AN1496

Debugging Stand-Alone Real-Time Clock/Calendar-Based Applications

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INTRODUCTION

An increasing number of applications require Real-Time Clock/Calendar (RTCC) devices.

Microchip's RTCC's (I^2C™ and SPI) are feature-rich devices that incorporate EEPROM, Time/Date registers, Time-Stamp registers, alarm modules, SRAM, a watchdog timer, and event detect modules, making them useful in many timekeeping applications.

This application note describes how to debug an application using Microchip's MCP794XX and MCP795XX RTCC devices.

Several code examples are detailed and explained in Table 1.

COMMON ISSUES

TABLE 1: COMMON ISSUES

Problem	Solution
The oscillator does not function	Take into account two main factors: hardware and firmware. **Hardware** • Verify that you have the correct type and value of crystal. Every type of crystal has specific parameters such as: C_{LOAD} (equivalent capacitance of the crystal); ESR (equivalent series resistor of the crystal, at the resonance frequency). • Verify that you have the correct values of the capacitors, as stated in the crystal manufacturer's data sheet and/or in Microchip's documents. • Make sure the board is clean. Some of the flux used in the Pb-free may be slightly conductive; leaving residue on the board will delay the oscillator from starting or prevent oscillation completely (a dirty board will create parasitic resistors and capacitors). • Verify your layout for the oscillator. An example is described in AN1365, *"Recommended Usage of Microchip Serial RTCC Devices"*. • Ensure that the crystal was not overheated during soldering. **Firmware** • Make sure the Start bit (ST) in register 00h is set; Set ST = `1` to enable the oscillator. • Check if the EXTOSC bit in the Control register (addr 07h) is clear; EXTOSC = `0`. This should be cleared when using an external crystal.
The oscillator occasionally starts and stops	If the oscillator starts and stops, it means that the Start bit is set. Take into account only the hardware issues described above (crystal, capacitors, board, layout). Additionally, moisture on the board can affect crystal operation, as can trying to measure the crystal using a standard (x1 or x10) oscilloscope probe.
The SRAM is losing data and the clock is resetting when V_{CC} is removed	Make sure that you have enabled battery backup in the code, through the VBATEN bit in register 03h; VBATEN = `1`. Measure the backup supply voltage to make sure it is within the specification given in the data sheet.

TABLE 1: COMMON ISSUES (CONTINUED)

Problem	Solution

Cannot communicate with the I^2C™ device (or does not acknowledge)	• Make sure that RTCC is powered and $V_{CC} > V_{TRIP}$.
	• Verify the I^2C bus is pulled high when inactive/idle..
	• Ensure that you have the correct value pull-up resistors, refer to AN1028, *"Recommended Usage of Microchip I^2C™ Serial EEPROM Devices"*.
	• Is the I^2C bus address correct for the MCP794XX?
	  - Nonvolatile (EEPROM): 0xAE (for writes), 0xAF (for reads).
	  - Volatile (SRAM): 0xDE (for writes), 0xDF (for reads).
	• Is the address of the byte location correct? Entering an address past 0x5F for an SRAM operation will result in the MCP7941X not acknowledging the address. Addressing undefined EEPROM locations will result in the MCP7941X not acknowledging the address.
	• Have you installed the battery? If your application does not need a battery, the V_{BAT} pin should be connected to ground.

MFP does not toggle (MCP7941X)	Please consider two possible factors:
	Hardware
	MFP is an open-drain pin and needs a pull-up resistor. Verify that you have the correct resistor and the pin is high at power-up.
	Firmware
	MFP may be used as clockout (in timekeeping applications) or as interrupt (in alarm applications). The MFP pin can also be driven via the OUT bit. Ensure that this bit is not being modified by the code.

	In timekeeping applications (such as an electronic watch), MFP can output pulses to offer a time reference.
	An example of how to program the Control register (07h) for such an application is described in the code of AN1355, *"A Complete Electronic Watch Based on MCP79410 I^2C™ RTCC"* (the code will toggle MFP at 1 Hz).
	`rtcc_wr(SQWE + ALM_NONE + MFP_1HZ, ADDR_CTRL),` where constants are defined as below:
	`#define ADDR_CTRL        0x07     // address of the control register`
	`#define SQWE             0x40     // MFP = square wave`
	`#define ALM_NONE         0x00     // no alarms activated`
	`#define MFP_1HZ          0x00     // MFP = square wave at 1 Hz`
	
