UNIVERSITY OF MOHAMED BOUDIAF M'SILA FACULTY OF TECHNOLOGY DEPARTMENT OF ELECTRICAL ENGINEERING 3rd year Engineer's degree ELT		جامعة محمد بوضياف المسيلة كلية التكنولوجيا قسم الهندسة الكهربائية السنة الثالثة هندسة

TP n°: 3 Microcontroller Analog to Digital Converter used for temperature regulation with LM35 sensor

I. Objective

- Program in Mikroc an Analog-to-Digital Converter of a PIC 16F876 and analyze the result obtained.
- Applying digital temperature regulation using an LM35 sensor.

II. Required Equipment

Microcomputer workstation, ISIS and MIKROC software;

III. Introduction

An Analog-to-Digital Converter (ADC) converts an analog signal into a digital signal. The system's acquisition and control chain is shown in the figure (1):

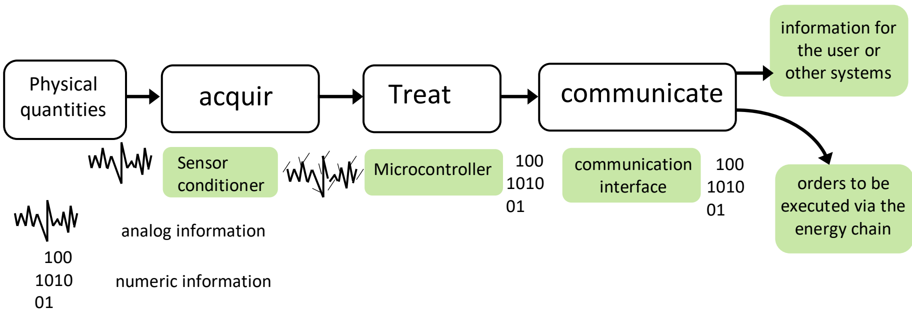

Figure (1) system's acquisition and control chain

The system's power chain is shown in the figure (2):

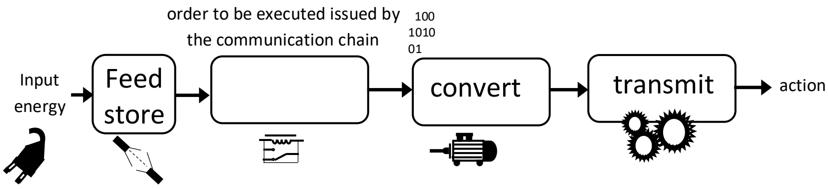

Figure (2) system's power chain

III.1 Analog-to-Digital Converter (ADC)

The idea of the Analog-to-Digital Converter (ADC) is quite simple. It consists of associating a digital value (an integer) with each analog value within a very specific voltage range (figure (4)). It's important to note that precision is lost in this process: while analog signals can be expected to have infinite precision, digital signals are limited by the sampling rate (figure (3)). The PIC16F876 has 5 analog channels, so up to 5 analog signals can be sampled sequentially.

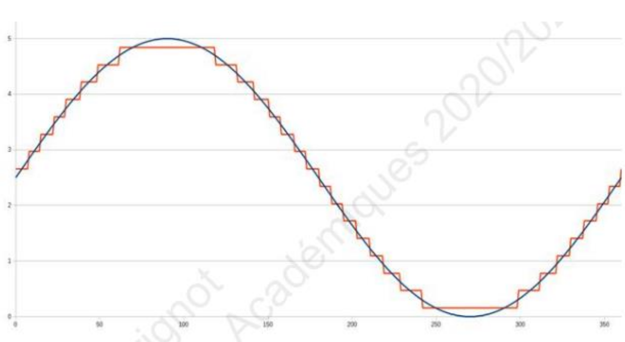

Figure (3) Analog and discrete signal

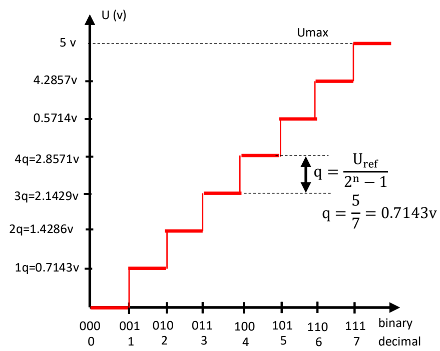

Figure (4) Binary values of discrete signal

The smallest detectable variation by the ADC (resolution or quantum) will therefore be (in volts)

$$q = \frac{U_{ref}}{2^n - 1} \quad \text{where:}$$

U_{ref}: reference voltage. n = number of bits of the converter

We observe that with U_{ref}=5V q=0.0048828 V or 4.88 mV.

Typically, on this type of microcontroller, the voltage range to be measured is from 0 to 5V (supply voltage), while the number of numerical values is linked to the number of bits of the converter. For the P16F876 ADC, since the conversion is done on 10 bits (binary), the number of associated values will be $2^n = 2^{10}$, or 1024 values (from 0 to 1023):

0V will be associated with $(0000000000)_2$ so N = $(0)_{10}$.

