
AVR1515: XMEGA-A1 Xplained training - XMEGA Programmable Multi Interrupt Controller



Prerequisites

- Required knowledge
 - Completed AVR1512 XMEGA Basics training
- Software prerequisites
 - Atmel® AVR Studio® 5
- Hardware prerequisites
 - XMEGA-A1 Xplained
 - JTAGICE3 (or JTAGICE mkII or AVR ONE!)
- Estimated completion time:
 - 1.5 hours

1 Introduction

Atmel AVR® XMEGA® has an advanced Programmable Multi-level Interrupt Controller (PMIC). The PMIC allows control over interrupt priorities and scheduling of interrupts.

In this hands-on we will learn more about the Atmel XMEGA Programmable Interrupt Controller.

**8-bit Atmel
Microcontrollers**

Application Note

Rev. 8401A-AVR-06/11





2 Introduction to the PMIC

Atmel® AVR® XMEGA® has a Programmable Multi-level Interrupt Controller (PMIC). All peripherals can define three different priority levels for interrupts; high, medium or low. Medium level interrupts may interrupt low level interrupt service routines. High level interrupts may interrupt both low and medium level interrupt service routines. Low level interrupts have an optional Round Robin scheme to make sure all interrupts are serviced within a certain amount of time.

3 Overview

This training session covers the basic features of the Atmel XMEGA Programmable Multi-level Interrupt Controller (PMIC). The goal for this training is to get you started with simple interrupt handlers, using the priority levels and scheduling features of the PMIC to create robust interrupt controlled applications.

Here is a short overview of the tasks in this training:

Task 1: Overflow Interrupt

This task shows how to create a simple interrupt handler for a timer overflow interrupt.

Task 2: Interrupt Levels

This task shows how different interrupt levels interact.

Task 3: Round Robin

This task shows how interrupt priorities can cause starvation of interrupts with lower priority, and how the Round Robin scheduling feature can be used to prevent starvation.

GOOD LUCK!

4 Task 1: Overflow Interrupt

Blinking LEDs is fun, but blinking LEDs with interrupts is even funnier! This task shows the necessary steps to configure a timer and enable its overflow interrupt to blink an LED for us.

The goals for this task are that you know how to:

- Write an interrupt handler function, and associate it with the corresponding interrupt vector
- Enable an interrupt source such as a timer's overflow interrupt, and select the interrupt level
- Configure the PMIC to enable interrupts of a certain level, and to enable interrupts globally



TASK:

1. Locate the XMEGA-PMIC folder, open the `xmega_pmic.avrsln` solution file and set Task 1 active by selecting it as StartUp project.
2. Look through the code and ensure you understand how things are set up
3. Notice how easy it is to change LEDPORT and LEDMASK definitions, if you want another LED port and/or other LEDs than the default one
4. Build the project and start a debug session (click on the Play icon) in AVR Studio
5. Place a breakpoint (F9) inside the interrupt handler, run the code (F5) and observe it stopping at the breakpoint

```
// Tell compiler to associate this interrupt handler with the TCC0_OVF_vect vector.
ISR(TCC0_OVF_vect)
{
    LEDPORT.OUTTGL = LEDMASK; // Just toggle LED(s) when interrupt is executed.
}

int main( void )
{
    // ...
}
```

6. Remove the breakpoint (F9 again) and run the code to see the LED blink
7. Feel free to change interrupt levels, and timer speed. Recompile and run again

5 Task 2: Interrupt Levels

If an interrupt handler is badly designed and ends up in an endless loop, for instance by doing something stupid like waiting for a switch to be pressed by the user, it halts the entire processor, right? Not quite so with Atmel XMEGA... This task shows how different interrupt levels interact, and how lower level interrupts can easily be interrupted by higher level ones.

The goals for this task are that you know how to:

- Implement several interrupt handlers, and assign different levels to the interrupt sources



- Enable several interrupt levels in the PMIC
- Make code that utilizes nested interrupts



TASK:

1. Locate the XMEGA-PMIC folder, open the `xmega_pmic.avrsln` solution file and set Task 2 active by selecting it as StartUp project.
2. Look through the code and ensure you understand how things are set up
3. Build the project and start a debug session (click on the Play icon) in AVR Studio

The code sets up three different interrupt service routines (ISR) with different priority levels. Each ISR blinks a LED, and does not return as long as the corresponding switch is being pressed.

