Sudan University of Science and Technology

College of Engineering

School of Electrical and Nuclear Engineering

Design of Digital Temperature Sensor

تصميم المتحسس الحراري الرقمي

A Project Submitted Partial Fulfillment for the Requirements of the Degree of B.Sc. (Honor) in Electrical Engineering

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الآية

أعوذ بالله من الشيطان الرجيم

قال تعالي (اللَّهُ نُورُ السَّمَاوَاتِ وَالْأَرْضِ ۚ مَثَلُ نُورِهِ كَمِشْكَاةٍ فِيهَا مِصْبَاحٌ ۖ الْمِصْبَاحُ فِي زُجَاجَةٍ ۖ الزُّجَاجَةُ كَأَنَّهَا كَوْكَبٌ دُرِّيٌّ يُوقَدُ مِنْ شَجَرَةٍ مُبَارَكَةٍ زَيْتُونَةٍ لَا شَرْقِيَّةٍ وَلَا غَرْبِيَّةٍ يَكَادُ زَيْتُهَا يُضِيءُ وَلَوْ لَمْ تَمْسَسْهُ نَارٌ ۚ نُورٌ عَلَىٰ نُورٍ ۗ يَهْدِي اللَّهُ لِنُورِهِ مَنْ يَشَاءُ ۚ وَيَضْرِبُ اللَّهُ الْأَمْثَالَ لِلنَّاسِ ۗ وَاللَّهُ بِكُلِّ شَيْءٍ عَلِيمٌ)

سورة النور الآية (35)

DEDICATION

To whom listen thoughtfully In the vastness of space and immensity of time where the truth barred.

To whom listen to the truth Who lead monotonous lives In the hope that they may experience the delight and danger of adventures of life.

To my mother whose courageous sons and daughters not a few were caused by myself …

To my father so after all that you have done for me, at least that I can do for you is to write you these word.

To everyone who helped lighten our lives.

To my beloved friends whom they color our lives and shared memories…

ACKNOWLEDEMENT

I would like to express my gratitude and sincere thanks to my respected supervisor Ashraf Nour Aldeen for the guidance and support that he has provided throughout the course of this work.

ABSTRACT

The process of measuring the temperature interference in many fields of industry, medical and others. It was necessary to obtain a correct and accurate readings.

The main components to design digital temperature sensor are: microcontroller and lm35.

To achieve the design there are auxiliary components such as: diodes, resistor, capacitor and LCD 16*2 display.

According to these components the circuit has been designed

مستخلص

عملية قياس درجات الحرارة تدخل في كثير من المجالات الصناعية والطبية وغيرها فكان لابد من الحصول علي قراءات صحيحة ودقيقة .المكونات الأساسية لتصميم المتحسس الحراري الرقمي هي المايكرو كونترولر والمحساس الحراري. لتحقيق التصميم هنالك مكونات اضافية يجب ادخالها هي: الثنائيات والمقاومات والمكثفات بالاضافة لشاشة العرض الرقمية وفقا لهذه المكونات تم تصميم الدائرة.

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LIST OF ABBREVIATIONS

ADC	Analogue to Digital Convertor
LCD	Liquid Cristal Display
IC	Integrated Circuit
ALU	Arithmetic Logic Unit
MPU	Microprocessor Unit

CHAPTER ONE

INTRODUCTION

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INTRODUCTION

1.1 Introduction

Temperature is by far the most measured parameter. It impacts the physical, chemical and biological world in numerous ways. Yet, a full appreciation of the complexities of temperature and its measurement has been relatively slow to develop.

Intuitively, people have known about temperature for a long time: fire is hot and snow is cold. Greater knowledge was gained as man attempted to work with metals through the bronze and iron ages. Some of the technological processes required a degree of control over temperature, but to control temperature you need to be able to measure what you are controlling.

Until about 260 years ago temperature measurement was very subjective. Galileo invented the first documented thermometer in about 1592. It was an air thermometer consisting of a glass bulb with a long tube attached. This type of thermometer is sensitive, but is affected by changes in atmospheric pressure.

In The Eighteenth Century Daniel Gabriel Fahrenheit invented both the mercury and the alcohol thermometer. Fahrenheit's mercury thermometer consists of a capillary tube which after being filled with mercury is heated to expand the mercury and expel the air from the tube.

Later in the 18th century, Anders Celsius realised that it would be advantageous to use more common calibration references and to divide the scale into 100 increments instead of 96. He chose to use one hundred degrees as the freezing point and zero degrees as the boiling point of water. Sensibly the scale was later reversed and the Centigrade scale was born.

In The Nineteenth Century William Thomson (later Lord Kelvin) postulated the existence of an absolute zero. Sir William Hershel, discovered that when sunlight was spread into a colour swath using a prism, he could detect an increase in temperature when moving a blackened thermometer across the spectrum of colours.

The late 19th century saw the introduction of bimetallic temperature sensor. These thermometers contain no liquid but operate on the principle of unequal expansion between two metals.

The 20^{th} Century has seen the discovery of semiconductor devices, such as: the thermistor, the integrated circuit sensor, a range of non-contact sensors and also fibre-optic temperature sensors. The 20th century also saw the refinement of the temperature scale. Temperatures can now be measured to within about 0.001°C over a wide range, although it is not a simple task.

1.2 problem Statement:

Analogue temperature sensor device reading is not accurate, slow response of suddenly changing in temperature, the distance of sensitivity is too short and also the range of measuring is limited (0-100).

1.3 objectives

The project cover the following objectives:

- Measuring temperature in high accuracy
- Fast reading
- High response in suddenly change in temperature

1.4 Methodology

Literature review to understand concept of :

- Collecting data that it's required to design circuit.
- Design circuit using protues7.7 program.
- Write code using Bascom program.
- Testing circuit.

1.5 layout

This study consists of five chapters. The introduction of this study is given in chapter one which contain entrance, problem statement, objectives and methodology. The next section is chapter two presents the theoretical background of components microcontroller, Lm35 crystal display (LCD), bread board, diodes, capacitor, and resistor. In the third section display the embedded controller and comparing between microcontroller and microprocessor.In chapter four the experimental work is done and explain the operation in the project, describe a method of work of each device in the circuit, write the code of microcontroller, draw circuit diagram and the result are presented in this chapter too. Chapter five display a general conclusion from the research and provide suggestions for the future research.

CHAPTER TWO

COMPONENTS

CHAPTER TWO

COMPONENTS

2.1 ATmega16L

8-bit Microcontroller with 16K Bytes In-System Programmable Flash as shown in figure (2.1)

2.1.1 Features:

• High-performance, Low-power Atmel AVR 8-bit Microcontroller

• Advanced RISC Architecture

– 131 Powerful Instructions – MostSingle-clock Cycle Execution

– 32 x 8 General Purpose Working Registers

– Fully Static Operation

– Up to 16 MIPS Throughput at 16 MHz

– On-chip 2-cycle Multiplier

• High Endurance Non-volatile Memory segments

– 16 Kbytes of In-System Self-programmable Flash program memory

– 512 Bytes EEPROM

– 1 Kbyte Internal SRAM

– Write/Erase Cycles: 10,000 Flash/100,000 EEPROM

– Data retention: 20 years at 85°C/100 years at 25°C (1)

– Optional Boot Code Section with Independent Lock Bits

In-System Programming by On-chip Boot Program True Read-While-Write Operation

– Programming Lock for Software Security

• JTAG (IEEE std. 1149.1 Compliant) Interface

– Boundary-scan Capabilities According to the JTAG Standard

– Extensive On-chip Debug Support

– Programming of Flash, EEPROM, Fuses, and Lock Bits through the JTAG Interface.

