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
Keywords	PCF2127T, PCF2129AT, OM13513, accurate RTC, Real-Time Clock, get started, SPI bus, I^{2}C-bus, time stamp, temperature compensation, integrated quartz, tuning, battery switch, Watch-Dog
Abstract	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**

1. Introduction

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.

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^{2}C-bus) need to be connected. The OM13518 (USB to I^{2}C-bus dongle) could be used for the I^{2}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.

UM10762

User manual **Rev. 2 — 1 September 2014** **3 of 20**
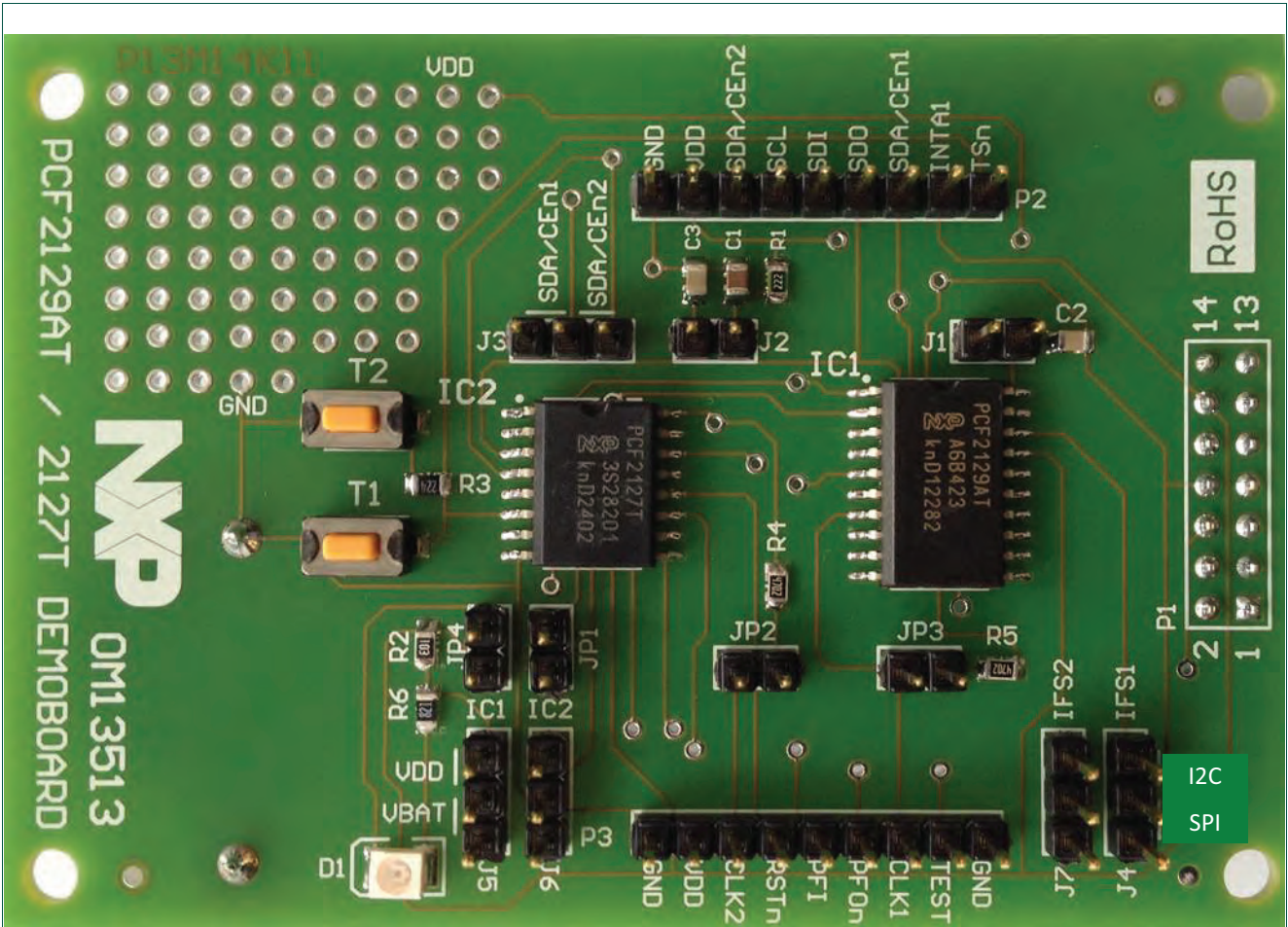
For configuring the board, see Section 3.4.

