GOA COLLEGE OF ENGINEERING
FARMAGUDI, GOA

DEPARTMENT OF ELECTRONICS & TELECOMMUNICATION ENGINEERING

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OPTIMIZING THE PERFORMANCE OF CONTROLLED ENVIRONMENT AGRICULTURE USING MODERN TECHNIQUES

by

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A project submitted
in partrial fulfilment of the requirements
for the degree of
Bachelor of Engineering
in
Electronics and Telecommunication Engineering
GOA UNIVERSITY

under the guidance of

Prof. Devendra Sutar
Assistant Professor,
Electronics & Telecommunication Department
Goa College of Engineering

CERTIFICATE

This is to certify that the project entitled

"OPTIMIZING THE PERFORMANCE OF CONTROLLED ENVIRONMENT AGRICULTURE USING MODERN TECHNIQUES"

submitted by

Enola Picardo	**(P.R. No.:201305995)**
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has been successfully completed in the academic year 2016-2017 as a partial fulfilment of the requirement for the degree of BACHELOR OF ENGINEERING in Electronics and Telecommunication Department, at Goa College of Engineering, Farmagudi.

_____ _____

(Internal Examiner) (External Examiner)

Place: Farmagudi, Ponda, Goa
Date:

PROJECT APPROVAL SHEET

The project entitled

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completed in the year 2016-2017 is approved as a partial fulfilment of the requirements for the degree of **BACHELOR OF ENGINEERING in Electronics and Telecommunication Engineering** and is a record of bonafide work carried out successfully under our guidance.

_____

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Dr. R. B. Lohani
Goa College of Engineering

Place: Farmagudi, Ponda, Goa
Date:

Acknowledgement

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We sincerely thank the Directorate of Agriculture, Government of Goa for providing us the opportunity to embark on this project. We wish to express our gratitude to **Mr. Pritam Patil** for permitting us to implement the project in his greenhouse. We thank the staff at Zonal Agricultural Office, Ponda for their guidance and constant support in carrying out the project work.

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Abstract

Agriculture is the backbone of Indian Economy. Most agricultural practices in India are neither economically nor environmentally sustainable. Adoption of modern agricultural practices and use of technology is inadequate, hampered by ignorance, high costs and impracticality. Thus, our project aims to put in place, a system that efficiently utilizes the available resources and introduces the accuracy, precision, reliability and efficiency of the modern technology in farming.

The motive of the project is to automate the irrigation system in a farm by constantly monitoring the various concerned soil parameters and the quality of water. The project also aims to keep a track of the climatic conditions like temperature and humidity and maintain them at a level conducive to plant growth and develop an application that will keep the farmer informed, at all times, about the activities in the farm. The system will thus assist the farmer in creating an artificial environment to grow the crop of his choice without any seasonal constraints. It reduces labour and thereby human errors. While such systems are already in existence, the project aims to develop a cost-effective system with minimum probability of failure.

Chapter 1

Introduction

1.1 Preamble

The project proposes to automate various agricultural processes like irrigation, fertigation, humidity control, temperature control and day-night control within a greenhouse. The system has been developed taking into consideration the requirements of Chrysanthemum plant. Climatic conditions in Goa are not conducive to the growth of this plant all round the year. Thus, an artificial environment is created that facilitates its growth. The automated irrigation system consists of soil moisture sensors which monitor the soil moisture and notify the micro-controller to activate the solenoid and irrigate the plants using drip pipes. Humidity control and temperature control is achieved using humidity and temperature sensors respectively. Fertigation system is automated through the use of software timers. Day-night control system manipulates the length of the day and night in accordance with the plant requirements. Finally, an application will keep the farmer informed about the proceedings

in the farm. Thus, the project aims to put in place a system to increase the production and profits in an environmentally sustainable and economically viable manner.

1.2 Motivation

Agriculture has been the backbone of human existence since time immemorial. However, the agricultural practices carried out in India are still largely traditional. These practices are carried out using simple and conventional tools and implements like wooden plough, sickle etc. Little or no use of machines is made. However, efficiency of traditional methods is hampered by various factors. They do not ensure optimum and sustainable utilization of resources. Their heavy dependence on labour makes them unreliable. Moreover, adoption of technology in farming has lagged owing to farmers' misconception that high level of technical expertise is required.

In the recent past, there has been an effort to introduce modern techniques in agriculture. However, these are limited to using timers and counters to perform specific tasks as instructed by the farmers and manipulating environmental conditions based on real time inputs is not much exploited. Hence, this project makes an effort to utilize real time inputs to increase the production efficiency in a sustainable manner.

1.3 Objective

- To automate the irrigation system by constantly monitoring the soil moisture.
- To maintain the temperature at a level favourable for plant growth by putting in place

a cooling system.

- To meet the plant humidity requirement through the use of foggers.
- To automate the fertigation system.
- To create artificial day and night conditions for optimum plant growth.
- To develop an application for keeping the farmer informed, at all times, about the activities in the farm.

Chapter 2

Literature Review

2.1 Currrent Scenario

Today, India ranks second worldwide in farm output. Demand for agriculture is rising rapidly with increase in population and per capita income. However, the agricultural practices carried out in India are still largely traditional. Hence, efforts are being made to force a fundamental shift from the traditional methods to modern techniques.

The papers published in various journals regarding the introduction of automation in agriculture were referred to develop this project.

2.1.1 Papers Studied

- **Design of Automated Irrigation System**

  Author: Marie France Leroux

Institution: McGill University

Journal: NABEC Student Paper Presentation

Overview: A design is proposed for residential environment. It is made of reliable parts and has a relatively low cost. Its different sections have been simulated and tested and their effectiveness in reducing water consumption and human intervention has been demonstrated. The design is also resource-efficient by itself by consuming low power. However, much more testing on the system as a whole must be conducted to measure the real water and labour savings.

- **Automation of Irrigation System Using ANN based Controller**

  Author: S. Muhammd, Umair R. Usman

  Institution: National University of Science and Technology, Pakistan

  Journal: International Journal of Electrical & Computer Sciences Vol: 10 No: 02

  Overview: This paper has described a simple approach to Irrigation control problem using Artificial Neural Network Controller. The proposed system is compared with ON/OFF controller and it is shown that ON/OFF Controller Based System fails miserably because of its limitations. On the other hand, ANN based approach has resulted in possible implementation of better and more efficient control. These controllers do not require a prior knowledge of system and have inherent ability to adapt to the changing conditions unlike conventional methods. It is noteworthy that ANN based systems can save a lot of resources(energy and water)and can provide optimized results to all types of agricultural areas.

- **Implementation Of Agricultural Automation System Using Web & GSM Technologies**

  Author: Vidadala Srija1, P. Bala Murali Krishna

Institution: Sri Mittapalli Institute of Technology for Women, A.P, India

Journal: International Journal of Research in Engineering and Technology

Overview: This project probes into the implementation of agricultural automation system using WEB and GSM technologies. The aim of this embedded project is to design and develop a low cost system which is based on embedded platform for agricultural automation. Optimum usage of water is the main objective of this system. This project uses soil moisture sensor to detect the water quantity present in the soil and water level sensor is used for detecting water level in the tank. In this system, status of the sensors is monitored through WEB and GSM technologies. Here temperature, soil moisture and water level can be monitored on a web page through micro-controller and information will be sent by SMS.