• Peripheral Features

– Two 8-bit Timer/Counters with Separate Prescalers and Compare Modes

– One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture

Mode

– Real Time Counter with Separate Oscillator

– Four PWM Channels

– 8-channel, 10-bit ADC

8 Single-ended Channels

7 Differential Channels in TQFP Package Only

2 Differential Channels with Programmable Gain at 1x, 10x, or 200x

– Byte-oriented Two-wire Serial Interface

– Programmable Serial USART

– Master/Slave SPI Serial Interface

– Programmable Watchdog Timer with Separate On-chip Oscillator

– On-chip Analog Comparator

• Special Microcontroller Features

– Power-on Reset and Programmable Brown-out Detection

– Internal Calibrated RC Oscillator

– External and Internal Interrupt Sources

– Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby

and Extended Standby

• I/O and Packages

– 32 Programmable I/O Lines

– 40-pin PDIP, 44-lead TQFP, and 44-pad QFN/MLF

• Operating Voltages

– 2.7V - 5.5V for ATmega16L

– 4.5V - 5.5V for ATmega16

• Speed Grades

– 0 - 8 MHz for ATmega16L

– 0 - 16 MHz for ATmega16

• Power Consumption @ 1 MHz, 3V, and 25°C for ATmega16L

– Active: 1.1 mA

– Idle Mode: 0.35 mA

– Power-down Mode: < 1 µA

Figure 2.1: Atmega16l

2.1.2 Pin Configurations

This figure describe Atmega16l pin configurations

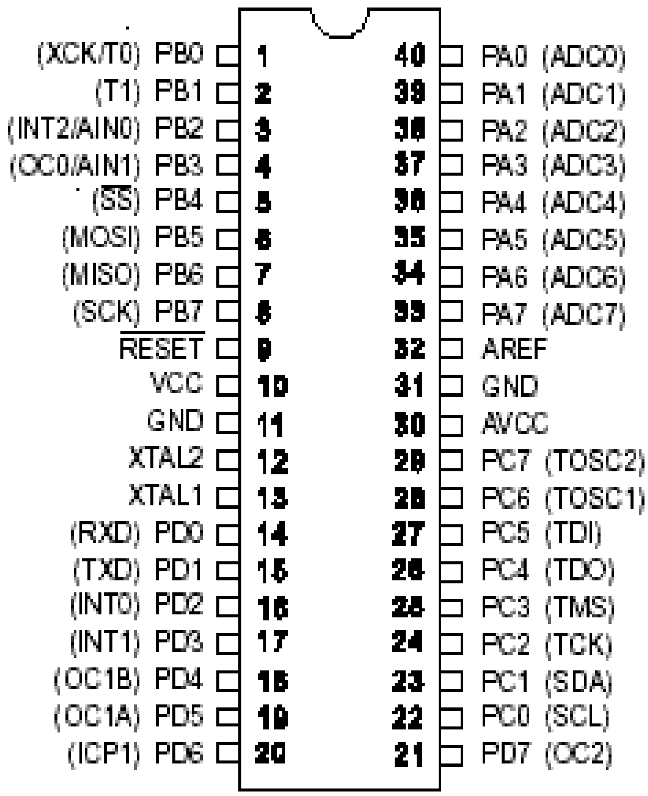
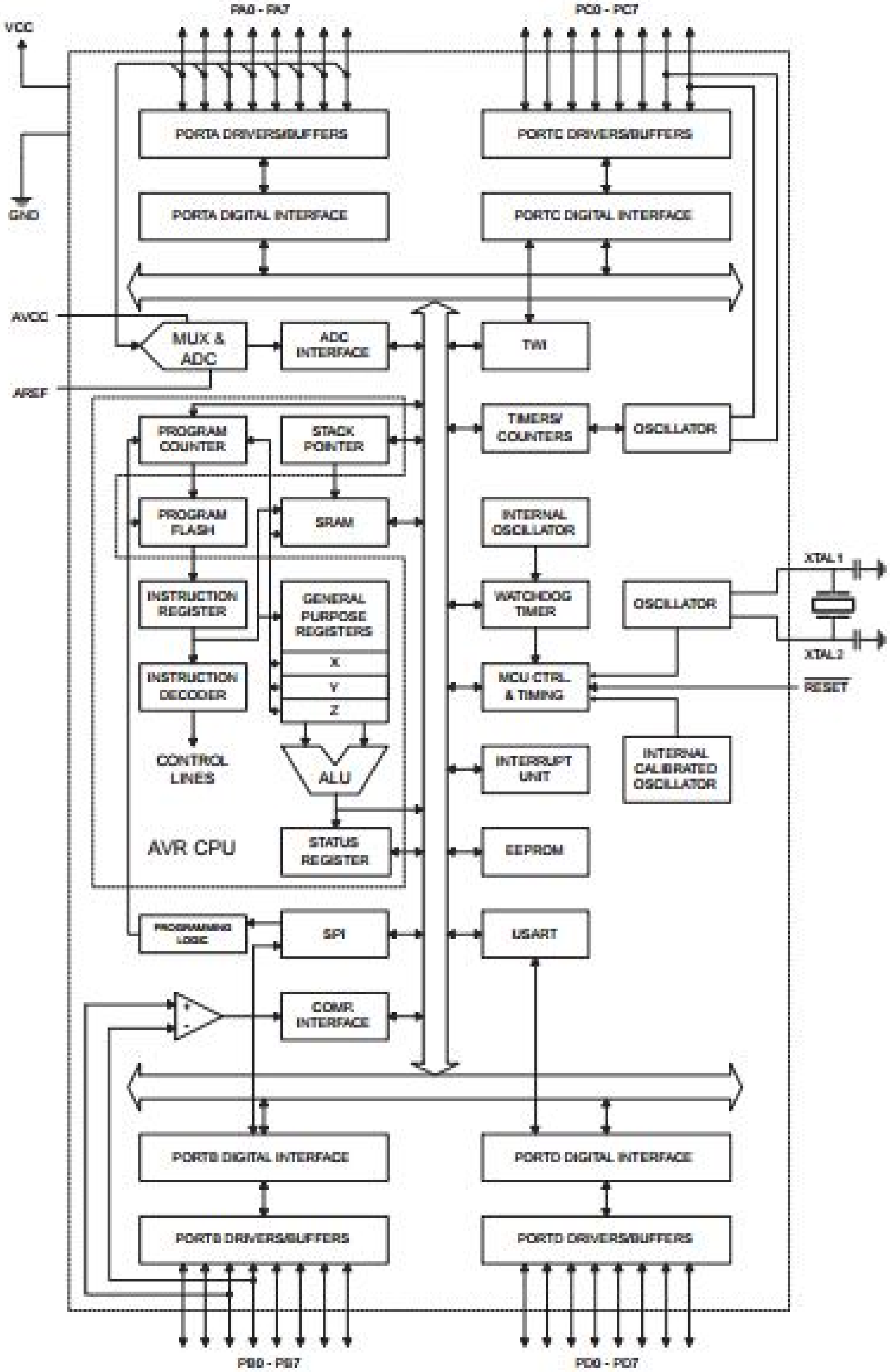


Figure 2.2: Pin Configurations



igure 2.3: Atmega16l Block Diagram

2.1.4 Pin Descriptions

VCC Digital supply voltage.

