

UM10762

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

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User manual

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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 I²C-bus) need to be connected. The OM13518 (USB to I²C-bus dongle) could be used for the I²C-bus connection.

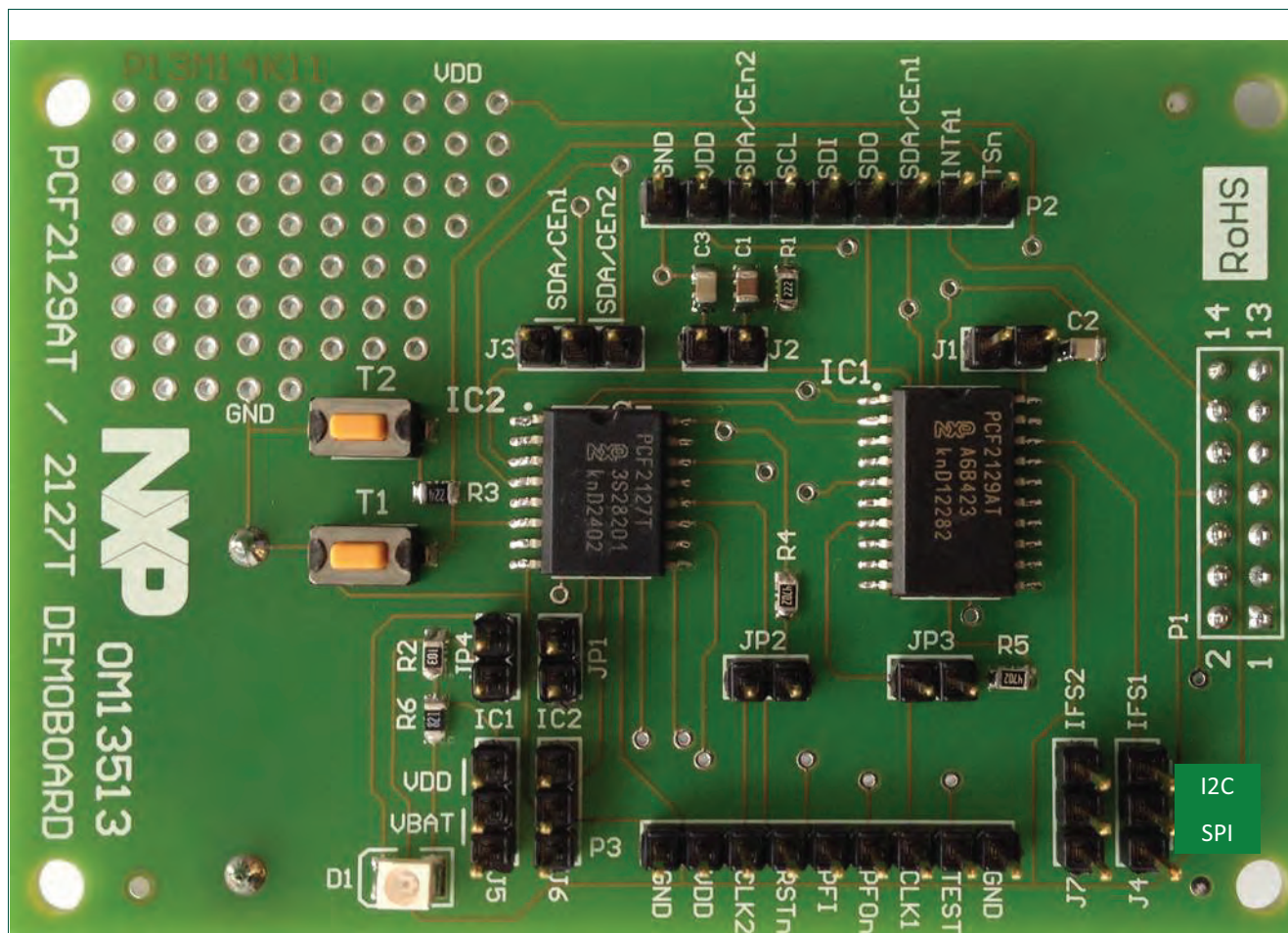
2. Key features

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: ± 3 ppm
- Battery backup input pin and switch-over circuitry
- Battery backed output voltage
- Universal interface to select between SPI- and I²C-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 I²C-bus

