

Voltage stability improvement of wind power grid-connected system using TCSC-STATCOM control

Submitted in partial fulfillment of the requirements for the award of

Bachelor of Engineering Degree in
Electrical and Electronics Engineering

by

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
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SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)

Accredited with Grade "A" by NAAC

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **ACHANTA BALARAM** (Reg. No. 38140003) who carried out the project entitled **"Voltage stability improvement of wind power grid-connected system using TCSC STATCOM control"** under our supervision from November 2021 to May 2022.


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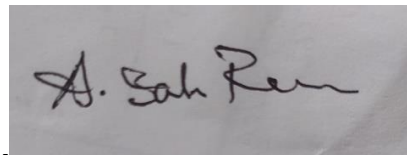
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DECLARATION

We **ACHANTA BALARAM** (Reg. No. 38140003) hereby declare that the Project Report entitled “**Voltage stability improvement of wind power grid-connected system using TCSC-STATCOM control**” done by me under the guidance of **Dr. W. ABITHA MEMALA** is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Electrical and Electronics Engineering.

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A rectangular box containing a handwritten signature in black ink. The signature appears to be 'A. Achanta Balaram' written in a cursive style.

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SIGNATURE OF THE CANDIDATE

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DESIGN ANALYSIS OF LAND SURVEYING ROBOT USING ARDUINO UNO

The static synchronous compensator is a device that improves the voltage of a specific bus while also compensating for reactive power in a power system network. It's linked to a bus close to the source to optimize the voltage profile and compensate for reactive power. In the power system block, the STATCOM control strategy for grid linked systems for power quality enhancement is simulated using MATLAB/SIMULINK. For both linear and nonlinear loads, the proposed technique is used.

Abstract:

This work proposes a cooperative control strategy of Thyristor Controlled Series Compensator (TCSC) and Static Synchronous Compensator (STATCOM) to address the voltage stability problem of wind power grid-connected systems. The suggested approach is used in a grid-connected wind power system.

To guarantee that the system has adequate reactive power to sustain its usual task during operation, a combined control strategy based on STATCOM double closed-loop feedback control and the TCSC device is implemented. In MATLAB/Simulink, a simulation model of the grid-connected wind power system is created.

The cooperative control of TCSC and STATCOM can quickly and effectively recover the bus voltage at the point of grid-connected wind farms after a fault, which has good performance in improving the voltage stability of wind power grid-connected systems. It increases the low-voltage ride-through capability, as shown by analysing and comparing the waveforms of the operating examples with only TCSC, only STATCOM, and TCSC STATCOM.

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**Voltage stability improvement of wind power
grid-connected system using TCSC-STATCOM
control**

CHAPTER 1

INTRODUCTION

1.1 GENERAL INTRODUCTION

With the depletion of conventional energy sources, the development of new energy sources has received more and more attention. Wind power generation with its mature technology, superior economic performance and huge market attraction has made the development of new energy by leaps and bounds.

However, due to the intermittent and random nature of wind energy, wind turbines connected to the grid have an adverse impact on the stable operation of the grid. At present, grid-connected wind turbines also use asynchronous wind generators. While the squirrel-cage asynchronous generator provides the active power for the grid and also absorbs certain reactive power from the grid to maintain the normal operation of the wind turbine. If the reactive power cannot meet asynchronous generator requirements, it will not only affect the normal operation of the generator set but also reduce the stability of the grid voltage. Therefore, how to improve the stability of the grid connected system is one of the current major problems facing wind power grid integration. This paper focuses on the research of asynchronous squirrel cage induction generators, the research on doubly-fed induction generators will be carried out in another paper.

1.2 Literature survey

Kaung, H., Zhang, S., Zeng, L., et al.: ‘Stability and power quality improvement of wind power integrated system using STATCOM-PSS control’, J. Power Supply, 2015, 13, (3), pp. 100–106+133

"Electric Power Quality (EPQ) is a term that refers to maintaining the near sinusoidal waveform of power distribution bus voltages and currents at rated magnitude and frequency". Today customers are more aware of the seriousness that the power quality possesses, this prompts the utilities to assure good quality of power to their customer. The power quality is basically customer centric. Increased focus of utilities toward maintaining reliable power supply by employing power quality improvement tools has reduced the power outages and black out considerably. Good power quality is the characteristic of reliable power supply. Low power factor, harmonic pollution, load imbalance, fast voltage variations are some common parameters which are used to define the power quality. If the power quality issues are not checked i.e., the parameters that define power quality doesn't fall within the predefined standards then it will lead into high electricity bill, high running cost in industries, malfunctioning of equipment's, challenges in connecting renewable. Capacitor banks, FACTS devices, harmonic filters, SVC's (static voltage compensators), STATCOM (Static-Compensator) are the solutions to achieve the power quality. The performance of Wind turbine generators is affected by poor quality power, at the same time these wind power generating plant affects the power quality negatively. This paper presents the STATCOM-BESS (battery energy storage system) system and studies its impact on the power quality in a system which consists of wind turbine generator, nonlinear load, hysteresis controller for controlling the operation of STATCOM and grid. The model is simulated in the MATLAB/Simulink. This scheme mitigates the power quality issues,

improves voltage profile and also reduces harmonic distortion of the waveforms. BESS level out the imbalances caused in real power due to intermittent nature of wind power available due to varying wind speeds.

CHAPTER 2

INTRODUCTION TO DOMAIN

2.1 Introduction Of Embedded System

Each day, our lives become more dependent on 'embedded systems', digital information technology that is embedded in our environment. More than 98% of processors applied today are in embedded systems, and are no longer visible to the customer as 'computers' in the ordinary sense. An Embedded System is a special-purpose system in which the computer is completely encapsulated by or dedicated to the device or system it controls. Unlike a general-purpose computer, such as a personal computer, an embedded system performs one or a few pre-defined tasks, usually with very specific requirements. Since the system is dedicated to specific tasks, design engineers can optimize it, reducing the size and cost of the product. Embedded systems are often mass-produced, benefiting from economies of scale. The increasing use of PC hardware is one of the most important developments in high-end embedded systems in recent years. Hardware costs of high-end systems have dropped dramatically as a result of this trend, making feasible some projects which previously would not have been done because of the high cost of non-PC-based embedded hardware. But software choices for the embedded PC platform are not nearly as attractive as the hardware.

Typically, an embedded system is housed on a single Microprocessor board with the Programs stored in ROM. Virtually all appliances that have a Digital interface-- watches, microwaves, VCRs, cars -- utilize embedded systems. Some embedded systems include an Operating system, but many are so

specialized that the entire logic can be implemented as a single program.

Physically, Embedded Systems range from portable devices such as digital watches and MP3 players, to large stationary installations like traffic lights, factory controllers, or the systems controlling nuclear power plants.

In terms of complexity embedded systems can range from very simple with a single microcontroller chip, to very complex with multiple units, peripherals and networks mounted inside a large chassis or enclosure.

2.2 Definition of an Embedded System

Embedded system is defined as, For a particular/specific application implementing the software code to interact directly with that particular hardware what we built. Software is used for providing features and flexibility, Hardware = {Processors, ASICs, Memory,} is used for Performance (& sometimes security)

There are many definitions of embedded system but all of these can be combined into a single concept. An embedded system is a special purpose computer system that is used for particular task.

2.3 Features of Embedded Systems

The versatility of the embedded computer system lends itself to utility in all kinds of enterprises, from the simplification of deliverable products to a reduction in costs in their development and manufacture. Complex systems with rich functionality employ special operating systems that take into account major

characteristics of embedded systems. Embedded operating systems have minimized footprint and may follow real-time operating system specifics.

The special computers system is usually less powerful than general-purpose systems, although some expectations do exist where embedded systems are very powerful and complicated. Usually, a low power consumption CPU with a limited amount of memory is used in embedded systems. Many embedded systems use very small operating systems; most of these provide very limited operating system capabilities.

Since the embedded system is dedicated to specific tasks, design engineers can optimize it, reducing the size and cost of the product, or increasing the reliability and performance. Some embedded systems are mass-produced, benefiting from Economies of Scale.

Some embedded systems have to operate in extreme environment conditions such as very high temperature & humidity.

For high volume systems such as portable music players or mobile phones, minimizing cost is usually the primary design consideration. Engineers typically select hardware that is just “good enough” to implement the necessary functions.

For low volume or prototype embedded systems, general purpose computers may be adapted by limiting the programs or by replacing the operating system with a real-time operating system.

