AVR1503: Xplain training - XMEGA Programmable Multi Interrupt Controller

8-bit AVR®
Microcontrollers

Application Note

Prerequisites

- **Required knowledge**
  Completed AVR1500 XMEGA™ Basics training
- **Software prerequisites**
  Atmel® AVR® Studio® 4.18 SP2 or later
  WinAVR/GCC 20100110 or later
- **Hardware prerequisites**
  Xplain evaluation board
  JTAGICE mkII
- **Estimated completion time:**
  1.5 hours

1 Introduction

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

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

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2 Introduction to the PMIC

Atmel 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 of 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 are fun, but interrupt controlled blinking LEDs are more fun! This task shows the necessary steps to configure a timer and enable its overflow interrupt to blink an LED for us.

The goal for this task is 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 let through interrupts of a certain level, and to enable interrupts globally

Todo

TASK:

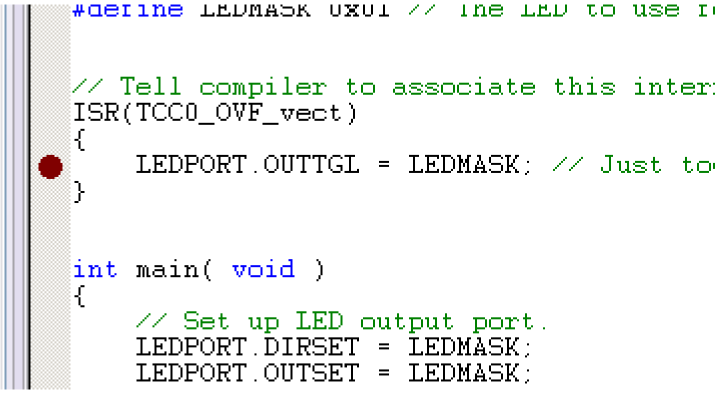
1. Locate the XMEGA-PMIC folder, find the Task 1 folder and open the OverflowInterrupt.aps project file in Atmel AVR Studio

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



```
#define LEDMASK 0x01 // The LED to use f

// Tell compiler to associate this inter
ISR(TCC0_OVF_vect)
{
    LEDPORT.OUTTGL = LEDMASK; // Just to
}

int main( void )
{
    // Set up LED output port.
    LEDPORT.DIRSET = LEDMASK;
    LEDPORT.OUTSET = LEDMASK;
```

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 goal for this task is 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

Todo

TASK:

1. Locate the XMEGA-PMIC folder, find the Task 2 folder and open the InterruptLevels.aps project file in Atmel AVR Studio

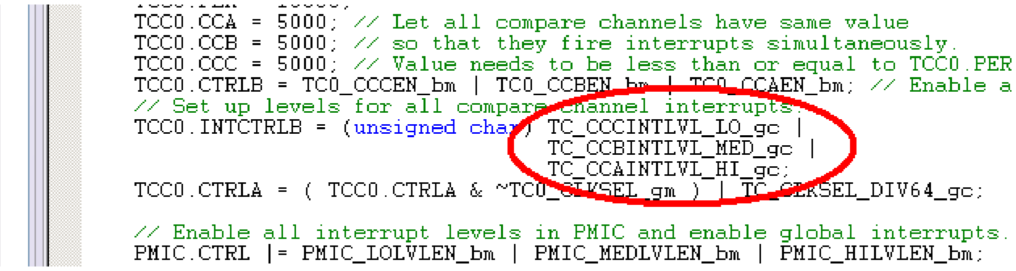
2. Look through the code and ensure you understand how things are set up

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
TCC0.CTRLB = TC0_CCCEN_bm | TC0_CCBEN_bm | TC0_CCAEN_bm; // Enable a
// 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_gm ) | TC_CLKSEL_DIV64_gc;

// Enable all interrupt levels in PMIC and enable global interrupts.
PMIC.CTRL |= PMIC_LOLVLEN_bm | PMIC_MEDLVLEN_bm | PMIC_HILVLEN_bm;
```

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

Todo

TASK:

1. Locate the XMEGA-PMIC folder, find the Task 3 folder and open the RoundRobin.aps project file in Atmel AVR Studio

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 with help files
  - http://www.atmel.com/products/AVR/
- WINAVR GCC compiler
  - http://winavr.sourceforge.net/
- 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:

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