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Designing and Applications of PIC Microcontroller Based Green House Monitoring and Controlling System

Nikhilesh M. Dharmadhikari and Dr. Y. B. Thakare

Department of Electronics & Telecommunication,
PVG's College of Engineering and Technology
Telephone, fax, and e-mail:+919561224340, dnikhilesh1993@gmail.com
Telephone, fax, and e-mail:+919422312905, ythakare@gmail.com

ABSTRACT

Greenhouses play an important part in the agriculture and horticulture sectors in our country, as they can be used to grow plants under controlled climatic conditions during any period of year for optimum produce. While tradition crop cultivation requires a tremendous amount of hard work and attention and there are several disadvantages in implementing traditional cultivation techniques. Automation of a greenhouse for monitoring and controlling of various climatic conditions which directly or indirectly govern the plant growth and hence their yield is very important. Automation is process control of industrial machinery and processes, thereby replacing human operators.
This system will be useful for farmers for cultivation of economically important plants.
Most crops can only be grown in certain climates during certain times of the year. The rise of Controlled Environment Agriculture (CEA) proposes a new direction for agriculture. CEA is an agriculture technique which allows for the growth of plants in controlled conditions.
The main focus of the present study is on building user friendly and cheap greenhouse monitoring and control system for a farmer which is provided with the facility of plant selection. This system can be readily used for the growth of various plants throughout the year by providing the favourable conditions required for their growth.

KEYWORDS: PIC, Green house effect, Soil analysis, GLCD.

INTRODUCTION

Use of poly house or Green house in agriculture is becoming indispensible because yield under poly house cultivation can be achieved to the level of 5-8 times as compared to the open crop cultivation**.** Various trials conducted at agro research centers in northern India indicates that capsicum (planted in mid-September), cucumber (planting –mid October) and tomato (November planting) under poly house produced 1060kg, 1460 kg and 1530 kg per 100 square meter. The duration of these crops were 4-9 months and more than 90% of total yield were obtained during off-season (during winter before the start of summer) which fetches significantly higher market price (2-4 times than normal season).

Further, the crop duration can be extended up to the July –August with the application of micro irrigation and fertilization and yield can be achieved to the level of 20-25 kg/m^2. Therefore, it is possible to harvest a single crop round the year with minimum additional inputs and higher income can be generated with the adaptation of controlled agriculture.

As a plant grows it undergoes many changes, its development is solely dependent on the environmental conditions. This environment is made up of many different factors like light, temperature, soil moisture, humidity, pH etc. Specific plants require typical conditions for their growth, thus this project aims at providing an automated greenhouse monitoring and control system for the farmers in a very user friendly way. All these parameters are directly related to the growth and development of plant.

The greenhouse system is complex system; any significant change in one climate parameter could have an adverse effect on another climate parameter as well as the development process of plants. Therefore continuous monitoring and control of these parameters is required for the proper growth of plants. Temperature, humidity, light intensity, soil moisture and pH are the five most common factors that most growers pay attention to. So now a day's farmers require more user friendly platform to deal with issues that arise due to climate changes. Previous researchers have used sensors such as leaf temperature and leaf wetness sensor in conjunction with ambient temperature sensor and humidity sensors to investigate greenhouse's status. These methods were found to be impractical as wetness varies from leaf to leaf and by location of plant in greenhouse. In general the greenhouse system can be divided into two main components that interact in more or less strong way: internal atmosphere and soil conditions. Most of the growers and researches are interested in internal atmosphere of greenhouse and often neglect the importance of soil conditions. The absorption and transportation of water and nutrients are dependent on the condition of soil. Therefore it is very essential to maintain the temperature and moisture level in the soil at an optimum level in order to keep the plant healthy.

Therefore, the automation system proposed in this study is expected to create surplus value for both producers and national economy. Additionally, inside the greenhouse, crops will be protected against damages caused by rain, wind or other weather conditions. System maintains the reference values taken from built in crop growing condition [7].

Temperature influences most plant development process including photosynthesis, transpiration, absorption, respiration and flowering. In general, growth of any crop plant is significantly affected by temperature. Each species of plant has a different temperature range in which they can grow. Below this range, processes necessary for life stop, ice forms within the tissue, tying up water necessary for life processes.

Above this range, important plant enzymes become inactive and growth of plant stops. Therefore careful monitoring and controlling of temperature are essential in agriculture. [11, 12].

Humidity is also important parameter for plants growth because it partly controls the moisture loss from the plant. The leaves of plants have tiny pores, CO_2 enters the plants through these pores, and oxygen and water leave through them. Transpiration rates decrease proportionally to the amount of humidity in the air. This is because water diffuses from areas of higher concentration to areas of lower concentration. Due to this phenomenon, plants growing in a dry room will most likely lose its moisture overtime. The damage can be even more severe when the difference in humidity is large. Plants stressed in this way frequently shed flower buds or flowers die soon after opening. High humidity can also affect the development of plant. Under very humid environments, fungal diseases are most likely to spread; on top of that air becomes saturated with water vapour which ultimately restricts transpiration. Plants are exposed to high humid environment for a long period of time and may suffer deficiencies, hence monitoring of humidity also become important criteria. [15].

