{DD} < V_{BAT} \text{ AND } V_{DD} < V_{th(sw)bat}$$

$V_{th(sw)bat}$  is the battery switch threshold voltage. Typical value is 2.5 V. The battery switch-over in standard mode works only for  $V_{DD} > 2.5$  V

**Direct switching mode** — the power failure condition happens when  $V_{DD} < V_{BAT}$ . Direct switching from  $V_{DD}$  to  $V_{BAT}$  without requiring  $V_{DD}$  to drop below  $V_{th(sw)bat}$

When a power failure condition occurs and the power supply switches to the battery, the following sequence occurs:

1. The battery switch flag BF (register Control\_3) is set logic 1.
2. An interrupt is generated if the control bit BIE (register Control\_3) is enabled (see [Section 8.13.7](#)).
3. If the control bit BTSE (register Control\_3) is logic 1, the timestamp registers store the time and date when the battery switch occurred (see [Section 8.12.4](#)).
4. The battery switch flag BF is cleared by command; it must be cleared to clear the interrupt.

The interface is disabled in battery backup operation:

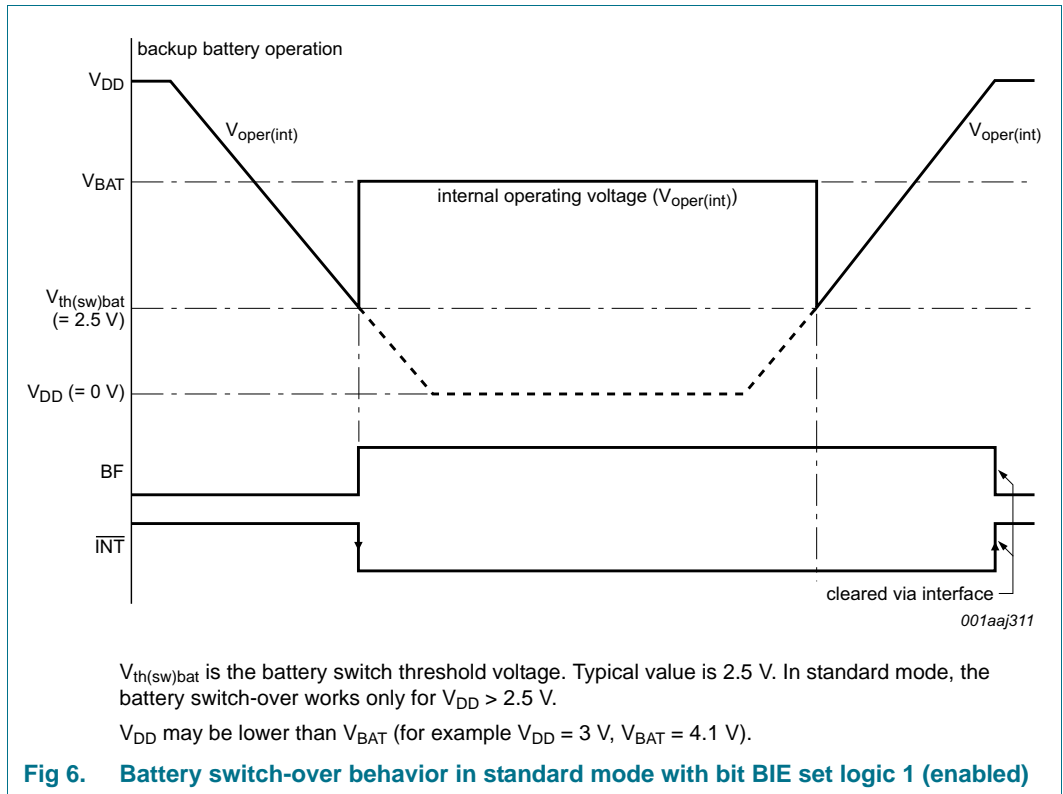
- Interface inputs are not recognized, preventing extraneous data being written to the device
- Interface outputs are high-impedance

For further information about I<sup>2</sup>C-bus communication and battery backup operation, see [Section 9.3 on page 70](#).

8.6.1.1 Standard mode

If  $V_{DD} > V_{BAT}$  OR  $V_{DD} > V_{th(sw)bat}$ :  $V_{oper(int)}$  is at  $V_{DD}$  potential.

If  $V_{DD} < V_{BAT}$  AND  $V_{DD} < V_{th(sw)bat}$ :  $V_{oper(int)}$  is at  $V_{BAT}$  potential.

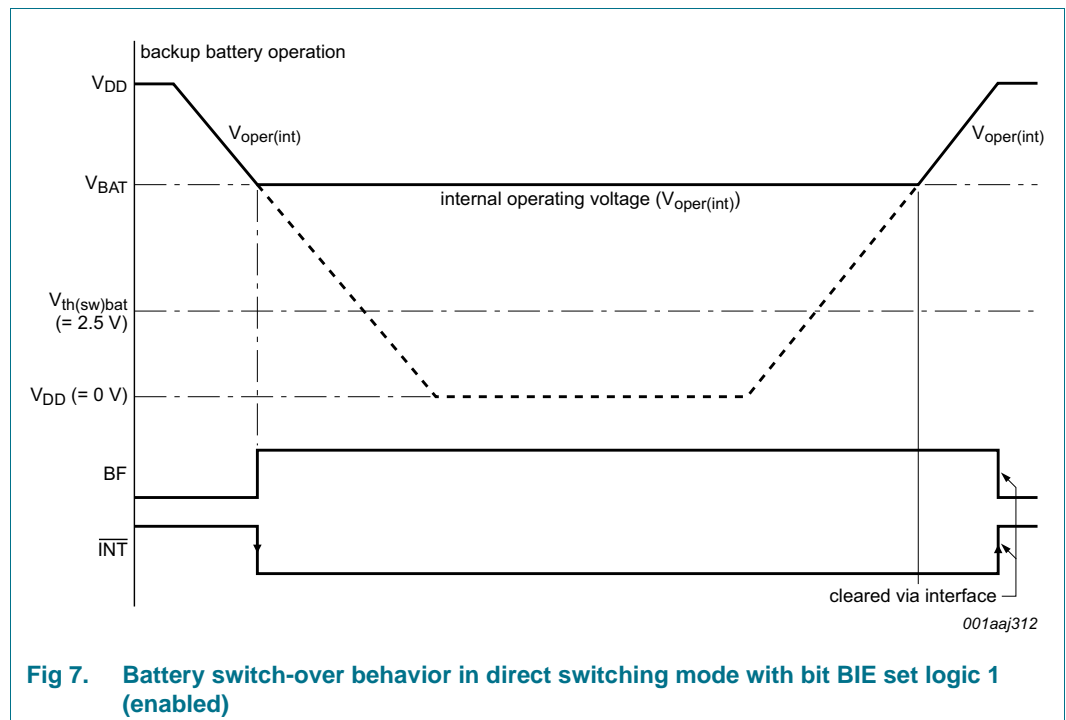


**8.6.1.2 Direct switching mode**

If  $V_{DD} > V_{BAT}$ :  $V_{oper(int)}$  is at  $V_{DD}$  potential.

If  $V_{DD} < V_{BAT}$ :  $V_{oper(int)}$  is at  $V_{BAT}$  potential.

The direct switching mode is useful in systems where  $V_{DD}$  is always higher than  $V_{BAT}$ . This mode is not recommended if the  $V_{DD}$  and  $V_{BAT}$  values are similar (for example,  $V_{DD} = 3.3\text{ V}$ ,  $V_{BAT} \geq 3.0\text{ V}$ ). In direct switching mode, the power consumption is reduced compared to the standard mode because the monitoring of  $V_{DD}$  and  $V_{th(sw)bat}$  is not performed.



**Fig 7. Battery switch-over behavior in direct switching mode with bit BIE set logic 1 (enabled)**

**8.6.1.3 Battery switch-over disabled: only one power supply ( $V_{DD}$ )**

When the battery switch-over function is disabled:

- The power supply is applied on the  $V_{DD}$  pin
- The  $V_{BAT}$  pin must be connected to ground
- $V_{oper(int)}$  is at  $V_{DD}$  potential
- The battery flag (BF) is always logic 0

8.6.1.4 Battery switch-over architecture

The architecture of the battery switch-over circuit is shown in [Figure 8](#).

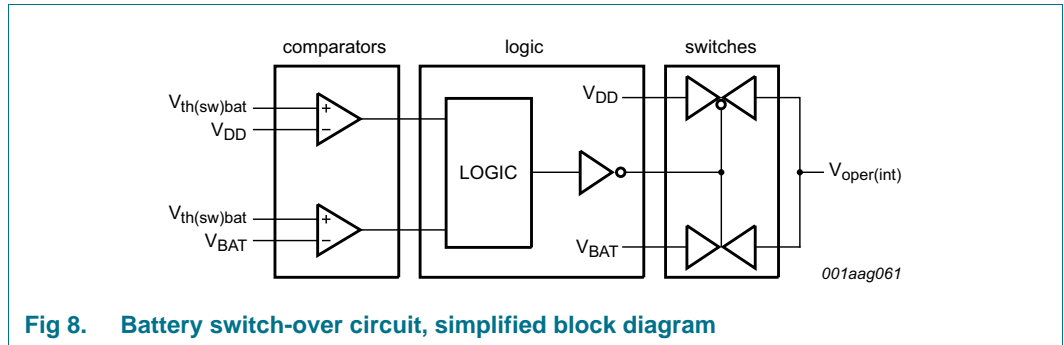


Fig 8. Battery switch-over circuit, simplified block diagram

$V_{oper(int)}$  is at  $V_{DD}$  or  $V_{BAT}$  potential.

**Remark:** It has to be assured that there are decoupling capacitors on the pins  $V_{DD}$ ,  $V_{BAT}$ , and BBS.

8.6.2 Battery low detection function

The PCF2127 has a battery low detection circuit which monitors the status of the battery  $V_{BAT}$ .

When  $V_{BAT}$  drops below the threshold value  $V_{th(bat)low}$  (typically 2.5 V), the BLF flag (register Control\_3) is set to indicate that the battery is low and that it must be replaced. Monitoring of the battery voltage also occurs during battery operation.

An unreliable battery cannot prevent that the supply voltage drops below  $V_{low}$  (typical 1.2 V) and with that the data integrity gets lost. (For further information about  $V_{low}$  see [Section 8.7.](#))

When  $V_{BAT}$  drops below the threshold value  $V_{th(bat)low}$ , the following sequence occurs (see [Figure 9](#)):

1. The battery low flag BLF is set logic 1.
2. An interrupt is generated if the control bit BLIE (register Control\_3) is enabled (see [Section 8.13.8](#)).
3. The flag BLF remains logic 1 until the battery is replaced. BLF cannot be cleared by command. It is automatically cleared by the battery low detection circuit when the battery is replaced or when the voltage rises again above the threshold value. This could happen if a super capacitor is used as a backup source and the main power is applied again.

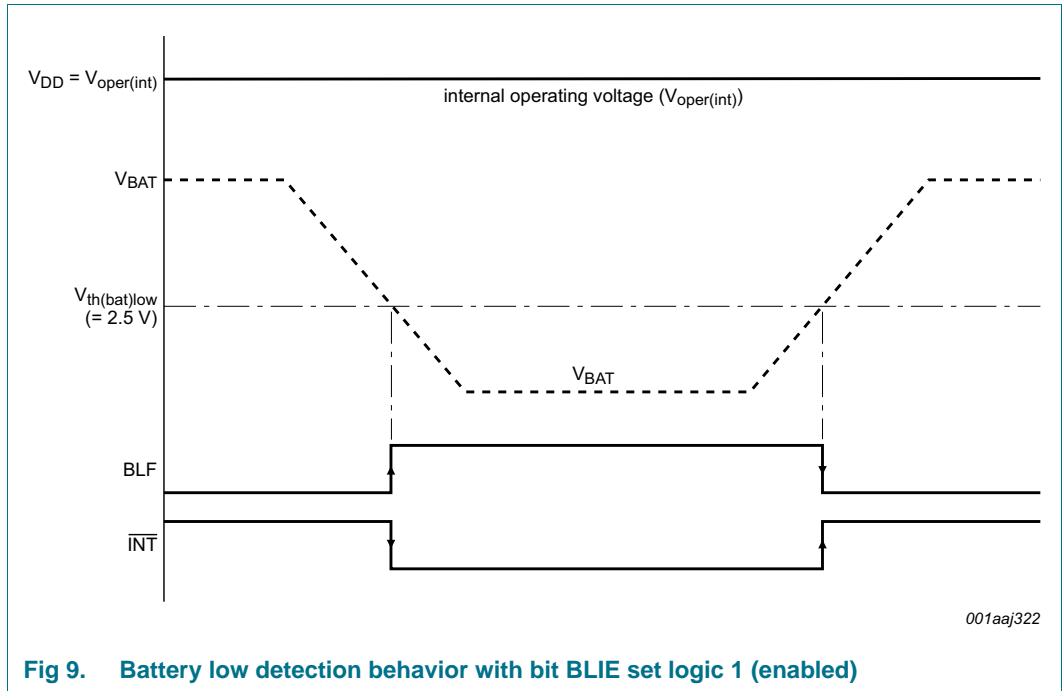


Fig 9. Battery low detection behavior with bit BLIE set logic 1 (enabled)

### 8.6.3 Extra power fail detection function

The PCF2127 has an extra power fail detection circuit which compares the voltage at the power fail input pin PFI to an internal reference voltage equal to 1.25 V.

If  $V_{PFI} < 1.25\text{ V}$ , the power fail output  $\overline{PFO}$  is driven LOW.  $\overline{PFO}$  is an open-drain, active LOW output which requires an external pull-up resistor in any application.

The extra power fail detection function is typically used as a low voltage detection for the main power supply  $V_{DD}$  (see [Figure 10](#)).

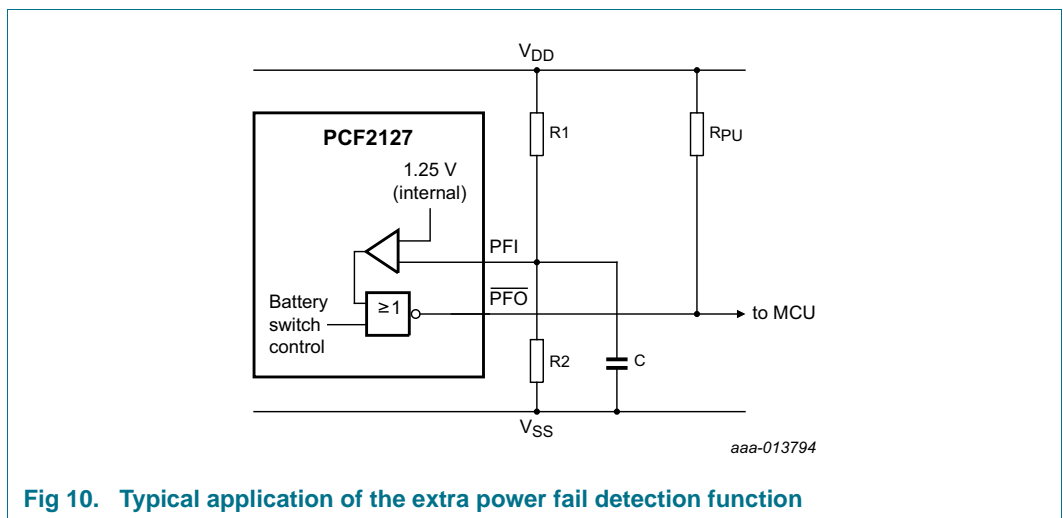


Fig 10. Typical application of the extra power fail detection function

Usually R1 and R2 should be chosen such that the voltage at pin PFI

- is higher than 1.25 V at start-up
- falls below 1.25 V when  $V_{DD}$  falls below a desired threshold voltage,  $V_{th(uvp)}$ , defined by [Equation 1](#):

$$V_{th(uvp)} = \left( \frac{R_1}{R_2} + 1 \right) \times 1.25V \quad (1)$$

$V_{th(uvp)}$  value is usually set to a value that there are several milliseconds before  $V_{DD}$  falls below the minimum operating voltage of the system, in order to allow the microcontroller to perform early backup operations, like terminating the communication with the PCF2127.

The value of C is determined from [Equation 2](#):

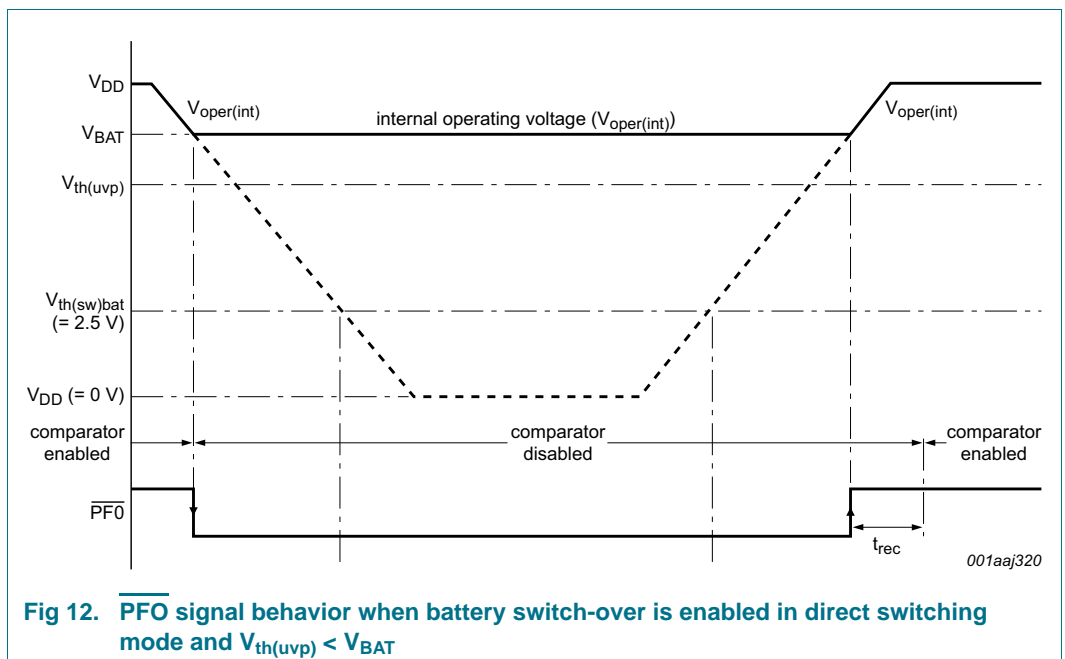
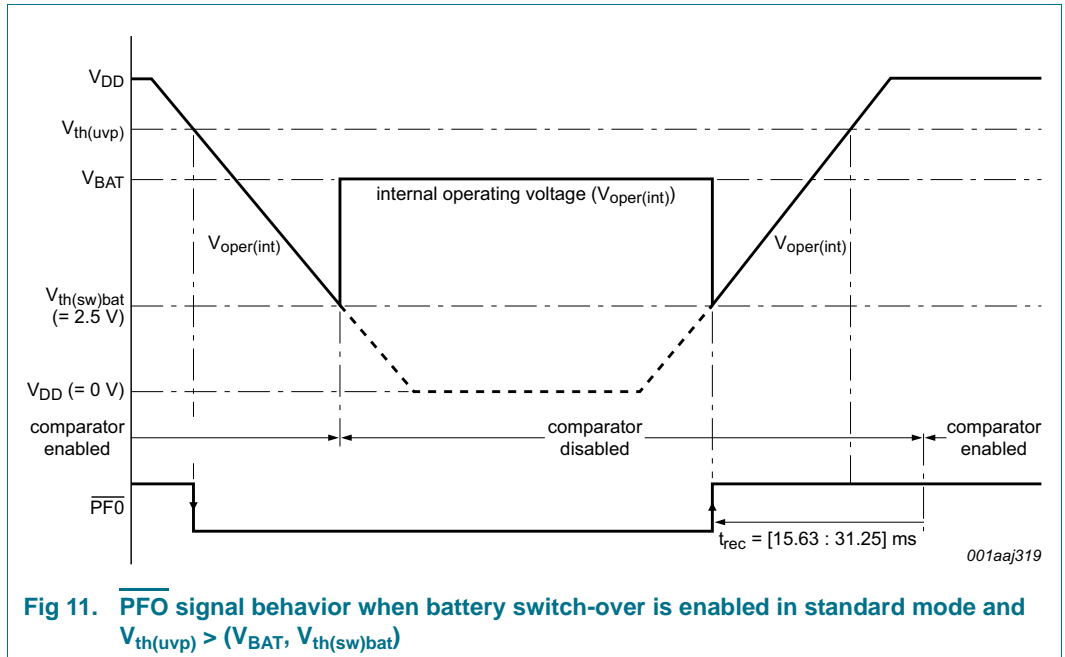
$$C = \frac{0.02}{(R_1/R_2)} \left[ \frac{As}{V} \right] \quad (2)$$

If the extra power fail detection function is not used, pin PFI must be connected to  $V_{SS}$  and pin  $\overline{PFO}$  must be left open circuit.

#### 8.6.3.1 Extra power fail detection when the battery switch-over function is enabled

- When the power switches to the backup battery supply  $V_{BAT}$ , the power fail comparator is switched off and the power fail output at pin  $\overline{PFO}$  goes (or remains) LOW
- When the power switches back to the main  $V_{DD}$ , the pin  $\overline{PFO}$  is not driven LOW anymore. It is pulled HIGH through the external pull-up resistance for a certain time ( $t_{rec} = 15.63$  ms to 31.25 ms). Then the power fail comparator is enabled again

For illustration, see [Figure 11](#) and [Figure 12](#).



8.6.3.2 Extra power fail detection when the battery switch-over function is disabled

If the battery switch-over function is disabled and the power fail comparator is enabled, the power fail output at pin  $\overline{\text{PFO}}$  depends only on the result of the comparison between  $V_{\text{PFI}}$  and 1.25 V:

- If  $V_{\text{PFI}} > 1.25 \text{ V}$ ,  $\overline{\text{PFO}} = \text{HIGH}$  (through the external pull-up resistor)
- If  $V_{\text{PFI}} < 1.25 \text{ V}$ ,  $\overline{\text{PFO}} = \text{LOW}$

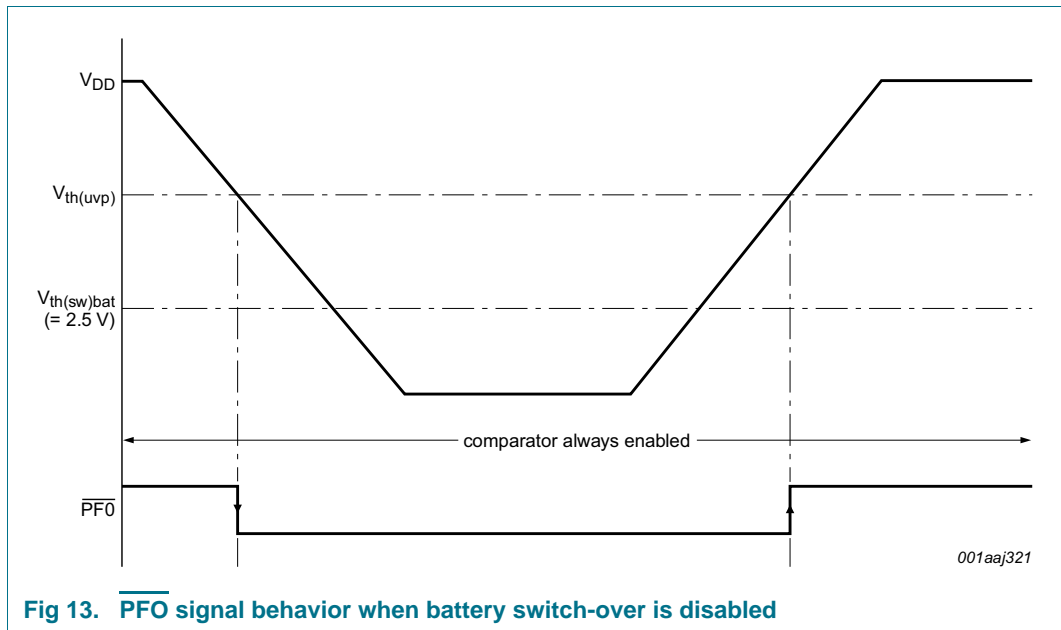


Fig 13.  $\overline{\text{PFO}}$  signal behavior when battery switch-over is disabled

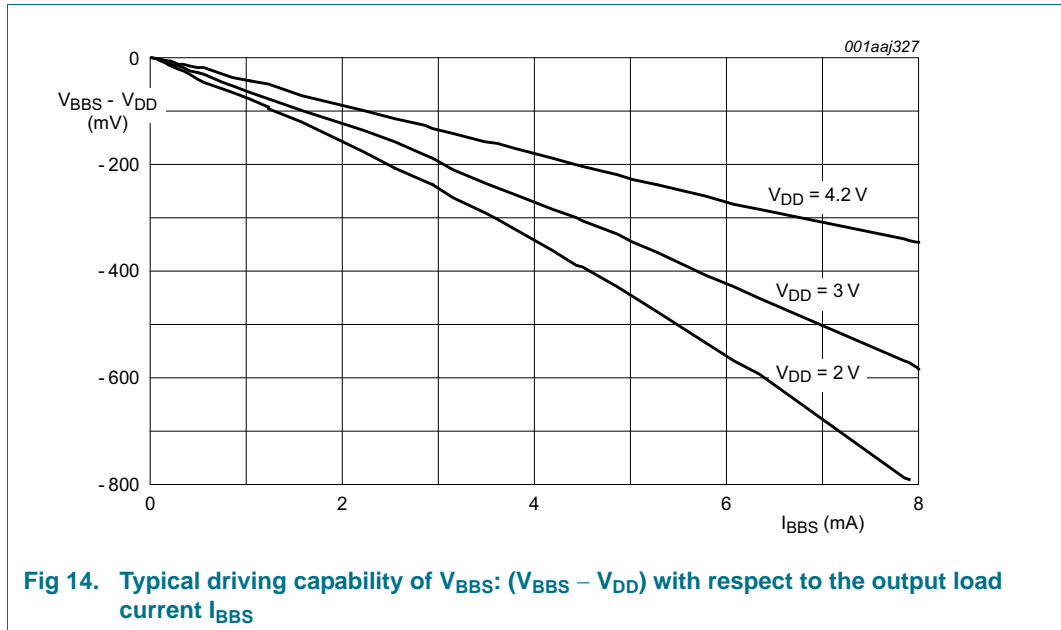
8.6.4 Battery backup supply

The  $V_{\text{BBS}}$  voltage on the output pin BBS is at the same potential as the internal operating voltage  $V_{\text{oper(int)}}$ , depending on the selected battery switch-over function mode:

Table 26. Output pin BBS

| Battery switch-over function mode | Conditions  | Potential of $V_{\text{oper(int)}}$ and $V_{\text{BBS}}$ |
|-----------------------------------|---|--|
| standard                          | $V_{\text{DD}} > V_{\text{BAT}}$ OR $V_{\text{DD}} > V_{\text{th(sw)bat}}$  | $V_{\text{DD}}$  |
|                                   | $V_{\text{DD}} < V_{\text{BAT}}$ AND $V_{\text{DD}} < V_{\text{th(sw)bat}}$ | $V_{\text{BAT}}$   |
| direct switching                  | $V_{\text{DD}} > V_{\text{BAT}}$  | $V_{\text{DD}}$  |
|                                   | $V_{\text{DD}} < V_{\text{BAT}}$  | $V_{\text{BAT}}$   |
| disabled                          | only $V_{\text{DD}}$ available, $V_{\text{BAT}}$ must be put to ground      | $V_{\text{DD}}$  |

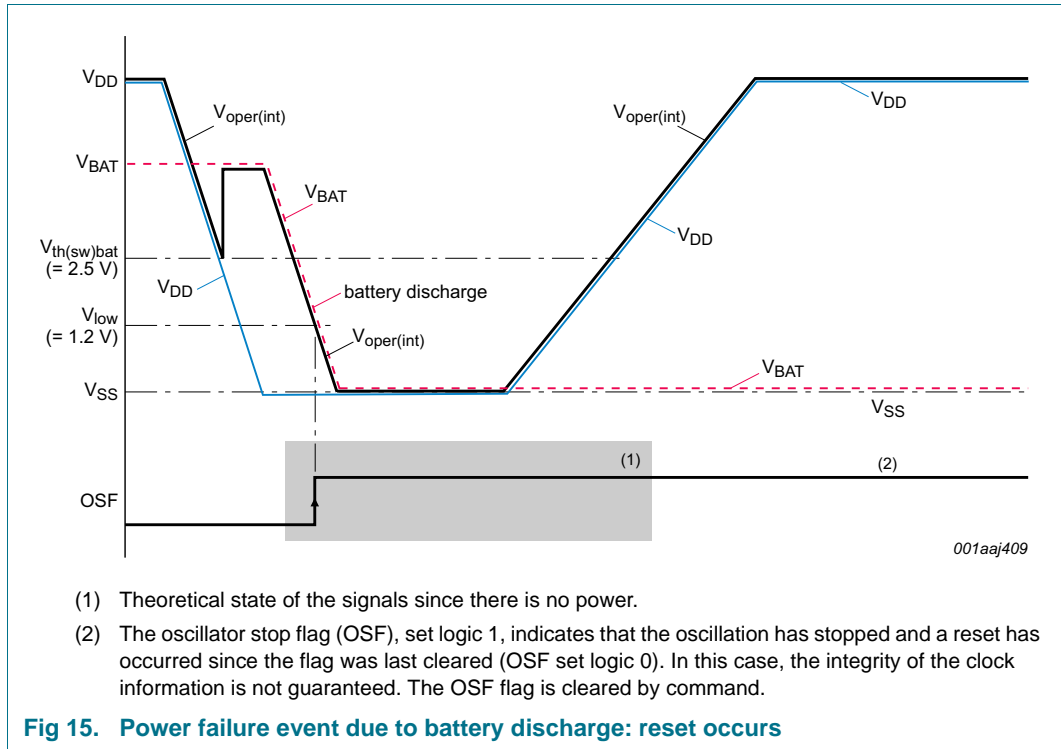
The output pin BBS can be used as a supply for external devices with battery backup needs, such as SRAM (see Ref. 3 “AN11266”). For this case, Figure 14 shows the typical driving capability when  $V_{\text{BBS}}$  is driven from  $V_{\text{DD}}$ .



### 8.7 Oscillator stop detection function

The PCF2127 has an on-chip oscillator detection circuit which monitors the status of the oscillation: whenever the oscillation stops, a reset occurs and the oscillator stop flag OSF (in register Seconds) is set logic 1.

- **Power-on:**
  - a. The oscillator is not running, the chip is in reset (OSF is logic 1).
  - b. When the oscillator starts running and is stable after power-on, the chip exits from reset.
  - c. The flag OSF is still logic 1 and can be cleared (OSF set logic 0) by command.
- **Power supply failure:**
  - a. When the power supply of the chip drops below a certain value ( $V_{low}$ ), typically 1.2 V, the oscillator stops running and a reset occurs.
  - b. When the power supply returns to normal operation, the oscillator starts running again, the chip exits from reset.
  - c. The flag OSF is still logic 1 and can be cleared (OSF set logic 0) by command.



