



PCF8563

Real-time clock/calendar

Rev. 06 — 21 February 2008

Product data sheet

1. General description

The PCF8563 is a CMOS real-time clock/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 a two-line bidirectional I²C-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

- Provides year, month, day, weekday, hours, minutes and seconds based on 32.768 kHz quartz crystal
- Century flag
- Clock operating voltage: 1.8 V to 5.5 V
- Low backup current; typical 0.25 μ A at $V_{DD} = 3.0$ V and $T_{amb} = 25$ °C
- 400 kHz two-wire I²C-bus interface (at $V_{DD} = 1.8$ V to 5.5 V)
- Programmable clock output for peripheral devices (32.768 kHz, 1024 Hz, 32 Hz and 1 Hz)
- Alarm and timer functions
- Integrated oscillator capacitor
- Internal power-on reset
- I²C-bus slave address: read A3h and write A2h
- Open-drain interrupt pin
- ElectroStatic Discharge (ESD) protection exceeds 2000 V Human Body Model (HBM) per JESD22-A114, 200 V Machine Model (MM) per JESD22-A115 and 2000 V Charged Device Model (CDM) per JESD22-C101
- Latch-up testing is done to JEDEC standard JESD78 which exceeds 100 mA

3. Applications

- Mobile telephones
- Portable instruments
- Electronic metering
- Battery powered products

4. Ordering information

Table 1. Ordering information

| Type number | Topside mark | Package | | Version |
|-------------|--------------|---------|--|----------|
| | | Name | Description | |
| PCF8563P | PCF8563P | DIP8 | plastic dual in-line package; 8 leads (300 mil) | SOT97-1 |
| PCF8563T | 8563T | SO8 | plastic small outline package; 8 leads; body width 3.9 mm | SOT96-1 |
| PCF8563TS | 8563 | TSSOP8 | plastic thin shrink small outline package; 8 leads; body width 3 mm | SOT505-1 |
| PCF8563BS | 8563S | HVSON10 | plastic thermal enhanced very thin small outline package; no leads; 10 terminals; body 3 × 3 × 0.85 mm | SOT650-1 |

5. Block diagram

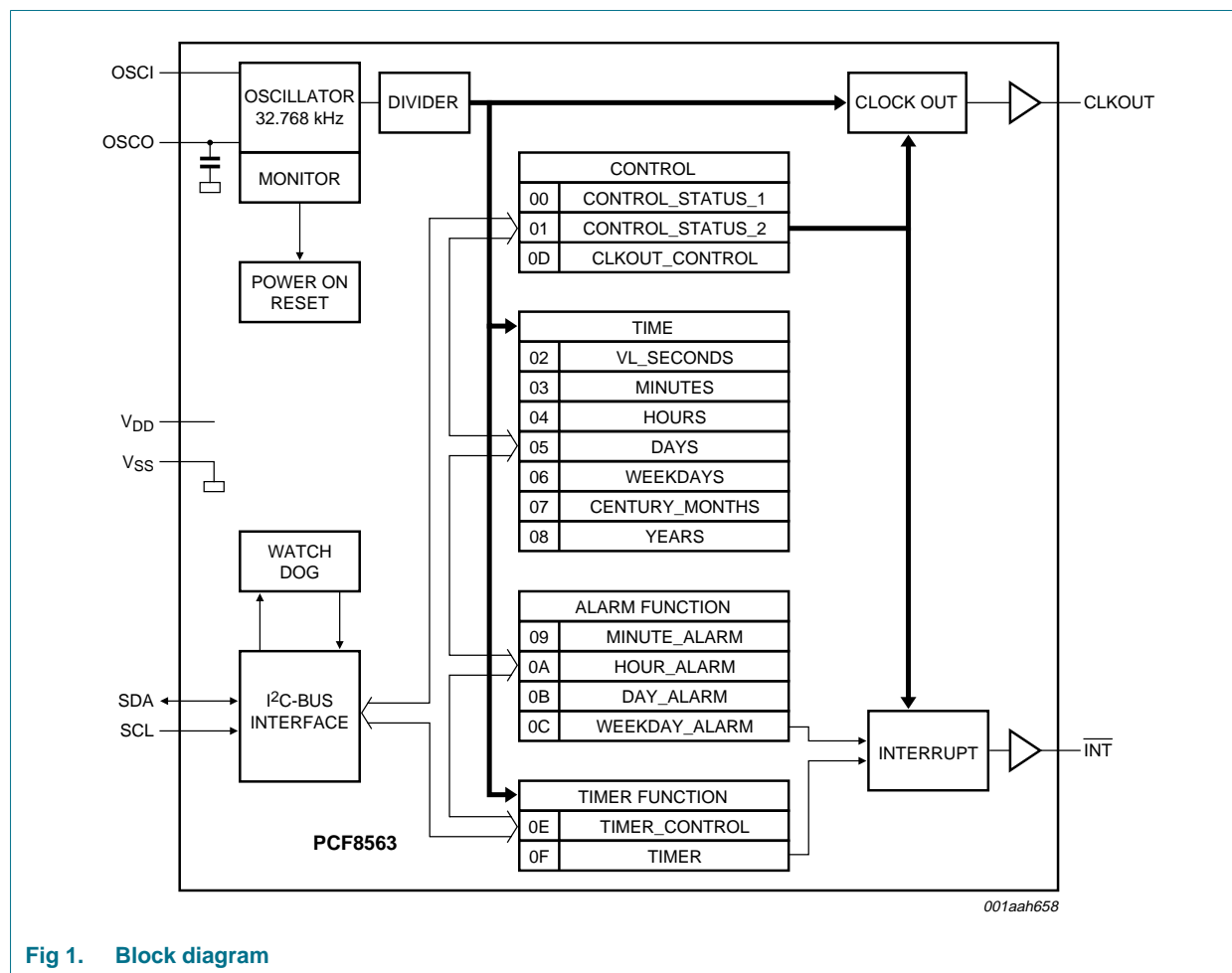
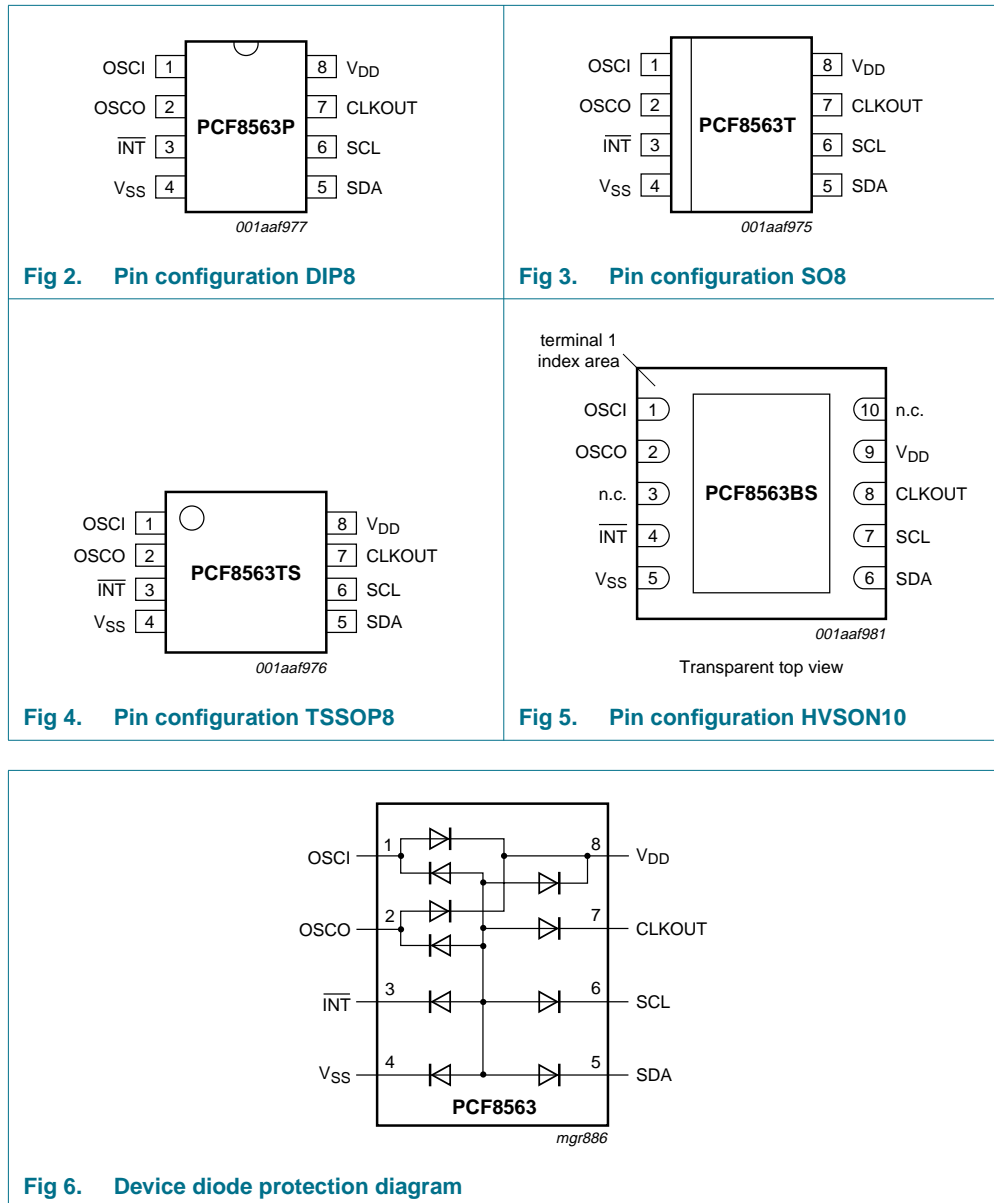


Fig 1. Block diagram

6. Pinning information

6.1 Pinning



6.2 Pin description

Table 2. Pin description

| Symbol | Pin | | Description |
|-------------------------|-------------------|---------|---|
| | DIP8, SO8, TSSOP8 | HVSON10 | |
| OSCI | 1 | 1 | oscillator input |
| OSCO | 2 | 2 | oscillator output |
| n.c. | - | 3 | not connected |
| $\overline{\text{INT}}$ | 3 | 4 | interrupt output (open-drain; active LOW) |
| V _{SS} | 4 | 5 | ground |
| SDA | 5 | 6 | serial data input and output |
| SCL | 6 | 7 | serial clock input |
| CLKOUT | 7 | 8 | clock output, open-drain |
| V _{DD} | 8 | 9 | positive supply voltage |
| n.c. | - | 10 | not connected |

7. Functional description

The PCF8563 contains sixteen 8-bit registers with an auto-incrementing address register, an on-chip 32.768 kHz oscillator with one integrated capacitor, a frequency divider which provides the source clock for the Real-Time Clock/calendar (RTC), a programmable clock output, a timer, an alarm, a voltage-low detector and a 400 kHz I²C-bus interface.

