



# PCA2129T

Accurate RTC with integrated quartz crystal for automotive

Rev. 2.1 — 14 November 2012

Product data sheet

## 1. General description

The PCA2129T 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 PCA2129T has 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.

## 2. Features and benefits

- AEC-Q100 compliant for automotive applications
- Temperature Compensated Crystal Oscillator (TCXO) with integrated capacitors
- Typical accuracy:  $\pm 3$  ppm from  $-30$  °C to  $+80$  °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
- 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)
- Programmable 1 second or 1 minute interrupt
- Programmable watchdog timer with interrupt
- Programmable alarm function with interrupt capability
- Programmable square output
- Clock operating voltage: 1.8 V to 4.2 V
- Low supply current: typical 0.70  $\mu$ A at  $V_{DD} = 3.3$  V

1. The definition of the abbreviations and acronyms used in this data sheet can be found in [Section 19](#).



### 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  |
| PCA2129T/Q900/2 | SO16    | plastic small outline package; 16 leads;<br>body width 7.5 mm | SOT162-1 |

#### 4.1 Ordering options

Table 2. Ordering options

| Type number     | IC revision | Sales item (12NC) | Delivery form                    |
|-----------------|-------------|-------------------|----------------------------------|
| PCA2129T/Q900/2 | 2           | 935296923518      | tape and reel, 13 inch, dry pack |

### 5. Marking

Table 3. Marking codes

| Type number     | Marking code |
|-----------------|--------------|
| PCA2129T/Q900/2 | PCA2129T/Q   |

6. Block diagram

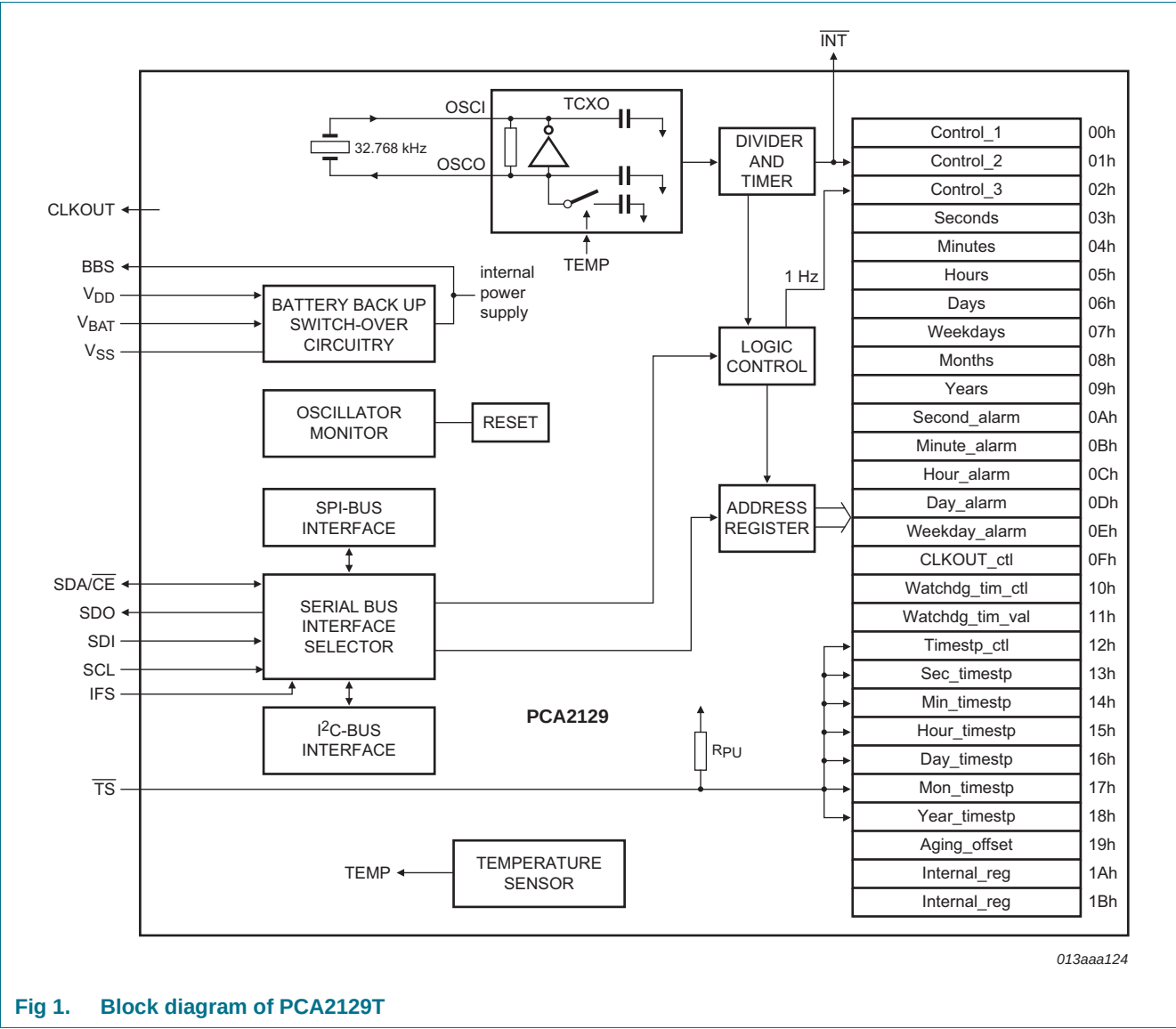
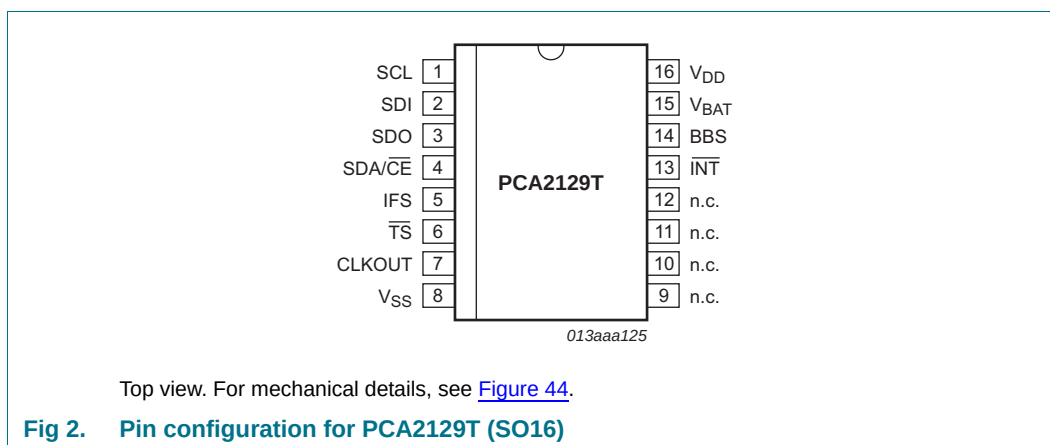


Fig 1. Block diagram of PCA2129T

## 7. Pinning information

### 7.1 Pinning



### 7.2 Pin description

**Table 4. Pin description of PCA2129T**

| Symbol           | Pin     | Description                                                                                                                               |
|------------------|---------|-------------------------------------------------------------------------------------------------------------------------------------------|
| SCL              | 1       | combined serial clock input for both I <sup>2</sup> C-bus and SPI-bus; may float when SDA/CE inactive                                     |
| SDI              | 2       | serial data input for SPI-bus; may float when SDA/CE inactive                                                                             |
| SDO              | 3       | serial data output for SPI-bus, push-pull                                                                                                 |
| SDA/CE           | 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       | interface selector input<br>connect to pin V <sub>SS</sub> to select the SPI-bus<br>connect to pin BBS to select the I <sup>2</sup> C-bus |
| TS               | 6       | timestamp input (active LOW) with 200 kΩ internal pull-up resistor (R <sub>PU</sub> )                                                     |
| CLKOUT           | 7       | clock output (open-drain)                                                                                                                 |
| V <sub>SS</sub>  | 8       | ground supply voltage                                                                                                                     |
| n.c.             | 9 to 12 | not connected; do not connect; do not use as feed through                                                                                 |
| INT              | 13      | interrupt output (open-drain; active LOW)                                                                                                 |
| BBS              | 14      | output voltage (battery backed)                                                                                                           |
| V <sub>BAT</sub> | 15      | battery supply voltage (backup)                                                                                                           |
| V <sub>DD</sub>  | 16      | supply voltage                                                                                                                            |

## 8. Functional description

The PCA2129T 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 8.3.2](#)).

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 PCA2129T 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 8.5.1](#)). 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 8.5.3](#)). 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 PCA2129T 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 3](#)).

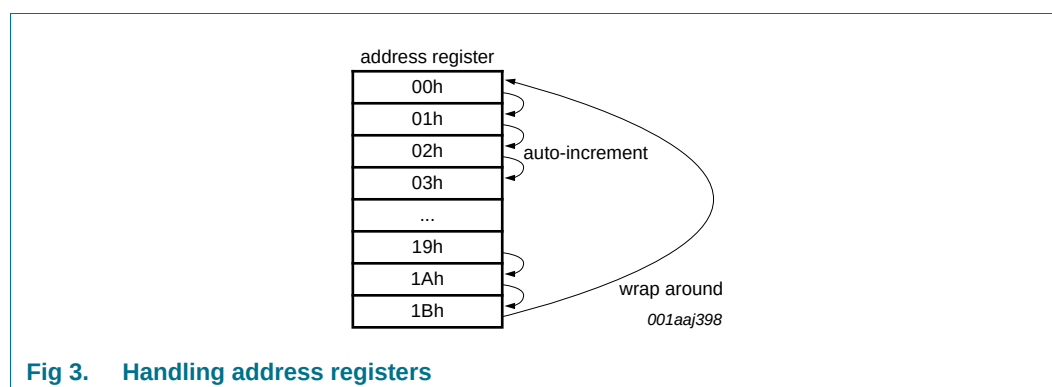


Fig 3. Handling address registers

- 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 8.8](#)).
- Addresses 0Ah through 0Eh define the alarm function. It can be selected that an interrupt is generated when an alarm event occurs (see [Section 8.9](#)).

- The register 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 10](#)). 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 11](#)).
- Address registers 10h and 11h are used for the watchdog 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 33](#)). An interrupt will be generated when the watchdog times out.
- Address registers 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 8.11](#)).
- Address register 19h is used for the correction of the crystal aging effect (see [Section 8.4.1](#)).
- Address registers 1Ah and 1Bh are for internal use only.
- 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 8.8.8](#)).

**Table 5. Register overview**

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

| Address                 | Register name   | Bit                   |                        |                                   |                                   |          |                        |             |                                     | Reset value                         | Reference                           |
|-------------------------|-----------------|-----------------------|------------------------|-----------------------------------|-----------------------------------|----------|------------------------|-------------|-------------------------------------|-------------------------------------|-------------------------------------|
|                         |                 | 7                     | 6                      | 5                                 | 4                                 | 3        | 2                      | 1           | 0                                   |                                     |                                     |
| Control registers       |                 |                       |                        |                                   |                                   |          |                        |             |                                     |                                     |                                     |
| 00h                     | Control_1       | EXT_TEST              | T                      | STOP                              | TSF1                              | POR_OVRD | 12_24                  | MI          | SI                                  | 0000 0000                           | <a href="#">Table 6 on page 9</a>   |
| 01h                     | Control_2       | MSF                   | WDTF                   | TSF2                              | AF                                | T        | TSIE                   | AIE         | T                                   | 0000 0000                           | <a href="#">Table 7 on page 10</a>  |
| 02h                     | Control_3       | PWRMNG[2:0]           |                        |                                   | BTSE                              | BF       | BLF                    | BIE         | BLIE                                | 0000 0000                           | <a href="#">Table 8 on page 11</a>  |
| Time and date registers |                 |                       |                        |                                   |                                   |          |                        |             |                                     |                                     |                                     |
| 03h                     | Seconds         | OSF                   | SECONDS (0 to 59)      |                                   |                                   |          |                        |             | 1XXX XXXX                           | <a href="#">Table 16 on page 23</a> |                                     |
| 04h                     | Minutes         | -                     | MINUTES (0 to 59)      |                                   |                                   |          |                        |             | - XXX XXXX                          | <a href="#">Table 18 on page 23</a> |                                     |
| 05h                     | Hours           | -                     | -                      | AMPM                              | HOURS (1 to 12) in 12 h mode      |          |                        |             | - - XX XXXX                         | <a href="#">Table 19 on page 24</a> |                                     |
|                         |                 |                       |                        | HOURS (0 to 23) in 24 h mode      |                                   |          |                        | - - XX XXXX |                                     |                                     |                                     |
| 06h                     | Days            | -                     | -                      | DAYS (1 to 31)                    |                                   |          |                        | - - XX XXXX | <a href="#">Table 20 on page 24</a> |                                     |                                     |
| 07h                     | Weekdays        | -                     | -                      | -                                 | -                                 | -        | WEEKDAYS (0 to 6)      |             | - - - - XXX                         | <a href="#">Table 21 on page 24</a> |                                     |
| 08h                     | Months          | -                     | -                      | -                                 | MONTHS (1 to 12)                  |          |                        |             | - - - X XXXX                        | <a href="#">Table 23 on page 25</a> |                                     |
| 09h                     | Years           | YEARS (0 to 99)       |                        |                                   |                                   |          |                        | XXXX XXXX   | <a href="#">Table 25 on page 25</a> |                                     |                                     |
| Alarm registers         |                 |                       |                        |                                   |                                   |          |                        |             |                                     |                                     |                                     |
| 0Ah                     | Second_alarm    | AE_S                  | SECOND_ALARM (0 to 59) |                                   |                                   |          |                        |             | 1XXX XXXX                           | <a href="#">Table 26 on page 27</a> |                                     |
| 0Bh                     | Minute_alarm    | AE_M                  | MINUTE_ALARM (0 to 59) |                                   |                                   |          |                        |             | 1XXX XXXX                           | <a href="#">Table 27 on page 28</a> |                                     |
| 0Ch                     | Hour_alarm      | AE_H                  | -                      | AMPM                              | HOUR_ALARM (1 to 12) in 12 h mode |          |                        |             | 1 - XX XXXX                         | <a href="#">Table 28 on page 28</a> |                                     |
|                         |                 |                       |                        | HOUR_ALARM (0 to 23) in 24 h mode |                                   |          |                        | 1 - XX XXXX |                                     |                                     |                                     |
| 0Dh                     | Day_alarm       | AE_D                  | -                      | DAY_ALARM (1 to 31)               |                                   |          |                        | 1 - XX XXXX | <a href="#">Table 29 on page 28</a> |                                     |                                     |
| 0Eh                     | Weekday_alarm   | AE_W                  | -                      | -                                 | -                                 | -        | WEEKDAY_ALARM (0 to 6) |             | 1 - - - - XXX                       | <a href="#">Table 30 on page 29</a> |                                     |
| CLKOUT control register |                 |                       |                        |                                   |                                   |          |                        |             |                                     |                                     |                                     |
| 0Fh                     | CLKOUT_ctl      | TCR[1:0]              |                        | -                                 | -                                 | -        | COF[2:0]               |             | 00 - - - 000                        | <a href="#">Table 9 on page 12</a>  |                                     |
| Watchdog registers      |                 |                       |                        |                                   |                                   |          |                        |             |                                     |                                     |                                     |
| 10h                     | Watchdg_tim_ctl | WD_CD                 | T                      | TI_TP                             | -                                 | -        | -                      | TF[1:0]     |                                     | 000 - - - 11                        | <a href="#">Table 31 on page 30</a> |
| 11h                     | Watchdg_tim_val | WATCHDGD_TIM_VAL[7:0] |                        |                                   |                                   |          |                        | XXXX XXXX   | <a href="#">Table 32 on page 30</a> |                                     |                                     |
| Timestamp registers     |                 |                       |                        |                                   |                                   |          |                        |             |                                     |                                     |                                     |
| 12h                     | Timestamp_ctl   | TSM                   | TSOFF                  | -                                 | 1_O_16_TIMESTP[4:0]               |          |                        |             | 00 - X XXXX                         | <a href="#">Table 38 on page 35</a> |                                     |

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

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

| Address               | Register name | Bit                    |                          |                                     |                                     |         |   |   |             | Reset value                         | Reference                           |
|-----------------------|---------------|------------------------|--------------------------|-------------------------------------|-------------------------------------|---------|---|---|-------------|-------------------------------------|-------------------------------------|
|                       |               | 7                      | 6                        | 5                                   | 4                                   | 3       | 2 | 1 | 0           |                                     |                                     |
| 13h                   | Sec_timestp   | -                      | SECOND_TIMESTP (0 to 59) |                                     |                                     |         |   |   |             | - XXX XXXX                          | <a href="#">Table 39 on page 35</a> |
| 14h                   | Min_timestp   | -                      | MINUTE_TIMESTP (0 to 59) |                                     |                                     |         |   |   |             | - XXX XXXX                          | <a href="#">Table 40 on page 35</a> |
| 15h                   | Hour_timestp  | -                      | -                        | AMPM                                | HOUR_TIMESTP (1 to 12) in 12 h mode |         |   |   |             | - - XX XXXX                         | <a href="#">Table 41 on page 36</a> |
|                       |               |                        |                          | HOUR_TIMESTP (0 to 23) in 24 h mode |                                     |         |   |   | - - XX XXXX |                                     |                                     |
| 16h                   | Day_timestp   | -                      | -                        | DAY_TIMESTP (1 to 31)               |                                     |         |   |   | - - XX XXXX | <a href="#">Table 42 on page 36</a> |                                     |
| 17h                   | Mon_timestp   | -                      | -                        | -                                   | MONTH_TIMESTP (1 to 12)             |         |   |   |             | - - - X XXXX                        | <a href="#">Table 43 on page 36</a> |
| 18h                   | Year_timestp  | YEAR_TIMESTP (0 to 99) |                          |                                     |                                     |         |   |   | XXXX XXXX   | <a href="#">Table 44 on page 36</a> |                                     |
| Aging offset register |               |                        |                          |                                     |                                     |         |   |   |             |                                     |                                     |
| 19h                   | Aging_offset  | -                      | -                        | -                                   | -                                   | AO[3:0] |   |   |             | - - - - 1000                        | <a href="#">Table 12 on page 14</a> |
| Internal registers    |               |                        |                          |                                     |                                     |         |   |   |             |                                     |                                     |
| 1Ah                   | Internal_reg  | -                      | -                        | -                                   | -                                   | -       | - | - | -           | - - - - - - -                       | -                                   |
| 1Bh                   | Internal_reg  | -                      | -                        | -                                   | -                                   | -       | - | - | -           | - - - - - - -                       | -                                   |



## 8.2 Control registers

The first 3 registers of the PCA2129T, 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 description

| Bit | Symbol   | Value | Description                                                                                                                                                | Reference                      |
|-----|----------|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|
| 7   | EXT_TEST | 0     | [1] normal mode                                                                                                                                            | <a href="#">Section 8.13</a>   |
|     |          | 1     | external clock test mode                                                                                                                                   |                                |
| 6   | T        | 0     | [2] unused                                                                                                                                                 | -                              |
| 5   | STOP     | 0     | [1] RTC source clock runs                                                                                                                                  | <a href="#">Section 8.14</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     | [1] no timestamp interrupt generated                                                                                                                       | <a href="#">Section 8.11.1</a> |
|     |          | 1     | flag set when $\overline{\text{TS}}$ input is driven to an intermediate level between power supply and ground;<br>flag must be cleared to clear interrupt  |                                |
| 3   | POR_OVRD | 0     | [1] Power-On Reset Override (PORO) facility disabled;<br><b>set logic 0 for normal operation</b>                                                           | <a href="#">Section 8.7.2</a>  |
|     |          | 1     | PORO enabled                                                                                                                                               |                                |
| 2   | 12_24    | 0     | [1] 24 hour mode selected                                                                                                                                  | <a href="#">Table 19</a>       |
|     |          | 1     | 12 hour mode selected                                                                                                                                      |                                |
| 1   | MI       | 0     | [1] minute interrupt disabled                                                                                                                              | <a href="#">Section 8.12.1</a> |
|     |          | 1     | minute interrupt enabled                                                                                                                                   |                                |
| 0   | SI       | 0     | [1] second interrupt disabled                                                                                                                              |                                |
|     |          | 1     | second interrupt enabled                                                                                                                                   |                                |

[1] Default value.

