Epson RTC Webinar

Jan 2024

RTC for Smart Light

EPSON

Agenda

- RTC Introduction
- Epson RTC Advantage
- Applications
- RTC Functions & Features
- Epson RTC Product Lines
- RTC Selection & Sales tool
- Summary & Call to action

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RTC Introduction

# RTC Basic Concept

Independently track time

- Maintain accurate time & enable tasks at specific times.
- Play a crucial role with MCU
- Provide precise timekeeping & advanced features like: Alarms, Timers, Timestamp, and Scheduling

Electronic devices with IC & Backup battery

- Equipped with its own power source, usually a small battery
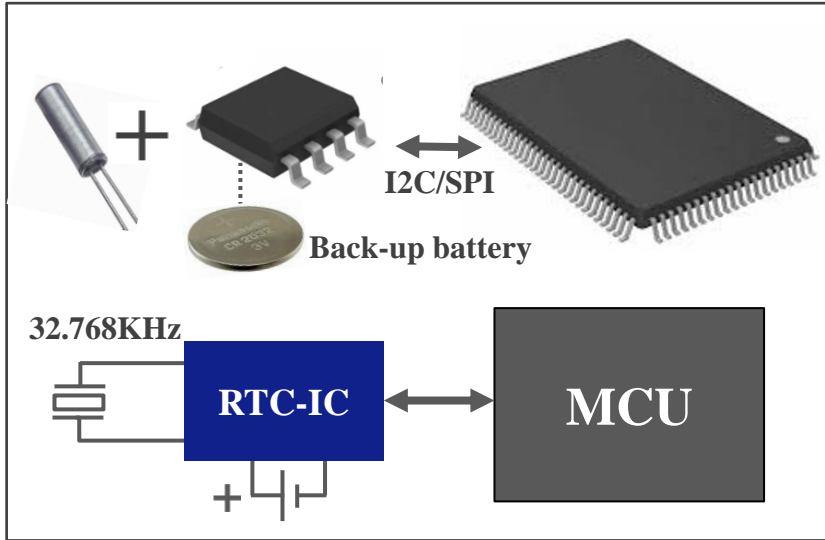- Ensuring continuous operation even when devices are off

Utilize kHz Crystal

- Ensure stable & accurate timekeeping
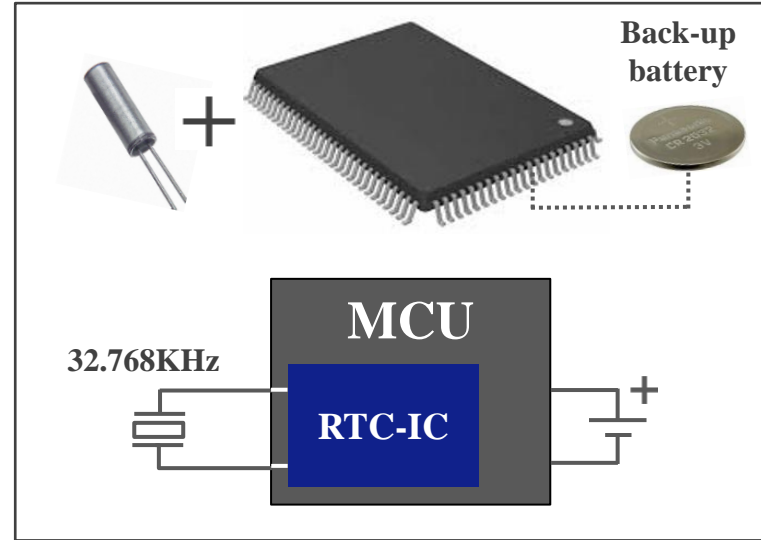- Independence and reliability are essential across diverse applications
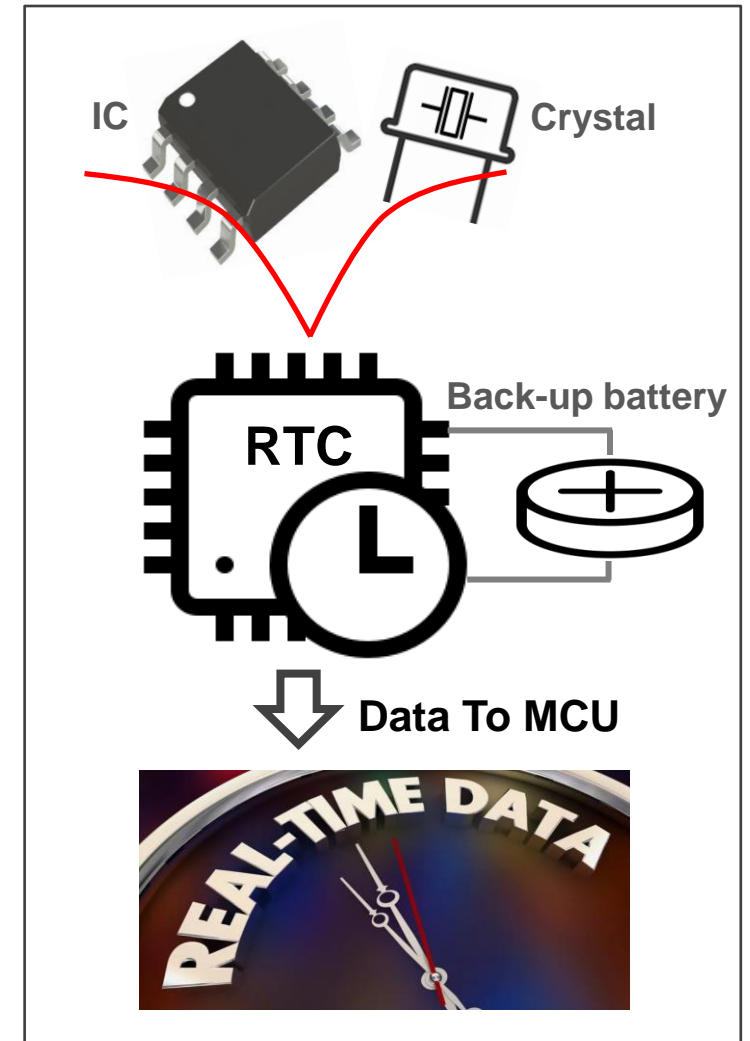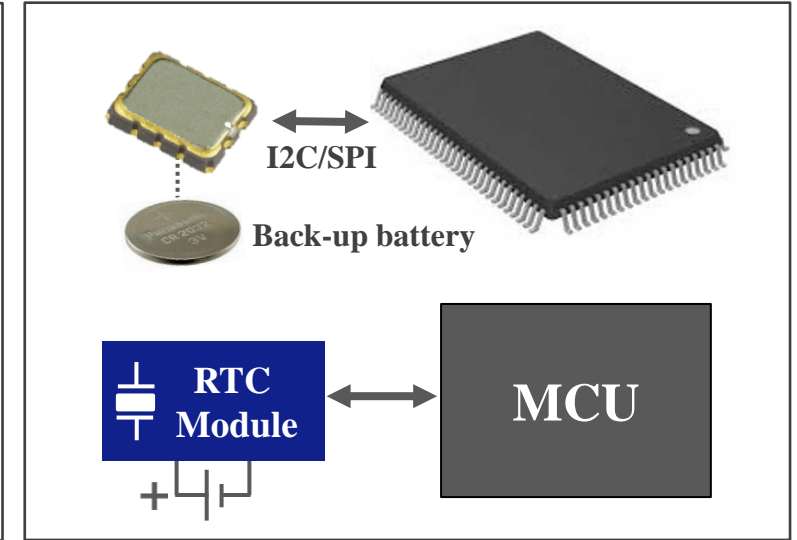
RTC Architecture Types

Standalone RTC-IC

32.768KHz

I2C/SPI

Back-up battery

RTC-IC ↔ MCU

- External Crystal to RTC-IC
- Require circuit matching
- Require I2C/SPI interface

RTC-IC in MCU

Back-up battery

32.768KHz

MCU

RTC-IC

- Integrated RTC-IC in MCU
- External Crystal to MCU
- Require circuit matching
- No I2C/SPI interface

RTC Module

I2C/SPI

Back-up battery

RTC Module ↔ MCU

Built-in crystal in RTC Module

- No circuit matching: Save design time & resources

Save Cost $$$

Major RTC Types & Comparison

	Integrated RTC in MCU	RTC Module
Major Types		
St-by Power Consumption	**Higher St-by current :** MCU maintains minimal operating for RTC	**Reduce power consumption :** RTC Module enables low-power sleep mode for MCU
Back-up Time	**Shorter Backup time :** Battery timekeeping voltage range: 3.3V to 1.6V	**Longer Backup time :** Timekeeping voltage range: 4.5V to 1.0V
Accuracy	**Lower Stability :** Tolerance from: Crystal + MCU + Stray Capacitance	**Higher Stability :** Tolerance only from RTC Module
Dependency	**Processor-Controlled Access :** Relies on host processor operation	**Operates independently of MCU :** Persistent Timekeeping during main system power-down
Calibration	**Open-Loop Calibration :** Requires validation: Matching MCU & external Crystal	**Closed Loop Calibration :** Factory Calibration and Testing in Manufacturing

Epson RTC Advantage

Epson RTC Value Proposition

- **Built-in Crystal**
  - Eliminates matching effort, enables higher accuracy,
  - Simplify designs & manufacturing process

