Assignment #2

Heat/Cool Temperature Control

Proportional Control- Fall 2025

In this assignment, you will design and Control a Cooler in order to Control the temperature of a house by using Pulse Width Modulation and Proportional Control as Follows. We also use a heater but we will NOT control the Temperature in this case. We will use Compare mode to generate PWM for the Heater. We will Implement **4** modes: *OFF*, *Heat*, *Cool*, and *Auto-Cool*

Analog Input 0 (AI0): It is the (Pot. P1), It will be used to set the ***Set Point***. It is a Potentiometer of 10K Ohm. Scale the value read to 0 – 100C. This will be used in Auto-Cool Mode. It should be displayed on Line 2(see Pages, 4,5,6) We will Refer to it as ***SP (Set Point Temperature).***

Analog Input 1 (AI1): It is the (Pot. P2), It will be used to set the ***Heat Percentage in Heat Mode and Cool Percentage in Cool mode***. It is a Potentiometer of 10K Ohm. We will use it as Raw value (0 – 1023) to set the Cooling in Cool mode and will use it to set the Compare Value in Heating Mode

Display it as a percentage on Line 3 to reflect the amount of Cooling in Cool mode or Heat Mode. Read it always and display it on Line 3 regardless of the Mode.

Scale it as HC =[(AI1 Voltage Value)/5.0]*100.0% (see Pages, 4,5,6)

Analog Input 2 (AI2): This is already connected to a simulator that reads a voltage already connected to a sensor. Read the Voltage (0 –5) then scale it to temperature by just multiplying it by **100** since an increase of 10ms represent an increase by 1C. The minimum Value that it reads is around 27 degrees without doing extra changes. We will leave it as is to simplify things and we will control Temperatures above the minimum Value. The Value of this sensor is the actual temperature of the room.

We shall Refer to it as ***T (Temperature) or RT (Room Temperature).***

Heater: This is already connected to ***RC5***. We will Control the RC5(Heater) by using the Compare Mode to generate a Pulse width Modulated Signal by using Time1 Interrupt and the CCPP2IE interrupt.

Cooler (Fan): This is already connected to ***RC2*** which is the CCP1. We will use actual Pulse width Modulation to control the amount of Cooling.

Hysteresis (HS): This is a Value that we should set by INT1 at RB1 The HS should between 0 – 3 (use Enumeration). INT1 increments HS until it reaches 3, after that rollover to 0 if RB1 is pressed again. Hysteresis has meaning **only in Auto-Cool mode** when we are Controlling the temperature to reach the Set-point.

Operation Modes: This is a Value (Mode) that we should set Digitally through Interrupt INT0 at RB0. There shall be **4** Modes: OFF mode, Heat mode, Cool Mode, Auto Cool mode. Use ***INT0*** (**RB0**) will circulate through the Modes (You can use 4 values e.g. (0 – 3) (use Enumeration) and circulate through them. Rollover when the value exceeds 3. Also, use INT2(RB2) to turn the system OFF.

If INT2 (BB2) is pressed, reset the system to OFF mode directly (Mode = 0). Therefore, Mode 0 can be reached either by rotating through INT0 or pressing INT2(RB2). Mode details are explained below:

1. **Mode 0**: OFF mode. The system shall start in this mode. The System Shall be turned OFF: Heater OFF and Cooler OFF(0%). Turn the CCPIE Interrupt off in this mode. This mode can be reached by rotating the mode by INT0(RB0) or directly pressing INT2(RB2). The system can get out of this mode if INT0(RB0) is pressed.

2. **Mode 1 (Heat):** In this mode, set the Heating amount by using the Compare mode and its Interrupt and Timer 1 Interrupt to generate PWM. We are not using actual PWM because the Simulator has the heater on RC5. Also, we cannot use directly compare because the simulator does not have the heater at RC1..

   In the Initialization code do:
   Initialize the CCP2 mode in Compare mode 9 (CCP2CON = 9).Use Timer 1 for CCP2 only, Prescaler of 4. Enable Timer 1 Interrupt.
   In the main code do:
   In this mode Turn the Cooler Off and Enable the CCPIE2 Interrupt.
   Set the ***Compare-Value = AI1_RAW_Value * 64***. We multiplied the value by 64 (just shift left by 6 bits) to make the compare value represent the percentage, since the period will correspond to 2^16 = 65536 when Timer 1 overflow, so we scale the ***AI1_raw_Value*** to 16 bit and hence the multiplication by 64
   The work will actually be in the Interrupt as explained in the following Figure:

