INTRODUCTION

An increasing number of applications that involve time measurement are requiring a Real-Time Clock/Calendar (RTCC) device. The MCP79410 is a feature-rich RTCC that incorporates EEPROM, SRAM, unique ID and time-stamp.

FEATURES OF THE RTCC STRUCTURE

• I2C™ Bus Interface
• RTCC with Time/Date Registers: Year, Month, Date, Day of Week, Hours, Minutes, Seconds
• Support for Leap Year
• Low-power CMOS Technology
• Input for External Battery Backup (maintains SRAM, RTCC and Timekeeping)
• On-board 32,768 kHz Crystal Oscillator for the RTCC
• On-chip Digital Trimming/Calibration of the Oscillator
• Operates down to 1.3V VBAT Minimum
• Operating Temperature Range:
  - Industrial (I): -40°C to +85°C
• Multi-function Pin:
  - Open-drain configuration
  - Programmable clock frequency out
  - Programmable alarm output
• Interrupt Capability (based on the 2 sets of Alarm Registers, ALM0 and ALM1)
• Time-stamp Registers for holding the Time/Date of Crossing:
  - from VDD to VBAT
  - from VBAT to VDD

SCHEMATIC

The schematic includes a PIC18 Explorer demo board and the I2C RTCC PICtail™ daughter board as shown in Figure 1.
The resources used on the demo board are:

- LCD
- 2 push buttons
- AC164140 RTCC PICtail daughter board

To access the LCD through a minimum of pins, the SPI on the MSSP1 module is used, in conjunction with a 16-bit I/O expander with SPI interface (MCP23S17). The two on-board push buttons are S1 and S2, connected to RB0, RA5 GPIOs. The I²C RTCC is part of the RTCC PICtail evaluation board and is directly connected to the MSSP1 module of the MCU. Another necessary connection is between the MFP signal of the RTCC and RA4 (T0CKI), the clock input of TMR0. The RTCC is programmed to offer a square wave of 1Hz on MFP. TMR0 is programmed as the counter and is initialized at 0xFFFF, in order to give a software interrupt at every second. All connections between the I²C RTCC and the MCU (SDA, SCL, MFP) are open drain and use pull-up resistors. The RTCC PICtail daughter board has two other components:

- a 32,768 Hz crystal driving the internal clock of the RTCC
- a 3-volt battery sustaining the RTCC when VDD is not present on the demo board

DETAILS ABOUT IMPLEMENTATION

The application is performed on a PIC18 Explorer demo board on which is mounted a PIC18F87J11 MCU. The code is written in ‘C’ using the C18 compiler. It implements an electronic watch (based on the MCP79410 RTCC), displaying the six basic time/date variables on the on-board LCD. It includes a setup sequence, which sets the same six time/date variables, using the two push buttons of the evaluation board (S1 = MENU KEY, S2 = INCREMENT KEY).

FUNCTIONAL DESCRIPTION

The MCP79410 is an I²C slave device, working on the related bidirectional 2-wire bus. SDA is a bidirectional pin used to transfer addresses and data in and out of the device. It is an open-drain terminal, therefore, the SDA bus requires a pull-up resistor to VCC (typically 10kΩ for 100 kHz and 2kΩ for 400 kHz). For normal data transfers, SDA is allowed to change only during SCL low. Changes during SCL high are reserved for indicating the Start and Stop conditions. SCL input is used to synchronize the data transfer from and to the device. The related internal structures have the following device addresses/control bytes (the RTCC is included in the SRAM bank):

- RTCC + SRAM: 0xDE for writes, 0xDF for reads
- EEPROM: 0xAE for writes, 0xAF for reads

The chip can support speeds up to:

- 400 kHz 2.5 to 5V
- 100 kHz 1.8 to 2.5V

APPLICATION DESCRIPTION

The application performs an electronic watch that has two main functions:

- display of the six time/date variables (year, month, date, hour, minutes, seconds) using the interrupts of the microcontroller (this operation is performed on the on-board LCD; the format is 24 hours).
- setup of the above variables using the two on-board push buttons: S1 = MENU KEY, S2 = INCREMENT KEY. The real-time display of the time/date variables is performed as long as the MENU KEY (S1) is not pressed (the action of the INCREMENT KEY (S2) has no effect on the watch continuously displaying the time and the date).