[2] When writing to the register this bit always has to be set logic 0.

## 8.2.2 Register Control\_2

Table 7. Control\_2 - control and status register 2 (address 01h) bit description

| Bit | Symbol | Value | Description                                                                                                 | Reference                      |
|-----|--------|-------|-------------------------------------------------------------------------------------------------------------|--------------------------------|
| 7   | MSF    | 0     | [1] no minute or second interrupt generated                                                                 | <a href="#">Section 8.12</a>   |
|     |        | 1     | flag set when minute or second interrupt generated;<br>flag must be cleared to clear interrupt              |                                |
| 6   | WDTF   | 0     | [1] no watchdog timer interrupt or reset generated                                                          | <a href="#">Section 8.12.3</a> |
|     |        | 1     | flag set when watchdog timer interrupt or reset generated;<br>flag cannot be cleared by command (read-only) |                                |
| 5   | TSF2   | 0     | [1] no timestamp interrupt generated                                                                        | <a href="#">Section 8.11.1</a> |
|     |        | 1     | flag set when $\overline{\text{TS}}$ input is driven to ground;<br>flag must be cleared to clear interrupt  |                                |
| 4   | AF     | 0     | [1] no alarm interrupt generated                                                                            | <a href="#">Section 8.9.6</a>  |
|     |        | 1     | flag set when alarm triggered;<br>flag must be cleared to clear interrupt                                   |                                |
| 3   | T      | 0     | [2] unused                                                                                                  | -                              |
| 2   | TSIE   | 0     | [1] no interrupt generated from timestamp flag                                                              | <a href="#">Section 8.12.5</a> |
|     |        | 1     | interrupt generated when timestamp flag set                                                                 |                                |
| 1   | AIE    | 0     | [1] no interrupt generated from the alarm flag                                                              | <a href="#">Section 8.12.4</a> |
|     |        | 1     | interrupt generated when alarm flag set                                                                     |                                |
| 0   | T      | 0     | [2] unused                                                                                                  | -                              |

[1] Default value.

[2] When writing to the register this bit always has to be set logic 0.

### 8.2.3 Register Control\_3

**Table 8. Control\_3 - control and status register 3 (address 02h) bit description**

| Bit    | Symbol      | Value | Description                                                                                         | Reference                                                        |
|--------|-------------|-------|-----------------------------------------------------------------------------------------------------|------------------------------------------------------------------|
| 7 to 5 | PWRMNG[2:0] | [1]   | control of the battery switch-over, battery low detection, and extra power fail detection functions | <a href="#">Section 8.5</a>                                      |
| 4      | BTSE        | 0     | [2] no timestamp when battery switch-over occurs                                                    | <a href="#">Section 8.11.4</a>                                   |
|        |             | 1     | time-stamped when battery switch-over occurs                                                        |                                                                  |
| 3      | BF          | 0     | [2] no battery switch-over interrupt generated                                                      | <a href="#">Section 8.5.1</a> and <a href="#">Section 8.11.4</a> |
|        |             | 1     | flag set when battery switch-over occurs; flag must be cleared to clear interrupt                   |                                                                  |
| 2      | BLF         | 0     | [2] battery status ok; no battery low interrupt generated                                           | <a href="#">Section 8.5.3</a>                                    |
|        |             | 1     | battery status low; flag cannot be cleared by command                                               |                                                                  |
| 1      | BIE         | 0     | [2] no interrupt generated from the battery flag (BF)                                               | <a href="#">Section 8.12.6</a>                                   |
|        |             | 1     | interrupt generated when BF is set                                                                  |                                                                  |
| 0      | BLIE        | 0     | [2] no interrupt generated from battery low flag (BLF)                                              | <a href="#">Section 8.12.7</a>                                   |
|        |             | 1     | interrupt generated when BLF is set                                                                 |                                                                  |

[1] Values see [Table 14](#).

[2] Default value.

## 8.3 Register CLKOUT\_ctl

**Table 9.** CLKOUT\_ctl - CLKOUT control register (address 0Fh) bit description

| Bit    | Symbol   | Value                        | Description                    |
|--------|----------|------------------------------|--------------------------------|
| 7 to 6 | TCR[1:0] | see <a href="#">Table 10</a> | temperature measurement period |
| 5 to 3 | -        | -                            | unused                         |
| 2 to 0 | COF[2:0] | see <a href="#">Table 11</a> | CLKOUT frequency selection     |

### 8.3.1 Temperature compensated crystal oscillator

The frequency of tuning fork quartz crystal oscillators is temperature-dependent. In the PCA2129T, 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  $f_{\text{CLKOUT}} = 32.768 \text{ kHz}$  (default value) leads to inaccurate measurements. Accurate frequency measurement occurs when  $f_{\text{CLKOUT}} = 16.384 \text{ kHz}$  or lower is selected (see [Table 11](#)).

#### 8.3.1.1 Temperature measurement

The PCA2129T 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 10.** 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 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.

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 will be 50 : 50.

Table 11. CLKOUT frequency selection

| COF[2:0]              | CLKOUT frequency (Hz) | Typical duty cycle <sup>[1]</sup> |
|-----------------------|-----------------------|-----------------------------------|
| 000 <sup>[2][3]</sup> | 32 768                | 60 : 40 to 40 : 60                |
| 001                   | 16 384                | 50 : 50                           |
| 010                   | 8 192                 | 50 : 50                           |
| 011                   | 4 096                 | 50 : 50                           |
| 100                   | 2 048                 | 50 : 50                           |
| 101                   | 1 024                 | 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.

## 8.4 Register Aging\_offset

**Table 12. Aging\_offset - crystal aging offset register (address 19h) bit description**

| Bit    | Symbol  | Value                        | Description        |
|--------|---------|------------------------------|--------------------|
| 7 to 4 | -       | -                            | unused             |
| 3 to 0 | AO[3:0] | see <a href="#">Table 13</a> | aging offset value |

### 8.4.1 Crystal aging correction

The PCA2129T 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.

**Table 13. 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   | <a href="#">[1]</a> 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.

2. For further information, refer to the application note [Ref. 3 "AN11120"](#).

## 8.5 Power management functions

The PCA2129T has two power supply pins and one power output pin:

- $V_{DD}$  - the main power supply input pin
- $V_{BAT}$  - the battery backup input pin
- BBS - battery backed output voltage pin (equal to the internal power supply)

The PCA2129T has two power management functions implemented:

- Battery switch-over function
- Battery low detection function

The power management functions are controlled by the control bits PWRMNG[2:0] in register Control\_3:

**Table 14. Power management control bit description**

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

[1] Default value.

[2] When the battery switch-over function is disabled, the PCA2129T works only with the power supply  $V_{DD}$ .  $V_{BAT}$  must be put to ground and the battery low detection function is disabled.

### 8.5.1 Battery switch-over function

The PCA2129T 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:  
 $V_{DD} < V_{BAT}$  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 8.12.6](#)).
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 8.11.4](#)).
4. The battery switch flag BF is cleared by command; it must be cleared to clear the interrupt.

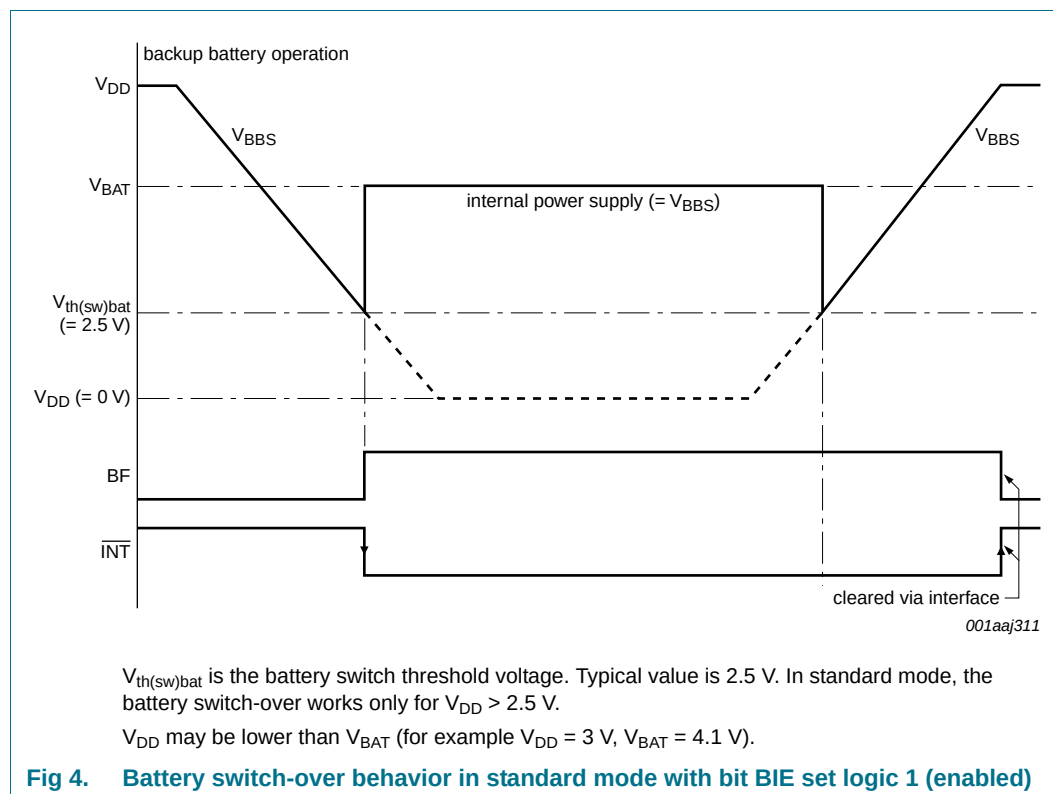
The interface is disabled in battery backup operation:

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

#### 8.5.1.1 Standard mode

If  $V_{DD} > V_{BAT}$  OR  $V_{DD} > V_{th(sw)bat}$ , the internal power supply is  $V_{DD}$ .

If  $V_{DD} < V_{BAT}$  AND  $V_{DD} < V_{th(sw)bat}$ , the internal power supply is  $V_{BAT}$ .



**Fig 4. Battery switch-over behavior in standard mode with bit BIE set logic 1 (enabled)**

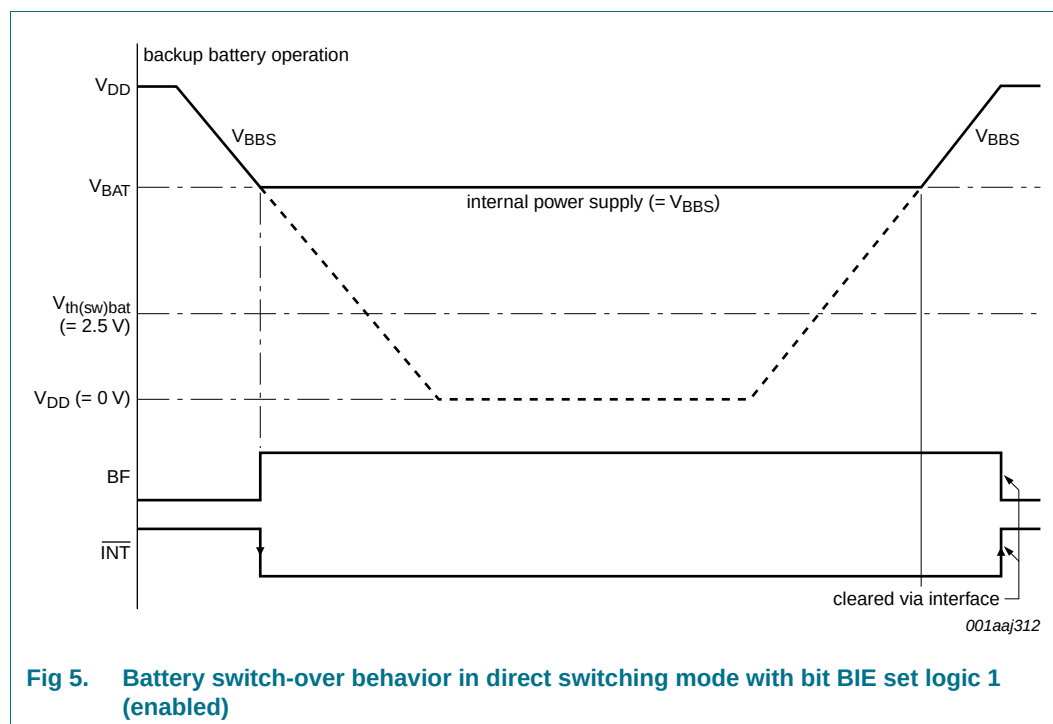
#### 8.5.1.2 Direct switching mode

If  $V_{DD} > V_{BAT}$  the internal power supply is  $V_{DD}$ .

If  $V_{DD} < V_{BAT}$  the internal power supply is  $V_{BAT}$ .



The direct switching mode is useful in systems where  $V_{DD}$  is higher than  $V_{BAT}$  at all times. 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.



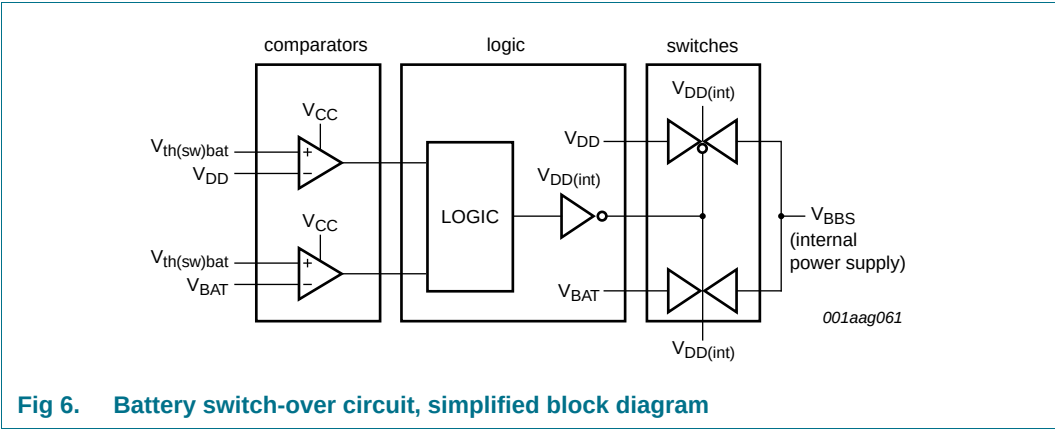
#### 8.5.1.3 Battery switch-over disabled: only one power supply ( $V_{DD}$ )

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
- The internal power supply, available at the output pin BBS, is equal to  $V_{DD}$
- The battery flag (BF) is always logic 0

#### 8.5.1.4 Battery switch-over architecture

The architecture of the battery switch-over circuit is shown in [Figure 6](#).



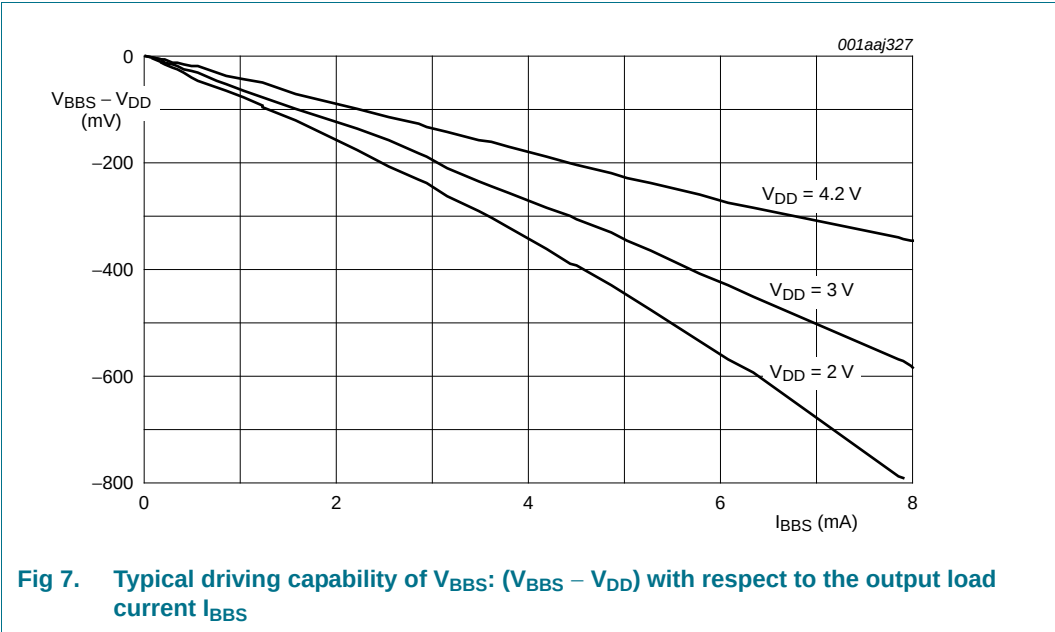
The internal power supply (available on pin BBS) is equal to  $V_{DD}$  or  $V_{BAT}$ . It has to be assured that there are decoupling capacitors on the pins  $V_{DD}$ ,  $V_{BAT}$ , and BBS.

8.5.2 Battery backup supply

The  $V_{BBS}$  voltage on the output pin BBS is equal to the internal power supply, depending on the selected battery switch-over function mode:

Table 15. Output pin BBS

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



The output pin BBS can be used as a supply for external devices with battery backup needs, such as SRAM (see [Ref. 3 "AN11120"](#)). For this case, [Figure 7](#) shows the typical driving capability when  $V_{BBS}$  is driven from  $V_{DD}$ .