2.4 Characteristics of Embedded Systems

Embedded computing systems generally exhibit rich functionality—complex functionality is usually the reason for introducing CPUs into

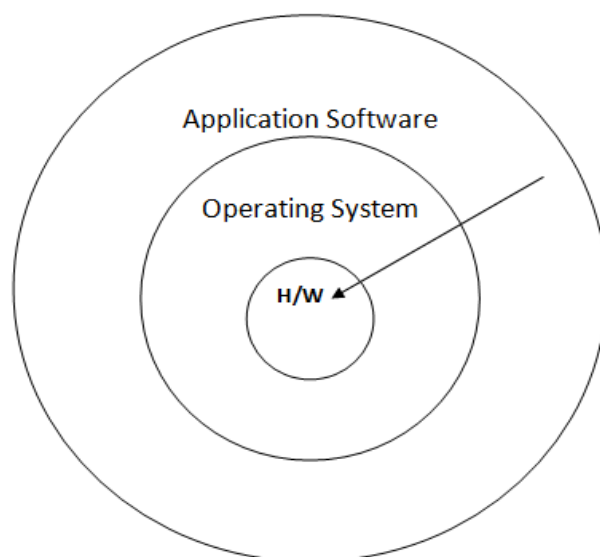
the design. However, they also exhibit many non-functional requirements that make the task especially challenging:

- Real-time deadlines that will cause system failure if not met;
- Multi-rate operation;
- In many cases, low power consumption;
- Low manufacturing cost, which often means limited code size.

Workstation programmers often concentrate on functionality. They may consider the performance characteristics of a few computational kernels of their software, but rarely analyze the total application. They almost never consider power consumption and manufacturing cost. The need to juggle all these requirements makes embedded system programming very challenging and is the reason why embedded system designers need to understand computer architecture.

2.5 Overview of an Embedded System Architecture

Every Embedded system consists of a custom-built hardware built around a central processing unit. This hardware also contains memory chips onto which the software is loaded.



The operating system runs above the hardware and the application software runs above the operating system. The same architecture is applicable to any computer including desktop computer. However these are significant differences. It is not compulsory to have an operating system in every embedded system. For small applications such as remote-control units, air conditioners, toys etc.

2.6 Applications of Embedded Systems

Some of the most common embedded systems used in everyday life are

Small embedded controllers: 8-bit CPUs dominate, simple or no operating system

(e.g., thermostats)

Control systems: Often use DSP chip for control computations

(e.g., automotive engine control)

Distributed embedded control: Mixture of large and small nodes on a real-time

Embedded networks

(e.g., cars, elevators, factory automation)

System on chip: ASIC design tailored to application area

(e.g., consumer electronics, set-top boxes)

Network equipment: Emphasis on data movement/packet flow

(e.g., network switches; telephone switches)

Critical systems: Safety and mission critical computing
(e.g., pacemakers, automatic trains)

Signal processing: Often use DSP chips for vision, audio,
or other signal
Processing (e.g., face recognition)

Robotics: Uses various types of embedded
computing (especially
Vision and control) (e.g., autonomous vehicles)

Computer peripherals: Disk drives, keyboards, laser printers,
etc.

Wireless systems: Wireless network-connected “sensor
networks” and
“Motes” to gather and report information

Embedded PCs: Palmtop and small form factor PCs
embedded into
Equipment

Command and control: Often huge military systems and “systems
of systems”
(e.g., a fleet of warships with interconnected Computers)

Home Appliances, intercom, telephones, security systems, garage
door openers, answering machines, fax machines, home computers,
TVs, cable TV tuner, VCR, camcorder, remote controls, video games,
cellular phones, musical instruments, sewing machines, lighting
control, paging, camera, pinball machines, toys, exercise equipment

Office Telephones, computers, security systems, fax machines, microwave, copier, laser printer, color printer, paging

Auto Trip computer, engine control, air bag, ABS, instrumentation, security system, transmission control, entertainment, climate control, cellular phone, keyless entry

2.7 TYPES OF EMBEDDED SYSTEMS

Based on functionality and performance embedded systems categorized as 4 types

1. Standalone embedded systems
2. Real time embedded systems
3. Networked information appliances
4. Mobile devices

2.8.1 Standalone embedded systems: -

As the name implies, standalone systems work in standalone mode. They take i/p, process them and produce the desire o/p. The i/p can be an electrical signal from transducer or temperature signal or commands from human being. The o/p can be electrical signal to drive another system a led or LCD display

ex digital camera, microwave oven, CD player, Air conditioner etc.

2.9.2 Real time embedded systems: -

In this type of an embedded system a specific work has to be complete in a particular period of time.

Hard Real time systems: - embedded real time used in missiles

Soft Real time systems: - DVD players

2.10.3 Networked information appliances: -

Embedded systems that are provided with n/w interfaces and accessed by n/w such as local area n/w or internet are called Network Information Appliances

Ex A web camera is connected to the internet. Camera can send pictures in real time to any computers connected to the internet

2.11.4 Mobile devices: -

Actually, it is a combination of both VLSI and Embedded System

Mobile devices such as Mobile phone, Personal digital assistants, smart phones etc. are special category of embedded systems

CHAPTER 3

INTRODUCTION

Land surveying forms an integral part of this conversion. Survey Robot, also referred as SURVOBOT is being designed keeping in mind the complexities that are involved in present techniques of area measurement and land survey. Area measurement module. Timer concept is used to calculate the distance travelled by the robot and the value is transmitted to the LCD screen using Bluetooth technology. The advantages of this robot is that manpower required to carry out such area calculation activities can be reduced drastically and also the number of equipment's required. It helps both in time saving and achieving better accuracy compared to the conventional methodologies. Bluetooth technology is a bi-directional wireless communication technology for lower complexity, lower cost & power consumption. Also because of low data rate, this technology is mainly used in automatic control of systems.

Surveying or land surveying is a technique of determining the terrestrial or three-dimensional positions of points and therefore the distances and angles between them. The points are typically on the surface of the land. They are often accustomed to establish maps and bounds for ownership, locations, like the designed positions of structural components for construction or the surface location of subsurface features or for property sales. A professional is termed a land surveyor. Surveying has been an integral part of the development of the human environment since the start of recorded history. The design and execution of most types of construction require it. It is also employed in transport, communications, mapping, and definition of legal boundaries for land ownership, and is a crucial tool for research in many other scientific disciplines. In recent times, from manufacturing to finance, every industry is becoming more and more

automated. Although it's not talked about as often, field surveying is additionally becoming increasingly automated with the employment of advanced robots. The first surveying robots were developed more than two decades ago. They were bots mounted with total stations and other surveying gear that allowed them to find the dimensions of a region with greater precision than a human surveyor. While a number of today's robots have identical functionality, surveyors have more advanced models at their disposal. Many reputable surveying companies employ aerial drones to capture a holistic view of a locality. Additionally, getting a broad view of the land we're surveying, drones allow us to perform a 3D boundary analysis. The downside of drones is that they can't navigate interior structures, which could be a crucial requirement for some surveying projects. Nowadays, surveyors can mount a 360-degree camera to their hardhat that maps the region while tracking their steps using GPS. This blend of human interaction and robot automation is invaluable for any surveyor. The robotics company Boston Dynamics is building on a robot called Spot Walk that's more advanced than anything we've seen before. This machine is capable of moving around a plot with no assistance. While this may save a surveyor plenty of their time, it cuts out that crucial human element.

Population in our country is increasing rapidly, with the increase in the number of people comes the proper management of service. A place like hospital needs 24 by 7 surveillance. Inadequate staff members, negligence of nurses can cause big risk to patients life. Also there arises a problem of transporting goods such as medicines, food, linens and other equipment's from one place to another. Of course, increasing staff members is the simple solution for this but not effective. This is the era of technology and automation. If automation is brought to healthcare center, then it will be far effective. Automation can be introduced in hospitals by the application of line following robot. A line following robot can act as temporary nurse which can

assist hospital staff in case of any emergency. Also, this kind of robot will work as a delivery robot in operation room where doctors will need any extra accessories at any emergency instance. This kind of robot has advantages such as fast service, available 24x7, more reliable, more efficient. This robot is a kind of robot which follows white or black path instructed by the user [1]. In this project IR sensors are used for detecting the path [6]. The reason for choosing this sensor is they are good for detection of line from minimum 100cm to maximum 500cm, low power and fit in small spaces. Also, for control and running the robot Arduino and motor driving module are used respectively. For better understanding the whole mechanism of line following robot, prior knowledge of IR sensors, Arduino and Motor driver modules is necessary. IR sensor is an electronic device used to detect properties of surroundings. It detects by either transmitting or detecting infrared radiation. The IR sensor was discovered by F.W. Herschel in 1800. The working principle of IR sensor is governed by three laws: Planck's radiation law, Stephan Boltzmann law, Wein's Displacement law [6]. As the light is incident on colored surface it is partially reflected back.

The light is completely reflected in case of white surface. Whereas if the light is incident on the black surface, it is completely drawled up due to the property of absorption of black color. This principle is utilized in the design of infrared sensors. When light is made incident on a normal or regular surface it returns back to the photodiode whereas it is absorbed when incident on a black object, hence no light rays are not captured by the photodiode. The complete mechanism of IR sensors is explained in working. The arduino IDE is free to use based on Atmel microcontroller. Arduino IDE is used to program the arduino board. It is able to simulate input and in return produces an output. When the sensors come in contact with white object the input goes high, whereas the input goes low for the black object. A typical motor driving IC allows the DC motor to drive on any direction [4].

This IC consists of 16-pins which are used to control a set of two DC motors. Motor driving IC act as bridge between the controller (here Arduino) and the motor [8]. The input to this IC is the output of Arduino.

