Faculty of Electronics, Telecommunications and Information Technology

MINISTERUL EDUCAȚIEI NAȚIONALE

UNIVERSITATEA TEHNICĂ DIN CLUJ-NAPOCA

Room Thermostat

Microcontrollers project

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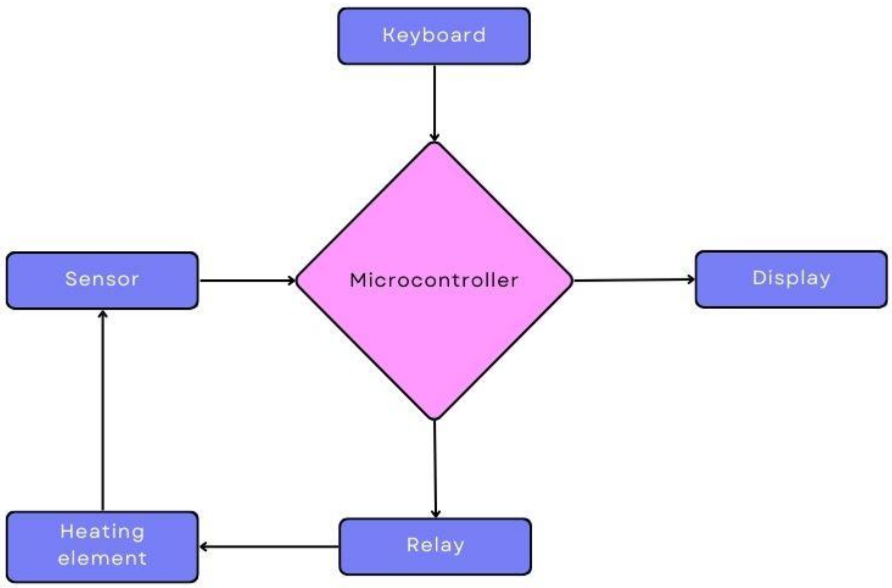
Contents

Block scheme

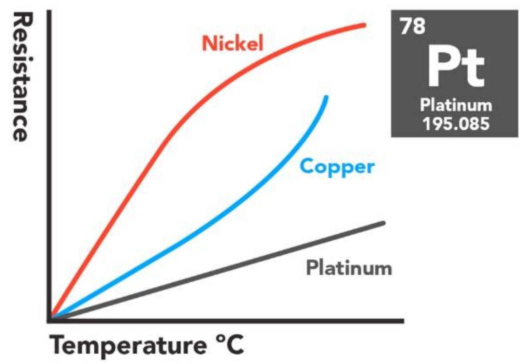


Sensor classes

1. Resistance Temperature Detectors (RTDs)

As temperature changes, the resistance of any metal changes as well. This difference in resistance is what RTD temperature sensors are based on. The RTD's resistance increases linearly when the temperature increases. An RTD is a resistor with well-defined resistance vs. temperature characteristics.

RTDs are made from a film and a glass or ceramic core with wire wrapped around it for greater accuracy. Platinum makes up the most accurate RTDs.

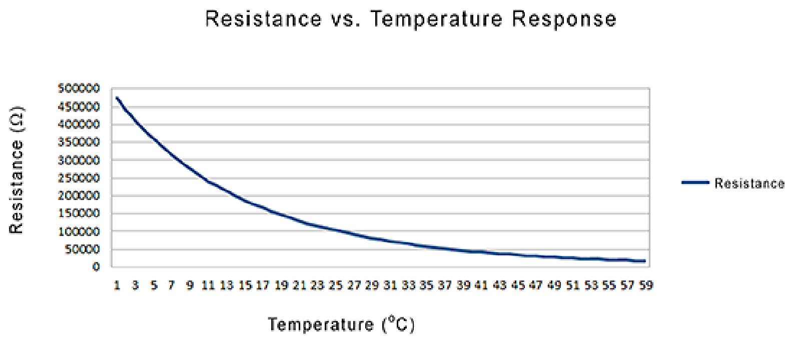


In terms of how it works, the RTD follows a basic principle. When the temperature of a metal increases, the resistance to the flow of electricity increases as well. An electrical current is passed through the sensor, the resistance element is used to measure the resistance of the current being passed through it. As the temperature of the resistance element increases the electrical resistance also increases.

2. Negative Temperature Coefficient (NTC) Thermistors

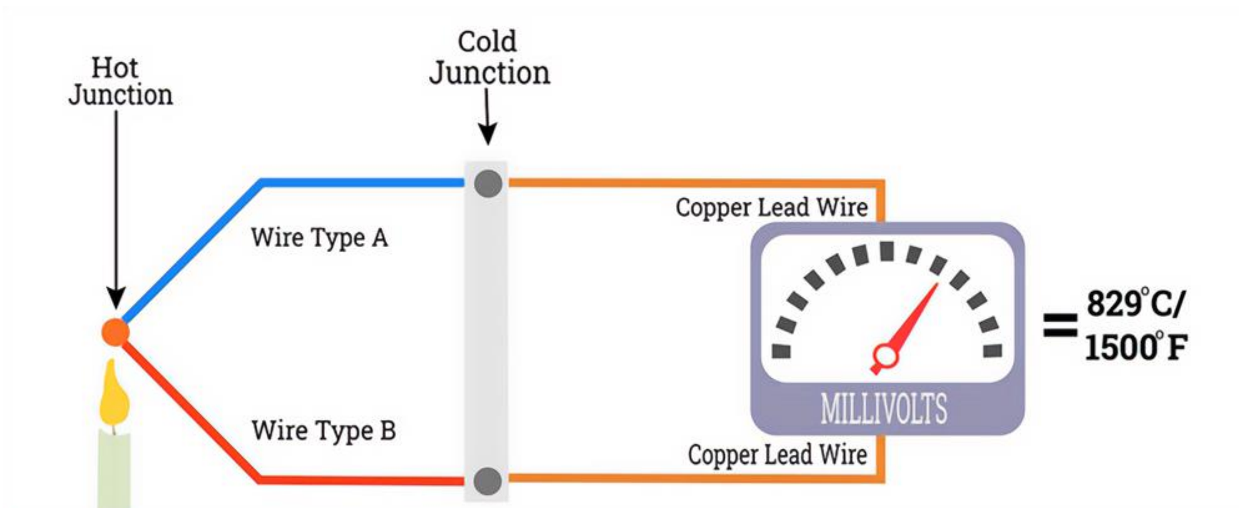
Thermistors are similar to RTDs as temperature changes cause measurable resistance changes. Thermistors, however, are made from semiconductor materials. An NTC thermistor provides higher resistance at low temperatures.

The output of an NTC thermistor is non-linear due to its exponential nature; however, it can be linearized based on its application. Thus, in the thermistors operating range, we can see a large resistance change for a very small temperature change. This makes for a highly sensitive device.



3. Thermocouples

Thermocouples are made by joining two dissimilar metal wires, electrically bonded at two points. The connecting end is called the "hot junction", and the other end is known as the "cold junction". The varying voltage between the two metals mirrors proportional changes in temperature.



The working principle is very simple. When the two dissimilar metal wires are fused, they create a thermoelectric result, which provides a small voltage. This causes a Seebeck Effect.

The Seebeck Effect is a phenomenon in which a temperature difference of two dissimilar conductors produces a voltage difference between the two substances.

The biggest disadvantage to using a thermocouple sensor is its small output voltage, making it challenging to measure the temperature. This results in a low accuracy. Thermocouples operate across the widest temperature range.

4. **Semiconductor Sensors**

Semiconductor-based temperature sensors (also known as IC sensors) have a dual integrated circuit (IC) containing two similar diodes. The diodes have temperature-sensitive voltage vs current characteristics that are used to monitor changes in temperature.

Semiconductor based temperature sensor ICs come in two different types: local temperature sensor and remote digital temperature sensor. Local temperature sensors are ICs that measure their own die temperature by using the physical properties of a transistor. Remote digital temperature sensors measure the temperature of an external transistor.

Choosing the sensor

	Temperature range	Price	Accuracy	Resolution
LM35	-55°C - 150°C	3.5$	±1°C	10mV/°C
AD22100	-50°C - 150°C	7.5$	±2°C	22.5mV/°C
AD592	-25°C - 105°C	12$	±0.5°C	-
TC1047	-40°C - 125°C	0.7$	±3°C	10mV/°C

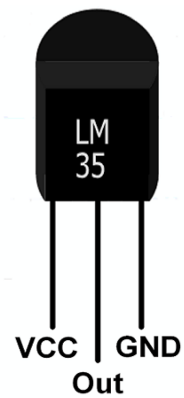
Temperature sensor accuracy is critical to ensure that temperature sensors give effective measurements. Accuracy of temperature sensors is how close the sensor output is to the physical temperature being measured.

