

Software Real Time Clock Implementation on MC9S08LG32

by: **Nitin Gupta**
Automotive and Industrial Solutions Group

Contents

1 Introduction

The MC9S08LG32 is a member of the Freescale HCS08 family MCUs. It uses the S08 core and integrates many peripherals, such as LCD, SPI, I²C, SCI, ADC, and Real Time Counters. This application note describes how to initialize and maintain the Real Time Clock (RTC) in the MC9S08LG32 microcontroller family.

MC9S08LG32 Demo Board used for RTC setup is shown in [Figure 1](#). The system communicates with the MC9S08LG32 target via a USB Background Debug Mode (BDM) interface. With BDM protocol, system can update the MC9S08LG32 firmware. RTC is implemented using the Real Time Counter IP (S08RTCV1) on MC9S08LG32. RTC can be displayed on the LCD connected on the board.

In this application note, the MC9S08LG32 RTC driver interfaces are explained. Various applications for MC9S08LG32 can make use of this driver. The following sections will describe the details and the steps for creating an application using it.

This application note does not cover how to configure the LCD. For details, please see AN3823 on <http://www.freescale.com>.

- 1 Introduction.....1
- 2 Real Time Clock (RTC).....2
- 3 RTC driver framework.....2
 - 3.1 RTC.c.....3
 - 3.2 RTC.h.....5
 - 3.3 RTC_main.c.....6
- 4 Integration of RTC driver.....7
- 5 Test results.....7
- 6 Conclusion.....8
- 7 References.....8

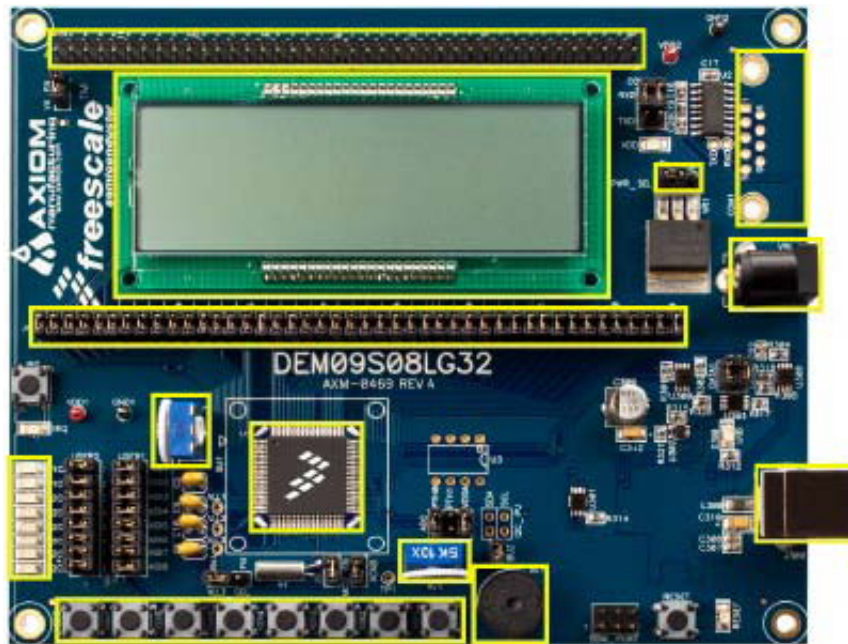


Figure 1. MC9S08LG32 demo board setup

2 Real Time Clock (RTC)

The RTC, or, sometimes referred to as time of the day, can be implemented using either a hardware or a software module. The primary function of an RTC implementation is to provide the information of time, day, week, month, and year.

A hardware RTC implementation refers to one that uses an external RTC hardware module that may be connected through I²C or SPI bus. On the other hand, some hardware RTC implementations are provided by an on-chip peripheral in the MCU. The advantage of hardware RTC is accuracy of time. Although not sought after for their accuracy, software RTCs can be a viable solution for some applications.

Software RTC can be implemented with a timer or a counter that generates an interrupt based on a specified time interval. The number of time intervals are counted and then converted to time. A one second time interval is a convenient configuration for the software RTC.

Since the software RTC function is not a part of the hardware, legacy systems can implement software RTC functionality with a firmware update. If the RTC is implemented in software, it will have lower system cost, requires fewer external components, and requires less power.

For MC9S08LG32, software RTC is implemented using Real Time Counter (S08RTCV1), configured to use the external oscillator of 32.768 kHz. S08RTCV1 accurately keeps the track of time in low-power mode, which is a critical parameter in automotive applications to prevent high battery discharge rates and conserve the battery charge between vehicle starts (recharge cycles).