Land measurement is a general terminology which is used to describe, in best possible manner, the theory and application of measurement of land. This also includes land conversion that can be known as the procedure by which land or property is measured. It is the process which explains how the land or property is converted from one unit to another. To put it in more specific terms how much of land is one acre and so on. Land surveying forms an integral part of this conversion. Survey Robot, also referred as SURVOBOT is being designed keeping in mind the complexities that are involved in present techniques of area measurement and land survey. In conventional survey operations, a primary requirement of the survey party is to determine distance between two points. The surveyor has many devices that are used to determine distance. These range from the 30-meter steel tape to electronic instruments.

Surveillance is the method for observing a location, an area or a person for protection and security purpose. This activity always happens in a military, police, public places and even in houses nowadays for monitoring and to control the illegal activities. Especially, the surveillance activity is used mainly for human because the people were doing all illegal work against the government and at the same time to protect them from those activities. The advent of technology has brought a revolutionary change in the field of robotics, especially in the automation sector. The usage of robotics is increasing day by day, which reduces the human work but the efficiency of work increases in all department from military to our home and even in hotels. Today's life has changed a lot in every activity due to usage of Smartphone. The people can do all works using smart phone and they can operate any system by developing an application, which can be

installed in the smart and providing numerous applications on different operating systems. Especially, the Android OS is one of the important sources, which is available in open and helps in building the application for many activities for people in their day today life. Even the people with minimum knowledge can able to make a small robot for protective purpose. There were numerous work carried out for surveillance recently.

Intelligent agents and multiagent systems represent a relatively novel field of artificial intelligence applicable for efficient solving of different problems Weiss, 2000; Ferber, 1999; Ivanovic's, 2007. The intelligence of the agents cannot be defined uniquely based on the large variety of agents and the problems that they have to solve Weiss, 2000; Ferber, 1999; Ivanovic's, 2007. The intelligence of a system must give improvements in problems solving, like: efficient problem solving; flexible problem solving; solving difficult problem; efficient solving of large numbers of problems etc. In our research we consider the intelligence of the nce in the problems solving based on the use of a computational intelligence algorithm. Important research directions are represented by mobile agents that could be software mobile agents Kirn, 2003; Kun, 2003, or robotic mobile agents Sgorbissa, 2012; López, 2007. Robotic mobile agents have a wide range of applicability in different areas of life Wang, 2005; Kim, 2003; Cirillo, 2012, and Leitão, 2012. A large number of scientists are working on finding new solutions for different subsections of mobile agent applications such as navigation, localization, optimal path planning, object detection, movement of the robot. In our research, as mobile agent a mobile robot is considered. In this paper we will focus on path planning optimization of the mobile agent using a computational intelligence algorithm. We will focus on discussing solutions for: TSP problem and a modified TSP when the agent does not have to get back to the starting point. Finding a closely optimal path from the resolved TSP. For the TSP solving a Kohonen map was used with a proposed cost

function in the winner neuron selection. In the following section, the TSP problem , the artificial neural network structure and network training, results with the resolved TSP with Korhonen map and optimization of path planning between a starting node and a target node on the map will be presented.

CHAPTER 4

LITERATURE SURVEY

1. Artificial Intelligence in the path planning optimization of mobile agent navigation: Many difficult problem solving require computational intelligence. One of the major directions in artificial intelligence consists in the development of efficient computational intelligence algorithms, like: evolutionary algorithms, and neural networks. Systems, that operate in isolation or cooperate with each other, like mobile robots could use computational intelligence algorithms for different problems/tasks solving, however in their behavior could emerge an intelligence called system s intelligence, intelligence of a system. The traveling salesman problem TSP has a large application area. It is a well-known business problem. Maximum benefits TSP, price collecting TSP have a large number of economic applications. TSP is also used in the transport logic Raja, 2012. It also has a wide range of applicability in the mobile robotic agent path planning optimization. In this paper a mobile robotic agent path planning will be discussed, using unsupervised neural networks for the TSP solving, and from the TSP results the finding of a closely optimal path between two points in the agent working area. In the paper a modification of the criteria function of the winner neuron selection will also be presented. At the end of the paper measurement results will be presented.
2. Design and Fabrication of Robot for Surveillance using Arduino: The World Is Full Of Surveillance, Which Was monitored by enemy countries. Especially, the border

region of any country was controlled and monitored by the own country for their safety purpose, for that many technology was used to monitor the region. Earlier, the surveillance was done by human, which causes many deaths by enemy country. To overcome the problem, the technology was introduced for surveillance with the help of robot. But now, the technology was upgraded, which made us to make a new robot for surveillance, bomb detector with automated gun. In this project, this was controlled using arduino with Wi-Fi module. The camera was fixed and captures the video and monitored through it. The robot can move ups and downs of any place for surveillance with the help of motors. This was one of the multipurpose robots for military use.

3. **Line Following Robot Using Arduino for Hospitals:** This paper describes the line following robot using Arduino for surveying, inspecting and enhancing the transportation of necessary materials inside the healthcare institutions, industries also. The proposed system spots the black path and proceed in its direction on to the ground. This system eases the work of material conveyance as well as minimizes the manpower. This technology targets on the secured, punctual and constructing transportation of goods. This paper aims to implement controlled movement of robot by tuning control parameters and thus achieve better performance. This robot is predominantly design to proceed in a predefined path. To locate this path two sensors are used. Robots like this are mainly used in industrial plants comprising of pick and place facility. This robot carries components from desired source to destination by following fixed path. Recently lot of research

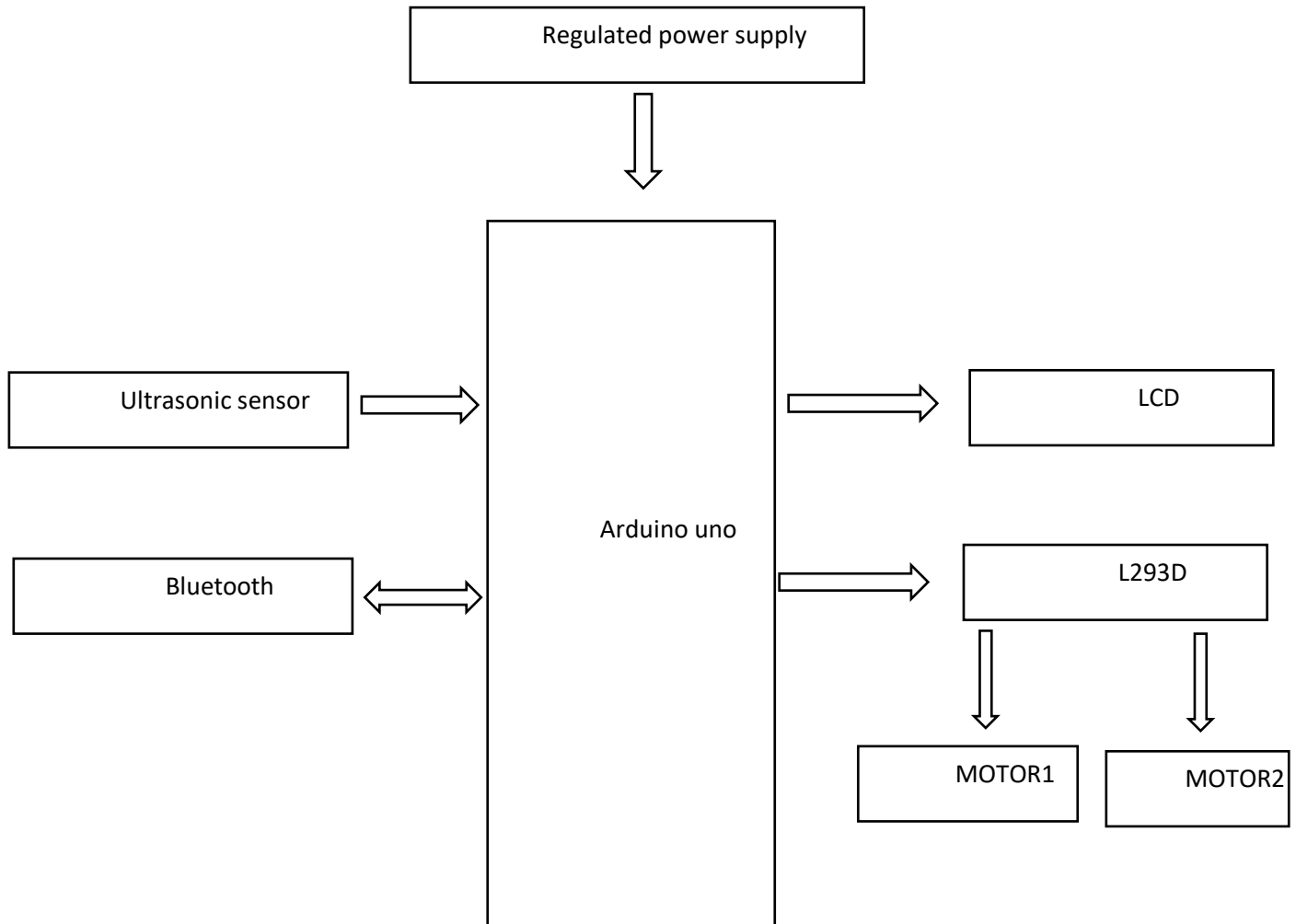
has been done to empower the automation in hospitals as well in industries. This robot is made to supply the essential goods such injections, medicine, etc. This paper is divided into hardware and software modules.