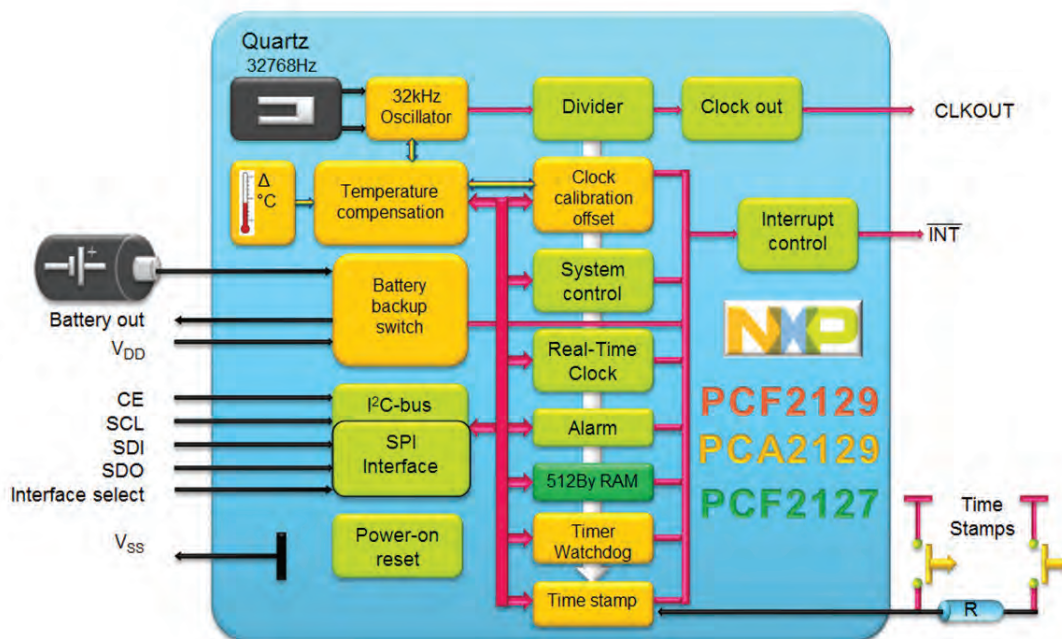


Fig 2. Block diagram of the accurate RTC family

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 $+65^{\circ}\text{C}$: PCF2127AT, PCF2129AT (on the OM13513)

2. Temperature compensation covering $-40\text{ }^{\circ}\text{C}$ to $+85\text{ }^{\circ}\text{C}$: PCF2127T (on the OM13513), PCF2129T
 3. Automotive grade AEC-Q100 covering $-40\text{ }^{\circ}\text{C}$ to $+85\text{ }^{\circ}\text{C}$: 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 $-30\text{ }^{\circ}\text{C}$ to $+60\text{ }^{\circ}\text{C}$ and the PCF2127T, PCF2129T and PCA2129T/Q900 are temperature compensated over the temperature range of $-40\text{ }^{\circ}\text{C}$ to $+85\text{ }^{\circ}\text{C}$, 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; $< 3\text{ ppm}$ or $1\text{ s}/4\text{days}$ can be expected. Other consideration regard the ambient temperature over the day, respectively over the year. Temperatures below e.g. -15°C and above $+60\text{ }^{\circ}\text{C}$ are usually only present for a limited time of the day and may even not be present most of the year.