- **Comprehensive Product Lines**
  - Package sizes, Interfaces, embedded user memories
  - Extended temp range, built-in temp sensor

- **Exceptional Performance**
  - Longer backup times than the built-in RTC in MCU
  - High accuracy with embedded temperature compensation

- **Vertical Integration**
  - ICs & Crystals: from operating fabs to final assembly/test
  - Total Quality Control, Autonomous Supply management
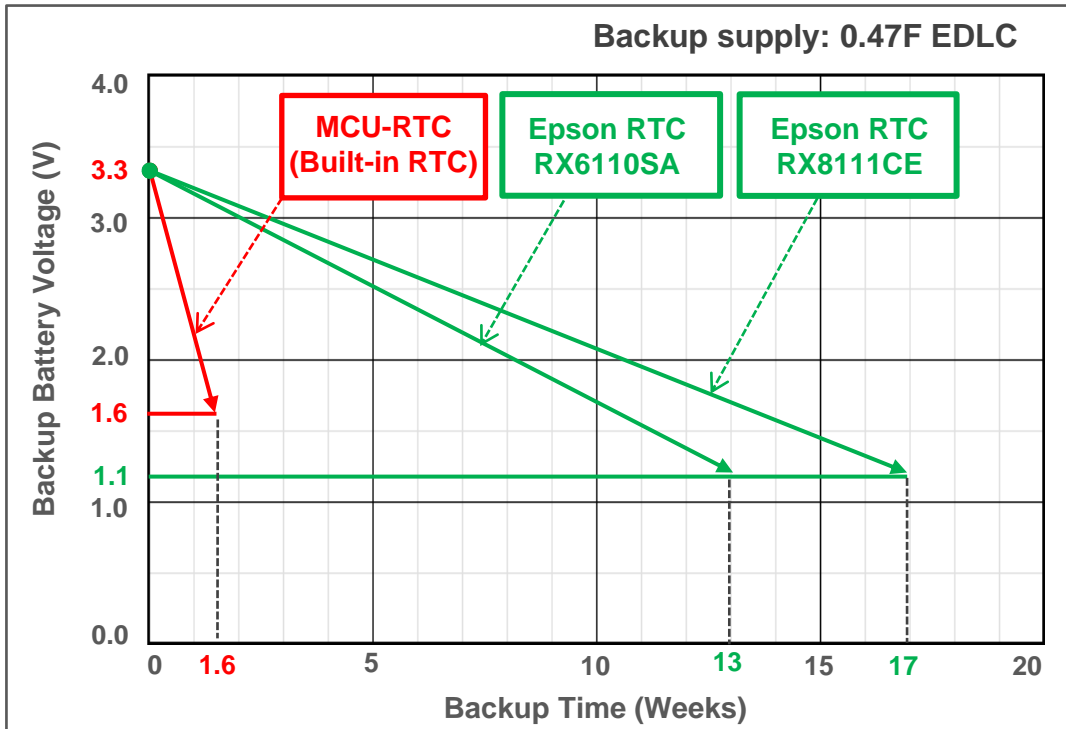
Variety of Choices ✓

- ✓ **Package sizes**
  16.3 x 12.2 to 3.2 x 2.5 mm

- ✓ **Interfaces**
  I2C or SPI

- ✓ **User memories**
  128bit to 512bit

- ✓ **Extended Temp ranges**
  -40 to +85C, +105C, +125C

- ✓ **Low Back-up current**
  0.1µA(Typ.), 0.45µA(Max.)

- ✓ **Temp. Compensation**
  ±3ppm @ -40 to +85C

Unmatched Backup Time

10 times longer than MCU-RTC

- MCU RTC (Built-in RTC)   : 1.6 weeks
- Epson RTC (RTC Module) : 17 weeks

Backup supply: 0.47F EDLC

Backup Battery Voltage (V) vs Backup Time (Weeks)

- MCU-RTC (Built-in RTC) — 3.3 V to 1.6 V at 1.6 weeks
- Epson RTC RX6110SA — 3.3 V to 1.1 V at 13 weeks
- Epson RTC RX8111CE — 3.3 V to 1.1 V at 17 weeks

* The estimated backup time does not take into account the self-discharge of the EDCs.

Major Enabler in Epson RTC

- Low Current during backup mode (I_{BACKUP})
- Wide range of backup supply voltage:
  Higher V_{START}, Lower V_{MIN}

	MCU-RTC	RX6110SA	RX8111CE
Backup battery Voltage	V_{START} 3.3 V V_{MIN} 1.6 V	V_{START} 3.3 V V_{MIN} 1.1 V	V_{START} 3.3 V V_{MIN} 1.1 V
EDLC	0.47F	0.47F	0.47F
Typ. Current in Backup mode	800nA	130nA	100nA
Backup Time	1.6 wks	13 wks.	17 wks

$$\text{Backup Time (Weeks)} = \frac{C\,(F) \times (V_{START} - V_{MIN})}{I_{BACKUP}} \times \frac{1}{3600\,(sec)} \times \frac{1}{24\,(hr)} \times \frac{1}{7\,(day)}$$

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Superior Accuracy with Temp. Compensation
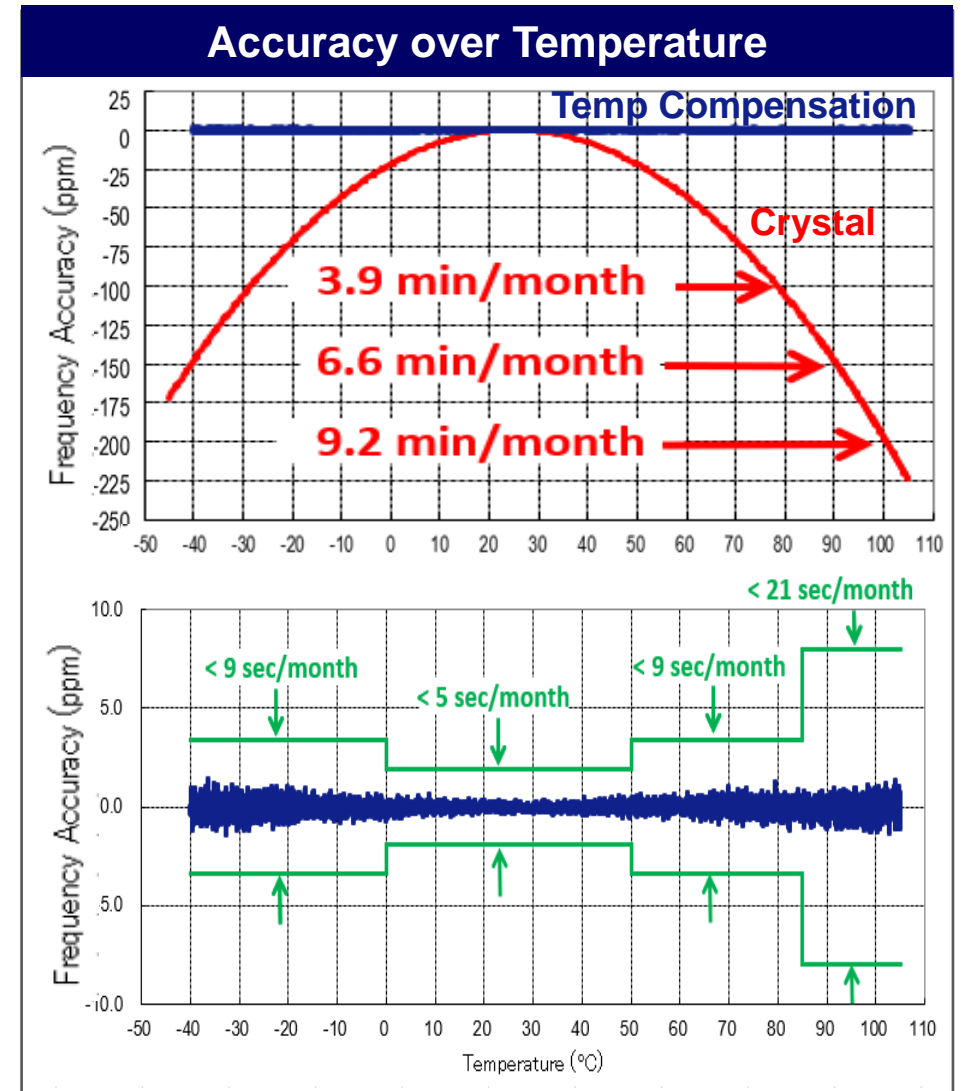
Why time error worsen over time?