Resolution refers to the smallest detectable increment of measurement on an instrument. A thermometer that displays temperature readings to the hundredth of a degree (e.g. 100.26°) has a greater resolution than one that only shows the tenths of a degree (e.g. 100.3°) or whole degrees (100°).

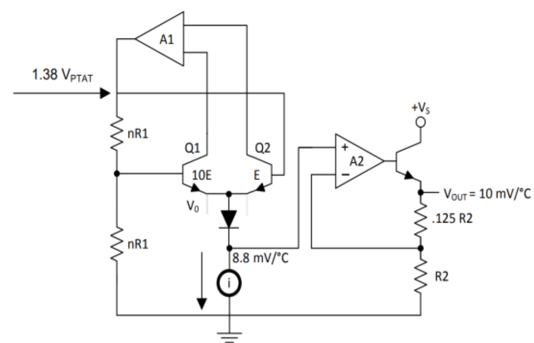
Based on the criteria from the table above, I will choose for my project the LM35 sensor, having the best resolution, the second best accuracy and the second best price.

Temperature Sensor: LM35

LM35 is a temperature measuring device having an analog output voltage proportional to the temperature. It provides output voltage in Centigrade (Celsius). It does not require any external calibration circuitry. The sensitivity of LM35 is 10 mV/degree Celsius. As temperature increases, output voltage also increases.



Functional Block Diagram



VCC: Supply Voltage (4V – 30V)

Out: It gives analog output voltage which is proportional to the temperature (in degree Celsius).

GND: Ground

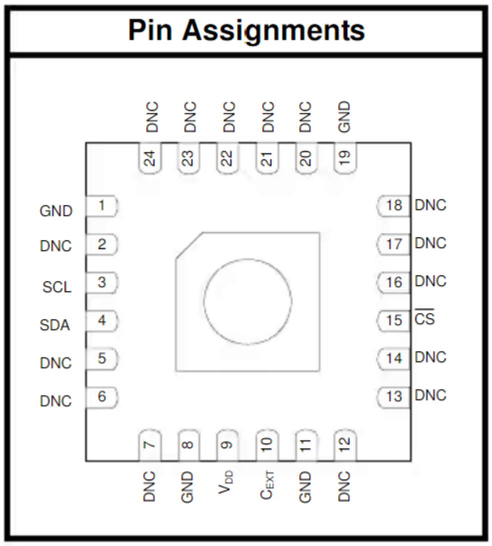
Specifications:

- Operating voltage: 4V to 30V
- Sensitivity: 10mV/°C
- Linearity Error: ±1°C
- Operating Temperature: -55°C to +150°C
- Typical Power Consumption: 60 µA

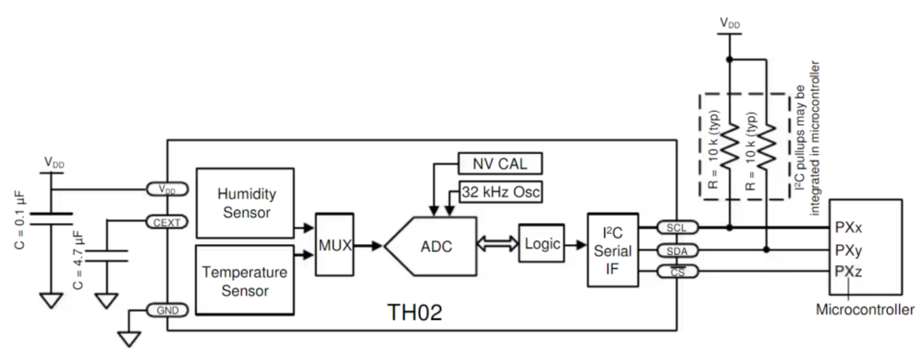
- Output Type: Analog
- Accuracy: ±1°C

Humidity Sensor: TH02

The TH02 is a digital relative humidity and temperature sensor. This monolithic CMOS IC integrates temperature and humidity sensor elements, an analog-to-digital converter, signal processing, calibration data, and an I2C host interface.



Functional Block Diagram



Specifications:

- Operating Voltage: 2.1V to 3.6V

- Power Consumption: 240 µA during RH conversion
- Relative Humidity Sensor: ±4.5% RH (maximum @0-80% RH)

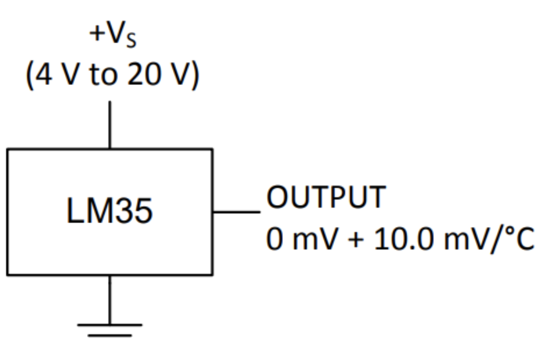
Connecting LM35 to the Microcontroller

Since the temperature sensor LM35 has an analog output and the microcontroller 8051 has a digital input, we need an analog to digital converter to connect them.

The output voltage of the sensor increases with 10mV/°C so for our temperature range (0°C - 40°C), the maximum output voltage of the sensor should be 400mV. We need to reach the full scale voltage of the ADC through a differential amplifier.

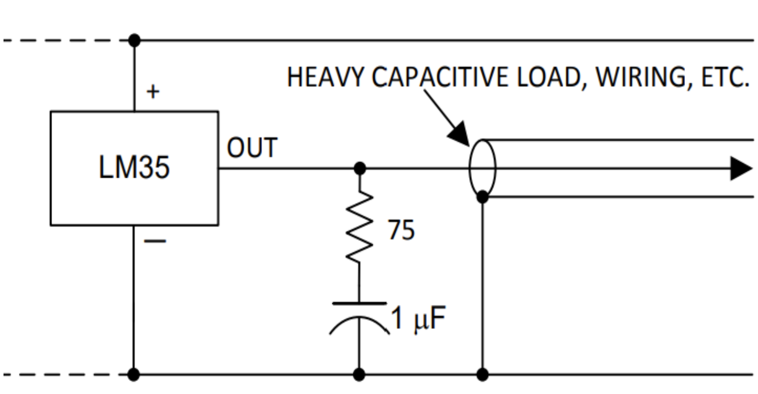
These are the elements needed further, all of them being supplied by the same source:

Connecting the sensor



The LM35 temperature sensor has 3 pins: +Vs, Vout and GND. The supply voltage, Vs, has the absolute maximum ratings in the datasheet of -0.2V (MIN) and 35V (MAX), but in practice it needs to be comprised between 4V and 20V. The chosen supply for this project is 5V. The output of the sensor will be connected to the non-inverting input of the amplifier.

The device has a limited ability to drive heavy capacitive loads. The tolerance of capacitance can be improved with a series R-C damper from output to ground.



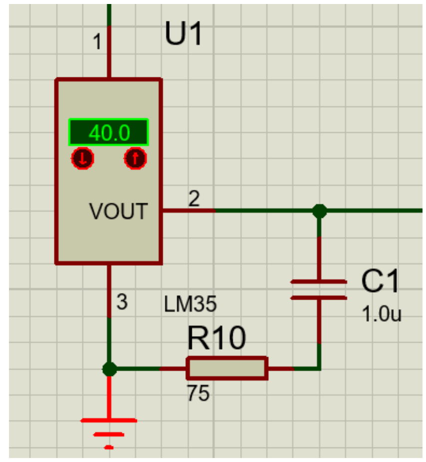
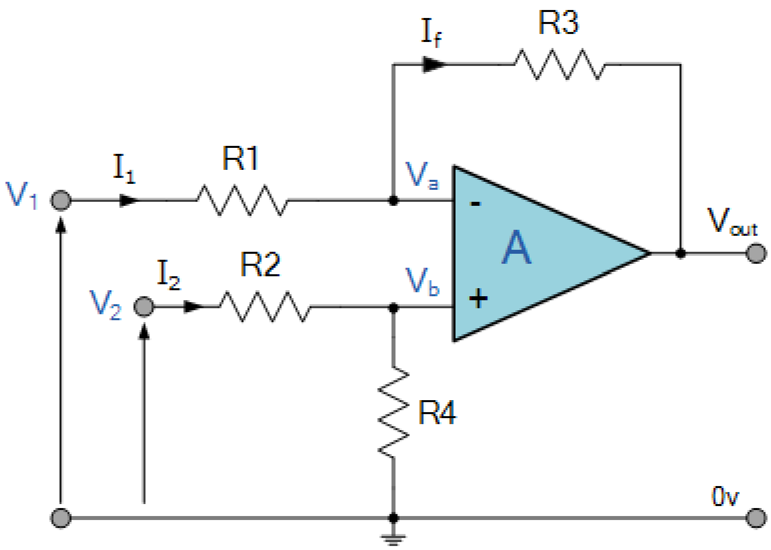


Figure 13. LM35 with R-C Damper

Connecting the amplifier

For this project, a differential amplifier is needed, because of the low output voltage of the temperature sensor. Differential amplifiers are useful in electrically noisy environments where a low amplitude electrical signal can be easily corrupted by the effect of unwanted external noise. A single-ended amplifier would be unsuitable since it would also amplify the unwanted noise signal as well as the desired input signal. The output of the sensor will be connected to the non-inverting input of the amplifier (V2), and the inverting input (V1) will be connected to ground.