Vehicle manufacturers expect that a vehicle should start even if the battery is not charged for long period (say 6-8 weeks), and still keep a very good accuracy on the daily digital clock. The MC9S08LG32 family of microcontrollers provides a range of features to enable users to achieve this goal.

3 RTC driver framework

The RTC driver is provided as “C” code files.

The driver consists of three files, namely:

- RTC.c
- RTC.h
- RTC_main.c

MC9S08LG32 RTC driver project is illustrated in [Figure 2](#)

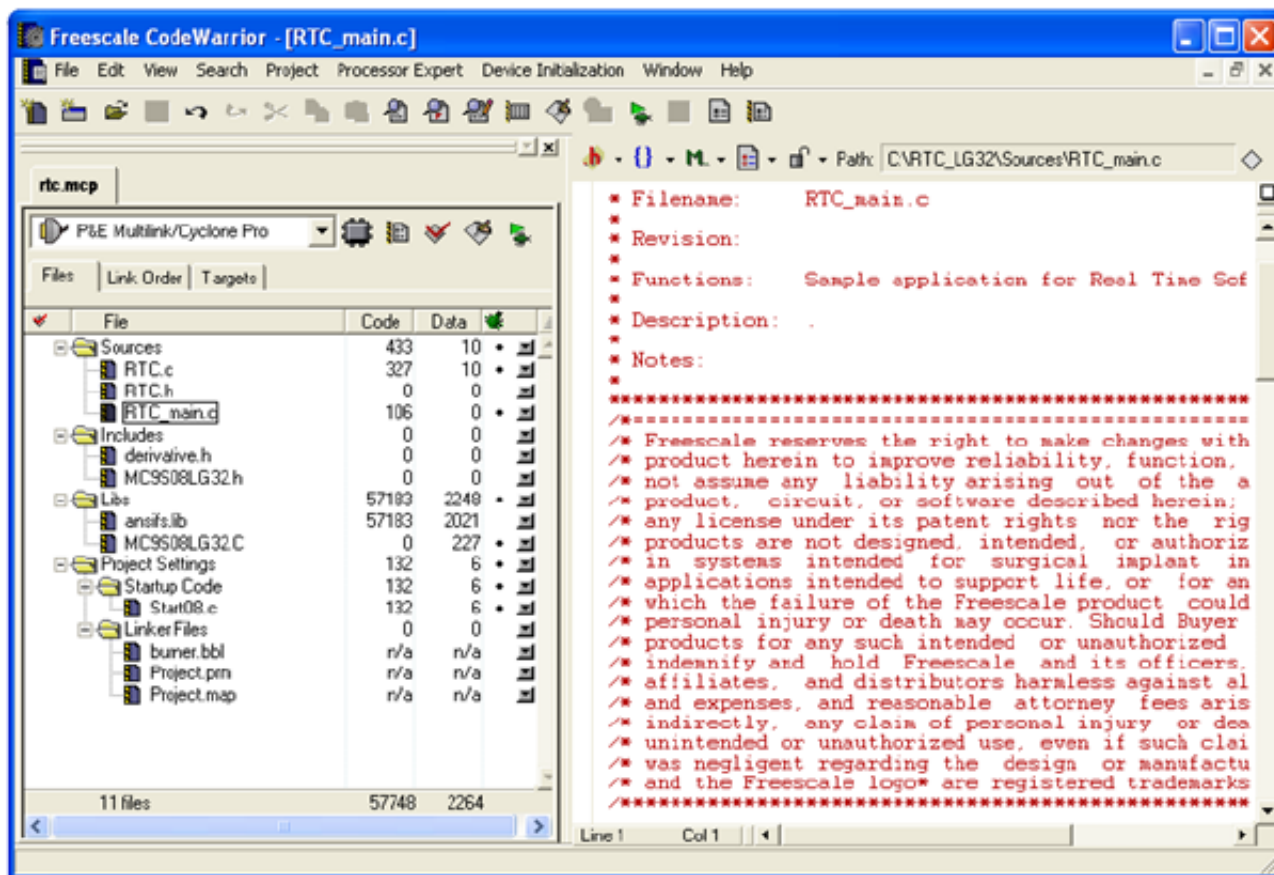


Figure 2. MC9S08LG32 RTC driver

The details of each of the files are given in the following subsections.

