

# UM10762

User manual for the accurate RTC demo board OM13513  
containing PCF2127T and PCF2129AT

Rev. 2 — 1 September 2014

User manual

## Document information

Info	Content
<b>Keywords</b>	PCF2127T, PCF2129AT, OM13513, accurate RTC, Real-Time Clock, get started, SPI bus, I <sup>2</sup> C-bus, time stamp, temperature compensation, integrated quartz, tuning, battery switch, Watch-Dog
<b>Abstract</b>	User manual for the accurate RTC demo board OM13513 containing PCF2127T and PCF2129AT



## Revision history

Rev	Date	Description
v.2	20140901	updated revision
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](mailto:salesaddresses@nxp.com)

## 1. Introduction

---

它们具有完全集成的温度补偿  
石英振荡器 ( TCXO )

The PCF2127, PCA2129 and PCF2129 are a family of very accurate Real-Time Clocks. They feature a fully integrated temperature compensated quartz oscillator (TCXO). Time stamp, battery management and watchdog blocks reduce the system overhead considerably. 时间戳

The OM13513 is the ideal evaluation and demo board to be used during the design phase of any project; only power and a serial bus (SPI-bus or I<sup>2</sup>C-bus) need to be connected. The OM13518 (USB to I<sup>2</sup>C-bus dongle) could be used for the I<sup>2</sup>C-bus connection.

## 2. Key features

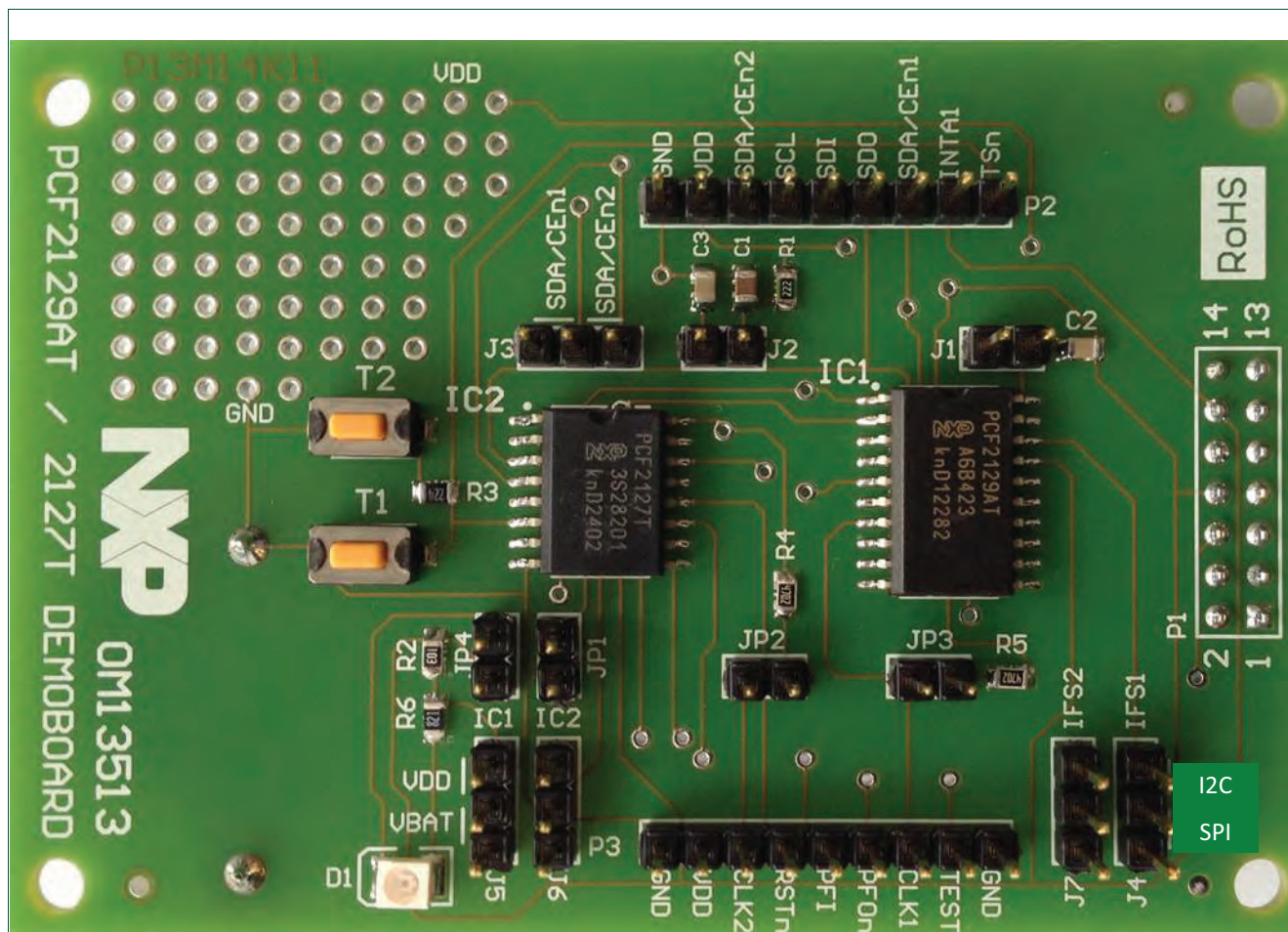
---

### 2.1 Evaluation board OM13513

The accurate RTCs PCF2127T and PCF2129AT are mounted together with a back-up lithium battery on a small PC-board. Two push buttons allow initiating time stamps.