All things need energy to grow, human and animals get energy from food. Plants, on the other hand, get energy from sun light through a process called photosynthesis. This is how light affects the growth of a plant. Light also influences the growth of individual organs or of the entire plant in less direct ways. The most striking effect can be seen when a plant is grown in normal light and in the total darkness. The plant grown in the dark will have a tall and spindling stem, small leaves, and both leaves and stem, lacking chlorophyll, are pale yellow. Plants grown in shade instead of darkness show a different response. Moderate shading tends to reduce transpiration more than it does photosynthesis. Hence, shaded plants may be taller and have larger leaves because the water supply within the growing tissues is better. [13, 14].

Water is taken by the root system and lost through transpiring leaves. Evaporation from the leaves is the driving force for transfer of water across the plant and only a small proportion of the uptake water is used for growth. It was calculated that the water lost per day by transpiration from some plants is equal to twice the weight of the plant. The rate of water lost depends on the condition of soil, air flow, relative humidity in air and the temperature of the environment. Loss of water from the soil by means of drainage is quite common during the dry season. When absorption of water by the roots fails to keep up with the rate of transpiration, loss of turgor occurs, and the stomata close. This immediately reduces the rate of transpiration as well as photosynthesis. If the loss of turgor extends to the rest of the leaf and stem, the plant will eventually wilt. In more extreme cases burns may begin on the margin of leaves and spread inward affecting whole leaves. While necessary to point out the importance of having soils well moistened, it is also important for the growers to be aware of the effects of overly moist soil on the development of plants. [16].

A very careful attention is needed to be given to the pH value of the soil. Some plants require acidic conditions for their growth, so the required pH of the soil should be between 1to 6.9.

If proper attention is not paid to this factor, the growth of the plant is affected.

The objective of the proposed research work is to build a greenhouse monitoring and control system for farmers.

- This system can be used for monitoring of conditions required for proper growth of plants.
- The GLCD shows the variation of data which is acquired from RTC in dotted bar graph waveform which can be useful for analysis.
- All actions taken as per requirements and their effect will be stored in E^2PROM. It can be used for analysis.
- All the data stored in E^2PROM can be viewed with the help of UART on computer/laptop.

MATERIAL AND METHODS

Following table indicates threshold values for various parameters corresponding to different plants, which have to be maintained by our system.

Table. 1. Threshold values of various parameters.

Plant	Temperature	Light (lux)	pH	Soil Moisture (%)	Humidity (%)
Gerbera	30°C	900	6.0	58	50%
Cotton	26°C	700	7.5	65	80%
Rice	29°C	850	7	80	90%
Rose	30°C	650	6	58	50%
Sugarcane	38°C	950	6.5	72	63%
Tomato	26°C	650	6.8	65	65%
Onion	24°C	700	6.8	55	25%

PROPOSED METHOD

DETAILS OF COMPONENTS OF EACH BLOCK

MICROCONTROLLER-PIC18F452

Microcontroller used in this system was of Microchip PIC18F452, which is having Operating Frequency 40MHz; input is Analog/Digital Voltage. With low voltage requirement +5V. Total power dissipation by above microcontroller was 1.0W and having Voltage Operating Range VDD in between -0.3V to +7.5V. Microcontroller also has in built 10 bit ADC.

Five different types of Sensors are used in the above system, details of which are mentioned in the following table.

Table. 2. Detail of Sensor used

SENSOR USED	DESCRIPTION
LIGHT SENSOR (LDR)	• Manufacturer-NORP12 • Voltage, ac or dc peak-100V • Current-5mA • Power dissipation at 25°C-50mW • Operating temperature range--25°C +75°C
TEMPERATURE SENSOR (LM 35)	• Manufacturer-Texas Instruments • Rated for Full −55°C to +150°C Range • Operates from 4 to 30 V • Output voltage varies from-1V to 6V • Output Current = 10mA • Maximum o/p current sourced by any i/o pin=25mA
HUMIDITY SENSOR (SY-HS-220)	• Rated voltage is DC 5V • Operating temperature is 0-60 ^{0}C • Operating Humidity is 30~90%RH • Storage Humidity is within 95% RH • Accuracy is ±5%RH(at 25^{0}C, 60 % RH)
SOIL MOISTURE SENSOR (FC-28-D)	• Power supply: 3. 3v or 5v • Output voltage signal: 0~4. 2v • Current: 35mA • Pin definition: Analog output (Blue wire) GND Black wire) Power(Red wire) • Size: 60x20x5mm
pH sensor	• Combined Electrode • Inbuilt reference electrode

CIRCUIT DIAGRAM OF GREENHOUSE MONITORING AND CONTROL SYSTEM

So as to avoid the bulkiness of the circuit, we separated the main (microcontroller) circuit and the relay circuit, whereas solar inverter is totally isolated from these two.