4. Run the code (press F5) to see the code blink the three LEDs. Press the switches to block one of the interrupts and observe higher level interrupts are still running. Also observe that lower level interrupts are blocked
5. Change the interrupt levels. Recompile and run again

```
TCC0.CCA = 5000; // Let all compare channels have same value
TCC0.CCB = 5000; // so that they fire interrupts simultaneously.
TCC0.CCC = 5000; // Value needs to be less than or equal to TCC0.PER register.
TCC0.CTRLB = TC0_CCCEN_bm | TC0_CCBEN_bm | TC0_CCAEN_bm; // Enable all compare channels
// Set up levels for all compare channel interrupts:
TCC0.INTCTRLB = (unsigned char) TC_CCCINTLVL_LO_gc |
TC_CCBINTLVL_MED_gc |
TC_CCAINTLVL_HI_gc;
TCC0.CTRLA = ( TCC0.CTRLA & ~TC0_CLKSEL_bm ) | TC_CLKSEL_DIV64_gc;
```

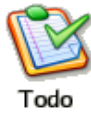
6 Task 3: Round Robin

When several interrupts are assigned the same interrupt level, the interrupt vector number decides the priority. Lower numbers first. What happens if an interrupt takes so much CPU time that interrupts with lower priority never gets to run? Well, they starve... unless you enable the Round Robin scheduling scheme of the PMIC. The last interrupt vector that got CPU time will have the lower priority. This task shows how to use the Round Robin scheme to allow two interrupts to execute, even if one of them would take almost 100% CPU time. Note that Round Robin scheduling is only available for low level interrupts.

The goal for this task is that you know how to:

- Turn on and off Round Robin scheduling for low level interrupts

- Know how to prevent one high rate interrupt from starving another low rate interrupt



TASK:

1. Locate the XMEGA-PMIC folder, open the `xmega_pmic.avrsln` solution file and set Task 3 active by selecting it as StartUp project.
2. Look through the code and ensure you understand how things are set up
3. Build the project and start a debug session in AVR Studio
4. Run the code (press F5) to see the code blink one LED while the other does not get CPU time to blink. Press the switch SW1 to enable Round Robin scheduling and SW0 to turn Round Robin scheduling off. When enabled observe the other LED also getting CPU time to blink
5. Comment away the `PMIC.INTPRI = 0;` line, recompile, run



What happens the next time you release the switch to turn off Round Robin scheduling again, and why?

7 Summary

In this training we have looked at the programmable interrupt controller (PMIC). We have seen how you can set up different priorities for interrupts (low, medium, high). We have also seen that the low level interrupts can have different priority schemes (Round Robin or fixed) and what effect this has on the interrupts.

8 Resources

- Atmel XMEGA Manual and Datasheets
 - <http://www.atmel.com/xmega>
- Atmel AVR Studio 5
 - <http://www.atmel.com/avrstudio>
- Atmel IAR Embedded Workbench® compiler
 - <http://www.iar.com/>





9 Atmel Technical Support Center

Atmel has several support channels available:

- | | | |
|---------------|---|----------------------------|
| • Web portal: | http://support.atmel.no/ | All Atmel microcontrollers |
| • Email: | avr@atmel.com | All Atmel AVR products |
| • Email: | avr32@atmel.com | All 32-bit AVR products |

Please register on the web portal to gain access to the following services:

- Access to a rich FAQ database
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Atmel Corporation
2325 Orchard Parkway
San Jose, CA 95131
USA
Tel: (+1)(408) 441-0311
Fax: (+1)(408) 487-2600
www.atmel.com

Atmel Asia Limited
Unit 01-5 & 16, 19F
BEA Tower, Millennium City 5
418 Kwun Tong Road
Kwun Tong, Kowloon
HONG KONG
Tel: (+852) 2245-6100
Fax: (+852) 2722-1369

Atmel Munich GmbH
Business Campus
Parkring 4
D-85748 Garching b. Munich
GERMANY
Tel: (+49) 89-31970-0
Fax: (+49) 89-3194621

Atmel Japan
9F, Tonetsu Shinkawa Bldg.
1-24-8 Shinkawa
Chou-ku, Tokyo 104-0033
JAPAN
Tel: (+81) 3523-3551
Fax: (+81) 3523-7581

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