All 16 registers 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 memory 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, weekdays, months, years as well as the minute alarm, hour alarm, day alarm and weekday alarm registers are all coded in Binary Coded Decimal (BCD) format.

When one of the RTC registers is read the contents of all counters are frozen. Therefore, faulty reading of the clock/calendar during a carry condition is prevented.

7.1 Alarm function modes

By clearing the MSB of one or more of the alarm registers (bit AE = Alarm Enable), the corresponding alarm condition(s) will be active. In this way an alarm can be generated from once per minute up to once per week. The alarm condition sets the Alarm Flag (AF). The asserted AF can be used to generate an interrupt (on pin $\overline{\text{INT}}$). The AF can only be cleared by software.

7.2 Timer

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 (4096 Hz, 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 Timer Flag (TF). The TF may only be cleared by software. The asserted TF can be used to generate an interrupt (on pin $\overline{\text{INT}}$). The interrupt may be generated as a pulsed signal every countdown period or as a permanently active signal which follows the state of TF. Bit TI_TP is used to control this mode selection. When reading the timer, the current countdown value is returned.

7.3 Clock output

A programmable square wave is available at pin CLKOUT. Operation is controlled by the CLKOUT control register at address 0Dh. Frequencies of 32.768 kHz (default), 1024 Hz, 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 an open-drain output and enabled at power-on. If disabled it becomes high-impedance.

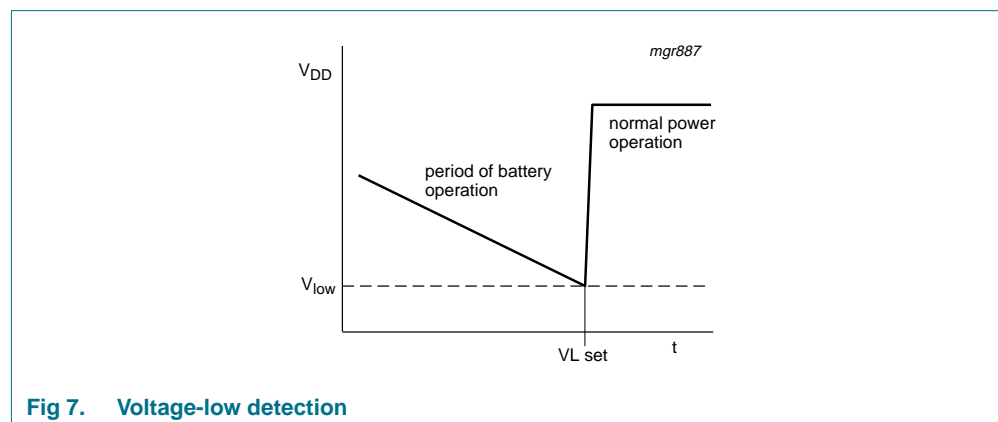
7.4 Reset

The PCF8563 includes an internal reset circuit which is active whenever the oscillator is stopped. In the reset state the I²C-bus logic is initialized and all registers are reset according to [Table 25](#).

7.5 Voltage-low detector

The PCF8563 has an on-chip voltage-low detector (see [Figure 7](#)). When V_{DD} drops below V_{low} , bit VL in the seconds register is set to indicate that the integrity of the clock information is no longer guaranteed. The VL flag can only be cleared by software.

Bit VL is intended to detect the situation when V_{DD} is decreasing slowly, for example under battery operation. Should V_{DD} reach V_{low} before power is re-asserted then bit VL is set. This will indicate that the time may be corrupted.



7.6 Register organization

Table 3. Formatted registers overview

Bit positions labelled as *x* are not relevant. Bit positions labelled with 0 should always be written with logic 0; if read they could be either logic 0 or logic 1.

| Address | Register name | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|---------|------------------|-------------------------------|--------------------------------------|------------------------------------|--------------------------------|-------|-------------------------------|-------|-------|
| 00h | control_status_1 | TEST1 | 0 | STOP | 0 | TESTC | 0 | 0 | 0 |
| 01h | control_status_2 | 0 | 0 | 0 | TI_TP | AF | TF | AIE | TIE |
| 02h | VL_seconds | VL | <seconds 00 to 59 coded in BCD> | | | | | | |
| 03h | minutes | x | <minutes 00 to 59 coded in BCD> | | | | | | |
| 04h | hours | x | x | <hours 00 to 23 coded in BCD> | | | | | |
| 05h | days | x | x | <days 01 to 31 coded in BCD> | | | | | |
| 06h | weekdays | x | x | x | x | x | <weekdays 0 to 6 in BCD> | | |
| 07h | century_months | C | x | x | <months 01 to 12 coded in BCD> | | | | |
| 08h | years | <years 00 to 99 coded in BCD> | | | | | | | |
| 09h | minute_alarm | AE | <minute alarm 00 to 59 coded in BCD> | | | | | | |
| 0Ah | hour_alarm | AE | x | <hour alarm 00 to 23 coded in BCD> | | | | | |
| 0Bh | day_alarm | AE | x | <day alarm 01 to 31 coded in BCD> | | | | | |
| 0Ch | weekday_alarm | AE | x | x | x | x | <weekday alarm 0 to 6 in BCD> | | |
| 0Dh | CLKOUT_control | FE | x | x | x | x | x | FD1 | FD0 |
| 0Eh | timer_control | TE | x | x | x | x | x | TD1 | TD0 |
| 0Fh | timer | <timer countdown value> | | | | | | | |

7.6.1 Control_status_1 register

Table 4. Control_status_1 - Control and Status register 1 (address 00h) bit description

| Bit | Symbol | Value | Description |
|--------|--------|--------------------------|--|
| 7 | TEST1 | 0 | Normal mode |
| | | 1 | EXT_CLK test mode |
| 6 | 0 | default value is logic 0 | |
| 5 | STOP | 0 | RTC source clock runs |
| | | 1 | all RTC divider chain flip-flops are asynchronously set to logic 0; the RTC clock is stopped (CLKOUT at 32.768 kHz is still available) |
| 4 | 0 | default value is logic 0 | |
| 3 | TESTC | 0 | Power-on reset override facility is disabled; set to logic 0 for normal operation |
| | | 1 | Power-on reset override may be enabled |
| 2 to 0 | 0 | default value is logic 0 | |

7.6.2 Control_status_2 register

Bits TF and AF: When an alarm occurs, AF is set to logic 1. Similarly, at the end of a timer countdown, TF is set to logic 1. These bits maintain their value until overwritten by software. 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.

Table 5. Control_status_2 - Control and Status register 2 (address 01h) bit description

| Bit | Symbol | Value | Description |
|--------|--------|-----------|---|
| 7 to 5 | 0 | | default value is logic 0 |
| 4 | TI_TP | 0 | $\overline{\text{INT}}$ is active when TF is active (subject to the status of TIE) |
| | | 1 | $\overline{\text{INT}}$ pulses active according to Table 6 (subject to the status of TIE); note that if AF and AIE are active then $\overline{\text{INT}}$ will be permanently active |
| 3 | AF | 0 (read) | alarm flag inactive |
| | | 1 (read) | alarm flag active |
| | | 0 (write) | alarm flag is cleared |
| | | 1 (write) | alarm flag remains unchanged |
| 2 | TF | 0 (read) | timer flag inactive |
| | | 1 (read) | timer flag active |
| | | 0 (write) | timer flag is cleared |
| | | 1 (write) | timer flag remains unchanged |
| 1 | AIE | 0 | alarm interrupt disabled |
| | | 1 | alarm interrupt enabled |
| 0 | TIE | 0 | timer interrupt disabled |
| | | 1 | timer interrupt enabled |

Table 6. $\overline{\text{INT}}$ operation (bit TI_TP = 1)

| Source clock (Hz) | $\overline{\text{INT}}$ period (s) ^[1] | |
|-------------------|---|----------------------|
| | n = 1 ^[2] | n > 1 ^[2] |
| 4096 | $\frac{1}{8192}$ | $\frac{1}{4096}$ |
| 64 | $\frac{1}{128}$ | $\frac{1}{64}$ |
| 1 | $\frac{1}{64}$ | $\frac{1}{64}$ |
| $\frac{1}{60}$ | $\frac{1}{64}$ | $\frac{1}{64}$ |

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

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

7.6.3 Time and date registers

Table 7. VL_seconds - Validity and Seconds register (address 02h) bit description

| Bit | Symbol | Value | Description |
|--------|--------------|----------|---|
| 7 | VL | 0 | clock integrity is guaranteed |
| | | 1 | integrity of the clock information is no longer guaranteed |
| 6 to 0 | SECONDS[6:0] | 00 to 59 | the current seconds, coded in BCD format. Example: seconds register contains x101 1001 = 59 seconds |

Table 8. Minutes - Minutes register (address 03h) bit description

| Bit | Symbol | Value | Description |
|--------|--------------|----------|--|
| 7 | x | | not relevant |
| 6 to 0 | MINUTES[6:0] | 00 to 59 | the current minutes, coded in BCD format |

Table 9. Hours - Hours register (address 04h) bit description

| Bit | Symbol | Value | Description |
|--------|------------|----------|--|
| 7 to 6 | x | | not relevant |
| 5 to 0 | HOURS[5:0] | 00 to 23 | the current hours, coded in BCD format |

Table 10. Days - Days register (address 05h) bit description

| Bit | Symbol | Value | Description |
|--------|-----------|----------|---|
| 7 to 6 | x | | not relevant |
| 5 to 0 | DAYS[5:0] | 01 to 31 | the current day, coded in BCD format ^[1] |

[1] The PCF8563 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.

Table 11. Weekdays - Weekdays register (address 06h) bit description

| Bit | Symbol | Value | Description |
|-----------------------|---------------|--------|--|
| 7 to 3 | x | | not relevant |
| 2 to 0 ^[1] | WEEKDAYS[2:0] | 0 to 6 | the current weekday, coded in BCD format, see Table 12 . |

[1] These bits may be re-assigned by the user.