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: ± 3 ppm
- Battery backup input pin and switch-over circuitry
- Battery backed output voltage
- Universal interface to select between SPI- and I^{2}C-bus
- Time stamp facility
  - With interrupt capability
  - Detection of two different events on one multilevel input pin (for example, for tamper detection)
- Programmable watchdog timer with interrupt

- Programmable alarm function with interrupt capability

In addition PCF2127T has the following features:

- 512 Byte of battery buffered RAM
- Programmable countdown timer with interrupt
- Additional power fail detector to, for example, pre-alert the microcontroller that the power supply is going down

The block diagram in Figure 2 nicely illustrates the key blocks:

- Time stamp facility
- Temperature compensated quartz oscillator TCXO
- Battery back-up switch
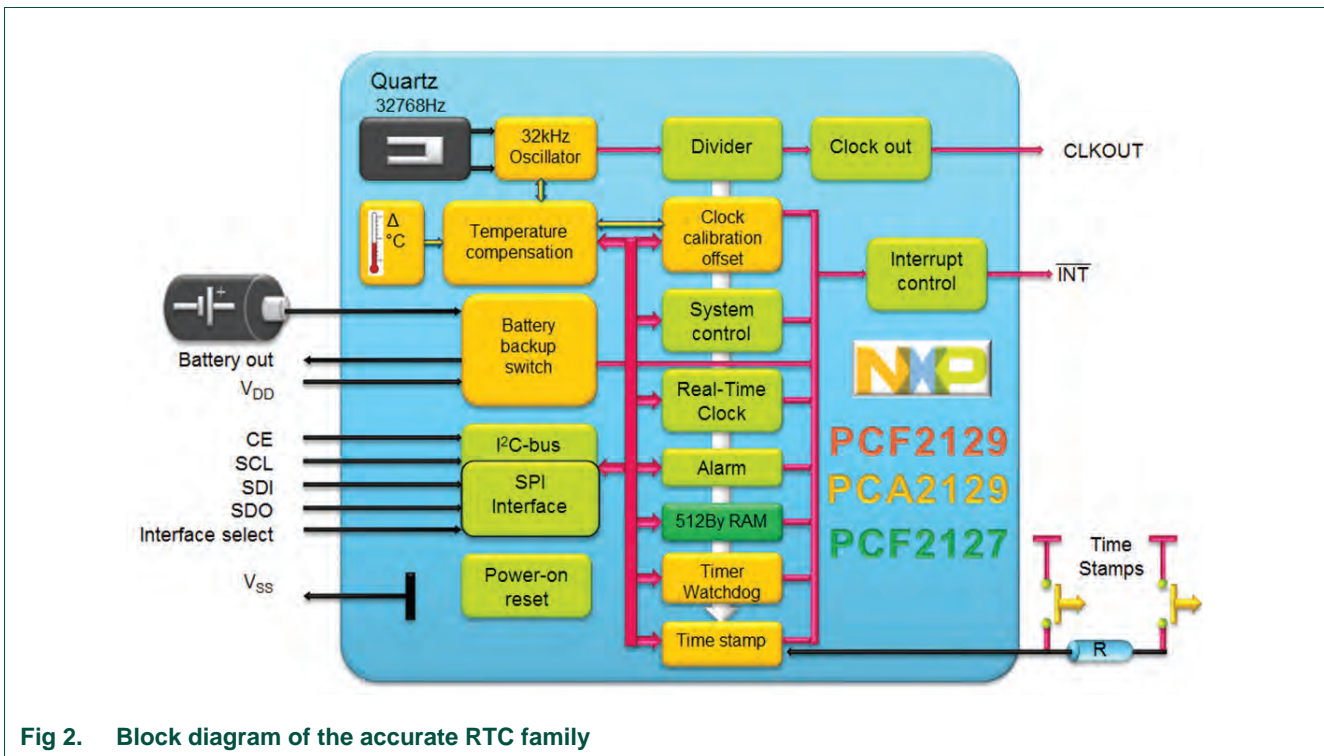- Universal interface to select between SPI-bus and I^2C-bus

Fig 2.   Block diagram of the accurate RTC family

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 °C to +65 °C: PCF2127AT, PCF2129AT (on the OM13513)

2. Temperature compensation covering −40 °C to +85 °C: PCF2127T (on the OM13513), PCF2129T

3. Automotive grade AEC-Q100 covering −40 °C to +85 °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 °C to +60 °C and the PCF2127T, PCF2129T and PCA2129T/Q900 are temperature compensated over the temperature range of −40 °C to +85 °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°C and above +60 °C are usually only present for a limited time of the day and may even not be present most of the year.