GND Ground.

Port A (PA7..PA0) Port A serves as the analogue inputs to the A/D Converter.

Port A also serves as an 8-bit bi-directional I/O port, if the A/D Converter is not used. Port pins can provide internal pull-up resistors (selected for each bit). The Port A output buffers have symmetrical drive characteristics with both high sink and source capability. When pins PA0 to PA7 are used as inputs and are externally pulled low, they will source current if the internal pull-up resistors are activated. The Port A pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port B (PB7..PB0) Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port B pins that are externally pulled low will source current if the pull-up resistors are activated. The Port B pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port C (PC7..PC0) Port C is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port C output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port C pins that are externally pulled low will source current if the pull-up resistors are activated. The Port C pins are tri-stated when a reset condition becomes active, even if the clock is not running. If the JTAG interface is enabled, the pull-up resistors on pins PC5(TDI), PC3(TMS) and PC2(TCK) will be activated even if a reset occurs.

Port D (PD7..PD0) Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port D pins that are externally pulled low will source current if the pull-up resistors are activated. The Port D pins are tri-stated when a reset condition becomes active, even if the clock is not running.

RESET Reset Input. A low level on this pin for longer than the minimum pulse length will generate a reset, even if the clock is not running.

XTAL1 Input to the inverting Oscillator amplifier and input to the internal clock operating circuit.

XTAL2 Output from the inverting Oscillator amplifier.

AVCC AVCC is the supply voltage pin for Port A and the A/D Converter. It should be externally connected to VCC, even if the ADC is not used. If the ADC is used, it should be connected to VCC through a low-pass filter.

AREF AREF is the analogue reference pin for the A/D Converter.

2.1.5 ALU –Arithmetic Logic Unit

The high-performance AVR ALU operates in direct connection with all the 32 general purpose working registers. Within a single clock cycle, arithmetic operations between general purpose registers or between a register and an immediate are executed. The ALU operations are divided into three main categories – arithmetic, logical, and bit-functions. Some implementations of the architecture also provide a powerful multiplier supporting both signed/unsigned multiplication and fractional format. See the “Instruction Set” section for a detailed description.

2.1.6 Status Register

The Status Register contains information about the result of the most recently executed arithmetic instruction. This information can be used for altering program flow in order to perform conditional operations. Note that the Status Register is updated after all ALU operations, as specified in the Instruction Set Reference. This will in many cases remove the need for using the dedicated compare instructions, resulting in faster and more compact code.

The Status Register is not automatically stored when entering an interrupt routine and restored when returning from an interrupt. This must be handled by software.

The AVR Status Register – SREG – is defined as:

Table 2.1: Status Register

Bit								
	I	T	H	S	V	N	Z	C
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

• Bit 7 – I: Global Interrupt Enable:

The Global Interrupt Enable bit must be set for the interrupts to be enabled.

The individual interrupt enable control is then performed in separate control registers. If the Global Interrupt Enable Register is cleared, none of the interrupts are enabled independent of the individual interrupt enable settings. The I-bit is cleared by hardware after an interrupt has occurred, and is set by the RETI instruction to enable subsequent interrupts. The I-bit can also be set and cleared by the application with the SEI and CLI instructions.

• Bit 6 – T: Bit Copy Storage:

The Bit Copy instructions BLD (Bit Load) and BST (Bit Store) use the T-bit as source or destination for the operated bit. A bit from a register in the Register File can be copied into T by the BST instruction, and a bit in T can be copied into a bit in a register in the Register File by the BLD instruction.

• Bit 5 – H: Half Carry Flag:

The Half Carry Flag H indicates a Half Carry in some arithmetic operations. Half Carry is useful in BCD arithmetic.

• Bit 4 – S: Sign Bit, $S = N \oplus V$:

The S-bit is always an exclusive or between the Negative Flag N and the Two’s Complement Overflow Flag V.

• Bit 3 – V: Two’s Complement Overflow Flag:

The Two’s Complement Overflow Flag V supports two’s complement arithmetic’s.

• Bit 2 – N: Negative Flag:

The Negative Flag N indicates a negative result in an arithmetic or logic operation.

• Bit 1 – Z: Zero Flag:

The Zero Flag Z indicates a zero result in an arithmetic or logic operation. • Bit 0 – C: Carry Flag:

The Carry Flag C indicates a carry in an arithmetic or logic operation.

2.2 Lm 35

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 that shown in figure (2.4) thus has an advantage over linear temperature sensors calibrated in ˚ Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1⁄4˚C at room temperature and ±3⁄4˚C over a full −55 to +150˚C temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 µA from its supply, it has very low self-heating, less than 0.1˚C in still air. The LM35 is rated to operate over a −55˚ to +150˚C temperature range, while the LM35C is rated for a −40˚ to +110˚C range (−10˚ with improved accuracy). The LM35 series is available packaged in hermetic TO-46 transistor packages, while the LM35C, LM35CA, and LM35D are also available in the plastic TO-92 transistor package. The LM35D is also available in an 8-lead surface mount small outline package and a plastic TO-220 package.

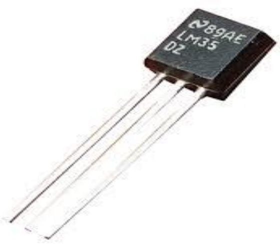


Figure 2.4: lm35

2.2.1 Features

- Calibrated directly in ˚ Celsius (Centigrade)
- Linear + 10.0 mV/˚C scale factor
- 0.5˚C accuracy guarantee able (at +25˚C)
- Rated for full −55˚ to +150˚C range
- Suitable for remote applications
- Low cost due to wafer-level trimming
- Operates from 4 to 30 volts
- Less than 60 µA current drain
- Low self-heating, 0.08˚C in still air
- Nonlinearity only ±1⁄4˚C typical
- Low impedance output, 0.1 Ω for 1 mA load

2.3.2 Block Diagram

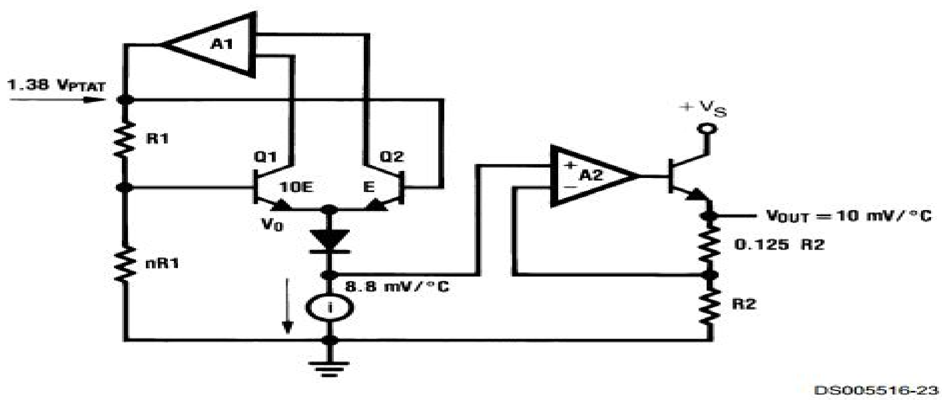


Figure 2.5: Lm35 block diagram

2.3Liquid Crystal Display (LCD)

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display that shown in figure (3.1) is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs.

The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on.

A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data.

The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD.