3.1 RTC.c

RTC.c consists of application programming interfaces (APIs) which enable the software RTC on the MC9S08LG32 series. The description of each API is as follows:

3.1.1 RTC_Init

This API initializes the RTC and the system clock. It uses a 32.768 kHz external crystal oscillator, having 30 ppm tolerance. During the initialization of the clock, the operating modes have been taken into consideration. As per the application, the operating mode can be either of the following:

- Normal mode: In this mode, the RTC interrupt will occur every 1 second.
- Stop3 mode: In this mode, the RTC interrupt will occur after every 8 seconds.

RTC driver framework

Syntax

```
void RTC_Init(void)
```

Parameters

None

Return Value

None

3.1.2 IRQ_Init

This API initializes the IRQ pin, which is connected to the ignition. It is assumed that a proper signal conditioning is present on the pin.

Syntax

```
void IRQ_Init(void)
```

Parameters

None

Return Value:

None

3.1.3 RTC_ISR

This interrupt service routine (ISR) is called each time the RTC interrupt occurs. In this, clock-time is updated as per the mode and interrupt flag is cleared. There can be two possibilities:

- Normal mode: In this mode, the time interval of the interrupt is 1 second (frequency ~ 1 Hz).
- Stop3 mode: In this low-power Stop3 mode, the RTC interrupt acts as a wakeup source for the MCU and the time interval of the interrupt is increased to 8 seconds (frequency ~ 0.125 Hz). This, in-turn will reduce the overall current consumption, as the execution of the ISR will take 2-10 μ s, depending on the number of instructions which need to be executed in this ISR.

NOTE

The time interval given above is as per the present RTC driver.

Syntax

```
void interrupt VectorNumber_Vrtc RTC_ISR(void)
```

Parameters

None

Return Value

None

3.1.4 IRQ_ISR

This ISR is called each time a falling edge is detected at the IRQ/Ignition pin. It is assumed that the falling edge will be generated, each time ignition is ON/OFF, which is done through a signal conditioning on the Ignition pin.

Syntax

```
void interrupt VectorNumber_Vrtc IRQ_ISR(void)
```

Parameters

None

Return Value

None

3.1.5 UpdateAndDisplayTime

This API should be called each time there is an interrupt from the RTC or from the IRQ to update the clock structures to the latest values.

Syntax

```
void UpdateAndDisplayTime(void)
```

Parameters

None

Return Value

None

3.1.6 ClockCorrection

This API should be called, each time there is a correction required. This API should be changed as per the crystal characteristics. For example, when the crystal characteristics are such that the clock is gaining 1 second every 8 hours under the ambient temperature conditions, this API should be called when the hours are equal to 8, 16, and 24, but only once and consequently, 1 should be subtracted from the seconds variable in order to provide a correct and accurate clock.

Syntax

```
void ClockCorrection(void)
```

Parameters

None

Return Value

None

3.2 RTC.h

This header file contains the clock structure and the function prototypes. This file also contains the macros, which are used to initialize the clock structures, which are described in detail below:

3.2.1 RTC_HOURS

This macro is used to initialize the hours value in the clock structure and can be changed as per the requirement of the application.

3.2.2 RTC_MINUTES

This macro is used to initialize the minutes value in the clock structure and can be changed as per the requirement of the application.

3.2.3 RTC_SECONDS

This macro is used to initialize the seconds value in the clock structure and can be changed as per the requirement of the application.

3.2.4 RTCMOD_NORMAL_VALUE

This macro is used in Normal mode to load the RTCMOD register.

3.2.5 RTCMOD_LP_VALUE

This macro is used in Stop3 mode to load the RTCMOD register.

3.3 RTC_main.c

This file contains the main function, which acts as an application for the present RTC driver. This can be removed, when the driver is integrated into the application.

3.3.1 System_Init

This API initializes the overall system. It disables the watchdog and enables the Stop3 mode only when the ignition is stopped and is captured through the IRQ, and Low Voltage Detect (LVD) reset is disabled.

Syntax

```
void System_Init(void)
```

Parameters

None

Return Value

None

3.3.2 Main

This API is the entry point.

Syntax

```
void main(void)
```

Parameters

None

Return Value

None

4 Integration of RTC driver

In order to integrate the RTC driver in the existing code, add the following files:

- RTC.c
- RTC.h

From the main of the existing application, call `RTC_Init()` and `IRQ_Init()`. The present RTC driver presumes the external crystal oscillator used is 32.768 kHz and configures the prescaler value to 2^{10} (1024), thus, making the RTC clock to 32 Hz (32.768 kHz/ 1024). If an application uses a crystal with a different frequency, then the prescaler needs to be reconfigured and the RTC driver needs to be recalibrated. See [ClockCorrection](#) for more details.

The application should always wait for the oscillator clock to stabilize and then initialize other drivers.