Table 12. Weekday assignments

| Weekday | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-----------|-------|-------|-------|-------|-------|-------|-------|-------|
| Sunday | x | x | x | x | x | 0 | 0 | 0 |
| Monday | x | x | x | x | x | 0 | 0 | 1 |
| Tuesday | x | x | x | x | x | 0 | 1 | 0 |
| Wednesday | x | x | x | x | x | 0 | 1 | 1 |
| Thursday | x | x | x | x | x | 1 | 0 | 0 |
| Friday | x | x | x | x | x | 1 | 0 | 1 |
| Saturday | x | x | x | x | x | 1 | 1 | 0 |

Table 13. Century_months - Century and Months register (address 07h) bit description

| Bit | Symbol | Value | Description |
|--------|------------------|----------|--|
| 7 | C ^[1] | | century; this bit is toggled when the years register overflows from 99 to 00 |
| | | 0 | indicates the century is 20xx |
| | | 1 | indicates the century is 19xx |
| 6 to 5 | x | | not relevant |
| 4 to 0 | MONTHS[4:0] | 01 to 12 | the current month, coded in BCD format, see Table 14 |

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

Table 14. Month assignments

| Month | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|-----------|-------|-------|-------|-------|-------|-------|-------|-------|
| January | C | x | x | 0 | 0 | 0 | 0 | 1 |
| February | C | x | x | 0 | 0 | 0 | 1 | 0 |
| March | C | x | x | 0 | 0 | 0 | 1 | 1 |
| April | C | x | x | 0 | 0 | 1 | 0 | 0 |
| May | C | x | x | 0 | 0 | 1 | 0 | 1 |
| June | C | x | x | 0 | 0 | 1 | 1 | 0 |
| July | C | x | x | 0 | 0 | 1 | 1 | 1 |
| August | C | x | x | 0 | 1 | 0 | 0 | 0 |
| September | C | x | x | 0 | 1 | 0 | 0 | 1 |
| October | C | x | x | 1 | 0 | 0 | 0 | 0 |
| November | C | x | x | 1 | 0 | 0 | 0 | 1 |
| December | C | x | x | 1 | 0 | 0 | 1 | 0 |

Table 15. Years - Years register (address 08h) bit description

| Bit | Symbol | Value | Description |
|--------|------------|----------|---------------------------------------|
| 7 to 0 | YEARS[7:0] | 00 to 99 | the current year, coded in BCD format |

7.6.4 Alarm registers

When one or more of these registers are loaded with a valid minute, hour, day or weekday and its corresponding bit Alarm Enable (AE) is logic 0, then that information will be compared with the current minute, hour, day and weekday. When all enabled comparisons first match, the Alarm Flag (AF) is set. AF will remain set until cleared by software. 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 bit AE at logic 1 will be ignored.

Table 16. Minute_alarm - Minute alarm register (address 09h) bit description

| Bit | Symbol | Value | Description |
|--------|--------------------|----------|---|
| 7 | AE | 0 | minute alarm is enabled |
| | | 1 | minute alarm is disabled |
| 6 to 0 | ALARM_MINUTES[6:0] | 00 to 59 | the minute alarm information, coded in BCD format |

Table 17. Hour_alarm - Hour alarm register (address 0Ah) bit description

| Bit | Symbol | Value | Description |
|--------|------------------|----------|---|
| 7 | AE | 0 | hour alarm is enabled |
| | | 1 | hour alarm is disabled |
| 6 | x | | not relevant |
| 5 to 0 | ALARM_HOURS[5:0] | 00 to 23 | the hour alarm information, coded in BCD format |

Table 18. Day_alarm - Day alarm register (address 0Bh) bit description

| Bit | Symbol | Value | Description |
|--------|-----------------|----------|--|
| 7 | AE | 0 | day alarm is enabled |
| | | 1 | day alarm is disabled |
| 6 | x | | not relevant |
| 5 to 0 | ALARM_DAYS[5:0] | 01 to 31 | the day alarm information, coded in BCD format |

Table 19. Weekday_alarm - Weekday alarm register (address 0Ch) bit description

| Bit | Symbol | Value | Description |
|--------|---------------------|--------|--|
| 7 | AE | 0 | weekday alarm is enabled |
| | | 1 | weekday alarm is disabled |
| 6 to 3 | x | | not relevant |
| 2 to 0 | ALARM_WEEKDAYS[2:0] | 0 to 6 | the weekday alarm information, coded in BCD format |

7.6.5 Clock output control register

Table 20. CLKOUT_control - CLKOUT control register (address 0Dh) bit description

| Bit | Symbol | Value | Description |
|--------|---------|------------------------------|--|
| 7 | FE | 0 | the CLKOUT output is inhibited and set to high-impedance |
| | | 1 | the CLKOUT output is activated |
| 6 to 2 | x | | not relevant |
| 1 to 0 | FD[1:0] | see Table 21 | these bits control the frequency output at pin CLKOUT |

Table 21. FD1 and FD0: CLKOUT frequency selection

| FD1 | FD0 | CLKOUT frequency |
|-----|-----|------------------|
| 0 | 0 | 32.768 kHz |
| 0 | 1 | 1024 Hz |
| 1 | 0 | 32 Hz |
| 1 | 1 | 1 Hz |

7.6.6 Countdown timer

The timer register is an 8-bit binary countdown timer. It is enabled and disabled via the timer control register bit TE. The source clock for the timer is also selected by the timer control register. Other timer properties such as interrupt generation are controlled via control_status_2 register.

For accurate read back of the countdown value, the I²C-bus clock (SCL) must be operating at a frequency of at least twice the selected timer clock.

Table 22. Timer_control - Timer control register (address 0Eh) bit description

| Bit | Symbol | Value | Description |
|--------|---------|------------------------------|---|
| 7 | TE | 0 | timer is disabled |
| | | 1 | timer is enabled |
| 6 to 2 | x | | not relevant |
| 1 to 0 | TD[1:0] | see Table 23 | timer source clock frequency select; these bits determine the source clock for the countdown timer; when not in use, TD[1:0] should be set to 11 (1/60 Hz) for power saving |

Table 23. TD1 and TD0: Timer frequency selection

| TD1 | TD0 | TIMER Source clock frequency |
|-----|-----|------------------------------|
| 0 | 0 | 4096 Hz |
| 0 | 1 | 64 Hz |
| 1 | 0 | 1 Hz |
| 1 | 1 | 1/60 Hz |

Table 24. Timer - Timer value register (address 0Fh) bit description

| Bit | Symbol | Value | Description |
|--------|--------|------------|--|
| 7 to 0 | TIMER | 00h to FFh | countdown value = n; $CountdownPeriod = \frac{n}{SourceClockFrequency}$ |

7.7 EXT_CLK test mode

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

The Test mode is entered by setting bit TEST1 in control_status_1 register. Then pin CLKOUT becomes an input. The Test mode replaces the internal 64 Hz signal with the signal applied to pin CLKOUT. Every 64 positive edges applied to pin CLKOUT will then generate an increment of one second.

The signal applied to pin CLKOUT should have a minimum pulse width of 300 ns and a minimum period of 1000 ns. The internal 64 Hz clock, now sourced from CLKOUT, is divided down to 1 Hz by a 2⁶ divide chain called a pre-scaler. The pre-scaler can be set into a known state by using bit STOP. When bit STOP is set, the pre-scaler is reset to 0 (STOP must be cleared before the pre-scaler can operate again).

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 one-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 pre-scaler can be made.

Operation example:

1. Set EXT_CLK test mode (control_status_1, bit TEST1 = 1)
2. Set STOP (control_status_1, bit STOP = 1)
3. Clear STOP (control_status_1, bit STOP = 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 steps 7 and 8 for additional increments.

7.8 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 mechanism has been built in to disable the POR and hence speed up on-board test of the device. The setting of this mode requires that the I²C-bus pins, SDA and SCL, be toggled in a specific order as shown in [Figure 8](#). All timings are required minimums.

Once the Override mode has been entered, the device immediately stops being reset and normal operation may commence i.e. entry into the EXT_CLK test mode via I²C-bus access. The Override mode may be cleared by writing a 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.

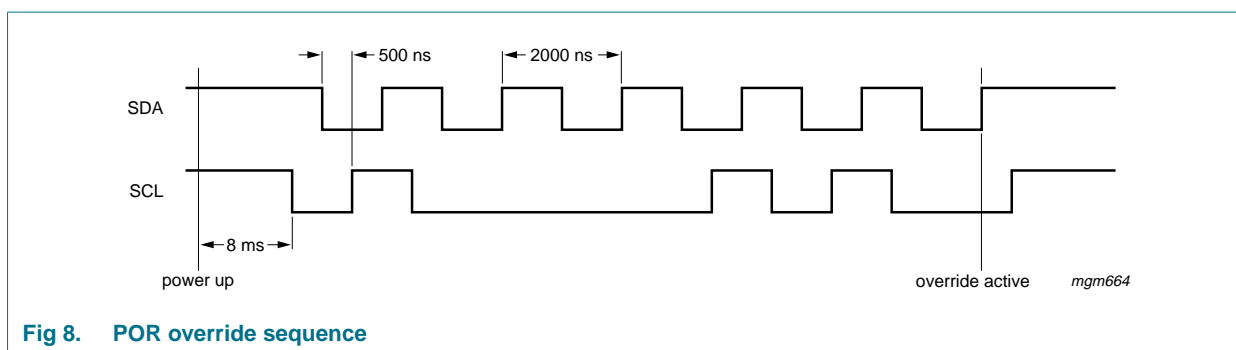


Fig 8. POR override sequence

[Table 25](#) shows the register reset values.

Table 25. Register reset value^[1]

| Address | Register name | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|---------|------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| 00h | control_status_1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 01h | control_status_2 | x | x | 0 | 0 | 0 | 0 | 0 | 0 |
| 02h | VL_seconds | 1 | x | x | x | x | x | x | x |
| 03h | minutes | 1 | x | x | x | x | x | x | x |
| 04h | hours | x | x | x | x | x | x | x | x |

Table 25. Register reset value^[1] ...continued

| Address | Register name | Bit 7 | Bit 6 | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 |
|---------|----------------|-------|-------|-------|-------|-------|-------|-------|-------|
| 05h | days | x | x | x | x | x | x | x | x |
| 06h | weekdays | x | x | x | x | x | x | x | x |
| 07h | century_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_control | 1 | x | x | x | x | x | 0 | 0 |
| 0Eh | timer_control | 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-up and unchanged by subsequent resets.

8. Characteristics of the I²C-bus

The I²C-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.

8.1 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 9](#)).

