

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

Contact information

For more information, please visit: <http://www.nxp.com>

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

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.

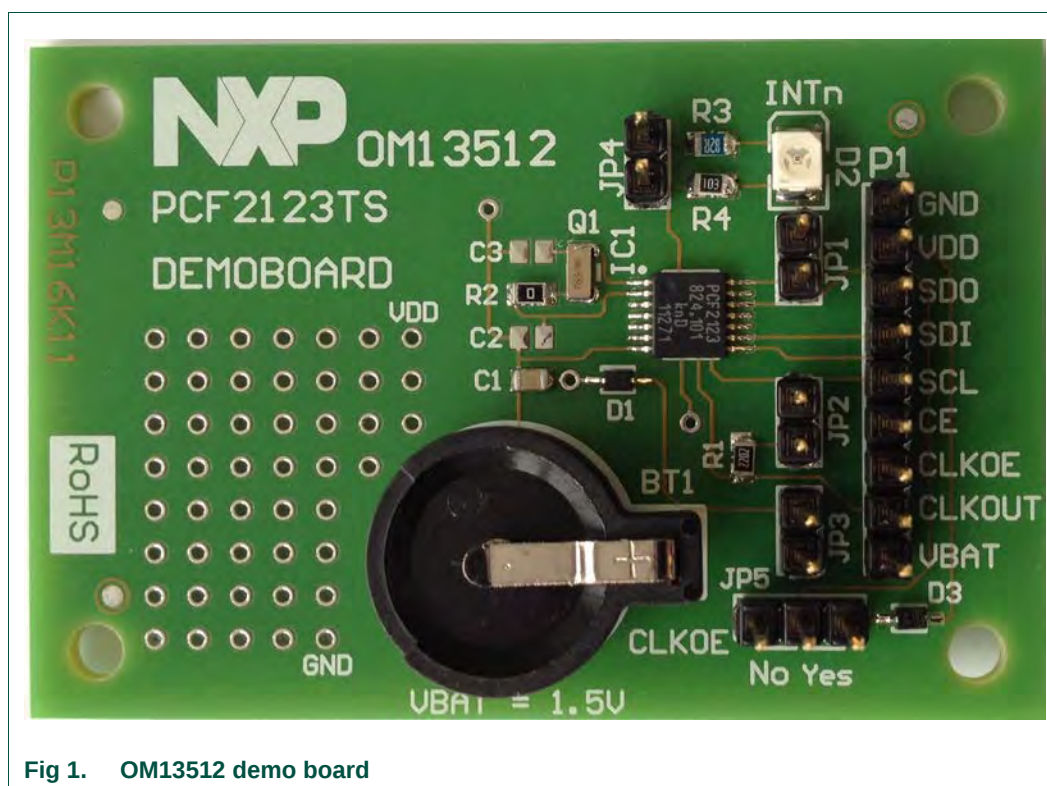


Fig 1. OM13512 demo board

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 $V_{DD} = 2.0\text{ V}$ and $T_{amb} = 25\text{ }^{\circ}\text{C}$

- 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 $V_{DD} = 1.8 \text{ V}$ to 5.5 V
- Integrated oscillator load capacitors for quartzes with $C_L = 7 \text{ pF}$
- Internal Power-On Reset (POR)
- Open-drain interrupt and clock output pins
- Programmable offset register for frequency trimming