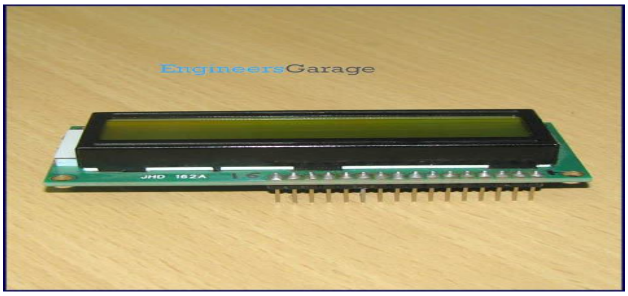


Figure 2.6: 16x2 LCD Display

2.3.1 Features

- 5*8 dots with cursor
- 16 characters *2lines display
- 4-bit or 8-bit MPU interfaces
- Built-in controller (ST7066 or equivalent)
- Display mode & backlight variations
- ROHS compliant

2.3.2 Block Diagram

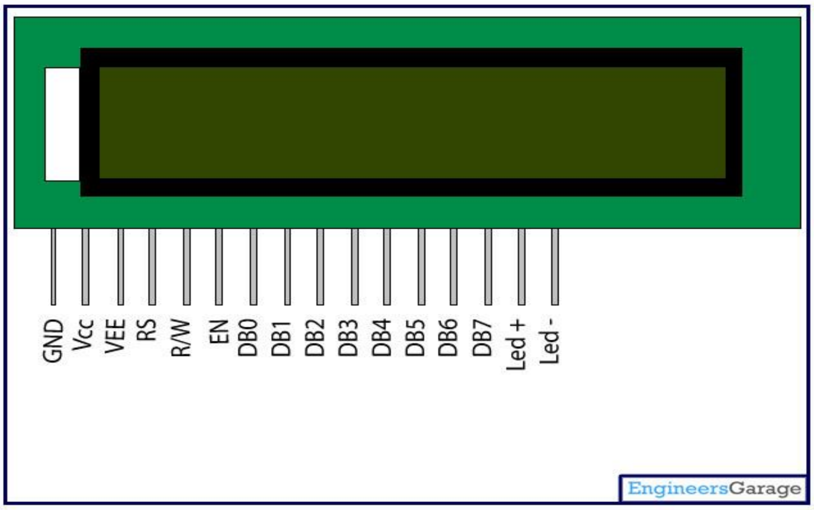


Figure 2.7: LCD block diagram

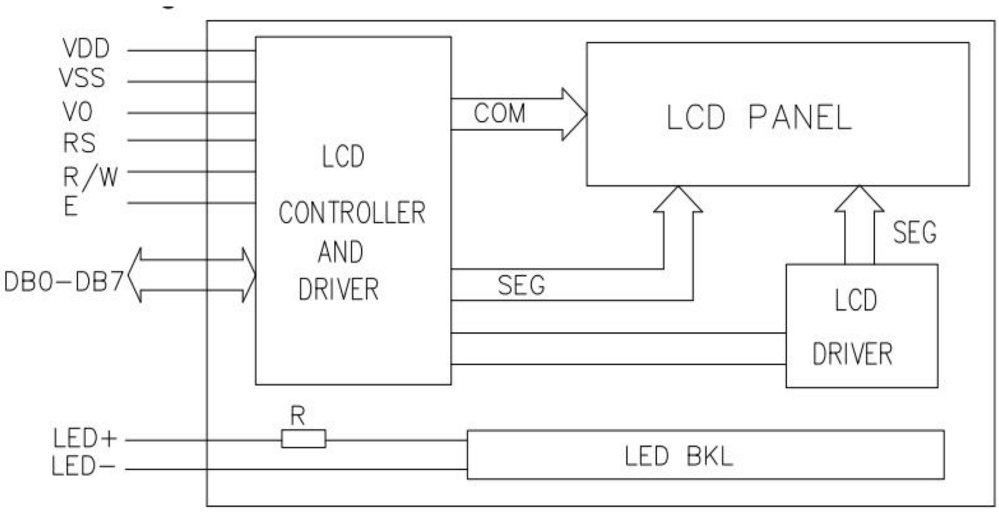


Figure 2.8: Pin Diagram of LCD 16*2 Display

2.3.4 Pin Description

This table contain pin description of LCD

Table 2.2: pin description

Pin No	Function	Name
1	Ground (0V)	Ground
2	Supply voltage; 5V (4.7V – 5.3V)	Vcc
3	Contrast adjustment; through a variable resistor	V_{EE}
4	Selects command register when low; and data register when high	Register Select
5	Low to write to the register; High to read from the register	Read/write
6	Sends data to data pins when a high to low pulse is given	Enable
7	8-bit data pins	DB0
8		DB1
9		DB2
10		DB3
11		DB4
12		DB5
13		DB6
14		DB7
15	Backlight V_{CC} (5V)	Led+
16	Backlight Ground (0V)	Led-

2.3.5 PROGRAMMING OF LCD:

For programming the 16x2 LCD display there are three basic steps.

- Initialization of LCD.
- Giving command for reading the given data.
- Giving command for writing data and displaying on the screen.

LCD COMMANDS:

CODE (HEX)	COMMAND TO LCD
1	Clear display Screen
2	Return home
4	Decrement cursor (shift cursor to left)
6	Increment cursor (shift cursor to right)
5	Shift display right
7	Shift display left
8	Display off, cursor off
A	Display off, cursor on
C	Display on, cursor off
E	Display on, cursor blinking
F	Display on, cursor blinking
10	Shift cursor position to left
14	Shift cursor position to right
18	Bring the entire display to the left
1C	Bring the entire display to the right

80 Bring cursor to beginning of 1st line

C0 Bring cursor to beginning of 2nd line

2.4Breadboard

Specifications

Pitch: 2.54mm Terminal Strips: 300 Tie-point Distribution Strips: 100 Tie-point Rated Voltage / Current: 300V / 3 to 5A Insulation Resistance: 500MΩ / DC500V Withstanding Voltage: 1,000V AC / 1 minute. Wire Range: 29AWG to 20AWG Temperature Range: -25°C to +80°C Strip Length: 7mm to 8mm

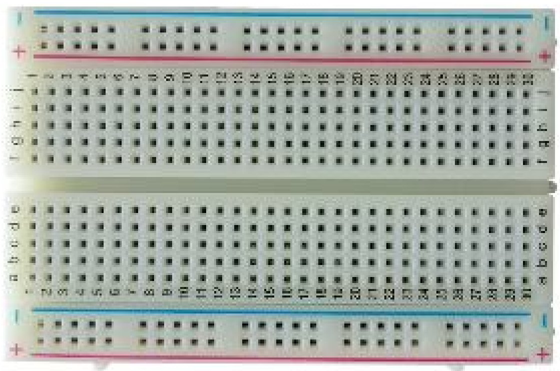


Figure 2.9: Breadboard

2.5Diodes

The 1N4001 series is a family of popular 1.0 A (ampere) general purpose siliconrectifierdiodes commonly used in AC adapters for common household appliances. Blocking voltage varies from 50 to 1000 volts. This diode is made in an axial-lead DO-41 plastic package

Features

• Low forward voltage drop

• Low leakage current

• High forward surge capability

• Solder dip 275 °C max. 10 s, per JESD 22-B106

Figure 2.10: 1N4001 diode

2.6 Capacitor

Capacitoris a simple passive device that is used to store electricity. The capacitor is a component which has the ability or (capacity) to store energy in the form of an electrical charge producing a potential difference (Static Voltage) across its plates, much like a small rechargeable battery.

Ceramic capacitors have a high dielectric constant, what makes possible a high capacitance values in reduced dimensions, however temperature coefficient and loss factor are greater than Class.