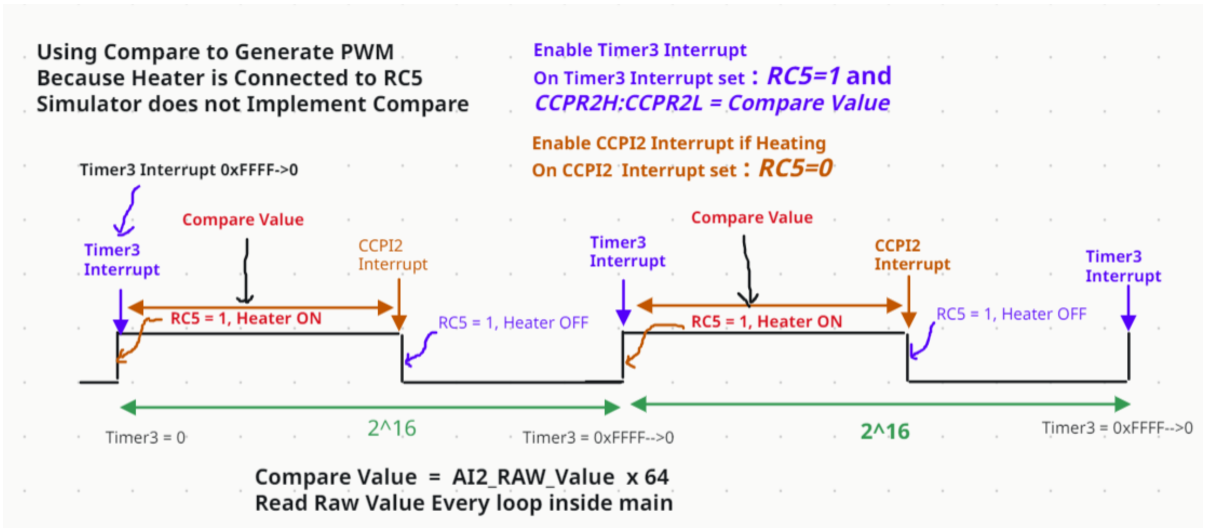

Using Compare to Generate PWM
Because Heater is Connected to RC5
Simulator does not Implement Compare
Enable Timer3 Interrupt
On Timer3 Interrupt set : RC5=1 and
CCPR2H:CCPR2L = Compare Value
Enable CCPI2 Interrupt if Heating
On CCPI2 Interrupt set : RC5=0
Timer3 Interrupt 0xFFFF->0
Timer3 Interrupt
Compare Value
CCPI2 Interrupt
RC5 = 1, Heater ON
RC5 = 1, Heater OFF
Timer3 Interrupt
Compare Value
CCPI2 Interrupt
RC5 = 1, Heater ON
RC5 = 1, Heater OFF
Timer3 Interrupt
Timer3 = 0
2^16
Timer3 = 0xFFFF-->0
2^16
Timer3 = 0xFFFF-->0
Compare Value = AI2_RAW_Value x 64
Read Raw Value Every loop inside main

Figure 1

3. **Mode 2 (Cool):** In this mode, use PWM2 module(CCP1) to set the Cooling amount.
   PWM raw-value = ***AI1-raw_Value***. Use *Prescaler of 16 for Timer 2*

4. **Mode 3 (Auto Cool):**
   In this mode, the amount of Heating or Cooling will be proportional to the difference between the Actual Temperature and the Set Point as explained below.
   In this Mode, we will control cooler such that the Temperature will be automatically Controlled to become Almost Equal to the Set Point. In other words, we bring it to the Set Point to within a Hysteresis(H) Value (A small value, we will restrict to a Max of 3 as explained in Page 1 it can be from (0 --3). This Means that the Difference between the actual Temperature and the Setpoint should be very small (No more than the H Value).
   We should Not Heat and Cool at the Same Time.
   Auto Cool: The Temperature(T) should be controlled such that the Actual Temperature should be around the Set Point referred to ad ***SP (SetPoint)***. The ***Cooler*** should be controlled by the Pulse Width Modulation signal CCP1 at RC2. The Value of the PWM percentage should be proportional to the **CoolError = T – SP** if T > SP and should be turned Off if T < (SP-HS). The percentage of Cooling (PWM percentage value) should be set as follows.

```
CoolError = T – SP
 If( CoolError > 0){
      PWM percentage value = CError*100/10;
      Set the CCP1 PWM to PWM percentage value
      If this value is less than 25% set it to 25%
      heater should be off here
 }
 If( T < (SP -HS)  )
      PWM percentage value =0 ;// Cooler OFF (turn heater here, see below)
```