All signals are accessible on the pin connectors P2 and P3 (see [Figure 4](#)), overcoming the need to build a test PC-board before the circuit can be evaluated or the functionality can be tested together with the final application.

The board is also helpful to evaluate the functionality of PCF2127AT, PCF2129T and PCA2129T/Q900, the automotive grade version. Also check section [Section 2.3](#).



For configuring the board, see [Section 3.4](#).

Fig 1. OM13513 evaluation/demo board

## 2.2 Accurate RTC

The specific features of the accurate RTC are complementing the main functionality.

### PCF2127T and PCF2129AT:

- Temperature compensated quartz oscillator TCXO with embedded quartz crystal
  - Typical accuracy:  $\pm 3$  ppm
- Battery backup input pin and switch-over circuitry
- Battery backed output voltage
- Universal interface to select between SPI- and I<sup>2</sup>C-bus
- Time stamp facility
  - With interrupt capability 具有中断功能 在一个多级输入引脚上检测两个不同的事件 (例如, 用于篡改检测)
  - Detection of two different events on one multilevel input pin (for example, for tamper detection)
- Programmable watchdog timer with interrupt

篡改检测是设备感知正在尝试破坏设备完整性或与设备相关的数据的主动尝试的能力；威胁的检测可以使设备启动适当的防御行动

- Programmable alarm function with interrupt capability 具有中断能力的可编程报警功能

In addition PCF2127T has the following features:

- 512 Byte of battery buffered RAM 512 字节的电池缓冲 RAM ? ?
- Programmable countdown timer with interrupt 带中断的可编程倒计时器
- Additional power fail detector to, for example, pre-alert the microcontroller that the power supply is going down 额外的电源故障检测器，例如，预先警告微控制器电源正在下降

The block diagram in [Figure 2](#) nicely illustrates the key blocks:

- Time stamp facility
- Temperature compensated quartz oscillator TCXO
- Battery back-up switch 备用电池开关
- Universal interface to select between SPI-bus and I<sup>2</sup>C-bus

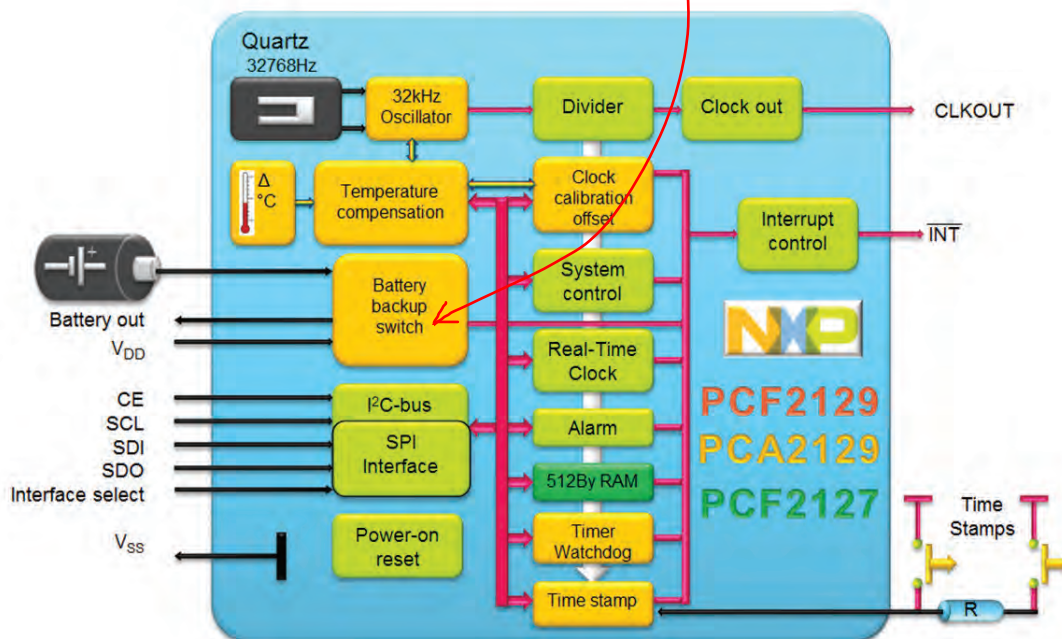


Fig 2. Block diagram of the accurate RTC family

Time Stamp就是RTC计数器值(时间戳)  
需要写算法与常用时间格式(年月日时分秒) 互相转换

## 2.3 Accurate Real-Time Clock PCF2127T, PCF2129AT

The high accuracy is achieved by the integration of a temperature compensated quartz oscillator including the quartz crystal in one package. Additional features are battery management, time stamp facility and in case of the PCF2127T additional 512 bytes of battery buffered RAM.

