RTC Fundamentals

Features of different RTC types and the main functions of RTC modules

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2. Key components between different RTC solutions
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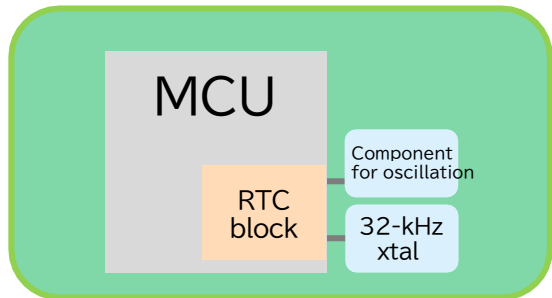   3. Use Case examples

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RTC is an abbreviation for Real Time Clock.
An RTC is a dedicated IC that generates and outputs time, date, and other digital data from a clock source. It may also refer to functional blocks and software that realize these same functions.
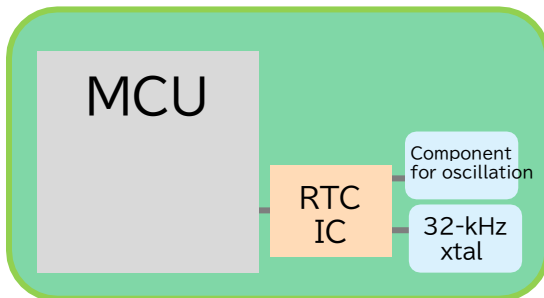
Three configurations that provide RTC functions

（1）An MCU with built-in RTC functions and an external crystal unit

（2）An RTC IC and an external crystal unit

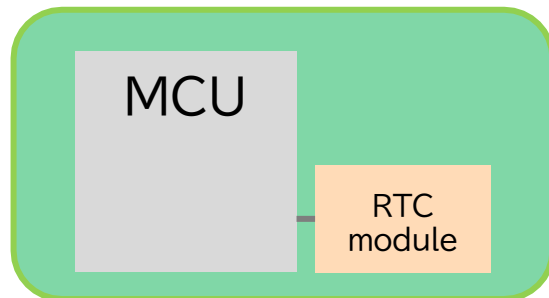（3）An RTC module with an RTC IC and a built-in crystal in a single package
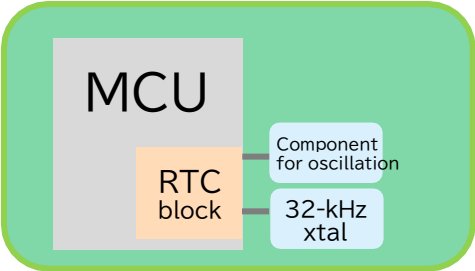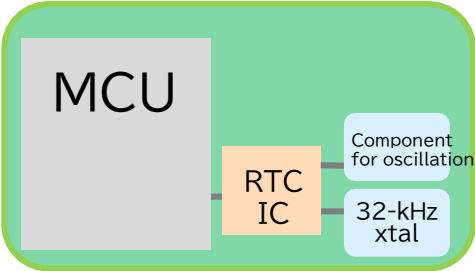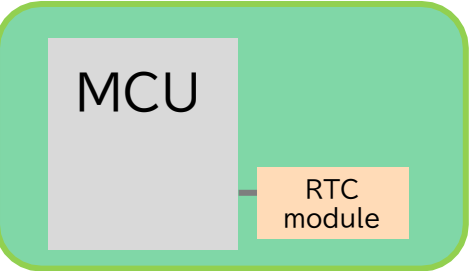
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	(1) MCU with a built-in RTC	(2) RTC IC	(3) RTC Module
RTC Solution			
PCB Layout	1: MCU 2: 32-kHz Crystal 3: Component for oscillation	1: MCU 2: RTC IC 3: 32-kHz Crystal 4: Component for oscillation	1: MCU 2: RTC Module
Circuit design	1: Require verification for each part change 2: Designing built-in temperature compensation can be challenging. 3: Mass production quality must be ensured, considering variations in the characteristics of each component.		No required
Current consumption	1μA or over	100nA or under	
Minimum clocking voltage	MCU Operating voltage	1.0V	
Software development load	High	Low	

3. Three major reasons why RTC modules are recommended **EPSON**

(1) Facilitates the design of low-power consumption systems

In wearable products and IoT systems that are powered by small batteries, the maintenance of time information is left to an external RTC. The MCU can go into deep Sleep/HALT, in which all functions are deactivated.
In the meantime, the RTC keeps the time with a small battery, but the RTC can wake up the MCU by having the RTC detect a system startup event or by being programmed to do so.