- Crystal naturally drifts in frequency over time:

  Due to temperature, aging, manufacturing tolerances
- This drift causes accumulated time errors over time

Epson RTC with built-in DTCXO

- Superior Accuracy over wide temperature range
- ±3.4ppm (-40 to +85C) : 3.9min/m -> less than 0.2min/m
- ±8.0ppm (-40 to +105C): 9.2min/m -> less than 0.4min/m

** Temp compensation increases current consumption:
  - Periodic compensation to reduce consumption
  - Adjustable from every 0.5s to every 30s

Accuracy over Temperature

Temp Compensation

Crystal

3.9 min/month

6.6 min/month

9.2 min/month

< 21 sec/month

< 9 sec/month

< 5 sec/month

< 9 sec/month

Key Features Comparison

	Epson	ABLIC	ADI	MicroCrystal	Nisshinbo	NXP	STM
Built-in Crystal	√(100%)	No	√	√(100%)	No	√	√
Built-in DTCXO	√	No	√	√	No	√	√
High Stability	• ±3.0ppm (-40~85℃) • ±5.0ppm (-85~105℃)	N/A	• ±3.5ppm (-40~85℃)	• ±3ppm (-40~85℃) • ±7.0ppm (-85~105℃)	N/A	• ±3ppm (-40~85℃) • ±8.0ppm (-85~105℃)	• ±5ppm (-40~85℃)
Lowest Backup Current (Typ.) (Built-in Crystal)	Down to 100nA	Down to 250nA (External Crystal)	Down to 240nA	Down to 45nA	Down to 300nA (External Crystal)	Down to 350nA	Down to 500nA
Industrial Grade (-40~105℃)	√	√	No	√	No	√	No
Automotive AEC-Q100/200	√	√	No	√	No	√	No

Applications

RTC module Applications

FA/CNC	Medical Devices	Smart Meter	Surveillance	Smart lighting	IoT	Infotainment	BMS (*)	OBD (**)

* Battery Management System
** On Board Diagnostic system

Key Requirements

Consumer & Industrial

- Accurate Time Information
- Back-up power supply with automatic power switching
- High Stability against temperature fluctuation
- Low power consumption & Long Backup time
- Compact design for limited board space applications

Automotive

- Low power consumption when engine is off
- Maintains Clock accuracy for high temperature
- Battery charging time management
- Failure diagnosis system (Timer function)
- Guaranteed operation in high temperature

Epson's RTC Module

RX8901CE/4901CE	RX8111CE/4111CE	RX8804CE	RX8900CE	RX8130CE	RA8000CE	RA4000CE	RA8900CE	RA8804CE
240 nA, I²C/SPI	100 nA, I2C/SPI	350 nA, I2C	700 nA, I2C	300 nA, I2C	300 nA, I2C	300 nA, SPI	700 nA, I2C	350 nA, I2C
• Accurate clock (+105C)	• Time Stamp(8 times)	• Accurate clock (+105C)	• Accurate clock	• Power switching	• Wide temperature（125C)	• Wide temperature（125C)	• Accurate clock、	• Wide temperature（105C)
• Time stamp (32times)	• Power switching	• Time stamp (1time)	• Power switching	• Rechargeable battery charge management	• Accurate clock、Reset	• Accurate clock、Reset	• Power switching	• Accurate clock、Reset
• Power switching				• Reset output	• Time Stamp (2 times)	• Time Stamp (2 times)	AEC-Q200	• Time Stamp (1 times)
					AEC-Q100	AEC-Q100		AEC-Q100

Factory Automation

Use Cases

- Timer for process controls
- Timestamps to record malfunctions
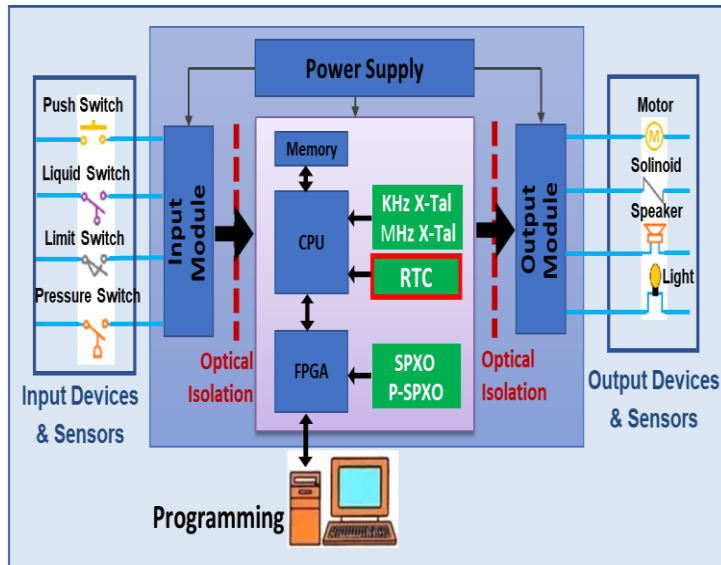- Scheduling for maintenance tasks

Epson RTC Module Benefits

- Accuracy : Minimizing errors, rework
- High Stability : Stable over temperature
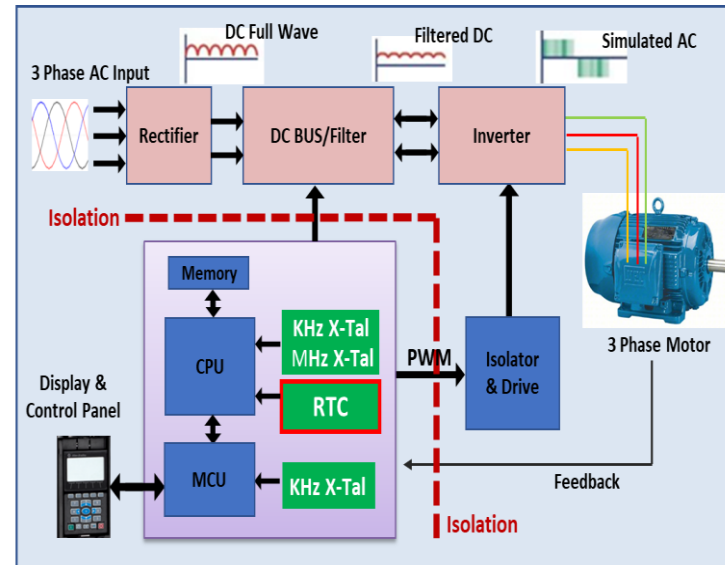- Reliability : Robust, Industrial grade

Recommended RTC

- RX8901CE
- RX8111CE
- RX8900CE
- RX4901CE
- RX4111CE
- RX8130CE

PLC: Programmable Logic Control

VFD: Variable Frequency Drive

PLC

VFD

Motor drive

Computer & HMI

Medical Devices

Use Cases

- Timekeeping: medication/therapy
- Timestamps: diagnosis/treatment
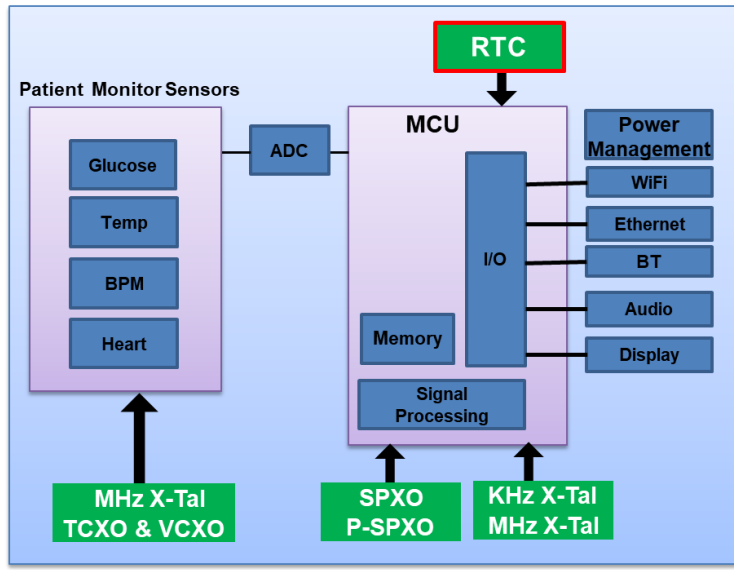- Trigger Event: when detect changes

Epson RTC Module Benefits

- Accuracy: Avoid overdoses/underdoses
- Low backup current: Longer battery life
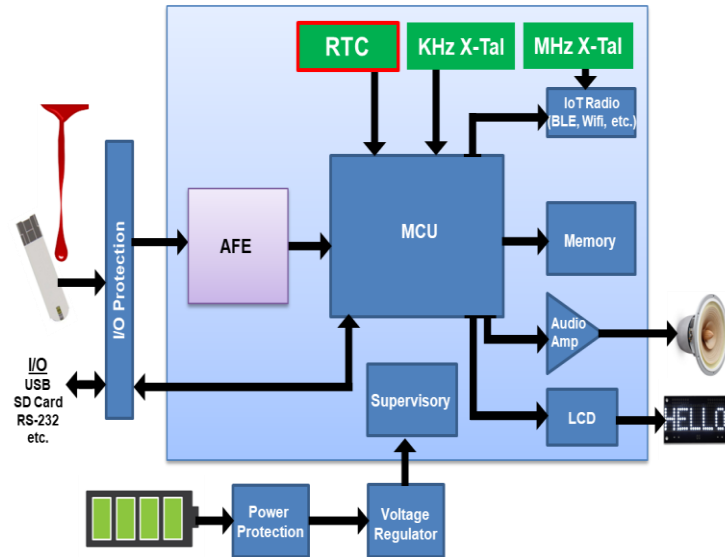- Up to 32 timestamps + extra user memory