### 8.5.3 Battery low detection function

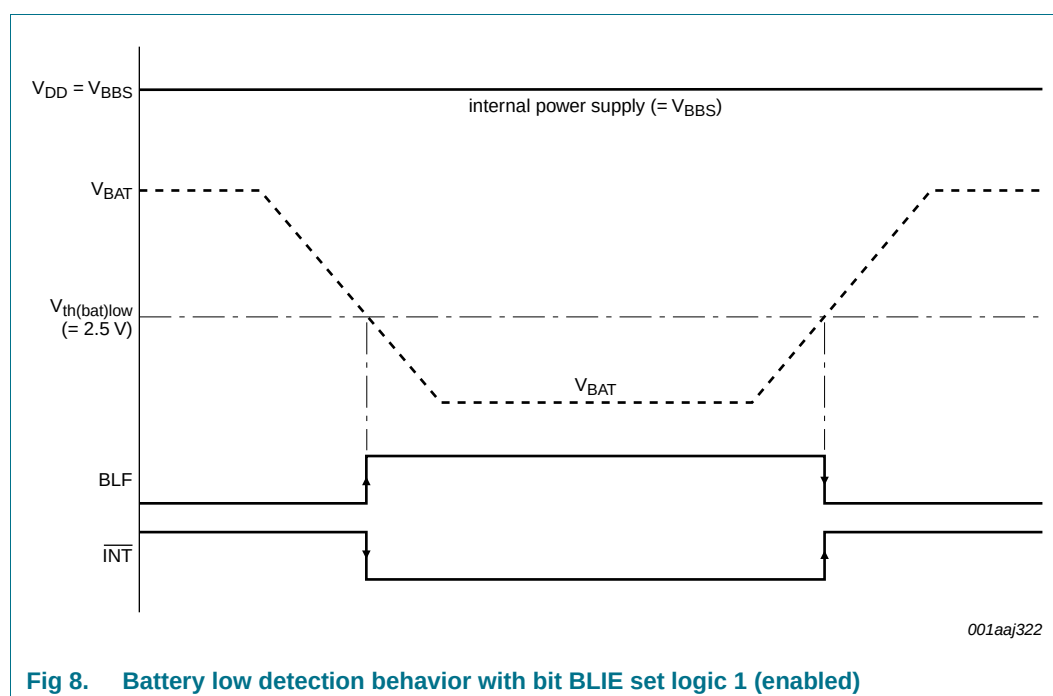
The PCA2129T has a battery low detection circuit which monitors the status of the battery  $V_{BAT}$ .

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.

When  $V_{BAT}$  drops below the threshold value  $V_{th(bat)low}$ , the following sequence occurs (see [Figure 8](#)):

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 8.12.7](#)).
3. The flag BLF remains logic 1 until the battery is replaced. BLF cannot be cleared by command. It is cleared automatically by the battery low detection circuit when the battery is replaced.

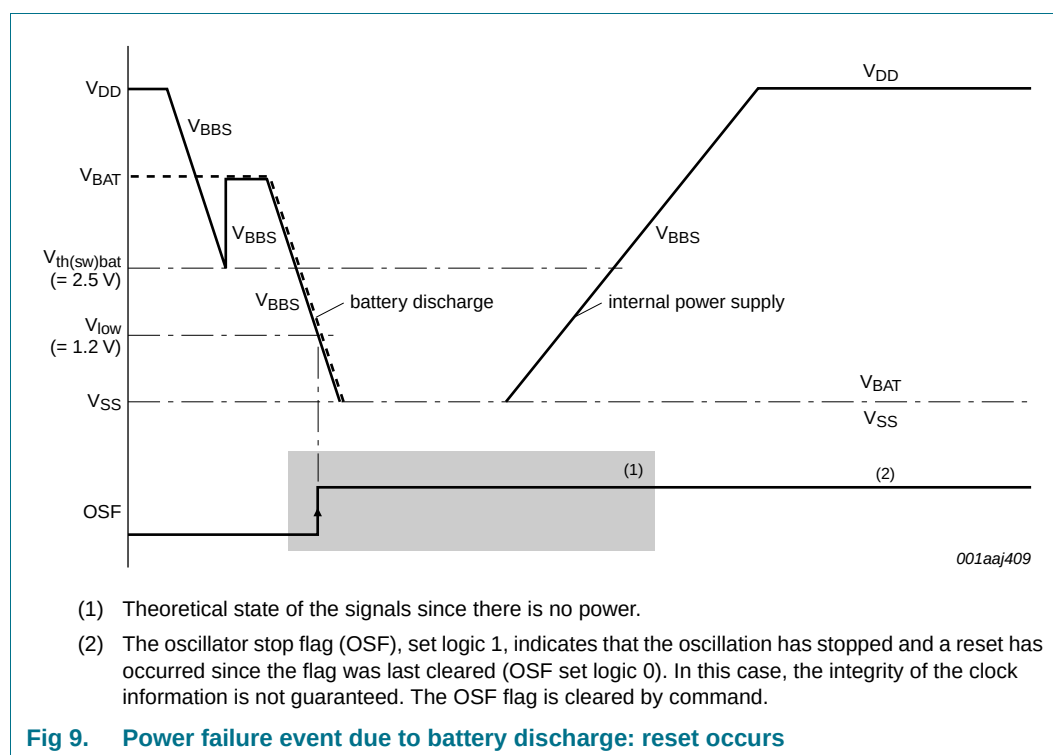


**Fig 8. Battery low detection behavior with bit BLIE set logic 1 (enabled)**

## 8.6 Oscillator stop detection function

The PCA2129T 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 ( $V_{BBS}$ , see [Section 8.5.2](#)) 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.



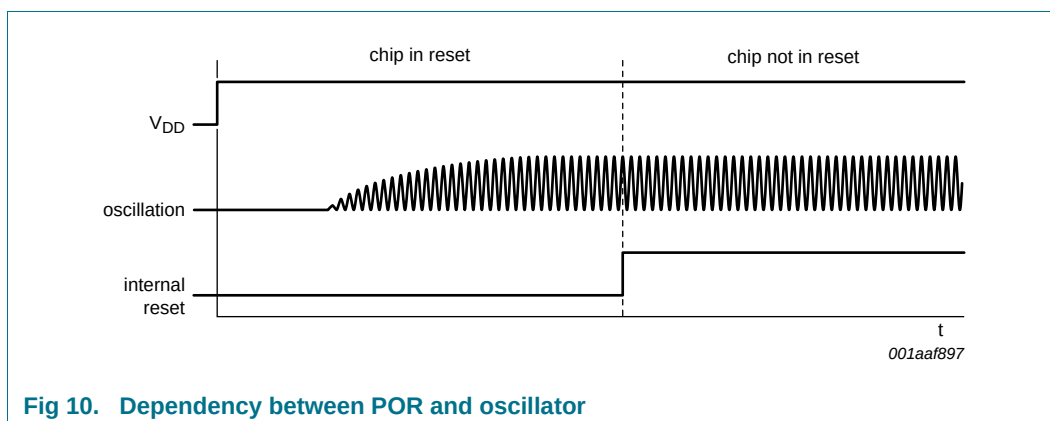
**Fig 9. Power failure event due to battery discharge: reset occurs**

## 8.7 Reset function

The PCA2129T has a Power-On Reset (POR) and a Power-On Reset Override (PORO) function implemented.

### 8.7.1 Power-On Reset (POR)

The POR is active whenever the oscillator is stopped. The oscillator is also considered to be stopped during the time between power-on and stable crystal resonance (see [Figure 10](#)). 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).



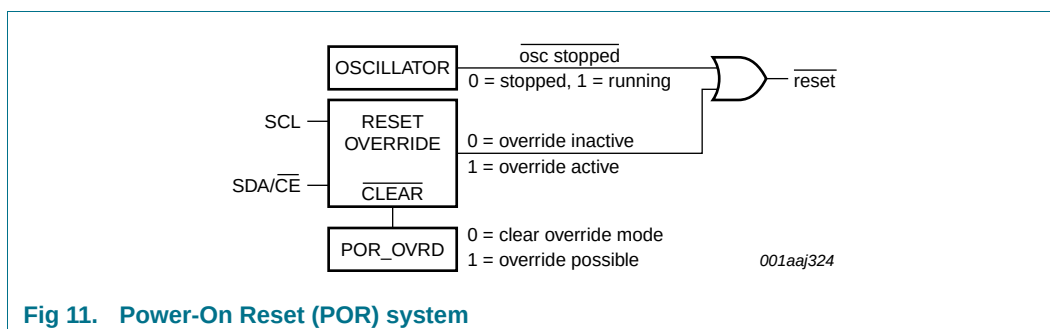
After POR, the following mode is entered:

- 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

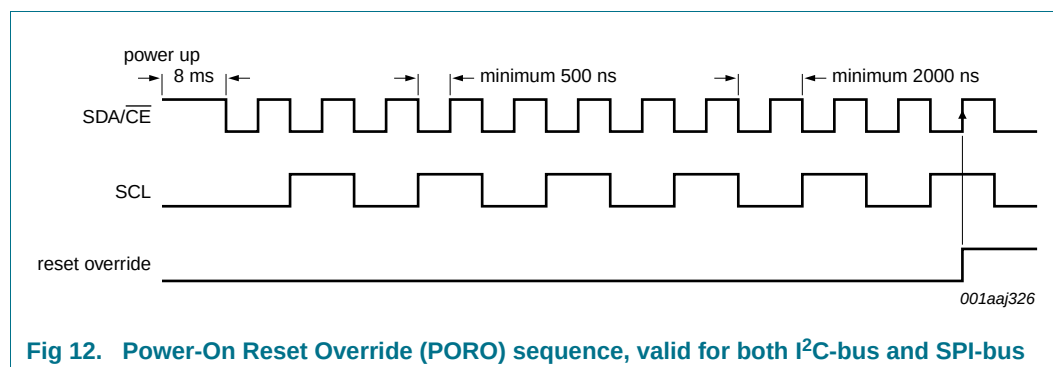
The register values after power-on are shown in [Table 5](#).

### 8.7.2 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.



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/CE` and `SCL` are toggled as illustrated in [Figure 12](#). All timings shown are required minimum.



**Fig 12. 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.

## 8.8 Time and date function

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

### 8.8.1 Register Seconds

**Table 16. Seconds - seconds and clock integrity register (address 03h) bit description**

| Bit    | Symbol  | Value            | Place value | Description                                                                                                             |
|--------|---------|------------------|-------------|-------------------------------------------------------------------------------------------------------------------------|
| 7      | OSF     | 0                | -           | clock integrity is guaranteed                                                                                           |
|        |         | 1 <sup>[1]</sup> | -           | clock integrity is not guaranteed:<br>oscillator has stopped and chip reset<br>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  |                                                                                                                         |

[1] Start-up value.

**Table 17. 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     |

### 8.8.2 Register Minutes

**Table 18. Minutes - minutes register (address 04h) bit description**

| 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  |                                    |

### 8.8.3 Register Hours

**Table 19. Hours - hours register (address 05h) bit description**

| Bit                         | Symbol | Value  | Place value | Description                                           |
|-----------------------------|--------|--------|-------------|-------------------------------------------------------|
| 7 to 6                      | -      | -      | -           | unused                                                |
| 12 hour mode <sup>[1]</sup> |        |        |             |                                                       |
| 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  |                                                       |
| 24 hour mode <sup>[1]</sup> |        |        |             |                                                       |
| 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.

### 8.8.4 Register Days

**Table 20. 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.

### 8.8.5 Register Weekdays

**Table 21. Weekdays - weekdays register (address 07h) bit description**

| Bit    | Symbol   | Value  | Description                                        |
|--------|----------|--------|----------------------------------------------------|
| 7 to 3 | -        | -      | unused                                             |
| 2 to 0 | WEEKDAYS | 0 to 6 | actual weekday value, see <a href="#">Table 22</a> |

Although the association of the weekdays counter to the actual weekday is arbitrary, the PCA2129T will assume that Sunday is 000 and Monday is 001 for the purposes of determining the increment for calendar weeks.

**Table 22. 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.



### 8.8.6 Register Months

**Table 23. Months - months register (address 08h) bit description**

| 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 24</a> |
| 3 to 0 |        | 0 to 9 | unit place  |                                                                |

**Table 24. Month assignments in BCD format**

| Month     | Upper-digit<br>(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     |

### 8.8.7 Register Years

**Table 25. Years - years register (address 09h) bit description**

| 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  |                                 |

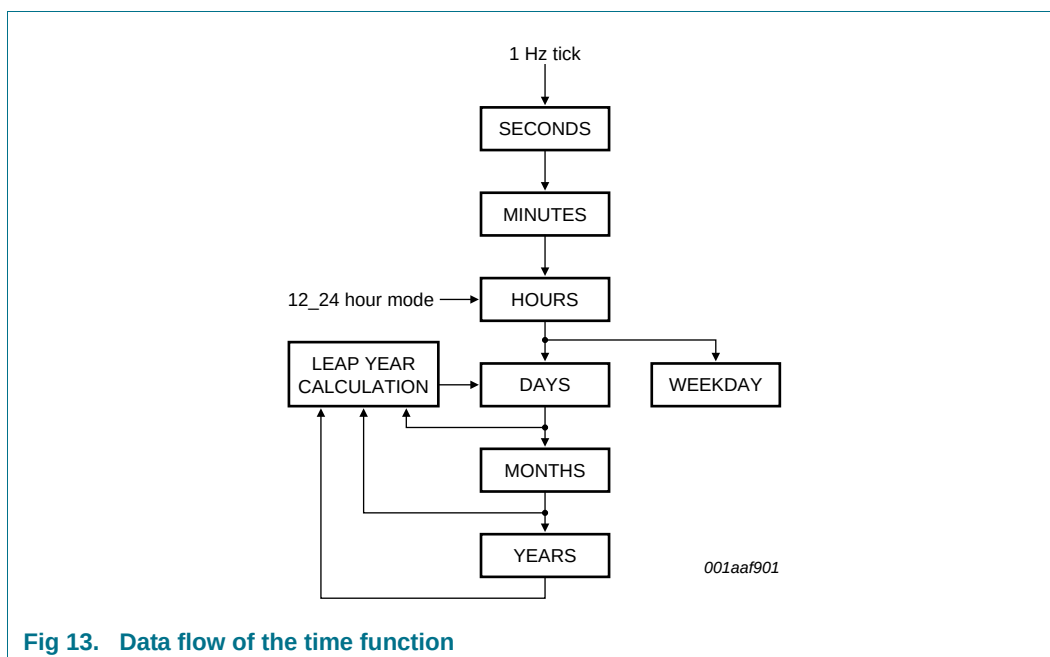
### 8.8.8 Setting and reading the time

[Figure 13](#) 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.

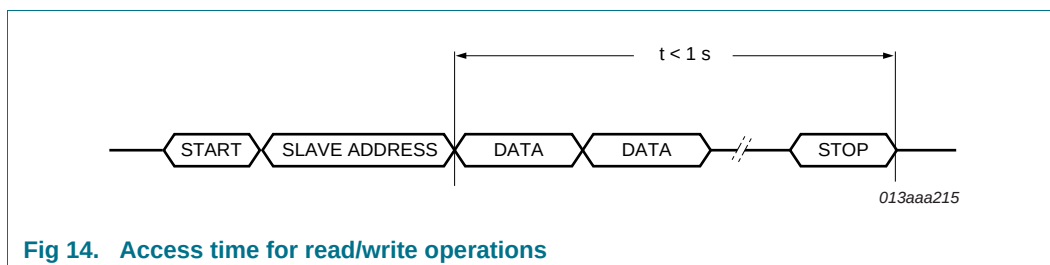
This prevents

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



**Fig 13. 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 14](#)).



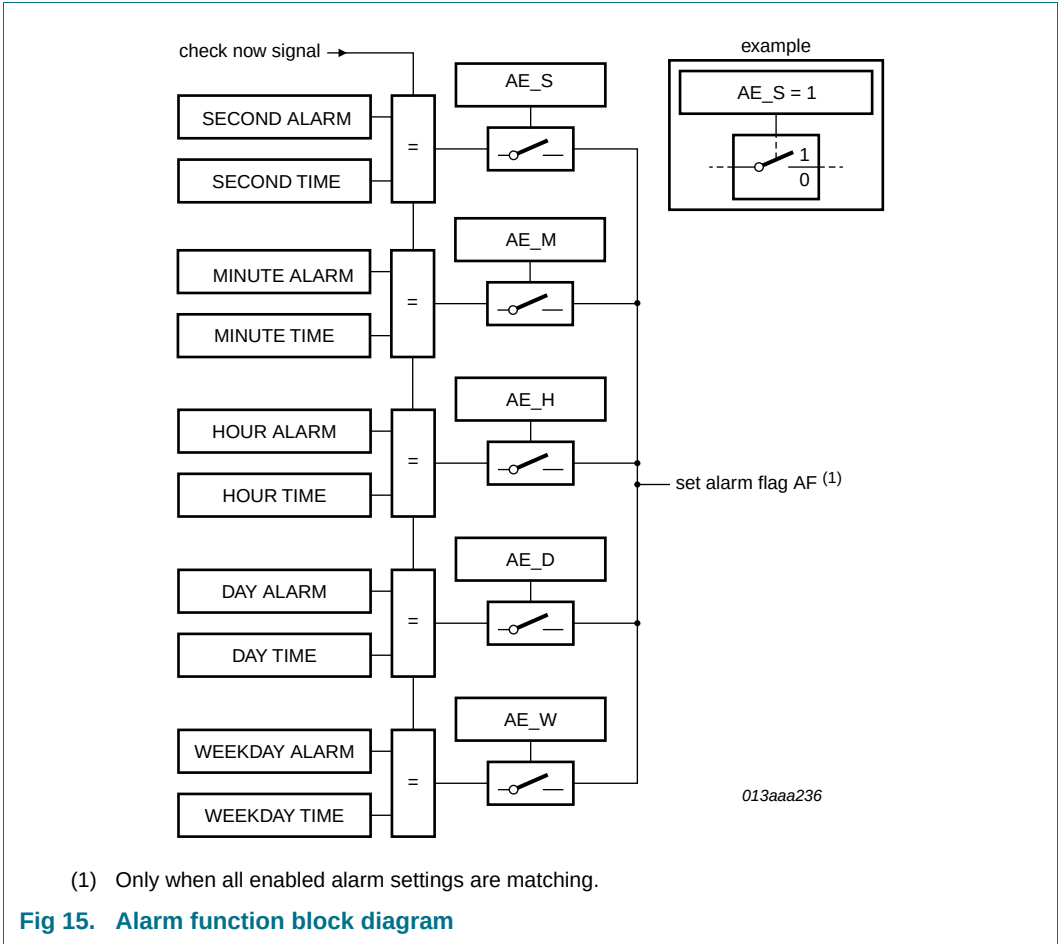
**Fig 14. Access time for read/write operations**

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.

8.9 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 15](#)).



The generation of interrupts from the alarm function is described in [Section 8.12.4](#).

8.9.1 Register Second\_alarm

Table 26. Second\_alarm - second alarm register (address 0Ah) bit description

| Bit    | Symbol       | Value  | Place value | Description                                  |
|--------|--------------|--------|-------------|----------------------------------------------|
| 7      | AE_S         | 0      | -           | second alarm is enabled                      |
|        |              | 1[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  |                                              |

[1] Default value.

### 8.9.2 Register Minute\_alarm

**Table 27. Minute\_alarm - minute alarm register (address 0Bh) bit description**

| Bit    | Symbol       | Value            | Place value | Description                                  |
|--------|--------------|------------------|-------------|----------------------------------------------|
| 7      | AE_M         | 0                | -           | minute alarm is enabled                      |
|        |              | 1 <sup>[1]</sup> | -           | 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  |                                              |

[1] Default value.

