

3V SPI Real-Time Clock Calendar with Battery Switchover

Device Selection Table

| Part Number | SRAM (Bytes) | EEPROM (Kbits) | Unique ID |
|-------------|--------------|----------------|-----------|
| MCP79520 | 64 | 2 | Blank |
| MCP79510 | 64 | 1 | Blank |
| MCP79521 | 64 | 2 | EUI-48™ |
| MCP79511 | 64 | 1 | EUI-48™ |
| MCP79522 | 64 | 2 | EUI-64™ |
| MCP79512 | 64 | 1 | EUI-64™ |

Timekeeping Features:

- Real-Time Clock/Calendar:
 - Hours, Minutes, Seconds, Hundredth of Seconds, Day of Week, Month, Year, Leap Year
- Crystal Oscillator requires External 32,768 kHz Tuning Fork Crystal and Load Capacitors.
- Clock Out Function:
 - 1Hz, 4.096 kHz, 8.192 kHz, 32.768 kHz
- 2 Programmable Alarms
- Programmable open drain output – Alarm or Interrupt
- On-Chip Digital Trimming/Calibration:
 - +/- 255 PPM range in 1 PPM steps
- Power-Fail Time-Stamp @ Battery Switchover:
 - Logs time when VCC fails and VCC is restored

Low-Power Features:

- Wide Operating Voltage:
 - VCC: 1.8V to 3.6V
 - VBAT: 1.3V to 3.6V
- Low Operating Current:
 - VCC Standby Current < 1uA @ 3V
 - VBAT Timekeeping Current: <700nA @ 1.8V
- Automatic Battery Switchover from VCC to VBAT:
 - Backup power for timekeeping and SRAM retention

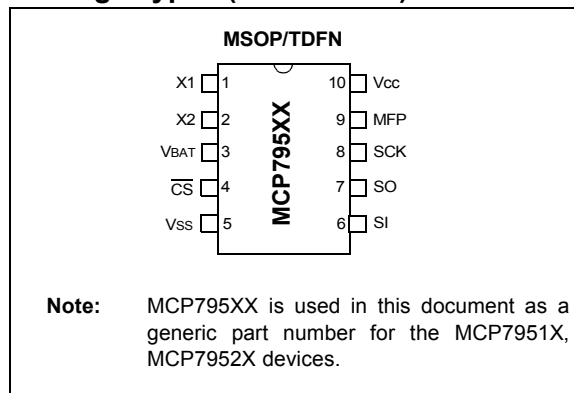
User Memory:

- 64-Byte Battery-Backed SRAM
- 2 Kbit and 1 Kbit EEPROM Memory:
 - Software block write-protect (¼, ½, or entire array)
 - Write Page mode (up to 8 bytes)
 - Endurance: 1M erase/write cycles
- 128-Bit Unique ID in Protected Area of EEPROM:
 - Available blank or preprogrammed
 - EUI-48™ or EUI-64™ MAC address
 - Unlock sequence for user programming

Operating Ranges:

- SPI Clock Speed up to 5 MHz
- Operating Temperature Ranges:
 - Industrial (I Temp): -40°C to +85°C.
- Packages include 10-Lead MSOP and TDFN

Package Types (not to scale)



MCP7952X/MCP7951X

Description:

The MCP795XX is a low-power Real-Time Clock/Calendar (RTCC) that uses digital trimming compensation for an accurate clock/calendar, an interrupt output to support alarms and events, a power sense circuit that automatically switches to the backup supply, nonvolatile memory for safe data storage and several enhanced features that support system requirements.

Along with a low-cost 32,768 kHz crystal, this RTCC tracks time using several internal registers and then communicates the data over a 5 MHz SPI bus that is fast enough to support a programmable millisecond alarm.

The device is fully accessible through the serial interface, while VCC is between 1.8V and 3.6V, but can operate down to 1.3V through the backup supply connected to the VBAT input for timekeeping and SRAM retention only.

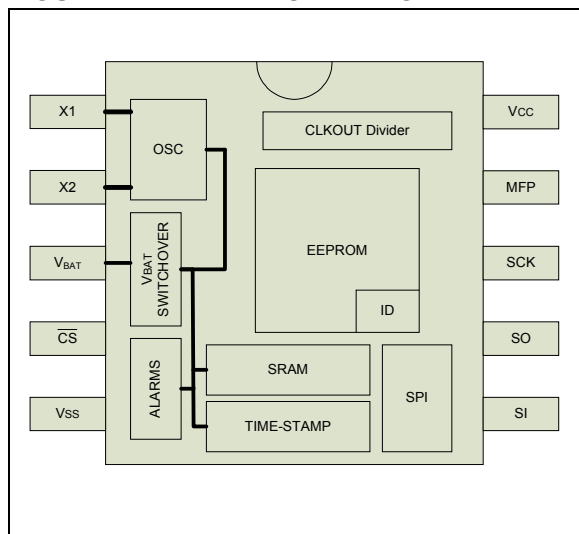
As part of the power sense circuit, a time saver function is implemented to store the time when main power is lost and again, when power is restored to log the duration of a power failure.

Along with the on-board serial EEPROM and battery-backed SRAM, a 128-bit protected space is available for a unique ID. This space can be ordered preprogrammed with a MAC address, or blank for the user to program.

This clock/calendar automatically adjusts for months with fewer than 31 days including corrections for leap years. The clock operates in either 24-hour or 12-hour format with AM/PM indicator and settable alarm(s).

Using the external crystal, the MFP pin can be set to generate a number of output frequencies.

FIGURE 1-1: BLOCK DIAGRAM



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1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings (†)

| | |
|---|-----------------|
| V _{CC} | 6.5V |
| All inputs and outputs w.r.t. V _{SS} | -0.6V to +6.5V |
| Storage temperature | -65°C to +150°C |
| Ambient temperature under bias..... | -40°C to +85°C |
| ESD protection on all pins..... | 4 kV |

† NOTICE: Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

TABLE 1-1: DC CHARACTERISTICS

| DC CHARACTERISTICS | | | Industrial (I): T _{AMB} = -40°C to +85°C V _{CC} = 1.8V to 3.6V | | | |
|--------------------|-----------------------|---|--|--------------------|-------|--|
| Param. No. | Sym. | Characteristic | Min. | Max. | Units | Test Conditions |
| D001 | V _{IH1} | High-level input voltage | .7 V _{CC} | V _{CC} +1 | V | |
| D002 | V _{IL1} | Low-level input voltage | -0.3 | 0.3V _{CC} | V | V _{CC} ≥ 2.5V |
| D003 | V _{IL2} | | -0.3 | 0.2V _{CC} | V | V _{CC} < 2.5V |
| D004 | V _{OL} | Low-level output voltage | — | 0.4 | V | I _{OL} = 2.1 mA |
| D005 | V _{OL} | | — | 0.2 | V | I _{OL} = 1.0 mA, V _{CC} < 2.5V |
| D006 | V _{OH} | High-level output voltage | V _{CC} -0.5 | — | V | I _{OH} = -400 μA |
| D007 | I _{LI} | Input leakage current | | ±1 | μA | $\overline{CS} = V_{CC}$, V _{IN} = V _{SS} TO V _{CC} |
| D008 | I _{LO} | Output leakage current | | ±1 | μA | $\overline{CS} = V_{CC}$, V _{OUT} = V _{SS} TO V _{CC} |
| D009 | C _{INT} | Internal Capacitance (all inputs and outputs) | — | 7 | pF | T _{AMB} = 25°C, CLK = 1.0 MHz V _{CC} = 5.0V (Note 1) |
| D010 | I _{CC} Read | Operating Current | — | 3 | mA | V _{CC} = 3.6V; F _{CLK} = 5 MHz SO = Open |
| D011 | I _{DD} write | Write Current | — | 5 | mA | V _{CC} = 3.6V |
| D012 | I _{BAT} | V _{BAT} Current | — | 700 | nA | V _{BAT} = 1.8V @ 25°C (Note 2) |
| D013 | V _{TRIP} | V _{BAT} Change Over | 1.3 | 1.7 | V | 1.5V typical at T _{AMB} = 25°C |
| D014 | V _{CCFT} | V _{CC} Fall Time | 300 | | μs | From V _{TRIP} (max) to V _{TRIP} (min) |
| D015 | V _{CCRT} | V _{CC} Rise Time | 0 | | μs | From V _{TRIP} (min) to V _{TRIP} (max) |
| D016 | V _{BAT} | V _{BAT} Voltage Range | 1.3 | 3.6 | V | — |
| D017 | I _{CCS} | Standby Current | — | 1 | μA | — |

Note 1: This parameter is periodically sampled and not 100% tested.

2: With oscillator running.

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TABLE 1-2: AC CHARACTERISTICS

| AC CHARACTERISTICS | | | Industrial (I): T _{AMB} = -40°C to +85°C V _{CC} = 1.8V to 3.6V | | | |
|--------------------|------------------|-------------------------------------|--|------|------------|--|
| Param. No. | Sym. | Characteristic | Min. | Max. | Units | Test Conditions |
| 1 | FCLK | Clock Frequency | — | 5 | MHz | 2.5V ≤ V _{CC} < 3.6V |
| | | | — | 3 | MHz | 1.8V ≤ V _{CC} < 2.5V |
| 2 | T _{CSS} | $\overline{\text{CS}}$ Setup Time | 100 | — | ns | 2.5V ≤ V _{CC} < 3.6V |
| | | | 150 | — | ns | 1.8V ≤ V _{CC} < 2.5V |
| 3 | T _{CSH} | $\overline{\text{CS}}$ Hold Time | 100 | — | ns | 2.5V ≤ V _{CC} < 3.6V |
| | | | 150 | — | ns | 1.8V ≤ V _{CC} < 2.5V |
| 4 | T _{CSD} | $\overline{\text{CS}}$ Disable Time | 50 | — | ns | — |
| 5 | T _{SU} | Data Setup Time | 20 | — | ns | 2.5V ≤ V _{CC} < 3.6V |
| | | | 30 | — | ns | 1.8V ≤ V _{CC} < 2.5V |
| 6 | T _{HD} | Data Hold Time | 40 | — | ns | 2.5V ≤ V _{CC} < 3.6V |
| | | | 50 | — | ns | 1.8V ≤ V _{CC} < 2.5V |
| 7 | T _R | CLK Rise Time | — | 100 | ns | (Note 1) |
| 8 | T _F | CLK Fall Time | — | 100 | ns | (Note 1) |
| 9 | T _{HI} | Clock High Time | 100 | — | ns | 2.5V ≤ V _{CC} < 3.6V |
| | | | 150 | — | ns | 1.8V ≤ V _{CC} < 2.5V |
| 10 | T _{LO} | Clock Low Time | 100 | — | ns | 2.5V ≤ V _{CC} < 3.6V |
| | | | 150 | — | ns | 1.8V ≤ V _{CC} < 2.5V |
| 11 | T _{CLD} | Clock Delay Time | 50 | — | ns | — |
| 12 | T _{CLE} | Clock Enable Time | 50 | — | ns | — |
| 13 | T _V | Output Valid from Clock Low | — | 100 | ns | 2.5V ≤ V _{CC} < 3.6V |
| | | | — | 160 | ns | 1.8V ≤ V _{CC} < 2.5V |
| 14 | T _{HO} | Output Hold Time | 0 | — | ns | (Note 1) |
| 15 | T _{DIS} | Output Disable Time | — | 80 | ns | 2.5V ≤ V _{CC} < 3.6V (Note 1) |
| | | | — | 160 | ns | 1.8V ≤ V _{CC} < 2.5V (Note 1) |
| 16 | T _{WC} | Internal Write Cycle Time | — | 5 | ms | (Note 3) |
| 17 | — | Endurance | 1,000,000 | — | E/W Cycles | (Note 2) |

Note 1: This parameter is periodically sampled and not 100% tested.

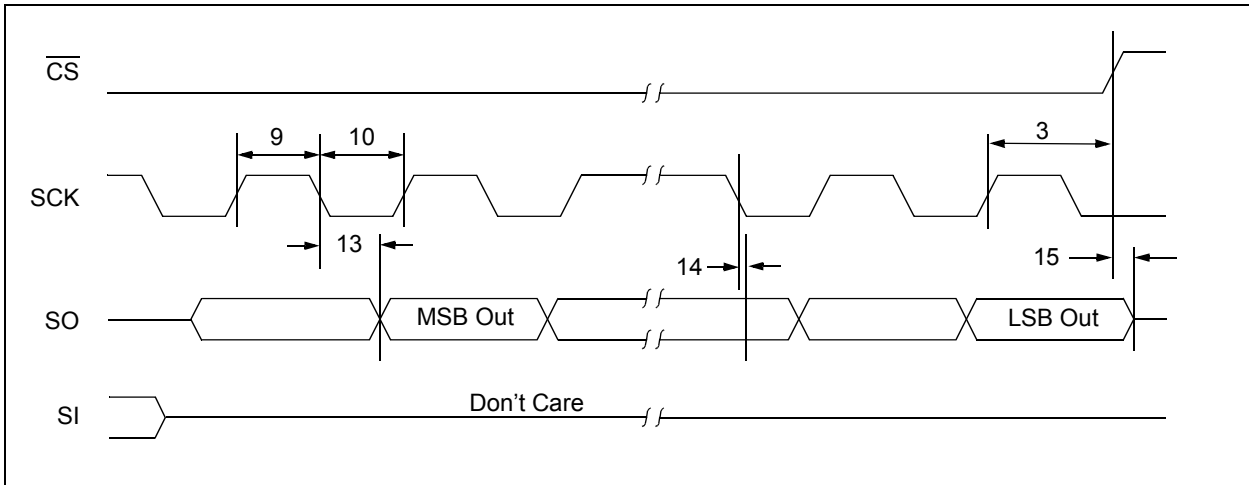
2: This parameter is not tested but ensured by characterization. For endurance estimates in a specific application, please consult the Total Endurance™ Model which can be obtained from Microchip's web site: www.microchip.com.

3: T_{WC} begins on the rising edge of $\overline{\text{CS}}$ after a valid write sequence and ends when the internal write cycle is complete.