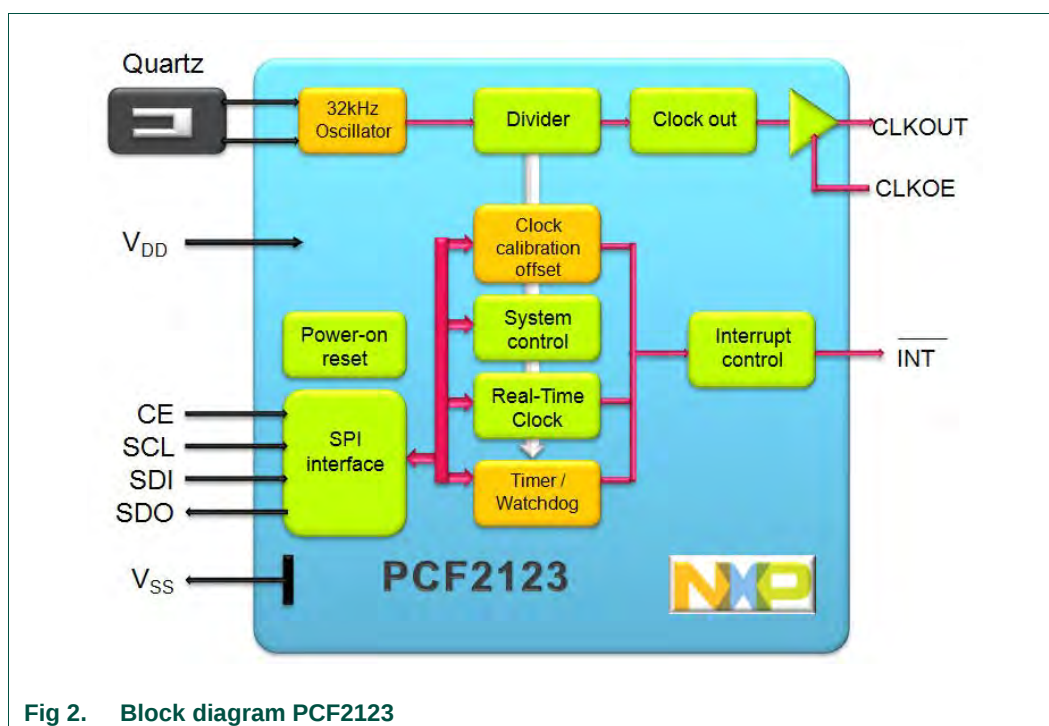


Fig 2. Block diagram PCF2123

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

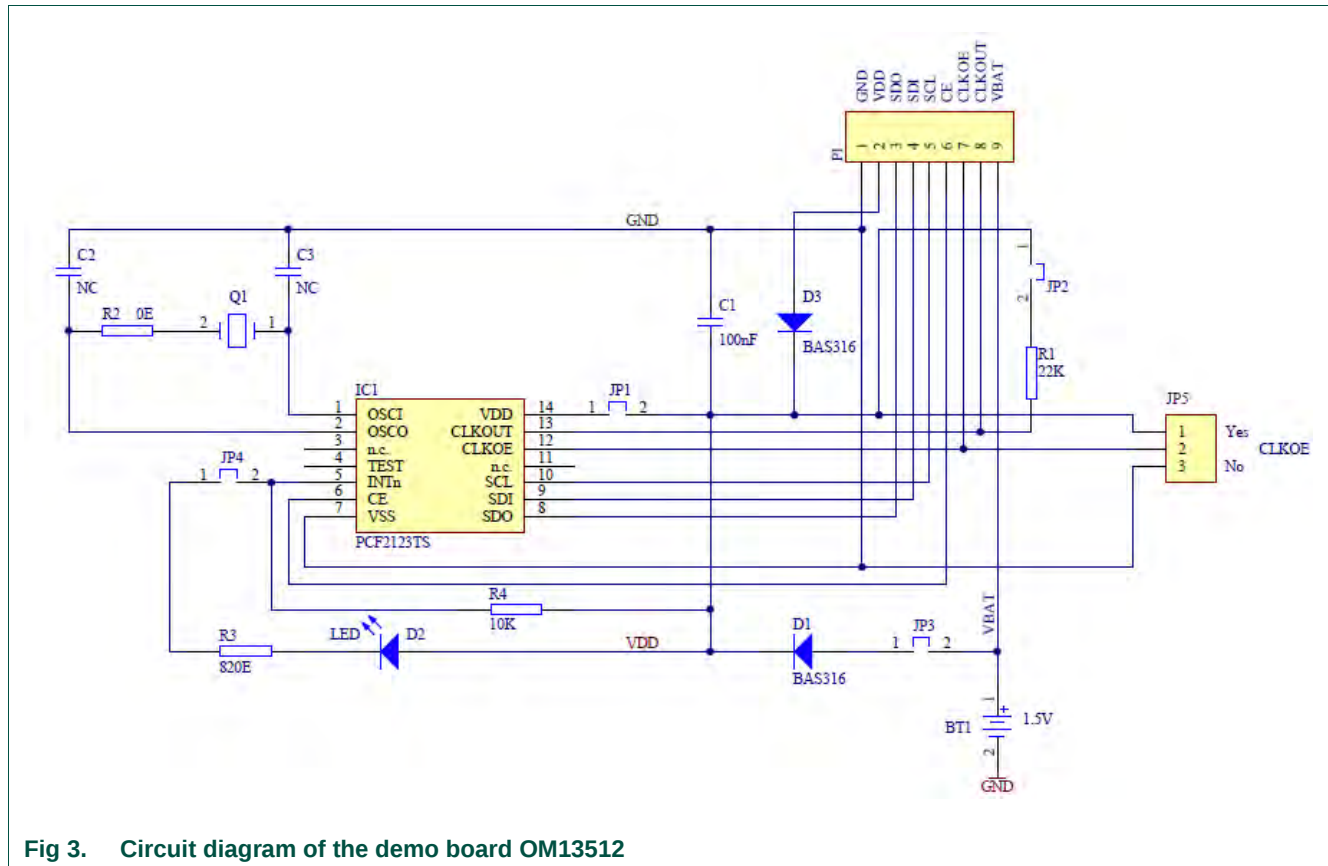


Fig 3. Circuit diagram of the demo board OM13512

