IN HOUSE-GREEN HOUSE

Submitted in partial fulfilment of the requirements for the
Degree of
Bachelors in Engineering
(Electronics)

Name	Roll no.	Exam no.
PATEL SAGAR K	1014	
PANDYA HARSH V	1028	

DEPARTMENT OF ELECTRICAL ENGINEERING
FACULTY OF TECHNOLOGY AND ENGINEERING
THE MAHARAJA SAYAJIRAO UNIVERSITY OF BARODA
GUJARAT, INDIA

MARCH 2012

DEPARTMENT OF ELECTRICAL ENGINEERING
FACULTY OF TECHNOLOGY AND ENGINEERING
THE MAHARAJA SAYAJIRAO UNIVERSITY OF BARODA
GUJARAT, INDIA
MARCH 2012

CERTIFICATE

This is to certify that the project report entitled "IN HOUSE-GREEN HOUSE" is submitted by Sagar. K. Patel and Harsh. V. Pandya towards partial fulfilment of the requirements of the Bachelors in Engineering (Electronics). It is the record of work carried out under our supervision and guidance. In our opinion, the submitted work has reached a level required for being accepted for examination. The results embodied in this project work, to the best of our knowledge, have not been submitted to any other university or institution for award of any degree or diploma

GUIDE
Mr, Ankit berawala
Associate Professor
Department of Electrical Engg
Faculty of Tech. and Engg.
The Maharaja Sayajirao University of Baroda

HEAD OF DEPT.
Prof. Satish K Shah
Professor
Department of Electrical Engg.
Faculty of Tech.& Engg.
The Maharaja Sayajirao university of baroda

.

ACKNOWLEDGEMENTS

We are very grateful to our guide Mr. ANKIT BERAWALA who laid the time bound program for the successful completion of this project. He initiated, channeled our thoughts and extended timely suggestions for which we are deeply indebted to him. We are grateful to him for his comments and insights in the preparation of this report.

We express our heartfelt gratitude and thanks to Mrs. SORUM KOTIYA, for her valuable suggestions.

We express our sincere thanks to laboratory in charge and support staff for providing necessary support in the lab.

We sincerely thank, ELECTRICAL ENGINEERING DEPARTMENT staff members of our College, for their valuable support.

We also express our gratitude to the college Management and to all those who have indirectly helped us in the successful completion of my project.

Last but not the least we are deeply indebted to our parents for what we are today, because this project would not have been a reality without their love and support.

Yours Sincerely,

PANDYA HARSH V.
(harshu0999@gmail.com)
PATEL SAGAR
(sagarpatel072@gmail.com)

ABSTRACT

Appropriate environmental conditions are necessary for optimum plant growth, improved crop yields, and efficient use of water and other resources. Automating the data acquisition process of the soil conditions and various climatic parameters that govern plant growth allows information to be collected at high frequency with less labour requirements . The existing systems employ PC or SMS-based systems for keeping the user continuously informed of the conditions inside the greenhouse; but are unaffordable, bulky, difficult to maintain and less accepted by the technologically unskilled workers.

The objective of this project is to design a simple, easy to install, microcontroller-based circuit to monitor and record the values of temperature, soil moisture and sunlight of the natural environment that are continuously modified and controlled in order optimize them to achieve maximum plant growth and yield. The controller used is a low power, cost efficient and easily available. It communicates with the various sensor modules in real-time in order to control the light, aeration and drainage process efficiently inside a greenhouse by actuating a cooler, fogger, dripper and lights respectively according to the necessary condition of the crops. An integrated Liquid crystal display (LCD) is also used for real time display of data acquired from the various sensors and the same data is sent serially to a remote computer where complete data logging takes place. Also, the use of easily available components reduces the manufacturing and maintenance costs. The design is quite flexible as the software can be changed any time. It can thus be tailor-made to the specific requirements of the user.

This makes the proposed system to be an economical, portable and a low maintenance solution for greenhouse applications, especially in rural areas and for small scale agriculturists.

CONTENTS

NAME OF THE CHAPTER **PAGE NO.**

4. SIMULATION AND TESTING

5. RESULTS AND CONCLUSION

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

INTRODUCTION

We live in a world where everything can be controlled and operated automatically, but there are still a few important sectors in our country where automation has not been adopted or not been put to a full-fledged use, perhaps because of several reasons one such reason is cost. One such field is that of agriculture. Agriculture has been one of the primary occupations of man since early civilizations and even today manual interventions in farming are inevitable. Greenhouses form an important part of the agriculture and horticulture sectors in our country as they can be used to grow plants under controlled climatic conditions for optimum produce. Automating a greenhouse envisages monitoring and controlling of the climatic parameters which directly or indirectly govern the plant growth and hence their produce. Automation is process control of industrial machinery and processes, thereby replacing human operators.

1.1 CURRENT SCENARIO

Greenhouses in India are being deployed in the high-altitude regions where the subzero temperature up to -40° C makes any kind of plantation almost impossible and in arid regions where conditions for plant growth are hostile. The existing set-ups primarily are:

1.1.1 MANUAL SET-UP:

This set-up involves visual inspection of the plant growth, manual irrigation of plants, turning ON and OFF the temperature controllers, manual spraying of the fertilizers and pesticides. It is time consuming, vulnerable to human error and hence less accurate and unreliable.

1.1.2 PARTIALLY AUTOMATED SET-UP:

This set-up is a combination of manual supervision and partial automation and is similar to manual set-up in most respects but it reduces the labour involved in terms of irrigating the set-up.

1.1.3 FULLY- AUTOMATED:

This is a sophisticated set-up which is well equipped to react to most of the climatic changes occurring inside the greenhouse. It works on a feedback system which helps it to respond to the external stimuli efficiently. Although this set-up overcomes the problems caused due to human errors it is not completely automated and expensive.

1.2 PROBLEM DEFINITION

A number of problems associated with the above mentioned systems are enumerated as below:

1) Complexity involved in monitoring climatic parameters like humidity, soil moisture, illumination, soil pH, temperature, etc which directly or indirectly govern the plant growth.
2) Investment in the automation process are high, as today’s greenhouse control systems are designed for only one parameter monitoring (as per GKVK research

centre); to control more than one parameter simultaneously there will be a need to buy more than one system.

3) High maintenance and need for skilled technical labour**.** The modern proposed systems use the mobile technology as the communication schemes and wireless data acquisition systems, providing global access to the information about one's farms. But it suffers from various limitations like design complexity, inconvenient repairing and high price. Also the reliability of the system is relatively low, and when there are malfunctions in local devices, all local and tele data will be lost and hence the whole system collapses. More over farmers in India do not work under such sophisticated environment and find no necessity of such an advanced system, and cannot afford the same.

Keeping these issues in view, a microcontroller based monitoring and control system is designed to find implementation in the near future that will help Indian farmers.

1.3 BASIC MODEL OF THE SYSTEM

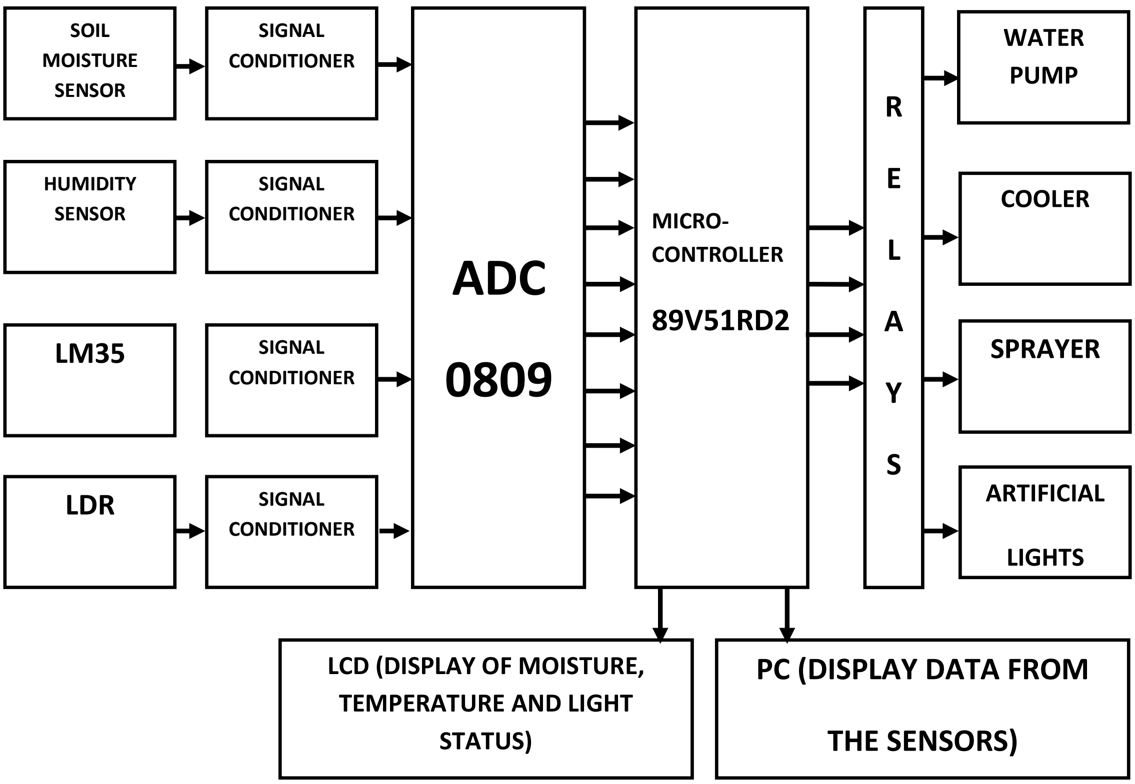


Fig. 1.1 Block diagram of the system

1.3.1 PARTS OF THE SYSTEM:

- Sensors (Data acquisition system)
    1. Temperature sensor (LM35)
    2. Light sensor (LDR)
    3. Moisture sensor
- Analog to Digital Converter (ADC 0809)
- Microcontroller (P89V51RD2)
- Liquid Crystal Display

- Remote computer
- Actuators – Relays
- Devices controlled
    1. Water Pump (simulated as a bulb)
    2. Sprayer (simulated as a bulb)
    3. Cooler (simulated as a fan)
    4. Artificial Lights (simulated as a bulb)

- **TRANSDUCERS (Data acquisition system):**

This part of the system consists of various sensors, namely soil moisture, humidity, temperature and light. These sensors sense various parameters- temperature, humidity, soil moisture and light intensity and are then sent to the Analog to Digital Converter.

- **ANALOG TO DIGITAL CONVERDER (ADC):**

The analog parameters measured by the sensors are then converted to corresponding digital values by the ADC.

- **MICROCONTROLLER:**

The microcontroller is the heart of the proposed embedded system. It constantly monitors the digitized parameters of the various sensors and verifies them with the predefined threshold values and checks if any corrective action is to be taken for the condition at that instant of time. In case such a situation arises, it activates the actuators to perform a controlled operation.

- **ACTUATORS:**

An array of actuators can be used in the system such as relays, contactors, and change over switches etc. They are used to turn on AC devices such as motors, coolers, pumps, fogging machines, sprayers. For the purpose of demonstration relays have been used to drive AC bulbs to simulate actuators and AC devices. A complete working system can be realized by simply replacing these simulation devices by the actual devices.

- **DISPLAY UNIT:**
    1. A Liquid crystal display is used to indicate the present status of parameters locally. The information displayed is continuously updated in REAL-TIME for monitoring any changes in the parameters.
    2. A pc is used for remote display , wherein data is sent serially via micro controller for remote monitoring.

- **DATA LOGGING:**

  Specific software like ELTIMA RS232 LOGGER is preinstalled in the remote pc , which generates data logs for future reference.

CHAPTER 2

THEORETICAL BACKGROUND

2.1 THEORETICAL BACKGROUND

LIFE PROCESSES INSIDE GREENHOUSE

2.1.1 PHOTOSYNTHETIC PROCESS

The two major life-processes occurring in plants are photosynthesis and transpiration. Photosynthesis is the conversion of light energy into chemical energy by living organisms. The raw materials are carbon dioxide and water; the energy source is sunlight; and the end products are oxygen and (energy rich) carbohydrates, for example sucrose, glucose and starch. This process is arguably the most important biochemical pathway, since nearly all life on Earth either directly or indirectly depends on it.

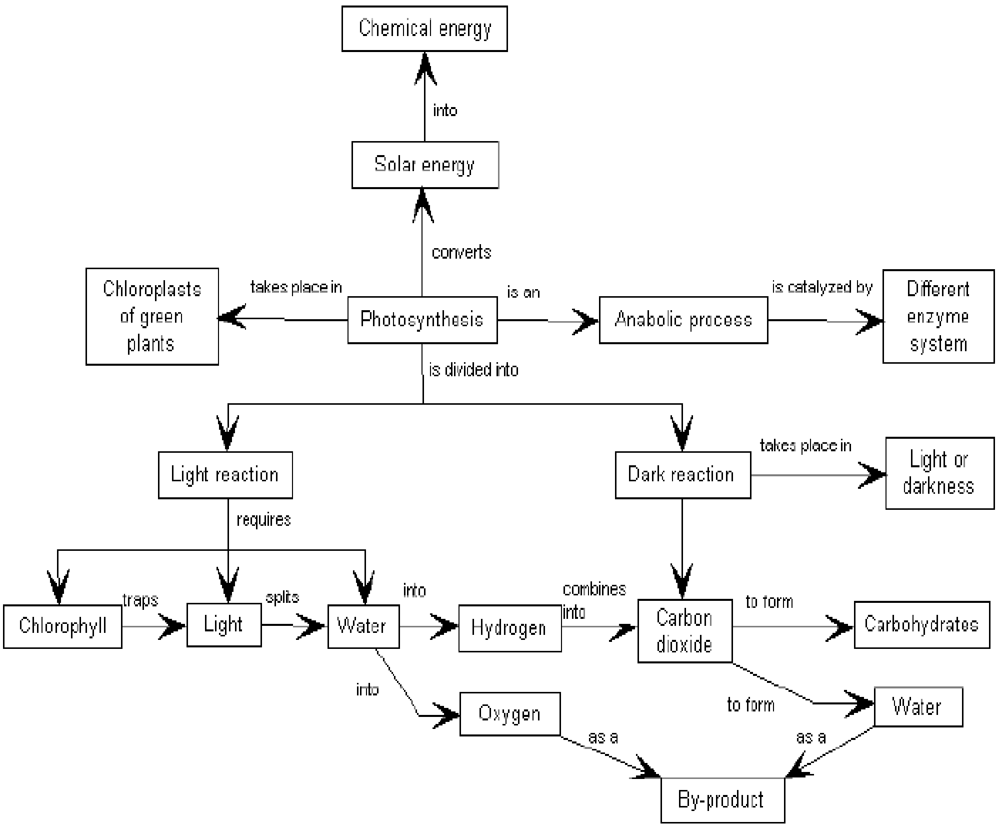


Fig 2.1 Block diagram of photosynthesis

A commonly used but slightly simplified equation for photosynthesis is:

$6\ CO_2(g) + 12\ H_2O(l) + \text{photons} \rightarrow C_6H_{12}O_6(aq.) + 6\ O_2(g) + 6\ H_2O(l)$

Carbon dioxide + water + light energy → glucose + oxygen + water Light energy obtained from the sun is very essential for photosynthesis. The photons present in light are responsible for triggering the light-reaction in plants. Plants need an optimum amount of exposure to light in a day. This optimum period is called its photoperiod. The plant sensitivity curve for photosynthesis has its peak at the red side of the spectrum. This indicates that providing plants with the wavelengths best suited to photosynthesis is most efficient with the use of artificial light. Tests show a mean deviation from the average sensitivity curve of less than 5% for a wide variety of plants. The curve shows that the maximum sensitivity for photosynthesis lies in the far red at approximately 675 nm. The plant sensitivity curve disputes two common misconceptions. The first is that an "ideal" plant growing lamp duplicates the spectral energy distribution of the sun. Sunlight has a continual spectrum, radiating energy in wavelengths that contribute less to photosynthesis, and are therefore "wasted" on the plant. For this reason, many lamps are more efficient than sunlight for plants. Plants need dark periods. Periods of light (called photo-periods) and dark periods and their relative lengths have an effect on plant maturity. The dark period of each day affects flowering and seeding of most plants. Although many plants can grow under continuous light, nearly all plants prefer a dark period each day for normal growth. All plants need some darkness to grow well or to trigger flowering. The ideal photoperiods of plants vary, some preferring long days and short nights; others the reverse; and some do best when the length of the night and day periods are equal.

2.1.2 TRANSPIRATION

Transpiration is the evaporation of water from the aerial parts of plants, especially leaves but also stems, flowers and roots Transpiration also cools plants and enables mass flow of mineral nutrients and water from roots to shoots. Mass flow is caused by the decrease in hydrostatic (water) pressure in the upper parts of the plants due to the diffusion of water out of stomata into the atmosphere. Water is absorbed at the roots by osmosis, and any dissolved mineral nutrients travel with it through the xylem.

