



# PCF8564A

## Real time clock and calendar

Rev. 3 — 26 August 2013

Product data sheet

## 1. General description

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The PCF8564A is a CMOS<sup>1</sup> real-time clock and calendar optimized for low power consumption. A programmable clock output, interrupt output and voltage low detector are also provided. All addresses and data are transferred serially via the two-line bidirectional I<sup>2</sup>C-bus. Maximum bus speed is 400 kbit/s. The built-in word address register is incremented automatically after each written or read data byte.

## 2. Features and benefits

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- Provides year, month, day, weekday, hours, minutes, and seconds based on a 32.768 kHz quartz crystal
- Wide clock operating voltage: 1.0 V to 5.5 V
- Low back-up current typical 250 nA at 3.0 V and 25 °C
- 400 kHz two-wire I<sup>2</sup>C interface (1.8 V to 5.5 V)
- Low-voltage detector
- Alarm and timer functions
- Two integrated oscillator capacitors
- Programmable clock output for peripheral devices (32.768 kHz, 1.024 kHz, 32 Hz, and 1 Hz)
- Internal Power-On Reset (POR)
- I<sup>2</sup>C slave address: read A3h, write A2h

## 3. Applications

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- Timing devices
  - ◆ Time of the day tracking
  - ◆ Process timing
  - ◆ Alarm
- Portable instruments
- Electronic metering
- Battery powered products

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1. The definition of the abbreviations and acronyms used in this data sheet can be found in [Section 20](#).



## 4. Ordering information

Table 1. Ordering information

| Type number | Package  |                               |            |
|-------------|----------|-------------------------------|------------|
|             | Name     | Description                   | Version    |
| PCF8564AU   | bare die | wire bond die; 9 bonding pads | PCF8564AU  |
| PCF8564AUG  | bare die | 9 bumps                       | PCF8564AUG |

### 4.1 Ordering options

Table 2. Ordering options

| Product type number | Sales item (12NC) | Orderable part number | IC revision | Delivery form  |
|---------------------|-------------------|-----------------------|-------------|--|
| PCF8564AU/10AB/1    | 935289478005      | PCF8564AU/10AB/1,0    | 1           | wafer, sawn, on FFC  |
| PCF8564AU/5BB/1     | 935289319015      | PCF8564AU/5BB/1,01    | 1           | unsawn wafer   |
| PCF8564AU/5GB/1     | 935289477015      | PCF8564AU/5GB/1,01    | 1           | unsawn wafer   |
| PCF8564AU/5GC/1     | 935293569015      | PCF8564AU/5GC/1,01    | 1           | unsawn wafer   |
| PCF8564AUG/12HB/1   | 935301011005      | PCF8564AUG/12HB/1V    | 1           | wafer, sawn, on 8 inch metal FFC; chips with soft bumps <sup>[1]</sup> |

[1] Bump hardness, see [Table 36](#).

## 5. Marking

Table 3. Marking codes

| Type number | Marking code |
|-------------|--------------|
| PCF8564AU   | PC8564A-1    |
| PCF8564AUG  | PC8564A-1    |

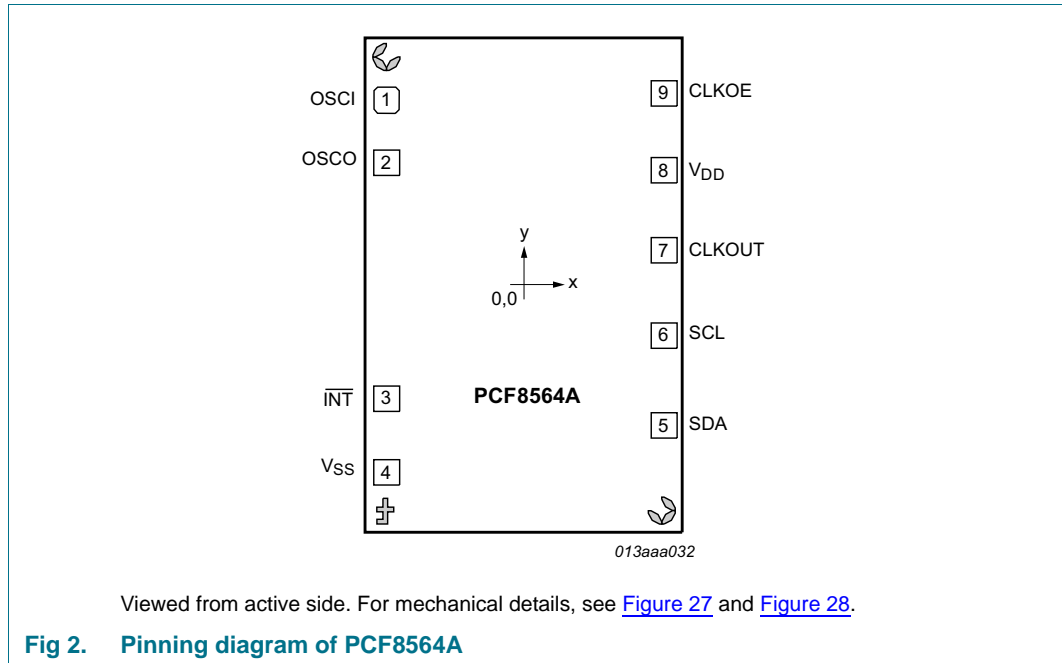
6. Block diagram



Fig 1. Block diagram of PCF8564A

## 7. Pinning information

### 7.1 Pinning



### 7.2 Pin description

**Table 4. Pin description**

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

| Symbol                  | Pin | Description                              |
|-------------------------|-----|--|
| OSCI                    | 1   | oscillator input                         |
| OSCO                    | 2   | oscillator output                        |
| $\overline{\text{INT}}$ | 3   | interrupt output, open-drain, active LOW |
| $V_{SS}$                | 4   | ground <sup>[1]</sup>                    |
| SDA                     | 5   | serial data input and output             |
| SCL                     | 6   | serial clock input                       |
| CLKOUT                  | 7   | clock output, push-pull                  |
| $V_{DD}$                | 8   | supply voltage                           |
| CLKOE                   | 9   | CLKOUT enable input                      |

[1] The substrate (rear side of the die) is at  $V_{SS}$  potential and must not be connected.

## 8. Functional description

The PCF8564A contains sixteen 8-bit registers with an auto-incrementing address register, an on-chip 32.768 kHz oscillator with integrated capacitors, a frequency divider which provides the source clock for the RTC, a programmable clock output, a timer, a voltage low detector, and a 400 kHz I<sup>2</sup>C-bus interface.

All sixteen registers (see [Table 5](#)) are designed as addressable 8-bit parallel registers although not all bits are implemented. The first two registers (memory address 00h and 01h) are used as control and/or status registers. The addresses 02h through 08h are used as counters for the clock function (seconds up to years counters). Address locations 09h through 0Ch contain alarm registers which define the conditions for an alarm. Address 0Dh controls the CLKOUT output frequency. 0Eh and 0Fh are the timer control and timer registers, respectively.

The seconds, minutes, hours, days, months, years, as well as the minute alarm, hour alarm, and day alarm registers are all coded in BCD format.

### 8.1 CLKOUT output

A programmable square wave is available at the CLKOUT pin. Frequencies of 32.768 kHz, 1.024 kHz, 32 Hz and 1 Hz can be generated for use as a system clock, microcontroller clock, input to a charge pump, or for calibration of the oscillator. CLKOUT is a CMOS push-pull output, and if disabled it becomes logic 0.

## 8.2 Register organization

**Table 5. Register overview**

Bit positions labelled as - are not implemented. Bit positions labelled as N should always be written with logic 0. After reset, all registers are set according to [Table 28](#).

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

### Control registers

|     |           |       |   |      |       |       |    |     |     |
|-----|-----------|-------|---|------|-------|-------|----|-----|-----|
| 00h | Control_1 | TEST1 | N | STOP | N     | TESTC | N  | N   | N   |
| 01h | Control_2 | N     | N | N    | TI_TP | AF    | TF | AIE | TIE |

### Time and date registers

|     |          |                 |                   |                 |                 |   |          |  |  |
|-----|----------|-----------------|-------------------|-----------------|-----------------|---|----------|--|--|
| 02h | Seconds  | VL              | SECONDS (0 to 59) |                 |                 |   |          |  |  |
| 03h | Minutes  | -               | MINUTES (0 to 59) |                 |                 |   |          |  |  |
| 04h | Hours    | -               | -                 | HOURS (0 to 23) |                 |   |          |  |  |
| 05h | Days     | -               | -                 | DAYS (1 to 31)  |                 |   |          |  |  |
| 06h | Weekdays | -               | -                 | -               | -               | - | WEEKDAYS |  |  |
| 07h | Months   | C               | -                 | -               | MONTH (1 to 12) |   |          |  |  |
| 08h | Years    | YEARS (0 to 99) |                   |                 |                 |   |          |  |  |

### Alarm registers

|     |               |       |                        |                      |   |   |               |  |  |
|-----|---------------|-------|------------------------|----------------------|---|---|---------------|--|--|
| 09h | Minute_alarm  | AEN_M | MINUTE_ALARM (0 to 59) |                      |   |   |               |  |  |
| 0Ah | Hour_alarm    | AEN_H | -                      | HOUR_ALARM (0 to 23) |   |   |               |  |  |
| 0Bh | Day_alarm     | AEN_D | -                      | DAY_ALARM (1 to 31)  |   |   |               |  |  |
| 0Ch | Weekday_alarm | AEN_W | -                      | -                    | - | - | WEEKDAY_ALARM |  |  |

### CLKOUT control register

|     |             |    |   |   |   |   |   |         |  |
|-----|-------------|----|---|---|---|---|---|---------|--|
| 0Dh | CLKOUT_ctrl | FE | - | - | - | - | - | FD[1:0] |  |
|-----|-------------|----|---|---|---|---|---|---------|--|

### Timer registers

|     |            |         |   |   |   |   |   |         |  |
|-----|------------|---------|---|---|---|---|---|---------|--|
| 0Eh | Timer_ctrl | TE      | - | - | - | - | - | TD[1:0] |  |
| 0Fh | Timer      | TV[7:0] |   |   |   |   |   |         |  |

## 8.3 Control registers

### 8.3.1 Register Control\_1

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

| Bit    | Symbol | Value              | Description  | Reference                      |
|--------|--------|--------------------|--|--------------------------------|
| 7      | TEST1  | 0 <sup>[1]</sup>   | normal mode;<br><ul style="list-style-type: none"> <li>must be set to logic 0 during normal operations</li> </ul>  | <a href="#">Section 8.9</a>    |
|        |        | 1                  | EXT_CLK test mode (see <a href="#">Section 8.9</a> )   |                                |
| 6      | N      | 0 <sup>[2]</sup>   | default value  |                                |
| 5      | STOP   | 0 <sup>[1]</sup>   | RTC source clock runs  | <a href="#">Section 8.10</a>   |
|        |        | 1                  | <ul style="list-style-type: none"> <li>RTC divider chain flip-flops are asynchronously set to logic 0</li> <li>the RTC clock is stopped (CLKOUT at 32.768 kHz is still available)</li> </ul> |                                |
| 4      | N      | 0 <sup>[2]</sup>   | default value  |                                |
| 3      | TESTC  | 0                  | Power-On Reset (POR) override facility is disabled;<br><ul style="list-style-type: none"> <li>set to logic 0 for normal operation (see <a href="#">Section 8.11.1</a>)</li> </ul>            | <a href="#">Section 8.11.1</a> |
|        |        | 1 <sup>[1]</sup>   | Power-On Reset (POR) override is enabled   |                                |
| 2 to 0 | N      | 000 <sup>[2]</sup> | default value  |                                |

[1] Default value.

[2] Bits labeled as N should always be written with logic 0.

