# UM10759

## Demo board OM13512 for the SPI-bus RTC PCF2123

**Rev. 1 — 02 June 2014** **User manual**

**Document information**

| Info | Content |
|---|---|
| **Keywords** | PCF2123, OM13512, ultra-low power, evaluation, demo board, how to get started, SPI bus, RTC, Real-Time Clock, tuning, battery switch, watch-dog, timer |
| **Abstract** | User manual for the RTC SPI-bus demo board OM13512 which contains the RTC PCF2123 |

**Revision history**

| Rev | Date | Description |
|---|---|---|
| v.1 | 20140602 | First revision |

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# 1. Introduction

The PCF2123 is a real time clock based on an ultra-low power oscillator and using an SPI-bus for interfacing. The OM13512 is the ideal evaluation/demo board to use during the design phase of any project, just the power supply and the SPI-bus must be connected. In case that an I2C-bus would be the preferred interface, the PCF8523 with demo board OM13511 could be used for evaluation

# 2. Key features

## 2.1 Demo board OM13512

The RTC PCF2123TS with SPI-bus is mounted together with a quartz crystal, a coin cell 1.5 V battery and the decoupling capacitor to buffer the supply voltage. All signals are accessible on a row of pins, overcoming the need to build a test pc-board before the circuit can be evaluated or the functionality being tested together with the final application.

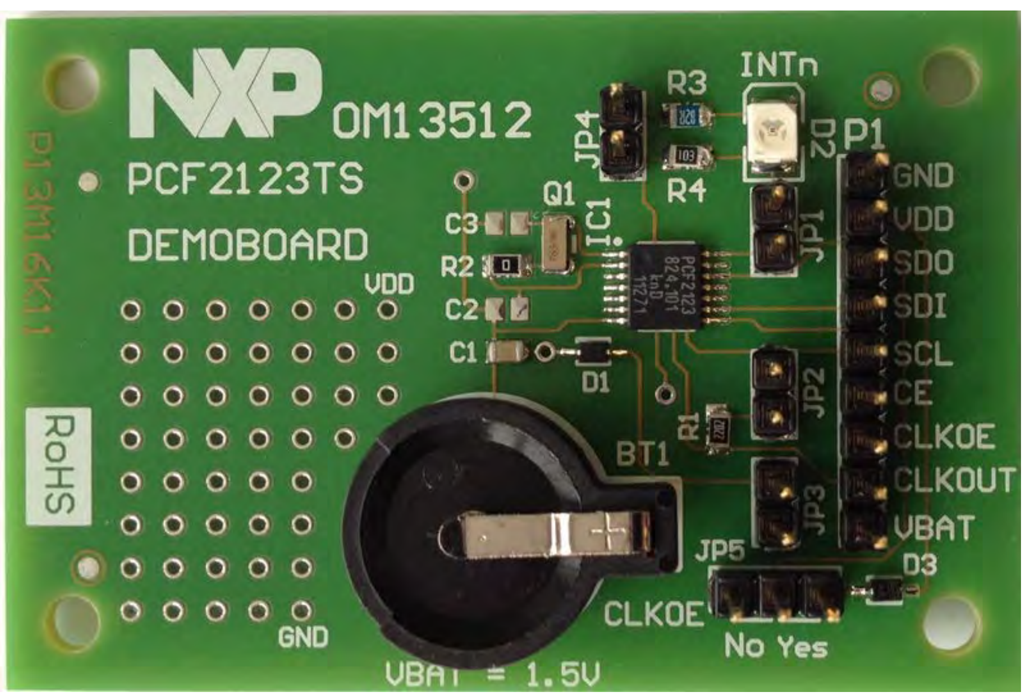



**Fig 1. OM13512 demo board**

## 2.2 Real time clock PCF2123

- The PCF2123 features ultra-low power consumption
- Provides time and calendar from seconds to years
- Accuracy is based on a 32.768 kHz quartz crystal
- Low backup current while running: typical 100 nA at $V_{DD}$ = 2.0 V and $T_{amb}$ = 25 ºC

- Watchdog functionality
- Freely programmable timer and alarm with interrupt capability
- Pre-programmed 1 second or 1 minute interrupt
- Clock operating voltage: 1.1 V to 5.5 V
- SPI-bus with separate, but combinable data input and output, up to 8 MHz
- Serial interface at $V_{DD}$ = 1.8 V to 5.5 V
- Integrated oscillator load capacitors for quartzes with $C_L$ = 7 pF
- Internal Power-On Reset (POR)
- Open-drain interrupt and clock output pins
- Programmable offset register for frequency trimming