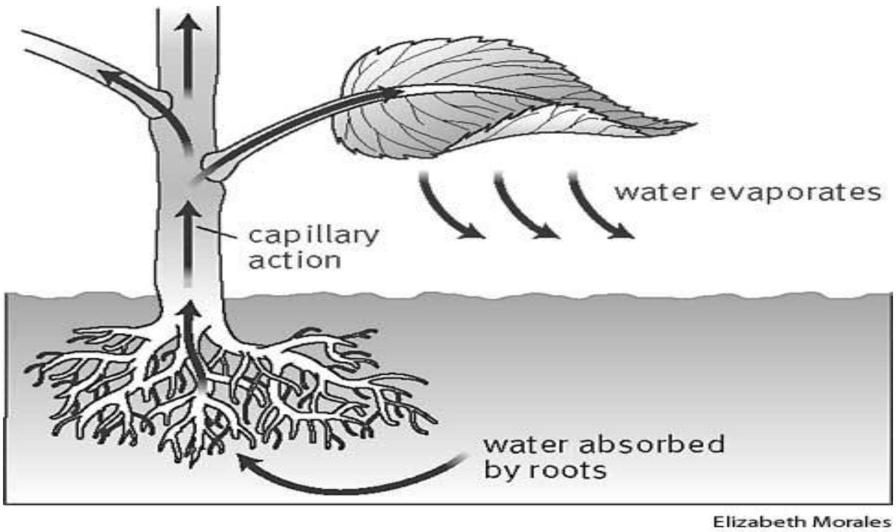


Fig 2.2 Transpiration

The rate of transpiration is directly related to the degree of stomatal opening, and to the evaporative demand of the atmosphere surrounding the leaf. The amount of water lost by a plant depends on its size, along with the surrounding light intensity, temperature, humidity, and wind speed (all of which influence evaporative demand). Soil water supply and soil temperature can influence stomatal opening, and thus the transpiration rate. The moisture content in the soil is a very crucial factor in the process of transpiration as the absorption of mineral salts from the soil through the process of osmosis is directly dependent on the moisture content in the soil**.** The greenhouse works best when the temperature is not too hot and not too cold. Though it sounds simple in the spring and autumn we can easily have a wide range of temperatures from the cold in the middle of the night to the excessive heat of the day when the sun is shining. During the day the rays from the sun penetrate the greenhouse and warm up and light up the surroundings. Light escapes through the glass walls but the heat in form of infra-red radiations gets trapped inside the green house leading to an incubating effect and the temperature inside gradually increases. This increased temperature leads to an increase in the rate of transpiration which is harmful to the plants.

2.2 WORKING MODEL AND WORKING PRINCIPLE

The proposed system is an embedded system which will closely monitor and control the climatic parameters of a greenhouse on a regular basis round the clock for cultivation of crops or specific plant species which could maximize their production over the whole crop growth season and to eliminate the difficulties involved in the system by reducing human intervention to the best possible extent. The system comprises of sensors, Analog to Digital Converter, microcontroller and actuators.

When any of the above mentioned climatic parameters cross a safety threshold which has to be maintained to protect the crops, the sensors sense the change and the microcontroller reads this from the data at its input ports after being converted to a digital form by the ADC. The microcontroller then performs the needed actions by employing relays until the strayed-out parameter has been brought back to its optimum level. Since a microcontroller is used as the heart of the system, it makes the set-up low-cost and effective nevertheless. As the system also employs an LCD display and data logging for continuously alerting the user about the condition inside the greenhouse, the entire set-up becomes user friendly. Thus, this system eliminates the drawbacks of the existing set-ups mentioned in the previous section and is designed as an easy to maintain, flexible and low cost solution.

CHAPTER 3

FUNCTIONAL DESCRIPTION

3.1 HARDWARE DESCRIPTION

3.1.1 TRANSDUCERS:

A transducer is a device which measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument. Monitoring and controlling of a greenhouse environment involves sensing the changes occurring inside it which can influence the rate of growth in plants. The parameters which are of importance are the temperature inside the greenhouse which affect the photosynthetic and transpiration processes are humidity, moisture content in the soil, the illumination etc. Since all these parameters are interlinked, a closed loop (feedback) control system is employed in monitoring it. The sensors used in this system are:

1. Soil Moisture Sensor(Transistor amplifier)
2. Light Sensor (LDR (Light Dependent Resistor))
3. Temperature Sensor (LM35)

3.1.1.1 SOIL MOISTURE SENSOR

3.1.1.1.1 Features of the Soil moisture sensor:

1. The circuit designed uses a 5V supply, fixed resistance of 100Ω, variable resistance of 10KΩ, two copper leads as the sensor probes, 2N222N transistor.
2. It gives a voltage output corresponding to the conductivity of the soil.
3. The conductivity of soil depends upon the amount of moisture present in it. It increases with increase in the water content of the soil.
4. The voltage output is taken at the transmitter which is connected to a variable resistance. This variable resistance is used to adjust the sensitivity of the sensor.

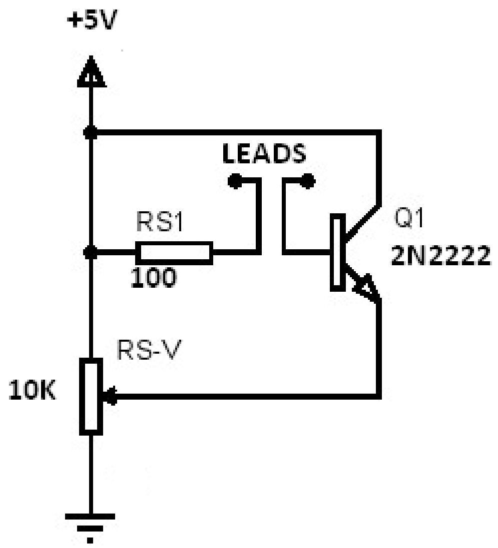


Fig. 3.1 Soil moisture sensor

3.1.1.1.2 Functional description of Soil moisture sensor:

The two copper leads act as the sensor probes. They are immersed into the specimen soil whose moisture content is under test. The soil is examined under three conditions:

Case#1: Dry condition- The probes are placed in the soil under dry conditions and are inserted up to a fair depth of the soil. As there is no conduction path between the two copper leads the sensor circuit remains open. The voltage output of the emitter in this case ranges from 0 to 0.5V.

Case#2: Optimum condition- When water is added to the soil, it percolates through the successive layers of it and spreads across the layers of soil due to capillary force. This water increases the moisture content of the soil. This leads to an increase in its conductivity which forms a conductive path between the two sensor probes leading to a close path for the current flowing from the supply to the transistor through the sensor probes. The voltage output of the circuit taken at the emitter of the transistor in the optimum case ranges from 1.9 to 3.4V approximately.

Case#3: Excess water condition- With the increase in water content beyond the optimum level, the conductivity of the soil increases drastically and a steady conduction path is established between the two sensor leads and the voltage output from the sensor increases no further beyond a certain limit. The maximum possible value for it is not more than 4.2V.

3.1.2 LIGHT SENSOR

Light Dependent Resistor (LDR) also known as photoconductor or photocell, is a device which has a resistance which varies according to the amount of light falling on its surface. Since LDR is extremely sensitive in visible light range, it is well suited for the proposed application.

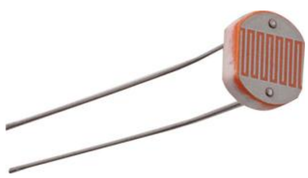


Fig. 3.2 Light Dependent Resistor

3.1.1.2.1 Features of the light sensor:

- The Light Dependent Resistor (LDR) is made using the semiconductor Cadmium Sulphide (CdS).
- The light falling on the brown zigzag lines on the sensor causes the resistance of the device to fall. This is known as a negative co-efficient. There are some LDRs that work in the opposite way i.e. their resistance increases with light (called positive coefficient).
- The resistance of the LDR decreases as the intensity of the light falling on it increases. Incident photons drive electrons from the valence band into the conduction band.

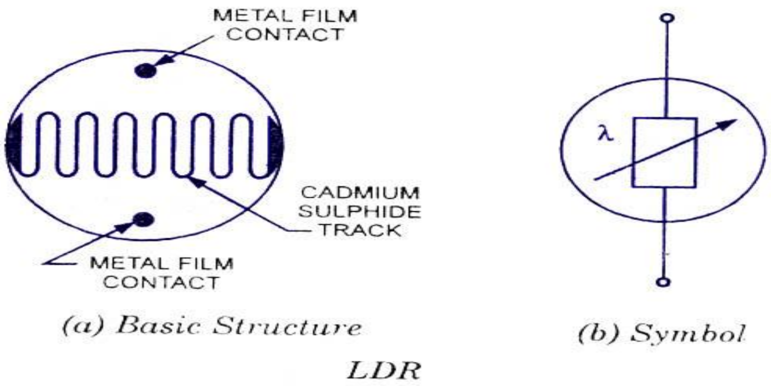


Fig. 3.3 Structure of a Light Dependent Resistor, showing Cadmium Sulphide track and an atom to illustrate electrons in the valence and conduction bands

3.1.1.2.2 Functional description

- An LDR and a normal resistor are wired in series across a voltage, as shown in the circuit below. Depending on which is tied to the 5V and which to 0V, the voltage at the point between them, call it the sensor node, will either rise or fall with increasing light. If the LDR is the component tied directly to the 5V, the sensor node will increase in voltage with increasing light
- The LDR's resistance can reach 10 k ohms in dark conditions and about 100 ohms in full brightness.
- The circuit used for sensing light in our system uses a 10 kΩ fixed resistor which is tied to +5V. Hence the voltage value in this case decreases with increase in light intensity.

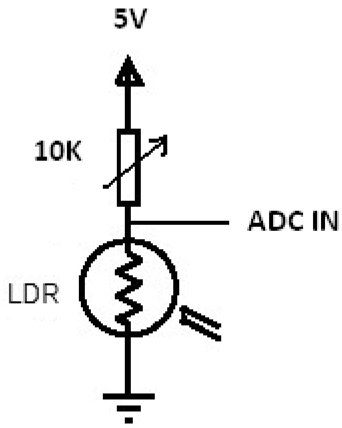


Fig. 3.4 Light sensor circuit

- The sensor node voltage is compared with the threshold voltages for different levels of light intensity corresponding to the four conditions- Optimum, dim, dark and night.
- The relationship between the resistance **RL** and light intensity **Lux** for a typical LDR is:

RL = 500 / **Lux** kΩ

- With the LDR connected to 5V through a 10K resistor, the output voltage of the LDR is :

$$Vo = 5*RL / (RL+10)$$

- In order to increase the sensitivity of the sensor we must reduce the value of the fixed resistor in series with the sensor. This may be done by putting other resistors in parallel with it.

3.1.1.3 TEMPERATURE SENSOR

National Semiconductor's LM35 IC has been used for sensing the temperature. It is an integrated circuit sensor that can be used to measure temperature with an electrical output proportional to the temperature (in **o**C). The temperature can be measured more accurately with it than using a thermistor. The sensor circuitry is sealed and not subject to oxidation, etc.

Fig. 3.5 LM35 temperature sensor

3.1.1.3.1 Features:

• Calibrated directly in ° Celsius (Centigrade)
• Linear + 10.0 mV/°C scale factor
• 0.5°C accuracy guaranteed (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

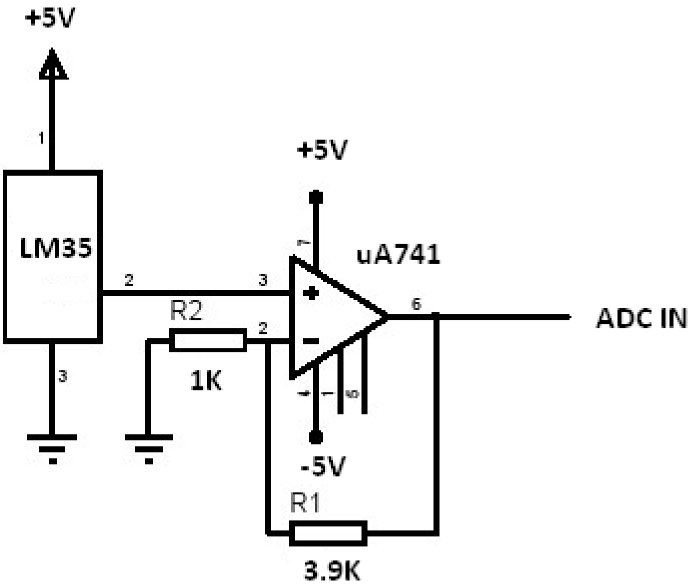


Fig. 3.6 Temperature sensor circuit

3.1.1.3.2 Functional description:

- The sensor has a sensitivity of 10mV / ˚C.
- The output of LM35 is amplified using a LM324 single power supply (+5V) op-amp.
- The op-amp is designed to have a gain of 5.
- The circuitry measures temperatures with a resolution of up to 0.5 degree Celsius.
- The output voltage is converted to temperature by a simple conversion factor. The general equation used to convert output voltage to temperature is:

Temperature (˚C) = (Vout * 100) / 5 ˚C
So if Vout is 5V, then, Temperature = 100 ˚C

- The output voltage varies linearly with temperature.

3.1.2 ANALOG TO DIGITAL CONVERTER (ADC 0809)

In physical world parameters such as temperature, pressure, humidity, and velocity are analog signals. A physical quantity is converted into electrical signals. We need an analog to digital converter (ADC), which is an electronic circuit that converts continuous signals into discrete form so that the microcontroller can read the data. Analog to digital converters are the most widely used devices for data acquisition.

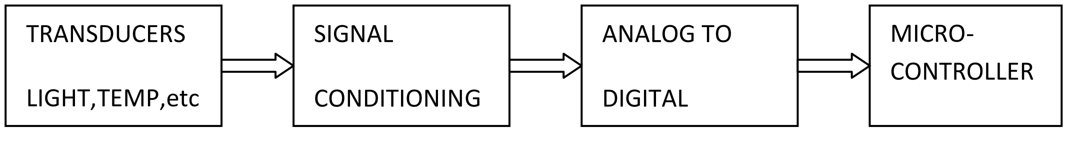


Fig. 3.7 Getting data from the analog world

3.1.2.1 DESCRIPTION

The ADC0809 data acquisition component is a monolithic CMOS device with an 8- bit analog-to-digital converter, 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 8-channel multiplexer can directly access any of 8-single-ended analog signals. The design of the ADC0809 has been optimized by incorporating the most desirable aspects of several A/D conversion techniques. The device offers high speed, high accuracy, minimal temperature dependence, excellent long-term accuracy and repeatability, and consumes minimal power. These features make it ideally suited for applications from process and machine control to consumer and automotive applications.

3.1.2.2 FEATURES

1. Easy interface to all microcontrollers.
2. Operates ratiometrically or with 5 VDC or analog span adjusted voltage reference.
3. No zero or full-scale adjust required.
4. 8-channel multiplexer with address logic.
5. 0V to 5V input range with single 5V power supply.
6. Outputs meet TTL voltage level specifications.
7. 28-pin molded chip carrier package**.**

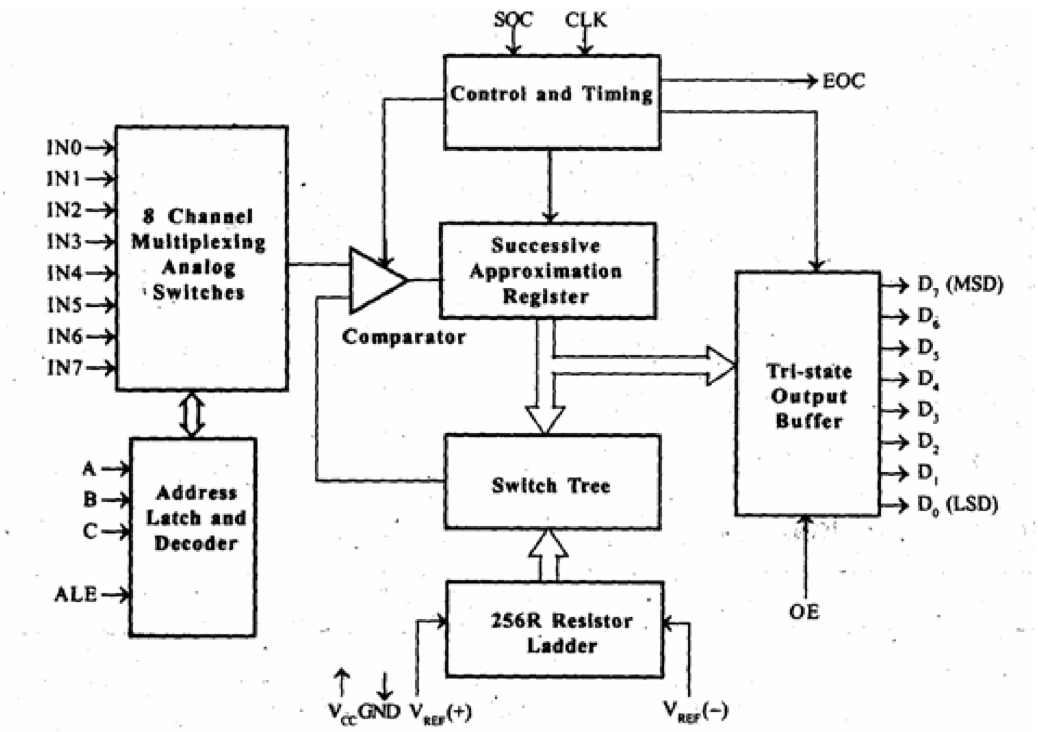


Fig. 3.8 Block diagram of ADC 0809

3.1.2.3 CONVERSION METHOD USED

Following are the most used conversion methods:

1. Digital-Ramp ADC
2. Successive Approximation ADC
3. Flash ADC

Successive approximation ADC is suitable for the proposed application. It is much faster than the digital ramp ADC because it uses digital logic to converge on the value closest to the input voltage. A comparator and a DAC (Digital to Analog Converter) are used in the process. A flowchart explaining the working is shown below.