Recommended RTC

- RX8901CE
- RX8111CE
- RX8900CE
- RX4901CE
- RX4111CE
- RX8130CE

Patient Monitor & Medical Equipment

Glucose Monitor

Patient Monitor

Infusion Pump

Pulse Oximeters

BGM

Industrial Devices: Smart Meters, Surveillance
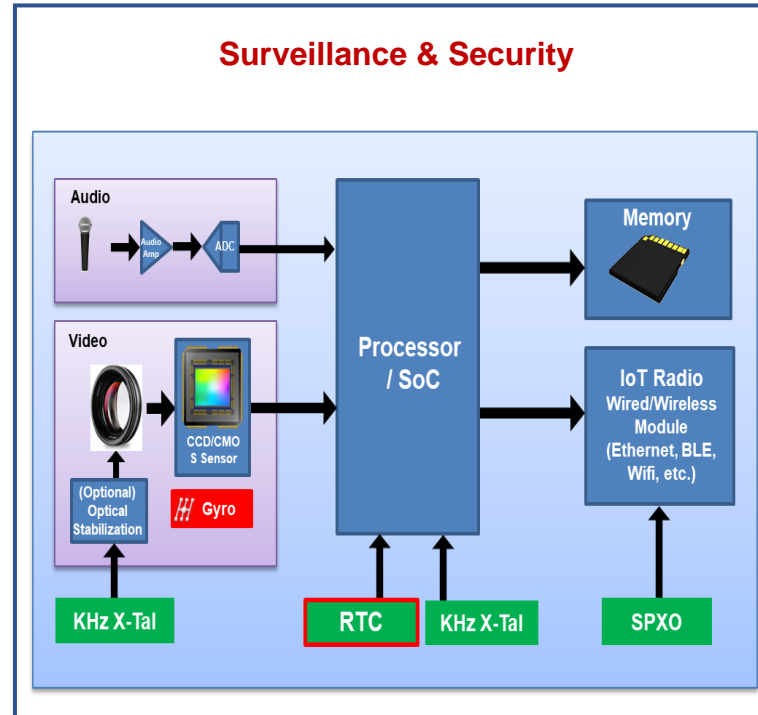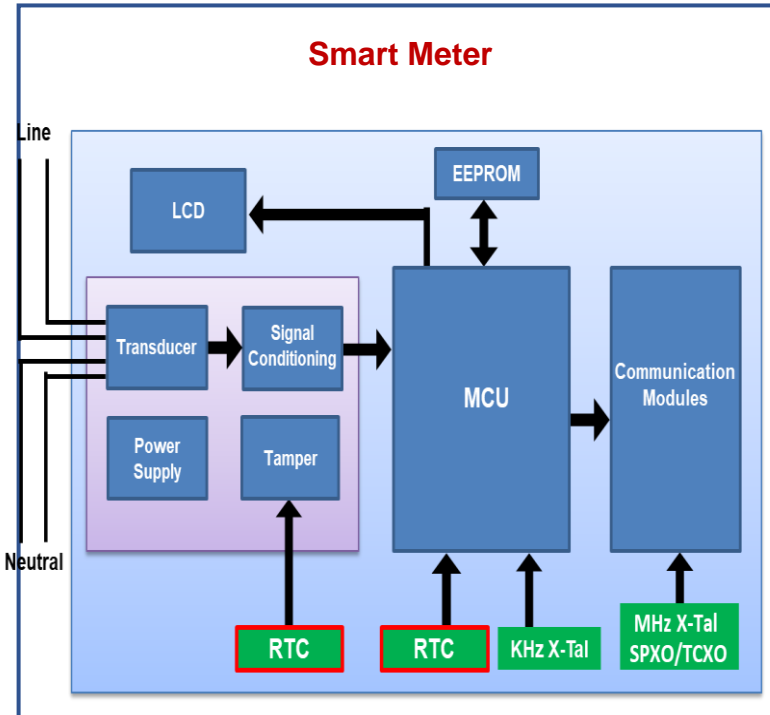
Use Cases

- Timekeeping for accurate billing
- Timestamps to monitor events
- Trigger alarms in monitored area.

Epson RTC Module Benefits

- Accurate data collection and analysis
- Ensure precise timestamps on events
- High Stability : Stable over temperature

Recommended RTC

- RX8901CE
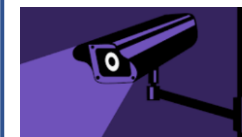- RX8111CE
- RX8900CE
- RX4901CE
- RX4111CE
- RX8130CE

Smart Meter

Surveillance & Security

Water Meter   Gas Meter   Electric Meter

Security   Surveillance

Consumer & IoT

Use Cases

- Alams, Calendar & Timers
- Timestamp for tracking operations
- Backup time while main power off

Epson RTC Module Benefits

- Accurate time synchronization
- Low backup current: Longer battery life
- Save design time, resources, cost

Recommended RTC

- RX8901CE
- RX8111CE
- RX8900CE
- RX4901CE
- RX4111CE
- RX8130CE

Home Automation

Wearables & IoT

Automotive Infotainment

Use Cases

- Timekeeping: system clock (time/calendar function)
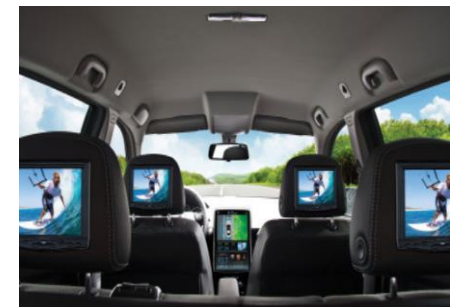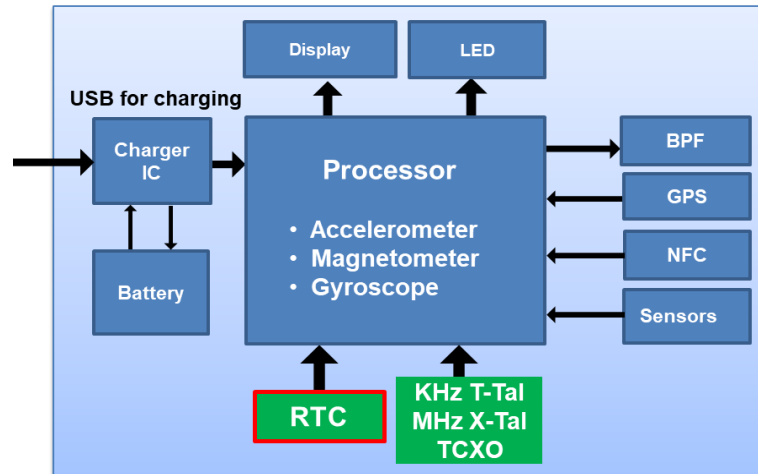- Endure harsh operation condition

Epson RTC Module Benefits

- Accurate functional operation
- Reliable & Efficient functionalities
- Enhanced Reliability: AEC-Q100/AEC-Q200

Recommended RTC

- RA8000CE
- RA8804CE
- RA4000CE
- RA8900CE

Vehicle Infotainment System Block Diagram

Automotive: Battery Management System

Use Cases

- Timekeeping: system management
- Timestamps for self monitoring
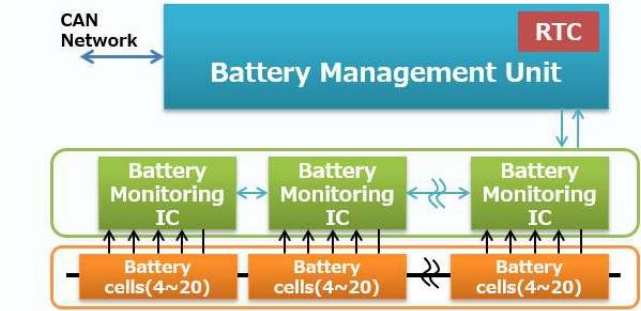- Endure harsh operation condition

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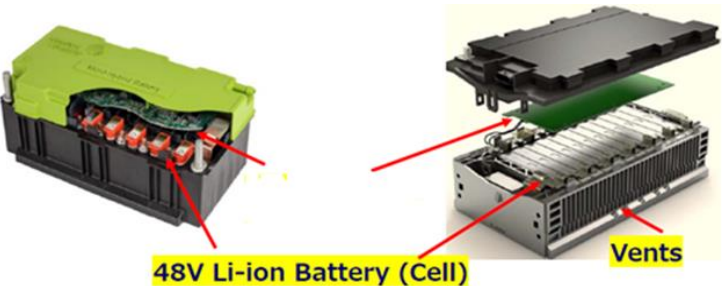- Enhanced Reliability: AEC-Q100/AEC-Q200

Recommended RTC

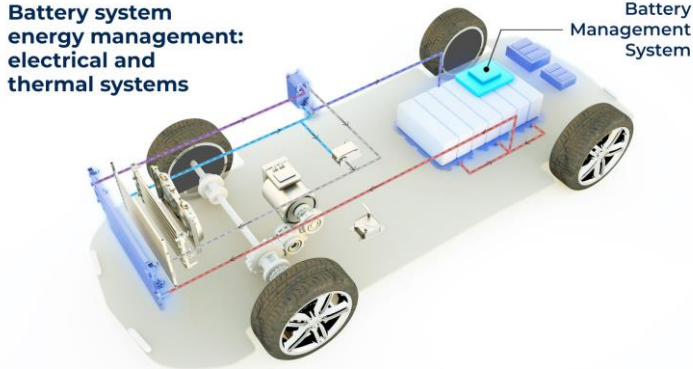- RA8000CE
- RA8804CE
- RA4000CE
- RA8900CE

Battery Management System (BMS)

CAN Network — Battery Management Unit — RTC

Battery Monitoring IC — Battery Monitoring IC — Battery Monitoring IC

Battery cells(4~20) — Battery cells(4~20) — Battery cells(4~20)

Battery Pack

48V Li-ion Battery (Cell)