(2) No need to verify the oscillation characteristics

To use the RTC functions built into an MCU, you must select and evaluate the match between a crystal unit and related components. It is not uncommon to see a poor match between a theoretical design and evaluation results.
Nor is it uncommon to see problems emerge related to variations in characteristics after mass production. Rather than spending time resolving these issues, it is more efficient to use a stand-alone, accuracy-guaranteed RTC module to free up development resources for other design quality improvements.
Epson's RTC modules are individually adjusted for clock accuracy and inspected before shipping.

(3) Save software development time

In addition to an alarm and timer, RTC modules have timestamps, memory, self-monitoring to detect things such as voltage drops, and other useful functions. If these functions are handled by the MCU, the CPU must operate for longer, making it difficult to reduce power consumption. Software development and verification will also be required.
Furthermore, it can be difficult for MCUs to control long periods of time, such as seconds.
Thus, the use of an RTC module reduces the CPU load as well as the software development load.

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What are Epson's crystal devices?

- Epson leverages its efficient, compact, and precise technologies, advanced over many years, to manufacture low-power crystal devices that deliver outstanding quality and accuracy.
- Epson develops and fabricates the synthetic quarts crystal and ICs.

Epson's RTC modules

Epson provides multi-function RTC modules by integrating quartz crystal and RTC IC in a single package. This RTC modules enable saving development time and cost while meeting customers' requirement for low power consumption.
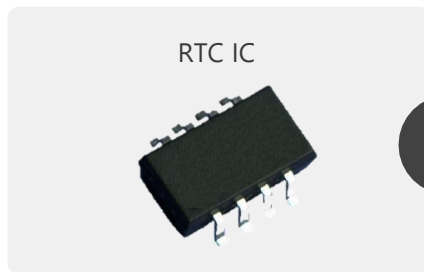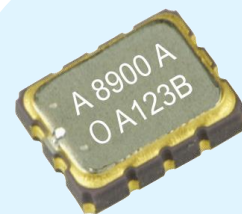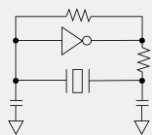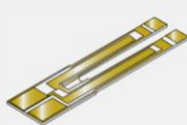
| Reduced process | Save space | High accuracy and stable | Low power consumption | Multi-function |

RTC IC

Crystal chip / Oscillation circuit

+

4-1. Epson's RTC modules Main product lineup

	RX8130CE	RX8900CE	RX8804CE	RX8111CE	RX4111CE	RA8000CE	RA4000CE	RX8901CE	RX4901CE
DTCXO		Yes	Yes			Yes	Yes	Yes	Yes
Interface	I2C	I2C	I2C	I2C	SPI	I2C	SPI	I2C	SPI
Operating Temperature Max.	+85 ℃	+85 ℃	+105 ℃	+105 ℃	+105 ℃	+125 ℃	+125 ℃	+105 ℃	+105 ℃
Backup current Typ. / 3 V	300 nA	700 nA	350 nA	100 nA	100 nA	300 nA	300 nA	240 nA	240 nA
Time stamp (Max.)			1 time	8 times	8 times	2 times	2 times	32 times	32 times
EVIN pins			1ch	1ch		2 ch	1 ch (SPI3-wire) 2 ch (SPI4-wire)	2-3 ch	0-2 ch
Power switching	Yes Backup battery charge control function	Yes		Yes	Yes			Yes	Yes
Reset output	Yes					Yes	Yes		
For Automotive		Available RA8900CE	Available RA8804CE			Available	Available		

