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Temperature Sensor Using Microcontroller

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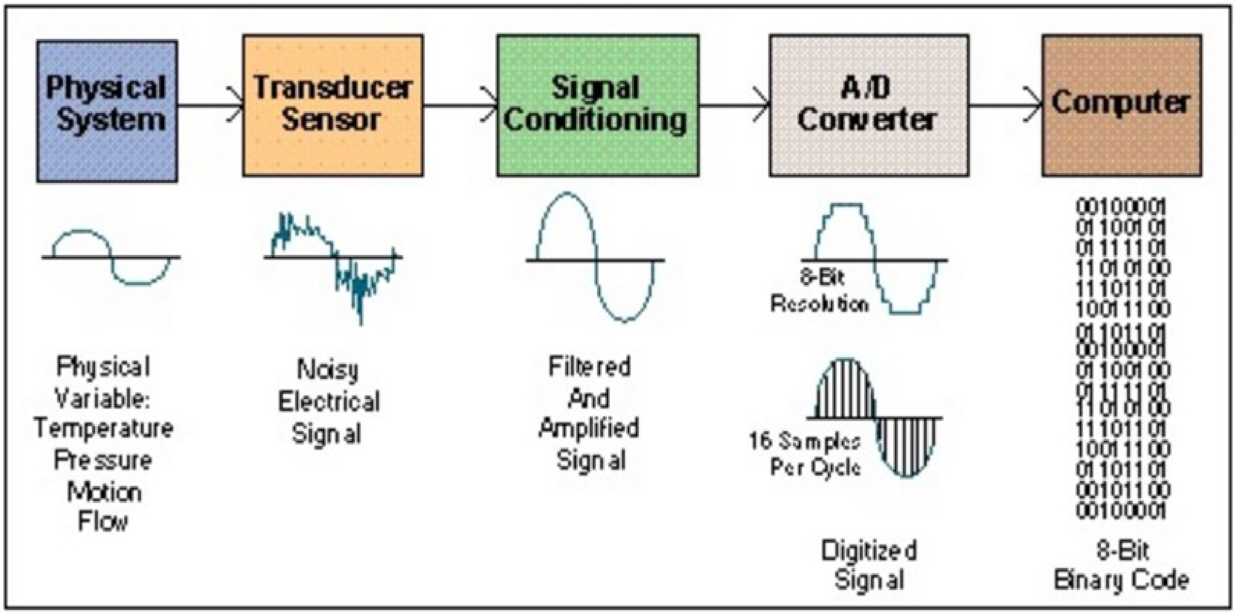
Abstract:

Data acquisition is the process of sampling signals (voltage, current, temperature, pressure, or sound) that measure real world physical conditions and converting the resulting samples (analog Waveforms) into digital numeric values for processing and manipulating (as per the requirements) by a computer.



The components of data acquisition systems include:

- Sensors, to convert physical parameters to electrical signals.
- Signal conditioning circuitry, to convert sensor signals into a form that can be converted to digital values.
- Analog-to-digital converters, to convert conditioned sensor signals to digital values.
- Data acquisition applications are usually controlled by software programs developed using various general purpose programming languages such as Assembly,BASIC,C,C++,C#,Fortran, Java,LabVIEW,Lisp, Pascal, etc. including various Open Source Software as well.

Stand-alone data acquisition systems are often called **data-loggers**.

In our project, the Temperature data was monitored by using the Microcontroller & LCD. The Project has an Inbuilt Data logger which is used to Log the Temperature data on the LCD. A data logger is any device that can be used to store data.

The main objectives of the Project are :

1. Real-time monitoring the ambient temperature (in both the ^{0}**C** and ^{0}**F** scales) on the LCD-Screen
2. Log the Rise and Fall of temperature with heating and cool-down of the LM35 Sensor.