- **Water-Saving Irrigation System Based on Automatic Control by Using GSM Technology**

  Author: K.S.S. Prasad, Nitesh Kumar, Nitish Kumar Sinha and Palash Kumar Saha

  Institution: Department of EEE, Bharath University, Chennai, India

  Journal: Middle-East Journal of Scientific Research 12 (12): 1824-1827, 2012

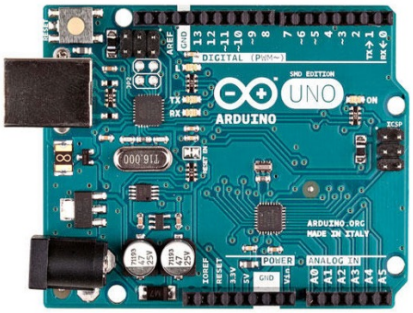
  Overview: Embedded system for automatic irrigation of an agricultural field offers a potential solution to support site specific irrigation management that allows producers to maximize their productivity while saving water. The project is designed using ARM 7 microcontroller. The temperature and humidity sensors detect the environmental conditions and send them to the base station. The base station checks the conditions for irrigation and performs automatic irrigation. Field condition is specifically monitored by the base station. Each field station wirelessly communicates with a base station by GSM technology.

2.1.2 Conclusion of Papers Studied

Detailed study of the above mentioned papers brought us to the conclusion that taking real time inputs improves the system performance significantly as opposed to the prior knowledge-based systems. It was inferred that water saving and optimum power consumption are of utmost importance in any system that aims to automate agriculture. WEB and GSM technologies could be used as an effective communication interface between the agricultural site and the farmer. A system that integrates the discrete features mentioned above was then designed.

2.2 Components Studied

2.2.1 Arduino Board with Atmega 328 Microcontroller

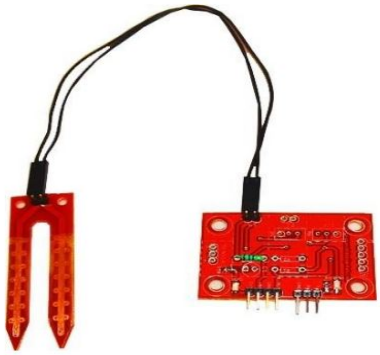


Arduino/Genuino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button.

It contains everything needed to support the microcontroller; it can simply be connected to

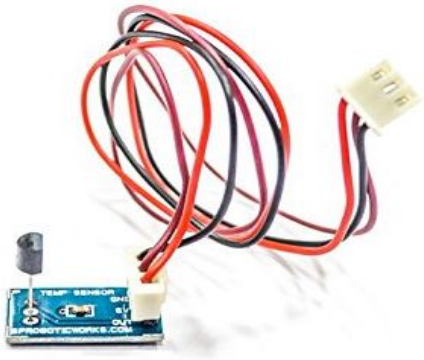
a computer with a USB cable or an AC-to-DC adapter or a battery to get started.[7]

2.2.2 Moisture Sensor



Moisture sensor is a device that provides an output voltage proportional to the soil moisture content. The two probes of the sensor act as a variable resistor; more water in the soil means better conductivity which results in a lower resistance and hence a higher voltage output. The sensor consists of three major pins-VCC, GND and OUT. Supply voltage at the VCC pin must be in the range 3.3-5V. The voltage at the OUT pin will be between almost VCC and GND, depending on the amount of water in the soil.[14]

2.2.3 Temperature Sensor(LM35)



The Temperature Sensor LM35 series are precision integrated-circuit temperature devices with an output voltage linearly proportional to the Centigrade temperature. It provides typical accuracies of +/- 0.25 degree Celcius at room temperature and +/- 0.725 degree Celcius over a full 55 degree Celcius to 150 degree Celcius temperature range.

Technical Specifications:

o Calibrated directly in Celsius (Centigrade)

o Linear +10mV/degree Celcius scale factor

o 0.5 degree Celcius ensured accuracy (at 25 degree Celcius)

o Rated for full 55 degree Celcius to 150 degree Celcius range

This sensor has three terminals: VS, VOUT and GND. An analog voltage proportional to the existing temperature is obtained on the pin VOUT. Supply voltage is given to the sensor between the pins VS and GND.[9]

2.2.4 Humidity Sensor(DHT-22)

The DHT-22 (also named as AM2302) is a digital-output, relative humidity, and temperature sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and sends a digital signal on the data pin.

Technical Specifications:

o Power: 3-5V

o Max Current: 2.5mA

o Humidity: 0-100percent, 2-5percent accuracy

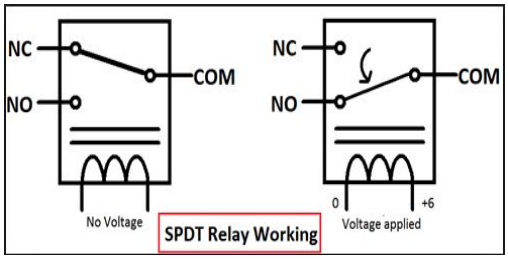
o Temperature: -40 to 80 degree Celcius, 0.5 degree Celcius accuracy

DHT22 sensor has four terminals VCC, DATA, NC, GND. Voltage proportional to the existing humidity or temperature is obtained on the pin DATA. Supply voltage is given to the sensor between the pins VCC and GND.[17]

2.2.5 Solenoid(2W-220V AC-1/2inch)

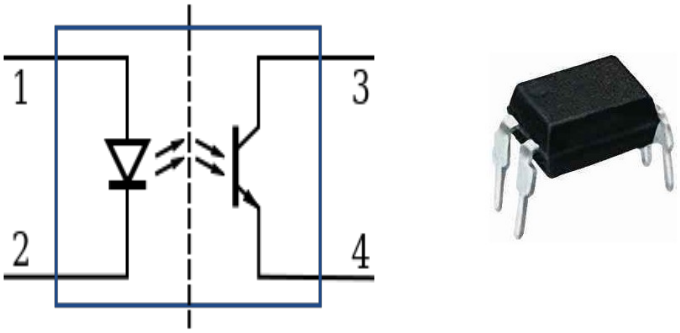
A solenoid valve is an electromechanically operated valve. The valve is controlled by an electric current through the solenoid. In a two-port valve the fluid flow is switched on or off. If the valve is open, then the two ports are connected and fluid may flow between the ports; if the valve is closed, then the ports are isolated.[18]

2.2.6 Relay



A relay is an electrically operated switch. Relays are used where it is necessary to control a circuit by a separate low-power signal, or where several circuits must be controlled by one signal. The relay consists of five terminals: COMMON, NC, NO and two coil terminals. The voltage to be provided at the output is connected to the COMMON terminal. In the OFF condition, when the relay coil is not powered, COMMON remains connected to NC terminal. In the ON condition, when the relay coil is powered, COMMON switches from NC to NO and the voltage is now available at the output.[19]

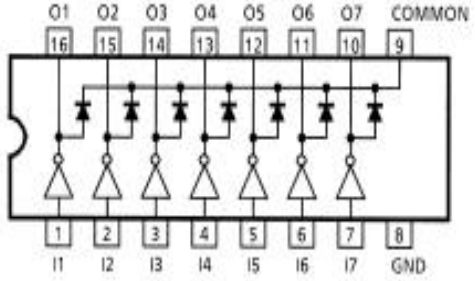
2.2.7 Opto-isolator(LTV-846)

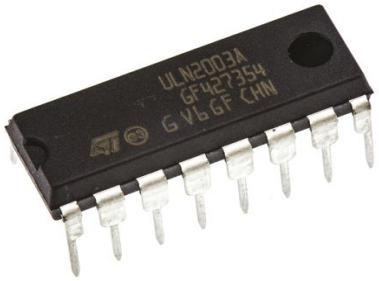


An opto-isolator is a component that transfers electrical signals between two isolated circuits by using light. Opto-isolators prevent high voltages from affecting the system receiving the signal. Commercially available opto-isolators withstand input-to-output voltages up to 10kV. A common type of opto-isolator consists of an LED and a phototransistor in the same opaque package. Other types of source-sensor combinations include LED-photodiode, LED-LASCR, and lamp-photresistor pairs.[20]

2.2.8 Relay Driver IC(ULN 2003)

ULN2003A is an array of seven NPN Darlington transistors capable of 500mA, 50V output. It features common-cathode flyback diodes for switching inductive loads.[28]





A Darlington transistor (also known as Darlington pair) achieves very high current amplification by connecting two bipolar transistors in direct DC coupling so the current amplified by the first transistor is amplified further by the second one. The resultant current gain is the product of those of the two component transistors.

