DESIGN OF MICROCONTROLLER BASED BABY INCUBATOR

A THESIS REPORT SUBMITTED TO THE DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING, ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT) IN PRACTICAL FULFILLMENT FOR THE DEGREE OF BACHELOR OF SCIENCE IN ELECTRICAL & ELECTRONIC ENGINEERING

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*This is to certify that the work presented in this thesis is the result of the implementation of "**MICROCONTROLLER BASED BABY INCUBATOR**" which has been supervised by GOLAM SAROWAR, Assistant Professor, EEE Department of Islamic University Of Technology (IUT).*

This thesis was undertaken as a partial fulfillment of requirements for the Bachelor of Science degree in Electrical &Electronic Engineering. It is also declared that this thesis thereof has not been submitted anywhere else for the award of any degree or any publication.

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ABSTRACT

Infant incubator provides a controlled environment for newborns needing special care, such as those born prematurely. By placing an infant in an incubator, doctors and nurses can set and monitor different aspects of the child's environment in order to create ideal conditions for survival and moreover it protect infants from pollutants and infection. Infant incubators and other advances in medical technology have made it possible for small or premature babies to survive in higher numbers than they did in the middle of the 20th century.

Design and development of microcontroller based temperature and humidity controller for an infant incubator monitors and controls these two parameters constantly which are very critical for the normal growth of the new born (premature) babies In this thesis work, focus has been to develop:

1. Hardware for temperature and humidity control

2. Compatible software

This system can automatically control the infant's temperature at optimum level usingPID concept and to maintain high relative humidity so as to minimize the thermal loss. The developed system must be user friendly, cost effective and accurate.

ACKNOWLEDGEMENT

Words are often to less to revel one's deep regards. An understanding of the work like this is never the outcome of the efforts of a single person. I take this opportunity to express my profound sense of gratitude and respect to all those who helped me through the duration of this thesis. First of all we would like to thank the Supreme Power, one who has always guided me to work on the right path of the life. Without his grace this would never come to be today's realty. This work would not have been possible without the encouragement and able guidance of my supervisor Mr. Golam Sarowar, his enthusiasm and optimism made this experience both rewarding and enjoyable. Most of the novel ideas and solutions found in this thesis are the result of our numerous stimulating discussions. His feedback and editorial comments were also invaluable for the writing of this thesis .We are also grateful to Head of the Department Mr. Shahidullah for providing the facilities and the encouragement for the completion of thesis. We would also like to thank our parents without whom none of this would have been possible ever.

At last, we would like to thank to all the members of EEE department whose love and affection made our stay at iut campus a memorable one.

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Introduction:

A neonatal incubator is a device consisting of a rigid box-like enclosure in which an infant may be kept in a controlled environment for medical care. The device may include a heating element, a fan for forced convection, a water bath to add humidity, a valve through which oxygen may be controlled, and access ports for nursing care.[3] Another type of incubator is the neonatal transport incubator which can be used to safely transport a baby to different rooms of a hospital or even outside during an emergency. If the infant is born with complications it can be put in a neonatal intensive care unit (NICU). NICUs were developed in the 1950s and 1960s by pediatricians to provide better temperature support, isolation from infection risk, specialized feeding, and access to specialized equipment and resources.

In infants born before 31 weeks gestation, evaporative water loss is the single most important channel of heat loss. This is due to a loss in moisture of the skin cells, which allows a high permeability of water to the skin. The permeability drops rapidly in the first 7 to 10 days after birth unless the skin becomes traumatized or secondarily infected.[3] In that 7 to 10 day period, the absolute humidity must be monitored so that evaporative heat loss is kept to a minimum as well as water loss through the skin.[3] The current way to monitor the baby's temperature is with a thermistor and a controlled heating unit, but it cannot account for the water lost through the skin, which is critical to maintain for the first 7 to 10 days after birth to prevent dehydration.

Prematurely born babies often have difficulty regulating their body temperature this can lead to organ failure; neonatal incubators are an important device for reducing infant mortality. The goal of this project is to design an efficient and cost effective neonatal incubator.

1.0 Infant Incubator:

An incubator is an infant-stimulating system used for intensive care of the new born, premature or sick baby. It provides a safe and clean environment, which has fresh air, clean and sterile ambient conditions for the babies. In addition to these, the incubator environment provides a homogeneous and stable temperature, a relative humidity (RH) level and oxygen gas concentration that are needed especially for intensive care of the premature baby. Since the incubator is a medical device and has a lot of limitations as other medical equipment, the most suitable humidity measurement and humidifying method have to be used. For continuous recording and control of the RH level, many kinds of electrical transducers can be employed such as resistive, capacitive, lithium chloride, electrolytic and integrated circuit (IC) type RH sensors which measure the RH level in the air. Owing to the suitable electrical characteristics for the measurement and control process, capacitive and IC types RH sensors are more suitable than the others .Infant incubator is used mainly to keep a baby's core temperature stable at 37 degrees Celsius. The core temperature of the human body needs to be kept at a constant temperature of 37 degrees Celsius because the temperature goes too high or too low, then the organs can be damaged and illness or death can result. Premature babies (babies born before they are due to be born) have undeveloped nervous systems and also lack the energy to regulate their own temperature, which drop significantly because of heat loss from conduction (heat loss to cooler surfaces in direct contact with the infant), convection (heat loss to air moving past the infant), radiation (heat loss to cooler objects not in direct contact with the infant), and water evaporation (heat loss from the infant's lungs and skin surface). Whereas term neonates naturally regulate their body temperature to some extent, premature infants have thinner skin, which allows surface blood vessels to more readily lose heat to the environment; a large ratio of surface area to volume, resulting in greater heat losses from radiation and convection; and there is no subcutaneous fat to either metabolize into heat or act as an insulator. Prolonged cold stress in neonates can cause oxygen deprivation, hypoglycemia, metabolic acidosis, and rapid depletion of glycogen stores; therefore, energy conservation provided by thermal support is critical and hence their temperature needs to be maintained by an incubator [3]. We can only give small babies a small amount of food for growing. We want them to use all of their energy for growth rather than wasting it on keeping warm, so sometimes we use the incubator to help them grow faster. Every year, about 1 million infants in the developing world die due to heat loss and dehydration that can be prevented by an intensive care unit. Thus the function of the incubator is to compensate for these disadvantages and provide a congenial atmosphere for the infants .

