MICROCHIP

AN1365

Recommended Usage of Microchip Serial RTCC Devices

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INTRODUCTION

Many embedded systems require some form of accurate timekeeping. There are a growing number of applications that require an external Real-Time Clock/Calendar (RTCC) and higher integration of external peripheral components into the RTCC. In order to achieve a highly robust and repeatable system, the designer must consider the rest of the system components including pull-up resistor values and the crystal selection. There are a number of situations that can result in less than optimal operation, many of which are easy mistakes that are avoidable with some initial knowledge. These are discussed in this application note.

This application note provides assistance and guidance in using the Microchip RTCC family of devices. This application note covers both the I²C™ (MCP794XX) and SPI (MCP795XXX) family of devices. These recommendations are not meant as requirements, however, their adoption will lead to a more robust overall design. The following topics are discussed:

- Basic Design Considerations
- VCC Supply
- Backup Supply options
- Input Pins
- Output Pins
- Crystal Selection
- Recommended Schematics (Appendix B-D)

All of the recommended practices that are detailed in this document are used on the RTCC PICtail™ daughter boards available from Microchip.

Appendix B: "Recommended Connections for MCP794XX Series Devices" shows the suggested connections for using the Microchip I²C MCP794XX RTCC family.

Appendix C: "Recommended Connections for MCP795XX Series Devices" and **Appendix D: "Recommended Connections for MCP795WXX Series Devices"** show similar schematic for the SPI RTCC devices. The basis for these connections will be explained in the following sections.

POWER SUPPLY

Microchip I²C RTCC devices feature a robust serial communication protocol that guards against unintentional writes and data corruption while power is within normal operating levels.

The Microchip Serial RTCC devices operate over a wide voltage range. Two power supplies are required for full device operation:

- Main VCC – Required for full Read/Write functionality and clock/calendar operation.
- VBAT Supply – Required to maintain the clock/calendar during the time when VCC is not present.

Please refer to the device data sheet for voltage range information. Additional information regarding the VBAT supply is provided later in this text.

As is shown in the schematics in Appendix B through D, a decoupling capacitor (typically 0.1 µF) should be used to help filter out noise on VCC.

Power-Up

On power-up, VCC should always begin at 0V and rise to its normal operating voltage to ensure a proper Power-on Reset. VCC should not linger at an ambiguous voltage (i.e., below the minimum operating voltage).

However, if VCC happens to fall below the minimum retention voltage for the device (see data sheet DC Characteristics), it is recommended that VCC be brought down fully to 0V before returning to normal operating level. This will help to ensure that the device is reset properly.

Furthermore, if the microcontroller features a Brown-out Reset with a threshold higher than that of the RTCC, bringing VCC down to 0V will allow both devices to be reset together. Otherwise, the microcontroller may reset during communication while the RTCC is still in an operational condition.

VCC Ramp Rates

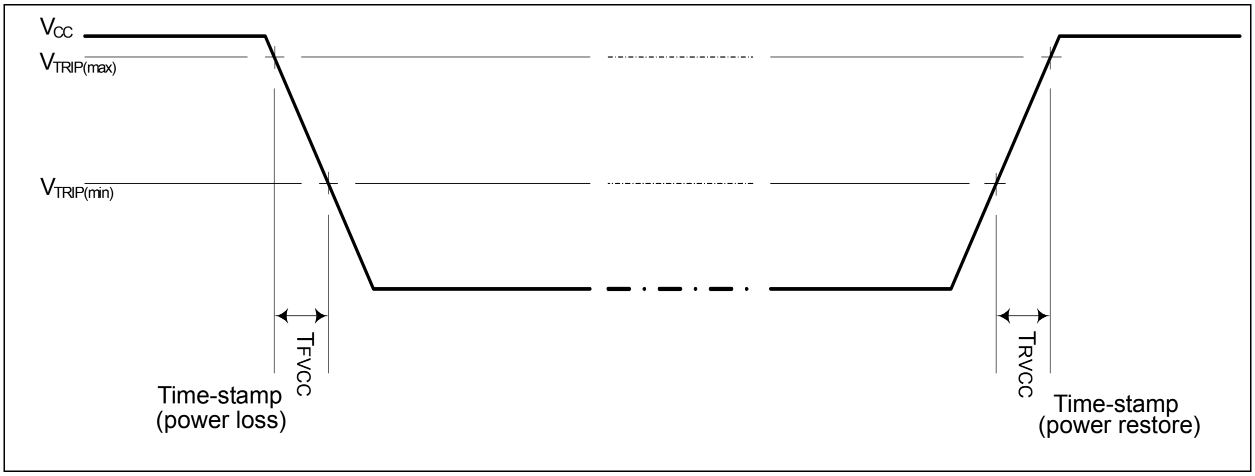
The Microchip RTCC family integrates a battery switch over circuit to maintain the time and also the contents of the SRAM during the time when VCC is below the VTRIP threshold as defined in the data sheet. Due to the fact that the circuit operates at a very low current level, care should be exercised to ensure that the rise and fall times listed in the data sheet are met.