	In alarm applications, the initialization code could be (example from AN1364):
	`rtcc_wr(ALM_0, ADDR_CTRL)         ;// enable ALARM0, OUT=0, no SQWAVE`
	`rtcc_wr(ALMx_POL+ALMxC_ALL+MONDAY,`
	`ADDR_ALM0CTL)                     ;//  MFP=1  on  ALARM,  match  on  all  vars,`
	`                                  //  (alarm) day of week for alarm = 1`
	
	Definitions of constants for this example are:
	`#define ALM_0          0x10      // ALARM0 is activated (ADDR_CTRL)`
	`#define ALMx_POL       0x80      // polarity of MFP alarm (ADDR_ALMxCTL)`
	`#define ALMxC_ALL      0x70      // ALARM compare on all param (ADDR_ALMxCTL)`
	`#define ADDR_ALM0CTL   0x0d      // address of ALARM0 CONTROL register`

Alarms do not trigger (MCP7941X)	Same issues that may effect MFP apply: • MFP is open-drain and needs a pull-up. • The initialization code for an alarm application includes the two above statements related to Control register (07h) and ALARM0 Control register (0Dh).

TABLE 1: COMMON ISSUES (CONTINUED)

<table>
<tr><th>Problem</th><th>Solution</th></tr>
<tr><td>An alarm cannot be retriggered</td><td>The alarm interrupt flag, ALMxIF (bit 3 in the Alarm Control registers), is set automatically by the hardware but must be cleared in firmware in order to retrigger the alarm.
The previous examples of code show the correct procedure, too. After every alarm match, re-initialize the alarm module, this is done by clearing the Alarm Interrupt Flag (ALMxIF).</td></tr>
<tr><td>Cannot read the SPI device (MCP9752X)</td><td>A read from an SPI device needs the master to produce the SPI clock. The clock generator is started only when writing a byte in the SPI data buffer. Accordingly, before reading the SPI device, write a byte in the SPI data buffer of the master. A generic example of code for a PIC18 application (including the SPI RTCC) could be:
<pre>
unsigned char spi_rdbyte (void) { // READ A BYTE FROM THE SPI RTCC
unsigned char aux   ; // auxiliary variable
SSP1BUF = 0x55   ; // start ck generator, writing a dummy byte
                               // you may write any value in the range
                                  00h - FFh
while (!PIR1bits.SSP1IF)   ; // polling the SPI interrupt flag
aux=SSP1BUF   ; // temporary variable to store the received
                                  value
PIR1bits.SSP1IF = 0   ; // clear the interrupt flag after end of
                                  reception
return aux   ; // return the SPI received value
</pre></td></tr>
<tr><td>Time is not accurate</td><td>This is the most common issue in timekeeping applications.
Inaccurate timekeeping can be caused by three factors: the 32,768 Hz crystal, the two external capacitors and the thermal drift of the crystal. There are two methods to solve the problem:

A good choice/match of the two capacitors (which can solve the problem of the offset of the frequency). Take into account the crystal tolerance.
The calibration register of the RTCC, which can compensate the two deviations of the frequency: offset and thermal drift.

The order of operations should be:

Match the capacitors to the chosen crystal;
Only after completing this, compensate the remaining offset through the calibration register;
The best tool to measure the frequency is an (expensive) high precision counter/frequency-meter. Due to the low-power operation of the oscillator, this cannot be tested with an oscilloscope probe without affecting the operation. The 32.768 kHz clock can also be observed as a square wave by enabling the CLKOUT.
Tolerance of crystals.
Crystal frequency varies with frequency. The system should be tested across all temperature and environmental conditions.
If the crystal is replaced with a device having equivalent parameters, the system should be re-qualified.
</td></tr>
</table>

Common Crystal Issues

Please refer to AN1365, *"Recommended Usage of Microchip Serial RTCC Devices"* (DS01365).

CONCLUSION

A number of application notes are available to assist in developing with the RTCC. These are available on the Microchip web site at www.microchip.com/rtcc.

For additional information, please refer to the following documents:

- AN1365 – *"Recommended Usage of Microchip Serial RTCC Devices"*
- AN1364 – *"Using the Alarm Feature on the MCP79410 RTCC to Implement a Delayed Alarm"*
- AN1355 – *"A Complete Electronic Watch Based on MCP79410 I^2C™ RTCC"*
- AN1413 – *"Temperature Compensation of a Tuning Fork Crystal Based on MCP79410"*
- TB3065 – *"Enabling Intelligent Automation Using the MCP7941X I^2C™ RTCC"*
- AN1379 – *"Stopwatch Based on MCP79410 I^2C™ RTCC"*
- AN1412 – *"How to Calculate UNIX® Time Using a PIC18 Microcontroller and the MCP795W20 SPI RTCC"*

APPENDIX A: REVISION HISTORY

Revision A (02/2013)

Initial Release.

NOTES:

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