FIGURE 1-1: SERIAL INPUT TIMING



FIGURE 1-2: SERIAL OUTPUT TIMING

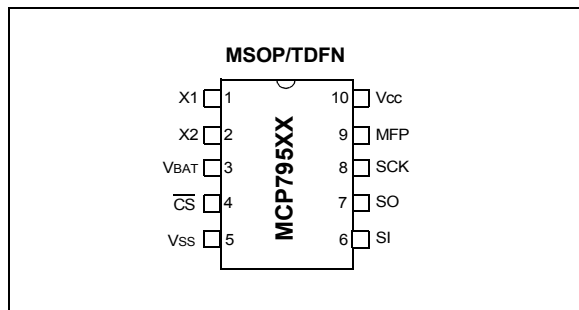


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2.0 PIN DESCRIPTION

The descriptions of the pins are listed in [Table 2-1](#).

FIGURE 2-1: DEVICE PINOUTS



2.1 Chip Select (\overline{CS})

A low level on this pin selects the device. A high level deselects the device and forces it into Standby mode. However, a programming cycle which is already initiated or in progress will be completed, regardless of the \overline{CS} input signal. If \overline{CS} is brought high during a program cycle, the device will go into Standby mode as soon as the programming cycle is complete. When the device is deselected, SO goes into the high-impedance state, allowing multiple parts to share the same SPI bus. A low-to-high transition on \overline{CS} after a valid write sequence initiates an internal write cycle. After power-up, a low level on \overline{CS} is required prior to any sequence being initiated.

2.2 Serial Output (SO)

The SO pin is used to transfer data out of the MCP795XX. During a read cycle, data is shifted out on this pin after the falling edge of the serial clock.

2.3 Serial Input (SI)

The SI pin is used to transfer data into the device. It receives instructions, addresses and data. Data is latched on the rising edge of the serial clock.

2.4 Serial Clock (SCK)

The SCK is used to synchronize the communication between a master and the MCP795XX. Instructions, addresses or data present on the SI pin are latched on the rising edge of the clock input, while data on the SO pin is updated after the falling edge of the clock input.

2.5 Multifunction Pin (MFP)

The MFP pin is shared with the clock divider and the alarms. This pin requires an external pull-up to VCC or VBAT. The pin remains low until such time that the interrupt flag in the register is cleared by software. This pin has a maximum sink current of 10mA.

2.6 X1, X2

The X1 and X2 pins connect to the on-board oscillator block. X1 is the input to the module and X2 is the output of the module. The device can be run from an external CMOS signal by feeding into the X1 pin. If driving X1 the X2 pin should be a No Connect.

2.7 VBAT

The VBAT pin is a secondary supply input to maintain the Clock and SRAM contents when VCC is removed.

TABLE 2-1: PIN DESCRIPTIONS

| Pin Name | Pin Function |
|-----------------|---------------------------------------|
| VSS | Ground |
| X1 | Xtal Input, External Oscillator Input |
| X2 | Xtal Output |
| VBAT | Battery Backup Input (3V Typ) |
| VCC | +1.8V to +3.6V Power Supply |
| SI | Serial Input |
| SCK | Serial Clock |
| \overline{CS} | Chip Select |
| MFP | Multifunction Pin |
| SO | Serial Output |

2.8 RTCC Memory Map

The RTCC registers are contained in addresses 0x00h-0x1fh. 64 bytes of user-accessible SRAM are located in the address range 0x20-0x5f. The SRAM memory is a separate block from the RTCC control and Configuration registers. All SRAM locations are battery-backed-up during a VCC power fail. Unused locations are not accessible.

- Addresses 0x00h-0x07h are the RTCC Time and Date registers. These are read/write registers. Care must be taken when writing to these registers with the oscillator running.
- Incorrect data can appear in the Time and Date registers if a write is attempted during the time frame where these internal registers are being incremented. The user can minimize the likelihood of data corruption by ensuring that any writes to the Time and Date registers occur before the contents of the second register reach a value of 0x59H.

- Addresses 0x08h-0x0Bh are the device Configuration and Calibration registers.
- Addresses 0x0ch-0x11h are the Alarm 0 registers. These are used to set up the Alarm 0, the interrupt pin and the Alarm 0 compare.
- Addresses 0x12h-0x17h are the Alarm 1 registers. These are used to set up the Alarm 1, the interrupt pin and the Alarm 1 compare. Alarm 1 offers an enhanced resolution of tenth and hundredths of seconds.
- Addresses 0x18h-0x1Fh are used for the power-down and power-up time-stamp feature. The detailed memory map is shown in [Table 4-1](#). No error checking is provided when loading Time and Date registers.

FIGURE 2-2: MEMORY MAP



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3.0 SPI BUS OPERATION

The MCP795XX is designed to interface directly with the Serial Peripheral Interface (SPI) port of many of today's popular microcontroller families, including Microchip's PIC[®] microcontrollers. It may also interface with microcontrollers that do not have a built-in SPI port by using discrete I/O lines programmed properly in software to match the SPI protocol.

The MCP795XX contains an 8-bit instruction register.

The device is accessed via the SI pin, with data being clocked in on the rising edge of SCK. The CS pin must be low for the entire operation.

Table 3-1 contains a list of the possible instruction bytes and format for device operation. All instructions, addresses, and data are transferred MSb first, LSb last.

Data (SI) is sampled on the first rising edge of SCK after CS goes low.

TABLE 3-1: INSTRUCTION SET SUMMARY

| Instruction Name | Instruction Format | Description |
|------------------|--------------------|--|
| EEREAD | 0000 0011 | Read data from EE memory array beginning at selected address |
| EEWRITE | 0000 0010 | Write data to EE memory array beginning at selected address |
| EEWRDI | 0000 0100 | Reset the write enable latch (disable write operations) |
| EEWREN | 0000 0110 | Set the write enable latch (enable write operations) |
| SRREAD | 0000 0101 | Read STATUS register |
| SRWRITE | 0000 0001 | Write STATUS register |
| READ | 0001 0011 | Read RTCC/SRAM array beginning at selected address |
| WRITE | 0001 0010 | Write RTCC/SRAM data to memory array beginning at selected address |
| UNLOCK | 0001 0100 | Unlock ID Locations |
| IDWRITE | 0011 0010 | Write to the ID Locations |
| IDREAD | 0011 0011 | Read the ID Locations |
| CLRRAM | 0101 0100 | Clear RAM Location to '0' |

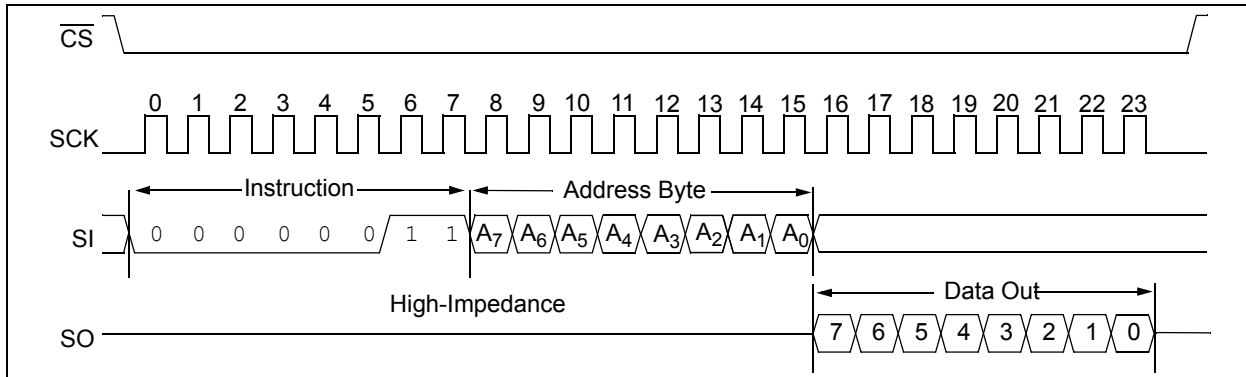
3.1 Read Sequence

The device is selected by pulling CS low. The various 8-bit read instructions are transmitted to the MCP795XX followed by an 8-bit address. See Figure 3-1 for more details.

After the correct instruction and address are sent, the data stored in the memory at the selected address is shifted out on the SO pin. Data stored in the memory at

the next address can be read sequentially by continuing to provide clock pulses to the slave. The internal Address Pointer automatically increments to the next higher address after each byte of data is shifted out. When the highest address is reached, the address counter rolls over to the first valid address allowing the read cycle to be continued indefinitely. The read operation is terminated by raising the CS pin (Figure 1-1).

FIGURE 3-1: EEREAD SEQUENCE



3.2 Nonvolatile Memory Write Sequence

Prior to any attempt to write data to the nonvolatile memory (EEPROM, Unique ID and STATUS register) in the MCP795XX, the write enable latch must be set

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by issuing the `EEWREN` instruction (Figure 3-4). This is done by setting \overline{CS} low and then clocking out the proper instruction into the MCP795XX. After all eight bits of the instruction are transmitted, \overline{CS} must be driven high to set the write enable latch. If the write operation is initiated immediately after the `EEWREN` instruction without \overline{CS} driven high, data will not be written to the array since the write enable latch was not properly set.

After setting the write enable latch, the user may proceed by driving \overline{CS} low, issuing either an `EEWRITE`, `IDWRITE` or a `SWRITE` instruction, followed by the remainder of the address, and then the data to be written. Up to 8 bytes of data can be sent to the device before a write cycle is necessary. The only restriction is that all of the bytes must reside in the same page. Additionally, a page address begins with `XXXX 0000` and ends with `XXXX X111`. If the internal address counter reaches `XXXX X111` and clock signals continue to be

applied to the chip, the address counter will roll back to the first address of the page and overwrite any data that previously existed in those locations.

For the data to be actually written to the array, the \overline{CS} must be brought high after the Least Significant bit (D0) of the nth data byte has been clocked in. If \overline{CS} is driven high at any other time, the write operation will not be completed. Refer to Figure 3-2 and Figure 3-3 for more detailed illustrations on the byte write sequence and the page write sequence, respectively. While the non-volatile memory write is in progress, the STATUS register may be read to check the status of the WIP, WEL, BP1 and BP0 bits. Attempting to read a memory array location will not be possible during a write cycle. Polling the WIP bit in the STATUS register is recommended in order to determine if a write cycle is in progress. When the nonvolatile memory write cycle is completed, the write enable latch is reset.

FIGURE 3-2: BYTE EEWWRITE SEQUENCE

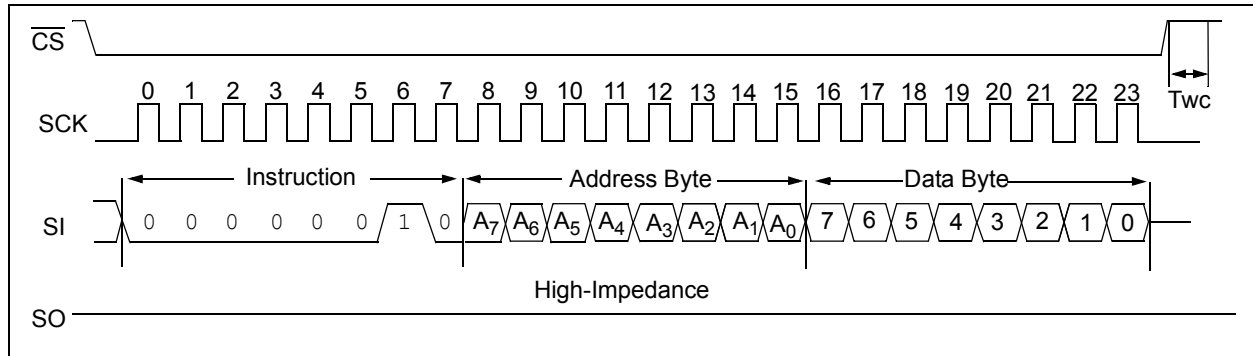
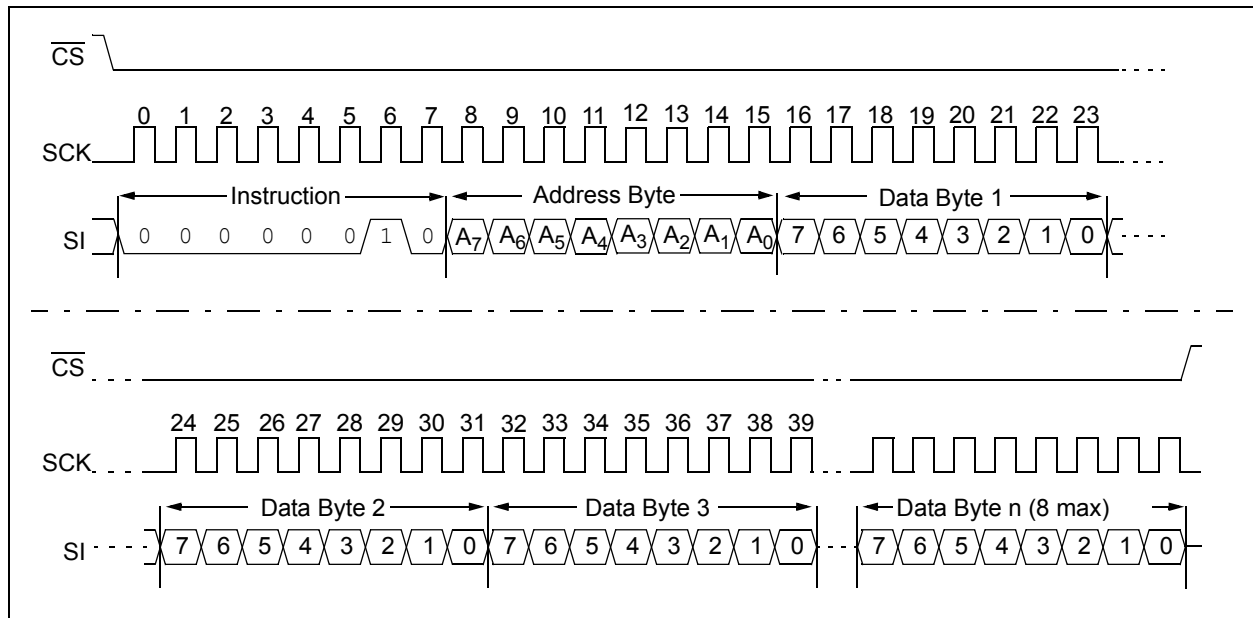


FIGURE 3-3: PAGE EEWWRITE SEQUENCE



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3.3 Write Enable (EEWREN) and Write Disable (EEWRDI)

The MCP795XX contains a write enable latch.