V_{FS} (Full Scale voltage) will be associated with $(1111111111)_2$ so N = $(1023)_{10}$.

III.2 Regulation

Control is a branch of engineering called automation. It encompasses all the techniques used to control a physical process, without human intervention, to maintain it at a given value, denoted by Y. This value, representing the desired objective of the process, is constant, while disturbances strongly influence the variable to be controlled, denoted by y(t). There are several types of control. We mention the following:

- On/Off (ON/OFF) Control
- Hysteresis
- Proportional-Integral-Derivative (PID) Controller

A- On/Off (Operate/None) Regulation:

This device is used primarily for temperature or level control, i.e., for processes with high inertia. On/Off regulation is characterized by its action on the control element, which can only operate at 100% or 0%. The regulator's action can be an open or closed contact, or a 0V or 24V signal to control a solenoid valve. Figure (5) shows the discontinuous action of an on/off regulator .

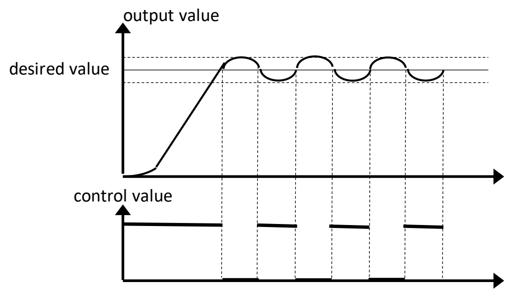

Figure (5) On/Off Regulation:

- Hysteresis

This corresponds to the difference between two thresholds in a "forward" phase and a "reverse" phase, or a "rising" phase and a "falling" phase. Generally, hysteresis exists when there is a difference between the "forward" curve and the "reverse" curve (Figure (6)). Hysteresis can also describe a delay between the cause and the appearance of the consequence.

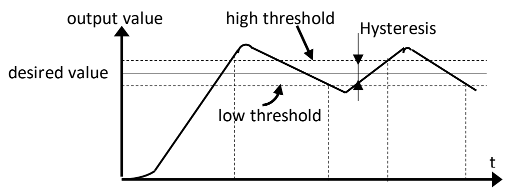

Figure (6) Hysteresis

C- Proportional-Integral-Derivative (PID) Controller

This is a control device that performs closed-loop regulation of an industrial system. It is the most widely used controller in industry and can control a large number of processes. The observed error is the difference between the set point and the measured value. The PID allows for three actions based on this error: Proportional action: the error is multiplied by a gain G; Integral action: the error is integrated over a time interval s, then divided by a gain T_i; Derivative action: the error is differentiated over a time interval s, then multiplied by a gain T_d. Several possible architectures exist to combine the three effects (series, parallel, or mixed). Tuning a PID involves determining the coefficients G, T_d, and T_i to obtain an appropriate process and control response. The goal is to be robust, fast, and precise. To achieve this, it is necessary to limit any potential overshoots. The most commonly used tuning methods in theory are the Ziegler-Nichols method, the Naslin method (normal polynomials with adjustable damping), and the inverse Nyquist locus method (which uses the Nyquist diagram). Figure (7) shows the response of a system following PID control.

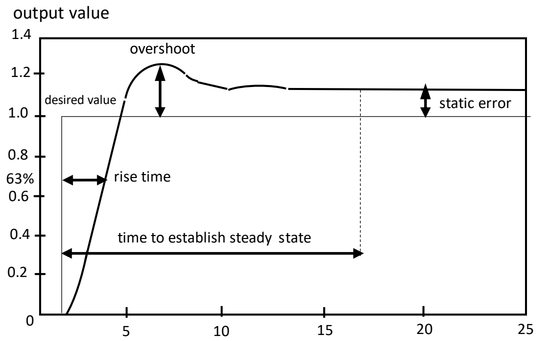

Figure (7) PID controller

III. Simulation work:

Part 1:

1.1- Write a program in MikroC that treat a physical quantity (speed) whose output characteristic is given in the figure (8), and verify the result using ISIS (a 10-bit result).

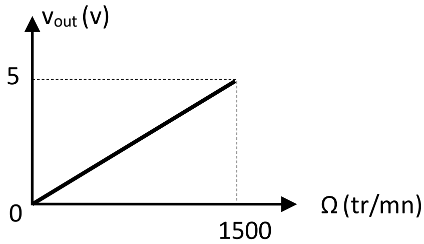

Figure (8) Output characteristic V_{out}(v) = f(Ω (tr/mn))

1.2- Treat the same physical quantity as before and display the result on an LM016 LCD.

Part 2:

2.1- Apply hysteresis regulation to control the temperature of a liquid through a heating resistance using the LM35 sensor whose output characteristic is given by the figure (9).

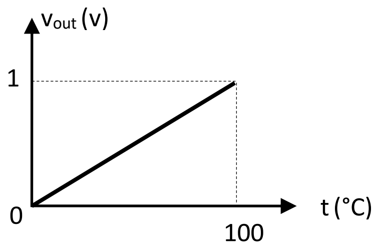

Figure (9) Output characteristic of LM35 sensor V_{out}(v) = f(t (°C)))