Figure 2.11: ceramic capacitor 104

2.7 Resistor

Resistor is an electrical component that reduces the electric current.The resistor's ability to reduce the current is called resistance and is measured in units of ohms (symbol: Ω).

Figure 2.12: 10 kΩ resistor

CHAPTER THREE

MICROCONTROLLER BASED SYSTEM

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MICROCONTROLLER BASED SYSTEM
3.1 Introduction

Microcontrollers have only been with us for a few decades but their impact (direct or indirect) on our lives is profound. Usually these are supposed to be just data processors performing exhaustive numeric operations. But their presence is unnoticed at most of the places like:

- At supermarkets in Cash Registers, Weighing Scales, etc.
- At home in Ovens, Washing Machines, Alarm Clocks, etc.
- At play in Toys, VCRs, Stereo Equipment, etc.
- At office in Typewriters, Photocopiers, Elevators, etc.
- In industry in Industrial Automation, safety systems, etc.
- On roads in Cars, Traffic Signals, etc.

What inside them makes these machines ‘smart’? The answer is microcontroller. Creating applications for the microcontrollers is different than any other development job in electronics and computing. Before selecting a particular device for an application, it is important to understand what the different options and features are and what they can mean with regard to developing the application.

The purpose of this chapter is to introduce the concept of a microcontrollers, how it differ from microprocessors, different type of commercial microcontrollers available as well as their applications. The reminder of the book will go through and present different types of microcontrollers and also programming and interfacing techniques of microcontroller, mainly 8051, in detail.

3.2 Embedded Controller

Simply an embedded controller is a controller that is embedded in a greater system. One can define an embedded controller as a controller (or computer) that is embedded into some device for some purpose other than to provide general purpose computing. Is an embedded controller is the same as a microcontroller? The answer is definitely no. One can state devices such as 68000, 32032, x86, Z80, and so on that are used as embedded controllers but they aren't microcontrollers.

We might be correct by stating that an embedded controller controls something (for example controlling a device such as a microwave oven, car braking system or a cruise missile). An embedded controller may also embed the on-chip resources like a microcontroller. Microcontrollers and microprocessors are widely used in embedded systems. Though microcontrollers are preferred over microprocessors for embedded systems due to low power consumption.

3.3 Microcontrollers and Microprocessors

A controller is used to control some process. At one time, controllers were built exclusively from logic components, and were usually large, heavy boxes. Later on, microprocessors were used and the entire controller could fit on a small circuit board. This is still common– one can find many controllers powered by one of the many common microprocessors (including Zilog Z80, Intel 8088, Motorola 6809, and others).

As the process of miniaturization continued, all of the components needed for a controller were built right onto one chip. A one chip computer, or microcontroller was born.

A CPU built into a single VLSI chip is called microprocessor. The simplified block diagram of the CPU is shown in the Fig. 1.1. It contains arithmetic and logic unit (ALU), Instruction decode and control unit, Instruction register, Program counter (PC), clock circuit (internal or external), reset circuit (internal or external) and registers. For example, Intel 8085 is 8-bit microprocessor and Intel 8086/8088 is 16-bit microprocessor.

Microprocessor is general-purpose digital computer central processing unit (CPU). The microprocessor is general-purpose device and additional external circuitry are added to make it microcomputer.

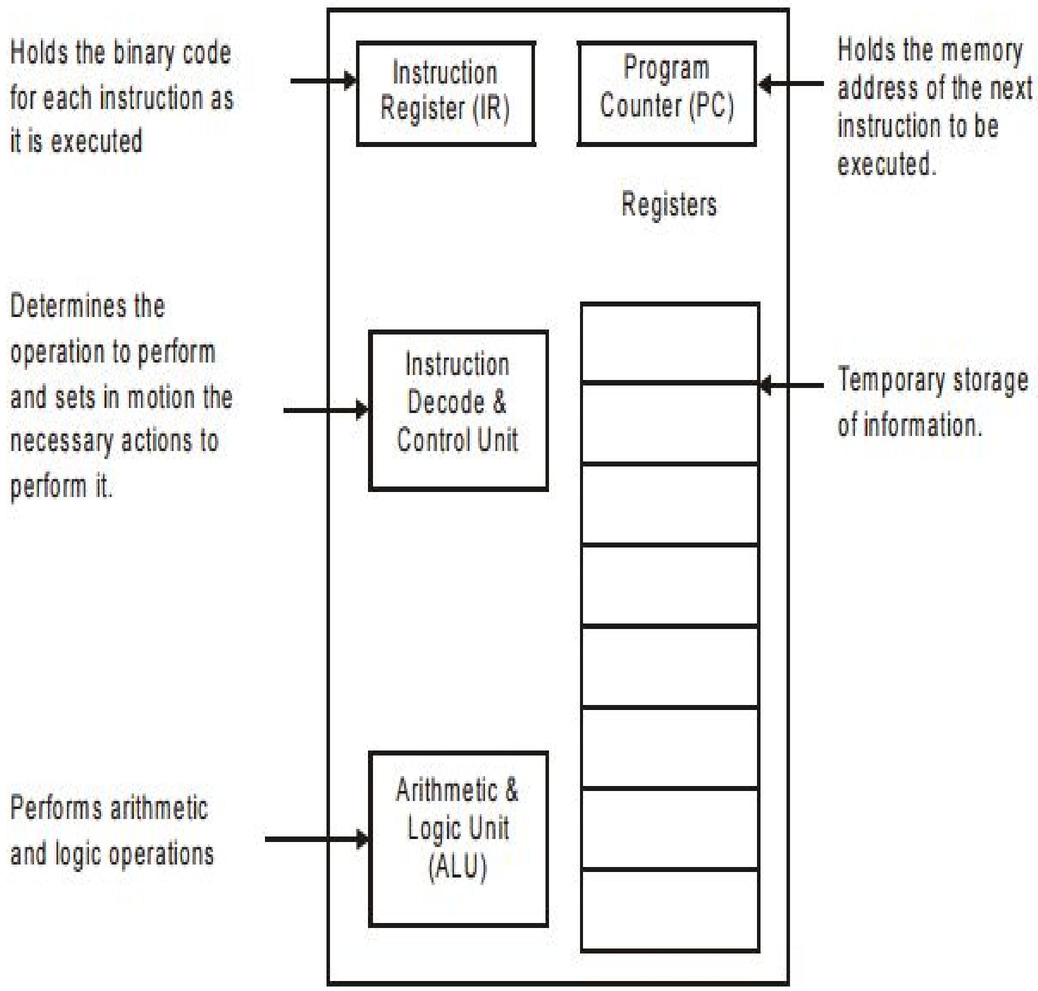


Figure:3.1 General block diagram of CPU Microprocessor

A digital computer having microprocessor as the CPU along with I/O devices and memory is known as microcomputer. The block diagram in the Fig. 1.2 shows a microcomputer.