**Fig 15. Power failure event due to battery discharge: reset occurs**

## 8.8 Reset function

The PCF2127 has a Power-On Reset (POR) and a Power-On Reset Override (PORO) function implemented.

### 8.8.1 Power-On Reset (POR)

The POR is active whenever the oscillator is stopped. The oscillator is considered to be stopped during the time between power-on and stable crystal resonance (see [Figure 16](#)). This time may be in the range of 200 ms to 2 s depending on temperature and supply voltage. Whenever an internal reset occurs, the oscillator stop flag is set (OSF set logic 1).

The OTP refresh (see [Section 8.3.2 on page 13](#)) should ideally be executed as the first instruction after start-up and also after a reset due to an oscillator stop.

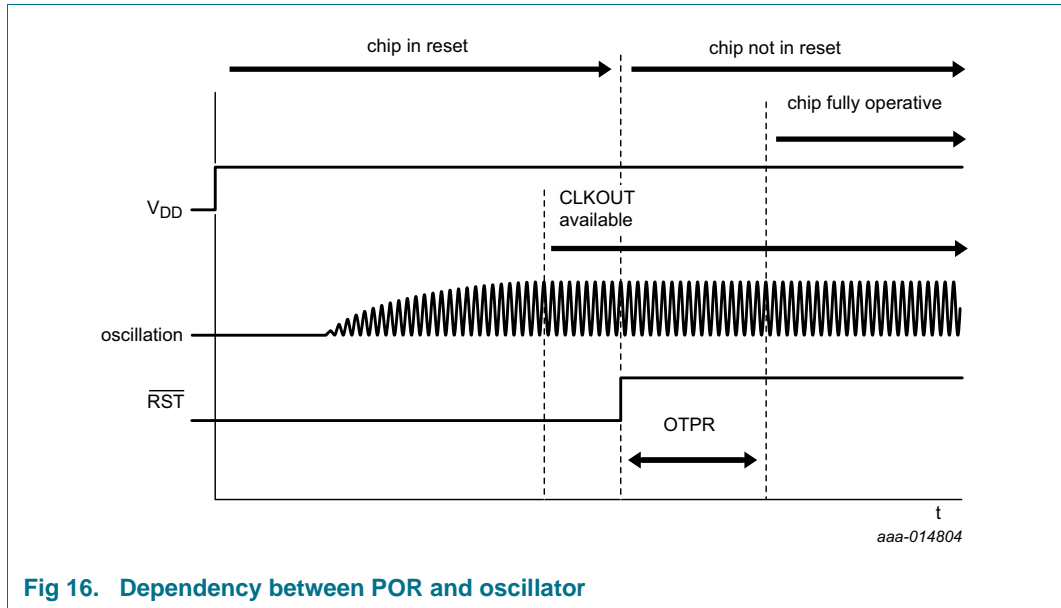


Fig 16. Dependency between POR and oscillator

After POR, the following mode is entered:

- 32.768 kHz CLKOUT active
- Power-On Reset Override (PORO) available to be set
- 24-hour mode is selected
- Battery switch-over is enabled
- Battery low detection is enabled
- Extra power fail detection is enabled

The register values after power-on are shown in [Table 5 on page 8](#).

### 8.8.2 Power-On Reset Override (PORO)

The POR duration is directly related to the crystal oscillator start-up time. Due to the long start-up times experienced by these types of circuits, a mechanism has been built in to disable the POR and therefore speed up the on-board test of the device.

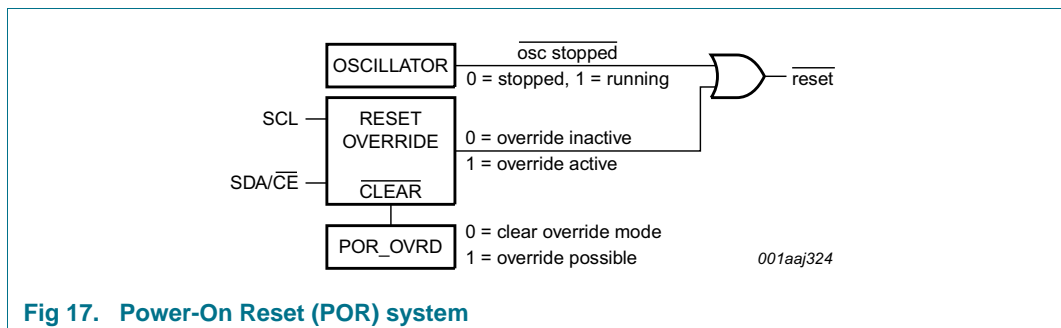
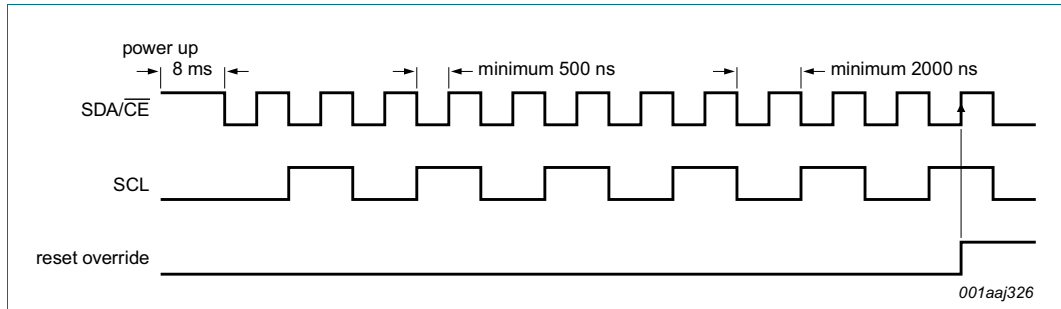


Fig 17. Power-On Reset (POR) system

The setting of the PORO mode requires that POR\_OVRD in register Control\_1 is set logic 1 and that the signals at the interface pins SDA/CĒ and SCL are toggled as illustrated in [Figure 18](#). All timings shown are required minimum.



**Fig 18. Power-On Reset Override (PORO) sequence, valid for both I<sup>2</sup>C-bus and SPI-bus**

Once the override mode is entered, the device is immediately released from the reset state and the set-up operation can commence.

The PORO mode is cleared by writing logic 0 to POR\_OVRD. POR\_OVRD must be logic 1 before a re-entry into the override mode is possible. Setting POR\_OVRD logic 0 during normal operation has no effect except to prevent accidental entry into the PORO mode.

### 8.9 Time and date function

Most of these registers are coded in the Binary Coded Decimal (BCD) format.

#### 8.9.1 Register Seconds

**Table 27. Seconds - seconds and clock integrity register (address 03h) bit allocation**

Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit         | 7   | 6                 | 5 | 4 | 3 | 2 | 1 | 0 |
|-------------|-----|-------------------|---|---|---|---|---|---|
| Symbol      | OSF | SECONDS (0 to 59) |   |   |   |   |   |   |
| Reset value | 1   | X                 | X | X | X | X | X | X |

**Table 28. Seconds - seconds and clock integrity register (address 03h) bit description**

Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit    | Symbol  | Value  | Place value | Description  |
|--------|---------|--------|-------------|--|
| 7      | OSF     | 0      | -           | clock integrity is guaranteed  |
|        |         | 1      | -           | clock integrity is not guaranteed:<br>oscillator has stopped and chip reset has occurred since flag was last cleared |
| 6 to 4 | SECONDS | 0 to 5 | ten's place | actual seconds coded in BCD format   |
| 3 to 0 |         | 0 to 9 | unit place  |  |

**Table 29. Seconds coded in BCD format**

| Seconds value in decimal | Upper-digit (ten's place) |       |       | Digit (unit place) |       |       |       |
|--------------------------|---------------------------|-------|-------|--------------------|-------|-------|-------|
|                          | Bit 6                     | Bit 5 | Bit 4 | Bit 3              | Bit 2 | Bit 1 | Bit 0 |
| 00                       | 0                         | 0     | 0     | 0                  | 0     | 0     | 0     |
| 01                       | 0                         | 0     | 0     | 0                  | 0     | 0     | 1     |
| 02                       | 0                         | 0     | 0     | 0                  | 0     | 1     | 0     |
| :                        | :                         | :     | :     | :                  | :     | :     | :     |
| 09                       | 0                         | 0     | 0     | 1                  | 0     | 0     | 1     |
| 10                       | 0                         | 0     | 1     | 0                  | 0     | 0     | 0     |
| :                        | :                         | :     | :     | :                  | :     | :     | :     |
| 58                       | 1                         | 0     | 1     | 1                  | 0     | 0     | 0     |
| 59                       | 1                         | 0     | 1     | 1                  | 0     | 0     | 1     |

### 8.9.2 Register Minutes

**Table 30. Minutes - minutes register (address 04h) bit allocation**

Bit positions labeled as - are not implemented and return 0 when read. Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit         | 7 | 6                 | 5 | 4 | 3 | 2 | 1 | 0 |
|-------------|---|-------------------|---|---|---|---|---|---|
| Symbol      | - | MINUTES (0 to 59) |   |   |   |   |   |   |
| Reset value | - | X                 | X | X | X | X | X | X |

**Table 31. Minutes - minutes register (address 04h) bit description**

Bit positions labeled as - are not implemented and return 0 when read. Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit    | Symbol  | Value  | Place value | Description                        |
|--------|---------|--------|-------------|------------------------------------|
| 7      | -       | -      | -           | unused                             |
| 6 to 4 | MINUTES | 0 to 5 | ten's place | actual minutes coded in BCD format |
| 3 to 0 |         | 0 to 9 | unit place  |                                    |

### 8.9.3 Register Hours

**Table 32. Hours - hours register (address 05h) bit allocation**

Bit positions labeled as - are not implemented and return 0 when read. Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit         | 7 | 6 | 5    | 4                               | 3 | 2 | 1 | 0 |
|-------------|---|---|------|---------------------------------|---|---|---|---|
| Symbol      | - | - | AMPM | HOURS (1 to 12) in 12-hour mode |   |   |   |   |
|             |   |   |      | HOURS (0 to 23) in 24-hour mode |   |   |   |   |
| Reset value | - | - | X    | X                               | X | X | X | X |

**Table 33. Hours - hours register (address 05h) bit description**

Bit positions labeled as - are not implemented and return 0 when read. Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit                               | Symbol | Value  | Place value | Description   |
|-----------------------------------|--------|--------|-------------|---|
| 7 to 6                            | -      | -      | -           | unused  |
| <b>12-hour mode<sup>[1]</sup></b> |        |        |             |   |
| 5                                 | AMPM   | 0      | -           | indicates AM  |
|                                   |        | 1      | -           | indicates PM  |
| 4                                 | HOURS  | 0 to 1 | ten's place | actual hours coded in BCD format when in 12-hour mode |
| 3 to 0                            |        | 0 to 9 | unit place  |   |
| <b>24-hour mode<sup>[1]</sup></b> |        |        |             |   |
| 5 to 4                            | HOURS  | 0 to 2 | ten's place | actual hours coded in BCD format when in 24-hour mode |
| 3 to 0                            |        | 0 to 9 | unit place  |   |

[1] Hour mode is set by the bit 12\_24 in register Control\_1 (see [Table 7](#)).

### 8.9.4 Register Days

**Table 34. Days - days register (address 06h) bit allocation**

Bit positions labeled as - are not implemented and return 0 when read. Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit         | 7 | 6 | 5              | 4 | 3 | 2 | 1 | 0 |
|-------------|---|---|----------------|---|---|---|---|---|
| Symbol      | - | - | DAYS (1 to 31) |   |   |   |   |   |
| Reset value | - | - | X              | X | X | X | X | X |

**Table 35. Days - days register (address 06h) bit description**

| Bit    | Symbol              | Value  | Place value | Description                    |
|--------|---------------------|--------|-------------|--------------------------------|
| 7 to 6 | -                   | -      | -           | unused                         |
| 5 to 4 | DAYS <sup>[1]</sup> | 0 to 3 | ten's place | actual day coded in BCD format |
| 3 to 0 |                     | 0 to 9 | unit place  |                                |

[1] If the year counter contains a value which is exactly divisible by 4, including the year 00, the RTC compensates for leap years by adding a 29<sup>th</sup> day to February.

### 8.9.5 Register Weekdays

**Table 36. Weekdays - weekdays register (address 07h) bit allocation**

Bit positions labeled as - are not implemented and return 0 when read. Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit         | 7 | 6 | 5 | 4 | 3 | 2                 | 1 | 0 |
|-------------|---|---|---|---|---|-------------------|---|---|
| Symbol      | - | - | - | - | - | WEEKDAYS (0 to 6) |   |   |
| Reset value | - | - | - | - | - | X                 | X | X |

**Table 37. Weekdays - weekdays register (address 07h) bit description**

Bit positions labeled as - are not implemented and return 0 when read. Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit    | Symbol   | Value  | Description  |
|--------|----------|--------|--|
| 7 to 3 | -        | -      | unused   |
| 2 to 0 | WEEKDAYS | 0 to 6 | actual weekday value, see <a href="#">Table 38</a> |

Although the association of the weekdays counter to the actual weekday is arbitrary, the PCF2127 assumes that Sunday is 000 and Monday is 001 for the purpose of determining the increment for calendar weeks.

**Table 38. Weekday assignments**

| Day <sup>[1]</sup> | Bit |   |   |
|--------------------|-----|---|---|
|                    | 2   | 1 | 0 |
| Sunday             | 0   | 0 | 0 |
| Monday             | 0   | 0 | 1 |
| Tuesday            | 0   | 1 | 0 |
| Wednesday          | 0   | 1 | 1 |
| Thursday           | 1   | 0 | 0 |
| Friday             | 1   | 0 | 1 |
| Saturday           | 1   | 1 | 0 |

[1] Definition may be reassigned by the user.

### 8.9.6 Register Months

**Table 39. Months - months register (address 08h) bit allocation**

Bit positions labeled as - are not implemented and return 0 when read. Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit         | 7 | 6 | 5 | 4                | 3 | 2 | 1 | 0 |
|-------------|---|---|---|------------------|---|---|---|---|
| Symbol      | - | - | - | MONTHS (1 to 12) |   |   |   |   |
| Reset value | - | - | - | X                | X | X | X | X |

**Table 40. Months - months register (address 08h) bit description**

Bit positions labeled as - are not implemented and return 0 when read. Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit    | Symbol | Value  | Place value | Description  |
|--------|--------|--------|-------------|--|
| 7 to 5 | -      | -      | -           | unused   |
| 4      | MONTHS | 0 to 1 | ten's place | actual month coded in BCD format, see <a href="#">Table 41</a> |
| 3 to 0 |        | 0 to 9 | unit place  |  |

**Table 41. Month assignments in BCD format**

| Month     | Upper-digit (ten's place) | Digit (unit place) |       |       |       |
|-----------|---------------------------|--------------------|-------|-------|-------|
|           | Bit 4                     | Bit 3              | Bit 2 | Bit 1 | Bit 0 |
| January   | 0                         | 0                  | 0     | 0     | 1     |
| February  | 0                         | 0                  | 0     | 1     | 0     |
| March     | 0                         | 0                  | 0     | 1     | 1     |
| April     | 0                         | 0                  | 1     | 0     | 0     |
| May       | 0                         | 0                  | 1     | 0     | 1     |
| June      | 0                         | 0                  | 1     | 1     | 0     |
| July      | 0                         | 0                  | 1     | 1     | 1     |
| August    | 0                         | 1                  | 0     | 0     | 0     |
| September | 0                         | 1                  | 0     | 0     | 1     |
| October   | 1                         | 0                  | 0     | 0     | 0     |
| November  | 1                         | 0                  | 0     | 0     | 1     |
| December  | 1                         | 0                  | 0     | 1     | 0     |

### 8.9.7 Register Years

**Table 42. Years - years register (address 09h) bit allocation**

Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit         | 7               | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|-------------|-----------------|---|---|---|---|---|---|---|
| Symbol      | YEARS (0 to 99) |   |   |   |   |   |   |   |
| Reset value | X               | X | X | X | X | X | X | X |

**Table 43. Years - years register (address 09h) bit description**

Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit    | Symbol | Value  | Place value | Description                     |
|--------|--------|--------|-------------|---------------------------------|
| 7 to 4 | YEARS  | 0 to 9 | ten's place | actual year coded in BCD format |
| 3 to 0 |        | 0 to 9 | unit place  |                                 |

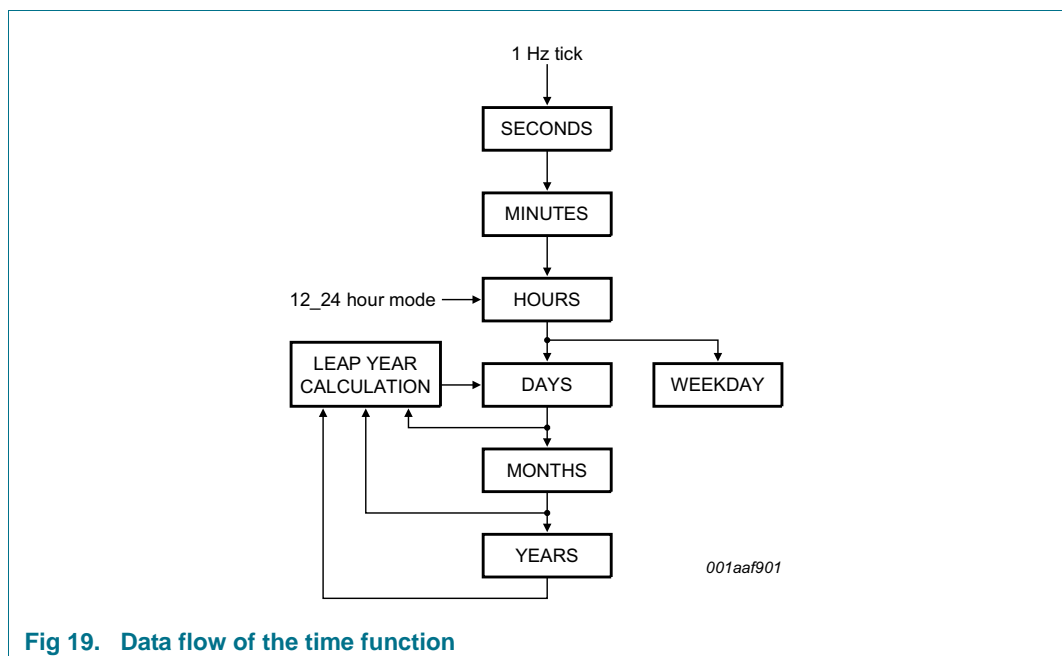
### 8.9.8 Setting and reading the time

Figure 19 shows the data flow and data dependencies starting from the 1 Hz clock tick.

During read/write operations, the time counting circuits (memory locations 03h through 09h) are blocked.

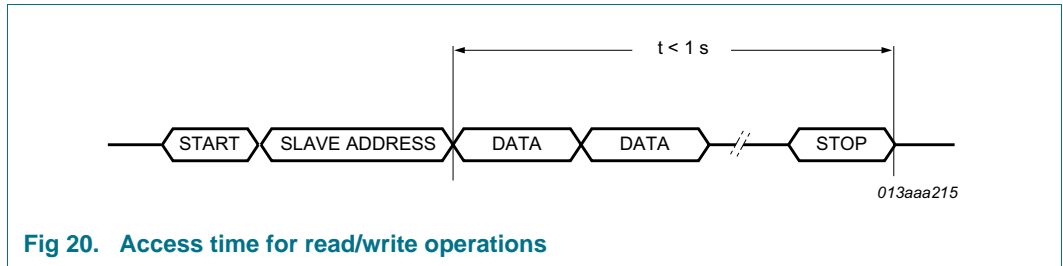
This prevents

- Faulty reading of the clock and calendar during a carry condition
- Incrementing the time registers during the read cycle



**Fig 19. Data flow of the time function**

After this read/write access is completed, the time circuit is released again. Any pending request to increment the time counters that occurred during the read/write access is serviced. A maximum of 1 request can be stored; therefore, all accesses must be completed within 1 second (see Figure 20).



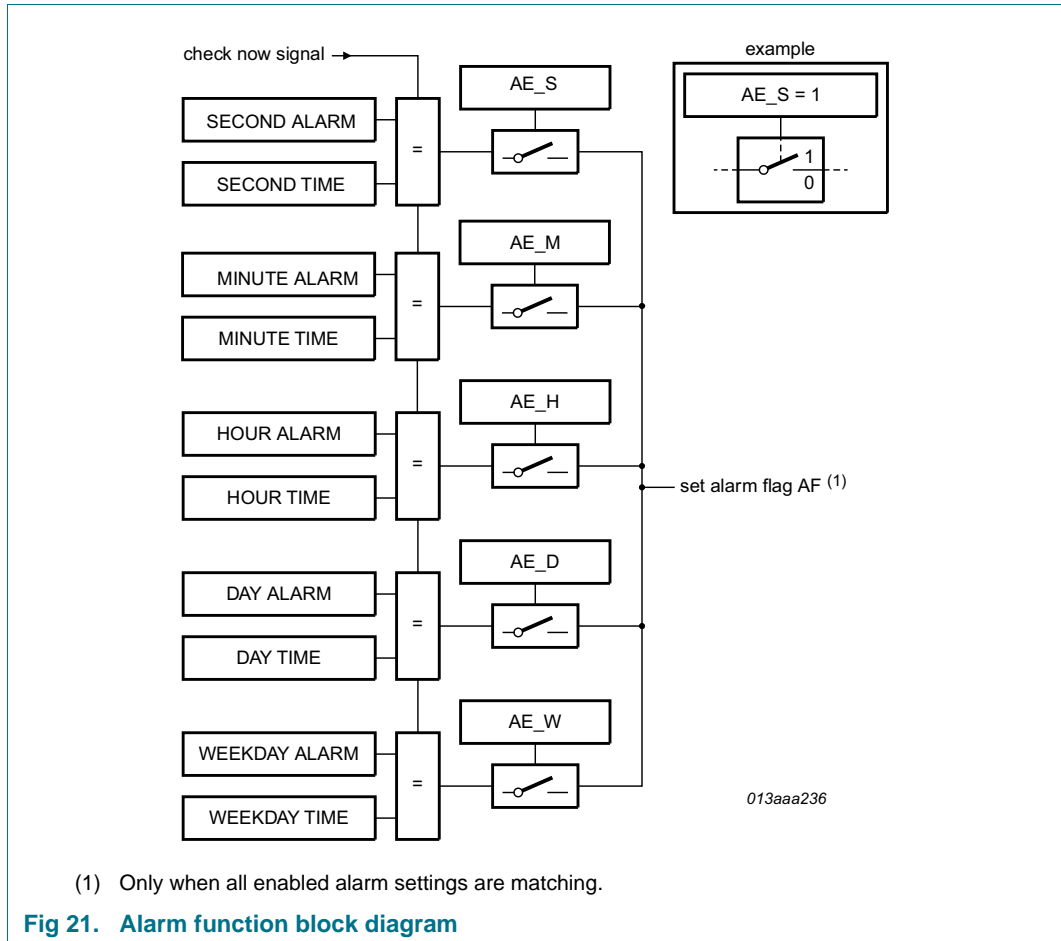
**Fig 20. Access time for read/write operations**

As a consequence of this method, it is very important to make a read or write access in one go. That is, setting or reading seconds through to years should be made in one single access. Failing to comply with this method could result in the time becoming corrupted.

As an example, if the time (seconds through to hours) is set in one access and then in a second access the date is set, it is possible that the time may increment between the two accesses. A similar problem exists when reading. A roll-over may occur between reads thus giving the minutes from one moment and the hours from the next. Therefore it is advised to read all time and date registers in one access.

### 8.10 Alarm function

When one or more of the alarm bit fields are loaded with a valid second, minute, hour, day, or weekday and its corresponding alarm enable bit (AE\_x) is logic 0, then that information is compared with the actual second, minute, hour, day, and weekday (see [Figure 21](#)).



The generation of interrupts from the alarm function is described in [Section 8.13.5](#).

### 8.10.1 Register Second\_alarm

**Table 44. Second\_alarm - second alarm register (address 0Ah) bit allocation**

Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit         | 7    | 6                      | 5 | 4 | 3 | 2 | 1 | 0 |
|-------------|------|------------------------|---|---|---|---|---|---|
| Symbol      | AE_S | SECOND_ALARM (0 to 59) |   |   |   |   |   |   |
| Reset value | 1    | X                      | X | X | X | X | X | X |

**Table 45. Second\_alarm - second alarm register (address 0Ah) bit description**

| Bit    | Symbol       | Value  | Place value | Description                                  |
|--------|--------------|--------|-------------|--|
| 7      | AE_S         | 0      | -           | second alarm is enabled                      |
|        |              | 1      | -           | second alarm is disabled                     |
| 6 to 4 | SECOND_ALARM | 0 to 5 | ten's place | second alarm information coded in BCD format |
| 3 to 0 |              | 0 to 9 | unit place  |  |

### 8.10.2 Register Minute\_alarm

**Table 46. Minute\_alarm - minute alarm register (address 0Bh) bit allocation**

Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit         | 7    | 6                      | 5 | 4 | 3 | 2 | 1 | 0 |
|-------------|------|------------------------|---|---|---|---|---|---|
| Symbol      | AE_M | MINUTE_ALARM (0 to 59) |   |   |   |   |   |   |
| Reset value | 1    | X                      | X | X | X | X | X | X |

**Table 47. Minute\_alarm - minute alarm register (address 0Bh) bit description**

Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit    | Symbol       | Value  | Place value | Description                                  |
|--------|--------------|--------|-------------|--|
| 7      | AE_M         | 0      | -           | minute alarm is enabled                      |
|        |              | 1      | -           | minute alarm is disabled                     |
| 6 to 4 | MINUTE_ALARM | 0 to 5 | ten's place | minute alarm information coded in BCD format |
| 3 to 0 |              | 0 to 9 | unit place  |  |

### 8.10.3 Register Hour\_alarm

**Table 48. Hour\_alarm - hour alarm register (address 0Ch) bit allocation**

Bit positions labeled as - are not implemented and return 0 when read. Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit         | 7    | 6 | 5                                    | 4                                    | 3 | 2 | 1 | 0 |
|-------------|------|---|--------------------------------------|--------------------------------------|---|---|---|---|
| Symbol      | AE_H | - | AMPM                                 | HOUR_ALARM (1 to 12) in 12-hour mode |   |   |   |   |
|             |      |   | HOUR_ALARM (0 to 23) in 24-hour mode |                                      |   |   |   |   |
| Reset value | 1    | - | X                                    | X                                    | X | X | X | X |

**Table 49. Hour\_alarm - hour alarm register (address 0Ch) bit description**

Bit positions labeled as - are not implemented and return 0 when read. Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit                               | Symbol     | Value  | Place value | Description   |
|-----------------------------------|------------|--------|-------------|---|
| 7                                 | AE_H       | 0      | -           | hour alarm is enabled   |
|                                   |            | 1      | -           | hour alarm is disabled  |
| 6                                 | -          | -      | -           | unused  |
| <b>12-hour mode<sup>[1]</sup></b> |            |        |             |   |
| 5                                 | AMPM       | 0      | -           | indicates AM  |
|                                   |            | 1      | -           | indicates PM  |
| 4                                 | HOUR_ALARM | 0 to 1 | ten's place | hour alarm information coded in BCD format when in 12-hour mode |
| 3 to 0                            |            | 0 to 9 | unit place  |   |
| <b>24-hour mode<sup>[1]</sup></b> |            |        |             |   |
| 5 to 4                            | HOUR_ALARM | 0 to 2 | ten's place | hour alarm information coded in BCD format when in 24-hour mode |
| 3 to 0                            |            | 0 to 9 | unit place  |   |

[1] Hour mode is set by the bit 12\_24 in register Control\_1.

### 8.10.4 Register Day\_alarm

**Table 50. Day\_alarm - day alarm register (address 0Dh) bit allocation**

Bit positions labeled as - are not implemented and return 0 when read. Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit         | 7    | 6 | 5                   | 4 | 3 | 2 | 1 | 0 |
|-------------|------|---|---------------------|---|---|---|---|---|
| Symbol      | AE_D | - | DAY_ALARM (1 to 31) |   |   |   |   |   |
| Reset value | 1    | - | X                   | X | X | X | X | X |

**Table 51. Day\_alarm - day alarm register (address 0Dh) bit description**

Bit positions labeled as - are not implemented and return 0 when read. Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit    | Symbol    | Value  | Place value | Description                               |
|--------|-----------|--------|-------------|---|
| 7      | AE_D      | 0      | -           | day alarm is enabled                      |
|        |           | 1      | -           | day alarm is disabled                     |
| 6      | -         | -      | -           | unused                                    |
| 5 to 4 | DAY_ALARM | 0 to 3 | ten's place | day alarm information coded in BCD format |
| 3 to 0 |           | 0 to 9 | unit place  |   |

### 8.10.5 Register Weekday\_alarm

**Table 52. Weekday\_alarm - weekday alarm register (address 0Eh) bit allocation**

Bit positions labeled as - are not implemented and return 0 when read. Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit         | 7    | 6 | 5 | 4 | 3 | 2                      | 1 | 0 |
|-------------|------|---|---|---|---|------------------------|---|---|
| Symbol      | AE_W | - | - | - | - | WEEKDAY_ALARM (0 to 6) |   |   |
| Reset value | 1    | - | - | - | - | X                      | X | X |

**Table 53. Weekday\_alarm - weekday alarm register (address 0Eh) bit description**

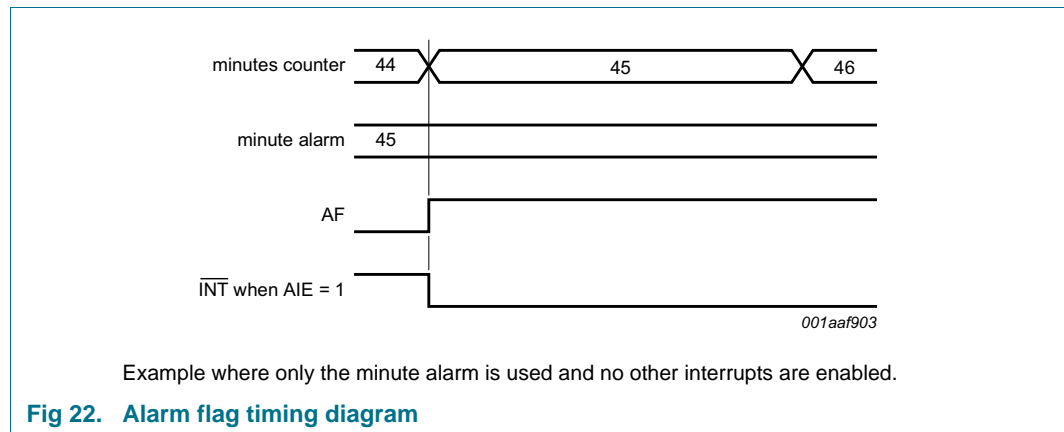
Bit positions labeled as - are not implemented and return 0 when read. Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit    | Symbol        | Value  | Description               |
|--------|---------------|--------|---------------------------|
| 7      | AE_W          | 0      | weekday alarm is enabled  |
|        |               | 1      | weekday alarm is disabled |
| 6 to 3 | -             | -      | unused                    |
| 2 to 0 | WEEKDAY_ALARM | 0 to 6 | weekday alarm information |

### 8.10.6 Alarm flag

When all enabled comparisons first match, the alarm flag AF (register Control\_2) is set. AF remains set until cleared by command. Once AF has been cleared, it will only be set again when the time increments to match the alarm condition once more. For clearing the flags, see [Section 8.11.6](#)

Alarm registers which have their alarm enable bit AE\_x at logic 1 are ignored.