The seven Darlington pairs in ULN2003 can operate independently except the common cathode diodes that connect to their respective collectors.[28]

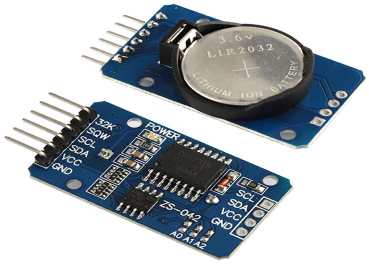
2.2.9 Digital I/O Port Expander(MCP23017)

MCP23017 provides 16-bit, general purpose parallel I/O expansion for I2C bus applications. It consists of multiple 8-bit configuration registers for input, output and polarity selection. The system master can enable the I/Os as either inputs or outputs by writing the I/O configuration bits (IODIRA/B). The data for each input or output is kept in the corresponding input or output register. The polarity of the Input Port register can be inverted with the Polarity Inversion register. All registers can be read by the system master.[11]

2.2.10 Analog Multiplexer/Demultiplexer(4051)

A multiplexer or demultiplexer allows to expand the inputs and outputs on the Arduino board. The 4051 is an eight channel analog multiplexer/demultiplexer. Thus, when used as a multiplexer, one can choose between eight different inputs and select just one to read at a time. On the other hand, when used as a demultiplexer, one can choose between eight different outputs and select just one to write at a time. Furthermore, 4051 is able to work with analog values; in case of Arduino, one can use the analog inputs with a voltage between 0-5V and route them to an Analog-In Pin on the Arduino.[10][25]

2.2.11 Real Time Clock(DS3231)

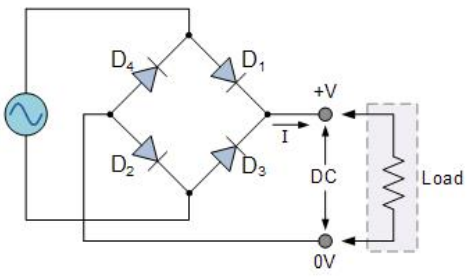


A Real Time Clock is a computer clock (most often in the form of an integrated circuit) that keeps track of the current time. RTCs are present in almost any electronic device which needs to keep accurate time[23]. This RTC module contains DS3231 IC which is an extremely accurate real time clock (RTC) IC with an integrated temperature compensated crystal oscillator. The device incorporates a battery input, and maintains accurate timekeeping when main power to the device is interrupted. RTC maintains seconds, minutes, hours, day, date, month, and year information[12]. The date at the end of the month is automatically adjusted for months with fewer than 31 days, including corrections for leap year. Two programmable time of day alarms and a programmable square wave output are provided. Address and data are transferred serially through an I2C bidirectional bus.[21]

2.2.12 Step-down Transformer(12V,3A)

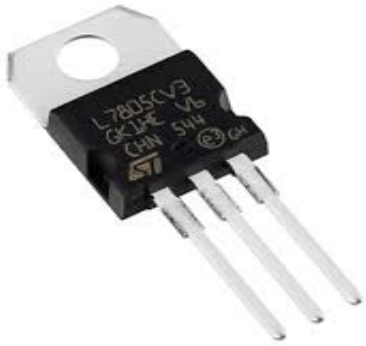
Transformer is a device that changes/transforms the voltage of power supplied to meet the individual needs of power consumers. It uses the principle of electromagnetic induction. A transformer is made of a soft iron core with two coils wound around it, but not connected with one another. The coil to which the alternating voltage is supplied is known as primary winding or primary coil. The alternating current in the primary winding produces a changing magnetic field around it whenever an alternating potential is supplied. An alternating current is in turn produced by the changing field in the secondary coil and the amount of current produced depends on the number of windings in the secondary coil. In a step-down transformer, secondary windings are fewer than the primary windings. In other words, the secondary voltage is less than the primary voltage. So, the transformer is designed to convert high-voltage, low-current power into a low-voltage, high current power.[28]

2.2.13 Bridge Rectifier(BR1010)



A bridge rectifier is an arrangement of four or more diodes in a bridge circuit configuration which provides the same output polarity for either input polarity. It is used for converting an alternating current (AC) input into a direct current (DC) output. A bridge rectifier provides full-wave rectification from a two-wire AC input.

2.2.14 Voltage Regulators(7805 and 7808)



Voltage sources in a circuit may have fluctuations resulting in not giving fixed voltage outputs. Voltage regulator IC maintains the output voltage at a constant value. 7805 IC, a voltage regulator integrated circuit (IC) is a member of 78xx series of fixed linear voltage regulator ICs used to eliminate such fluctuations. The xx in 78xx indicates the fixed output voltage it provides. 7805 IC provides +5 volts regulated power supply with provisions to add heat sink as well. Similarly, 7808 IC provides +8 volts regulated power supply.[24]

2.2.15 Wiper Motors

The electric wiper motor is a permanent magnet, rotary electric motor. It offers high torque at constant speeds and has multiple speed settings. This project utilizes two wiper motors

to implement the day-night control system. Their voltage and current requirements are 12V and 3A respectively.

2.2.16 Pump(1/2 HP)

A pump is a device that moves fluids by mechanical action. This project utilizes a pump to meet the pressure requirements of the irrigation system and the fogger(humidity-control system).

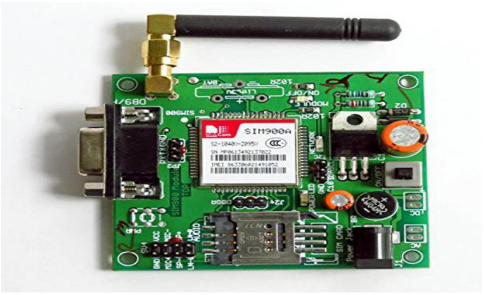
2.2.17 Fogger

A fogger is any device that creates a fog. It uses high pressure to spray tiny water droplets and thereby increases the humidity within the greenhouse.

2.2.18 Fan

Fan makes up the cooling system and is used in conjunction with the fogger to reduce the temperature within the greenhouse.

2.2.19 GSM Module



GSM/GPRS module is used to establish communication between a computer and a GSM-GPRS system. Global System for Mobile communication (GSM) is an architecture used for mobile communication in most of the countries. Global Packet Radio Service (GPRS) is an extension of GSM that enables higher data transmission rate. GSM/GPRS module consists of a GSM/GPRS modem assembled together with power supply circuit and communication interfaces (like RS-232, USB, etc) for computer.[29]

Chapter 3

Implementation

The system developed in this project meets the requirements of the chrysanthemum plants.

Chrysanthemum Plant Requirements:

- Water: 5-7 litres per square meter per day.
- Temperature: 17-28 degree Celsius.
- Humidity: Around 40%
- Day and Night conditions: Initial stages of growth require long days. Later stages of growth require short days.[16]

Nevertheless, this system can be adopted to grow other plants as well by changing a few parameters in the software.