DTCXO: Digital Temperature Compensated Xtal Oscillator

Package size… CE：3.2 x 2.5 x 1.0mm

1. Calendar
2. Temperature compensation
3. Wake up timer & Alarm
4. Timestamps
5. Power supply switching
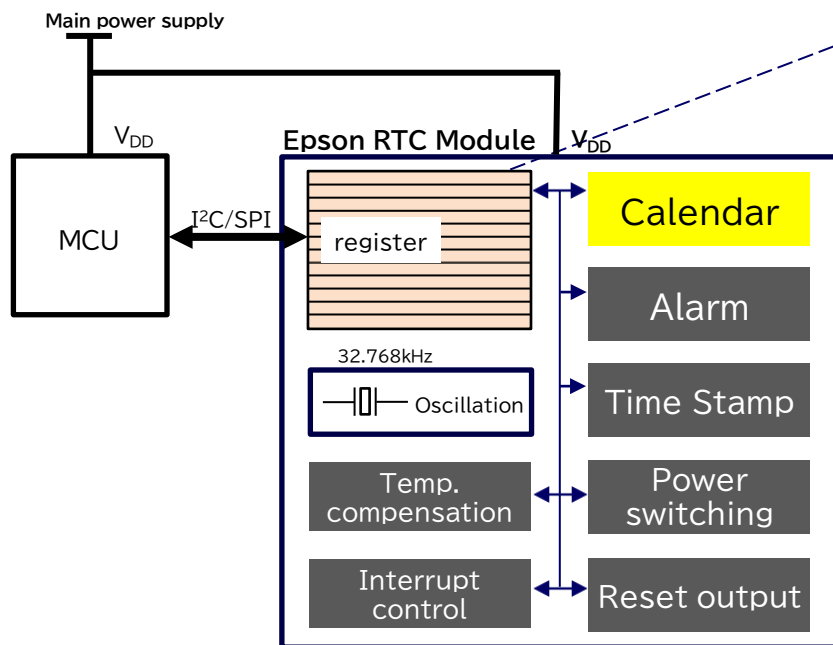
4-2-1. Calendar

RTC's Basic function

Table of resister

Table 8-1. 00h~1Fh

| Address	Function	bit 7	bit 6	bit 5	bit 4	bit 3	bit 2	bit 1	bit 0	Read	Write
00 or 10	SEC	○	40	20	10	8	4	2	1	可	可
01 or 11	MIN	○	40	20	10	8	4	2	1	可	可
02 or 12	HOUR	○	○	20	10	8	4	2	1	可	可
03 or 13	WEEK	○	6	5	4	3	2	1	0	可	可
04 or 14	DAY	○	○	20	10	8	4	2	1	可	可
05 or 15	MONTH	○	○	○	10	8	4	2	1	可	可
06 or 16	YEAR	80	40	20	10	8	4	2	1	可	可
07	RAM	•	•	•	•	•	•	•	•	可	可
08	MIN Alarm	AE	40	20	10	8	4	2	1	可	可
09	HOUR Alarm	AE	•	20	10	8	4	2	1	可	可
0A	WEEK Alarm	AE	6	5	4	3	2	1	0	可	可
	DAY Alarm		•	20	10	8	4	2	1		
0B or 1B	Timer Counter 0	128	64	32	16	8	4	2	1	可	可
0C or 1C	Timer Counter 1	•	•	•	•	2048	1024	512	256	可	可
0D or 1D	Extension Register	TEST	WADA	USEL	TE	FSEL1	FSEL0	TSEL1	TSEL0	可	可 (※5)
0E or 1E	Flag Register	○	○	UF	TF	AF	○	VLF	VDET	可	可 (※2)
0F or 1F	Control Register	CSEL1	CSEL0	UIE	TIE	AIE	○	○	RESET	可	可

Calendar data consists of 7 consecutive bytes of registers.