### 8.11 Timer functions

The PCF2127 has two different timer functions, a watchdog timer and a countdown timer. The timers can be selected by using the control bits WD\_CD[1:0] in the register Watchdog\_tim\_ctl.

- The watchdog timer has four selectable source clocks. It can, for example, be used to detect a microcontroller with interrupt and reset capability which is out of control (see [Section 8.11.3](#))

- The countdown timer has four selectable source clocks allowing for countdown periods from less than 1 ms to more than 4 hours (see [Section 8.11.4](#))

To control the timer functions and timer output, the registers Control\_2, Watchdg\_tim\_ctl, and Watchdg\_tim\_val are used.

### 8.11.1 Register Watchdg\_tim\_ctl

**Table 54. Watchdg\_tim\_ctl - watchdog timer control register (address 10h) bit allocation**

Bit positions labeled as - are not implemented and return 0 when read.

| Bit         | 7          | 6 | 5     | 4 | 3 | 2 | 1       | 0 |
|-------------|------------|---|-------|---|---|---|---------|---|
| Symbol      | WD_CD[1:0] |   | TI_TP | - | - | - | TF[1:0] |   |
| Reset value | 0          | 0 | 0     | - | - | - | 1       | 1 |

**Table 55. Watchdg\_tim\_ctl - watchdog timer control register (address 10h) bit description**

Bit positions labeled as - are not implemented and return 0 when read.

| Bit    | Symbol     | Value | Description   |
|--------|------------|-------|---|
| 7 to 6 | WD_CD[1:0] | 00    | Watchdog timer disabled;<br>countdown timer disabled  |
|        |            | 01    | watchdog timer disabled;<br>countdown timer enabled<br>if CDTIE is set logic 1, the interrupt pin $\overline{\text{INT}}$ is activated when the countdown timed out |
|        |            | 10    | watchdog timer enabled;<br>the interrupt pin $\overline{\text{INT}}$ is activated when timed out;<br>countdown timer not available                                  |
|        |            | 11    | watchdog timer enabled;<br>the reset pin $\overline{\text{RST}}$ is activated when timed out;<br>countdown timer not available                                      |
| 5      | TI_TP      | 0     | the interrupt pin $\overline{\text{INT}}$ is configured to generate a permanent active signal when MSF and/or CDTF is set   |
|        |            | 1     | the interrupt pin $\overline{\text{INT}}$ is configured to generate a pulsed signal when MSF flag and/or CDTF flag is set (see <a href="#">Figure 27</a> )          |
| 4 to 2 | -          | -     | unused  |
| 1 to 0 | TF[1:0]    |       | timer source clock for watchdog and countdown timer   |
|        |            | 00    | 4.096 kHz   |
|        |            | 01    | 64 Hz   |
|        |            | 10    | 1 Hz  |
|        |            | 11    | $\frac{1}{60}$ Hz   |

### 8.11.2 Register Watchdg\_tim\_val

**Table 56. Watchdg\_tim\_val - watchdog timer value register (address 11h) bit allocation**

Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit         | 7                     | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|-------------|-----------------------|---|---|---|---|---|---|---|
| Symbol      | WATCHDGD_TIM_VAL[7:0] |   |   |   |   |   |   |   |
| Reset value | X                     | X | X | X | X | X | X | X |

**Table 57. Watchdg\_tim\_val - watchdog timer value register (address 11h) bit description**

Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit    | Symbol                | Value    | Description   |
|--------|-----------------------|----------|---|
| 7 to 0 | WATCHDGD_TIM_VAL[7:0] | 00 to FF | timer period in seconds:<br>$TimerPeriod = \frac{n}{SourceClockFrequency}$ where n is the timer value |

**Table 58. Programmable watchdog timer**

| TF[1:0] | Timer source clock frequency | Units | Minimum timer period (n = 1) | Units | Maximum timer period (n = 255) | Units |
|---------|------------------------------|-------|------------------------------|-------|--------------------------------|-------|
| 00      | 4.096                        | kHz   | 244                          | μs    | 62.256                         | ms    |
| 01      | 64                           | Hz    | 15.625                       | ms    | 3.984                          | s     |
| 10      | 1                            | Hz    | 1                            | s     | 255                            | s     |
| 11      | 1/60                         | Hz    | 60                           | s     | 15300                          | s     |

### 8.11.3 Watchdog timer function

The watchdog timer function is enabled or disabled by the WD\_CD[1:0] bits of the register Watchdg\_tim\_ctl (see [Table 55](#)).

The two bits TF[1:0] in register Watchdg\_tim\_ctl determine one of the four source clock frequencies for the watchdog timer: 4.096 kHz, 64 Hz, 1 Hz, or 1/60 Hz (see [Table 58](#)).

When the watchdog timer function is enabled, the 8-bit timer in register Watchdg\_tim\_val determines the watchdog timer period (see [Table 58](#)).

The watchdog timer counts down from the software programmed 8-bit binary value n in register Watchdg\_tim\_val. When the counter reaches 1, the watchdog timer flag WDTF (register Control\_2) is set logic 1.

If WDTF is logic 1 and:

- if WD\_CD[1:0] = 10 an interrupt will be generated
- if WD\_CD[1:0] = 11 a reset will be generated

The counter does not automatically reload.

When WD\_CD[1:0] = 10 or WD\_CD[1:0] = 11 and the Microcontroller Unit (MCU) loads a watchdog timer value n:

- the flag WDTF is reset
- $\overline{INT}$  or  $\overline{RST}$  is cleared

- the watchdog timer starts again

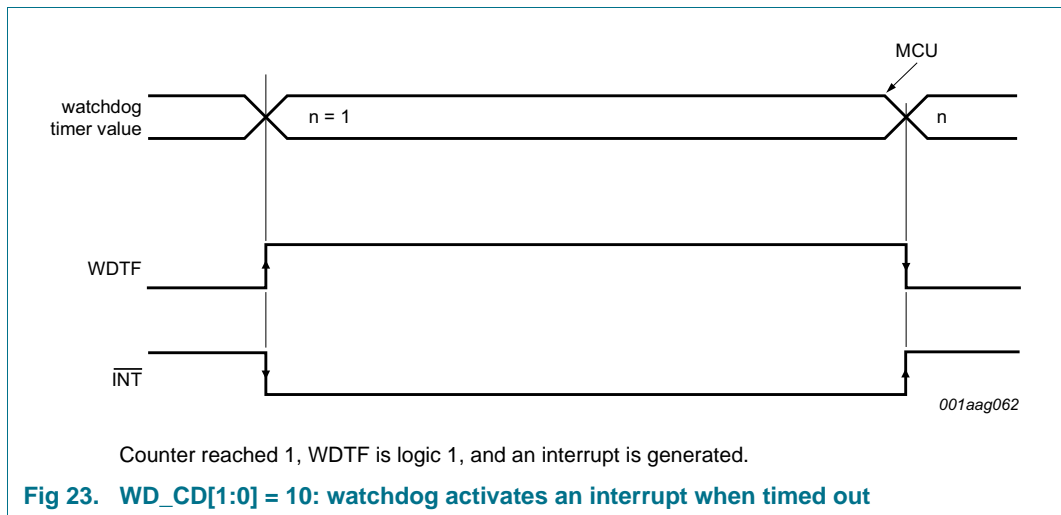
Loading the counter with 0 will:

- reset the flag WDTF
- clear  $\overline{\text{INT}}$  or  $\overline{\text{RST}}$
- stop the watchdog timer

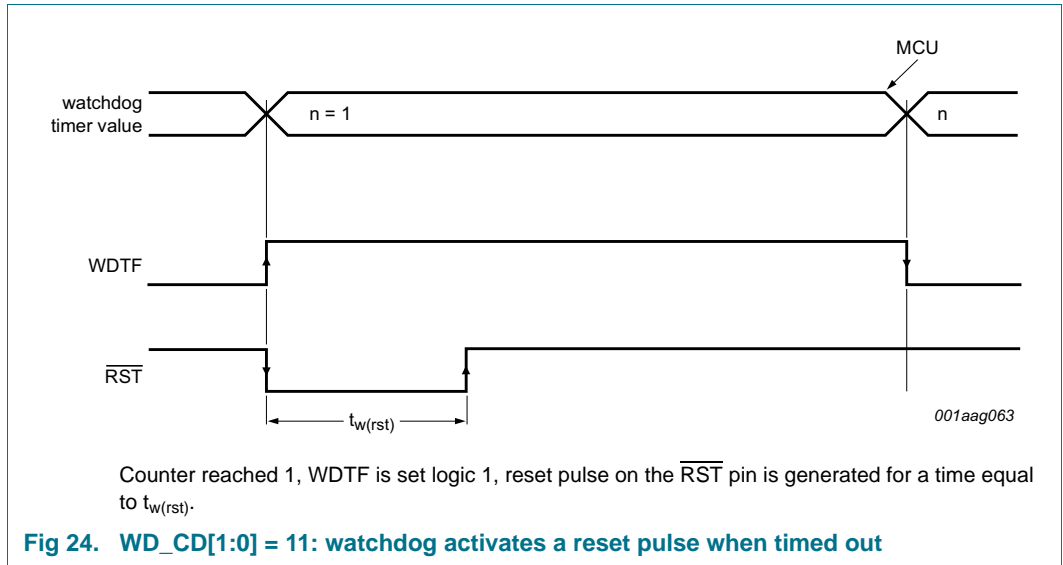
**Remark:** WDTF is read only and cannot be cleared by command. WDTF can be cleared by:

- loading a value in register Watchdg\_tim\_val
- reading of the register Control\_2

Writing a logic 0 or logic 1 to WDTF has no effect.



- When the watchdog timer counter reaches 1, the watchdog timer flag WDTF is set logic 1
- When a minute or second interrupt occurs, the minute/second flag MSF is set logic 1 (see [Section 8.13.1](#))



**Table 59. Specification of  $t_{w(\text{rst})}$**

| WD_CD[1:0] | TF[1:0] | $t_{w(\text{rst})}$ |
|------------|---------|---------------------|
| 11         | 00      | 244 $\mu\text{s}$   |
|            | 01      | 15.625 ms           |
|            | 10      | 15.625 ms           |
|            | 11      | 15.625 ms           |

**8.11.4 Countdown timer function**

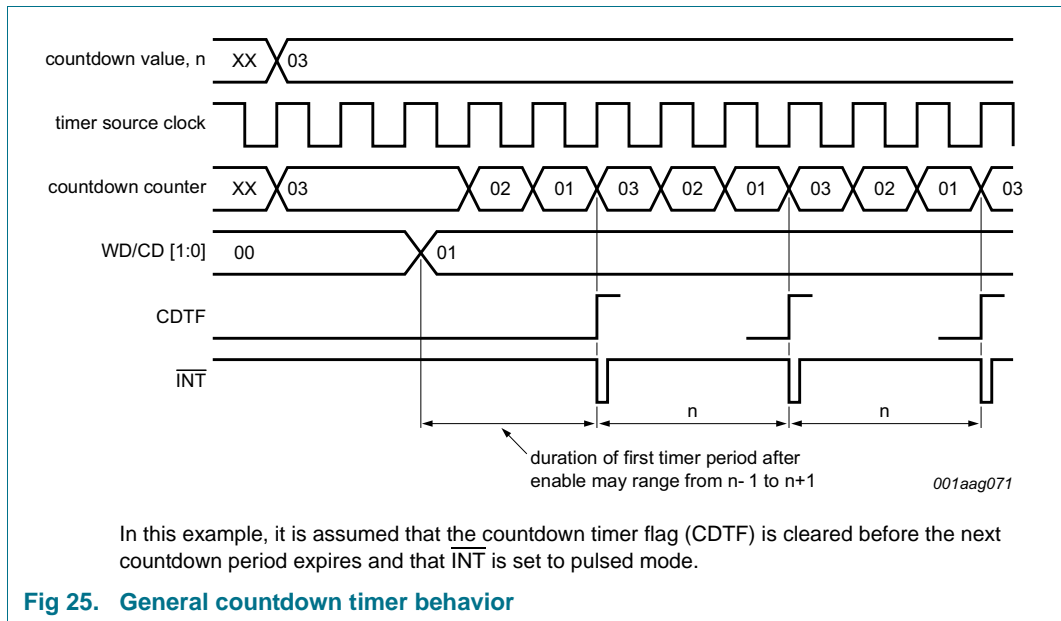
The countdown timer function is controlled by the WD\_CD[1:0] bits in register Watchdgm\_tim\_ctl (see [Table 55](#)).

The timer counts down from the software programmed 8-bit binary value n in register Watchdgm\_tim\_val. When the counter reaches 1

- the countdown timer flag CDTF is set
- the counter automatically reloads
- and the next time period starts

Loading the counter with 0 effectively stops the timer.

Reading the timer returns the actual value of the countdown counter.



If a new value of n is written before the end of the actual timer period, this value takes immediate effect. It is not recommended to change n without first disabling the counter by setting WD\_CD[1:0] = 00. The update of n is asynchronous to the timer clock. Therefore changing it on the fly could result in a corrupted value loaded into the countdown counter. This can result in an undetermined countdown period for the first period. The countdown value n will, however, be correctly stored and correctly loaded on subsequent timer periods.

If this mode is enabled and the countdown timer flag CDTF is set, an interrupt signal on INT will be generated. See Section 8.13.2 for details on how the interrupt can be controlled.

When starting the countdown timer for the first time, only the first period will not have a fixed duration. The amount of inaccuracy for the first timer period depends on the chosen source clock, see Table 60.

**Table 60. First period delay for timer counter**

| Timer source clock        | Minimum timer period                | Maximum timer period          |
|---------------------------|-------------------------------------|-------------------------------|
| 4.096 kHz                 | n                                   | n + 1                         |
| 64 Hz                     | n                                   | n + 1                         |
| 1 Hz                      | $(n - 1) + \frac{1}{64} \text{ Hz}$ | $n + \frac{1}{64} \text{ Hz}$ |
| $\frac{1}{60} \text{ Hz}$ | $(n - 1) + \frac{1}{64} \text{ Hz}$ | $n + \frac{1}{64} \text{ Hz}$ |

At the end of every countdown, the timer sets the countdown timer flag (CDTF). CDTF may only be cleared by command. The asserted CDTF can be used to generate an interrupt (INT). The interrupt may be generated as a pulsed signal every countdown period or as a permanently active signal which follows the condition of CDTF. TI\_TP is used to control this mode selection. The interrupt output may be disabled with the CDTIE bit, see Table 9.

When reading the timer, the actual countdown value is returned and **not** the initial value *n*. Since it is not possible to freeze the countdown timer counter during read back, it is recommended to read the register twice and check for consistent results.

**8.11.5 Pre-defined timers: second and minute interrupt**

PCF2127 has two pre-defined timers which are used to generate an interrupt either once per second or once per minute (see [Section 8.13.1](#)). The pulse generator for the minute or second interrupt operates from an internal 64 Hz clock. It is independent of the watchdog or countdown timers. Each of these timers can be enabled by the bits SI (second interrupt) and MI (minute interrupt) in register Control\_1.

**8.11.6 Clearing flags**

The flags MSF, CDTF, AF and TSF<sub>x</sub> can be cleared by command. To prevent one flag being overwritten while clearing another, a logic AND is performed during the write access. A flag is cleared by writing logic 0 while a flag is not cleared by writing logic 1. Writing logic 1 results in the flag value remaining unchanged.

Four examples are given for clearing the flags. Clearing the flags is made by a write command:

- Bits labeled with - must be written with their previous values
- WDTF is read only and has to be written with logic 0

Repeatedly rewriting these bits has no influence on the functional behavior.

**Table 61. Flag location in register Control\_2**

| Register  | Bit |      |      |    |      |   |   |   |
|-----------|-----|------|------|----|------|---|---|---|
|           | 7   | 6    | 5    | 4  | 3    | 2 | 1 | 0 |
| Control_2 | MSF | WDTF | TSF2 | AF | CDTF | - | - | - |

**Table 62. Example values in register Control\_2**

| Register  | Bit |   |   |   |   |   |   |   |
|-----------|-----|---|---|---|---|---|---|---|
|           | 7   | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| Control_2 | 1   | 0 | 1 | 1 | 1 | 0 | 0 | 0 |

The following tables show what instruction must be sent to clear the appropriate flag.

**Table 63. Example to clear only CDTF (bit 3)**

| Register  | Bit |   |   |   |   |      |      |      |
|-----------|-----|---|---|---|---|------|------|------|
|           | 7   | 6 | 5 | 4 | 3 | 2    | 1    | 0    |
| Control_2 | 1   | 0 | 1 | 1 | 0 | -[1] | -[1] | -[1] |

[1] The bits labeled as - have to be rewritten with the previous values.

**Table 64. Example to clear only AF (bit 4)**

| Register  | Bit |   |   |   |   |      |      |      |
|-----------|-----|---|---|---|---|------|------|------|
|           | 7   | 6 | 5 | 4 | 3 | 2    | 1    | 0    |
| Control_2 | 1   | 0 | 1 | 0 | 1 | 0[1] | 0[1] | 0[1] |

[1] The bits labeled as - have to be rewritten with the previous values.

Table 65. Example to clear only MSF (bit 7)

| Register  | Bit |   |   |   |   |                  |                  |                  |
|-----------|-----|---|---|---|---|------------------|------------------|------------------|
|           | 7   | 6 | 5 | 4 | 3 | 2                | 1                | 0                |
| Control_2 | 0   | 0 | 1 | 1 | 1 | 0 <sup>[1]</sup> | 0 <sup>[1]</sup> | 0 <sup>[1]</sup> |

[1] The bits labeled as - have to be rewritten with the previous values.

Table 66. Example to clear both CDTF and MSF

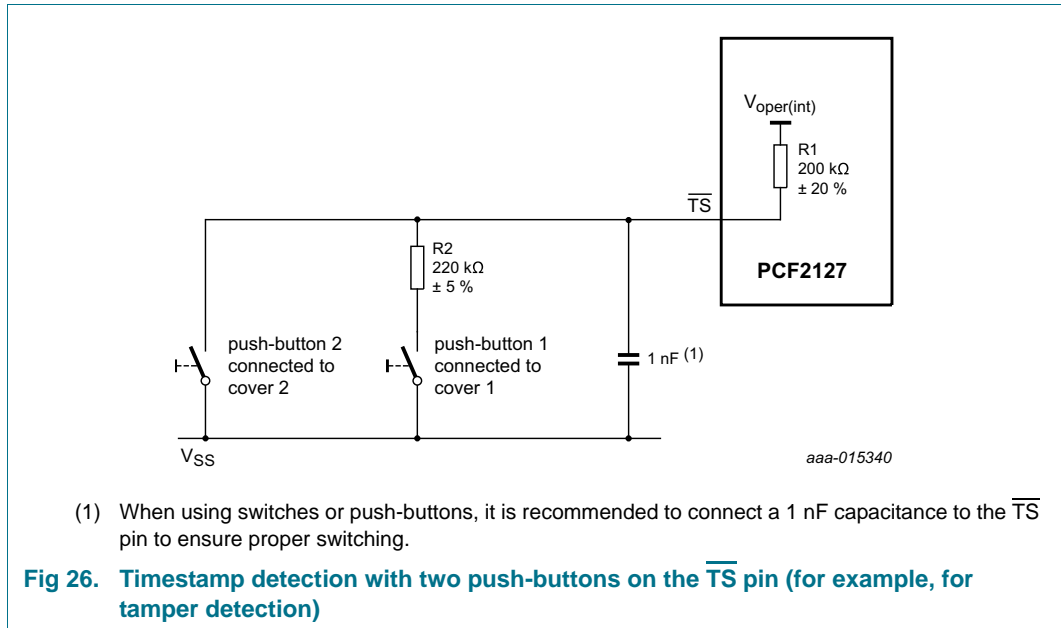
| Register  | Bit |   |   |   |   |                  |                  |                  |
|-----------|-----|---|---|---|---|------------------|------------------|------------------|
|           | 7   | 6 | 5 | 4 | 3 | 2                | 1                | 0                |
| Control_2 | 0   | 0 | 1 | 1 | 0 | 0 <sup>[1]</sup> | 0 <sup>[1]</sup> | 0 <sup>[1]</sup> |

[1] The bits labeled as - have to be rewritten with the previous values.

### 8.12 Timestamp function

The PCF2127 has an active LOW timestamp input pin  $\overline{TS}$ , internally pulled with an on-chip pull-up resistor to  $V_{oper(int)}$ . It also has a timestamp detection circuit which can detect two different events:

1. Input on pin  $\overline{TS}$  is driven to an intermediate level between power supply and ground.
2. Input on pin  $\overline{TS}$  is driven to ground.



The timestamp function is enabled by default after power-on and it can be switched off by setting the control bit TSOFF (register `Timestampctl`).

A most common application of the timestamp function is described in [Ref. 3 “AN11266”](#).

See [Section 8.13.6](#) for a description of interrupt generation from the timestamp function.

#### 8.12.1 Timestamp flag

1. When the  $\overline{TS}$  input pin is driven to an intermediate level between the power supply and ground, either on the falling edge from  $V_{DD}$  or on the rising edge from ground, then the following sequence occurs:
  - a. The actual date and time are stored in the timestamp registers.
  - b. The timestamp flag TSF1 (register `Control_1`) is set.
  - c. If the TSIE bit (register `Control_2`) is active, an interrupt on the  $\overline{INT}$  pin is generated.

The TSF1 flag can be cleared by command. Clearing the flag clears the interrupt. Once TSF1 is cleared, it will only be set again when a new negative or positive edge on pin  $\overline{TS}$  is detected.

2. When the  $\overline{TS}$  input pin is driven to ground, the following sequence occurs:
  - a. The actual date and time are stored in the timestamp registers.
  - b. In addition to the TSF1 flag, the TSF2 flag (register `Control_2`) is set.

c. If the TSIE bit is active, an interrupt on the  $\overline{\text{INT}}$  pin is generated.

The TSF1 and TSF2 flags can be cleared by command; clearing both flags clears the interrupt. Once TSF2 is cleared, it will only be set again when  $\overline{\text{TS}}$  pin is driven to ground once again.

### 8.12.2 Timestamp mode

The timestamp function has two different modes selected by the control bit TSM (timestamp mode) in register Timestp\_ctl:

- If TSM is logic 0 (default): in subsequent trigger events without clearing the timestamp flags, the last timestamp event is stored
- If TSM is logic 1: in subsequent trigger events without clearing the timestamp flags, the first timestamp event is stored

The timestamp function also depends on the control bit BTSE in register Control\_3, see [Section 8.12.4](#).

### 8.12.3 Timestamp registers

#### 8.12.3.1 Register Timestp\_ctl

**Table 67. Timestp\_ctl - timestamp control register (address 12h) bit allocation**

Bit positions labeled as - are not implemented and return 0 when read. Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit         | 7   | 6     | 5 | 4                   | 3 | 2 | 1 | 0 |
|-------------|-----|-------|---|---------------------|---|---|---|---|
| Symbol      | TSM | TSOFF | - | 1_O_16_TIMESTP[4:0] |   |   |   |   |
| Reset value | 0   | 0     | - | X                   | X | X | X | X |

**Table 68. Timestp\_ctl - timestamp control register (address 12h) bit description**

Bit positions labeled as - are not implemented and return 0 when read. Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit    | Symbol              | Value | Description  |
|--------|---------------------|-------|--|
| 7      | TSM                 | 0     | in subsequent events without clearing the timestamp flags, the last event is stored  |
|        |                     | 1     | in subsequent events without clearing the timestamp flags, the first event is stored |
| 6      | TSOFF               | 0     | timestamp function active  |
|        |                     | 1     | timestamp function disabled  |
| 5      | -                   | -     | unused   |
| 4 to 0 | 1_O_16_TIMESTP[4:0] |       | $\frac{1}{16}$ second timestamp information coded in BCD format                      |

#### 8.12.3.2 Register Sec\_timestp

**Table 69. Sec\_timestp - second timestamp register (address 13h) bit allocation**

Bit positions labeled as - are not implemented and return 0 when read. Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit         | 7 | 6                        | 5 | 4 | 3 | 2 | 1 | 0 |
|-------------|---|--------------------------|---|---|---|---|---|---|
| Symbol      | - | SECOND_TIMESTP (0 to 59) |   |   |   |   |   |   |
| Reset value | - | X                        | X | X | X | X | X | X |

**Table 70. Sec\_timestp - second timestamp register (address 13h) bit description**

Bit positions labeled as - are not implemented and return 0 when read. Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit    | Symbol         | Value  | Place value | Description                                      |
|--------|----------------|--------|-------------|--|
| 7      | -              | -      | -           | unused   |
| 6 to 4 | SECOND_TIMESTP | 0 to 5 | ten's place | second timestamp information coded in BCD format |
| 3 to 0 |                | 0 to 9 | unit place  |  |

### 8.12.3.3 Register Min\_timestp

**Table 71. Min\_timestp - minute timestamp register (address 14h) bit allocation**

Bit positions labeled as - are not implemented and return 0 when read. Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit         | 7 | 6                        | 5 | 4 | 3 | 2 | 1 | 0 |
|-------------|---|--------------------------|---|---|---|---|---|---|
| Symbol      | - | MINUTE_TIMESTP (0 to 59) |   |   |   |   |   |   |
| Reset value | - | X                        | X | X | X | X | X | X |

**Table 72. Min\_timestp - minute timestamp register (address 14h) bit description**

Bit positions labeled as - are not implemented and return 0 when read. Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit    | Symbol         | Value  | Place value | Description                                      |
|--------|----------------|--------|-------------|--|
| 7      | -              | -      | -           | unused   |
| 6 to 4 | MINUTE_TIMESTP | 0 to 5 | ten's place | minute timestamp information coded in BCD format |
| 3 to 0 |                | 0 to 9 | unit place  |  |

### 8.12.3.4 Register Hour\_timestp

**Table 73. Hour\_timestp - hour timestamp register (address 15h) bit allocation**

Bit positions labeled as - are not implemented and return 0 when read. Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit         | 7 | 6 | 5    | 4                                      | 3 | 2 | 1 | 0 |
|-------------|---|---|------|--|---|---|---|---|
| Symbol      | - | - | AMPM | HOUR_TIMESTP (1 to 12) in 12-hour mode |   |   |   |   |
|             |   |   |      | HOUR_TIMESTP (0 to 23) in 24-hour mode |   |   |   |   |
| Reset value | - | - | X    | X                                      | X | X | X | X |

**Table 74. Hour\_timestp - hour timestamp register (address 15h) bit description**

Bit positions labeled as - are not implemented and return 0 when read. Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit                               | Symbol       | Value  | Place value | Description   |
|-----------------------------------|--------------|--------|-------------|---|
| 7 to 6                            | -            | -      | -           | unused  |
| <b>12-hour mode<sup>[1]</sup></b> |              |        |             |   |
| 5                                 | AMPM         | 0      | -           | indicates AM  |
|                                   |              | 1      | -           | indicates PM  |
| 4                                 | HOUR_TIMESTP | 0 to 1 | ten's place | hour timestamp information coded in BCD format when in 12-hour mode |
| 3 to 0                            |              | 0 to 9 | unit place  |   |
| <b>24-hour mode<sup>[1]</sup></b> |              |        |             |   |
| 5 to 4                            | HOUR_TIMESTP | 0 to 2 | ten's place | hour timestamp information coded in BCD format when in 24-hour mode |
| 3 to 0                            |              | 0 to 9 | unit place  |   |

[1] Hour mode is set by the bit 12\_24 in register Control\_1.

### 8.12.3.5 Register Day\_timestp

**Table 75. Day\_timestp - day timestamp register (address 16h) bit allocation**

Bit positions labeled as - are not implemented and return 0 when read. Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit         | 7 | 6 | 5                     | 4 | 3 | 2 | 1 | 0 |
|-------------|---|---|-----------------------|---|---|---|---|---|
| Symbol      | - | - | DAY_TIMESTP (1 to 31) |   |   |   |   |   |
| Reset value | - | - | X                     | X | X | X | X | X |

**Table 76. Day\_timestp - day timestamp register (address 16h) bit description**

Bit positions labeled as - are not implemented and return 0 when read. Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit    | Symbol      | Value  | Place value | Description                                   |
|--------|-------------|--------|-------------|---|
| 7 to 6 | -           | -      | -           | unused  |
| 5 to 4 | DAY_TIMESTP | 0 to 3 | ten's place | day timestamp information coded in BCD format |
| 3 to 0 |             | 0 to 9 | unit place  |   |

### 8.12.3.6 Register Mon\_timestp

**Table 77. Mon\_timestp - month timestamp register (address 17h) bit allocation**

Bit positions labeled as - are not implemented and return 0 when read. Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit         | 7 | 6 | 5 | 4                       | 3 | 2 | 1 | 0 |
|-------------|---|---|---|-------------------------|---|---|---|---|
| Symbol      | - | - | - | MONTH_TIMESTP (1 to 12) |   |   |   |   |
| Reset value | - | - | - | X                       | X | X | X | X |

**Table 78. Mon\_timestp - month timestamp register (address 17h) bit description**

Bit positions labeled as - are not implemented and return 0 when read. Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit    | Symbol        | Value  | Place value | Description                                     |
|--------|---------------|--------|-------------|---|
| 7 to 5 | -             | -      | -           | unused  |
| 4      | MONTH_TIMESTP | 0 to 1 | ten's place | month timestamp information coded in BCD format |
| 3 to 0 |               | 0 to 9 | unit place  |   |

### 8.12.3.7 Register Year\_timestp

**Table 79. Year\_timestp - year timestamp register (address 18h) bit allocation**

Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit         | 7                      | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|-------------|------------------------|---|---|---|---|---|---|---|
| Symbol      | YEAR_TIMESTP (0 to 99) |   |   |   |   |   |   |   |
| Reset value | X                      | X | X | X | X | X | X | X |

**Table 80. Year\_timestp - year timestamp register (address 18h) bit description**

Bits labeled as X are undefined at power-on and unchanged by subsequent resets.

| Bit    | Symbol       | Value  | Place value | Description                                    |
|--------|--------------|--------|-------------|--|
| 7 to 4 | YEAR_TIMESTP | 0 to 9 | ten's place | year timestamp information coded in BCD format |
| 3 to 0 |              | 0 to 9 | unit place  |  |

### 8.12.4 Dependency between Battery switch-over and timestamp

The timestamp function depends on the control bit BTSE in register Control\_3:

**Table 81. Battery switch-over and timestamp**

| BTSE | BF | Description   |
|------|----|---|
| 0    | -  | [1] the battery switch-over does not affect the timestamp registers   |
| 1    | 0  | [1] If a battery switch-over event occurs:<br>the timestamp registers store the time and date when the switch-over occurs;<br>after this event occurred BF is set logic 1 |
|      | 1  | the timestamp registers are not modified;<br>in this condition subsequent battery switch-over events or falling edges on pin $\overline{TS}$ are not registered           |

[1] Default value.

