# Tamper Detection using a RTC Module

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[Summary]

In recent years, the use of the IoT has increased convenience by connecting various things to things via the Internet, allowing home appliances to be operated with a smartphone or voice, and in the business scene, collecting information on the frequency of use of products and services by users to improve products and services. However, it also contains a lot of personal information, and security is becoming increasingly important to prevent information leaks due to product modification or tampering by people with malicious intent. To prevent this, a tamper detect feature is an effective countermeasure to protect personal information and enhance security. Real time clock (RTC) module is able to provide tamper detect protection and security with a low power consumption. The combination of Epson's RTC module RX8901CE/RX4901CE and tamper detection is explained in the following sections.

[Market Trend]

As a market trend, there are many applications that require tamper detect function. Many of the products listed below are being used for this purpose.

- IoT product
- Home appliance
- Smart meter
- Surveillance camera
- Automobile
- Office equipment such as multifunction device
- Medical equipment
- Industrial equipment
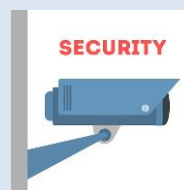
[Use Case]

In recent years, smart meters, which digitally measure and transmit usage to utility meters for electricity, gas, water, etc. using communication functions, have become increasingly popular. Since electricity data is highly confidential information about life and individuals, security is of high importance, and smart meters are an application that requires tamper detection. This smart meter is described as a use case of RTC tamper detection.

The tamper detect function is a mechanism that uses a sensor to generate a signal that indicates an abnormality when an attempt is made to disassemble or destroy the smart meter housing in order to tamper with the digital data of usage charges recorded in the microcomputer (MCU) built into the smart meter, and the signal is input to the MCU for countermeasures processing.

In addition, time management is important for smart meters in order to comply with a rate system that varies depending on the amount and time of use, and timekeeping operations must be performed even when electricity is not being measured. Therefore, it is necessary to make a system that consumes as low power as possible in order to operate for a long time using the batteries built into the smart meter. Therefore, the RTC module can be used to reduce the power consumption of the system by enabling the MCU to be turned off and the RTC module to operate

with lower power consumption than the MCU. The RTC module can receive an abnormal signal from a sensor and record the time when the abnormality occurred as time stamp data in the RTC module. The RTC module can notify the MCU that an abnormality has occurred.

Figure 1 shows an example of the tamper detect function. When an abnormality occurs, such as the cover of the smart meter being opened or the meter being removed, the abnormal signal from the sensor is input to the EVIN pin for event input of the RTC module. The time when this abnormal signal occurs is recorded in the RTC module's built-in memory as time stamp information. In addition, the RTC module's interface (I/F) pins can output an interrupt signal to the system's MCU to indicate the occurrence of an abnormality and output the time stamp information.
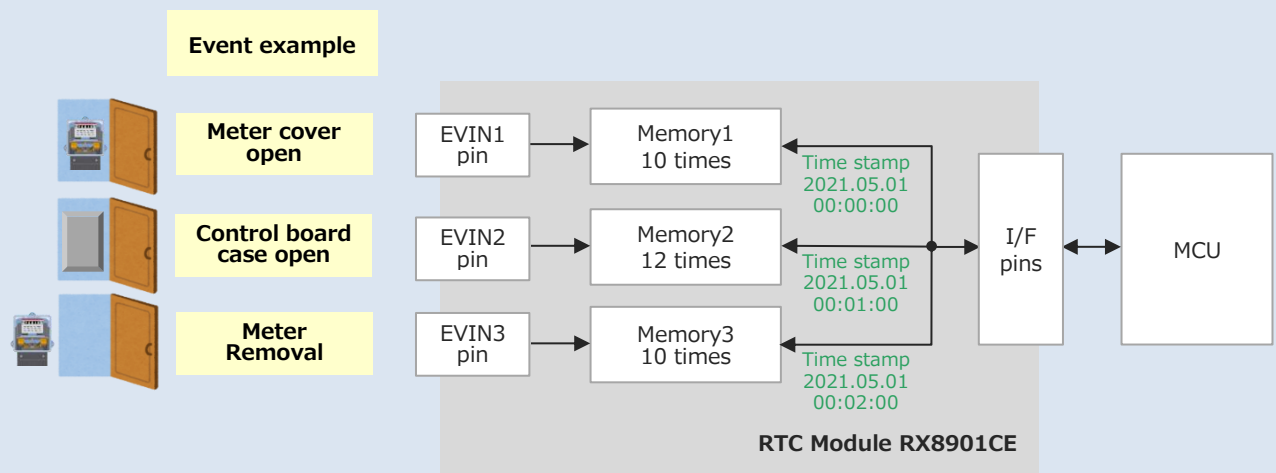

