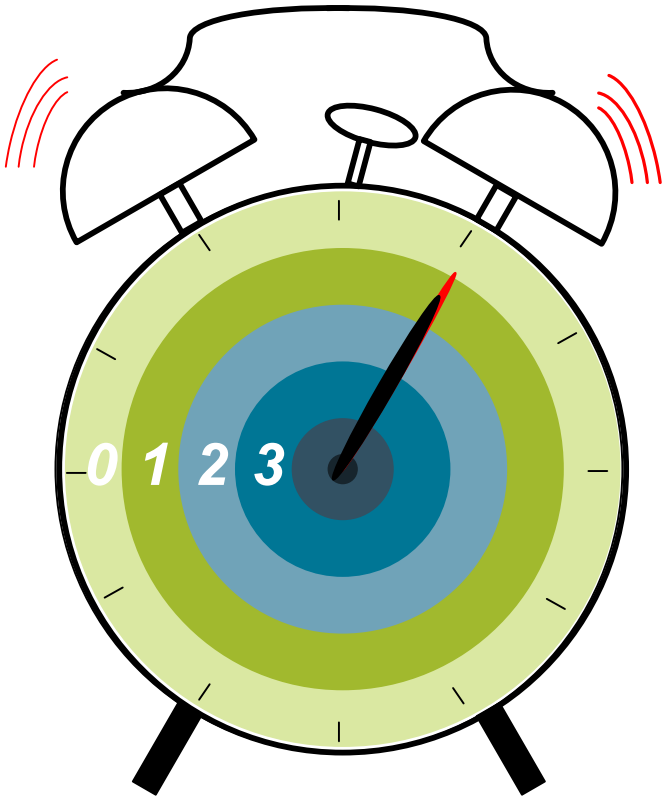
AN0005: EFM32 Real Time Counters

This application note describes the RTC, RTCC and the Backup RTC (BURTC). The software examples include how to use the RTC, RTCC and the BURTC to wake up from Energy Mode 2 (EM2).

The software examples focus on generating periodic event with real time counters and timekeeping with real time counter and calendar.

KEY POINTS

- Features vary slightly between the RTC, RTCC, and BURTC.
- The RTCDRV is a high-level library that easily enables use of the RTC and RTCC.
- This application note includes:
  - This PDF document
  - Source files
  - Example C code
  - Multiple IDE projects



1. Real Time Counters

1.1 General

Many microcontroller applications have long time intervals in which almost no activity is required. In order to save energy, these intervals should be spent in an appropriate sleep mode. The EFM32 features several such modes, including Energy Mode 2 (EM2). In this mode, the core and high-speed peripherals are shut down, whereas low-energy peripherals such as LCD, LEUART and RTC may be enabled. These peripherals run on a low-frequency oscillator, hence their current consumption is very low. The RTC can be used to keep track of time and to wake up while in sleep mode.

1.2 Comparison

The Gecko has three different real time counters: the RTC, RTCC, and the Backup RTC (BURTC). The Real Time Counter and Calendar (RTCC) includes a calendar mode for easy time and date keeping. The RTCC also includes 128 bytes of general purpose retention data, allowing persistent data storage in all energy modes except EM4S. The RTCC is only available in the Jade, Pearl, and Wireless Gecko families. The BURTC uses less power than the RTC and also works in the backup power domain. The backup power domain allows the Gecko to be powered by a reserve power supply if a main power brownout should occur. In this mode, the device still has access to the BURTC and 512 bytes of retention memory. For more information, see application note *AN0041: Backup Power Domain*. The BURTC and the backup power domain is only available on the Giant, Leopard, and Wonder Gecko families.

The RTC, RTCC and the BURTC can be clocked from a 32.768 kHz crystal oscillator, a 32.768 kHz RC oscillator, or the 2 kHz Ultra Low Frequency RC Oscillator (except EFM32G family) which is the most energy effective clock in the Gecko. The real time counters have a maximum wrap time of 194 days or 136 years, and where the RTC and RTCC have a resolution of 1 s, the BURTC has a resolution of 3.9 ms. See below table for a comparison between the three real time counters.