Vents

Electrical Vehicle

Battery system energy management: electrical and thermal systems

Battery Management System

Automotive: Vehicle Computer Gateway

Use Cases

- Timekeeping for metering and display
- Timestamps for system checks
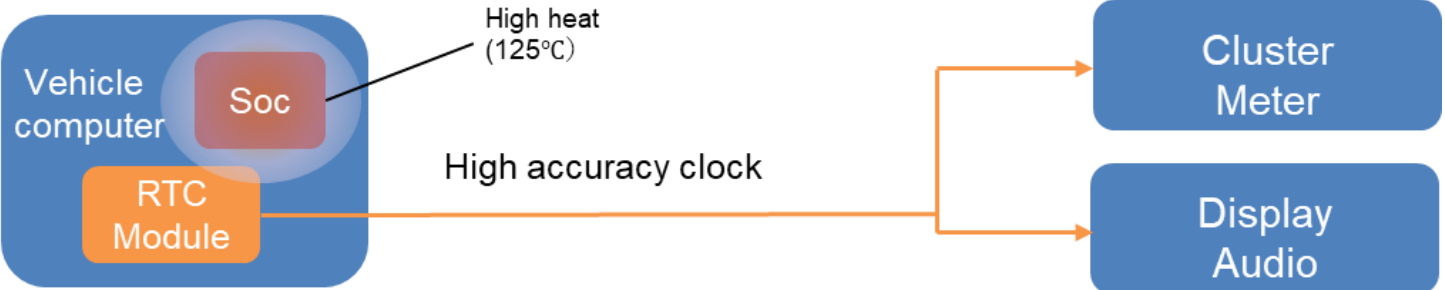- Endure harsh operation condition

Epson RTC Module Benefits

- Accurate functional operation
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- Enhanced Reliability: AEC-Q100/AEC-Q200
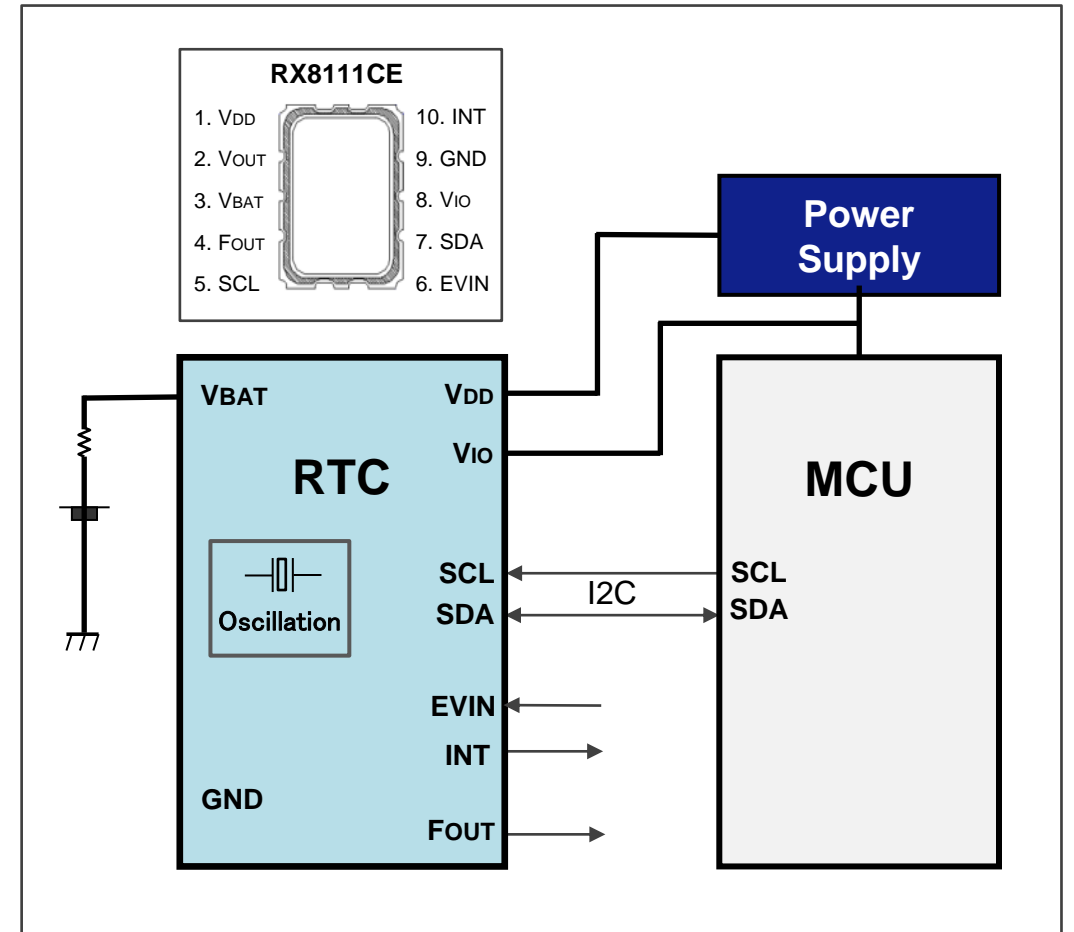
Recommended RTC

- RA8000CE
- RA4000CE

Vehicle Central Computer Gateway

RTC Features & Functions

RTC Pin In/Out Functions

RTC Pin	Functions
V_{BAT}	Backup battery supply input
V_{DD}	Power supply for internal logic
V_{IO}	Interface power supply
SCL/SDA	I2C-Bus interface with MCU
EVIN	External event input (for Time Stamp)
INT	Interrupt output by Alarm & Timer events
F_{OUT}	Frequency output. CMOS Output. Selectable 32.768 kHz, 1024 Hz, 1 Hz

RX8111CE

1. V_{DD}	10. INT
2. V_{OUT}	9. GND
3. V_{BAT}	8. V_{IO}
4. F_{OUT}	7. SDA
5. SCL	6. EVIN

RTC

Oscillation

VBAT — VDD — VIO — SCL — SDA — EVIN — INT — FOUT — GND

Power Supply

MCU

SCL — SDA — I2C
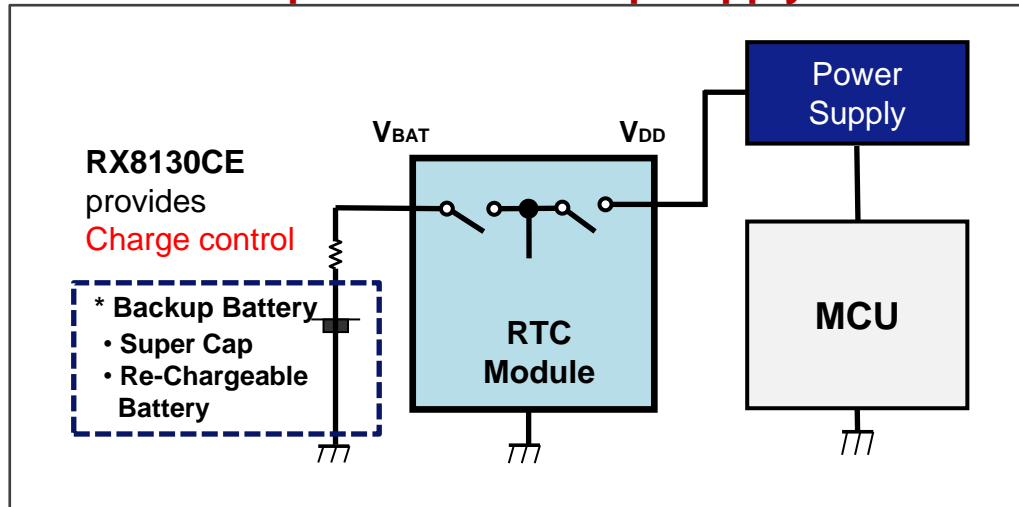
Power Switch to Backup Supply

Automatic switches when The main power supply fails

- RTC switches to backup battery automatically
- Systems start safely after short power interrupt
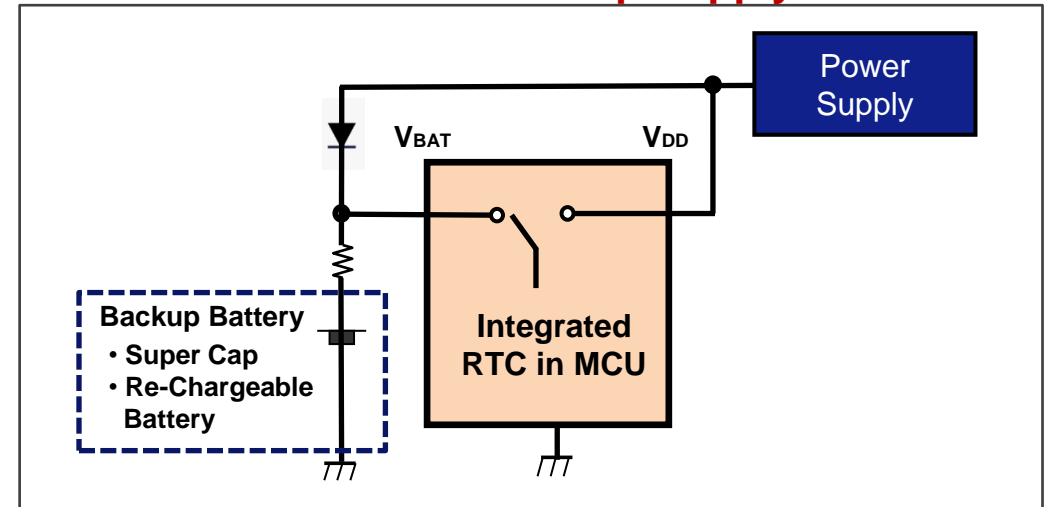- Charging the backup battery