Many applications will meet these requirements simply based on the capacitance on the VCC lines and also the output impedance of the power supply circuit and the PCB copper resistance.

The following data sheet timing specifications should be met.

- TFVCC – VTRIP(max) to VTRIP(min)
- TRVCC – VTRIP(min) to VTRIP(max)

FIGURE 1: VTRIP GRAPH



Internal Switch to VBAT

Internally, the RTCC will switch to the VBAT supply when VCC drops to the VTRIP voltage detailed in the data sheet.

Failure of VCC During a Read

During a read of the RTCC registers, SRAM or EEPROM, if the VCC supply drops, the device will continue to operate as per the device data sheet and communication is still possible with the device until VCC reaches the VBAT trip point.

Failure of VCC During an EEPROM Write

During the time that data is being written to the EEPROM or unique ID locations, VCC should remain above the minimum operating voltage – typically 1.8V. If at any time VDD drops below this minimum voltage but remains above the VBAT switch over voltage (VTRIP as specified in the device data sheet) then care should be taken to ensure that the data written to the device is free from errors by verifying the contents of the memory written.

If at any time the VCC voltage drops below 1.5V (VBAT switch over) then the I^2C and SPI interface is disabled and any writes that are in process will be terminated. It is recommended that, after such a condition, the EEPROM locations that were being written are verified.

Failure of VCC During an SRAM or RTCC Write

SRAM and RTCC writes are possible when VCC is dropping until the VBAT trip point is reached. It is not recommended to communicate during this time and all I^2C and SPI communication should be stopped as soon as possible if the system is able to detect a power-fail condition.

VBAT Selection

This is not applicable to the MCP7940M device.

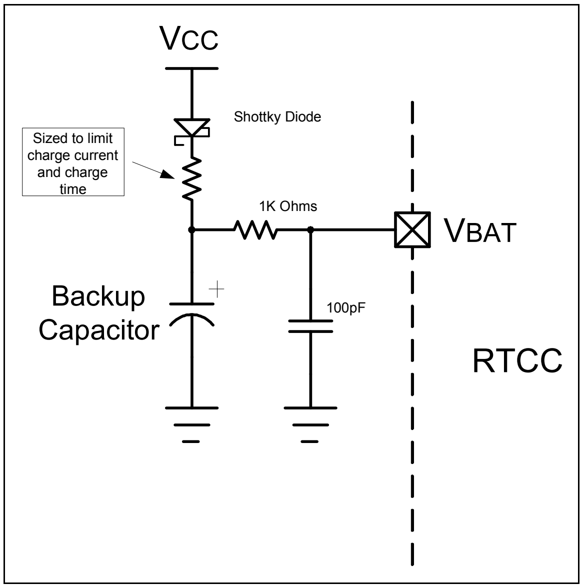
The external VBAT pin supplies power to maintain the RTCC and also the SRAM during a VCC power fail. If this function is not required, then the VBAT pin should be connected to GND. Connecting this pin to GND will result in the lowest current configuration.

The supported voltage on this pin is from 1.3V to 5.5V. The internal circuit will switch to the VBAT voltage when VCC drops to 1.5V (data sheet parameter VTRIP). The RTCC and SRAM will continue to be maintained until the VBAT voltage drops to 1.3V.

The Microchip RTCC devices will support both primary backup supplies (battery etc.) and also rechargeable solutions (NiCad, Super Cap, etc). When using any supply it is recommended to include a 1K series resistor between the supply and the VBAT pin and a 100pF capacitor between VBAT pin and GND. Additionally, a series diode is recommended when using a non-rechargeable supply to eliminate any current flowing into the cell during a device failure.