There are 3 different grades available:

1. Temperature compensation covering  $-25^{\circ}\text{C}$  to  $+65^{\circ}\text{C}$ : PCF2127AT, PCF2129AT (on the OM13513)

2. Temperature compensation covering  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ : PCF2127T (on the OM13513), PCF2129T
  3. Automotive grade AEC-Q100 covering  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ : PCA2129T/Q900
1. uses a quartz crystal packed in a metal can package.
  2. and 3. use a quartz, packed in a ceramic package.

## 2.4 Expected accuracy

The accuracy of an RTC is commonly specified in deviation of seconds per day or ppm; 1 s/day corresponds to 11.5ppm.

The PCF2127AT and PCF2129AT are temperature compensated over the temperature range of  $-30^{\circ}\text{C}$  to  $+60^{\circ}\text{C}$  and the PCF2127T, PCF2129T and PCA2129T/Q900 are temperature compensated over the temperature range of  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ , see [Figure 3](#).

Since the actual deviations at different temperatures may be positive (running to fast) or negative (running too slow) they may cancel out each other to a high extend. Therefore the actual accuracy over timer is much better than specified in with the max values;  $< 3$  ppm or 1 s/4days can be expected. Other consideration regard the ambient temperature over the day, respectively over the year. Temperatures below e.g.  $-15^{\circ}\text{C}$  and above  $+60^{\circ}\text{C}$  are usually only present for a limited time of the day and may even not be present most of the year.

RTC 的精度通常以每天秒数或 ppm 的偏差来指定; 1 秒/天对应于 11.5ppm。

PCF2127AT 和 PCF2129AT 在  $-30^{\circ}\text{C}$  至  $+60^{\circ}\text{C}$  的温度范围内进行温度补偿, PCF2127T、PCF2129T 和 PCA2129T/Q900 在  $-40^{\circ}\text{C}$  至  $+85^{\circ}\text{C}$  的温度范围内进行温度补偿, 参见图 3。

由于不同温度下的实际偏差可能是正的 (跑得快) 或负的 (跑得太慢), 它们可能会在很大程度上相互抵消。因此, 定时器的实际精度比最大值中指定的要好得多; 预计  $< 3$  ppm 或 1 秒/4 天。其他考虑因素分别是全年的环境温度。温度低于例如  $-15^{\circ}\text{C}$  及以上  $+60^{\circ}\text{C}$  通常只在一天中的有限时间出现, 甚至可能在一年中的大部分时间都不会出现。