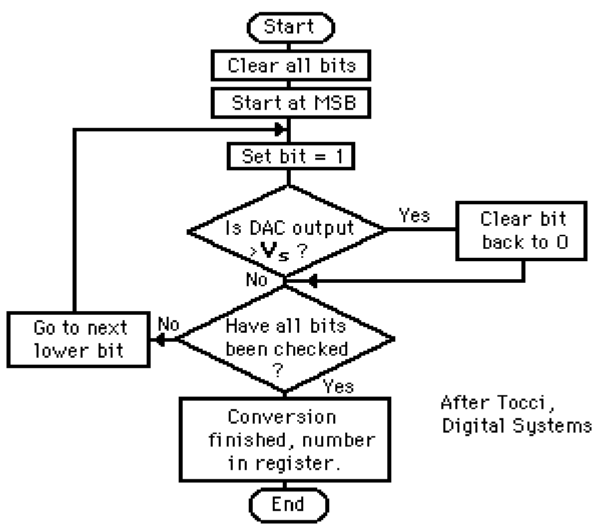


Fig. 3.9 Flowchart explaining the Successive approximation method

3.1.2.4 PIN DIAGRAM OF ADC 0808/0809

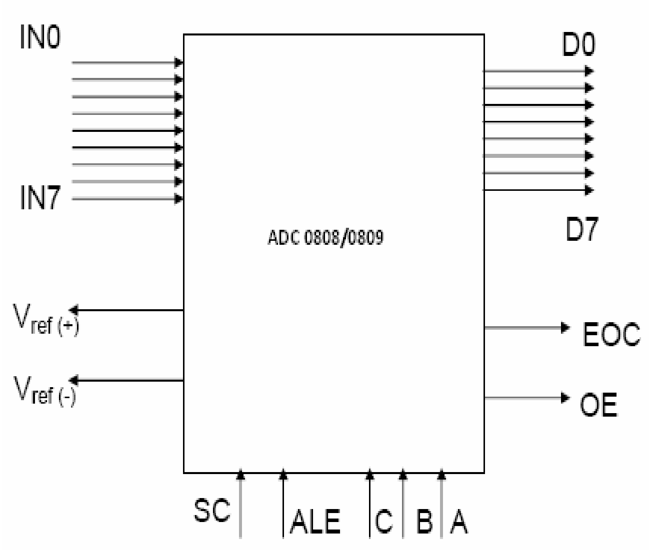


Fig. 3.10 Pin diagram of ADC 0809

We use A, B, C addresses to select IN0-IN7 and activate Address latch enable (ALE) to latch in the address. SC is for Start Conversion. EOC is for End of Conversion and OE is for Output Enable. The output pins D0-D7 provides the digital output from the chip. Vref (-) and Vref (+) are the reference voltages

3.1.2.5 SELECTING AN ANALOG CHANNEL

How to select the channel using three address pins A, B, C is shown in Table below:

SELECTING ANALOG CHANNEL	C	B	A
IN0	0	0	0
IN1	0	0	1
IN2	0	1	0
IN3	0	1	1
IN4	1	0	0
IN5	1	0	1
IN6	1	1	0
IN7	1	1	1

Table 3.1 Selection of the input channels

The ADC 0804 is most widely used chip, but since it has only one analog input, ADC 0809 is chosen as this chip allows the monitoring of up to 8 different transducers using only a single chip. The 8 analog input channels are multiplexed and selected according to the requirement. But for the proposed application only the last 4 channels i.e., IN4, IN5, IN6 and IN7 are used to monitor the four parameters-temperature, humidity, soil moisture and light intensity. Hence the address line

ADD_C is given to Vcc (+ 5V) as it is always high in this case. Vref (+) and Vref (-) set the reference voltages. If Vref (-) =Gnd and Vref (+) =5V, the step size is 5V/256=19.53. Since there is no self clocking in this chip, the clock must be provided from an external source to the Clock (CLK) pin. The 8-bit output from the ADC is given to Port 0 of the microcontroller and the control signals ADD_A, ADD_B, ADD_C, ALE, START, OE, EOC are given to Port 1 as shown in the figure below.

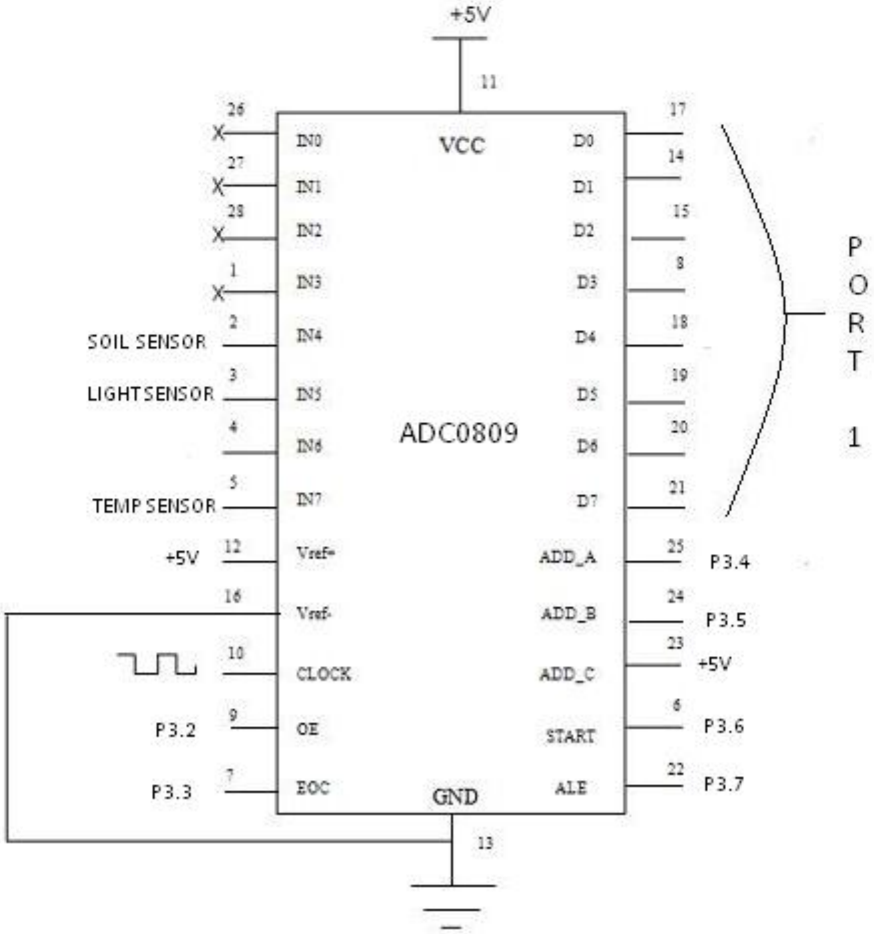


Fig. 3.11 ADC 0809 pin details as used for this application

At a certain point of time, even though there is no conversion in progress the ADC0809 is still internally cycling through 8 clock periods. A start pulse can occur any time during this cycle but the conversion will not actually begin until the converter internally cycles to the beginning of the next 8 clock period sequence. As long as the start pin is held high no conversion begins, but when the start pin is taken low the conversion will start within 8 clock periods. The EOC output is triggered on the rising edge of the start pulse. It, too, is controlled by the 8 clock period cycle, so it will go low within 8 clock periods of the rising edge of the start pulse. One can see that it is entirely possible for EOC to go low before the conversion starts internally, but this is not important, since the positive transition of EOC, which occurs at the end of a conversion, is what the control logic is looking for. Once EOC does go high this signals the interface logic that the data resulting from the conversion is ready to be read. The output enable (OE) is then raised high.

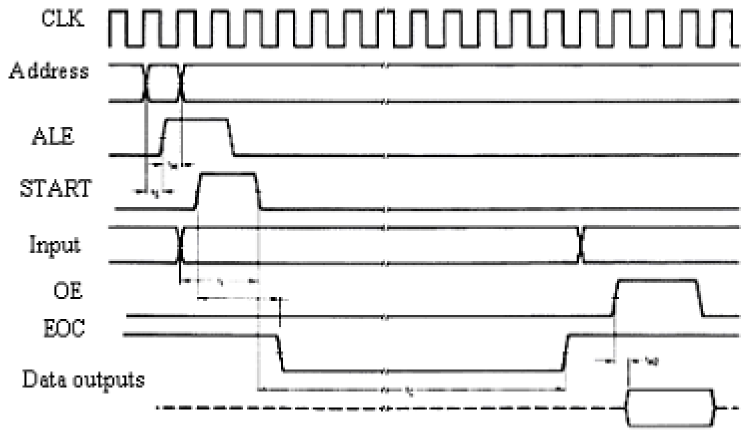


Fig 3.12 Timing diagram of ADC 0809

3.1.2.6 CLOCK CIRCUITRY FOR ADC:

3.1.2.6.1 Functional Description:

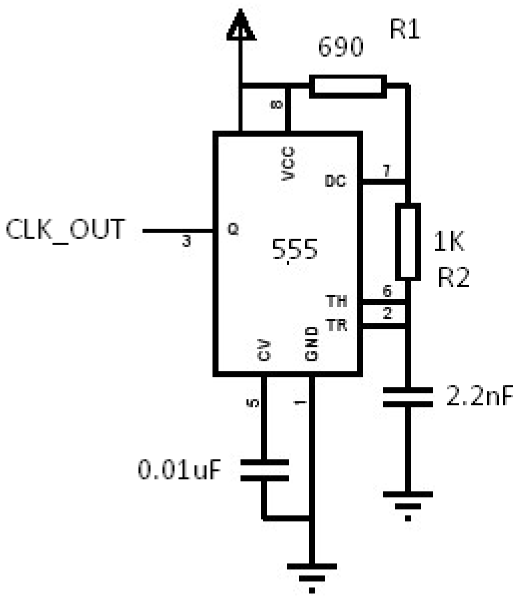


Fig 3.13 Clock circuit of ADC 0809

3.1.3 MICROCONTROLLER (P89V51RD2)

3.1.3.1 CRITERIA FOR CHOOSING A MICROCONTROLLER

The basic criteria for choosing a microcontroller suitable for the application are:

1) The first and foremost criterion is that it must meet the task at hand efficiently and cost effectively. In analyzing the needs of a microcontroller-based project, it is seen whether an 8- bit, 16-bit or 32-bit microcontroller can best handle the computing needs of the task most effectively. Among the other considerations in this category are:

a) **Speed:** The highest speed that the microcontroller supports.

b) **Packaging:** It may be a 40-pin DIP (dual inline package) or a QFP (quad flat package), or some other packaging format. This is important in terms of space, assembling, and prototyping the end product.
c) **Power consumption:** This is especially critical for battery-powered products.
d) The number of I/O pins and the timer on the chip.
e) How easy it is to upgrade to higher –performance or lower consumption versions.
f) **Cost per unit**: This is important in terms of the final cost of the product in which a microcontroller is used.

2) The second criterion in choosing a microcontroller is how easy it is to develop products around it. Key considerations include the availability of an assembler, debugger, compiler, technical support.

3) The third criterion in choosing a microcontroller is its ready availability in needed quantities both now and in the future. Currently of the leading 8-bit microcontrollers, the 8051 family has the largest number of diversified suppliers. By supplier is meant a producer besides the originator of the microcontroller. In the case of the 8051, this has originated by Intel several companies also currently producing the 8051. Thus the microcontroller P89V51RD2, satisfying the criterion necessary for the proposed application is chosen for the task.

3.1.3.2 DESCRIPTION:

The 8051 family of microcontrollers is based on an architecture which is highly optimized for embedded control systems. It is used in a wide variety of applications from military equipment to automobiles to the keyboard. Second only to the Motorola 68HC11 in eight bit processors sales, the 8051 family of microcontrollers is available in a wide array of variations from manufacturers such as Intel, Philips, and Siemens. These manufacturers have added numerous features and peripherals to the 8051 such as I2C interfaces, analog to digital converters, watchdog timers, and pulse width modulated outputs. Variations of the 8051 with clock speeds up to 40MHz and voltage requirements down to 1.5 volts are available. This wide range of parts based on one core makes the 8051 family an excellent choice as the base architecture for a company's entire line of products since it can perform many functions and developers will only have to learn this one platform. The P89V51RD2 is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory. The device is manufactured using PHILIPS's high-density non-volatile memory technology and is compatible with the industry standard 80C51 instruction set and pin out. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional non-volatile memory programmer. By combining a versatile 8-bit CPU with in-system programmable Flash on a monolithic chip, the PHILIPS P89V51RD2 is a powerful microcontroller which provides a highly-flexible and cost effective solution to many embedded control applications. In addition, the P89V51RD2 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port, and interrupt system to continue functioning.

3.1.3.3 FEATURES:

- 80C51 Central Processing Unit
- 5 V Operating voltage from 0 to 40 MHz
- 64 kB of on-chip Flash program memory with ISP (In-System Programming) and IAP (In-Application Programming)
- Supports 12-clock (default) or 6-clock mode selection via software or ISP
- SPI (Serial Peripheral Interface) and enhanced UART
- PCA (Programmable Counter Array) with PWM and Capture/Compare functions
- Four 8-bit I/O ports with three high-current Port 1 pins (16 mA each)
- Three 16-bit timers/counters
- Programmable Watchdog timer (WDT)
- Eight interrupt sources with four priority levels
- Second DPTR register
- Low EMI mode (ALE inhibit)
- TTL- and CMOS-compatible logic levels
- Brown-out detection
- Low power modes
- Power-down mode with external interrupt wake-up
- Idle mode
- PDIP40, PLCC44 and TQFP44 packages

3.1.3.4 PIN CONFIGURATION

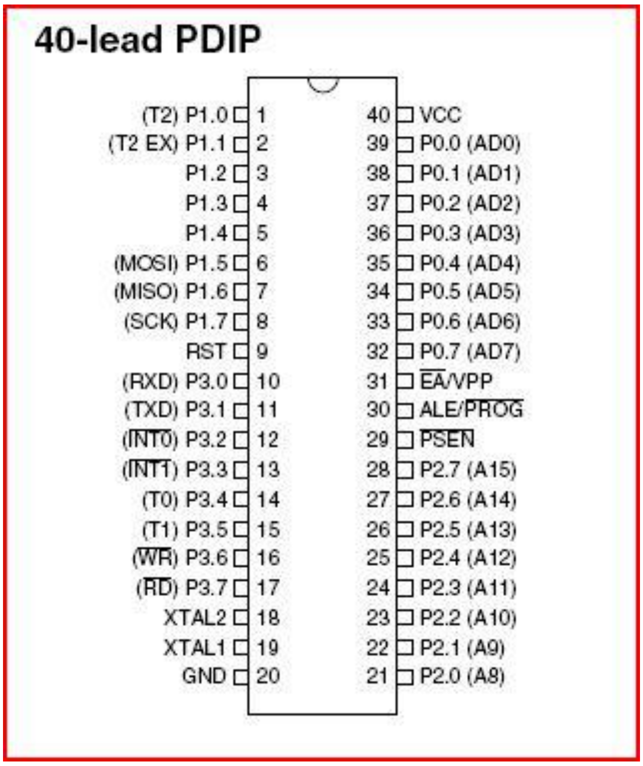


Fig. 3.14 Pin diagram of P89V51RD2

3.1.3.5 BLOCK DIAGRAM

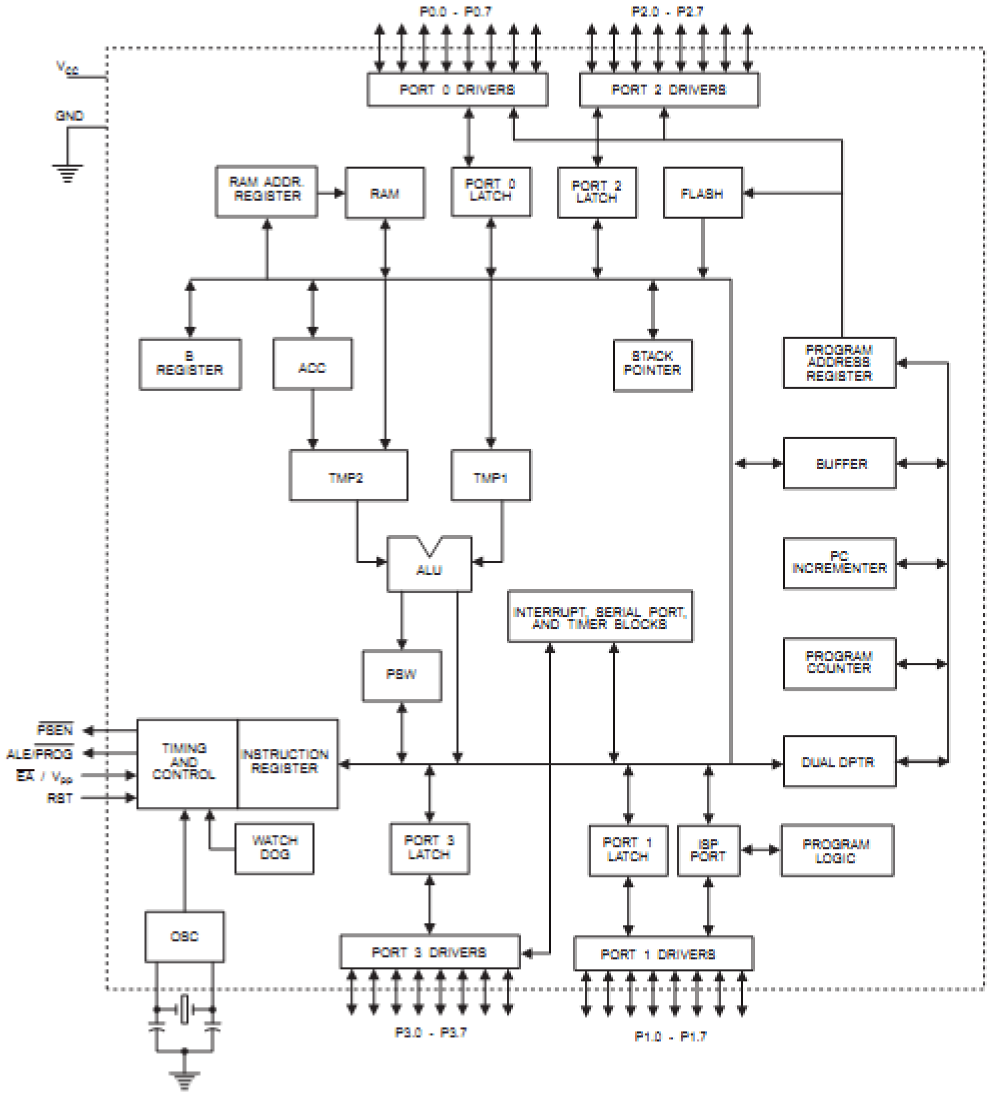


Fig. 3.15 Block diagram of the microcontroller

3.1.3.6 PIN DESCRIPTION

• **VCC:** Supply voltage.