8.13 Interrupt output,  $\overline{\text{INT}}$

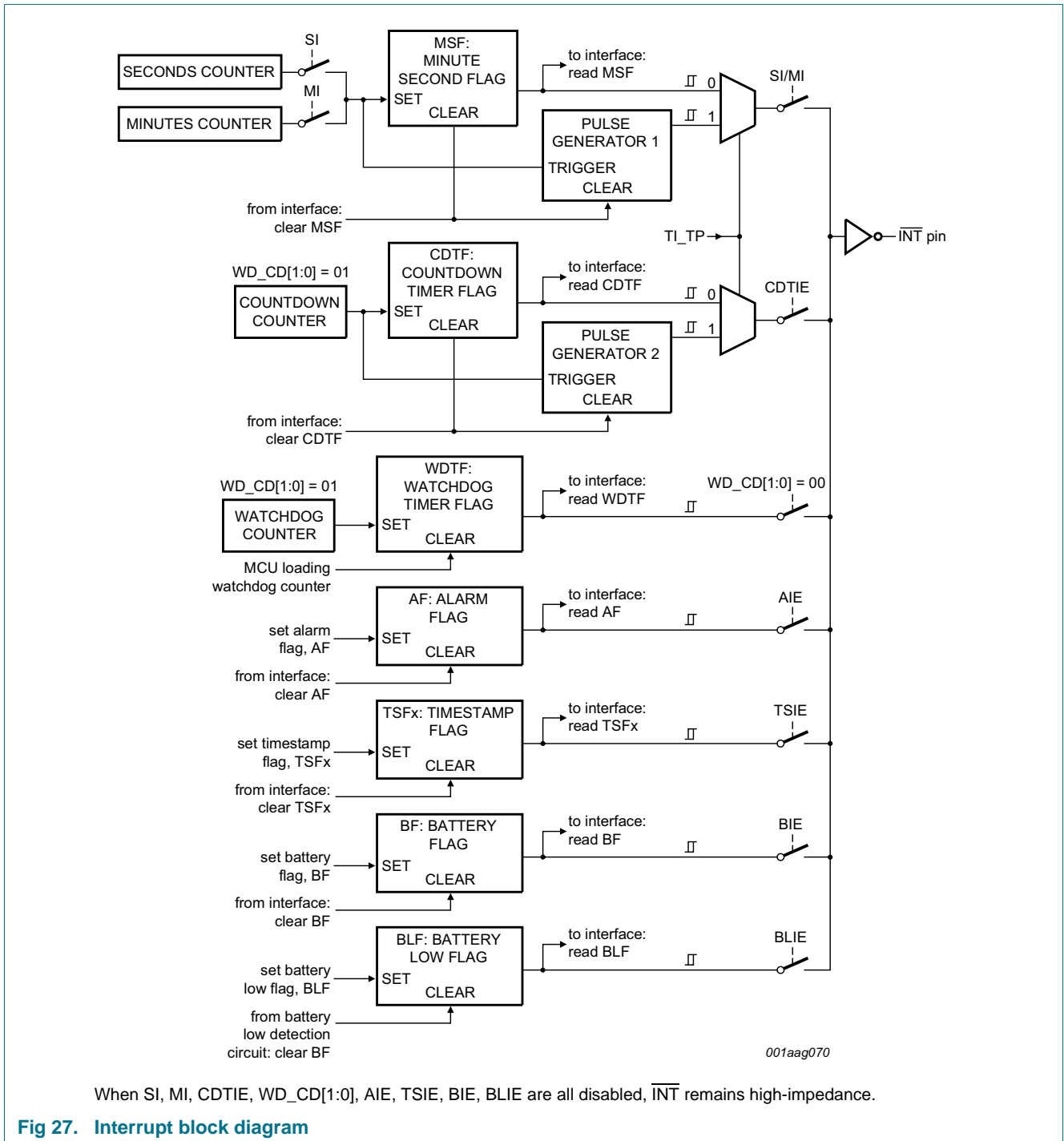


Fig 27. Interrupt block diagram

PCF2127 has an interrupt output pin  $\overline{\text{INT}}$  which is open-drain, active LOW (requiring a pull-up resistor if used). Interrupts may be sourced from different places:

- second or minute timer
- countdown timer

- watchdog timer
- alarm
- timestamp
- battery switch-over
- battery low detection

The control bit TI\_TP (register Watchdg\_tim\_ctl) is used to configure whether the interrupts generated from the second/minute timer (flag MSF in register Control\_2) and the countdown timer (flag CDTF in register Control\_2) are pulsed signals or a permanently active signal. All the other interrupt sources generate a permanently active interrupt signal which follows the status of the corresponding flags. When the interrupt sources are all disabled,  $\overline{\text{INT}}$  remains high-impedance.

- The flags MSF, CDTF, AF, TSFx, and BF can be cleared by command.
- The flag WDTF is read only. How it can be cleared is explained in [Section 8.11.6](#).
- The flag BLF is read only. It is cleared automatically from the battery low detection circuit when the battery is replaced.

### 8.13.1 Minute and second interrupts

Minute and second interrupts are generated by predefined timers. The timers can be enabled independently from one another by the bits MI and SI in register Control\_1. However, a minute interrupt enabled on top of a second interrupt cannot be distinguishable since it occurs at the same time.

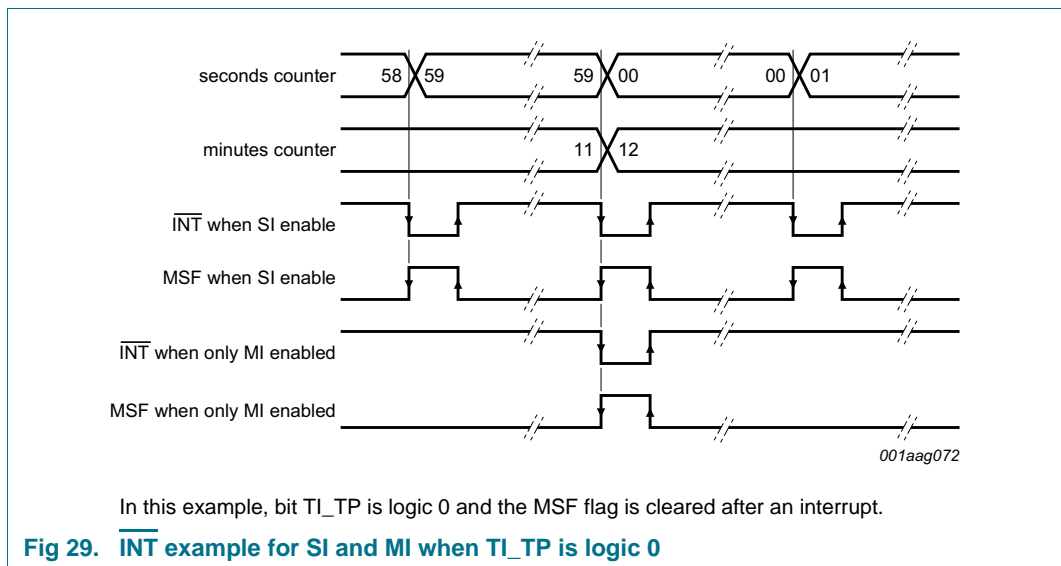
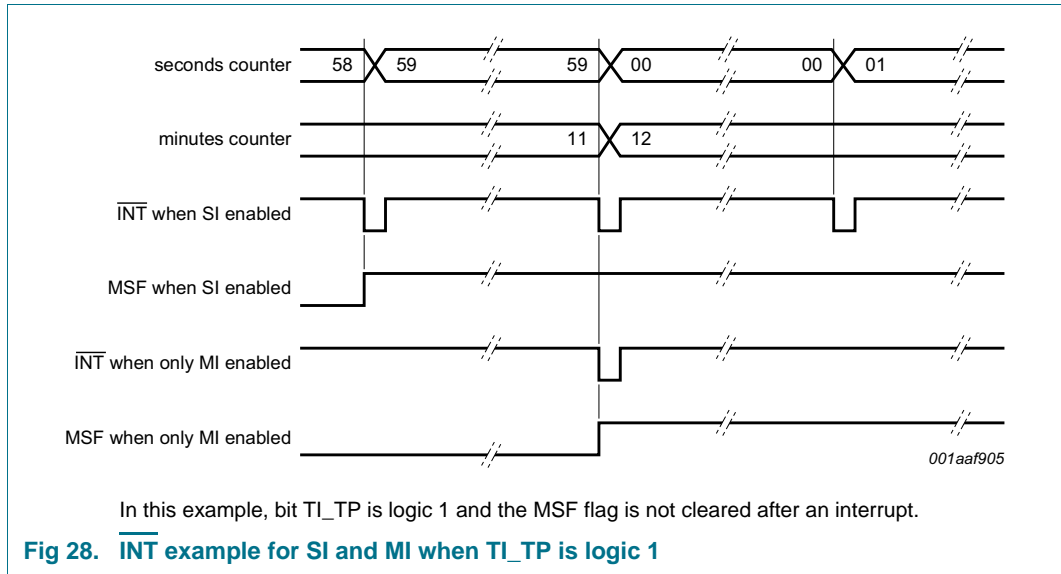
The minute/second flag MSF (register Control\_2) is set logic 1 when either the seconds or the minutes counter increments according to the enabled interrupt (see [Table 82](#)). The MSF flag can be cleared by command.

**Table 82. Effect of bits MI and SI on pin  $\overline{\text{INT}}$  and bit MSF**

| MI | SI | Result on $\overline{\text{INT}}$ | Result on MSF                                  |
|----|----|-----------------------------------|--|
| 0  | 0  | no interrupt generated            | MSF never set                                  |
| 1  | 0  | an interrupt once per minute      | MSF set when <b>minutes</b> counter increments |
| 0  | 1  | an interrupt once per second      | MSF set when <b>seconds</b> counter increments |
| 1  | 1  | an interrupt once per second      | MSF set when <b>seconds</b> counter increments |

When MSF is set logic 1:

- If TI\_TP is logic 1, the interrupt is generated as a pulsed signal.
- If TI\_TP is logic 0, the interrupt is permanently active signal that remains until MSF is cleared.



The pulse generator for the minute/second interrupt operates from an internal 64 Hz clock and generates a pulse of  $\frac{1}{64}$  seconds in duration.

### 8.13.2 Countdown timer interrupts

The generation of interrupts from the countdown timer is controlled by the CDTIE bit (register Control\_2).

The interrupt may be generated as a pulsed signal at every countdown period or as a permanently active signal which follows the status of the countdown timer flag CDTF. Bit TI\_TP is used to control this bit.

### 8.13.3 $\overline{\text{INT}}$ pulse shortening

The pulse generator for the countdown timer interrupt also uses an internal clock, but this time it is dependent on the selected source clock for the countdown timer and on the countdown value n. As a consequence, the width of the interrupt pulse varies (see

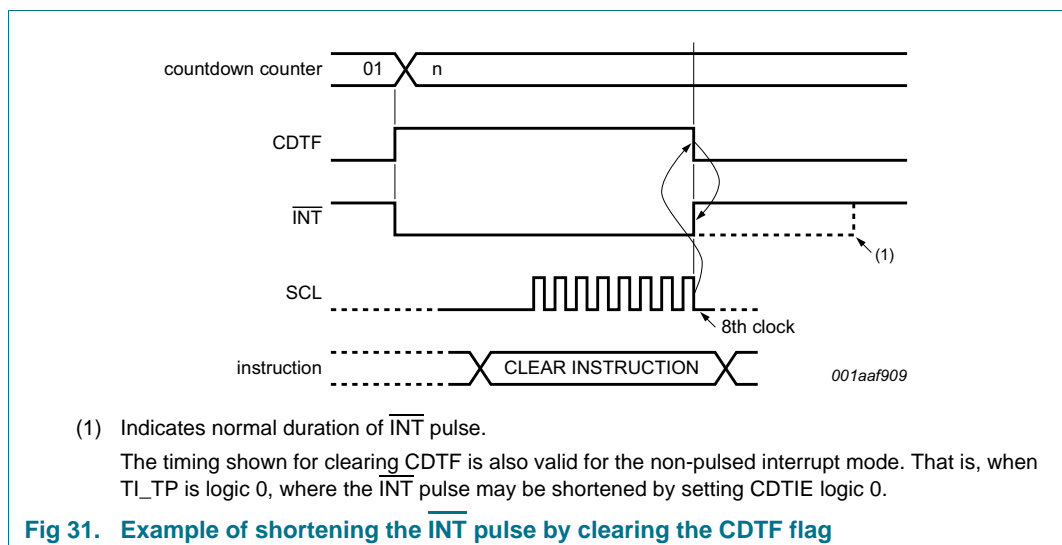
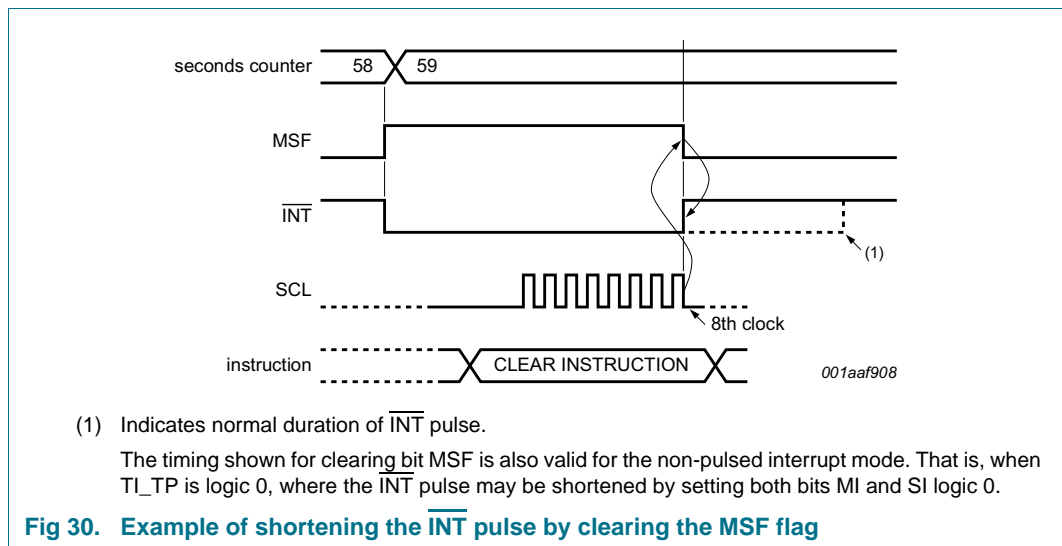
Table 83).

Table 83.  $\overline{\text{INT}}$  operation (bit TI\_TP = 1)

| Source clock (Hz) | $\overline{\text{INT}}$ period (s) |                  |
|-------------------|------------------------------------|------------------|
|                   | n = 1 [1]                          | n > 1            |
| 4096              | $\frac{1}{8192}$                   | $\frac{1}{4096}$ |
| 64                | $\frac{1}{128}$                    | $\frac{1}{64}$   |
| 1                 | $\frac{1}{64}$                     | $\frac{1}{64}$   |
| $\frac{1}{60}$    | $\frac{1}{64}$                     | $\frac{1}{64}$   |

[1] n = loaded countdown value. Timer stopped when n = 0.

If the MSF or CDTF flag (register Control\_2) is cleared before the end of the  $\overline{\text{INT}}$  pulse, then the  $\overline{\text{INT}}$  pulse is shortened. This allows the source of a system interrupt to be cleared immediately when it is serviced, that is, the system does not have to wait for the completion of the pulse before continuing, see Figure 30 and Figure 31. Instructions for clearing bit MSF and bit CDTF can be found in Section 8.11.6.



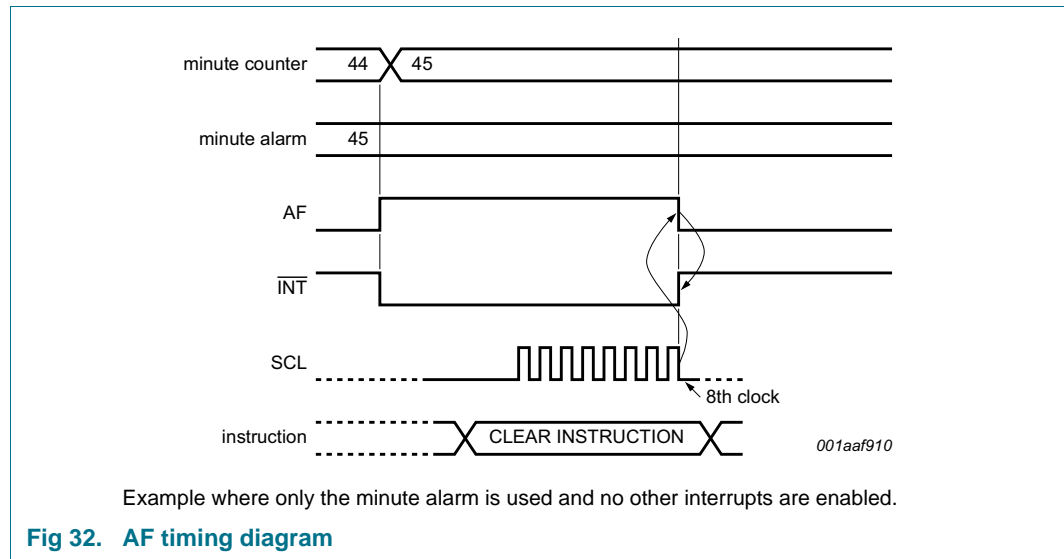
**8.13.4 Watchdog timer interrupts**

The generation of interrupts from the watchdog timer is controlled using the WD\_CD[1:0] bits (register Watchdog\_tim\_ctl). The interrupt is generated as an active signal which follows the status of the watchdog timer flag WDTF (register Control\_2). No pulse generation is possible for watchdog timer interrupts.

The interrupt is cleared when the flag WDTF is reset. WDTF is a read-only bit and cannot be cleared by command. Instructions for clearing it can be found in [Section 8.11.6](#).

**8.13.5 Alarm interrupts**

Generation of interrupts from the alarm function is controlled by the bit AIE (register Control\_2). If AIE is enabled, the  $\overline{\text{INT}}$  pin follows the status of bit AF (register Control\_2). Clearing AF immediately clears  $\overline{\text{INT}}$ . No pulse generation is possible for alarm interrupts.



**8.13.6 Timestamp interrupts**

Interrupt generation from the timestamp function is controlled using the TSIE bit (register Control\_2). If TSIE is enabled, the  $\overline{\text{INT}}$  pin follows the status of the flags TSFx. Clearing the flags TSFx immediately clears  $\overline{\text{INT}}$ . No pulse generation is possible for timestamp interrupts.

**8.13.7 Battery switch-over interrupts**

Generation of interrupts from the battery switch-over is controlled by the BIE bit (register Control\_3). If BIE is enabled, the  $\overline{\text{INT}}$  pin follows the status of bit BF in register Control\_3 (see [Table 81](#)). Clearing BF immediately clears  $\overline{\text{INT}}$ . No pulse generation is possible for battery switch-over interrupts.

**8.13.8 Battery low detection interrupts**

Generation of interrupts from the battery low detection is controlled by the BLIE bit (register Control\_3). If BLIE is enabled, the  $\overline{\text{INT}}$  pin follows the status of bit BLF (register Control\_3). The interrupt is cleared when the battery is replaced (BLF is logic 0) or when bit BLIE is disabled (BLIE is logic 0). BLF is read only and therefore cannot be cleared by command.

## 8.14 External clock test mode

A test mode is available which allows on-board testing. In this mode, it is possible to set up test conditions and control the operation of the RTC.

The test mode is entered by setting bit EXT\_TEST logic 1 (register Control\_1). Then pin CLKOUT becomes an input. The test mode replaces the internal clock signal (64 Hz) with the signal applied to pin CLKOUT. Every 64 positive edges applied to pin CLKOUT generate an increment of one second.

The signal applied to pin CLKOUT should have a minimum pulse width of 300 ns and a maximum period of 1000 ns. The internal clock, now sourced from CLKOUT, is divided down by a  $2^6$  divider chain called prescaler (see [Table 84](#)). The prescaler can be set into a known state by using bit STOP. When bit STOP is logic 1, the prescaler is reset to 0. STOP must be cleared before the prescaler can operate again.

From a stop condition, the first 1 second increment will take place after 32 positive edges on pin CLKOUT. Thereafter, every 64 positive edges cause a 1 second increment.

**Remark:** Entry into test mode is not synchronized to the internal 64 Hz clock. When entering the test mode, no assumption as to the state of the prescaler can be made.

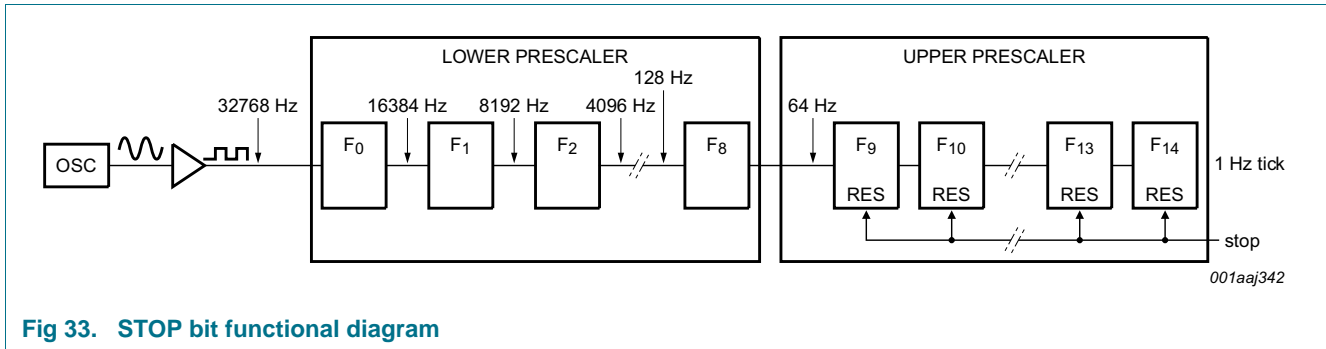
Operating example:

1. Set EXT\_TEST test mode (register Control\_1, EXT\_TEST is logic 1).
2. Set bit STOP (register Control\_1, STOP is logic 1).
3. Set time registers to desired value.
4. Clear STOP (register Control\_1, STOP is logic 0).
5. Apply 32 clock pulses to CLKOUT.
6. Read time registers to see the first change.
7. Apply 64 clock pulses to CLKOUT.
8. Read time registers to see the second change.

Repeat 7 and 8 for additional increments.

## 8.15 STOP bit function

The function of the STOP bit is to allow for accurate starting of the time circuits. STOP causes the upper part of the prescaler ( $F_9$  to  $F_{14}$ ) to be held in reset and thus no 1 Hz ticks are generated. The time circuits can then be set and will not increment until the STOP bit is released. STOP doesn't affect the CLKOUT signal but the output of the prescaler in the range of 32 Hz to 1 Hz (see [Figure 33](#)).

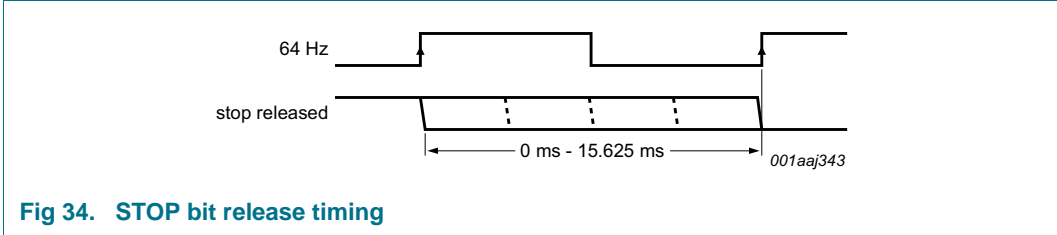


The lower stages of the prescaler, F<sub>0</sub> to F<sub>8</sub>, are not reset and because the I<sup>2</sup>C-bus and the SPI-bus are asynchronous to the crystal oscillator, the accuracy of restarting the time circuits is between 0 and one 64 Hz cycle (0.484375 s and 0.500000 s), see [Table 84](#) and [Figure 34](#).

Table 84. First increment of time circuits after stop release

| Bit STOP   | Prescaler bits <sup>[1]</sup><br>F <sub>0</sub> to F <sub>8</sub> - F <sub>9</sub> to F <sub>14</sub> | 1 Hz tick | Time<br>hh:mm:ss | Comment   |
|--|---|-----------|------------------|---|
| <b>Clock is running normally</b>   |   |           |                  |   |
| 0  | 010000111-010100  |           | 12:45:12         | prescaler counting normally                                       |
| <b>STOP bit is activated by user. F<sub>0</sub> to F<sub>8</sub> are not reset and values cannot be predicted externally</b> |   |           |                  |   |
| 1  | xxxxxxxx-000000   |           | 12:45:12         | prescaler is reset; time circuits are frozen                      |
| <b>New time is set by user</b>   |   |           |                  |   |
| 1  | xxxxxxxx-000000   |           | 08:00:00         | prescaler is reset; time circuits are frozen                      |
| <b>STOP bit is released by user</b>  |   |           |                  |   |
| 0  | xxxxxxxx-000000   |           | 08:00:00         | prescaler is now running  |
| 0  | xxxxxxxx-100000   |           | 08:00:00         |   |
| 0  | xxxxxxxx-100000   |           | 08:00:00         |   |
| 0  | xxxxxxxx-110000   |           | 08:00:00         |   |
| :  | :   |           | :                |   |
| 0  | 11111111-111110   |           | 08:00:00         |   |
| 0  | 00000000-000001   |           | 08:00:01         | 0 to 1 transition of F <sub>14</sub> increments the time circuits |
| 0  | 10000000-000001   |           | 08:00:01         |   |
| :  | :   |           | :                |   |
| 0  | 11111111-111111   |           | 08:00:01         |   |
| 0  | 00000000-000000   |           | 08:00:01         |   |
| 0  | 10000000-000000   |           |                  |   |
| :  | :   |           | :                |   |
| 0  | 11111111-111110   |           | 08:00:01         |   |
| 0  | 00000000-000001   |           | 08:00:02         | 0 to 1 transition of F <sub>14</sub> increments the time circuits |

[1] F<sub>0</sub> is clocked at 32.768 kHz.

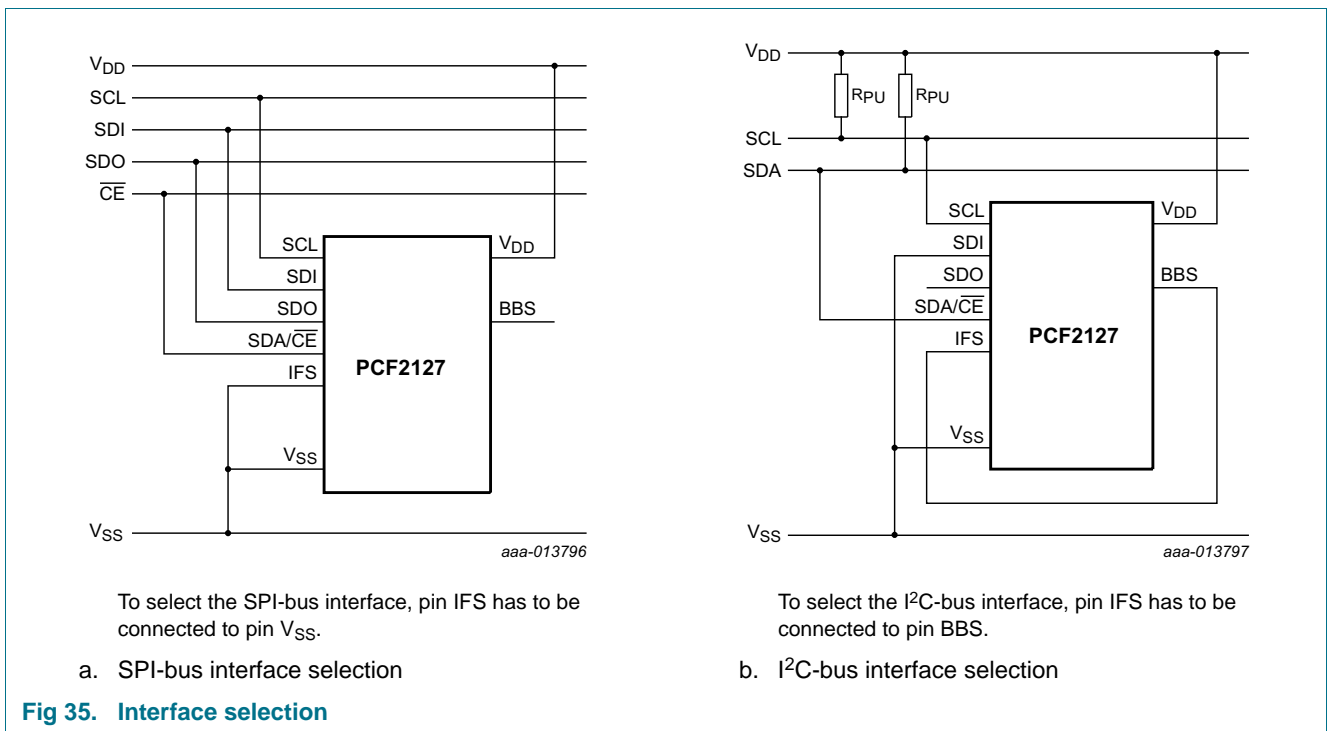


## 9. Interfaces

The PCF2127 has an I<sup>2</sup>C-bus or SPI-bus interface using the same pins. The selection is done using the interface selection pin IFS (see [Table 85](#)).

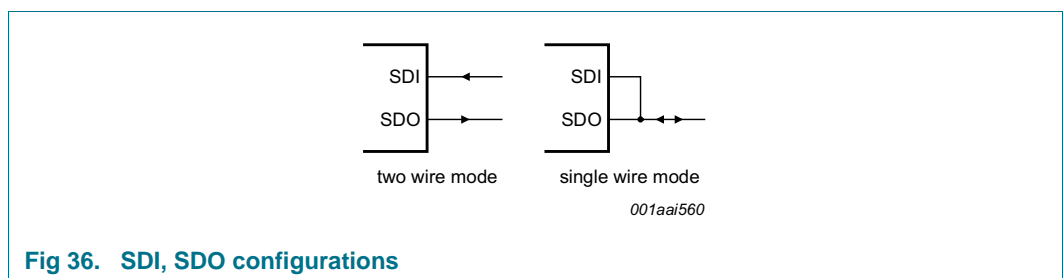
**Table 85. Interface selection input pin IFS**

| Pin | Connection      | Bus interface        | Reference                   |
|-----|-----------------|----------------------|-----------------------------|
| IFS | V <sub>SS</sub> | SPI-bus              | <a href="#">Section 9.1</a> |
|     | BBS             | I <sup>2</sup> C-bus | <a href="#">Section 9.2</a> |



### 9.1 SPI-bus interface

Data transfer to and from the device is made by a 3 line SPI-bus (see [Table 86](#)). The data lines for input and output are split. The data input and output line can be connected together to facilitate a bidirectional data bus (see [Figure 36](#)). The SPI-bus is initialized whenever the chip enable line pin SDA/CE is inactive.