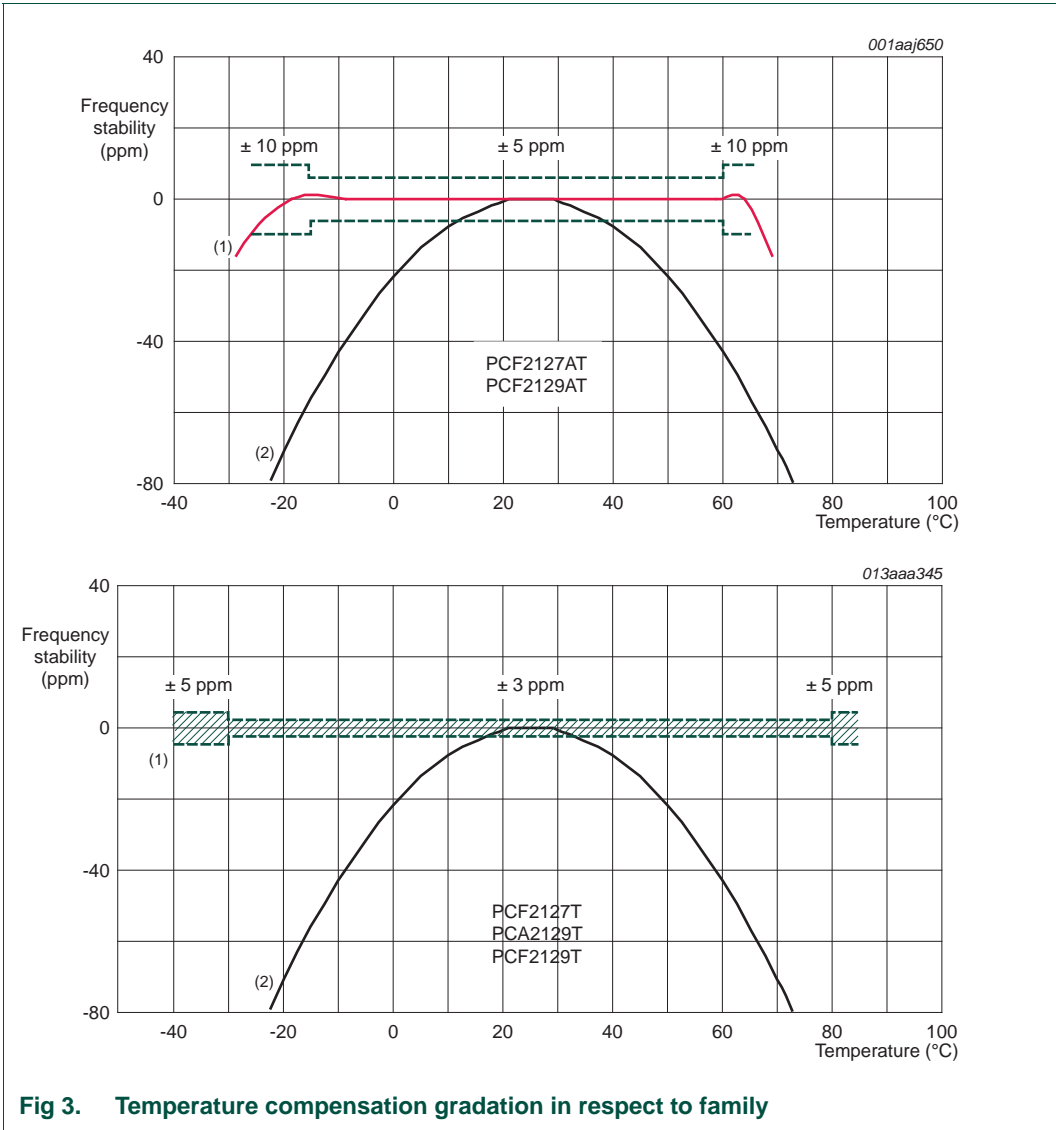


Fig 3. Temperature compensation gradation in respect to family



### 3. Hardware setup

#### 3.1 Detailed circuit diagram

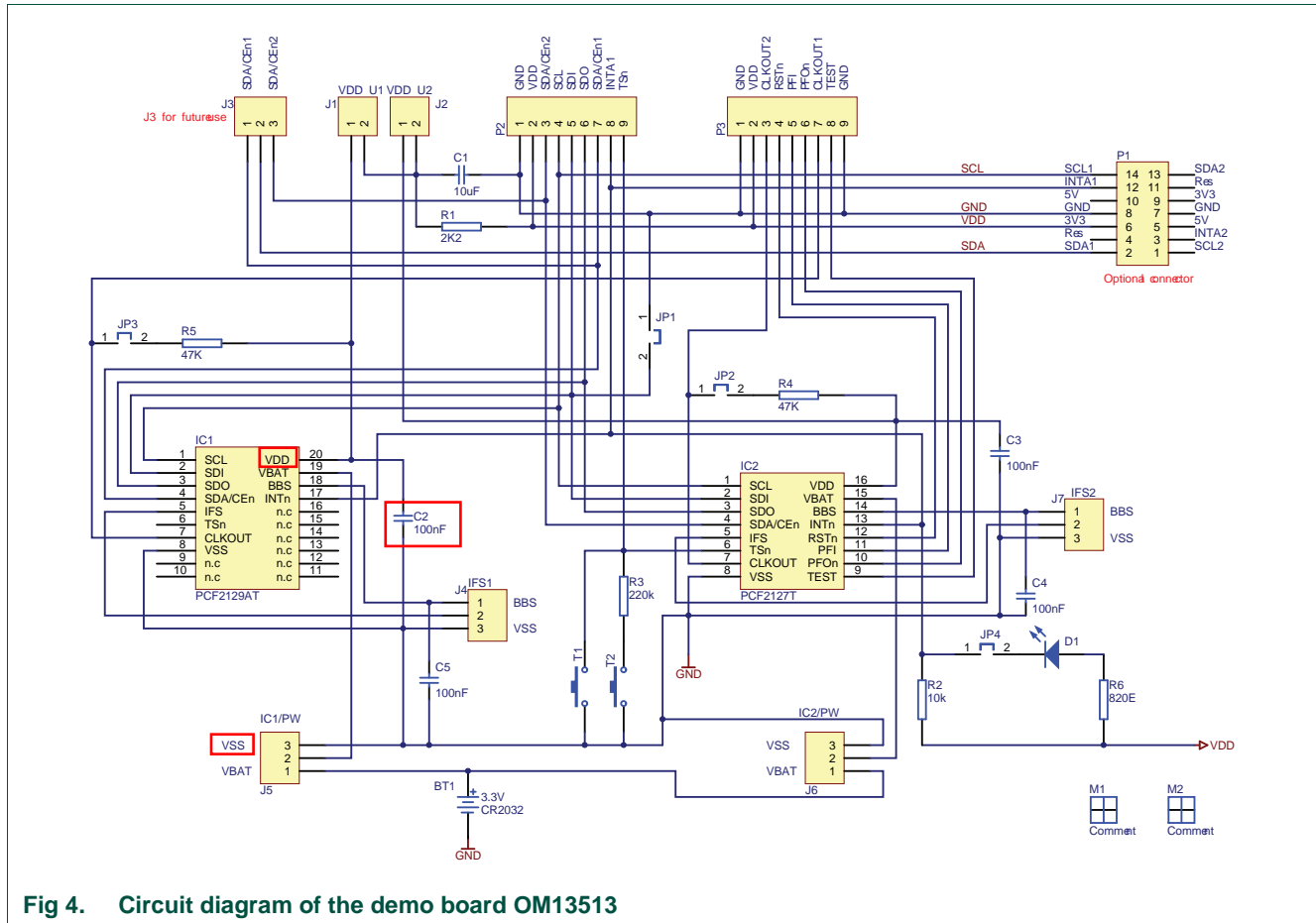


Fig 4. Circuit diagram of the demo board OM13513

The position of the jumpers and connectors can be found in the circuit diagram (Figure 4) and the layout drawing (Figure 5).