3.1 Hardware Design

The sub-systems are as follows:

3.1.1 Irrigation System

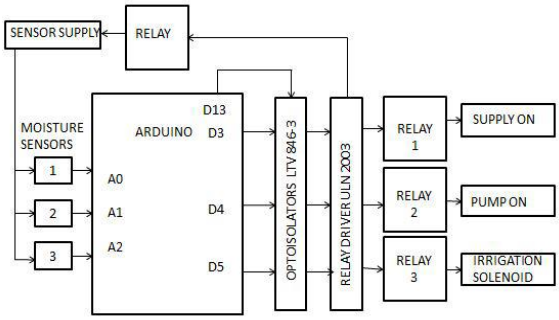


Figure 3.1: Irrigation System

It consists of a network of moisture sensors that provide an output voltage proportional to the soil moisture level. The sensors notify the micro-controller when the soil moisture level drops below a pre-defined threshold(set in accordance with the chrysanthemum requirements). Digital pin13 of Arduino is set when we wish to read from the sensors. This activates a relay(R11) that powers the sensors. The sensor inputs are read at Analog pins A0, A1, A2 and compared with the threshold. If necessary, pins D3, D4, D5 are set, thus activating the relays R1, R2, R3 which will in turn put on the power supply, the pump and the irrigation solenoid respectively.

3.1.2 Humidity Control System

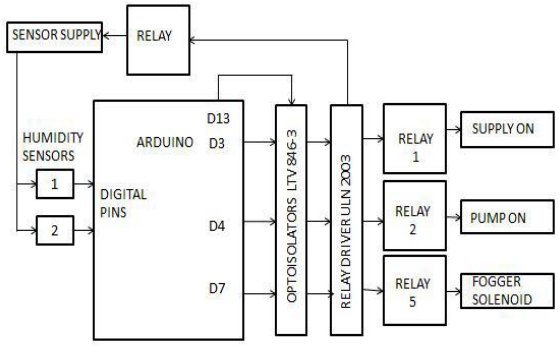


Figure 3.2: Humidity Control System

It uses DHT-22 (AM2302) as a digital-output Humidity Sensor. Voltage proportional to the existing humidity is obtained. The humidity sensor is activated as mentioned previously. The sensor inputs are read at the Digital pins and compared with the threshold. If the humidity is found to be less than the threshold, pins D3, D4, D7 are set, thus activating the relays R1, R2, R5 which will in turn put on the power supply, pump and the fogger solenoid respectively.

3.1.3 Temperature Control System

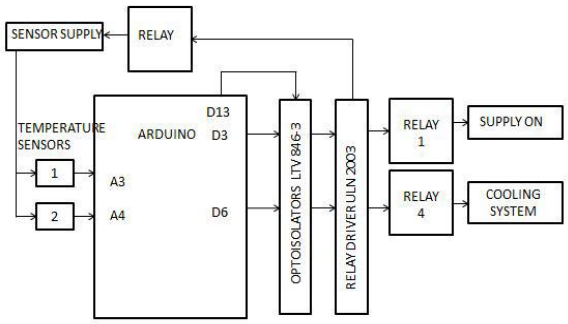


Figure 3.3: Temperature Control System

It uses the LM35 Temperature Sensor which has an output voltage linearly proportional to the Centigrade temperature. The temperature sensors are activated as mentioned previously. The sensor inputs are read at the Analog pins A3 and A4 and compared with the threshold. If the temperature is found to be higher than the threshold, pins D3 and D6 are set, thus activating the relays R1 and R4 which will in turn put on the power supply and cooling system respectively.

3.1.4 Fertigation System

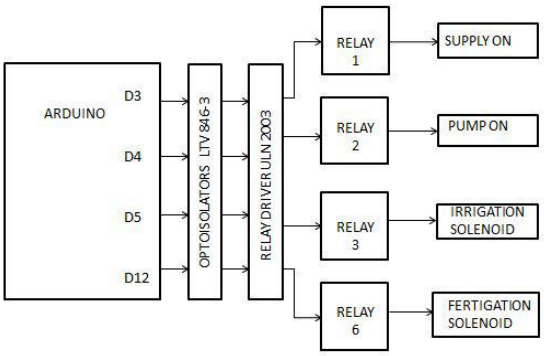


Figure 3.4: Fertigation System

It employs RTC and timers to deliver the daily doses of fertilizers required by the plants. The fertilizers are supplied to the plants at pre-defined times of the day. At pre-defined time intervals, Arduino sets the Digital pins D3, D4, D5, D12, thus activating the relays R1, R2, R3, R6, which will in turn put on the power supply, pump, irrigation solenoid and fertigation solenoid respectively.

3.1.5 Day-Night Control System

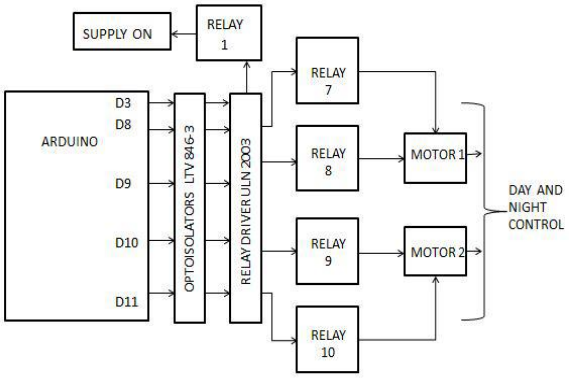


Figure 3.5: Day-Night Control System

It manipulates the length of the day and night to create an artificial environment to ensure optimum plant growth. At time intervals defined using RTC, Arduino sets the Digital pins D3, D8, D9, D10, D11 thus activating the relays R1,R7, R8, R9, R10, which will in turn put on the power supply and drive the two wiper motors. The activated wiper motors open/close the tarpaulin sheets (mounted over a cuboidal framework housing the plants) thus creating the day/night effect as required.

3.1.6 GSM Based Communication System

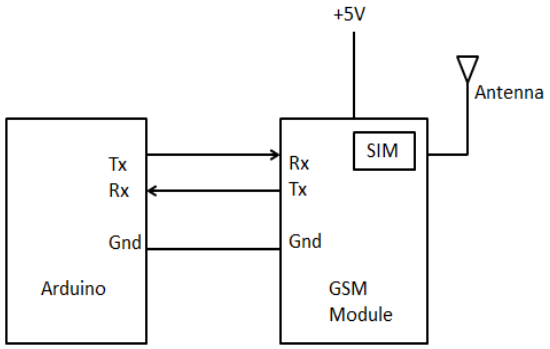


Figure 3.6: GSM Based Communication System

A communication system that utilizes GSM is developed to allow the farmer to keep track of the various activities in the farm. Tx, Rx and GND pins of the GSM module are connected to the Rx, Tx and GND pins of the microcontroller respectively. The GSM module is programmed such that when it receives "Check" message from the farmer (with the registered phone number saved in the GSM module), it collects the relevant data from the controller and sends it to the farmer in the form of an SMS.

3.1.7 Automatic and Manual Control System

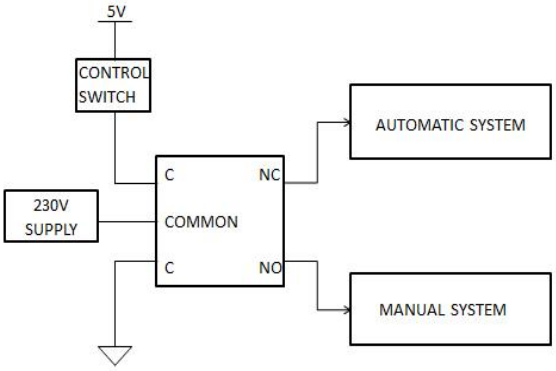


Figure 3.7: Automatic and Manual Control System

The system allows the farmer to switch from Automatic mode to Manual mode. This feature provides the farmer with an alternative in case of failure of the automated system. It thus helps in ensuring that the plant growth is not hampered even if the automated system happens to fail. Such a control is provided using a relay and a control switch that switches the system from Automatic mode to Manual mode. When the relay is powered through the control switch, the relay cuts the power supply to the microcontroller and switches to manual mode. In the manual mode, the farmer can control all the activities in the farm without any interference.