Epson RTC Advantages: Advanced Charging Control

- Monitor charging status and Automatic Charging-stop to prevent over charging
- Charging through RTC internal routing

Epson RTC Backup Supply

RX8130CE provides Charge control

V_{BAT} V_{DD}

Power Supply

* Backup Battery
- Super Cap
- Re-Chargeable Battery

RTC Module

MCU

MCU-RTC Backup Supply

V_{BAT} V_{DD}

Power Supply

Backup Battery
- Super Cap
- Re-Chargeable Battery

Integrated RTC in MCU

* **Super-cap or Re-Chargeable Battery** Gets charged from the main power supply.
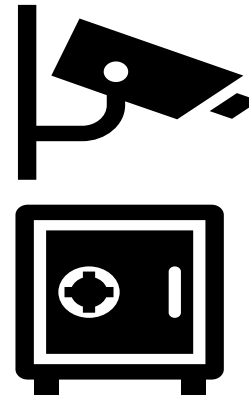
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Time Stamp

Records events from external sources

- Indicates a specific moment in time and date:
  From 1/1024 seconds to 1 year

- Detect through EVIN input pin

- Events, Track data, Logging activities in systems
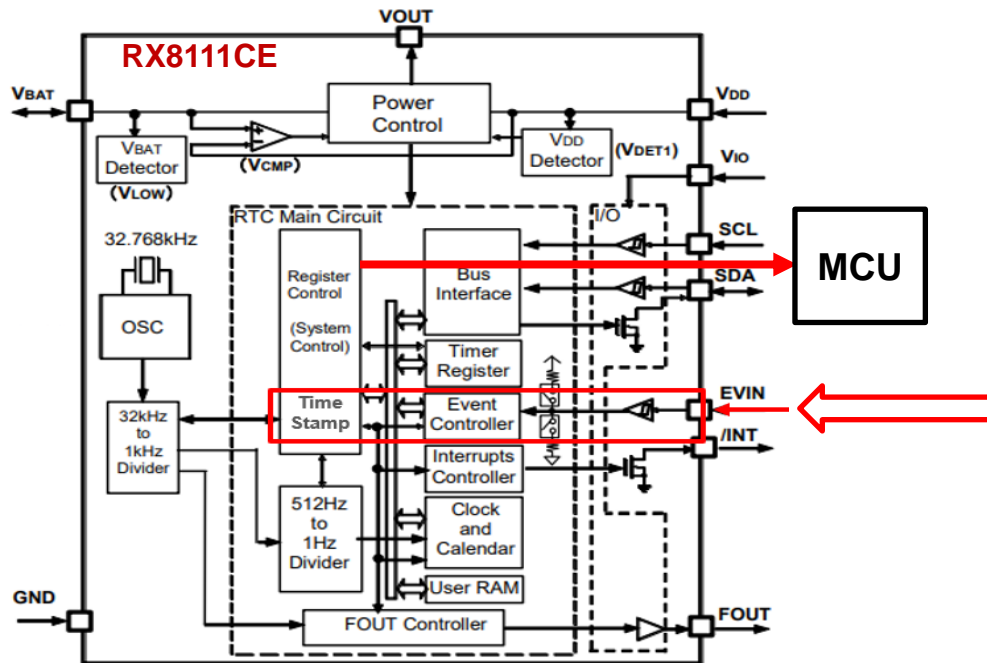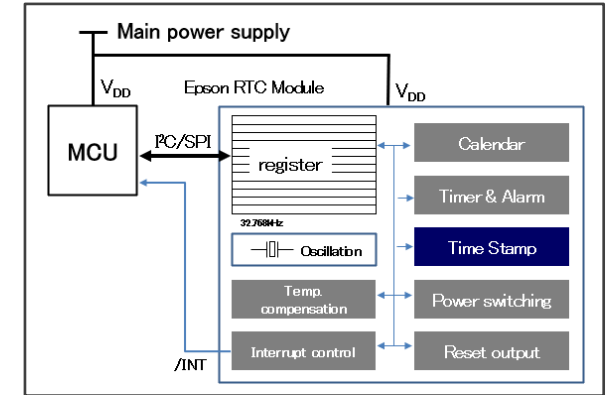

Sensor for detection

- Surveillance camera
- Security equipment
- Smart Meter
- ATM
- Open/Close detection

Alarm & Wake-up Timer

Generates Interrupt event

- Event out through INT pin (8-bit)
- Into MCU or other processors

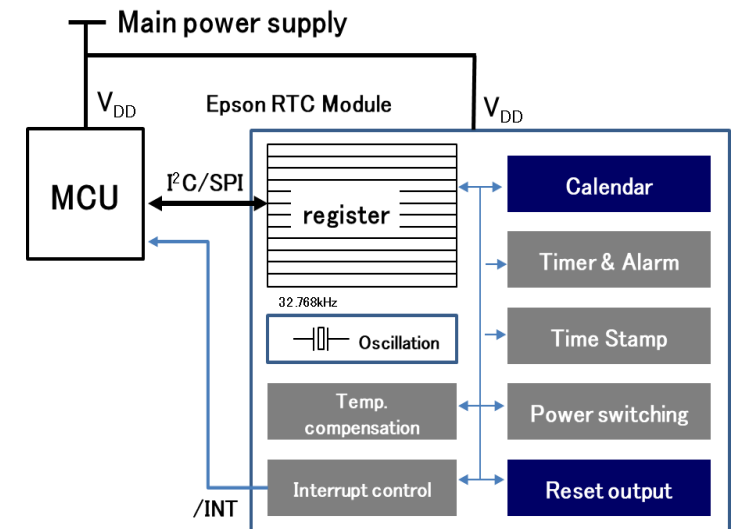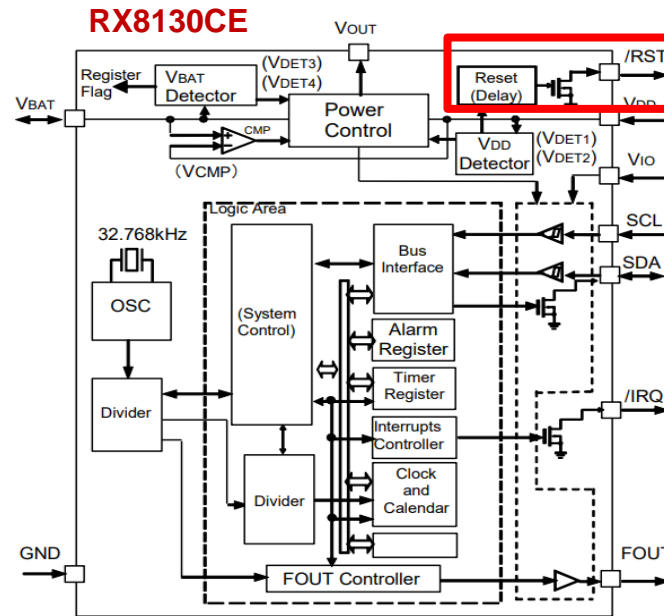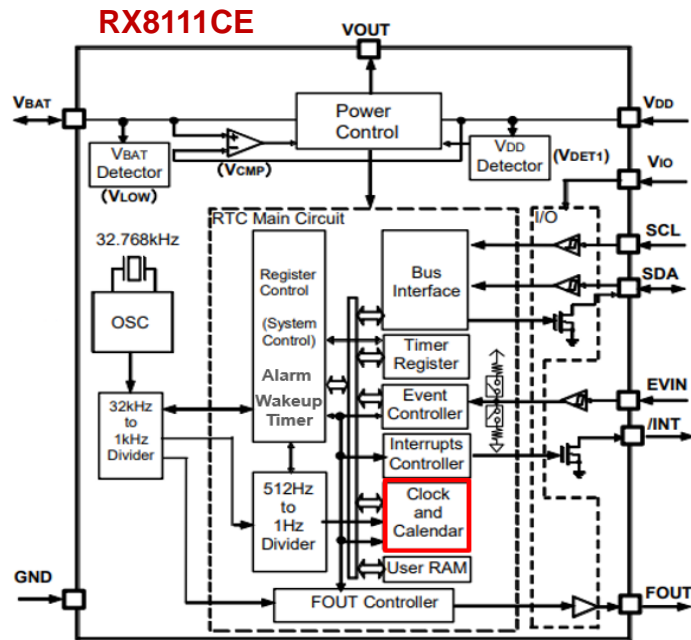|	Alarm	Wake-up Timer
Purpose	Trigger events at specific times/dates	Periodic interrupts at a specific interval
Repeatability	One-time or recurring (date, hr, min, sec)	Recurring
Primary Focus	Scheduling events at specific times	Generating regular interrupts
Common Use Cases	Scheduling tasks, triggering alerts	Regular system activity, periodic tasks, low-power wakeups
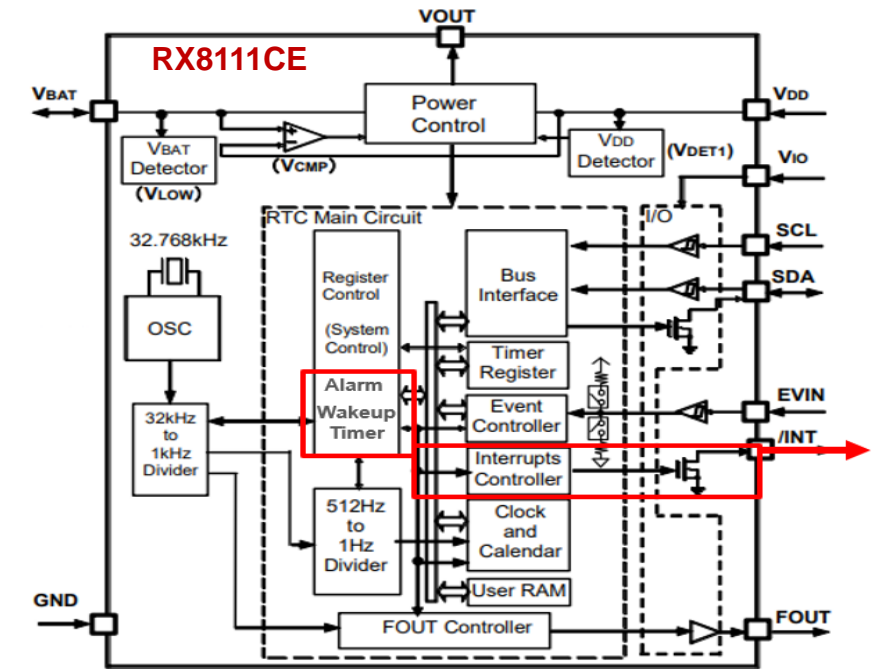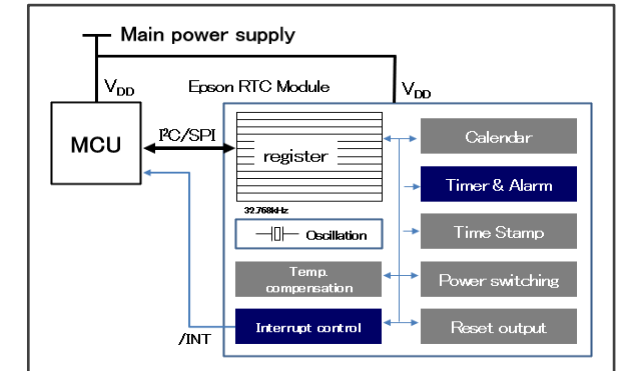
Other Features