MAIN CIRCUIT

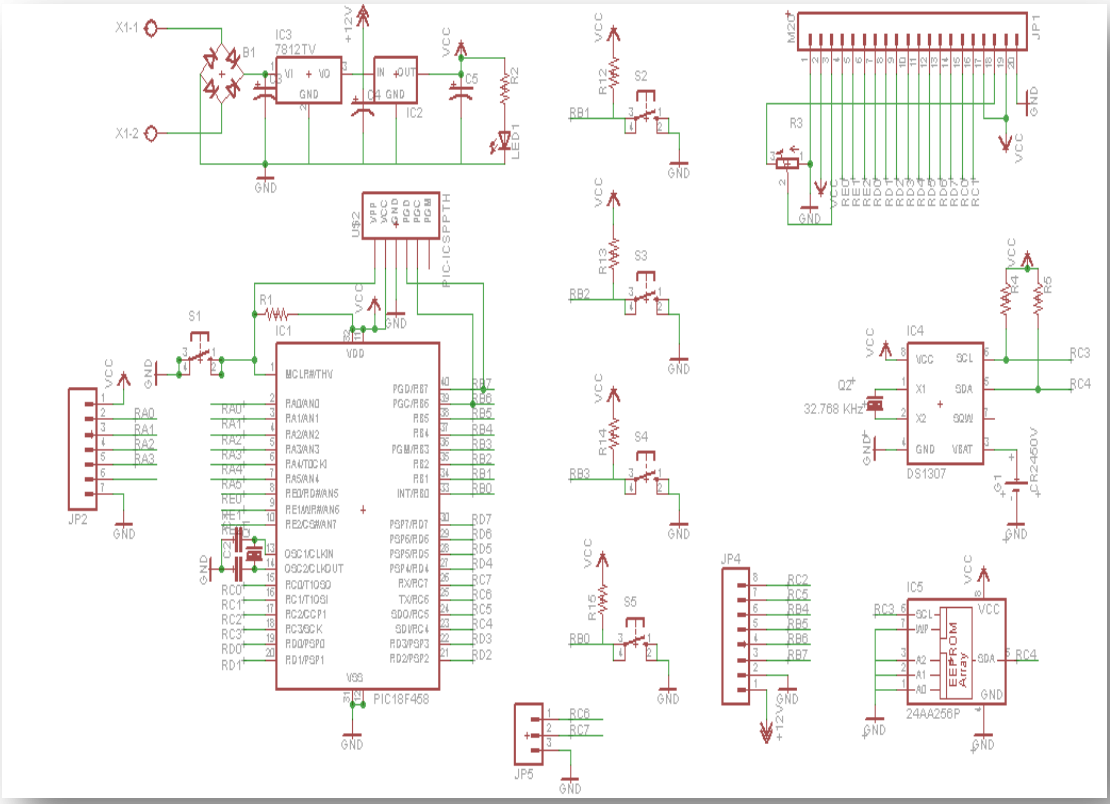

Figure. 1. Main circuit (Controller Board)

We have used a power supply of 5V, but in power supply design we will first step down 230V to 12V using LM7812 and then 12V will be stepped down to 5V using LM7805. We require 12V because at the output side we have used relays whose ratings are 12V, 5A. From the above circuit diagram it is quite evident that we have connected 5 sensors to 5 different ADC channels of PIC18F452. We have interfaced temperature sensor (LM35D) to ADC channel 0, Light sensor (LDR) to ADC channel 1, Soil Moisture sensor to ADC channel 2, pH sensor to ADC channel 3 while Humidity sensor (SY HS 220) to ADC channel 4 of the micro controller.

We are using 10 MHz crystal oscillator for PIC, which is used to clock. A reset button is connected to the MCLR pin of PIC. The circuit also consists of ICSP pins which are connected to the controller for the sake of programming. There are 4 push buttons which are connected to RB0 to RB3 pins of controller for plant selection and graph view purpose.

Pins RC3 and RC4 of the controller corresponding to serial clock and serial data are connected to I2C based E^2PROM and RTC. As per property of I2C, we can connect multiple devices to I2C pins of controller. The RTC uses a 3V battery and a standard 32.768 KHz oscillator. Pins RC6 and RC7 are connected to the UART USB module to view the data stored on E^2PROM on laptop/PC. Pins 1, 3, 18 of the GLCD are connected to a pot to adjust the contrast of GLCD. Various pins from ports E, D and C of controller are connected to the GLCD.

Pins corresponding to RC2, RC5, RB4, RB5, RB6 and RB7 are connected to the relay board.