4. Design and Implementation of a Land Surveying Robot:

Land measurement is a general nomenclature which is used to explain, in the absolute manner, the knowledge and application of measurement of land. This conjointly includes land conversion that can be known as the procedure by which land or property is measured. It is the technique using which a piece of land or property is converted from one unit to a different one. The proposed design is to make the land survey by using a robot using the updated technology. Here, a robot is designed and programmed to conduct land survey, specifically to calculate the length traversed and area of a given land followed by subdividing the given plot it into subplots if required. The survey robot traverses along the given path and sends the values for the distance measured and area calculated. After optimizing the power given to the motors for proper simulation the speed of the robot was brought down to 0.5 meters per second which was desirable for effective control of the robot and sub plotting. After the ASCII code for the plotting details was sent to the survey robot through the Bluetooth application, the robot successfully decoded by the micro controller and the sub plotting was accomplished. A 3% error has been observed while calculating the distance measured and 6% error while calculating the area measured.

CHAPTER 5

HARDWARE AND SOFTWARE REQUIREMENTS



Hardware requirements:

- **Power supply**
- **Arduino**
- **Ultrasonic sensor**
- **Bluetooth**

- **Lcd**
- **L293d driver**
- **Motor**

5.1 Power supply:

In mains-supplied electronic systems the AC input voltage must be converted into a DC voltage with the right value and degree of stabilization. In these basic configurations the peak voltage across the load is equal to the peak value of the AC voltage supplied by the transformer's secondary winding. For most applications the output ripple produced by these circuits is too high. However, for some applications - driving small motors or lamps, for example - they are satisfactory. If a filter capacitor is added after the rectifier diodes the output voltage waveform is improved considerably. The section b-c is a straight line. During this time, it is the filter capacitor that supplies the load current.

The slope of this line increases as the current increases, bringing point c lower. Consequently, the diode conduction time (c-d) increases, increasing ripple. With zero load current the DC output voltage is equal to the peak value of the rectified AC voltage. Figure shows how to obtain positive and negative outputs referred to a common ground. In particular they are helpful in determining the voltage ripple for a given load current and filter capacitor value. The value of the voltage ripple obtained is directly proportional to the load current and inversely proportional to the filter capacitor value. The performance of a supply commonly used in consumer applications – in audio amplifiers.

Often the degree of stability provided by the circuits described above is insufficient and a stabilizer circuit is needed. This circuit is often used as a reference voltage to apply to the base of a transistor or to the input of an op amp to obtain higher output current. The simplest example of a series regulator is shown in Figure. In this

circuit the transistor is connected as a voltage follower and the output voltage is about 600 - 700mV lower than the Zener voltage.

The resistor R must be dimensioned so that the zener is correctly biased and that sufficient base current is supplied to the base of Q1. For high load currents the base current of Q1 is no longer negligible. To avoid that the current in the zener drops to the point where effective regulation is not possible a Darlington may be used in place of the transistor. When better performance is required the op amp circuit shown in Figure is recommended. In this circuit the output voltage is equal to the reference voltage applied to the input of the op amp. With a suitable output buffer higher currents can be obtained. The output voltage of the Figure 14 circuit can be varied by adding a variable divider in parallel with the Zener diode and with its wiper connected to the op amp's input.

The design of stabilized supplies has been simplified dramatically by the introduction of voltage regulator ICs such as the L78xx and L79xx - three-terminal series regulators which provide a very stable output and include current limiter and thermal protection functions. Regulated power supply is mainly used to providing power to this project because it is providing regulated dc power and it converts 220v ac supply into regulated dc power of 5v, 9v, 12v, 15v etc. Regulated power supply consists of step down transformer, bridge rectifier which is combination of 4 diodes connected in bridge shape. Bridge rectifier has the maximum efficiency and it is best than other rectifiers that's why we prefer it. This rectifier converts ac into pulsating dc. After rectifier filter circuit is employed, usually capacitor in parallel is used as filter or we can use number of capacitors in parallel and number of inductors in series. All these filters are low pass filters as we required dc at the o/p. Then after capacitor voltage regulator is used for observing the pure dc o/p. We can use various voltage regulators for obtaining pure dc o/p but we prefer 78xx series voltage regulators as they are simpler, cheaper and easier than others.

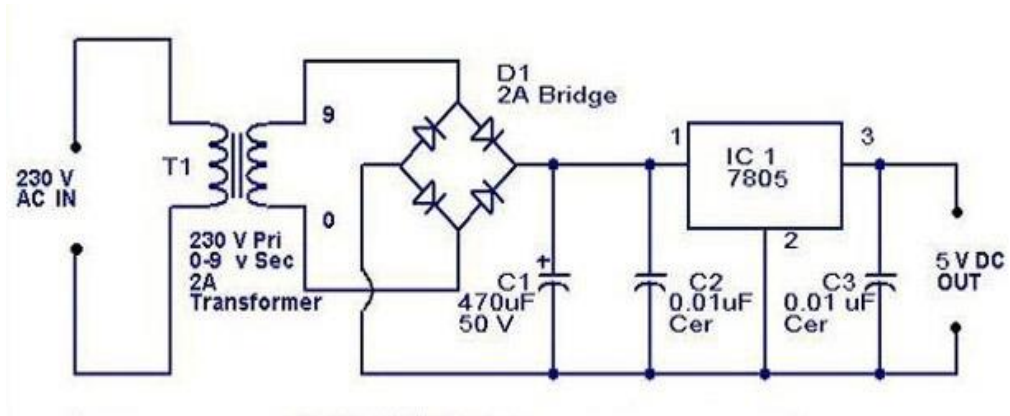


Fig. 5.1: Circuit diagram of regulated power supply section

5.1.1) AC Input: This is the input supply from the public utility where the device will be energized. It is also supplied directly to the relay contacts in the device which connects the load to the supply when the supply is within 200V – 240V range.

(5.1.2) Step down transformer: It steps down the AC supply into 5v on the secondary side. It is therefore a 230/5 v transformer. Any change in the primary reflects in the secondary of the transformer. So any fluctuations in the input are also reflected as a fluctuation in the output.

(5.1.3) Rectifier: A center tapped transformer, with four diodes for full wave rectification is used to convert the ac voltage to a pulsating dc voltage followed by a filter, comprising of a capacitor to filter out (smooth) the pulsation. After the rectification and smoothening, a sample of the output voltage is fed to the micro controller. This voltage is unregulated and therefore varies as the input mains voltage varies. Since the system is to prevent against over voltage, the transformer was designed and the windings were so selected for the device to be able to sense and withstand input mains voltage up to 600Vac.

5.1.4 Arduino:

The Arduino is a family of microcontroller boards to simplify electronic design, prototyping and experimenting for artists, hackers, hobbyists, but also many professionals. People use it as brains for their robots, to build new digital music instruments, or to build a system that lets your house plants tweet you when they're dry. Arduinos (we use the standard Arduino Uno) are built around an AT mega microcontroller essentially a complete computer with CPU, RAM, Flash memory, and input/output pins, all on a single chip. Unlike, say, a Raspberry Pi, it's designed to attach all kinds of sensors, LEDs, small motors and speakers, servos, etc. directly to these pins, which can read in or output digital or analog voltages between 0 and 5 volts. The Arduino connects to your computer via USB, where you program it in a simple language (C/C++, similar to Java) from inside the free Arduino IDE by uploading your compiled code to the board. Once programmed, the Arduino can run with the USB link back to your computer, or stand-alone without it no keyboard or screen needed, just power.