When using a rechargeable solution, additional components will be required to support a charge current to maintain the voltage on the battery/capacitor. Care should be exercised to ensure that the backup supply cannot power the VCC supply during a main supply failure, this is accomplished using a diode in series with the current limit resistor. Figure 2 shows a typical schematic for using a supercap, the same schematic would also apply to a rechargable battery.

FIGURE 2: SUPERCAP



UL Considerations

One of the requirements for UL approval and certification is related to the VBAT supply. If a lithium primary cell is used (CR2032 or similar), then there are reverse leakage currents that have to be taken into consideration. By using the recommended low voltage drop (Schottky) diode in series with the lithium backup battery, this issue is limited.

In addition to the recommended diode and series resistor, internally the VBAT/VCC switch over circuit has been designed such that in the event of a catastrophic failure of the device, the switch will fail in a safe manner and not conduct from VCC to VBAT.

INPUT-ONLY PINS

It is never good practice to leave a digital input pin floating. This can cause an elevated standby current as well as undesired functionality. If a pin is left floating, it can float either low or high. The final logic state is dependent upon a number of factors, including noise in the system and capacitive coupling. Because of this, the level seen by the input circuitry is relatively random and likely to change during operation. This applies to the EVHS and EVLS pins detailed below.

EVHS and EVLS

These pins are only available on the following device:

- MCP795WXX – 14-pin SPI RTCC Family

The High-Speed Event (EVHS) detect and Low-Speed Event (EVLS) detect are digital input pins and require either a pull-up or pull-down resistor.

These pins are used as the input to the Event Detection circuit. If this feature is not being used in the application then these inputs should be connected to GND.

SERIAL COMMUNICATION PINS

SPI Communication

The MCP795XXX supports the industry standard SPI bus protocol using the SCK, SD, SO and $\overline{CS}$ Lines.

The $\overline{CS}$ line must be brought low at the start of a command and raised at the end of the command. The $\overline{CS}$ line being raised completes the command and performs the write cycle for a nonvolatile memory write.

The $\overline{CS}$ line should not toggle during the command sequence, as raising the $\overline{CS}$ line before the command is complete terminates the current command. A pull up is recommended on $\overline{CS}$ to ensure that the RTCC powers up in an unselected state.

I²C Communication

The MCP794XX supports an I²C-compatible serial interface. To follow the I²C specification, both the Serial Data (SDA) and Serial Clock (SCL) lines require a pull up to VCC. As the MCP794XX is designed to run at a maximum of 400 kHz, suggested values at this speed for both SCL and SDA are 2.2K Ohms at 5.5V.

Application Note AN1028, "*Recommended Usage of Microchip I²C™ Serial EEPROM Devices*", on the Microchip web site, provides additional guidance for the use and implementation of the I²C bus.

OUTPUT-ONLY PINS

MFP Pin

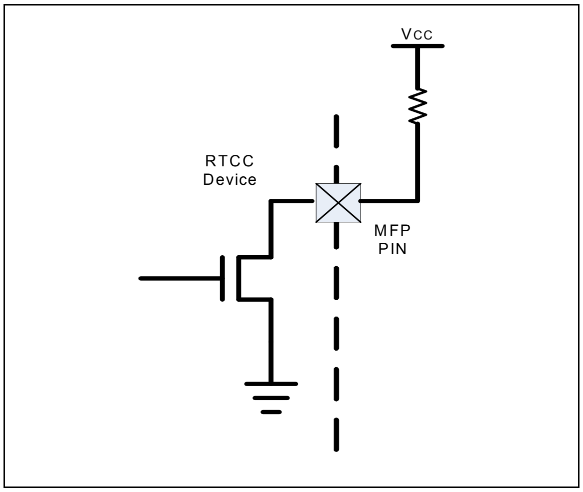
This Pin is available on the following devices:

- MCP794XX – I²C RTCC Family
- MCP795XX – 10-pin SPI RTCC Family

The multi-function pin (MFP) is used for a number of functions when enabled by the RTCC registers. As this pin is an open-drain output, a pull up is required to VCC (it is not recommended to use a pull up to the VBAT timekeeping supply).

This pin can sink a maximum of 10mA.