RELAY BOARD

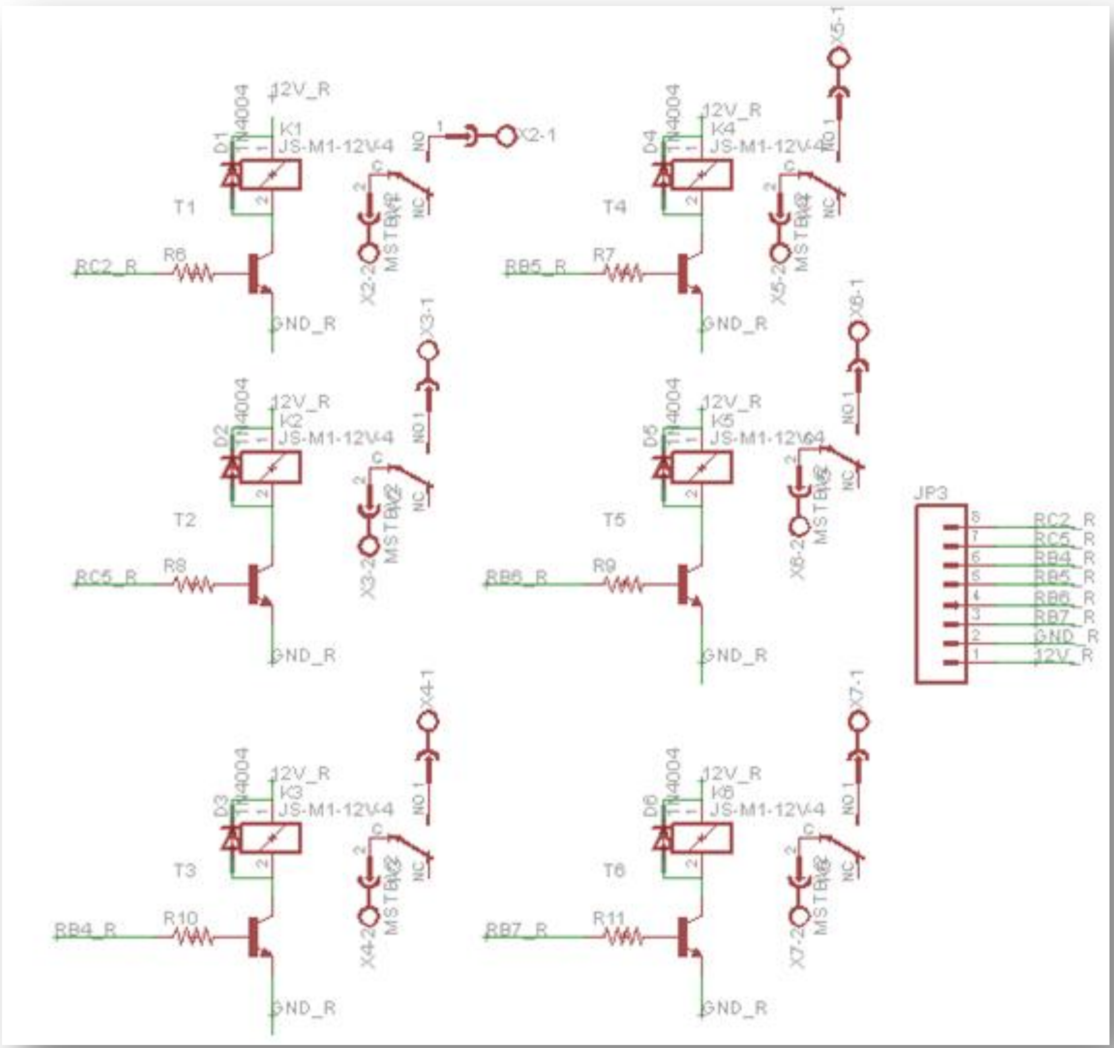

Figure. 2. Relay Board

The PCB of relay board is separate from the main PCB because we have used 6 relays and thus there will be more amount of current taking part.
Various devices like cooling fan, exhaust fan, heating element, water pump, Bulb and heating coil will be connected to the relays for the purpose of control actions.

