

Lab3: Digital Thermometer

1. Introduction

The purpose of this lab is to design a digital thermometer and display the measured value on the multiplexed 7-segment display of the EasyPIC 7 demo board.

2. Basic Theory

In this lab, you will be implementing a digital thermostat using the LM35 temperature sensor which provides an output voltage of 10 mV/°C. The sensor is intended to measure a temperature range between 0 and 100 °C. This means that the sensor's output voltage for this range is 0V to 1 V. Generally, the A/D converter uses the internal references VDD = 5 V and VSS = 0 V. In order to take advantage of the full-scale range of the A/D, an amplifier with a gain of 5 is placed between the sensor and the A/D input of the microcontroller as illustrated in figure 1. This way the temperature range of 0 to 100 °C is mapped to a voltage range between 0 and 5V. The MCP601 by Microchip is an operational amplifier that can be powered up with a single supply of + 5V. A potentiometer may be placed in series with R₁ to calibrate the temperature. Note that the error on the measurement is ± 0.2 °C for n = 8 and ± 0.05 °C for n = 10.

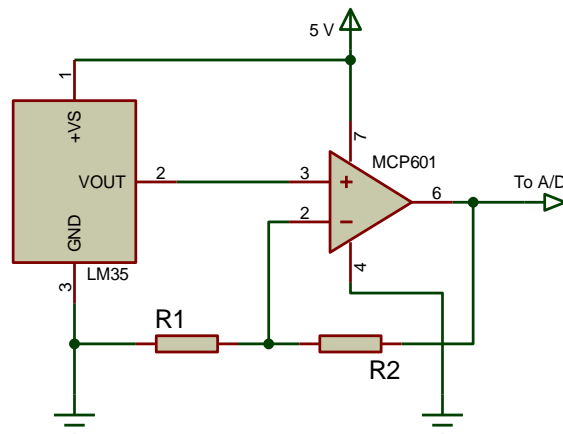


Figure 1: LM35 (10 mV/°C) temperature sensor amplified by a factor of 5 ($1+R_2/R_1=5$).

3. Lab Requirements

- Write a program to implement the digital thermometer on the multiplexed 7-segment display. Use a voltage divider (analog pot) to emulate a temperature range between 0 and 100 °C. For this purpose, you may show that for an 8-bit resolution with a left justified result:

$$T_C = 100 \text{ ADRESH} / 256 \quad (1)$$

- b. Add the option of displaying the temperature in Celsius or Fahrenheit. Initially, the system displays degree Celsius. When the user presses the button tied to **RB0**, the temperature unit is toggled (Celsius \rightarrow Fahrenheit and vice versa). Recall that $^{\circ}\text{F} = 1.8\ ^{\circ}\text{C} + 32$.
- c. Add a function `Control` that turns on the LEDs: HI (**RB7**), MED (**RB6**) and LO (**RB5**) in accordance with the following algorithm:

$0\ ^{\circ}\text{C} \leq T_c < 20\ ^{\circ}\text{C},$	<i>Turn on LO LED</i>
$20\ ^{\circ}\text{C} \leq T_c \leq 30\ ^{\circ}\text{C},$	<i>Turn on MED LED</i>
$30\ ^{\circ}\text{C} < T_c \leq 100\ ^{\circ}\text{C},$	<i>Turn on HI LED</i>

- d. Plug the LM35 temperature sensor provided to you by your instructor in the appropriate socket on the demo board. Make sure the sensor's output is applied to the analog channel RE2. Configure the A/D to use $V_{\text{REF-}} = 0\text{V}$ and $V_{\text{REF+}} = 1.024\text{V}$. For this purpose, you need to setup the fixed voltage reference (FVR) to output 1024 mV and subsequently apply this voltage to $V_{\text{REF+}}$. You will be given a brief overview of the FVR. Write the full-blown program to measure room temperature in Celsius and Fahrenheit. Use the following display format: 25°C or 77°F.