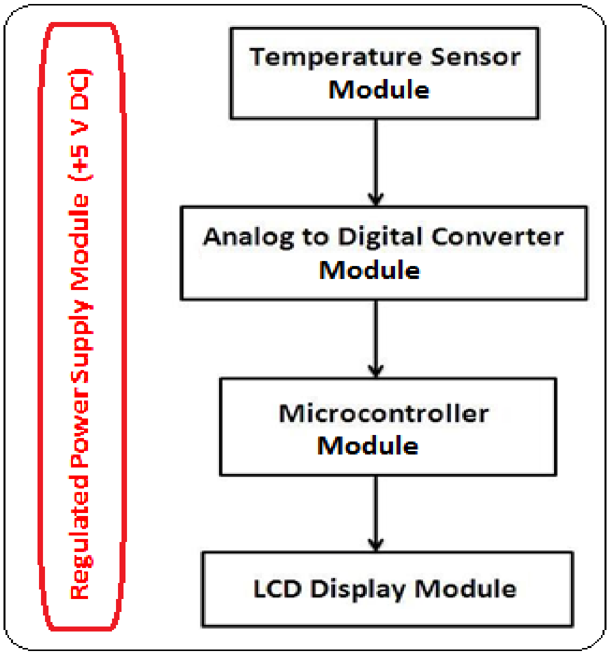
INTRODUCTION

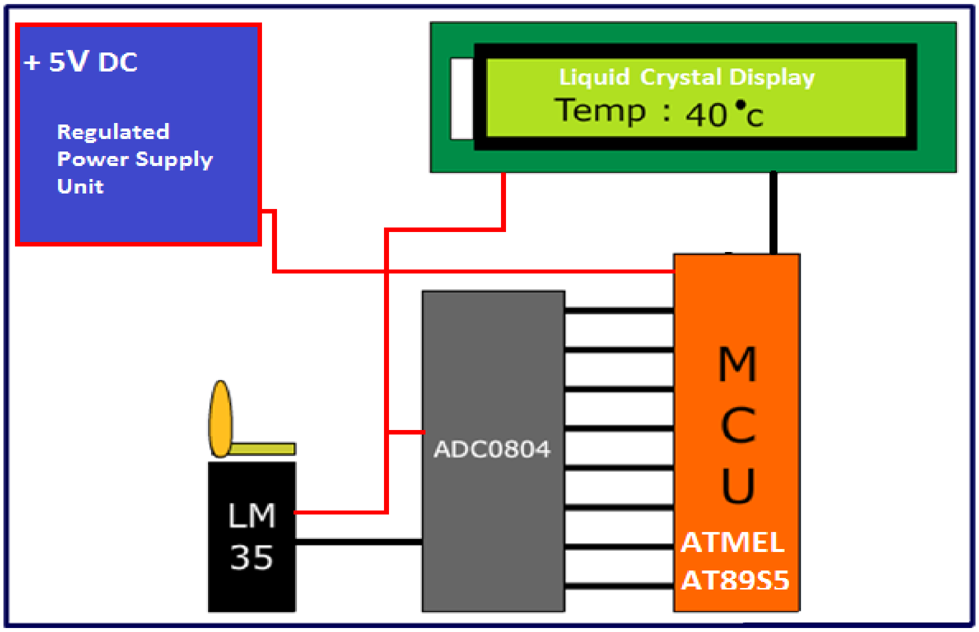
Digital thermometer (Celsius and Fahrenheit scale) using 8051 microcontroller (AT89S52)

Celsius and Fahrenheit scale thermometer displays the ambient temperature through a LCD display. It consists of two sections. One is that which senses the temperature. This is a temperature sensor LM 35. The other section converts the temperature value into a suitable number in Celsius scale which is done by the ADC0804. The temperature sensed in Celsius scale is converted into the Fahrenheit scale temperature just by using the Celsius to Fahrenheit conversion formulae through a little modification of the code in the microcontroller program.

Design and Implementation

Figure 1: (Modular–Block Diagram)


Regulated Power Supply Module (+5 V DC)
Temperature Sensor Module
Analog to Digital Converter Module
Microcontroller Module
LCD Display Module



Flow Chart (Coding Logic)