1.1 Principles of Operation

The neonate lies on a mattress in the infant compartment, which is enclosed by a clear plastic hood. Most incubators have hand access ports with doors that permit the infant to be handled while limiting the introduction of cool room air. The clinician can raise or remove the plastic hood or open a panel to gain greater access to the infant. Some units feature an air curtain that causes warm air to sweep past the opening. Most incubators warm the infant by a forced or natural flow of heated air. At least one unit supplements air convection by actively warming the incubator walls to reduce radiant heat loss. Another unit uses a mattress of warm water, rather than a convective airflow, to warm the infant. Heating and humidification systems are located beneath the infant compartment. A fan or natural flow circulates air past the heater and the temperature measuring device, over a water reservoir used to humidify the air (if desired), and up into the infant compartment. Most incubators are equipped with proportional heating controls that provide electrical.power to the heating coil in response to the difference between the actual temperature and the desired temperature. Most units have two modes of operation:

a) Air-temperature control: With the air-temperature (manual) control, the operator sets the temperature of the air in the incubator; changes in infant body temperature are usually measured periodically with a thermometer, and adjustments in air temperature are made accordingly.

b) Skin-temperature control: In the skin temperature control mode, also called the servo (automatic) mode, a sensor is taped to the infant's skin, and the heater responds to changes in the sensor to keep the skin temperature at the preset level. Most units allow the user to vary relative humidity from either a built-in reservoir or an outside source (e.g., a humidifier that attaches to one of the inlet ports). Although increasing the relative humidity in an incubator can reduce evaporative heat loss, many clinicians avoid supplemental humidification because of concern that infectious organisms may proliferate in the water reservoir. Many incubators have one or two oxygen inlet ports and can be equipped with optional oxygen controllers. These incubators can also provide support and protection for oxygen cylinders when oxygen must be delivered to the infant in the incubator. Because the room temperature of the nursery is nearly always lower than the temperature inside the incubator, radiant heat loss through the incubator walls accounts for as much as half the infant's total heat loss. In so although the double-walled incubator decreased radiant heat loss, it increased convective heat loss; total heat loss and metabolic heat production were the same as in single-walled incubators .

me nurseries, a plastic heat shield is placed over the infant inside the incubator to minimize radiant heat loss. In addition, some incubators have double walls separated by an air space to prevent excessive heat loss. However, in a study comparing heat loss from servo-regulated single- and double walled incubators.

1.2 Basic Biomedical Instrumentation System

The primary purpose of medical instrumentation system is to measure or determine the

presence of some physical quantity that may some way assist the medical personnel to

make better diagnosis and treatment VARIOUS PARTS OF INCUBATOR:

1. Measurand: The physical quantity or condition that the instrumentation system measure is called measurand. The source for the measurand is the human body, which generates a variety of signals.

2. Transducer/Sensor: A transducer convert's one form of energy to another. The primary function of the transducer is to provide a usable output in response to the measurand, which may be a specific physical quantity, property or condition.

Basically, a sensor converts a physical measurand to an electrical signal. Depending on the transducer, the output produced is in the form of voltage, current, resistance, or capacitance. The sensor should be minimally invasive and interface with the living system with minimum extraction or energy. The primary function of the transducer is to provide a usable output in response to the measurand.

3. Signal Conditioner: For interfacing analog signals to the microprocessor or microcontroller, use is made of some kind of data acquisition system. The function of the system is to acquire and digitize data, often from hostile clinical environments, without any degradation in the resolution or accuracy of the signal. Signal conditioner converts the output of the transducer into an electrical quantity suitable for operation of the display or recording system or control purposes. Signal conditioning usually includes functions such as amplification, conversion analog to digital or signal transmission circuitry. Buffer amplifier help in increasing the sensitivity of instruments by amplification of the original signal or its transducer form. The A/D converter carries out the process of the analog to digital conversion. The higher the no of bits, the higher the precision of conversion. Since software costs generally far exceed the hardware costs, the analog or digital interface structure must permit software effective transfers of data and command and status signals to avail of the full capability of the micro controller.

The key parameters in A/D converters are:

•

Resolution of the A/D converter is a measure of the number of discrete digital code that it can handle and is expressed as number of bits (binary).

For example, for an 8- bit converter the resolution is 1 part in 256.

•

Accuracy is expressed as either a percentage of full scale or alternatively in bits of resolution.

•

Integral non-linearity is a measure of the deviation of the transfer function from a straight line.

•

Speed of an A/D converter is generally expressed as its conversion time i.e. the time elapsed between application of a convert command and the availability of data at its outputs.

4. Display System: Provides a visible representation of the quantity. It may be on the chart recorder, or on the screen of a cathode tube or in numeric form or LCD display.

5. Alarm System: With upper and lower adjustable thresholds to indicate when the measurand goes beyond present limits.

6. Data transmission: Standard interface connections can be used so that the information obtained may be carried to other parts of an integrated system or to transmit from one location to another.

