**CG1112 Engineering Principles & Practices II**

**Week 5 – Tutorial 2 – Part 1**

Objectives:

* Explore the Atmel microcontroller in more detail.
* Review GPIO Peripheral Block
* Understand Energy-Saving Concepts

**Q1.**

Most Microcontroller Pins have multiple functionalities. It is up to the designer to plan ahead and be aware of the peripherals that are needed and select the appropriate pins to be used in the project. In the studio we have used PORT B pins for the LED’s and Switches.

PB7 and PB6 are currently mapped to the external crystal oscillator (XTAL1 and XTAL2 for the Uno Board).



You have decided to create your own board using the Atmega328p and want to make use of all 8-bits of PORTB. Is it possible? What are the factors to consider?

(Hint: Refer to “Section 13: System Clock and Clock Options” in the Atmega datasheet)

Answer:

Referring to Table 13-1, it can be seen that there are different clocking options available for the 328p. Two of those options refer to the ability to use an internal clock. By selecting those options we can free up PB7 and PB6 to be used as GPIO.



The most important factor to consider is that when we use an external clock, we have a wide range of frequencies to choose from. Once we switch to an internal clock, we are limited by what the device provides. We need to check and see if what is provided is sufficient for our needs.

Internal 128KHz RC Oscillator: 128khz

Calibrated Internal RC Oscillator: 8MHz

DISCUSSION POINTS:

What are the factors to consider when choosing the Frequency? Speed, Power Consumption, Stability.

Implication to the code: Calculated values for timing related features like ADC Sampling, Timers, etc.

**Q 2.**

In our studio we configured LED’s in “Active-High” logic, i.e. we applied a Logic ‘1’ to Turn it ‘ON’ and a Logic ‘0’ to turn it ‘OFF’.

1. Draw a circuit connection to connect an LED in “Active-Low” logic to PORTB Pin 1, i.e. you need to apply a Logic ‘0’ to turn it ‘ON’ and a Logic ‘1’ to turn it ‘OFF’.

Answer:

Vcc (+5V)

Resistor

PB1

1. Write the code to set the DDRB register value according to your schematic.

Answer: DDRB |= 0b00000010; // Set Bit 1 to output by OR with ‘1’.

1. In a design such as this, we say that the microcontroller is “sinking” current. That means, that current is now flowing into the pin of the device. The manufacturer specifies a limit to the amount of sinking current. Anything more than this, could lead to a “smoke-effect” + “water-sprinkler” effect in the lab.

Refer to Table 32-2 in the Atmega328p datasheet and state the maximum sinking current when the device is operating at 5V.

Answer: 20mA

1. The voltage drop across the LED is 0.7V. Choose an appropriate R value to prevent a “smoke-effect”.

Answer:

R >= (5 – 0.7) / 20 mA = 215 ohms

The minimum value of R is 215 ohms.

DISCUSSION POINTS:

How much is the source current when you set the output to ‘1’?

Answer: 20mA. The absolute maximum is 40mA.

Is that enough?

Answer: Depends on the application. If you are controlling an LED, then it should be. If you are trying to interface to a Motor, then it may not be enough.

What if I want a higher output voltage / current?

Answer: Think back to what you did in EPP1.

For a current boost, consider a Darlington Transistor Pair.

<https://www.kitronik.co.uk/blog/how-a-darlington-pair-transistor-works/>

For a voltage boost, you can consider using an op-amp.

**Q 3.** Power Consumption is a critical factor in Embedded Systems and it is important to minimize is to as to extend its usage before recharging the batteries. You read from Section 14 of the datasheet that the AT328P has some energy-saving features that you want to implement for “Alex” your robot. Mainly, you wish to put the robot in “Standby Mode” when the robot is idle and not doing anything useful.

1. Which is the main register that controls these features and what value should be written to it?

Answer:

The Sleep Mode Control Register (SMCR) contains the control bits for power management. To put the device in Standby Mode, a value of 110 must be written to it bits SM2:SM0 (Bits 3:1).

1. In Standby Mode, which events can trigger the device to “wake-up” and resume full-functionality?

Answer:

Only one of these events can wake up the MCU:

• External Reset

• Watchdog System Reset

• Watchdog Interrupt

• Brown-out Reset

• 2-wire Serial Interface address match

• External level interrupt on INT

• Pin change interrupt

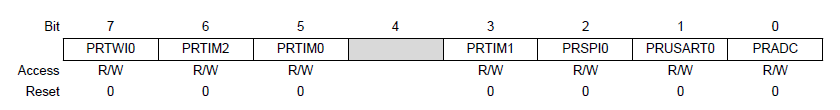
1. How many clock cycles does it take for the device to come out of Standby mode to full operation.

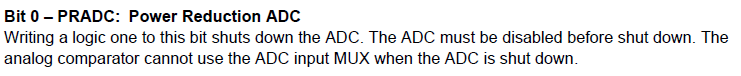
It takes 6 clock cycles.

1. Based on your initial assessment, you feel that you may not need to use the ADC module for this project. As such, you want to disable it so that it doesn’t consume any additional power. How can this be achieved?

Answer:

The Power Reduction Register (PRR) provides a method to stop the clock to individual peripherals to reduce power consumption.





DISCUSSION POINTS:

Implication of Power Consumption.

* Battery Life / Electricity Bill
* Challenges to meet Certification Standard

<https://www.energystar.gov/>

If you don’t meet their standard, you can’t put their sticker on your product. Most Consumer Electronic Products have to meet Energy Star requirements. In some countries, it is mandatory for some classes of products to meet E\* requirements. In local context, we can think of the “ticks” assigned to products like Washing Machines, Air-Cons, etc.

It is important that Energy Consumption must be thought through while you are designing the project and not after it is complete. The microcontroller is only one component in the system. Your device may have a lot of other subsystems that consume power. Putting those components into a low-energy state may be more complicated and require HW design like “electronic-switches”.