### 8.3.2 Register Control\_2

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

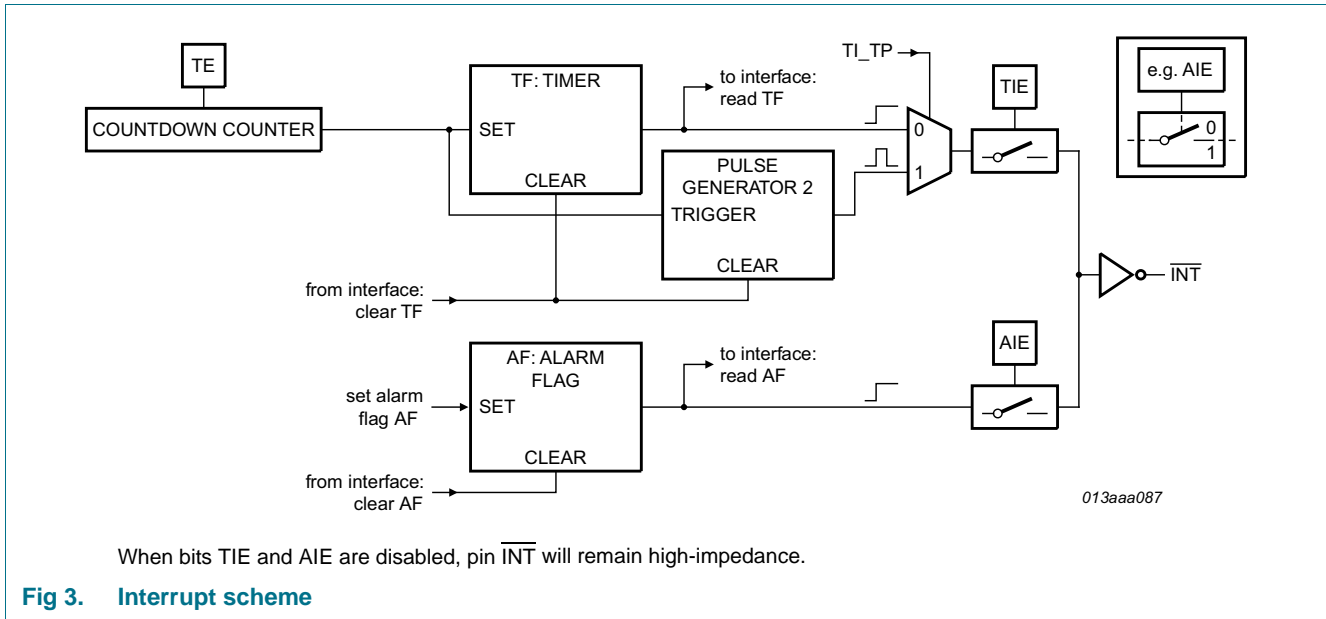
| Bit    | Symbol | Value              | Description  | Reference   |
|--------|--------|--------------------|--|---|
| 7 to 5 | N      | 000 <sup>[1]</sup> | default value  |   |
| 4      | TI_TP  | 0 <sup>[2]</sup>   | $\overline{\text{INT}}$ is active when TF is active (subject to the status of TIE)   | <a href="#">Section 8.3.2.1</a><br>and<br><a href="#">Section 8.8</a> |
|        |        | 1                  | $\overline{\text{INT}}$ pulses active according to <a href="#">Table 8</a> (subject to the status of TIE);<br><ul style="list-style-type: none"> <li><b>Remark:</b> note that if AF and AIE are active then <math>\overline{\text{INT}}</math> will be permanently active</li> </ul> |   |
| 3      | AF     | 0 <sup>[2]</sup>   | alarm flag inactive  | <a href="#">Section 8.3.2.1</a>                                       |
|        |        | 1                  | alarm flag active  |   |
| 2      | TF     | 0 <sup>[2]</sup>   | timer flag inactive  | <a href="#">Section 8.3.2.1</a>                                       |
|        |        | 1                  | timer flag active  |   |
| 1      | AIE    | 0 <sup>[2]</sup>   | alarm interrupt disabled   | <a href="#">Section 8.3.2.1</a>                                       |
|        |        | 1                  | alarm interrupt enabled  |   |
| 0      | TIE    | 0 <sup>[2]</sup>   | timer interrupt disabled   | <a href="#">Section 8.3.2.1</a>                                       |
|        |        | 1                  | timer interrupt enabled  |   |

[1] Bits labeled as N should always be written with logic 0.

[2] Default value.

8.3.2.1 Interrupt output

**Bits TF and AF:** When an alarm occurs, AF is set to 1. Similarly, at the end of a timer countdown, TF is set to 1. These bits maintain their value until overwritten by command. If both timer and alarm interrupts are required in the application, the source of the interrupt can be determined by reading these bits. To prevent one flag being overwritten while clearing another, a logic AND is performed during a write access.



**Bits TIE and AIE:** These bits activate or deactivate the generation of an interrupt when TF or AF is asserted respectively. The interrupt is the logical OR of these two conditions when both AIE and TIE are set.

**Countdown timer interrupts:** The pulse generator for the countdown timer interrupt uses an internal clock and is dependent on the selected source clock for the countdown timer and on the countdown value TV. As a consequence, the width of the interrupt pulse varies (see [Table 8](#)).

**Table 8.  $\overline{\text{INT}}$  operation (bit TI\_TP = 1)<sup>[1]</sup>**

| Source clock (Hz) | $\overline{\text{INT}}$ period (s) |        |
|-------------------|------------------------------------|--------|
|                   | TV = 1 <sup>[2]</sup>              | TV > 1 |
| 4096              | 1/8192                             | 1/4096 |
| 64                | 1/128                              | 1/64   |
| 1                 | 1/64                               | 1/64   |
| 1/60              | 1/64                               | 1/64   |

[1] TF and  $\overline{\text{INT}}$  become active simultaneously.

[2] TV = loaded countdown value. Timer is stopped when TV = 0.



### 8.4 Time and date registers

The majority of the registers are coded in the BCD format to simplify application use.

#### 8.4.1 Register Seconds

**Table 9. Seconds - seconds and clock integrity status register (address 02h) bit description**

| Bit    | Symbol  | Value            | Place value | Description  |
|--------|---------|------------------|-------------|--|
| 7      | VL      | 0                | -           | clock integrity is guaranteed                                    |
|        |         | 1 <sup>[1]</sup> | -           | integrity of the clock information is not guaranteed             |
| 6 to 4 | SECONDS | 0 to 5           | ten's place | actual seconds coded in BCD format, see <a href="#">Table 10</a> |
| 3 to 0 |         | 0 to 9           | unit place  |  |

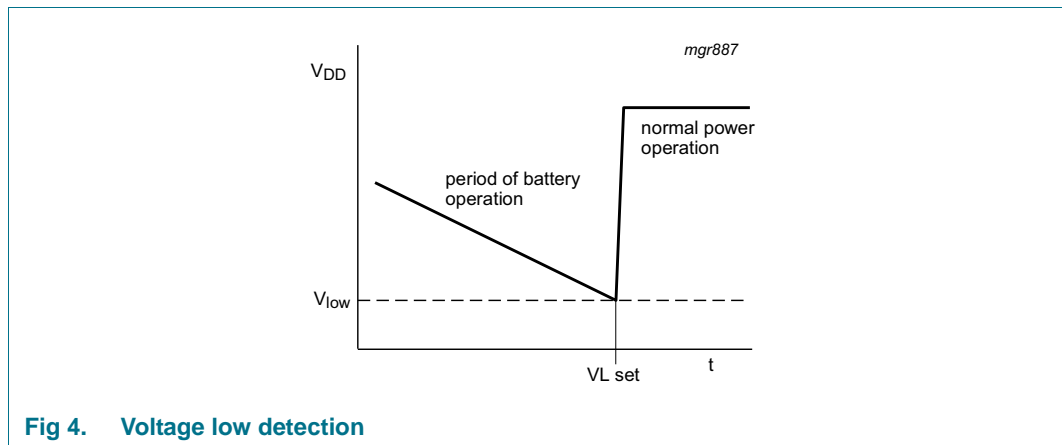
[1] Start-up value.

**Table 10. 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     |

##### 8.4.1.1 Voltage low detector and clock monitor

The PCF8564A has an on-chip voltage low detector. When  $V_{DD}$  drops below  $V_{low}$  the VL (Voltage Low) flag is set to indicate that the integrity of the clock information is no longer guaranteed. The VL flag can only be cleared by command.



**Fig 4. Voltage low detection**

The VL flag is intended to detect the situation when  $V_{DD}$  is decreasing slowly, for example under battery operation. Should the oscillator stop or  $V_{DD}$  reach  $V_{low}$  before power is re-asserted, then the VL flag will be set. This indicates that the time is possibly corrupted.

### 8.4.2 Register Minutes

Table 11. Minutes - minutes register (address 03h) 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  |                                    |

### 8.4.3 Register Hours

Table 12. Hours - hours register (address 04h) bit description

| Bit    | Symbol | Value  | Place value | Description                      |
|--------|--------|--------|-------------|----------------------------------|
| 7 to 6 | -      | -      | -           | unused                           |
| 5 to 4 | HOURS  | 0 to 2 | ten's place | actual hours coded in BCD format |
| 3 to 0 |        | 0 to 9 | unit place  |                                  |

### 8.4.4 Register Days

Table 13. Days - days register (address 05h) 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] The PCF8564A compensates for leap years by adding a 29th day to February if the year counter contains a value which is exactly divisible by 4, including the year 00.

### 8.4.5 Register Weekdays

Table 14. Weekdays - weekdays register (address 06h) bit description

| Bit    | Symbol   | Value  | Description   |
|--------|----------|--------|---|
| 7 to 3 | -        | -      | unused  |
| 2 to 0 | WEEKDAYS | 0 to 6 | actual weekday values, see <a href="#">Table 15</a> |

Table 15. 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 re-assigned by the user.

### 8.4.6 Register Months

Table 16. Months - months and century flag register (address 07h) bit description

| Bit    | Symbol           | Value            | Place value | Description  |
|--------|------------------|------------------|-------------|--|
| 7      | C <sup>[1]</sup> | 0 <sup>[2]</sup> | -           | indicates the century is x                                     |
|        |                  | 1                | -           | indicates the century is x + 1                                 |
| 6 to 5 | -                | -                | -           | unused   |
| 4      | MONTHS           | 0 to 1           | ten's place | actual month coded in BCD format, see <a href="#">Table 17</a> |
| 3 to 0 |                  | 0 to 9           | unit place  |  |

[1] This bit may be re-assigned by the user.

[2] This bit is toggled when the register Years overflows from 99 to 00.

Table 17. Month assignments coded 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     |

### 8.4.7 Register Years

Table 18. Years - years register (08h) bit description

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

[1] When the register Years overflows from 99 to 00, the century bit C in the register Months is toggled.

The PCF8564A compensates for leap years by adding a 29th day to February if the year counter contains a value which is divisible by 4, including the year 00.

### 8.5 Setting and reading the time

Figure 5 shows the data flow and data dependencies starting from the 1 Hz clock tick.



Fig 5. Data flow for the time function

During read/write operations, the time counting circuits (memory locations 02h through 08h) are blocked.

This prevents

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

After this read/write access is completed, the time circuit is released again and any pending request to increment the time counters, that occurred during the read access, is serviced. A maximum of 1 request can be stored; therefore, all accesses must be completed within 1 second (see Figure 6).



Fig 6. 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.

Recommended method for reading the time:

1. Send a START condition and the slave address for write (A2h).
2. Set the address pointer to 2 (seconds) by sending 02h.
3. Send a RE-START condition or STOP followed by START.
4. Send the slave address for read (A3h).
5. Read the seconds.
6. Read the minutes.
7. Read the hours.
8. Read the days.
9. Read the weekdays.
10. Read the century and month.
11. Read the years.
12. Send a STOP condition.

## 8.6 Alarm registers

### 8.6.1 Register Minute\_alarm

Table 19. Minute\_alarm - minute alarm register (address 09h) bit description

| Bit    | Symbol       | Value            | Place value | Description                                  |
|--------|--------------|------------------|-------------|--|
| 7      | AEN_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.

### 8.6.2 Register Hour\_alarm

Table 20. Hour\_alarm - hour alarm register (address 0Ah) bit description

| Bit    | Symbol     | Value            | Place value | Description                                |
|--------|------------|------------------|-------------|--|
| 7      | AEN_H      | 0                | -           | hour alarm is enabled                      |
|        |            | 1 <sup>[1]</sup> | -           | hour alarm is disabled                     |
| 6      | -          | -                | -           | unused                                     |
| 5 to 4 | HOUR_ALARM | 0 to 2           | ten's place | hour alarm information coded in BCD format |
| 3 to 0 |            | 0 to 9           | unit place  |  |

[1] Default value.

### 8.6.3 Register Day\_alarm

Table 21. Day\_alarm - day alarm register (address 0Bh) bit description

| Bit    | Symbol    | Value            | Place value | Description                               |
|--------|-----------|------------------|-------------|---|
| 7      | AEN_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.