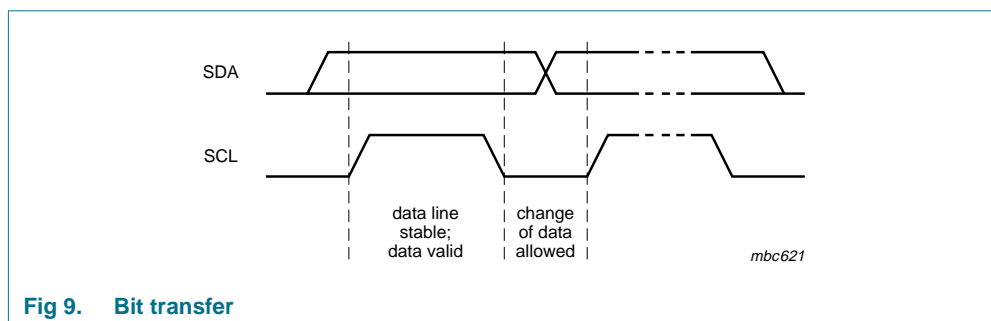


Fig 9. Bit transfer

8.2 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 10](#).

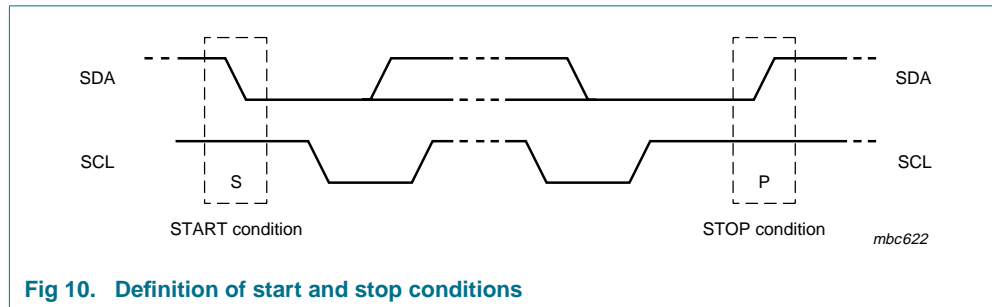


Fig 10. Definition of start and stop conditions

8.3 System configuration

A device generating a message is a transmitter, a device receiving a message is a receiver. The device that controls the message is the master and the devices which are controlled by the master are the slaves (see [Figure 11](#)).

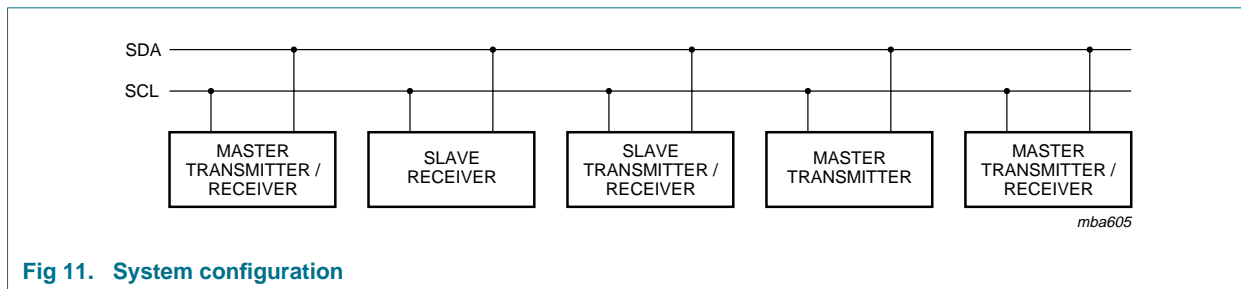


Fig 11. System configuration

8.4 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 bit. The acknowledge bit is a HIGH-level signal put on the bus by the transmitter during which time the master generates an extra acknowledge-related clock pulse. 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 (see [Figure 12](#)).

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.

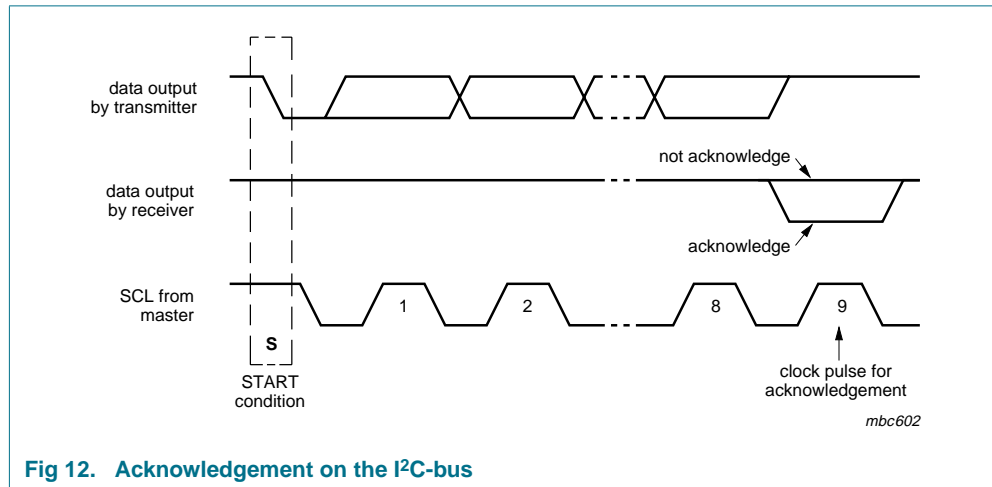


Fig 12. Acknowledgement on the I²C-bus

8.5 I²C-bus protocol

8.5.1 Addressing

Before any data is transmitted on the I²C-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 PCF8563 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.

The PCF8563 slave address is shown in [Figure 13](#).

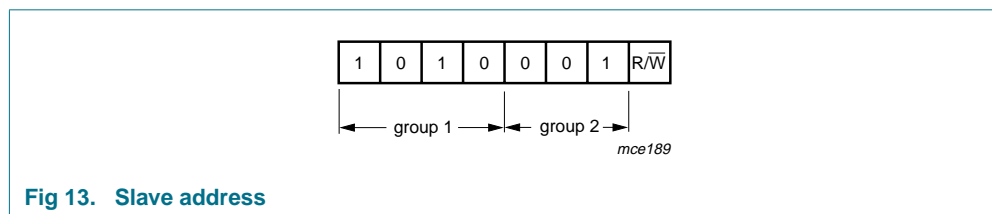


Fig 13. Slave address

8.5.2 Clock/calendar read/write cycles

The I²C-bus configuration for the different PCF8563 read and write cycles is shown in [Figure 14](#), [Figure 15](#) and [Figure 16](#). 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.

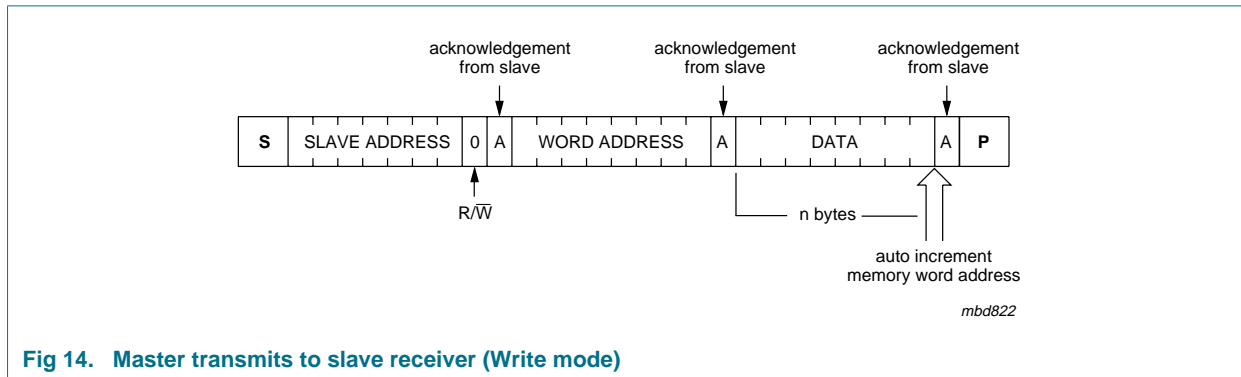


Fig 14. Master transmits to slave receiver (Write mode)

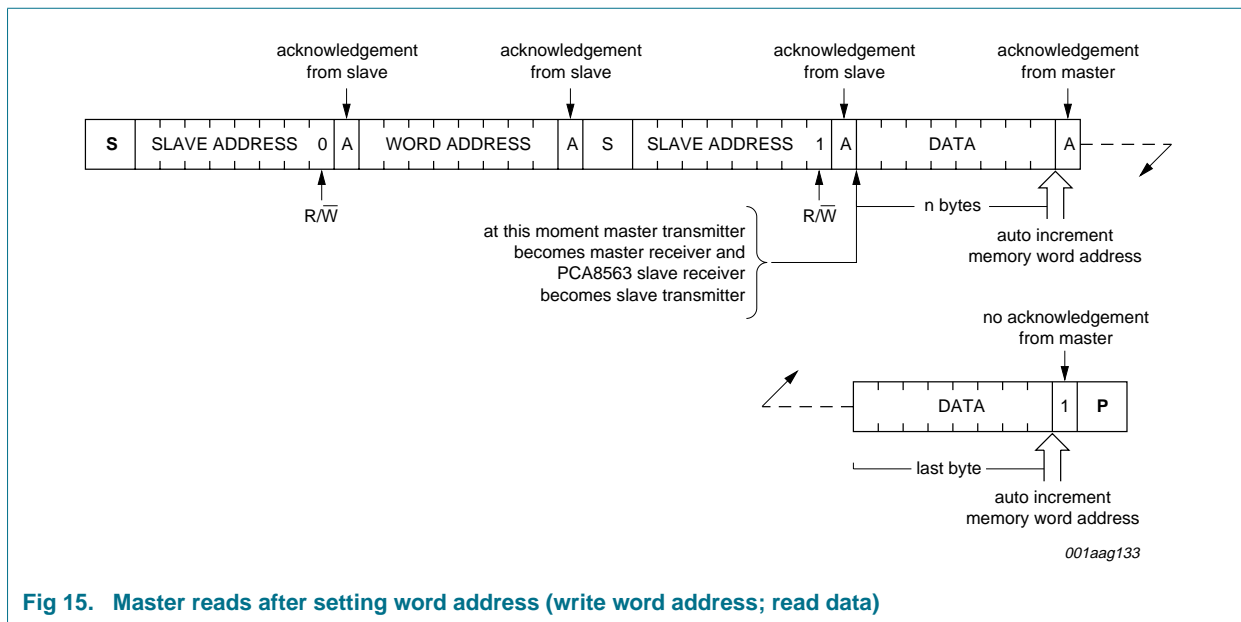


Fig 15. Master reads after setting word address (write word address; read data)