Combining all of the above sub-systems, the entire system set-up is as follows:

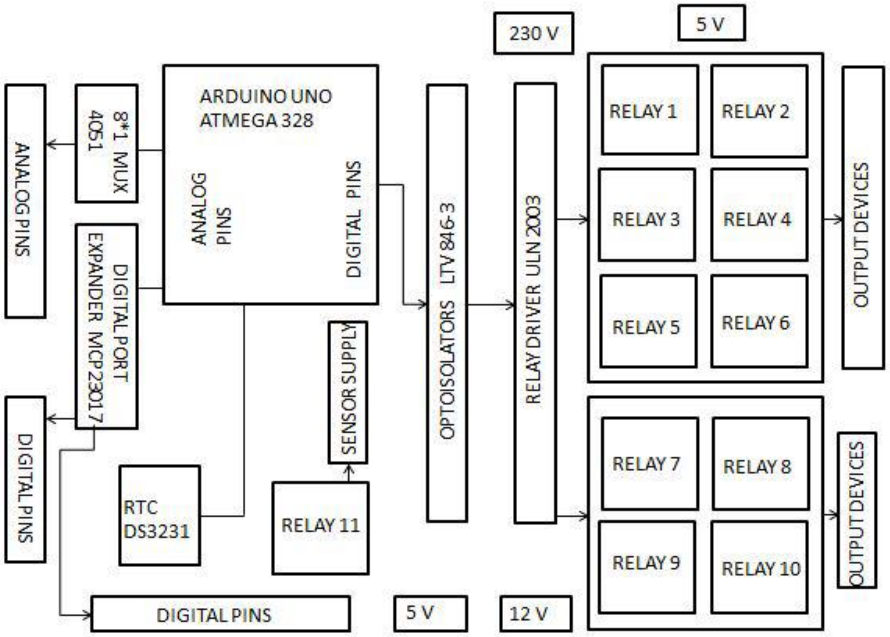


Figure 3.8: Entire System

- 4051 (8*1 Multiplexer/1*8 Demultiplexer) and MCP23017 (I/O Port Expander) ICs have been used to expand the number of available analog and digital pins respectively.
- DS 3231 (Real Time Clock) has been used to keep a track of time in case of power failure.
- LTV-846 (Optoisolators) have been employed to isolate the micro-controller from rest of the circuitory.
- ULN 2003(Relay-driver IC) to meet the high current requirements of the relays which cannot be fulfilled by the micro-controller.

3.1.8 Power Section

The following board has been developed to meet the power requirements of all the components of the system discussed previously. In order to meet the high current requirements

of the wiper motors, a step-down transformer (12V, 3A) has been used. The stepped-down voltage has then been rectified using BR1010 (Bridge Rectifier) and is available to drive the motors for the day-night control system. 7808 (8V Voltage Regulator) has been used to obtain a regulated 8V output from 12V input. This 8V is further dropped to 5V using 7805 (5V Voltage Regulators). These 5V sources are then available for use by various sensors and relay coils of the system.

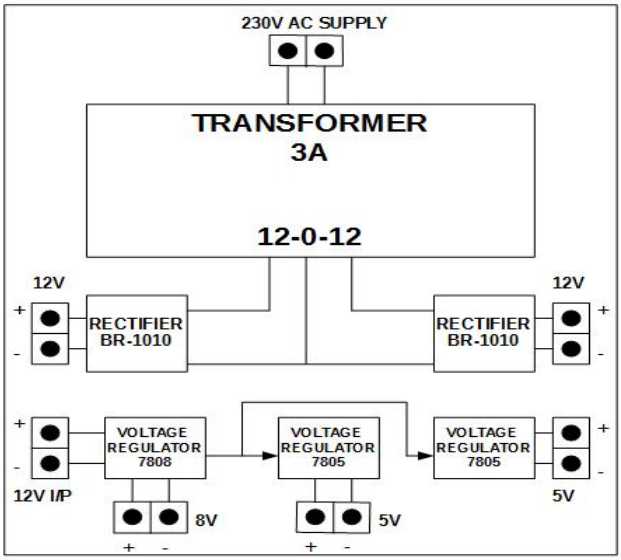


Figure 3.9: Power Section

3.2 Software Design

The following flow-chart depicts the logic of the code that has been developed to implement the system discussed above.

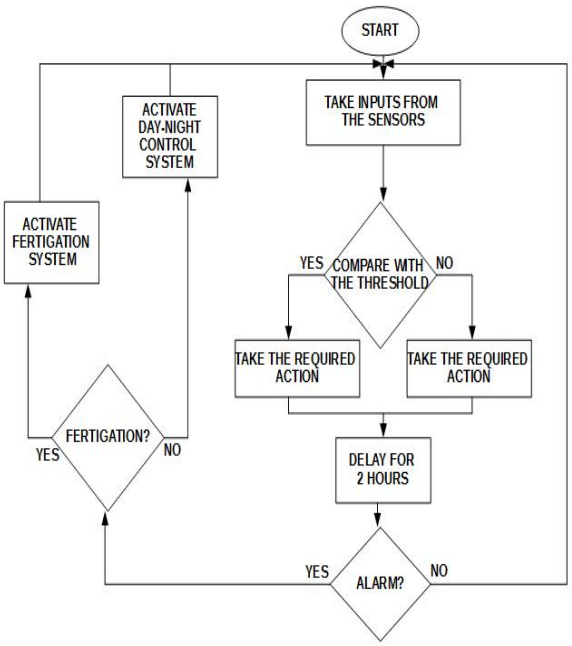


Figure 3.10: Flowchart

Step 1: Initially, the readings from the sensors (moisture, humidity and temperature) are taken and fed to the Arduino.

Step 2: Arduino compares the input from the sensors with the thresholds. The thresholds for moisture, temperature and humidity are set in the code in accordance with the plant requirements.

Step 3: It then triggers the appropriate relays to perform the necessary actions.

Step 4: After two hours, go to step 1 and repeat the entire procedure.

During the course of the program RTC could interrupt the Arduino through an alarm. Arduino then checks whether the alarm belongs to the Fertigation system or Day-Night Control system and activates the respective system.

Chapter 4

System Analysis

4.1 Observations

Inorder to understand the working principle of the moisture sensor and determine the range of its output voltages, different amount of water was added to the soil samples and the corresponding output voltages were tabulated as follows:

Water Added (ml)	Sensor Voltage(V)
0	2.937
10	3.594
20	3.65
30	3.722
40	3.820

Table 4.1: Water Content v/s Output Voltage

It was understood that the output voltage of the sensor is proportional to the water content of the soil. As the amount of water added increases, the conductivity and hence the output voltage also tends to increase.

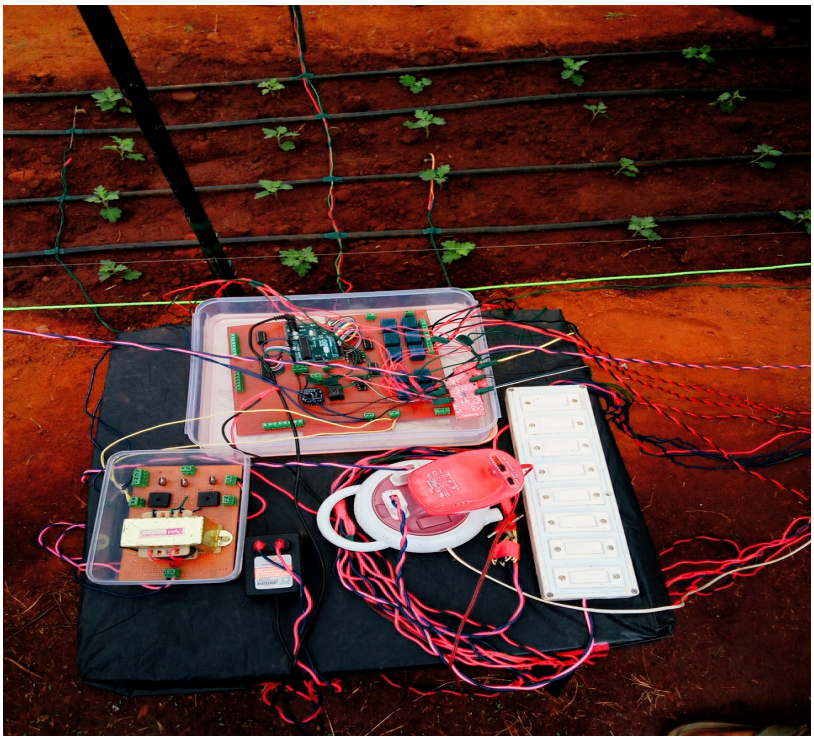
For calibrating the moisture sensors, soil samples from the patch were taken and their moisture content was approximated by performing a dry test.

