Question (1): (6 Marks)

The figure below shows 200 step/revolution **Stepper Motor**. Inter-state time delay changes according to the stepper motor speed. (Assume any missing data if any)

a) Calculate the **delay time (ms),** for step transition, to rotate the stepper motor with 6RPM.
b) Complete the following code to run the stepper motor with 6RPM.

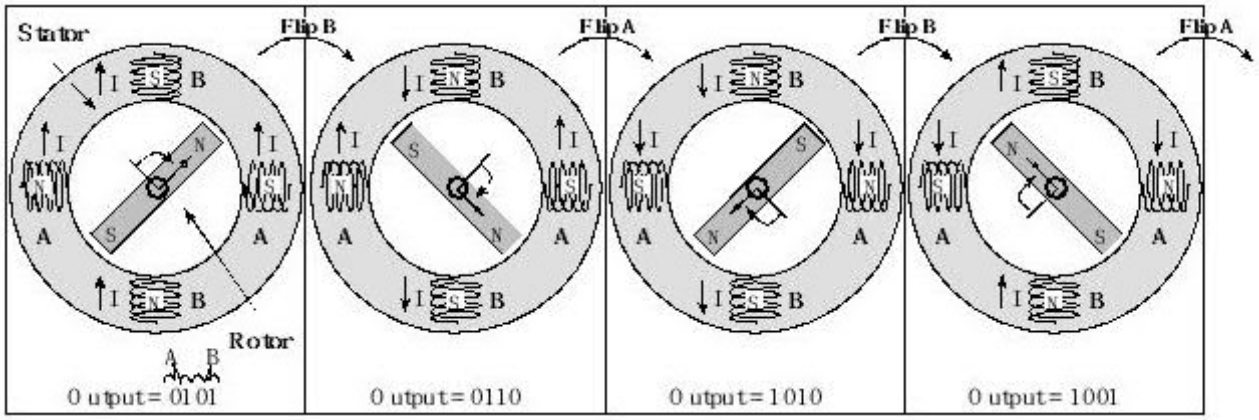

Figure: Stepper Motor states

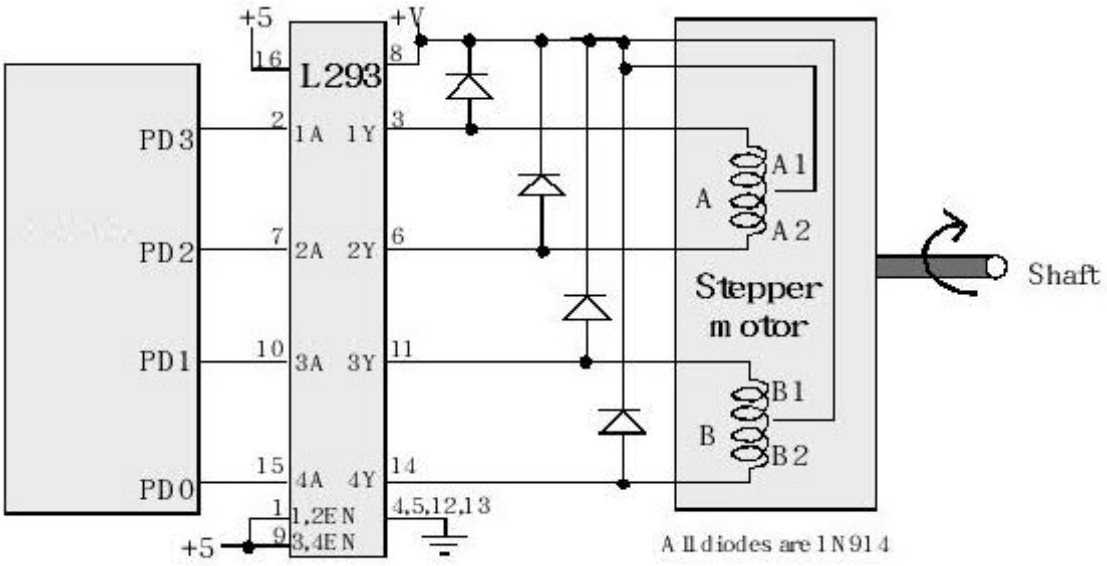

Figure: Stepper Motor Connections to Microcontroller

```
struct State{
  uint8_t Out;
  const struct State Next;
  uint8_t Delay;
};
typedef const struct State StateType;
StateType fsm[4]={
  {_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _},
  {_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _},
  {_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _},
  {_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _}
};
const struct State Pt;

int main(void){
  while(1)
 {
    PORTD = _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ ;
    Wait_ms(_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _);
    Pt = _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ ;          // Update the current state with the next state
  }
}
```

Question (2): (6 Marks)

The following figure represents a closed loop control system for an automatic electric oven. A thermistor has a resistance value of 10KΩ at 25ºC and a resistance value of 100Ω at 100ºC is used with V_{cc} = 5v. By means of voltage divider, the change in resistance is sensed as change in voltage.