#### 3.2 General requirements for the PCF2127T and PCF2129AT

The RTC circuit just requires a few external components to buffer the supply voltage.

Avoid any tracks with high frequency signals (fast edges) close to the RTC or its connections.

需要在靠近 RTC 的 VDD-VSS 轨上安装一个 100 nF 的去耦电容；需要在 BBS 引脚上使用类似的去耦电容。由于几  $\mu$ W 的低功耗，即使在密封的外壳环境中，也不需要采取散热措施。

Vbat需要100nF电容不？  
原理图上没有

It is required to have a decoupling capacitor of 100 nF on the VDD-VSS rails close to the RTC; a similar decoupling capacitor on pin BBS is required. Due to the low power consumption of a few  $\mu$ W, no precautions for heat dissipations are required, even in a sealed housing environment.

Frequencies of 1 Hz to 16.884 kHz at the CLKOUT pin can be used to measure the frequency for calibration and/or for general purpose use, e.g. as reference for the frequency generation with a PLL. If the CLKOUT frequency is set to 32.768 kHz, then the accuracy may be less.



### 3.3 Battery back-up

To guarantee the autonomy of the clock a continuous supply of power is needed. The battery back-up facility will assure this. For storage and delivery the jumpers J5 and J6 are set such that the battery will not be discharged.

To reduce power consumption, always switch-off functions and outputs not in use.

### 3.4 Hardware settings

#### 3.4.1 General settings

- Set Jumper JP4 to activate LED D1 for signaling an interrupt
- The single in line connectors P2 and P3 (100 mil pitch) give access to all pins for integrating the RTC into an application
- Resistor R1 and C1 reduce the  $V_{DD}$  slew rate when removing  $V_{DD}$  to ensure clean battery switch over 移除  $V_{DD}$  时，电阻 R1 和 C1 可降低  $V_{DD}$  压摆率，以确保干净的电池切换
- A Lithium coin cell battery 2032 is mounted underneath the board to buffer the voltage in case of loss of supply voltage  $V_{DD}$
- Jumper J1, respectively J2 allows to measure the current consumption, replace it by a  $\mu A$  meter