FIGURE 3: MFP DIAGRAM



The MFP pin is used for the following operation when VCC is present on the device:

- Alarm output – an active alarm generated from one of the programmable alarms will assert this line (pull the line low). The line can be wire OR'd to other open-drain signals to drive a single MCU IRQ line.
- General purpose output – can be used as an additional I/O line under the control of the MCU.
- Output a clock signal – can be used to output a frequency derived from the 32.768 kHz crystal. As this is an open drain, the size of the pull-up resistor and the bus capacitance of that line will determine the rise and fall time of the signal.

When VCC is removed and the device is running from the backup supply, VBAT, the only functions that are active on this pin are the alarms; all other functions are disabled until VCC is restored.

CLKOUT Pin

This pin is only available on the following device:

- MCP795WXX – 14-Pin SPI RTCC Family

The CLKOUT is a push/pull output that can produce a square-wave that is derived from the crystal and on-board oscillator.

Please consult the device data sheet for the source/sink specifications of this pin. If this pin is used to provide a clock source to another device, care must be taken to ensure that the load of the driven device does not exceed the drive capability of this pin.

If this pin is not used it can be left floating; do not connect to VCC or GND, as this is a digital output.

$\overline{\text{WDO}}$ and $\overline{\text{IRQ}}$

These pins are only available on the following device:

- MCP795WXX – 14-pin SPI RTCC Family

The $\overline{\text{WDO}}$ and $\overline{\text{IRQ}}$ pins are open-drain and are capable of sinking 10mA (Please refer to the DC Characteristics in the data sheet). A pull-up to VCC is required on these pins.

The $\overline{\text{WDO}}$ and $\overline{\text{IRQ}}$ pins are used as the output from the on-board watchdog timer and the alarm interrupt event.

If the $\overline{\text{WDO}}$ and $\overline{\text{IRQ}}$ pins are not used they can be left floating.

CRYSTAL SELECTION

The MCP794XX and MCP795XXX have been designed to operate with a standard 32.768 kHz tuning fork crystal with external loading capacitors.

Suitable crystals have a load capacitance of 6-9pF. It is not recommended using crystals with a load capacitance of 12.5pF.

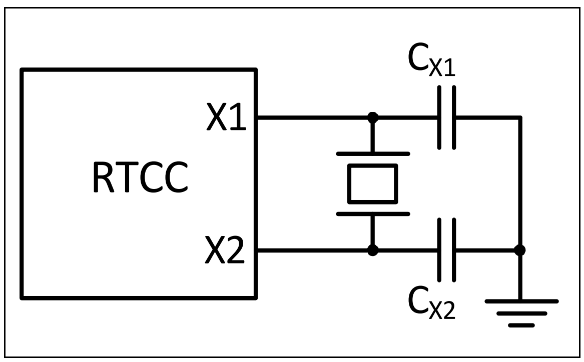
For a list of tested crystals and suggested load capacitors, please refer to AN1519, "*Recommended Crystals for Microchip Stand-Alone Real-Time Clock/Calendar Devices*".

One of the key points in selecting a crystal and load capacitors is the load capacitance of the crystal. A crystal with a specified C_L of 7pF will not operate at the desired frequency using two 7pF capacitors. The C_L is the effective load capacitance, which includes the physical capacitors, pin capacitance and stray board capacitance. When calculating the effective load capacitance, Equation 1 can be used:

EQUATION 1:

$$C_L = \frac{C_{x2} \times C_{x1}}{C_{x2} + C_{x1}} + C_{stray}$$

FIGURE 4: OSCILLATOR DIAGRAM



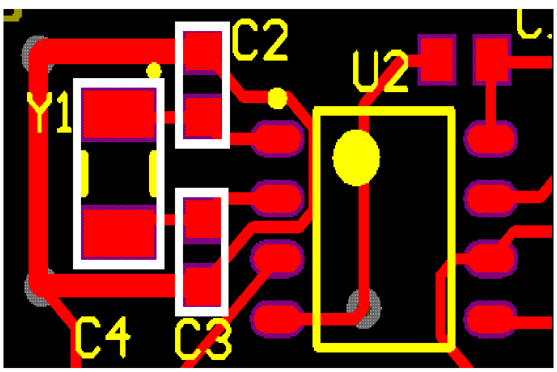
The recommended board layout for the oscillator area for the MCP794XX (also applicable to the MCP795XXX) is shown in Figure 4.