Table 1.1. Real Time Counter Comparison

	Counter Width	Maximum Wrap Time	Compare Channels	Available down to Energy Mode	Clock Sources
RTC	24-bit	194 days @ 1 s ticks	2	EM2	LFRCO, LFXO, ULFRCO
RTCC	32-bit	136 years @ 1 s ticks	3	EM4H	LFRCO, LFXO, ULFRCO
BURTC	32-bit	194 days @ 3.9 ms ticks	1	EM4	LFRCO, LFXO, ULFRCO

2. RTC

2.1 General

The RTC increments a counter on each positive edge of its clock. When the value of the counter is equal to either of its compare registers, an interrupt is triggered (if enabled). This interrupt can wake up the Gecko from EM2, and code execution is resumed. The RTC can also issue an interrupt on overflow.

It is possible to set up a compare register (RTC_COMP0) to be the top value. In this mode, the RTC will restart the counter when reaching the value of the compare register.

2.2 Software Example

In the RTC software example (`main_rtc_rtcc.c`), the 32.768 kHz Low Frequency RC Oscillator (LFRCO) is used as source for the RTC.

In this example, the Gecko repeatedly enters Energy Mode 2 (EM2) and sleeps for 500 ms using the RTC. The RTC is configured to interrupt and to automatically reset the counter on compare match on channel 0.

3. RTCC

3.1 General

The RTCC consists of two counters: the 32-bit main counter, RTCC_CNT (RTCC_TIME and RTCC_DATE in calendar mode), and a 15-bit pre-counter, RTCC_PRECNT. The pre-counter can be used as an independent counter, or to generate a specific frequency for the main counter. In both configurations, the pre-counter can be used to generate compare match events or be captured in the Capture/Compare channels as a result of an external PRS event.

The main counter of the RTCC, RTCC_CNT, has two modes: normal mode and calendar mode. In normal mode, the main counter is available in RTCC_CNT and increments upon each tick given from the pre-counter. In calendar mode, the counter value is available in RTCC_TIME and RTCC_DATE, keeping track of seconds, minutes, hours, day of month, day of week, months, and years, all encoded in BCD format.

The RTCC has one interrupt for each of its 3 Capture/Compare channels, CC0, CC1, and CC2. Each Capture/Compare channel has a PRS output with configurable actions upon compare match. The interrupt flag CNTTICK is set each time the main counter receives a tick (each second in calendar mode). In calendar mode, there are also interrupt flags being set each minute, hour, day, week, and month.

The RTCC is available in all Energy Modes except EM4S. To enable RTCC operation in EM4H, the EMU_EM4CTRL register in the EMU has to be configured. Any enabled RTCC interrupt will wake the system up from EM4H if EM4WU in the RTCC_EM4WUEN register is set.

3.2 Software Example

In the RTCC normal mode example (`main_rtc_rtcc.c`), the 32.768 kHz Low Frequency RC Oscillator (LFRCO) is used as source for the RTCC. The DC-DC converter of Pearl Gecko is used in this example.

In this example, the Gecko repeatedly enters Energy Mode 2 (EM2) and sleeps for 500 ms using the RTCC. The RTCC is configured to interrupt and automatically reset the counter on Capture/Compare channel CC1.

In the RTCC calendar mode example (`main_rtcc_calendar.c`), the 32.768 kHz Low Frequency Crystal Oscillator (LFXO) is used as source for the RTCC. The DC-DC converter of Pearl Gecko is used in this example.

In this example, the Gecko repeatedly enters Energy Mode 2 (EM2) and sleeps for 1 s using the RTCC. The RTCC is configured to interrupt on second and day ticks with leap year correction, and the time and date will display on the LCD panel.