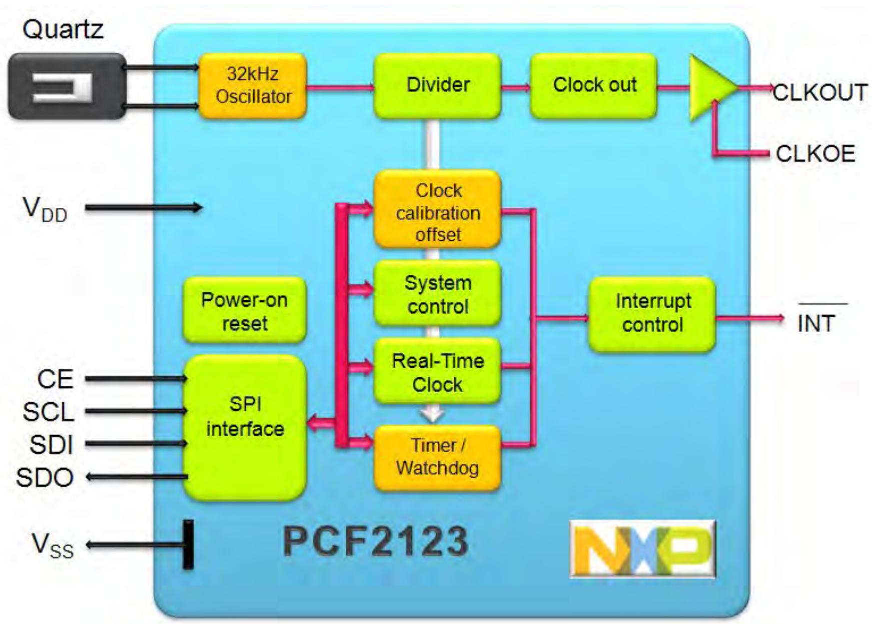



Fig 2. Block diagram PCF2123

## 3. Hardware setup

### 3.1 General requirement for the PCF2123

The RTC circuit just requires one external part: the tuning fork quartz as resonator. The oscillation capacitors are integrated and therefore there is no need for external load capacitors. The quartz crystal must be closely placed to the RTC circuit, avoiding long lines which may pick up noise. Any tracks with high frequency signals (fast edges) close to the RTC, quartz, or quartz interconnect should be avoided.

The SPI-bus interface works up to 8 MHz. Supply voltage: 1.8 V to 5.5 V. The RTC, excluding the SPI-bus interface, however is operating down to as low as 0.9 V. It is recommended to have a decoupling capacitor of 100 nF on the $V_{DD}$-$V_{SS}$ rails close by.

Due to the low power consumption of below 1 μW, no precautions for heat dissipations are required, even in a sealed housing environment. Frequencies of 1 Hz to 32.768 kHz on the CLKOUT pin can be used to measure the frequency for calibration and/or for general purpose, e.g. as reference for frequency generation with a PLL. A separate clock out enable pin is available to control the CLKOUT signal also by hardware.

## 3.2 Battery back-up

To guarantee the autonomy of the clock, a continuous power supply is needed. The battery back-up of the demo board assures it (see Fig 3).

## 3.3 Optimizing power consumption

There are a number of factors influencing the power consumption:

- Supply voltage: the lower the supply voltage the lower the power consumption
- Oscillator: the quartz crystal is specified with a series resistance $R_S$ and a load capacitance $C_L$. The PCF2123 is tailored to use quartzes with a $C_L$ of 7 pF (as used on the demo board). If a quartz with 12.5 pF is used, the frequency can be compensated either by the tuning register or by adding a 2.7 pF capacitor on the OSCI and on the OSCO (C2 and C3 on the board). With lower capacitance the power consumption is lower. 6 pF quartzes can also be used; the frequency must then slightly be adjusted via the offset register. The serial resistance of the quartz dissipates energy. The lower $R_S$, the less energy is used. General rule: the larger the mechanical size of the quartz package, the lower is the impedance. Check the components' parameters of your preferred quartz supplier.

