

## Battery-Backed I<sup>2</sup>C™ Real-Time Clock/Calendar with SRAM, EEPROM and Protected EEPROM

### Device Selection Table

Part Number	Protected EEPROM
MCP79410	Unprogrammed
MCP79411	EUI-48™
MCP79412	EUI-64™

### Timekeeping Features:

- Real-Time Clock/Calendar (RTCC):
  - Hours, minutes, seconds, day of week, day, month, year
  - Leap year compensated to 2399
  - 12/24-hour modes
- Oscillator for 32.768 kHz Crystals:
  - Optimized for 6-9 pF crystals
- On-Chip Digital Trimming/Calibration:
  - ±1 ppm resolution
  - ±129 ppm range
- Dual Programmable Alarms
- Versatile Output Pin:
  - Clock output with selectable frequency
  - Alarm output
  - General purpose output
- Power-Fail Time-Stamp:
  - Time logged on switchover to and from Battery mode

### Low-Power Features:

- Wide Voltage Range:
  - Operating voltage range of 1.8V to 5.5V
  - Backup voltage range of 1.3V to 5.5V
- Low Typical Timekeeping Current:
  - Operating from V<sub>CC</sub>: 1.2 µA at 3.3V
  - Operating from V<sub>BAT</sub>: 925 nA at 3.0V
- Automatic Switchover to Battery Backup

### User Memory:

- 64-byte Battery-Backed SRAM
- 1 Kbit EEPROM Memory:
  - Software write-protect
  - Page write up to 8 bytes
  - Endurance: 1M Erase/Write cycles
- 64-bit Protected EEPROM Area:
  - Robust write unlock sequence
  - EUI-48™ MAC address (MCP79411)
  - EUI-64™ MAC address (MCP79412)

### Operating Ranges:

- 2-Wire Serial Interface, I<sup>2</sup>C™ Compatible:
  - I<sup>2</sup>C clock rate up to 400 kHz
- Temperature Range:
  - Industrial (I): -40°C to +85°C

### Packages:

- 8-Lead SOIC, MSOP, TSSOP and 2x3 TDFN

### General Description:

The MCP7941X Real-Time Clock/Calendar (RTCC) tracks time using internal counters for hours, minutes, seconds, days, months, years, and day of week. Alarms can be configured on all counters up to and including months. For usage and configuration, the MCP7941X supports I<sup>2</sup>C communications up to 400 kHz.

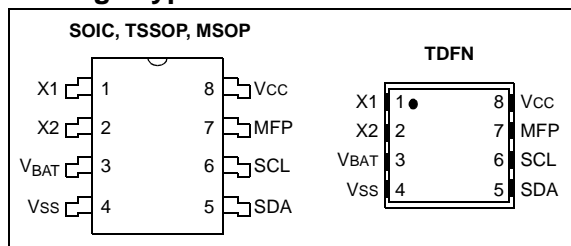
The open-drain, multi-functional output can be configured to assert on an alarm match, to output a selectable frequency square wave or as a general purpose output.

The MCP7941X is designed to operate using a 32.768 kHz tuning fork crystal with external crystal load capacitors. On-chip digital trimming can be used to adjust for frequency variance caused by crystal tolerance and temperature.

SRAM and timekeeping circuitry are powered from the backup supply when main power is lost, allowing the device to maintain accurate time and the SRAM contents. The times when the device switches over to the back-up supply and when primary power returns are both logged by the power-fail time-stamp.