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](#).

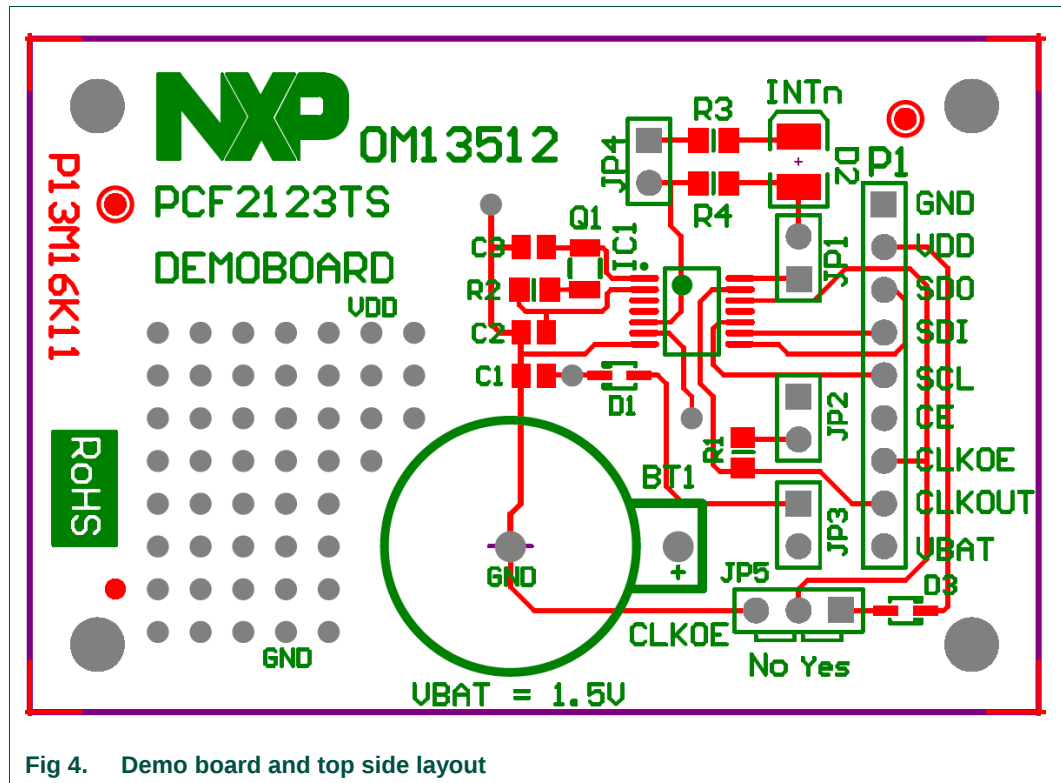


Fig 4. Demo board and top side layout

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 k Ω .