The gain of the amplifier is calculated such that the maximum output of the sensor (400 mV) reaches the maximum voltage of the ADC. The maximum voltage of the ADC is found by using the formula:

$$V_{ADCmax} = V_{FS} - V_{LSB} = V_{FS} - \frac{V_{FS}}{2^n}$$

Where V_{FS} is the full-scale voltage of the ADC and n is the number of bits. In this case an 8-bit ADC will be used, with the reference voltage of 5V. The formula becomes:

$$V_{ADCmax} = 5V - \frac{5V}{2^8} = 5V - \frac{5V}{256} \cong 5V - 0.02V \cong 4.98V$$

We will approximate the result to 5V. The gain will be the following:

$$A = \frac{V_{ADCmax}}{V_{LM35max}} = \frac{5V}{400mV} \cong 12.5$$

After denoting V_2 with V_{in} and connecting V_1 to GND the following equations describe the circuit:

$$V^+ = \frac{R_4}{R_4 + R_2} \times V_{in}$$

$$V^- = \frac{R_1}{R_1 + R_3} \times V_{out}$$

Because of the negative feedback, the two input voltages will be equal.

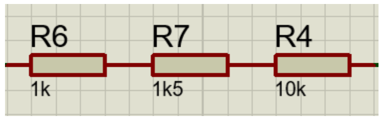
$$V^+ = V^- \rightarrow \frac{R_4}{R_4 + R_2} \times V_{in} = \frac{R_1}{R_1 + R_3} \times V_{out} \rightarrow \frac{V_{in}}{V_{out}} = \frac{R_4}{R_4 + R_2} \times \frac{R_1 + R_3}{R_1}$$

If the two sums of resistances are equal, $R_1 + R_3 = R_2 + R_4$, the gain will be: $A = \frac{R_4}{R_1}$.

The values of the resistances are chosen as follows:

$$R_1 = R_2 = 1k\Omega \; R_3 = R_4 = 12.5k\Omega$$

In Proteus, the $12.5k\Omega$ value will be obtained by placing three resistors in series as follows:



Choosing the operational amplifier

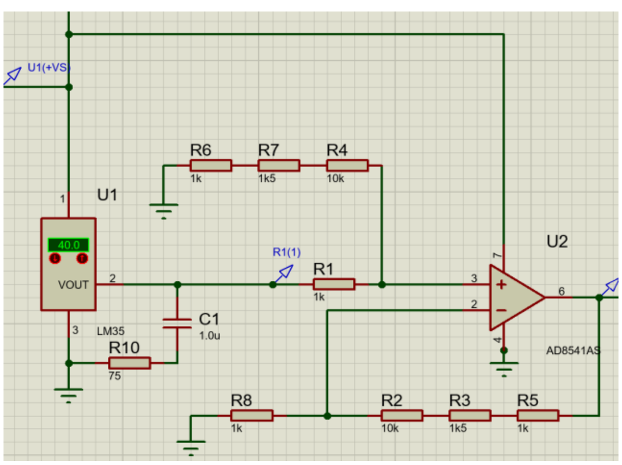
Rail-to-rail operational amplifiers

Op-amps having a common-mode input voltage range that almost covers the GND-V_{CC} or V_{EE}-to-V_{CC} range are called rail-to-rail input op-amps (or full-swing op-amps).

Since the final product is wanted to be implemented in real life, a rail-to-rail operational amplifier is needed. Because we need the minimum voltage at the output to be as close as possible to 0, with a normal operational amplifier this could have been achieved only with a negative supply, which cannot be implemented with a normal battery.

The chosen amplifier is AD8541, based on the following criteria:

- Rail-to-rail input and output
- Single-supply operation: 2.7V to 5.5V
- Low supply current: 45μA/amplifier

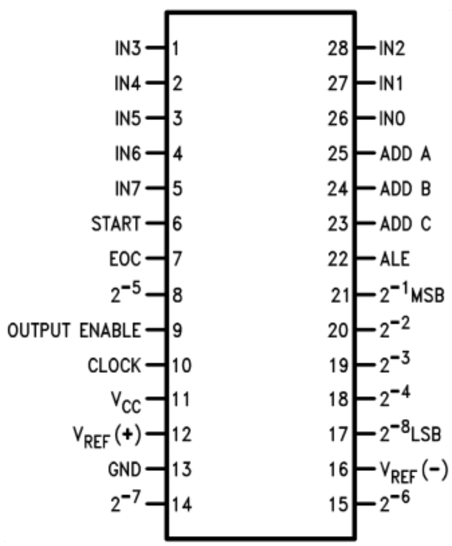


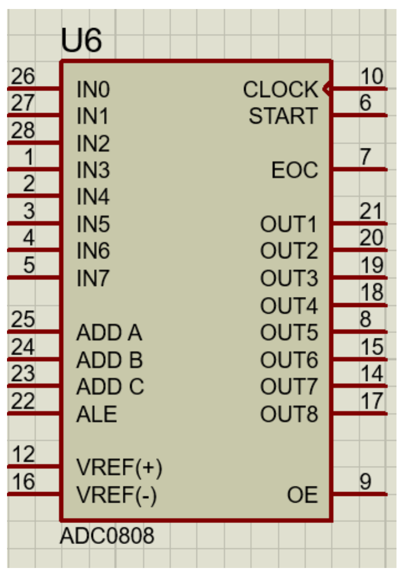
Connecting the ADC

In electronics, an analog-to-digital converter is a system that converts an analog signal, such as a sound picked up by a microphone or light entering a digital camera, into a digital signal.

The chosen ADC is ADC0808 based on the following features:

- Easy Interface to All Microprocessors
- Operates with 5 VDC
- 8-Channel Multiplexer with Address Logic
- 0V to VCC Input Range





The ADC0808 data acquisition component is a monolithic CMOS device with an 8-bit analog-to-digital, 8-channel multiplexer and microprocessor compatible control logic. The 8-bit A/D converter uses successive approximation as the conversion technique. The converter features a high impedance chopper stabilized comparator, a 256R voltage divider with analog switch tree and a successive approximation register.

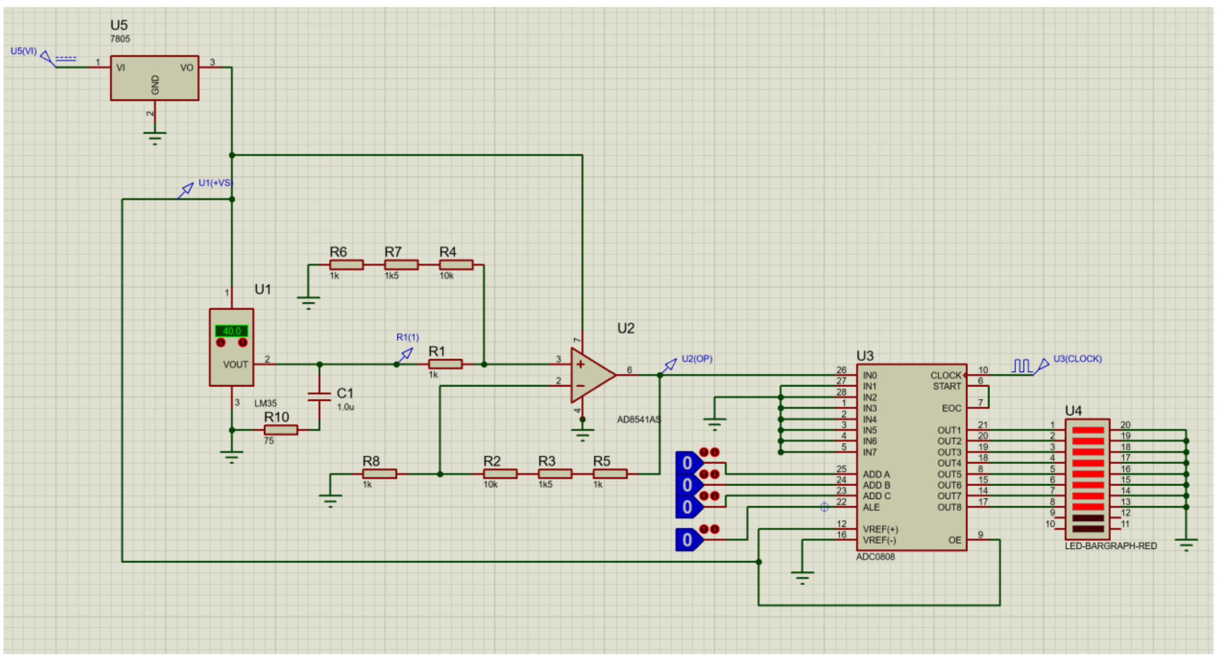
The heart of this single chip data acquisition system is its 8-bit analog-to-digital converter. The converter is designed to give fast, accurate, and repeatable conversions over a wide range of temperatures. The converter is partitioned into 3 major sections: the 256R ladder network, the successive approximation register, and the comparator.