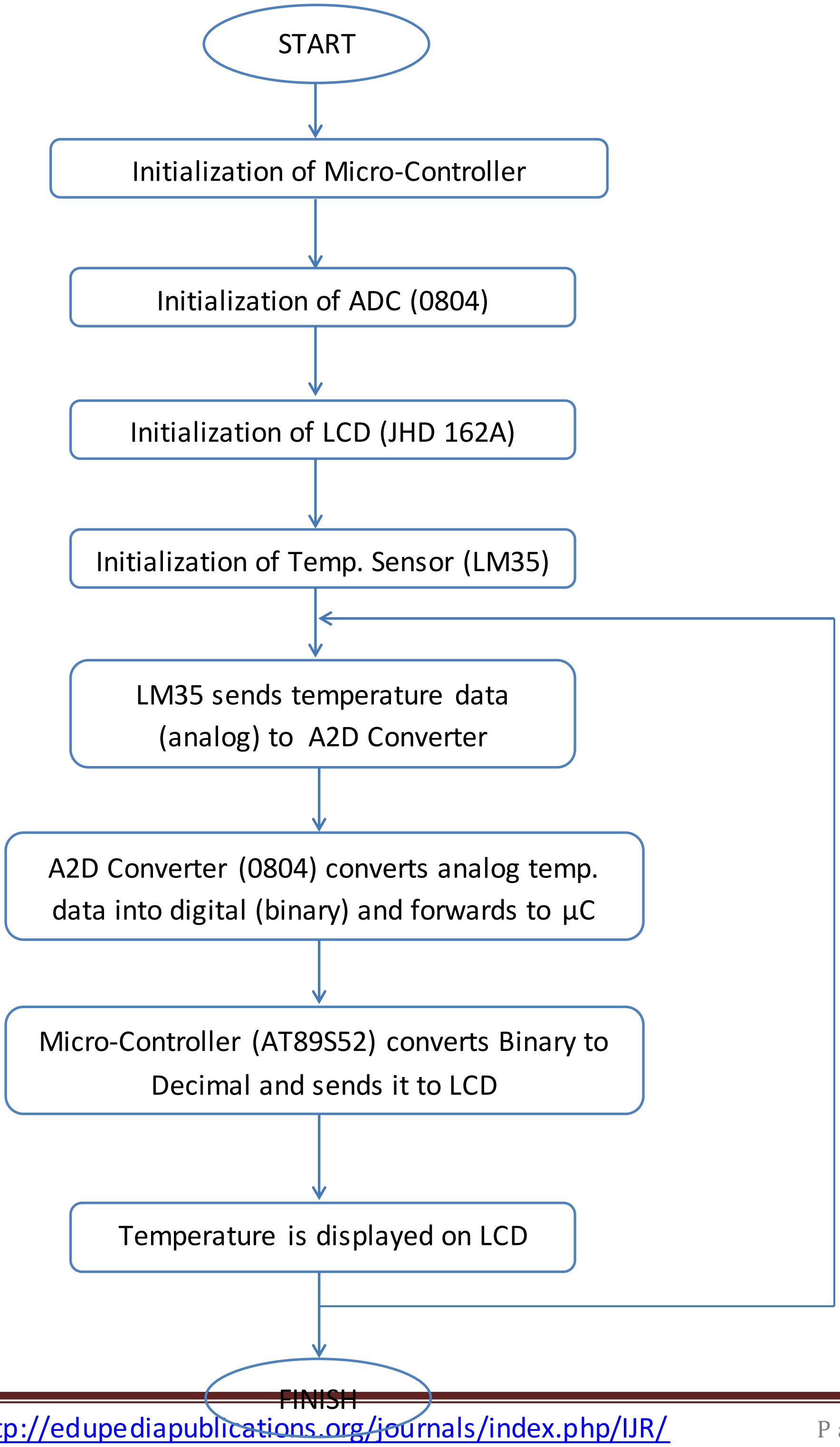

START
Initialization of Micro-Controller
Initialization of ADC (0804)
Initialization of LCD (JHD 162A)
Initialization of Temp. Sensor (LM35)
LM35 sends temperature data (analog) to A2D Converter
A2D Converter (0804) converts analog temp. data into digital (binary) and forwards to µC
Micro-Controller (AT89S52) converts Binary to Decimal and sends it to LCD
Temperature is displayed on LCD
FINISH

Figure 2: Flow chart

Algorithm (Functional)

1) Initialize LCD
2) Start the ADC to measure temp
3) Read ADC byte
4) Convert ADC byte into temperature and record into the flash
5) Increase no of samples by one
6) Display temp on LCD
7) Compare the temperature with the threshold value
8) Waiting time according to recording interval
9) Start the conversion of ADC (conversion frequency is around 640KHz)
10) Convert ADC digital output into temperature and store its 2 digit value into flash
11) Increase number of samples by one
12) Convert decimal to hexadecimal value
13) Add one to hex value of no of samples
14) Convert hex value to decimal number
15) Display 2 digit temperature to LCD
16) Compare temp value with threshold values
17) hex value of current temperature
18) hex value of threshold temperature
19) LED on if current temperature more than threshold value
20) LED off if current temperature more than threshold value
21) Provide measuring interval delay
22) Converts the ADC 8 bit output to 2-digit temperature value in ASCII
23) Convert the 4 digit decimal into 2 byte hex
24) Input in t3 t2 t1 t0 and output in hex1 hex0
25) Provide threshold value range from 20 to 49 degree celcius for user
26) Provide recording interval range from 01 to 99 secs for user
27) Display a 16 byte in ASCII string on LCD
28) Send the command to LCD
29) Send ASCII data to LCD