### 8.9.3 Register Hour\_alarm

**Table 28. Hour\_alarm - hour alarm register (address 0Ch) bit description**

| Bit                         | Symbol     | Value            | Place value | Description                                                     |
|-----------------------------|------------|------------------|-------------|-----------------------------------------------------------------|
| 7                           | AE_H       | 0                | -           | hour alarm is enabled                                           |
|                             |            | 1 <sup>[1]</sup> | -           | hour alarm is disabled                                          |
| 6                           | -          | -                | -           | unused                                                          |
| 12 hour mode <sup>[2]</sup> |            |                  |             |                                                                 |
| 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  |                                                                 |
| 24 hour mode <sup>[2]</sup> |            |                  |             |                                                                 |
| 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] Default value.

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

### 8.9.4 Register Day\_alarm

**Table 29. Day\_alarm - day alarm register (address 0Dh) bit description**

| Bit    | Symbol    | Value            | Place value | Description                               |
|--------|-----------|------------------|-------------|-------------------------------------------|
| 7      | AE_D      | 0                | -           | day alarm is enabled                      |
|        |           | 1 <sup>[1]</sup> | -           | 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  |                                           |

[1] Default value.

8.9.5 Register Weekday\_alarm

Table 30. Weekday\_alarm - weekday alarm register (address 0Eh) bit description

| Bit    | Symbol        | Value            | Description               |
|--------|---------------|------------------|---------------------------|
| 7      | AE_W          | 0                | weekday alarm is enabled  |
|        |               | 1 <sup>[1]</sup> | weekday alarm is disabled |
| 6 to 3 | -             | -                | unused                    |
| 2 to 0 | WEEKDAY_ALARM | 0 to 6           | weekday alarm information |

[1] Default value.

8.9.6 Alarm flag

When all enabled comparisons first match, the alarm flag AF (register Control\_2) is set. AF will remain 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 8.10.5](#)

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

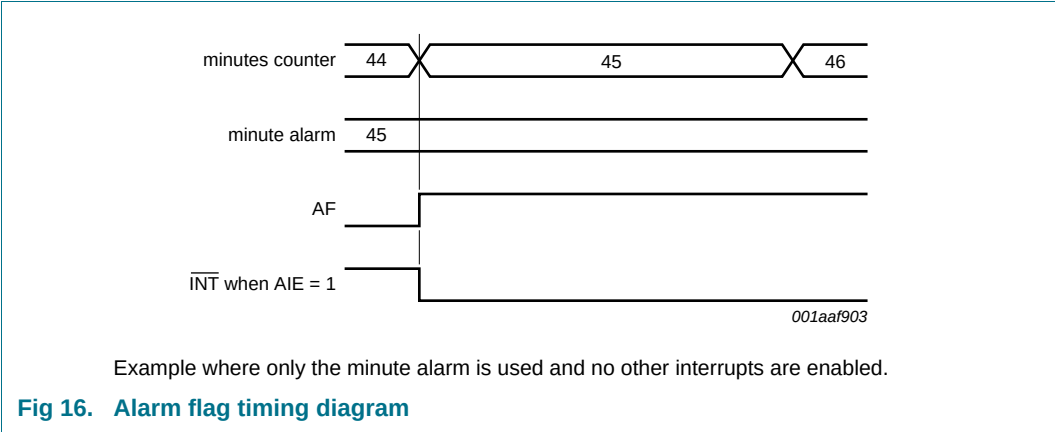


Fig 16. Alarm flag timing diagram

## 8.10 Timer functions

The PCA2129T has a watchdog timer function. The timer can be switched on and off by using the control bit WD\_CD in the register Watchdg\_tim\_ctl.

The watchdog timer has four selectable source clocks. It can, for example, be used to detect a microprocessor with interrupt and reset capability which is out of control (see [Section 8.10.3](#))

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

### 8.10.1 Register Watchdg\_tim\_ctl

**Table 31. Watchdg\_tim\_ctl - watchdog timer control register (address 10h) bit description**

| Bit    | Symbol  | Value             | Description                                                                                                                               |
|--------|---------|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| 7      | WD_CD   | 0 <sup>[1]</sup>  | watchdog timer disabled                                                                                                                   |
|        |         | 1                 | watchdog timer enabled;<br>the interrupt pin $\overline{\text{INT}}$ is activated when timed out                                          |
| 6      | T       | 0 <sup>[2]</sup>  | unused                                                                                                                                    |
| 5      | TI_TP   | 0 <sup>[1]</sup>  | the interrupt pin $\overline{\text{INT}}$ is configured to generate a permanent active signal when MSF (register Control_2) is set        |
|        |         | 1                 | the interrupt pin $\overline{\text{INT}}$ is configured to generate a pulsed signal when MSF flag is set (see <a href="#">Figure 19</a> ) |
| 4 to 2 | -       | -                 | unused                                                                                                                                    |
| 1 to 0 | TF[1:0] | -                 | timer source clock for watchdog timer                                                                                                     |
|        |         | 00                | 4.096 kHz                                                                                                                                 |
|        |         | 01                | 64 Hz                                                                                                                                     |
|        |         | 10                | 1 Hz                                                                                                                                      |
|        |         | 11 <sup>[1]</sup> | $\frac{1}{60}$ Hz                                                                                                                         |

[1] Default value.

[2] When writing to the register this bit always has to be set logic 0.

### 8.10.2 Register Watchdg\_tim\_val

**Table 32. Watchdg\_tim\_val - watchdog timer value register (address 11h) bit description**

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

Table 33. 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      | $\frac{1}{60}$               | Hz    | 60                           | s     | 15300                          | s     |

### 8.10.3 Watchdog timer function

The watchdog timer function is enabled or disabled by the WD\_CD bit of the register Watchdog\_tim\_ctl (see [Table 31](#)).

The two bits TF[1:0] in register Watchdog\_tim\_ctl determine one of the four source clock frequencies for the watchdog timer: 4.096 kHz, 64 Hz, 1 Hz, or  $\frac{1}{60}$  Hz (see [Table 33](#)).

When the watchdog timer function is enabled, the 8-bit timer in register Watchdog\_tim\_val determines the watchdog timer period (see [Table 33](#)).

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

The counter does not automatically reload.

When WD\_CD is logic 0 (watchdog timer disabled) and the microcontroller unit (MCU) loads a watchdog timer value n, then:

- the flag WDTF is reset
- $\overline{\text{INT}}$  is cleared
- the watchdog timer starts again

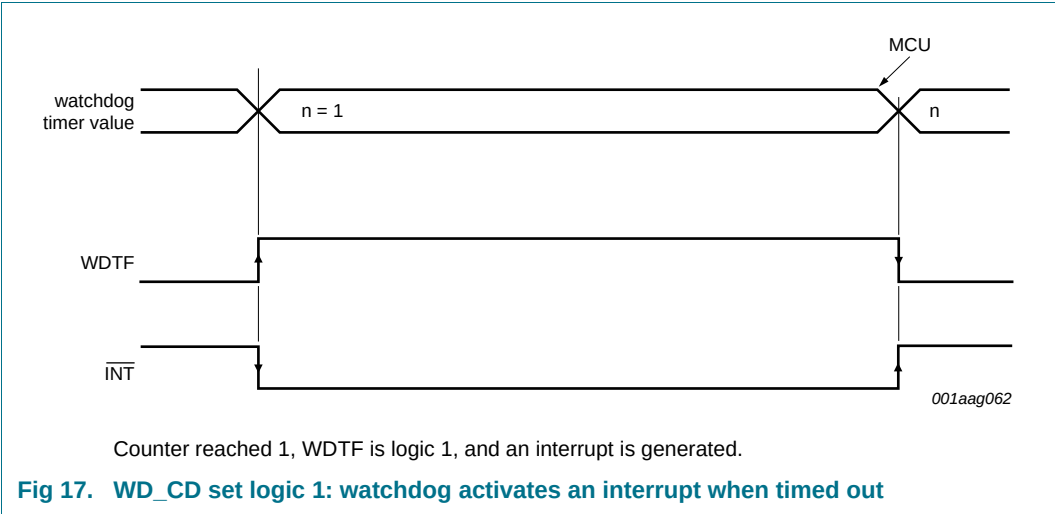
Loading the counter with 0 will:

- reset the flag WDTF
- clear  $\overline{\text{INT}}$
- 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 Watchdog\_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 (register Control\_2) is set logic 1
- When a minute or second interrupt occurs, the minute/second flag MSF (register Control\_2) is set logic 1 (see [Section 8.12.1](#)).

8.10.4 Pre-defined timers: second and minute interrupt

PCA2129T has two pre-defined timers which are used to generate an interrupt either once per second or once per minute. The pulse generator for the minute or second interrupt operates from an internal 64 Hz clock. It is independent of the watchdog timer. Each of these timers can be enabled by the bits SI (second interrupt) and MI (minute interrupt) in register Control\_1.

8.10.5 Clearing flags

The flags MSF, 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 will result in the flag value remaining unchanged.

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

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

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

Table 34. Flag location in register Control\_2

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



**Table 35. Example values in register Control\_2**

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

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

**Table 36. Example to clear only AF (bit 4)**

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

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

**Table 37. Example to clear only MSF (bit 7)**

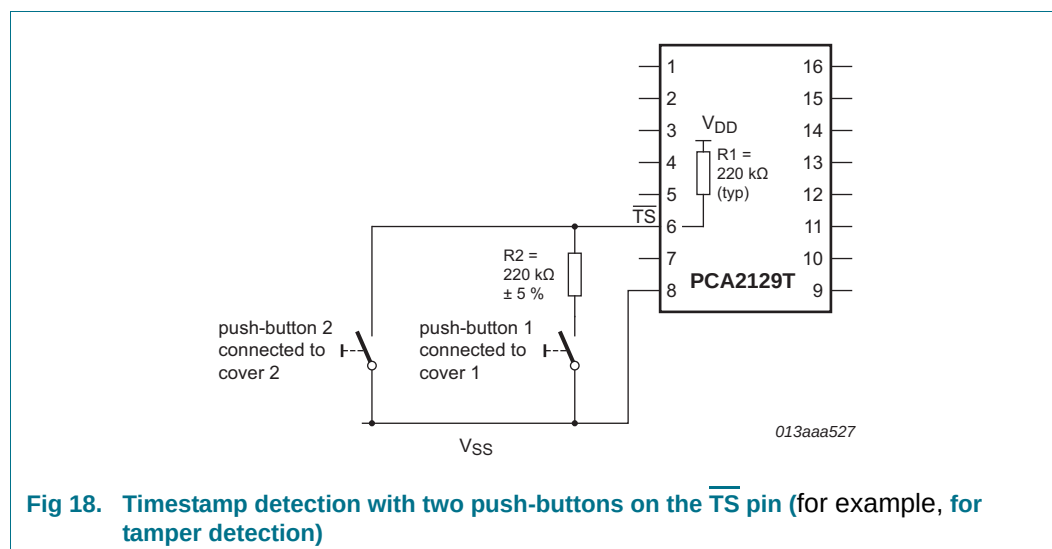
| Register  | Bit |   |   |   |   |                  |                  |   |
|-----------|-----|---|---|---|---|------------------|------------------|---|
|           | 7   | 6 | 5 | 4 | 3 | 2                | 1                | 0 |
| Control_2 | 0   | 0 | 1 | 1 | 0 | 0 <sup>[1]</sup> | 0 <sup>[1]</sup>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

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

## 8.11 Timestamp function

The PCA2129T has an active LOW timestamp input pin  $\overline{TS}$ , internally pulled with an on-chip pull-up resistor to the internal power supply of the device. 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.



**Fig 18. Timestamp detection with two push-buttons on the  $\overline{TS}$  pin (for example, for tamper detection)**

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

A most common application of the timestamp function is described in [Ref. 3 "AN11120"](#).

See [Section 8.12.5](#) for a description of interrupt generation from the timestamp function.

### 8.11.1 Timestamp flag

1. When the  $\overline{TS}$  input pin is driven to an intermediate level between the power supply and 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 will clear the interrupt. Once TSF1 is cleared, it will only be set again when a new negative 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  $\overline{INT}$  pin is generated.

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

### 8.11.2 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 8.11.4](#).

### 8.11.3 Timestamp registers

#### 8.11.3.1 Register Timestp\_ctl

**Table 38. Timestp\_ctl - timestamp control register (address 12h) bit description**

| Bit    | Symbol              | Value            | Description                                                                          |
|--------|---------------------|------------------|--------------------------------------------------------------------------------------|
| 7      | TSM                 | 0 <sup>[1]</sup> | 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 <sup>[1]</sup> | 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                      |

[1] Default value.

#### 8.11.3.2 Register Sec\_timestp

**Table 39. Sec\_timestp - second timestamp register (address 13h) bit description**

| 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  |                                                  |

#### 8.11.3.3 Register Min\_timestp

**Table 40. Min\_timestp - minute timestamp register (address 14h) bit description**

| 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  |                                                  |

## 8.11.3.4 Register Hour\_timestp

Table 41. Hour\_timestp - hour timestamp register (address 15h) bit description

| Bit                         | Symbol       | Value  | Place value | Description                                                         |
|-----------------------------|--------------|--------|-------------|---------------------------------------------------------------------|
| 7 to 6                      | -            | -      | -           | unused                                                              |
| 12 hour mode <sup>[1]</sup> |              |        |             |                                                                     |
| 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  |                                                                     |
| 24 hour mode <sup>[1]</sup> |              |        |             |                                                                     |
| 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.

## 8.11.3.5 Register Day\_timestp

Table 42. Day\_timestp - day timestamp register (address 16h) bit description

| 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  |                                               |

## 8.11.3.6 Register Mon\_timestp

Table 43. Mon\_timestp - month timestamp register (address 17h) bit description

| 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  |                                                 |

## 8.11.3.7 Register Year\_timestp

Table 44. Year\_timestp - year timestamp register (address 18h) bit description

| 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  |                                                |

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

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

**Table 45. Battery switch-over and timestamp**

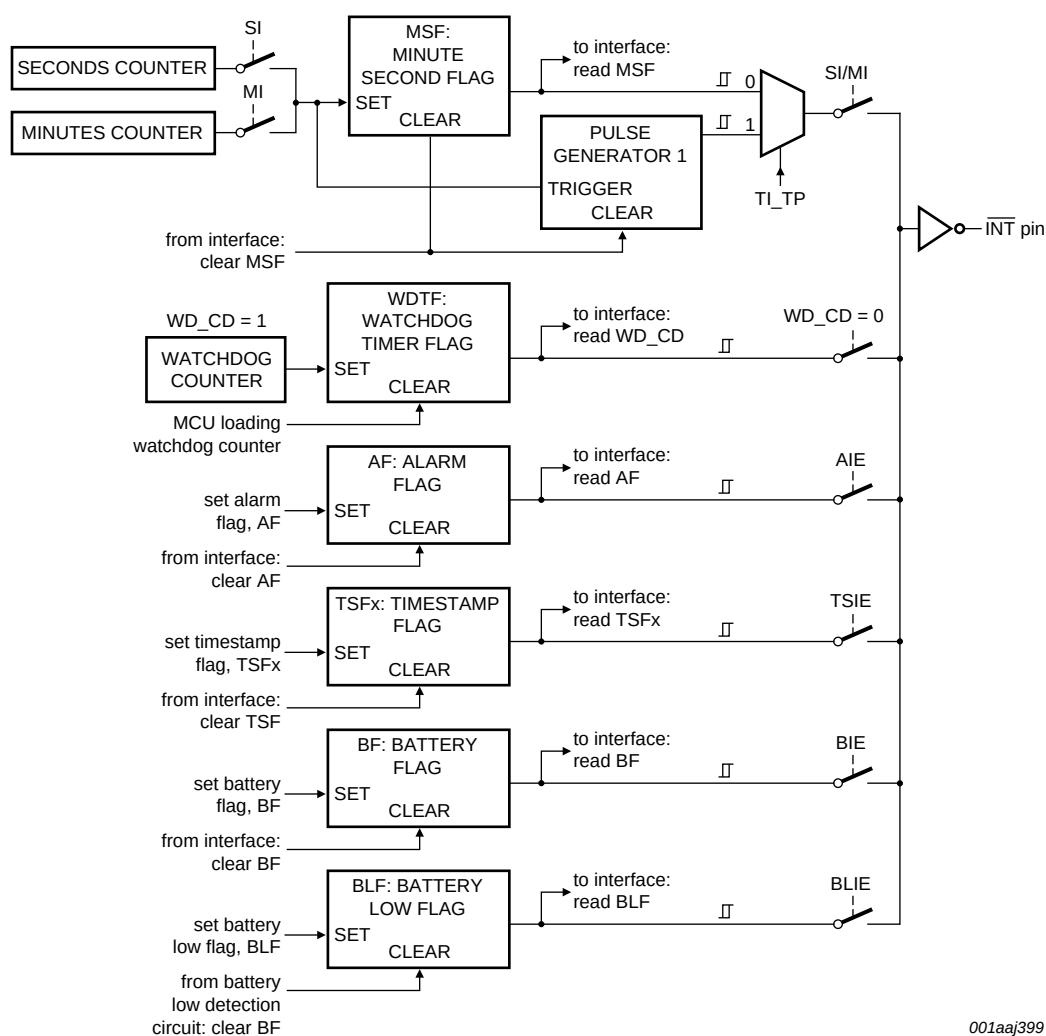
| BTSE | BF | Description                                                                                                                                     |
|------|----|-------------------------------------------------------------------------------------------------------------------------------------------------|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

[1] Default value.

## 8.12 Interrupt output, $\overline{\text{INT}}$

PCA2129T 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
- watchdog timer
- alarm
- timestamp
- battery switch-over
- battery low detection



When SI, MI, WD\_CD, AIE, TSIE, BIE, BLIE are all disabled,  $\overline{\text{INT}}$  will remain high-impedance (output HIGH).

Fig 19. Interrupt block diagram

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) 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, INT remains high-impedance.

- The flags MSF, AF, TSF<sub>x</sub>, and BF can be cleared by command.
- The flag WDTF is read only. How it can be cleared is explained in [Section 8.10.5](#).
- The flag BLF is read only. It is cleared automatically from the battery low detection circuit when the battery is replaced.

### 8.12.1 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 will not be distinguishable since it will occur at the same time.