Oscillator Layout

Given that the oscillator is designed for minimum operating current, care must be taken when laying out the PCB traces. This is discussed below.

- Keep traces as short as possible to the crystal and the load capacitors. Minimizing the length is important to keep stray capacitance to a minimum. For that reason, it is not recommended to use any kind of a socket, or package interposer when developing with the RTCC devices. An alternative that can be used is the RTCC PICtail daughter board.
- Use a ground ring. During the PCB layout, a ground ring should be placed around both the crystal and also the X1 and X2 pins (pins 1, 2) on the device. This ground ring should be connected to a low-impedance ground connection. A recommended layout is shown in Figure 5. In the PCB layout example below, C2 and C3 are the load capacitors C_{X1} and C_{X2}.

FIGURE 5: CRYSTAL LAYOUT (MCP794XX SHOWN)



It is recommended that the final application be tested with the chosen crystal and capacitor across all environmental and operating conditions.

The Gerber files for the PICtail daughter board are available on the web site following the link on www.microchip.com/rtcc.

SUMMARY

This application note illustrates recommended techniques for increasing design robustness when using the Microchip family of RTCC's. These recommendations fall directly in line with how Microchip designs, manufactures, qualifies and tests its RTCC devices and will allow the devices to operate within the data sheet parameters. It also serves to explain in detail some of the features of the device and makes the user aware of any potential pitfalls that may be encountered.

This document should be read in conjunction with the following additional resources:

- Device Data Sheet
- AN1491, "*Configuring the MCP794XX RTCC Family*"
- AN1496, "*Debugging Stand-Alone Real-Time Clock/Calendar-Based Applications*"
- AN1519, "*Recommended Crystals for Microchip Stand-Alone Real-Time Clock/Calendar Devices*"

APPENDIX A: REVISION HISTORY

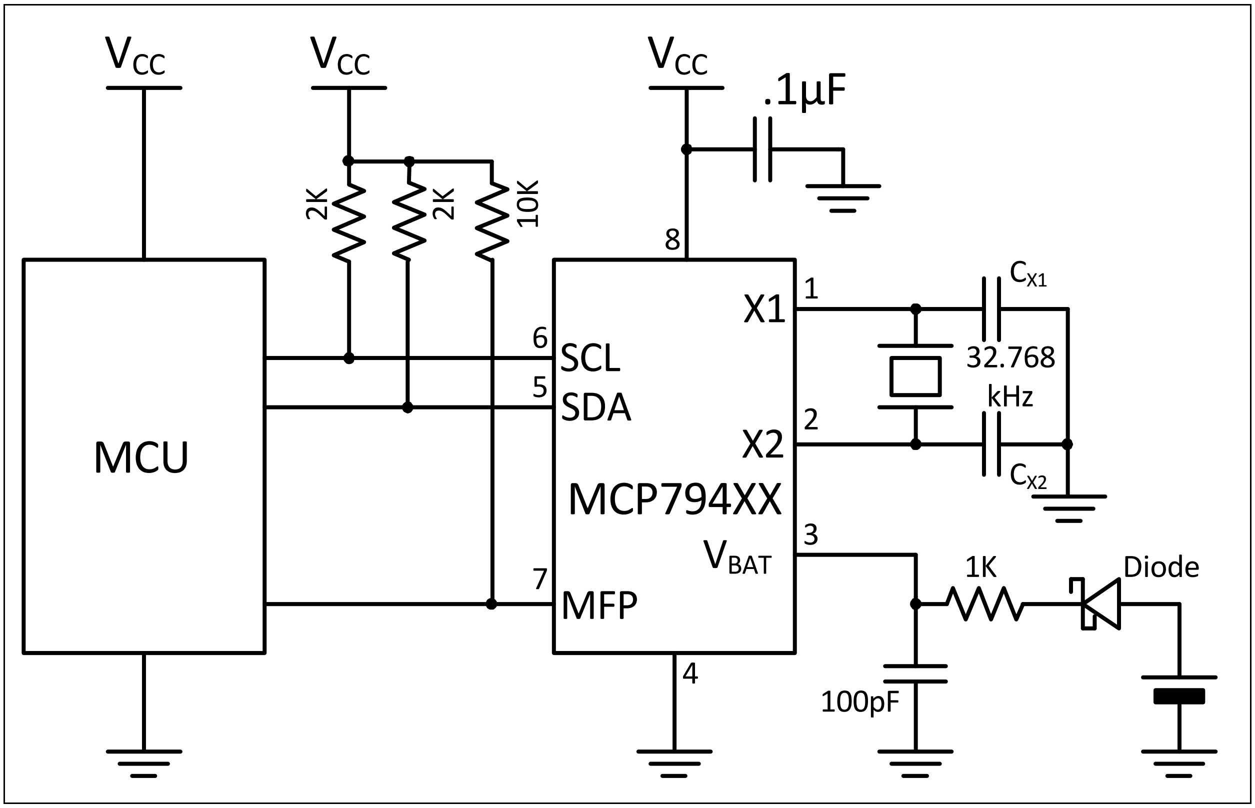
Revision C (11/2011)