The observations of the dry test are illustrated below in a tabular form.

Soil Type	Moisture Content(%)
Dry	12
Ideal	22
Wet	35

Table 4.2: Dry Test Observation Table.

4.1.1 Circuitry Designed(Controller Board and Power Supply Board)

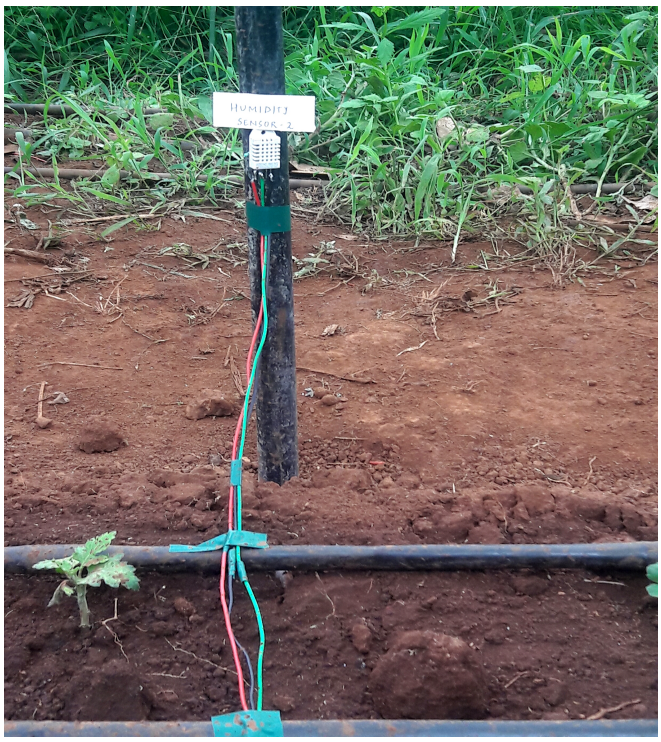


4.1.2 Irrigation System

The moisture threshold set in the code is 420 (This value corresponds to the required moisture level). When the soil moisture content drops below this threshold, the pump is put on and the irrigation solenoid gets activated for 3 minutes. This sends the water through the drip lines.

4.1.3 Humidity Control System

The humidity threshold set in the code is 40%. When the humidity in the greenhouse drops below this threshold, the pump is put on and the fogger solenoid gets activated for 2 minutes. This inturn activates the fogger which sprays water droplets to increase the humidity.



4.1.4 Temperature Control System

The temperature threshold set in the code is 28 degree Celsius. When the temperature in the greenhouse rises above this threshold, the cooling system is activated for 2 minutes. It consists of the fan in conjunction with the fogger.

4.1.5 Fertigation System

Fertigation system utilizes software timers for its functioning. It operates everyday at 7.30am for 30 seconds by activating the fertigation solenoid. This discharges the diluted fertilizer stored in a container through the same drip lines as irrigation.

4.1.6 Day-Night Control System

Day-Night Control system also utilizes software timers for its functioning. During the initial stages of growth, Chrysanthemum plants requires longer days and shorter nights. So the tarpaulin sheets have to be kept open. During the later stages, when they require longer nights, the sheets are opened and closed at predefined times i.e 8am and 4:30pm respectively.

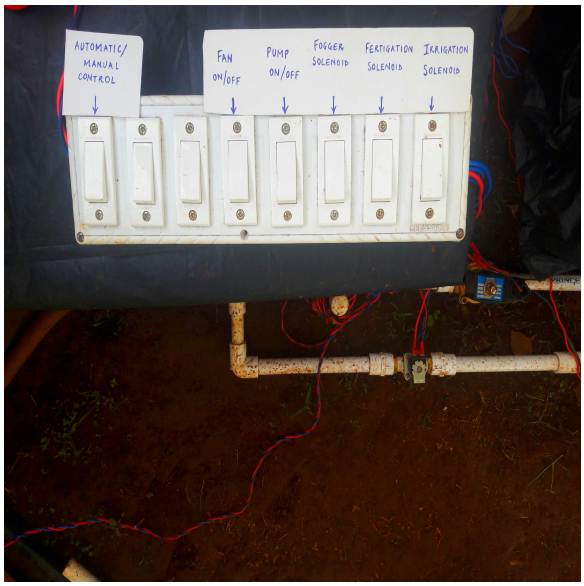
4.1.7 GSM Based Communication System

GSM Based Communication System utilizes serial communication at a baud rate of 9600bps to communicate with the microcontroller. When the farmer wishes to inquire about the activities in the farm, he sends a "Check" message to the registered phone number of the SIM card inserted in the GSM module. In response to this message, the module collects the necessary information from the controller and transfers it to the farmer as an SMS. The SMS sent by the GSM module includes information such as the number of times irrigation,

humidity control and temperature control were performed. Additionally, it confirms that the daily dosage of fertilizer was delivered to the plants. Finally, it informs the farmer about the current status of the day-night control system (open-day or close-night).

4.1.8 Manual System

During the downtime of the designed automatic system, plant growth can be ensured by switching to the manual system. This system enables the farmer to control all the individual processes through switches.



4.2 Results

All the sub-systems mentioned above are successfully implemented on a small patch of land.It is observed that these sub-systems are able to sustain plant growth.

Chapter 5

Conclusion

5.1 General Conclusion

Technology in agriculture is an untapped domain. Hence, this project makes an effort to introduce automation in the field of agriculture. The proposed design consists of Irrigation, Temperature-Control, Humidity-Control, Fertigation and Day-Night Control Systems which automate the respective agricultural practices. Hardware and software required to implement the designed system were then developed. The software has been developed to meet the requirements of the Chrysanthemum plants. Nevertheless, this system can be adopted to grow other plants as well by changing certain parameters in the software. The farmer is kept informed regarding the activities in the farm using GSM technology. We thus hope to introduce the precision and reliability of technology in agriculture and make the conventional agricultural practices free of human error.

5.2 Challenges

One of the prime challenges faced was to ensure that the plant growth does not suffer in case of failure of the designed automatic system. This was overcome by introducing a manual system wherein all the operations could be performed using the existing set-up through switches.

Since the number of sensors and the devices to be used in the system exceeded the number of pins available on the Arduino board, ICs like MCP23017 (digital port expander) and 4051 Multiplexer/Demultiplexer (analog port expander) were used to make provisions for the additional I/O pin requirements.

Moisture sensors required calibration. Hence, dry test of soil was conducted and reference table of water content v/s voltage was obtained.

Another challenge encountered was to meet the high current requirements of the wiper motors used in the Day-Night Control system. This was achieved by designing a suitable power supply consisting of high current step down transformer and bridge rectifiers.

Another problem faced was that a power failure in the greenhouse would cause the Arduino to reset itself, thus disrupting the operation of Fertigation and Day-Night Control system. Hence, an arrangement was made to keep a track of the current date and time by introducing Real Time Clock(RTC) in the system. Finally, to safeguard the developed electronic circuitory from the harsh environmental conditions in the greenhouse, adequate casing needed to be ensured.