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, 15th day of the month
- Weekdays register: 01h, Monday (1st 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

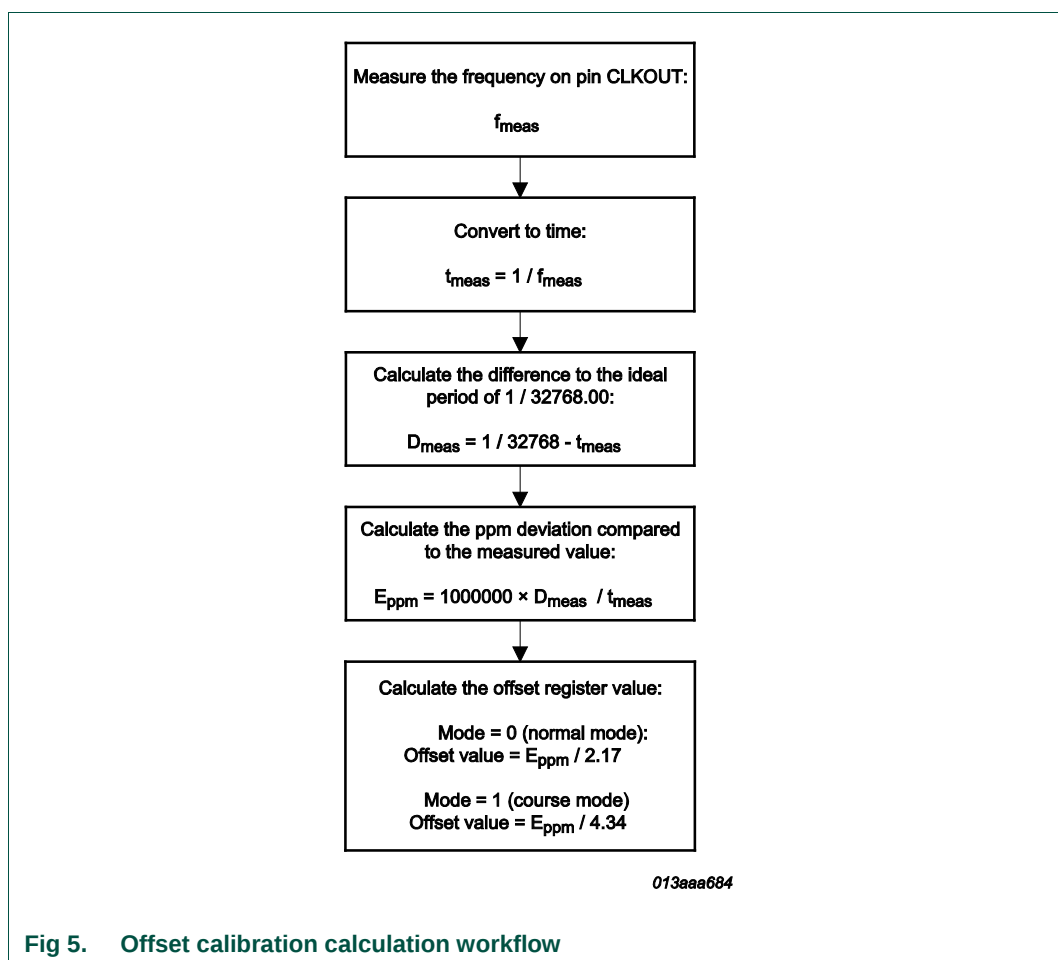
The 32 kHz quartzes are typically sold with a tolerance at room temperature of either ± 10 ppm or ± 20 ppm.