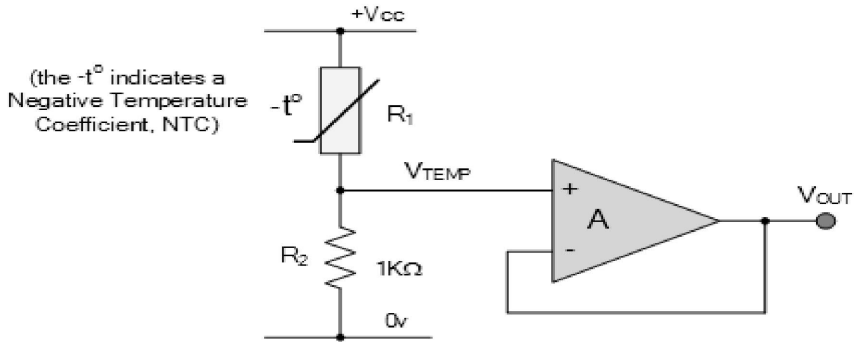

Figure: Thermistor interfacing circuit

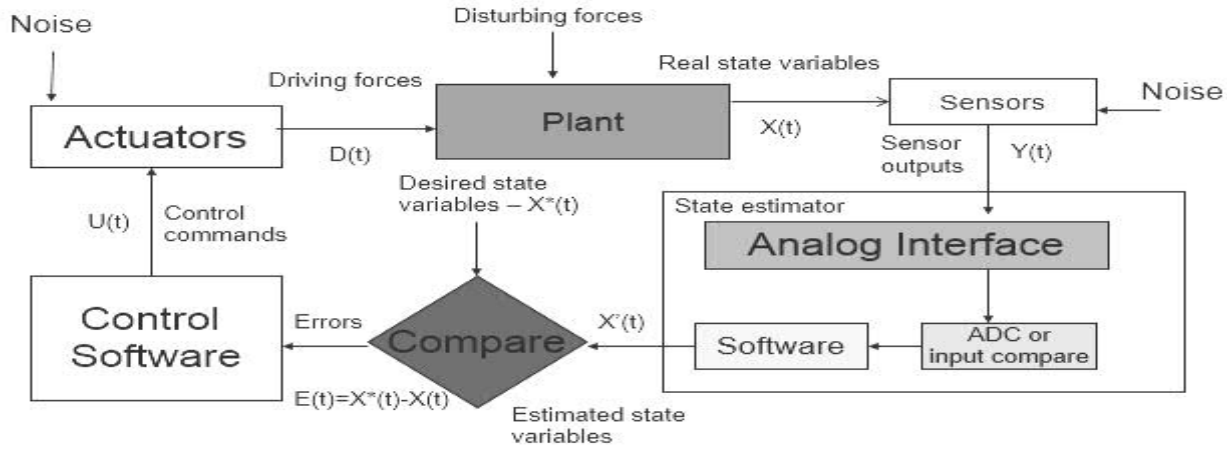

Figure Closed loop control system

The oven operates between 25 ºC to 100 ºC

a. Using PIC18 12-bit ADC, determine the V_{ref+} (saturation maximum voltage) and V_{ref-} (saturation minimum voltage). Can we use the default 0v and 5v of the PIC ADC?
b. Determine the resolution for the PIC18 12-bit ADC measuring voltage change.
c. Determine the equation to calculate the temperature **T** given the converted value D which has range of **0 -> (2^{12}-1)**.
d. The control system is based on PI controller of K_p = 1000 and K_i = 200. Write the PI controller implementation instructions **only**. Given the system time constant = 30 seconds. In order to control the PWM of the heater, your code must show the error calculation, PI computation and finally the saturation of the control signal between 100 and 39900.

AIN SHAMS UNIVERSITY FACULTY OF ENGINEERING *Computer and Systems Engineering Department*		
27th. May, 2017	**Course Code: CSE 347**	***Time: 3 Hours***
Embedded System Design		
The Exam/Answer-Sheet Consist of 7 Questions in 8 Pages	***Total Marks: 40 Marks***	**4/8**

Question (3): (6 Marks)

The following is a partial FreeRtos based application. Complete the dashed blank spaces while following the given comments. Sketch CPU-tasks utilization timing digram for the first 200 ms. Assume any missing necessary data if any.

```
/* Scheduler include files. */
_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

#define mainLED_FLASH_PRIORITY 1

#pragma config WDT=OFF

/* Necessary Tasks Prototypes
_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

/* Used to hold the handle of Task2. */
TaskHandle_t xTask2Handle;

void main( void )
{
/* Initialise the required hardware. */
vParTestInitialise();

/* Create the first task at priority 1.  */
xTaskCreate( vTask1, "Task1", configMINIMAL_STACK_SIZE, _ _ _ _, _ _ _ _ , _ _ _ _  );

/* Start the scheduler. */
_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _  ;
}
```