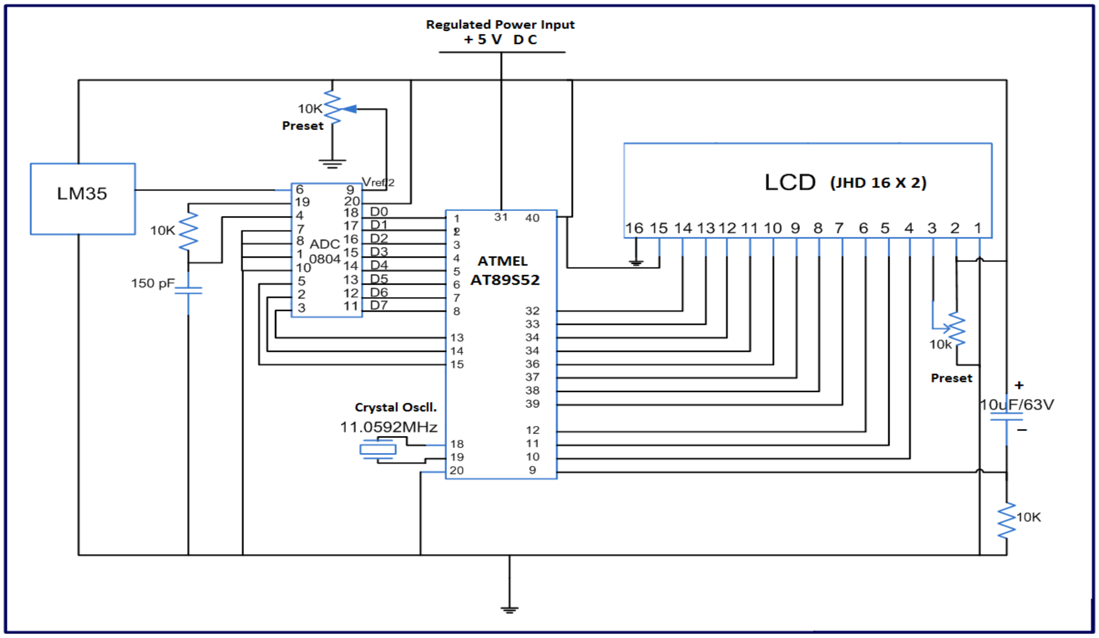
THE SOURCE CODE

The Embedded-C Program Code which is burnt onto the Micro-Controller is as under :

```
//Program to display temperature in Celsius
and Farenheit scale.

#include<stdio.h>
#include<string.h>
#include<Regx52.h>
#define port P3
#define adc_input P1
#define dataport P0
#define sec 100
sbitrs = port^0;
sbitrw = port^1;
sbit e = port^2;
sbitwr= port^3;
sbitrd= port^4;
sbitintr= port^5;

int test_intermediate3=0,
test_final=0,test_intermediate1[10],test_intermediate
2[3]={0,0,0};

void delay(unsigned intmsec )
{
int i ,j ;
   for(i=0;i<msec;i++)
      for(j=0; j<1275; j++);
}

void lcd_cmd(unsigned char item)    // Function to
send commands to LCD
{
dataport = item;
rs= 0;
rw=0;
   e=1;
   delay(1);
   e=0;
   return;
}

void lcd_data(unsigned char item)    // Function to
send data to LCD
{
dataport = item;
rs= 1;
rw=0;
   e=1;
   delay(1);
   e=0;
   return;
}

void lcd_data_string(unsigned char *str)  // Function
to string to LCD
{
int i=0;
   while(str[i]!='\0')
   {
lcd_data(str[i]);
      i++;
      delay(10);
   }
   return;
}

void shape()      // Function to make the shape of
degree symbol
{
lcd_cmd(64);
lcd_data(2);
lcd_data(5);
lcd_data(2);
lcd_data(0);
lcd_data(0);
lcd_data(0);
lcd_data(0);
lcd_data(0);
}

void convert()    // Function to convert the values of
ADC into numeric value to be sent to LCD
{
int   s;
lcd_cmd(0x81);
   delay(2);
lcd_data_string("TEMP:");
test_final=(((9*test_intermediate3)/5)+32);
   s=test_final/100;
test_final=test_final%100;
lcd_cmd(0x88);
   if(s!=0)
lcd_data(s+48);
```

```
   else
lcd_cmd(0x06);
   s=test_final/10;
test_final=test_final%10;
lcd_data(s+48);
lcd_data(test_final+48);
lcd_data(0);
lcd_data('F');
lcd_data(' ');

test_final=test_intermediate3;
lcd_cmd(0xc1);        //Setting  cursor to first position
of first line
   delay(2);
lcd_data_string("TEMP:");
   s=test_final/100;
test_final=test_final%100;
lcd_cmd(0xc8);
   if(s!=0)
lcd_data(s+48);
   else
lcd_cmd(0x06);
   s=test_final/10;
test_final=test_final%10;
lcd_data(s+48);
lcd_data(test_final+48);
lcd_data(0);
lcd_data('c');
lcd_data(' ');
   delay(2);
}

void main()
{
inti,j;
adc_input=0xff;
lcd_cmd(0x38);        //2 Line,  5X7  Matrix display
lcd_cmd(0x0c);        //Display On, Cursor blinking
   delay(2);
lcd_cmd(0x01);        // clear screen
   delay(2);

   while(1)
   {
      for(j=0;j<3;j++)
      {
         for(i=0;i<10;i++)
         {
            delay(1);
rd=1;
wr=0;
            delay(1);
wr=1;
            while(intr==1);
rd=0;
lcd_cmd(0x88);
            test_intermediate1[i]=adc_input/10;
            delay(1);
intr=1;
         }
         for(i=0;i<10;i++)

test_intermediate2[j]=test_intermediate1[i]+test_inter
mediate2[j];
      }

      test_intermediate2[0]=test_intermediate2[0]/3;
      test_intermediate2[1]=test_intermediate2[1]/3;
      test_intermediate2[2]=test_intermediate2[2]/3;

test_intermediate3=test_intermediate2[0]+test_interm
ediate2[1]+test_intermediate2[2];
      shape();
      convert();
   }
}
```

