GOAL

The goal of this lab is to understand the concept of Analog to Digital Converter and use this peripheral of AVR atmega328p.

BACKGROUND

REFERENCE VOLTAGE $V_{ref}$

$V_{ref}$ It is the input voltage used for reference for ADC conversion. Reference voltage along with ADC resolution dictates the step size of ADC.

STEP SIZE

Step Size is the smallest change that can be recognized by ADC.

$$Step\ Size = \frac{V_{ref}}{number\ of\ steps}$$

- number of steps = $2^n$
- $n$ – resolution of ADC
- $V_{ref}$ – reference voltage

CONVERSION TIME

Time taken by ADC to convert analog input to digital output.
**Digital Data Output \( D_{out} \)**

\( D_{out} \) is the digital data converted by ADC.

\[
D_{out} = \frac{V_{in}}{\text{Step Size}}
\]

- \( V_{in} \) – input to ADC for conversion

Example:
For 8 bit ADC with 2.56v reference, 1.7v input will be:

\[
\text{Step Size} = \frac{2.56}{2^8} = 10mV
\]

\[
D_{out} = \frac{1.7V}{10mV} = 170
\]

170 decimal = 10101010 in binary.

**Code: ADC Polling**

// Function of this program is to write a code to convert the analog value to digital and show it in the LED. With low value with all LED off and high with all LED on

Code:

```cpp
//set channel to take input for ADC0, left adjust, AVcc with external cap at AREF
//ADC prescaler 64, enable ADC, Start conversion, enable auto trigger
while (1)
{
    //check if ADIF is 1, loop here if ADIF is 0
    //set ADIF 1
    //read conversion from ADCH register
}
```
**CODE: ADC INTERRUPT**

```c
#include <avr/io.h>
#include <avr/interrupt.h>

ISR (ADC_vect)
{
    PORTD = ADCH;
    ADCSRA |= (1<<ADSC);
}

int main(void)
{
    //set necessary PORT direction
    sei();
    //set channel to take input for ADC0,left adjust,AVcc with external cap at AREF
    //set prescaler to 128, enable ADC interrupt,enable adc,start conversion
    while (1)
    {
    }
}
```

Fig. 1. Schematic for ADC.
CODE: ADC RESULT ON LCD

//WRITE A CODE AS IN PART 1 AND DISPLAY RESULT ON LCD INSTEAD OF LED. USE FUNCTION GIVEN BELOW FOR DISPLAY

```c
void view(uint16_t adxl)
{
    lcd_data((0x30 + ((adxl/1000)%10)));
    lcd_data((0x30 + ((adxl/100)%10)));
    lcd_data((0x30 + ((adxl/10)%10)));
    lcd_data((0x30 + (adxl%10)));
}
```

PRELAB

1. Answer the questions
   1. What effects step size of ADC and how?
   2. Name one serial ADC IC and one parallel ADC IC commercially available.
   3. Find step size for 8-bit ADC with $V_{ref} = 1.28\text{V}$.
   4. What is digital output for analog input 1V and 0.8V?
   5. Expand each bit of ADMUX with value 96 and explain the effect.
   6. Expand each bit of ADCSRA with value 230 and explain the effect.

EXPERIMENTS

1. Implementing ADC on LED
   a) Write a ADC polling code and show the working experiment.
   b) Modify the code with different ADC Channel.
   c) Find input for digital output to be 128 for 10-bit ADC with reference 5V and verify that with given formula.

2. ADC Interrupt
   a) Write a ADC interrupt code and verify the ADC interrupt operation.

3. Result on LCD
   a) Write the code for a ADC and display result on LCD.
### Postlab

Include the following elements in the report document:

<table>
<thead>
<tr>
<th>Section</th>
<th>Element</th>
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<tbody>
<tr>
<td>1</td>
<td>Theory of operation</td>
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<td></td>
<td><em>Include a brief description of every element and phenomenon that appears during the experiments.</em></td>
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<tr>
<td>2</td>
<td>Prelab report</td>
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<tr>
<td>3</td>
<td>Results of the experiments</td>
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<td><strong>Experiment</strong></td>
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<td>a. Code with comments</td>
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<td>b. Picture of the circuit wired</td>
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<td>4</td>
<td>Answer the questions</td>
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<td>5</td>
<td>Conclusions</td>
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|         | *Write down your conclusions, things learned, problems encountered during the lab and how they were solved, etc.*