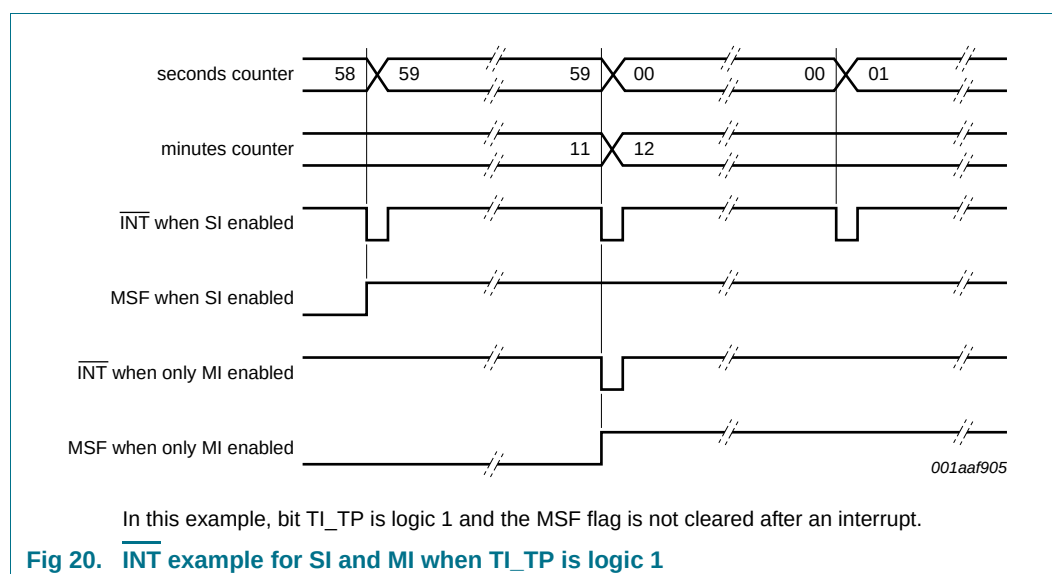
The minute/second flag MSF (register Control\_2) is set logic 1 when either the seconds or the minutes counter increments according to the enabled interrupt (see [Table 46](#)). The MSF flag can be cleared by command.

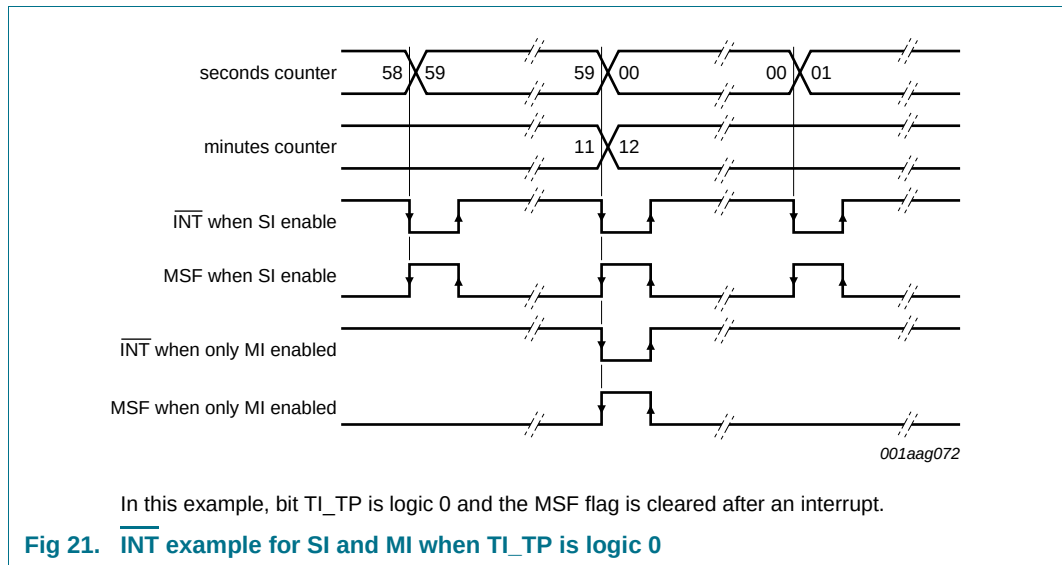
**Table 46. Effect of bits MI and SI on pin  $\overline{\text{INT}}$  and bit MSF**

| MI | SI | Result on 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.

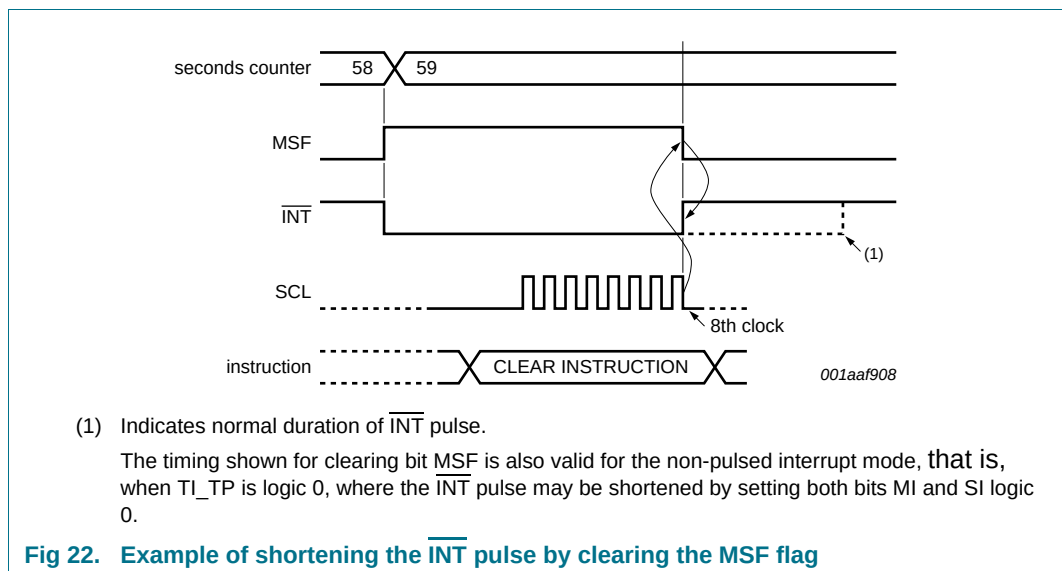




The pulse generator for the minute/second interrupt operates from an internal 64 Hz clock and generates a pulse of  $\frac{1}{64}$  seconds in duration.

### 8.12.2 $\overline{\text{INT}}$ pulse shortening

If the MSF 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 22](#). Instructions for clearing the bit MSF can be found in [Section 8.10.5](#).



### 8.12.3 Watchdog timer interrupts

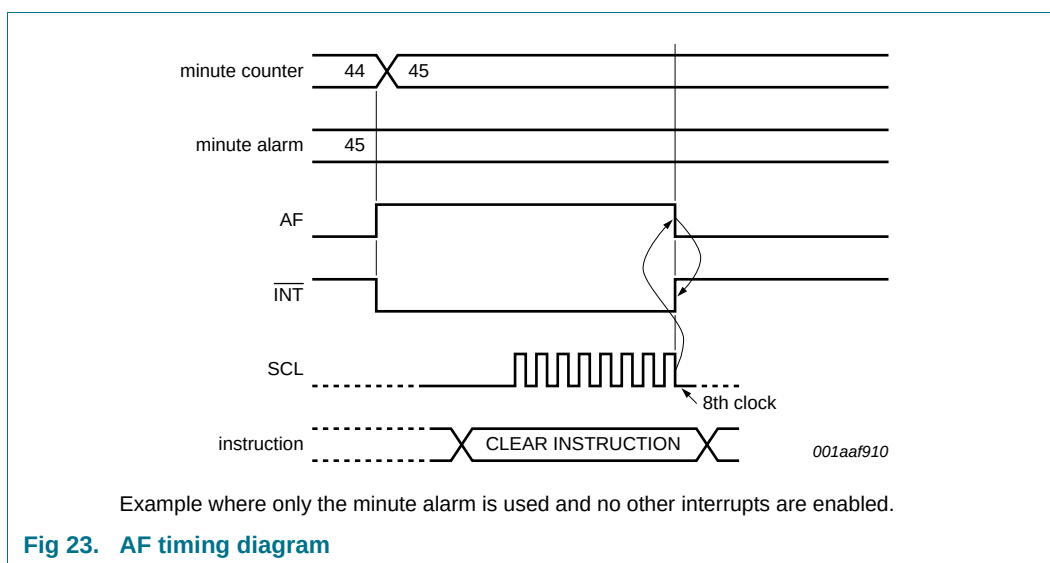
The generation of interrupts from the watchdog timer is controlled using the WD\_CD bit (register Watchdog\_tim\_ctl). The interrupt is generated as an active signal which follows the status of the watchdog timer flag WDTF (register Control\_2). No pulse generation is possible for watchdog timer interrupts.



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 8.10.5](#).

#### 8.12.4 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 will follow the status of bit AF (register Control\_2). Clearing AF will immediately clear  $\overline{\text{INT}}$ . No pulse generation is possible for alarm interrupts.



#### 8.12.5 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 TSF<sub>x</sub>. Clearing the flags TSF<sub>x</sub> immediately clears  $\overline{\text{INT}}$ . No pulse generation is possible for timestamp interrupts.

#### 8.12.6 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 45](#)). Clearing BF immediately clears  $\overline{\text{INT}}$ . No pulse generation is possible for battery switch-over interrupts.

#### 8.12.7 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 will follow 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.

### 8.13 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 47](#)). 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 will 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.

8.14 STOP bit function

The function of the STOP bit is to allow for accurate starting of the time circuits. STOP will cause 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 will not affect the CLKOUT signal but the output of the prescaler in the range of 32 Hz to 1 Hz (see [Figure 24](#)).

The lower stages of the prescaler,  $F_0$  to  $F_8$ , 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 47](#) and [Figure 25](#).

Table 47. First increment of time circuits after stop release

| Bit STOP                                                                                              | Prescaler bits <sup>[1]</sup><br>$F_0$ to $F_8$ - $F_9$ to $F_{14}$ | 1 Hz tick | Time<br>hh:mm:ss | Comment                                                    |
|-------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|-----------|------------------|------------------------------------------------------------|
| Clock is running normally                                                                             |                                                                     |           |                  |                                                            |
| 0                                                                                                     | 010000111-010100                                                    |           | 12:45:12         | prescaler counting normally                                |
| STOP bit is activated by user. $F_0$ to $F_8$ are not reset and values cannot be predicted externally |                                                                     |           |                  |                                                            |
| 1                                                                                                     | xxxxxxxx-000000                                                     |           | 12:45:12         | prescaler is reset; time circuits are frozen               |
| New time is set by user                                                                               |                                                                     |           |                  |                                                            |
| 1                                                                                                     | xxxxxxxx-000000                                                     |           | 08:00:00         | prescaler is reset; time circuits are frozen               |
| STOP bit is released by user                                                                          |                                                                     |           |                  |                                                            |
| 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 $F_{14}$ 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 $F_{14}$ increments the time circuits |

[1]  $F_0$  is clocked at 32.768 kHz.

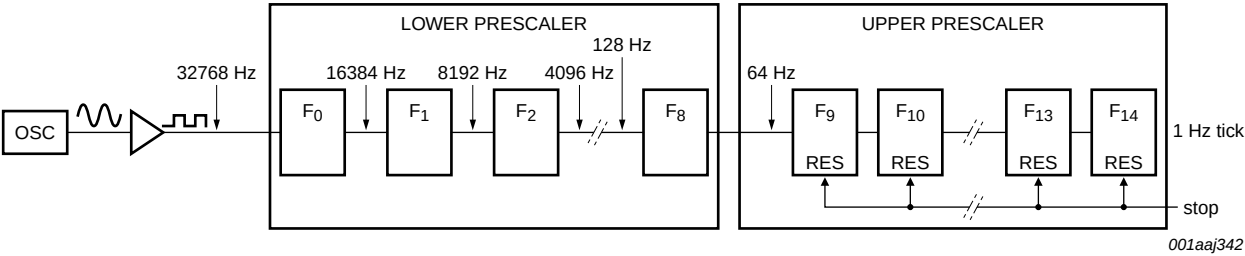


Fig 24. STOP bit functional diagram

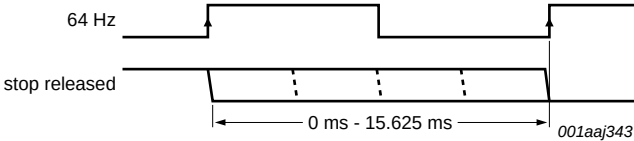


Fig 25. STOP bit release timing

9. Interfaces

The PCA2129T 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 48](#)).

Table 48. 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> |

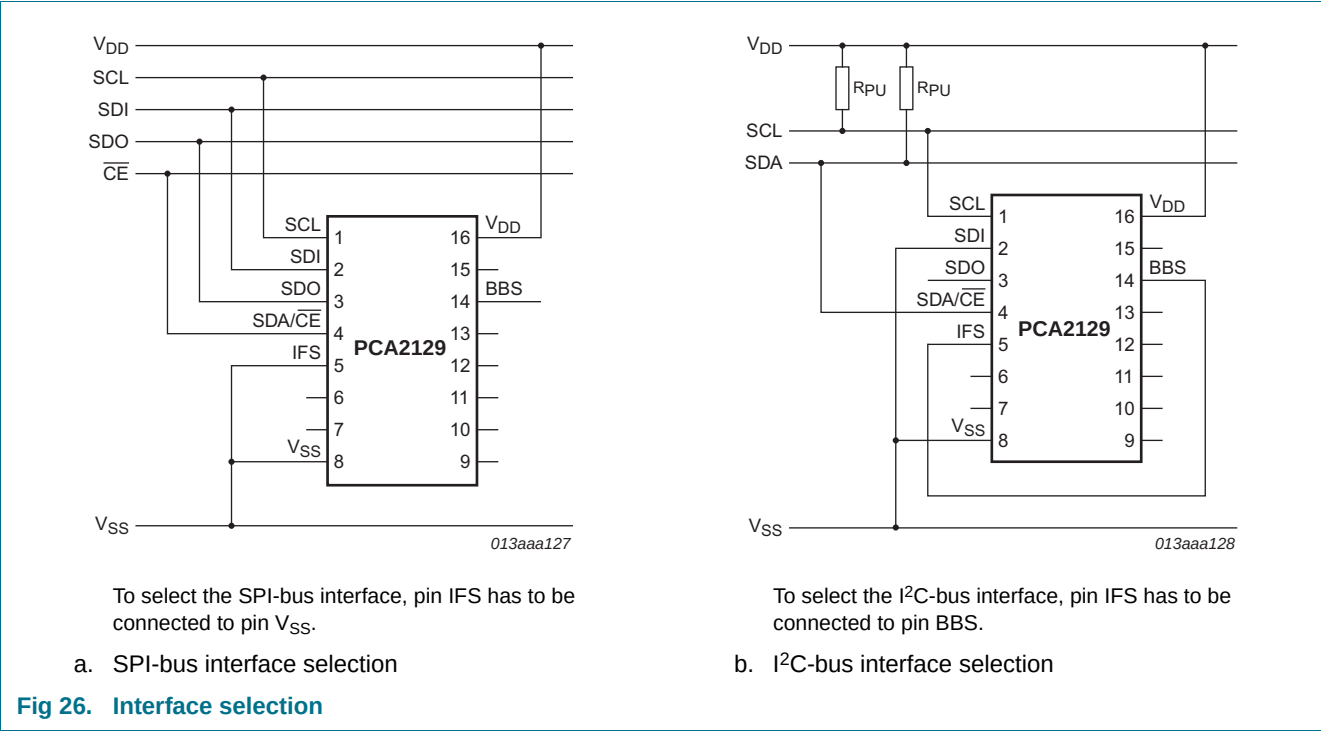


Fig 26. Interface selection

9.1 SPI-bus interface

Data transfer to and from the device is made by a 3 line SPI-bus (see Table 49). 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 27). The SPI-bus is initialized whenever the chip enable line pin SDA/CE is inactive.

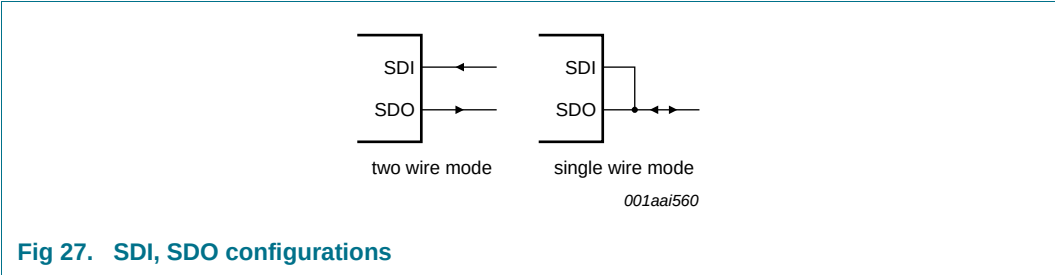


Table 49. Serial interface

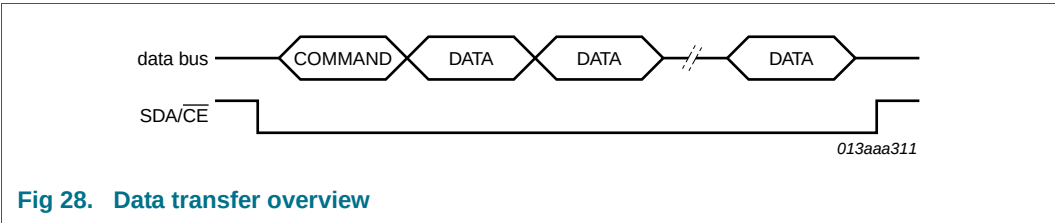
| Symbol | Function                      | Description                                                                                                                      |
|--------|-------------------------------|----------------------------------------------------------------------------------------------------------------------------------|
| SDA/CE | chip enable input; active LOW | [1] when HIGH, the interface is reset; input may be higher than V <sub>DD</sub>                                                  |
| SCL    | serial clock input            | when SDA/CE is HIGH, input may float; input may be higher than V <sub>DD</sub>                                                   |
| SDI    | serial data input             | when SDA/CE is HIGH, input may float; input may be higher than V <sub>DD</sub> ; input data is sampled on the rising edge of SCL |
| SDO    | serial data output            | push-pull output; drives from V <sub>SS</sub> to V <sub>BBS</sub> ; 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.

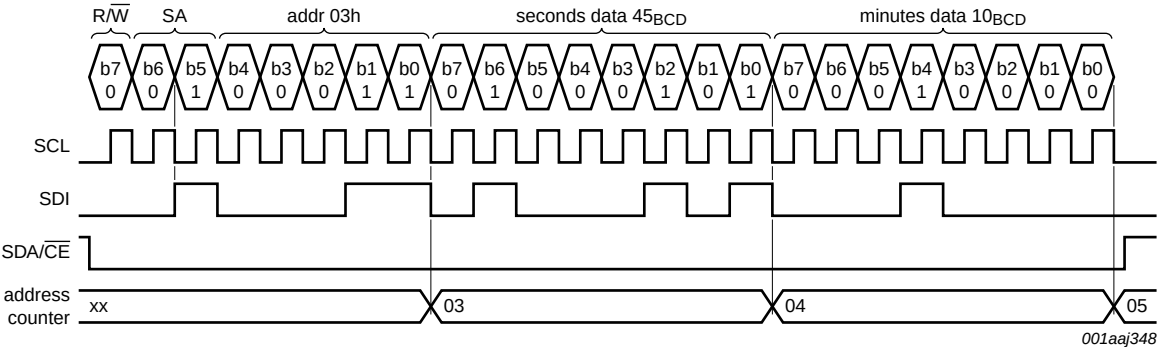
The transmission is controlled by the active LOW chip enable signal SDA/CE. The first byte transmitted is the command byte. Subsequent bytes will be either data to be written or data to be read (see Figure 28).