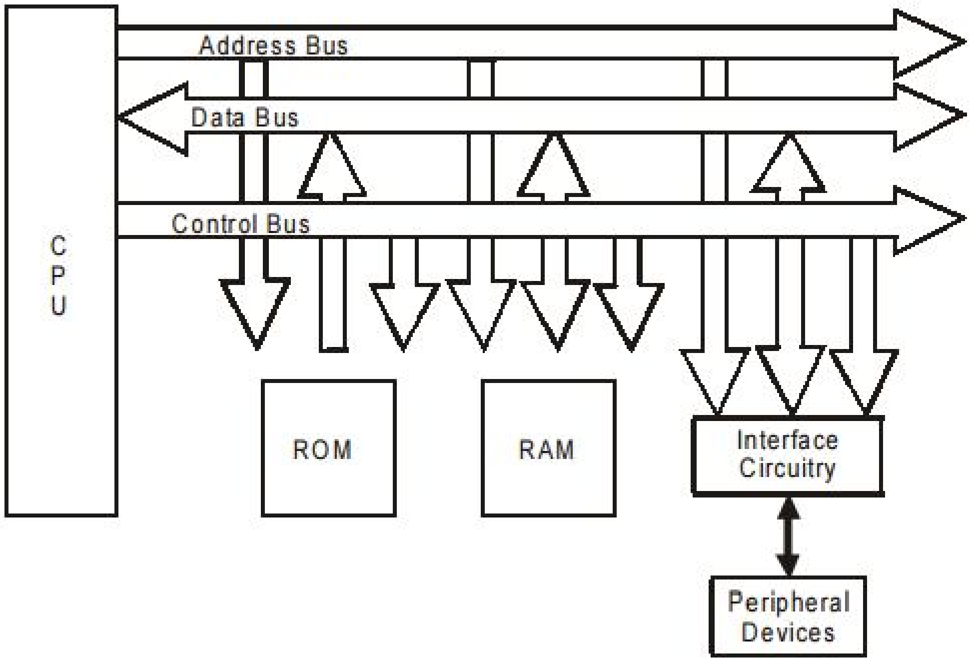


Figure: 3.2 Microcomputer block diagram

A microcontroller is a highly integrated chip, which includes on single chip, all or most of the parts needed for a controller. The microcontroller typically includes: CPU (Central Processing Unit), RAM (Random Access Memory), EPROM/PROM/ROM (Erasable Programmable Read Only Memory), I/O (input/output) – serial and parallel, timers, interrupt controller. For example, Intel 8051 is 8-bit microcontroller and Intel 8096 is 16-bit microcontroller.

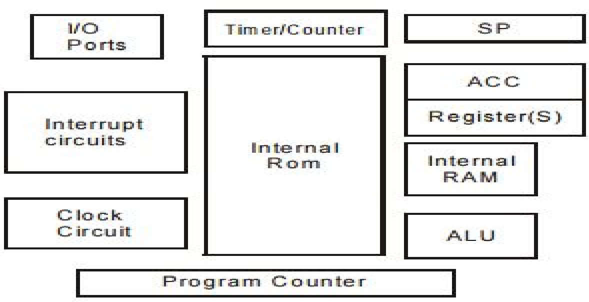


Figure: 1.3 block diagram of a microcontroller

By only including the features specific to the task (control), cost is relatively low. A typical microcontroller has bit manipulation instructions, easy and direct access to I/O (input/output), and quick and efficient interrupt processing. Figure 1.3 shows the block diagram of a typical microcontroller.

3.4Comparing Microprocessors and Microcontrollers

- Microprocessor is a single chip CPU, microcontroller contains, a CPU and much of the remaining circuitry of a complete microcomputer system in a single chip.
- Microcontroller includes RAM, ROM, serial and parallel interface, timer, interrupt schedule circuitry (in addition to CPU) in a single chip.
- Microprocessors are most commonly used as the CPU in microcomputer systems. Microcontrollers are used in small, minimum component designs performing control-oriented activities.
- Microprocessor instruction sets are ‘processing intensive’ implying powerful addressing modes with instructions catering to large volumes of data. Their instructions operate on nibbles, bytes, etc. Microcontrollers have instruction sets catering to the control of inputs and outputs. Their instructions operate also on a single bit. E.g., a motor may be turned ON and OFF by a 1-bit output port.

CHAPTER FOUR

PRACTICAL APPLICATION

CHAPTER FOUR

PRACTICAL APPLICATION

4.1 Introduction

In this project, we learned How to interface a LM35 temperature sensor with AVR ATmega16 microcontroller and 16x2 LCD display. Here, we measured the temperature of the surrounding or any other material to which the LM35 temperature sensor is connected for its temperature measurement and we displayed the temperature value in degree centigrade in 16x2 LCD display. But, the output of LM35 temperature sensor is analogue in nature and microcontroller cannot process the analogue signal directly. So, first it converted the analogue output of LM35 temperature sensor to digital values using its analogue to digital converter and then it processed the digital value to convert the digital value in degree centigrade value. Then the microcontroller displayed the temperature in degree centigrade in the 16x2 LCD display. Finally, we matched stick or lighter near the LM35 temperature sensor and saw the changes in its output value in the 16x2 LCD display.

4.2 Components

The components that used to build the circuit is:

4.2.1 Breadboard

A bread board is used to make up temporary circuits for testing or to try out an idea. No soldering is required, so it is easy to change connections and replace components. Parts will not be damaged in this manner so that they will be available to reuse afterwards. The breadboard has many strips of metal (copper usually) which run underneath the board.

These strips connect the holes on the top of the board. This makes it easy to connect components together to build circuits. To use the bread board, the legs of the components are placed in the holes (the sockets).The holes are made so that they will hold the components in place. Each hole is connected to one of the metal strips running underneath the board. Each wire forms a node. A node is a point in a circuit where two components are connected. Connections between different components are formed by putting their legs in a common node. On the breadboard, a node is the row of holes that are connected by strip of metal underneath. The long top and bottom row of holes are generally used for power supply connections.

Finally, the required components are assembled and soldered in a general purpose printed circuit board and the connections are made accordingly. A power supply of +5V DC for the microcontroller.

4.2.2 Atmega16l

This is the CPU (Central Processing Unit) of the project. It had been used for reading the temperature, hold the monitoring and the controlling program. It receives the analogue voltage signal coming from the sensor. And convert it into digital signal and fed 16*2 LCD display with it.

4.2.3 Lm 35

National semiconductor's lm35 IC has been used for sensing temperature.

It's an integrated circuit sensor that can be used to measure temperature with an electrical output proportional to the temperature (in °C). the temperature can be measured with it more accurately than a thermistor .

the sensor circuitry provides accurately linear and directly proportional output signal in millivolts over the temperature range of 0°C to 155°C.

4.2.4 LCD 16*2 Display

Since the data from the microcontroller needs to be displayed a HD44780 based Liquid Crystal Display – JHD162A is used. The display section consists of 16*2 LCD, which is used to display the temperature.

4.2.5 Diodes

It had been used to sense the negative temperature value

4.2.6 Capacitor

The 100uF electrolytic capacitor is to reduce any variations in power supply voltage.