### 8.6.4 Register Weekday\_alarm

Table 22. Weekday\_alarm - weekday alarm register (address 0Ch) bit description

| Bit    | Symbol        | Value            | Description                                   |
|--------|---------------|------------------|---|
| 7      | AEN_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 coded in BCD format |

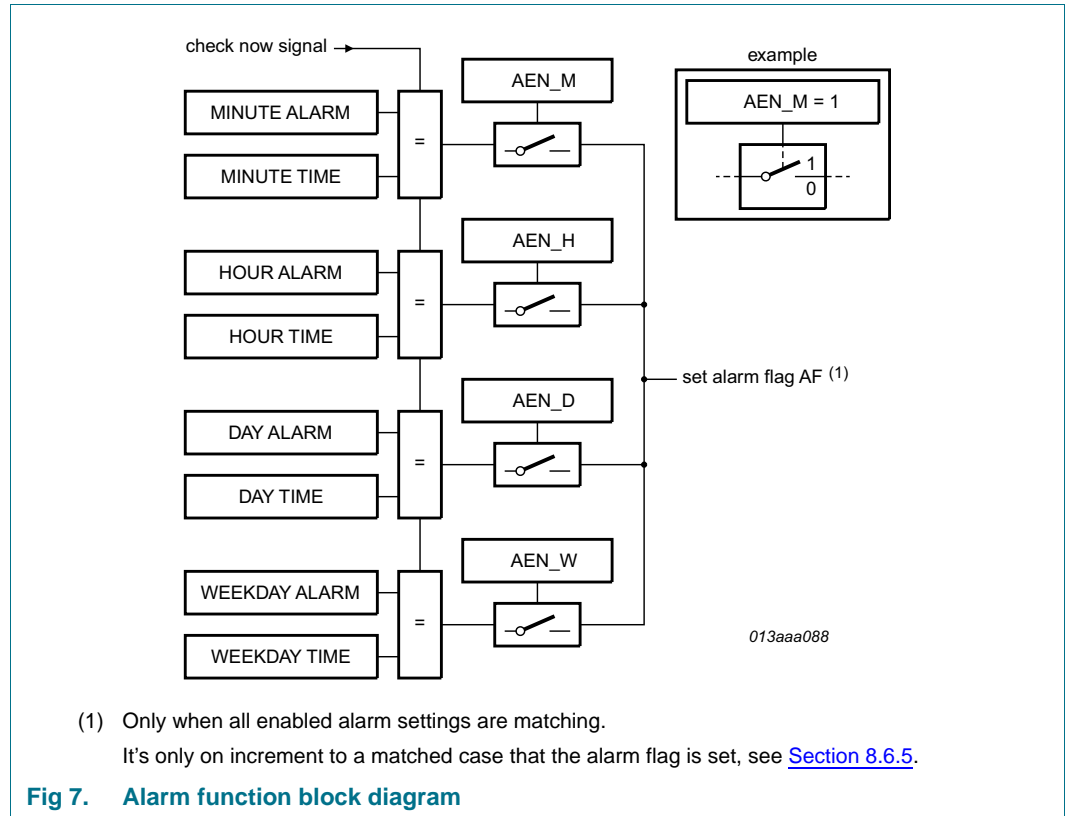
[1] Default value.

### 8.6.5 Alarm flag

By clearing the MSB of one or more of the alarm registers AEN\_x (Alarm Enable), the corresponding alarm condition(s) are active. When an alarm occurs, AF is set to logic 1. The asserted AF can be used to generate an interrupt (INT). The AF is cleared by command.

The registers at addresses 09h through 0Ch contain alarm information. When one or more of these registers is loaded with a valid minute, hour, day, or weekday and its corresponding Alarm Enable bit (AEN\_x) is logic 0, then that information is compared with the current minute, hour, day, and weekday. When all enabled comparisons first match, the Alarm Flag (AF in register Control\_2) is set to logic 1.

The generation of interrupts from the alarm function is controlled via bit AIE. If bit AIE is enabled, the  $\overline{\text{INT}}$  pin follows the condition of bit AF. 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. Alarm registers which have their AEN\_x bit at logic 1 are ignored.



### 8.7 Register CLKOUT\_ctrl and clock output

A programmable square wave is available at pin CLKOUT. Operation is controlled by the FE bit in register CLKOUT\_ctrl at address 0Dh and the CLKOUT output enable pin (CLKOE). To enable pin CLKOUT pin CLKOE must be set HIGH.

Frequencies of 32.768 kHz (default), 1.024 kHz, 32 Hz, and 1 Hz can be generated for use as a system clock, microcontroller clock, input to a charge pump, or for calibration of the oscillator.

**Table 23. CLKOUT\_ctrl - CLKOUT control register (address 0Dh) bit description**

| Bit    | Symbol  | Value             | Description  |
|--------|---------|-------------------|--|
| 7      | FE      | 0                 | the CLKOUT output is inhibited and CLKOUT output is set to logic 0 |
|        |         | 1 <sup>[1]</sup>  | the CLKOUT output is activated                                     |
| 6 to 2 | -       | -                 | unused   |
| 1 to 0 | FD[1:0] |                   | frequency output at pin CLKOUT                                     |
|        |         | 00 <sup>[1]</sup> | 32.768 kHz   |
|        |         | 01                | 1.024 kHz  |
|        |         | 10                | 32 Hz  |
|        |         | 11                | 1 Hz   |

[1] Default value.

## 8.8 Timer function

The 8-bit countdown timer at address 0Fh is controlled by the timer control register at address 0Eh. The timer control register determines one of 4 source clock frequencies for the timer (4.096 kHz, 64 Hz, 1 Hz, or  $\frac{1}{60}$  Hz) and enables or disables the timer. The timer counts down from a software-loaded 8-bit binary value. At the end of every countdown, the timer sets the TF (Timer Flag) to logic 1. The TF may only be cleared using the interface.

The generation of interrupts from the timer function is controlled via bit TIE. If bit TIE is enabled the  $\overline{\text{INT}}$  pin follows the condition of bit TF. The interrupt may be generated as a pulsed signal every countdown period or as a permanently active signal which follows the condition of the timer flag TF. TI\_TP is used for this mode control. When reading the timer, the current countdown value is returned.

### 8.8.1 Register Timer\_ctrl

**Table 24. Timer\_ctrl - timer control register (address 0Eh) bit description**

| Bit    | Symbol  | Value             | Description  |
|--------|---------|-------------------|--|
| 7      | TE      | 0 <sup>[1]</sup>  | timer is disabled                                  |
|        |         | 1                 | timer is enabled                                   |
| 6 to 2 | -       | -                 | unused   |
| 1 to 0 | TD[1:0] |                   | timer source clock frequency select <sup>[2]</sup> |
|        |         | 00                | 4.096 kHz  |
|        |         | 01                | 64 Hz  |
|        |         | 10                | 1 Hz   |
|        |         | 11 <sup>[2]</sup> | $\frac{1}{60}$ Hz                                  |

[1] Default value.

[2] These bits determine the source clock for the countdown timer; when not in use, TD[1:0] should be set to  $\frac{1}{60}$  Hz for power saving.



### 8.8.2 Register Timer

**Table 25. Timer - timer register (address 0Fh) bit description**

| Bit    | Symbol  | Value     | Description                          |
|--------|---------|-----------|--------------------------------------|
| 7 to 0 | TV[7:0] | 0h to FFh | countdown timer value <sup>[1]</sup> |

[1] Countdown period in seconds:  $CountdownPeriod = \frac{TV}{SourceClockFrequency}$  where TV is the countdown timer value.

**Table 26. Timer register bits value range**

| Bit |    |    |    |   |   |   |   |
|-----|----|----|----|---|---|---|---|
| 7   | 6  | 5  | 4  | 3 | 2 | 1 | 0 |
| 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 |

The timer register is an 8-bit binary countdown timer. It is enabled or disabled via the timer control register. The source clock for the timer is also selected by the timer control register. Other timer properties such as single or periodic interrupt generation are controlled via the register Control\_2 (address 01h).

For accurate read back of the count down value, the I<sup>2</sup>C-bus clock (SDA) must be operating at a frequency of at least twice the selected timer clock. Since it is not possible to freeze the countdown timer counter during read back, it is recommended to read the register twice and check for consistent results.

### 8.9 EXT\_CLK test mode

The test mode is entered by setting the TEST1 bit of register Control\_1 to logic 1. The CLKOUT pin then becomes an input. The test mode replaces the internal 64 Hz signal with that applied to the CLKOUT pin. Every 64 positive edges applied to CLKOUT then generates an increment of one second.

The signal applied to the CLKOUT pin should have a minimum pulse width of 300 ns and a maximum period of 1000 ns. The 64 Hz clock, now sourced from CLKOUT, is divided down to 1 Hz by a 2<sup>6</sup> divide chain called a prescaler. The prescaler can be set to a known state by using the STOP bit. When the STOP bit is set, the prescaler is reset to logic 0. (STOP must be cleared before the prescaler can operate.)

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

**Remark:** Entry into EXT\_CLK 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.

#### 8.9.1 Operation example

1. Set EXT\_CLK test mode (Bit 7 Control\_1 = 1).
2. Set STOP (Bit 5 Control\_1 = 1).
3. Clear STOP (Bit 5 Control\_1 = 0).
4. Set time registers to desired value.
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.

### 8.10 STOP bit function

The function of the STOP bit is to allow for accurate starting of the time circuits. The STOP bit function will cause the upper part of the prescaler ( $F_2$  to  $F_{14}$ ) to be held in reset and thus no 1 Hz ticks will be generated (see [Figure 8](#)). The time circuits can then be set and will not increment until the STOP bit is released (see [Figure 9](#) and [Table 27](#)).

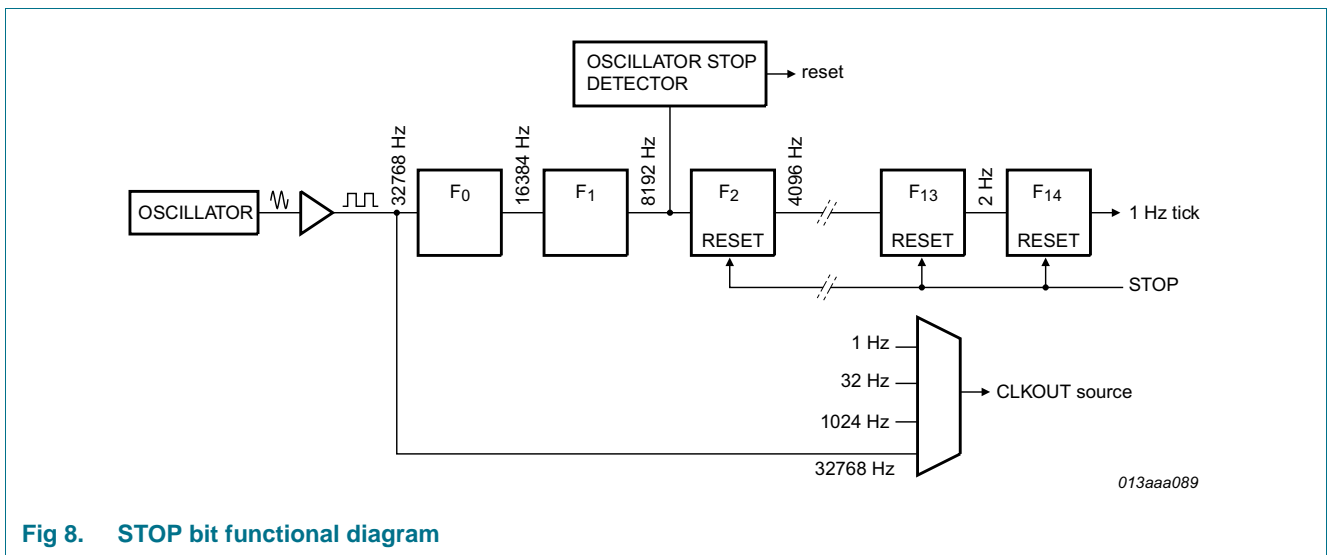


Fig 8. STOP bit functional diagram

The STOP bit function will not affect the output of 32.768 kHz on CLKOUT, but will stop the generation of 1.024 kHz, 32 Hz and 1 Hz.

The lower two stages of the prescaler ( $F_0$  and  $F_1$ ) are not reset and because the I<sup>2</sup>C-bus is asynchronous to the crystal oscillator, the accuracy of re-starting the time circuits will be between zero and one 8.192 kHz cycle (see [Figure 9](#)).