The 256R ladder network approach was chosen over the conventional R/2R ladder because of its inherent monotonicity, which ensures no missing digital codes.

The successive approximation register (SAR) performs 8 iterations to approximate the input voltage. For any SAR type converter, n-iterations are required for an n-bit converter.

The most important section of the A/D converter is the comparator. It is this section which is responsible for the ultimate accuracy of the entire converter. It is also the comparator drift which has the greatest influence on the repeatability of the device. A chopper-stabilized comparator provides the most effective method of satisfying all the converter requirements.

The output of the amplifier could be connected to any of the 8 inputs, and then the addresses A, B and C modified accordingly. The Address Latch Enable is used to set the addresses. Start must be connected to End Of Conversion so that after finishing a conversion the circuit automatically starts a new one. The Output Enable signal causes the ADC to actually output the digital values on the output lines.



Connecting the Microcontroller

Next up, the “brain” of the project needs to be connected. The whole circuit will work controlled by the microcontroller.

A microcontroller is a small computer on a single integrated chip. It contains one or more central processing units, along with memory and programmable input/output peripherals.

Microcontrollers are designed for embedded applications, in contrast to the microprocessors used in personal computers or other general purpose applications consisting of various discrete chips.

8051 architecture

The 8051 architecture provides many functions (central processing unit (CPU), random-access memory (RAM), read-only memory (ROM), input/output (I/O) ports, serial port, interrupt control, timers) in one package.

The 8051 family became widely popular after Intel allowed other manufacturers to make and market any flavors of the 8051 they please with the condition that they remain code-compatible with the 8051. This has led to many, versions of the 8051 with different speeds and amounts of on-chip ROM marketed by more than half a dozen manufacturers. If you write your program for one, it will run on any of them regardless of the manufacturer.

8051 microcontroller

In 1981, Intel Corporation introduced an 8-bit microcontroller called the 8051. This microcontroller had 128 bytes of RAM, 4K bytes of on-chip ROM, two timers, one serial port, and four ports (each 8-bits wide) all on a single chip. At the time it was also referred to as a “system on a chip.” The 8051 is an 8-bit processor, meaning that the CPU can work on only 8 bits of data at a time. Data larger than 8 bits has to be broken into 8-bit pieces to be processed by the CPU. The 8051 has a total of four I/O ports, each 8 bits wide.

8052 microcontroller

The 8052 is another member of the 8051 family. The 8052 has all the standard features of the 8051 as well as an extra 128 bytes of RAM and an extra timer. In other words, the 8052 has 256 bytes of RAM and 3 timers. It also has 8K bytes of on-chip program ROM instead of 4K bytes.

8031 microcontroller

This chip is often referred to as a ROM-less 8051 since it has 0K bytes of on-chip ROM. To use this chip you must add external ROM to it. This external ROM must contain the program that the 8031 will fetch and execute.

In the process of adding external ROM to the 8031, you lose two ports. That leaves only 2 ports (of the 4 ports) for I/O operations. To solve this problem, you can add external I/O to the 8031.

8032 microcontroller

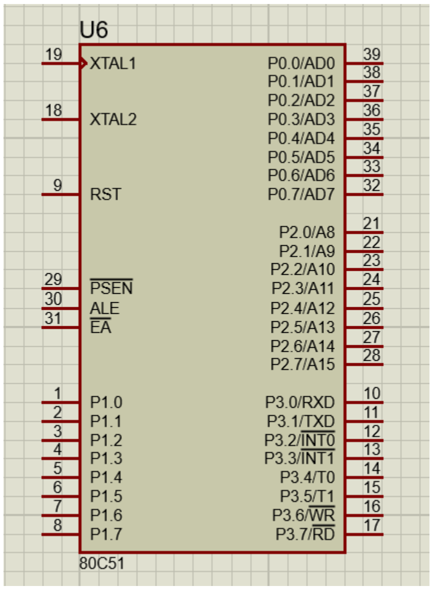
The Intel 8032 is a MCS-51 NMOS single-chip 8-bit microcontroller with 32 I/O lines, 3 Timers/Counters, 6 Interrupts/4 priority levels ROM-less, 256 Bytes on-chip RAM.

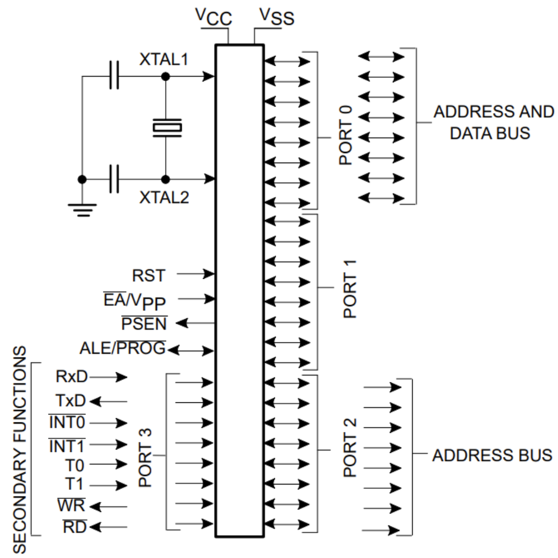
8751 microcontroller

This 8751 chip has only 4K bytes of on-chip UV-EPROM. Using this chip for development requires access to a PROM burner, as well as a UV-EPROM eraser to erase the contents of UV-EPROM inside the 8751 chip before you can program it again.

Feature	8051	8052	8031	8032	8751
ROM (program space in bytes)	4K	8K	0K	0K	4K
RAM (bytes)	128	256	128	256	128
Timers	2	3	2	3	2
I/O pins	32	32	32	32	32
Serial port	1	1	1	1	1

80C51 microcontroller





Pins:

- PSEN – is used for enabling the external program memory, connected to the external ROM memory chip
- EA – forces the controller to use the external program memory when connected to GND
- XTAL1, XTAL2 – used for connecting the crystal to the microcontroller, which gives the clock pulses
- RST – used for restarting the microcontroller
- ALE – Address Latch Enable, positive going pulse generated when a new operation is started by the microprocessor

Cod C:

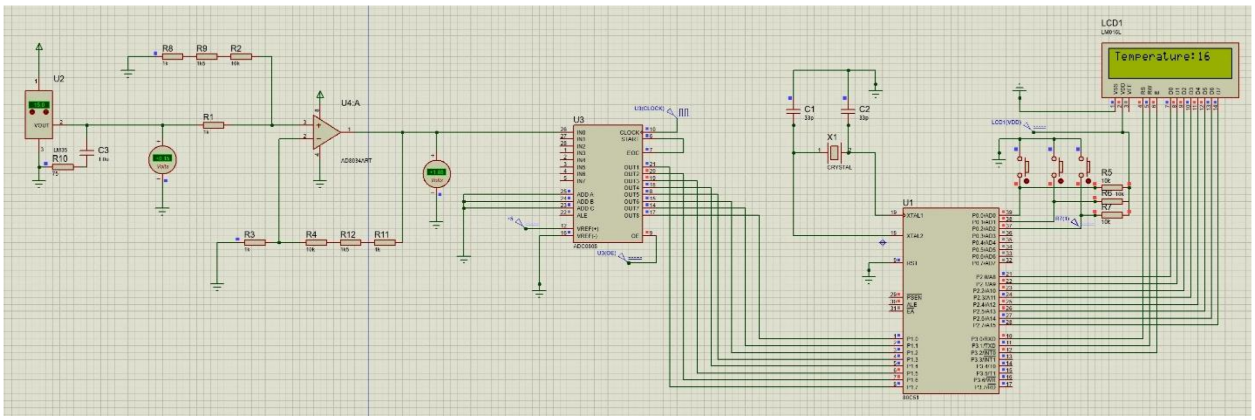
```
#include <reg51.h>

sbit rs = P3^0;
sbit en = P3^2;

unsigned int  aux=0, tab[2];
```

```
float t=0;

void LCD_cmd(unsigned char);
void LCD_data(unsigned char);
void message();
void delay();
void port_init();
void temp_display();

void main(){
        port_init();
        message();

                temp_display();

}

void LCD_cmd(unsigned char x){
        P2 = x;
        rs = 0;
        en = 1;
        delay();
        en = 0;
}

void LCD_data(unsigned char x){
        P2 = x;
        rs = 1;
        en = 1;
        delay();
        en = 0;
}

void delay(){
```

```
	unsigned int i;
	for(i=0; i<1200; i++);
}

void message(){
			LCD_cmd(0x38); //5X7 MATRIX CRYSTAL
	  LCD_cmd(0x0E); // display on, cursion on
			LCD_cmd(0x0c);
			LCD_cmd(0x80); //cursor at line 1, position 0
			LCD_data('T');
			LCD_data('e');
			LCD_data('m');
			LCD_data('p');
	  LCD_data('e');
	  LCD_data('r');
	  LCD_data('a');
	  LCD_data('t');
	  LCD_data('u');
	  LCD_data('r');
	  LCD_data('e');
			LCD_data(':');
}

void port_init(){
	P1 = 0xFF;  //input
	P2 = 0;     //output
	P3 = 0;     //output
}

void temp_display(){
	t = (P1*0.019 + 0.019)/11;
	aux = t * 10000;
	tab[1] = aux/100%10;
	tab[0] = aux/1000%10;
```

```
        if(tab[0] == 0)
                LCD_data(0x20);
        else
                                LCD_data(tab[0]+'0');
        LCD_data(tab[1]+'0');

}
```

Functionare C:



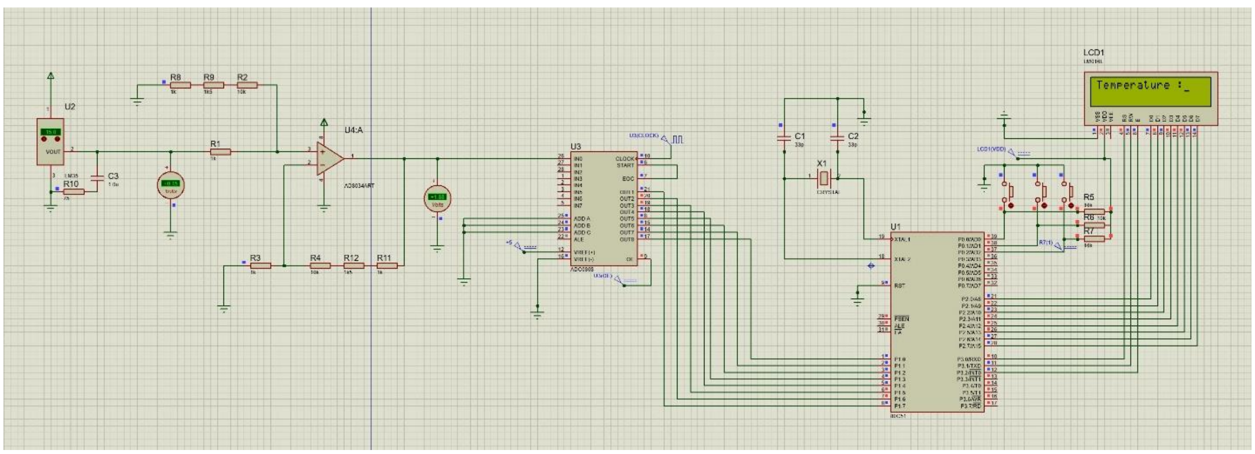
Cod assembly:

```
ORG 0H
        MOV A, #38H ; initialiase LCD 2 LINES, 5X7 MATRIX
        ACALL COMNWRT ; call command subroutine
        ACALL DELAY ; give LCD some time
        MOV A, #0EH ; display on, cursion on
        ACALL COMNWRT ;call command subroutine
        ACALL DELAY ;give LCD some time
        MOV A, #01; clear LCD
        ACALL COMNWRT
        ACALL DELAY

        MOV A, #80H ;cursor at line 1, position 0
        ACALL COMNWRT
```

```
ACALL DELAY

MOV A,#'T' ;display letter T
ACALL DATAWRT
ACALL DELAY

MOV A,#'e'
ACALL DATAWRT
ACALL DELAY

MOV A,#'m'
ACALL DATAWRT
ACALL DELAY

MOV A, #'p'
ACALL DATAWRT
ACALL DELAY

MOV A, #'e'
ACALL DATAWRT
ACALL DELAY

MOV A, #'r'
ACALL DATAWRT
ACALL DELAY

MOV A, #'a'
ACALL DATAWRT
ACALL DELAY

MOV A, #'t'
ACALL DATAWRT
ACALL DELAY
```

```
        MOV A, #'u'
        ACALL DATAWRT
        ACALL DELAY

        MOV A, #'r'
        ACALL DATAWRT
        ACALL DELAY

        MOV A, #'e'
        ACALL DATAWRT
        ACALL DELAY
        MOV A, #' '
        ACALL DATAWRT

        MOV A, #':'
        ACALL DATAWRT
        ACALL DELAY



;ACALL DATAWRT

AGAIN: SJMP AGAIN ;stay here
        COMNWRT:
            MOV P2,A ;copy reg A to port 2
                    CLR P3.0 ; RS=0 for command
                    CLR P3.1 ;R/W for write
                    SETB P3.2 ;E=1 FOR HIGH PULSE
                    ACALL DELAY
                    CLR P3.2 ;E=0 for H-to-L pulse
                    RET
        DATAWRT:    ;write data to the LCD
            MOV P2, A; copy reg A to port 2
                    SETB P3.0 ;RS=1 for data
```

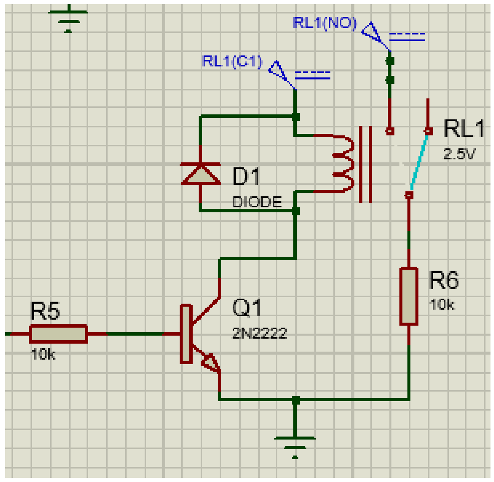
```
                CLR P3.1 ;R/W for write
                SETB P3.2 ;E=1 for high pulse
                ACALL DELAY
                CLR P3.2 ;E=0 for H-to-L pulse
                RET
DELAY: MOV R3, #50 ;50 or higher for fast CPUs
HERE2: MOV R4, #255; R4=255
HERE: DJNZ R4, HERE ;stay untill R4 becomes 0
    DJNZ R3, HERE2
          RET
          END
```