4.2.7 Resistor

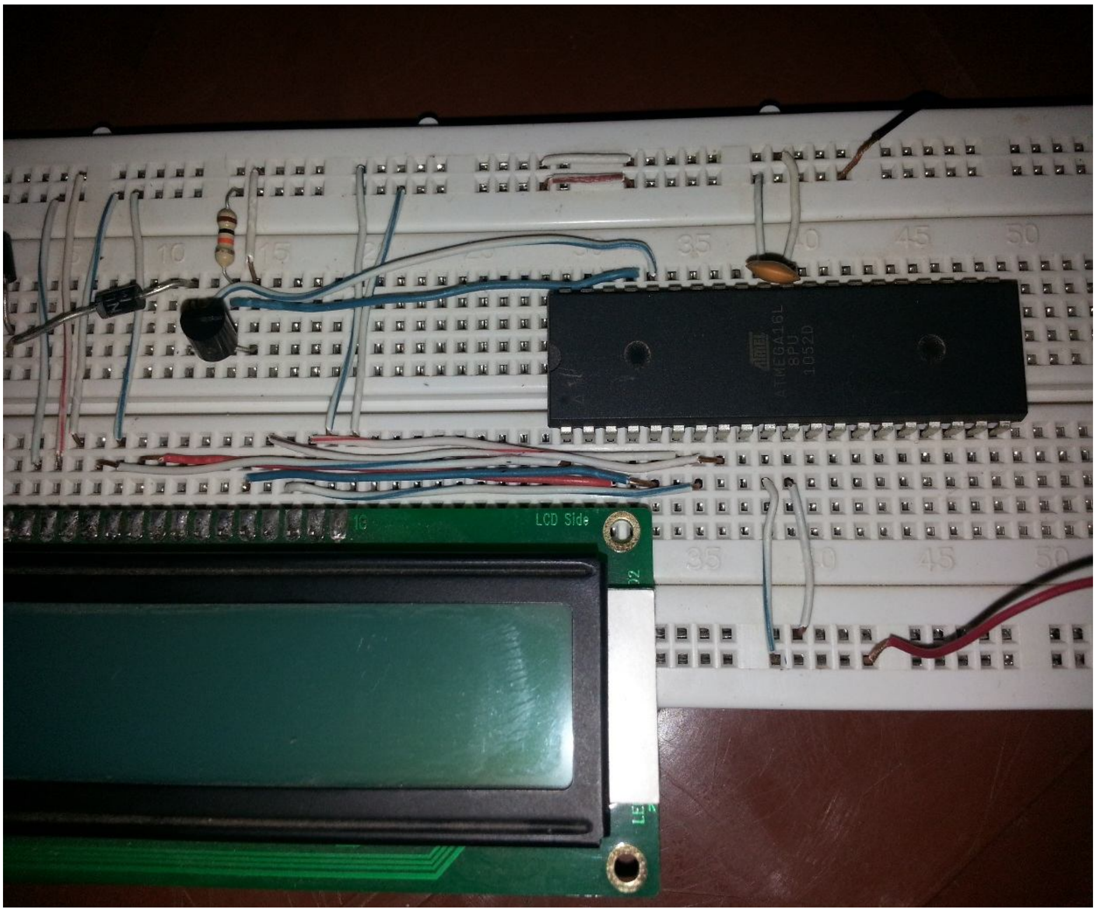
The 10k is a pull-up resistor for the reset pin, a low on this pin will halt the microcontroller and when it is held high the program will run from the beginning.

4.3 Operation

The circuit is based on LM35 analogue temperature sensor and ATMega16l microcontroller. For example, if the temperature is 38°C, the output voltage will be 38 x 10mV = 380mV. ATMega16l has an inbuilt ADC that is used to convert the analogue output voltage of the LM35 to a proportional 10 bit digital value suitable for the microcontroller. The microcontroller accepts the output of ADC, performs necessary manipulations on it and displays it numerically on an LCD display. Output of the LM35 is connected to the analogue input pin (pin 37) of the microcontroller. Data lines are Pins 1, 3, 5, 6, 7 and 8 of the microcontroller which are the digital inputs rs, e, D4, D5, D6 and D7 respectively. These Pins are interfaced with the LCD as- LCD RS pin to digital pin 1, LCD Enable pin to digital pin 3, LCD D4 pin to digital pin 5, LCD D5 pin to digital pin 6, LCD D6 pin to digital pin 7, LCD D7 pin to digital pin 8, LCD R/W pin to ground and 10K resistor

ends to +5V and ground, wiper to LCD Vo pin (pin 3) for contrast adjustment of the LCD. The reset switch is connected to pin 1 of the microcontroller through a 10k resistor. A ceramic capacitor is connected between pins 30 and 31 of the microcontroller.