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 R/W bit defines if the following bytes will be read or write information.

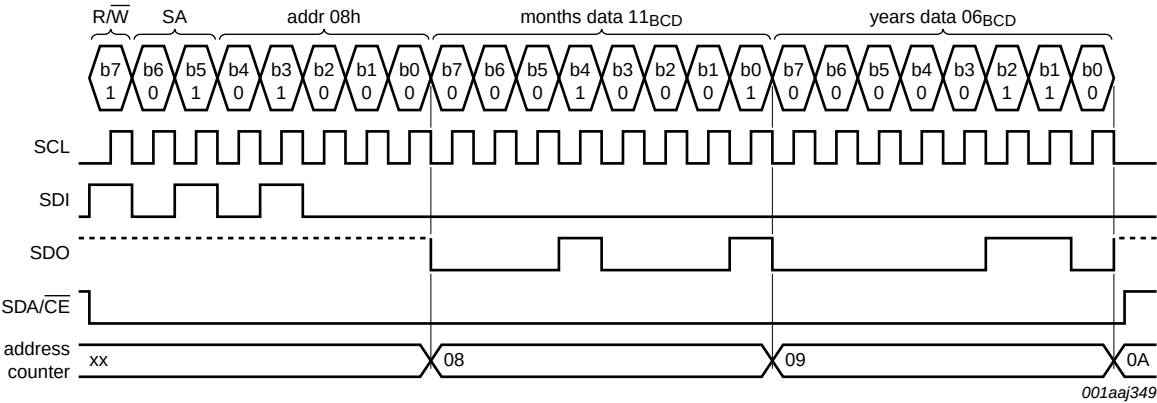
Table 50. Command byte definition

| Bit    | Symbol           | Value      | Description                                                              |
|--------|------------------|------------|--------------------------------------------------------------------------|
| 7      | $\overline{R/W}$ |            | 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 1Bh | register address                                                         |



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

Fig 29. SPI-bus write example



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  $I_{DD}$  currents may result.

Fig 30. SPI-bus read example

## 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 31](#)).

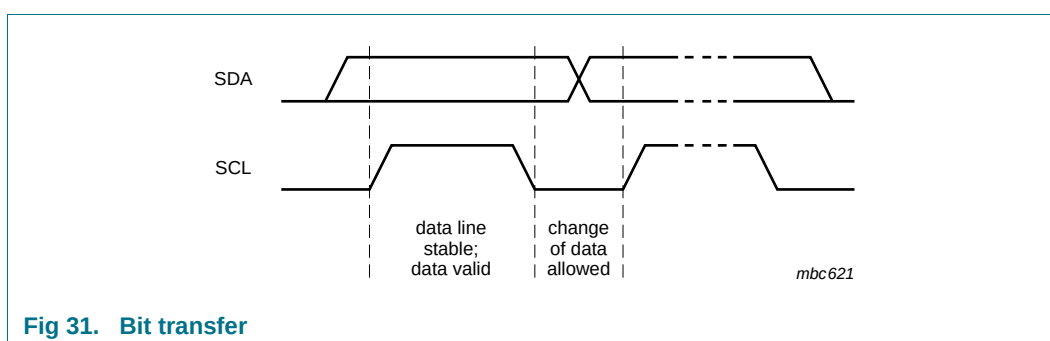


Fig 31. Bit transfer

### 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 32](#)).

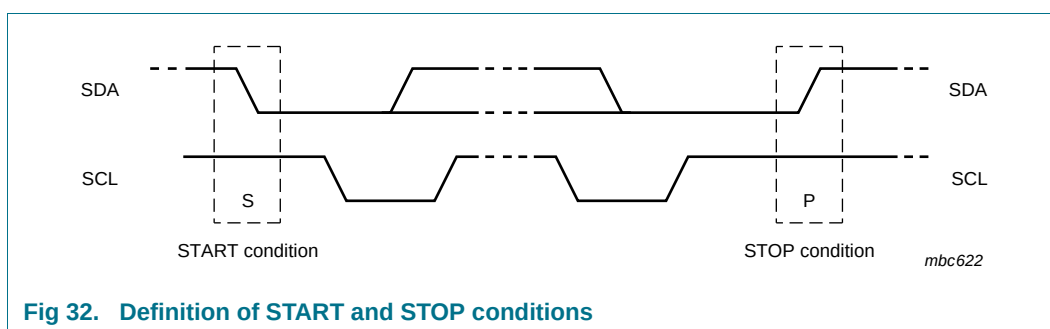


Fig 32. Definition of START and STOP conditions

**Remark:** For the PCA2129T, 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 PCA2129T can act as a slave transmitter and a slave receiver.



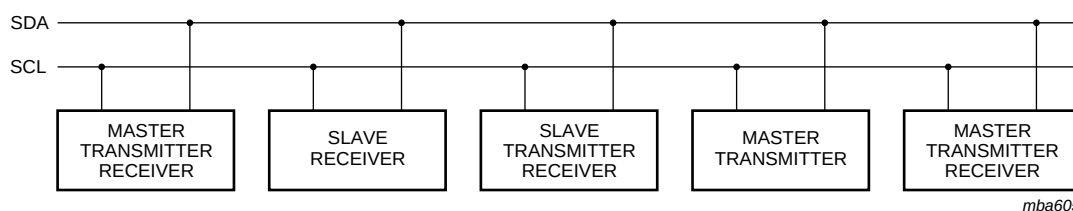


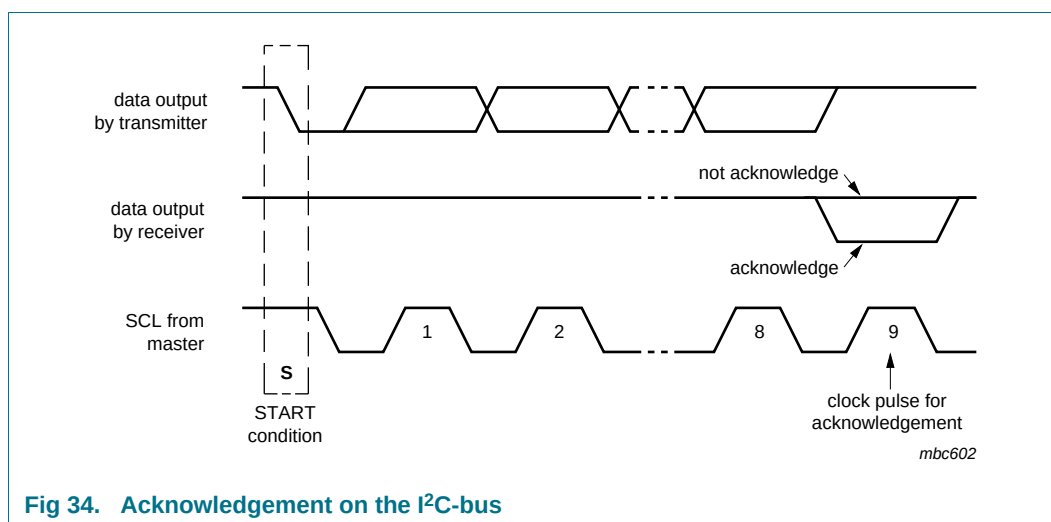
Fig 33. System configuration

### 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 34](#).

Fig 34. Acknowledgement on the I<sup>2</sup>C-bus

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

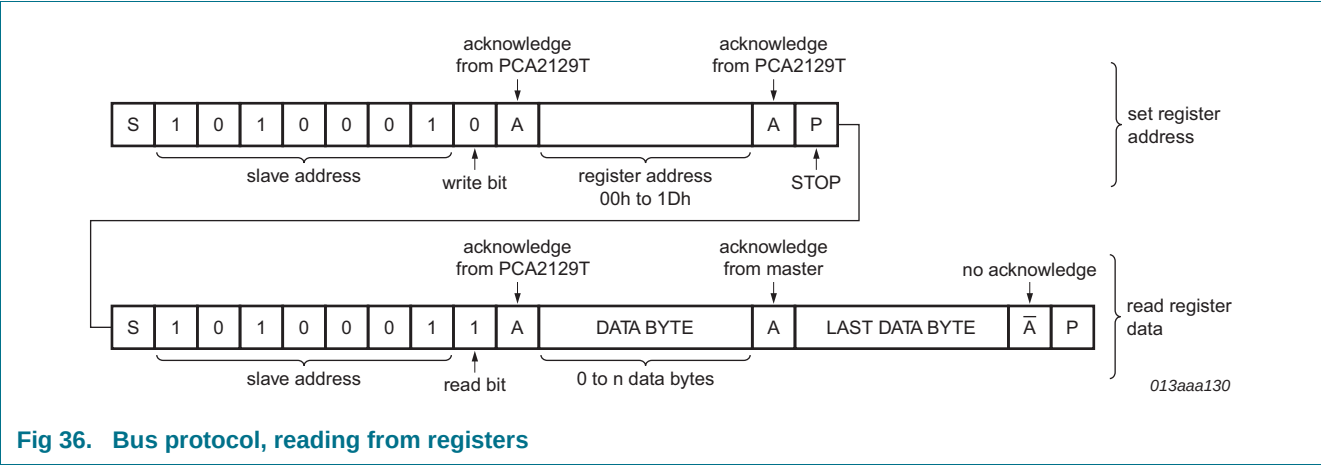
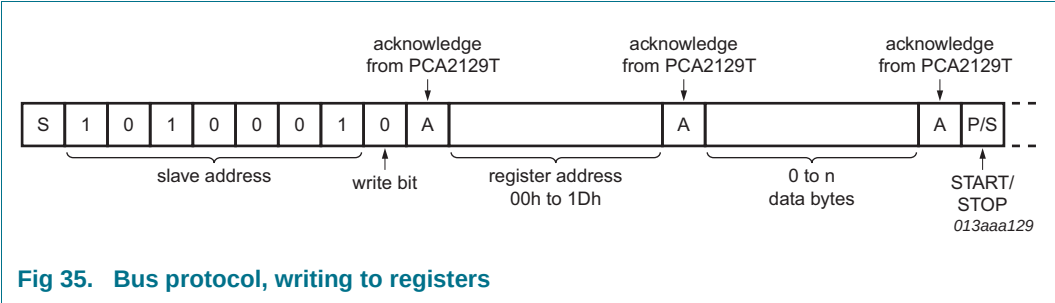
After a start condition, a valid hardware address has to be sent to a PCA2129T device. The appropriate I<sup>2</sup>C-bus slave address is 1010001. The entire I<sup>2</sup>C-bus slave address byte is shown in [Table 51](#).

Table 51. I<sup>2</sup>C slave address byte

| Bit | Slave address |   |   |   |   |   |   | 0   |
|-----|---------------|---|---|---|---|---|---|-----|
|     | 7             | 6 | 5 | 4 | 3 | 2 | 1 |     |
|     | 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. 11 “UM10204”](#) and the characteristics table ([Table 56](#)). In the write mode, a data transfer is terminated by sending either a STOP condition or the START condition of the next data transfer.



10. Internal circuitry

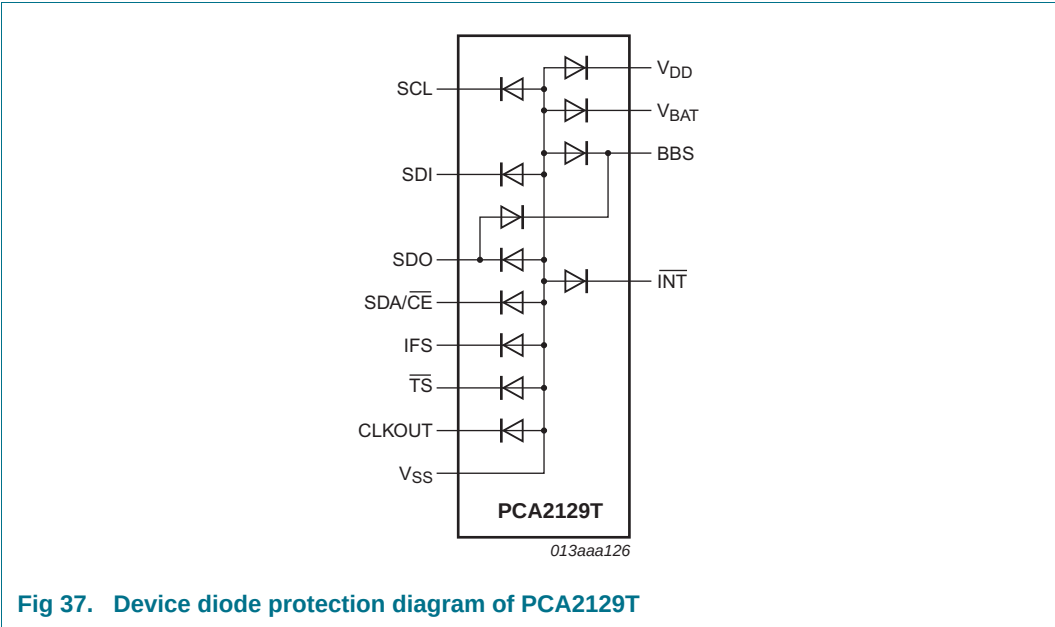


Fig 37. Device diode protection diagram of PCA2129T

## 11. Limiting values

**Table 52. Limiting values**

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

| Symbol    | Parameter                       | Conditions       | Min     | Max   | Unit |
|-----------|---------------------------------|------------------|---------|-------|------|
| $V_{DD}$  | supply voltage                  |                  | -0.5    | +6.5  | V    |
| $I_{DD}$  | supply current                  |                  | -50     | +50   | mA   |
| $V_i$     | input voltage                   |                  | -0.5    | +6.5  | V    |
| $I_i$     | input current                   |                  | -10     | +10   | mA   |
| $V_O$     | output voltage                  |                  | -0.5    | +6.5  | V    |
| $I_O$     | output current                  |                  | -10     | +10   | mA   |
|           |                                 | at pin SDA/CE    | -10     | +20   | mA   |
| $V_{BAT}$ | battery supply voltage          |                  | -0.5    | +6.5  | V    |
| $P_{tot}$ | total power dissipation         |                  | -       | 300   | mW   |
| $V_{ESD}$ | electrostatic discharge voltage | HBM              | [1] -   | ±4000 | V    |
|           |                                 | CDM              | [2] -   | ±1250 | V    |
| $I_{lu}$  | latch-up current                |                  | [3] -   | 200   | mA   |
| $T_{stg}$ | storage temperature             |                  | [4] -55 | +85   | °C   |
| $T_{amb}$ | 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 ( $T_{amb(max)}$ ).

[4] According to the store and transport requirements (see [Ref. 12 "UM10569"](#)) the devices have to be stored at a temperature of +8 °C to +45 °C and a humidity of 25 % to 75 %.

## 12. Static characteristics

**Table 53. Static characteristics**

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

| Symbol                  | Parameter                        | Conditions                                                                                                                       | Min     | Typ  | Max  | Unit          |
|-------------------------|----------------------------------|----------------------------------------------------------------------------------------------------------------------------------|---------|------|------|---------------|
| <b>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 ( $f_{SCL} = 0\text{ Hz}$ )[2];<br>TCR[1:0] = 00 (see Table 9 on page 12)                                     |         |      |      |               |
|                         |                                  | PWRMNG[2:0] = 111 (see Table 14 on page 15);<br>TSOFF = 1 (see Table 38 on page 35);<br>COF[2:0] = 111 (see Table 11 on page 13) |         |      |      |               |
|                         |                                  | $V_{DD} = 2.0\text{ V}$                                                                                                          | -       | 500  | -    | nA            |
|                         |                                  | $V_{DD} = 3.3\text{ V}$                                                                                                          | -       | 700  | 1500 | nA            |
|                         |                                  | $V_{DD} = 4.2\text{ V}$                                                                                                          | -       | 800  | -    | nA            |
|                         |                                  | PWRMNG[2:0] = 111 (see Table 14 on page 15);<br>TSOFF = 1 (see Table 38 on page 35);<br>COF[2:0] = 000 (see Table 11 on page 13) |         |      |      |               |
|                         |                                  | $V_{DD} = 2.0\text{ V}$                                                                                                          | -       | 600  | -    | nA            |
|                         |                                  | $V_{DD} = 3.3\text{ V}$                                                                                                          | -       | 850  | -    | nA            |
|                         |                                  | $V_{DD} = 4.2\text{ V}$                                                                                                          | -       | 1050 | -    | nA            |
|                         |                                  | PWRMNG[2:0] = 000 (see Table 14 on page 15);<br>TSOFF = 0 (see Table 38 on page 35);<br>COF[2:0] = 111 (see Table 11 on page 13) |         |      |      |               |
|                         |                                  | $V_{DD}\text{ or }V_{BAT} = 2.0\text{ V}$ [3]                                                                                    | -       | 1800 | -    | nA            |
|                         |                                  | $V_{DD}\text{ or }V_{BAT} = 3.3\text{ V}$ [3]                                                                                    | -       | 2150 | -    | nA            |
|                         |                                  | $V_{DD}\text{ or }V_{BAT} = 4.2\text{ V}$ [3]                                                                                    | -       | 2350 | 3500 | nA            |
|                         |                                  | PWRMNG[2:0] = 000 (see Table 14 on page 15);<br>TSOFF = 0 (see Table 38 on page 35);<br>COF[2:0] = 000 (see Table 11 on page 13) |         |      |      |               |
|                         |                                  | $V_{DD}\text{ or }V_{BAT} = 2.0\text{ V}$ [3]                                                                                    | -       | 1900 | -    | nA            |
|                         |                                  | $V_{DD}\text{ or }V_{BAT} = 3.3\text{ V}$ [3]                                                                                    | -       | 2300 | -    | nA            |
|                         |                                  | $V_{DD}\text{ or }V_{BAT} = 4.2\text{ V}$ [3]                                                                                    | -       | 2600 | -    | nA            |
| $I_{L(bat)}$            | battery leakage current          | $V_{DD}$ is active supply;<br>$V_{BAT} = 3.0\text{ V}$                                                                           | -       | 50   | 100  | nA            |
| <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             |