7. Data Storage: To maintain the data for future reference. It may be a hard copy on a paper or on magnetic or semiconductor memories.

8. Control System: It controls all the operations of the instrument. It consists of a microprocessor or a micro-controller and software stored inside it to provide the necessary controls. The control logic provides the necessary interface between the microcontroller system and the elements of the acquisition unit in providing the necessary timing control. It has to ensure that the correct analog signal is selected, samples data at correct time, initiate the A/D conversion process and signals to the microcontroller or microprocessors on completion of conversion.

1.3 Problem Definition

Baby Incubator is one of the quite essential life supportive equipment for the premature babies in the hospitals. Unfortunately, there is a lack of low cost infant incubators in the developing world. “The aim of the thesis is to design and develop a microcontroller based temperature control using PID concept and humidity control in an infant incubator”. Advances in electronic techniques coupled with economical prices make humidity and temperature control cost-effective with highly accurate and stable performance. In this work main focus will be to:

1. Design and develop hardware for temperature and humidity control.

2. The development of software using ATMEGA16 microcontroller.

The developed system should be accurate, economical, user friendly and must provide the required environment for the growth of the premature baby.

2: MICROCONTROLLER:

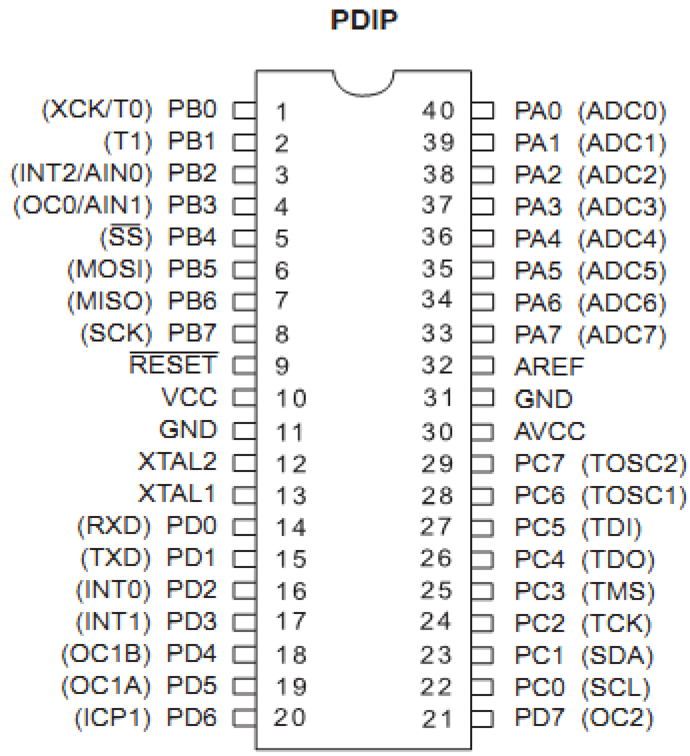
2.0 ELECTRICAL COMPONENT USED:

1. Microcontroller
2. Temperature Sensor
3. Humidity Sensor
4. Heater
5. Relay
6. Bipolar Transistor
7. Fluorescent Bulb
8. Liquid Crystal Display

A short description is given below about this component

2.1 Microcontroller:

For our project we use atmega32 microcontroller which is from atmel.It is a risc micro-controller.A pictorial representation is given below for this micro-controller



.. .

It has several features just like I/O, Interrupt , ADC, Serial Communication, Timer/Counter etc.

But for our project we only needs ADC and I/O features. A short description about this two features is given below

2.2 INPUT/OUTPUT FEATURE:

All AVR ports have true Read-Modify-Write functionality when used as general digital I/O ports.This means that the direction of one port pin can be changed without unintentionally changing the direction of any other pin with the SBI and CBI instructions. The same applies when changing drive value (if configured as output) or enabling/disabling of pull-up resistors (if configured asinput). Each output buffer has symmetrical drive characteristics with both high sink and source capability. The pin driver is strong enough to drive LED displays directly. All port pins have individually selectable pull-up resistors with a supply-voltage invariant resistance. All I/O pins have protection diodes to both VCC and Ground as indicated in Figure below

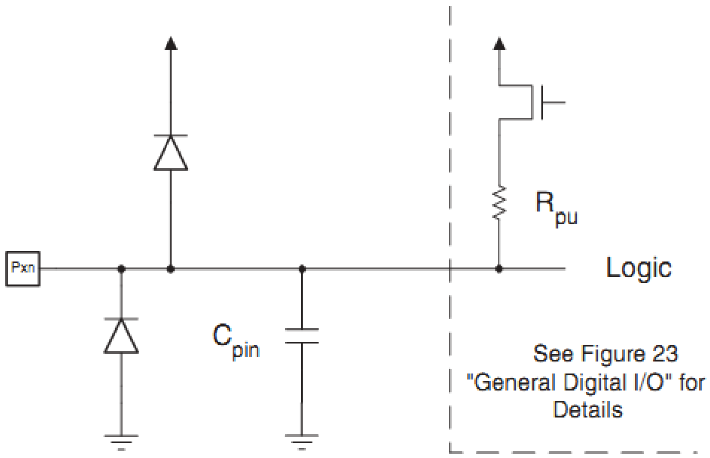


Figure : I/O Pin Equivalent Schematic

The register set used for I/O operation is given below:

Register Description for I/O Ports

Port A Data Register – PORTA

Bit	7	6	5	4	3	2	1	0	
	PORTA7	PORTA6	PORTA5	PORTA4	PORTA3	PORTA2	PORTA1	PORTA0	PORTA
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Initial Value	0	0	0	0	0	0	0	0	