a. Second
b. Minutes
c. Hour
d. Week (day of the week)
e. Day
f. Month
g. Year

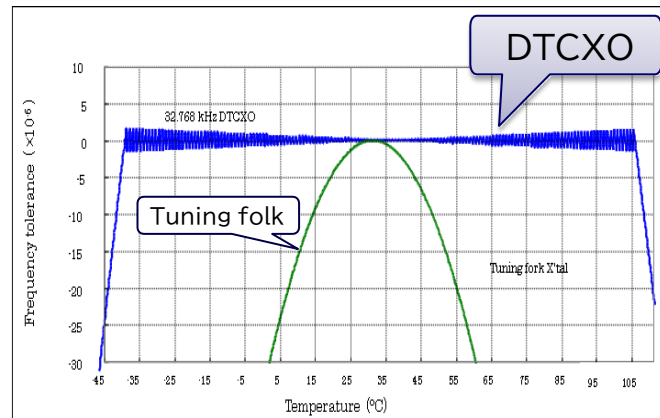The leap year is automatically calculated.

4-2-2. Temperature compensation

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Provides accurate time by automatically compensating for changes in oscillation frequency due to temperature fluctuations.
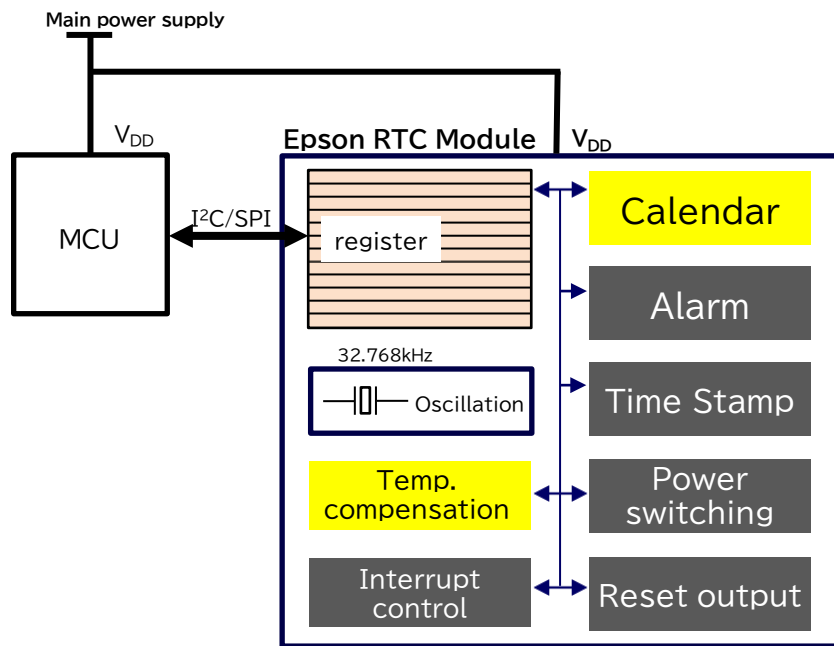
Frequency Temperature Characteristics

Provide high accuracy clock over a wide operating temperature range

Example of clock accuracy specification: $\pm 5.0 \times 10^{-6}$ / -40 $^\circ$C to +85 $^\circ$C

Ex.)Operated continuously for one month in a -40°C environment
⇒Equivalent to 13 seconds per month（Max.）

*DTCXO：Digital Temperature Compensated X'tal(crystal) Oscillator
Crystal oscillator / Oscillator circuit with a function for compensating the frequency variation according to the crystal oscillator's temperature.

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4-2-3. Wake up timer & Alarm

RTC modules **output interrupt signals to the MCU at any timing** set by the customer.