• **GND:** Ground.

• **Port 0:** Port 0 is an 8-bit open drain bidirectional I/O port. As an output port, each pin can sink eight TTL inputs. When 1s are written to port 0 pins, the pins can be used as high-impedance inputs. Port 0 can also be configured to be the multiplexed low-order address/data bus during accesses to external program and data memory. In this mode, P0 has internal pull-ups.

• **Port 1:** Port 1 is an 8-bit bidirectional I/O port with internal pull-ups. The Port 1 output buffers can sink/source four TTL inputs. When 1s are written to Port 1 pins, they are pulled high by the internal pull-ups and can be used as inputs. As inputs, Port 1 pins that are externally being pulled low will source current (IIL) because of the internal pull-ups. In addition, P1.0 and P1.1 can be configured to be the timer/counter 2 external count input (P1.0/T2) and the timer/counter 2 trigger input (P1.1/T2EX), respectively, as shown in the following table.

• **Port 2:** Port 2 is an 8-bit bidirectional I/O port with internal pull-ups. The Port 2 output buffers can sink/source four TTL inputs. When 1s are written to Port 2 pins, they are pulled high by the internal pull-ups and can be used as inputs. As inputs, Port 2 pins that are externally being pulled low will source current (IIL) because of the internal pull-ups. Port 2 emits the high-order address byte during fetches from external program memory and during accesses to external data memory that use 16-bit addresses (MOVX @ DPTR). In this application, Port 2 uses strong internal pull ups when emitting 1s. During accesses to external data memory that uses 8-bit addresses (MOVX @ RI), Port 2 emits the contents of the P2 Special Function register.

• **Port 3:** Port 3 is an 8-bit bidirectional I/O port with internal pull-ups. The Port 3 output buffers can sink/source four TTL inputs. When 1s are written to Port 3 pins, they are pulled high by the internal pull-ups and can be used as inputs. As inputs, Port 3 pins that are externally being pulled low will source current (IIL) because of the pull-ups. Port 3 receives some control signals for Flash programming an verification. Port 3 also serves the functions of various special features of the P89V51RD2, as shown in the following table.

Alternate functions of Port 3:

Port Pin	Alternate Functions
P3.0	RXD (serial input port)
P3.1	TXD (serial output port)
P3.2	$\overline{INT0}$ (external interrupt 0)
P3.3	$\overline{INT1}$ (external interrupt 1)
P3.4	T0 (timer 0 external input)
P3.5	T1 (timer 1 external input)
P3.6	$\overline{WR}$ (external data memory write strobe)
P3.7	$\overline{RD}$ (external data memory read strobe)

Table 3.2 Alternate functions of Port 3

• **RST:** Reset input. A high on this pin for two machine cycles while the oscillator is running resets the device. This pin drives high for 98 oscillator periods after the watchdog times out.

3.1.3.7 Power-On Reset circuit

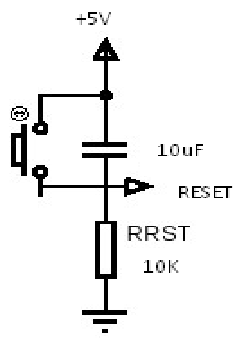


Fig. 3.16 Power-on reset circuit

In order for the RESET input to be effective, it must have a minimum duration of two machine cycles.

• **ALE/PROG:** Address Latch Enable (ALE) is an output pulse for latching the low byte of the address during accesses to external memory. This pin is also the program pulse input (PROG) during Flash programming. In normal operation, ALE is emitted at a constant rate of 1/6 the oscillator frequency and may be used for external timing or clocking purposes. Note, however, that one ALE pulse is skipped during each access to external data memory. If desired, ALE operation can be disabled by setting bit 0 of SFR location 8EH. With the bit set, ALE is active only during a MOVX or MOVC instruction. Otherwise, the pin is weakly pulled high. Setting the ALE-disable bit has no effect if the microcontroller is in external execution mode.

• **PSEN:** Program Store Enable (PSEN) is the read strobe to external program memory. When the P89V51RD2 is executing code from external program memory, PSEN is activated twice each machine cycle, except that two PSEN activations are skipped during each access to external data memory.

• **EA:** External Access Enable. EA must be strapped to GND in order to enable the device to fetch code from external program memory locations starting at 0000H up to FFFFH. Note, however, that if lock bit 1 is programmed, EA will be internally latched on reset. EA should be strapped to VCC for internal program executions. This pin also receives the 12-volt programming enable voltage (VPP) during Flash programming.

• **XTAL1:** Input to the inverting oscillator amplifier and input to the internal clock operating circuit.

• **XTAL2:** Output from the inverting oscillator amplifier.

3.1.3.8 The P89V51RD2 oscillator clock circuit

• It uses a quartz crystal oscillator.

• We can observe the frequency on the XTAL2 pin.

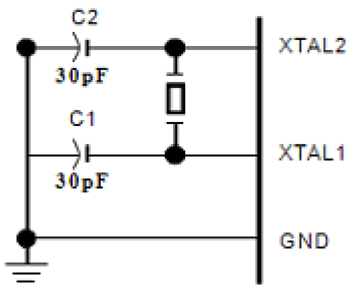


Fig 3.17 The P89V51RD2 oscillator clock circuit

• The crystal frequency is the basic internal frequency of the microcontroller.

• The internal counters must divide the basic clock rate to yield standard communication bit per second (baud) rates.

• An 11.0592 megahertz crystal, although seemingly an odd value, yields a crystal frequency of 921.6 kilohertz, which can be divided evenly by the standard communication baud rates of 19200, 9600, 4800, 2400, 1200, and 300 hertz.

3.1.3.9 SPECIAL FUNCTION REGISTERS

The Special Function Registers (SFRs) contain memory locations that are used for special tasks.

- Each SFR occupies internal RAM from 0x80 to 0xFF.They are 8-bits wide.
- The A (accumulator) register or accumulator is used for most ALU operations and Boolean Bit manipulations.

- Register B is used for multiplication & division and can also be used for general purpose storage.
- PSW (Program Status Word) is a bit addressable register
- PC or program counter is a special 16-bit register. It is not part of SFR. Program instruction bytes are fetched from locations in memory that are addressed by the PC.
- Stack Pointer (SP) register is eight bits wide. It is incremented before data is stored during PUSH and CALL executions. While the stack may reside anywhere in on-chip RAM, the Stack Pointer is initialized to 07H after a reset. This causes the stack to begin at location 08H.
- DPTR or data pointer is a special 16-bit register that is accessible as two 8- bit registers: DPL and DPH, which are used to used to furnish memory addresses for internal and external code access and external data access.
- Control Registers: Special Function Registers IP, IE, TMOD, TCON, SCON, and PCON contain control and status bits for the interrupt system, the
- Timer/Counters, and the serial port.
- Timer Registers: Register pairs (TH0, TL0) and (TH1, TL1) are the 16-bit
- Counter registers for Timer/Counters 0 and 1, respectively.

3.1.3.10 MEMORY ORGANIZATION

MCS-51 devices have a separate address space for Program and Data Memory. Up to 64K bytes each of external Program and Data Memory can be addressed.

- **Program Memory:** If the EA pin is connected to GND, all program fetches are directed to external memory. On the P89V51RD2, if EA is connected to VCC, program fetches to addresses 0000H through 1FFFH are directed to internal memory and fetches to addresses 2000H through FFFFH are to external memory.
- **Data Memory:** The P89V51RD2 implements 256 bytes of on-chip RAM. The upper 128 bytes occupy a parallel address space to the Special Function Registers. This means that the upper 128 bytes have the same addresses as the SFR space but are physically separate from SFR space. When an instruction accesses an internal location above address 7FH, the address mode used in the instruction specifies whether the CPU accesses the upper 128 bytes of RAM or the SFR space. Instructions which use direct addressing access the SFR space. The lower 128 bytes of RAM can be divided into three segments:

1. Register Banks 0-3: locations 00H through 1FH (32 bytes). The device after reset defaults software. Each register bank contains eight 1-byte registers R0-R7. Reset initializes the stack point to location 07H, and is incremented once to start from 08H, which is the first register of the second register bank.

2. Bit Addressable Area: 16 bytes have been assigned for this segment 20H-2FH. Each one of the 128 bits of this segment can be directly addressed (0-7FH). Each of the 16 bytes in this segment can also be addressed as a byte.

3. Scratch Pad Area: 30H-7FH are available to the user as data RAM. However, if the data pointer has been initialized to this area, enough bytes should be left aside to prevent SP data destruction.

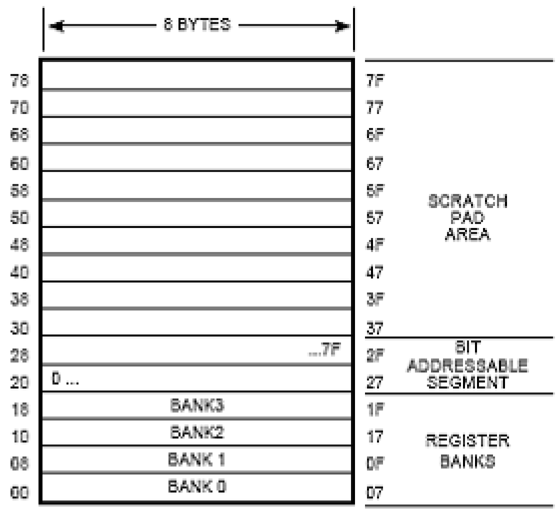


Fig. 3.18 Internal memory block

3.1.3.11 WATCHDOG TIMER (One-time Enabled with Reset-out)

The WDT is intended as a recovery method in situations where the CPU may be subjected to software upsets. The WDT consists of a 14-bit counter and the Watchdog Timer Reset (WDTRST) SFR. The WDT is defaulted to disable from exiting reset. To enable the WDT, a user must write 01EH and 0E1H in sequence to the WDTRST register (SFR location 0A6H). When the WDT is enabled, it will increment every machine cycle while the oscillator is running. The WDT timeout period is dependent on the external clock frequency. There is no way to disable the WDT except through reset (either hardware reset or WDT overflow reset). When WDT over-flows, it will drive an output RESET HIGH pulse at the RST pin.

3.1.3.12 TIMERS AND COUNTERS

Many microcontroller applications require the counting of external events such as the frequency of a pulse train, or the generation of precise internal time delays between computer actions. Both of these tasks can be accomplished using software techniques, but software loops for counting or timing keep the processor occupied so that, other perhaps more important, functions are not done. Hence the better option is to use interrupts & the two 16-bit count-up timers. The microcontroller can be programmed for either of the following:

1. Count internal - acting as timer
2. Count external - acting as counter

All counter action is controlled by the TMOD (Timer Mode) and the TCON

(Timer/Counter Control) registers. TCON Timer control SFR contains timer 1& 2 overflow flags, external interrupt flags, timer control bits, falling edge/low level selector bit etc. TMOD timer mode SFR comprises two four-bit registers (timer-1, timer-0) used to specify the timer/counter mode and operation. The timer may operate in any one of four modes that are determined by modes bits M1 and M0 in the TMOD register:

TIMER MODE-0: Setting timer mode bits to 00b in the TMOD register results in using the TH register as an 8-bit counter and TL as a 5-bit counter. Therefore mode0 is a 13-bit counter.

TIMER MODE-1: Mode-1 is similar to mode-0 except TL is configured as a full 8-bit counter when the mode bits are set to 01b in TMOD.

TIMER MODE-2: Setting the mode bits to 10b in TMOD configures the timer to use only the TL counter as an 8-bit counter. TH is used to hold a value that is loaded into TL every time TL overflows from FFh to 00h. The timer flag is also set when TL overflows.

TIMER MODE-3: In mode-3, timer-1 simply hold its count, where as timer 0 registers TL0 and TH0 are used as two separate 8-bit counters. TL0 uses the Timer-0 control bits. TH0 counts machine cycles and takes over the use of TR1 and TF1 from Timer-1.

3.1.3.13 INTERRUPTS

A computer has only two ways to determine the conditions that exist in internal and external circuits. One method uses software instructions that jump to subroutines on the states of flags and port pins. The second method responds to hardware signals, called interrupts that force the program to call a subroutine. The P89V51RD2 has a total of six interrupt vectors: two external interrupts (INT0 and INT1), three timer interrupts (Timers 0, 1, and 2), and the serial port interrupt. Each of these interrupt sources can be individually enabled or disabled by setting or clearing a bit in Special Function Register IE. IE also contains a global disable bit, EA, which disables all interrupts at once. Each interrupt forces the processor to jump at the interrupt location in the memory. The interrupted program must resume operation at the instruction where the interrupt took place. Program resumption is done by storing the interrupted PC address on to stack. RETI instruction at the end of ISR will restore the PC address.

3.1.3.14 MICROCONTROLLER CONFIGURATION USED IN THE SET-UP

The microcontroller is interfaced with the ADC in polling mode.

Port details:

- Port 0: Interfaced with the LCD data lines.
- Port 1: Interfaced with the ADC data lines
- Port 2: Interfaced with the LCD Control lines and AC Interface control
- Port 3: Interfaced with the ADC control lines

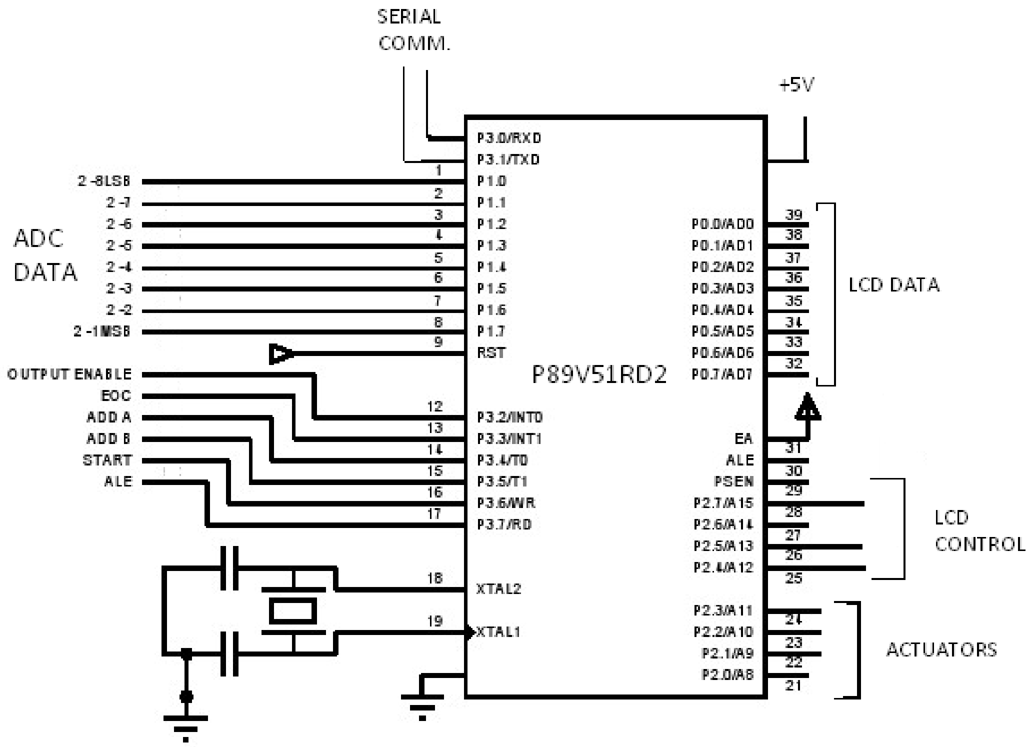


Fig. 3.19 Microcontroller pin details

3.1.4 LIQUID CRYSTAL DISPLAY

A liquid crystal display (LCD) is a thin, flat display device made up of any number of color or monochrome pixels arrayed in front of a light source or reflector. Each pixel consists of a column of liquid crystal molecules suspended between two transparent electrodes, and two polarizing filters, the axes of polarity of which are perpendicular to each other. Without the liquid crystals between them, light passing through one would be blocked by the other. The liquid crystal twists the polarization of light entering one filter to allow it to pass through the other. Many microcontroller devices use 'smart LCD' displays to output visual information. LCD displays designed around Hitachi's LCD HD44780 module, are inexpensive, easy to use, and it is even possible to produce a readout using the 8x80 pixels of the display. They have a standard ASCII set of characters and mathematical symbols. For an 8-bit data bus, the display requires a +5V supply plus 11 I/O lines. For a 4-bit data bus it only requires the supply lines plus seven extra lines. When the LCD display is not enabled, data lines are tri-state and they do not interfere with the operation of the microcontroller. Data can be placed at any location on the LCD. For 16×2 LCD, the address locations are:

First line	**80**	**81**	**82**	**83**	**84**	**85**	**86**	**through**	**8F**
Second line	**C0**	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**through**	**CF**

Fig 3.20 Address locations for a 2x16 line LCD

3.1.4.1 SIGNALS TO THE LCD

The LCD also requires 3 control lines from the microcontroller:

1) Enable (E)

This line allows access to the display through R/W and RS lines. When this line is low, the LCD is disabled and ignores signals from R/W and RS. When (E) line is high, the LCD checks the state of the two control lines and responds accordingly.