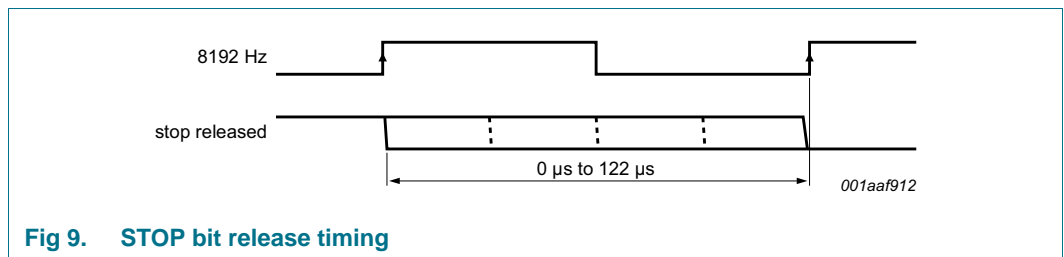


Fig 9. STOP bit release timing

Table 27. First increment of time circuits after STOP bit release

| Bit  | Prescaler bits <a href="#">[1]</a>                               | 1 Hz tick | Time     | Comment   |
|--|--|-----------|----------|---|
| STOP   | F <sub>0</sub> F <sub>1</sub> -F <sub>2</sub> to F <sub>14</sub> |           | hh:mm:ss |   |
| <b>Clock is running normally</b>   |  |           |          |   |
| 0  | 01-0 0001 1101 0100  |           | 12:45:12 | prescaler counting normally                                       |
| <b>STOP bit is activated by user. F<sub>0</sub>F<sub>1</sub> are not reset and values cannot be predicted externally</b> |  |           |          |   |
| 1  | XX-0 0000 0000 0000  |           | 12:45:12 | prescaler is reset; time circuits are frozen                      |
| <b>New time is set by user</b>   |  |           |          |   |
| 1  | XX-0 0000 0000 0000  |           | 08:00:00 | prescaler is reset; time circuits are frozen                      |
| <b>STOP bit is released by user</b>  |  |           |          |   |
| 0  | XX-0 0000 0000 0000  |           | 08:00:00 | prescaler is now running  |
|  | XX-1 0000 0000 0000  |           | 08:00:00 | -   |
|  | XX-0 1000 0000 0000  |           | 08:00:00 | -   |
|  | XX-1 1000 0000 0000  |           | 08:00:00 | -   |
|  | :  |           | :        | :   |
|  | 11-1 1111 1111 1110  |           | 08:00:00 | -   |
|  | 00-0 0000 0000 0001  |           | 08:00:01 | 0 to 1 transition of F <sub>14</sub> increments the time circuits |
|  | 10-0 0000 0000 0001  |           | 08:00:01 | -   |
|  | :  |           | :        | :   |
|  | 11-1 1111 1111 1111  |           | 08:00:01 | -   |
|  | 00-0 0000 0000 0000  |           | 08:00:01 | -   |
|  | 10-0 0000 0000 0000  |           | 08:00:01 | -   |
|  | :  |           | :        | -   |
|  | 11-1 1111 1111 1110  |           | 08:00:01 | -   |
|  | 00-0 0000 0000 0001  |           | 08:00:02 | 0 to 1 transition of F <sub>14</sub> increments the time circuits |

013aaa076

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

The first increment of the time circuits is between 0.507813 s and 0.507935 s after STOP bit is released. The uncertainty is caused by the prescaler bits F<sub>0</sub> and F<sub>1</sub> not being reset (see [Table 27](#)) and the unknown state of the 32 kHz clock.

### 8.11 Reset

The PCF8564A includes an internal reset circuit which is active whenever the oscillator is stopped. In the reset state the I<sup>2</sup>C-bus logic is initialized including the address pointer and all registers are set according to [Table 28](#). I<sup>2</sup>C-bus communication is not possible during reset.

Table 28. Register reset values<sup>[1]</sup>

| Address | Register name | Bit |   |   |   |   |   |   |   |
|---------|---------------|-----|---|---|---|---|---|---|---|
|         |               | 7   | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 00h     | Control_1     | 0   | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 01h     | Control_2     | 0   | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 02h     | Seconds       | 1   | x | x | x | x | x | x | x |
| 03h     | Minutes       | x   | x | x | x | x | x | x | x |
| 04h     | Hours         | x   | x | x | x | x | x | x | x |
| 05h     | Days          | x   | x | x | x | x | x | x | x |
| 06h     | Weekdays      | x   | x | x | x | x | x | x | x |
| 07h     | Months        | x   | x | x | x | x | x | x | x |
| 08h     | Years         | x   | x | x | x | x | x | x | x |
| 09h     | Minute_alarm  | 1   | x | x | x | x | x | x | x |
| 0Ah     | Hour_alarm    | 1   | x | x | x | x | x | x | x |
| 0Bh     | Day_alarm     | 1   | x | x | x | x | x | x | x |
| 0Ch     | Weekday_alarm | 1   | x | x | x | x | x | x | x |
| 0Dh     | CLKOUT_ctrl   | 1   | x | x | x | x | x | 0 | 0 |
| 0Eh     | Timer_ctrl    | 0   | x | x | x | x | x | 1 | 1 |
| 0Fh     | Timer         | x   | x | x | x | x | x | x | x |

[1] Registers marked 'x' are undefined at power-on and unchanged by subsequent resets.

### 8.11.1 Power-On Reset (POR) override

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 circuit has been implemented to disable the POR and speed up functional test of the module. The setting of this mode requires that the I<sup>2</sup>C signals on the pins SDA and SCL are toggled as illustrated in [Figure 10](#). All timings shown are required minimums.

Once the override mode has been entered, the chip immediately stops, being reset, and normal operation may begin, i.e., entry into the EXT\_CLK test mode via I<sup>2</sup>C access. The override mode may be cleared by writing logic 0 to TESTC. TESTC must be set to logic 1 before re-entry into the override mode is possible. Setting TESTC to logic 0 during normal operation has no effect, except to prevent entry into the POR override mode.

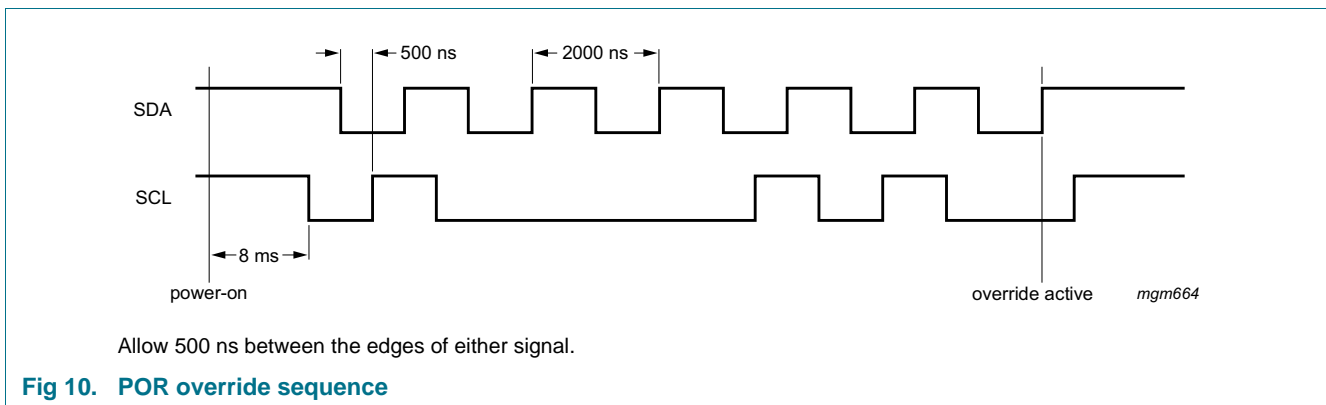


Fig 10. POR override sequence

## 9. Characteristics of the I<sup>2</sup>C-bus

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 must be connected to a positive supply via a pull-up resistor. Data transfer may be initiated only when the bus is not busy.

### 9.1 Bit transfer

One data bit is transferred during each clock pulse. The data on the SDA line must remain stable during the HIGH period of the clock pulse as changes in the data line at this time will be interpreted as a control signal (see [Figure 11](#)).



Fig 11. Bit transfer

### 9.2 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 12](#).

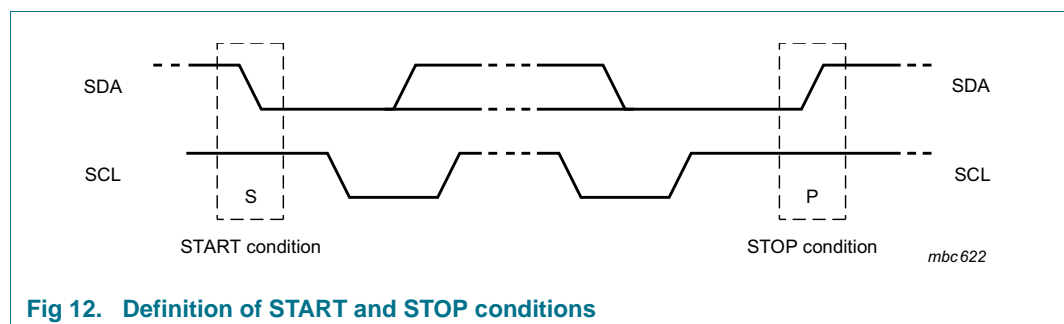


Fig 12. Definition of START and STOP conditions

### 9.3 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 (see [Figure 13](#)).

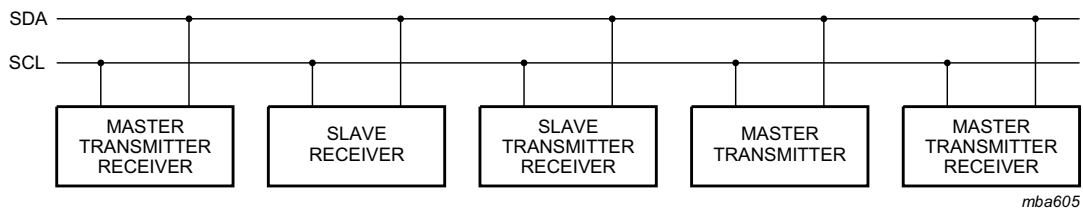


Fig 13. System configuration

### 9.4 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 taken into consideration).
- 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 shown in [Figure 14](#).

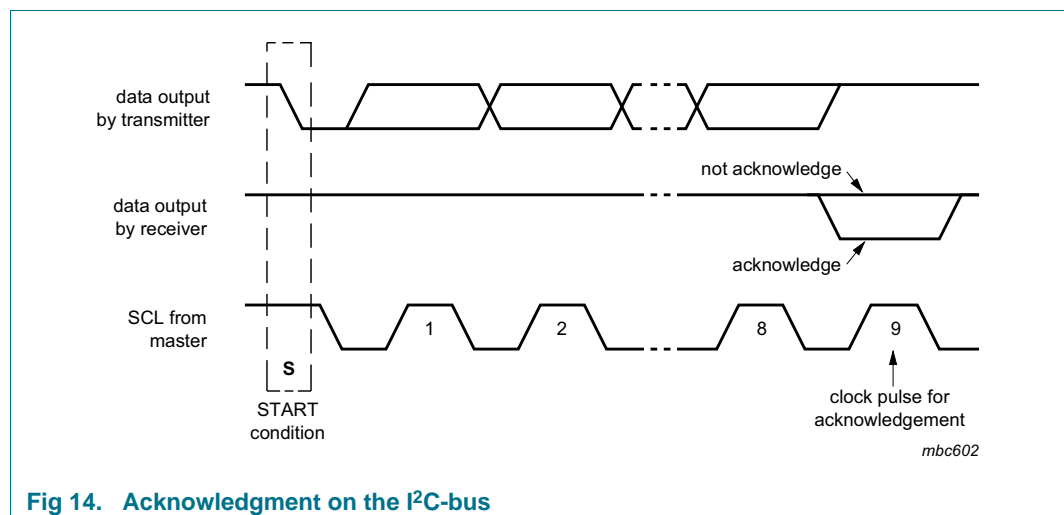


Fig 14. Acknowledgment on the I<sup>2</sup>C-bus

## 10. I<sup>2</sup>C-bus protocol

### 10.1 Addressing

Before any data is transmitted on the I<sup>2</sup>C-bus, the device which should respond is addressed first. The addressing is always carried out with the first byte transmitted after the start procedure.

The PCF8564A acts as a slave receiver or slave transmitter. Therefore, the clock signal SCL is only an input signal, but the data signal SDA is a bidirectional line.

Two slave addresses are reserved for the PCF8564A:

Read: A3h (1010 0011)

Write: A2h (1010 0010)

The PCF8564A slave address is shown in [Figure 14](#).

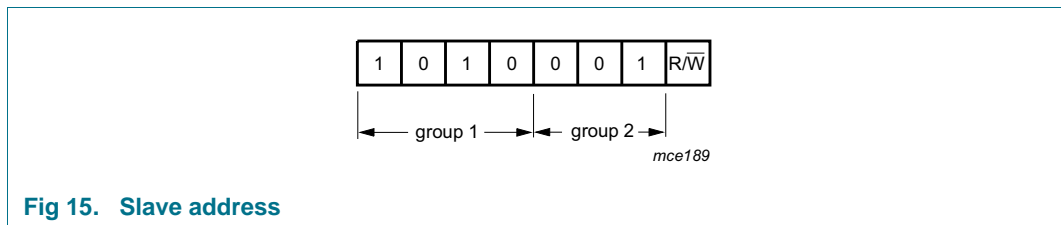


Fig 15. Slave address

### 10.2 Clock and calendar READ or WRITE cycles

[Figure 16](#), [Figure 17](#), and [Figure 18](#) show the I<sup>2</sup>C-bus configuration for the different PCF8564A READ and WRITE cycles. The word address is a 4-bit value that defines which register is to be accessed next. The upper four bits of the word address are not used.