In real life, the ***Heater*** should be always off but ***here*** we are ***forced*** to make it ***(50% see note below)*** **when T fall below (SP – HS), that is (if T < (SP -HS))** ***because we cannot increase the temperature. If we do not do that. in real life, in summer, the temperature rises when we turn the cooler off, we cannot do that here.***

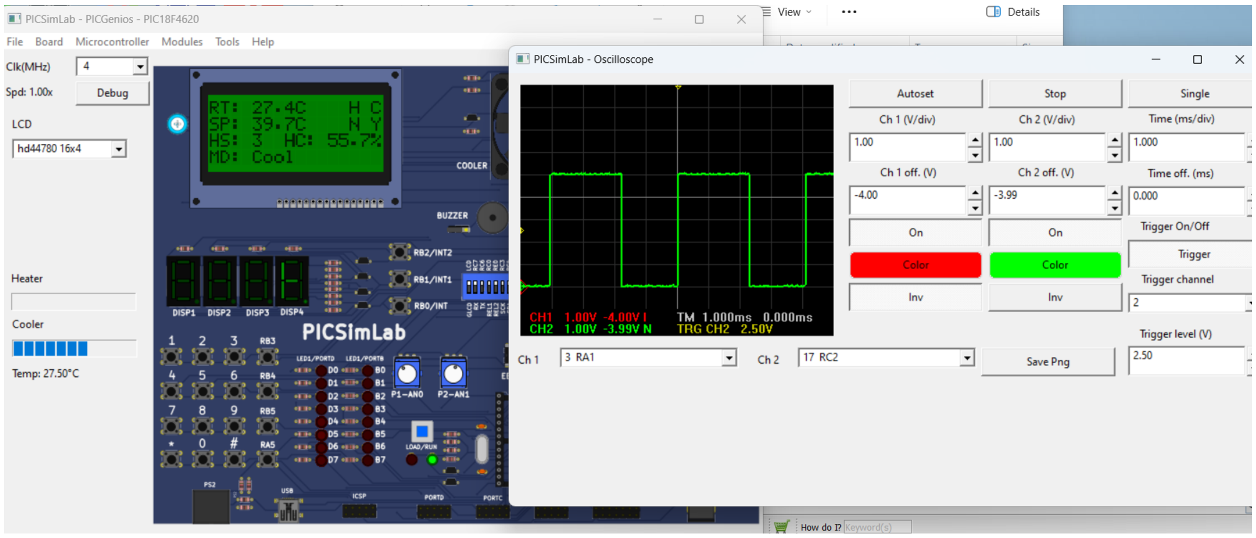
Note: So we will need to turn the heater ON as we did on mode 2 (heat) by the same Compare method explained above.It is up to you, to force the heater to 50% or simply turn AI2 to almost 50% . Turn the heater on by the Code by enabling the Compare interrupt but only when t

Notes:

1. The temperature should be automatically updated as well as HS and the Mode if changed.
2. See the figures on this page and following pages to see what and where to display.
3. The main program should an infinite loop and there should be noticeable flicker in the screen. It should be continuously reading the Analog Inputs and displaying them. You can put a small delay if needed.
4. The Interrupt code should be minimal, just change the Variables) and do actual displaying in the Main Program. Do not read any analog values or display inside the Interrupts.
5. In the auto mode use set point between 35 and 46 for best performance because of the special cases. So not worry about special cases of the heater.

   There are special cases for the Heater, since this is a simulator. You cannot make the Temperature more than 76 and cannot be less than 27.
6. Make sure when you enable your Interrupts to Enable the Most Two significant bits bit 7 and 6 in INTCON. (GIEH, and GIEL) Otherwise your Timer 1 interrupt will not work correctly. Disable the Priority.
7. Work in Groups of 2 and start as soon as possible.

Both Partners must submit the assignment. If one submits and the other does not. The one that does not submit will get 0.