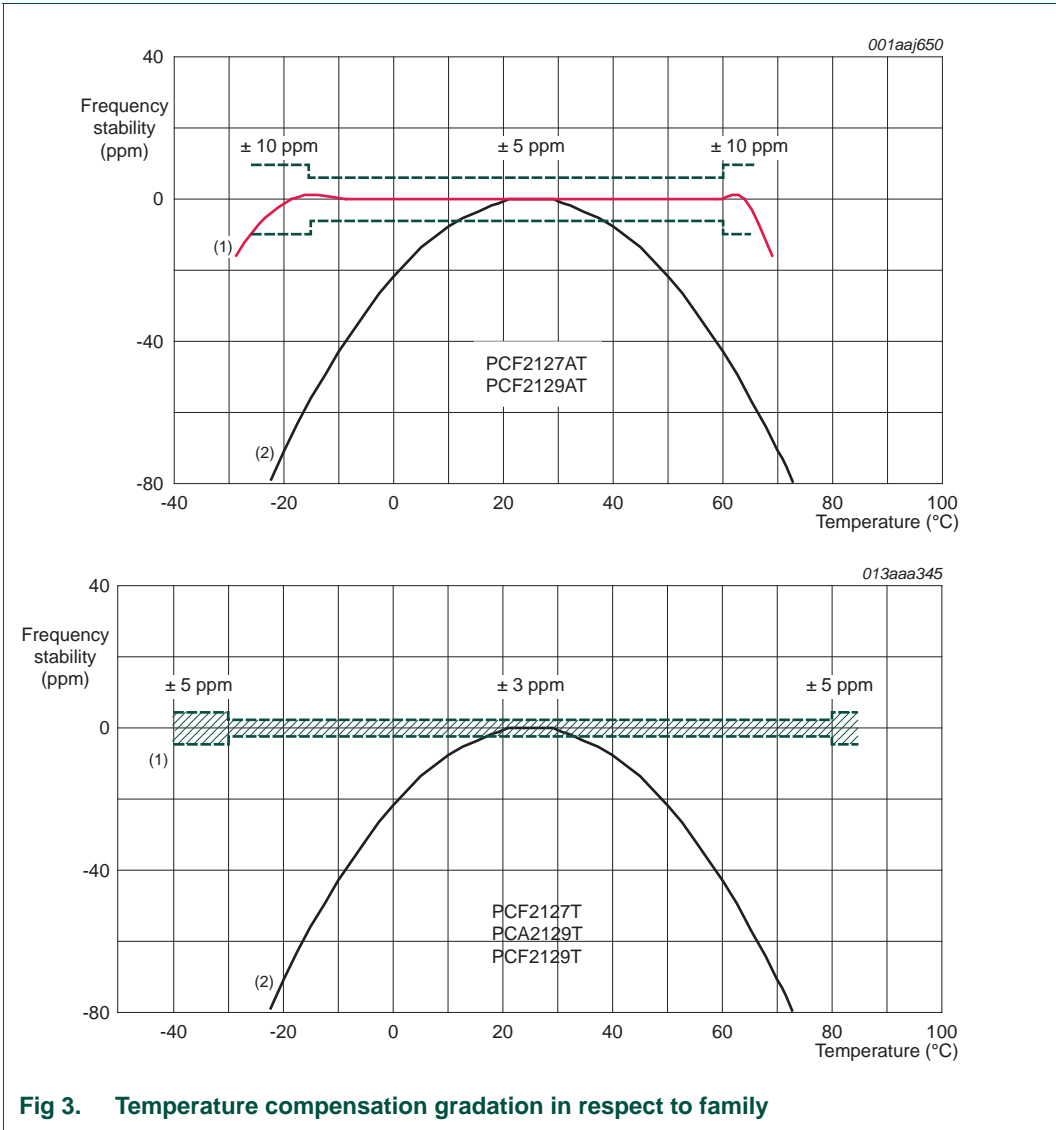


Fig 3. Temperature compensation gradation in respect to family

3. Hardware setup

3.1 Detailed circuit diagram

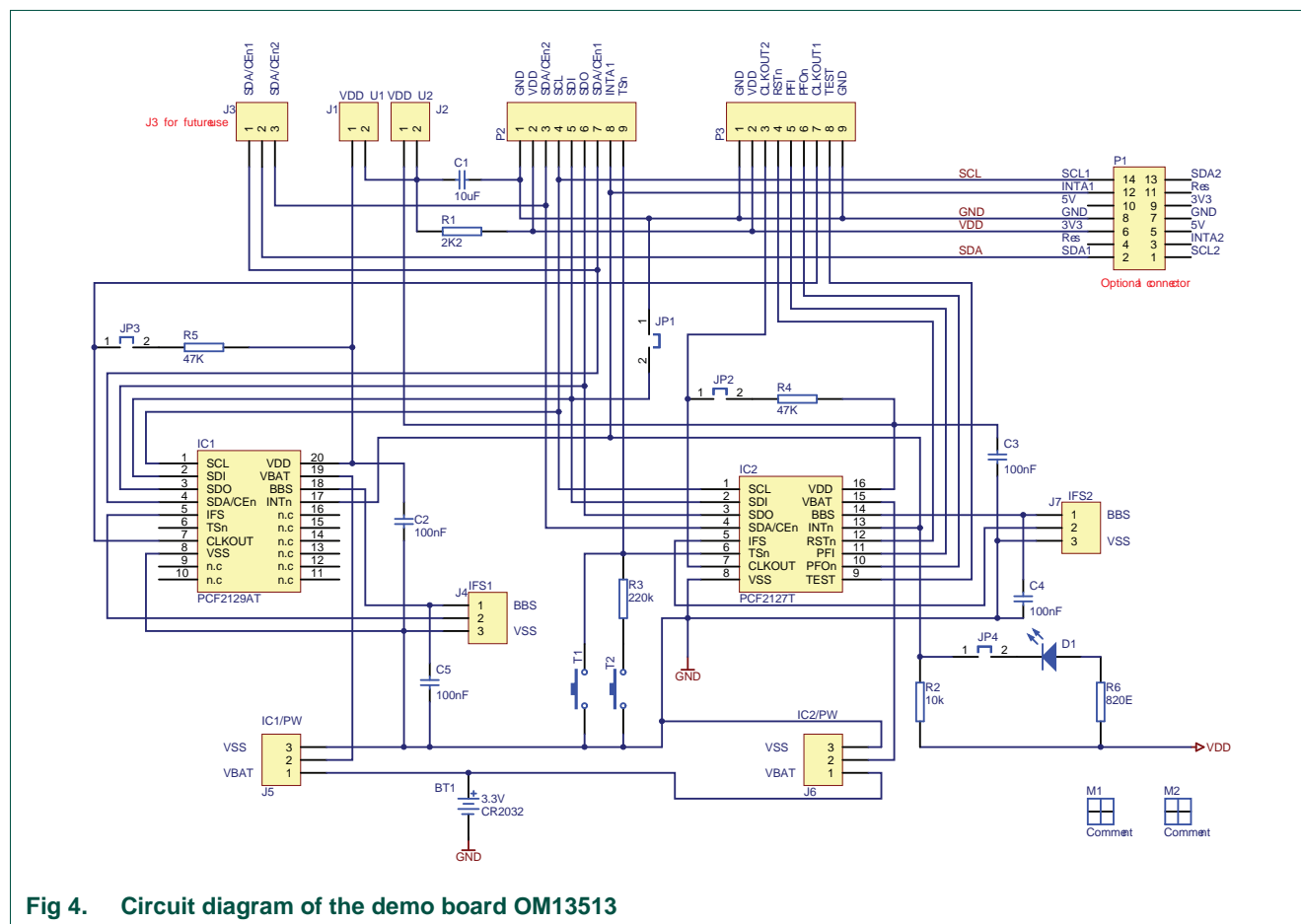


Fig 4. Circuit diagram of the demo board OM13513

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 μ 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
- 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