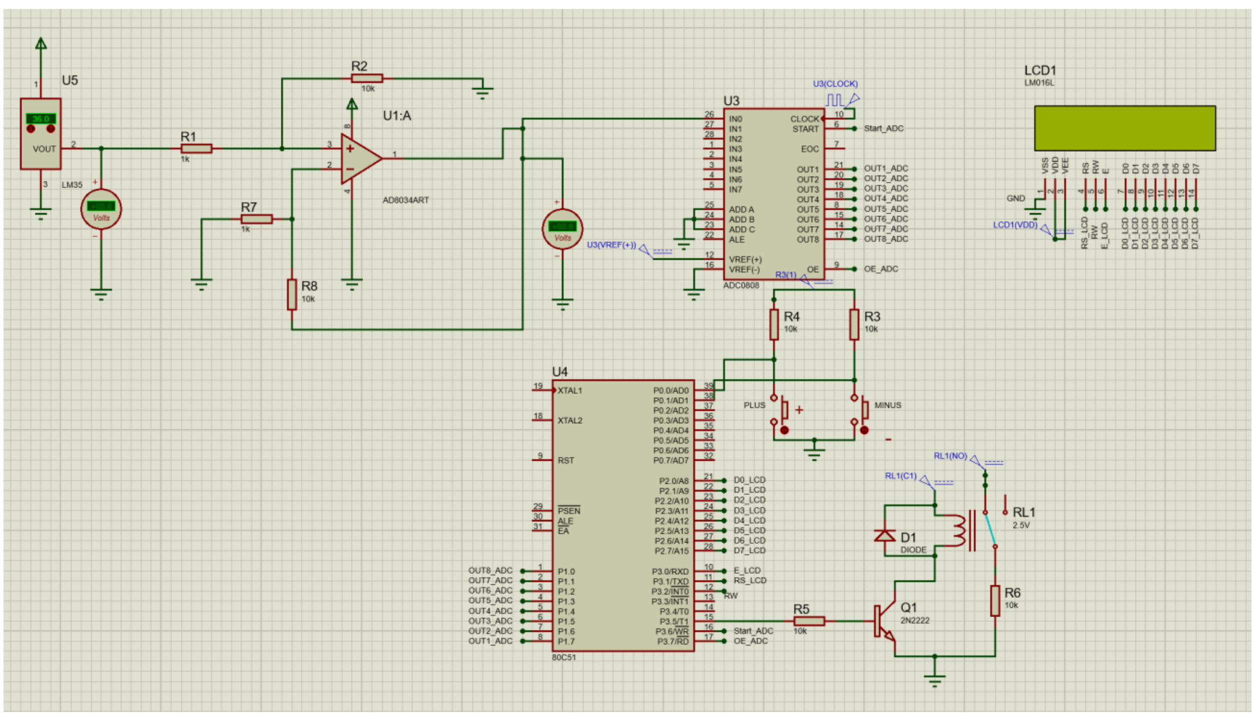
Connecting the Relay

The last, but not the least lectronic component added to the schematic is the relay. A relay is an electrical device that is used to control the flow of electric current in a circuit. It is an electromagnetic switch that uses a small current to control a larger current or voltage. Relays are commonly used in various applications to provide electrical isolation, amplify signals, and control high-power devices.

The basic operation of a relay involves an electromagnet and a set of contacts. When a small current is applied to the electromagnet, it creates a magnetic field that attracts or releases a set of contacts, thereby opening or closing a circuit. This allows the relay to control the flow of electricity to another device or circuit.



Final schematic



Final code

Assembly

```
RS equ P3.1
E  equ P3.0
functionset equ 38h ; Instruction to set LCD to display
;characters on a 5x7 matrix
displayONoff equ 0Eh  ; Instruction to turn on the LCD
cleardisplay equ 01h ; Instruction to clear the LCD
fistLineCursor equ 80h ; Positioning the cursor on the first line
secondLineCursor equ 0C0h  ; Positioning the cursor on the second line

org 0000h
; Initialize variables and set buttons as not pressed
mov R0,#20 ; Reference voltage in the room
setb P0.0 ; Set button 1 as not pressed
setb P0.1  ; Set button 2 as not pressed

; Call functions to initialize and display on the LCD
acall LCD ; Initialize LCD
acall first_row_text ; Display message on the first line
acall second_row_text  ; Display message on the second line
acall ADC ; Read temperature from ADC

LCD:
//Initializare LCD
    mov a,#functionset  ; Set LCD to display characters on a 5x7 matrix
    acall instructiuni
    acall delay

    mov a,#displayONoff ; Turn on the LCD
    acall instructiuni
    acall delay

    mov a,#cleardisplay ; Clear the LCD
    acall instructiuni
    acall delay

    mov a,#fistLineCursor; Position the cursor on the first line at position 0
    acall instructiuni
    acall delay
 ; Display a message on the first line
first_row_text:
    mov dptr,#0900h; Point to the memory location containing the message
    mov R1,#0h  ; Initialize loop counter
iar2:
    mov a,#0h  ; Clear accumulator A
    movc a, @a+dptr ; Read character from memory
    inc dptr   ; Increment memory pointer
    inc r1 ; Increment loop counter
```

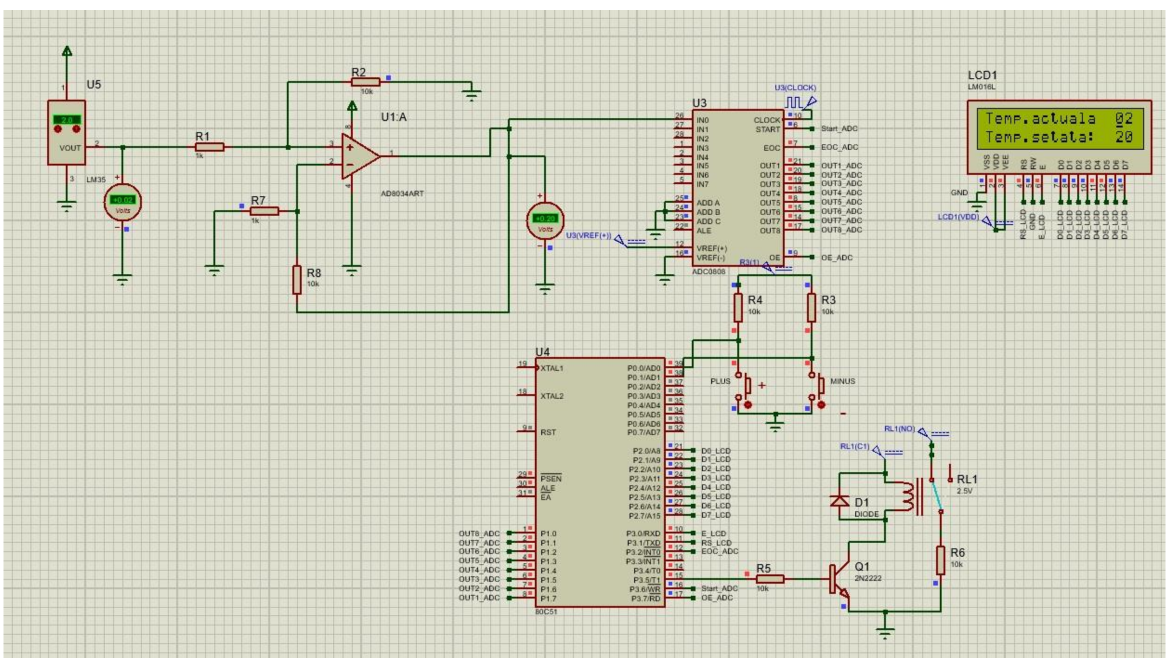
```
iar2:
    mov a,#0h  ; Clear accumulator A
    movc a, @a+dptr ; Read character from memory
    inc dptr   ; Increment memory pointer
    inc r1 ; Increment loop counter
    acall date ; Send character to LCD
    acall delay ; Delay for stability
    cjne r1,#0Eh,iar2 ; Continue loop until all characters
ret

; Display the message "Temp.setata" on the second line
second_row_text:
    mov a,#secondLineCursor ; Position the cursor on the second line at position 0              ;Pozitionare cursor pe linia a doua la pozitia 0
    acall instructiuni
    acall delay
    mov dptr,#0500h ; Point to the memory location containing the message
    mov R1,#0h ; Initialize loop counter
iar3:
    mov a,#0h ; Clear accumulator A
    movc a, @a+dptr ; Read character from memory
    inc dptr  ; Increment memory pointer
    inc r1 ; Increment loop counter
    acall date ; Send character to LCD
    acall delay ; Delay for stability
    cjne r1,#0Eh,iar3
    acall show_set_temp ; Display the set temperature
ret
; Send instruction to LCD data pins
instructiuni:
    mov P2,a
    acall enable_instructiuni
    ret
; Enable instructions on the LCD
enable_instructiuni:
    clr RS  ;RS=0 for instructions
    setb E    ; Enable E pin                          ;E=1 se activeaza pinul E
    acall delay ; Delay for stability
    clr E  ; Disable E pin                            ;E=0 se dezactiveaza pinul E
    ret


date: ;Scrie date pe LCD
    mov P2,a
    acall enable_date
    ret
```