# 4. Circuit diagram

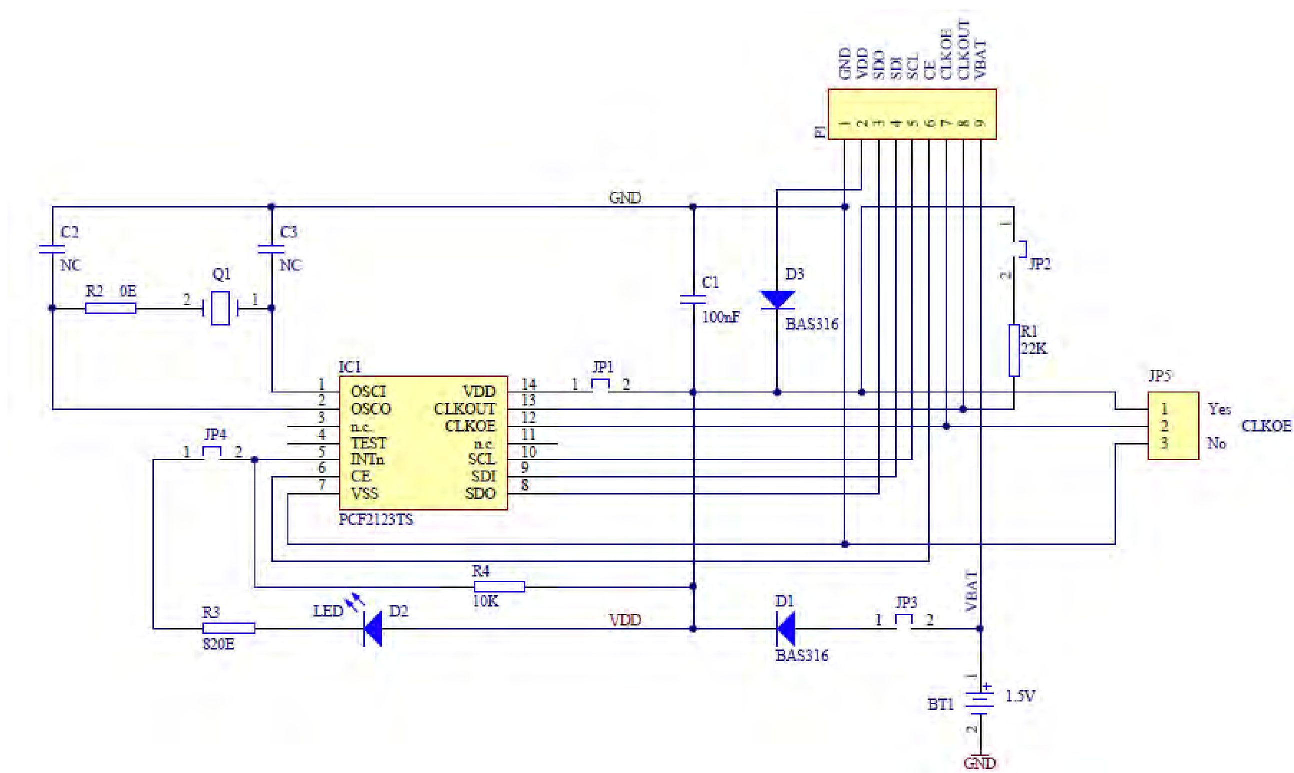



**Fig 3. Circuit diagram of the demo board OM13512**

## 4.1 Detailed circuit diagram

Connectors and features

- The single in line connector P1 (100 mil pitch) is providing access to all pins for integrating the RTC into an application
- Jumper JP1 allows to measure the current consumption; for this the jumper has to be removed and replaced by a µA meter
- Jumper JP2 switches in a pull-up to CLKOUT, in case none is provided in the target circuit. CLKOUT is an open drain output.
- Jumper JP3 enables the battery. For delivery it is set open. The Schottky diode D1 switches to the battery as soon as $V_{DD}$ is lower than $V_{BAT}$.
- Jumper JP4 allows visualizing the interrupts by the LEDs on $\overline{\text{INT}}$ on top of the board.
- Jumper JP5 enables the CLKOUT pin. When the jumper is connected to $V_{DD}$, the CLKOUT is enabled; when it is connected to $V_{SS}$ the CLKOUT is disabled.
- The diode D3 avoids that the remaining circuits are supplied by the battery and therefore draining it. D3 is not required if no battery backup is used.

- Position of the Jumpers and connectors are found in the circuit diagram in Fig 3 and the layout drawing in Fig 4.