**Table 86. Serial interface**

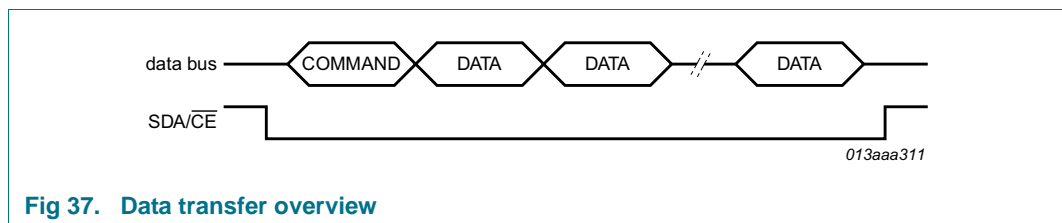
| Symbol                      | Function                         | Description  |
|-----------------------------|----------------------------------|--|
| SDA/ $\overline{\text{CE}}$ | chip enable input;<br>active LOW | [1] when HIGH, the interface is reset;<br>input may be higher than $V_{DD}$  |
| SCL                         | serial clock input               | when SDA/ $\overline{\text{CE}}$ is HIGH, input may float;<br>input may be higher than $V_{DD}$  |
| SDI                         | serial data input                | when SDA/ $\overline{\text{CE}}$ is HIGH, input may float;<br>input may be higher than $V_{DD}$ ;<br>input data is sampled on the rising edge of SCL |
| SDO                         | serial data output               | push-pull output;<br>drives from $V_{SS}$ to $V_{oper(int)}$ ( $V_{BBS}$ );<br>output data is changed on the falling edge of SCL                     |

[1] The chip enable must not be wired permanently LOW.

### 9.1.1 Data transmission

The chip enable signal is used to identify the transmitted data. Each data transfer is a whole byte, with the Most Significant Bit (MSB) sent first.

The transmission is controlled by the active LOW chip enable signal SDA/ $\overline{\text{CE}}$ . The first byte transmitted is the command byte. Subsequent bytes are either data to be written or data to be read (see [Figure 37](#)).

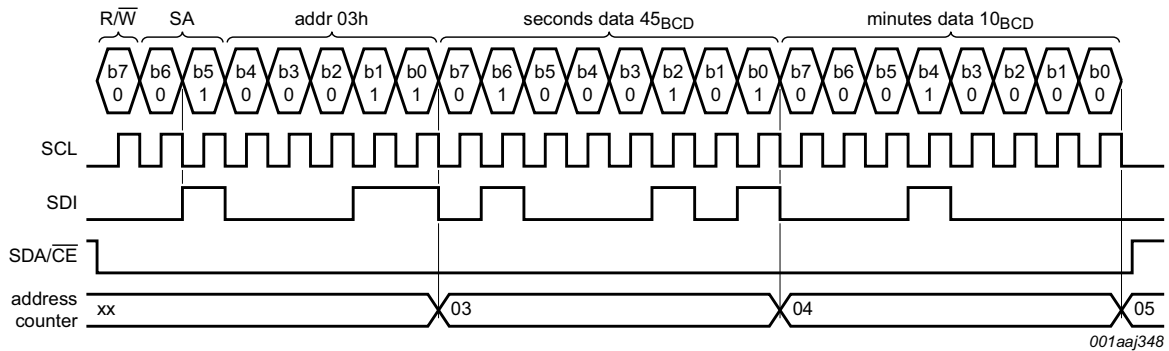


**Fig 37. Data transfer overview**

The command byte defines the address of the first register to be accessed and the read/write mode. The address counter will auto increment after every access and will reset to zero after the last valid register is accessed. The  $\overline{\text{R/W}}$  bit defines if the following bytes are read or write information.

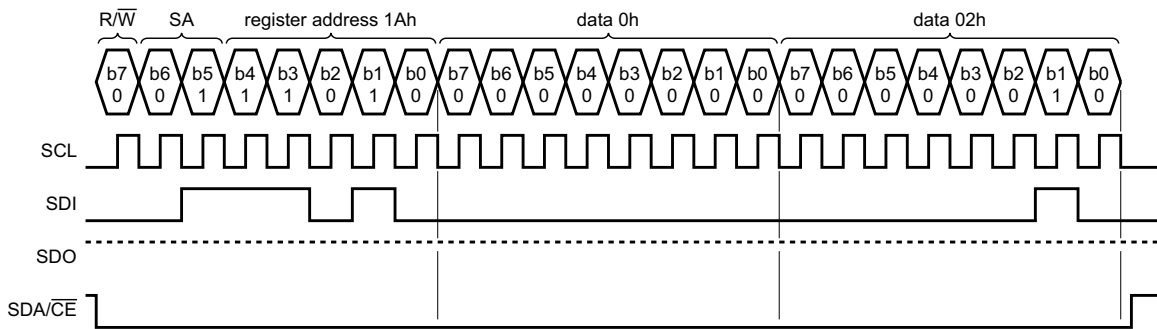
**Table 87. Command byte definition**

| Bit    | Symbol                  | Value      | Description  |
|--------|-------------------------|------------|--|
| 7      | $\overline{\text{R/W}}$ |            | data read or write selection   |
|        |                         | 0          | write data   |
|        |                         | 1          | read data  |
| 6 to 5 | SA                      | 01         | subaddress;<br>other codes will cause the device to ignore data transfer |
| 4 to 0 | RA                      | 00h to 1Dh | register address   |



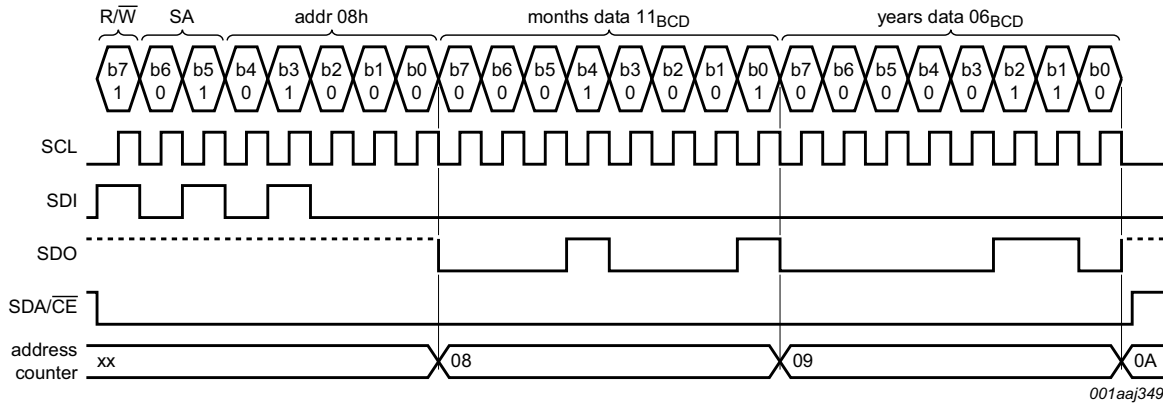
In this example, the Seconds register is set to 45 seconds and the Minutes register to 10 minutes.

a. Writing seconds and minutes



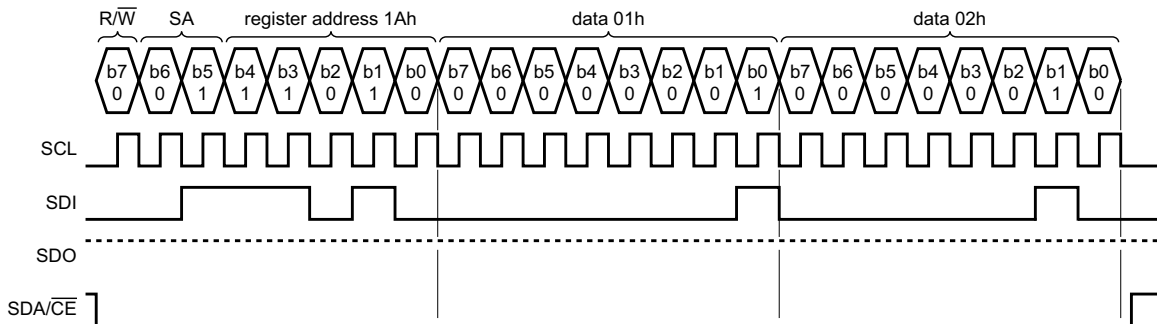
b. Writing to RAM address 02h

Fig 38. SPI-bus write examples



In this example, the registers Months and Years are read. The pins SDI and SDO are not connected together. For this configuration, it is important that pin SDI is never left floating. It must always be driven either HIGH or LOW. If pin SDI is left open, high I<sub>DD</sub> currents may result.

a. Reading month and year



b. Reading from RAM address 12h

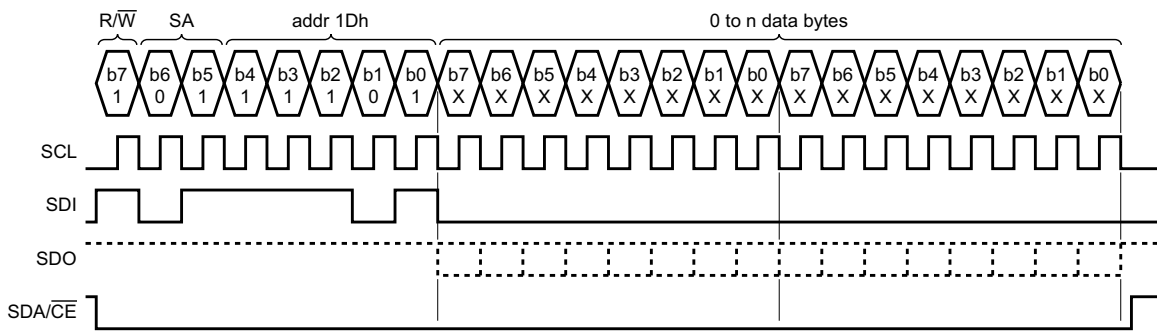


Fig 39. SPI-bus read examples

## 9.2 I<sup>2</sup>C-bus interface

The I<sup>2</sup>C-bus is for bidirectional, two-line communication between different ICs or modules. The two lines are a Serial Data line (SDA) and a Serial Clock line (SCL). Both lines are connected to a positive supply by a pull-up resistor. Data transfer is initiated only when the bus is not busy.

### 9.2.1 Bit transfer

One data bit is transferred during each clock pulse. The data on the SDA line remains stable during the HIGH period of the clock pulse as changes in the data line at this time are interpreted as control signals (see [Figure 40](#)).

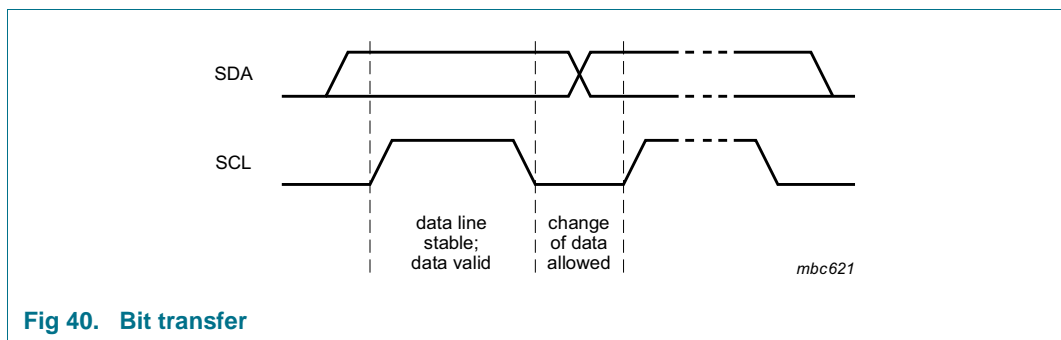


Fig 40. Bit transfer

### 9.2.2 START and STOP conditions

Both data and clock lines remain HIGH when the bus is not busy. A HIGH-to-LOW transition of the data line, while the clock is HIGH, is defined as the START condition S. A LOW-to-HIGH transition of the data line while the clock is HIGH is defined as the STOP condition P (see [Figure 41](#)).

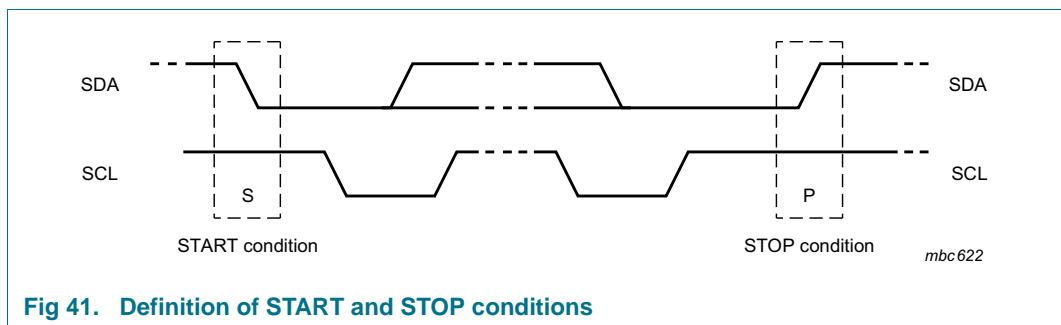


Fig 41. Definition of START and STOP conditions

**Remark:** For the PCF2127, a repeated START is not allowed. Therefore a STOP has to be released before the next START.

### 9.2.3 System configuration

A device generating a message is a transmitter; a device receiving a message is the receiver. The device that controls the message is the master; and the devices which are controlled by the master are the slaves.

The PCF2127 can act as a slave transmitter and a slave receiver.

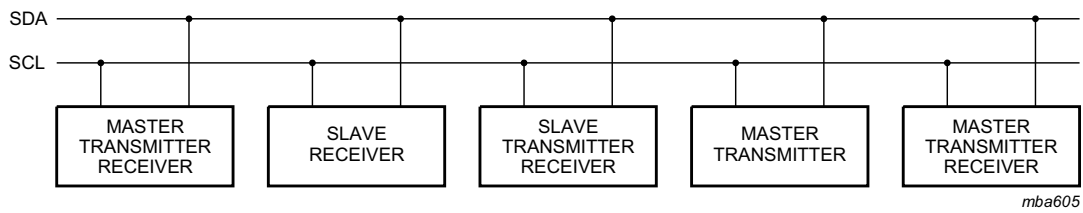


Fig 42. System configuration

### 9.2.4 Acknowledge

The number of data bytes transferred between the START and STOP conditions from transmitter to receiver is unlimited. Each byte of eight bits is followed by an acknowledge cycle.

- A slave receiver which is addressed must generate an acknowledge after the reception of each byte.
- Also a master receiver must generate an acknowledge after the reception of each byte that has been clocked out of the slave transmitter.
- The device that acknowledges must pull-down the SDA line during the acknowledge clock pulse, so that the SDA line is stable LOW during the HIGH period of the acknowledge related clock pulse (set-up and hold times must be considered).
- A master receiver must signal an end of data to the transmitter by not generating an acknowledge on the last byte that has been clocked out of the slave. In this event, the transmitter must leave the data line HIGH to enable the master to generate a STOP condition.

Acknowledgement on the I<sup>2</sup>C-bus is illustrated in [Figure 43](#).

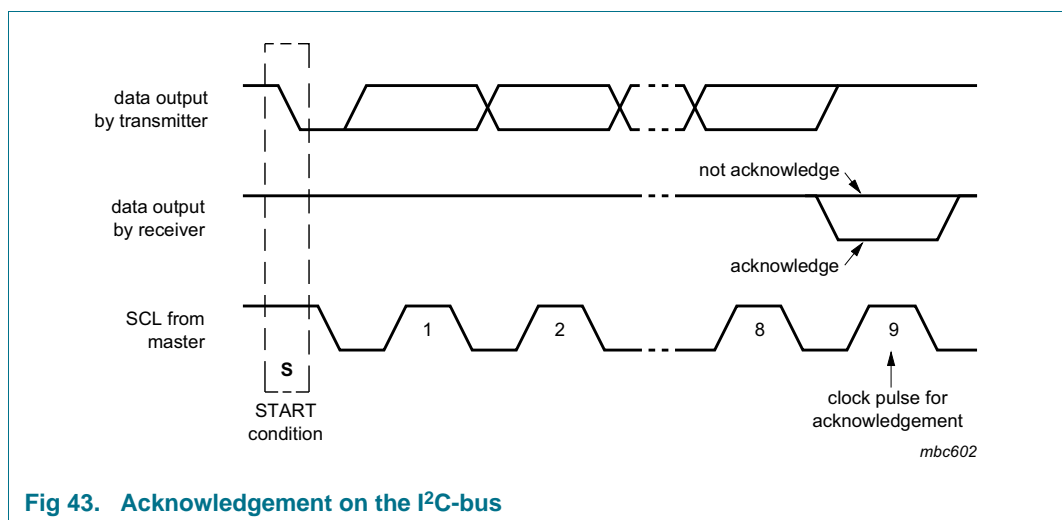


Fig 43. Acknowledgement on the I<sup>2</sup>C-bus

### 9.2.5 I<sup>2</sup>C-bus protocol

After a start condition, a valid hardware address has to be sent to a PCF2127 device. The appropriate I<sup>2</sup>C-bus slave address is 1010001. The entire I<sup>2</sup>C-bus slave address byte is shown in [Table 88](#).

Table 88. I<sup>2</sup>C slave address byte

|     |     | Slave address |   |   |   |   |   |     |  |
|-----|-----|---------------|---|---|---|---|---|-----|--|
| Bit | 7   | 6             | 5 | 4 | 3 | 2 | 1 | 0   |  |
|     | MSB |               |   |   |   |   |   | LSB |  |
|     | 1   | 0             | 1 | 0 | 0 | 0 | 1 | R/W |  |

The R/W bit defines the direction of the following single or multiple byte data transfer (read is logic 1, write is logic 0).

For the format and the timing of the START condition (S), the STOP condition (P), and the acknowledge (A) refer to the I<sup>2</sup>C-bus specification [Ref. 13 "UM10204"](#) and the characteristics table ([Table 93](#)). In the write mode, a data transfer is terminated by sending a STOP condition. A repeated START (Sr) condition is not applicable.

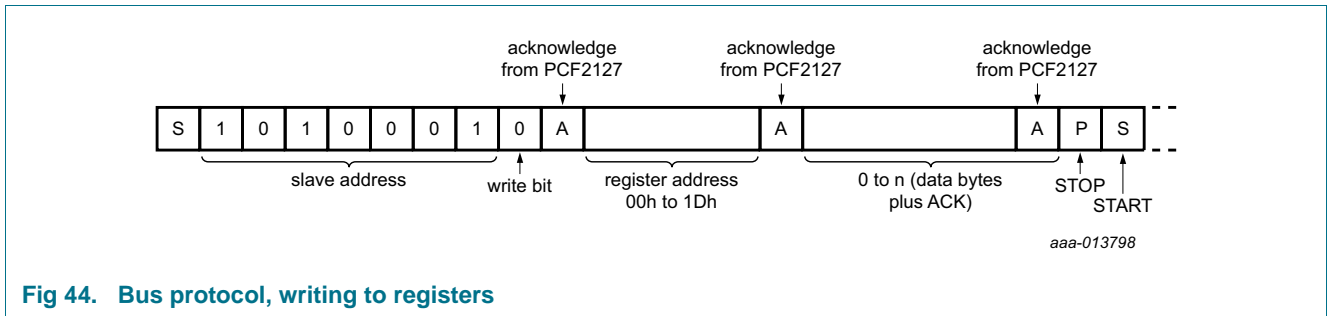


Fig 44. Bus protocol, writing to registers

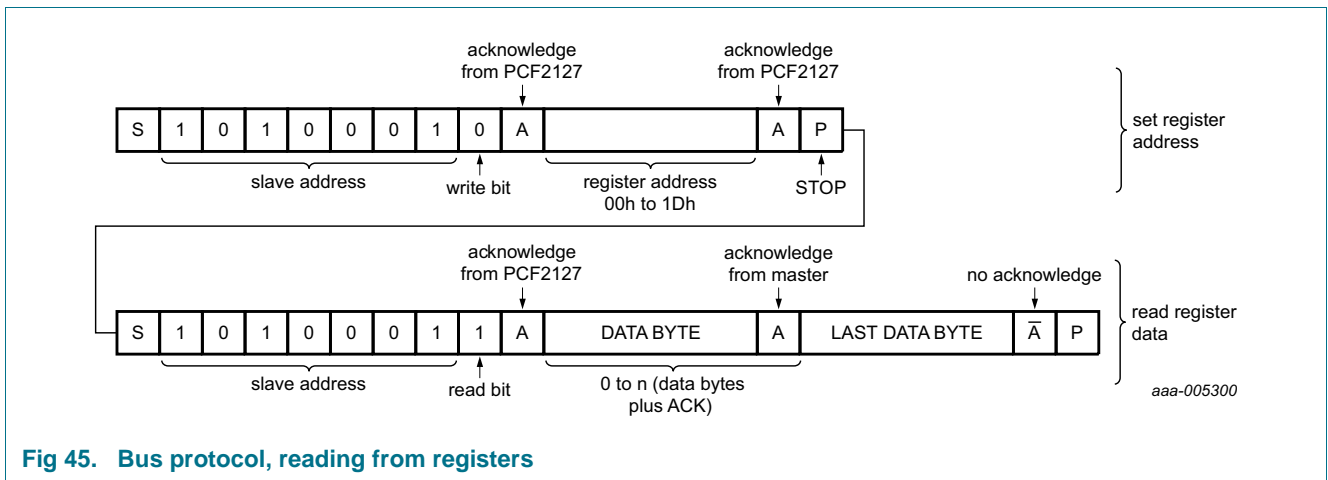


Fig 45. Bus protocol, reading from registers

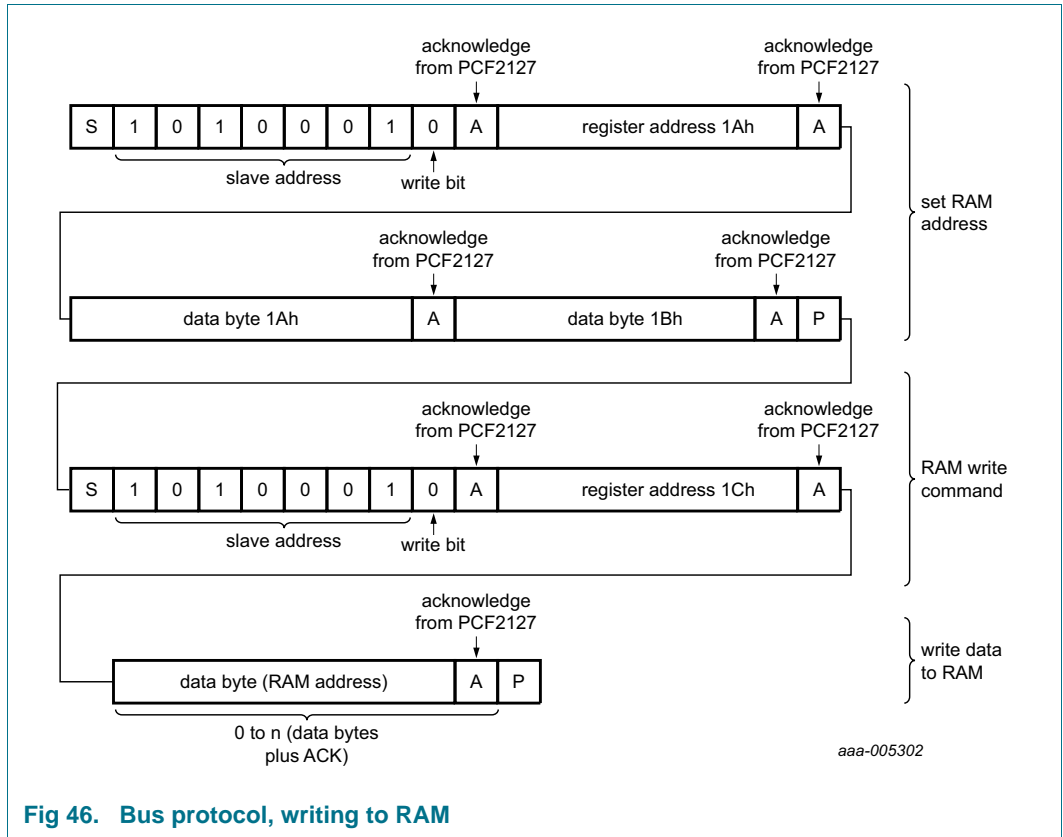


Fig 46. Bus protocol, writing to RAM

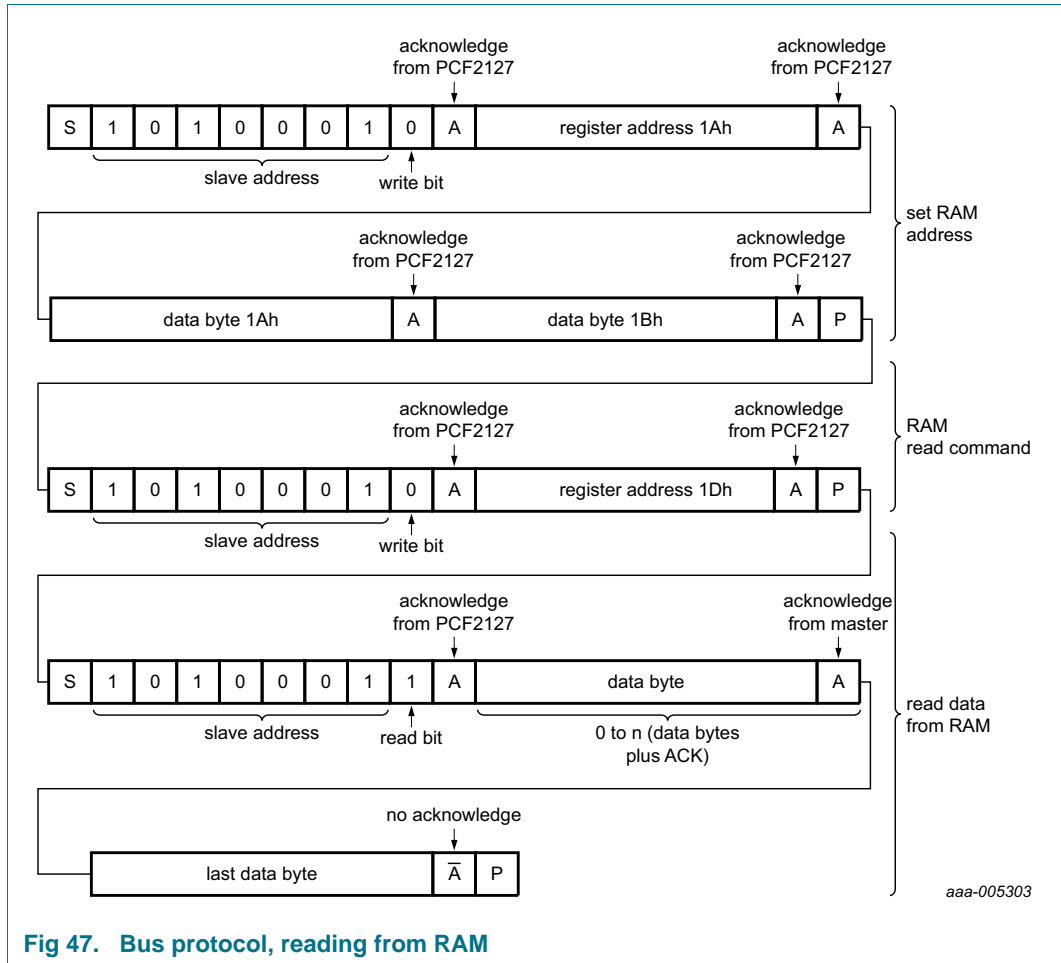


Fig 47. Bus protocol, reading from RAM

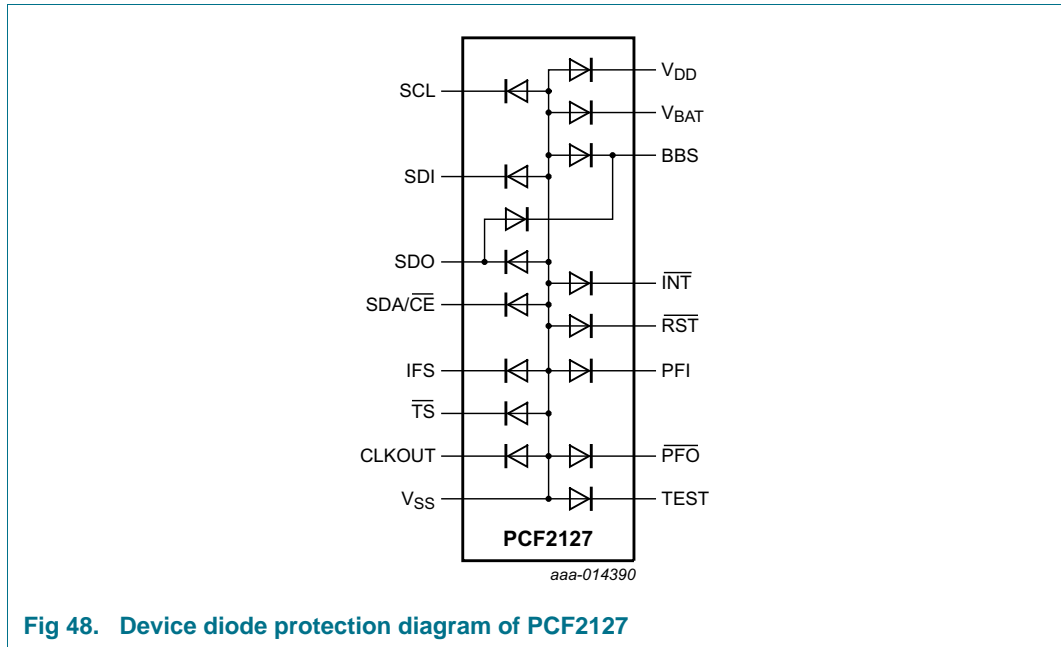
### 9.3 Bus communication and battery backup operation

To save power during battery backup operation (see [Section 8.6.1](#)), the bus interfaces are inactive. Therefore the communication via I<sup>2</sup>C- or SPI-bus should be terminated before the supply of the PCF2127 is switched from V<sub>DD</sub> to V<sub>BAT</sub>.

The extra power fail detection function (see [Section 8.6.3](#)) of the PCF2127 allows early detection of a dropping V<sub>DD</sub>. The output on pin PFO indicates to the microcontroller to terminate the bus communication properly. When the bus communication is not terminated in a proper way, the time counters get corrupted.