Port A Data Direction Register – DDRA

Bit	7	6	5	4	3	2	1	0	
	DDA7	DDA6	DDA5	DDA4	DDA3	DDA2	DDA1	DDA0	DDRA
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Initial Value	0	0	0	0	0	0	0	0	

Port A Input Pins Address – PINA

Bit	7	6	5	4	3	2	1	0	
	PINA7	PINA6	PINA5	PINA4	PINA3	PINA2	PINA1	PINA0	PINA
Read/Write	R	R	R	R	R	R	R	R	
Initial Value	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	

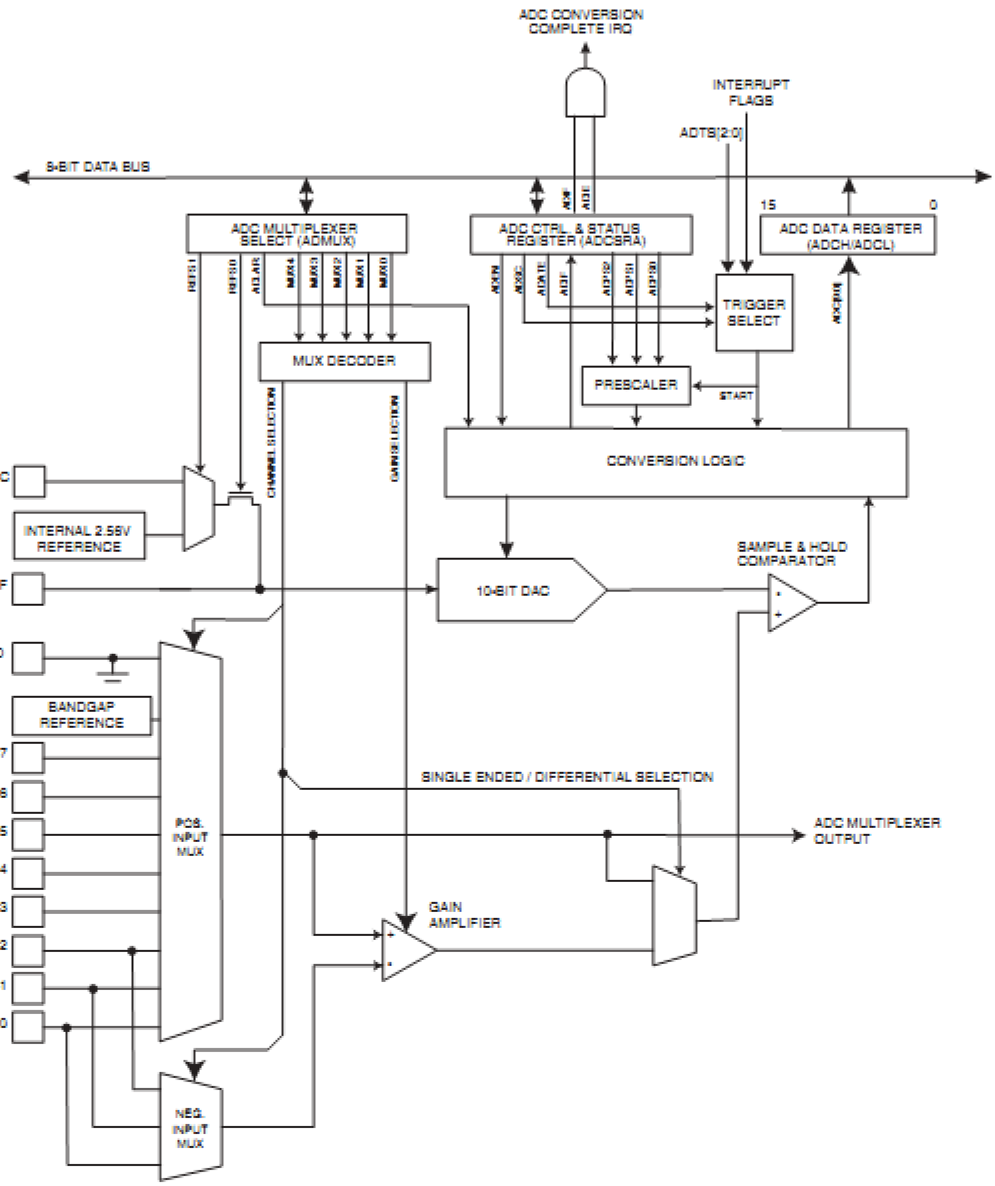
Here the Port Data register signifies the input operation of a I/O pin.DDR register signifies the direction of the pin as it works as input or output.

2.3 Analog to Digital Converter:

The ATmega32 features a 10-bit successive approximation ADC. The ADC is connected to an 8-channel Analog Multiplexer which allows 8 single-ended voltage inputs constructed from the pins of Port A. The single-ended voltage inputs refer to 0V (GND).

The device also supports 16 differential voltage input combinations. Two of the differential inputs (ADC1, ADC0 and ADC3, ADC2) are equipped with a programmable gain stage, providing amplification steps of 0 dB (1x), 20 dB (10x), or 46 dB (200x) on the differential input voltage before the A/D conversion. Seven differential analog input channels share a common negative terminal (ADC1), while any other ADC input can be selected as the positive input terminal. If 1x or 10x gain is used, 8-bit resolution can be expected. If 200x gain is used, 7-bit resolution can be expected.

The ADC contains a Sample and Hold circuit which ensures that the input voltage to the ADC is held at a constant level during conversion. A block diagram of the ADC is shown below



The ADC has a separate analog supply voltage pin, AVCC. AVCC must not differ more than ±0.3 V from VCC. See the paragraph “ADC Noise Canceler” on page 208 on how to connect this pin.