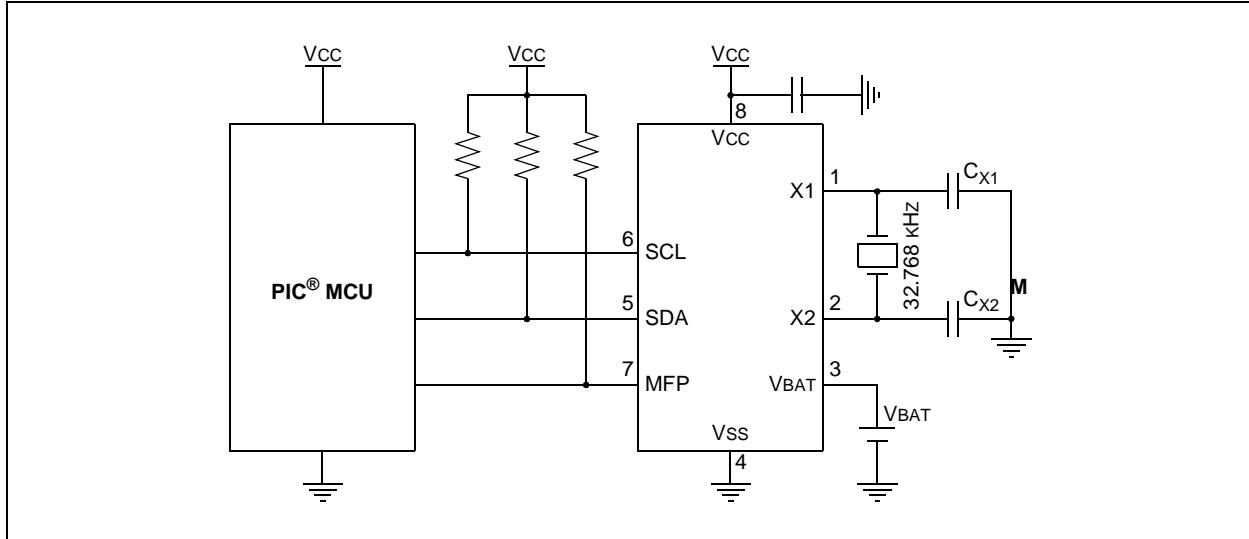
The MCP7941X features 1 Kbit of internal nonvolatile EEPROM with software write-protectable regions. There is an additional 64 bits of protected nonvolatile memory which is only writable after an unlock sequence, making it ideal for storing a unique ID or other critical information. The MCP79411 and MCP79412 are pre-programmed with EUI-48 and EUI-64 addresses, respectively. Custom programming is also available.