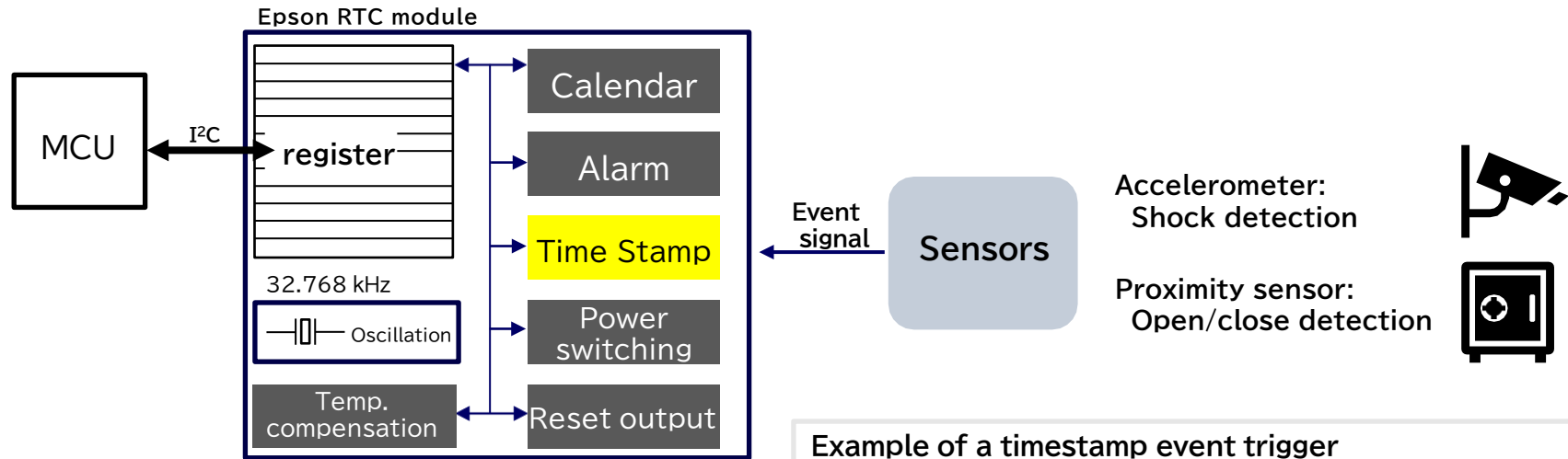Wake-up timer : Interrupts are periodically output at a given cycle

Alarm : Interrupts are output at a specified time that is anywhere form seconds to a month/day (or month/week)
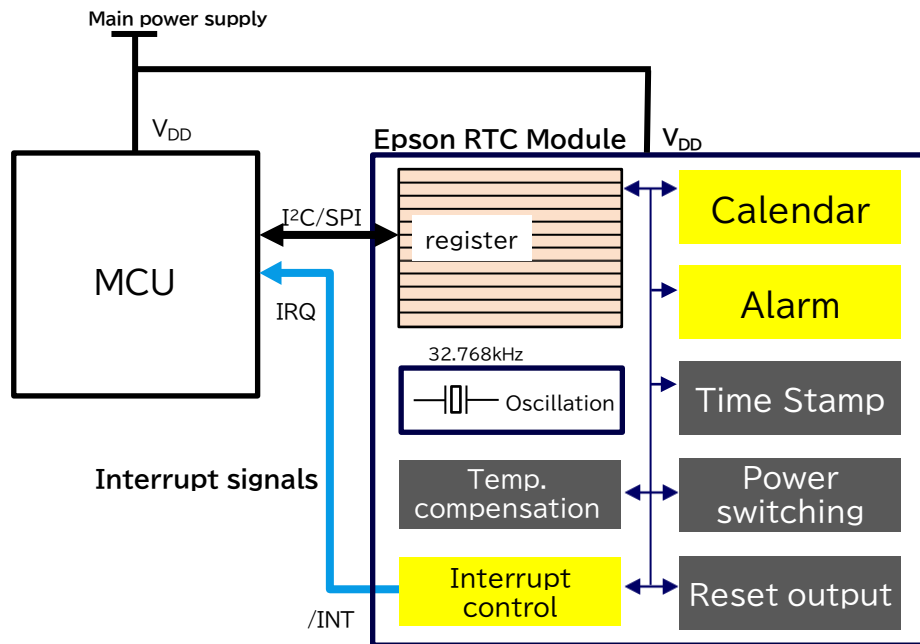
This function **stores the time when an event (signal) is detected.**