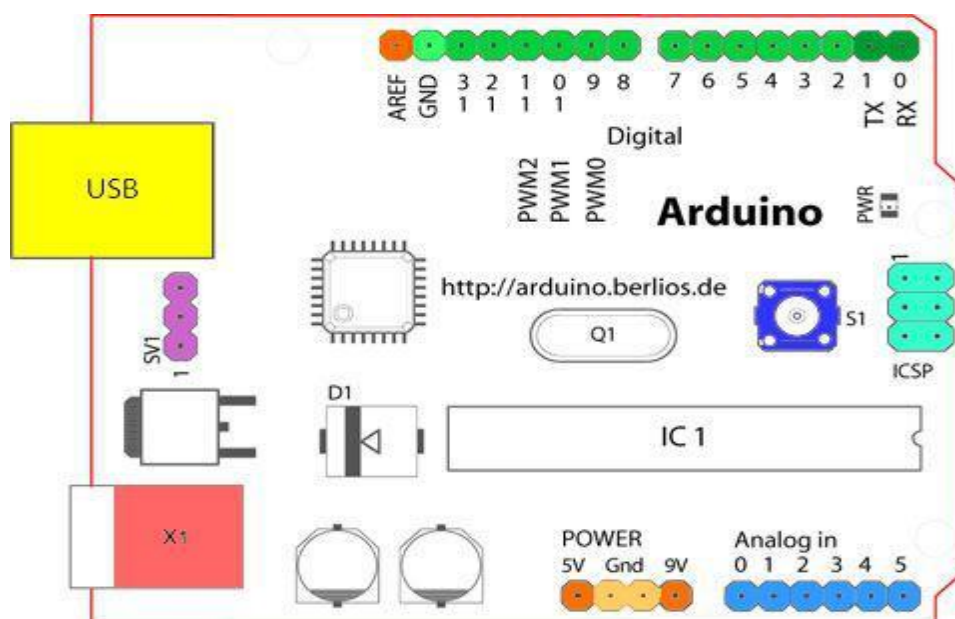


Figure Structure of Arduino Board Fig . 5.1.4(a)

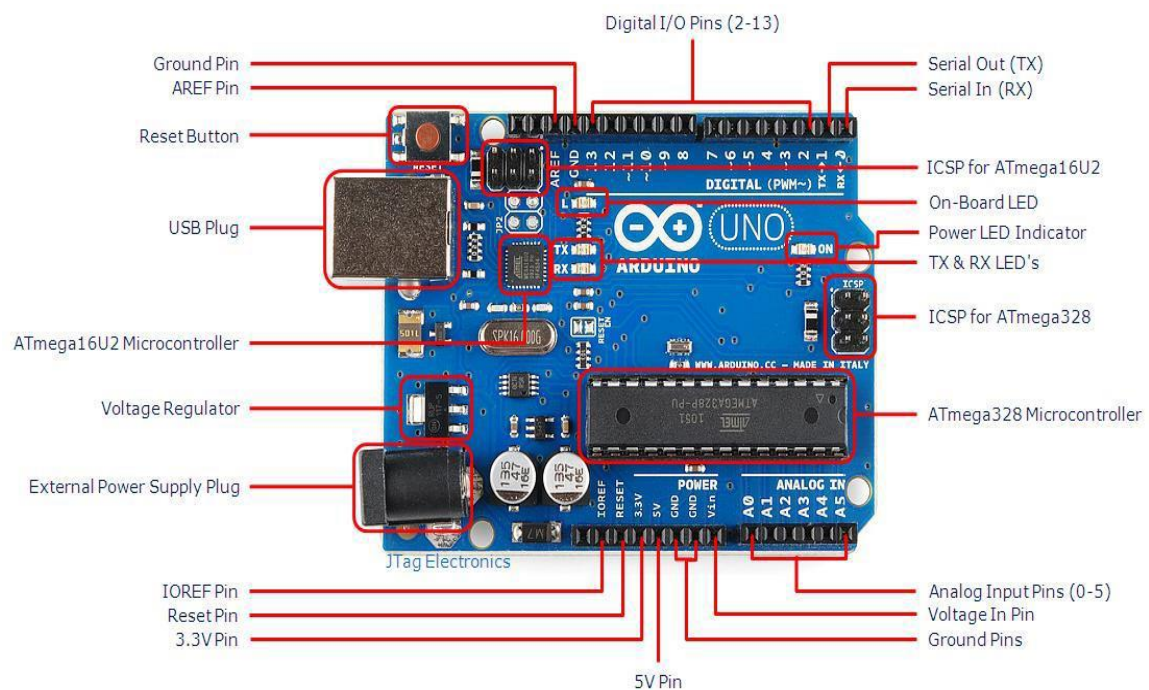


Fig . 5.1.4(b): Arduino Board

Looking at the board from the top down, this is an outline of what you will see (parts of the board you might interact with in the course of normal use are highlighted).

Starting clockwise from the top center:

- Analog Reference pin (orange)
- Digital Ground (light green)
- Digital Pins 2-13 (green)

- Digital Pins 0-1/Serial In/Out - TX/RX (dark green) - These pins cannot be used for digital i/o (Digital Read and Digital Write) if you are also using serial communication (e.g.Serial.begin).
- Reset Button - S1 (dark blue)
- In-circuit Serial Programmer (blue-green)
- Analog In Pins 0-5 (light blue)
- Power and Ground Pins (power: orange, grounds: light orange)
- External Power Supply In (9-12VDC) - X1 (pink)
- Toggles External Power and USB Power (place jumper on two pins closest to desired supply) - SV1 (purple)
- USB (used for uploading sketches to the board and for serial communication between the board and the computer; can be used to power the board) (yellow)

5.2 Digital Pins

In addition to the specific functions listed below, the digital pins on an Arduino board can be used for general purpose input and output via the pin Mode(),Digital Read(),and Digital Write()commands. Each pin has an internal pull-up resistor which can be turned on and off using digital Write() (w/ a value of HIGH or LOW, respectively) when the pin is configured as an input. The maximum current per pin is 40mA.

- **Serial: 0 (RX) and 1 (TX).** Used to receive (RX) and transmit (TX) TTL serial data. On the ArduinoDiecimila, these pins are connected to the corresponding pins of the FTDI USB-to-TTL

Serial chip. On the Arduino BT, they are connected to the corresponding pins of the WT11Bluetooth module. On the Arduino Mini and LilyPad Arduino, they are intended for use with an external TTL serial module (e.g. the Mini-USB Adapter).

- **External Interrupts: 2 and 3.** These pins can be configured to trigger an interrupt on a low value, arising or falling edge, or a change in value. See the `attachInterrupt()` function for details.
- **PWM: 3, 5, 6, 9, 10, and 11** Provide 8-bit PWM output with the `analogWrite()` function. Onboards with an ATmega8, PWM output is available only on pins 9, 10, and 11.
- **BT Reset: 7.**(Arduino BT-only) Connected to the reset line of the Bluetooth module.
- **SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK).** These pins support SPI communication, which, although provided by the underlying hardware, is not currently included in the Arduino language.
- **LED: 13.** On the Diecimila and Lilypad, there is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

5.3 Analog Pins

In addition to the specific functions listed below, the analog input pins support 10-bit analog-to-digital conversion (ADC) using the `analogRead()` function. Most of the analog inputs can also be used as digital pins: analog input 0 as digital pin 14 through analog input 5 as digital pin 19. Analog inputs 6 and 7 (present on the Mini and BT) cannot be used as digital pins.

Power Pins:

- **VIN** (sometimes labeled "9V"): The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin. Also note that the Lily Pad has no VIN pin and accepts only a regulated input.
- 5V**: The regulated power supply used to power the microcontroller and other components on the board. This can come either from VIN via an on-board regulator, or be supplied by USB or another regulated 5V supply.
- **3V3** (Diecimila-only) :A 3.3 volt supply generated by the on-board FTDI chip.
- **GND**: Ground pins.

5.4 Other Pins

- **AREF:**Reference voltage for the analog inputs. Used with analog reference ().
- **Reset:** (Diecimila-only) Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

5.5 Ultrasonic sensor:

An ultrasonic sensor is an instrument that measures the distance to an object using ultrasonic sound waves. An ultrasonic sensor uses a transducer to send and receive ultrasonic pulses that relay back information about an object's proximity. High-frequency sound waves reflect from boundaries to produce distinct echo patterns.



Fig . 5.5 ultrasonic sensor

Sound is a mechanical wave travelling through the mediums, which may be a solid, or liquid or gas. Sound waves can travel through the mediums with specific velocity depends on the medium of propagation. The sound waves which are having high frequency reflect from boundaries and produces distinctive echo patterns.

5.6 Laws of physics for sound waves

Sound waves are having specific frequencies or number of oscillations per second. Humans can detect sounds in a frequency range from about 20Hz to 20 KHz. However the frequency range normally employed in ultrasonic detection is 100 KHz to 50MHz. The velocity of ultrasound at a particular time and temperature is constant in a medium.

5.7 Transducers for Wave Propagation and particle detection

For sending sound waves and receiving echo, ultrasonic sensors, normally called transceivers or transducers will be used. They work on a principle similar to radar that will convert electrical energy into mechanical energy in the form of sound, and vice versa.

The commonly used transducers are contact transducers, angle beam transducers, delay line transducers, immersion transducers, and dual element transducers. Contact transducers are typically used for locating voids and cracks to the outside surface of a part as well as measuring thickness. Angle beam transducers use the principle of reflection and mode conversion to produce refracted shear or longitudinal waves in the test material.

Delay line transducers are single element longitudinal wave transducers used in conjunction with a replaceable delay line. One of the reasons for choosing delay line transducer is that near surface resolution can be improved. The delay allows the element to stop vibrating before a return signal from the reflector can be received.

How Ultrasonic Sensors Work.

Ultrasonic sound vibrates at a frequency above the range of human hearing. Transducers are the microphones used to receive and send the ultrasonic sound. Our ultrasonic sensors, like many others, use a single transducer to send a pulse and to receive the echo. The sensor determines the distance to a target by measuring time lapses between the sending and receiving of the ultrasonic pulse.