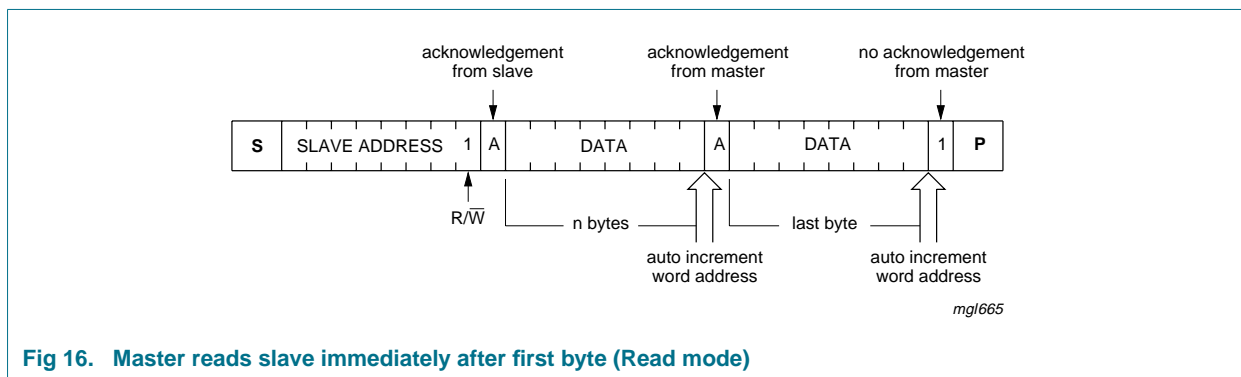


Fig 16. Master reads slave immediately after first byte (Read mode)

9. Limiting values

Table 26. 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 | on pins SCL and SDA | -0.5 | +6.5 | V |
| | | on pin OSC1 | -0.5 | $V_{DD} + 0.5$ | V |
| V_O | output voltage | on pins CLKOUT and \overline{INT} | -0.5 | +6.5 | V |
| I_I | input current | at any input | -10 | +10 | mA |
| I_O | output current | at any output | -10 | +10 | mA |
| P_{tot} | total power dissipation | | - | 300 | mW |
| T_{amb} | ambient temperature | | -40 | +85 | °C |
| T_{stg} | storage temperature | | -65 | +150 | °C |

10. Static characteristics

Table 27. 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 | |
|-------------------------|----------------|---|-----|-----------|-----|------|---------------|
| Supplies | | | | | | | |
| V_{DD} | supply voltage | interface inactive; $f_{SCL} = 0\text{ Hz}$; $T_{amb} = 25\text{ °C}$; see Figure 20 | [1] | 1.0 | - | 5.5 | V |
| | | interface active; $f_{SCL} = 400\text{ kHz}$; see Figure 20 | [1] | 1.8 | - | 5.5 | V |
| | | clock data integrity; $T_{amb} = 25\text{ °C}$ | | V_{low} | - | 5.5 | V |
| I_{DD} | supply current | interface active; see Figure 19 | | | | | |
| | | $f_{SCL} = 400\text{ kHz}$ | | - | - | 800 | μA |
| | | $f_{SCL} = 100\text{ kHz}$ | | - | - | 200 | μA |
| | | interface inactive ($f_{SCL} = 0\text{ Hz}$); CLKOUT disabled; $T_{amb} = 25\text{ °C}$; see Figure 17 | [2] | | | | |
| | | $V_{DD} = 5.0\text{ V}$ | | - | 275 | 550 | nA |
| | | $V_{DD} = 3.0\text{ V}$ | | - | 250 | 500 | nA |
| | | $V_{DD} = 2.0\text{ V}$ | | - | 225 | 450 | nA |
| | | interface inactive ($f_{SCL} = 0\text{ Hz}$); CLKOUT disabled; $T_{amb} = -40\text{ °C to }+85\text{ °C}$; see Figure 17 | [2] | | | | |
| $V_{DD} = 5.0\text{ V}$ | | - | 500 | 750 | nA | | |
| $V_{DD} = 3.0\text{ V}$ | | - | 400 | 650 | nA | | |
| $V_{DD} = 2.0\text{ V}$ | | - | 400 | 600 | nA | | |

Table 27. Static characteristics ...continued

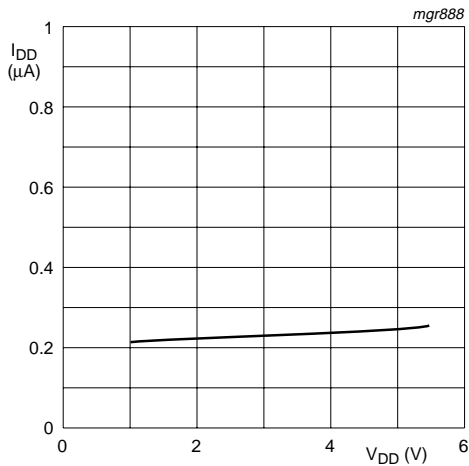
$V_{DD} = 1.8\text{ V to }5.5\text{ V}$; $V_{SS} = 0\text{ V}$; $T_{amb} = -40\text{ }^{\circ}\text{C to }+85\text{ }^{\circ}\text{C}$; $f_{osc} = 32.768\text{ kHz}$; quartz $R_s = 40\text{ k}\Omega$; $C_L = 8\text{ pF}$; unless otherwise specified.

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit | |
|-------------------------|---------------------------|--|-------------|------|-------------|---------------|--|
| I_{DD} | supply current | interface inactive ($f_{SCL} = 0\text{ Hz}$); CLKOUT enabled at 32 kHz; $T_{amb} = 25\text{ }^{\circ}\text{C}$; see Figure 18 | [2] | | | | |
| | | $V_{DD} = 5.0\text{ V}$ | - | 825 | 1600 | nA | |
| | | $V_{DD} = 3.0\text{ V}$ | - | 550 | 1000 | nA | |
| | | $V_{DD} = 2.0\text{ V}$ | - | 425 | 800 | nA | |
| | | interface inactive ($f_{SCL} = 0\text{ Hz}$); CLKOUT enabled at 32 kHz; $T_{amb} = -40\text{ }^{\circ}\text{C to }+85\text{ }^{\circ}\text{C}$; see Figure 18 | [2] | | | | |
| | | $V_{DD} = 5.0\text{ V}$ | - | 950 | 1700 | nA | |
| | $V_{DD} = 3.0\text{ V}$ | - | 650 | 1100 | nA | | |
| | $V_{DD} = 2.0\text{ V}$ | - | 500 | 900 | nA | | |
| Inputs | | | | | | | |
| V_{IL} | LOW-level input voltage | | V_{SS} | - | $0.3V_{DD}$ | V | |
| V_{IH} | HIGH-level input voltage | | $0.7V_{DD}$ | - | V_{DD} | V | |
| I_{LI} | input leakage current | $V_I = V_{DD}$ or V_{SS} | -1 | 0 | +1 | μA | |
| C_i | input capacitance | | [3] | - | 7 | pF | |
| Outputs | | | | | | | |
| I_{OL} | LOW-level output current | $V_{OL} = 0.4\text{ V}$; $V_{DD} = 5\text{ V}$ | | | | | |
| | | on pin SDA | -3 | - | - | mA | |
| | | on pin $\overline{\text{INT}}$ | -1 | - | - | mA | |
| | | on pin CLKOUT | -1 | - | - | mA | |
| I_{OH} | HIGH-level output current | on pin CLKOUT; $V_{OH} = 4.6\text{ V}$; $V_{DD} = 5\text{ V}$ | 1 | - | - | mA | |
| I_{LO} | output leakage current | $V_O = V_{DD}$ or V_{SS} | -1 | 0 | +1 | μA | |
| Voltage detector | | | | | | | |
| V_{low} | low voltage | $T_{amb} = 25\text{ }^{\circ}\text{C}$; sets bit VL; see Figure 7 | - | 0.9 | 1.0 | V | |

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

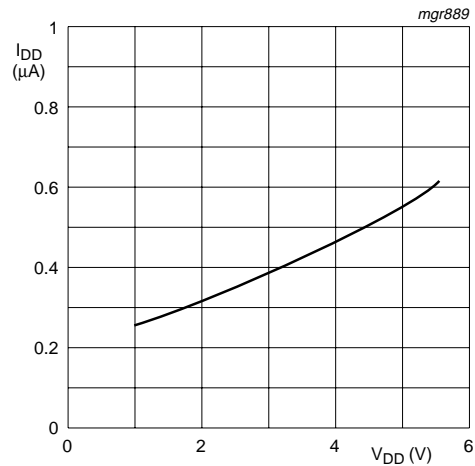
[2] Timer source clock = $\frac{1}{60}$ Hz, level of pins SCL and SDA is V_{DD} or V_{SS} .

[3] Tested on sample basis.



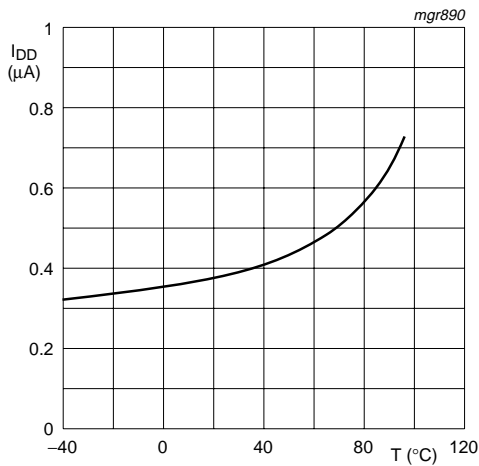
$T_{amb} = 25\text{ }^\circ\text{C}$; Timer = 1 minute.

Fig 17. Supply current I_{DD} as a function of supply voltage V_{DD} ; CLKOUT disabled



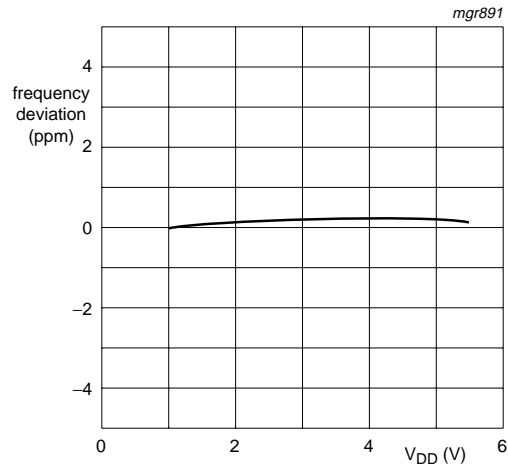
$T_{amb} = 25\text{ }^\circ\text{C}$; Timer = 1 minute.