Since the RTC receives and records signals directly, it is possible to record the date and time even when the MCU is stopped.
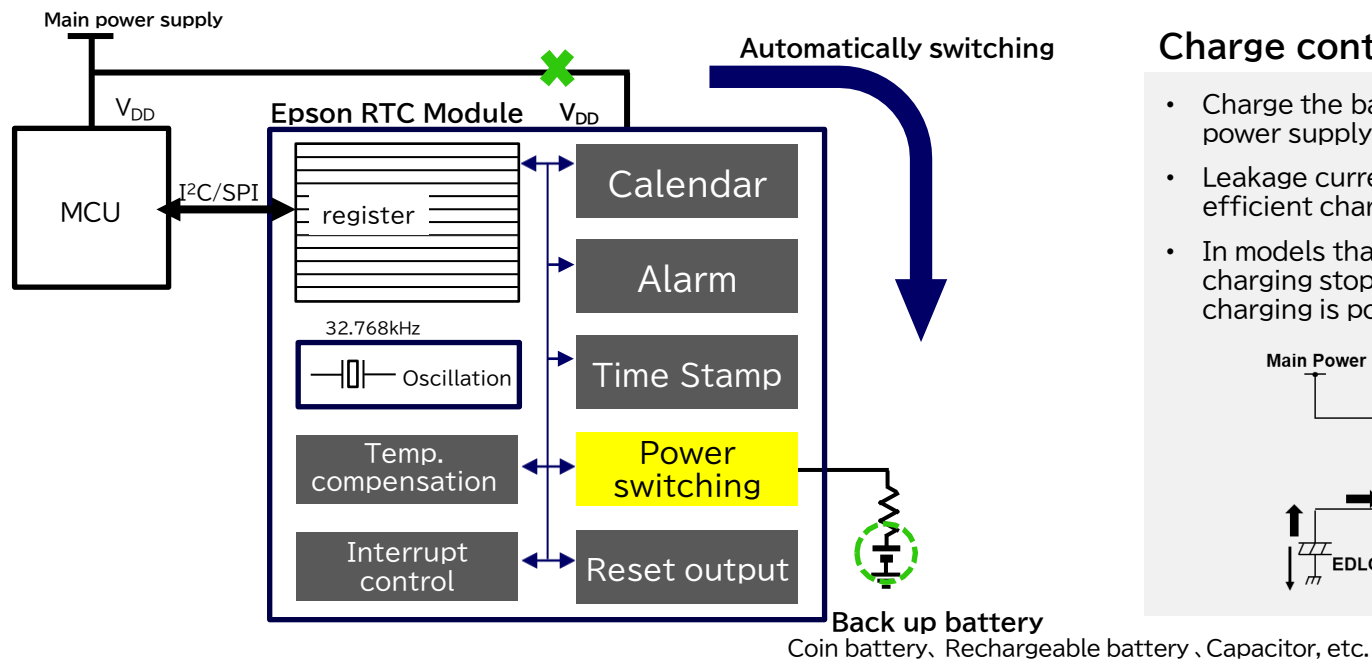
Epson RTC module

MCU

I²C

register

Calendar

Alarm

Time Stamp

32.768 kHz

Oscillation

Temp. compensation

Power switching

Reset output

Event signal

Sensors

Accelerometer: Shock detection

Proximity sensor: Open/close detection

Example of a timestamp event trigger

- EVIN pin input
- Linked to a specified self-monitoring flag in the RTC
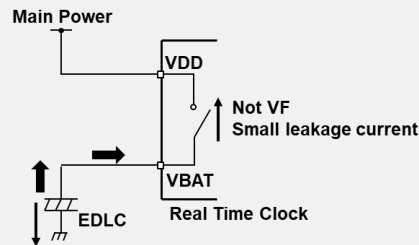- Stamp instruction access from MCU

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RTC modules monitor main power and ensure that VDD automatically switches to backup battery when the supply voltage drops. RTC detects loss of power due to unexpected power failure or destruction and switches to backup battery.

Main power supply

Automatically switching

Epson RTC Module

V_{DD}

V_{DD}

MCU

I²C/SPI

register

Calendar

Alarm

Time Stamp

32.768kHz

Oscillation

Temp. compensation

Power switching

Interrupt control

Reset output

Back up battery
Coin battery、Rechargeable battery 、Capacitor, etc.