UM10762

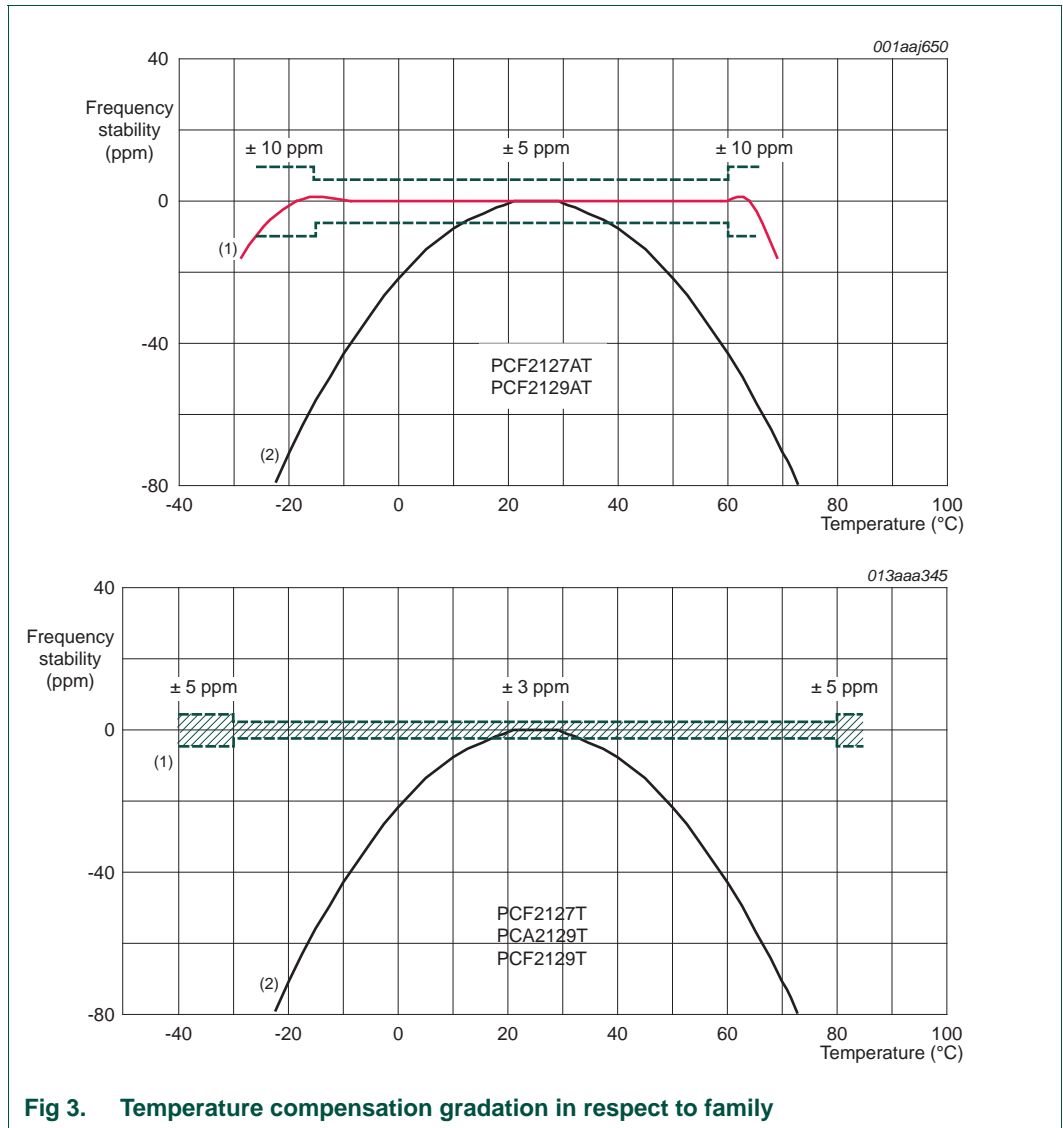**User manual** **Rev. 2 — 1 September 2014** **6 of 20**