In the main loop, the application should always check the MCU operating mode, so that when the MCU wakes up due to ignition, the application should correct the clock, by loading the correct value in milliseconds.

5 Test results

RTC soaking results under various temperature conditions, with and without corrections are displayed in [Table 1](#). All the readings are noted, after the temperature was stabilized. The results may show lot of variation in time due to PCB characteristics, crystal characteristics and the components used on the board.

Table 1. RTC driver test results under various temperature conditions

S. No.	Parameters	Results without correction	Results with 1 second correction / 8 hours
1	Temperature	Ambient	Ambient
	Number of hours	185 h	185 h
	Time gain	24 s	1 s
2	Temperature	40.1°C	40.1°C
	Number of hours	65 h	65 h
	Time gain	10 s	2 s

Table continues on the next page...

Table 1. RTC driver test results under various temperature conditions (continued)

S. No.	Parameters	Results without correction	Results with 1 second correction / 8 hours
3	Temperature	60.9°C	60.9°C
	Number of hours	70 h	70 h
	Time gain	12 s	3 s
4	Temperature	80.5°C	80.5°C
	Number of hours	24 h	24 h
	Time gain	8 s	5 s

6 Conclusion

The RTC driver can be added into the application, by easily adding 2 files (described in [Integration of RTC driver](#)), but care must be taken to calibrate the driver as per the crystal characteristics in order to get accurate clock in the vehicle. The application can also add compensation algorithm based on the temperature characteristics of the crystal for better accuracy of the clock with temperature.

The accuracy of the software RTC is affected by the frequency tolerance of the microcontroller clock source. If the clock source is an external crystal (for instance), a high ppm frequency tolerance would be preferred.

7 References

1. MC9S08LG32RM available at <http://www.freescale.com>
2. DEMO9S08LG32 Schematic available at <http://www.freescale.com>

How to Reach Us:

Home Page:

www.freescale.com

Web Support:

<http://www.freescale.com/support>

USA/Europe or Locations Not Listed:

Freescale Semiconductor
Technical Information Center, EL516
2100 East Elliot Road
Tempe, Arizona 85284
+1-800-521-6274 or +1-480-768-2130
www.freescale.com/support

Europe, Middle East, and Africa:

Freescale Halbleiter Deutschland GmbH
Technical Information Center
Schatzbogen 7
81829 Muenchen, Germany
+44 1296 380 456 (English)
+46 8 52200080 (English)
+49 89 92103 559 (German)
+33 1 69 35 48 48 (French)
www.freescale.com/support

Japan:

Freescale Semiconductor Japan Ltd.
Headquarters
ARCO Tower 15F
1-8-1, Shimo-Meguro, Meguro-ku,
Tokyo 153-0064
Japan
0120 191014 or +81 3 5437 9125
support.japan@freescale.com

Asia/Pacific:

Freescale Semiconductor China Ltd.
Exchange Building 23F
No. 118 Jianguo Road
Chaoyang District
Beijing 100022
China
+86 10 5879 8000
support.asia@freescale.com

Information in this document is provided solely to enable system and software implementers to use Freescale Semiconductors products. There are no express or implied copyright licenses granted hereunder to design or fabricate any integrated circuits or integrated circuits based on the information in this document.

Freescale Semiconductor reserves the right to make changes without further notice to any products herein. Freescale Semiconductor makes no warranty, representation, or guarantee regarding the suitability of its products for any particular purpose, nor does Freescale Semiconductor assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any liability, including without limitation consequential or incidental damages. "Typical" parameters that may be provided in Freescale Semiconductor data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals", must be validated for each customer application by customer's technical experts. Freescale Semiconductor does not convey any license under its patent rights nor the rights of others. Freescale Semiconductor products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which failure of the Freescale Semiconductor product could create a situation where personal injury or death may occur. Should Buyer purchase or use Freescale Semiconductor products for any such unintended or unauthorized application, Buyer shall indemnify Freescale Semiconductor and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claims alleges that Freescale Semiconductor was negligent regarding the design or manufacture of the part.

RoHS-compliant and/or Pb-free versions of Freescale products have the functionality and electrical characteristics as their non-RoHS-complaint and/or non-Pb-free counterparts. For further information, see <http://www.freescale.com> or contact your Freescale sales representative.

For information on Freescale's Environmental Products program, go to <http://www.freescale.com/epp>.

Freescale™ and the Freescale logo are trademarks of Freescale Semiconductor, Inc. All other product or service names are the property of their respective owners.

© 2012 Freescale Semiconductor, Inc.