### Package Types

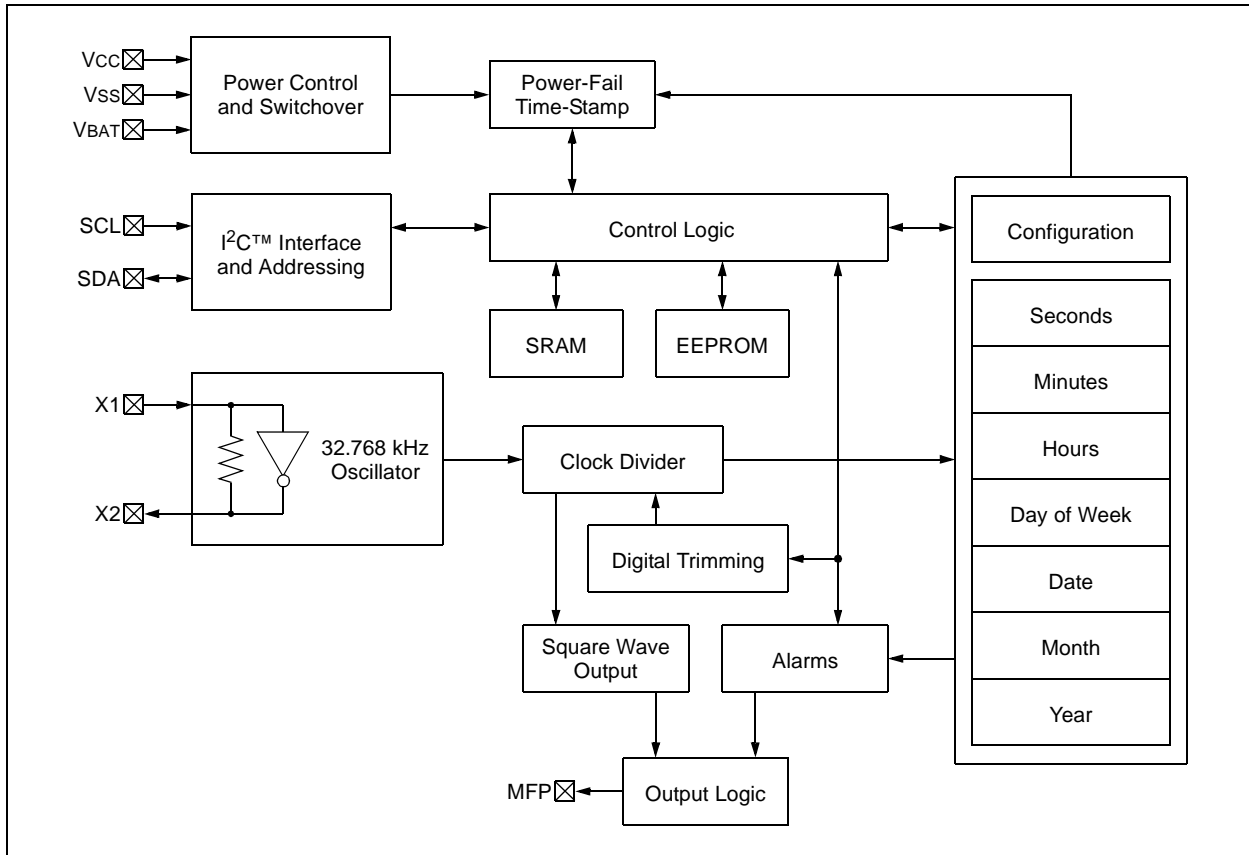


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**FIGURE 1-1: TYPICAL APPLICATION SCHEMATIC**



**FIGURE 1-2: BLOCK DIAGRAM**



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## 1.0 ELECTRICAL CHARACTERISTICS

### Absolute Maximum Ratings <sup>(†)</sup>

V <sub>CC</sub> .....	6.5V
All inputs and outputs (except SDA and SCL) w.r.t. V <sub>SS</sub> .....	-0.6V to V <sub>CC</sub> +1.0V
SDA and SCL w.r.t. V <sub>SS</sub> .....	-0.6V to 6.5V
Storage temperature .....	-65°C to +150°C
Ambient temperature with power applied.....	-40°C to +125°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			Electrical Characteristics: Industrial (I): V <sub>CC</sub> = +1.8V to 5.5V TA = -40°C to +85°C				
Param. No.	Symbol	Characteristic	Min.	Typ. <sup>(2)</sup>	Max.	Units	Conditions
D1	V <sub>IH</sub>	High-level Input Voltage	0.7 V <sub>CC</sub>	—	—	V	
D2	V <sub>IL</sub>	Low-level Input Voltage	—	—	0.3 V <sub>CC</sub>	V	V <sub>CC</sub> ≥ 2.5V
					0.2 V <sub>CC</sub>		V <sub>CC</sub> < 2.5V
D3	V <sub>HYS</sub>	Hysteresis of Schmitt Trigger Inputs (SDA, SCL pins)	0.05 V <sub>CC</sub>	—	—	V	(Note 1)
D4	V <sub>OL</sub>	Low-level Output Voltage (MFP, SDA pins)	—	—	0.40	V	I <sub>OL</sub> = 3.0 mA; V <sub>CC</sub> = 4.5V
							I <sub>OL</sub> = 2.1 mA; V <sub>CC</sub> = 2.5V
D5	I <sub>LI</sub>	Input Leakage Current	—	—	±1	μA	V <sub>IN</sub> = V <sub>SS</sub> or V <sub>CC</sub>
D6	I <sub>LO</sub>	Output Leakage Current	—	—	±1	μA	V <sub>OUT</sub> = V <sub>SS</sub> or V <sub>CC</sub>
D7	C <sub>IN</sub>	Pin Capacitance (SDA, SCL, MFP pins)	—	—	10	pF	V <sub>CC</sub> = 5.0V (Note 1)
	C <sub>OUT</sub>						TA = 25°C, f = 1 MHz
D8	C <sub>OSC</sub>	Oscillator Pin Capacitance (X1, X2 pins)	—	3	—	pF	(Note 1)
D9	I <sub>CC</sub> eed	EEPROM Operating Current	—	—	400	μA	V <sub>CC</sub> = 5.5V, SCL = 400 kHz
	I <sub>CC</sub> ewr				3	mA	V <sub>CC</sub> = 5.5V
D10	I <sub>CC</sub> read	SRAM/RTCC Register Operating Current	—	—	300	μA	V <sub>CC</sub> = 5.5V, SCL = 400 kHz
	I <sub>CC</sub> write				400	μA	V <sub>CC</sub> = 5.5V, SCL = 400 kHz
D11	I <sub>CC</sub> dat	V <sub>CC</sub> Data-retention Current (oscillator off)	—	—	1	μA	SCL, SDA, V <sub>CC</sub> = 5.5V
D12	I <sub>CC</sub> t	Timekeeping Current	—	1.2	—	μA	V <sub>CC</sub> = 3.3V (Note 1)
D13	V <sub>TRIP</sub>	Power-fail Switchover Voltage	1.3	1.5	1.7	V	
D14	V <sub>BAT</sub>	Backup Supply Voltage Range	1.3	—	5.5	V	(Note 1)