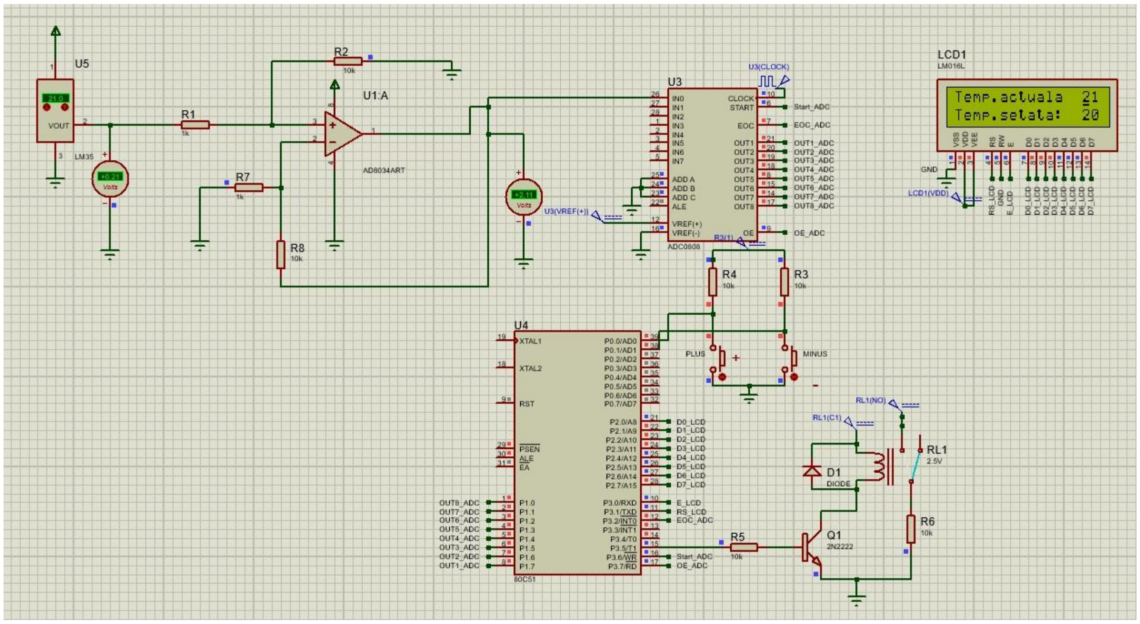
```
enable_date:
    setb RS ;RS=1 pentru date
    setb E  ;Rs=1 se activeaza pinul E
    acall delay
    clr E ;E=0 se dezactiveaza pinul E
    ret


ADC:

    acall readtemp
    acall show_current_temp

    acall temp_control
    acall relay
    sjmp adc
readtemp:
    setb P3.6; we give a command to ADC in order to 'start' a conversion
    nop
    nop ; wait some time
    nop

    clr P3.6; we stop the 'start' conversion

    waitEOC_low:
        jb P3.2, waitEOC_low; we wait for 'EOC' pin to be LOW
    waitEOC_high:
        jnb P3.2, waitEOC_high  ; we wait for 'EOC' pin to be HIGH again

    setb P3.7 ;setting P3.7 we enable the 'OE' of the ADC
    nop
    nop
    nop

    mov A, P1; store in A what we have on P1
    clr P3.7; disable 'OE' of the ADC
    mov B, #5 ; because 1 Celsius Degree represents 5 LSB on ADC,
    div AB  ; we want to divide to those 5 LSB in order to find the temperature
    mov r6, a   ; salvam in r6 temperatura citita
ret
```

```
//Afisare temperatura setata
show_current_temp:
    mov a,#8Eh      ;Pozitionare cursor pe prima linie pozitia 14
    acall instructiuni
    acall delay
    mov a,r6; punem in acc temperatura citita
    mov B,#10
    div AB  ; divide at 10 in order to get the tens from A value. Ex: 45/10 = 4
    add A, #30h ; add 30h to get the ascii value of the tens remaining in A
    mov P2, A; mov in P2, A in order to transmit the character
    acall date
    acall delay
    mov A,B ; the remainder of the division will be saved in B so we will move in A the remainder
    add A, #30h ; get ascii character
    mov P2, A; transmit the character to LCD
    acall date
    acall delay
ret


// Afisare temperatura actuala
show_set_temp:
    mov a,#0CEh ; Pozitionare cursor pe a doua linie pozitia 14
    acall instructiuni
    acall delay
    mov a,R0    ; punem in a valoarea temperaturii de referinta
    mov b,#0ah  ; punem in b 10
    div ab; facem impartirea pt a obtine zecile
    add a,#30h  ; adaugam 30 pt a aobtine valoarea ascii
    acall date
    acall delay
    mov a,b ; mutam in a ceea ce ne-a ramas in b in urma impartirii
    add a,#30h  ; obtinem valoareaa ascii
    acall date
    acall delay
ret
```

```
//Tastatura
temp_control:
    jnb P0.0,Buton1 ;Se verifica daca "+" este apasat
    jnb P0.1,Buton2 ;Se verifica daca "-" este apasat
    sjmp gata

Buton1:
    mov r3,#255 ; call delay
debouncing_1:
    jb P0.0,Buton1
    djnz r3,debouncing_1
    mov a, r0; punem in a temp de referinta
    subb a, #51 ; facem o verificare ca temp sa nu fie mai mare decat 51, adica val maxima pe care o pot avea in urma convertirii
    jz gata ; daca diferenta e zero, inseamna ca am citit 51 de grade si nu mai putem incrementa
    inc R0; altfel, incrementeaza valoarea de referinta
    acall show_set_temp

b1:
    jnb P0.0,b1 ; numai cand nu mai e apasat butonul se iese din eticheta Buton1
    sjmp gata

Buton2:
    mov r3,#255
debouncing_2:
    jb P0.1,Buton2
    djnz r3,debouncing_2
    mov a,r0
    jz gata
    dec R0
    acall show_set_temp
b2:jnb P0.1,b2
    jmp gata
gata: ret
```

```
//Releu
relay:
    push acc
     mov a,r6 ;Valoarea citita o punem in a
     subb a,R0 ; scadem din valoarea cittia, valoarea actuala
     jc start ; Se verifica daca temperatura setata este mai mare decat cea actuala
     sjmp oprire
start:
    setb P3.5 ; Pornire releu
        sjmp gata2
oprire:
    clr P3.5;Oprire releu
gata2: pop acc
    ret


//Intarzierea
delay:
    mov R7,#229 ; 229 - the value which will multiply the x time delay
    repeat:
        nop ; 6 cycles -1 for each nop and 2 for djnz - => 6 * 1.085 us = 6.51us delay for one loop
        nop
        nop
        nop
        djnz R7,repeat  ; 6.51 us * 229 = 1.5 ms total delay
ret


org 0500h
    db "Temp.setata:"

org  0900h
    db 'Temp.actuala', 00h


end
```





Code in C

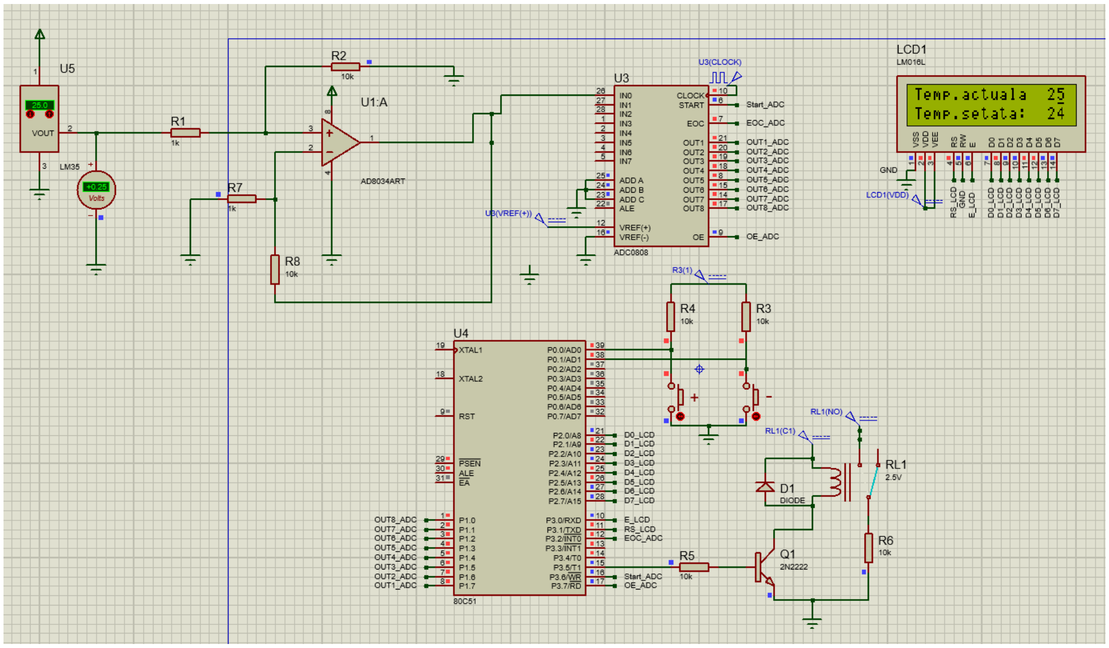
```c
#include <reg51.h>
#include <stdio.h>
#include <stdlib.h>

#define dataADC P1              //define variable "dataADC" for port P0
#define dataLCD P2              //define variable "dataADC" for port P2

sbit rs = P3^1;                 //register select (LCD)
sbit rw = P3^2;                 //read/write  (LCD)
sbit en = P3^0;                 //enable signal (LCD)

//sbit commonpin = P3^3;          //common pin (matrix keypad)
sbit tplus = P0^0;              // button increase temperature (matrix keypad)
sbit tminus = P3^1;             // button decrease temperature (matrix keypad)
//sbit tset = P3^6;               // button set temperature (matrix keypad)

sbit relay = P3^5;              // relay switch signal

int tempint = 25;               //default Temperature Set value
int tempread;                   //temperature read from sensor
unsigned char tempchar[5];      //string variable for display temperature


void delay(unsigned int d);     //delay function
unsigned int read_keypad();     //test if button pushed for increase/decrease temperature
unsigned int relay_switch();    //test Temperature Set button
void lcd_cmd(unsigned char val);//command LCD
void lcd_init();                //initialize LCD
void lcd_data(unsigned char val);//send a byte of data to LCD
void lcd_msg(unsigned char s[]);// display a string of characters on LCD
unsigned int read_adc();        //reads a 8bit value from ADC
void dispval(unsigned int x);//display an integer value
```