Internal reference voltages of nominally 2.56V or AVCC are provided On-chip. The voltage reference may be externally decoupled at the AREF pin by a capacitor for better noise performance.

2.4 ADC Conversion Result:

After the conversion is complete (ADIF is high), the conversion result can be found in the ADC

Result Registers (ADCL, ADCH). For single ended conversion, the result is

$$ADC = \frac{V_{IN} \cdot 1024}{V_{REF}}$$

where VIN is the voltage on the selected input pin and VREF the selected voltage reference.

If differential channels are used, the result is

$$ADC = \frac{(V_{POS} - V_{NEG}) \cdot GAIN \cdot 512}{V_{REF}}$$

where VPOS is the voltage on the positive input pin, VNEG the voltage on the negative input pin, GAIN the selected gain factor, and VREF the selected voltage reference. The result is presented in two's complement form, from 0x200 (-512d) through 0x1FF (+511d). Note that if the user wants to perform a quick polarity check of the results, it is sufficient to read the MSB of the result (ADC9 in ADCH). If this bit is one, the result is negative, and if this bit is zero, the result is positive.

2.5 TEMPERATURE SENSOR:

For our project the temperature sensor we used is the LM35.The circuit diagram for this sensor is given below

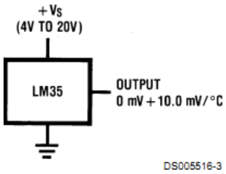
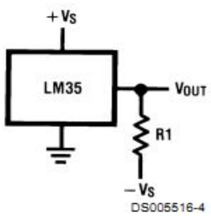


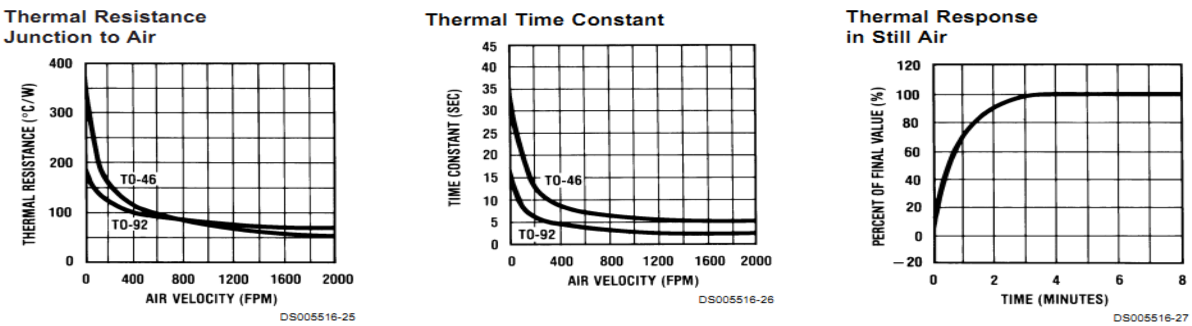
FIGURE 1. Basic Centigrade Temperature Sensor (+2˚C to +150˚C)



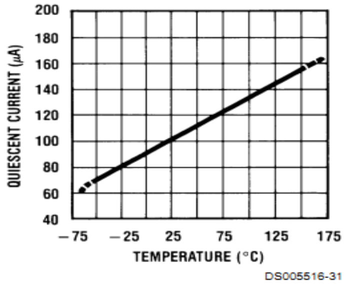
Choose $R_1 = -V_S/50\ \mu A$
V_{OUT}=+1,500 mV at +150˚C
= +250 mV at +25˚C
= −550 mV at −55˚C

FIGURE 2. Full-Range Centigrade Temperature Sensor

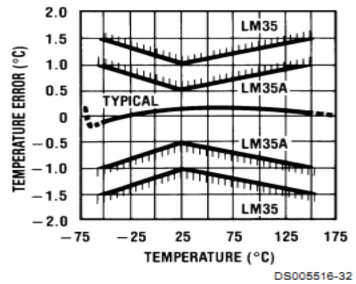
Typical Performance Characteristics



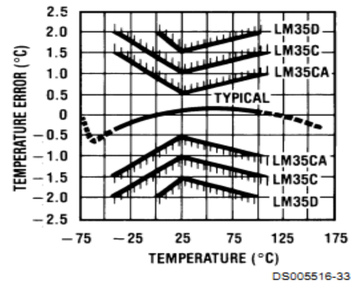
Quiescent Current vs. Temperature (In Circuit of *Figure 2*.)



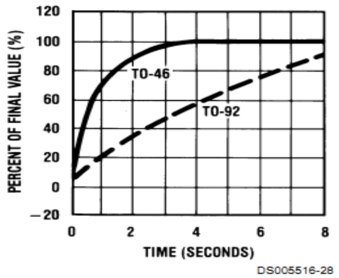
Accuracy vs. Temperature (Guaranteed)



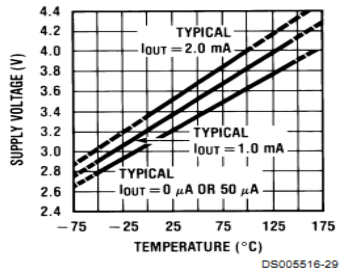
Accuracy vs. Temperature (Guaranteed)



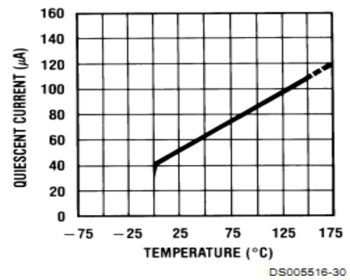
Thermal Response in Stirred Oil Bath



Minimum Supply Voltage vs. Temperature



Quiescent Current vs. Temperature (In Circuit of *Figure 1*.)