Fig 3. **Temperature compensation gradation in respect to family**

3. Hardware setup

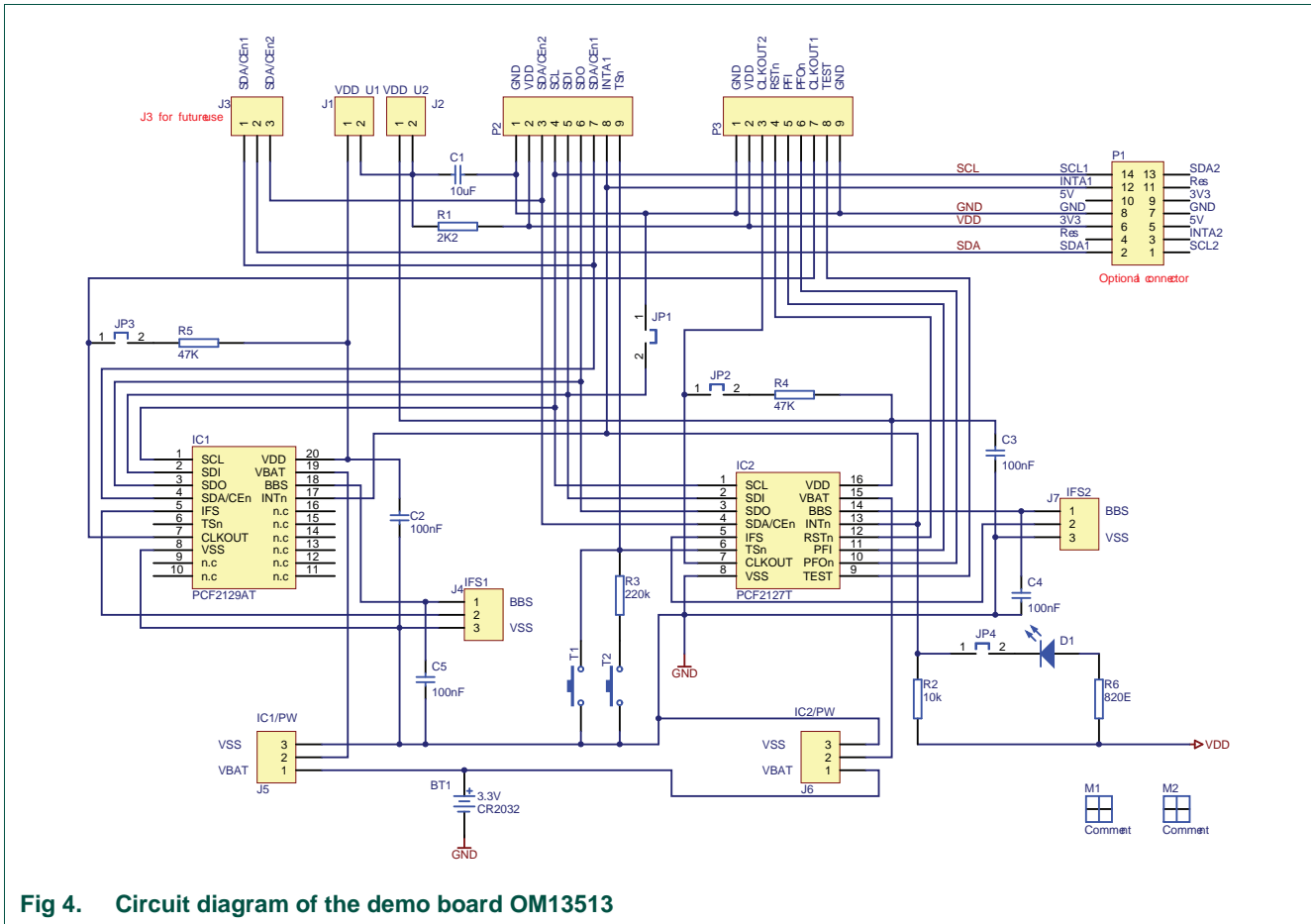### 3.1 Detailed circuit diagram

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.