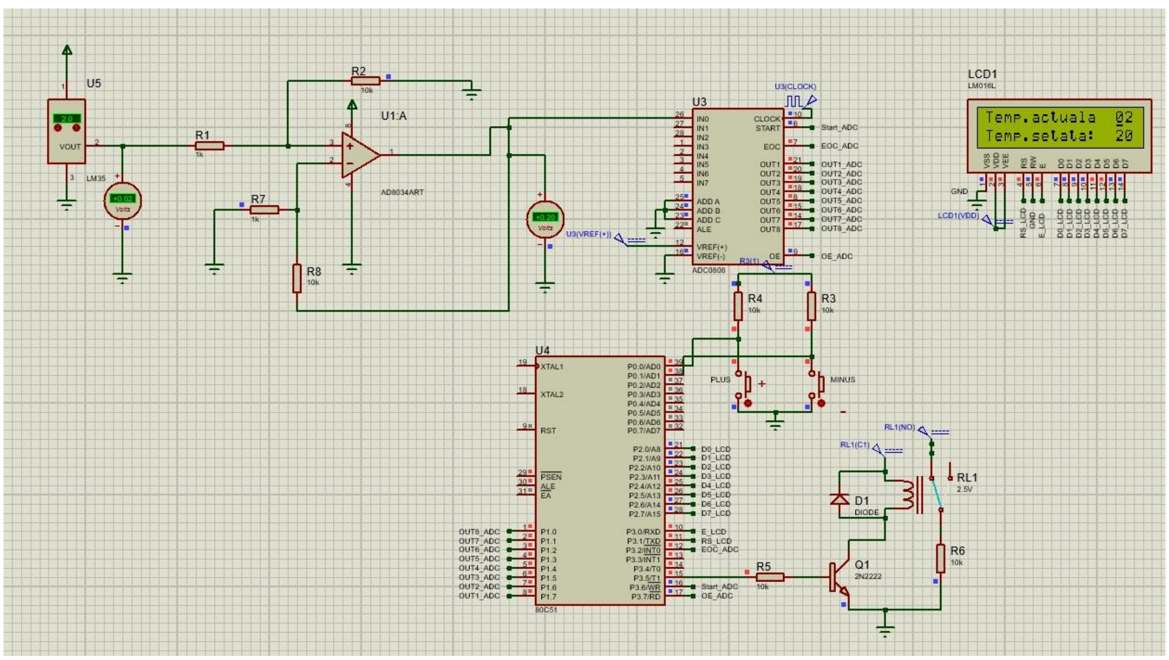
```c
void main(){
  relay=0;//relay initially off
  dataLCD= 0x00;  //output port
  lcd_init();//initialize LCD
  while(1){
      tempread=read_adc();//read temperature from sensor
      if(read_keypad()==1){//increase TempSet value
         tempint++;
       delay(75);
      }
      else
       if(read_keypad()==2){//decrease TempSet value
       tempint--;
       delay(75);
      }
    lcd_cmd(0x80);  //first line of lcd display
    lcd_msg("Temp.actuala: ");
    dispval(tempint);//display temp set value
    lcd_msg("C ");
    lcd_cmd(0xC0);  //second line
    lcd_msg("Temp.setata: ");//display temp read value
    dispval(tempread);
    lcd_msg("C ");

      if(relay_switch()==1&&tempint<=tempread){//switch off relay
      relay=0;
      delay(1);
      }
      else if(relay_switch()==1&&tempint>tempread){//switch on relay
        delay(1);
        relay=1;
    }
  }
```

```c
  unsigned int i,j;
  for(i = 0; i <= d; i++)
  for(j = 0; j <= 200; j++);
}
unsigned int read_keypad(){//test if button pushed for increase/decrease temperature
  unsigned int j=0;
  tplus=tminus=1;//input pins
  commonpin= 0;
  if(tplus==0){//button "TempIncrease" pushed -> return 1
    j=1;
    }
  if(tminus==0){//button "TempDecrease" pushed -> return 2
    j=2;
    }
  return j;
}

unsigned int relay_switch(){//test Temperature Set button
  tset=1;//input pin
  commonpin= 0;
  if(tset==0){// if tset pressed returns 1
    return 1;
    }
  else
    return 0;
}

void lcd_cmd(unsigned char val){// command LCD function
  dataLCD = val; //send command to LCD
  rs = 0; //command register
  rw = 0; //write
  en = 1; //enable for latcha data to LCD from uC (high to low)
  delay(1); //delay
```

```
  en = 0;
}
void lcd_init(){//initialize LCD
  lcd_cmd(0x38); //2 lines and 5x7 matrix
  delay(1);
  lcd_cmd(0x01); //clear display
  delay(1);
  lcd_cmd(0x0C); //display on and cursor off
  delay(1);
  lcd_cmd(0x80); //set first line as first location of LCD
  delay(1);
  lcd_cmd(0x06); //auto increment cursor
  delay(1);
}
void lcd_data(unsigned char val){//send a byte of data to LCD
  dataLCD = val; //send command to LCD
  rs = 1; //data register
  rw = 0; //write
  en = 1; //enable for latch data to LCD from uC (high to low)
  delay(1); //delay
  en = 0;
}
void lcd_msg(unsigned char s[]){// display a string of characters on LCD
  unsigned int i=0;
  while(s[i] != '\0'){
    lcd_data(s[i]);
    i++;
  }
}
```

```
}
unsigned int read_adc(){//reads a 8bit value from ADC
 unsigned int  t;
 dataADC=0xFF;//port 0 input
 rd=1;// read disable
 intr=1;
 wr=0;
 wr=1;//low to high -> start conversion
 while(intr==1);//intr=0 -> end of conversion
 rd=0; //enable read -> high to low
 t=dataADC;//mov data from output of ADC (port 0 for microcontorller) to variable t
 return t;
}
void dispval(unsigned int x){//display an integer value
    sprintf(tempchar,"%d",x);
    lcd_msg(tempchar);
}
```


U5
LM35
VOUT
R1
1k
R2
10k
R7
1k
R8
10k
U1:A
AD8034ART
U3
ADC0808
U3(CLOCK)
U3(VREF(+))
Start_ADC
EOC_ADC
OE_ADC
LCD1
LM016L
Temp.actuala 25
Temp.setata: 24
LCD1(VDD)
GND
R3(1)
R4
10k
R3
10k
U4
80C51
RL1(NO)
RL1(C1)
RL1
2.5V
D1
DIODE
R5
10k
Q1
2N2222
R6
10k


U5
LM35
VOUT
R1
1k
R2
10k
R7
1k
R8
10k
U1:A
AD8034ART
U3
ADC0808
U3(CLOCK)
U3(VREF(+))
Start_ADC
EOC_ADC
OE_ADC
LCD1
LM016L
Temp.actuala 02
Temp.setata: 20
LCD1(VDD)
GND
R3(1)
R4
10k
R3
10k
PLUS
MINUS
U4
80C51
RL1(NO)
RL1(C1)
RL1
2.5V
D1
DIODE
R5
10k
Q1
2N2222
R6
10k

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