SOLAR INVERTER CIRCUIT

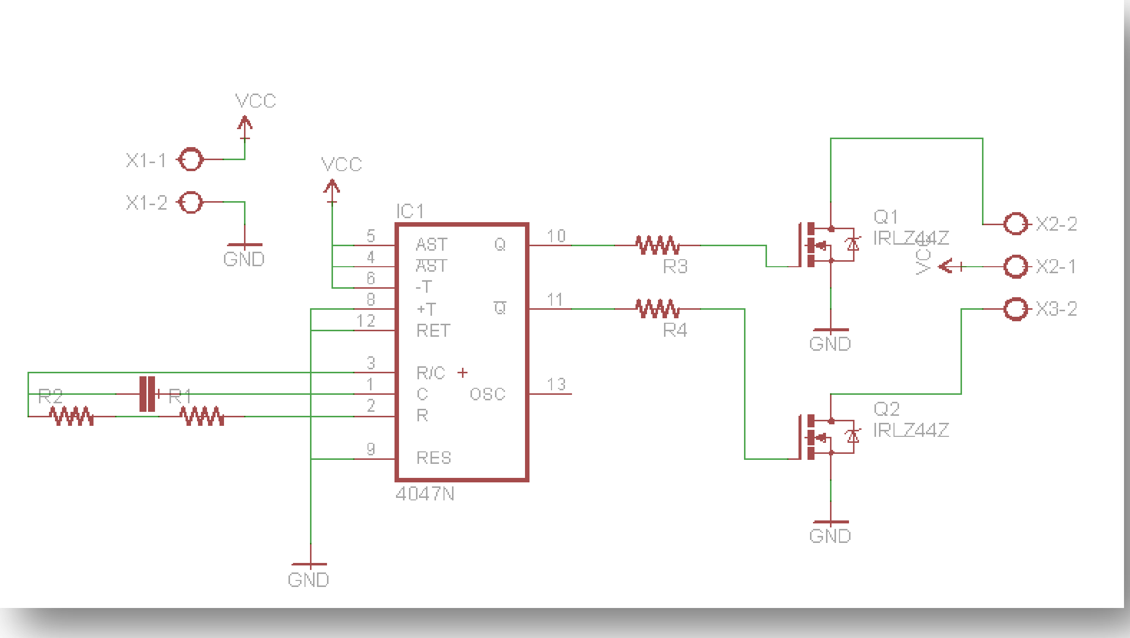

Figure. 3. Solar inverter circuit

The solar inverter circuit is totally different PCB from the above mentioned PCB's. In solar inverter circuit we have used astable Multivibrator CD4047 to get a square wave output of frequency 50Hz.
We get these waves from both Q and Qbar outputs of astable multivibartor. These will be given as inputs to the two power MOSFETS IRFZ44, which will act as a driver to the transformer circuit (primary winding). We need to set the frequency so as to get a 50Hz output.
The frequency depends on the values of R and C and its formula is given by:
f = 1/4. 4RC
In the above equation if we substitute R = 1K + 18K = 19K and C = 0. 22uF
We get f = 54.7Hz which can be approximated as 50Hz.
IRFZ44 is selected as it is cheap and can be used for higher voltages as well.

PCB LAYOUT OF GREENHOUSE MONITORING AND CONTROL SYSTEM:

In PCB layout, the tracks corresponding to supply and ground are 1.27mm in width because they carry more amount of current as compared to the other pins. All other tracks are of width 0.6-0.8mm depending on the amount of current that will be flowing through it.

The dotted line on the PCB layout corresponds to the ground polygon. In this all the ground pins are given ground simultaneously through this polygon. The grounded polygon can be checked by using ratsnest option in PCB editor of Eagle. Different pads as used for different tracks depending on the amount of current flowing through it.

We have designed PCB layouts for main circuit, relay board and solar inverter circuit.