Charge control function

- Charge the backup battery from the main power supply

- Leakage current is also minimized, enabling efficient charging

- In models that can detect a full charge, charging stops at full charge, so safe charging is possible

Main Power

VDD

Not VF
Small leakage current

EDLC

VBAT

Real Time Clock

4-3. Epson's RTC modules Use Case examples

Model	Application	Reason for Recommendation
RX8901CE RX4901CE	Security camera Infrastructure equipment, etc. Equipment installed indoors or outdoors	• **Equipped with a DTCXO (-40℃ to 105℃)** Provides highly accurate timekeeping over a wide temperature range • **Power switching function, extensive self-monitoring functions** Long-term maintenance-free, optimized battery operation time
RA8000CE RA4000CE	Automotive Industrial equipment, etc. Equipment that requires guaranteed operation in a +125℃ environment	• **Equipped with a DTCXO(-40℃ to 125℃)** High timekeeping accuracy is maintained even over a wide temperature range. • **Can operate under a high temperature condition (up to 125℃).** • **Extensive self-monitoring functions** Contributes to high system reliability
RX8111CE RX4111CE	Wearable device Battery powered device (Handy terminal, etc.) Large-scale medical equipment, etc. Equipment that is normally stored for long periods of time in warehouses, etc.	• **Low power (100nA)** Can operate on a smaller battery or capacitor. No battery replacement required for long periods of time in equipment used infrequently.
RX8804CE	General microcontrollers systems without a network connection	• **Equipped with a programmable general-purpose output port** Contributes to system GPIO design optimization • **Equipped with a DTCXO(-40℃ to 105℃)** Provides high-accuracy timekeeping as a stand-alone

DTCXO: Digital Temperature Compensated Xtal Oscillator

4-3. Epson's RTC modules Use Case examples

Model	Application	Reason for Recommendation
RX8130CE	IoT Devices Wide range of networked electronic devices	• **Backup battery charge control function** No backup battery maintenance required • **Reset output** Peripheral devices can be stabilized when system power is low
RX8900CE RX8900SA	Systems in any field that use rechargeable batteries for RTC backup Basic RTC function experimental evaluation & educational equipment	• **SOP 14-pin package** (※ RX8900SA) Easy wiring • **Equipped with a DTCXO(-40℃ to 85℃)** • **Equipped with all the basic functions of Epson 's RTC modules** Accurate clock, Power switching, Timer·Alarm, etc.
RX6110SA RX-8010SJ	When there is a minor changes of legacy products to reduce RTC current consumption	• **Interface type : SPI & I2C both** (※ RX6110SA) Connectable to most CPUs • **Easily replaces SOP 8-pin RTCs of other companies** (※ RX8010SJ) No pattern changes required, plenty of documentation for replacements available
RX-4803SA/LC RX-8803SA/LC	1-pps sync systems, IoT terminals, etc. Systems requiring mutual time synchronization	• **Equipped with synchronous input EVIN pin** Zero-clear synchronized timekeeping start for 1 sec. to 1/4096 sec. • **Equipped with a DTCXO(-40℃ to 85℃)** Provides highly accurate timekeeping in a wide temperature range

Learn more about Epson's RTCs···

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If you're interested in use cases by function or application-specific examples, we have prepared some materials for you.

You can download all of these materials by requesting them.

Document Request >

·Functions and Use Case examples

This document introduces applications that can leverage RTC functionality, along with use cases addressing related challenges and solutions.

·Solving Time Data Issue in FA Equipment

Regarding the time data in FA devices: (1) It is difficult to determine whether the time needs resetting upon device startup. (2) Error signal detection and logging are required even when the system is stopped. (3) The time may deviate due to device heat generation. This material explains how to use the RTC module to address these three issues.

·Solving Technical Issues in Security Cameras

For security cameras, accurate date and time data must be maintained even in the event of a long power outage or network outage, and the occurrence history of high-priority event signals must be maintained even when power is lost. This material explains how to use RTC modules to solve the following three problems: (1) when installed outdoors, (2) the temperature changes rapidly, and (3) time accuracy cannot be maintained.