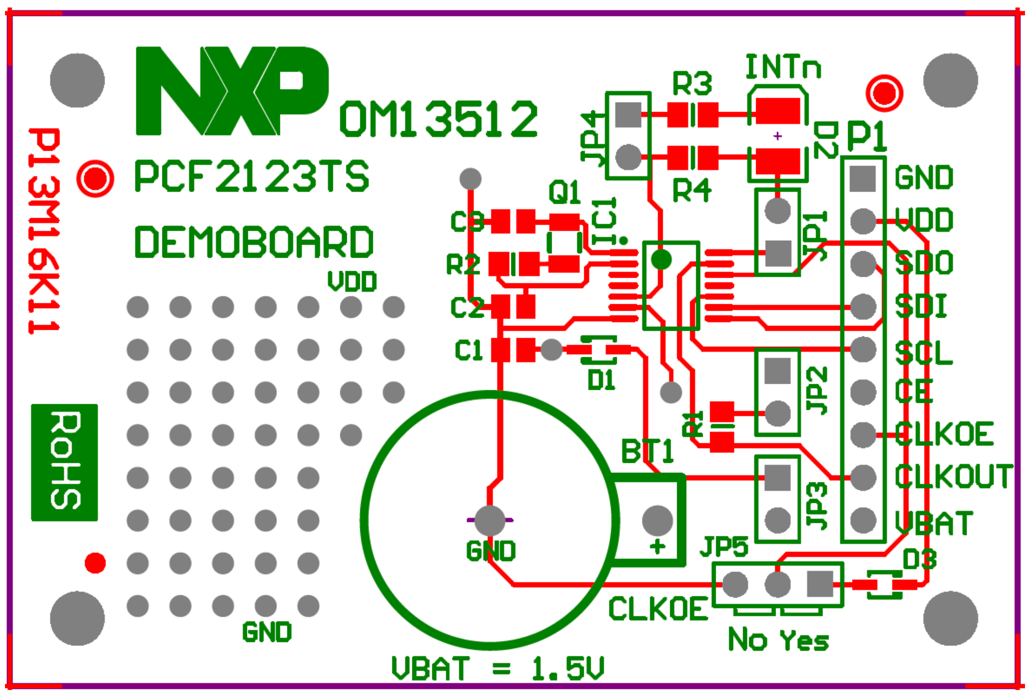



Fig 4. Demo board and top side layout

# 5. Optional features for test and evaluation

## 5.1 Oscillator

The characteristics of the oscillator with different quartzes can easily be verified.

The Resistor R4 (0 Ω) can be replaced to simulate varying $R_S$ of quartzes. The maximum total impedance can be 100 kΩ.

## 5.2 Experimental area

On the board there is space for adding a custom circuitry for general purpose. $V_{SS}$ and $V_{DD}$ are available for easy set up.

# 6. Software

The actual time must be set after power on. For this, straight forward SPI-bus instructions are used.

## 6.1 Functionality

The RTC PCF2123 is controlled via a standard SPI-bus interface. The common SPI protocol applies. The Chip Enable (CE) signal allows using different devices on the same bus.

It is advised to program the control register first to set the correct functions and modes.

## 6.2 Software instructions for setting the clock

### 6.2.1 Setting the time

**Setting the clock to 3.45 PM Monday, December 15, 2014**

- Chip select: CE = 1
- Software reset:10h, 58h
- Chip select off: CE = 0
- Chip select: CE = 1
- Address pointer: 01h
- Status word 0: 04h, 12 hour mode is selected
- Status word 1: 00h, timer not initiated
- Seconds register: 00h, 0 seconds (clock integrity ok→ MSB OS = 0)
- Minutes register: 45h, 45 min
- Hours register: 23h, PM flag, 3 PM
- Days register: 15h, 15$^{th}$ day of the month
- Weekdays register: 01h, Monday (1$^{st}$ day of the week)
- Months register: 12h, December
- Years register: 14h, (20)14
- Chip select off: CE = 0

### 6.2.2 Reading the clock

**Example reading the clock (some 2 minutes after writing)**

- Chip select: CE = 1
- Set address: 02h

**Read**

- Seconds: e.g. 56 (seconds, clock integrity ok, OS = 0)
- Minutes: e.g. 46 (minutes)
- Hours: 23 (3 PM)
- Days: 15 (15th)
- Weekdays: 01 (Monday)
- Months: 12 (December)
- Years: 14 (2014)
- Chip select off: CE = 0

## 6.3 Frequency tuning

The 32 kHz quartzes are typically sold with a tolerance at room temperature of either ±10 ppm or ±20 ppm.