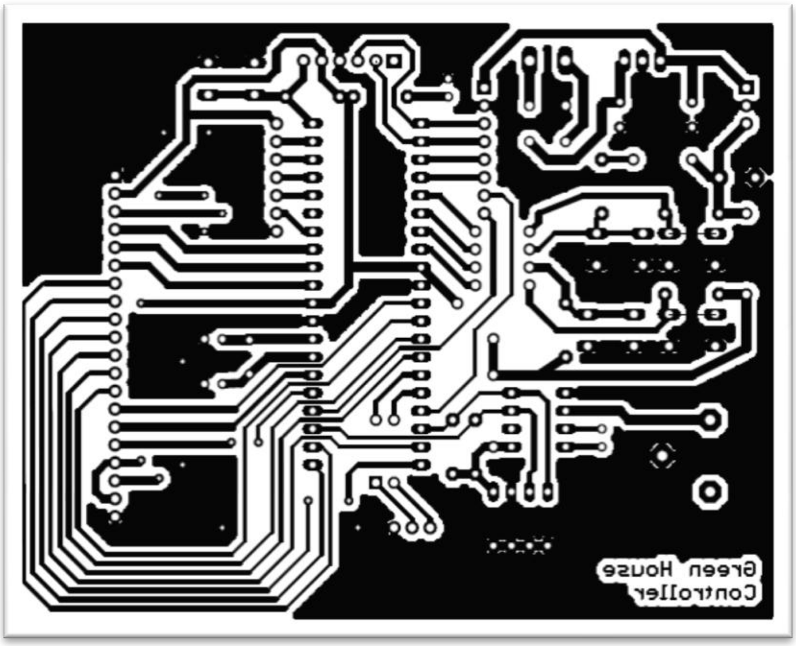

Figure. 4. Main circuit PCB

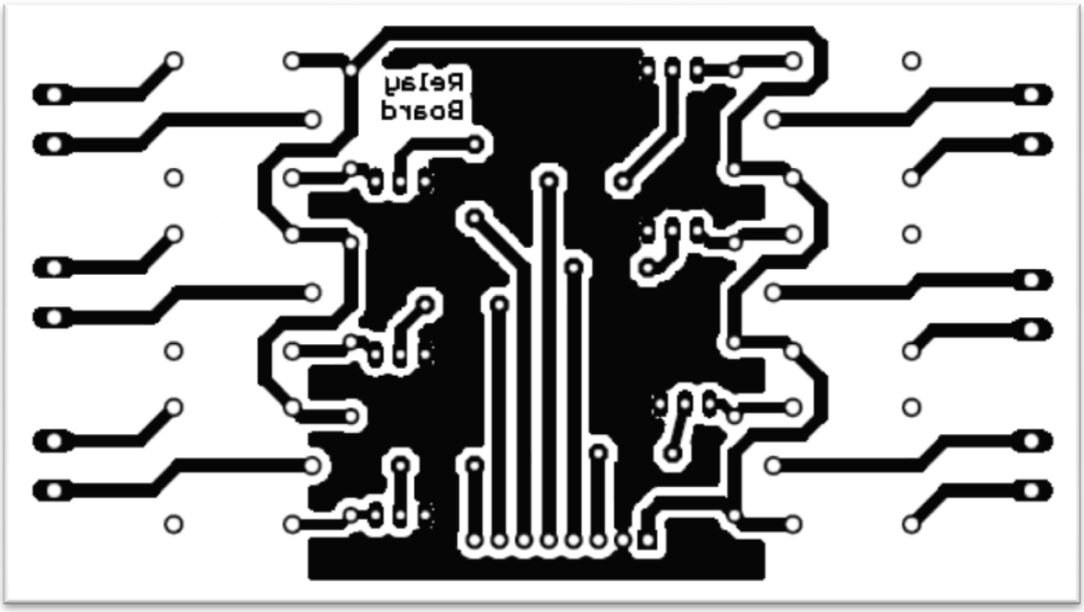

Figure. 5. Relay circuit PCB

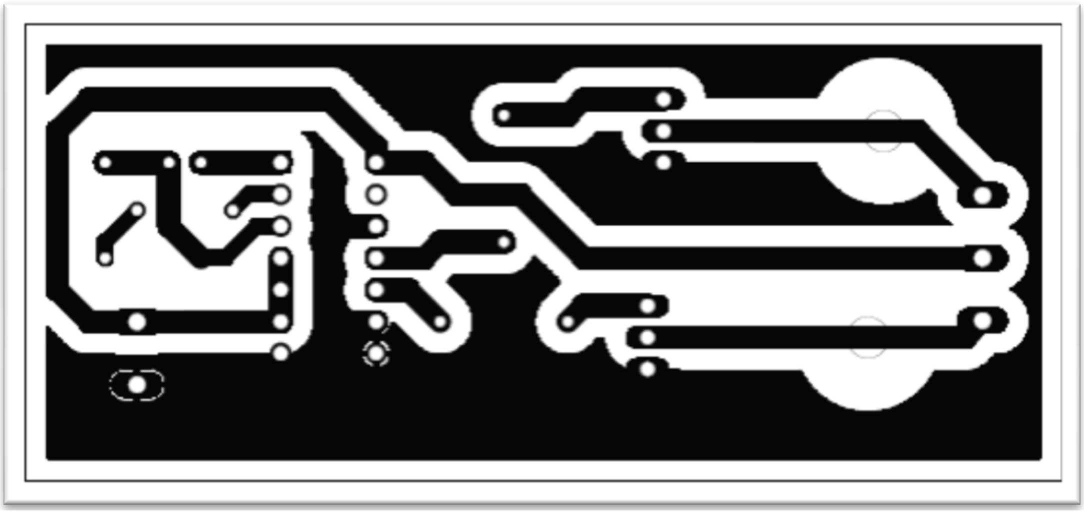

Figure. 6. Solar inverter PCB

SOFTWARE USED FOR DESIGN OF GREENHOUSE MONITORING AND CONTROL SYSTEM

MPLAB IDE

MPLAB IDE is a Windows® Operating System (OS) software program that runs on a PC to develop applications for Microchip microcontrollers and digital signal controllers.

It is called an Integrated Development Environment, or IDE, because it provides a single integrated “environment” to develop code for embedded microcontrollers. MPLAB IDE runs on a PC and contains all the components needed to design and deploy embedded systems applications. A development system for embedded controllers is a system of programs running on a desktop PC to help write, edit, debug and program code – the intelligence of embedded systems applications – into a microcontroller.

EAGLE v7. 1. 0

EAGLE is a powerful graphics editor for designing PC board layouts and schematic. Eagle 7. 1. 0 combines circuit simulation, animated components and microprocessor models to co-simulate the complete microcontroller based designs. This is the perfect tool for engineers to test their microcontroller designs before constructing a physical prototype in real time. This program allows users to interact with the design using on-screen indicators and/or LED and LCD displays and, if attached to the PC, switches and buttons.

WORKING OF GREENHOUSE MONITORING AND CONTROL SYSTEM

When the supply of 5V is given to the controller, it enables itself. All the sensors namely temperature, light, soil moisture, humidity and pH get activated and give output in terms of voltage to the controller. Firstly the ADC initialization will take place for the conversion of analog signals to digital. I2C initialization will take place immediately that means all the devices which are connected to the controller via I2C pin will get initialized. Here we have used DS1307 and AT24512C (E^2PROM) on I2C pins. After I2C there will be initialization of keys (that we have used for plant selection and changing of window) and the relays (which are used for switching on/off output devices). At the last there will be initialization of GLCD and the menu will appear on the main screen of GLCD.