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.

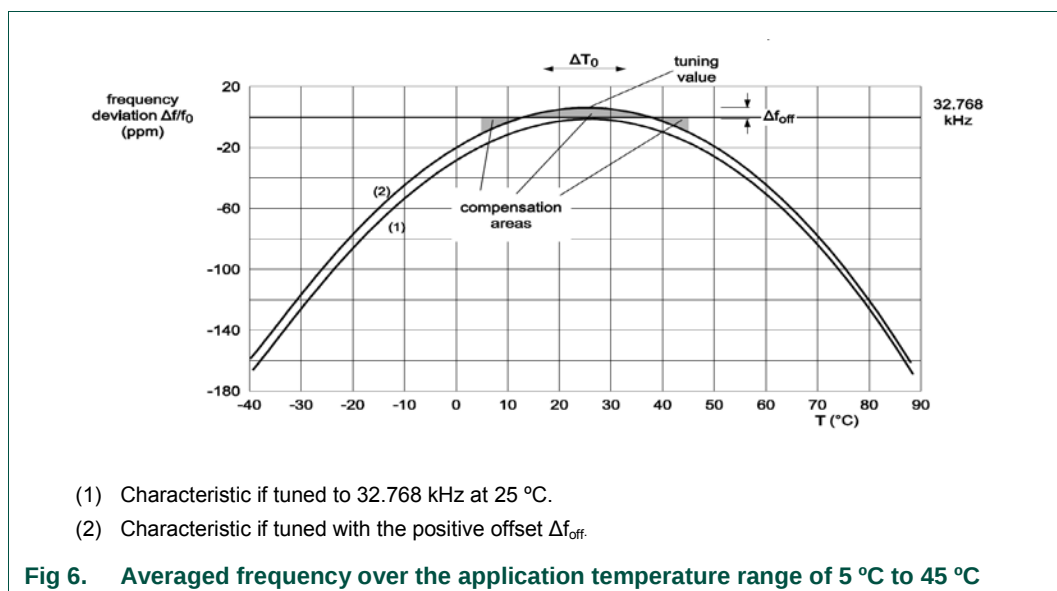
Tuning procedure:

- 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).



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 °C (clock goes too fast) is then compensated during the time when temperature is lower or higher. For example, for operation between 5 °C and 45 °C, tune the clock 8 ppm faster than the value for 25 °C would be. (See [Fig 6](#).)



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

8. Legal information

8.1 Definitions

Draft — The document is a draft version only. The content is still under internal review and subject to formal approval, which may result in modifications or additions. NXP Semiconductors does not give any representations or warranties as to the accuracy or completeness of information included herein and shall have no liability for the consequences of use of such information.

8.2 Disclaimers

Limited warranty and liability — Information in this document is believed to be accurate and reliable. However, NXP Semiconductors does not give any representations or warranties, expressed or implied, as to the accuracy or completeness of such information and shall have no liability for the consequences of use of such information.

In no event shall NXP Semiconductors be liable for any indirect, incidental, punitive, special or consequential damages (including - without limitation - lost profits, lost savings, business interruption, costs related to the removal or replacement of any products or rework charges) whether or not such damages are based on tort (including negligence), warranty, breach of contract or any other legal theory.

Notwithstanding any damages that customer might incur for any reason whatsoever, NXP Semiconductors' aggregate and cumulative liability towards customer for the products described herein shall be limited in accordance with the Terms and conditions of commercial sale of NXP Semiconductors.

Right to make changes — NXP Semiconductors reserves the right to make changes to information published in this document, including without limitation specifications and product descriptions, at any time and without notice. This document supersedes and replaces all information supplied prior to the publication hereof.