**Remark:** 11.5 ppm corresponds to 1 s/day. The quartzes feature a characteristic load capacity of either 7 pF or 12.5 pF. Oscillators, utilizing 7 pF quartzes, feature slightly lower power consumption, where the quartzes of 12.5 pF have largest production quantities. The tracks between quartz and RTC represent also some parasitic capacitances and must be kept short. The PCF2123 has a tuning facility where above tolerances can be compensated.

### Tuning procedure:

- Measure the 32xxx Hz (f) signal at the CLKOUT pin.
- The offset is calculated as described in Fig 5.
- Consult the offset table in the data sheet. Take the correction value and write it into the register 0Dh.
- The correction is done by means of inhibition or addition: the oscillator runs at constant speed, then every 2 hours (mode 0) 1 second is corrected by making it shorter or longer. This is only visible with CLKOUT set to 1 Hz. Corrections can also be applied every minute by using mode 1. This mode will consume slightly more power. (<1% more).

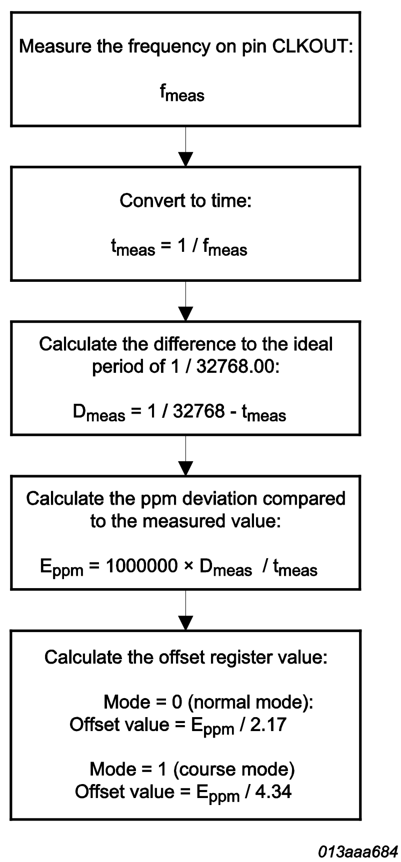
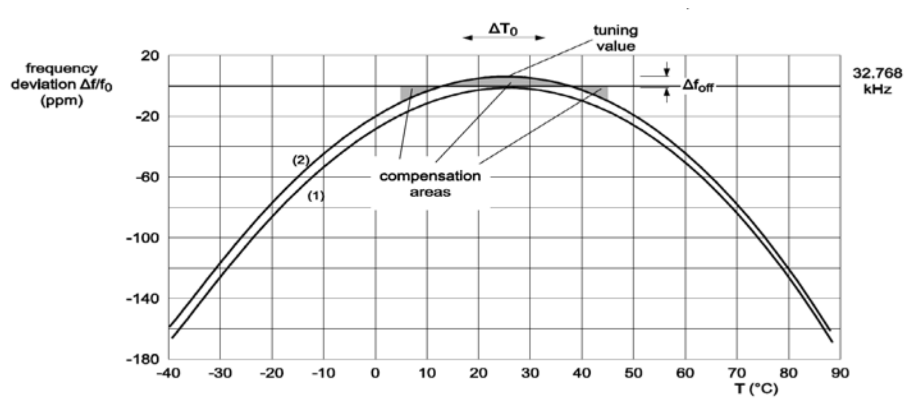



**Fig 5. Offset calibration calculation workflow**

The 32 kHz quartzes are of the tuning fork type and feature a parabolic frequency response over temperature. When the application is dominantly used over a limited temperature range, it is often helpful to tune the frequency to be slightly higher at the turnover point. The error around 25 ºC (clock goes too fast) is then compensated during the time when temperature is lower or higher. For example, for operation between 5 ºC and 45 ºC, tune the clock 8 ppm faster than the value for 25 ºC would be. (See Fig 6.)




(1) Characteristic if tuned to 32.768 kHz at 25 ºC.

(2) Characteristic if tuned with the positive offset $\Delta f_{off}$.

**Fig 6. Averaged frequency over the application temperature range of 5 ºC to 45 ºC**

## 7. Reference

[1] **AN11247** - Improved timekeeping accuracy with PCF85063, PCF8523 and PCF2123 using an external temperature sensor, Application Note

[2] **PCF2123** - SPI Real time clock/calendar, Data Sheet

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## 9. List of List of figures

## 10. Contents





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