Changed part number from MCP795XX to MCP795XXX; Added Revision History.

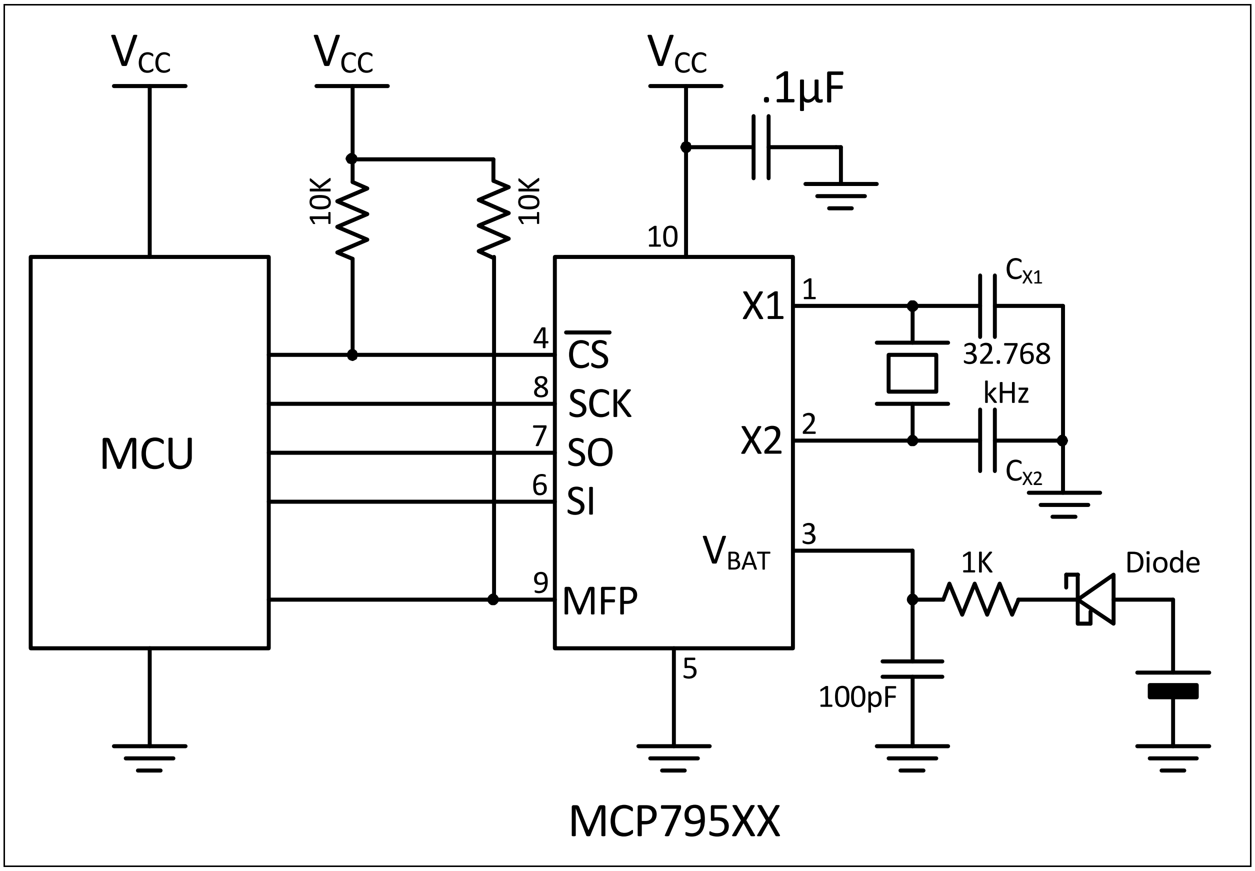
Revision D (03/2013)

Document format changed. Added additional information for crystal selection. Removed incorrect references.