System have provide with 4 keys for various functions, out of which first 3 keys are for plant selection purpose and last key that is the key (0) is for changing the monitoring window to the graph. Each of the first 3 keys corresponds to a plant. Like 1st key corresponds to “Gerbera”, 2nd key corresponds to “Rose”, 3rd key corresponds to “Tomato”. For each plant specific threshold limits for 5 different parameters are stored. Whenever a key from 1 to 3 is pressed, the respective plant will get selected and thresholds corresponding to the plant will be set accordingly. After a key is pressed to select a plant, plant monitoring window will appear after 7s as programmed and thus after 7s monitoring of that plant will take place. In our project along with monitoring and controlling, we are also providing analysis part in the form of graph which will be displayed on the GLCD through key (0).

This key (0) is activated through the external interrupt of the controller. External interrupt is initialized only after the monitoring window as initializing it before plant selection would cause the system to hang. It means key (0) will be of no use before plant monitoring. For the graph the readings from the sensors are to be wrote to the E^2PROM after certain time duration, we have given it as 5 min. That means after every 5 min a packet will be wrote on E^2PROM. Here a packet means an array which consists of data of temperature, light, soil moisture, humidity and pH also the date and time. After the monitoring part comes the controlling part. As mentioned earlier we have set certain thresholds for various parameters for a plant, to maintain these parameters inside a greenhouse we need a proper controlling mechanism.

Through program we have provided a buffer to temperature threshold of-2^0C to +2 ^{0}C, it means if a plant has a threshold of 30^0C, then the temperature of that plant within the greenhouse would be maintained between 28^0C to 32^0C. For humidity we have given a buffer of-5^0C to +5^0C. Thus when the temperature goes above the threshold, relay (1) will turn ON thus enabling the cooling FAN connected to it. It will remain ON till the temperature goes below the threshold. When the temperature goes below the minimum threshold, relay (2) will turn ON thus enabling the heating element/device connected to it. Similarly when light intensity falls below a certain threshold then relay (3) will be turned ON and thus the BULB connected to the relay will be turned ON. Whenever the controller detects soil moisture less than the required, it will turn ON relay (4) and thus the water pump connected to it will get activated, it will remain ON till the soil moisture crosses the threshold set. When the humidity falls below the threshold, small coil connected to the relay (5) will be turned ON till it crosses the threshold. In case of having the humidity more than required, EXHAUST FAN which is connected to relay (6) will be turned till it reaches the lower limit.

We have also provided communication facility to transmit the data stored on E^2PROM to laptop/PC through UART to USB module. To run it completely we require device driver as well as software to see the data stored on E^2PROM. So as to display the stored data on E^2PROM in DATE, TIME and PARAMETER format we have given programming instructions about these 3 things in E^2PROM function.

ANALYSIS

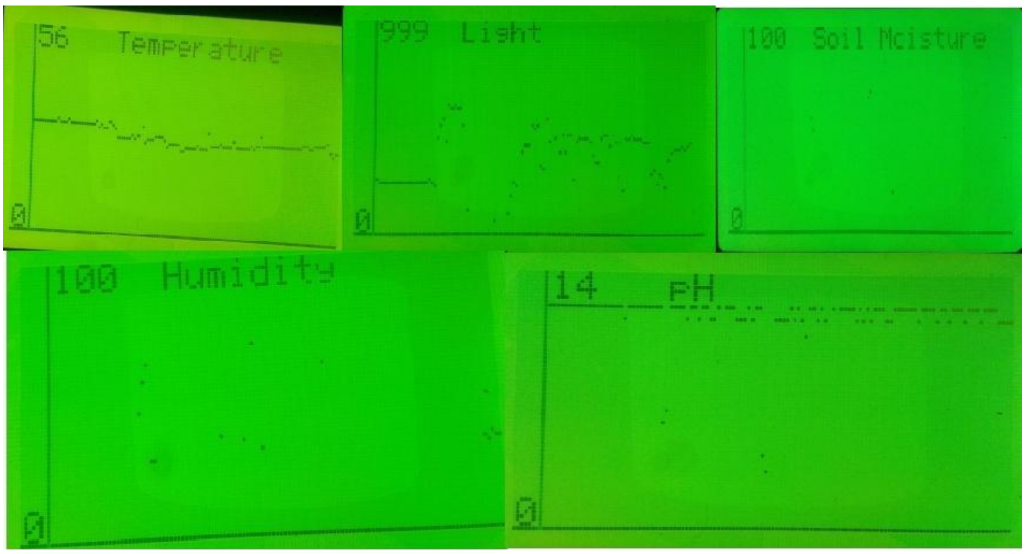

Figure. 7. Analysis of Variables

The above graphs were plotted on GLCD for the sake of analysis. It was observed that the system temperature varied during daytime. The temperature ranges between 32 to 37^{0}C, during night it was 22 to 27^{0}C. Likewise other parameters also varied and their value has been reflected on the analysis graph that is mentioned as above.
More detail analysis was provided by the data transmission through UART. The data stored on E^{2}PROM was viewed on laptop through UART to USB module, and it showed the variations in parameters with respect to date and time.