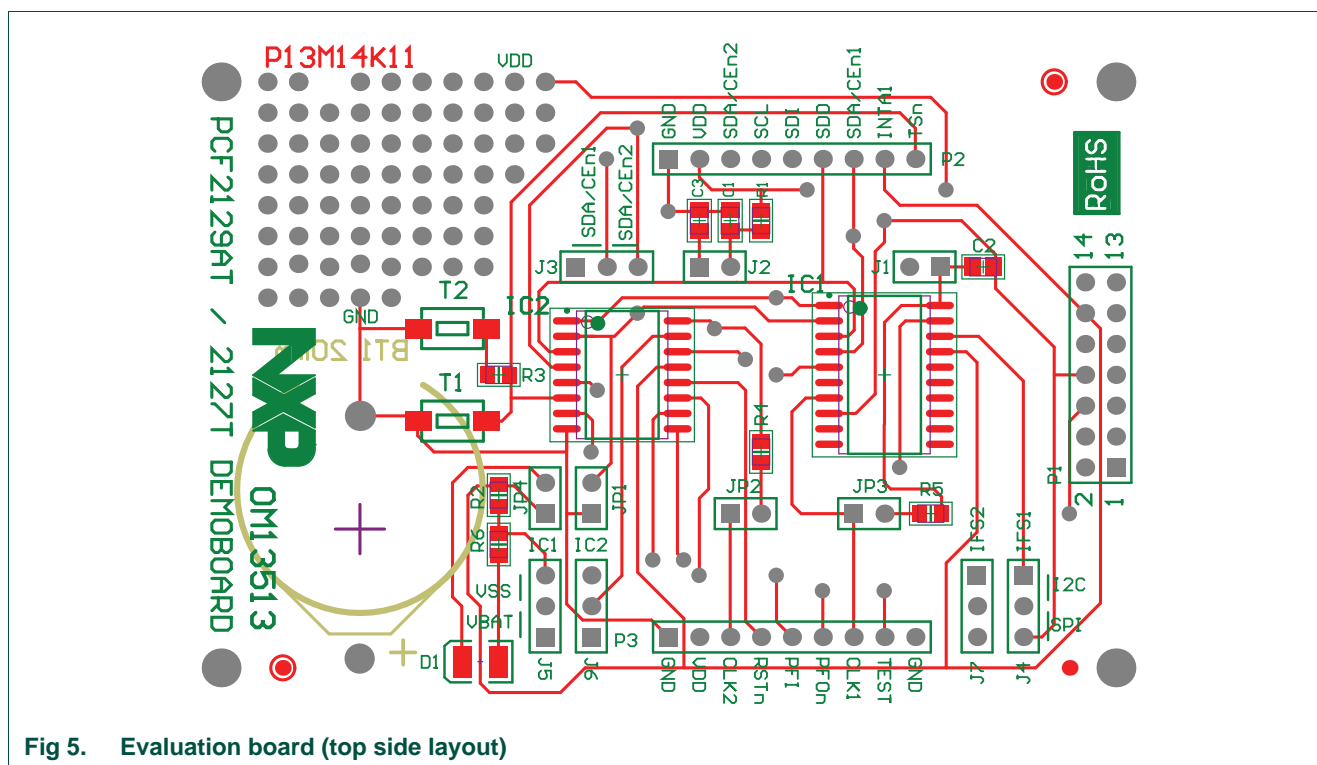
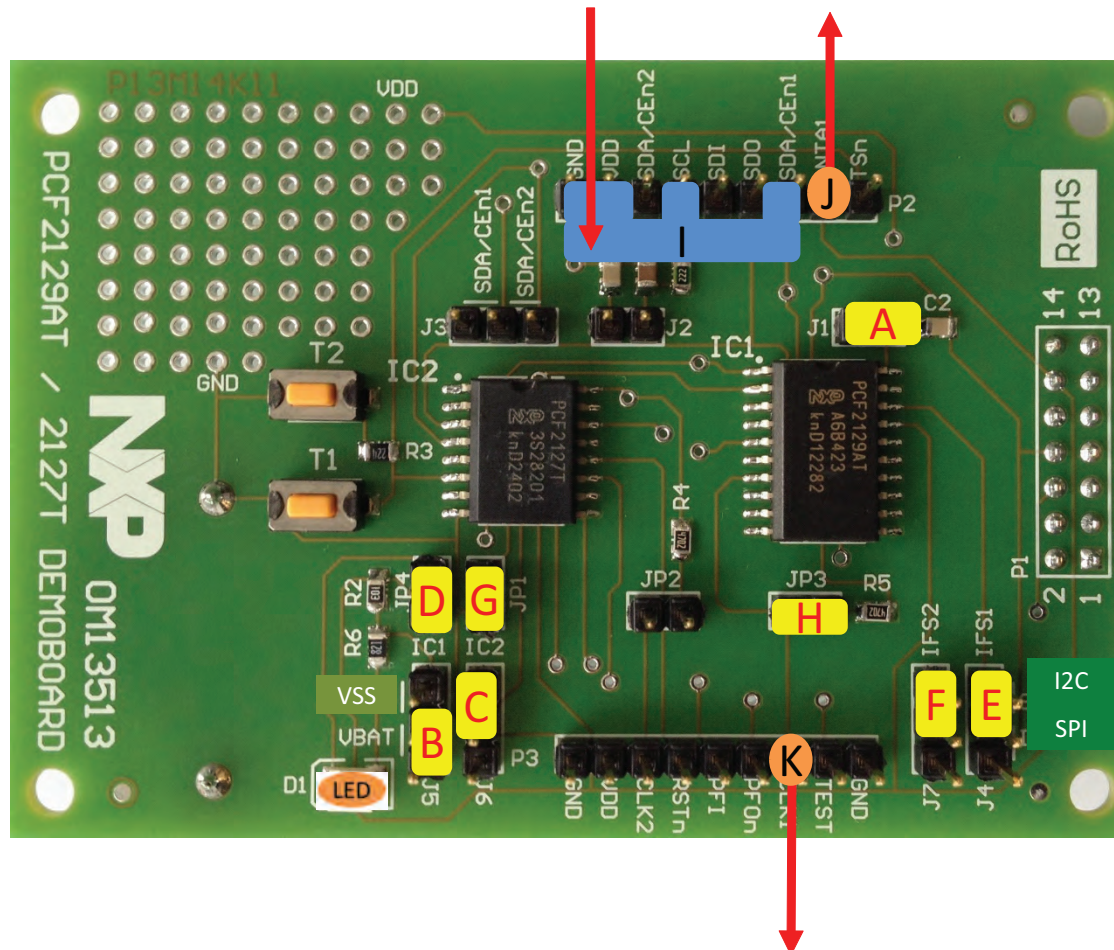


Fig 5. Evaluation board (top side layout)

### 3.4.2 Settings for PCF2129AT (IC1)

Default jumper settings to operate PCF2129AT and disable PCF2127T on the board. The hardware settings are illustrated in [Figure 6](#).



**Fig 6. Hardware settings for PCF2129AT**

Table 1. Jumper settings to operate PCF2129AT (IC1)

Indicator	Description	Jumper	Setting <sup>[1]</sup>
<b>Jumpers</b>			
A	V <sub>DD</sub> selected for PCF2129AT	J1	■ ■
B	battery backup of PCF2129AT enabled	J6	□ ■ ■
C	battery backup of PCF2127T disabled	J5	■ ■ □
D	LED D1 connected to interrupt pin	JP4	■ ■
E	I <sup>2</sup> C-bus selected for the PCF2129AT	J4	□ ■ ■
	SPI-bus selected for the PCF2129AT		■ ■ □
G	unused SDI-interface connected to GND	JP1	■ ■
H	pull-up on CLKOUT	JP2	-
<b>Interface</b>			
I	supply and interface connector	P2	-
<b>Outputs</b>			
J	interrupt output	P2	-
K	clock output	P3	-

[1] In direction of reading "Jn".

### 3.4.3 Settings for PCF2127T (IC2)

Default jumper settings to operate PCF2127T and disable PCF2129AT on the board. The hardware settings are illustrated in [Figure 7](#).