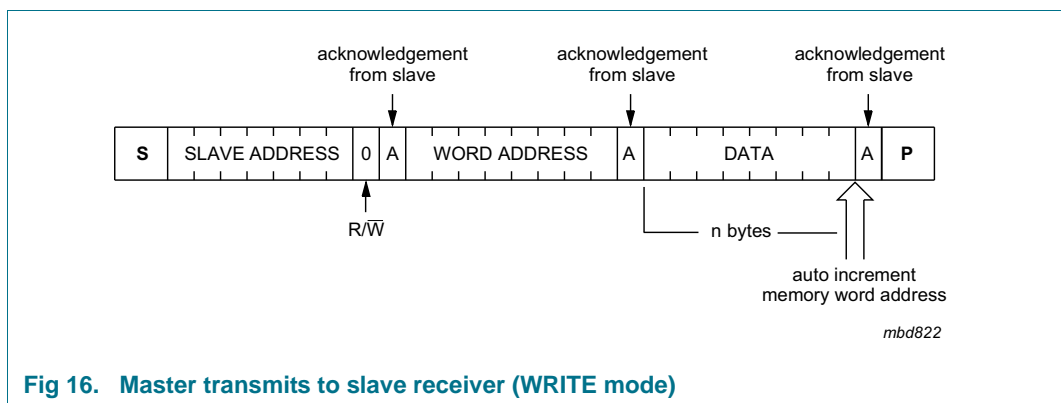
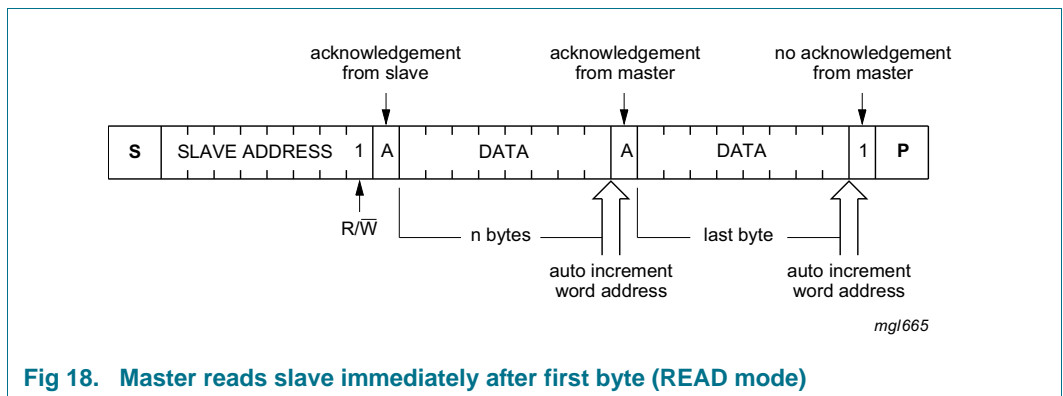
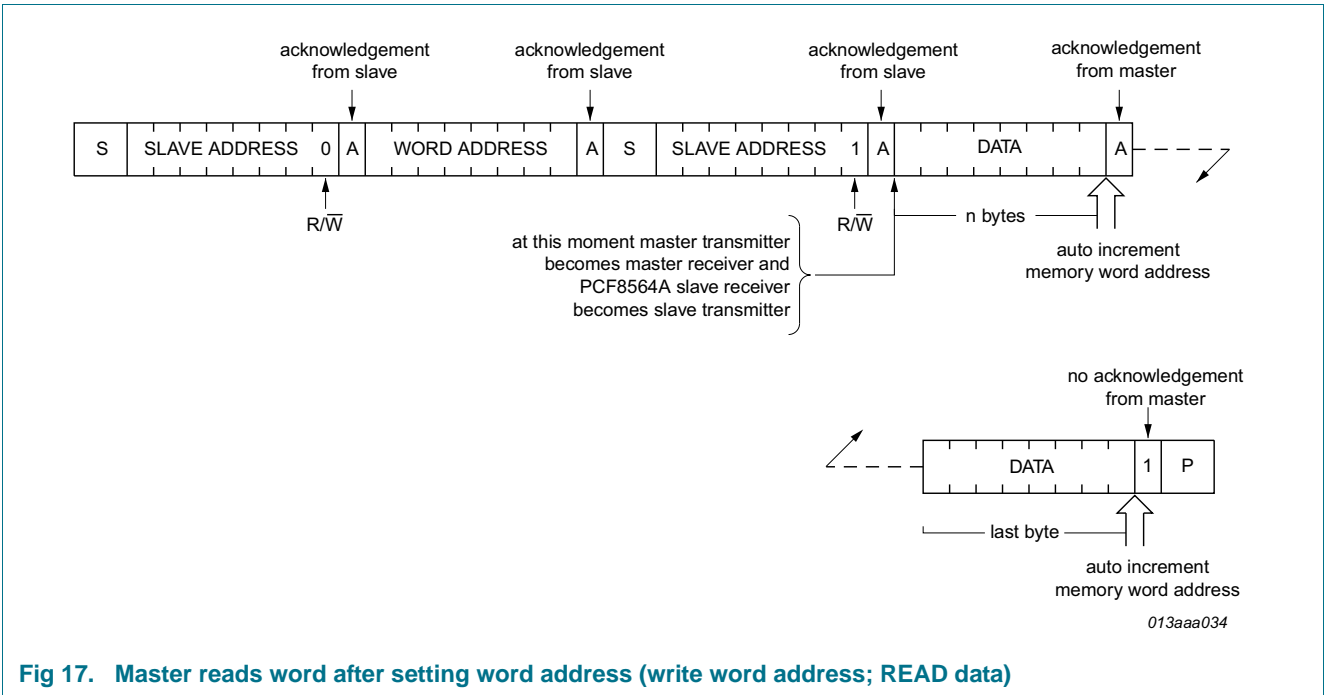


Fig 16. Master transmits to slave receiver (WRITE mode)





10.3 Interface watchdog timer



Fig 19. Interface watchdog timer

During read/write operations, the time counting circuits are frozen. To prevent a situation where the accessing device becomes locked and does not clear the interface, the PCF8564A has a built in watchdog timer. Should the interface be active for more than 1 s from the time a valid slave address is transmitted, then the PCF8564A will automatically clear the interface and allow the time counting circuits to continue counting. The watchdog will trigger between 1 s and 2 s after receiving a valid slave address. Each time the watchdog period is exceeded, 1 s will be lost from the time counters.

The watchdog is implemented to prevent the excessive loss of time due to interface access failure e.g. if main power is removed from a battery backed-up system during an interface access.

## 11. Internal circuitry

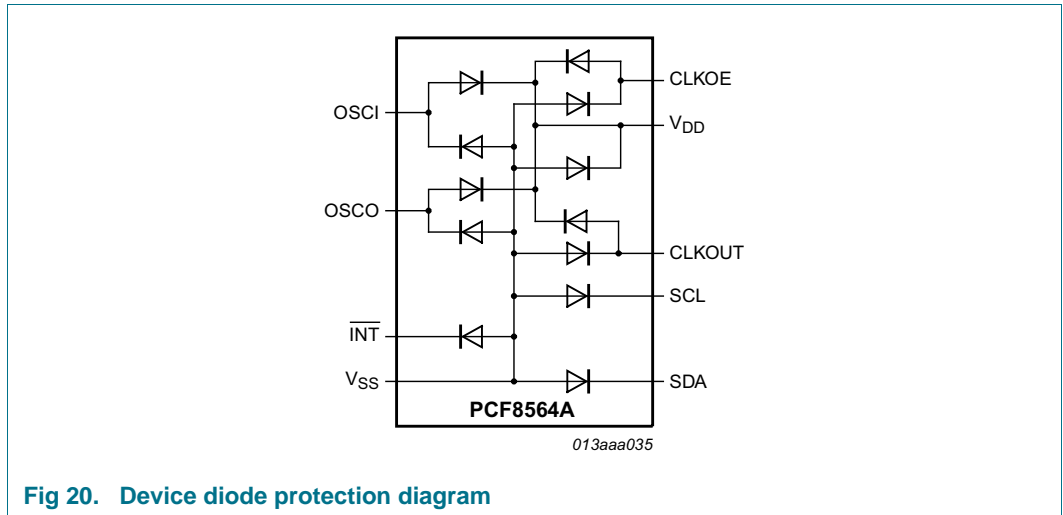


Fig 20. Device diode protection diagram

## 12. Safety notes

### CAUTION



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

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

### CAUTION



Semiconductors are light sensitive. Exposure to light sources can cause the IC to malfunction. The IC must be protected against light. The protection must be applied to all sides of the IC.

## 13. Limiting values

**Table 29. Limiting values**

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

| Symbol           | Parameter                       | Conditions        | Min     | Max   | Unit |
|------------------|---------------------------------|-------------------|---------|-------|------|
| V <sub>DD</sub>  | supply voltage                  |                   | -0.5    | +6.5  | V    |
| V <sub>I</sub>   | input voltage                   |                   | -0.5    | +6.5  | V    |
| V <sub>O</sub>   | output voltage                  |                   | -0.5    | +6.5  | V    |
| I <sub>DD</sub>  | supply current                  |                   | -50.0   | +50.0 | mA   |
| I <sub>I</sub>   | input current                   |                   | -10.0   | +10.0 | mA   |
| I <sub>O</sub>   | output current                  |                   | -10.0   | +10.0 | mA   |
| I <sub>SS</sub>  | ground supply current           |                   | -50.0   | +50.0 | mA   |
| P <sub>tot</sub> | total power dissipation         |                   | -       | 300   | mW   |
| V <sub>ESD</sub> | electrostatic discharge voltage | HBM               | [1] -   | ±3500 | V    |
|                  |                                 | MM                | [2] -   | ±250  | V    |
| I <sub>lu</sub>  | latch-up current                | all pins but OSCI | [3] -   | 100   | mA   |
| T <sub>stg</sub> | storage temperature             |                   | [4] -65 | +150  | °C   |
| T <sub>amb</sub> | ambient temperature             | operating device  | -40     | +85   | °C   |

[1] Pass level; Human Body Model (HBM) according to [Ref. 5 "JESD22-A114"](#).

[2] Pass level; Machine Model (MM), according to [Ref. 6 "JESD22-A115"](#).

[3] Pass level; latch-up testing, according to [Ref. 7 "JESD78"](#) at maximum ambient temperature (T<sub>amb(max)</sub>).

[4] According to the NXP store and transport conditions (see [Ref. 11 "UM10569"](#)) the devices have to be stored at a temperature of +5 °C to +45 °C and a humidity of 25 % to 75 %.

## 14. Static characteristics

**Table 30. Static characteristics**

$V_{DD} = 1.8\text{ V to }5.5\text{ V}$ ;  $V_{SS} = 0\text{ V}$ ;  $T_{amb} = -40\text{ °C to }+85\text{ °C}$ ;  $f_{osc} = 32.768\text{ kHz}$ ; quartz  $R_s = 40\text{ k}\Omega$ ;  $C_L = 8\text{ pF}$ ; unless otherwise specified.

| Symbol   | Parameter                | Conditions  | Min            | Typ  | Max            | Unit          |  |
|--|--------------------------|---|----------------|------|----------------|---------------|--|
| <b>Supplies</b>  |                          |   |                |      |                |               |  |
| $V_{DD}$   | supply voltage           | interface inactive; $T_{amb} = 25\text{ °C}$  | [1] 1.0        | -    | 5.5            | V             |  |
|  |                          | interface active; $f_{SCL} = 400\text{ kHz}$  | [1] 1.8        | -    | 5.5            | V             |  |
|  |                          | for clock data integrity;<br>$T_{amb} = 25\text{ °C}$   | $V_{low}$      | -    | 5.5            | V             |  |
| $I_{DD}$   | supply current           | interface active  |                |      |                |               |  |
|  |                          | $f_{SCL} = 400\text{ kHz}$  | -              | -    | 800            | $\mu\text{A}$ |  |
|  |                          | $f_{SCL} = 100\text{ kHz}$  | -              | -    | 200            | $\mu\text{A}$ |  |
|  |                          | interface inactive ( $f_{SCL} = 0\text{ Hz}$ );<br>CLKOUT disabled; $T_{amb} = 25\text{ °C}$                      | [2] [3]<br>[4] |      |                |               |  |
|  |                          | $V_{DD} = 5.0\text{ V}$   | -              | 275  | 550            | nA            |  |
|  |                          | $V_{DD} = 3.0\text{ V}$   | -              | 250  | 500            | nA            |  |
|  |                          | $V_{DD} = 2.0\text{ V}$   | -              | 225  | 450            | nA            |  |
|  |                          | interface inactive ( $f_{SCL} = 0\text{ Hz}$ );<br>CLKOUT disabled;<br>$T_{amb} = -40\text{ °C to }+85\text{ °C}$ | [2] [3]<br>[4] |      |                |               |  |
|  |                          | $V_{DD} = 5.0\text{ V}$   | -              | 500  | 750            | nA            |  |
|  |                          | $V_{DD} = 3.0\text{ V}$   | -              | 400  | 650            | nA            |  |
|  |                          | $V_{DD} = 2.0\text{ V}$   | -              | 400  | 600            | nA            |  |
|  |                          | interface inactive ( $f_{SCL} = 0\text{ Hz}$ );<br>CLKOUT enabled at 32 kHz;<br>$T_{amb} = 25\text{ °C}$          | [4] [5]<br>[6] |      |                |               |  |
|  |                          | $V_{DD} = 5.0\text{ V}$   | -              | 1500 | 3000           | nA            |  |
|  |                          | $V_{DD} = 3.0\text{ V}$   | -              | 1000 | 2000           | nA            |  |
|  |                          | $V_{DD} = 2.0\text{ V}$   | -              | 700  | 1400           | nA            |  |
| interface inactive ( $f_{SCL} = 0\text{ Hz}$ );<br>CLKOUT enabled at 32 kHz;<br>$T_{amb} = -40\text{ °C to }+85\text{ °C}$ | [4] [5]<br>[6]           |   |                |      |                |               |  |
| $V_{DD} = 5.0\text{ V}$  | -                        | 1700  | 3400           | nA   |                |               |  |
| $V_{DD} = 3.0\text{ V}$  | -                        | 1100  | 2200           | nA   |                |               |  |
| $V_{DD} = 2.0\text{ V}$  | -                        | 800   | 1600           | nA   |                |               |  |
| <b>Inputs</b>  |                          |   |                |      |                |               |  |
| $V_i$  | input voltage            | on pins SDA and SCL   | -0.5           | -    | +5.5           | V             |  |
|  |                          | on pins CLKOE and CLKOUT<br>(test mode)   | -0.5           | -    | $V_{DD} + 0.5$ | V             |  |
| $V_{iL}$   | LOW-level input voltage  |   | -              | -    | $0.3V_{DD}$    | V             |  |
| $V_{iH}$   | HIGH-level input voltage |   | $0.7V_{DD}$    | -    | -              | V             |  |