PROJECT CIRCUIT DIAGRAM



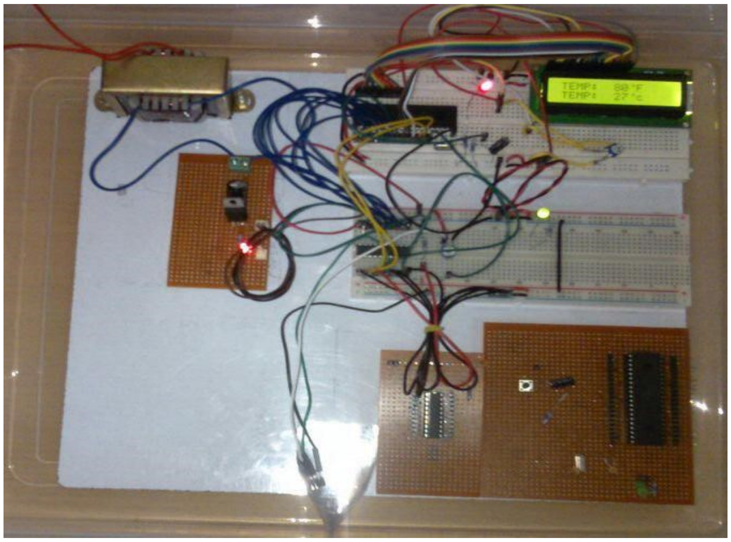


Figure 3 (a): Circuit Diagram, (b) Project Kit

CIRCUIT FUNCTIONING

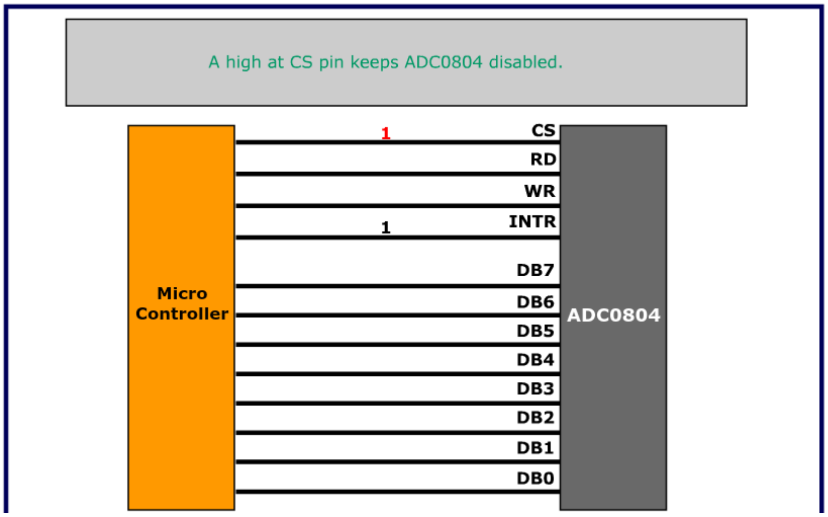
A digital thermometer can be easily made by interfacing a temperature sensor to the microcontroller AT89S52. The temperature sensor used in the project is LM35. The LM 35 IC generates a 10mV variation to its output voltage for every degree Celsius change in temperature. The Output of the temperature sensor is analog in nature so we need an analog to digital convertor for converting the analog input to its equivalent binary output. The ADC 0804is the analog to digital convertor IC used in the project. 0804 is a single channel convertor which converts the analog input up to a range of 5V to an equivalent 8-bit binary output.