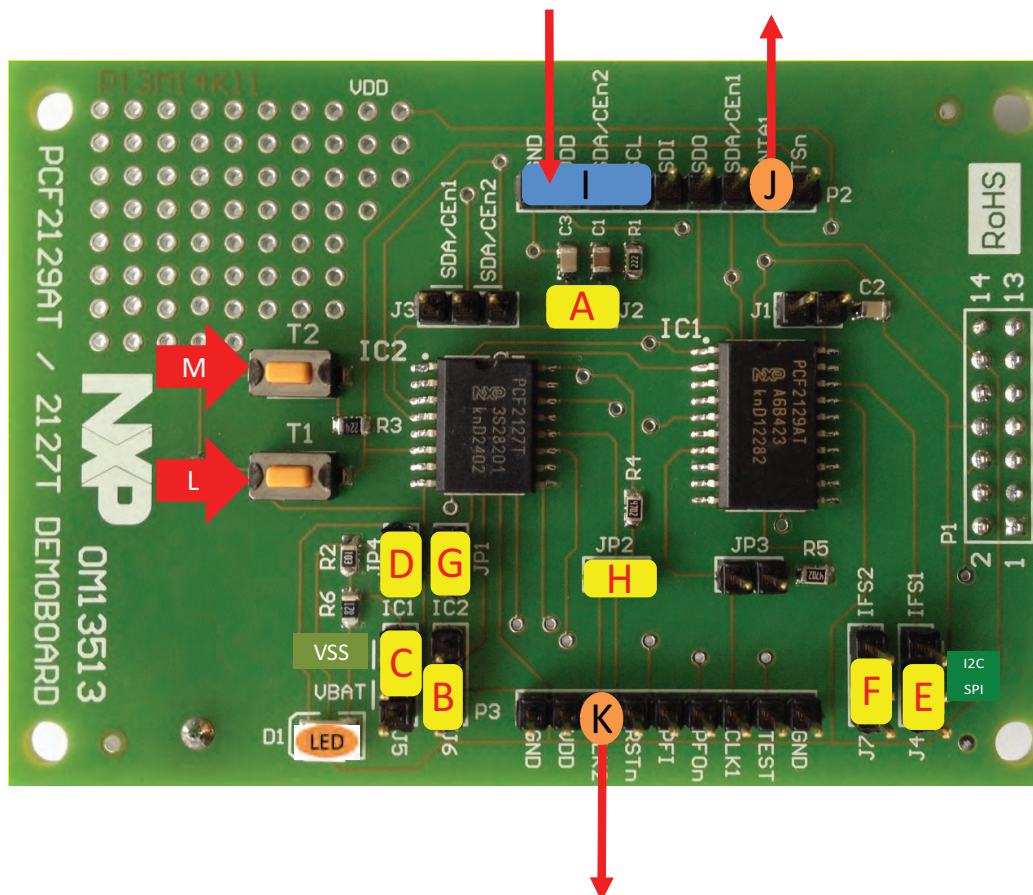


Fig 7. Hardware settings for PCF2127T

Table 2. Jumper settings to operate the PCF2127T (IC2)

Indicator	Description	Jumper	Setting <sup>[1]</sup>
<b>Jumpers</b>			
A	V <sub>DD</sub> selected for PCF2127T	J2	■ ■
B	battery backup of PCF2127T enabled	J5	□ ■ ■
C	battery backup of PCF2129AT disabled	J6	■ ■ □
D	LED D1 connected to interrupt pin	JP4	■ ■
F	I <sup>2</sup> C-bus selected for the PCF2127T	J7	□ ■ ■
	SPI-bus selected for the PCF2127T		■ ■ □
G	unused SDI-interface connected to GND	JP1	■ ■
H	pull-up on CLKOUT	JP2	-
<b>Interface</b>			
I	supply and interface connector	P2	-
<b>Outputs</b>			
J	interrupt output	P2	-
K	clock output	P3	-
<b>Push button</b>			
L	time stamp input 1	T1	-
M	time stamp input 2	T1	-

[1] In direction of reading "Jn".

## 4. Optional features for test and evaluation

---

### 4.1 Experimental area

Left of the NXP logo there is some space on the board where a custom circuitry can be placed.  $V_{SS}$  and  $V_{DD}$  are available for easy set up.

## 5. Software

---

The accurate RTC is controlled via a standard SPI-bus or an FM+ I<sup>2</sup>C-bus interface. Common protocols apply. After power-up the control register has to be programmed first to set the correct functions and modes. Then the current time should be programmed.

设置时钟的软件说明

### 5.1 Software instructions for setting the clock

#### 5.1.1 Configuring the function

Control registers 00h to 02h.

#### 5.1.2 Setting the time

Time and date registers 03h to 09h.

#### 5.1.3 Programming alarms

Alarm registers 0Ah to 0Eh.

#### 5.1.4 Clock out control

Register 0Fh.

#### 5.1.5 Watchdog

Registers 10h, 11h.

#### 5.1.6 Time stamp

Registers 12h to 18h.

#### 5.1.7 Aging compensation

Register 19h.

#### 5.1.8 RAM, PCF2127 only

Registers 1Ah to 1Dh.

