congatec Application Note

Affected Products	All congatec products featuring RTC
Subject	RTC Battery Know-How and Calculations
Confidential/Public	Public
Author	SDA

Revision History

Revision	Date (yyyy-mm-dd)	Author	Changes
1.0	2006-10-04	RCH	Initial Release
1.1	2017-03-14	SDA	Completely revised
1.2	2022-10-04	ZZD	Corrected units
1.3	2024-01-17	HJI	Updated subject, preface, and terminology Moved content of section 1 and section 3 to section 2 Changed section 1 from “Introduction” to “RTC Know-How”

Preface

This application note provides general information about Real-Time Clock (RTC). Additionally, it explains how to calculate the maximum battery service time when a specific RTC circuit battery type must be used and how to determine the required RTC circuit battery capacity when a specific battery service time is required.

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Symbols

The following are symbols used in this application note.

Note

Notes call attention to important information that should be observed.

Caution

Cautions warn the user about how to prevent damage to hardware or loss of data.

Warning

Warnings indicate that personal injury can occur if the information is not observed.

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Terminology

Term	Description
CMOS	Complementary Metal-Oxide-Semiconductor
NTP	Network Time Protocol
POST	Power-On Self-Test
RTC	Real Time Clock – battery backed circuit in PC-AT systems that keeps system time and date as well as certain system setup parameters. when the computer is not powered. It is normally supplied by a battery.
SNTP	Simple Network Time Protocol

1 RTC Know-How

This section provides general knowledge about Real-Time Clock (RTC) batteries.

1.1 RTC Battery Purpose

The RTC battery, also known as the Complementary Metal-Oxide-Semiconductor (CMOS) battery, powers the RTC and CMOS memory chip when the main power source is off or disconnected. This ensures that the RTC continues to track time and that critical system settings.

1.2 Systems Without an RTC Battery

Systems without an RTC Battery can experience the following issues:

- Loss of Time and Date: The system will lose time and date once RTC Battery is not connected.

- BIOS Errors: The system may display error messages during the boot process related to the CMOS or RTC, indicating that the system's timekeeping and configuration settings are not functioning correctly.

- Boot Delay: In case of missing RTC Battery, the system boot time may extend due to multiple restarts during the Power-On Self-Test (POST) process.

1.3 RTC Battery Alternatives

Supercapacitors and integrated rechargeable batteries can serve as alternatives to standard non-rechargeable RTC batteries, each with its own set of advantages and disadvantages:

- **Supercapacitors:** These offer high energy storage and a long lifespan, charging quickly and supporting up to a million cycles. However, they have a much lower energy density and higher self-discharge rate compared to lithium-ion batteries, making them less suitable for long-term backup.

- **Integrated Rechargeable Batteries:** These can be recharged when the main power source is connected and are suitable for devices with higher power demands or longer backup requirements, though they require recharging after extended periods.

1.4 RTC Clock Deviation

The RTC time deviation at specific temperatures can vary depending on the RTC device. RTC devices typically have a specified accuracy or tolerance, indicating the maximum allowable deviation from the actual time.

RTC devices may include temperature compensation features that help maintain accurate timekeeping across different temperature ranges. Refer to the technical documentation provided by the RTC device manufacturer to determine the RTC time deviation allowed at certain temperatures.

1.5 Clock Deviation at Extended Temperature

Clock deviation at extended temperatures refers to how much the time of an RTC device may drift when it operates outside its normal temperature range.

For example, an RTC device may have an accuracy of ±10 seconds per month at temperatures between -20°C and +70°C. This means the RTC can run up to 10 seconds faster or slower per month within this extended temperature range.

1.6 RTC Power Supply Voltage Connection

The RTC power supply voltage (VCC_RTC) is typically connected on the module and should be implemented on the carrier board according to the module's specifications and design guidelines.

1.7 RTC Power Supply Voltage Protection Diode and Resistors

A protection diode is typically used to prevent reverse voltage or voltage spikes from damaging the RTC and CMOS memory. A resistor is often used for current limiting or impedance matching purposes.

Refer to the module's documentation to understand how the protection diode and resistor are implemented and whether any additional components are required on the carrier board.

1.8 Minimum RTC Battery Voltage

The minimum RTC battery voltage for an RTC device can vary depending on the manufacturer and design. It is crucial to refer to the technical documentation.

Caution

If the RTC battery voltage drops below the specified level, it can result in inaccurate timekeeping and loss of data.

1.9 RTC Time Synchronization

The RTC time can be synchronized via the network using protocols like the Network Time Protocol (NTP) or Simple Network Time Protocol (SNTP). By default, both Windows and Linux are typically configured for automatic time synchronization, but manual options are available:

- Automatic Synchronization During Boot:
  - Windows: Windows operating systems typically have built-in NTP client functionality. During boot, Windows attempts to synchronize the system's RTC time with a network time server.
  - Linux: Linux distributions often include NTP or SNTP client software. During boot, Linux initiates the time synchronization process with a configured time server.