The step size is defined by the voltage applied at the Vref/2 pin of the ADC

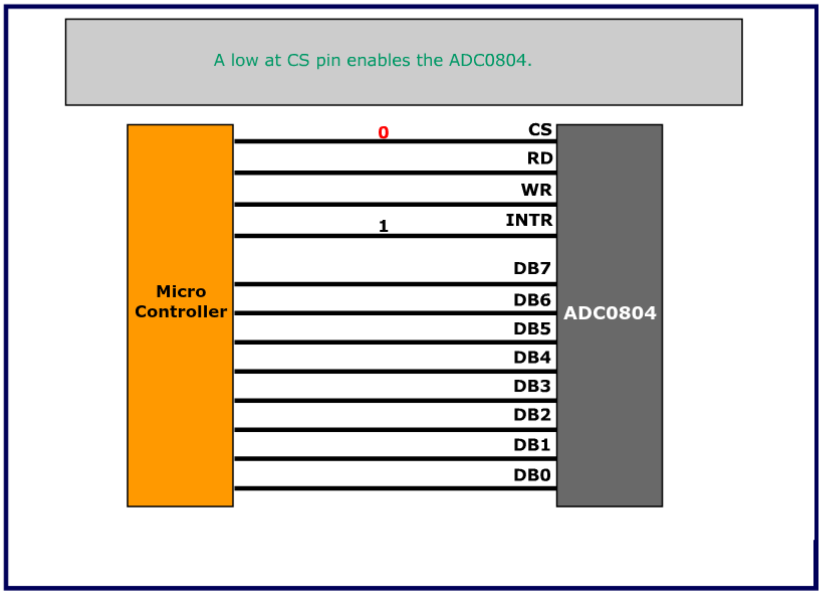
.

IC. For example, if the voltage at Vref/2 pin is set to 1.28V then ADC has a step size of 10 mV. So if the input voltage is 1V the equivalent binary output of ADC will be 100 or 0110 0100 in binary. The 8 bit binary output of the ADC is incremented by one for every 10 mV rise of input voltage. Different step size can be selected by changing the voltage input to the Vref/2 pin. The step size of the ADC is calibrated using a preset to match the actual temperature. Once the ADC is calibrated it will give the correct output further. The binary output of ADC is fed parallel to a port of the microcontroller .The microcontroller reads the input through ADC and displays the corresponding decimal value on LCD indicating the temperature

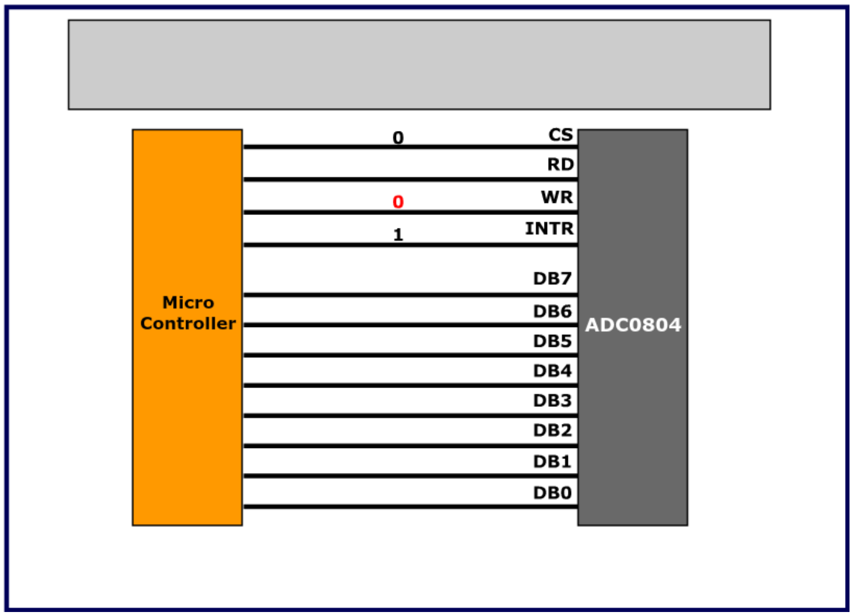
STEP 1


A high at CS pin keeps ADC0804 disabled.
Micro Controller
ADC0804
1
CS
RD
WR
1
INTR
DB7
DB6
DB5
DB4
DB3
DB2
DB1
DB0