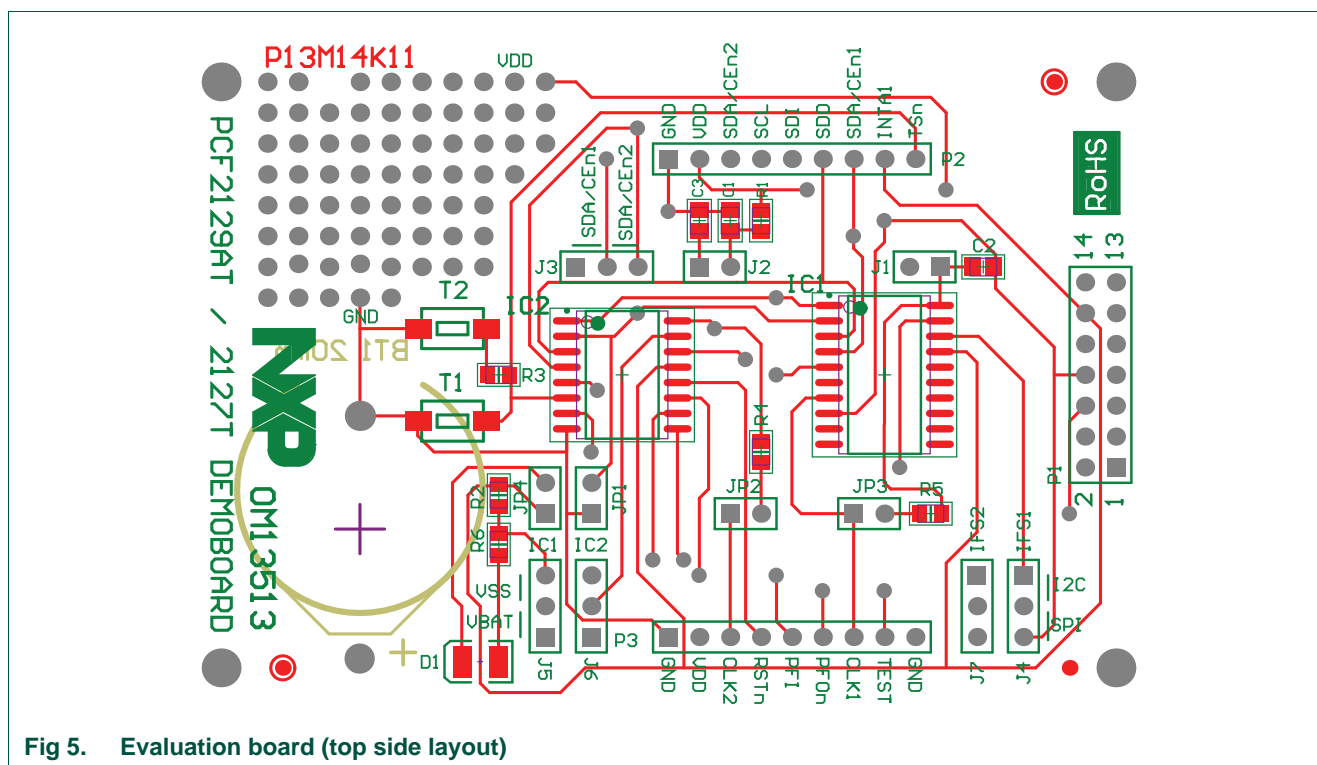


Fig 5. Evaluation board (top side layout)

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](#).

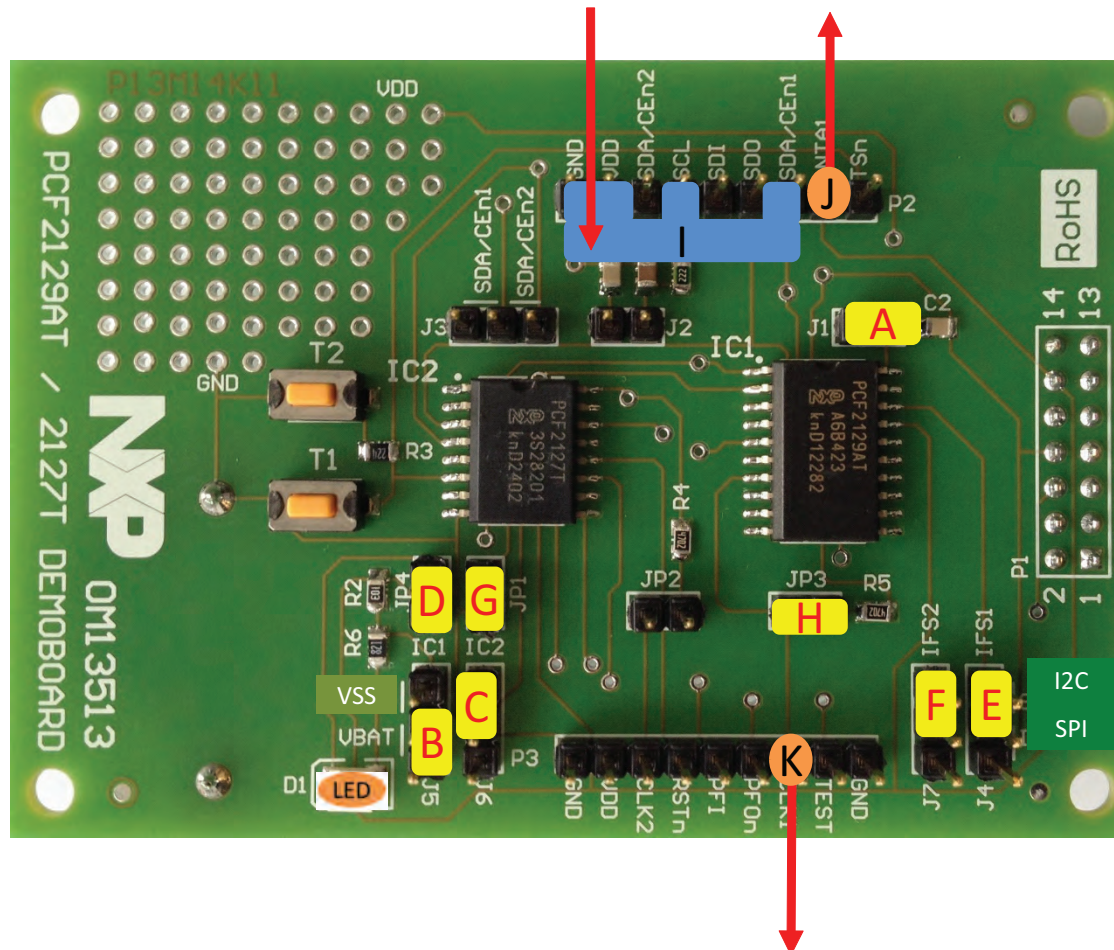


Fig 6. Hardware settings for PCF2129AT

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 | I ² 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 | - |
| Interface | | | |
| I | supply and interface connector | P2 | - |
| Outputs | | | |
| 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](#).