**Remark:** If the I<sup>2</sup>C-bus communication was terminated uncontrolled, the I<sup>2</sup>C-bus has to be reinitialized by sending a STOP followed by a START after the device switched back from battery backup operation to V<sub>DD</sub> supply operation.

## 10. Internal circuitry



## 11. Safety notes

**CAUTION**



This device is sensitive to ElectroStatic Discharge (ESD). Observe precautions for handling electrostatic sensitive devices.

Such precautions are described in the *ANSI/ESD S20.20*, *IEC/ST 61340-5*, *JESD625-A* or equivalent standards.

## 12. Limiting values

**Table 89. Limiting values**

In accordance with the Absolute Maximum Rating System (IEC 60134).

| Symbol           | Parameter                       | Conditions       | Min  | Max   | Unit |    |
|------------------|---------------------------------|------------------|------|-------|------|----|
| V <sub>DD</sub>  | supply voltage                  |                  | -0.5 | +6.5  | V    |    |
| I <sub>DD</sub>  | supply current                  |                  | -50  | +50   | mA   |    |
| V <sub>i</sub>   | input voltage                   |                  | -0.5 | +6.5  | V    |    |
| I <sub>I</sub>   | input current                   |                  | -10  | +10   | mA   |    |
| V <sub>O</sub>   | output voltage                  |                  | -0.5 | +6.5  | V    |    |
| I <sub>O</sub>   | output current                  |                  | -10  | +10   | mA   |    |
|                  |                                 | at pin SDA/CE    | -10  | +20   | mA   |    |
| V <sub>BAT</sub> | battery supply voltage          |                  | -0.5 | +6.5  | V    |    |
| P <sub>tot</sub> | total power dissipation         |                  | -    | 300   | mW   |    |
| V <sub>ESD</sub> | electrostatic discharge voltage | HBM [1]          | -    | ±4000 | V    |    |
|                  |                                 | CDM [2]          | -    | ±1250 | V    |    |
| I <sub>Iu</sub>  | latch-up current                |                  | [3]  | 200   | mA   |    |
| T <sub>stg</sub> | storage temperature             |                  | [4]  | -55   | +85  | °C |
| T <sub>amb</sub> | ambient temperature             | operating device | -40  | +85   | °C   |    |

[1] Pass level; Human Body Model (HBM) according to [Ref. 7 "JESD22-A114"](#).

[2] Pass level; Charged-Device Model (CDM), according to [Ref. 8 "JESD22-C101"](#).

[3] Pass level; latch-up testing according to [Ref. 9 "JESD78"](#) at maximum ambient temperature (T<sub>amb(max)</sub>).

[4] According to the store and transport requirements (see [Ref. 14 "UM10569"](#)) the devices have to be stored at a temperature of +8 °C to +45 °C and a humidity of 25 % to 75 %.

### 13. Static characteristics

**Table 90. Static characteristics**

$V_{DD} = 1.8\text{ V to }4.2\text{ V}$ ;  $V_{SS} = 0\text{ V}$ ;  $T_{amb} = -40\text{ }^{\circ}\text{C to }+85\text{ }^{\circ}\text{C}$ , unless otherwise specified.

| Symbol          | Parameter                  | Conditions  | Min | Typ  | Max  | Unit          |  |
|-----------------|----------------------------|---|-----|------|------|---------------|--|
| <b>Supplies</b> |                            |   |     |      |      |               |  |
| $V_{DD}$        | supply voltage             | [1]   | 1.8 | -    | 4.2  | V             |  |
| $V_{BAT}$       | battery supply voltage     |   | 1.8 | -    | 4.2  | V             |  |
| $V_{DD(cal)}$   | calibration supply voltage |   | -   | 3.3  | -    | V             |  |
| $V_{low}$       | low voltage                |   | -   | 1.2  | -    | V             |  |
| $I_{DD}$        | supply current             | interface active;<br>supplied by $V_{DD}$   |     |      |      |               |  |
|                 |                            | SPI-bus ( $f_{SCL} = 6.5\text{ MHz}$ )  | -   | -    | 800  | $\mu\text{A}$ |  |
|                 |                            | I <sup>2</sup> C-bus ( $f_{SCL} = 400\text{ kHz}$ )   | -   | -    | 200  | $\mu\text{A}$ |  |
|                 |                            | interface inactive ( $f_{SCL} = 0\text{ Hz}$ ) <sup>[2]</sup> ;<br>TCR[1:0] = 00 (see <a href="#">Table 13 on page 12</a> )   |     |      |      |               |  |
|                 |                            | PWRMNG[2:0] = 111 (see <a href="#">Table 25 on page 18</a> );<br>TSOFF = 1 (see <a href="#">Table 68 on page 50</a> );<br>COF[2:0] = 111 (see <a href="#">Table 15 on page 14</a> ) |     |      |      |               |  |
|                 |                            | $V_{DD} = 1.8\text{ V}$   | -   | 470  | -    | nA            |  |
|                 |                            | $V_{DD} = 3.3\text{ V}$   | -   | 700  | 1500 | nA            |  |
|                 |                            | $V_{DD} = 4.2\text{ V}$   | -   | 800  | -    | nA            |  |
|                 |                            | PWRMNG[2:0] = 111 (see <a href="#">Table 25 on page 18</a> );<br>TSOFF = 1 (see <a href="#">Table 68 on page 50</a> );<br>COF[2:0] = 000 (see <a href="#">Table 15 on page 14</a> ) |     |      |      |               |  |
|                 |                            | $V_{DD} = 1.8\text{ V}$   | -   | 560  | -    | nA            |  |
|                 |                            | $V_{DD} = 3.3\text{ V}$   | -   | 850  | -    | nA            |  |
|                 |                            | $V_{DD} = 4.2\text{ V}$   | -   | 1050 | -    | nA            |  |
|                 |                            | PWRMNG[2:0] = 000 (see <a href="#">Table 25 on page 18</a> );<br>TSOFF = 0 (see <a href="#">Table 68 on page 50</a> );<br>COF[2:0] = 111 (see <a href="#">Table 15 on page 14</a> ) |     |      |      |               |  |
|                 |                            | $V_{DD}$ or $V_{BAT} = 1.8\text{ V}$ [3]  | -   | 1750 | -    | nA            |  |
|                 |                            | $V_{DD}$ or $V_{BAT} = 3.3\text{ V}$ [3]  | -   | 2150 | -    | nA            |  |
|                 |                            | $V_{DD}$ or $V_{BAT} = 4.2\text{ V}$ [3]  | -   | 2350 | 3500 | nA            |  |
|                 |                            | PWRMNG[2:0] = 000 (see <a href="#">Table 25 on page 18</a> );<br>TSOFF = 0 (see <a href="#">Table 68 on page 50</a> );<br>COF[2:0] = 000 (see <a href="#">Table 15 on page 14</a> ) |     |      |      |               |  |
|                 |                            | $V_{DD}$ or $V_{BAT} = 1.8\text{ V}$ [3]  | -   | 1840 | -    | nA            |  |
|                 |                            | $V_{DD}$ or $V_{BAT} = 3.3\text{ V}$ [3]  | -   | 2300 | -    | nA            |  |
|                 |                            | $V_{DD}$ or $V_{BAT} = 4.2\text{ V}$ [3]  | -   | 2600 | -    | nA            |  |
| $I_{L(bat)}$    | battery leakage current    | $V_{DD}$ is active supply;<br>$V_{BAT} = 3.0\text{ V}$  | -   | 50   | 100  | nA            |  |

**Table 90. Static characteristics ...continued**

$V_{DD} = 1.8\text{ V to }4.2\text{ V}$ ;  $V_{SS} = 0\text{ V}$ ;  $T_{amb} = -40\text{ °C to }+85\text{ °C}$ , unless otherwise specified.

| Symbol                      | Parameter                        | Conditions   | Min         | Typ  | Max            | Unit          |    |
|-----------------------------|----------------------------------|--|-------------|------|----------------|---------------|----|
| <b>Power management</b>     |                                  |  |             |      |                |               |    |
| $V_{th(sw)bat}$             | battery switch threshold voltage |  | -           | 2.5  | -              | V             |    |
| $V_{th(bat)low}$            | low battery threshold voltage    |  | -           | 2.5  | -              | V             |    |
|                             |                                  | $T_{amb} = 25\text{ °C}$   | 2.25        | -    | 2.85           | V             |    |
| $V_{th(PFI)}$               | threshold voltage on pin PFI     |  | -           | 1.25 | -              | V             |    |
| <b>Inputs<sup>[4]</sup></b> |                                  |  |             |      |                |               |    |
| $V_I$                       | input voltage                    |  | -0.5        | -    | $V_{DD} + 0.5$ | V             |    |
| $V_{IL}$                    | LOW-level input voltage          |  | -           | -    | $0.25V_{DD}$   | V             |    |
|                             |                                  | $T_{amb} = -20\text{ °C to }+85\text{ °C}$ ;<br>$V_{DD} > 2.0\text{ V}$                                  | -           | -    | $0.3V_{DD}$    | V             |    |
| $V_{IH}$                    | HIGH-level input voltage         |  | $0.7V_{DD}$ | -    | -              | V             |    |
| $I_{LI}$                    | input leakage current            | $V_I = V_{DD}$ or $V_{SS}$   | -           | 0    | -              | $\mu\text{A}$ |    |
|                             |                                  | post ESD event   | -1          | -    | +1             | $\mu\text{A}$ |    |
| $C_i$                       | input capacitance                |  | [5]         | -    | 7              | pF            |    |
| <b>Outputs</b>              |                                  |  |             |      |                |               |    |
| $V_O$                       | output voltage                   | on pins CLKOUT, $\overline{\text{INT}}$ , $\overline{\text{RST}}$ and PFO, referring to external pull-up | -0.5        | -    | 5.5            | V             |    |
|                             |                                  | on pin BBS   | 1.8         | -    | 4.2            | V             |    |
|                             |                                  | on pin SDO   | -0.5        | -    | $V_{DD} + 0.5$ | V             |    |
| $V_{OH}$                    | HIGH output voltage              | on pin SDO   | $0.8V_{DD}$ | -    | $V_{DD}$       | V             |    |
| $V_{OL}$                    | LOW output voltage               | on pins CLKOUT, $\overline{\text{INT}}$ , $\overline{\text{RST}}$ , SDO, and PFO                         | $V_{SS}$    | -    | $0.2V_{DD}$    | V             |    |
| $I_{OL}$                    | LOW-level output current         | output sink current;<br>$V_{OL} = 0.4\text{ V}$  |             |      |                |               |    |
|                             |                                  | on pin SDA/ $\overline{\text{CE}}$   | [6]         | 3    | 17             | -             | mA |
|                             |                                  | on all other outputs   |             | 1.0  | -              | -             | mA |
| $I_{OH}$                    | HIGH-level output current        | output source current;<br>on pin SDO;<br>$V_{OH} = 3.8\text{ V}$ ;<br>$V_{DD} = 4.2\text{ V}$            | 1.0         | -    | -              | mA            |    |
| $I_{LO}$                    | output leakage current           | $V_O = V_{DD}$ or $V_{SS}$   | -           | 0    | -              | $\mu\text{A}$ |    |
|                             |                                  | post ESD event   | -1          | -    | +1             | $\mu\text{A}$ |    |

[1] For reliable oscillator start-up at power-on:  $V_{DD(po)min} = V_{DD(min)} + 0.3\text{ V}$ .

[2] Timer source clock =  $\frac{1}{60}\text{ Hz}$ , level of pins SDA/ $\overline{\text{CE}}$ , SDI, and SCL is  $V_{DD}$  or  $V_{SS}$ .

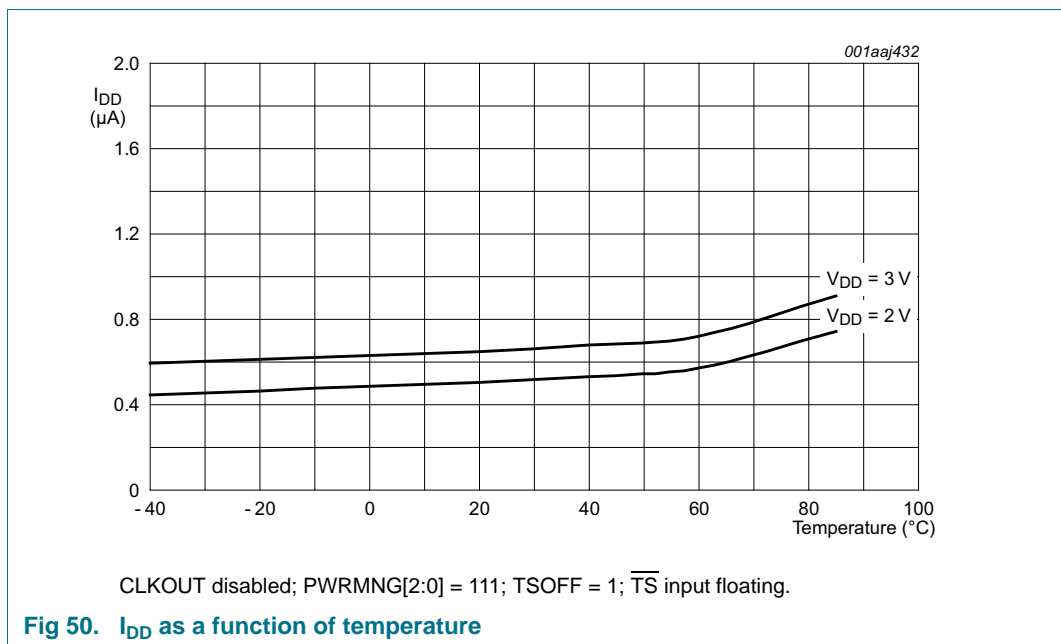
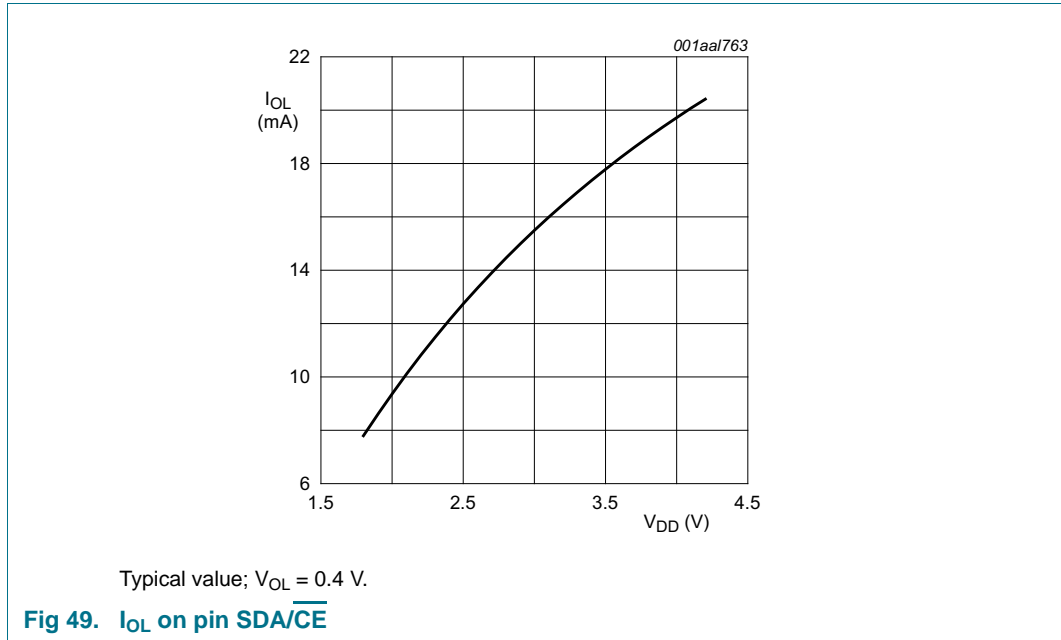
[3] When the device is supplied by the  $V_{BAT}$  pin instead of the  $V_{DD}$  pin, the current values for  $I_{BAT}$  are as specified for  $I_{DD}$  under the same conditions.

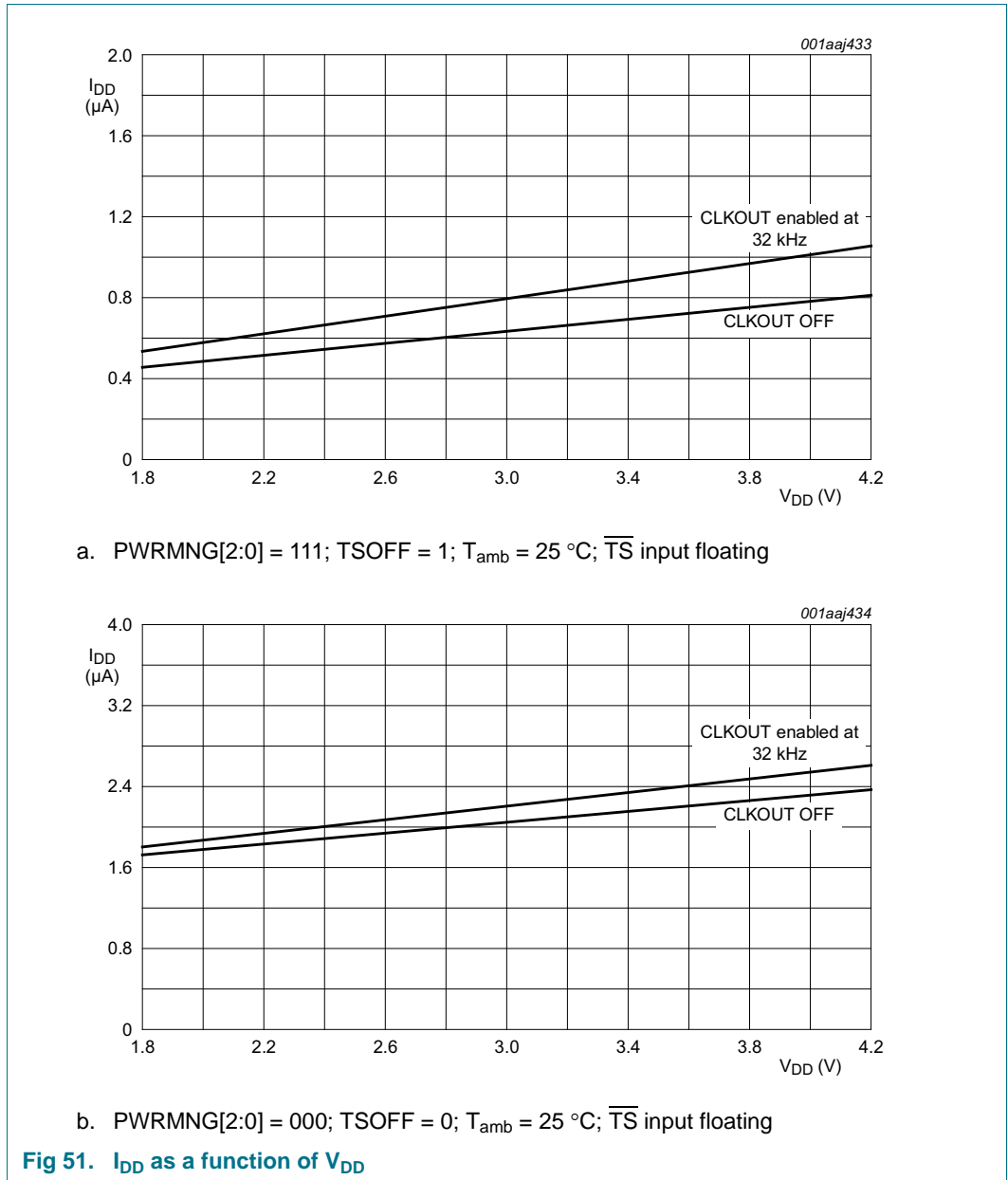
[4] The I<sup>2</sup>C-bus and SPI-bus interfaces of PCF2127 are 5 V tolerant.

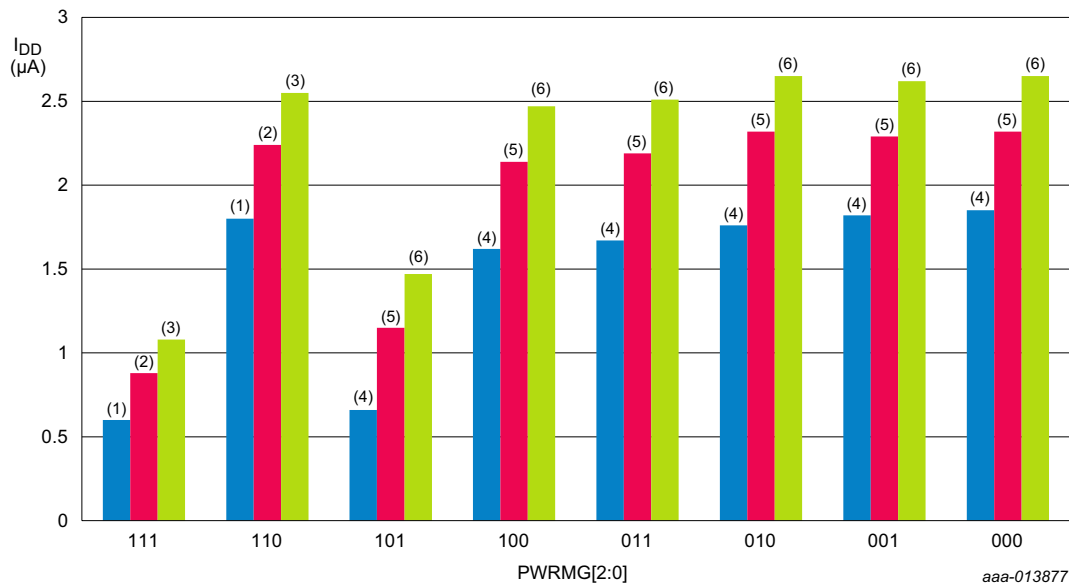
[5] Tested on sample basis.

[6] For further information, see [Figure 49](#).

13.1 Current consumption characteristics, typical







Interface inactive;  $T_{amb} = 25\text{ }^{\circ}\text{C}$ ;  $V_{BAT} = 0\text{ V}$ ; default configuration.

Description of the PWRMNG[2:0] settings, see [Table 25 on page 18](#).

- (1)  $V_{DD} = 1.8\text{ V}$ .
- (2)  $V_{DD} = 3.3\text{ V}$ .
- (3)  $V_{DD} = 4.2\text{ V}$ .
- (4)  $V_{DD}$  or  $V_{BAT} = 1.8\text{ V}$ .
- (5)  $V_{DD}$  or  $V_{BAT} = 3.3\text{ V}$ .
- (6)  $V_{DD}$  or  $V_{BAT} = 4.2\text{ V}$ .

**Fig 52. Typical  $I_{DD}$  as a function of the power management settings**

## 13.2 Frequency characteristics

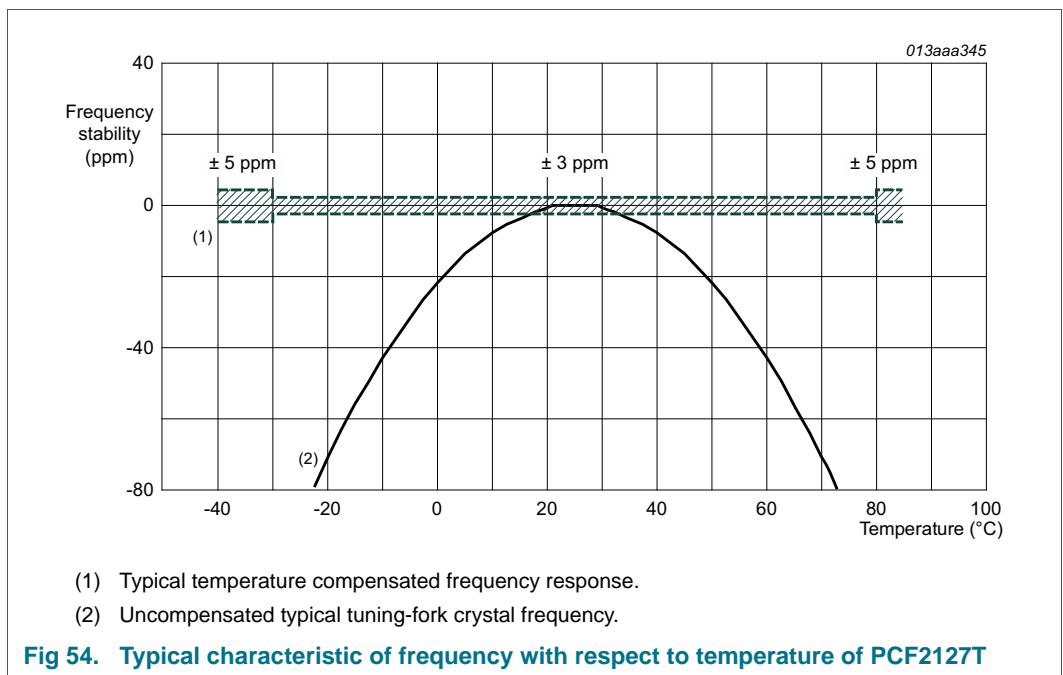
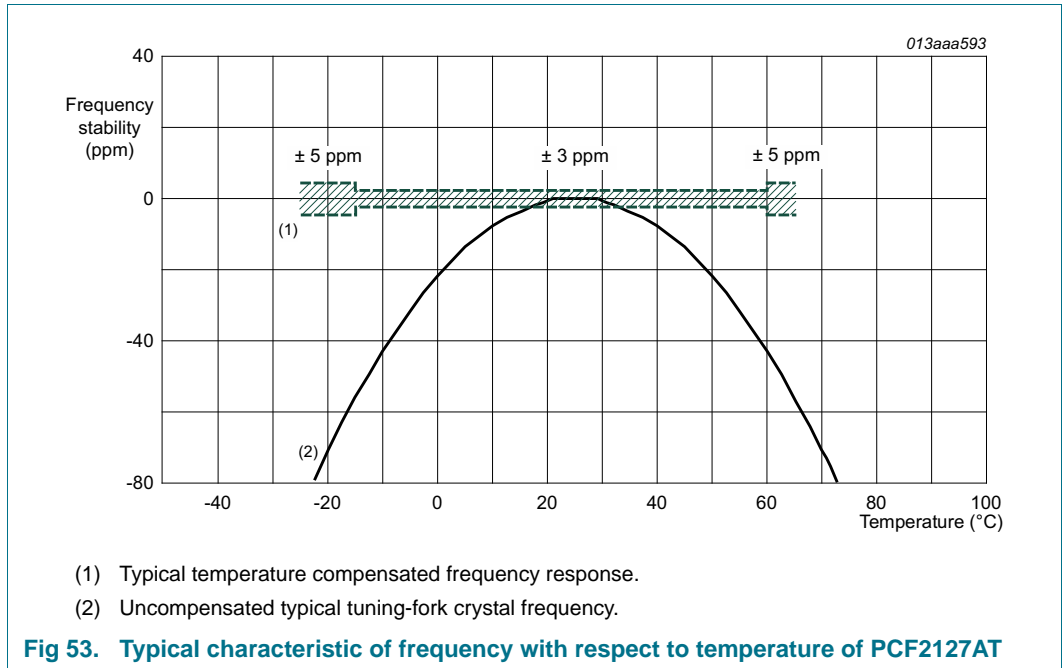
**Table 91. Frequency characteristics**
 $V_{DD} = 1.8\text{ V to }4.2\text{ V}$ ;  $V_{SS} = 0\text{ V}$ ;  $T_{amb} = +25\text{ }^{\circ}\text{C}$ , unless otherwise specified.

| Symbol                                   | Parameter                            | Conditions   | Min | Typ     | Max      | Unit  |
|--|--------------------------------------|--|-----|---------|----------|-------|
| $f_o$                                    | output frequency                     | on pin CLKOUT;<br>$V_{DD}$ or $V_{BAT} = 3.3\text{ V}$ ;<br>COF[2:0] = 000;<br>AO[3:0] = 1000  | -   | 32.768  | -        | kHz   |
| $\Delta f/f$                             | frequency stability                  | $V_{DD}$ or $V_{BAT} = 3.3\text{ V}$   |     |         |          |       |
|  |                                      | PCF2127AT  |     |         |          |       |
|  |                                      | $T_{amb} = -15\text{ }^{\circ}\text{C to }+60\text{ }^{\circ}\text{C}$   | -   | $\pm 3$ | $\pm 5$  | ppm   |
|  |                                      | $T_{amb} = -25\text{ }^{\circ}\text{C to }-15\text{ }^{\circ}\text{C}$<br>and<br>$T_{amb} = +60\text{ }^{\circ}\text{C to }+65\text{ }^{\circ}\text{C}$        | -   | $\pm 5$ | $\pm 10$ | ppm   |
|  |                                      | PCF2127T   |     |         |          |       |
|  |                                      | $T_{amb} = -30\text{ }^{\circ}\text{C to }+80\text{ }^{\circ}\text{C}$ [1][2]  | -   | $\pm 3$ | $\pm 8$  | ppm   |
|  |                                      | $T_{amb} = -40\text{ }^{\circ}\text{C to }-30\text{ }^{\circ}\text{C}$<br>and<br>$T_{amb} = +80\text{ }^{\circ}\text{C to }+85\text{ }^{\circ}\text{C}$ [1][2] | -   | $\pm 5$ | $\pm 15$ | ppm   |
| $\Delta f_{\text{xtal}}/f_{\text{xtal}}$ | relative crystal frequency variation | crystal aging [3]  |     |         |          |       |
|  |                                      | PCF2127AT  |     |         |          |       |
|  |                                      | first year;<br>$V_{DD}$ or $V_{BAT} = 3.3\text{ V}$  | -   | -       | $\pm 3$  | ppm   |
|  |                                      | PCF2127T   |     |         |          |       |
|  |                                      | first year   | -   | -       | $\pm 3$  | ppm   |
|  | ten years                            | -  | -   | $\pm 8$ | ppm      |       |
| $\Delta f/\Delta V$                      | frequency variation with voltage     | on pin CLKOUT  | -   | $\pm 1$ | -        | ppm/V |

[1]  $\pm 1\text{ ppm}$  corresponds to a time deviation of  $\pm 0.0864$  seconds per day.

[2] Only valid if CLKOUT frequencies are not equal to 32.768 kHz or if CLKOUT is disabled.

[3] Not production tested. Effects of reflow soldering are included (see [Ref. 3 "AN11266"](#)).