```
static void vTask1( void *pvParameters )
{
for( ;; )
        {
         PORTDbits.RD7 = !( PORTDbits.RD7 );
/* Create task 2 at a higher priority. */
         xTaskCreate( vTask2, "Task2", configMINIMAL_STACK_SIZE, _ _ _ _ , _ _ _ _ , _ _ _ _ );
         .
         .
         .
         vTaskDelay(100);
        }
}

static void vTask2( void *pvParameters )
{
for( ;; )
        {
         PORTDbits.RD6 = !( PORTDbits.RD6 );
/* Kill Task 2 */
         _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ ;
        }
}
```

Question (4): (6 Marks)

Code that is unreachable or that does not affect the program (e.g. dead stores) can be eliminated. Using this kind of "optimization", write the equivalent C-code for the following program:

```
int global;
void f ()
{
  int i;
  i = 1;
  global = 1;
  global = 2;
  return;
  global = 3;
}
```

Question (5): (6 Marks)

Assume three networked ECU 1,2,3 (electronic control units) simultaenously sending CAN frames with IDs; 433, 154, and 187 respectively. In the following figure, sketch each ECU output and CAN bus digital transitions. Assume any missing data if any.

ECU 1														
ECU 2														
ECU 3														
CAN Bus														

Question (6): (5 Marks)

For the tasks shown in the following table, verify whether these tasks are schedulable using Rate Monotonic Algorithm. Vertically split the following blank timing diagram between tasks while assuming 1ms for each horizontal square. Given that all time units are in ms, how much time the CPU is not utilized from 0ms till 12ms.

Tasks	Period	CPU Execution Time
T1	12	5
T2	7	3

Question (7): (5 Marks)

a) Write a C18 program to send "ASU" and "ENG" to PORTC. Use the program ROM space for data. "ASU" and "ENG" should be at addresses 0x200 and 0x220 respectively.

b) What changes should be done in order to use RAM space 0x300 and 0x320 instead?

c) What is the difference between "far" and "near" ROM storage?

d) What is the difference between #pragma code and #pragma romdata?

e) What is the difference between #pragma udata and #pragma idata?