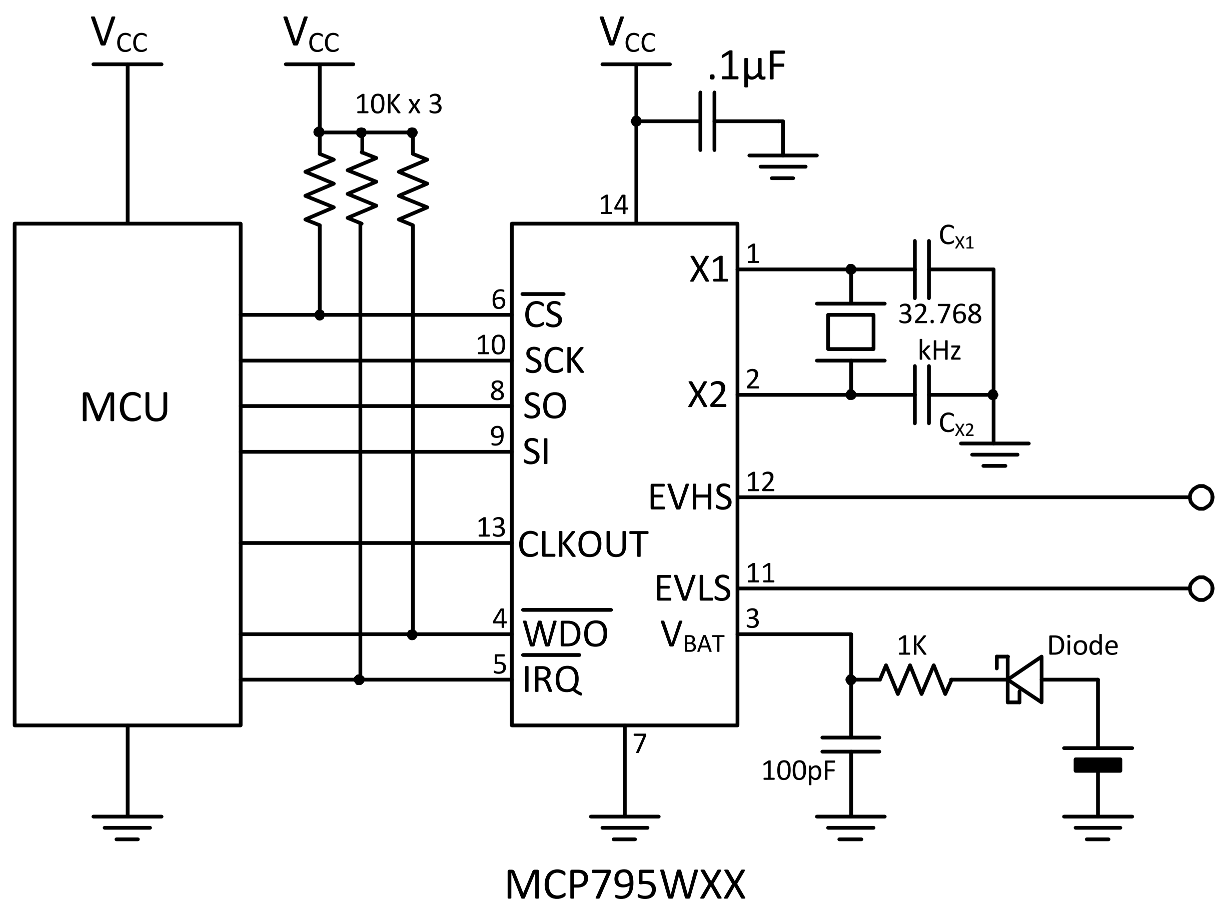
APPENDIX B: RECOMMENDED CONNECTIONS FOR MCP794XX SERIES DEVICES



APPENDIX C: RECOMMENDED CONNECTIONS FOR MCP795XX SERIES DEVICES



APPENDIX D: RECOMMENDED CONNECTIONS FOR MCP795WXX SERIES DEVICES



Note: Both the EVHS and EVLS should be externally connected to either pull-up or pull-down resistors depending on the polarity of the trigger.

NOTES:

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