2) Read/Write (R/W)

This line determines the direction of data between the LCD and microcontroller.

When it is low, data is written to the LCD. When it is high, data is read from the LCD.

3) Register Select (RS)

With the help of this line, the LCD interprets the type of data on data lines. When it is low, an instruction is being written to the LCD. When it is high, a character is being written to the LCD.

3.1.4.2 Logic status on control lines:

- E - 0 Access to LCD disabled
  - 1 Access to LCD enabled
- R/W - 0 Writing data to LCD
  - 1 Reading data from LCD
- RS - 0 Instructions
  - 1 Character

3.1.4.3 Writing and reading the data from the LCD:

Writing data to the LCD is done in several steps:

1) Set R/W bit to low
2) Set RS bit to logic 0 or 1 (instruction or character)
3) Set data to data lines (if it is writing)
4) Set E line to high
5) Set E line to low

Read data from data lines (if it is reading):

1) Set R/W bit to high
2) Set RS bit to logic 0 or 1 (instruction or character)
3) Set data to data lines (if it is writing)
4) Set E line to high
5) Set E line to low

3.1.4.4 PIN DESCRIPTION

Most LCDs with 1 controller has 14 Pins and LCDs with 2 controller has 16 Pins (two pins are extra in both for back-light LED connections).

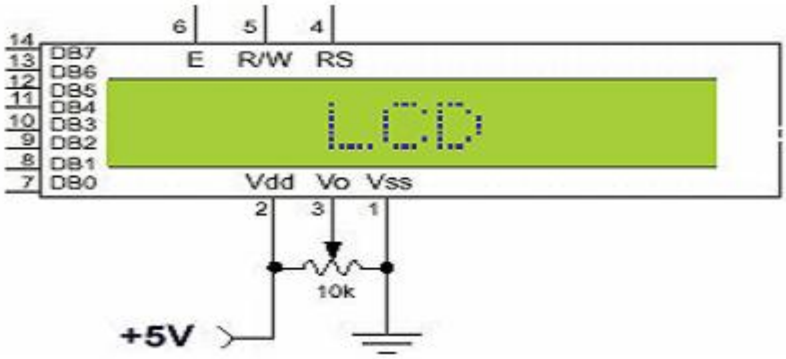


Fig 3.21 Pin diagram of 2x16 line LCD

Pin No.	Name	Description
Pin no. 1	**VSS**	Power supply (GND)
Pin no. 2	**VCC**	Power supply (+5V)
Pin no. 3	**VEE**	Contrast adjust
Pin no. 4	**RS**	0 = Instruction input 1 = Data input
Pin no. 5	**R/W**	0 = Write to LCD module 1 = Read from LCD module
Pin no. 6	**EN**	Enable signal
Pin no. 7	**D0**	Data bus line 0 (LSB)
Pin no. 8	**D1**	Data bus line 1
Pin no. 9	**D2**	Data bus line 2
Pin no. 10	**D3**	Data bus line 3
Pin no. 11	**D4**	Data bus line 4
Pin no. 12	**D5**	Data bus line 5
Pin no. 13	**D6**	Data bus line 6
Pin no. 14	**D7**	Data bus line 7 (MSB)

Table 3.3 Pin description of the LCD

3.1.5 RELAYS

A relay is an electrical switch that opens and closes under the control of another electrical circuit. In the original form, the switch is operated by an electromagnet to open or close one or many sets of contacts. It was invented by Joseph Henry in 1835. Because a relay is able to control an output circuit of higher power than the input circuit, it can be considered to be, in a broad sense, a form of an electrical amplifier.

Fig. 3.22 Sugar cube relay

Despite the speed of technological developments, some products prove so popular that their key parameters and design features remain virtually unchanged for years. One such product is the ‘sugar cube’ relay, shown in the figure above, which has proved useful to many designers who needed to switch up to 10A, whilst using relatively little PCB area Since relays are switches , the terminology applied to switches is also applied to relays. A relay will switch one or more poles, each of whose contacts can be thrown by energizing the coil in one of three ways:

1.**Normally - open (NO)** contacts connect the circuit when the relay is activated; the circuit is disconnected when the relay is inactive. It is also called a FORM A contact or “make” contact.

2.**Normally - closed (NC)** contacts disconnect the circuit when the relay is activated ; the circuit is connected when relay is inactive. It is also called form B contact or” break” contact

3.**Change-over or double-throw** contacts control two circuits ; one normally open contact and one normally –closed contact with a commom terminal. It is also called a Form C “transfer“ contact.

The following types of relays are commonly encountered:

• **SPST** - **S**ingle **P**ole **S**ingle **T**hrow: These have two terminals which can be connected or disconnected. Including two for the coil, such a relay has four terminals in total. It is ambiguous whether the pole is normally open or normally closed. The terminology "SPNO" and "SPNC" is sometimes used to resolve the ambiguity.

• **SPDT** - **S**ingle **P**ole **D**ouble **T**hrow: A common terminal connects to either of two others. Including two for the coil, such a relay has five terminals in total.

• **DPST** - **D**ouble **P**ole **S**ingle **T**hrow: These have two pairs of terminals. Equivalent to two SPST switches or relays actuated by a single coil. Including two for the coil, such a relay has six terminals in total. It is ambiguous whether the poles are normally open, normally closed, or one of each.

• **DPDT** - **D**ouble **P**ole **D**ouble **T**hrow: These have two rows of change-over terminals. Equivalent to two SPDT switches or relays actuated by a single coil. Such a relay has eight terminals, including the coil.

• **QPDT** - **Q**uadruple **P**ole **D**ouble **T**hrow: Often referred to as Quad Pole Double Throw, or 4PDT. These have four rows of change-over terminals. Equivalent to four SPDT switches or relays actuated by a single coil, or two DPDT relays. In total, fourteen terminals including the coil.

The Relay interfacing circuitry used in the application is:

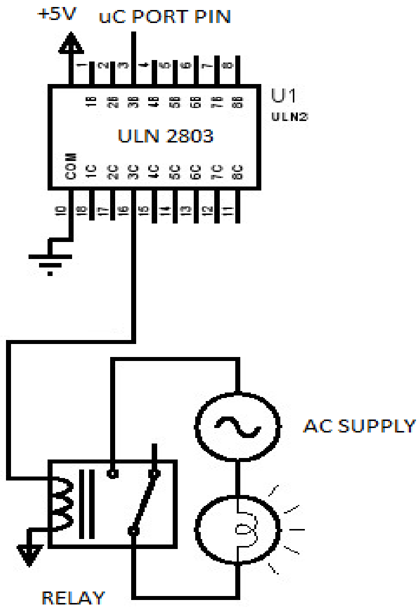


Fig. 3.23 Relay circuitry

3.1.6 POWER SUPPLY CONNECTION

The power supply section consists of step down transformers of 230V primary to 9V and 12V secondary voltages for the +5V and +12V power supplies respectively. The stepped down voltage is then rectified by 4 1N4007 diodes. The high value of capacitor 1000 µF charges at a slow rate as the time constant is low, and once the capacitor charges there is no resistor for capacitor to discharge. This gives a constant value of DC. IC 7805 is used for regulated supply of +5 volts and IC 7812 is used to provide a regulated supply of +12 volts in order to prevent the circuit ahead from any fluctuations. The filter capacitors connected after this IC filters the high frequency spikes. These capacitors are connected in parallel with supply and common so that spikes filter to the common. These give stability to the power supply circuit. As can be seen from the above circuit diagrams, the rectified voltage from the 4 diodes is given to pin 1 of the respective regulators. Pin 2 of the regulators is connected to ground and pin 3 to Vcc. With adequate heat sinking the regulator can deliver 1A output current. If internal power dissipation becomes too high for the heat sinking provided, the thermal shutdown circuit takes over preventing the IC from overheating.

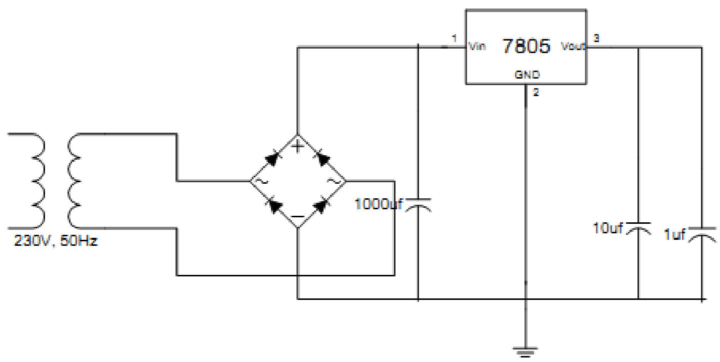


Fig. 3.24 +5V Power supply circuit

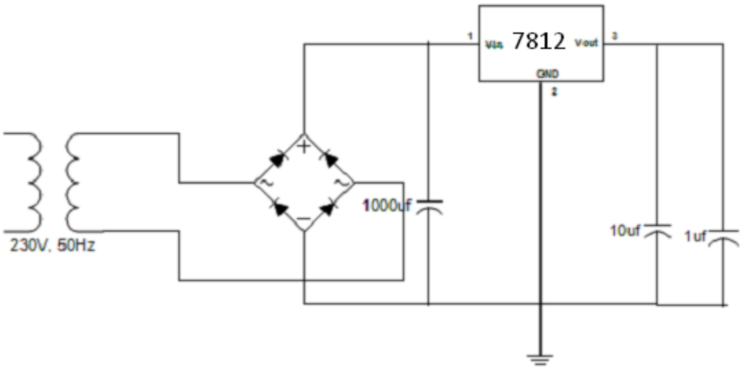


Fig. 3.25 +12V Power supply Circuit

3.1.7 REAL LIFE ACTUATORS

3.1.7.1 DRIP IRRIGATION SYSTEM FOR CONTROLLING SOIL MOISTURE

Drip, or micro-irrigation, technology uses a network of plastic pipes to carry a low flow of water under low pressure to plants. **Polyethylene tubing** is run from the source of water to the plant, where the emitter is attached for dripping water. Emitter line (poly tubing with pre-installed emitters) is used where a continuous band of water is needed. **Fittings** are available to make sharp turns (elbows), branch lines (tees), and to make the transition between different sizes of tubing. When plants are removed or die, drip lines should be plugged.

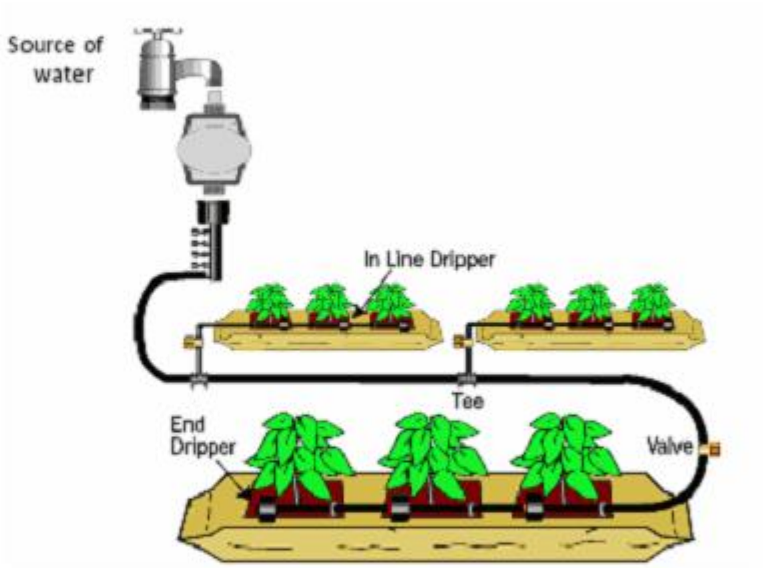


Fig. 3.26 Drip irrigation system

Drip irrigation (sometimes called trickle irrigation) works by applying water slowly, directly to the soil. The high efficiency of drip irrigation results from two primary factors. The first is that the water soaks into the soil before it can evaporate or run off. The second is that the water is only applied where it is needed, (at the plant's roots) rather than sprayed everywhere. A drip irrigation system slowly provides water to the plant's root system. Regular watering prevents plant dehydration, but roots don't get overly soaked and in turn, plant growth can increase up to 50%. Drip systems irrigate all types of landscape: shrubs, trees, perennial beds, ground covers, annuals and lawns. Drip is the best choice to water roof gar dens, containers on decks and patios, row crops and kitchen gardens, orchards, and vineyards.

3.1.7.2 ARTIFICIAL GROWING LIGHTS FOR CONTROLLING ILLUMINATION

Growing lights enable cultivators to extend daylight hours - useful for winter and spring growing when levels of natural lights can be low, and one can therefore improve plant growth. Three basic types of lamps used in greenhouse lighting are:

• **Fluorescent lamps** - These have the advantage of higher light efficiency with low heat. This type of lamp is the most widely used for supplemental light. It is available in a variety of colours but cool-white lamps are the most common. High intensity (1500 ma) fluorescent tubes that require higher wattage are also commonly used to reach 2000 foot candles.

• **Incandescent lamps -** These vary in size from 60 watts to 500 watts. The grower can vary foot-candle levels by adjusting the spacing and mounting height above the plants.

• **High-intensity discharge (HID) lamps -** These have a long life (5000 hours or more). With improvements made possible by the addition of sodium and metal alloys, the lamp has a high emission of light in the regions utilized by plants.

The following generally accepted cultural divisions describe light levels:

• **Very high:** Over 5000 footcandles--nearly full sun except at midday, when full summer sun in most latitudes may reach 10,000 fc.

• **High:** 4000-5000 footcandles--bright light, just under 50% of the full midday sun.

• **Intermediate:** 1800-4000 footcandles--dappled sunlight.

• **Low:** 1000-1800 footcandles--reduced sunlight, so that if a hand is passed over the leaves it does not produce a shadow. One footcandle is equal to 10.76 lux, although in the lighting industry, typically this is approximated as 1 footcandle being equal to 10 lux.

3.1.7.3 TEMPERATURE CONTROLLERS

3.1.7.3.1 COOLING EQUIPMENT

There are three primary cooling devices in most greenhouses. These are the vent system, exhaust fan, and swamp cooler. Some greenhouses may make use of air conditioners and/or misting systems as well.

• **Vents** are hinged or track connected panels in the roof or sides of greenhouses. They open up the greenhouse to outside natural air. Hot air that builds up in the greenhouse can escape, and fresh air can enter the house. The microcontroller can be used to automate the opening and closing of these vents depending upon requirement. But during hot summer days, venting alone will not get the job done.

• **Exhaust fans** can move a large volume of the hot greenhouse air out and pull fresh air in through the rear vent. They're powerful for a reason, as full sun on a hot summer day can cause temperatures inside the greenhouse to superheat. An exhaust fan must be able to pull this air out, or the temperatures will continue to rise.

• **Swamp coolers:** come in different widths and lengths. They can be configured to the appropriate size, as this varies depending on the length and width of the greenhouse, location where you live, and type of plants you wish to grow.

3.1.7.3.2 HEATING EQUIPMENT

• **Hot-water or steam heater:** A hot-water system with circulator or a steam system linked with automatic ventilation will give adequate temperature control. In some areas, coal or natural gas is readily available at low cost. This fuel is ideal for hot water or a central steam system. Steam has an advantage in that it can be used to sterilize growing beds and potting soils.

• **Electric heaters:** Overhead infrared heating equipment combined with soil cable heat provides a localized plant environment, which allows plants to thrive even though the surrounding air is at a lower than normal temperature. Electric resistance-type heaters are used as space heaters or in a forced air system.

3.1.8 Serial Communication

3.1.8.1 Introduction

UART (Universal Asynchronous Receiver Transmitter) or USART (Universal Synchronous Asynchronous Receiver Transmitter) are one of the basic interface which you will find in almost all the controllers available in the market till date. This interface provides a cost effective simple and reliable communication between one controller to another controller or between a controller and PC.

3.1.8.2 RS-232 Basics

RS-232 (Recommended Standard 232) is a standard for serial binary data signals connecting between a DTE (Data terminal equipment) and a DCE (Data Circuit-terminating Equipment).

Voltage Levels:

The RS-232 standard defines the voltage levels that correspond to logical one and logical zero levels. Valid signals are plus or minus 3 to 25 volts. The range near zero volts is not a valid RS-232 level; logic one is defined as a negative voltage, the signal condition is called marking, and has the functional significance of OFF. Logic zero is positive, the signal condition is spacing, and has the function ON. So a Logic Zero represented as +3V to +25V and Logic One represented as -3V to -25V.