This latch must be set before any EEWRITE, SRWRITE and IDWRITE operation will be completed internally. The EEWREN instruction will set the latch, and the EEWRDI will reset the latch.

The following is a list of conditions under which the write enable latch will be reset:

- Power-up
- EEWRDI instruction successfully executed
- SRWRITE instruction successfully executed
- EEWRITE instruction successfully executed
- IDWRITE instruction successfully executed

FIGURE 3-4: WRITE ENABLE SEQUENCE (EEWREN)



FIGURE 3-5: WRITE DISABLE SEQUENCE (EEWRDI)



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4.0 RTCC FUNCTIONALITY

4.0.1 RTCC REGISTER MAP

The RTCC register space runs from 0x00 through to 0x1F. Any read or write that is started within the RTCC register address space will wrap to the beginning of the RTCC registers.

All of the RTCC registers are backed up from the VBAT supply when VCC is not available, provided that the VBATEN bit is set. Any unused bits or non implemented addresses read back as '0'. No error checking is provided for any of the RTCC, the user may load any value.

The RTCC register map is shown in [Table 4-1](#).

TABLE 4-1: RTCC REGISTER MAP

| Address | BIT 7 | BIT 6 | BIT 5 | BIT 4 | BIT 3 | BIT 2 | BIT 1 | BIT 0 | FUNCTION | RANGE | |
|----------------------------------|-------------------------|---------------|---------------|----------|-----------------------|-----------------------|-------|-------|-----------------------|-------------------------|-------|
| Time and Configuration Registers | | | | | | | | | | | |
| 00h | Tenth Seconds | | | | Hundredths of Seconds | | | | Hundredths of seconds | 00-99 | |
| 01h | ST | 10 Seconds | | | | Seconds | | | | Seconds | 00-59 |
| 02h | | 10 Minutes | | | | Minutes | | | | Minutes | 00-59 |
| 03h | CALSGN | 12/24 | 10 Hour AM/PM | 10 Hour | Hour | | | | Hours | 1-12 + AM/PM 00 - 23 | |
| 04h | | | OSCON | VBAT | VBATEN | Day | | | Day | 1-7 | |
| 05h | | | 10 Date | | | Date | | | Date | 01-31 | |
| 06h | | | LP | 10 Month | Month | | | Month | 01-12 | | |
| 07h | 10 Year | | | | Year | | | | Year | 00-99 | |
| 08h | OUT | SQWE | ALM1 | ALM0 | EXTOSC | RS2 | RS1 | RS0 | Control Reg. | | |
| 09h | CALIBRATION | | | | | | | | Calibration | | |
| 0Ah | Reserved for future use | | | | | | | | | | |
| 0Bh | Reserved for future use | | | | | | | | | | |
| Alarm 0 Registers | | | | | | | | | | | |
| 0Ch | | 10 Seconds | | | | Seconds | | | | Seconds | 00-59 |
| 0Dh | | 10 Minutes | | | | Minutes | | | | Minutes | 00-59 |
| 0Eh | | 12/24 | 10 Hour AM/PM | 10 Hours | Hour | | | | Hours | 1-12 + AM/PM 00-23 | |
| 0Fh | | ALM0C2 | ALM0C1 | ALM0C0 | ALM0IF | Day | | | Day | 1-7 | |
| 10h | | 10 Date | | | | Date | | | | Date | 01-31 |
| 11h | | 10 Month | | | | Month | | | | Month | 01-12 |
| Alarm 1 Registers | | | | | | | | | | | |
| 12h | | Tenth Seconds | | | | Hundredths of seconds | | | | Hundredths of Seconds | 00-99 |
| 13h | | 10 Seconds | | | | Seconds | | | | Seconds | 00-59 |
| 14h | | 10 Minutes | | | | Minutes | | | | Minutes | 00-59 |
| 15h | | 12/24 | 10 Hour AM/PM | 10 Hours | Hour | | | | Hours | 1-12 + AM/PM 00-23 | |
| 16h | | ALM1C2 | ALM1C1 | ALM1C0 | ALM1IF | Day | | | Day | 1-7 | |
| 17h | | 10 Date | | | | Date | | | | Date | 01-31 |
| Power-Down Time-Stamp Registers | | | | | | | | | | | |
| 18h | | 10 Minutes | | | | Minutes | | | | | |
| 19h | | 12/24 | 10 Hour AM/PM | 10 Hours | Hour | | | | | | |
| 1Ah | | 10 Date | | | | Date | | | | | |
| 1Bh | | Day | | | 10 Month | Month | | | | | |
| Power-Up Time-Stamp Registers | | | | | | | | | | | |
| 1Ch | | 10 Minutes | | | | Minutes | | | | | |
| 1Dh | | 12/24 | 10 Hour AM/PM | 10 Hours | Hour | | | | | | |
| 1Eh | | 10 Date | | | | Date | | | | | |
| 1Fh | | Day | | | 10 Month | Month | | | | | |

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5.0 TIME AND CONFIGURATION REGISTERS

REGISTER 5-1: HUNDREDTHS OF SECONDS 0x00

| R/W | | R/W | |
|---------------|-------|-----------------------|-------|
| Tenth Seconds | | Hundredths of Seconds | |
| bit 7 | bit 4 | bit 3 | bit 0 |

Legend:

R = Readable bit W = Writable bit U = Unimplemented bit, read as '0'

bit 7-4 **TENTH SECONDS<3:0>**: Tenth Seconds

bit 3-0 **HUNDREDTHS OF SECONDS<3:0>**: Hundredths of Seconds

Note 1: Contains the BCD Tens and Hundredths of Seconds.

REGISTER 5-2: SECONDS 0x01

| R/W | | R/W | | R/W | |
|-------|-------|------------|-------|---------|--|
| ST | | 10 Seconds | | Seconds | |
| bit 7 | bit 6 | bit 4 | bit 3 | bit 0 | |

Legend:

R = Readable bit W = Writable bit U = Unimplemented bit, read as '0'

bit 7 **ST**: Start Oscillator bit

ST is the oscillator Start bit in the MCP795XX devices. Setting this bit to '1' starts the oscillator and clearing this bit to '0' stops the on-board oscillator.

bit 6-4 **10 SECONDS<2:0>**: 10 Seconds

bit 3-0 **SECONDS<3:0>**: Seconds

Note 1: Contains the BCD seconds and 10 seconds. The range is 00 to 59.

REGISTER 5-3: MINUTES 0x02

| U-0 | | R/W | | R/W | |
|-------|-------|------------|-------|---------|--|
| — | | 10 Minutes | | Minutes | |
| bit 7 | bit 6 | bit 4 | bit 3 | bit 0 | |

Legend:

R = Readable bit W = Writable bit U = Unimplemented bit, read as '0'

bit 7 **Unimplemented**: Read as '0'

bit 6-4 **10 MINUTES<2:0>**: 10 Minutes

bit 3-0 **MINUTES<3:0>**: Minutes

Note 1: Contains the BCD minutes and 10 minutes. The range is 00 to 59.

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REGISTER 5-4: HOUR 0x03

| | | | | | |
|--------|-------|---------------|---------|-------|-------|
| R/W | R/W | R/W | R/W | R/W | |
| CALSGN | 12/24 | 10 Hour AM/PM | 10 Hour | Hour | |
| bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 0 |

Legend:

R = Readable bit W = Writable bit U = Unimplemented bit, read as '0'

- bit 7 **CALSGN:** Calibration Sign bit
 Bit 7 is the sign bit (CALSGN) for the calibration. Clearing this bit produces a positive calibration, setting this bit produces a negative calibration.
- bit 6 **12/24:** Clearing this bit to '0' enables 24-hour format, setting this bit to '1' enables 12-hour format.
- bit 5 **10 HOUR:** AM/PM bit for 12-hour time
- bit 4 **10 HOUR**
- bit 3-0 **HOUR<3:0>**

Note 1: Contains the BCD hour in bits <3:0>. Bits <5:4> contain either the 10-hour in BCD for 24-hour format or the AM/PM indicator and the 10-hour bit for 12-hour format. Bit 5 determines the hour format.

REGISTER 5-5: DAY 0x04

| | | | | | | |
|-------|-------|-------|-------|--------|-------|-------|
| U-0 | U-0 | R | R/W | R/W | R/W | |
| — | — | OSCON | VBAT | VBATEN | Day | |
| bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 0 |

Legend:

R = Readable bit W = Writable bit U = Unimplemented bit, read as '0'

- bit 7-6 **Unimplemented:** Read as '0'
- bit 5 **OSCON:** Oscillator On bit
 This bit is set and cleared by hardware. If this bit is set, the oscillator is running; if clear, the oscillator is not running. This bit does not indicate that the oscillator is running at the correct frequency. The bit will wait 32 oscillator cycles before the bit is set.
- bit 4 **VBAT:** External Battery Switched Flag bit
 This bit is set by hardware when the VCC fails and the VBAT is used to power the oscillator and the RTCC registers. This bit is cleared by software.
- bit 3 **VBATEN:** External Battery Enable bit
 If this bit is set the internal circuitry is connected to the VBAT pin. If this bit is '0' then the VBAT pin is disconnected and the only current drain on the external battery is the VBAT pin leakage.
- bit 2-0 **DAY<2:0>**

Note 1: Contains the BCD day. The range is 1-7. Also, additional bits are used for configuration and status.

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REGISTER 5-6: DATE 0x05

| | | | | | |
|-------|-------|---------|-------|-------|-------|
| U-0 | U-0 | R/W | R/W | | |
| — | — | 10 Date | Date | | |
| bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 0 |

Legend:

R = Readable bit

W = Writable bit

U = Unimplemented bit, read as '0'

bit 7-6 **Unimplemented:** Read as '0'

bit 5-4 **10 DATE<1:0>**

bit 3-0 **DATE<3:0>**

Note 1: Contains the BCD Date and 10 Date. The range is 01-31.

REGISTER 5-7: MONTH 0x06

| | | | | | |
|-------|-------|-------|----------|-------|-------|
| U-0 | U-0 | R | R/W | R/W | |
| — | — | LP | 10 Month | Month | |
| bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 0 |

Legend:

R = Readable bit

W = Writable bit

U = Unimplemented bit, read as '0'

bit 7-6 **Unimplemented:** Read as '0'

bit 5 **LP:** Leap Year, set during a leap year and is read-only

bit 4 **10 MONTH**

bit 3-0 **MONTH<3:0>**

Note 1: Contains the BCD month. Bit 4 contains the 10 month.

REGISTER 5-8: YEAR 0x07

| | | | |
|---------|-------|-------|-------|
| R/W | R/W | | |
| 10 Year | Year | | |
| bit 7 | bit 4 | bit 3 | bit 0 |

Legend:

R = Readable bit

W = Writable bit

U = Unimplemented bit, read as '0'

bit 7-4 **10 YEAR<3:0>**

bit 3-0 **YEAR<3:0>**

Note 1: Contains the BCD Year and 10 Year. The Range is 00-99.

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REGISTER 5-9: CONTROL REG 0x08

| | | | | | | | |
|-------|-------|-------|-------|--------|-------|-------|-------|
| R/W | R/W | R/W | R/W | R/W | R/W | R/W | R/W |
| OUT | SQWE | ALM1 | ALM0 | EXTOSC | RS2 | RS1 | RS0 |
| bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 | bit 1 | bit 0 |

Legend:

R = Readable bit W = Writable bit U = Unimplemented bit, read as '0'

- bit 7 **OUT:** Output Polarity of MFP bit
This bit sets the logic level on the MFP pin when not using this as a square wave output.
- bit 6 **SQWE:** Squarewave Enable bit
Setting this bit enables the divided output from the crystal oscillator.
- bit 5-4 **ALM<1:0>:** Alarm Configuration bits
These bits determine which alarms are active
- 00 – No Alarms are active
 - 01 – Alarm 0 is active
 - 10 – Alarm 1 is active
 - 11 – Both Alarms are active
- bit 3 **EXTOSC:** External Oscillator Input bit
Enable bit. Setting this bit will allow an external 32.768 kHz signal to drive the RTCC registers, eliminating the need for an external crystal.
- bit 2-0 **RS<2:0>:** Calibration Mode bits
Sets the internal divider for the 32.768 kHz oscillator to be driven to the MFP pin. The following frequencies are available. The output is responsive to the Calibration register.
- 000 – 1 Hz
 - 001 – 4.096 kHz
 - 010 – 8.192 kHz
 - 011 – 32.768 kHz
 - 1XX – enables the Cal output function. Cal output appears on MFP if SQWE is set (1 Hz nominal).

Note 1: When RS2 is set to enable the Cal output function, the RTCC counters will continue to increment.

REGISTER 5-10: CALIBRATION 0x09

| | |
|-------------|-------|
| R/W | |
| CALIBRATION | |
| bit 7 | bit 0 |

Legend:

R = Readable bit W = Writable bit U = Unimplemented bit, read as '0'

- bit 7-0 **CALIBRATION VALUE<7:0>:** Calibration Value bits

Note 1: This is an 8-bit register that is used to add or subtract clocks from the RTCC counter every minute. The CALSGN (0x03:7) is the sign bit and indicates if the count should be added or subtracted. The 8 bits in the Calibration register, with each bit adding or subtracting two clocks, gives the user the ability to add or subtract up to 510 clocks per minute.