Fig 18. Supply current I_{DD} as a function of supply voltage V_{DD} ; CLKOUT = 32 kHz



$V_{DD} = 3\text{ V}$; Timer = 1 minute.

Fig 19. Supply current I_{DD} as a function of temperature T ; CLKOUT = 32 kHz



$T_{amb} = 25\text{ }^\circ\text{C}$; normalized to $V_{DD} = 3\text{ V}$.

Fig 20. Frequency deviation as a function of supply voltage V_{DD}

11. Dynamic characteristics

Table 28. Dynamic characteristics

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

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|--|--|---|-------|--------------------|-----|---------------|
| Oscillator | | | | | | |
| $C_{L(itg)}$ | integrated load capacitance | | 15 | 25 | 35 | pF |
| $\Delta f_{osc}/f_{osc}$ | relative oscillator frequency variation | $\Delta V_{DD} = 200\text{ mV}$; $T_{amb} = 25\text{ }^{\circ}\text{C}$ | - | 2×10^{-7} | - | |
| Quartz crystal parameters (f = 32.768 kHz) | | | | | | |
| R_s | series resistance | | - | - | 40 | k Ω |
| C_L | load capacitance | parallel | - | 10 | - | pF |
| C_{trim} | trimmer capacitance | | 5 | - | 25 | pF |
| CLKOUT output | | | | | | |
| δ_{CLKOUT} | duty cycle on pin CLKOUT | | [1] - | 50 | - | % |
| I²C-bus timing characteristics (see Figure 21) | | | | | | |
| f_{SCL} | SCL clock frequency | | [4] - | - | 400 | kHz |
| $t_{HD;STA}$ | hold time (repeated) START condition | | 0.6 | - | - | μs |
| $t_{SU;STA}$ | set-up time for a repeated START condition | | 0.6 | - | - | μs |
| t_{LOW} | LOW period of the SCL clock | | 1.3 | - | - | μs |
| t_{HIGH} | HIGH period of the SCL clock | | 0.6 | - | - | μs |
| t_r | rise time of both SDA and SCL signals | SDA | - | - | 0.3 | μs |
| | | SCL | - | - | 0.3 | μs |
| t_f | fall time of both SDA and SCL signals | SDA | - | - | 0.3 | μs |
| | | SCL | - | - | 0.3 | μs |
| 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 | - | - | μs |
| $t_{w(\text{spike})}$ | spike pulse width | on bus | - | - | 50 | ns |

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

[2] 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} .

[3] A detailed description of the I²C-bus specification, with applications, is given in brochure *The I²C-bus specification*. This brochure may be ordered using the code 9398 393 40011.

[4] I²C-bus access time between two STARTs or between a START and a STOP condition to this device must be less than one second.

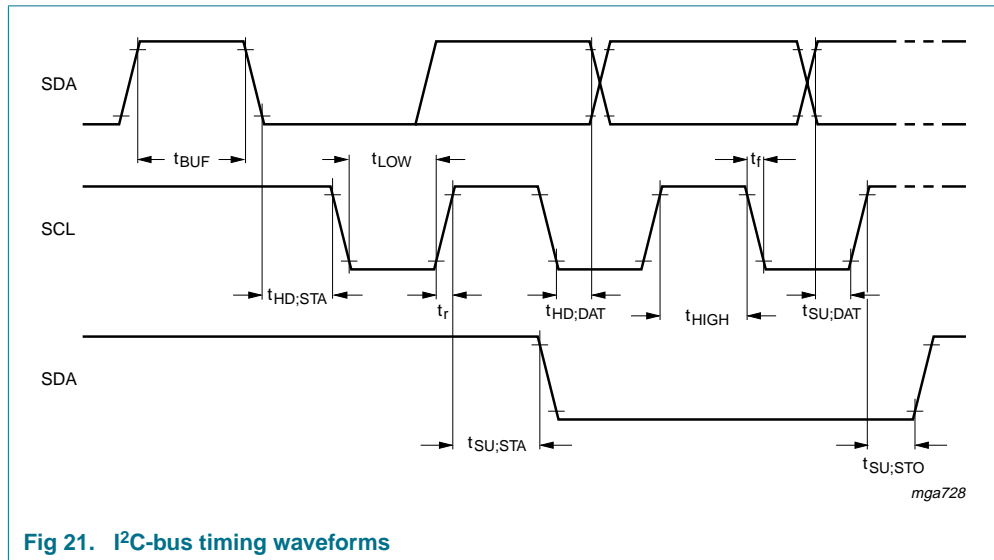


Fig 21. I²C-bus timing waveforms

12. Application information

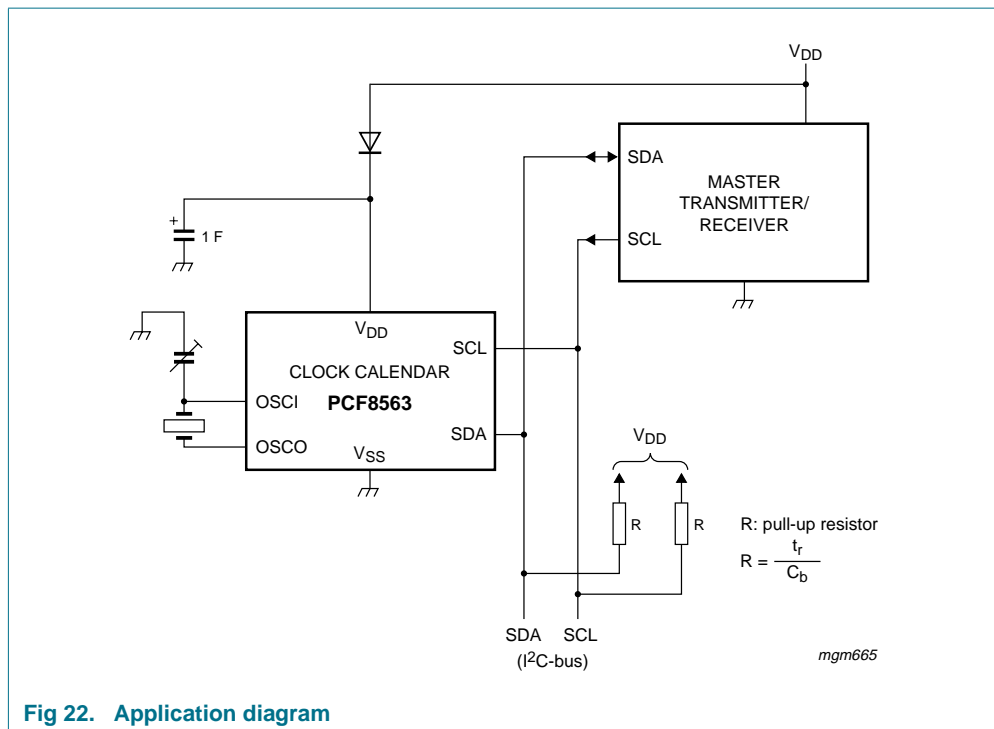


Fig 22. Application diagram

12.1 Quartz frequency adjustment

12.1.1 Method 1: fixed OSCI capacitor

By evaluating the average capacitance necessary for the application layout, a fixed capacitor can be used. The frequency is best measured via the 32.768 kHz signal available after power-on at pin CLKOUT. The frequency tolerance depends on the quartz crystal tolerance, the capacitor tolerance and the device-to-device tolerance (on average $\pm 5 \times 10^{-6}$). Average deviations of ± 5 minutes per year can be easily achieved.

12.1.2 Method 2: OSCI trimmer

Using the 32.768 kHz signal available after power-on at pin CLKOUT, fast setting of a trimmer is possible.

12.1.3 Method 3: OSCO output

Direct measurement of OSCO out (accounting for test probe capacitance).

13. Package outline

DIP8: plastic dual in-line package; 8 leads (300 mil)