#### 5.1.9 Frequency trimming

Since the oscillator is factory calibrated, there is no need for trimming. Optional trimming can be done to compensate for aging or to set purposely an offset to the nominal frequency. Just program the register 19h accordingly.

## 5.2 I<sup>2</sup>C-bus software example

Set time to 9:45:37, Aug. 1 2014

Generate a blinking LED at the Seconds interrupt: 在秒中断时生成闪烁的 LED :

**Table 3. I<sup>2</sup>C-bus software example**

Address	Value	Function
-	S	START condition
-	A2h	slave address + R/W = 0
-	00h	register address
00h	01h	enable seconds interrupt
01h	00h	default values
02h	00h	default values
03h	37h	set to 37 seconds
04h	45h	set to 45 minutes
05h	09h	set to 9 hours
06h	01h	set to day 1
07h	05h	set to Friday
08h	08h	set to August
09h	14h	set to year 14
-	P	STOP condition
-	S	START condition
-	A2h	slave address + R/W = 0
-	0Fh	register address
0Fh	01h	set CLKOUT frequency to 16 kHz
10h	23h	select pulsed interrupt signal
-	P	STOP condition



- [1] PCF2127T — 具有集成石英晶体的精确 RTC，用于工业  
[2] PCA2129T — 汽车用集成石英晶体的精确 RTC，数据表  
[3] PCF2129AT — 集成 RTC、TCXO 和石英晶体

## 6. References

---

- [1] **PCF2127T** — Accurate RTC with integrated quartz crystal for industrial
- [2] **PCA2129T** — Accurate RTC with integrated quartz crystal for automotive, data sheet
- [3] **PCF2129AT** — Integrated RTC, TCXO and quartz crystal
- [4] **AN11266** — Application and soldering information for the PCF2127T industrial TCXO RTC, Application note
- [5] **AN10857** — Application and soldering information for PCF2127A and PCF2129A TCXO RTC
- [6] **AN11120** — Application and soldering information for the PCA2129 automotive TCXO RTC

## 7. Legal information

### 7.1 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.

### 7.2 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. NXP Semiconductors takes no responsibility for the content in this document if provided by an information source outside of NXP Semiconductors.

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 and its suppliers accept 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.

**Translations** — A non-English (translated) version of a document is for reference only. The English version shall prevail in case of any discrepancy between the translated and English versions.

### 7.3 Trademarks

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

8. Tables

Table 1. Jumper settings to operate PCF2129AT (IC1) . 11

Table 2. Jumper settings to operate the PCF2127T (IC2) . 13

Table 3. I<sup>2</sup>C-bus software example .....15

## 9. Figures

---

Fig 1.	OM13513 evaluation/demo board . . . . .	4
Fig 2.	Block diagram of the accurate RTC family. . . . .	5
Fig 3.	Temperature compensation gradation in respect to family . . . . .	7
Fig 4.	Circuit diagram of the demo board OM13513 . . . .	8
Fig 5.	Evaluation board (top side layout) . . . . .	9
Fig 6.	Hardware settings for PCF2129AT . . . . .	10
Fig 7.	Hardware settings for PCF2127T . . . . .	12

## 10. Contents

---

<b>1</b>	<b>Introduction</b>	<b>3</b>
<b>2</b>	<b>Key features</b>	<b>3</b>
2.1	Evaluation board OM13513	3
2.2	Accurate RTC	4
2.3	Accurate Real-Time Clock PCF2127T, PCF2129AT	5
2.4	Expected accuracy	6
<b>3</b>	<b>Hardware setup</b>	<b>8</b>
3.1	Detailed circuit diagram	8
3.2	General requirements for the PCF2127T and PCF2129AT	8
3.3	Battery back-up	9
3.4	Hardware settings	9
3.4.1	General settings	9
3.4.2	Settings for PCF2129AT (IC1)	10
3.4.3	Settings for PCF2127T (IC2)	12
<b>4</b>	<b>Optional features for test and evaluation</b>	<b>14</b>
4.1	Experimental area	14
<b>5</b>	<b>Software</b>	<b>14</b>
5.1	Software instructions for setting the clock	14
5.1.1	Configuring the function	14
5.1.2	Setting the time	14
5.1.3	Programming alarms	14
5.1.4	Clock out control	14
5.1.5	Watchdog	14
5.1.6	Time stamp	14
5.1.7	Aging compensation	14
5.1.8	RAM, PCF2127 only	14
5.1.9	Frequency trimming	14
5.2	I <sup>2</sup> C-bus software example	15
<b>6</b>	<b>References</b>	<b>16</b>
<b>7</b>	<b>Legal information</b>	<b>17</b>
7.1	Definitions	17
7.2	Disclaimers	17
7.3	Trademarks	17
<b>8</b>	<b>Tables</b>	<b>18</b>
<b>9</b>	<b>Figures</b>	<b>19</b>
<b>10</b>	<b>Contents</b>	<b>20</b>

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

© NXP Semiconductors N.V. 2014.

All rights reserved.

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

For sales office addresses, please send an email to: [salesaddresses@nxp.com](mailto:salesaddresses@nxp.com)

Date of release: 1 September 2014

Document identifier: UM10762