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6.0 ALARM 0 REGISTERS

REGISTER 6-1: SECONDS 0x0C

| U-0 | | R/W | | R/W | |
|-------|-------|------------|-------|---------|--|
| — | | 10 Seconds | | Seconds | |
| bit 7 | bit 6 | bit 4 | bit 3 | bit 0 | |

Legend:

R = Readable bit W = Writable bit U = Unimplemented bit, read as '0'

bit 7 **Unimplemented:** Read as '0'
 bit 6-4 **10 SECONDS<2:0>:** 10 Seconds
 bit 3-0 **SECONDS<3:0>:** Seconds

Note: This contains the seconds match for the Alarm 0.

REGISTER 6-2: MINUTES 0x0D

| U-0 | | R/W | | R/W | |
|-------|-------|------------|-------|---------|--|
| — | | 10 Minutes | | Minutes | |
| bit 7 | bit 6 | bit 4 | bit 3 | bit 0 | |

Legend:

R = Readable bit W = Writable bit U = Unimplemented bit, read as '0'

bit 7 **Unimplemented:** Read as '0'
 bit 6-4 **10 MINUTES<2:0>:** 10 Seconds
 bit 3-0 **MINUTES<3:0>:** Seconds

Note: This contains the minutes match for the Alarm 0.

REGISTER 6-3: HOURS 0x0E

| U-0 | | R/W | | R/W | |
|-------|-------|-------|---------------|---------|-------|
| — | | 12/24 | 10 Hour AM/PM | 10 Hour | Hour |
| bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 0 |

Legend:

R = Readable bit W = Writable bit U = Unimplemented bit, read as '0'

bit 7 **Unimplemented:** Read as '0'
 bit 6 **12/24:** This is a copy of bit 6 in the Hours register (0x03)
 bit 5 **10 HOUR AM/PM**
 bit 4 **10 HOUR**
 bit 3-0 **HOUR<3:0>**

Note: This contains the minutes match for the Alarm 0.

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REGISTER 6-4: DAY 0x0F

| | | | | | |
|-------|--------|--------|--------|--------|-------|
| R/W | R/W | | | R/W | R/W |
| — | ALM0C2 | ALM0C1 | ALM0C0 | ALM0IF | Day |
| bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 |
| | | | | | bit 0 |

Legend:

R = Readable bit W = Writable bit U = Unimplemented bit, read as '0'

bit 7 **Unimplemented:** Read as '0'

bit 6-4 **ALM0C<2:0>:** Alarm 0 Configuration bits

Sets the condition on what the alarm will trigger. The following options are available:

- 000 – Seconds match
- 001 – Minutes match
- 010 – Hours match (logic takes into account 12/24 operation)
- 011 – Day match. Generates interrupt at 12:00:00 AM
- 100 – Date match
- 101 – Unimplemented, do not use
- 110 – Unimplemented, do not use
- 111 – Seconds, Minutes, Hour, Day, Date and Month

bit 3 **ALM0IF:** Alarm 0 Interrupt Flag bit

This bit is set by hardware when an alarm condition has been generated. The bit must be cleared in software.

bit 2-0 **DAY<2:0>**

Note 1: Contains the BCD day. The range is 1-7. Also, additional bits are used for configuration and status.

REGISTER 6-5: DATE 0x10

| | | | | |
|-------|-------|---------|-------|-------|
| U-0 | U-0 | R/W | | R/W |
| — | — | 10 Date | | Date |
| bit 7 | bit 6 | bit 5 | bit 4 | bit 3 |
| | | | | bit 0 |

Legend:

R = Readable bit W = Writable bit U = Unimplemented bit, read as '0'

bit 7-6 **Unimplemented:** Read as '0'

bit 5-4 **10 DATE<1:0>**

bit 3-0 **DATE<3:0>**

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REGISTER 6-6: MONTH 0x11

| | | | | |
|-------|-------|-------|----------|-------|
| U-0 | U-0 | U-0 | R/W | R/W |
| — | — | — | 10 Month | Month |
| bit 7 | bit 6 | bit 5 | bit 4 | bit 3 |
| | | | | bit 0 |

Legend:

R = Readable bit

W = Writable bit

U = Unimplemented bit, read as '0'

bit 7-5 **Unimplemented:** Read as '0'bit 4 **10 MONTH**bit 3-0 **MONTH<3:0>****Note 1:** Month match is only available on Alarm 0.

7.0 ALARM 1 REGISTERS

REGISTER 7-1: HUNDREDTHS OF SECONDS 0x12

| R/W | | R/W | |
|---------------|-------|-----------------------|-------|
| Tenth Seconds | | Hundredths of Seconds | |
| bit 7 | bit 4 | bit 3 | bit 0 |

Legend:

R = Readable bit W = Writable bit U = Unimplemented bit, read as '0'

bit 7-4 **TENTH SECONDS<3:0>**: Tenth Seconds
 bit 3-0 **HUNDREDTHS OF SECONDS<3:0>**: Hundredths of Seconds

Note 1: Hundredths and Tenth seconds only available on Alarm 1.

REGISTER 7-2: SECONDS 0x13

| U-0 | R/W | | R/W | |
|-------|------------|-------|---------|-------|
| — | 10 Seconds | | Seconds | |
| bit 7 | bit 6 | bit 4 | bit 3 | bit 0 |

Legend:

R = Readable bit W = Writable bit U = Unimplemented bit, read as '0'

bit 7 **Unimplemented:** Read as '0'
 bit 6-4 **10 SECONDS<2:0>**: 10 Seconds
 bit 3-0 **SECONDS<3:0>**: Seconds

REGISTER 7-3: MINUTES 0x14

| U-0 | R/W | | R/W | |
|-------|------------|-------|---------|-------|
| — | 10 Minutes | | Minutes | |
| bit 7 | bit 6 | bit 4 | bit 3 | bit 0 |

Legend:

R = Readable bit W = Writable bit U = Unimplemented bit, read as '0'

bit 7 **Unimplemented:** Read as '0'
 bit 6-4 **10 MINUTES<2:0>**: 10 Minutes
 bit 3-0 **MINUTES<3:0>**: Minutes

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REGISTER 7-4: HOURS 0x15

| | | | | | |
|-------|-------|------------------|---------|-------|-------|
| U-0 | | R/W | | | R/W |
| — | 12/24 | 10 Hour AM/PM | 10 Hour | Hour | |
| bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 0 |

Legend:

R = Readable bit W = Writable bit U = Unimplemented bit, read as '0'

bit 7 **Unimplemented:** Read as '0'
bit 6 **12/24**
bit 5 **10 HOUR AM/PM**
bit 4 **10 HOUR**
bit 3-0 **HOUR<3:0>**

REGISTER 7-5: DAY 0x16

| | | | | | |
|-------|--------|--------|--------|--------|-------|
| R/W | R/W | | | R/W | R/W |
| — | ALM1C2 | ALM1C1 | ALM1C0 | ALM1IF | Day |
| bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 2 |

Legend:

R = Readable bit W = Writable bit U = Unimplemented bit, read as '0'

bit 7 **Unimplemented:** Read as '0'
bit 6-4 **ALM1C<2:0>:** Alarm 1 Configuration bits
Sets the condition on what the Alarm will trigger. The following options are available:
- 000 – Seconds match
- 001 – Minutes match
- 010 – Hours match (logic takes into account 12/24 operation)
- 011 – Day match. Generates interrupt at 12:00:00 AM
- 100 – Date match
- 101 – Unimplemented, do not use
- 110 – Unimplemented, do not use
- 111 – Seconds, Minutes, Hour, Day, Date and Month
bit 3 **ALM1IF:** Alarm 1 Interrupt Flag bit
This bit is set by hardware when an alarm condition has been generated. The bit must be cleared in software.
bit 2-0 **DAY<2:0>**

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REGISTER 7-6: DATE 0x17

| | | | | | |
|-------|-------|---------|-------|-------|-------|
| U-0 | U-0 | R/W | R/W | | |
| — | — | 10 Date | Date | | |
| bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 0 |

Legend:

R = Readable bit

W = Writable bit

U = Unimplemented bit, read as '0'

bit 7-6 **Unimplemented:** Read as '0'

bit 5-4 **10 DATE<1:0>**

bit 3-0 **DATE<3:0>**

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8.0 POWER-DOWN TIME-STAMP REGISTERS

Note: It is strongly recommended that the timesaver function only be used when the oscillator is running. This will ensure accurate functionality.

REGISTER 8-1: MINUTES 0x18

| | | | | | |
|-------|-------|------------|-------|---------|--|
| U-0 | | R/W | | R/W | |
| — | | 10 Minutes | | Minutes | |
| bit 7 | bit 6 | bit 4 | bit 3 | bit 0 | |

Legend:

R = Readable bit W = Writable bit U = Unimplemented bit, read as '0'

bit 7 **Unimplemented:** Read as '0'
 bit 6-4 **10MINUTES<2:0>:** 10 Minutes
 bit 3-0 **MINUTES<3:0>:** Minutes

REGISTER 8-2: HOURS 0x19

| | | | | | |
|-------|-------|-------|---------------|---------|-------|
| U-0 | | R/W | | R/W | |
| — | | 12/24 | 10 Hour AM/PM | 10 Hour | Hour |
| bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 0 |

Legend:

R = Readable bit W = Writable bit U = Unimplemented bit, read as '0'

bit 7 **Unimplemented:** Read as '0'
 bit 6 **12/24:** This is a copy of the status of the bit in register 0x03:6 at the time of the event
 bit 5 **10 HOUR AM/PM**
 bit 4 **10 HOUR**
 bit 3-0 **HOUR<3:0>**

REGISTER 8-3: DATE 0x1A

| | | | | | | | |
|-------|-------|-------|-------|---------|-------|------|--|
| U-0 | | U-0 | | R/W | | R/W | |
| — | | — | | 10 Date | | Date | |
| bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 0 | | |

Legend:

R = Readable bit W = Writable bit U = Unimplemented bit, read as '0'

bit 7-6 **Unimplemented:** Read as '0'
 bit 5-4 **10 DATE<1:0>**
 bit 3-0 **DATE<3:0>**

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REGISTER 8-4: MONTH 0x1B

| R/W | | | R/W | | R/W | |
|-------|-------|-------|----------|-------|-------|--|
| Day | | | 10 Month | | Month | |
| bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 0 | |

Legend:

R = Readable bit

W = Writable bit

U = Unimplemented bit, read as '0'

bit 7-5 **DAY<2:0>**
bit 4 **10 MONTH**
bit 3-0 **MONTH<3:0>**

Note 1: Month match is only available on Alarm 0.

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9.0 POWER-UP TIME REGISTERS

Note: It is strongly recommended that the timesaver function only be used when the oscillator is running. This will ensure accurate functionality.

REGISTER 9-1: MINUTES 0x1C

| | | | | | |
|-------|-------|------------|-------|---------|--|
| U-0 | | R/W | | R/W | |
| — | | 10 Minutes | | Minutes | |
| bit 7 | bit 6 | bit 4 | bit 3 | bit 0 | |

Legend:

R = Readable bit W = Writable bit U = Unimplemented bit, read as '0'

bit 7 **Unimplemented:** Read as '0'
 bit 6-4 **10 MINUTES<2:0>:** 10 Minutes
 bit 3-0 **MINUTES<3:0>:** Minutes

REGISTER 9-2: HOURS 0x1D

| | | | | | |
|-------|-------|-------|---------------|---------|-------|
| U-0 | | R/W | | R/W | |
| — | | 12/24 | 10 Hour AM/PM | 10 Hour | Hour |
| bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 0 |

Legend:

R = Readable bit W = Writable bit U = Unimplemented bit, read as '0'

bit 7 **Unimplemented:** Read as '0'
 bit 6 **12/24:** This is a copy of the status of the bit in register 0x03:6 at the time of the event
 bit 5 **10 HOUR AM/PM**
 bit 4 **10 HOUR**
 bit 3-0 **HOUR<3:0>**

REGISTER 9-3: DATE 0x1E

| | | | | | | | |
|-------|-------|-------|-------|---------|-------|------|--|
| U-0 | | U-0 | | R/W | | R/W | |
| — | | — | | 10 Date | | Date | |
| bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 0 | | |

Legend:

R = Readable bit W = Writable bit U = Unimplemented bit, read as '0'

bit 7-6 **Unimplemented:** Read as '0'
 bit 5-4 **10 DATE<1:0>**
 bit 3-0 **DATE<3:0>**

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REGISTER 9-4: MONTH 0x1F

| R/W | | | R/W | | R/W | |
|-------|-------|-------|----------|-------|-------|--|
| Day | | | 10 Month | | Month | |
| bit 7 | bit 6 | bit 5 | bit 4 | bit 3 | bit 0 | |

Legend:

R = Readable bit

W = Writable bit

U = Unimplemented bit, read as '0'

bit 7-5 **DAY<2:0>**
bit 4 **10 MONTH**
bit 3-0 **MONTH<3:0>**

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9.1 Features

9.1.1 CALIBRATION

The Calibration register (0x09h) allows a number of RTCC counts to be added or subtracted (CALSGN bit located at 0x03:7) each minute. This allows for calibration to reduce the PPM error due to oscillator shift. This register is volatile.

The CALSGN bit determines if calibration is positive or negative.

A value of 0x00 in the Calibration register will result in no calibration.

The calibration is linear, with one bit representing two RTC clocks.

The MCP795XX utilizes digital calibration to correct for the inaccuracies of the input clock source (either external or crystal). Calibration is enabled by setting the value of the Calibration register at address 08H. Calibration is achieved by adding or subtracting a number of input clock cycles per minute in order to achieve ppm level adjustments in the internal timing function of the MCP795XX.

The CALSGN bit is the calibration sign bit, with a '1' indicating subtraction and a '0' indicating addition. The eight bits in the Calibration register indicate the number of input clock cycles (multiplied by two) that are subtracted or added per minute to the internal timing function.