**Table 53. 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.

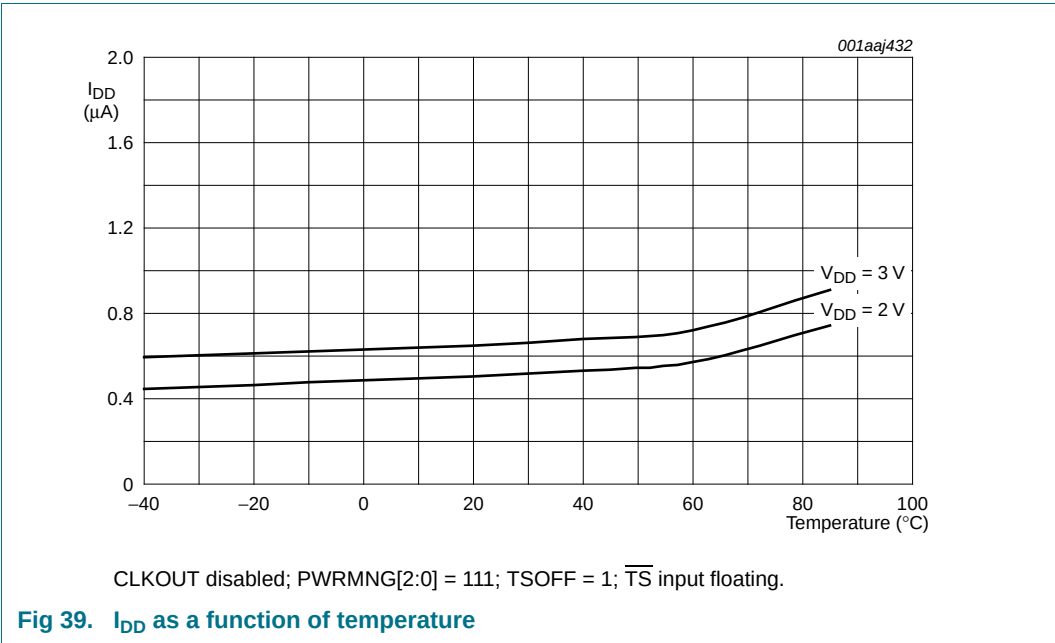
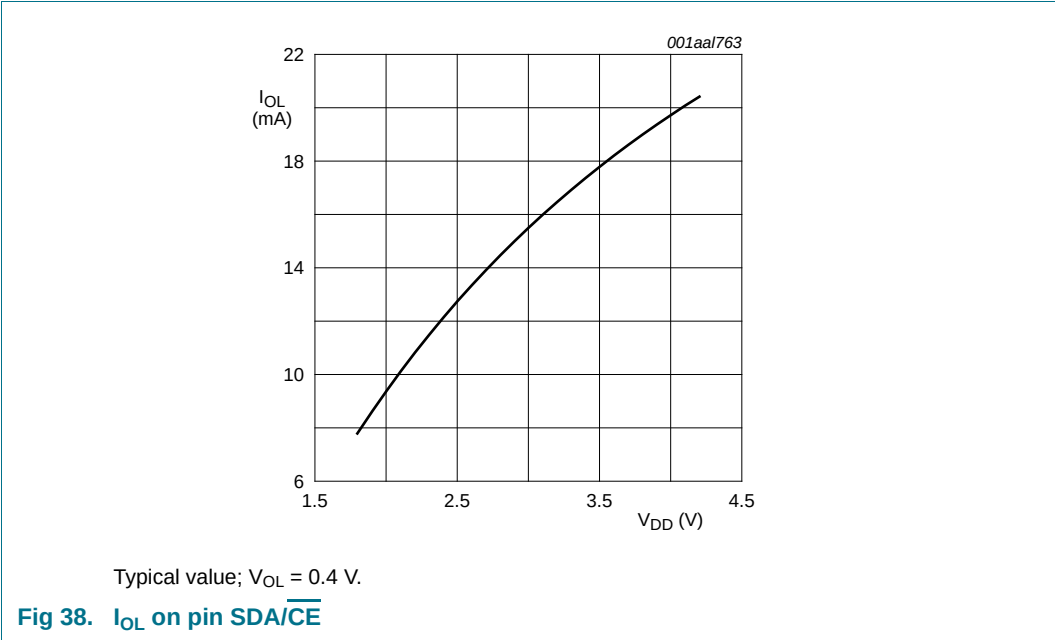
| Symbol                      | Parameter                 | Conditions                                                                                 | Min              | Typ | Max             | Unit          |
|-----------------------------|---------------------------|--------------------------------------------------------------------------------------------|------------------|-----|-----------------|---------------|
| <b>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     | $V_I = V_{DD}\text{ or }V_{SS}$                                                            | -                | 0   | -               | $\mu\text{A}$ |
|                             |                           | post ESD event                                                                             | -1               | -   | +1              | $\mu\text{A}$ |
| $C_i$                       | input capacitance         |                                                                                            | <sup>[5]</sup> - | -   | 7               | pF            |
| <b>Outputs</b>              |                           |                                                                                            |                  |     |                 |               |
| $V_O$                       | output voltage            | on pins CLKOUT, $\overline{\text{INT}}$ ,<br>referring to external pull-up                 | -0.5             | -   | 5.5             | V             |
|                             |                           | on pin SDO                                                                                 | -0.5             | -   | $V_{BBS} + 0.5$ | V             |
| $I_{OL}$                    | LOW-level output current  | output sink current;<br>$V_{OL} = 0.4\text{ V}$                                            |                  |     |                 |               |
|                             |                           | on pin SDA/ $\overline{\text{CE}}$                                                         | <sup>[6]</sup> 3 | 17  | -               | mA            |
|                             |                           | on all other outputs                                                                       | 1.0              | -   | -               | mA            |
| $I_{OH}$                    | HIGH-level output current | output source current;<br>on pin SDO; $V_{OH} = 3.8\text{ V}$ ;<br>$V_{DD} = 4.2\text{ V}$ | 1.0              | -   | -               | mA            |
| $I_{LO}$                    | output leakage current    | $V_O = V_{DD}\text{ or }V_{SS}$                                                            | -                | 0   | -               | $\mu\text{A}$ |
|                             |                           | post ESD event                                                                             | -1               | -   | +1              | $\mu\text{A}$ |

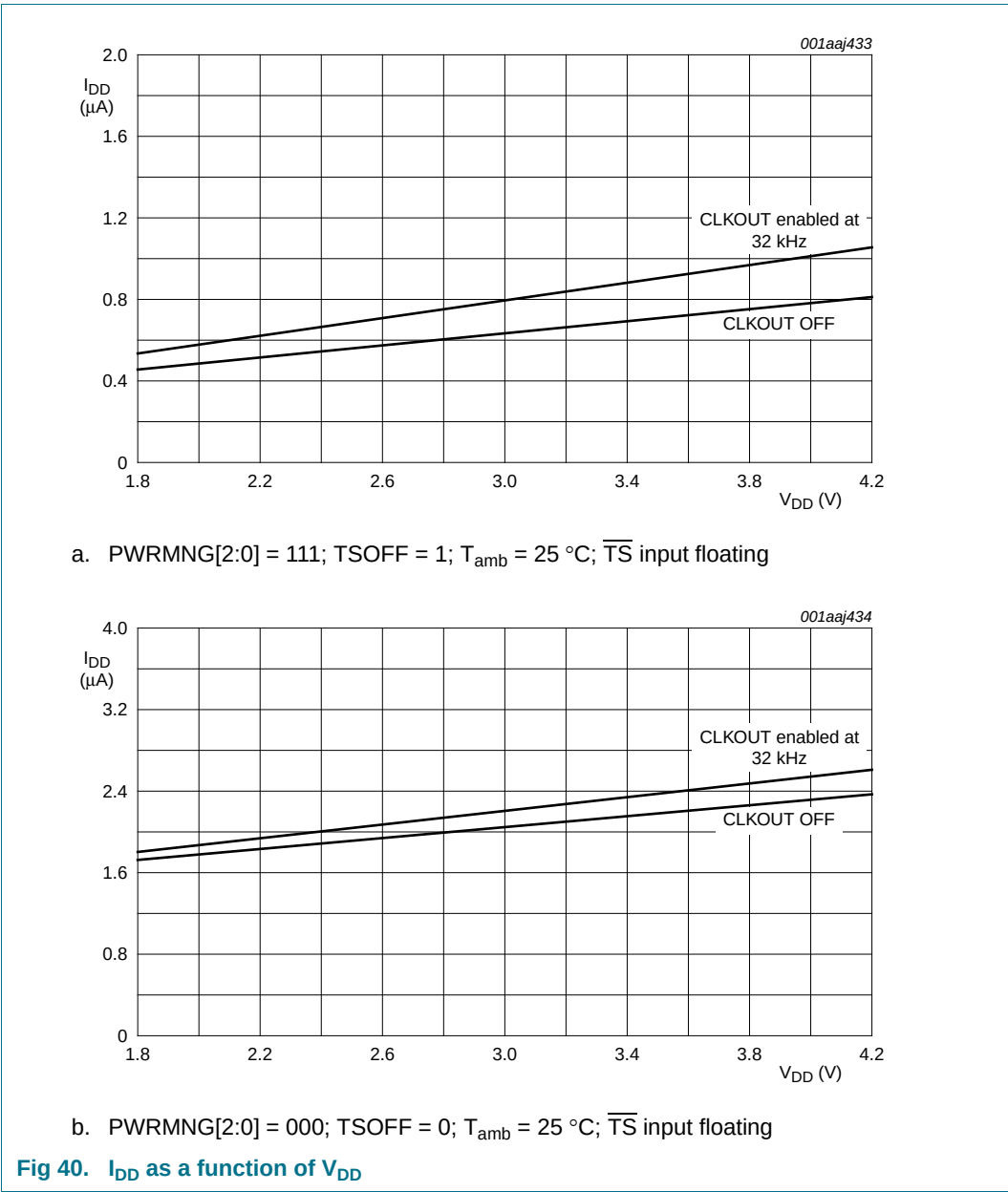
[1] For reliable oscillator start-up at power-on:  $V_{DD(po)min} = V_{DD(min)} + 0.3\text{ V}$ .[2] Timer source clock =  $\frac{1}{60}\text{ Hz}$ , level of pins SDA/ $\overline{\text{CE}}$ , SDI, and SCL is  $V_{DD}\text{ or }V_{SS}$ .[3] When the device is supplied by the  $V_{BAT}$  pin instead of the  $V_{DD}$  pin, the current values for  $I_{BAT}$  will be as specified for  $I_{DD}$  under the same conditions.[4] The I<sup>2</sup>C-bus interface of PCA2129T is 5 V tolerant.

[5] Tested on sample basis.

[6] For further information, see [Figure 38](#).

12.1 Current consumption characteristics, typical





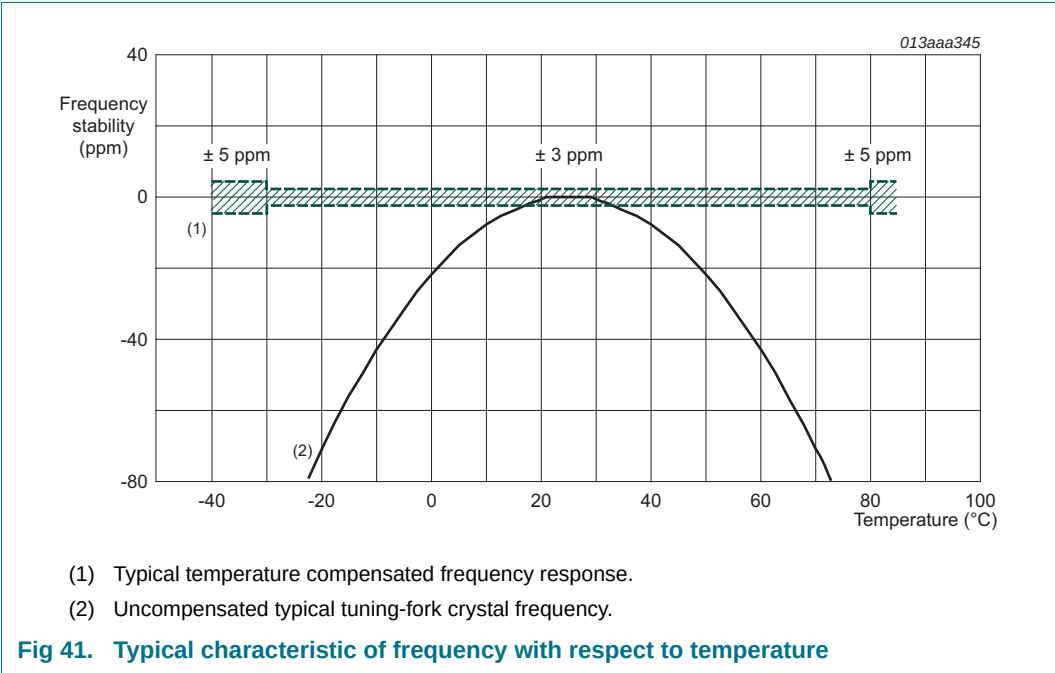


12.2 Frequency characteristics

Table 54. Frequency characteristics
VDD = 1.8 V to 4.2 V; VSS = 0 V; Tamb = +25 °C, unless otherwise specified.

| Symbol                                | Parameter                            | Conditions                                                                                          | Min    | Typ    | Max | Unit  |
|---------------------------------------|--------------------------------------|-----------------------------------------------------------------------------------------------------|--------|--------|-----|-------|
| f <sub>o</sub>                        | output frequency                     | on pin CLKOUT;<br>V <sub>DD</sub> or V <sub>BAT</sub> = 3.3 V;<br>COF[2:0] = 000;<br>AO[3:0] = 1000 | -      | 32.768 | -   | kHz   |
| Δf/f                                  | frequency stability                  | V <sub>DD</sub> or V <sub>BAT</sub> = 3.3 V                                                         |        |        |     |       |
|                                       |                                      | T <sub>amb</sub> = -30 °C to +80 °C                                                                 | [1][2] | ±3     | ±8  | ppm   |
|                                       |                                      | T <sub>amb</sub> = -40 °C to -30 °C<br>and<br>T <sub>amb</sub> = +80 °C to +85 °C                   | [1][2] | ±5     | ±15 | ppm   |
| Δf <sub>xtal</sub> /f <sub>xtal</sub> | relative crystal frequency variation | crystal aging                                                                                       |        |        |     |       |
|                                       |                                      | first year                                                                                          | [3]    | -      | ±3  | ppm   |
|                                       |                                      | ten years                                                                                           |        | -      | ±8  | ppm   |
| Δf/ΔV                                 | frequency variation with voltage     | on pin CLKOUT                                                                                       | -      | ±1     | -   | ppm/V |

- [1] ±1 ppm corresponds to a time deviation of ±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 "AN11120").



## 13. Dynamic characteristics

### 13.1 SPI-bus timing characteristics

**Table 55. 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 42](#)).

| Symbol                  | Parameter                       | Conditions               | V <sub>DD</sub> = 1.8 V |      | V <sub>DD</sub> = 4.2 V |      | Unit |
|-------------------------|---------------------------------|--------------------------|-------------------------|------|-------------------------|------|------|
|                         |                                 |                          | Min                     | Max  | Min                     | Max  |      |
| Pin SCL                 |                                 |                          |                         |      |                         |      |      |
| f <sub>clk(SCL)</sub>   | SCL clock frequency             |                          | -                       | 2.0  | -                       | 6.5  | MHz  |
| t <sub>SCL</sub>        | SCL time                        |                          | 800                     | -    | 140                     | -    | ns   |
| t <sub>clk(H)</sub>     | clock HIGH time                 |                          | 100                     | -    | 70                      | -    | ns   |
| t <sub>clk(L)</sub>     | clock LOW time                  |                          | 400                     | -    | 70                      | -    | ns   |
| t <sub>r</sub>          | rise time                       | for SCL signal           | -                       | 100  | -                       | 30   | ns   |
| t <sub>f</sub>          | fall time                       | for SCL signal           | -                       | 100  | -                       | 30   | ns   |
| Pin SDA/CE              |                                 |                          |                         |      |                         |      |      |
| t <sub>su(CE_N)</sub>   | CE_N set-up time                |                          | 60                      | -    | 30                      | -    | ns   |
| t <sub>h(CE_N)</sub>    | CE_N hold time                  |                          | 40                      | -    | 25                      | -    | ns   |
| t <sub>rec(CE_N)</sub>  | CE_N recovery time              |                          | 100                     | -    | 30                      | -    | ns   |
| t <sub>w(CE_N)</sub>    | CE_N pulse width                |                          | -                       | 0.99 | -                       | 0.99 | s    |
| Pin SDI                 |                                 |                          |                         |      |                         |      |      |
| t <sub>su</sub>         | set-up time                     | set-up time for SDI data | 70                      | -    | 20                      | -    | ns   |
| t <sub>h</sub>          | hold time                       | hold time for SDI data   | 70                      | -    | 20                      | -    | ns   |
| Pin SDO                 |                                 |                          |                         |      |                         |      |      |
| t <sub>d(R)SDO</sub>    | SDO read delay time             | C <sub>L</sub> = 50 pF   | -                       | 225  | -                       | 55   | ns   |
| t <sub>dis(SDO)</sub>   | SDO disable time                | [1]                      | -                       | 90   | -                       | 25   | ns   |
| t <sub>t(SDI-SDO)</sub> | transition time from SDI to SDO | to avoid bus conflict    | 0                       | -    | 0                       | -    | ns   |

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

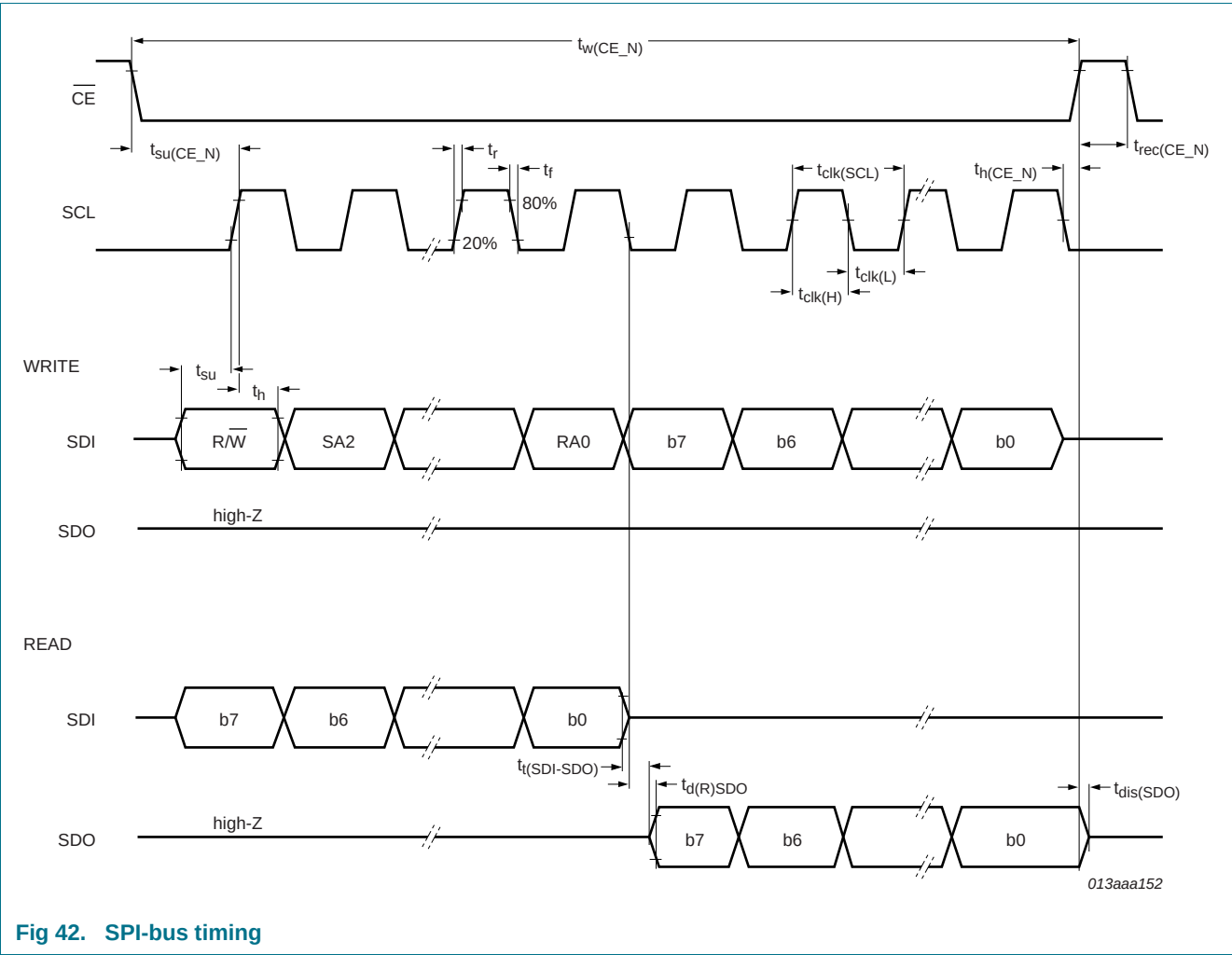


Fig 42. SPI-bus timing

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

**Table 56. 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 43](#)).

| Symbol              | Parameter                                                         | Standard mode |      | Fast-mode (Fm)         |     | Unit |
|---------------------|-------------------------------------------------------------------|---------------|------|------------------------|-----|------|
|                     |                                                                   | Min           | Max  | Min                    | Max |      |
| Pin SCL             |                                                                   |               |      |                        |     |      |
| f <sub>SCL</sub>    | SCL clock frequency                                               | [1] 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   |
| Pin SDA/CE          |                                                                   |               |      |                        |     |      |
| t <sub>SU;DAT</sub> | data set-up time                                                  | 250           | -    | 100                    | -   | ns   |
| t <sub>HD;DAT</sub> | data hold time                                                    | 0             | -    | 0                      | -   | ns   |
| Pins SCL and SDA/CE |                                                                   |               |      |                        |     |      |
| 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                             | [2][3][4] -   | 1000 | 20 + 0.1C <sub>b</sub> | 300 | ns   |
| t <sub>f</sub>      | fall time of both SDA and SCL signals                             | [2][3][4] -   | 300  | 20 + 0.1C <sub>b</sub> | 300 | ns   |
| t <sub>VD;ACK</sub> | data valid acknowledge time                                       | [5] 0.1       | 3.45 | 0.1                    | 0.9 | μs   |
| t <sub>VD;DAT</sub> | data valid time                                                   | [6] 300       | -    | 75                     | -   | ns   |
| t <sub>SP</sub>     | pulse width of spikes that must be suppressed by the input filter | [7] -         | 50   | -                      | 50  | ns   |