Figure 1   Example of tamper detect function

Epson's RX8901CE RTC module for I^2C-Bus I/F can use up to 3 pins, and can input the output of each sensor to EVIN1 to EVIN3 separately and record the time stamp in memory, so it is possible to distinguish which sensor has failed. In the RX4901CE RTC module for SPI-Bus I/F, the maximum number of EVIN pins that can be used is 2.
In addition, the RX8901CE/RX4901CE allows the user to select either direct mode or FIFO mode for the time stamp memory configuration. In the direct mode, a memory dedicated to each EVIN pin is prepared, so the time stamp of each individual sensor can be read out directly. FIFO mode records the time stamps of all EVIN pins in a single memory. This means that the time stamps of individual sensors cannot be distinguished until all time stamps are read out, but it allows for maximum memory usage. In Figure 1, the direct mode is selected.

[Features of the RTC module]
The RX8901CE/RX4901CE is a DTCXO (Digital Temperature Compensated X'tal Oscillator: a crystal oscillator / oscillator circuit with a function to compensate for changes in the frequency of a crystal unit with respect to temperature), with multiple functions including a power switch and up to 32 time stamps are available. Additional features includes frequency accuracy of $\pm 5 \times 10^{-6}$ / +105 °C, backup current consumption of 240 nA (Typ.), and up to 3 EVIN pins that can be used for direct event inputs, provides a highly integrated solution.

· Equipped with a 32.768 kHz DTCXO

- Interface: I^2C-Bus, SPI-Bus

- Low power consumption: 240 nA Typ. / 3 V

- High temperature operation: Ta = -40 to +105 °C

- High frequency accuracy: $\pm 3 \times 10^{-6}$ / +85 °C (±8 sec per month), $\pm 5 \times 10^{-6}$ / +105 °C (±13 sec per month)

- Automatic power switching: Monitors V_{DD}/V_{BAT} and automatically switches to backup power supply

- Time stamp: Up to 32 time stamps recorded

- Time update interrupt: Every hour, every minute, every second

- Alarm interrupt: day, date, hour, minute, second

- Fixed-cycle wake up timer interrupt

- Self-monitoring detection interrupt: crystal oscillation halt, V_{BAT} voltage drop, V_{DD} voltage drop

Table 1 shows a comparison of the characteristics of the main Epson RTC modules.

A wide range of products are available to meet customer requirements, including the RX8111CE/RX4901CE which offers lower current consumption with normal frequency accuracy, and the RA8000CE/RA4000CE which is automotive quality and supports a maximum operating temperature of +125 °C.

Table 1   Comparison of the characteristics of the Epson RTC modules

Item	RX8901CE	RX4901CE	RA8000CE	RA4000CE	RX8804CE	RX8900CE	RX8111CE	RX4111CE	RX8130CE
DTCXO	Yes	Yes	Yes	Yes	Yes	Yes	-	-	-
Interface	I^2C	SPI	I^2C	SPI	I^2C	I^2C	I^2C	SPI	I^2C
Maximum operating Temperature	+105 °C	+105 °C	+125 °C	+125 °C	+105 °C	+85 °C	+85 °C	+85 °C	+85 °C
Backup current Typ. / 3 V	240 nA	240 nA	300 nA	300 nA	350 nA	700 nA	100 nA	100 nA	300 nA
Time stamp	Yes 32 times (Max.)	Yes 32 times (Max.)	Yes 2 times	Yes 2 times	Yes 1 time	-	Yes 8 times	Yes 8 times	-
EVIN pin	Yes 2 or 3 pins	Yes 0 to 2 pins	Yes 1 or 2 pins	Yes 1 or 2 pins	Yes 1 pin	-	Yes 1 pin	-	-
Power switching	Yes	Yes	-	-	-	Yes	Yes	Yes	Yes
Reset output	-	-	Yes (optional)	Yes (optional)	-	-	-	-	Yes
Automotive grade	-	-	Available	Available	Available RA8804CE	Available RA8900CE	-	-	-

For your reference, product information of Epson's main RTC modules can be found below. *As of November 2021

(High accuracy products with DTCXO)

Industrial Applications: RX8901CE, RX4901CE, RX8804CE, RX8900CE

Automotive applications: RA8000CE, RA4000CE, RA8804CE, RA8900CE

(Normal accuracy products)

Consumer/Industrial Applications: RX8111CE, RX4111CE, RX8130CE