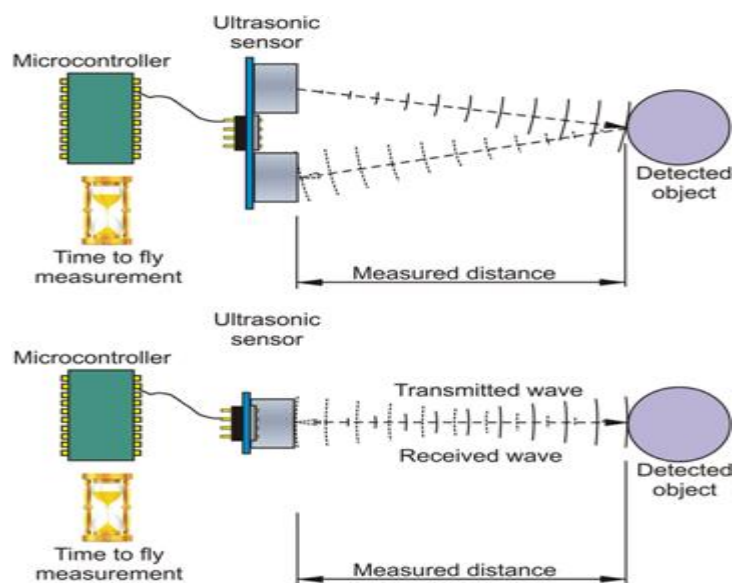


Fig . 5.7

Why use an ultrasonic sensor?

Ultrasound is reliable in any lighting environment and can be used inside or outside. Ultrasonic sensors can handle collision avoidance for a robot, and being moved often, as long as it isn't too fast. Ultrasonics are so widely used, they can be reliably implemented in grain bin sensing applications, water level sensing, drone applications and sensing cars at your local drive-thru restaurant or bank. Ultrasonic rangefinders are commonly used as devices to detect a collision.

Ultrasonic Sensors are best used in the non-contact detection of:

- Presence
- Presence
- Level
- Position
- Distance

Non-contact sensors are also referred to as proximity sensors.

Ultrasonics are Independent of :

- Light
- Smoke
- Dust
- Color

Material (except for soft surfaces, i.e. wool, because the surface absorbs the ultrasonic sound wave and doesn't reflect sound.)

Applications Involving Ultrasonic Detection

Ultrasonic Distance Measurement

Ex. Distance measurement would be applied in a garage parking application, sen

sing when a vehicle is pulled completely into a garage.

Ultrasonic Sensors for water level detection

Tank level measurement, Fuel gauging, irrigation control.

Ultrasonic Obstacle Detection

Our UAV Sensors for Drones as well as our proximity sensors that are used for robots are for obstacle detection.

5.8 Bluetooth:

HC-05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. Serial port Bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. It uses CSR Bluecore 04-External single chip Bluetooth system with CMOS technology and with AFH(Adaptive Frequency Hopping Feature). It has the footprint as small as 12.7mmx27mm. Hope it will simplify your overall design/development cycle.

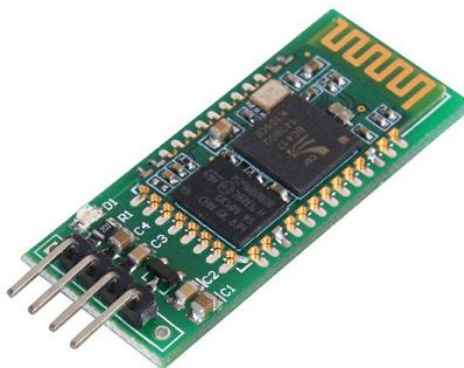


Fig 5.8 Bluetooth

5.8.1 Specifications Hardware features

Typical -80dBm sensitivity

Up to +4dBm RF transmit power

Low Power 1.8V Operation ,1.8 to 3.6V I/O

PIO control

UART interface with programmable baud rate

With integrated antenna

With edge connector

Software features

Default Baud rate: 38400, Data bits:8, Stop bit:1,Parity:No parity,

Data control: has.

Supported band rate:

9600,19200,38400,57600,115200,230400,460800.

Given a rising pulse in PIO0, device will be disconnected.λ

Status instruction port PIO1: low-disconnected, high-connected;

PIO10 and PIO11 can be connected to red and blue led separately.

When master and slaveλ are paired, red and blue led blinks

1time/2s in interval, while disconnected only blue led blinks

2times/s. Auto-connect to the last device on power as default.

Permit pairing device to connect as default.λ Auto-pairing

PINCODE:"0000" as defaultλ Auto-reconnect in 30 min when

disconnected as a result of beyond the range of connection

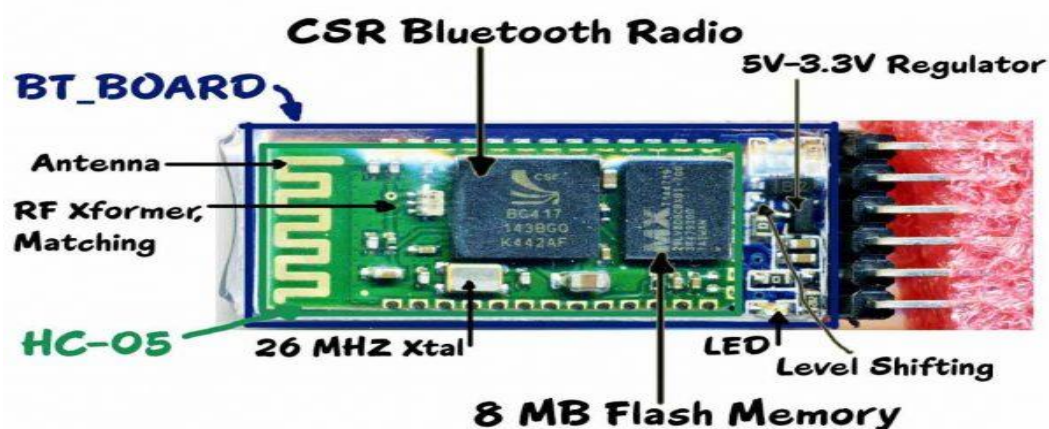


Fig 5.8.1

AT command Default: How to set the mode to server (master): 1.

Connect PIO11 to high level. 2. Power on, module into command state.

3. Using baud rate 38400, sent the "AT+ROLE=1\r\n" to module, with "OK\r\n" means setting successes.

4. Connect the PIO11 to low level, repower the module, the module work as server (master). AT commands: (all end with \r\n)

1. Test command: Command Respond Parameter AT OK –

2. Reset Command Respond Parameter AT+RESET OK –

3. Get firmware version Command Respond Parameter
AT+VERSION? +VERSION: OK Param : firmware version

Example: AT+VERSION?\r\n +VERSION:2.0-20100601 OK

4. Restore default Command Respond Parameter AT+ORGL OK
- Default state: Slave mode, pin code :1234, device name: H-C-2010-06-01 ,Baud 38400bits/s.

5. Get module address Command Respond Parameter
AT+ADDR? +ADDR: OK Param: address of Bluetooth module
Bluetooth address: NAP: UAP : LAP Example: AT+ADDR?\r\n
+ADDR:1234:56:abcdef OK

6. Set/Check module name: Command Respond Parameter
AT+NAME= OK

Param: Bluetooth module name (Default :HC-05) AT+NAME?
+NAME: OK (/FAIL) Example: AT+NAME=HC-05\r\n set the
module name to “HC-05” OK AT+NAME=ITeadStudio\r\n OK
AT+NAME?\r\n +NAME: ITeadStudio OK

1. Get the Bluetooth device name: Command Respond
Parameter

AT+RNAME? 1. +NAME: OK

2. FAIL Param1,Param 2 : the address of Bluetooth device

Example: (Device address 00:02:72:od:22:24, name :
ITead) AT+RNAME? 0002, 72, od2224\r\n

+RNAME:ITead OK 8. Set/Check module mode:

Command Respond Parameter AT+ROLE= OK Param:
AT+ ROLE? +ROLE: 0- Slave



5.9 Lcd:

This is an example for the Parallel Port. This doesn't use the Bi-directional feature found on newer ports, thus it should work with most, if noall Parallel Ports. It however doesn't show the use of the Status Port as an input.. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on.

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



Figure 5.9

5.10 LCD BACKGROUND:

The 44780 standard requires 3 control lines as well as either 4 or 8 I/O lines for the data bus. The user may select whether the LCD is to operate with a 4-bit data bus or an 8-bit data bus. If a 4-bit data bus is used the LCD will require a total of 7 data lines (3 control lines plus the 4 lines for the data bus). If an 8-bit data bus is used the LCD will require a total of 11 data lines (3 control lines plus the 8 lines for the data bus). The three control lines are referred as EN, RW and RS

EN: The **EN** line is called "Enable." This control line is used to tell the LCD that you are sending it data. To send data to the LCD, your program should make sure this line is low (0) and then set the other two control lines and/or put data on the data bus. When the other lines are completely ready, bring **EN** high (1) and wait for the minimum amount of time required by the LCD datasheet (this varies from LCD to LCD), and end by bringing it low (0) again.