The internal timing function can be monitored using the MFP output pin by setting bit 6 (SQWE) and bits <2:0> (RS2, RS1, RS0) of the Control register at address 07H. Note that the MFP output waveform is disabled when the MCP795XX is running in VBAT mode. With the SQWE bit set to '1', there are two methods that can be used to observe the internal timing function of the MCP795XX:

Method 1. RS2 bit set to '0'

With the RS2 bit set to '0', the RS1 and RS0 bits enable the following internal timing signals to be output on the MFP pin:

| RS2 | RS1 | RS0 | Output Signal |
|-----|-----|-----|---------------|
| 0 | 0 | 0 | 1 Hz |
| 0 | 0 | 1 | 4.096 kHz |
| 0 | 1 | 0 | 8.192 kHz |
| 0 | 1 | 1 | 32.768 kHz |

The frequencies listed in the table presume an input clock source of exactly 32.768 kHz. In terms of the equivalent number of input clock cycles, the table becomes:

| RS2 | RS1 | RS0 | Output Signal |
|-----|-----|-----|---------------|
| 0 | 0 | 0 | 32768 |
| 0 | 0 | 1 | 8 |
| 0 | 1 | 0 | 4 |
| 0 | 1 | 1 | 1 |

With regards to the calibration function, the Calibration register setting has no impact upon the MFP output clock signal when bits RS1 and RS0 are set to '11'. The setting of the Calibration register to a non-zero value enables the calibration function which can be observed on the MFP output pin. The calibration function can be expressed in terms of the number of input clock cycles added/subtracted from the internal timing function.

With bits RS1 and RS0 set to '00', the calibration function can be expressed as:

$$T_{\text{output}} = (32768 \pm (2 * \text{CALREG})) T_{\text{input}}$$

where:

$$T_{\text{output}} = \text{clock period of MFP output signal}$$

$$T_{\text{input}} = \text{clock period of input signal}$$

$$\text{CALREG} = \text{decimal value of Calibration register setting and the sign is determined by the CALSGN bit.}$$

Since the calibration is done once per minute (i.e., when the internal minute counter is incremented), only one cycle in sixty of the MFP output waveform is affected by the calibration setting. Also note that the duty cycle of the MFP output waveform will not necessarily be at 50% when the calibration setting is applied.

With bits RS1 and RS0 set to '01' or '10', the calibration function can not be expressed in terms of the input clock period. In the case where the MSB of the Calibration register is set to '0', the waveform appearing at the MFP output pin will be "delayed", once per minute, by twice the number of input clock cycles defined in the Calibration register. The MFP waveform will appear as shown in [Figure 9-1](#).

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In the case where the MSB of the Calibration register is set to '1', the MFP output waveforms that appear when bits RS1 and RS0 are set to '01' or '10' are not as responsive to the setting of the Calibration register. For example, when outputting the 4.096 kHz waveform (RS1, RS0 set to '01'), the output waveform is generated using only eight input clock cycles. Consequently, attempting to subtract more than eight input clock cycles from this output does not have a meaningful affect on the resulting waveform. Any affect on the output will appear as a modification in both the frequency and duty cycle of the waveform appearing on the MFP output pin.

Method 2. RS2 bit set to '1'

With the RS2 bit set to '1', the following internal timing signal is output on the MFP pin:

| RS2 | RS1 | RS0 | Output Signal |
|-----|-----|-----|---------------|
| 1 | x | x | 1.0 Hz |

The frequency listed in the table presumes an input clock source of exactly 32.768 kHz. In terms of the equivalent number of input clock cycles, the table becomes:

| RS2 | RS1 | RS0 | Output Signal |
|-----|-----|-----|---------------|
| 1 | x | x | 32768 |

Unlike the method previously described, the calibration setting is continuously applied and affects every cycle of the output waveform. This results in the modulation of the frequency of the output waveform based upon the setting of the Calibration register.

Using this setting, the calibration function can be expressed as:

$$T_{\text{output}} = (32768 \pm (2 * \text{CALREG})) T_{\text{input}}$$

where:

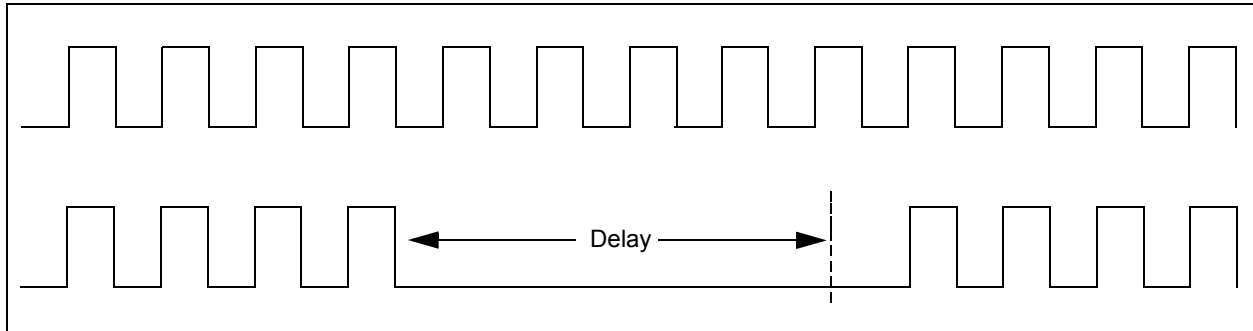
$$T_{\text{output}} = \text{clock period of MFP output signal}$$

$$T_{\text{input}} = \text{clock period of input signal}$$

$$\text{CALREG} = \text{decimal value of Calibration register setting and the sign is determined by the CALSGN bit.}$$

Since the calibration is done every cycle, the frequency of the output MFP waveform is constant.

FIGURE 9-1: MFP WAVEFORM



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9.1.2 MULTIFUNCTION PIN (MFP)

Pin 9 is a multifunction pin and supports the following functions:

- The value of the OUT bit determines the logic.
- Level of the I/O. This is only available when operating from VCC.
- Alarm Outputs – Available in VBAT mode
- FOUT mode – Driven from a FOSC divider – Not available in VBAT mode.

The internal control logic for the MFP is connected to the switched internal supply bus. This allows operation in VBAT mode. The Alarm Output is the only mode that operates in VBAT mode, other modes are suspended.

9.1.3 VBAT SWITCHOVER

If the VBAT feature is not used, the VBAT pin should be connected to GND. A low value series resistor and Schottky diode are recommended between the external battery and the VBAT pin to reduce inrush current and also to prevent any leakage current reaching the external VBAT source.

The VTRIP point is defined as 1.5V typical. When VDD falls below 1.5V the system will continue to operate the RTCC and SRAM using the VBAT supply. There is ~50mV hyst in the trip point changeover. The following conditions apply:

TABLE 9-1: VBAT CHANGOVER CONDITIONS

| Supply Condition | Read/Write Access | Powered By |
|---------------------------|-------------------|------------|
| $VCC < VTRIP, VCC < VBAT$ | No | VBAT |
| $VCC > VTRIP, VCC < VBAT$ | Yes | VCC |
| $VCC > VTRIP, VCC > VBAT$ | Yes | VCC |

For more information on VBAT conditions see the RTCC Best Practices Application Note, AN1365 (DS01365).

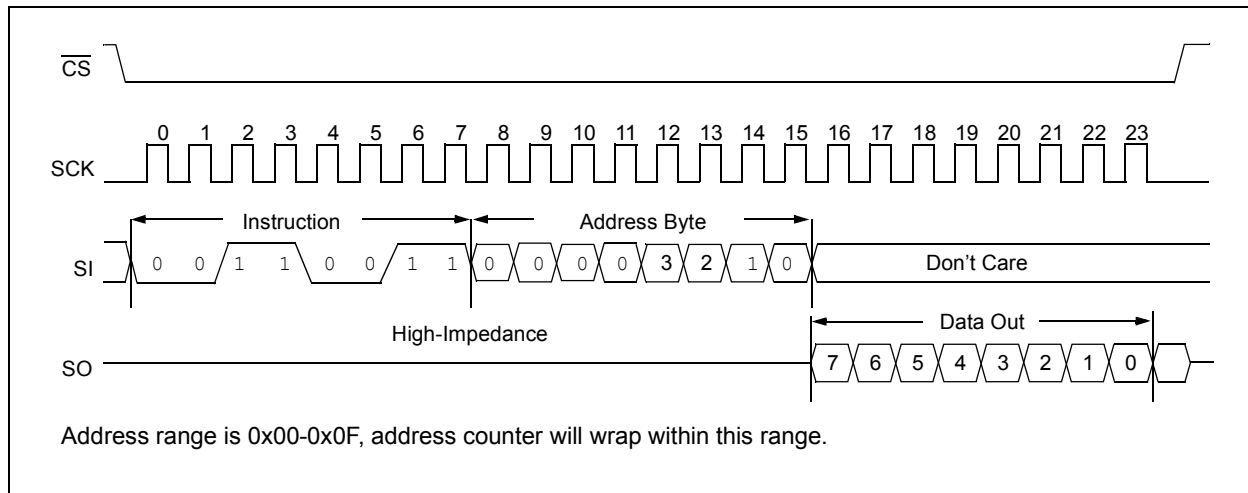
9.1.4 UNIQUE ID LOCATIONS

When the unique ID locations are preprogrammed from the factory with either an EUI-48 or EUI-64, the EUI code is programmed into location 0x00-0x07. Locations 0x08-0x0F are blank (0x0F).

Note: For EUI-64, the data is located in address 0x00-0x07. For EUI-48 locations, 0x02-0x07 contain the data. 0x00/01 contain 0xFF.

To read the unique ID location the IDREAD command is given with the starting address. Valid addresses are 0x00 through 0x0F. All 16 bytes can be read out in a single command by clocking the device. Trying to access locations past 0x0F will result in the address wrapping within these 16 bytes.

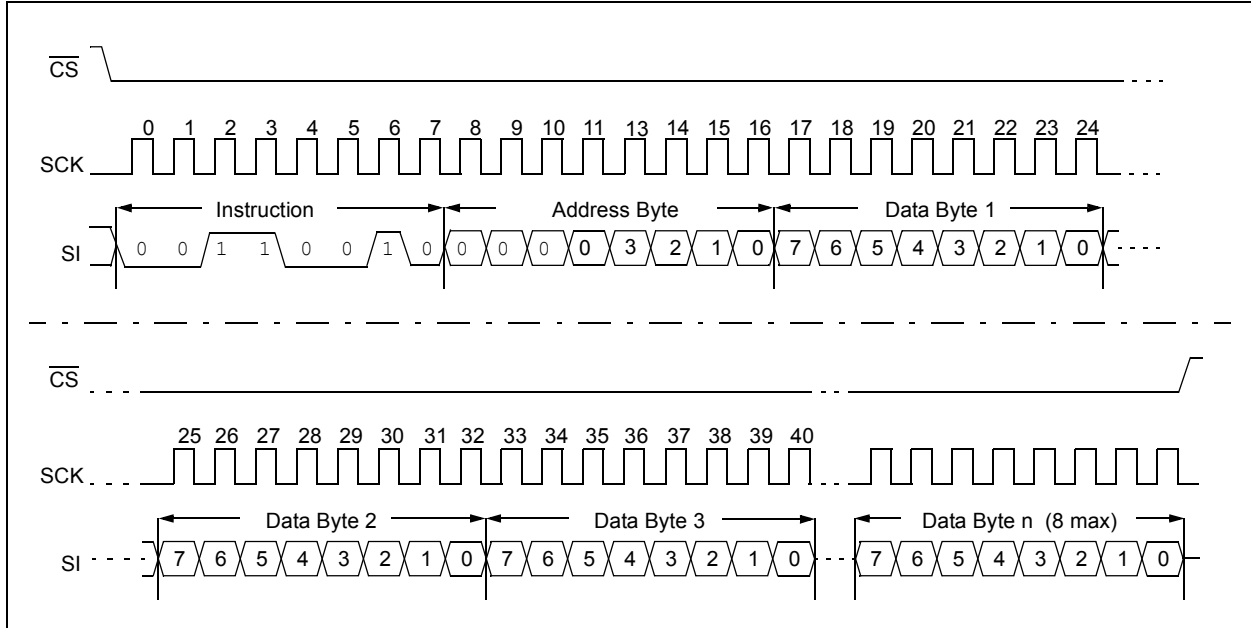
FIGURE 9-2: IDREAD COMMAND SEQUENCE



To write to the unique ID locations, the IDWRITE command is used. The device must be write enabled and the correct unlock sequence must have been performed. See [Section 10.1.4, Write to the Unlock Register](#) for more details.

The ID locations can be written to using the IDWRITE command. The valid address is between 0x00 and 0x0F. The entire 16 bytes must be written in two groups of 8 bytes. A maximum of 8 bytes can be written at once.

FIGURE 9-3: IDWRITE COMMAND SEQUENCE



MCP7952X/MCP7951X

9.1.5 POWER-FAIL TIME-STAMP

The MCP795XX family of RTCC devices feature a power-fail time-stamp feature. This feature will save the time at which VCC crosses the VTRIP voltage and is shown in Figure 9-4. To use this feature, a VBAT supply must be present and the oscillator must also be running. There are two separate sets of registers that are used to record this information:

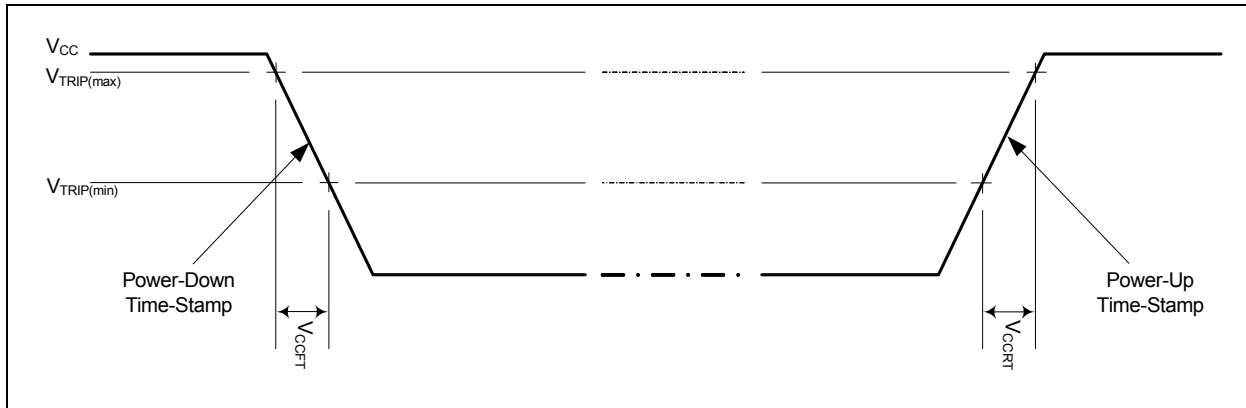
- The first set located at 0x18h through 0x1Bh are loaded at the time when VCC falls below VTRIP and the RTCC operates on the VBAT. The VBAT (register 0x03h bit 4) bit is also set at this time.