**Table 30. Static characteristics ...continued**

$V_{DD} = 1.8\text{ V to }5.5\text{ V}$ ;  $V_{SS} = 0\text{ V}$ ;  $T_{amb} = -40\text{ °C to }+85\text{ °C}$ ;  $f_{osc} = 32.768\text{ kHz}$ ; quartz  $R_s = 40\text{ k}\Omega$ ;  $C_L = 8\text{ pF}$ ; unless otherwise specified.

| Symbol                  | Parameter                 | Conditions  | Min   | Typ | Max            | Unit          |
|-------------------------|---------------------------|---|-------|-----|----------------|---------------|
| $I_{LI}$                | input leakage current     | $V_I = V_{SS}$ or $V_{DD}$  | -     | 0   | -              | $\mu\text{A}$ |
|                         |                           | post ESD event  | -1    | -   | +1             | $\mu\text{A}$ |
| $C_i$                   | input capacitance         |   | [7] - | -   | 7              | pF            |
| <b>Outputs</b>          |                           |   |       |     |                |               |
| $V_O$                   | output voltage            | on pin CLKOUT   | -0.5  | -   | $V_{DD} + 0.5$ | V             |
|                         |                           | on pin $\overline{\text{INT}}$  | -0.5  | -   | +5.5           | V             |
| $I_{OL}$                | LOW-level output current  | on pin SDA;<br>$V_{OL} = 0.4\text{ V}$ ; $V_{DD} = 5\text{ V}$                      | 3     | -   | -              | mA            |
|                         |                           | on pin $\overline{\text{INT}}$ ;<br>$V_{OL} = 0.4\text{ V}$ ; $V_{DD} = 5\text{ V}$ | -1    | -   | -              | mA            |
|                         |                           | on pin CLKOUT:<br>$V_{OL} = 0.4\text{ V}$ ; $V_{DD} = 5\text{ V}$                   | -1    | -   | -              | mA            |
| $I_{OH}$                | HIGH-level output current | on pin CLKOUT;<br>$V_{OH} = 4.6\text{ V}$ ; $V_{DD} = 5\text{ V}$                   | 1     | -   | -              | mA            |
| $I_{LO}$                | output leakage current    | $V_O = V_{SS}$ or $V_{DD}$  | -     | 0   | -              | $\mu\text{A}$ |
|                         |                           | post ESD event  | -1    | -   | +1             | $\mu\text{A}$ |
| <b>Voltage detector</b> |                           |   |       |     |                |               |
| $V_{low}$               | low voltage               | $T_{amb} = 25\text{ °C}$  | -     | 0.9 | 1.0            | V             |

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

[2] Timer source clock =  $\frac{1}{60}\text{ Hz}$ .

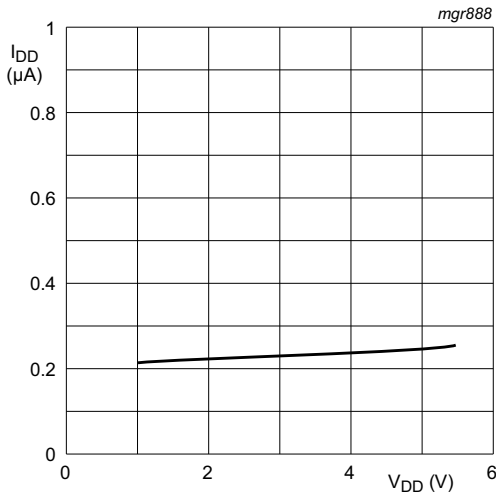
[3] CLKOUT disabled ( $FE = 0$  or  $CLKOE = 0$ ).

[4]  $V_{IL}$  and  $V_{IH}$  with an input voltage swing of  $V_{SS}$  to  $V_{DD}$ .

[5] CLKOUT is open circuit.

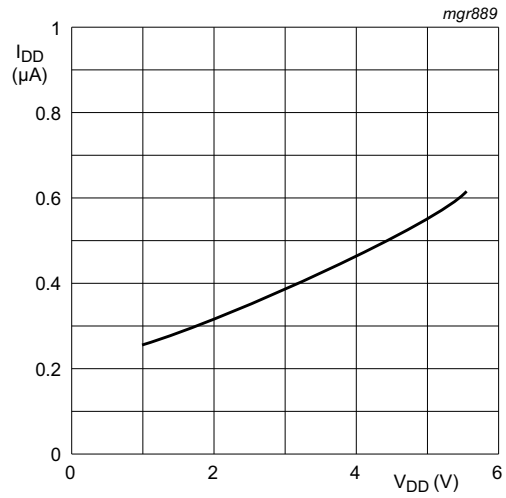
[6] Current consumption when the CLKOUT pin is enabled is a function of the load on the pin, the output frequency, and the supply voltage. The additional current consumption for a given load is calculated from:  $I_{DD} = C \times V_{DD} \times F_{CLKOUT}$ .

[7] Tested on sample basis.



T<sub>amb</sub> = 25 °C; timer = 1 minute; CLKOUT disabled.

Fig 21. I<sub>DD</sub> as a function of V<sub>DD</sub>



T<sub>amb</sub> = 25 °C; timer = 1 minute; CLKOUT = 32 kHz.

Fig 22. I<sub>DD</sub> as a function of V<sub>DD</sub>



V<sub>DD</sub> = 3 V; timer = 1 minute; CLKOUT = 32 kHz.

Fig 23. I<sub>DD</sub> as a function of temperature



T<sub>amb</sub> = 25 °C; normalized to V<sub>DD</sub> = 3 V.

Fig 24. Frequency deviation as a function of V<sub>DD</sub>

## 15. Dynamic characteristics

**Table 31. Dynamic characteristics**

$V_{DD} = 1.8\text{ V to }5.5\text{ V}$ ;  $V_{SS} = 0\text{ V}$ ;  $T_{amb} = -40\text{ °C to }+85\text{ °C}$ ;  $f_{osc} = 32.768\text{ kHz}$ ; quartz  $R_s = 40\text{ k}\Omega$ ;  $C_L = 8\text{ pF}$ ; unless otherwise specified.

| Symbol   | Parameter                                  | Conditions  | Min   | Typ | Max | Unit          |
|--|--|---|-------|-----|-----|---------------|
| <b>Oscillator</b>  |  |   |       |     |     |               |
| $C_{L(itg)}$   | integrated load capacitance                |   | [1] 6 | 8   | 10  | pF            |
| $\Delta f_{osc}/f_{osc}$   | relative oscillator frequency variation    | $\Delta V_{DD} = 200\text{ mV}$ ;<br>$T_{amb} = 25\text{ °C}$ | -     | 0.2 | -   | ppm           |
| <b>Quartz crystal parameters</b>                                       |  |   |       |     |     |               |
| $R_s$  | series resistance                          |   | -     | -   | 100 | k $\Omega$    |
| $C_L$  | load capacitance                           |   | -     | 8   | -   | pF            |
| <b>CLKOUT output</b>   |  |   |       |     |     |               |
| $\delta_{CLKOUT}$  | duty cycle on pin CLKOUT                   |   | [2] - | 50  | -   | %             |
| <b>I<sup>2</sup>C-bus timing characteristics (see Figure 25)[3][4]</b> |  |   |       |     |     |               |
| $f_{SCL}$  | SCL clock frequency                        |   | -     | -   | 400 | kHz           |
| $t_{HD;STA}$   | hold time (repeated) START condition       |   | 0.6   | -   | -   | $\mu\text{s}$ |
| $t_{SU;STA}$   | set-up time for a repeated START condition |   | 0.6   | -   | -   | $\mu\text{s}$ |
| $t_{LOW}$  | LOW period of the SCL clock                |   | 1.3   | -   | -   | $\mu\text{s}$ |
| $t_{HIGH}$   | HIGH period of the SCL clock               |   | 0.6   | -   | -   | $\mu\text{s}$ |
| $t_r$  | rise time of both SDA and SCL signals      |   | -     | -   | 0.3 | $\mu\text{s}$ |
| $t_f$  | fall time of both SDA and SCL signals      |   | -     | -   | 0.3 | $\mu\text{s}$ |
| $C_b$  | capacitive load for each bus line          |   | -     | -   | 400 | pF            |
| $t_{SU;DAT}$   | data set-up time                           |   | 100   | -   | -   | ns            |
| $t_{HD;DAT}$   | data hold time                             |   | 0     | -   | -   | ns            |
| $t_{SU;STO}$   | set-up time for STOP condition             |   | 0.6   | -   | -   | $\mu\text{s}$ |
| $t_{w(\text{spike})}$  | spike pulse width                          |   | -     | -   | 50  | ns            |

[1] Integrated load capacitance,  $C_{L(itg)}$ , is a calculation of  $C_{OSCI}$  and  $C_{OSCO}$  in series:  $C_{L(itg)} = \frac{(C_{OSCI} \cdot C_{OSCO})}{(C_{OSCI} + C_{OSCO})}$ .

[2] Unspecified for  $f_{CLKOUT} = 32.768\text{ kHz}$ .

[3] 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  $V_{DD}$ .

[4] A detailed description of the I<sup>2</sup>C-bus specification is given in [Ref. 9 "UM10204"](#).

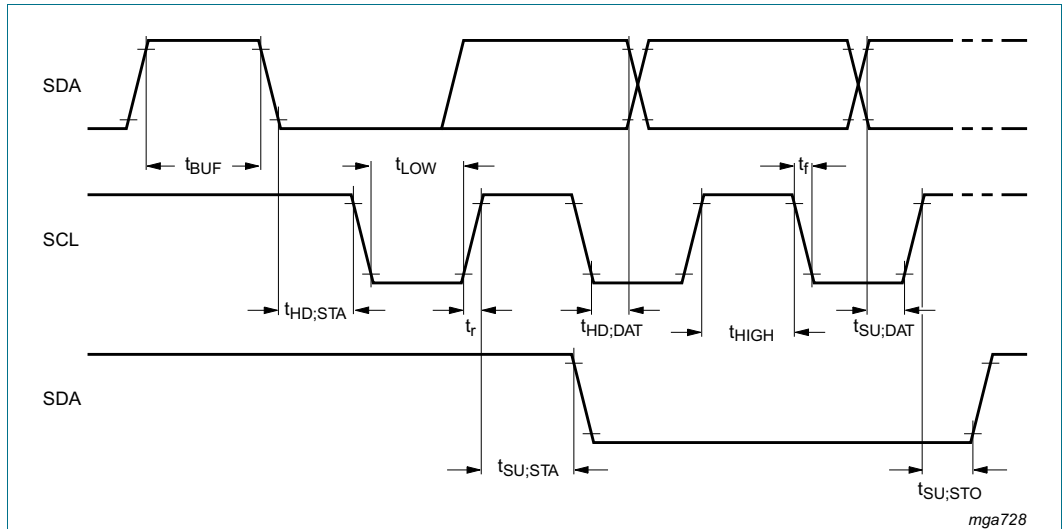
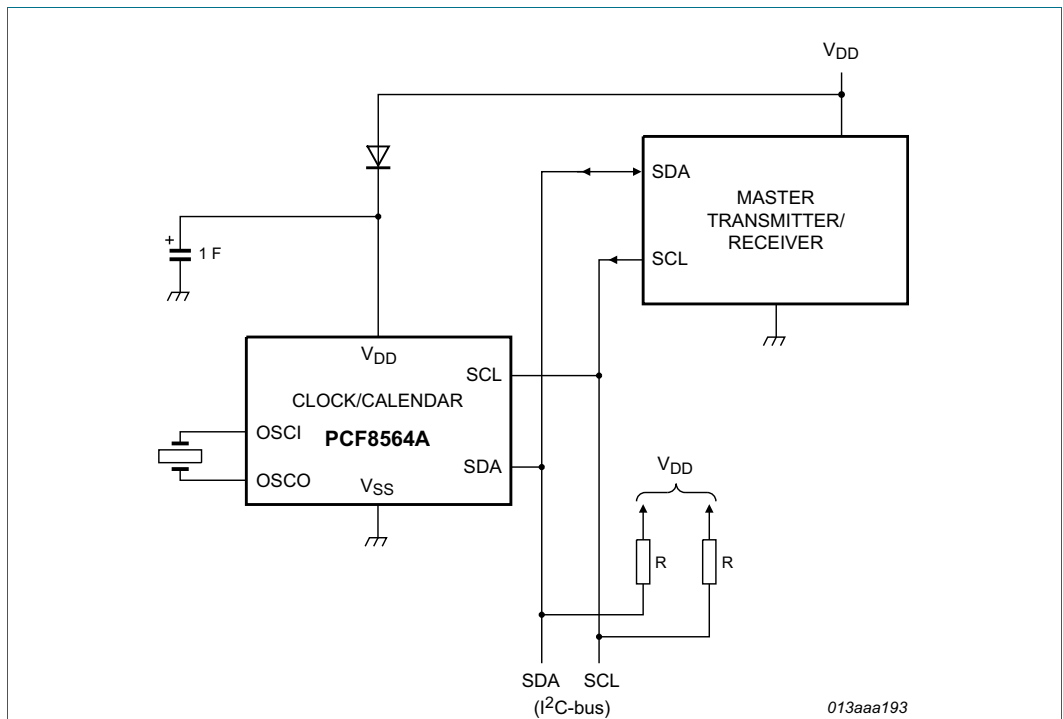


Fig 25. I<sup>2</sup>C-bus timing waveforms

## 16. Application information



Connect CLKOE to an appropriate level.