PICSimLab - PICGenios - PIC18F4620

Clk(MHz) 4

Spd: 1.00x

LCD hd44780 16x4

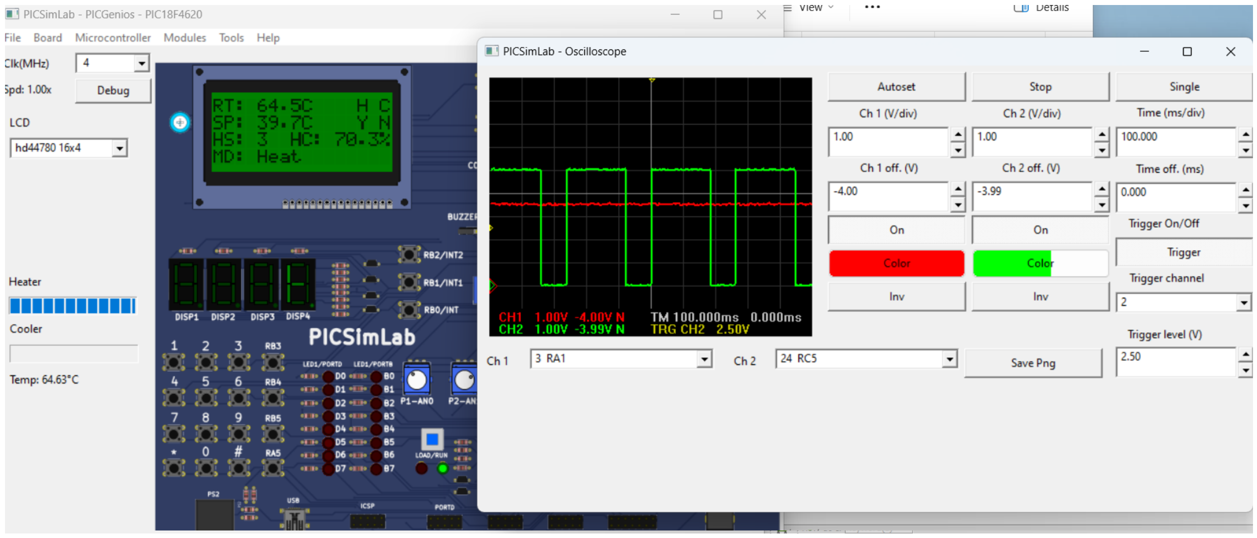
```
RT: 27.4C     H C
SP: 39.7C     N Y
HS: 3  HC: 55.7%
MD: Cool
```

Temp: 27.50°C

PICSimLab - Oscilloscope

```
CH1  1.00V  -4.00V I     TM  1.000ms   0.000ms
CH2  1.00V  -3.99V N     TRG CH2   2.50V
```

Ch 1 (V/div): 1.00
Ch 2 (V/div): 1.00
Time (ms/div): 1.000
Ch 1 off. (V): -4.00
Ch 2 off. (V): -3.99
Time off. (ms): 0.000
Trigger channel: 2
Trigger level (V): 2.50
Ch 1: 3 RA1
Ch 2: 17 RC2

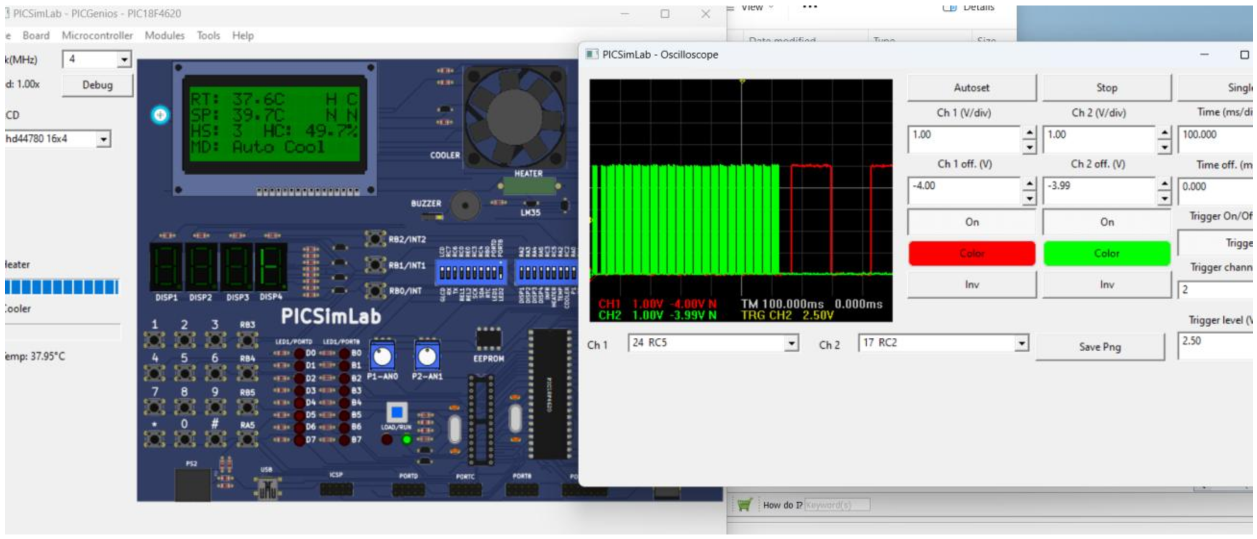


Clk(MHz) 4
Spd: 1.00x
LCD hd44780 16x4
Heater
Cooler
Temp: 64.63°C

```
RT: 64.5C    H C
SP: 39.7C    Y N
HS: 3  HC: 70.3%
MD: Heat
```

```
CH1  1.00V -4.00V N    TM 100.000ms  0.000ms
CH2  1.00V -3.99V N    TRG CH2  2.50V
```