**Note 1:** This parameter is not tested but ensured by characterization.

**Note 2:** Typical measurements taken at room temperature.

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DC CHARACTERISTICS (Continued)			Electrical Characteristics: Industrial (I): VCC = +1.8V to 5.5V TA = -40°C to +85°C				
Param. No.	Symbol	Characteristic	Min.	Typ. <sup>(2)</sup>	Max.	Units	Conditions
D15	IBATT	Timekeeping Backup Current	—	—	850	nA	VBAT = 1.3V, VCC = VSS <b>(Note 1)</b>
				925	1200		VBAT = 3.0V, VCC = VSS <b>(Note 1)</b>
				—	9000		VBAT = 5.5V, VCC = VSS <b>(Note 1)</b>
D16	IBATDAT	VBAT Data Retention Current (oscillator off)	—	—	750	nA	VBAT = 3.6V, VCC = VSS

**Note 1:** This parameter is not tested but ensured by characterization.

**Note 2:** Typical measurements taken at room temperature.

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**TABLE 1-2: AC CHARACTERISTICS**

AC CHARACTERISTICS			Electrical Characteristics: Industrial (I): VCC = +1.8V to 5.5V TA = -40°C to +85°C				
Param. No.	Symbol	Characteristic	Min.	Typ.	Max.	Units	Conditions
1	FCLK	Clock Frequency	—	—	100	kHz	1.8V ≤ VCC < 2.5V
					400		2.5V ≤ VCC ≤ 5.5V
2	THIGH	Clock High Time	4000	—	—	ns	1.8V ≤ VCC < 2.5V
			600				2.5V ≤ VCC ≤ 5.5V
3	Tlow	Clock Low Time	4700	—	—	ns	1.8V ≤ VCC < 2.5V
			1300				2.5V ≤ VCC ≤ 5.5V
4	Tr	SDA and SCL Rise Time (Note 1)	—	—	1000	ns	1.8V ≤ VCC < 2.5V
					300		2.5V ≤ VCC ≤ 5.5V
5	Tf	SDA and SCL Fall Time (Note 1)	—	—	1000	ns	1.8V ≤ VCC < 2.5V
					300		2.5V ≤ VCC ≤ 5.5V
6	Thd:sta	Start Condition Hold Time	4000	—	—	ns	1.8V ≤ VCC < 2.5V
			600				2.5V ≤ VCC ≤ 5.5V
7	Tsu:sta	Start Condition Setup Time	4700	—	—	ns	1.8V ≤ VCC < 2.5V
			600				2.5V ≤ VCC ≤ 5.5V
8	Thd:dat	Data Input Hold Time	0	—	—	ns	(Note 3)
9	Tsu:dat	Data Input Setup Time	250	—	—	ns	1.8V ≤ VCC < 2.5V
			100				2.5V ≤ VCC ≤ 5.5V
10	Tsu:sto	Stop Condition Setup Time	4000	—	—	ns	1.8V ≤ VCC < 2.5V
			600				2.5V ≤ VCC ≤ 5.5V
11	Taa	Output Valid from Clock	—	—	3500	ns	1.8V ≤ VCC < 2.5V
					900		2.5V ≤ VCC ≤ 5.5V
12	Tbuf	Bus Free Time: Bus time must be free before a new transmission can start	4700	—	—	ns	1.8V ≤ VCC < 2.5V
			1300				2.5V ≤ VCC ≤ 5.5V
13	Tsp	Input Filter Spike Suppression (SDA and SCL pins)	—	—	50	ns	(Note 1)
14	Twc	Write Cycle Time (byte or page)	—	—	5	ms	
15	Tfvcc	VCC Fall Time	300	—	—	μs	(Note 1)
16	Trvcc	VCC Rise Time	0	—	—	μs	(Note 1)
17	Fosc	Oscillator Frequency	—	32.768	—	kHz	
18	Tosf	Oscillator Timeout Period	1	—	—	ms	(Note 1)
19	—	Endurance	1M	—	—	cycles	Page Mode, 25°C, VCC = 5.5V (Note 2)

**Note 1:** Not 100% tested.

**2:** This parameter is not tested but ensured by characterization.

**3:** As a transmitter, the device must provide an internal minimum delay time to bridge the undefined region (minimum 300 ns) of the falling edge of SCL to avoid unintended generation of Start or Stop conditions.