Calendar

- RTC Basic Feature
- Clock counting for:
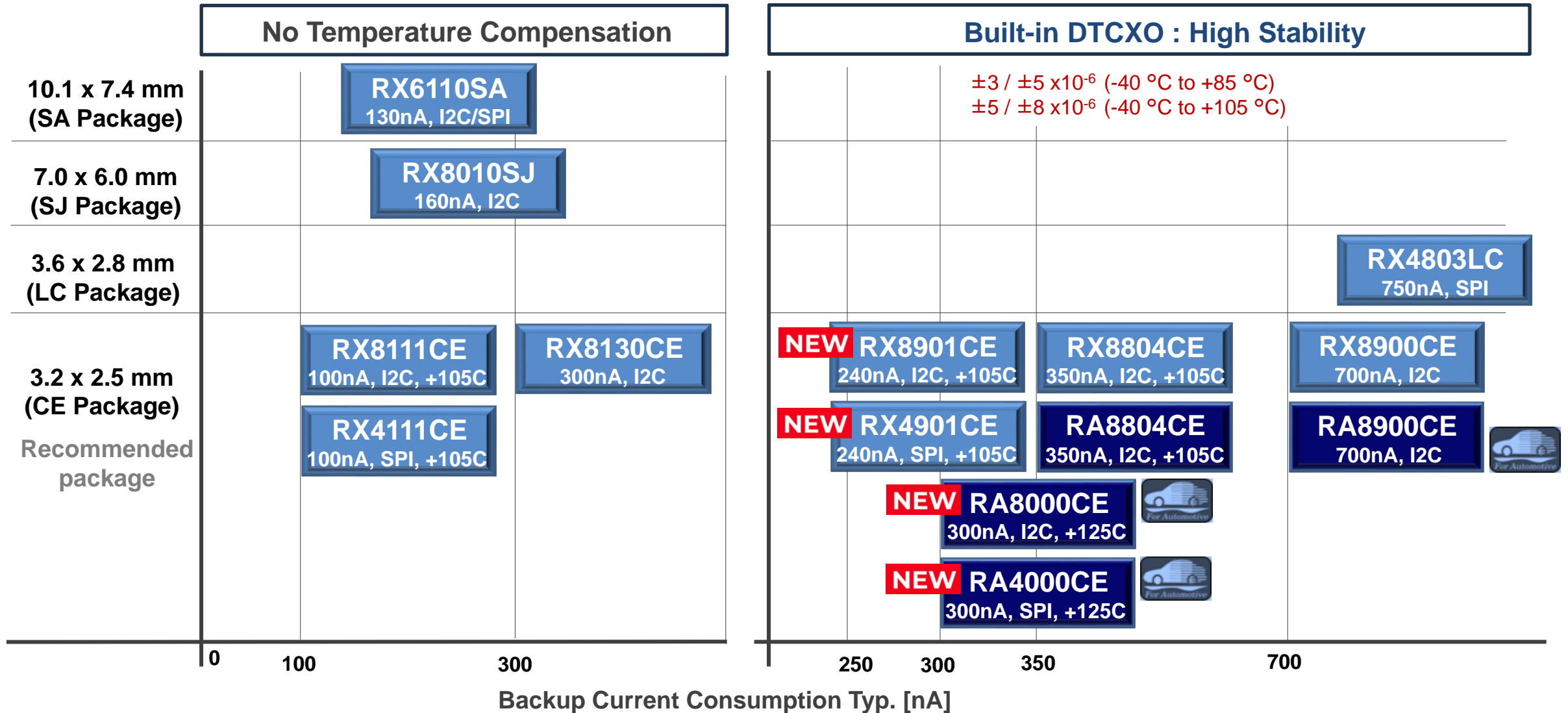 Year, Month, Date, Day, Hour, Minute, Second

Reset Control

- Monitor drop/rise in system supply voltage and output reset/reset release
- Save extra reset IC

Epson RTC Product Lines

Epson RTC Products Positioning

	No Temperature Compensation	Built-in DTCXO : High Stability
10.1 x 7.4 mm (SA Package)	**RX6110SA** 130nA, I2C/SPI	±3 / ±5 x10^{-6} (-40 °C to +85 °C) ±5 / ±8 x10^{-6} (-40 °C to +105 °C)
7.0 x 6.0 mm (SJ Package)	**RX8010SJ** 160nA, I2C	
3.6 x 2.8 mm (LC Package)		**RX4803LC** 750nA, SPI
3.2 x 2.5 mm (CE Package) Recommended package	**RX8111CE** 100nA, I2C, +105C **RX8130CE** 300nA, I2C **RX4111CE** 100nA, SPI, +105C	**NEW RX8901CE** 240nA, I2C, +105C **RX8804CE** 350nA, I2C, +105C **RX8900CE** 700nA, I2C **NEW RX4901CE** 240nA, SPI, +105C **RA8804CE** 350nA, I2C, +105C **RA8900CE** 700nA, I2C **NEW RA8000CE** 300nA, I2C, +125C **NEW RA4000CE** 300nA, SPI, +125C

0   100   300   250   300   350   700

Backup Current Consumption Typ. [nA]

Epson RTC for Consumer & Industrial

	RX8130CE	RX8111CE	RX8900CE	RX8804CE	RX8901CE
DTCXO			Yes	Yes	Yes
Interface	I²C	I²C	I²C	I²C	I²C
Operating temp. Max.	+85 ℃	+105 ℃	+85 ℃	+105 ℃	+105 ℃
Accuracy(x10⁻⁶)	B: 5 ± 23 @25℃ (±60sec/month)	A: ±11.5 @25℃ (±30sec/month) B: ±23.0 @25℃ (±60sec/month)	UA: ±3.4 @-40~+85℃ UB: ± 5.0 @-40~+85℃	XA: ± 3.4@-40~+85℃ ± 8.0@+85~+105℃ XB: ± 5.0@-40~+85℃ ± 8.0@+85~+105℃	XS: ±3.0 @-40~+85℃ ±5.0 @+85~+105℃ XB: ±5.0 @-40~+85℃ ±8.0 @+85~+105℃
Backup current Typ. / 3 V	300 nA	100 nA	700 nA	350 nA	240 nA
Time stamp (Max.)		8 times		1 time	32 times
Power switching	Yes	Yes	Yes		Yes
Reset output	Yes				
Other	Rechargeable battery charge control	SPI Interface RX4111CE	Available for Automotive RA8900CE	Available for Automotive RA8804CE	SPI Interface RX4901CE

Frequency tolerance:± 3.4 x10⁻⁶ (±9 sec/month)、± 5.0 x10⁻⁶ (±13.2 sec/month)、± 8.0 x10⁻⁶ (±21sec/m~

Epson RTC for Automotive

	RA8900CE	RA8804CE	RA8000CE (New)	RA4000CE
DTCXO	Yes	Yes	Yes	Yes
Interface	I^{2}C	I^{2}C	I^{2}C	SPI 3wire/4wire
Operating Temp. Max.	+85 °C	+105 °C	+125℃	+125℃
Accuracy (x10-6)	UA： ±3.4 @-40～+85℃ UB： ± 5.0 @-40～+85℃	XA： ± 3.4@-40～+85℃ ± 8.0@+85～+105℃ XB： ± 5.0@-40～+85℃ ± 8.0@+85～+105℃	YB： ±5.0 @-40～+85℃ ±8.0 @+85～+105℃ ±50.0 @+105～+125℃	YB： ±5.0 @-40～+85℃ ±8.0 @+85～+105℃ ±50.0 @+105～+125℃
Backup current Typ. / 3 V	700 nA	350 nA	300 nA	300 nA
Time stamp (Max.)		1 time	2 times	2 times
Power switching	Yes			
Reset output			Yes	Yes
Automotive	AEC-Q200 compliant	AEC-Q100 compliant	AEC-Q100 compliant	AEC-Q100 compliant

RTC Selection & Sales Tools

Key Parameters to Select RTC

☑ **Interface Protocol**   I2C? or SPI with MCU?