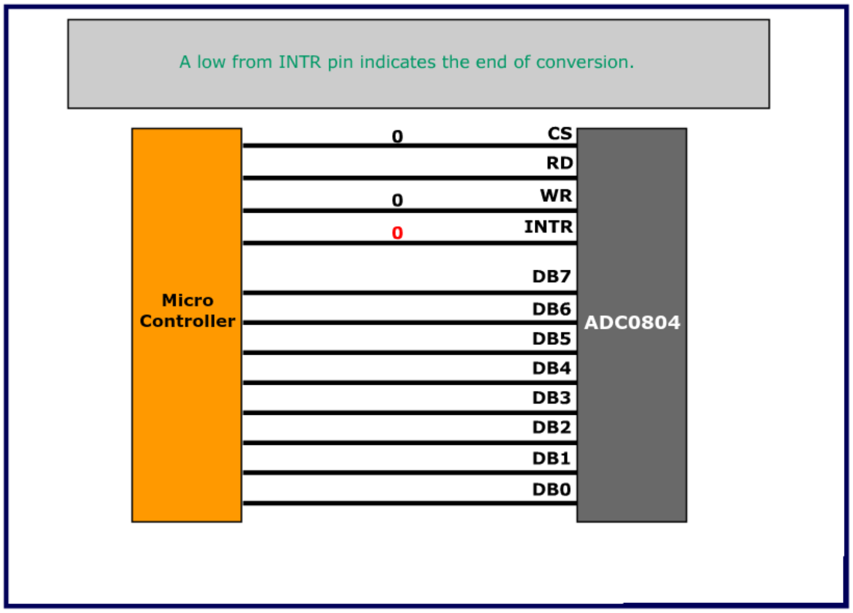
STEP 2


A low at CS pin enables the ADC0804.
Micro Controller
ADC0804
0
CS
RD
WR
1
INTR
DB7
DB6
DB5
DB4
DB3
DB2
DB1
DB0