- The second set of registers, located at 0x1Ch through 0x1Fh, are loaded at the time when VCC is restored and the RTCC switches to VCC.

The power-fail time-stamp registers are cleared when the VBAT bit is cleared in software.

Note: It is strongly recommended that the time-saver function only be used when the oscillator is running. This will ensure accurate functionality.

FIGURE 9-4: POWER-FAIL GRAPH



9.1.6 READ STATUS REGISTER (SRREAD)

The Read Status Register (SRREAD) instruction provides access to the STATUS register. The STATUS register may be read at any time, even during a write cycle. The STATUS register is formatted as follows:

| | | | | | | | |
|---|---|---|---|-----|-----|-----|-----|
| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| — | — | — | — | R/W | R/W | R | R |
| X | X | X | X | BP1 | BP0 | WEL | WIP |

Note: Once a Write Status Register is initiated and a Read Status Register is attempted the new values for the nonvolatile bits will be read regardless of whether the values have been actually programmed into the device. (i.e., The values are moved to the latches prior to the write operation).

The **Write-In-Process (WIP)** bit indicates whether the MCP795XX is busy with a nonvolatile memory write operation. When set to a '1', a write is in progress, when set to a '0', no write is in progress. This bit is read-only.

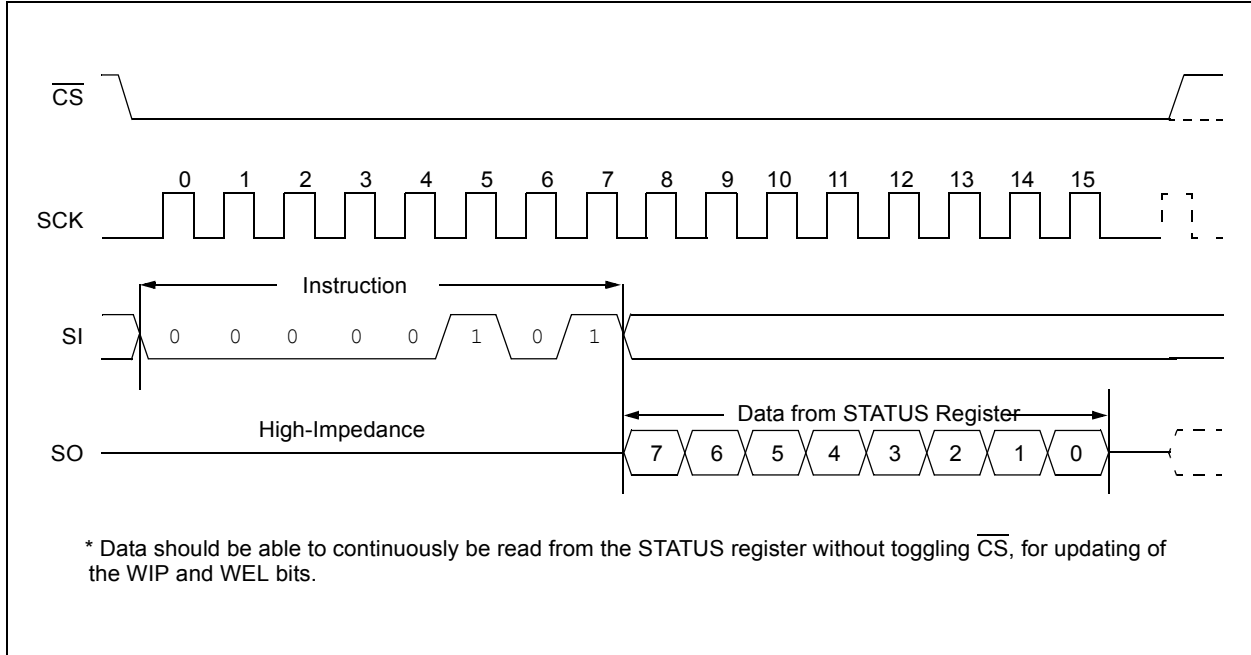
The **Write Enable Latch (WEL)** bit indicates the status of the write enable latch. When set to a '1', the latch allows writes to the nonvolatile memory, when set to a '0', the latch prohibits writes to the nonvolatile memory. The state of this bit can always be updated

via the WREN or WRDI commands, regardless of the state of write protection on the STATUS register. This bit is read-only.

The **Block Protection (BP0 and BP1)** bits indicate which blocks are currently write-protected. These bits are set by the user issuing the WRSR instruction. These bits are nonvolatile.

See Figure 9-5 for the RDSR timing sequence.

FIGURE 9-5: READ STATUS REGISTER TIMING SEQUENCE



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9.1.7 WRITE STATUS REGISTER (SRWRITE)

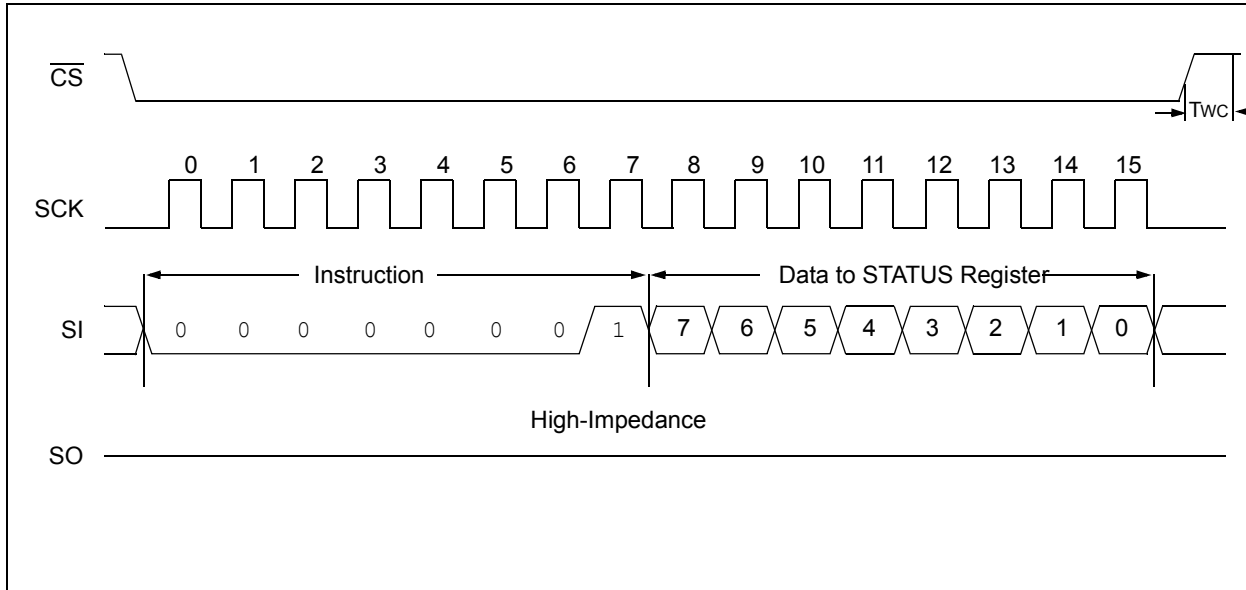
The Write Status Register (SRWRITE) instruction allows the user to select one of four levels of protection for the array by writing to the appropriate bits in the STATUS register. The array is divided up into four segments. The user has the ability to write-protect none, one, two, or all four of the segments of the array. The partitioning is controlled as shown in [Table 9-2](#).

See [Figure 9-6](#) for the SRWRITE timing sequence.

TABLE 9-2: ARRAY PROTECTION

| BP1 | BP0 | Array Addresses Write-Protected (2 kbit shown) |
|-----|-----|--|
| 0 | 0 | none |
| 0 | 1 | upper 1/4 (C0h-FFh) |
| 1 | 0 | upper 1/2 (80h-FFh) |
| 1 | 1 | all (00h-FFh) |

FIGURE 9-6: WRITE STATUS REGISTER TIMING SEQUENCE



9.1.8 DATA PROTECTION

The following protection has been implemented to prevent inadvertent writes to the array:

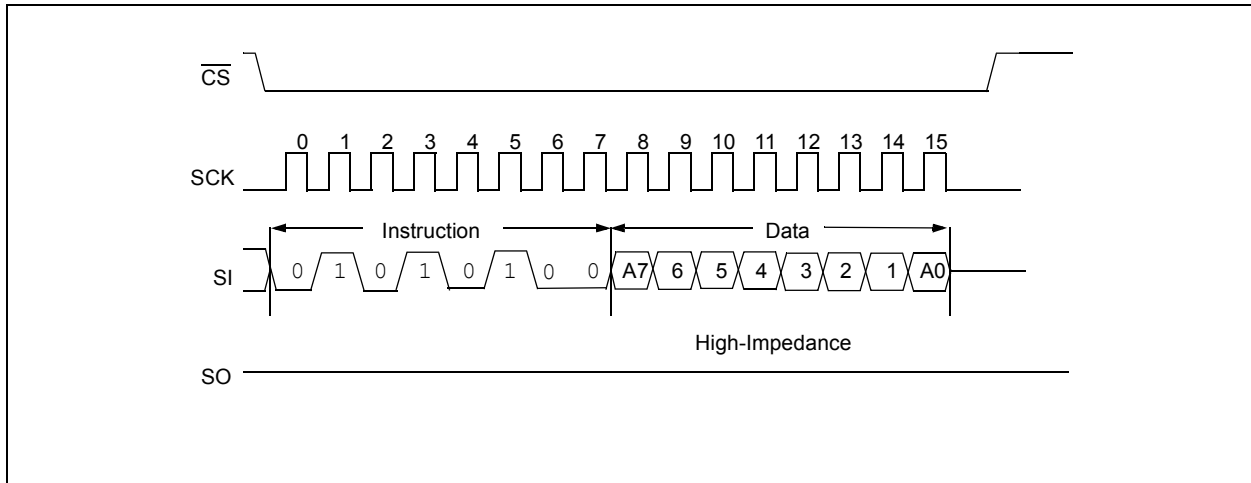
- The write enable latch is reset on power-up
- A Write Enable instruction must be issued to set the write enable latch
- After a byte write, page write, unique ID write, or STATUS register write, the write enable latch is reset
- \overline{CS} must be set high after the proper number of clock cycles to start an internal write cycle

- Access to the array during an internal EEPROM write cycle is ignored and programming is continued
- Block protect bits are ignored for UID writes

9.1.9 CLEAR RAM INSTRUCTION

The Clear Ram instruction is a 2-byte command that will reset the internal SRAM to the known value. Using this command, all locations in the SRAM are set to 00h and the data value contained in the second byte of the command is ignored.

FIGURE 9-7: CLRRAM



9.2 Crystal Specification and Selection

The MCP795XX has been designed to operate with a standard 32.768 kHz tuning fork crystal. The on-board oscillator has been characterized to operate with a crystal of maximum ESR of 70K Ohms.

Crystals with a comparable specification are also suitable for use with the MCP795XX.

The table below is given as design guidance and a starting point for crystal and capacitor selection.

| Manufacturer | Part Number | Crystal Capacitance | CX1 Value | CX2 Value |
|---------------|----------------------|---------------------|-----------|-----------|
| Micro Crystal | CM7V-T1A | 7pF | 10pF | 12pF |
| Citizen | CM200S-32.768KDZB-UT | 6pF | 10pF | 8 pF |

Please work with your crystal vendor.

EQUATION 9-1:

$$C_{load} = \frac{CX2 \times CX1}{CX2 + CX1} + C_{stray}$$

The following must also be taken into consideration:

- Pin capacitance (to be included in Cx2 and Cx1)

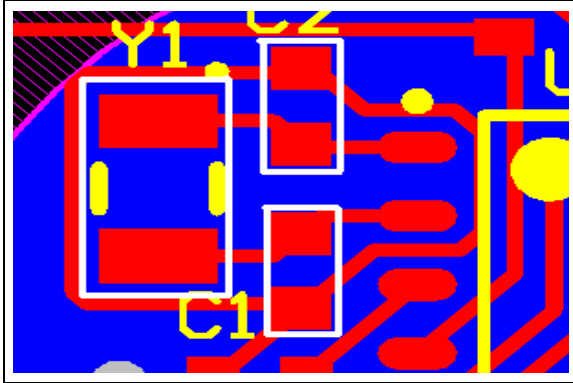
- Stray Board Capacitance

The recommended board layout for the oscillator area is shown in [Figure 9-8](#). This actual board shows the crystal and the load capacitors. In this example, C2 is CX1, C1 is CX2 and the crystal is designated as Y1.

When calculating the effective load capacitance, [Equation 9-1](#) can be used.

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FIGURE 9-8: BOARD LAYOUT



Gerber files are available on request. Please contact your Microchip Sales representative.

It is required that the final application should be tested with the chosen crystal and capacitor combinations across all operating and environmental conditions. Please also consult with the crystal specification to observe correct handling and reflow conditions and for information on ideal capacitor values.

For more information please see the RTCC Best Practices AN1365 (DS01365).

10.0 ON-BOARD MEMORY

The MCP795XX has both on-board EEPROM memory and battery-backed SRAM. The SRAM is arranged as 64 bytes and is retained when VCC supply is removed. The EEPROM is organized as 256 or 128 bytes. The EEPROM is nonvolatile and does not require VBAT supply for retention.

10.1 SRAM

The SRAM array is a battery-backed-up array of 64 bytes. The SRAM is accessed using the Read and Write commands, starting at address 0x20h.