Pressing the MENU KEY will start the setup menu, disabling the interrupts. The menu is covered once in the following order: year, month, date, hour, minutes, and seconds. Going from one variable to another is performed through the MENU KEY, and incrementing a variable is performed through the INCREMENT KEY. The last action of the MENU KEY exits the setup menu. According to a possible setup error, the setup menu must be re-entered. The upper limits of every variable are: year = (20) 99; month = 12; date = (always) 31; hour = 23 (24 hours format); minutes = 59; seconds = 59. Entering the setup menu will not stop the oscillator of the RTCC. At the end of the setup, the time/date variables are updated and entering the menu will stop the counting. If the user enters the Time Setup mode, all changes are written to the RTCC, even if no variables are changed. When entering the menu the watch will resume counting from the point where it was stopped.

FIRMWARE DESCRIPTION

Drivers

Drivers are divided into 4 classes:

- LCD drivers
- RTCC register access drivers
- Drivers related to the operating system (setup menu): keyboard drivers
- Interrupt system drivers (the interrupt function based on TMR0’s overflow and the related functions (interrupt initialization, start/stop interrupts)
**LCD Drivers**

The application is specifically implemented on the PIC18 Explorer demo board. On this board it was important to reduce the number of GPIO pins used to access the LCD. Accessing the LCD is performed on a SPI bus (included in the MSSP1 module) through an auxiliary chip, the MCP23S17 SPI expander. The related drivers are:

- Write command to LCD:  
  \[ \text{wrCmd_lcd (unsigned char cmnd_lcd)} \]
- Write data byte/character to LCD:  
  \[ \text{wrData_lcd (unsigned char data_lcd)} \]
- Write to LCD a string stored in the flash:  
  \[ \text{wrStr_lcd (const rom unsigned char \*str_lcd)} \]

**Drivers to Access RTCC Register**

Since the MCP79410 is an I2C RTCC, it will use the I2C bus of the MCU (the MSSP1 module). Accordingly, the related drivers will be divided into two categories: basic I2C drivers and RTCC drivers. They use as a control method the SPP1IF bit (flag) in the PIR1 register (interrupt flag of the MSSP1 module). They read through polling and not through interrupts, since interrupts are allocated to display the time/date using TMR0's overflow, once per second. Keep in mind that TMR0 acts as a counter, and its input is activated by the MFP signal coming from the RTCC (programmed as an one second square wave). The method represents an alternative to the classical "i2c.h" library, included in the C18 compiler.

**Keyboard Drivers (2 keys O.S.)**

The set of keyboard drivers has only one function: \text{keyb_press()}. The keyb_press() function awaits the selection of one of the two on-board switches: S1 (MENU KEY) or S2 (INCREMENT KEY). After the selection is made, the firmware updates the code of the pressed key. Upon exiting the function, a value is returned in either KEYB_MENU or KEYB_INCR. The function performs a key debounce of (2 x 100 msec). The function will exit only after the pressed key is released (deactivated). For more details about the operating system based on the two on-board switches, refer to the "Application Description" paragraph.