A 1 farad super capacitor combined with a low V<sub>F</sub> diode can be used as a standby or back-up supply. With the RTC in its minimum power configuration, the RTC may operate for weeks.

Fig 26. Application diagram



17. Bare die outline

Wire bond die; 9 bonding pads

PCF8564AU

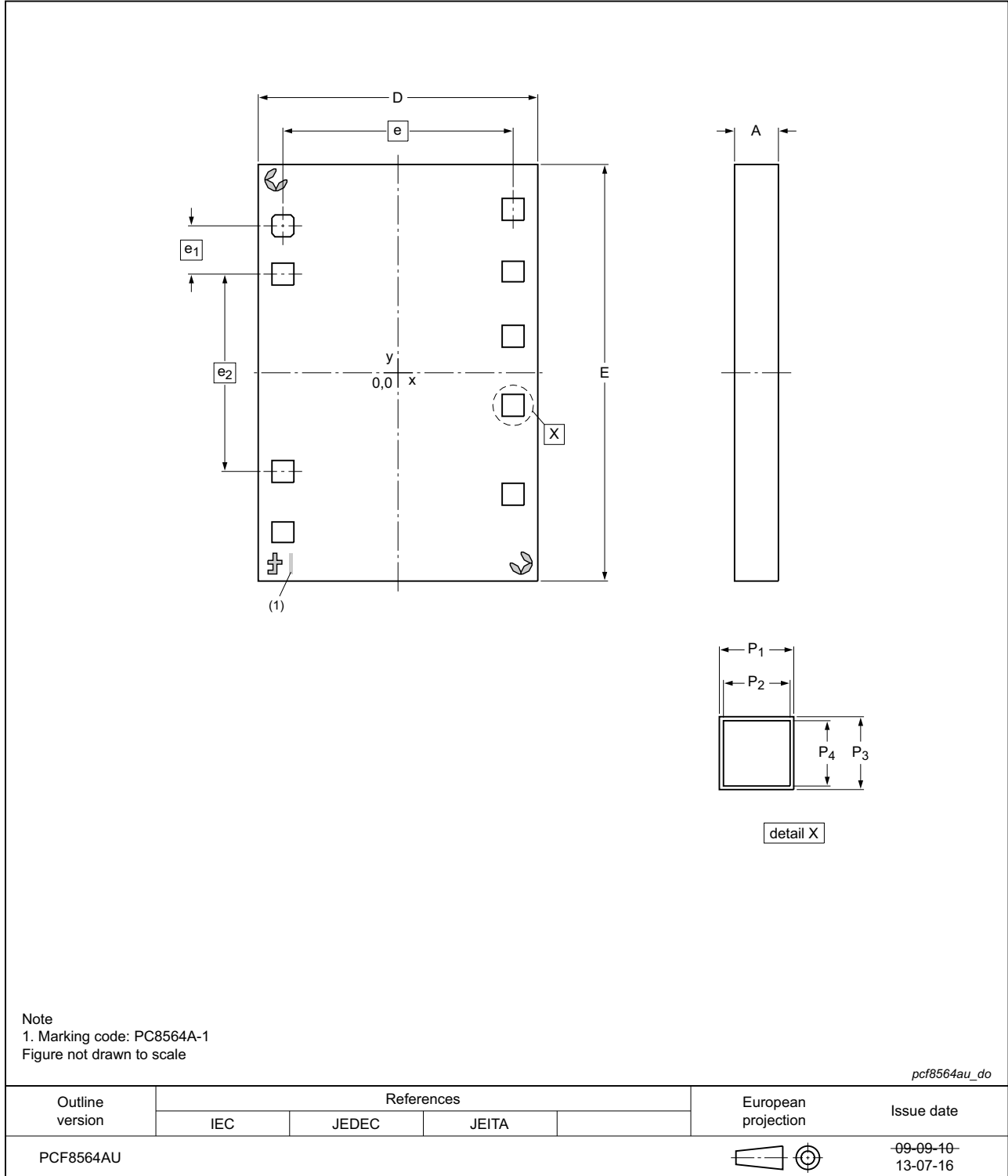


Fig 27. Bare die outline of PCF8564AU/x

**Table 32. Dimensions of PCF8564AU/x***Chip dimensions including saw line. Original dimensions are in mm.*

| Unit (mm) | A                   | D    | E    | e    | e <sub>1</sub> | e <sub>2</sub> | P <sub>1</sub> | P <sub>2</sub> | P <sub>3</sub> | P <sub>4</sub> |
|-----------|---------------------|------|------|------|----------------|----------------|----------------|----------------|----------------|----------------|
| max       | -                   | -    | -    | -    | -              | -              | -              | -              | -              | -              |
| nom       | <a href="#">[1]</a> | 1.26 | 1.89 | 1.05 | 0.22           | 0.9            | 0.1            | 0.09           | 0.1            | 0.09           |
| min       | -                   | -    | -    | -    | -              | -              | -              | -              | -              | -              |

[1] Depending on wafer thickness, see [Table 37](#).

Bare die; 9 bumps

PCF8564AUG

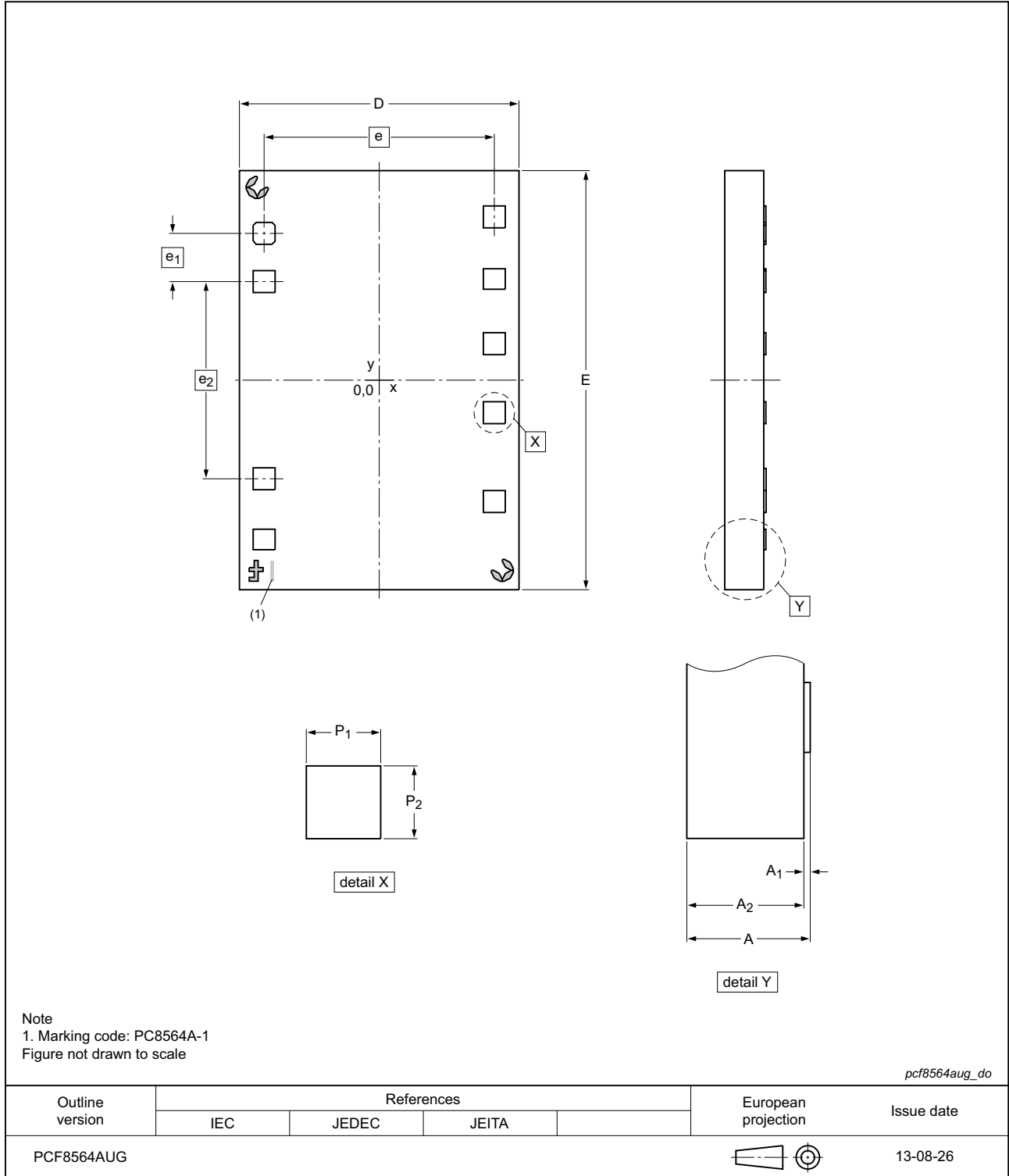


Fig 28. Bare die outline of PCF8564AUG/x

**Table 33. Dimensions of PCF8564AUG/x***Chip dimensions including saw line. Original dimensions are in mm.*

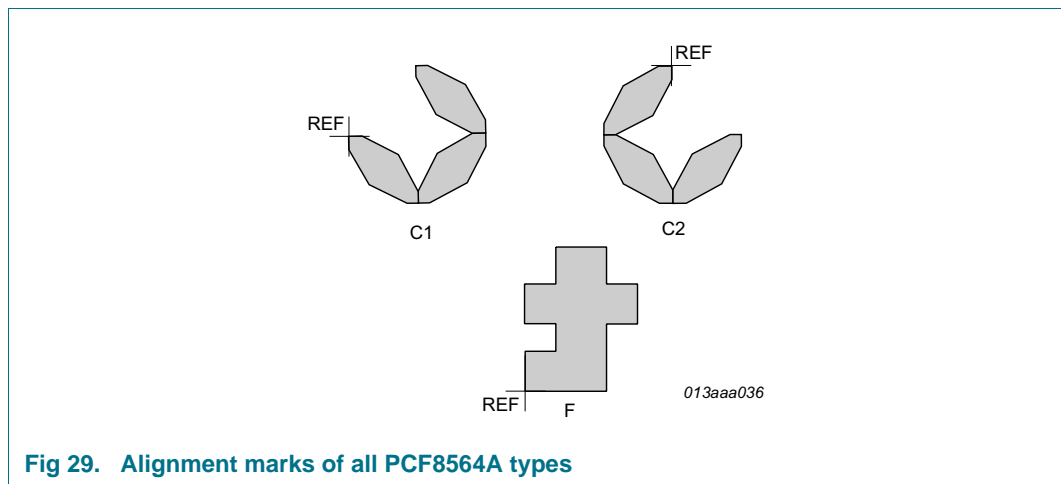
| Unit (mm) | A   | A <sub>1</sub> | A <sub>2</sub> | D    | E    | e    | e <sub>1</sub> | e <sub>2</sub> | P <sub>1</sub> | P <sub>2</sub> |
|-----------|-----|----------------|----------------|------|------|------|----------------|----------------|----------------|----------------|
| max       | -   | -              | -              | -    | -    | -    | -              | -              | -              | -              |
| nom       | [1] | 0.015          | [1]            | 1.26 | 1.89 | 1.05 | 0.22           | 0.9            | 0.09           | 0.09           |
| min       | -   | -              | -              | -    | -    | -    | -              | -              | -              | -              |

[1] Depending on wafer thickness, see [Table 37](#).