SOT97-1

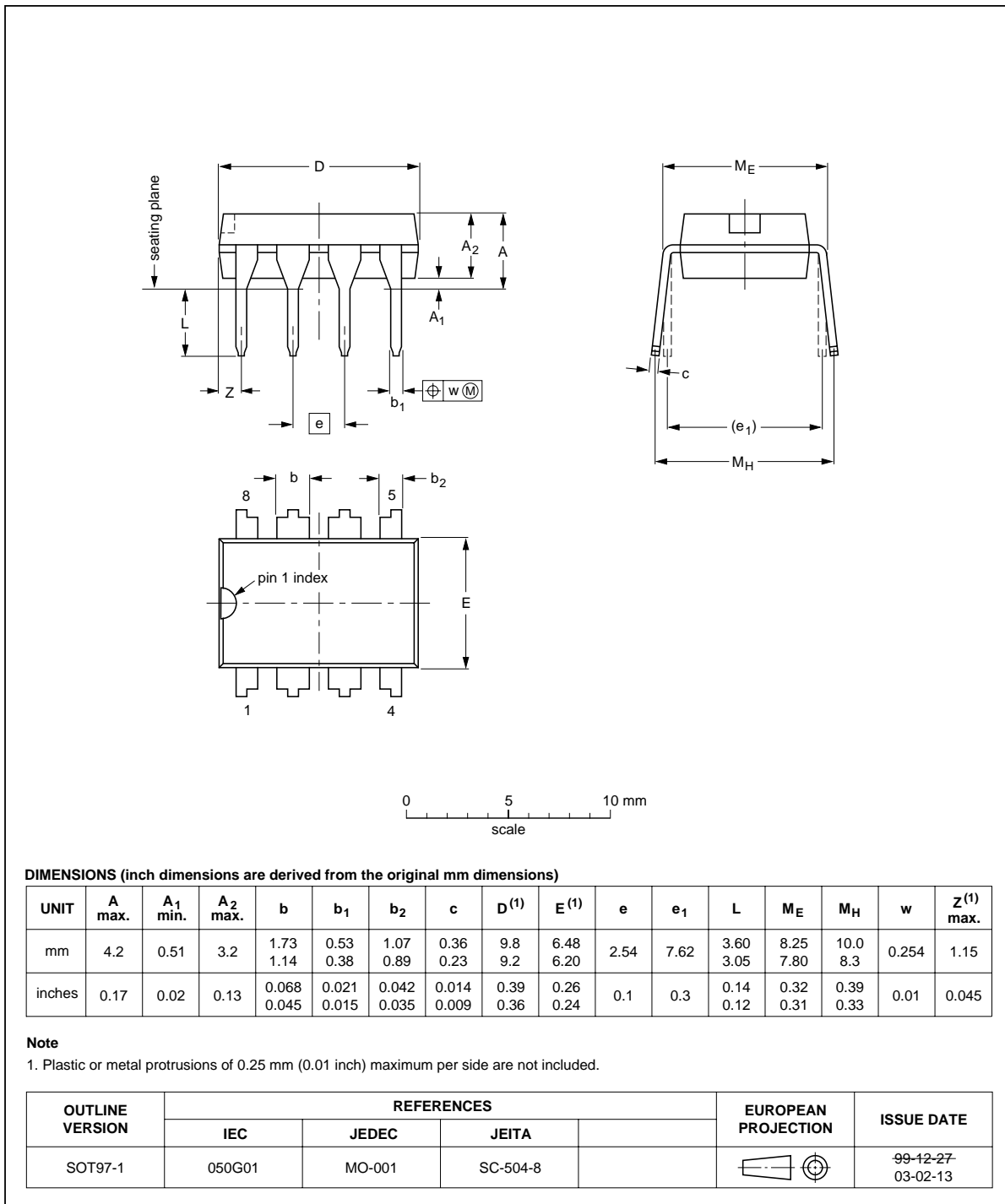


Fig 23. Package outline SOT97-1 (DIP8)

SO8: plastic small outline package; 8 leads; body width 3.9 mm

SOT96-1

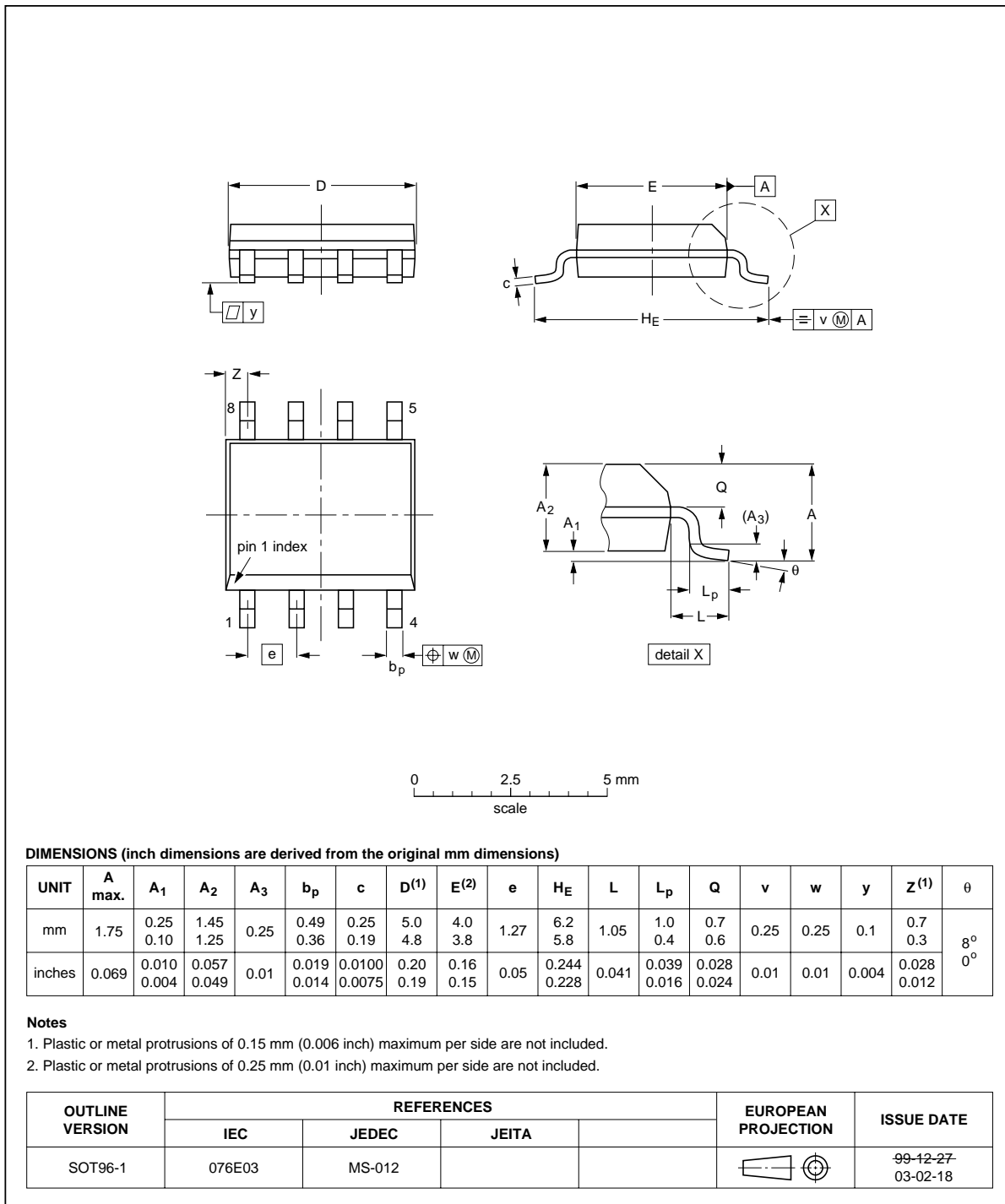


Fig 24. Package outline SOT96-1 (SO8)

TSSOP8: plastic thin shrink small outline package; 8 leads; body width 3 mm

SOT505-1

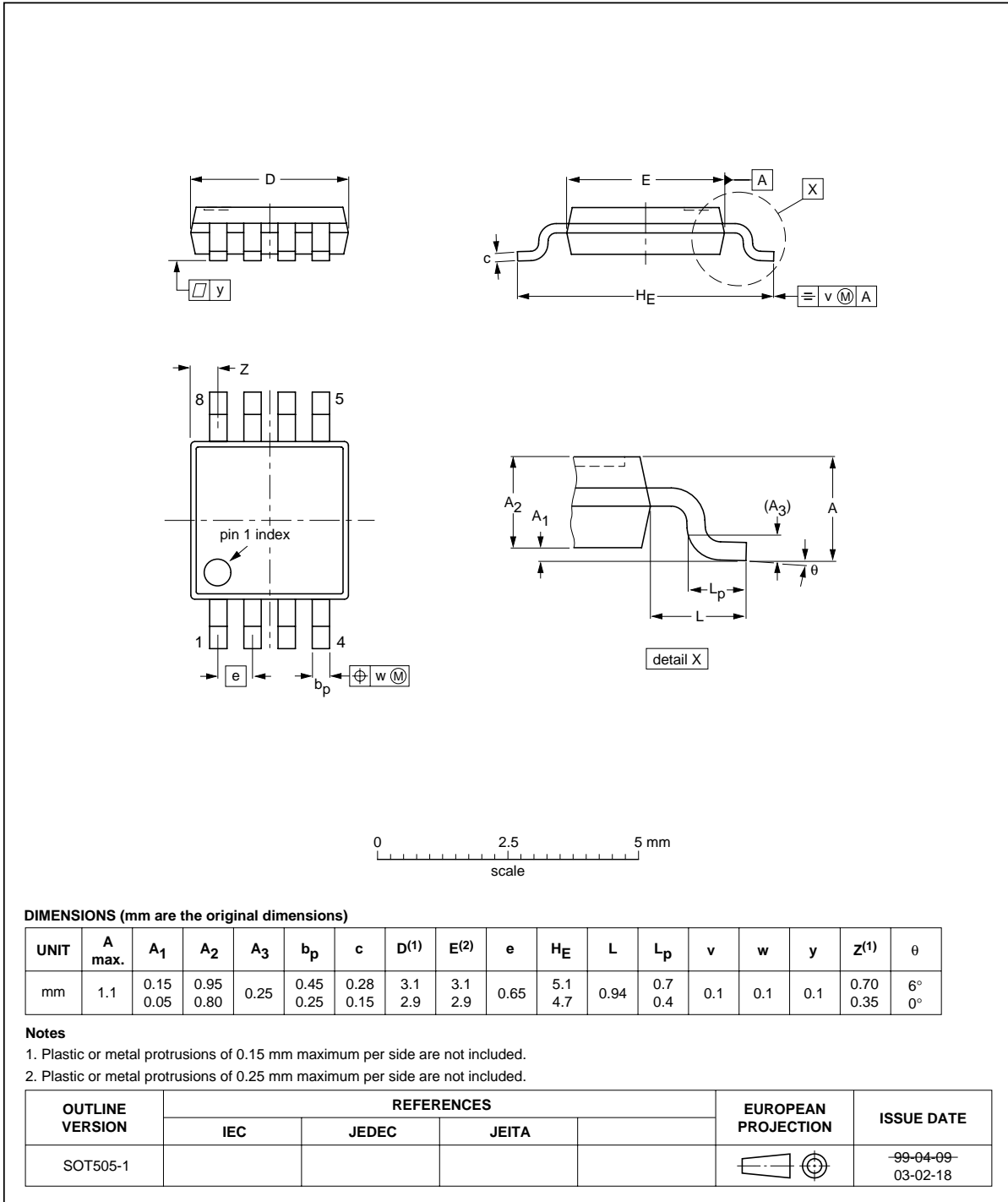


Fig 25. Package outline SOT505-1 (TSSOP8)

HVSON10: plastic thermal enhanced very thin small outline package; no leads;
10 terminals; body 3 x 3 x 0.85 mm