**The Interrupt Function**

Interrupts are generated by the TMR0 overflow, which is initialized at 0xFFFF as a counter. TIMER0 is incremented once per second by the MFP signal coming from the RTCC. The interrupt function calls one function: \text{display_time()}, which reads the six related registers of the RTCC and puts them in the six global variables (year, month, date, hour, minute, seconds). The Random Byte Access mode is used, as some versions of the application can use only a subset of these six variables. In the end, the interrupt function (through the display_time() driver) displays these six variables on the on-board LCD, according to the format below:

ROW1: “date” string year month date
ROW2: “time” string hour minutes seconds
ACCESSING THE RTCC REGISTERS

There are two basic functions for accessing the RTCC register: one for writes and one for reads. They can be defined as: void rtcc_wr (unsigned char time_var, unsigned char rtcc_reg), unsigned char rtcc_rd (unsigned char rtcc_reg). Each of these two functions include error messages displayed on LEDs, which could signal when an operation is not acknowledged by the slave (RTCC).

EXAMPLE 1: WRITES TO THE RTCC

```c
i2c_start(); // start I²C communication: SDA goes down while SCL remains high
i2c_wr(ADDR_RTCC_WRITE); // send the RTCC's address for write = 0xde
i2c_wr(rtcc_reg); // send the register’s address
i2c_wr (time_var); // send the data byte
i2c_stop(); // stop I²C communication: SDA goes high while SCL remains high
```

EXAMPLE 2: READS FROM THE RTCC

```c
i2c_start(); // start I²C communication: SDA goes down while SCL remains high
i2c_wr(ADDR_RTCC_WRITE); // send the RTCC's address for write = 0xde
i2c_wr(rtcc_reg); // send the register's address
i2c_restart(); // switch to reads
i2c_wr(ADDR_RTCC_READ); // send the RTCC's address for read = 0xdf
i2c_rd(); // read the byte from the RTCC (register's content)
i2c_nack ; // NoACK from MCU to the RTCC (no more bytes to read)
i2c_stop(); // stop I²C communication: SDA goes high while SCL remains high
```

As described in the data sheet, the addresses of the RTCC register are shown in Table 1.

<table>
<thead>
<tr>
<th>Address</th>
<th>BIT 7</th>
<th>BIT 6</th>
<th>BIT 5</th>
<th>BIT 4</th>
<th>BIT 3</th>
<th>BIT 2</th>
<th>BIT 1</th>
<th>BIT 0</th>
<th>FUNCTION</th>
<th>RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>00h</td>
<td>ST</td>
<td>10 Seconds</td>
<td>Seconds</td>
<td>Seconds</td>
<td>00-59</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>01h</td>
<td></td>
<td>10 Minutes</td>
<td>Minutes</td>
<td>Minutes</td>
<td>00-59</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>02h</td>
<td>12/24</td>
<td>10 Hour AM/PM</td>
<td>10 Hour</td>
<td>Hour</td>
<td>Hours</td>
<td>1-2 + AM/PM</td>
<td>00-23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>03h</td>
<td>OSCON</td>
<td>V_BAT</td>
<td>VBATEN</td>
<td>Day</td>
<td>Day</td>
<td>Day</td>
<td>Day</td>
<td>1-7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>04h</td>
<td></td>
<td>10 Date</td>
<td>Date</td>
<td>Date</td>
<td>Date</td>
<td>01-31</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>05h</td>
<td>LP</td>
<td>10 Month</td>
<td>Month</td>
<td>Month</td>
<td>Month</td>
<td>01-12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>06h</td>
<td></td>
<td>10 Year</td>
<td>Year</td>
<td>Year</td>
<td>Year</td>
<td>00-99</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>07h</td>
<td>OUT</td>
<td>SQWE</td>
<td>ALM1</td>
<td>ALM0</td>
<td>EXTOSC</td>
<td>RS2</td>
<td>RS1</td>
<td>RS0</td>
<td>Control Reg.</td>
<td></td>
</tr>
</tbody>
</table>

According to these addresses, in the basic read/write functions, only the register’s address will differ. Reads are used in the interrupt function (once/second). Writes are used in the initialization function and in the setup sequence (the main function).
CONCLUSION

This application note presents how to control (display and setup) an electronic watch, based on Microchip's i²C RTCC, MC79410. The project is performed on a PIC18 Explorer demo board, using the on-board resources: LCD (accessed through the SPI bus) and push buttons. The code (drivers and main function) is written in 'C', using the C18 compiler. The preferred microcontroller is the PIC18F87J11.
Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip’s Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as “unbreakable.”