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FIGURE 1-3: I<sup>2</sup>C™ BUS TIMING DATA

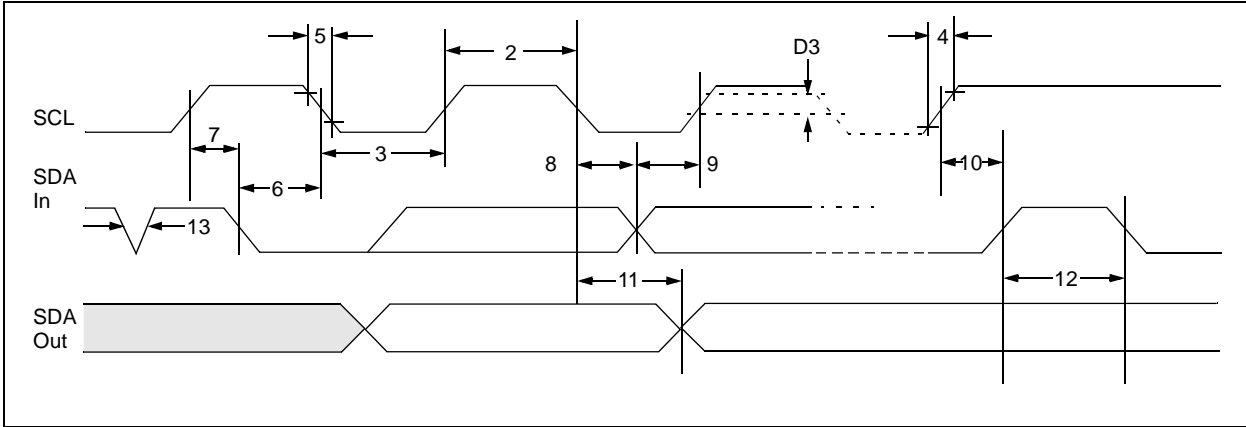
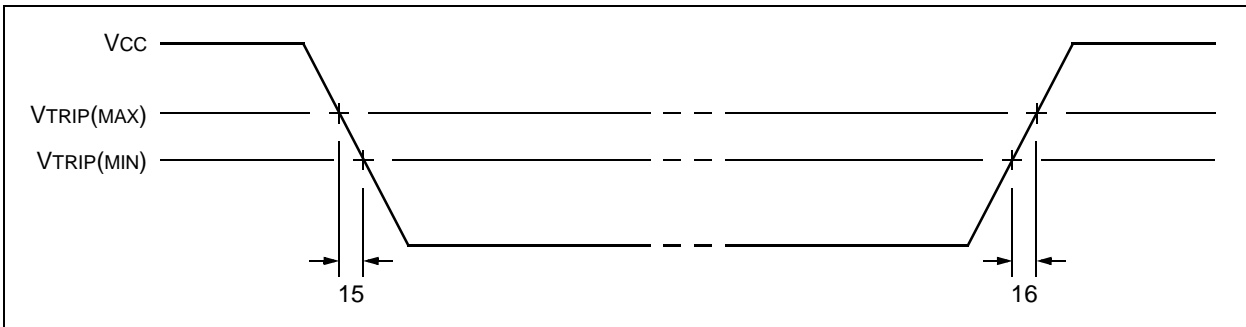


FIGURE 1-4: POWER SUPPLY TRANSITION TIMING



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## 2.0 TYPICAL PERFORMANCE CURVE

**Note:** The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data represented may be outside the specified operating range (e.g., outside specified power supply range) and therefore, outside the warranted range.

**FIGURE 2-1: TIMEKEEPING BACKUP CURRENT VS. BACKUP SUPPLY VOLTAGE**