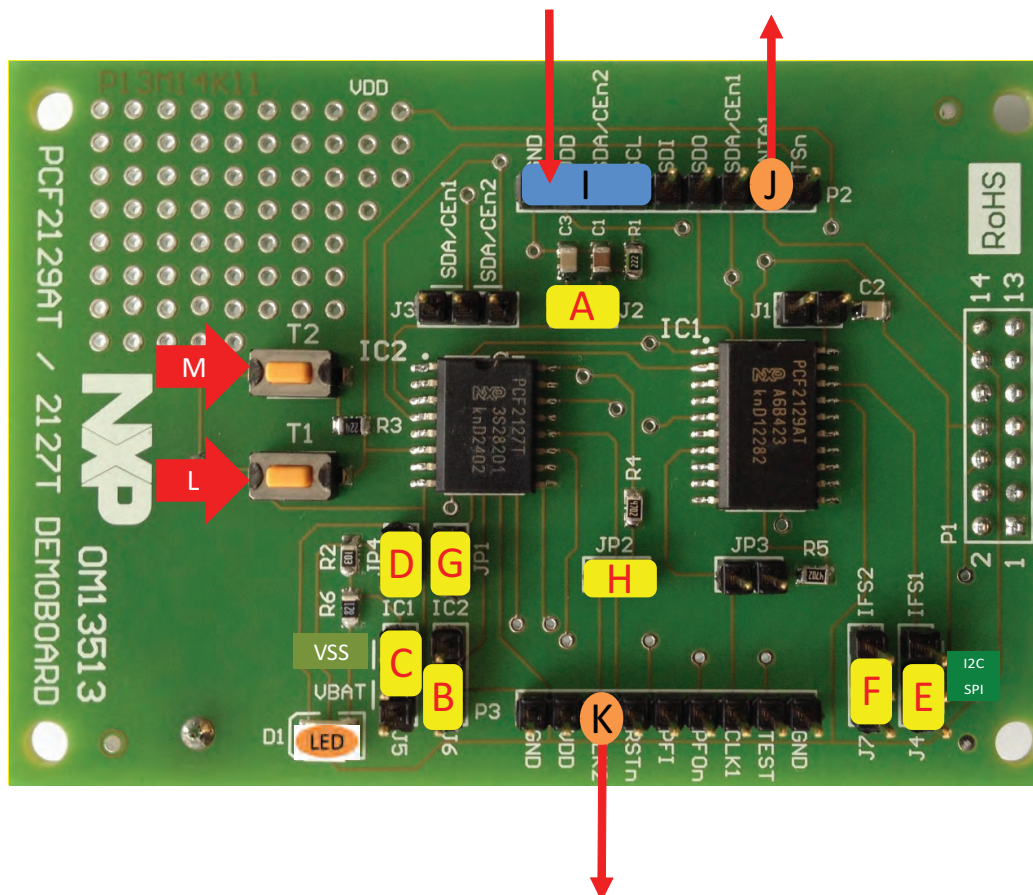


Fig 7. Hardware settings for PCF2127T

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

| Indicator | Description | Jumper | Setting ^[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 | I ² 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 | - |
| 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+ I²C-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 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 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/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 |

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

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8. Tables

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

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

Table 3. I²C-bus software example15

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

| | | |
|-----------|--|-----------|
| 1 | Introduction | 3 |
| 2 | Key features | 3 |
| 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 |
| 3 | Hardware setup | 8 |
| 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 |
| 4 | Optional features for test and evaluation | 14 |
| 4.1 | Experimental area | 14 |
| 5 | Software | 14 |
| 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 ² C-bus software example | 15 |
| 6 | References | 16 |
| 7 | Legal information | 17 |
| 7.1 | Definitions | 17 |
| 7.2 | Disclaimers | 17 |
| 7.3 | Trademarks | 17 |
| 8 | Tables | 18 |
| 9 | Figures | 19 |
| 10 | Contents | 20 |

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