- Manual Synchronization:
  - Windows: You can manually sync the RTC time by going to the Date and Time settings and clicking on the "Sync now" or "Update now" button, triggering immediate synchronization with the configured time server.
  - Linux: In Linux, you can use the *ntpdate* or *chronyc* commands to manually synchronize the RTC time with a time server. For example, *sudo ntpdate time.server.com* or *sudo chronyc -a burst 4/4* can be used to initiate manual synchronization.

2 How to Calculate

Section 2.1 shows how to calculate the maximum battery lifetime of a specific battery. Section 2.2 shows how to calculate the nominal capacity of a specific battery.

For detailed information about the power consumption of the RTC circuit on the various congatec products, refer to respective User's Guide on the congatec website at www.congatec.com

The RTC battery power consumption value is a measured value and may differ from the value listed in the chipset datasheet. The measurement for COMs is carried out with a congatec evaluation carrier board and therefore only valid with this setup.

To get the most accurate value for the RTC battery power consumption, it is recommended to perform the measurement with customer's carrier board and in worst case situation. This means you should measure the value when the board is in G3 mode (mechanical off – no AC power connected), at highest specified ambient temperature and when a new RTC battery is connected.

2.1 Calculating the Maximum Battery Lifetime

The maximum lifetime of a battery supplying the RTC circuitry when AC power is switched off can be calculated by using following formula:

$$t_{\max} = \frac{Bat_{\mathrm{NomCap}}}{24 \times 365 \times I_{\mathrm{BatMax}}} \times 0.8$$

t_{max}: Maximum battery lifetime [years].

Bat_{NomCap}: Nominal capacity of the installed battery [Ah].

I_{BatMax}: Maximum RTC battery current [A].

Caution

The lifetime of the battery begins at the date of manufacturing. The RTC starts as soon as the battery is installed to the system. Additionally, the battery will discharge even when it is not installed to a system. If a battery is not installed to a system, the nominal capacity will be decreased by approximately 1% per year.

Note

Factor 0.8 considers the external impacts that can affect the battery lifetime. This factor can vary from 0.7 to 0.9 depending on the battery and operating conditions.

2.2 Calculating the Nominal Battery Capacity

The nominal capacity of the battery supplying the RTC circuitry when AC power is switched off can be calculated by using following formula:

$$Bat_{\mathrm{NomCap}} = t_{\mathrm{min}} \times 24 \times 365 \times I_{\mathrm{BatMax}} \times 1.2$$

Bat_{NomCap}:	Nominal capacity of the installed battery [Ah].
t_{min}:	Minimum battery lifetime [years].
I_{BatMax}:	Maximum RTC battery current [A].

Note

Factor 1.2 considers the external impacts that can affect the battery lifetime. This factor can vary from 1.1 to 1.3 depending on the battery and operating conditions.

2.3 Example: Specified Battery Lifetime

This example shows how to calculate the maximum battery lifetime for a specified battery type. The values used in this example are typical.

Battery type:	CR 2032
Nominal battery voltage:	3V
Nominal capacity Bat_{NomCap}:	230 mAh
Maximum RTC battery current:	2.5 µA

$$t_{\mathrm{max}} = \frac{Bat_{\mathrm{NomCap}}}{24 \times 365 \times I_{\mathrm{BatMax}}} \times 0.8$$

$$t_{\mathrm{max}} = \frac{230 * 10^{-3}}{24 \times 365 \times 2.5 * 10^{-6}} \times 0.8$$

$$t_{\mathrm{max}} = 8.4\ years$$

2.4 Example: Specified Service Time

This example shows how to calculate the nominal battery capacity for a defined battery lifetime. The values used in this example are typical.

Required service time for battery:	15 years
Nominal battery voltage:	3V
Maximum RTC battery current:	3 µA

$$Bat_{\mathrm{NomCap}} = t_{\mathrm{min}} \times 24 \times 365 \times I_{\mathrm{BatMax}} \times 1.2$$

$$Bat_{\mathrm{NomCap}} = 15 \times 24 \times 365 \times 3 * 10^{-6} \times 1.2$$

$$Bat_{\mathrm{NomCap}} = 0.47304\ Ah = 473.04\ mAh$$

➔ The battery should have a nominal capacity equal to or greater than 473.04 mAh (e.g., the Panasonic CR2477).

Note

If you plan to use batteries for a longer service time, ensure that the battery is new and has its full nominal capacity. Batteries stored for a long time should not be used.