BLOCK DIAGRAM SYSTEM

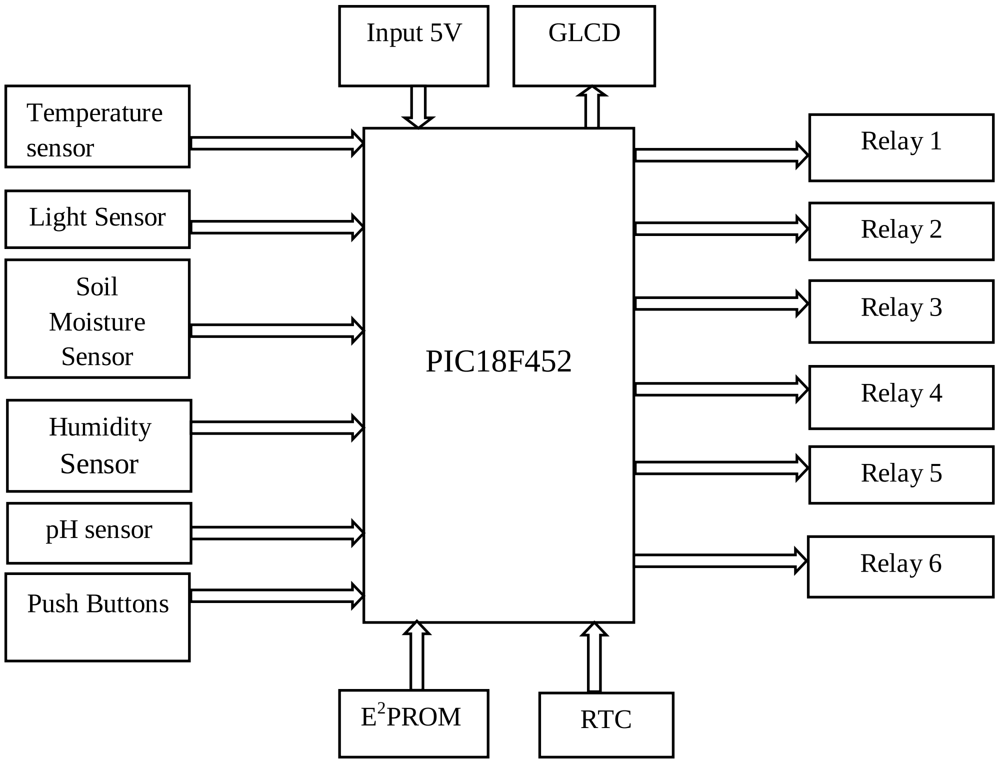

Figure. 8. Block diagram of overall circuit.

SOLAR PANEL

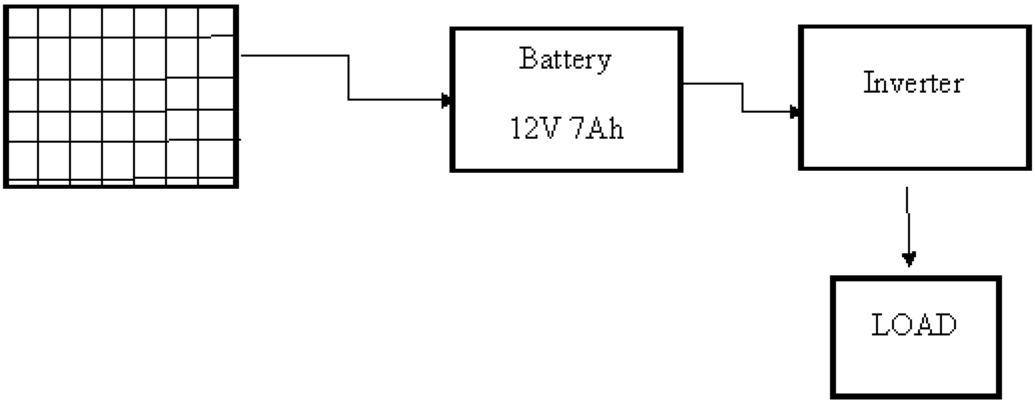

Figure. 9. Block Diagram of Solar Inverter

CONCLUSION

The present study provides a reliable **Greenhouse Monitoring and Control System,** having wide application in agriculture. In this system the sensor side acts like a data acquisition unit that is capable of measuring five different parameters like temperature, light, humidity, soil moisture and pH. The main part is the controller which carries out various tasks like collection, data storage, data processing and greenhouse climate adjustment. Also, the database of various plants which is already stored in our system containing the necessary climatic conditions needed for proper growth of those plants will be very useful in increasing yield of crop plants. With graphs provided and E^2PROM data, analysis will be very easily done and thus required changes can be implemented in system.

Thus the proposed system providing real time application and is beneficial for farmers of many developing countries like India.

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