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip’s code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

Information contained in this publication regarding device applications and the like is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION, INCLUDING BUT NOT LIMITED TO ITS CONDITION, QUALITY, PERFORMANCE, MERCHANTABILITY OR FITNESS FOR PURPOSE. Microchip disclaims all liability arising from this information and its use. Use of Microchip devices in life support and/or safety applications is entirely at the buyer’s risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights.

Trademarks
The Microchip name and logo, the Microchip logo, dsPIC, KEELOG, KEELOG logo, MPLAB, PIC, PICmicro, PICSTART, PIC32 logo, rPIC and Uni/I/O are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

FilterLab, Hampshire, HI-TECH C, Linear Active Thermistor, MXDEV, MXLAB, SEEVAL and The Embedded Control Solutions Company are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Analog-for-the-Digital Age, Application Maestro, CodeGuard, dsPICDEM, dsPICDEM.net, dsPICworks, dsSPEAK, ECAN, ECONOMONITOR, FanSense, HI-TIDE, In-Circuit Serial Programming, ICSP, Mindi, MiWi, MPASM, MPLAB Certified logo, MPLIB, MPLINK, mTouch, Omniscent Code Generation, PICC, PICC-18, PICDEM, PICDEM.net, PICkit, PICtail, REAL ICE, rLAB, Select Mode, Total Endurance, TSHARC, UniWinDriver, WiperLock and ZENA are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

All other trademarks mentioned herein are property of their respective companies.
© 2010, Microchip Technology Incorporated, Printed in the U.S.A., All Rights Reserved.

Printed on recycled paper.

ISBN: 978-1-60932-603-6

Microchip received ISO/TS-16949:2002 certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona; Gresham, Oregon and design centers in California and India. The Company’s quality system processes and procedures are for its PIC® MCUs and dsPIC® DSCs, KezLoc® code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip’s quality system for the design and manufacture of development systems is ISO 9001:2000 certified.
### AMERICAS

**Corporate Office**  
2355 West Chandler Blvd.  
Chandler, AZ 85224-6199  
Tel: 480-792-7200  
Fax: 480-792-7277  
Technical Support: [http://support.microchip.com](http://support.microchip.com)  
Web Address: [www.microchip.com](http://www.microchip.com)

- **Atlanta**  
  Duluth, GA  
  Tel: 678-957-9614  
  Fax: 678-957-1455

- **Boston**  
  Westborough, MA  
  Tel: 774-760-0087  
  Fax: 774-760-0088

- **Chicago**  
  Itasca, IL  
  Tel: 630-285-0071  
  Fax: 630-285-0075

- **Cleveland**  
  Independence, OH  
  Tel: 216-447-0084  
  Fax: 216-447-0043

- **Dallas**  
  Addison, TX  
  Tel: 972-818-7423  
  Fax: 972-818-2924

- **Detroit**  
  Farmington Hills, MI  
  Tel: 248-538-2250  
  Fax: 248-538-2260

- **Kokomo**  
  Kokomo, IN  
  Tel: 765-864-1300  
  Fax: 765-864-1359

- **Los Angeles**  
  Mission Viejo, CA  
  Tel: 949-462-9523  
  Fax: 949-462-9608

- **Santa Clara**  
  Santa Clara, CA  
  Tel: 408-961-6444  
  Fax: 408-961-6445

- **Toronto**  
  Mississauga, Ontario, Canada  
  Tel: 905-673-0699  
  Fax: 905-673-6509

### ASIA/PACIFIC

**Asia Pacific Office**  
Suites 3707-14, 37th Floor  
Tower 6, The Gateway  
Harbour City, Kowloon  
Hong Kong  
Tel: 852-2401-1200  
Fax: 852-2401-3431