RS: The **RS** line is the "Register Select" line. When RS is low (0), the data is to be treated as a command or special instruction (such as clear screen, position cursor, etc.). When RS is high (1), the data being sent is text data which should be displayed on the screen. For example, to display the letter "T" on the screen you would set RS high.

RW: The **RW** line is the "Read/Write" control line. When RW is low (0), the information on the data bus is being written to the LCD. When RW is high (1), the program is effectively querying (or reading) the LCD. Only one instruction ("Get LCD status") is a read command. All others are write commands--so RW will almost always be low.

Finally, the data bus consists of 4 or 8 lines (depending on the mode of operation selected by the user). In the case of an 8-bit

data bus, the lines are referred to as DB0, DB1, DB2, DB3, DB4, DB5, DB6, and DB7.

LCD PIN OUT

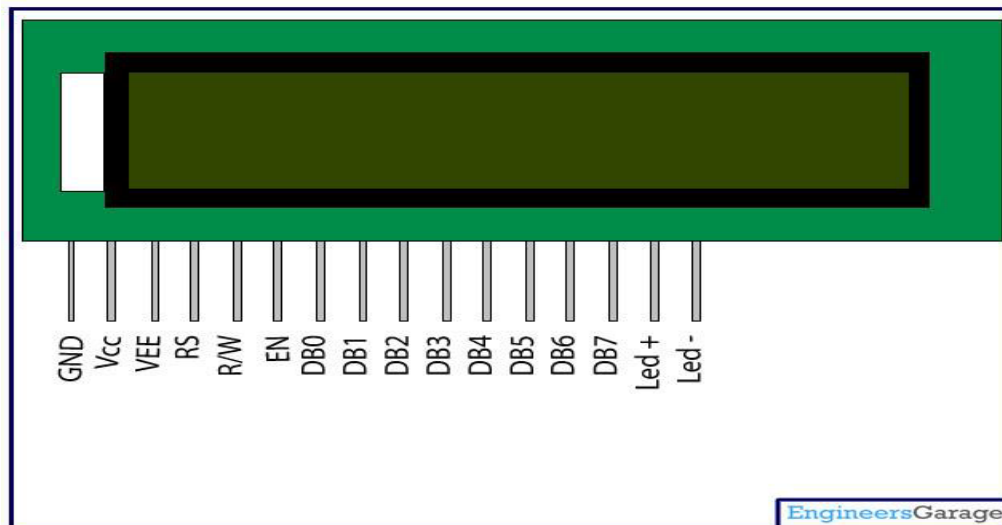


Fig 5.10

5.11 PIN DESCRIPTION

Pin No:	Name	Function
1	VSS	This pin must be connected to the ground
2	VCC	Positive supply voltage pin (5V DC)
3	VEE	Contrast adjustment
4	RS	Register selection
5	R/W	Read or write
6	E	Enable
7	DB0	Data
8	DB1	Data

9	DB2	Data
10	DB3	Data
11	DB4	Data
12	DB5	Data
13	DB6	Data
14	DB7	Data
15	LED+	Back light LED+
16	LED-	Back light LED

5.12 INTERFACING LCD WITH AN ARDUINO

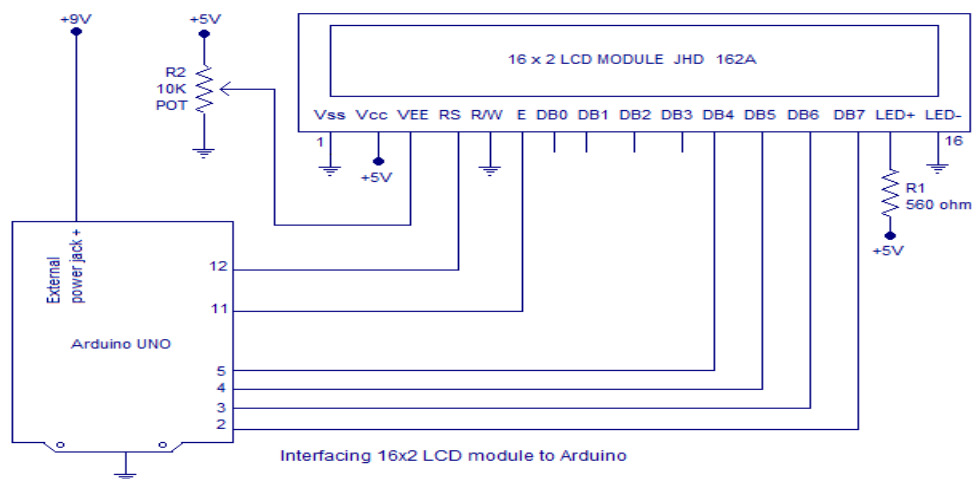


Fig 5.11

The circuit diagram of interfacing LCD to Arduino for displaying a text message is shown above. RS pin of the LCD module is connected to digital pin 12 of the Arduino. R/W pin of the LCD is grounded. Enable pin of the LCD module is connected to digital pin 11 of the Arduino. In this project, the LCD module and Arduino are interfaced in the 4-bit mode. That means only four of the digital input lines (DB4 to DB7 of the LCD are used). This method is very simple, requires less connections and you can almost utilize the full potential of the LCD module. Digital lines DB4, DB5, DB6 and DB7 are interfaced to

digital pins 5, 4, 3 and 2 of the Arduino. The 10K potentiometer is used for adjusting the contrast of the display. 560 ohm resistor R1 limits the current through the back light LED. The Arduino can be powered through the external power jack provided on the board. +5V required in some other parts of the circuit can be tapped from the 5V source on the Arduino board. The Arduino can be also powered from the PC through the USB port.

5.12 L293d driver:

L293D is a typical Motor driver or Motor Driver IC which allows DC motor to drive on either direction. L293D is a 16-pin IC which can control a set of two DC motors simultaneously in any direction. It means that you can control two DC motor with a single L293D IC. Dual H-bridge *Motor Driver integrated circuit (IC)*.

The l293d can drive small and quiet big motors as well, check the Voltage Specification at the end of this page for more info.

5.13 Concept:

It works on the concept of H-bridge. H-bridge is a circuit which allows the voltage to be flown in either direction. As you know voltage need to change its direction for being able to rotate the motor in clockwise or anticlockwise direction, hence H-bridge IC are ideal for driving a DC motor.

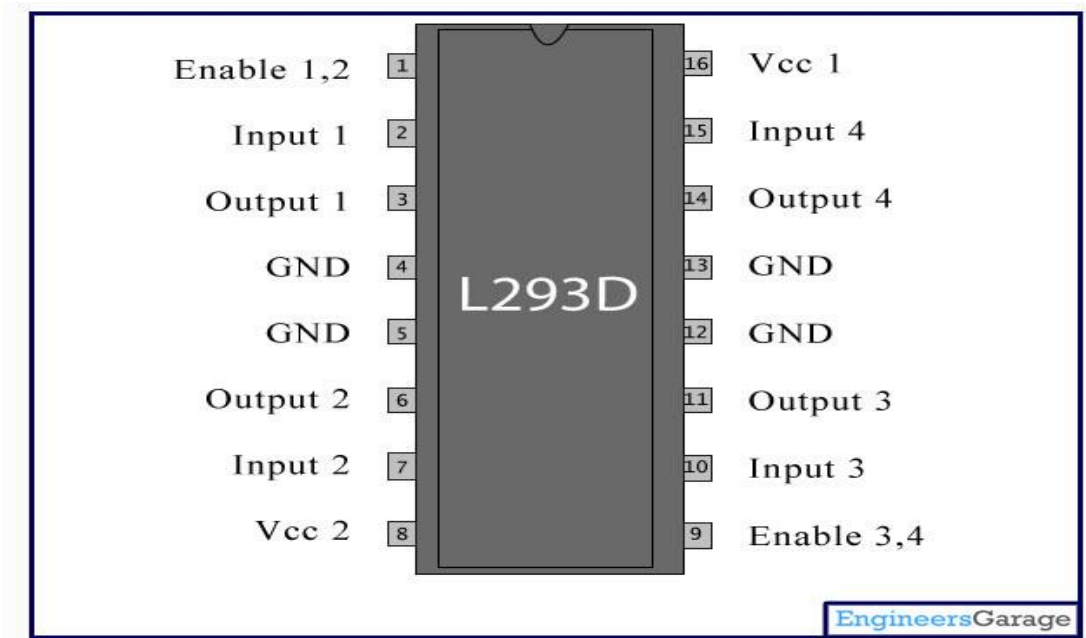
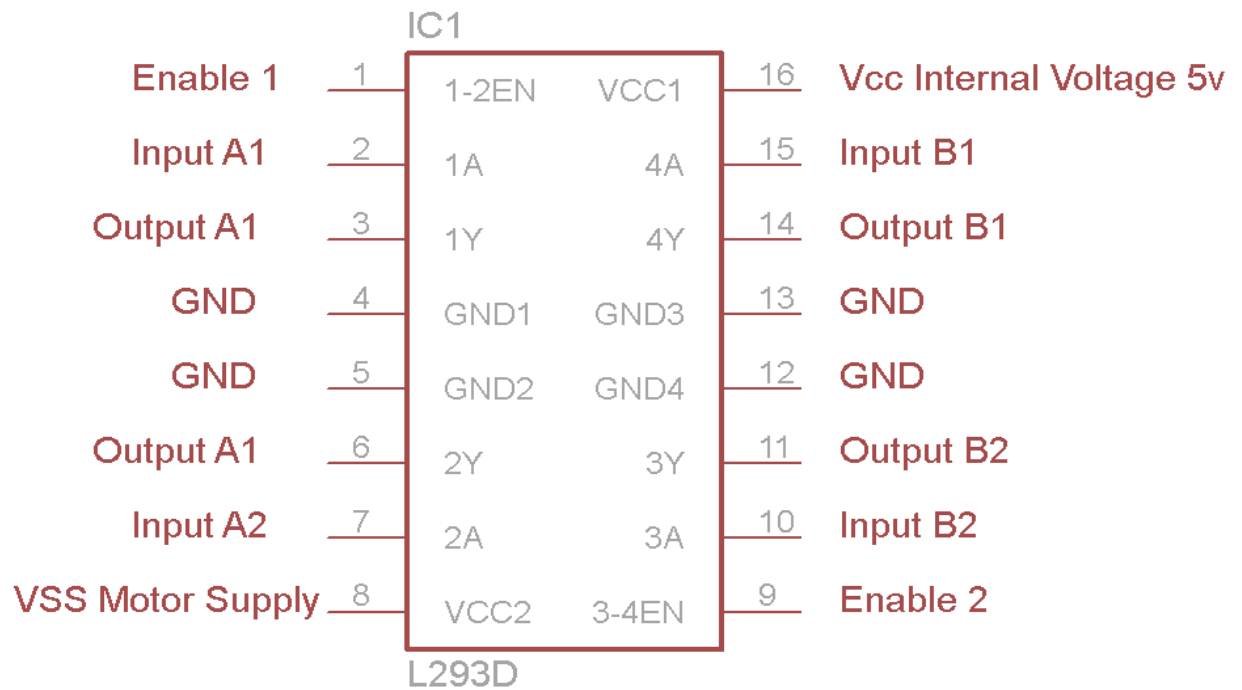