Ch 1 (V/div): 1.00
Ch 2 (V/div): 1.00
Time (ms/div): 100.000
Ch 1 off. (V): -4.00
Ch 2 off. (V): -3.99
Time off. (ms): 0.000
Trigger channel: 2
Trigger level (V): 2.50
Ch 1: 3 RA1
Ch 2: 24 RC5

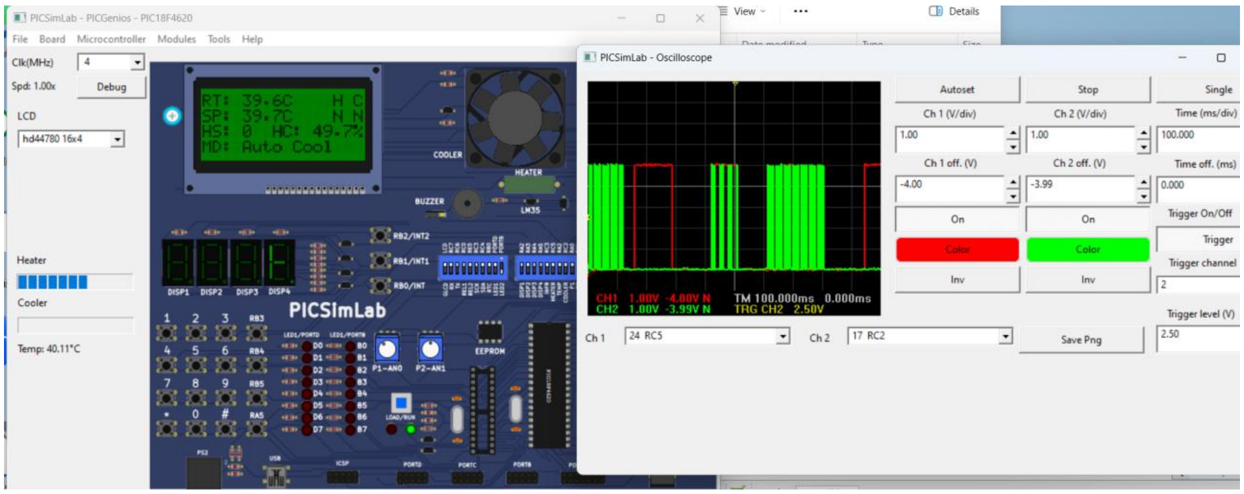


k(MHz) 4
d: 1.00x
CD hd44780 16x4
leater
Cooler
emp: 37.95°C

```
RT: 37.6C    H C
SP: 39.7C    N N
HS: 3  HC: 49.7%
MD: Auto Cool
```

```
CH1  1.00V -4.00V N    TM 100.000ms  0.000ms
CH2  1.00V -3.99V N    TRG CH2  2.50V
```

Ch 1 (V/div): 1.00
Ch 2 (V/div): 1.00
Time (ms/di 100.000
Ch 1 off. (V): -4.00
Ch 2 off. (V): -3.99
Time off. (m 0.000
Trigger chann 2
Trigger level (V 2.50
Ch 1: 24 RC5
Ch 2: 17 RC2


PICSimLab - PICGenios - PIC18F4620

Clk(MHz): 4
Spd: 1.00x
LCD: hd44780 16x4

```
RT: 39.6C     H C
SP: 39.7C     N N
HS: 0  HC: 49.7%
MD: Auto Cool
```

Heater
Cooler
Temp: 40.11°C

PICSimLab - Oscilloscope

```
CH1  1.00V -4.00V N    TM 100.000ms  0.000ms
CH2  1.00V -3.99V N    TRG CH2   2.50V
```

Ch 1 (V/div): 1.00
Ch 2 (V/div): 1.00
Time (ms/div): 100.000
Ch 1 off. (V): -4.00
Ch 2 off. (V): -3.99
Time off. (ms): 0.000
Trigger channel: 2
Trigger level (V): 2.50
Ch 1: 24 RC5
Ch 2: 17 RC2