☑ **Package Size**   Prefer compact Board design ?

☑ **High Accuracy**   Critical to environmental temperature ?

☑ **Operating Temperature**   For Consumer? Industrial? Automotive ?

☑ **Back-up Current**   Require longer backup time ?c

☑ **Other Additional Features**   Timestamp, Power Switch, User memory

*   Quick brainstorm : Any customer's feedback
about any other important parameter in addition to these factors ?

Epson RTC Selection Guide

Model	Interface	Package Size (mm)	Built-in DTCXO	Tolerance (ppm)				Operating Temperature	Backup Current (µA) @ 3V		Advanced Features			Datasheet Link
				25ºC	-40 to +85ºC	+85 to +105ºC	+105 to +125ºC		Typ (@25ºC)	Max	Time Stamp	Power Switch	User Memory	
RX8901CE RX4901CE	I2C SPI	3.2 x 2.5	√	-	±3.0	±5.0	-	-40 to 105ºC	0.24	1.5	32	√	256 bit	Datasheet
RX8111CE RX4111CE	I2C SPI	3.2 x 2.5	-	±11.5	-	-	-	-40 to 105ºC	0.1	0.45	8	√	512 bit	8111 Datasheet 4111 Datasheet
RX8804CE	I2C	3.2 x 2.5	√	-	±3.4	±8.0	-	-40 to 105ºC	0.35	1.5	1	-	-	Datasheet
RX8130CE	I2C	3.2 x 2.5	-	5±23	-	-	-	-40 to 85ºC	0.3	0.5	-	√	-	Datasheet
RX8900CE	I2C	3.2 x 2.5	√	-	±3.4	-	-	-40 to 85ºC	0.7	1.4	-	√	-	Datasheet
RA8000CE (AEC-Q100) RA4000CE (AEC-Q100)	I2C SPI	3.2 x 2.5	√	-	±5.0	±8.0	±5.0	-40 to 125ºC	0.3	1.7	2	-	-	Datasheet
RA8804CE (AEC-Q100)	I2C	3.2 x 2.5	√	-	±3.4	±8.0	-	-40 to 105ºC	0.35	1.5	1	-	-	Datasheet
RA8900CE (AEC-Q200)	I2C	3.2 x 2.5	√	-	±3.4	±8.0	-	-40 to 85ºC	0.7	1.4	-	√	-	Datasheet
RX-8731LC	I2C	3.6 x 2.8	-	5±23	-	-	-	-40 to 85ºC	0.35	1.4	-	-	128 bit	Datasheet
RX-8564LC	I2C	3.6 x 2.8	-	5±23	-	-	-	-40 to 85ºC	0.275	0.7	-	-	-	Datasheet
RX-8803LC/SA RX-4803LC/SA	I2C SPI	3.6 x 2.8 10.1 x 7.4	√	-	±3.4	-	-	-40 to 85ºC	0.75	2.1	-	-	-	Datasheet
RX-8035LC/SA RX-4035LC/SA	I2C SPI	3.6 x 2.8 10.1 x 7.4	-	±5.0	-	-	-	-40 to 85ºC	0.4	1.2	1 / -	√ / -	-	8035 Datasheet 4035 Datasheet
RX-8571LC/NB/SA RX-4571LC/NB/SA	I2C SPI	3.6 x 2.8 6.3 x 5.2 10.1 x 7.4	-	5±23	-	-	-	-40 to 85ºC	0.22 / 0.32	0.4 / 0.95	-	-	128 bit / -	8571 Datasheet 4571 Datasheet
RX-8025NB/SA RX-4045NB/SA	I2C SPI	6.3 x 5.2 10.1 x 7.4	-	±5.0	-	-	-	-40 to 85ºC	0.48	1.2	-	-	-	8025 Datasheet 4045 Datasheet
RX8010SJ	I2C	7.0 x 6.0	-	5±23	-	-	-	-40 to 85ºC	0.16	0.32	-	-	128 bit	Datasheet
RX8900SA	I2C	10.1 x 7.4	√	-	±3.4	-	-	-40 to 85ºC	0.7	1.4	-	√	-	Datasheet
RX6110SA	SPI & I2C	10.1 x 7.4	-	5±23	-	-	-	-40 to 85ºC	0.16	0.32	-	√	128 bit	Datasheet

Recommended Package

LC: 3.6 x 2.8 mm,   NB: 6.3 x 5.2,   SA: 7.0 x 6.0 mm

Products Information in Epson Website

Convenient to Search

- **Parametric Search**
- **Datasheet**
- **RoHS/REACH**
- **Development Tools**
- **Technical Note**
- **White paper**
- **Videos**

Contents in Public

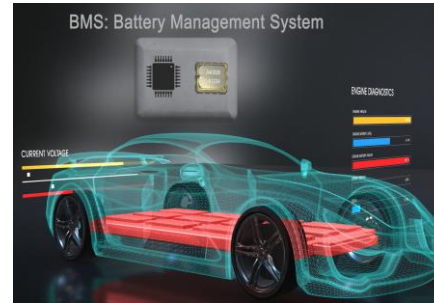 YouTube

RTC Module use case :
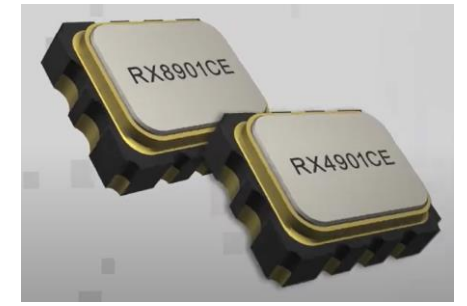**Smart Street Light** Link

RTC Module use case :
FA machine Link

RTC Module use case :
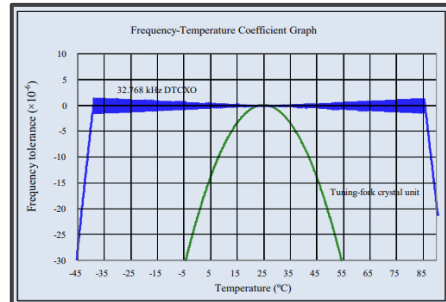**Security** Link

RTC Module use case :
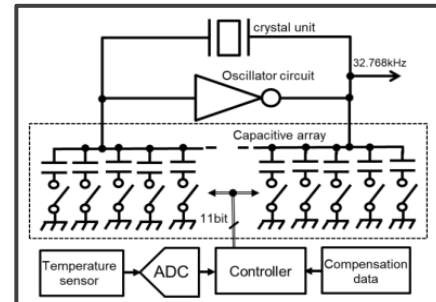**BMS** Link
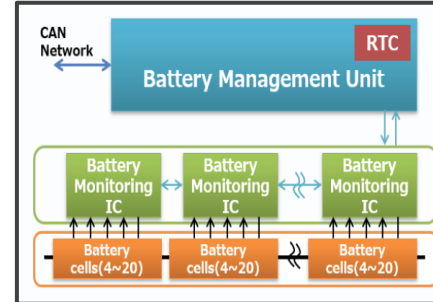
High-Accuracy RTC Module :
RX8901CE, RX4901CE Link

White Papers

RTC Module Features with
Built-in Digital TCXO Link
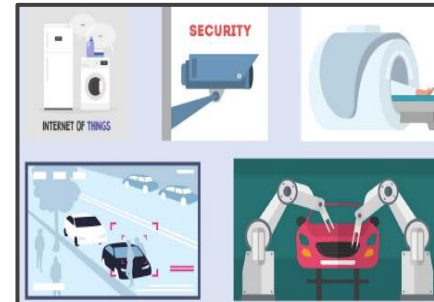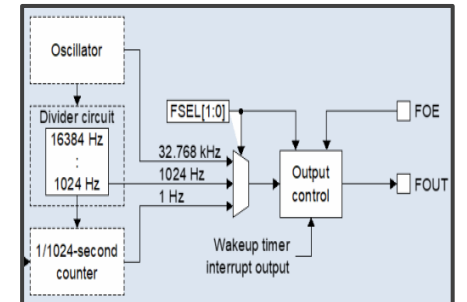
DTCXO Timekeeping
Accuracy Link

RTC Module Benefits in
Automotive BMS Link

Tamper Detection using
RTC Module Link

RTC sub second functions and
applications Link

EPSON

Contact information

For Questions and Technical Support
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Takeaways

Epson provides Epson provides Epson provides Epson provides Epson provides Epson provides

- Best-in-class performance

- Geared up with a full range of options

- Entire deliverables for seamless design

- Real Time Response & Support

- 7/24 contact window

Thank You