4. Backup RTC

4.1 General

The Backup Real Time Counter (BURTC) is available in the Giant, Leopard and Wonder Gecko families. It allows for timekeeping in all energy modes and can run in EM4 with a total current consumption of less than 0.5 µA. The BURTC contains a 32-bit counter and is clocked either by a 32.768 kHz crystal oscillator, a 32.768 kHz RC oscillator, or a 2 kHz Ultra Low Frequency RC Oscillator.

4.2 Software Example

The software example (`main_burtc.c`) shows how to set up the BURTC to wake up the MCU from EM2 every 500 ms using interrupt on match on channel 0.

4.3 More Information

For a software example on how to use the BURTC in EM4, see application note AN0007 Energy Modes. It shows how to repeatedly enter EM4 and sleep for 5 seconds and how to use the BURTC retention register to keep track of the number of times the MCU has woken up from a BURTC interrupt.

For more details on using the BURTC in the backup power domain, see application note *AN0041: Backup Power Domain*. It demonstrates how to use the BURTC while running on backup power. Also see the BURTC example found in the EFM32GG_STK3700 kit example for more software demonstrations.

Application Notes can be found on the Silicon Labs website (www.silabs.com/32bit-appnotes) or in Simplicity Studio using the [**Application Notes**] tile.

5. The RTCDRV

5.1 General

The EMDRV (EnergyAware Driver) is a set of function specific high-performance drivers for Gecko MCU and Wireless Gecko on-chip peripherals. The RTCDRV uses the RTC or RTCC peripheral of a device to provide a user configurable number of software millisecond timers.

Two kinds of timers are supported: oneshot timers and periodic timers. Timers will, when their timeout period has expired, call a user supplied callback function.

Refer to the [**Software Documentation**] tile in Simplicity Studio for details on how to configure the RTCDRV.

5.2 Software Example

In the RTCDRV example (`main_rtcdrv.c`), the 32.768 kHz Low Frequency Crystal Oscillator (LFXO) is used as source for the RTC or RTCC.

The 500 ms periodic interrupt of RTC software example and RTCC normal mode example (`main_rtc_rtcc.c`) is replicated by the periodic timer of RTCDRV. The callback function after a 500 ms time has expired is used to toggle two LEDs on the STK.

The DC-DC converter is initialized for Pearl Gecko in this example, the same source code can be used for Gecko MCU and Wireless Gecko. The real time counter peripheral (RTC or RTCC) actually employed by the RTCDRV is transparent to the user.

6. Revision History

6.1 Revision 1.09

2016-07-28

Updated example code (change main_rtc.c to main_rtc_rtcc.c) to support RTCC

Added example code (main_rtcc_calendar.c) for RTCC calendar mode

Replace example main_rtc_driver.c with main_rtcdrv.c (EMDRV)

6.2 Revision 1.08

2014-05-07

Updated example code to CMSIS 3.20.5

Changed to Silicon Labs license on code examples

Added example projects for Simplicity IDE

Removed example makefiles for Sourcery CodeBench Lite

6.3 Revision 1.07

2013-10-14

New cover layout

6.4 Revision 1.06

2013-07-31

Added Backup RTC software example

6.5 Revision 1.05

2013-05-08

Added software projects for ARM-GCC and Atollic TrueStudio.

6.6 Revision 1.04

2012-11-12

Added software projects for Tiny Gecko and Giant Gecko.

Adapted software projects to new kit-driver and bsp structure.

6.7 Revision 1.03

2012-04-20

Adapted software projects to new peripheral library naming and CMSIS_V3.

6.8 Revision 1.02

2012-03-14

Fixed makefile-error for CodeSourcery projects.