Figure 4.1: project circuit



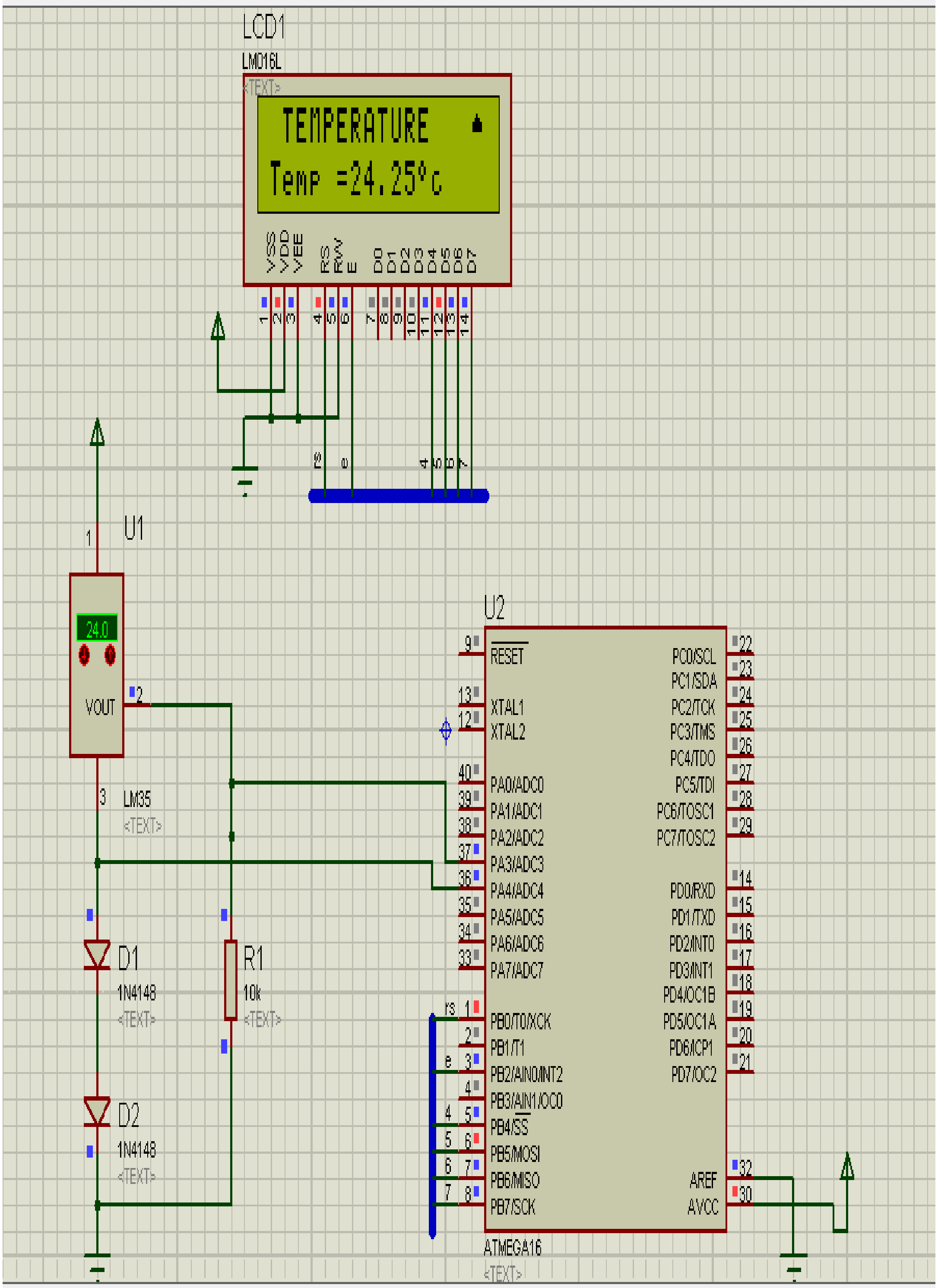
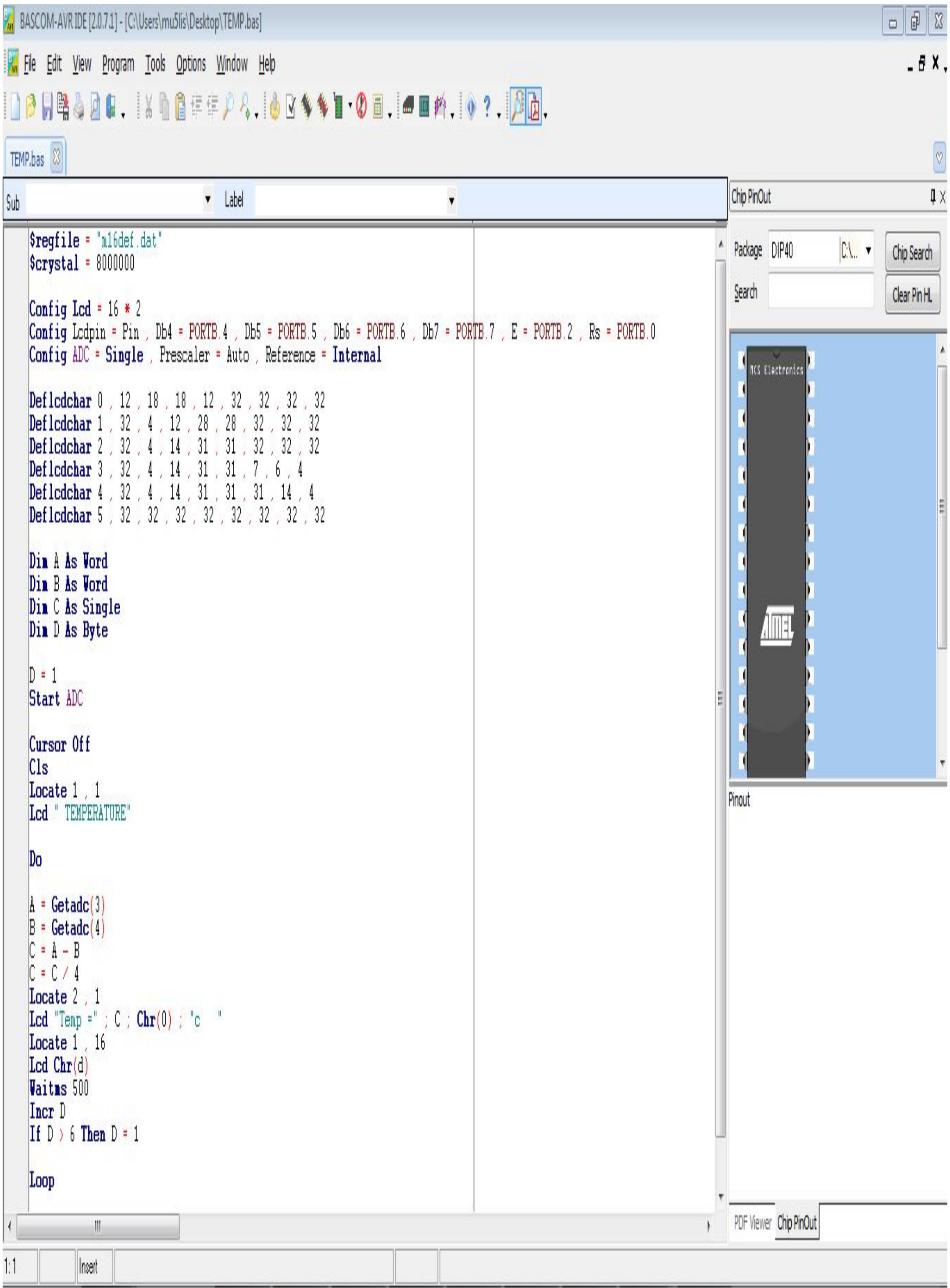


Figure 4.2: circuit diagram

4.4 Code or software

Bascom program has been used to write the following code



```
$regfile = "m16def.dat"

$crystal = 8000000


Config Lcd = 16 * 2

Config Lcdpin = Pin , Db4 = Portb.4 , Db5 = Portb.5 , Db6 = Portb.6 ,
Db7 = Portb.7 , E = Portb.2 , Rs = Portb.0

Config Adc = Single , Prescaler = Auto , Reference = Internal


Deflcdchar 0 , 12 , 18 , 18 , 12 , 32 , 32 , 32 , 32

Deflcdchar 1 , 32 , 4 , 12 , 28 , 28 , 32 , 32 , 32

Deflcdchar 2 , 32 , 4 , 14 , 31 , 31 , 32 , 32 , 32

Deflcdchar 3 , 32 , 4 , 14 , 31 , 31 , 7 , 6 , 4

Deflcdchar 4 , 32 , 4 , 14 , 31 , 31 , 31 , 14 , 4

Deflcdchar 5 , 32 , 32 , 32 , 32 , 32 , 32 , 32 , 32


Dim A As Word

Dim B As Word

Dim C As Single

Dim D As Byte

D = 1

Start Adc
```

```
Cursor Off

Cls

Locate 1 , 1

Lcd " TEMPERATURE"


Do


A = Getadc(3)

B = Getadc(4)

C = A - B

C = C / 4

Locate 2 , 1

Lcd "Temp =" ; C ; Chr(0) ; "c    "

Locate 1 , 16

Lcd Chr(d)

Waitms 500

Incr D

If D > 6 Then D = 1


Loop

End
```

4.5 Results

A step-by-step approach in designing the microcontroller based system for the measurement of temperature is followed. The following results had been obtained:

- The system performance is quite reliable and accurate.
- The sensor doesn't read temperature if the source is far than 20 cm.
- The measured temperature is therefore likely to have error of 0 to ± 0.5°C from the actual value.
- The device response is moderate if suddenly change happen in temperature.

CHAPTER FIVE
CONCLUSION AND RECOMMENDATIONS

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CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Digital temp has been designed using an AVR microcontroller as the main part of the system. To sense the temperature, LM35 sensor was employed. The measured temperature is then converted to digital format by an ADC located internally in the AVR microcontroller and displayed it on the LCD.

Finally the circuit have fast read, high accuracy in measuring and moderate response in the suddenly change in temperature.

5.2 Recommendations

At the end of this research we recommended by:

- The circuit can be enhanced by connecting a GSM Module to the circuit so that in industrial area when a machine crosses the set temperature, we can inform the control room by sending a message, or else a call to control room manager so that damages to the machine can be avoided by disconnecting the equipment with GSM technology.
- Change in the components of the circuit to improve the range of measuring.
- Improve design to reduce the error in measuring

References:

[1] ATmmega16 Data Book. (2001, November 4). Atmega16. Retrieved May 5, 2011, from Atmel.

[2]Introduction to Microcontrollers, February 26, 2007 Version 1.4,Gunther Gridling, Bettina Weiss.

[3]LM35 Data Book. (2000, 11). LM35 Presition Centigrade Temperature Sensors. Retrieved May 5th, 2010, from National Semiconductor.

[4] Datasheets, JHD162A, 16x2 LCD.