SOT650-1

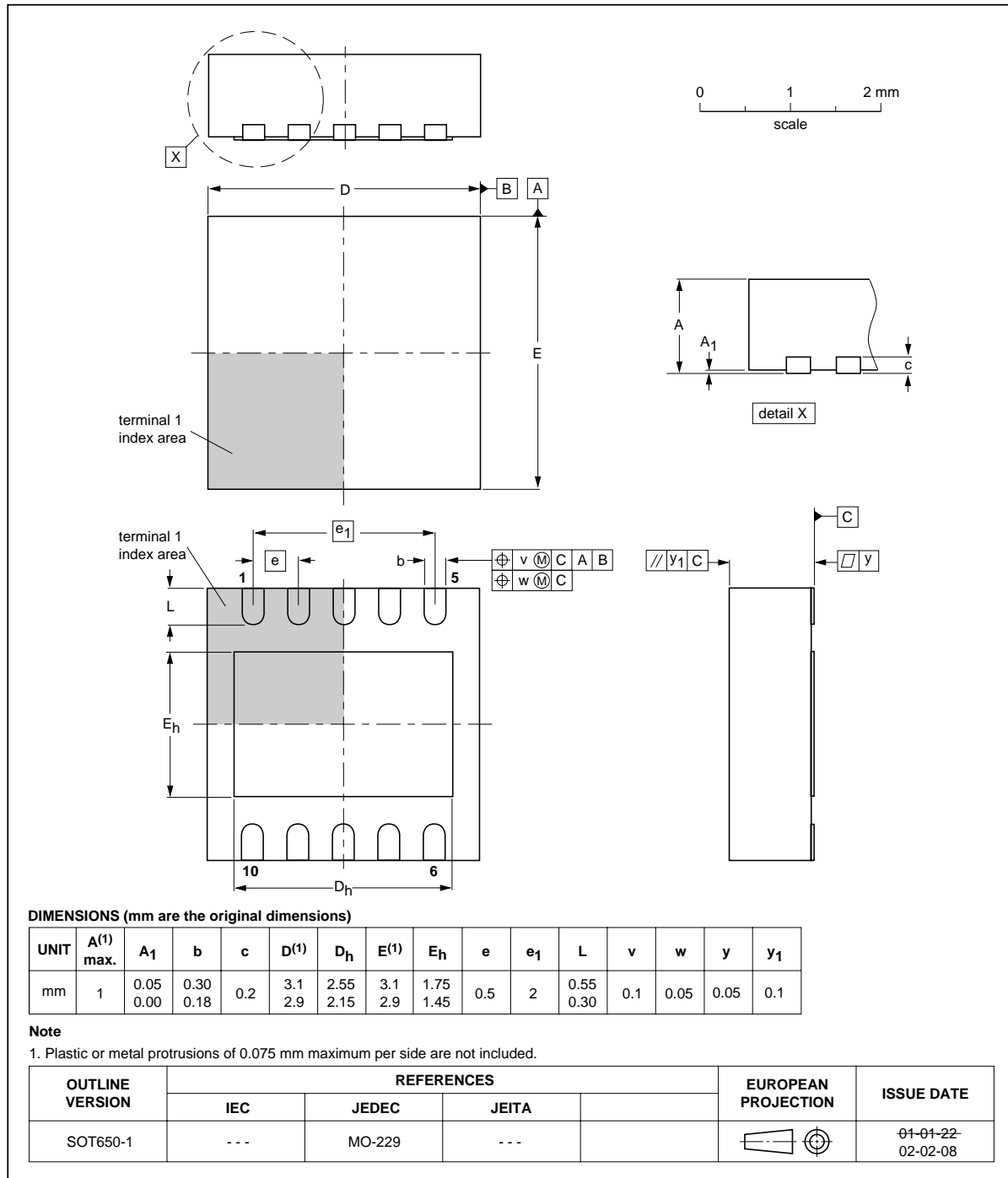


Fig 26. Package outline SOT650-1 (HVSON10)

14. Handling information

Inputs and outputs are protected against electrostatic discharge in normal handling. However, to be completely safe you must take normal precautions appropriate to handling MOS devices; see *JESD625-A* and/or *IEC61340-5*.

15. Soldering of SMD packages

This text provides a very brief insight into a complex technology. A more in-depth account of soldering ICs can be found in Application Note *AN10365 "Surface mount reflow soldering description"*.

15.1 Introduction to soldering

Soldering is one of the most common methods through which packages are attached to Printed Circuit Boards (PCBs), to form electrical circuits. The soldered joint provides both the mechanical and the electrical connection. There is no single soldering method that is ideal for all IC packages. Wave soldering is often preferred when through-hole and Surface Mount Devices (SMDs) are mixed on one printed wiring board; however, it is not suitable for fine pitch SMDs. Reflow soldering is ideal for the small pitches and high densities that come with increased miniaturization.

15.2 Wave and reflow soldering

Wave soldering is a joining technology in which the joints are made by solder coming from a standing wave of liquid solder. The wave soldering process is suitable for the following:

- Through-hole components
- Leaded or leadless SMDs, which are glued to the surface of the printed circuit board

Not all SMDs can be wave soldered. Packages with solder balls, and some leadless packages which have solder lands underneath the body, cannot be wave soldered. Also, leaded SMDs with leads having a pitch smaller than ~0.6 mm cannot be wave soldered, due to an increased probability of bridging.

The reflow soldering process involves applying solder paste to a board, followed by component placement and exposure to a temperature profile. Leaded packages, packages with solder balls, and leadless packages are all reflow solderable.

Key characteristics in both wave and reflow soldering are:

- Board specifications, including the board finish, solder masks and vias
- Package footprints, including solder thieves and orientation
- The moisture sensitivity level of the packages
- Package placement
- Inspection and repair
- Lead-free soldering versus SnPb soldering

15.3 Wave soldering

Key characteristics in wave soldering are:

- Process issues, such as application of adhesive and flux, clinching of leads, board transport, the solder wave parameters, and the time during which components are exposed to the wave
- Solder bath specifications, including temperature and impurities

15.4 Reflow soldering

Key characteristics in reflow soldering are:

- Lead-free versus SnPb soldering; note that a lead-free reflow process usually leads to higher minimum peak temperatures (see [Figure 27](#)) than a SnPb process, thus reducing the process window
- Solder paste printing issues including smearing, release, and adjusting the process window for a mix of large and small components on one board
- Reflow temperature profile; this profile includes preheat, reflow (in which the board is heated to the peak temperature) and cooling down. It is imperative that the peak temperature is high enough for the solder to make reliable solder joints (a solder paste characteristic). In addition, the peak temperature must be low enough that the packages and/or boards are not damaged. The peak temperature of the package depends on package thickness and volume and is classified in accordance with [Table 29](#) and [30](#)

Table 29. SnPb eutectic process (from J-STD-020C)

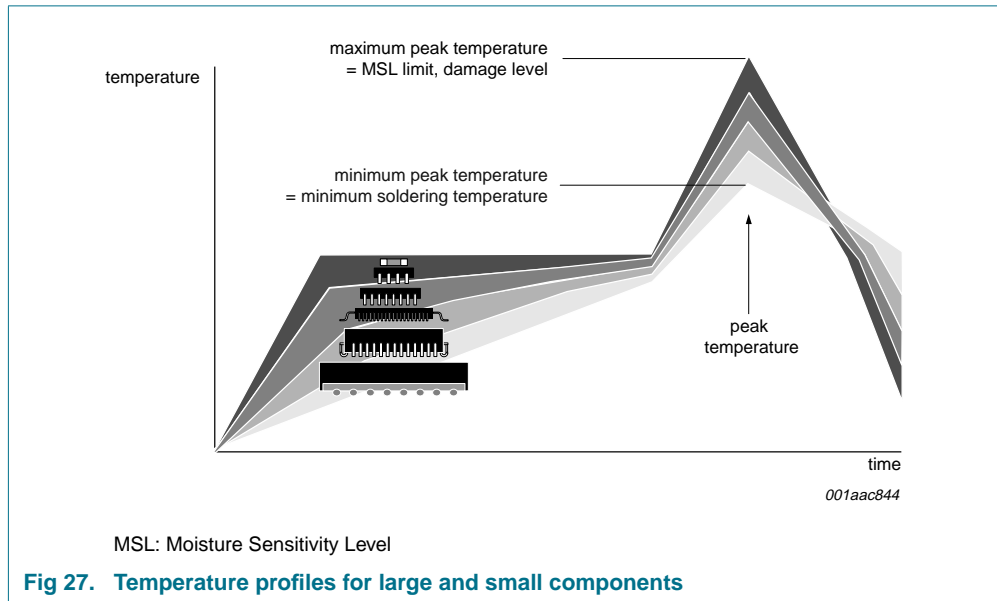
| Package thickness (mm) | Package reflow temperature (°C) | |
|------------------------|---------------------------------|-------|
| | Volume (mm ³) | |
| | < 350 | ≥ 350 |
| < 2.5 | 235 | 220 |
| ≥ 2.5 | 220 | 220 |

Table 30. Lead-free process (from J-STD-020C)

| Package thickness (mm) | Package reflow temperature (°C) | | |
|------------------------|---------------------------------|-------------|--------|
| | Volume (mm ³) | | |
| | < 350 | 350 to 2000 | > 2000 |
| < 1.6 | 260 | 260 | 260 |
| 1.6 to 2.5 | 260 | 250 | 245 |
| > 2.5 | 250 | 245 | 245 |

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

Studies have shown that small packages reach higher temperatures during reflow soldering, see [Figure 27](#).



For further information on temperature profiles, refer to Application Note AN10365 "Surface mount reflow soldering description".

16. Revision history

Table 31. Revision history

| Document ID | Release date | Data sheet status | Change notice | Supersedes |
|---------------------------------|--|-------------------------|---------------|-------------|
| PCF8563_6 | 20080221 | Product data sheet | - | PCF8563_5 |
| Modifications: | <ul style="list-style-type: none"> • Register names modified in Figure 1 and various tables. • Figure 17, Figure 18 and Figure 19: corrected the unit on the vertical axis. | | | |
| PCF8563_5 | 20070717 | Product data sheet | - | PCF8563-04 |
| Modifications: | <ul style="list-style-type: none"> • The format of this data sheet has been redesigned to comply with the new identity guidelines of NXP Semiconductors. • Legal texts have been adapted to the new company name where appropriate. • Quick reference data table removed to comply with guidelines. • Table 3: Table 3 and Table 4 combined in one table. • Section 4: added topside mark. • Section 4: added HVSON10 package. | | | |
| PCF8563-04 (9397 750 12999) | 20040312 | Product data | - | PCF8563-03 |
| PCF8563-03 (9397 750 11158) | 20030414 | Product data | - | PCF8563-02 |
| PCF8563-02 (9397 750 04855) | 19990416 | Product data | - | PCF8563_N_1 |
| PCF8563_N_1 (9397 750 03282) | 19980325 | Objective specification | - | - |

17. Legal information

17.1 Data sheet status

| Document status ^{[1][2]} | Product status ^[3] | 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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For more information, please visit: <http://www.nxp.com>

For sales office addresses, please send an email to: salesaddresses@nxp.com

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