If we express the input/output by straight line equation then it will be simply

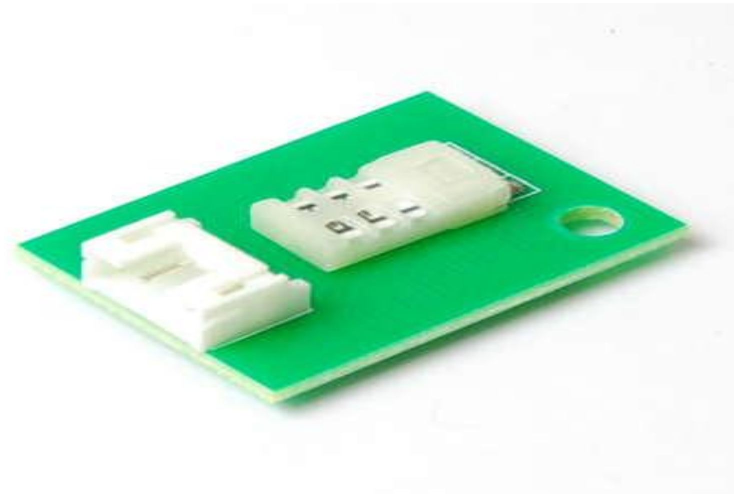
Temperature=Y*100=mX

Where Y=output voltage

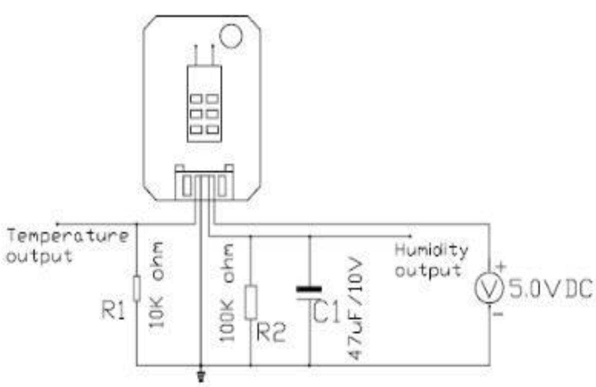
X=input voltage

2.6 HUMIDITY SENSOR:

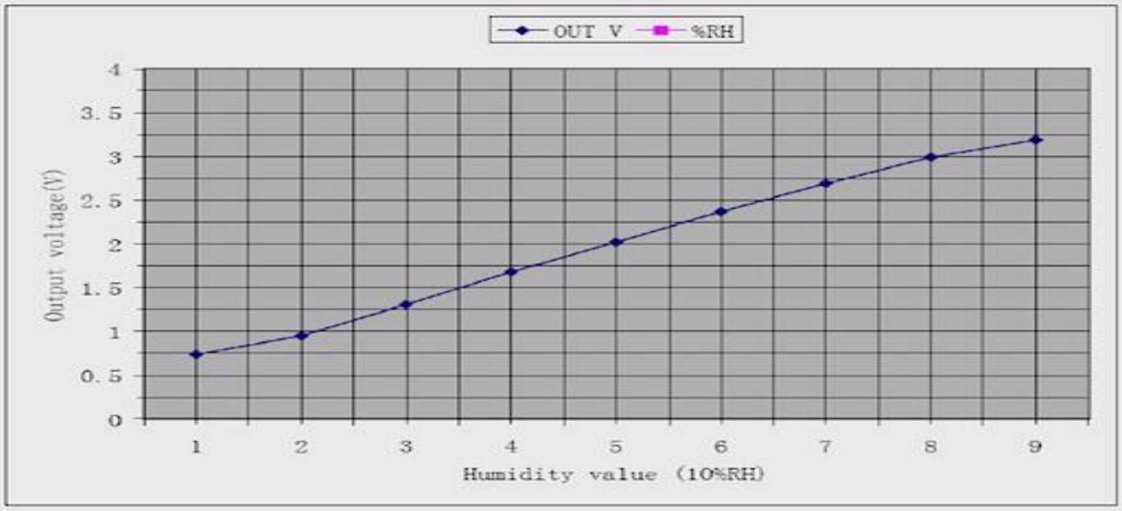
Humidity sensor we used for our project is HSM20g.The outlook of this sensor is like this



The circuit diagram for this sensor is given below



This is an analog sensor. It gives voltage as output according to humidity. The input humidity and output voltage curve is given below



STANDARD CHARACTERISTICS

%RH	10	20	30	40	50	60	70	80	90
OutpotV	0.74	0.95	1.31	1.68	2.02	2.37	2.69	2.99	3.19

For getting précised value we segmented the curve in different portion and express them using straight line equation. This equations are given below

```
if(voltage>=.74 & voltage<=.95)

humidity =(float)(voltage-.53)/.021;                    //for 10 to 20% humidity


if(voltage>=.96 & voltage<=2.02)

humidity =(float)(voltage-.170)/.037;                   //for 11 to 50% humidity


if(voltage>=2.03 & voltage<=2.69)
```

```
humidity =(float)(voltage-.240)/.035;                    //for 51 to 70% humidity


if(voltage>=2.70 & voltage<=2.99)

humidity =(float)(voltage-.430)/.032;                    //for 71 to 80% humidity

if(voltage>=3.00 & voltage<=3.19)

humidity =(float)(voltage-1.3)/.021;                      //for 81 to 90% humidity
```

3: PROGRAMS:

3.1 MAIN PROGRAM:

```
sbit LCD_RS at PORTB2_bit;
sbit LCD_EN at PORTB3_bit;
sbit LCD_D4 at PORTB4_bit;
sbit LCD_D5 at PORTB5_bit;
sbit LCD_D6 at PORTB6_bit;
sbit LCD_D7 at PORTB7_bit;

sbitLCD_RS_Direction at DDB2_bit;
sbitLCD_EN_Direction at DDB3_bit;
sbit LCD_D4_Direction at DDB4_bit;
sbit LCD_D5_Direction at DDB5_bit;
sbit LCD_D6_Direction at DDB6_bit;
sbit LCD_D7_Direction at DDB7_bit;
// End LCD module connections

char text1[]="HUMIDITY" ;
char text2[]="TEMPERATURE" ;


#include <built_in.h>
unsignedintadc_rd,ADC_value ;

void main() {
floatvoltage,humidity;
int C,D,E,F,G,H,I,J,K,L,M,N,P=0,u=0,z=0,x=0;;

  DDRB = 0xFF;            // Set PORTB as output
  DDRC = 0x00;            // Set PORTC as output
  DDRD = 0xFF;
Lcd_Init();               // Initialize LCD

Lcd_Cmd(_LCD_CLEAR);           // Clear display
Lcd_Cmd(_LCD_CURSOR_OFF);

while(1)
     {

adc_rd = ADC_Read(1);    // get ADC value from 2nd channel
    R0= adc_rd;          // display adc_rd[7..0]
    R1= Hi(adc_rd);      // display adc_rd[9..8]
ADC_value = R0;
ADC_value += (R1<<8);
voltage = (float)ADC_value*5/1023;
```

```
    C=voltage*100;
    D=C%10;
    E=C/10;
    F=E%10;
    G=E/10;


if((voltage>.74) && (voltage<.96))
   {                                            //for 10 to 20% humidity
humidity =((voltage-.53)/(.021));


   }
if((voltage>.95) && (voltage<2.03) )                  //for 11 to 50% humidity
    {
humidity=(voltage-.17)/.037;

    }
if((voltage>2.02 && voltage<2.7))                    //for 51 to 70% humidity
    {
humidity =(voltage-.24)/.035;

    }
if((voltage>2.69) && (voltage < 3))                     //for 71 to 80% humidity
    {
humidity =(voltage-.43)/.032;

   }
if((voltage>2.99) && (voltage<3.2))                    //for 81 to 90% humidity
    {
humidity =((voltage-1.3)/.021);


   }

    N= humidity*100;
    H=N%10;
    I=N/10;
    J=I%10;
    K=I/10;
    L=K%10;
    M=K/10;
    N=10*M+L;
if((N<=63))
{ if( PORTD.B3==0)goto DSP
elsegototmp;
    PORTD.B3=1;
```

```
    }
if(N>=64)
    {
if( PORTD.B3==1)goto DSP
elsegototmp;
    PORTD.B3=0;

    }


  DSP: Lcd_Out(1,1,text1);
Lcd_Chr(1,9,61);
Lcd_Chr(1,10,M+48);
Lcd_Chr(1,11,L+48);
Lcd_Chr(1,12,46);
Lcd_Chr(1,13,J+48);
Lcd_Chr(1,14,H+48);
Lcd_Chr(1,15,0x25);
tmp:  adc_rd = ADC_Read(2);    // get ADC value from 2nd channel
      R0= adc_rd;          // display adc_rd[7..0]
    R1= Hi(adc_rd);      // display adc_rd[9..8]
ADC_value = R0;
ADC_value += (R1<<8);

voltage = (float)ADC_value*5/1023;





    //newvolt=(((175-25)/(4.3-3.2))*(voltage-3.2))+25;

    N= voltage*100;
    H=N%10;
    I=N/10;
if(N<30)
        {
         z=9;
if(x==z)goto END;
        PORTD|=7;

goto SHOW;
        }
if(N<=36)

      {
if(u==0)goto DO;
      z=1;
if (x-z)goto END;
```

```
if(x==z)goto  END;
     DO: PORTD.B0=1;

      PORTD.B1=1;



      PORTD.B2=1;


      }

if((N>=37)&&(N<=40))
     {

      z=2;
if(x==z)goto END;


      PORTD.B0=0;
      PORTD.B1=0;
      PORTD.B2=1;
      }
     //PORTD|= 0x01;
if(N>40)
     {
      z=3;
if(x==z)goto  END;
     PORTD&=0b11111000;

     }

if((N>45))
      {

      PORTD.B3=1;
      }


         SHOW:     Lcd_Out(2,1,text2);
Lcd_Chr(2,12,0x3D);
Lcd_Chr(2,13,I+48);
Lcd_Chr(2,14,H+48);
Lcd_Chr(2,15,0x63);
 END: x=z;


     P=N;
     u=1;
```