5.3 Future Work

While the system developed in this project was implemented on a small patch of land (4 square meters) within the greenhouse, industrial grade sensors can be used to automate the entire greenhouse. Also, while the current Fertigation System assumes readily available fertilizer of necessary concentration and volume, detailed volumetric analysis can be carried out to automate the fertilizer preparation as well. Further, an Android Application can be developed to notify the farmer and allow him to remotely control the activities in the farm.

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Appendices

Appendix A

Appendix

1. Datasheet of ATmega328 Microcontroller.

2. Datasheet of DS3231 Real Time Clock(RTC).

3. Datasheet of MCP23017 Digital Port Expander.

4. Datasheet of ULN2003 Relay Driver IC.

5. Datasheet of 4051 8-channel Analog Mux/Demux.

6. Datasheet of SIM900 GSM/GPRS Module.

Appendix B

Data Sheets

B.1 Datasheet of ATmega328 Microcontroller

Introduction

The Atmel picoPower ATmega328/P is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega328/P achieves throughputs close to 1MIPS per MHz. This empowers system designer to optimize the device for power consumption versus processing speed.

Features

- Advanced RISC Architecture
  - 131 Powerful Instructions
  - Most Single Clock Cycle Execution
  - 32 x 8 General Purpose Working Registers
  - Fully Static Operation

- Up to 20 MIPS Throughput at 20MHz

- On-chip 2-cycle Multiplier

- High Endurance Non-volatile Memory Segments

  - 32KBytes of In-System Self-Programmable Flash program Memory

  - 1KBytes EEPROM

  - 2KBytes Internal SRAM

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

  - Data Retention: 20 years at 85C/100 years at 25C(1)

  - Optional Boot Code Section with Independent Lock Bits

  - In-System Programming by On-chip Boot Program

  - True Read-While-Write Operation

  - Programming Lock for Software Security

- Peripheral Features

  - Two 8-bit Timer/Counters with Separate Prescaler and Compare Mode

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

  - Real Time Counter with Separate Oscillator

  - Six PWM Channels

  - 8-channel 10-bit ADC in TQFP and QFN/MLF package

  - Temperature Measurement

  - 6-channel 10-bit ADC in PDIP Package

  - Temperature Measurement

  - Two Master/Slave SPI Serial Interface

  - One Programmable Serial USART

- One Byte-oriented 2-wire Serial Interface (Philips I2C compatible)

- Programmable Watchdog Timer with Separate On-chip Oscillator

- One On-chip Analog Comparator

- Interrupt and Wake-up on Pin Change

- Special Microcontroller Features

  - Power-on Reset and Programmable Brown-out Detection

  - Internal Calibrated Oscillator

  - External and Internal Interrupt Sources

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

- I/O and Packages

  - 23 Programmable I/O Lines

  - 28-pin PDIP, 32-lead TQFP, 28-pad QFN/MLF and 32-pad QFN/MLF

- Operating Voltage:

  - 1.8 - 5.5V

- Temperature Range:

  - -40C to 105C

- Speed Grade:

  - 0 - 4MHz @ 1.8 - 5.5V

  - 0 - 10MHz @ 2.7 - 5.5V

  - 0 - 20MHz @ 4.5 - 5.5V

- Power Consumption at 1MHz, 1.8V, 25C

  - Active Mode: 0.2mA

- Power-down Mode: 0.1A

- Power-save Mode: 0.75A (Including 32kHz RTC)

B.2 Datasheet of DS3231 Real Time Clock(RTC)

Introduction

The DS3231 is a low-cost, extremely accurate I2C realtime clock (RTC) with an integrated temperature compensated crystal oscillator (TCXO) and crystal. The device incorporates a battery input, and maintains accurate timekeeping when main power to the device is interrupted. The integration of the crystal resonator enhances the long-term accuracy of the device as well as reduces the piece-part count in a manufacturing line. The DS3231 is available in commercial and industrial temperature ranges, and is offered in a 16-pin, 300-mil SO package.

The RTC maintains seconds, minutes, hours, day, date, month, and year information. The date at the end of the month is automatically adjusted for months with fewer than 31 days, including corrections for leap year. The clock operates in either the 24-hour or 12-hour format with an AM/PM indicator. Two programmable time-ofday alarms and a programmable square-wave output are provided. Address and data are transferred serially through an I2C bidirectional bus. A precision temperature-compensated voltage reference and comparator circuit monitors the status of VCC to detect power failures, to provide a reset output, and to automatically switch to the backup supply when necessary. Additionally, the RST pin is monitored as a pushbutton input for generating a reset externally.

Features

- Accuracy 2ppm from 0C to +40C
- Accuracy 3.5ppm from -40C to +85C
- Battery Backup Input for Continuous Timekeeping
- Operating Temperature Ranges

  - Commercial: 0C to +70C

  - Industrial: -40C to +85C
- Low-Power Consumption
- Real-Time Clock Counts Seconds, Minutes,Hours, Day, Date, Month, and Year with Leap Year Compensation Valid Up to 2100
- Two Time-of-Day Alarms
- Programmable Square-Wave Output
- Fast (400kHz) I2C Interface
- 3.3V Operation
- Digital Temp Sensor Output: 3C Accuracy
- Register for Aging Trim
- RST Output/Pushbutton Reset Debounce Input
- Underwriters Laboratory (UL) Recognized

B.3 Datasheet of MCP23017 Digital Port Expander

Features

- 16-bit remote bidirectional I/O port
  - I/O pins default to input
- High-speed I2C interface (MCP23017)
  - 100 kHz
  - 400 kHz
  - 1.7MHz
- High-speed SPI interface (MCP23S17)
  - 10 MHz (max.)
- Three hardware address pins to allow up to eight devices on the bus
- Configurable interrupt output pins
  - Configurable as active-high, active-low or open-drain
- INTA and INTB can be configured to operate independently or together
- Configurable interrupt source
  - Interrupt-on-change from configured register defaults or pin changes
- Polarity Inversion register to configure the polarity of the input port data
- External Reset input
- Low standby current: 1 A (max.)
- Operating voltage:
  - 1.8V to 5.5V @ -40C to +85C