Upon power-up the SRAM locations are in an undefined state but can be set to a known value using the CLR_{SRAM} instruction (Figure 9-7).

10.1.1 SRAM/RTCC OPERATION

The MCP795XX contains a Real-Time Clock and Calendar. The RTCC registers and SRAM array are accessed using the same commands. The RTCC registers and SRAM array are powered internally from the switched supply that is either connected to VCC or VBAT supply. No external read/write operations are permitted when the device is running from the VBAT supply.

Table 3-1 contains a list of the possible instruction bytes and format for device operation.

10.1.2 READ SEQUENCE

The part is selected by pulling \overline{CS} low. The 8-bit READ instruction is transmitted to the MCP79520 followed by the 8-bit address (A7 through A0). After the correct READ instruction and address are sent, the data stored in the memory at the selected address is shifted out on the SO pin. The data stored in the memory at the next address can be read sequentially by continuing to provide clock pulses. The internal Address Pointer is automatically incremented to the next higher address after each byte of data is shifted out.

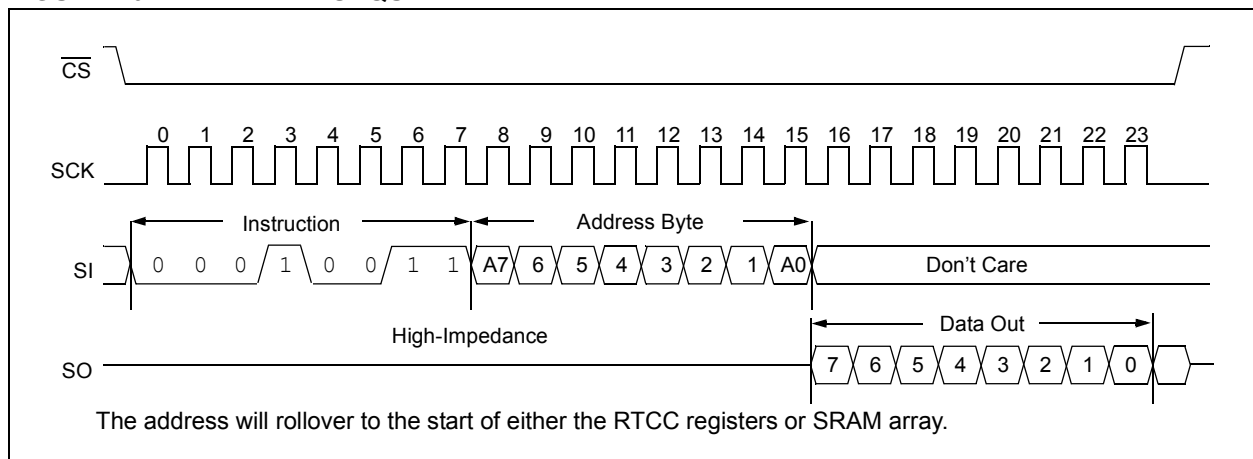
As the RTCC registers are separate from the SRAM array, when reading the RTCC registers set the address will wrap back to the start of the RTCC registers. Also when an address within the SRAM array is loaded the internal Address Pointer will wrap back to the start of the SRAM array. The READ instruction can be used to read the registers and array indefinitely by continuing to clock the device. The read operation is terminated by raising the \overline{CS} pin (Figure 10-1).

10.1.3 WRITE SEQUENCE

As the RTCC registers and SRAM array do not require the WREN sequence like the nonvolatile memory, the user may proceed by setting the \overline{CS} low, issuing the WRITE instruction, followed by the address, and then the data to be written. As no write cycle is required for the RTCC registers and SRAM array the entire contents can be written in a single command.

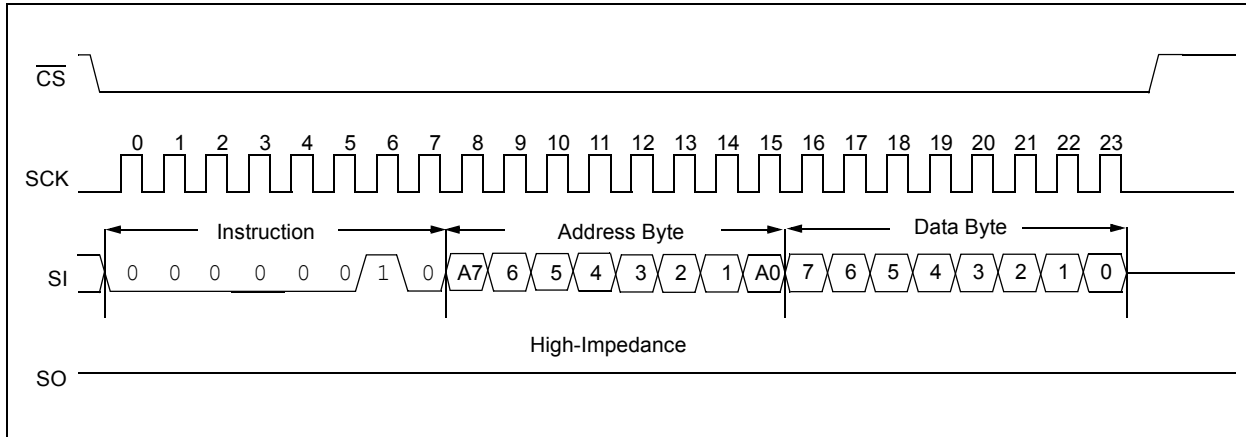
For the last data byte to be written to the RTCC registers and SRAM array, the \overline{CS} must be brought high after the last byte has been clocked in. If \overline{CS} is brought high at any other time, the last byte will not be written. Refer to Figure 10-2 for more detailed illustrations on the write sequence.

FIGURE 10-1: READ SEQUENCE



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FIGURE 10-2: WRITE SEQUENCE



10.1.4 WRITE TO THE UNLOCK REGISTER

The MCP795XX contains a protected area of 64 bits that can be used to hold a unique ID, such as a serial number or MAC address code. To gain write access to these locations, a specific sequence is required. Any deviation from this sequence will reset the lock on these locations. Once these locations have been unlocked they have to be written to in the next command by issuing the correct command. A write to a different location will lock the ID locations and clear the WEL bit.

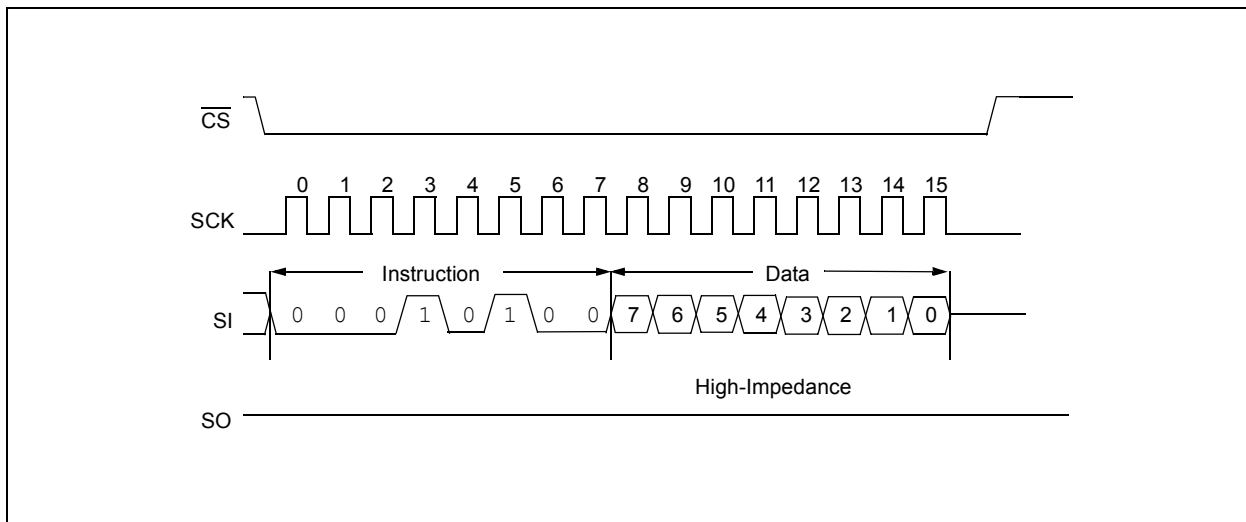
The following is a list of strict conditions which have to be followed before the unique locations can be written to:

- EEWREN instruction successfully executed
- UNLOCK 0x55 instruction successfully executed
- UNLOCK 0xAA instruction successfully executed

To issue each UNLOCK instruction the Unlock command is sent followed by 0x55. Then in a separate command the Unlock command is issued followed by 0xAA. It is a requirement that each command be separate, that is \overline{CS} must toggle between each command.

Information on how to read and write the ID locations is detailed in [Section 9.1.4, Unique ID Locations](#).

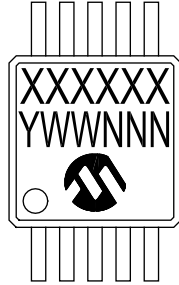
FIGURE 10-3: UNLOCK SEQUENCE



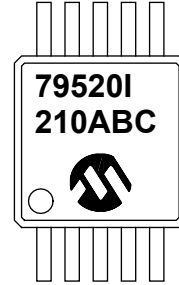
11.0 PACKAGING INFORMATION

11.1 Package Marking Information

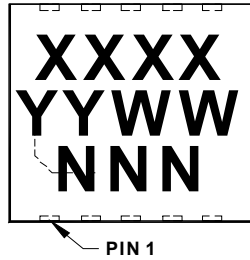
10-Lead MSOP (3x3 mm)



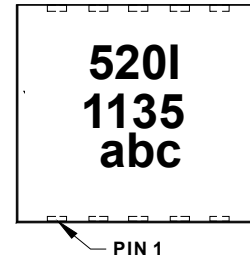
Example



10-Lead TDFN



Example



| Part Number | 1st Line Marking Codes | |
|-------------|------------------------|------|
| | MSOP | TDFN |
| MCP79520 | 79520I | 520I |
| MCP79510 | 79510I | 510I |
| MCP79521 | 79521I | 521I |
| MCP79511 | 79511I | 511I |
| MCP79522 | 79522I | 522I |
| MCP79512 | 79512I | 512I |

Note: T = Temperature grade
 NN = Alphanumeric traceability code

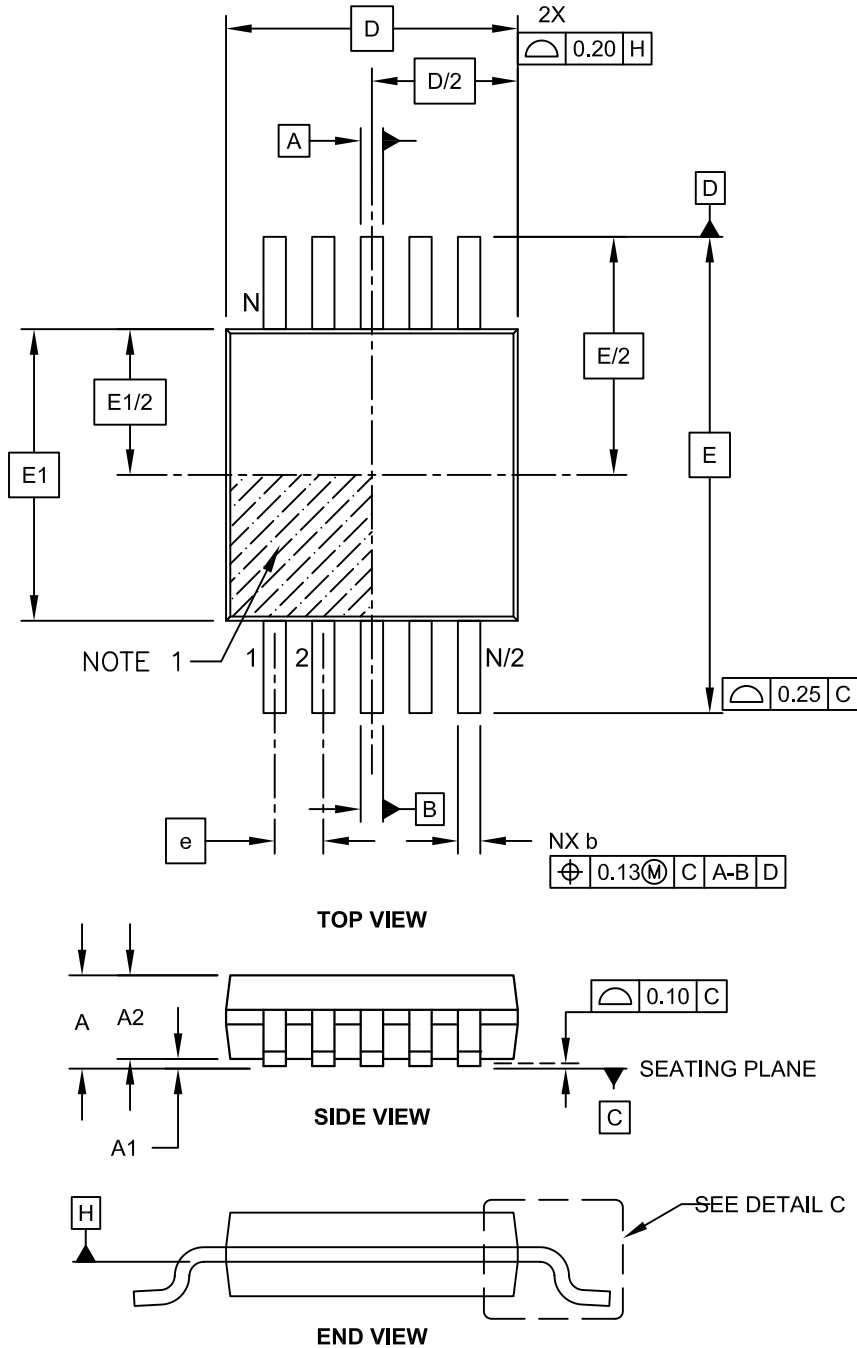
Legend: XX...X Customer-specific information
 Y Year code (last digit of calendar year)
 YY Year code (last 2 digits of calendar year)
 WW Week code (week of January 1 is week '01')
 NNN Alphanumeric traceability code
 (e3) Pb-free JEDEC designator for Matte Tin (Sn)
 * This package is Pb-free. The Pb-free JEDEC designator (e3) can be found on the outer packaging for this package.

Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information.

MCP7952X/MCP7951X

10-Lead Plastic Micro Small Outline Package (MS) [MSOP]

Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>

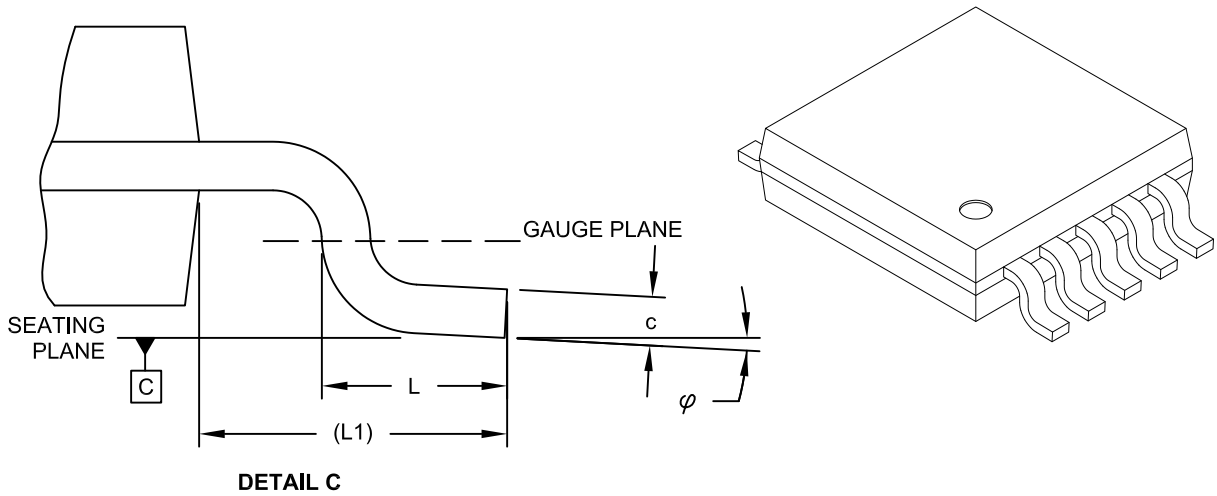


Microchip Technology Drawing C04-021C Sheet 1 of 2

MCP7952X/MCP7951X

10-Lead Plastic Micro Small Outline Package (MS) [MSOP]

Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



| Dimension | Units | MILLIMETERS | | |
|--------------------------|-------|-------------|------|------|
| | | MIN | NOM | MAX |
| Number of Pins | N | 10 | | |
| Pitch | e | 0.50 BSC | | |
| Overall Height | A | - | - | 1.10 |
| Molded Package Thickness | A2 | 0.75 | 0.85 | 0.95 |
| Standoff | A1 | 0.00 | - | 0.15 |
| Overall Width | E | 4.90 BSC | | |
| Molded Package Width | E1 | 3.00 BSC | | |
| Overall Length | D | 3.00 BSC | | |
| Foot Length | L | 0.40 | 0.60 | 0.80 |
| Footprint | L1 | 0.95 REF | | |
| Foot Angle | φ | 0° | - | 8° |
| Lead Thickness | c | 0.08 | - | 0.23 |
| Lead Width | b | 0.15 | - | 0.33 |

Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15mm per side.
3. Dimensioning and tolerancing per ASME Y14.5M.

BSC: Basic Dimension. Theoretically exact value shown without tolerances.

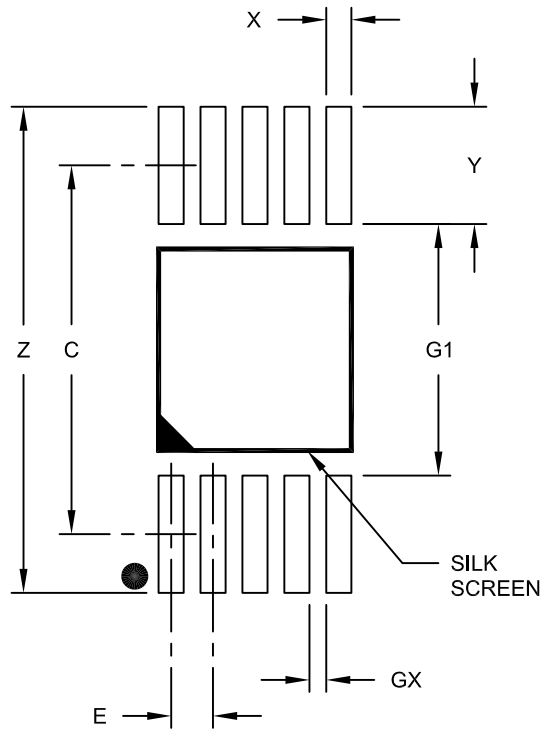
REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-021C Sheet 2 of 2

MCP7952X/MCP7951X

10-Lead Plastic Micro Small Outline Package (MS) [MSOP]

Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



RECOMMENDED LAND PATTERN

| Dimension Limits | Units | MILLIMETERS | | |
|--------------------------|-------|-------------|------|------|
| | | MIN | NOM | MAX |
| Contact Pitch | E | 0.50 BSC | | |
| Contact Pad Spacing | C | | 4.40 | |
| Overall Width | Z | | | 5.80 |
| Contact Pad Width (X10) | X1 | | | 0.30 |
| Contact Pad Length (X10) | Y1 | | | 1.40 |
| Distance Between Pads | G1 | 3.00 | | |
| Distance Between Pads | GX | 0.20 | | |

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M

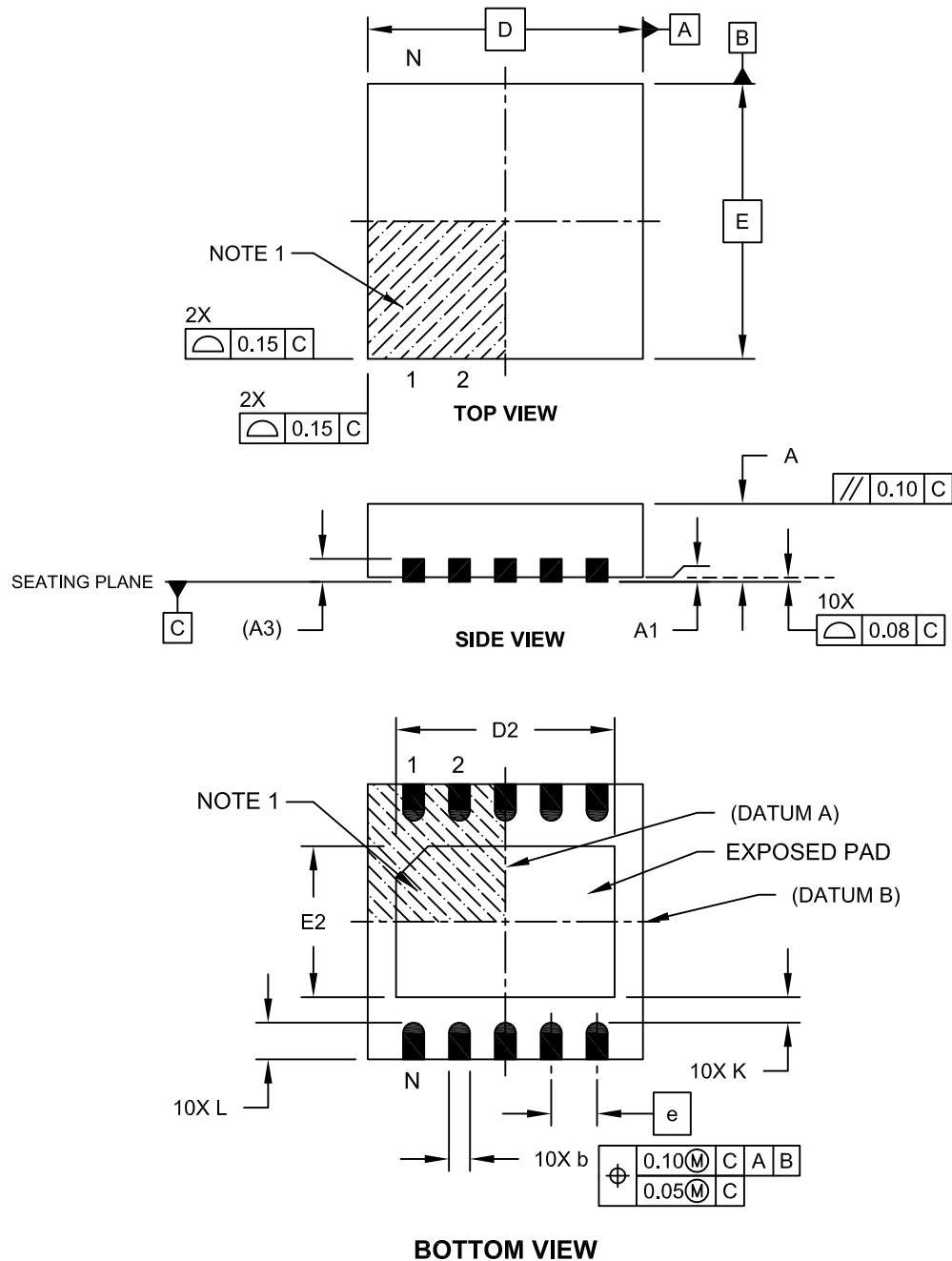
BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing No. C04-2021A

MCP7952X/MCP7951X

10-Lead Thin Plastic Dual Flat, No Lead Package (MN) - 3x3x0.8mm Body [TDFN]

Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>

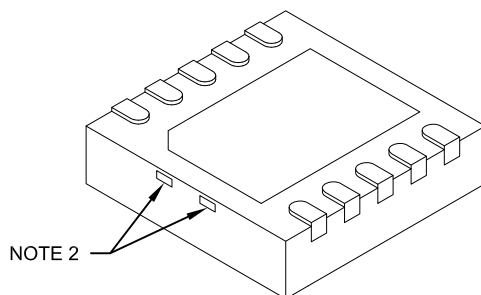


Microchip Technology Drawing C04-185A Sheet 1 of 2

MCP7952X/MCP7951X

10-Lead Thin Plastic Dual Flat, No Lead Package (MN) - 3x3x0.8mm Body [TDFN]

Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



| Dimension Limits | Units | MILLIMETERS | | |
|------------------------|-------|-------------|------|------|
| | | MIN | NOM | MAX |
| Number of Pins | N | 10 | | |
| Pitch | e | 0.50 BSC | | |
| Overall Height | A | 0.70 | 0.75 | 0.80 |
| Standoff | A1 | 0.00 | 0.02 | 0.05 |
| Contact Thickness | A3 | 0.20 REF | | |
| Overall Length | D | 3.00 BSC | | |
| Exposed Pad Length | D2 | 2.20 | 2.30 | 2.35 |
| Overall Width | E | 3.00 BSC | | |
| Exposed Pad Width | E2 | 1.55 | 1.65 | 1.70 |
| Contact Width | b | 0.18 | 0.25 | 0.30 |
| Contact Length | L | 0.30 | 0.40 | 0.50 |
| Contact-to-Exposed Pad | K | 0.20 | - | - |

Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Package may have one or more exposed tie bars at ends.
3. Package is saw singulated
4. Dimensioning and tolerancing per ASME Y14.5M
BSC: Basic Dimension. Theoretically exact value shown without tolerances.
REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing No. C04-0185A Sheet 2 of 2

APPENDIX A: REVISION HISTORY

Revision A (04/2012)

Initial Release.

MCP7952X/MCP7951X

NOTES:

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Technical support is available through the web site at: <http://microchip.com/support>

MCP7952XX/MCP7951XX

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Device: MCP7952XX/MCP7951XX

Literature Number: DS22300A

Questions:

1. What are the best features of this document?

2. How does this document meet your hardware and software development needs?

3. Do you find the organization of this document easy to follow? If not, why?

4. What additions to the document do you think would enhance the structure and subject?

5. What deletions from the document could be made without affecting the overall usefulness?

6. Is there any incorrect or misleading information (what and where)?

7. How would you improve this document?

MCP7952XX/MCP7951XX

PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, refer to the factory or the listed sales office. Not every possible ordering combination is listed below.

| <u>MCP795</u> | <u>1</u> | <u>0</u> | <u>T</u> | <u>-</u> | <u>I</u> | <u>/XX</u> |
|---|----------|-----------|----------|------------|------------|------------|
| Base Part | Memory | Unique ID | T/R | Temp Range | Temp Range | Package |
| Base Part No.: MCP795 = SPI RTCC | | | | | | |
| Memory: 1 = 1 Kbit EE, 64 Bytes SRAM 2 = 2 Kbits EE, 64 Bytes SRAM | | | | | | |
| ID/MAC Address: 0 = Blank 1 = EUI-48™ MAC Address 2 = EUI-64™ MAC Address | | | | | | |
| T/R: Blank = Tube T = Tape and Reel | | | | | | |
| Temperature Range: I = -40°C to +85°C | | | | | | |
| Package: MS = 10-Pin MSOP MN = 10-Pin TDFN | | | | | | |

Examples:

- a) MCP79510-I/MS: 1K EEPROM, Blank ID, Industrial Temperature, MSOP Package
- b) MCP79512-I/MS: 1K EEPROM, EUI-64™, Industrial Temperature, MSOP Package
- c) MCP79511T-I/MN: 1K EEPROM, EUI-48™, Industrial Temperature, Tape and Reel, TDFN Package
- d) MCP79520-I/MS: 2K EEPROM, Blank ID, Industrial Temperature, MSOP Package
- e) MCP79522-I/MS: 2K EEPROM, EUI-64™, Industrial Temperature, MSOP Package
- f) MCP79521T-I/MN: 2K EEPROM, EUI-48™, Industrial Temperature, Tape and Reel, TDFN Package

MCP7952XX/MCP7951XX

NOTES:

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.”

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