## 14. Dynamic characteristics

### 14.1 SPI-bus timing characteristics

**Table 92. SPI-bus characteristics**

$V_{DD} = 1.8\text{ V to }4.2\text{ V}$ ;  $V_{SS} = 0\text{ V}$ ;  $T_{amb} = -40\text{ }^{\circ}\text{C to }+85\text{ }^{\circ}\text{C}$ , unless otherwise specified. All timing values are valid within the operating supply voltage at ambient temperature and referenced to  $V_{IL}$  and  $V_{IH}$  with an input voltage swing of  $V_{SS}$  to  $V_{DD}$  (see Figure 55).

| Symbol                | Parameter                       | Conditions                 | $V_{DD} = 1.8\text{ V}$ |      | $V_{DD} = 4.2\text{ V}$ |      | Unit |
|-----------------------|---------------------------------|----------------------------|-------------------------|------|-------------------------|------|------|
|                       |                                 |                            | Min                     | Max  | Min                     | Max  |      |
| <b>Pin SCL</b>        |                                 |                            |                         |      |                         |      |      |
| $f_{clk(SCL)}$        | SCL clock frequency             | register read/write access | -                       | 2.0  | -                       | 6.5  | MHz  |
|                       |                                 | RAM write access           | -                       | 2.0  | -                       | 6.5  | MHz  |
|                       |                                 | RAM read access            | -                       | 1.11 | -                       | 6.25 | MHz  |
| $t_{SCL}$             | SCL time                        | register read/write access | 800                     | -    | 140                     | -    | ns   |
|                       |                                 | RAM write access           | 800                     | -    | 140                     | -    | ns   |
|                       |                                 | RAM read access            | 900                     | -    | 160                     | -    | ns   |
| $t_{clk(H)}$          | clock HIGH time                 | register read/write access | 100                     | -    | 70                      | -    | ns   |
|                       |                                 | RAM write access           | 100                     | -    | 70                      | -    | ns   |
|                       |                                 | RAM read access            | 450                     | -    | 80                      | -    | ns   |
| $t_{clk(L)}$          | clock LOW time                  | register read/write access | 400                     | -    | 70                      | -    | ns   |
|                       |                                 | RAM write access           | 400                     | -    | 70                      | -    | ns   |
|                       |                                 | RAM read access            | 450                     | -    | 80                      | -    | ns   |
| $t_r$                 | rise time                       | for SCL signal             | -                       | 100  | -                       | 100  | ns   |
| $t_f$                 | fall time                       | for SCL signal             | -                       | 100  | -                       | 100  | ns   |
| <b>Pin SDA/CE</b>     |                                 |                            |                         |      |                         |      |      |
| $t_{su(CE\_N)}$       | CE_N set-up time                |                            | 60                      | -    | 30                      | -    | ns   |
| $t_{h(CE\_N)}$        | CE_N hold time                  |                            | 40                      | -    | 25                      | -    | ns   |
| $t_{rec(CE\_N)}$      | CE_N recovery time              |                            | 100                     | -    | 30                      | -    | ns   |
| $t_{w(CE\_N)}$        | CE_N pulse width                |                            | -                       | 0.99 | -                       | 0.99 | s    |
| <b>Pin SDI</b>        |                                 |                            |                         |      |                         |      |      |
| $t_{su}$              | set-up time                     | set-up time for SDI data   | 70                      | -    | 20                      | -    | ns   |
| $t_h$                 | hold time                       | hold time for SDI data     | 70                      | -    | 20                      | -    | ns   |
| <b>Pin SDO</b>        |                                 |                            |                         |      |                         |      |      |
| $t_{d(R)SDO}$         | SDO read delay time             | $C_L = 50\text{ pF}$       |                         |      |                         |      |      |
|                       |                                 | register read access       | -                       | 225  | -                       | 55   | ns   |
|                       |                                 | RAM read access            | -                       | 410  | -                       | 55   | ns   |
| $t_{dis(SDO)}$        | SDO disable time                | [1]                        | -                       | 90   | -                       | 25   | ns   |
| $t_t(SDI\text{-}SDO)$ | transition time from SDI to SDO | to avoid bus conflict      | 0                       | -    | 0                       | -    | ns   |

[1] No load value; bus is held up by bus capacitance; use RC time constant with application values.

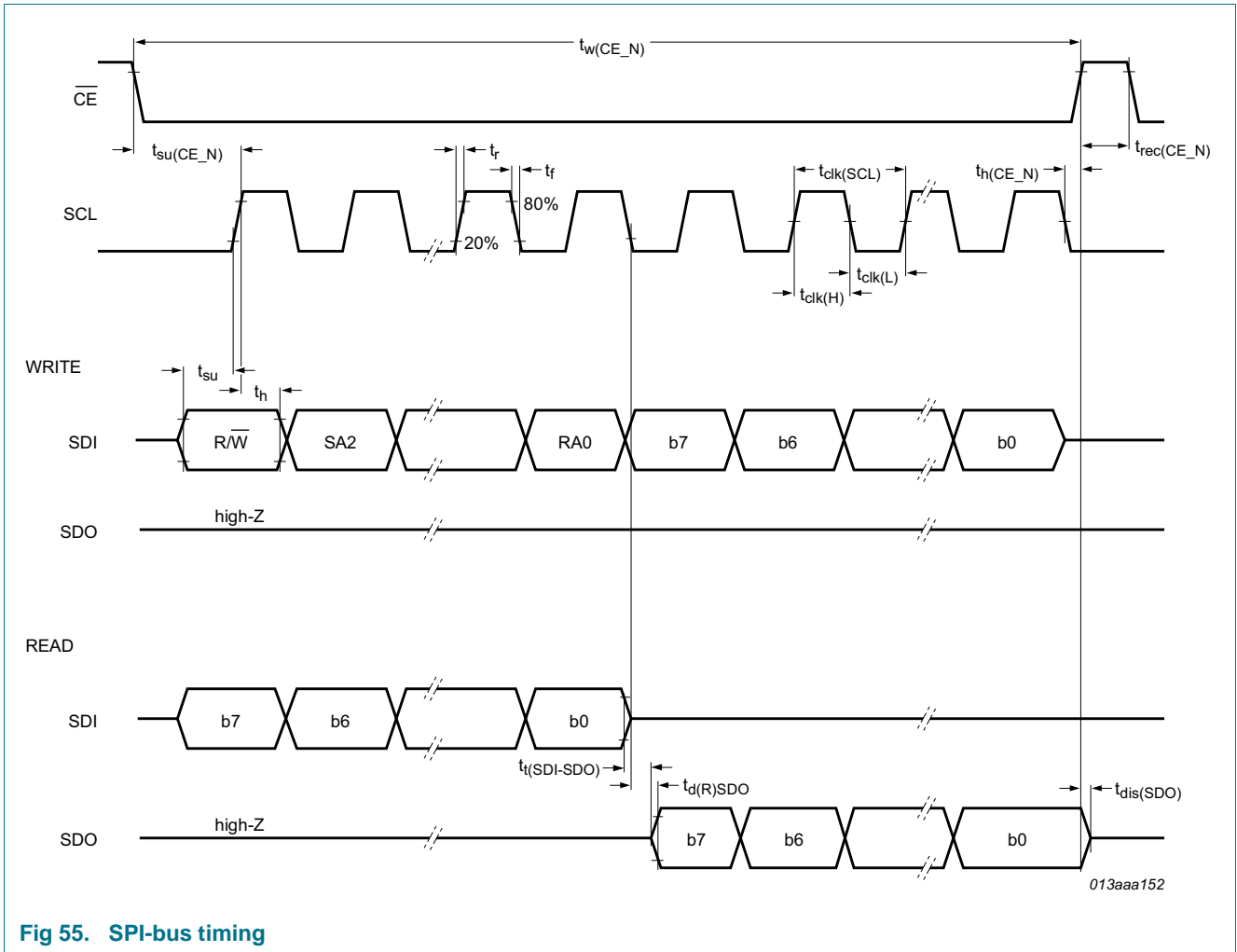


Fig 55. SPI-bus timing

## 14.2 I<sup>2</sup>C-bus timing characteristics

**Table 93. I<sup>2</sup>C-bus characteristics**

All timing characteristics are valid within the operating supply voltage and ambient temperature range and reference to 30 % and 70 % with an input voltage swing of  $V_{SS}$  to  $V_{DD}$  (see [Figure 56](#)).

| Symbol                     | Parameter   | Standard mode |      | Fast-mode (Fm)         |     | Unit |
|----------------------------|---|---------------|------|------------------------|-----|------|
|                            |   | Min           | Max  | Min                    | Max |      |
| <b>Pin SCL</b>             |   |               |      |                        |     |      |
| f <sub>SCL</sub>           | SCL clock frequency   | 0             | 100  | 0                      | 400 | kHz  |
| t <sub>LOW</sub>           | LOW period of the SCL clock   | 4.7           | -    | 1.3                    | -   | μs   |
| t <sub>HIGH</sub>          | HIGH period of the SCL clock  | 4.0           | -    | 0.6                    | -   | μs   |
| <b>Pin SDA/CE</b>          |   |               |      |                        |     |      |
| t <sub>SU;DAT</sub>        | data set-up time  | 250           | -    | 100                    | -   | ns   |
| t <sub>HD;DAT</sub>        | data hold time  | 0             | -    | 0                      | -   | ns   |
| <b>Pins SCL and SDA/CE</b> |   |               |      |                        |     |      |
| t <sub>BUF</sub>           | bus free time between a STOP and START condition                                      | 4.7           | -    | 1.3                    | -   | μs   |
| t <sub>SU;STO</sub>        | set-up time for STOP condition  | 4.0           | -    | 0.6                    | -   | μs   |
| t <sub>HD;STA</sub>        | hold time (repeated) START condition  | 4.0           | -    | 0.6                    | -   | μs   |
| t <sub>SU;STA</sub>        | set-up time for a repeated START condition  | 4.7           | -    | 0.6                    | -   | μs   |
| t <sub>r</sub>             | rise time of both SDA and SCL signals <a href="#">[1][2][3]</a>                       | -             | 1000 | 20 + 0.1C <sub>b</sub> | 300 | ns   |
| t <sub>f</sub>             | fall time of both SDA and SCL signals <a href="#">[1][2][3]</a>                       | -             | 300  | 20 + 0.1C <sub>b</sub> | 300 | ns   |
| t <sub>VD;ACK</sub>        | data valid acknowledge time <a href="#">[4]</a>                                       | 0.1           | 3.45 | 0.1                    | 0.9 | μs   |
| t <sub>VD;DAT</sub>        | data valid time <a href="#">[5]</a>   | 300           | -    | 75                     | -   | ns   |
| t <sub>SP</sub>            | pulse width of spikes that must be suppressed by the input filter <a href="#">[6]</a> | -             | 50   | -                      | 50  | ns   |

- [1] A master device must internally provide a hold time of at least 300 ns for the SDA signal (refer to the  $V_{IL}$  of the SCL signal) in order to bridge the undefined region of the falling edge of SCL.
- [2] C<sub>b</sub> is the total capacitance of one bus line in pF.
- [3] The maximum t<sub>r</sub> for the SDA and SCL bus lines is 300 ns. The maximum fall time for the SDA output stage, t<sub>f</sub> is 250 ns. This allows series protection resistors to be connected between the SDA/CE pin, the SCL pin, and the SDA/SCL bus lines without exceeding the maximum t<sub>r</sub>.
- [4] t<sub>VD;ACK</sub> is the time of the acknowledgement signal from SCL LOW to SDA (out) LOW.
- [5] t<sub>VD;DAT</sub> is the minimum time for valid SDA (out) data following SCL LOW.
- [6] Input filters on the SDA and SCL inputs suppress noise spikes of less than 50 ns.

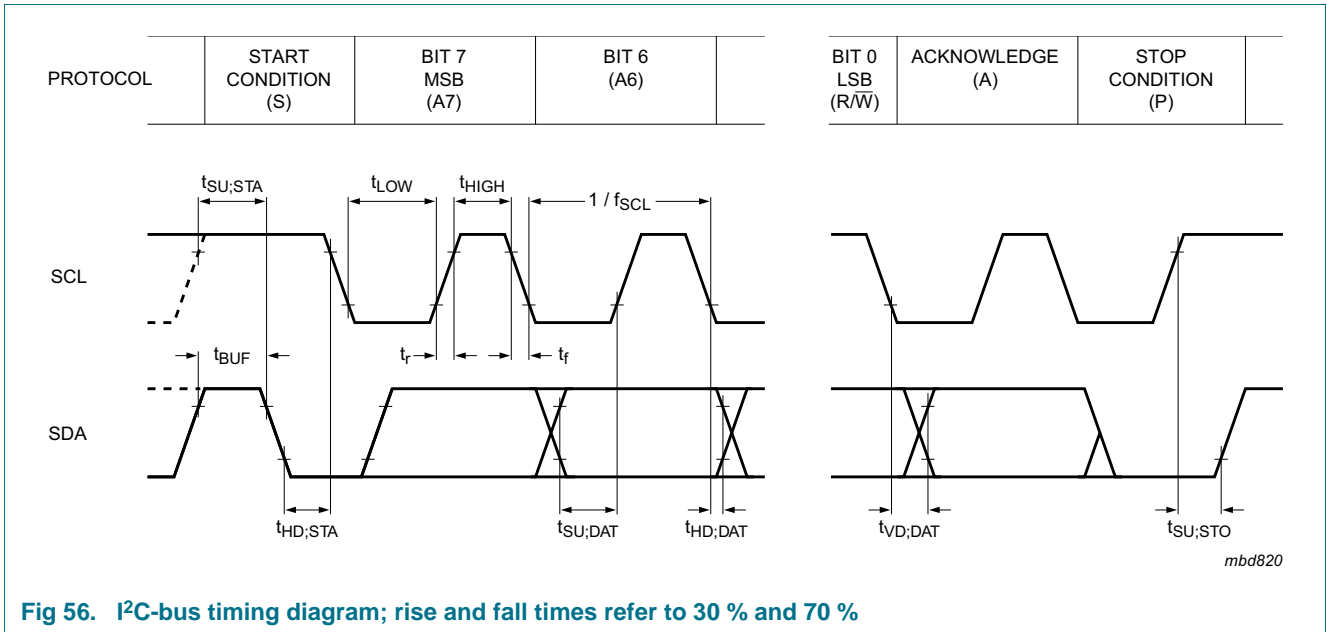
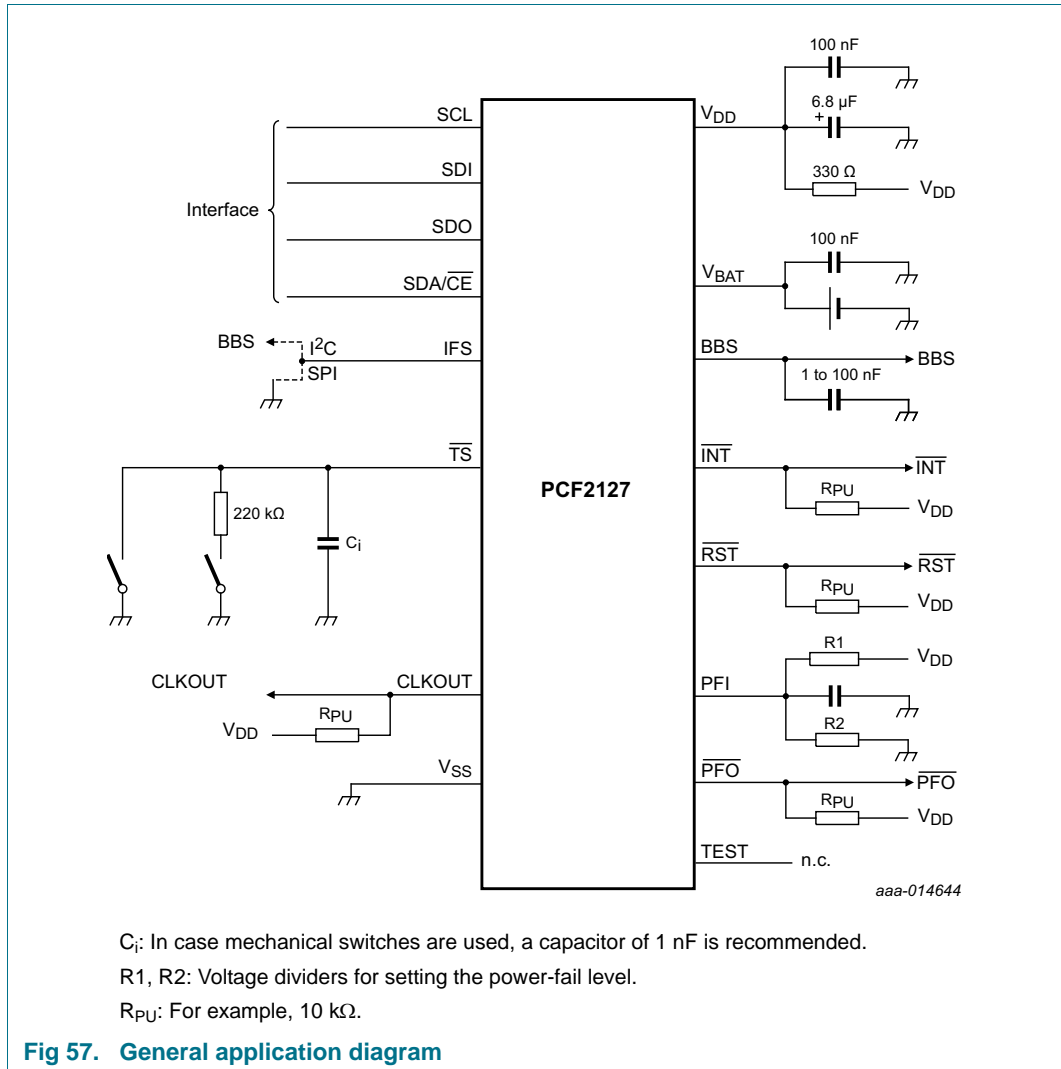


Fig 56. I<sup>2</sup>C-bus timing diagram; rise and fall times refer to 30 % and 70 %

### 15. Application information



For information about application configuration, see [Ref. 3 “AN11266” on page 92](#)

### 16. Test information

#### 16.1 Quality information

##### UL Component Recognition



This (component or material) is Recognized by UL. Representative samples of this component have been evaluated by UL and meet applicable UL requirements.

17. Package outline

SO20: plastic small outline package; 20 leads; body width 7.5 mm

SOT163-1

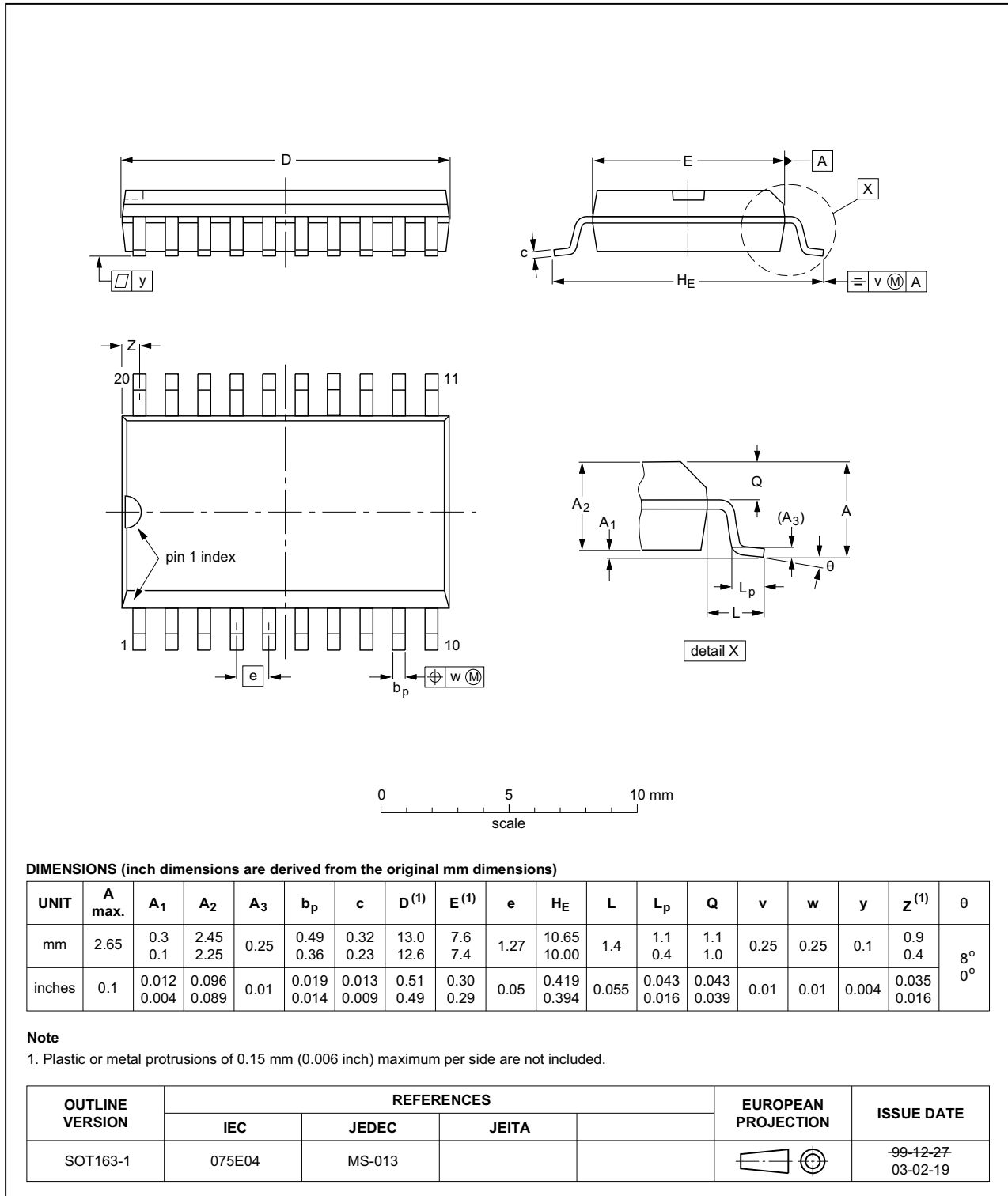


Fig 58. Package outline SOT163-1 (SO20) of PCF2127AT

SO16: plastic small outline package; 16 leads; body width 7.5 mm

SOT162-1

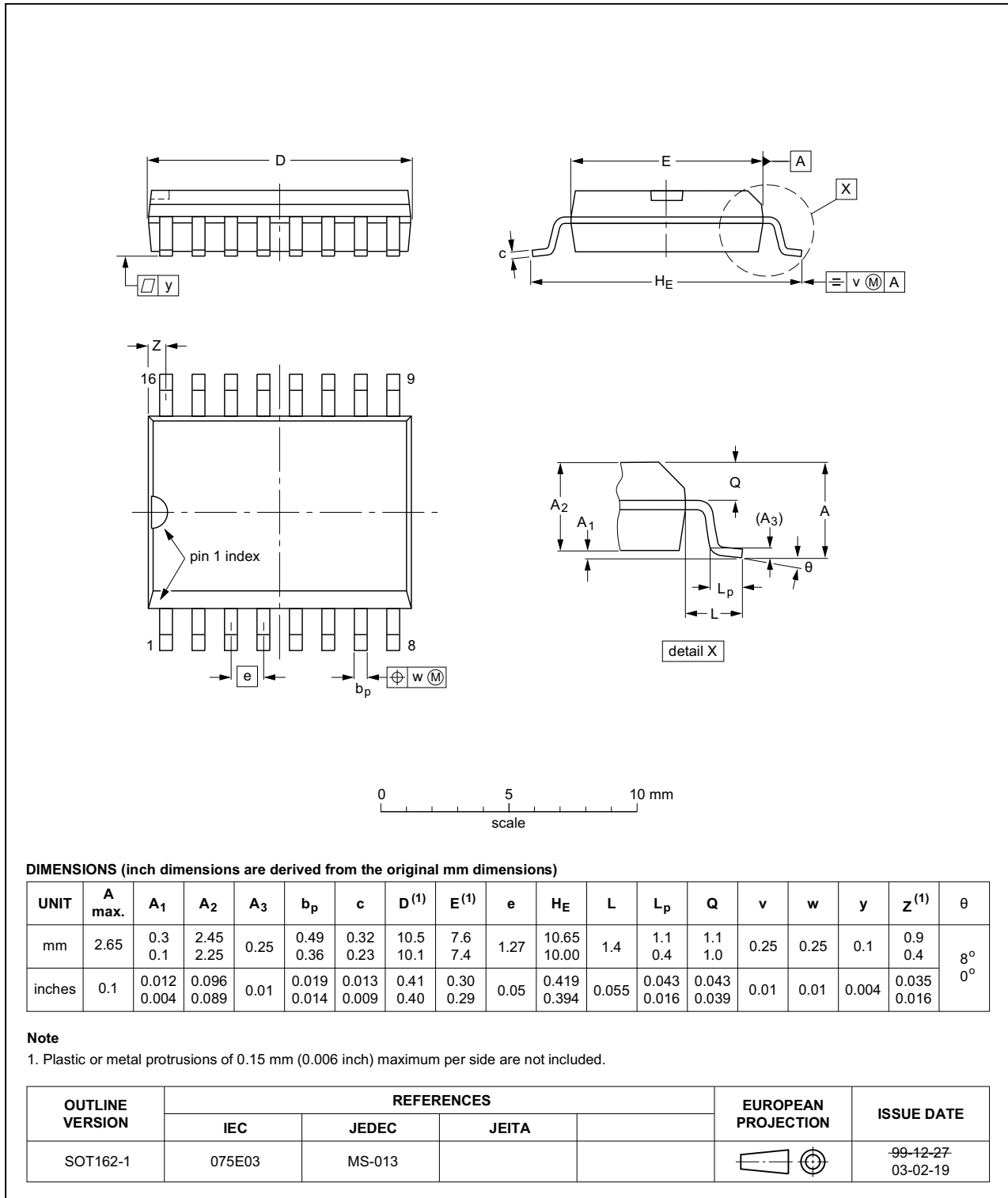


Fig 59. Package outline SOT162-1 (SO16) of PCF2127T

## 18. Packing information

### 18.1 Tape and reel information

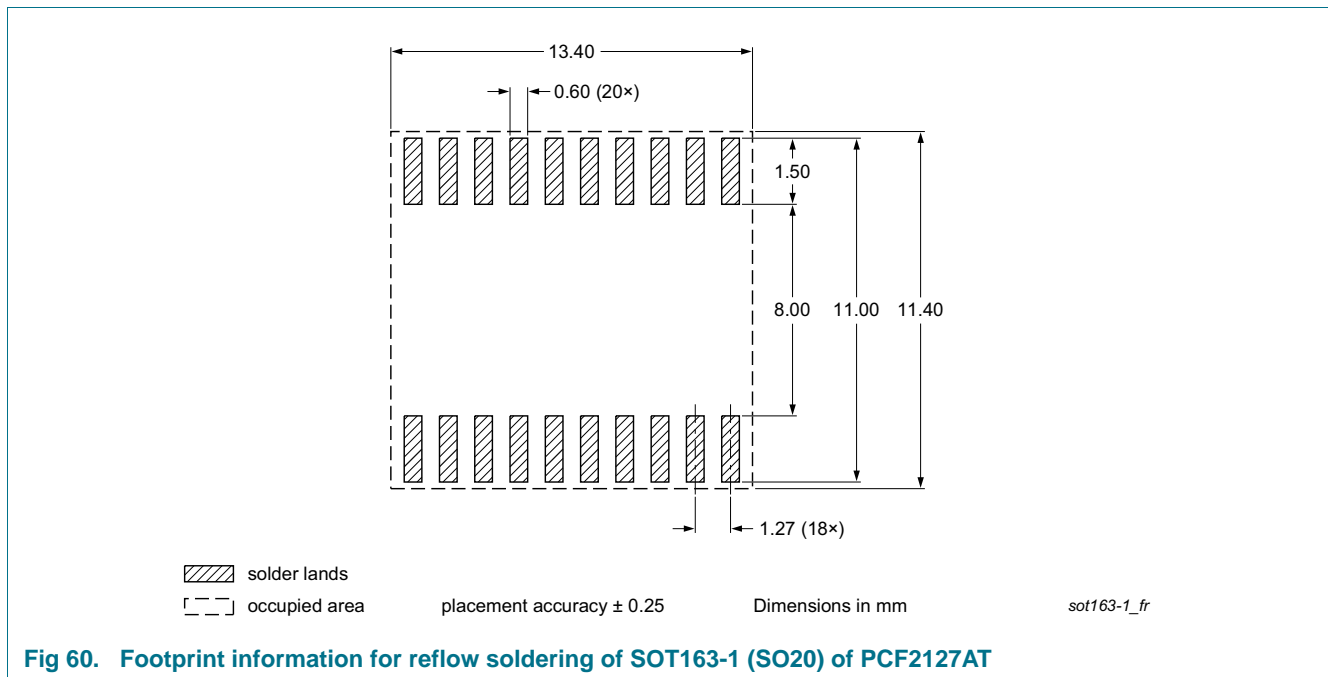
For tape and reel packing information, see

- [Ref. 11 “SOT162-1\\_518” on page 92](#) for the PCF2127T.
- [Ref. 12 “SOT163-1\\_518” on page 92](#) for the PCF2127AT.

## 19. Soldering

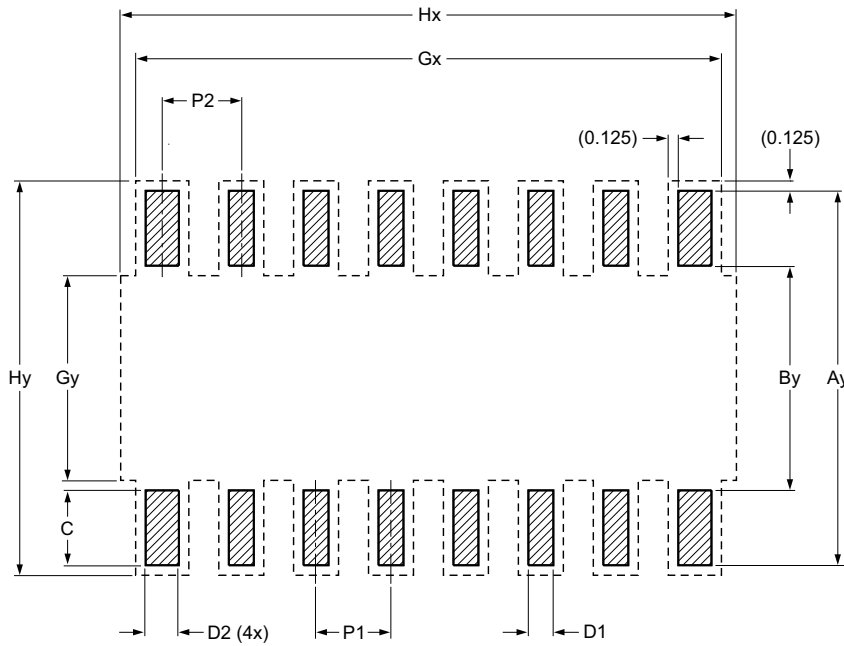
For information about soldering, see [Ref. 3 “AN11266” on page 92](#).