6.9 Revision 1.01

2010-11-16

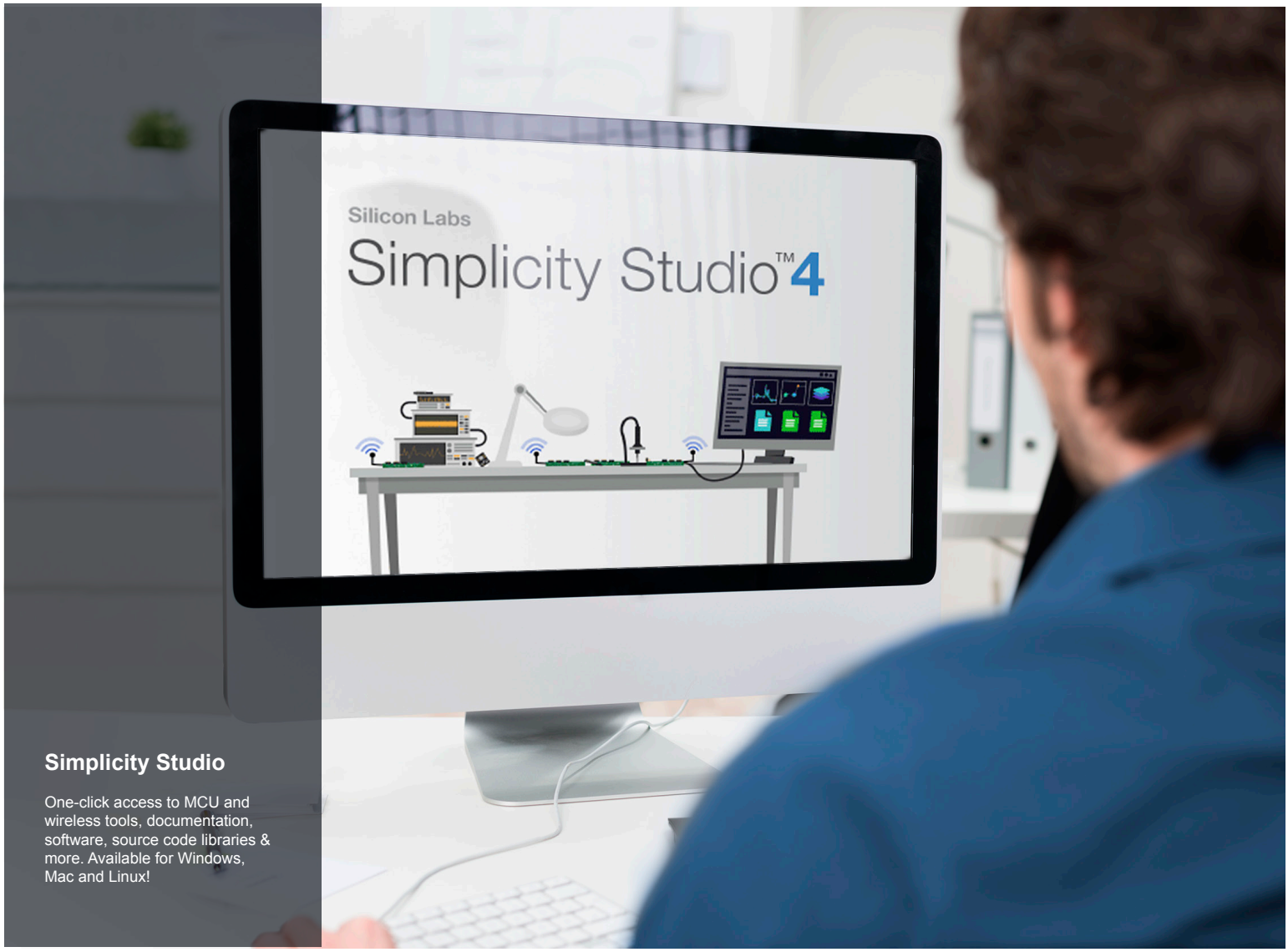
Changed example folder structure, removed build and src folders.

Added chip-init function.

6.10 Revision 1.00

September 20th, 2010.

Initial revision.



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