**Table 34. Pin location of all PCF8564A types**

All x/y coordinates represent the position of the center of each pin with respect to the center (x/y = 0) of the chip; see [Figure 27](#) and [Figure 28](#).

| Symbol          | Pad | X (μm) | Y (μm) | Description                              |
|-----------------|-----|--------|--------|--|
| OSCI            | 1   | -523.0 | 689.4  | oscillator input                         |
| OSCO            | 2   | -523.0 | 469.4  | oscillator output                        |
| INT             | 3   | -523.0 | -429.8 | open-drain interrupt output (active LOW) |
| V <sub>SS</sub> | 4   | -523.0 | -684.4 | ground (substrate)                       |
| SDA             | 5   | 524.9  | -523.8 | serial data I/O                          |
| SCL             | 6   | 524.9  | -138.6 | serial clock input                       |
| CLKOUT          | 7   | 524.9  | 162.5  | CMOS push-pull clock output              |
| V <sub>DD</sub> | 8   | 524.9  | 443.3  | supply                                   |
| CLKOE           | 9   | 524.9  | 716.3  | CLKOUT output enable                     |



**Fig 29. Alignment marks of all PCF8564A types**

**Table 35. Alignment marks of all PCF8564A types**

All x/y coordinates represent the position of the REF point (see [Figure 29](#)) with respect to the center (x/y = 0) of the chip; see [Figure 27](#) and [Figure 28](#).

| Alignment markers | Size (μm) | X (μm) | Y (μm) |
|-------------------|-----------|--------|--------|
| C1                | 100 × 100 | 465.2  | -826.3 |
| C2                | 100 × 100 | -523.0 | 890.0  |
| F                 | 90 × 117  | -569.9 | -885.5 |

**Table 36. Gold bump hardness**

| Type number       | Min | Max | Unit <sup>[1]</sup> |
|-------------------|-----|-----|---------------------|
| PCF8564AUG/12HB/1 | 35  | 80  | HV                  |

[1] Pressure of diamond head: 10 g to 50 g.

## 18. Handling information

---

All input and output pins are protected against ElectroStatic Discharge (ESD) under normal handling. When handling Metal-Oxide Semiconductor (MOS) devices ensure that all normal precautions are taken as described in *JESD625-A*, *IEC 61340-5* or equivalent standards.

## 19. Packing information

### 19.1 Wafer and Film Frame Carrier (FFC) information

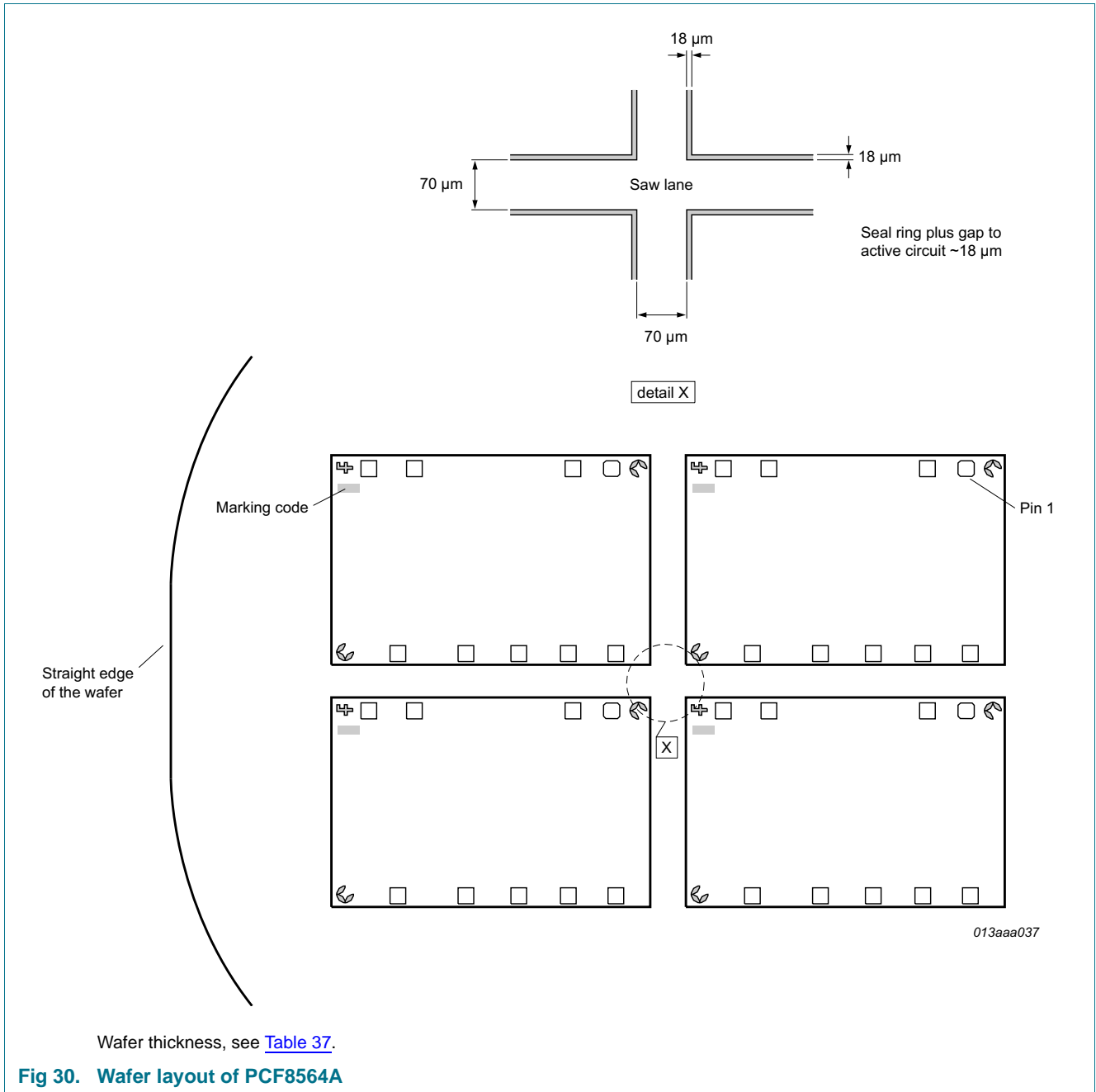


Table 37. PCF8564A wafer information

| Type number       | Wafer thickness | Wafer diameter | FFC for wafer size | Marking of bad die |
|-------------------|-----------------|----------------|--------------------|--------------------|
| PCF8564AU/5BB/1   | 0.28 mm         | 6 inch         | -                  | inking             |
| PCF8564AU/5GB/1   | 0.69 mm         | 6 inch         | -                  | inking             |
| PCF8564AU/5GC/1   | 0.69 mm         | 6 inch         | -                  | wafer mapping      |
| PCF8564AU/10AB/1  | 0.20 mm         | 6 inch         | 6 inch             | inking             |
| PCF8564AUG/12HB/1 | 0.15 mm         | 6 inch         | 8 inch             | inking             |

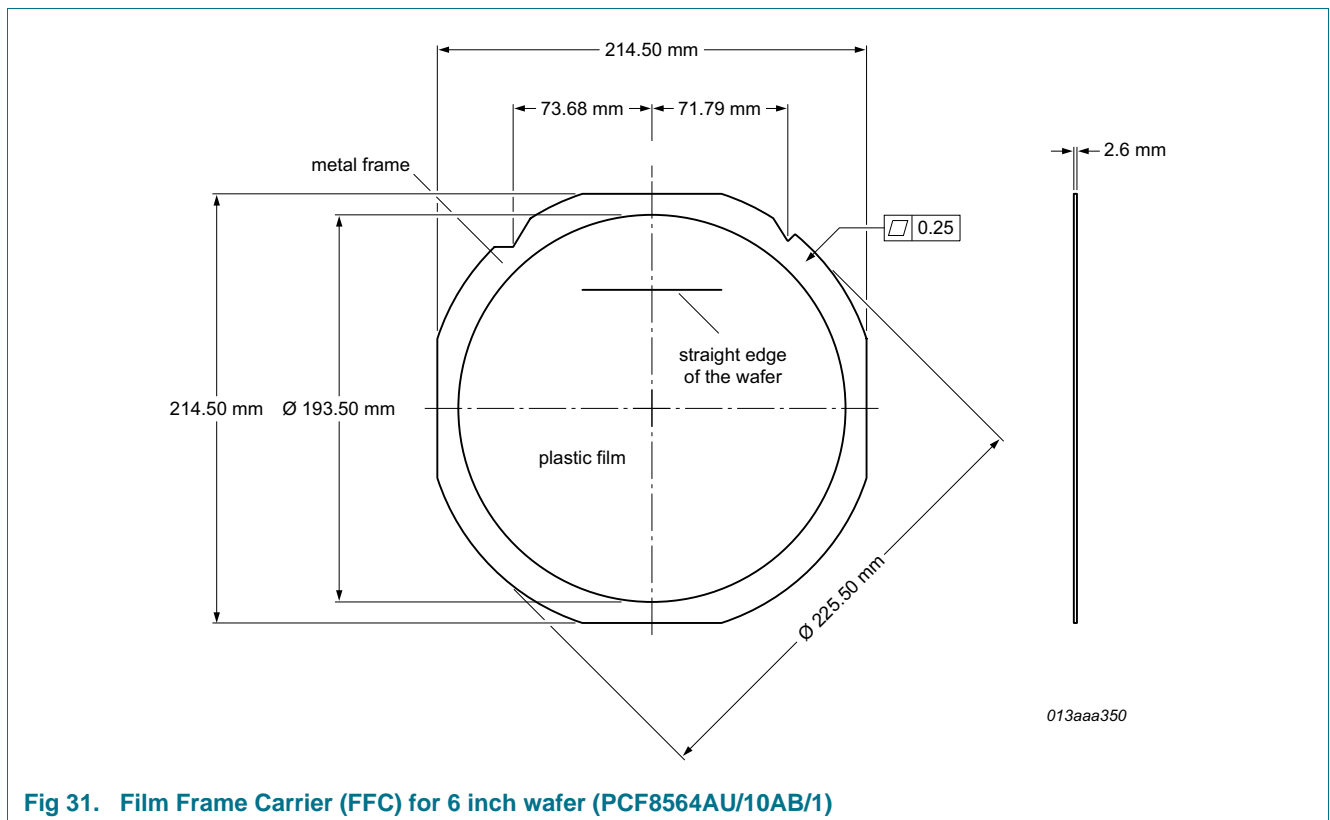






Fig 32. Film Frame Carrier (FFC) for 8 inch wafer (PCF8564AUG/12HB/1)

## 20. Abbreviations

**Table 38. Abbreviations**

| Acronym          | Description                             |
|------------------|---|
| BCD              | Binary Coded Decimal                    |
| CMOS             | Complementary Metal Oxide Semiconductor |
| FFC              | Film Frame Carrier                      |
| HBM              | Human Body Model                        |
| I <sup>2</sup> C | Inter-Integrated Circuit                |
| IC               | Integrated Circuit                      |
| LSB              | Least Significant Bit                   |
| MM               | Machine Model                           |
| MOS              | Metal Oxide Semiconductor               |
| MSB              | Most Significant Bit                    |
| MSL              | Moisture Sensitivity Level              |
| PCB              | Printed-Circuit Board                   |
| POR              | Power-On Reset                          |
| ROM              | Read Only Memory                        |
| RTC              | Real Time Clock                         |
| SCL              | Serial CLock line                       |
| SDA              | Serial DAta line                        |

## 21. References

- [1] **AN10439** — Wafer Level Chip Size Package
- [2] **AN10706** — Handling bare die
- [3] **IEC 60134** — Rating systems for electronic tubes and valves and analogous semiconductor devices
- [4] **IEC 61340-5** — Protection of electronic devices from electrostatic phenomena
- [5] **JESD22-A114** — Electrostatic Discharge (ESD) Sensitivity Testing Human Body Model (HBM)
- [6] **JESD22-A115** — Electrostatic Discharge (ESD) Sensitivity Testing Machine Model (MM)
- [7] **JESD78** — IC Latch-Up Test
- [8] **JESD625-A** — Requirements for Handling Electrostatic-Discharge-Sensitive (ESDS) Devices
- [9] **UM10204** — I<sup>2</sup>C-bus specification and user manual
- [10] **UM10301** — User Manual for NXP Real Time Clocks PCF85x3, PCA8565 and PCF2123, PCA2125
- [11] **UM10569** — Store and transport requirements

## 22. Revision history

Table 39. Revision history

| Document ID    | Release date  | Data sheet status  | Change notice | Supersedes   |
|----------------|---|--------------------|---------------|--------------|
| PCF8564A v.3   | 20130826  | Product data sheet | -             | PCF8564A v.2 |
| Modifications: | <ul style="list-style-type: none"><li>• adjusted product and ordering information</li><li>• added <a href="#">Figure 19</a></li></ul> |                    |               |              |
| PCF8564A v.2   | 20100930  | Product data sheet | -             | PCF8564A v.1 |
| PCF8564A v.1   | 20091008  | Product data sheet | -             | -            |

## 23. Legal information

### 23.1 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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