- [1] The minimum SCL clock frequency is limited by the bus time-out feature which resets the serial bus interface if either the SDA or SCL is held LOW for a minimum of 25 ms. The bus time-out feature must be disabled for DC operation.
- [2] 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.
- [3]  $C_b$  is the total capacitance of one bus line in pF.
- [4] The maximum  $t_f$  for the SDA and SCL bus lines is 300 ns. The maximum fall time for the SDA output stage,  $t_f$  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  $t_f$ .
- [5]  $t_{VD,ACK}$  is the time of the acknowledgement signal from SCL LOW to SDA (out) LOW.
- [6]  $t_{VD,DAT}$  is the minimum time for valid SDA (out) data following SCL LOW.
- [7] Input filters on the SDA and SCL inputs suppress noise spikes of less than 50 ns.

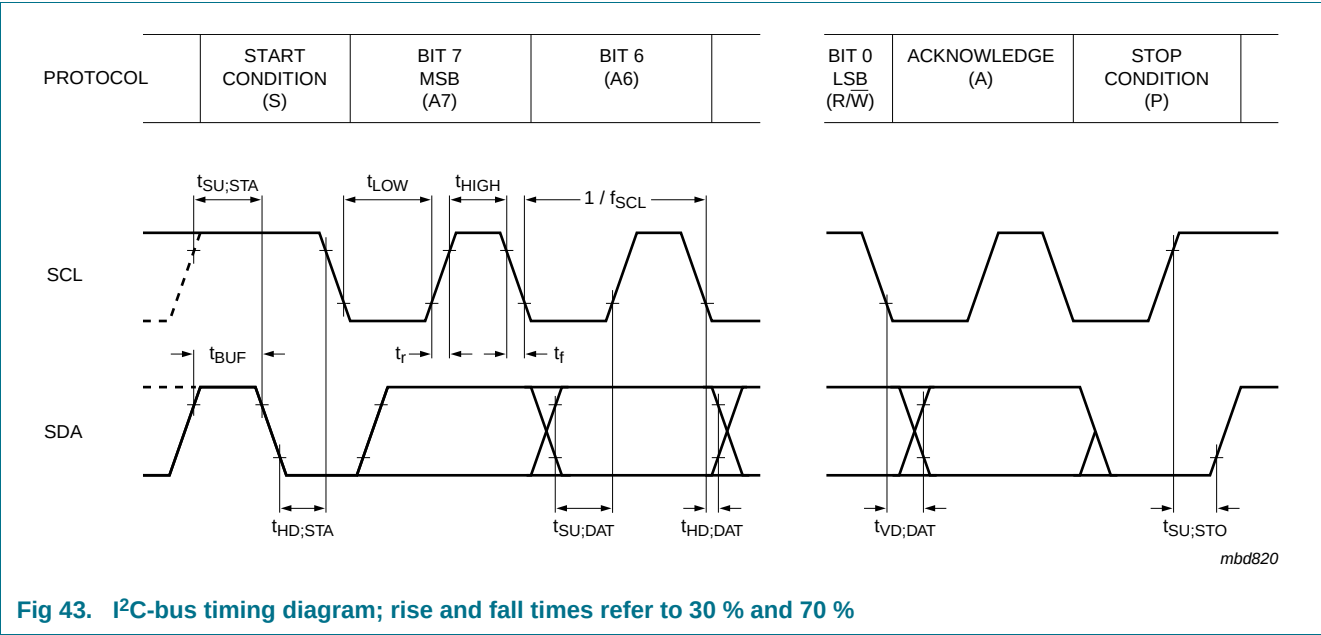


Fig 43. I<sup>2</sup>C-bus timing diagram; rise and fall times refer to 30 % and 70 %

14. Application information

For information about application configuration see [Ref. 3 “AN11120”](#).

15. Test information

15.1 Quality information

This product has been qualified in accordance with the Automotive Electronics Council (AEC) standard *Q100 - Failure mechanism based stress test qualification for integrated circuits*, and is suitable for use in automotive applications.

16. Package outline

SO16: plastic small outline package; 16 leads; body width 7.5 mm SOT162-1

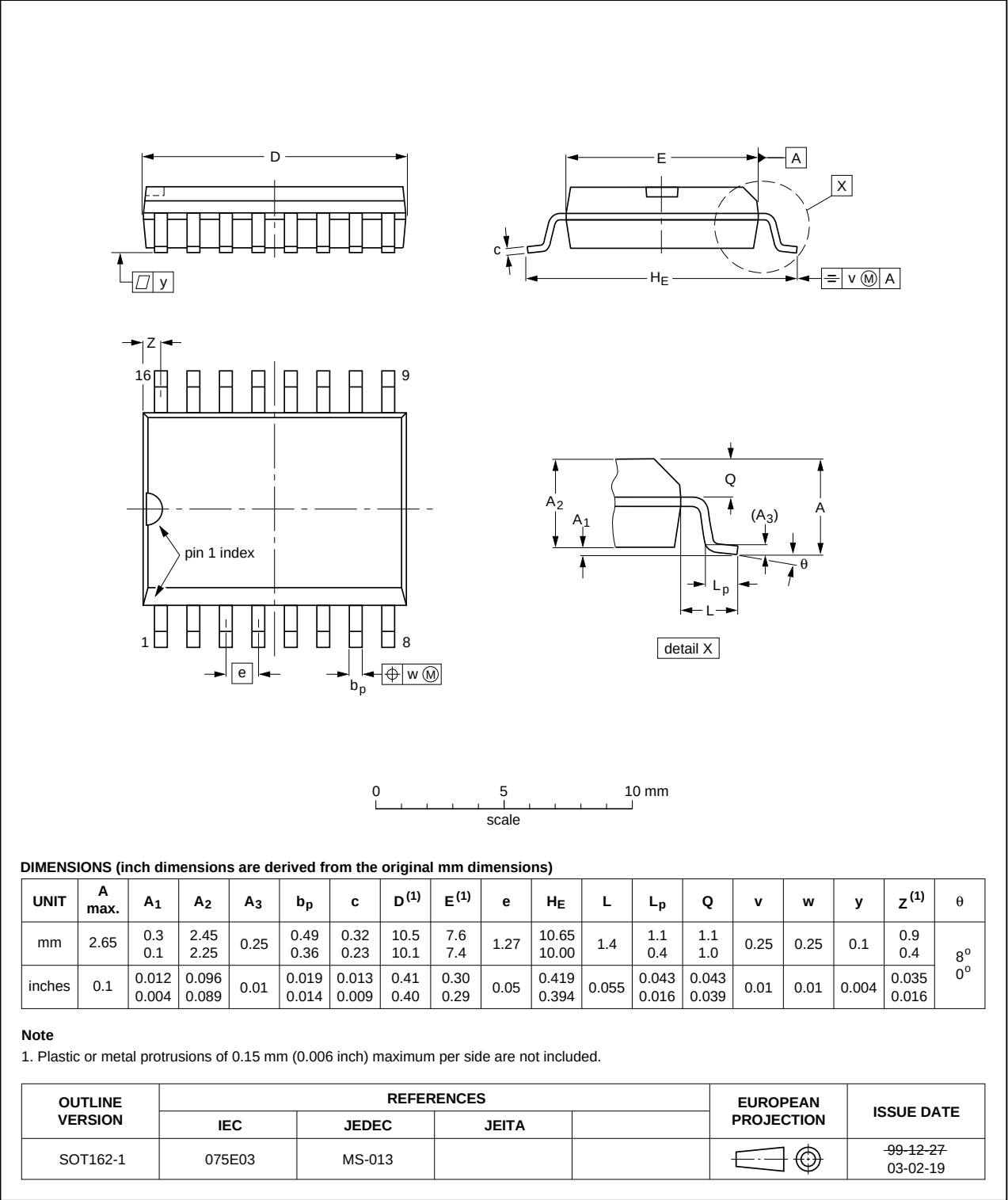
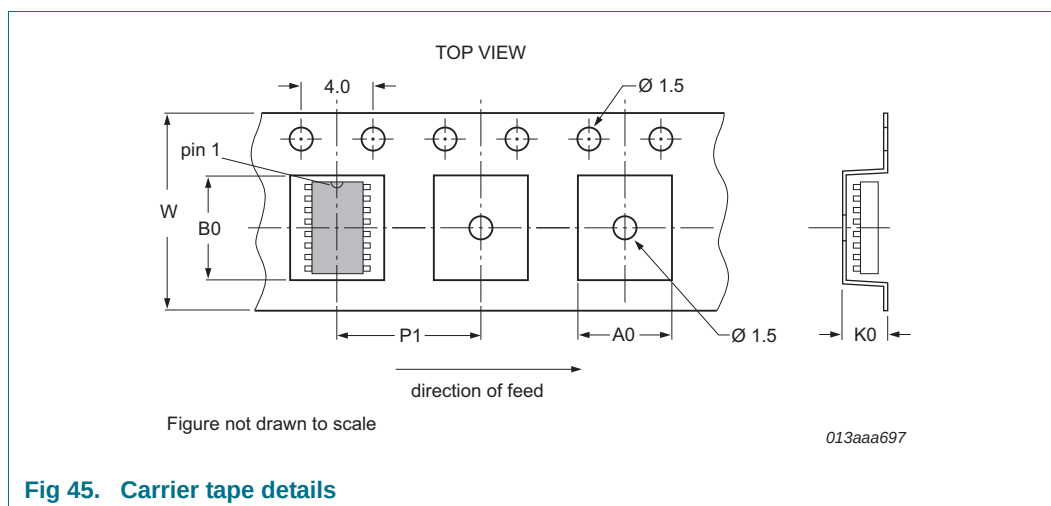


Fig 44. Package outline SOT162-1 (SO16) of PCA2129T

## 17. Packing information

### 17.1 Carrier tape information



**Fig 45. Carrier tape details**

**Table 57. Carrier tape dimensions**

| Symbol | Description                 | Value | Unit |
|--------|-----------------------------|-------|------|
| A0     | pocket width in x direction | 10.6  | mm   |
| B0     | pocket width in y direction | 10.7  | mm   |
| K0     | pocket height               | 3.3   | mm   |
| P1     | sprocket hole pitch         | 12    | mm   |
| W      | tape width in y direction   | 16    | mm   |

## 18. Soldering

For information about soldering, see [Ref. 3 "AN11120"](#).

18.1 Footprint information

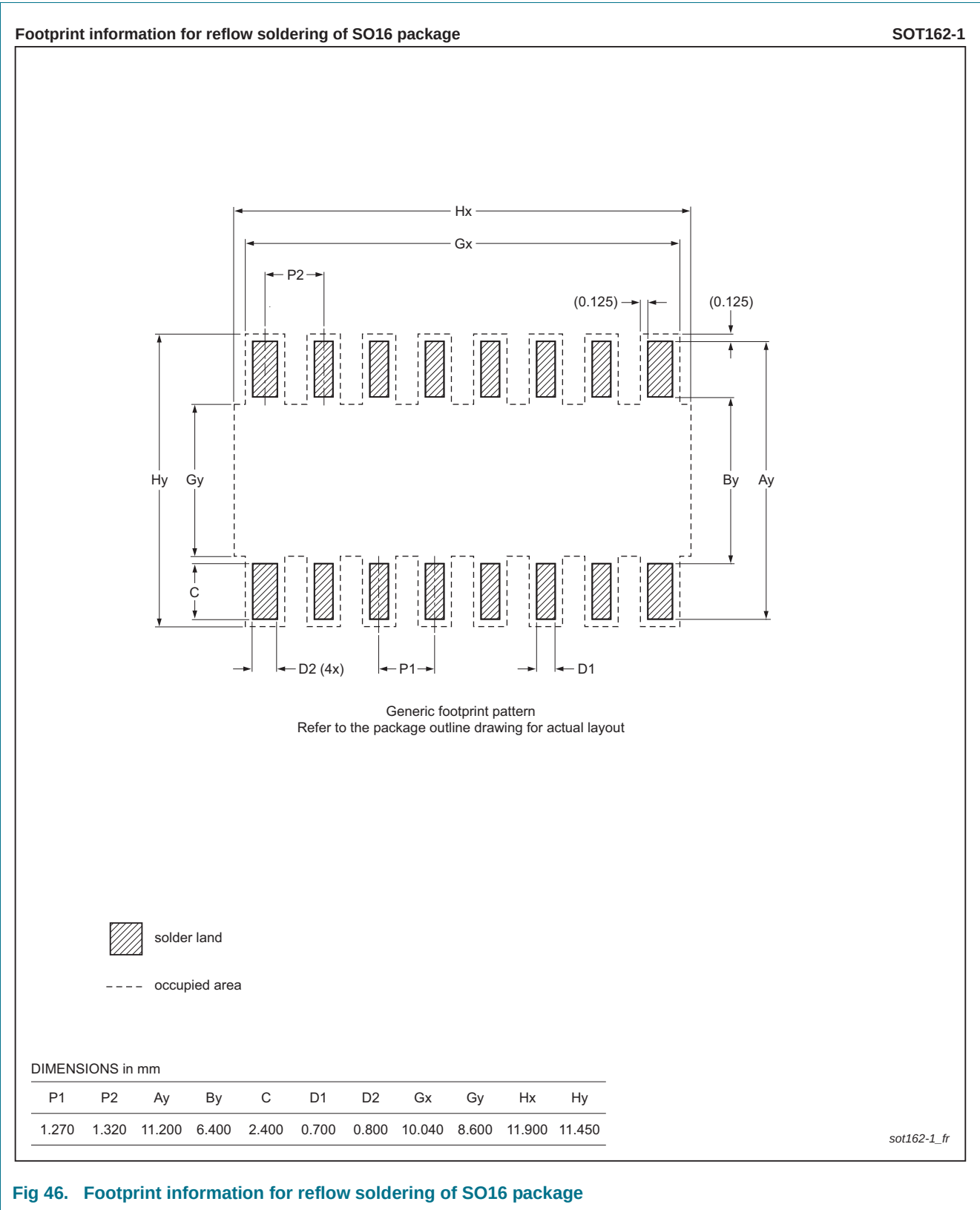


Fig 46. Footprint information for reflow soldering of SO16 package



## 19. Abbreviations

Table 58. Abbreviations

| Acronym          | Description                             |
|------------------|-----------------------------------------|
| AEC              | Automotive Electronics Council          |
| 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                    |
| MM               | Machine Model                           |
| MSB              | Most Significant Bit                    |
| PM               | Post Meridiem                           |
| POR              | Power-On Reset                          |
| PORO             | Power-On Reset Override                 |
| PPM              | Parts Per Million                       |
| 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                                 |

## 20. References

- [1] **AN10365** — Surface mount reflow soldering description
- [2] **AN10853** — Handling precautions of ESD sensitive devices
- [3] **AN11120** — Application and soldering information for the PCA2129 automotive 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] **UM10204** — I<sup>2</sup>C-bus specification and user manual
- [12] **UM10569** — Store and transport requirements

## 21. Revision history

**Table 59. Revision history**

| Document ID    | Release date                                                                                                                                                                                                                                                                                                                          | Data sheet status    | Change notice | Supersedes   |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|---------------|--------------|
| PCA2129T v.2.1 | 20121114                                                                                                                                                                                                                                                                                                                              | Product data sheet   | -             | PCA2129T v.2 |
| Modifications: | <ul style="list-style-type: none"> <li>Fixed typos</li> </ul>                                                                                                                                                                                                                                                                         |                      |               |              |
| PCA2129T v.2   | 20121113                                                                                                                                                                                                                                                                                                                              | Product data sheet   | -             | PCA2129T v.1 |
| Modifications: | <ul style="list-style-type: none"> <li>Improved description of I<sub>DD</sub> values (<a href="#">Table 53</a>)</li> <li>Added ordering options (<a href="#">Section 4.1</a>)</li> <li>Added packing information (<a href="#">Section 17.1</a>)</li> <li>Added soldering footprint information (<a href="#">Figure 46</a>)</li> </ul> |                      |               |              |
| PCA2129T v.1   | 20111027                                                                                                                                                                                                                                                                                                                              | Objective data sheet | -             | -            |

## 22. Legal information

### 22.1 Data sheet status

| Document status <sup>[1][2]</sup> | Product status <sup>[3]</sup> | Definition                                                                            |
|-----------------------------------|-------------------------------|---------------------------------------------------------------------------------------|
| Objective [short] data sheet      | Development                   | This document contains data from the objective specification for product development. |
| Preliminary [short] data sheet    | Qualification                 | This document contains data from the preliminary specification.                       |
| Product [short] data sheet        | Production                    | This document contains the product specification.                                     |

[1] Please consult the most recently issued document before initiating or completing a design.

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

[3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the Internet at URL <http://www.nxp.com>.

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Date of release: 14 November 2012

Document identifier: PCA2129T