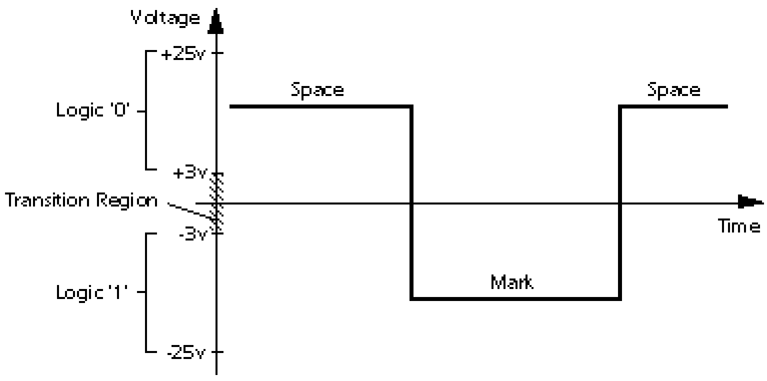
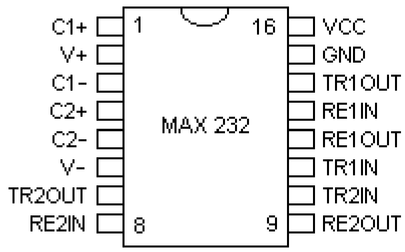


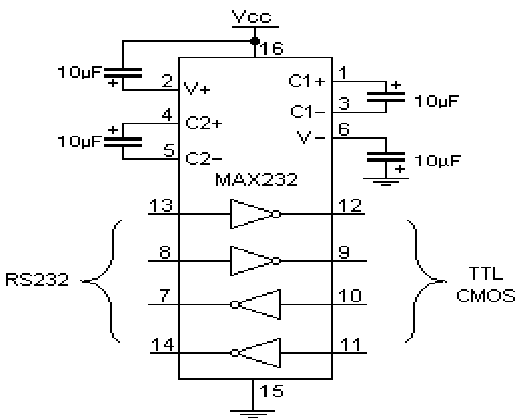
FIG 3.27 VOLTAGE LEVELS

3.1.8.3 RS-232 Level Converters

Usually all the digial ICs works on TTL or CMOS voltage levels which cannot be used to communicate over RS-232 protocol. So a voltage or level converter is needed which can convert TTL to RS232 and RS232 to TTL voltage levels. The most commonly used RS-232 level converter is MAX232. This IC includes charge pump which can generate RS232 voltage levels (-10V and +10V) from 5V power supply. It also includes two receiver and two transmitters and is capable of full-duplex UART/USART communication.



MAX232 Pin Description



MAX232 Typical Connection Circuit

FIG 3.28 MAX232

3.1.8.4 MAX232 Interfacing with Microcontrollers

To communicate over UART or USART, we just need three basic signals which are namely, RXD (receive), TXD (transmit), GND (common ground). So to interface MAX232 with any microcontroller (AVR, ARM, 8051, PIC etc..) we just need the basic signals. A simple schematic diagram of connections between a microcontroller and MAX232 is shown below

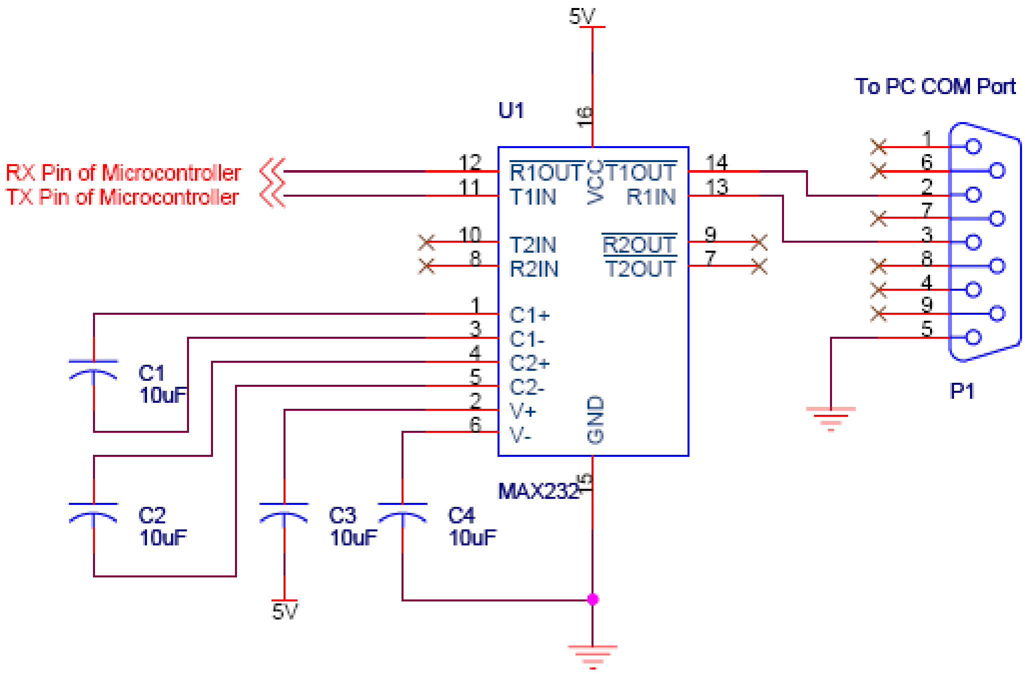


FIG 3.29 MAX232 CONNECTIONS

3.1.8 FULL CIRCUIT DIAGRAM

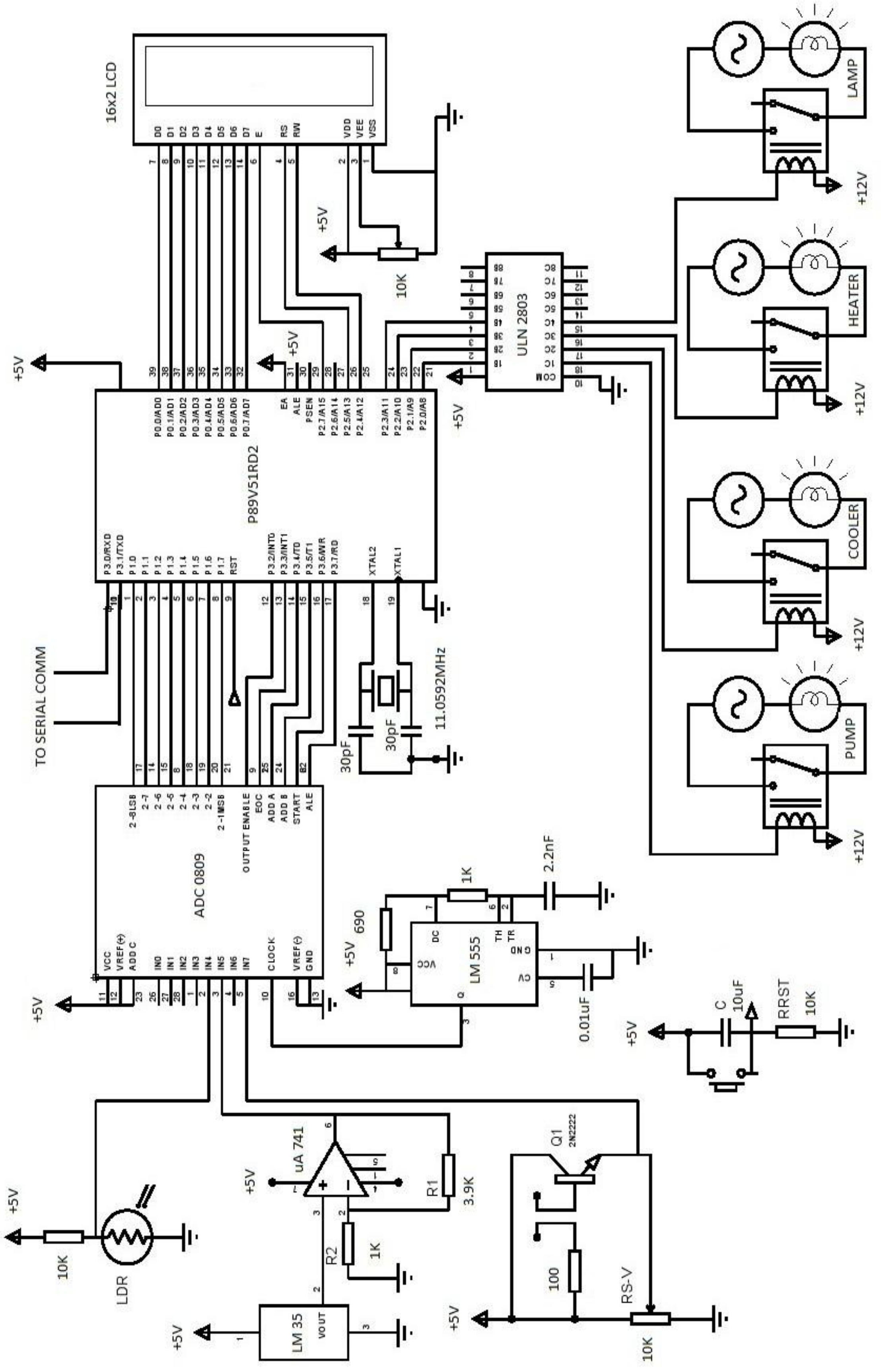


FIG 3.30 FULL CIRCUIT DIAGRAM

3.2 SOFTWARE

3.2.1 INTRODUCTION TO KEIL SOFTWARE

Keil MicroVision is an integrated development environment used to create software to be run on embedded systems (like a microcontroller). It allows for such software to be written either in assembly or C programming languages and for that software to be simulated on a computer before being loaded onto the microcontroller.

3.2.1.1 WHAT IS µVision3?

µVision3 is an IDE (Integrated Development Environment) that helps write, compile, and debug embedded programs. It encapsulates the following components:

- A project manager.
- A make facility.
- Tool configuration.
- Editor.
- A powerful debugger.

3.2.1.2 DEVICE DATABASE

A unique feature of the Keil µVision3 IDE is the Device Database, which contains information about more than 400 supported microcontrollers. When you create a new µVision3 project and select the target chip from the database, µVision3 sets all assembler, compiler, linker, and debugger options for you. The only option you must configure is the memory map.

3.2.1.3 PERIPHERAL SIMULATION

The µVision3 Debugger provides complete simulation for the CPU and on-chip peripherals of most embedded devices. To discover which peripherals of a device are supported, in µVision3 select the Simulated Peripherals item from the Help menu. You may also use the web-based Device Database. We are constantly adding new devices and simulation support for on-chip peripherals so be sure to check Device Database often.

3.2.2 COMPORT TOOL KIT

COM Port Toolkit is a protocol, data, and timing analyser designed specifically to help isolate problems with serial (RS-232/422/485) data communication control networks. COM Port Toolkit is an indispensable test tool for industrial control and SCADA design engineers, OEM development and test engineers, system integrators, field service and maintenance engineers. The product enables shorter and less costly development intervals for serial communications equipment, improved mean-time-to-repair following equipment

You can use this program for implementing, debugging or reverse-engineering serial protocol. The program can send and capture ASCII and HEX data. Split data option helps to format received data. You can change communications channel's settings easily including setting of non-standard baud rate.

You can write or use a script written by other developers to automate some specific tasks: CRC calculations, special transfer rules, outgoing data modifications and etc.

Internal scripting language is an enhanced, C-like programming language, including if, else, for, do and while constructs and the usage of user defined functions.

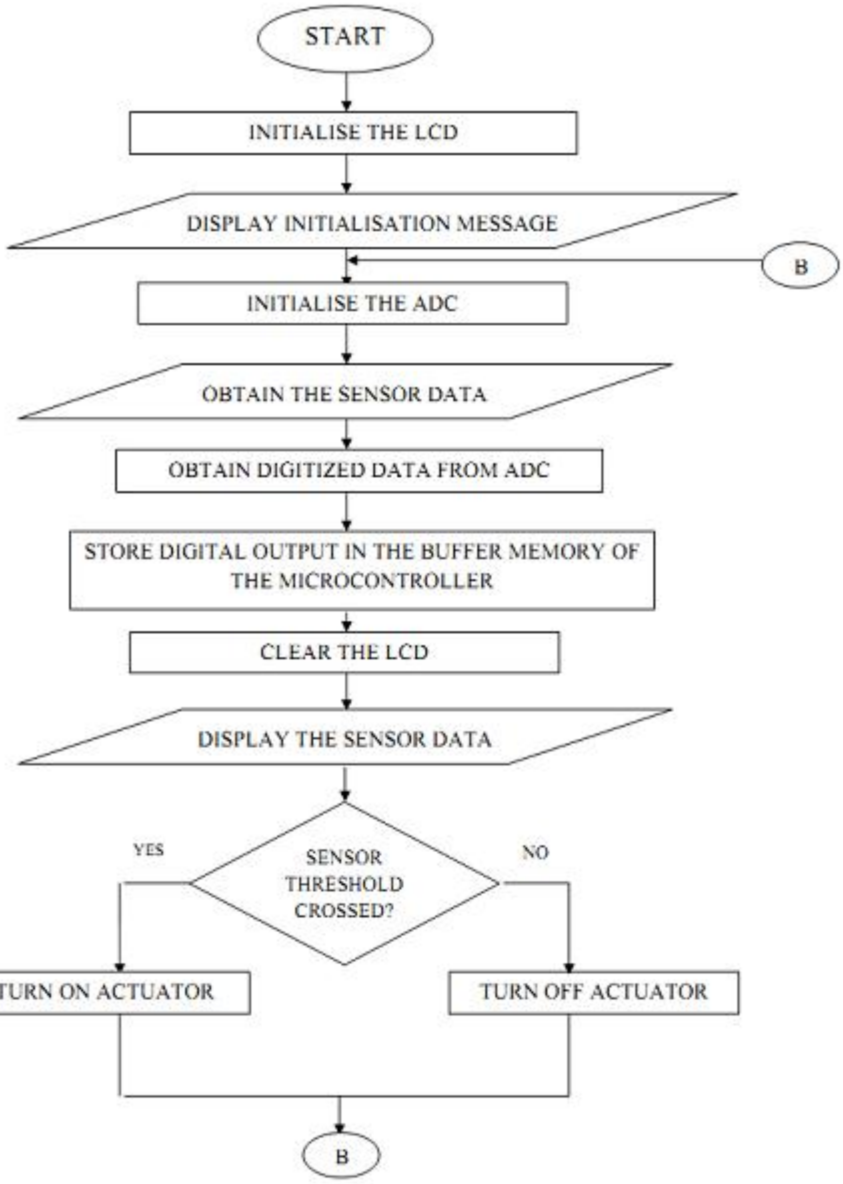
Main features:

- serial port monitor functionality;
- data transmission and logging;
- real-time data capture;
- time stamping;
- internal scripting language;
- multiple devices oriented environment;
- data export to the clipboard and to a file;
- HEX and ASCII data view;
- User friendly interface.

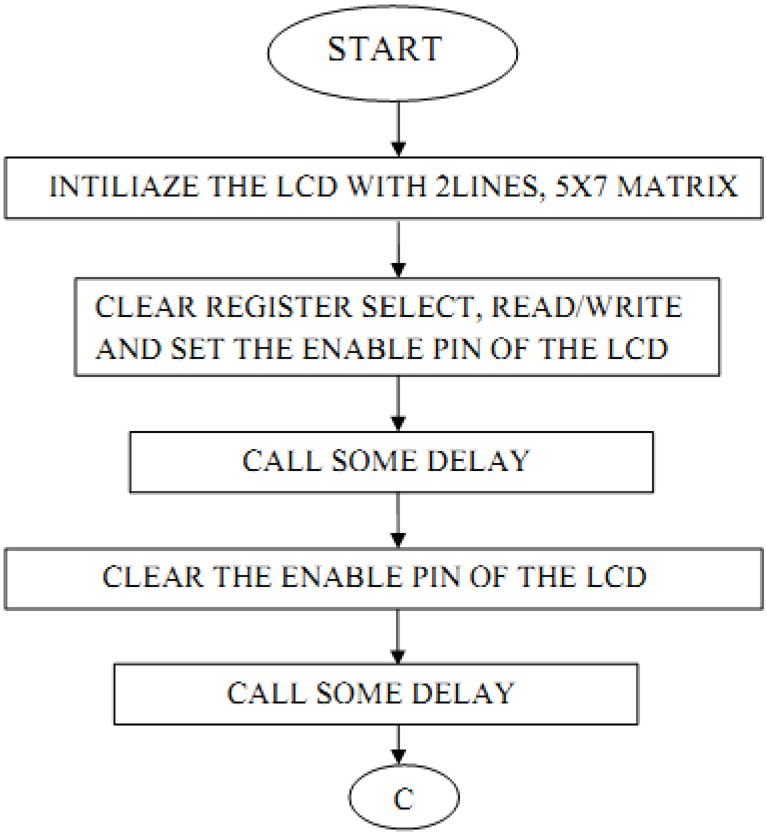
COM Port Toolkit works on Windows 95 OSR 2, Windows 98, Windows Me, Windows NT 4.0, Windows 2000/XP, Windows Vista operating systems.