Suitability for use — NXP Semiconductors products are not designed, authorized or warranted to be suitable for use in life support, life-critical or safety-critical systems or equipment, nor in applications where failure or malfunction of an NXP Semiconductors product can reasonably be expected to result in personal injury, death or severe property or environmental damage. NXP Semiconductors accepts no liability for inclusion and/or use of NXP Semiconductors products in such equipment or applications and therefore such inclusion and/or use is at the customer's own risk.

Applications — Applications that are described herein for any of these products are for illustrative purposes only. NXP Semiconductors makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification.

Customers are responsible for the design and operation of their applications and products using NXP Semiconductors products, and NXP Semiconductors accepts no liability for any assistance with applications or

customer product design. It is customer's sole responsibility to determine whether the NXP Semiconductors product is suitable and fit for the customer's applications and products planned, as well as for the planned application and use of customer's third party customer(s). Customers should provide appropriate design and operating safeguards to minimize the risks associated with their applications and products.

NXP Semiconductors does not accept any liability related to any default, damage, costs or problem which is based on any weakness or default in the customer's applications or products, or the application or use by customer's third party customer(s). Customer is responsible for doing all necessary testing for the customer's applications and products using NXP Semiconductors products in order to avoid a default of the applications and the products or of the application or use by customer's third party customer(s). NXP does not accept any liability in this respect.

Export control — This document as well as the item(s) described herein may be subject to export control regulations. Export might require a prior authorization from competent authorities.

Evaluation products — This product is provided on an "as is" and "with all faults" basis for evaluation purposes only. NXP Semiconductors, its affiliates and their suppliers expressly disclaim all warranties, whether express, implied or statutory, including but not limited to the implied warranties of non-infringement, merchantability and fitness for a particular purpose. The entire risk as to the quality, or arising out of the use or performance, of this product remains with customer.

In no event shall NXP Semiconductors, its affiliates or their suppliers be liable to customer for any special, indirect, consequential, punitive or incidental damages (including without limitation damages for loss of business, business interruption, loss of use, loss of data or information, and the like) arising out of the use of or inability to use the product, whether or not based on tort (including negligence), strict liability, breach of contract, breach of warranty or any other theory, even if advised of the possibility of such damages.

Notwithstanding any damages that customer might incur for any reason whatsoever (including without limitation, all damages referenced above and all direct or general damages), the entire liability of NXP Semiconductors, its affiliates and their suppliers and customer's exclusive remedy for all of the foregoing shall be limited to actual damages incurred by customer based on reasonable reliance up to the greater of the amount actually paid by customer for the product or five dollars (US\$5.00). The foregoing limitations, exclusions and disclaimers shall apply to the maximum extent permitted by applicable law, even if any remedy fails of its essential purpose.

8.3 Trademarks

Notice: All referenced brands, product names, service names and trademarks are property of their respective owners.

9. List of List of figures

Fig 1. OM13512 demo board3

Fig 2. Block diagram PCF21234

Fig 3. Circuit diagram of the demo board OM13512 ...6

Fig 4. Demo board and top side layout7

Fig 5. Offset calibration calculation workflow9

Fig 6. Averaged frequency over the application
temperature range of 5 °C to 45 °C 10

10. Contents

1.	Introduction	3
2.	Key features	3
2.1	Demo board OM13512	3
2.2	Real time clock PCF2123	3
3.	Hardware setup	4
3.1	General requirement for the PCF2123	4
3.2	Battery back-up	5
3.3	Optimizing power consumption	5
4.	Circuit diagram	6
4.1	Detailed circuit diagram	6
5.	Optional features for test and evaluation	7
5.1	Oscillator	7
5.2	Experimental area	7
6.	Software	7
6.1	Functionality	7
6.2	Software instructions for setting the clock	8
6.2.1	Setting the time	8
6.2.2	Reading the clock	8
6.3	Frequency tuning	8
7.	Reference	11
8.	Legal information	12
8.1	Definitions	12
8.2	Disclaimers	12
8.3	Trademarks	12
9.	List of List of figures	13
10.	Contents	14

Please be aware that important notices concerning this document and the product(s) described herein, have been included in the section 'Legal information'.