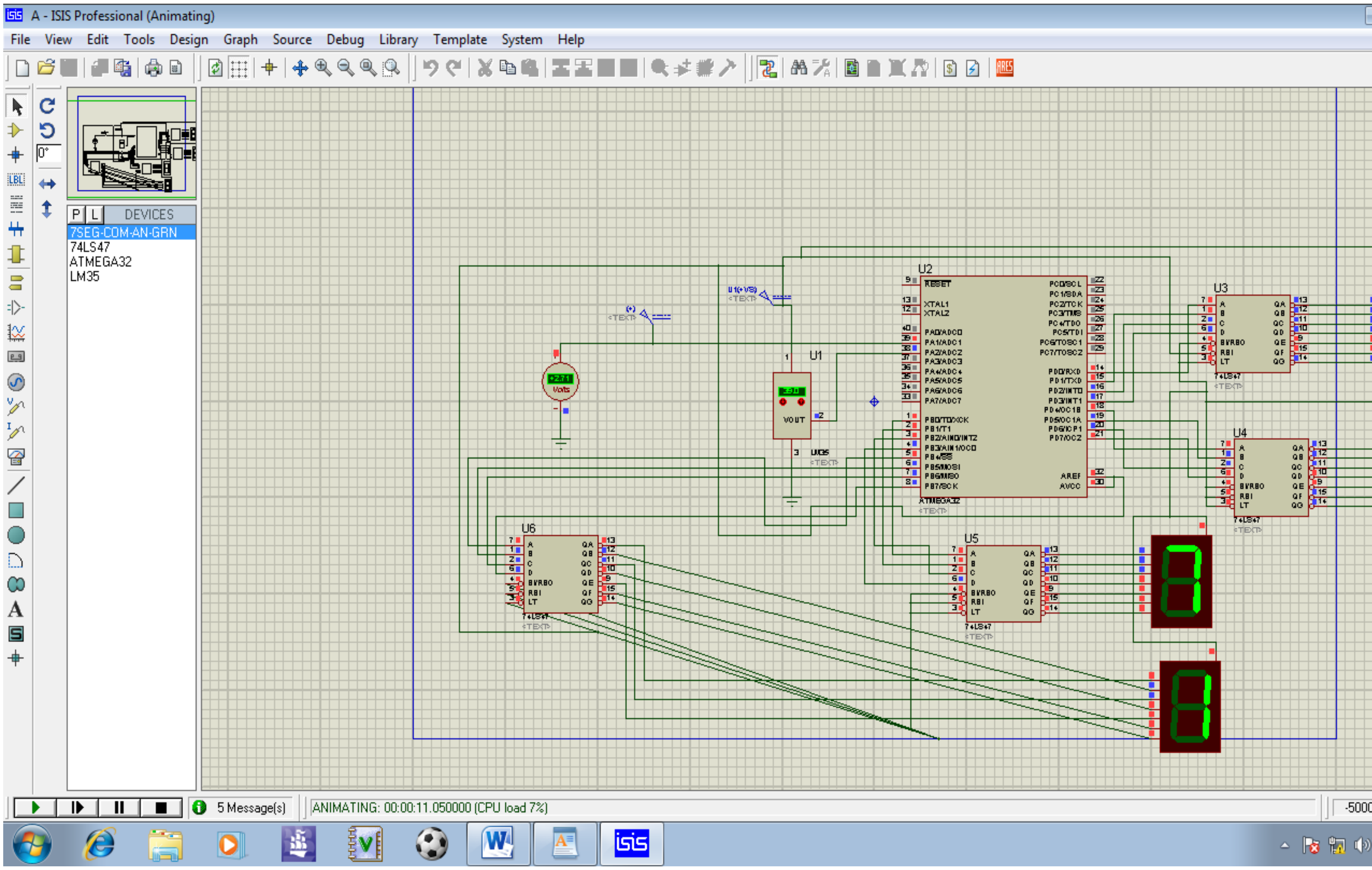
```
}
}
```

3.2PROGRAM FOR PWM WORK:

```
charcurrent_duty;
char current_duty1;

void main(){

  DDB0_bit = 0;                // Set PORTB pin 0 as input
  DDB1_bit = 0;                // Set PORTB pin 1 as input

  DDC0_bit = 0;                // Set PORTC pin 0 as input
  DDC1_bit = 0;                // Set PORTC pin 1 as input

current_duty  = 32;            // initial value for current_duty
  current_duty1 = 32;            // initial value for current_duty

  DDB3_bit = 1;                // Set PORTB pin 3 as output pin for the PWM (according to datasheet)
  DDD7_bit = 1;                // Set PORTD pin 7 as output pin for the PWM (according to datasheet)

PWM_Init(_PWM_FAST_MODE, _PWM_PRESCALER_8, _PWM_NON_INVERTED, current_duty);

  PWM1_Init(_PWM1_FAST_MODE, _PWM1_PRESCALER_8, _PWM1_NON_INVERTED, current_duty1);

do {
if (PINB0_bit) {                    // Detect if PORTB pin 0 is pressed
Delay_ms(40);                       // Small delay to avoid deboucing effect
current_duty++;                     // Increment duty ratio
PWM_Set_Duty(current_duty);             // Set incremented duty
    }
else
if (PINB1_bit) {                    // Detect if PORTB pin 1 is pressed
Delay_ms(40);                       // Small delay to avoid deboucing effect
current_duty--;                     // Decrement duty ratio
PWM_Set_Duty(current_duty);           // Set decremented duty ratio
      }
else
if (PINC0_bit) {                    // Detect if PORTC pin 0 is pressed
Delay_ms(40);                       // Small delay to avoid deboucing effect
current_duty1++;                    // Increment duty ratio
          PWM1_Set_Duty(current_duty1);         // Set incremented duty
        }
else
```

```
if (PINC1_bit) {                     // Detect if PORTC pin 1 is pressed
Delay_ms(40);                        // Small delay to avoid deboucing effect
current_duty1--;                     // Decrement duty ratio
          PWM1_Set_Duty(current_duty1);       // Set decremented duty ratio
         }

  } while(1);                                 // Endless loop

}
```

SCREENSHOT:



A - ISIS Professional (Animating)
File View Edit Tools Design Graph Source Debug Library Template System Help
DEVICES
7SEG-COM-AN-GRN
74LS47
ATMEGA32
LM35
U1
U2
U3
U4
U5
U6
ATMEGA32
5 Message(s)
ANIMATING: 00:00:11.050000 (CPU load 7%)

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