- **Australia - Sydney**  
  Tel: 61-2-9868-6733  
  Fax: 61-2-9868-6755

- **China - Beijing**  
  Tel: 86-10-8528-2100  
  Fax: 86-10-8528-2104

- **China - Chengdu**  
  Tel: 86-28-8665-5511  
  Fax: 86-28-8665-7889

- **China - Chongqing**  
  Tel: 86-23-8980-9588  
  Fax: 86-23-8980-9500

- **China - Hong Kong SAR**  
  Tel: 852-2401-1200  
  Fax: 852-2401-3431

- **China - Nanjing**  
  Tel: 86-25-8473-2460  
  Fax: 86-25-8473-2470

- **China - Qingdao**  
  Tel: 86-532-8502-7355  
  Fax: 86-532-8502-7205

- **China - Shanghai**  
  Tel: 86-21-5407-5533  
  Fax: 86-21-5407-5066

- **China - Shenyang**  
  Tel: 86-24-2334-2829  
  Fax: 86-24-2334-2393

- **China - Shenzhen**  
  Tel: 86-755-8203-2660  
  Fax: 86-755-8203-1760

- **China - Wuhan**  
  Tel: 86-27-5980-5300  
  Fax: 86-27-5980-5118

- **China - Xi'an**  
  Tel: 86-29-8833-7252  
  Fax: 86-29-8833-7256

- **China - Xiamen**  
  Tel: 86-592-2388138  
  Fax: 86-592-2388130

- **China - Zhuhai**  
  Tel: 86-756-3210040  
  Fax: 86-756-3210049

**India - Bangalore**  
Tel: 91-80-3090-4444  
Fax: 91-80-3090-4123

**India - New Delhi**  
Tel: 91-11-4160-8631  
Fax: 91-11-4160-8632

**India - Pune**  
Tel: 91-20-2566-1512  
Fax: 91-20-2566-1513

**Japan - Yokohama**  
Tel: 81-45-471-6166  
Fax: 81-45-471-6122

**Korea - Daegu**  
Tel: 82-53-744-4301  
Fax: 82-53-744-4302

**Korea - Seoul**  
Tel: 82-2-554-7200  
Fax: 82-2-554-8261 or 82-2-554-5934

**Malaysia - Kuala Lumpur**  
Tel: 60-3-6201-9857  
Fax: 60-3-6201-9859

**Malaysia - Penang**  
Tel: 60-4-227-8870  
Fax: 60-4-227-4068

**Philippines - Manila**  
Tel: 63-2-634-9065  
Fax: 63-2-634-9069

**Singapore**  
Tel: 65-6334-8870  
Fax: 65-6334-8850

**Taiwan - Hsin Chu**  
Tel: 886-3-6578-300  
Fax: 886-3-6578-370

**Taiwan - Kaohsiung**  
Tel: 886-7-213-7380  
Fax: 886-7-330-9305

**Taiwan - Taipei**  
Tel: 886-2-2500-6610  
Fax: 886-2-2500-8000

**Thailand - Bangkok**  
Tel: 66-2-694-1351  
Fax: 66-2-694-1350

### EUROPE

**Austria - Wels**  
Tel: 43-7242-2244-39  
Fax: 43-7242-2244-393

**Denmark - Copenhagen**  
Tel: 45-4450-2828  
Fax: 45-4485-2829

**France - Paris**  
Tel: 33-1-69-53-63-20  
Fax: 33-1-69-30-90-79

**Germany - Munich**  
Tel: 49-89-627-144-0  
Fax: 49-89-627-144-44

**Italy - Milan**  
Tel: 39-0331-742611  
Fax: 39-0331-466781

**Netherlands - Drunen**  
Tel: 31-416-690399  
Fax: 31-416-690340

**Spain - Madrid**  
Tel: 34-91-708-08-90  
Fax: 34-91-708-08-91

**UK - Wokingham**  
Tel: 44-118-921-5869  
Fax: 44-118-921-5820

08/04/10