It is required to have a decoupling capacitor of 100 nF on the V_{DD}-V_{SS} rails close to the RTC; a similar decoupling capacitor on pin BBS is required. Due to the low power consumption of a few μW, 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
- 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 μA meter

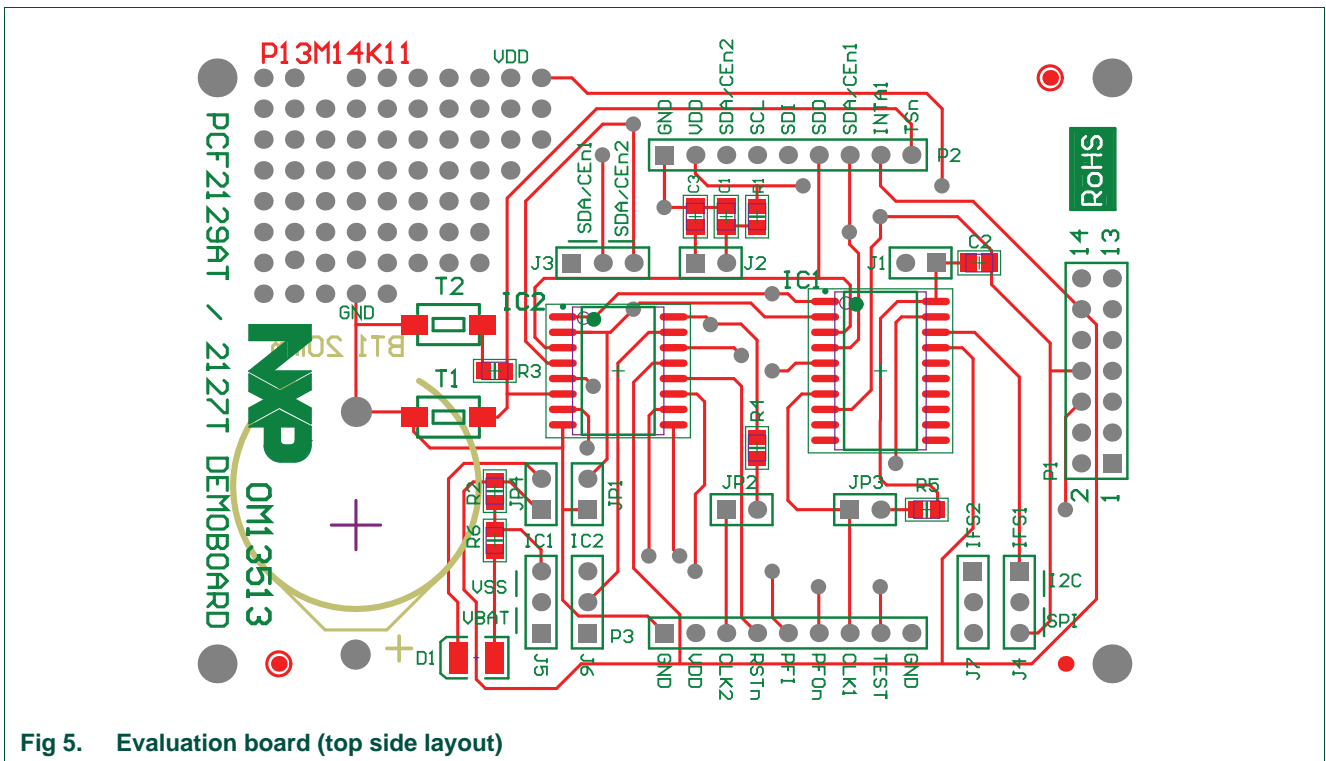**Fig 5.**   **Evaluation board (top side layout)**