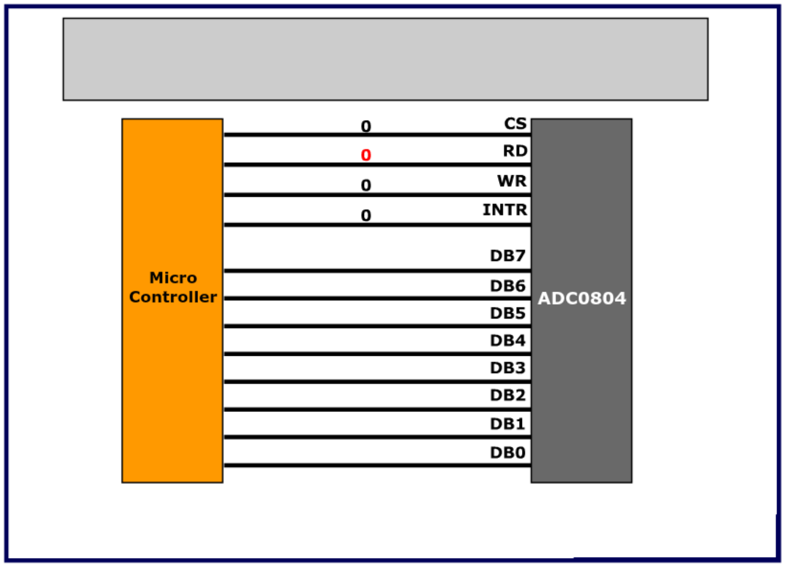
STEP 3



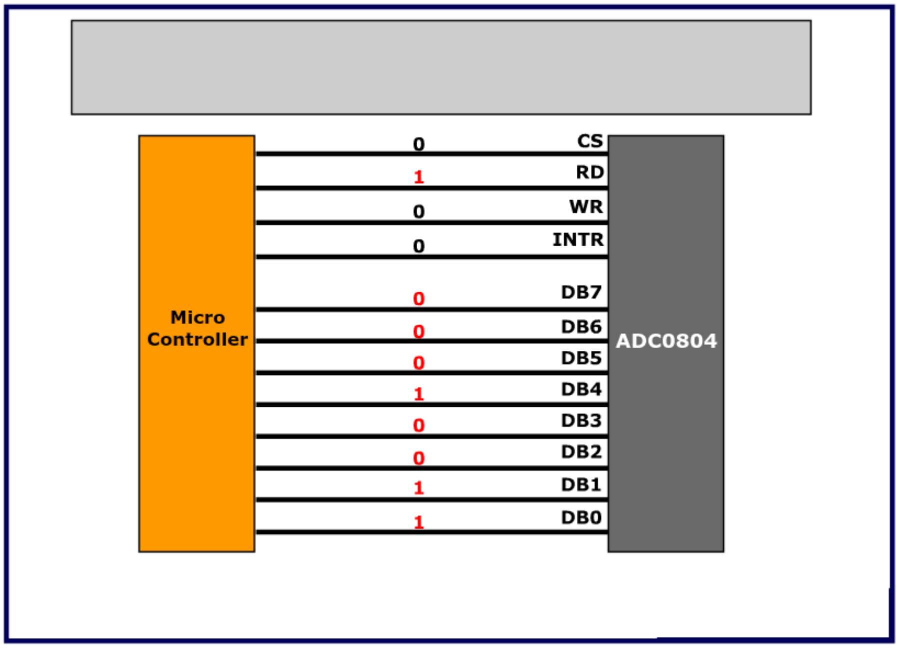
STEP 4


A low from INTR pin indicates the end of conversion.

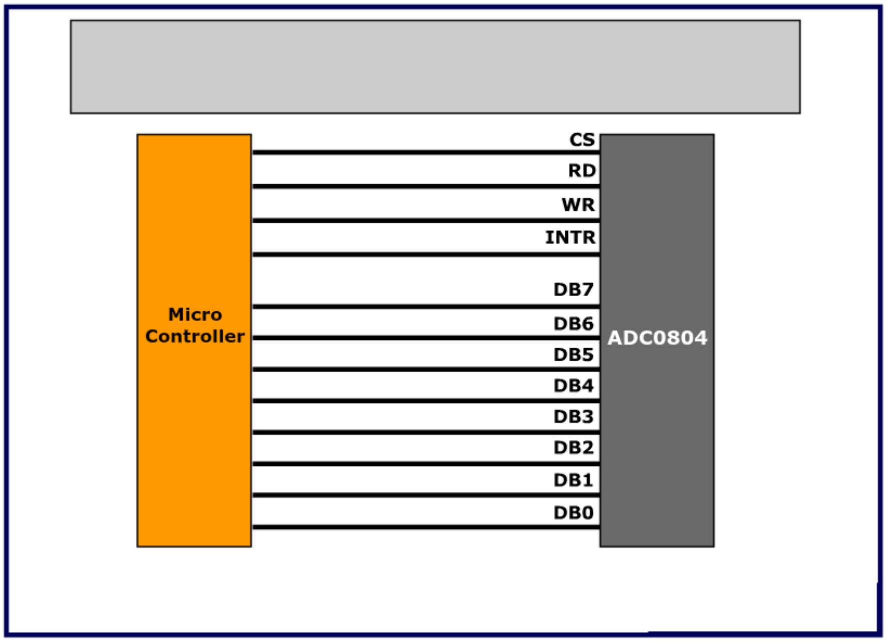
STEP 5


0 CS
0 RD
0 WR
0 INTR
DB7
DB6
DB5
DB4
DB3
DB2
DB1
DB0
Micro Controller
ADC0804

STEP 6


0 CS
1 RD
0 WR
0 INTR
0 DB7
0 DB6
0 DB5
1 DB4
0 DB3
0 DB2
1 DB1
1 DB0
Micro Controller
ADC0804

STEP 9



RESULT

The Project **"TEMPERATURE SENSOR USING MICROCONTROLLER"** was designed such that the Real-World Rise and Fall in the Ambient Temperature could be sensed and sampled digitally using ADC0804 and processed by the AT89S52 Micro-Controller to be displayed on a 16X2 Line LCD Display unit in both the 0Celsius and 0Fahrenheit Scales respectively(Data Logger).

CONCLUSION

Applications of Celsius Scale Thermometer Circuit:

- It can be used at mobile places like cars to keep a track of the temperature.

- It can be used to control the switching of loads like motors, heaters based upon the temperature.
- It can also be used at homes to get the temperature reading.

Limitations of the Circuit:

- It requires additional analog to digital conversion.
- The measurable Temperature range is between -55^{0}C to +150^{0}C
- This circuit can only measure values in +/- 1^{0}C steps.
- The Fahrenheit Scale values are obtained using the conversion formula in Source Code

ALTERNATIVES for this Circuit:

There are a number of various other ways in which this project task could be accomplished. Such as:

Using the same Analog Temp. Sensor LM35 with either ATMega / ATMega32 / PIC / Arduino or any other Micro-Controller with a combination of Display alternatives like a 7-Segment Display / LEDs / Andriod-SmartPhones etc.

A Few of which combinations are :

- Using AT89S51, 0804 and 7-Segment Display
- Using PIC Microcontroller with 7-Segment Display / LCD Display
- Without External ADC-IC and interfacing Using ATMega 32, 7 Segment / LCD Display
- Using PIC-µC & 7 Segment / LCD Display
- Using AT89C52, DS1621 Sensor (Digital) with 7-Segment / LCD Display

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