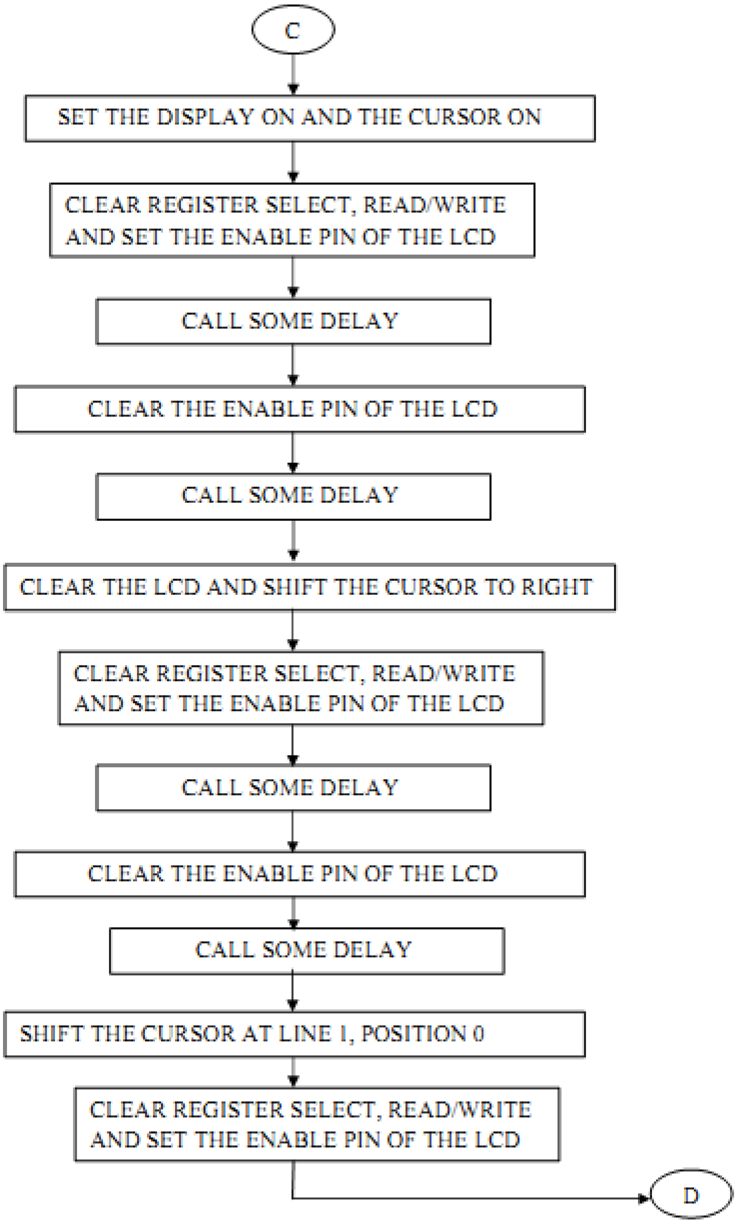
3.3 FLOW CHART

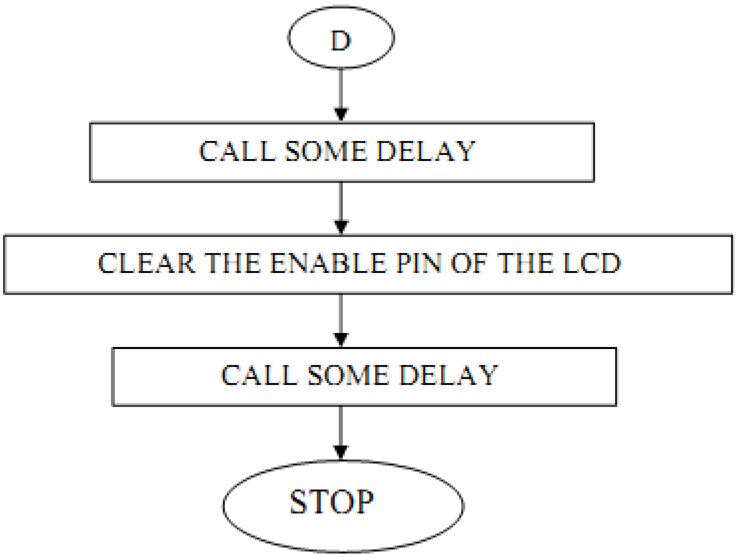
3.3.1 FLOWCHART REPRESENTING THE WORKING OF THE SYSTEM:



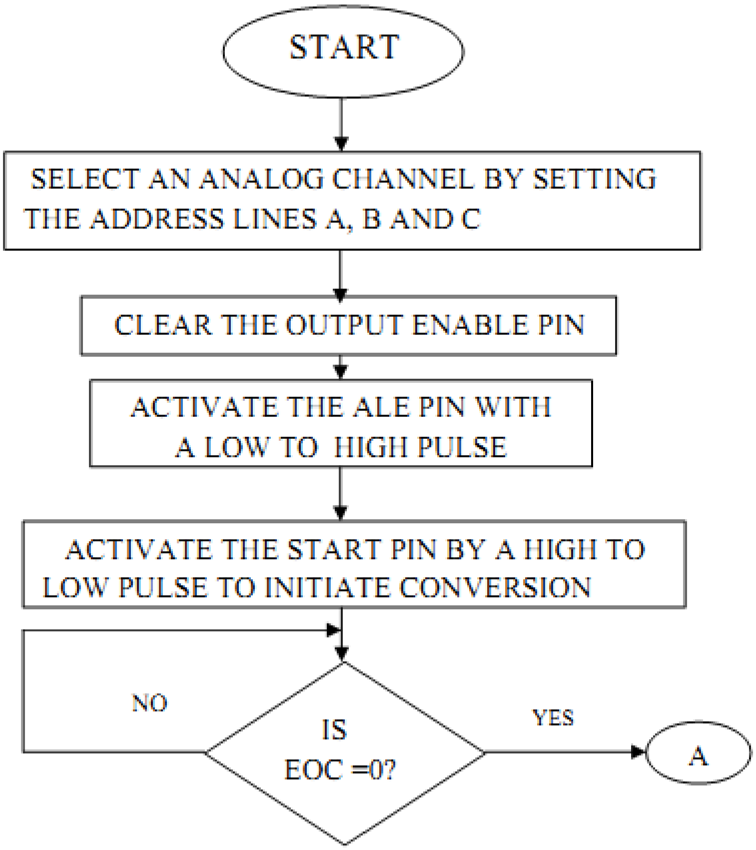
3.3.2 FLOWCHART FOR LCD INITIALIZATION

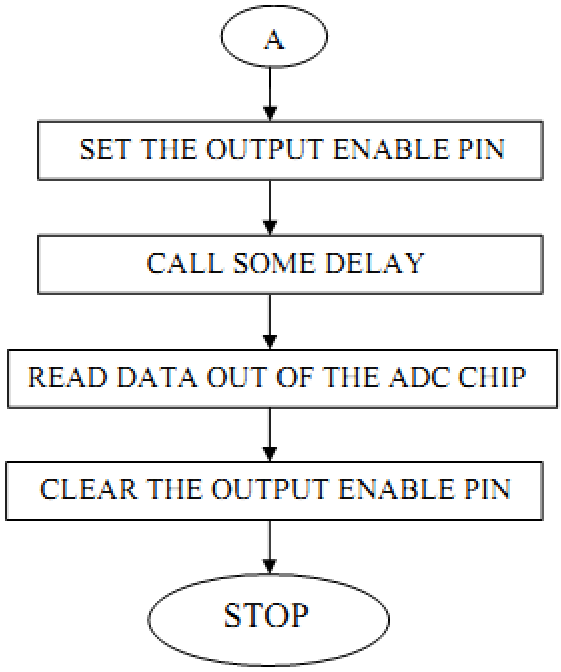



C
SET THE DISPLAY ON AND THE CURSOR ON
CLEAR REGISTER SELECT, READ/WRITE AND SET THE ENABLE PIN OF THE LCD
CALL SOME DELAY
CLEAR THE ENABLE PIN OF THE LCD
CALL SOME DELAY
CLEAR THE LCD AND SHIFT THE CURSOR TO RIGHT
CLEAR REGISTER SELECT, READ/WRITE AND SET THE ENABLE PIN OF THE LCD
CALL SOME DELAY
CLEAR THE ENABLE PIN OF THE LCD
CALL SOME DELAY
SHIFT THE CURSOR AT LINE 1, POSITION 0
CLEAR REGISTER SELECT, READ/WRITE AND SET THE ENABLE PIN OF THE LCD
D



3.3.3 FLOW CHART FOR ADC INITIALIZATION




A
SET THE OUTPUT ENABLE PIN
CALL SOME DELAY
READ DATA OUT OF THE ADC CHIP
CLEAR THE OUTPUT ENABLE PIN
STOP

CHAPTER 4
Simulation and Testing

4.1 USING KEIL uVISION 3

4.1.1 STEPS FOLLOWED IN CREATING AN APPLICATION IN uVision3:

To create a new project in uVision3:

1. Select Project - New Project.
2. Select a directory and enter the name of the project file.
3. Select Project –Select Device and select a device from Device Database.
4. Create source files to add to the project
5. Select Project - Targets, Groups, and Files. Add/Files, select Source Group1, and add the source files to the project.
6. Select Project - Options and set the tool options. Note that when the target device is selected from the Device Database™ all-special options are set automatically. Default memory model settings are optimal for most applications.
7. Select Project - Rebuild all target files or Build target

To create a new project, simply start MicroVision and select “Project”=>”New Project” from the pull–down menus. In the file dialog that appears, choose a name and base directory for the project. It is recommended that a new directory be created for each project, as several files will be generated. Once the project has been named, the dialog shown in the figure below will appear, prompting the user to select a target device. In this lab, the chip being used is the “P89V51RD2,” which is listed under the heading “PHILIPS”.

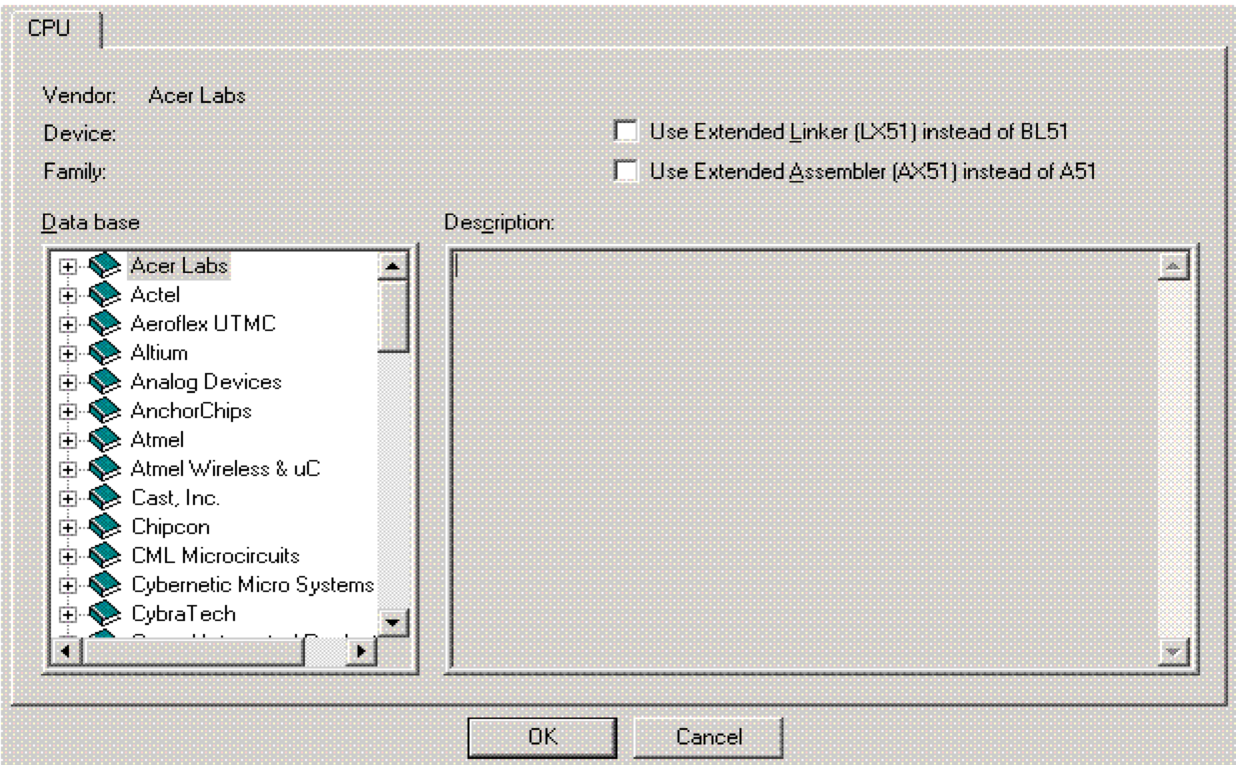


Fig. 4.1 Window for choosing the target device

Next, MicroVision must be instructed to generate a HEX file upon program compilation. A HEX file is a standard file format for storing executable code that is to be loaded onto the microcontroller. In the "Project Workspace" pane at the left, right–click on "Target 1" and select "Options for 'Target 1' ".Under the "Output" tab of the resulting options dialog, ensure that both the "Create Executable" and "Create HEX File" options are checked. Then click "OK" as shown in the two figures below.

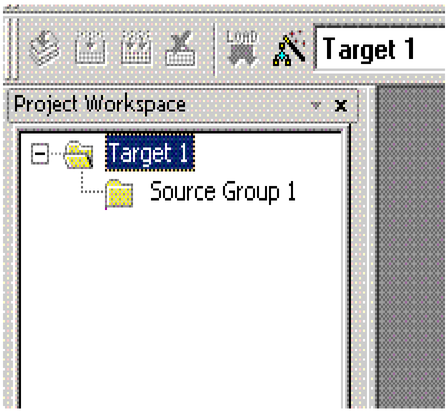


Fig. 4.2 Project Workspace Pane

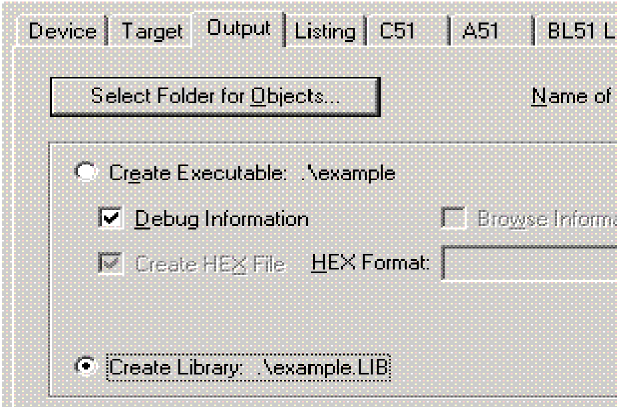


Fig. 4.3 Project Options Dialog

Next, a file must be added to the project that will contain the project code. To do this, expand the "Target 1" heading, right–click on the "Source Group 1" folder, and select "Add files…" Create a new blank file (the file name should end in ".asm"), select it, and click "Add." The new file should now appear in the "Project Workspace" pane under the "Source Group 1" folder. Double-click on the newly created file to open it in the editor. All code for this lab will go in this file. To compile the program, first save all source files by clicking on the "Save All" button, and then click on the "Rebuild All Target Files" to compile the program as shown in the figure below. If any errors or warnings occur during compilation, they will be displayed in the output window at the bottom of the screen. All errors and warnings will reference the line and column number in which they occur along with a description of the problem so that they can be easily located. Note that only errors indicate that the compilation failed, warnings do not (though it is generally a good idea to look into them anyway).

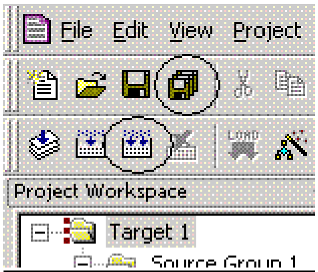


Fig. 4.4 "Save All" and "Build All Target Files" Buttons

When the program has been successfully compiled, it can be simulated using the integrated debugger in Keil MicroVision. To start the debugger, select "Debug"=>"Start/Stop Debug Session" from the pull–down menus. At the left side of the debugger window, a table is displayed containing several key parameters about the simulated microcontroller, most notably the elapsed time (circled in the figure below). Just above that, there are several buttons that control code execution. The

“Run” button will cause the program to run continuously until a breakpoint is reached, whereas the “Step Into” button will execute the next line of code and then pause (the current position in the program is indicated by a yellow arrow to the left of the code).

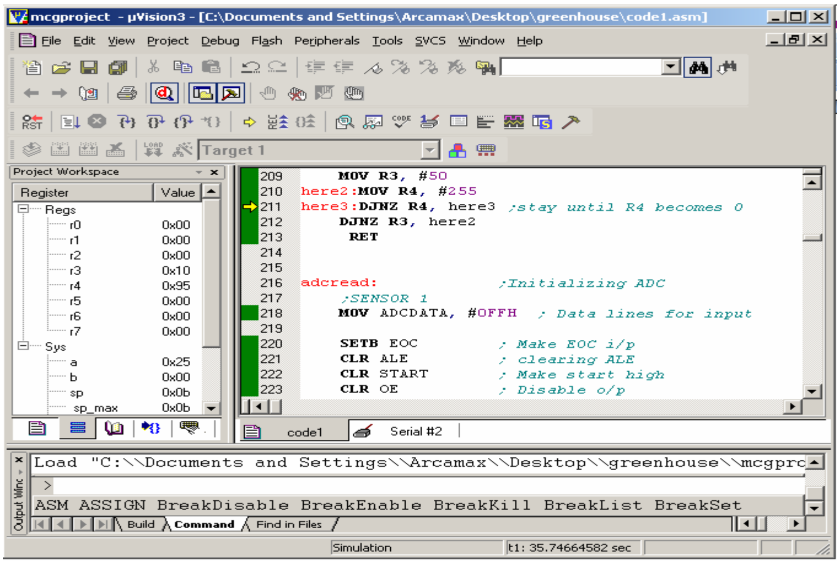


Fig. 4.5 µVision3 Debugger window

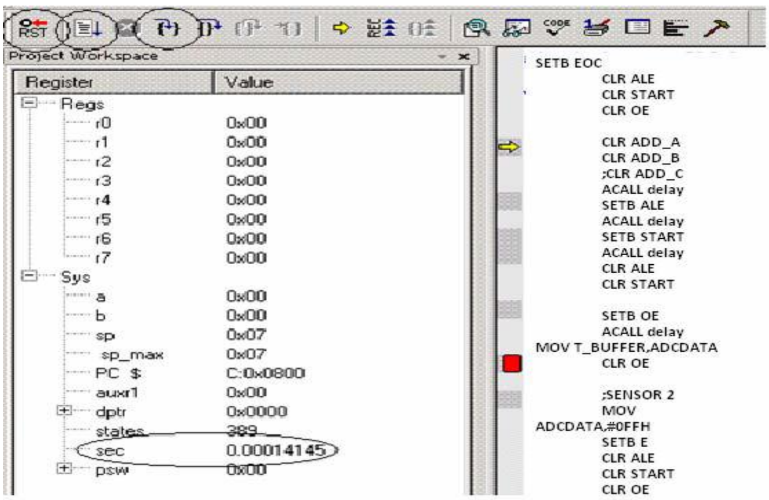


Fig. 4.6 ‘Reset’, ‘Run’ and ‘Step into’ options

The current state of the pins on each I/O port on the simulated microcontroller can also be displayed. To view the state of a port, select “Peripherals”=>”I/O orts”=>”Port *n*” from the pull–down menus, where *n* is the port number. A checked box in the port window indicates a high (1) pin, and an empty box indicates a low (0) pin. Both the I/O port data and the data at the left side of the screen are updated whenever the program is paused. The debugger will help eliminate many programming errors, however the simulation is not perfect and code that executes properly in simulation may not always work on the actual microcontroller.