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.
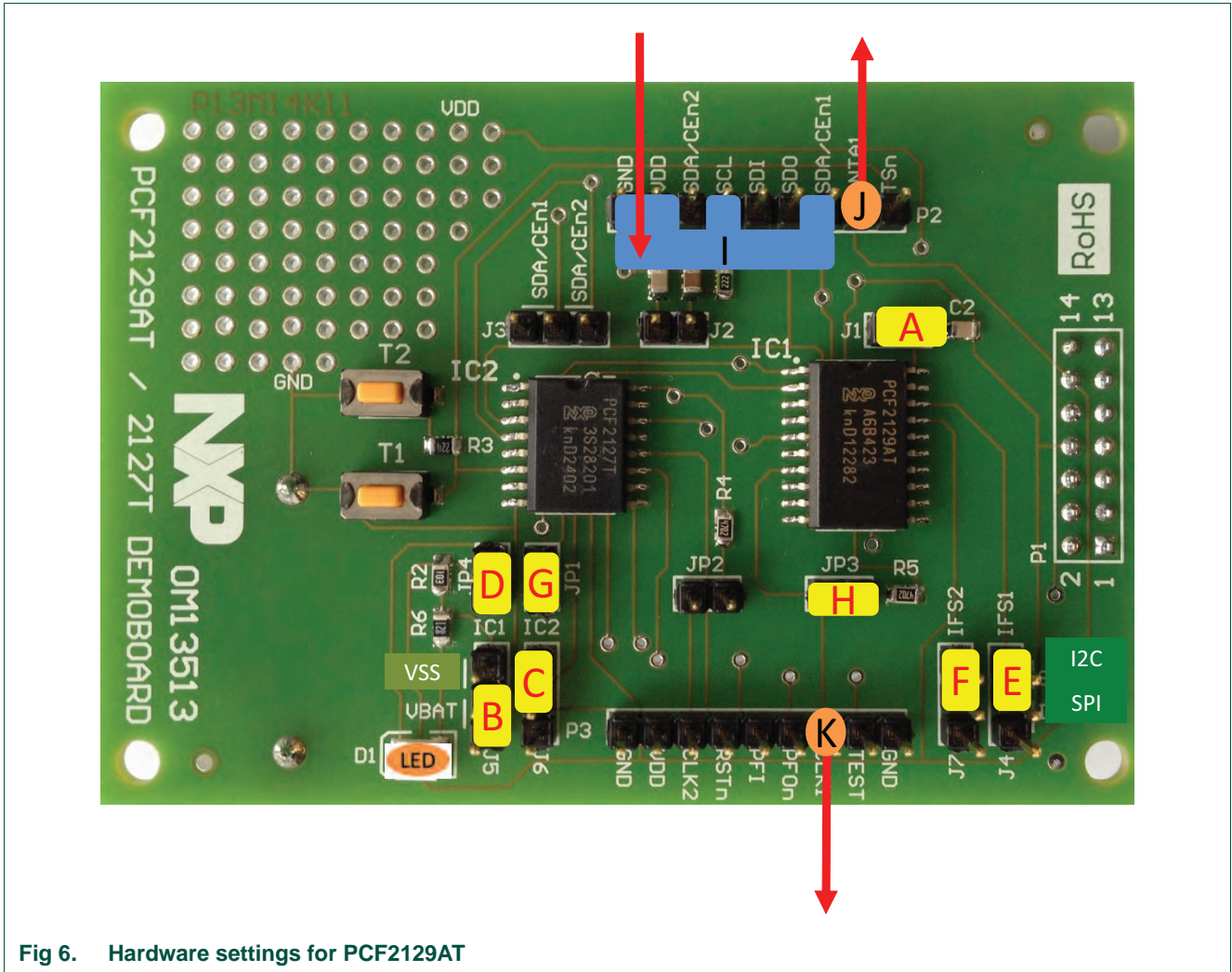
Fig 6.   Hardware settings for PCF2129AT

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

Indicator	Description	Jumper	Setting[1]
Jumpers			
A	V_{DD} 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	I²C-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	-
Interface			
I	supply and interface connector	P2	-
Outputs			
J	interrupt output	P2	-
K	clock output	P3	-

[1] In direction of reading "Jn".

UM10762

All information provided in this document is subject to legal disclaimers.

© NXP Semiconductors N.V. 2014. All rights reserved.

User manual **Rev. 2 — 1 September 2014** **11 of 20**

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.