### 19.1 Footprint information




Footprint information for reflow soldering of SO16 package

SOT162-1



Generic footprint pattern  
Refer to the package outline drawing for actual layout

 solder land  
- - - - occupied area

DIMENSIONS in mm

| P1    | P2    | Ay     | By    | C     | D1    | D2    | Gx     | Gy    | Hx     | Hy     |
|-------|-------|--------|-------|-------|-------|-------|--------|-------|--------|--------|
| 1.270 | 1.320 | 11.200 | 6.400 | 2.400 | 0.700 | 0.800 | 10.040 | 8.600 | 11.900 | 11.450 |

so162-1\_fr

Fig 61. Footprint information for reflow soldering of SOT162-1 (SO16) of PCF2127T

## 20. Appendix

### 20.1 Real-Time Clock selection

Table 94. Selection of Real-Time Clocks

| Type name | Alarm, Timer, Watchdog | Interrupt output | Interface                | I <sub>DD</sub> , typical (nA) | Battery backup | Timestamp, tamper input | AEC-Q100 compliant | Special features  |
|-----------|------------------------|------------------|--------------------------|--------------------------------|----------------|-------------------------|--------------------|---|
| PCF8563   | X                      | 1                | I <sup>2</sup> C         | 250                            | -              | -                       | -                  | -   |
| PCF8564A  | X                      | 1                | I <sup>2</sup> C         | 250                            | -              | -                       | -                  | integrated oscillator                                     |
| PCA8565   | X                      | 1                | I <sup>2</sup> C         | 600                            | -              | -                       | grade 1            | high robustness, T <sub>amb</sub> = -40 °C to 125 °C      |
| PCA8565A  | X                      | 1                | I <sup>2</sup> C         | 600                            | -              | -                       | -                  | integrated oscillator                                     |
| PCF85063  | -                      | 1                | I <sup>2</sup> C         | 220                            | -              | -                       | -                  | T <sub>amb</sub> = -40 °C to 125 °C                       |
| PCF85063A | X                      | 1                | I <sup>2</sup> C         | 220                            | -              | -                       | -                  | basic functions only                                      |
| PCF85063B | X                      | 1                | SPI                      | 220                            | -              | -                       | -                  | alarm   |
| PCF85263A | X                      | 2                | I <sup>2</sup> C         | 230                            | X              | X                       | -                  | tiny package  |
| PCF85263B | X                      | 2                | SPI                      | 230                            | X              | X                       | -                  | time stamp, battery backup, stopwatch                     |
| PCF85363A | X                      | 2                | I <sup>2</sup> C         | 230                            | X              | X                       | -                  | time stamp, battery backup, stopwatch                     |
| PCF85363B | X                      | 2                | SPI                      | 230                            | X              | X                       | -                  | time stamp, battery backup, stopwatch                     |
| PCF8523   | X                      | 2                | I <sup>2</sup> C         | 150                            | X              | -                       | -                  | lowest power 150 nA operation, FM+ 1 M                    |
| PCF2123   | X                      | 1                | SPI                      | 100                            | -              | -                       | -                  | lowest power 100 nA operation                             |
| PCF2127   | X                      | 1                | I <sup>2</sup> C and SPI | 500                            | X              | X                       | -                  | temperature compensated, quartz in, calibrated, 512 B RAM |

Table 94. Selection of Real-Time Clocks ...continued

| Type name | Alarm, Timer, Watchdog | Interrupt output | Interface                | I <sub>DD</sub> , typical (nA) | Battery backup | Timestamp, tamper input | AEC-Q100 compliant | Special features  |
|-----------|------------------------|------------------|--------------------------|--------------------------------|----------------|-------------------------|--------------------|---|
| PCF2127A  | X                      | 1                | I <sup>2</sup> C and SPI | 500                            | X              | X                       | -                  | temperature compensated, quartz in, calibrated, 512 B RAM |
| PCF2129   | X                      | 1                | I <sup>2</sup> C and SPI | 500                            | X              | X                       | -                  | temperature compensated, quartz in, calibrated            |
| PCF2129A  | X                      | 1                | I <sup>2</sup> C and SPI | 500                            | X              | X                       | -                  | temperature compensated, quartz in, calibrated            |
| PCA2129   | X                      | 1                | I <sup>2</sup> C and SPI | 500                            | X              | X                       | grade 3            | temperature compensated, quartz in, calibrated            |
| PCA21125  | X                      | 1                | SPI                      | 820                            | -              | -                       | grade 1            | high robustness, T <sub>amb</sub> = -40 °C to 125         |

## 21. Abbreviations

Table 95. Abbreviations

| Acronym          | Description                             |
|------------------|---|
| ACK              | ACKnowledge (I <sup>2</sup> C-bus)      |
| AM               | Ante Meridiem                           |
| BCD              | Binary Coded Decimal                    |
| CDM              | Charged Device Model                    |
| CMOS             | Complementary Metal-Oxide Semiconductor |
| DC               | Direct Current                          |
| GPS              | Global Positioning System               |
| HBM              | Human Body Model                        |
| I <sup>2</sup> C | Inter-Integrated Circuit                |
| IC               | Integrated Circuit                      |
| LSB              | Least Significant Bit                   |
| MCU              | Microcontroller Unit                    |
| MSB              | Most Significant Bit                    |
| PM               | Post Meridiem                           |
| POR              | Power-On Reset                          |
| PORO             | Power-On Reset Override                 |
| PPM              | Parts Per Million                       |
| RAM              | Random Access Memory                    |
| RC               | Resistance-Capacitance                  |
| RTC              | Real Time Clock                         |
| SCL              | Serial CLock line                       |
| SDA              | Serial DATa line                        |
| SPI              | Serial Peripheral Interface             |
| SRAM             | Static Random Access Memory             |
| TCXO             | Temperature Compensated Xtal Oscillator |
| Xtal             | crystal                                 |

## 22. References

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- [1] **AN10365** — Surface mount reflow soldering description
- [2] **AN10853** — Handling precautions of ESD sensitive devices
- [3] **AN11266** — Application and soldering information for the PCF2127 industrial TCXO RTC
- [4] **IEC 60134** — Rating systems for electronic tubes and valves and analogous semiconductor devices
- [5] **IEC 61340-5** — Protection of electronic devices from electrostatic phenomena
- [6] **IPC/JEDEC J-STD-020D** — Moisture/Reflow Sensitivity Classification for Nonhermetic Solid State Surface Mount Devices
- [7] **JESD22-A114** — Electrostatic Discharge (ESD) Sensitivity Testing Human Body Model (HBM)
- [8] **JESD22-C101** — Field-Induced Charged-Device Model Test Method for Electrostatic-Discharge-Withstand Thresholds of Microelectronic Components
- [9] **JESD78** — IC Latch-Up Test
- [10] **JESD625-A** — Requirements for Handling Electrostatic-Discharge-Sensitive (ESDS) Devices
- [11] **SOT162-1\_518** — SO16; Reel pack; SMD, 13", packing information
- [12] **SOT163-1\_518** — SO20; Reel pack; SMD, 13", packing information
- [13] **UM10204** — I<sup>2</sup>C-bus specification and user manual
- [14] **UM10569** — Store and transport requirements
- [15] **UM10762** — User manual for the accurate RTC demo board OM13513 containing PCF2127T and PCF2129AT

## 23. Revision history

Table 96. Revision history

| Document ID      | Release date   | Data sheet status  | Change notice | Supersedes                   |
|------------------|--|--------------------|---------------|------------------------------|
| PCF2127 v.8      | 20141219   | Product data sheet | -             | PCF2127 v.7                  |
| Modifications:   | <ul style="list-style-type: none"> <li>• Added <math>V_{OH}</math> and <math>V_{OL}</math> values in <a href="#">Table 90</a></li> <li>• Enhanced ESD HBM values</li> <li>• Corrected <a href="#">Figure 8</a></li> <li>• Enhanced description of internal operating voltage</li> <li>• Added register bit allocation tables</li> <li>• Fixed typos</li> </ul> |                    |               |                              |
| PCF2127 v.7      | 20141003   | Product data sheet | -             | PCF2127AT v.6<br>PCF2127 v.3 |
| <b>PCF2127AT</b> |  |                    |               |                              |
| PCF2127AT v.6    | 20130711   | Product data sheet | -             | PCF2127AT v.5                |
| PCF2127AT v.5    | 20130128   | Product data sheet | -             | PCF2127AT v.4                |
| PCF2127AT v.4    | 20121207   | Product data sheet | -             | PCF2127AT v.3                |
| PCF2127AT v.3    | 20121004   | Product data sheet | -             | PCF2127A v.2                 |
| PCF2127A v.2     | 20100507   | Product data sheet | -             | PCF2127A v.1                 |
| PCF2127A v.1     | 20100121   | Product data sheet | -             | -                            |
| <b>PCF2127T</b>  |  |                    |               |                              |
| PCF2127 v.3      | 20130711   | Product data sheet | -             | PCF2127 v.2                  |
| PCF2127 v.2      | 20130422   | Product data sheet | -             | PCF2127 v.1                  |
| PCF2127 v.1      | 20130212   | Product data sheet | -             | -                            |

## 24. Legal information

### 24.1 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>.

### 24.2 Definitions

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26. Tables

|  |    |   |    |
|--|----|---|----|
| Table 1. Ordering information . . . . .  | 2  | allocation . . . . .  | 32 |
| Table 2. Ordering options . . . . .  | 2  | Table 35. Days - days register (address 06h) bit description . . . . .                              | 32 |
| Table 3. Marking codes . . . . .   | 2  | Table 36. Weekdays - weekdays register (address 07h) bit allocation . . . . .                       | 33 |
| Table 4. Pin description of PCF2127 . . . . .  | 5  | Table 37. Weekdays - weekdays register (address 07h) bit description . . . . .                      | 33 |
| Table 5. Register overview . . . . .   | 8  | Table 38. Weekday assignments . . . . .   | 33 |
| Table 6. Control_1 - control and status register 1 (address 00h) bit allocation . . . . .        | 10 | Table 39. Months - months register (address 08h) bit allocation . . . . .                           | 34 |
| Table 7. Control_1 - control and status register 1 (address 00h) bit description . . . . .       | 10 | Table 40. Months - months register (address 08h) bit description . . . . .                          | 34 |
| Table 8. Control_2 - control and status register 2 (address 01h) bit allocation . . . . .        | 11 | Table 41. Month assignments in BCD format . . . . .   | 34 |
| Table 9. Control_2 - control and status register 2 (address 01h) bit description . . . . .       | 11 | Table 42. Years - years register (address 09h) bit allocation . . . . .                             | 35 |
| Table 10. Control_3 - control and status register 3 (address 02h) bit allocation . . . . .       | 12 | Table 43. Years - years register (address 09h) bit description . . . . .                            | 35 |
| Table 11. Control_3 - control and status register 3 (address 02h) bit description . . . . .      | 12 | Table 44. Second_alarm - second alarm register (address 0Ah) bit allocation . . . . .               | 38 |
| Table 12. CLKOUT_ctl - CLKOUT control register (address 0Fh) bit allocation . . . . .            | 12 | Table 45. Second_alarm - second alarm register (address 0Ah) bit description . . . . .              | 38 |
| Table 13. CLKOUT_ctl - CLKOUT control register (address 0Fh) bit description . . . . .           | 12 | Table 46. Minute_alarm - minute alarm register (address 0Bh) bit allocation . . . . .               | 38 |
| Table 14. Temperature measurement period . . . . .   | 13 | Table 47. Minute_alarm - minute alarm register (address 0Bh) bit description . . . . .              | 38 |
| Table 15. CLKOUT frequency selection . . . . .   | 14 | Table 48. Hour_alarm - hour alarm register (address 0Ch) bit allocation . . . . .                   | 39 |
| Table 16. Aging_offset - crystal aging offset register (address 19h) bit allocation . . . . .    | 14 | Table 49. Hour_alarm - hour alarm register (address 0Ch) bit description . . . . .                  | 39 |
| Table 17. Aging_offset - crystal aging offset register (address 19h) bit description . . . . .   | 14 | Table 50. Day_alarm - day alarm register (address 0Dh) bit allocation . . . . .                     | 39 |
| Table 18. Frequency correction at 25 °C, typical . . . . .                                       | 15 | Table 51. Day_alarm - day alarm register (address 0Dh) bit description . . . . .                    | 39 |
| Table 19. RAM_addr_MSB - RAM address MSB register (address 1Ah) bit allocation . . . . .         | 16 | Table 52. Weekday_alarm - weekday alarm register (address 0Eh) bit allocation . . . . .             | 40 |
| Table 20. RAM_addr_MSB - RAM address MSB register (address 1Ah) bit description . . . . .        | 16 | Table 53. Weekday_alarm - weekday alarm register (address 0Eh) bit description . . . . .            | 40 |
| Table 21. RAM_addr_LSB - RAM address LSB register (address 1Bh) bit allocation . . . . .         | 16 | Table 54. Watchdg_tim_ctl - watchdog timer control register (address 10h) bit allocation . . . . .  | 41 |
| Table 22. RAM_addr_LSB - RAM address LSB register (address 1Bh) bit description . . . . .        | 16 | Table 55. Watchdg_tim_ctl - watchdog timer control register (address 10h) bit description . . . . . | 41 |
| Table 23. RAM_wrt_cmd - RAM write command register (address 1Ch) bit description . . . . .       | 16 | Table 56. Watchdg_tim_val - watchdog timer value register (address 11h) bit allocation . . . . .    | 42 |
| Table 24. RAM_rd_cmd - RAM read command register (address 1Dh) bit description . . . . .         | 16 | Table 57. Watchdg_tim_val - watchdog timer value register (address 11h) bit description . . . . .   | 42 |
| Table 25. Power management control bit description . . . . .                                     | 18 | Table 58. Programmable watchdog timer . . . . .   | 42 |
| Table 26. Output pin BBS . . . . .   | 26 | Table 59. Specification of $t_{w(rst)}$ . . . . .   | 44 |
| Table 27. Seconds - seconds and clock integrity register (address 03h) bit allocation . . . . .  | 30 | Table 60. First period delay for timer counter . . . . .  | 45 |
| Table 28. Seconds - seconds and clock integrity register (address 03h) bit description . . . . . | 30 | Table 61. Flag location in register Control_2 . . . . .   | 46 |
| Table 29. Seconds coded in BCD format . . . . .  | 31 | Table 62. Example values in register Control_2 . . . . .  | 46 |
| Table 30. Minutes - minutes register (address 04h) bit allocation . . . . .                      | 31 | Table 63. Example to clear only CDTF (bit 3) . . . . .  | 46 |
| Table 31. Minutes - minutes register (address 04h) bit description . . . . .                     | 31 | Table 64. Example to clear only AF (bit 4) . . . . .  | 46 |
| Table 32. Hours - hours register (address 05h) bit allocation . . . . .                          | 32 | Table 65. Example to clear only MSF (bit 7) . . . . .   | 47 |
| Table 33. Hours - hours register (address 05h) bit description . . . . .                         | 32 | Table 66. Example to clear both CDTF and MSF . . . . .  | 47 |
| Table 34. Days - days register (address 06h) bit   |    | Table 67. Timestp_ctl - timestamp control register (address 12h) bit allocation . . . . .           | 50 |

Table 68. Timestp\_ctl - timestamp control register (address 12h) bit description .....50

Table 69. Sec\_timestp - second timestamp register (address 13h) bit allocation .....50

Table 70. Sec\_timestp - second timestamp register (address 13h) bit description .....50

Table 71. Min\_timestp - minute timestamp register (address 14h) bit allocation .....51

Table 72. Min\_timestp - minute timestamp register (address 14h) bit description .....51

Table 73. Hour\_timestp - hour timestamp register (address 15h) bit allocation .....51

Table 74. Hour\_timestp - hour timestamp register (address 15h) bit description .....51

Table 75. Day\_timestp - day timestamp register (address 16h) bit allocation .....52

Table 76. Day\_timestp - day timestamp register (address 16h) bit description .....52

Table 77. Mon\_timestp - month timestamp register (address 17h) bit allocation .....52

Table 78. Mon\_timestp - month timestamp register (address 17h) bit description .....52

Table 79. Year\_timestp - year timestamp register (address 18h) bit allocation .....52

Table 80. Year\_timestp - year timestamp register (address 18h) bit description .....52

Table 81. Battery switch-over and timestamp .....53

Table 82. Effect of bits MI and SI on pin INT and bit MSF55

Table 83. INT operation (bit TI\_TP = 1) .....57

Table 84. First increment of time circuits after stop release .....60

Table 85. Interface selection input pin IFS .....62

Table 86. Serial interface .....63

Table 87. Command byte definition .....63

Table 88. I<sup>2</sup>C slave address byte .....68

Table 89. Limiting values .....72

Table 90. Static characteristics .....73

Table 91. Frequency characteristics .....78

Table 92. SPI-bus characteristics .....80

Table 93. I<sup>2</sup>C-bus characteristics .....82

Table 94. Selection of Real-Time Clocks .....89

Table 95. Abbreviations .....91

Table 96. Revision history .....93

27. Figures

|   |    |   |    |
|---|----|---|----|
| Fig 1. Block diagram of PCF2127   | 3  | Fig 38. SPI-bus write examples  | 64 |
| Fig 2. Pin configuration for PCF2127AT (SO20)   | 4  | Fig 39. SPI-bus read examples   | 65 |
| Fig 3. Pin configuration for PCF2127T (SO16)  | 4  | Fig 40. Bit transfer  | 66 |
| Fig 4. Position of the stubs from the package assembly process  | 4  | Fig 41. Definition of START and STOP conditions   | 66 |
| Fig 5. Handling address registers   | 6  | Fig 42. System configuration  | 67 |
| Fig 6. Battery switch-over behavior in standard mode with bit BIE set logic 1 (enabled)   | 20 | Fig 43. Acknowledgement on the I <sup>2</sup> C-bus                                     | 67 |
| Fig 7. Battery switch-over behavior in direct switching mode with bit BIE set logic 1 (enabled)   | 21 | Fig 44. Bus protocol, writing to registers  | 68 |
| Fig 8. Battery switch-over circuit, simplified block diagram  | 22 | Fig 45. Bus protocol, reading from registers  | 68 |
| Fig 9. Battery low detection behavior with bit BLIE set logic 1 (enabled)   | 23 | Fig 46. Bus protocol, writing to RAM  | 69 |
| Fig 10. Typical application of the extra power fail detection function  | 23 | Fig 47. Bus protocol, reading from RAM  | 70 |
| Fig 11. PFO signal behavior when battery switch-over is enabled in standard mode and $V_{th(uvp)} > (V_{BAT}, V_{th(sw)bat})$                           | 25 | Fig 48. Device diode protection diagram of PCF2127                                      | 71 |
| Fig 12. PFO signal behavior when battery switch-over is enabled in direct switching mode and $V_{th(uvp)} < V_{BAT}$                                    | 25 | Fig 49. I <sub>OL</sub> on pin SDA/CE   | 75 |
| Fig 13. PFO signal behavior when battery switch-over is disabled  | 26 | Fig 50. I <sub>DD</sub> as a function of temperature                                    | 75 |
| Fig 14. Typical driving capability of V <sub>BBS</sub> : (V <sub>BBS</sub> - V <sub>DD</sub> ) with respect to the output load current I <sub>BBS</sub> | 27 | Fig 51. I <sub>DD</sub> as a function of V <sub>DD</sub>                                | 76 |
| Fig 15. Power failure event due to battery discharge: reset occurs  | 28 | Fig 52. Typical I <sub>DD</sub> as a function of the power management settings          | 77 |
| Fig 16. Dependency between POR and oscillator   | 29 | Fig 53. Typical characteristic of frequency with respect to temperature of PCF2127AT    | 79 |
| Fig 17. Power-On Reset (POR) system   | 29 | Fig 54. Typical characteristic of frequency with respect to temperature of PCF2127T     | 79 |
| Fig 18. Power-On Reset Override (PORO) sequence, valid for both I <sup>2</sup> C-bus and SPI-bus  | 30 | Fig 55. SPI-bus timing  | 81 |
| Fig 19. Data flow of the time function  | 35 | Fig 56. I <sup>2</sup> C-bus timing diagram; rise and fall times refer to 30 % and 70 % | 83 |
| Fig 20. Access time for read/write operations   | 36 | Fig 57. General application diagram   | 84 |
| Fig 21. Alarm function block diagram  | 37 | Fig 58. Package outline SOT163-1 (SO20) of PCF2127AT                                    | 85 |
| Fig 22. Alarm flag timing diagram   | 40 | Fig 59. Package outline SOT162-1 (SO16) of PCF2127T                                     | 86 |
| Fig 23. WD_CD[1:0] = 10: watchdog activates an interrupt when timed out   | 43 | Fig 60. Footprint information for reflow soldering of SOT163-1 (SO20) of PCF2127AT      | 87 |
| Fig 24. WD_CD[1:0] = 11: watchdog activates a reset pulse when timed out  | 44 | Fig 61. Footprint information for reflow soldering of SOT162-1 (SO16) of PCF2127T       | 88 |
| Fig 25. General countdown timer behavior  | 45 |   |    |
| Fig 26. Timestamp detection with two push-buttons on the TS pin (for example, for tamper detection)   | 48 |   |    |
| Fig 27. Interrupt block diagram   | 54 |   |    |
| Fig 28. INT example for SI and MI when TI_TP is logic 156   | 56 |   |    |
| Fig 29. INT example for SI and MI when TI_TP is logic 056   | 56 |   |    |
| Fig 30. Example of shortening the INT pulse by clearing the MSF flag  | 57 |   |    |
| Fig 31. Example of shortening the INT pulse by clearing the CDTF flag   | 57 |   |    |
| Fig 32. AF timing diagram   | 58 |   |    |
| Fig 33. STOP bit functional diagram   | 60 |   |    |
| Fig 34. STOP bit release timing   | 61 |   |    |
| Fig 35. Interface selection   | 62 |   |    |
| Fig 36. SDI, SDO configurations   | 62 |   |    |
| Fig 37. Data transfer overview  | 63 |   |    |

## 28. Contents

|          |  |          |          |  |    |
|----------|--|----------|----------|--|----|
| <b>1</b> | <b>General description</b> . . . . .   | <b>1</b> | 8.8      | Reset function . . . . .                                       | 28 |
| <b>2</b> | <b>Features and benefits</b> . . . . .   | <b>1</b> | 8.8.1    | Power-On Reset (POR) . . . . .                                 | 28 |
| <b>3</b> | <b>Applications</b> . . . . .  | <b>2</b> | 8.8.2    | Power-On Reset Override (PORO) . . . . .                       | 29 |
| <b>4</b> | <b>Ordering information</b> . . . . .  | <b>2</b> | 8.9      | Time and date function . . . . .                               | 30 |
| 4.1      | Ordering options . . . . .   | 2        | 8.9.1    | Register Seconds . . . . .                                     | 30 |
| <b>5</b> | <b>Marking</b> . . . . .   | <b>2</b> | 8.9.2    | Register Minutes . . . . .                                     | 31 |
| <b>6</b> | <b>Block diagram</b> . . . . .   | <b>3</b> | 8.9.3    | Register Hours . . . . .                                       | 32 |
| <b>7</b> | <b>Pinning information</b> . . . . .   | <b>4</b> | 8.9.4    | Register Days . . . . .  | 32 |
| 7.1      | Pinning . . . . .  | 4        | 8.9.5    | Register Weekdays . . . . .                                    | 33 |
| 7.2      | Pin description . . . . .  | 5        | 8.9.6    | Register Months . . . . .                                      | 34 |
| <b>8</b> | <b>Functional description</b> . . . . .  | <b>6</b> | 8.9.7    | Register Years . . . . .                                       | 35 |
| 8.1      | Register overview . . . . .  | 6        | 8.9.8    | Setting and reading the time . . . . .                         | 35 |
| 8.2      | Control registers . . . . .  | 10       | 8.10     | Alarm function . . . . .                                       | 37 |
| 8.2.1    | Register Control_1 . . . . .   | 10       | 8.10.1   | Register Second_alarm . . . . .                                | 38 |
| 8.2.2    | Register Control_2 . . . . .   | 11       | 8.10.2   | Register Minute_alarm . . . . .                                | 38 |
| 8.2.3    | Register Control_3 . . . . .   | 12       | 8.10.3   | Register Hour_alarm . . . . .                                  | 39 |
| 8.3      | Register CLKOUT_ctl . . . . .  | 12       | 8.10.4   | Register Day_alarm . . . . .                                   | 39 |
| 8.3.1    | Temperature compensated crystal oscillator . . . . .                                   | 13       | 8.10.5   | Register Weekday_alarm . . . . .                               | 40 |
| 8.3.1.1  | Temperature measurement . . . . .  | 13       | 8.10.6   | Alarm flag . . . . .   | 40 |
| 8.3.2    | OTP refresh . . . . .  | 13       | 8.11     | Timer functions . . . . .                                      | 40 |
| 8.3.3    | Clock output . . . . .   | 13       | 8.11.1   | Register Watchdog_tim_ctl . . . . .                            | 41 |
| 8.4      | Register Aging_offset . . . . .  | 14       | 8.11.2   | Register Watchdog_tim_val . . . . .                            | 42 |
| 8.4.1    | Crystal aging correction . . . . .   | 14       | 8.11.3   | Watchdog timer function . . . . .                              | 42 |
| 8.5      | General purpose 512 bytes static RAM . . . . .   | 15       | 8.11.4   | Countdown timer function . . . . .                             | 44 |
| 8.5.1    | Register RAM_addr_MSB . . . . .  | 16       | 8.11.5   | Pre-defined timers: second and minute interrupt . . . . .      | 46 |
| 8.5.2    | Register RAM_addr_LSB . . . . .  | 16       | 8.11.6   | Clearing flags . . . . .                                       | 46 |
| 8.5.3    | Register RAM_wrt_cmd . . . . .   | 16       | 8.12     | Timestamp function . . . . .                                   | 48 |
| 8.5.4    | Register RAM_rd_cmd . . . . .  | 16       | 8.12.1   | Timestamp flag . . . . .                                       | 48 |
| 8.5.5    | Operation examples . . . . .   | 17       | 8.12.2   | Timestamp mode . . . . .                                       | 49 |
| 8.5.5.1  | Writing to the RAM . . . . .   | 17       | 8.12.3   | Timestamp registers . . . . .                                  | 50 |
| 8.5.5.2  | Reading from the RAM . . . . .   | 17       | 8.12.3.1 | Register Timestp_ctl . . . . .                                 | 50 |
| 8.6      | Power management functions . . . . .   | 17       | 8.12.3.2 | Register Sec_timestp . . . . .                                 | 50 |
| 8.6.1    | Battery switch-over function . . . . .   | 19       | 8.12.3.3 | Register Min_timestp . . . . .                                 | 51 |
| 8.6.1.1  | Standard mode . . . . .  | 20       | 8.12.3.4 | Register Hour_timestp . . . . .                                | 51 |
| 8.6.1.2  | Direct switching mode . . . . .  | 21       | 8.12.3.5 | Register Day_timestp . . . . .                                 | 52 |
| 8.6.1.3  | Battery switch-over disabled: only one power supply (V <sub>DD</sub> ) . . . . .       | 21       | 8.12.3.6 | Register Mon_timestp . . . . .                                 | 52 |
| 8.6.1.4  | Battery switch-over architecture . . . . .   | 22       | 8.12.3.7 | Register Year_timestp . . . . .                                | 52 |
| 8.6.2    | Battery low detection function . . . . .   | 22       | 8.12.4   | Dependency between Battery switch-over and timestamp . . . . . | 53 |
| 8.6.3    | Extra power fail detection function . . . . .  | 23       | 8.13     | Interrupt output, INT . . . . .                                | 54 |
| 8.6.3.1  | Extra power fail detection when the battery switch-over function is enabled . . . . .  | 24       | 8.13.1   | Minute and second interrupts . . . . .                         | 55 |
| 8.6.3.2  | Extra power fail detection when the battery switch-over function is disabled . . . . . | 26       | 8.13.2   | Countdown timer interrupts . . . . .                           | 56 |
| 8.6.4    | Battery backup supply . . . . .  | 26       | 8.13.3   | INT pulse shortening . . . . .                                 | 56 |
| 8.7      | Oscillator stop detection function . . . . .   | 27       | 8.13.4   | Watchdog timer interrupts . . . . .                            | 58 |
|          |  |          | 8.13.5   | Alarm interrupts . . . . .                                     | 58 |
|          |  |          | 8.13.6   | Timestamp interrupts . . . . .                                 | 58 |
|          |  |          | 8.13.7   | Battery switch-over interrupts . . . . .                       | 58 |

continued >>

|           |  |           |
|-----------|--|-----------|
| 8.13.8    | Battery low detection interrupts               | 58        |
| 8.14      | External clock test mode                       | 59        |
| 8.15      | STOP bit function                              | 59        |
| <b>9</b>  | <b>Interfaces</b>                              | <b>62</b> |
| 9.1       | SPI-bus interface                              | 62        |
| 9.1.1     | Data transmission                              | 63        |
| 9.2       | I <sup>2</sup> C-bus interface                 | 66        |
| 9.2.1     | Bit transfer                                   | 66        |
| 9.2.2     | START and STOP conditions                      | 66        |
| 9.2.3     | System configuration                           | 66        |
| 9.2.4     | Acknowledge                                    | 67        |
| 9.2.5     | I <sup>2</sup> C-bus protocol                  | 67        |
| 9.3       | Bus communication and battery backup operation | 70        |
| <b>10</b> | <b>Internal circuitry</b>                      | <b>71</b> |
| <b>11</b> | <b>Safety notes</b>                            | <b>71</b> |
| <b>12</b> | <b>Limiting values</b>                         | <b>72</b> |
| <b>13</b> | <b>Static characteristics</b>                  | <b>73</b> |
| 13.1      | Current consumption characteristics, typical   | 75        |
| 13.2      | Frequency characteristics                      | 78        |
| <b>14</b> | <b>Dynamic characteristics</b>                 | <b>80</b> |
| 14.1      | SPI-bus timing characteristics                 | 80        |
| 14.2      | I <sup>2</sup> C-bus timing characteristics    | 82        |
| <b>15</b> | <b>Application information</b>                 | <b>84</b> |
| <b>16</b> | <b>Test information</b>                        | <b>84</b> |
| 16.1      | Quality information                            | 84        |
| <b>17</b> | <b>Package outline</b>                         | <b>85</b> |
| <b>18</b> | <b>Packing information</b>                     | <b>87</b> |
| 18.1      | Tape and reel information                      | 87        |
| <b>19</b> | <b>Soldering</b>                               | <b>87</b> |
| 19.1      | Footprint information                          | 87        |
| <b>20</b> | <b>Appendix</b>                                | <b>89</b> |
| 20.1      | Real-Time Clock selection                      | 89        |
| <b>21</b> | <b>Abbreviations</b>                           | <b>91</b> |
| <b>22</b> | <b>References</b>                              | <b>92</b> |
| <b>23</b> | <b>Revision history</b>                        | <b>93</b> |
| <b>24</b> | <b>Legal information</b>                       | <b>94</b> |
| 24.1      | Data sheet status                              | 94        |
| 24.2      | Definitions                                    | 94        |
| 24.3      | Disclaimers                                    | 94        |
| 24.4      | Trademarks                                     | 95        |
| <b>25</b> | <b>Contact information</b>                     | <b>95</b> |
| <b>26</b> | <b>Tables</b>                                  | <b>96</b> |
| <b>27</b> | <b>Figures</b>                                 | <b>98</b> |
| <b>28</b> | <b>Contents</b>                                | <b>99</b> |

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Date of release: 19 December 2014






Document identifier: PCF2127

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