- 2.7V to 5.5V @ -40C to +85C

- 4.5V to 5.5V @ -40C to +125C

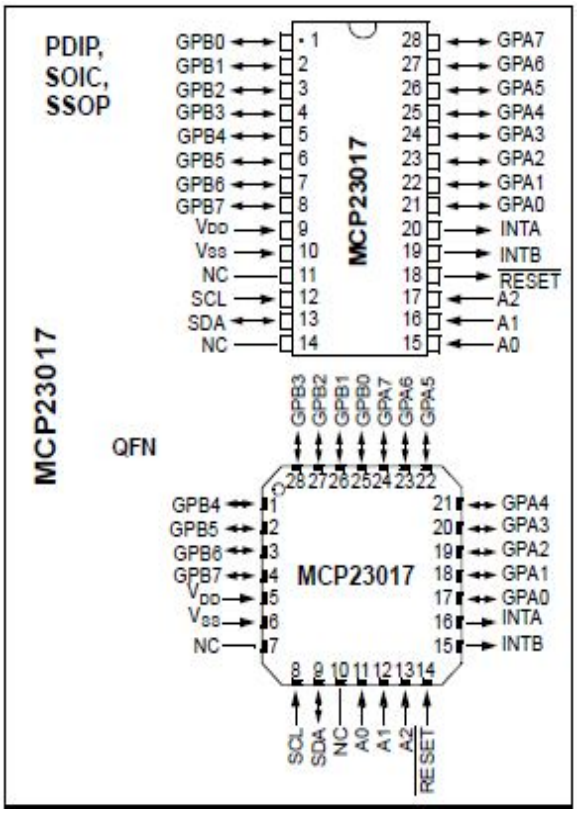


Figure B.1: Package Types

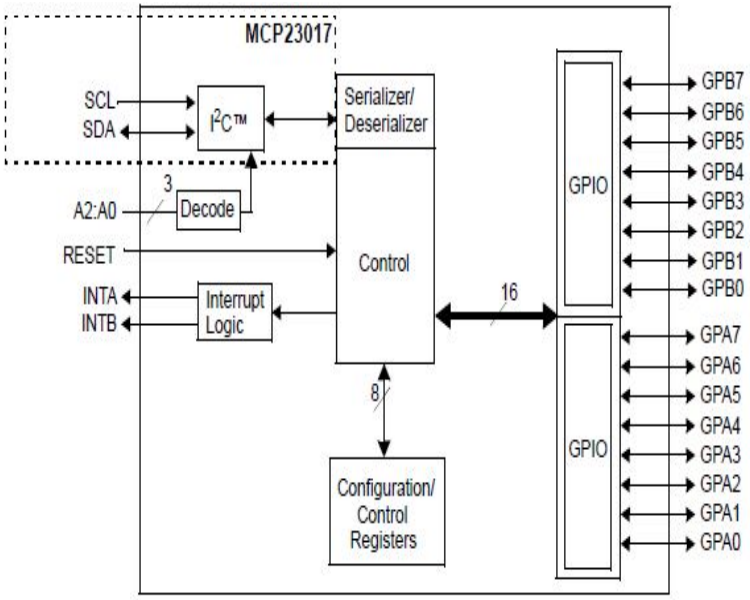


Figure B.2: Functional Block Diagram

B.4 Datasheet of ULN2003 Relay Driver IC

Introduction

The ULx200xA devices are high-voltage, high-current Darlington transistor arrays. Each consists of seven NPN Darlington pairs that feature high-voltage outputs with common-cathode clamp diodes for switching inductive loads. The collector-current rating of a single Darlington pair is 500 mA. The Darlington pairs can be paralleled for higher current capability. Applications include relay drivers, hammer drivers, lamp drivers, display drivers (LED and gas discharge), line drivers, and logic buffers.The ULx2003A devices have a 2.7-k series base resistor for each Darlington pair for operation directly with TTL or 5-V CMOS devices.

Features

- High-Voltage Outputs: 50 V
- Output Clamp Diodes
- Inputs Compatible With Various Types of Logic
- Relay-Driver Applications

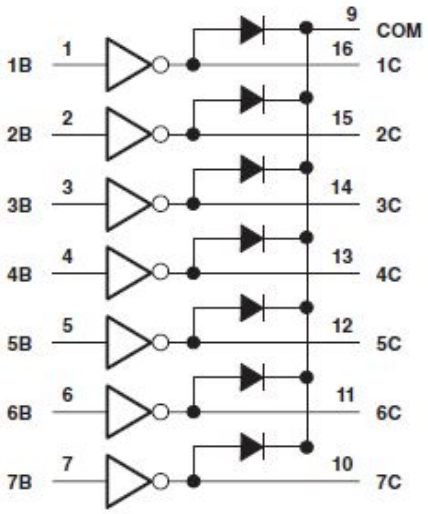
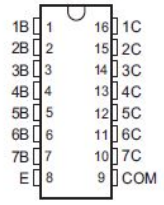


Figure B.3: Simplified Block Diagram

D, N, NS, and PW Package
16-Pin SOIC, PDIP, SO, and TSSOP
Top View



Pin Functions

PIN		I/O(1)	DESCRIPTION
NAME	NO.		
1B	1	I	Channel 1 through 7 Darlington base input
2B	2		
3B	3		
4B	4		
5B	5		
6B	6		
7B	7		
1C	16	O	Channel 1 through 7 Darlington collector output
2C	15		
3C	14		
4C	13		
5C	12		
6C	11		
7C	10		
COM	9	—	Common cathode node for flyback diodes (required for inductive loads)
E	8	—	Common emitter shared by all channels (typically tied to ground)

(1) I = Input, O = Output

Figure B.4: Pin Configuration and Functions

B.5 Datasheet of 4051 8-channel Analog Mux/Demux

Introduction

The 74HC4051; 74HCT4051 is a single-pole octal-throw analog switch (SP8T) suitable for use in analog or digital 8:1 multiplexer/demultiplexer applications. The switch features three digital select inputs (S0, S1 and S2), eight independent inputs/outputs (Yn), a common input/output (Z) and a digital enable input (E). When E is HIGH, the switches are turned off. Inputs include clamp diodes. This enables the use of current limiting resistors to interface inputs to voltages in excess of VCC.

Features

- Wide analog input voltage range from -5 V to +5 V

- Complies with JEDEC standard no. 7A
- Low ON resistance:
  - 80 ohms (typical) at VCC - VEE = 4.5 V
  - 70 ohms (typical) at VCC - VEE = 6.0 V
  - 60 ohms (typical) at VCC - VEE = 9.0 V
- Logic level translation: to enable 5 V logic to communicate with +/-5 V analog signals
- Typical break before make built-in
- ESD protection:
  - HBM JESD22-A114F exceeds 2000 V
  - MM JESD22-A115-A exceeds 200 V
  - CDM JESD22-C101E exceeds 1000 V
- Multiple package options
- Specified from -40C to +85C and -40C to +125C

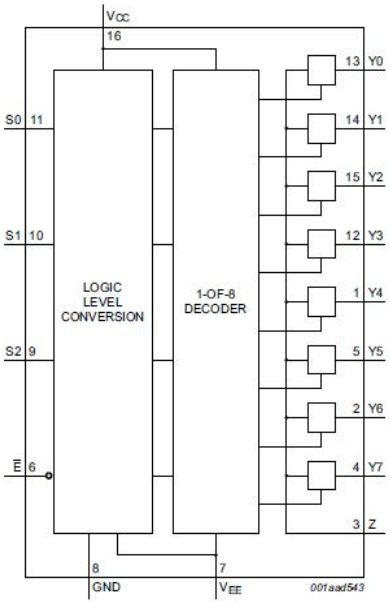


Figure B.5: Functional Diagram

B.6 Datasheet of SIM900 GSM/GPRS Module

Introduction

GSM/GPRS RS232 Modem is built with SIMCOM Make SIM900 Quad-band GSM/GPRS engine, works on frequencies 850 MHz, 900 MHz, 1800 MHz and 1900 MHz. It is very compact in size and easy to use as plug in GSM Modem. The Modem is designed with RS232 Level converter circuitry, which allows you to directly interface PC Serial port .The baud rate can be configurable from 9600-115200 through AT command. Initially Modem is in Autobaud mode.

This GSM/GPRS RS232 Modem is having internal TCP/IP stack to enable you to connect with internet via GPRS. It is suitable for SMS as well as DATA transfer application in M2M interface. The modem needed only 3 wires (Tx,Rx,GND) except Power supply to interface with microcontroller/Host PC. The built in Low Dropout Linear voltage regulator allows you to connect wide range of unregulated power supply (4.2V -13V). Yes, 5 V is in between !! .Using this modem, you will be able to send & Read SMS, connect to internet via GPRS through simple AT commands.

Features

- High Quality Product (Not hobby grade)
- Quad-Band GSM/GPRS 850/ 900/ 1800/ 1900 MHz
- Built in RS232 Level Converter (MAX3232)
- Configurable baud rate
- SMA connector with GSM L Type Antenna

- Built in SIM Card holder
- Built in Network Status LED
- Inbuilt Powerful TCP/IP protocol stack for internet data transfer over GPRS.
- Audio interface Connector
- Most Status & Controlling Pins are available at Connector
- Normal operation temperature: -20 C to +55 C
- Input Voltage: 5V-12V DC