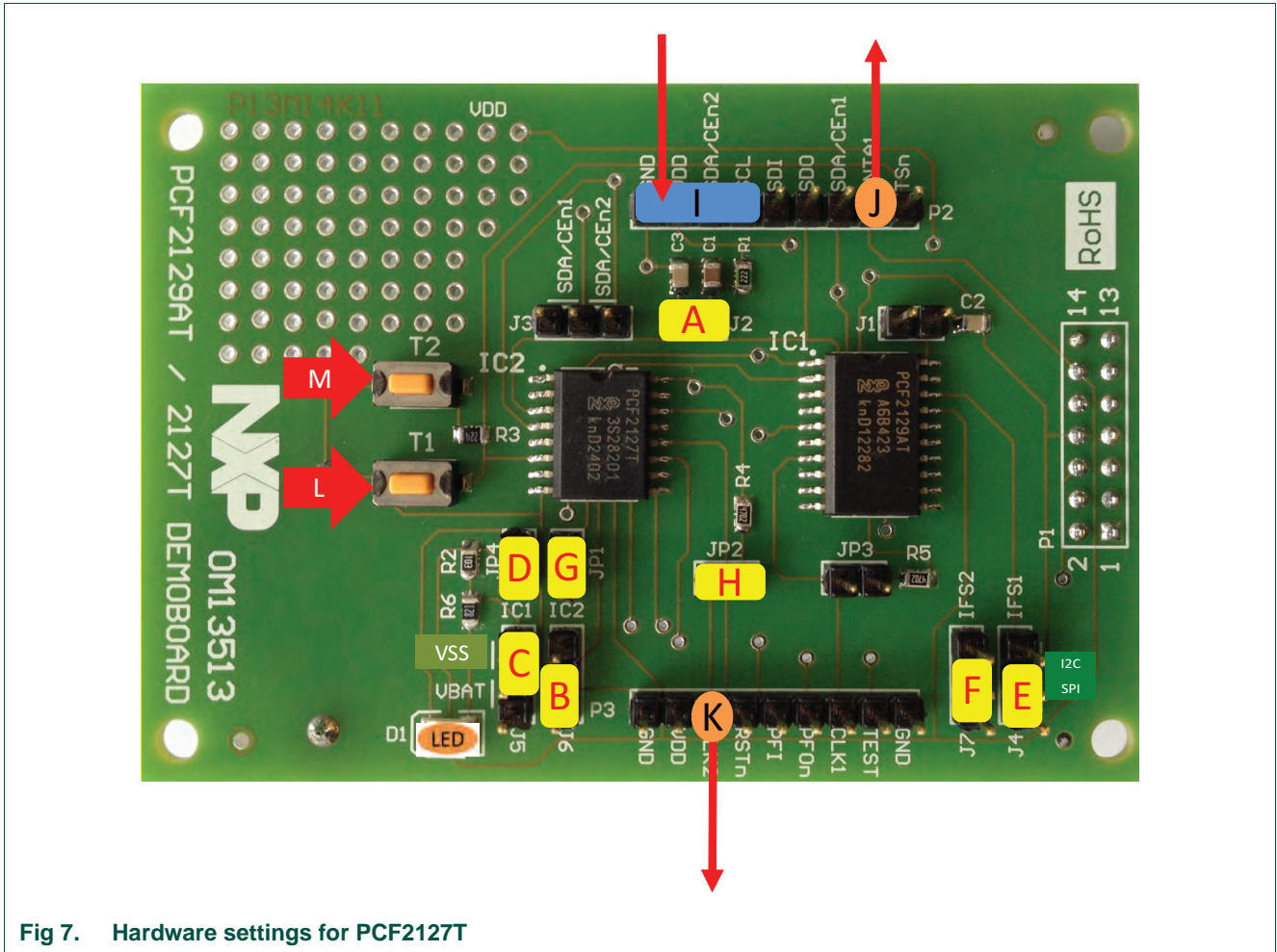**Fig 7.   Hardware settings for PCF2127T**

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

Indicator	Description	Jumper	Setting[1]
Jumpers			
A	V_{DD} 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	I²C-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	-
Interface			
I	supply and interface connector	P2	-
Outputs			
J	interrupt output	P2	-
K	clock output	P3	-
Push button			
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^{2}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.

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 to18h.

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 I²C-bus software example

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

Generate a blinking LED at the Seconds interrupt:

Table 3. I²C-bus software example

Address	Value	Function
-	S	START condition
-	A2h	slave address + R/$\overline{W}$ = 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/$\overline{W}$ = 0
-	0Fh	register address
0Fh	01h	set CLKOUT frequency to 16 kHz
10h	23h	select pulsed interrupt signal
-	P	STOP condition

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 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

9. Figures

10. Contents

Date of release: 1 September 2014
Document identifier: UM10762