4.2 USING FLASH MAGIC FOR ISP(IN SYSTEM PROGRAMMING)

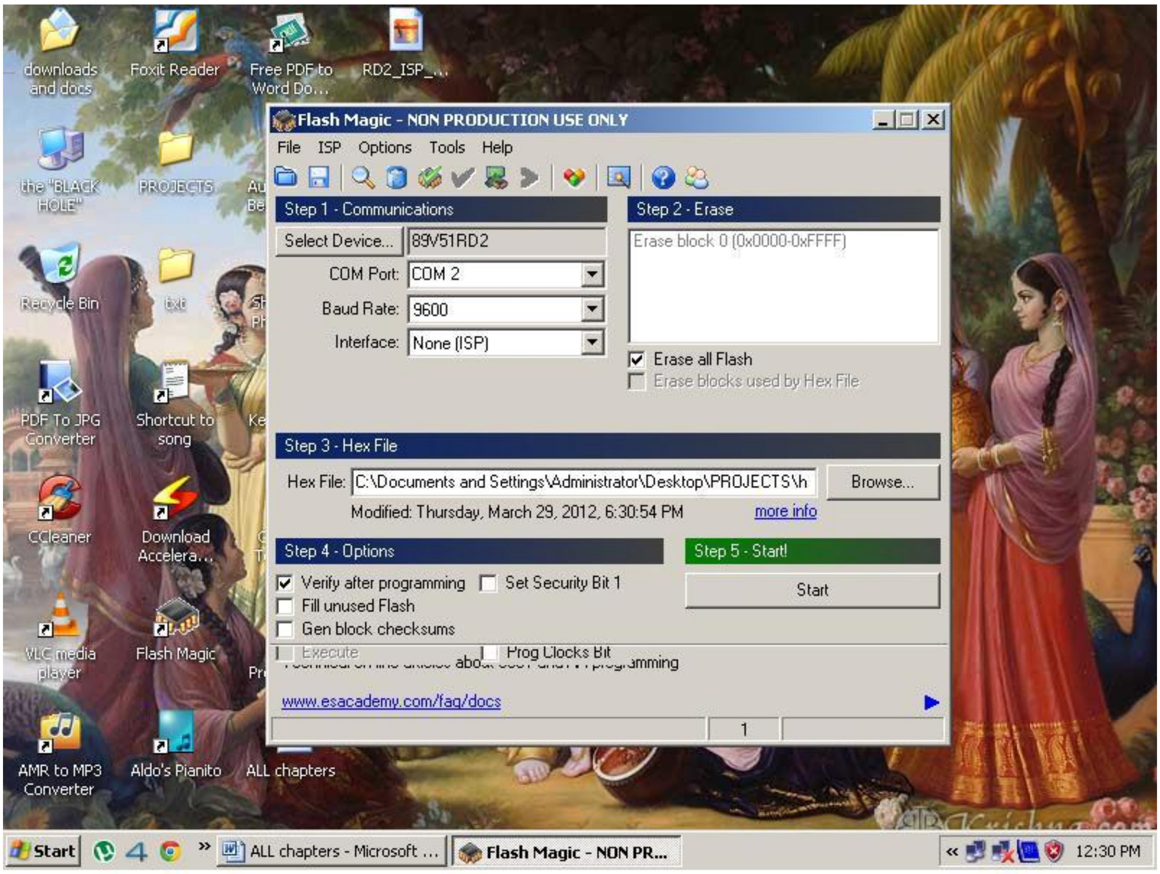


Fig. 4.7 FLASH MAGIC CONFIGURATION

Flash magic, is a programming tool which allows ISP for a bundle of supporting controllers. The above screenshot depicts the main screen for the same. Following steps are to be taken for successful use of ISP :

STEP - 1

- Select proper device (in our case P89V51RD2)
- Select proper port of communication (in our case COM 2)
- Select proper baud rate (in our case 9600)

NOTE : Make sure the device BAUD RATE matches with selected BAUD RATE.

STEP - 2

- Select – Erase FLASH option.

STEP - 3

- Select proper HEX file to be burnt in the controller IC.

STEP – 4

- Check the verify after programming checkbox.

STEP - 5

- Switch on the power supply to programmer board and hit “Start”.
- Reset the device when asked to do so.
- Now the program has been successfully loaded into the target controller.

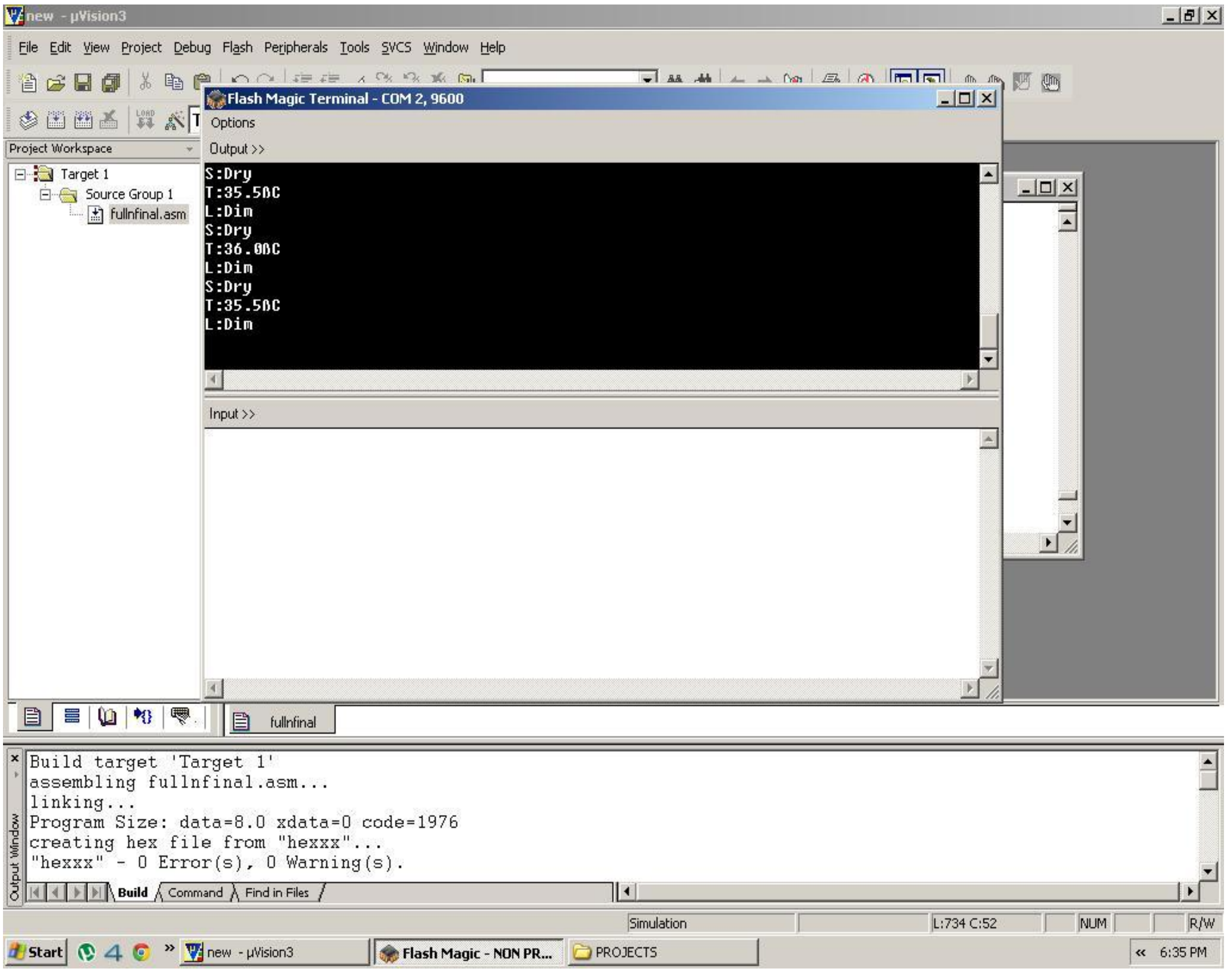


Fig. 4.8 Terminal window

Conversely FLASH MAGIC TOOL can also be used for monitoring the serial data coming from the controller using its “TERMINAL WINDOW” facility as shown above.

4.3 USING COMPORT TOOL KIT FOR DATA LOGGING

The program can capture serial communications between the device and the software by using special driver. So the program acts as a software protocol analyzer in this mode. This feature is available under Windows 9x, Me, NT, 2000, XP, Vista.

This software is specifically used for a combined operation of MONITORING as well as LOGGING the information from various sensors for future reference.

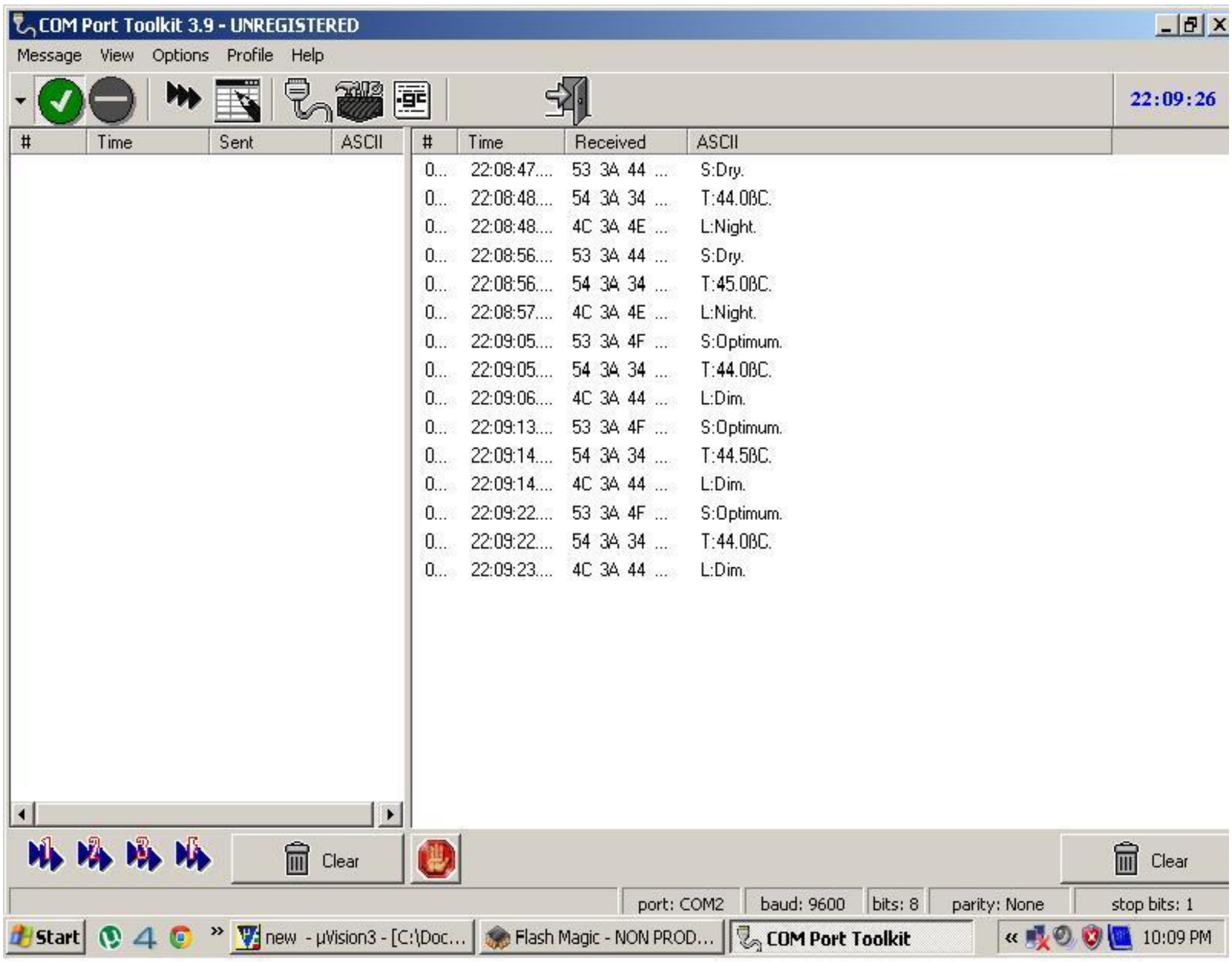


Fig. 4.9 COMPORT TOOLKIT TERMINAL

As seen above, it has a simple user interface which requires one time setting up the PORT number, BAUD RATE and receive options. After setting up, just open the port and data coming at the serial port gets automatically logged into a data (.dat) file along with the date and time.

This file can be referred in the future for referring the climatic conditions of any specific date and time.

CHAPTER 5 Results and Conclusion

5.1 RESULT ANALYSIS

5.1.1 SOIL MOISTURE SENSOR

Soil Condition	Transducer Optimum Range
Soil is dry	0-1.9V
Optimum level of soil moisture	1.9-3.2V
Slurry soil	>3.2V

5.1.2 LIGHT SENSOR

Illumination Status	Transducer Optimum Range
OPTIMUM ILLUMINATION	0V-0.69V
DIM LIGHT	0.7V-2.5V
DARK	2.5V- 3V
NIGHT	3V-3.47V

5.1.3 TEMPERATURE SENSOR

TEMPERATURE RANGE IN DEGREE CELSIUS	TEMPERATURE SENSOR OUTPUT IN V
10 ˚	0.5V
15˚C-20˚C	0.75-1V
20˚C-25˚C	1-1.25V
25˚C-30˚C	1.25-1.5V
30˚C-35˚C	1.5-1.75V
35˚C-40˚C	1.75-2V
40˚C-45˚C	2-2.25V
45˚C-50˚C	2.25-2.5V
50˚C-55˚C	2.5-2.75V
55˚C-60˚C	2.75-3V
60˚C-65˚C	3-3.25V
65˚C-70˚C	3.25-3.5V
70˚C-75˚C	3.5-3.75V
75˚C-80˚C	3.75-4V
80˚C-85˚C	4-4.25V
85˚C-90˚C	4.25-4.5V
90˚C-95˚C	4.5-4.75V
95˚C-100˚C	4.75-5V

5.2 ADVANTAGES AND DISADVANTAGES

5.2.1 ADVANTAGES

1) Sensors used have high sensitivity and are easy to handle.
2) Low cost system, providing maximum automation.
3) Closed loop design prevents any chances of disturbing the greenhouse environment.
4) Low maintenance and low power consumption.
5) The system is more compact compared to the existing ones, hence is easily portable.
6) Can be used for different plant species by making minor changes in the ambient environmental parameters.
7) Can be easily modified for improving the setup and adding new features.
8) Labor saving.
9) Provides a user-friendly interface hence will have a greater acceptance by the technologically unskilled workers.
10) In response to the sensors, the system will adjust the heating, fans, lighting, irrigation immediately, hence protect greenhouse from damage.
11) Malfunctioning of single sensor will not affect the whole system.
12) Natural resource like water saved to a great extent.

5.2.2 DISADVANTAGES

1) Complete automation in terms of pest and insect detection and eradication cannot be achieved.
2) No self-test system to detect malfunction of sensors.
3) Requires uninterrupted power supply.

5.3 FUTURE SCOPE

1) The performance of the system can be further improved in terms of the operating speed, memory capacity, instruction cycles period of the microcontroller by using other controllers such as AVRs and PICs. The number of channels can be increased to interface more number of sensors which is possible by using advanced versions of microcontroller.

2) This system can be connected to communication devices such as modems, cellular phones or satellite terminal to enable the remote collection of recorded data or alarming of certain parameters.

3) The device can be made to perform better by providing the power supply with the help of battery source which can be rechargeable or non-rechargeable, to reduce the requirement of main AC power.

4) Time bound administration of fertilizers, insecticides and pesticides can be introduced.

5) A multi-controller system can be developed that will enable a master controller along with its slave controllers to automate multiple greenhouses simultaneously.

5.4 CONCLUSION

A step-by-step approach in designing the microcontroller based system for measurement and control of the four essential parameters for plant growth, i.e. temperature, humidity, soil moisture, and light intensity, has been followed. The results obtained from the measurement have shown that the system performance is quite reliable and accurate. The system has successfully overcome quite a few shortcomings of the existing systems by reducing the power consumption, maintenance and complexity, at the same time providing a flexible and precise form of maintaining the environment. The continuously decreasing costs of hardware and software, the wider acceptance of electronic systems in agriculture, and an emerging agricultural control system industry in several areas of agricultural production, will result in reliable control systems that will address several aspects of quality and quantity of production. Further improvements will be made as less expensive and more reliable sensors are developed for use in agricultural production. Although the enhancements mentioned in the previous chapter may seem far in the future, the required technology and components are available, many such systems have been independently developed, or are at least tested at a prototype level. Also, integration of all these technologies is not a daunting task and can be successfully carried out.

5.5 REFRENCES

5.5.1 WEB RESOURCES

- www.8052.com
- www.edaboard.com
- www.treehugger.com
- howstuffworks.com
- cityfarmer.org

5.5.2 BOOKS

- Kenneth J Ayala, *The 8051 Microcontroller Architecture, Programming & Applications,* Penram International, 2nd Edition, 1996.
- Muhammad Ali Mazidi, Janice Gillispie Mazidi, Rolin D. Mc Kinlay , *The 8051 Microcontroller & Embedded Systems*, Pearson Education Inc. 2nd Edition, 2008.