Fig 5.13

In a single L293D chip there are two h-Bridge circuit inside the IC which can rotate two dc motor independently. Due its size it is very much used in robotic application for controlling DC motors. Given below is the pin diagram of a L293D motor controller.

There are two Enable pins on l293d. Pin 1 and pin 9, for being able to drive the motor, the pin 1 and 9 need to be high. For driving the motor with left H-bridge you need to enable pin 1 to high. And for right H-Bridge you need to make the pin 9 to high. If anyone of the either pin1 or pin9 goes low then the motor in the corresponding section will suspend working. It's like a switch.

TIP: you can simply connect the pin16 VCC (5v) to pin 1 and pin 9 to make them high.



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Fig 5.14

5.15 Working of L293D

There are 4 input pins for l293d, pin 2,7 on the left and pin 15 ,10 on the right as shown on the pin diagram. Left input pins will regulate the rotation of motor connected across left side and right input for motor on the right hand side. The motors are rotated on the basis of the inputs provided across the input pins as LOGIC 0 or LOGIC 1.

In simple you need to provide Logic 0 or 1 across the input pins for rotating the motor.

5.16 L293D Logic Table.

Let's consider a Motor connected on left side output pins (pin 3,6). For rotating the motor in clockwise direction the input pins has to be provided with Logic 1 and Logic 0.

- **Pin 2 = Logic 1 and Pin 7 = Logic 0** | Clockwise Direction
- **Pin 2 = Logic 0 and Pin 7 = Logic 1** | Anticlockwise Direction

- **Pin 2 = Logic 0 and Pin 7 = Logic 0** | Idle [No rotation] [Hi-Impedance state]
- **Pin 2 = Logic 1 and Pin 7 = Logic 1** | Idle [No rotation]

In a very similar way the motor can also operate across input pin 15, 10 for motor on the right hand side.

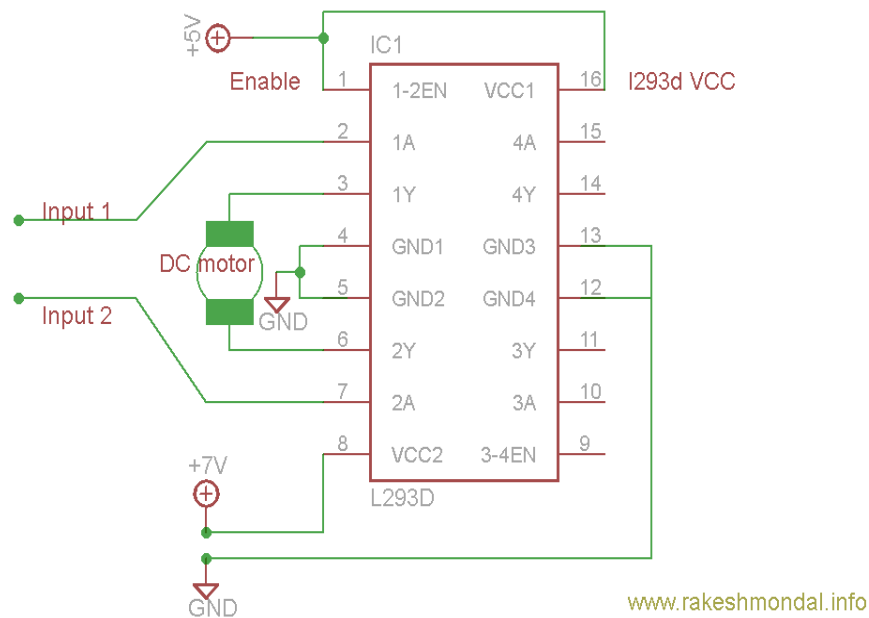


Fig 5.16

5.17 Voltage Specification

VCC is the voltage that it needs for its own internal operation 5v; L293D will not use this voltage for driving the motor. For driving the motors it has a separate provision to provide motor supply VSS (V supply). L293d will use this to drive the motor. It means if you want to operate a motor at 9V then you need to provide a Supply of 9V across VSS Motor supply.

The maximum voltage for VSS motor supply is 36V. It can supply a max current of 600mA per channel. Since it can drive motors Up to 36v hence you can drive pretty big motors with this l293d.

VCC pin 16 is the voltage for its own internal Operation. The maximum voltage ranges from 5v and upto 36v.

5.17 Motor:

DC motors like this are great for battery-powered toys (things like model trains, radio-controlled cars, or electric shavers), but you don't find them in many household appliances. Small appliances (things like coffee grinders or electric food blenders) tend to use what are called **universal motors**, which can be powered by either AC or DC. Unlike a simple DC motor, a universal motor has an electromagnet, instead of a permanent magnet, and it takes its power from the DC or AC power you feed in:

- When you feed in DC, the electromagnet works like a conventional permanent magnet and produces a magnetic field that's always pointing in the same direction. The commutator reverses the coil current every time the coil flips over, just like in a simple DC motor, so the coil always spins in the same direction.
- When you feed in AC, however, the current flowing through the electromagnet and the current flowing through the coil both reverse, exactly in step, so the force on the coil is always in the same direction and the motor always spins either clockwise or counter-clockwise. What about the commutator? The frequency of the current changes much faster than the motor rotates and, because the field and the current are always in step, it doesn't actually matter what position the commutator is in at any given moment.

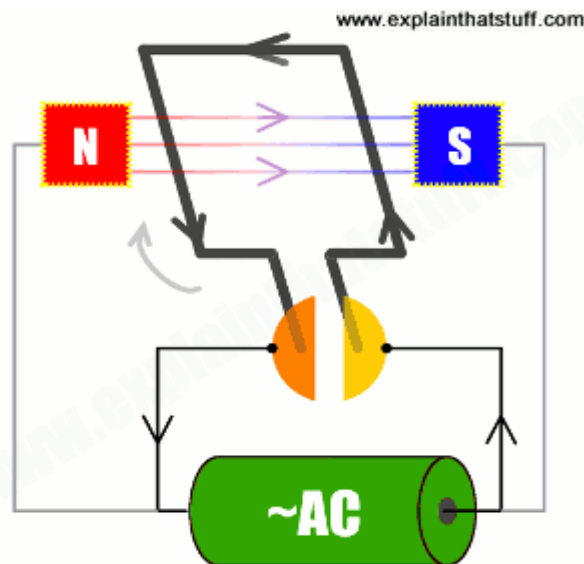


Fig 5.17

There are two ways to overcome this problem. One is to use a kind of electric current that periodically reverses direction, which is known as an alternating current (AC). In the kind of small, battery-powered motors we use around the home, a better solution is to add a component called a commutator to the ends of the coil. (Don't worry about the meaningless technical name: this slightly old-fashioned word "commutation" is a bit like the word "commute".

It simply means to change back and forth in the same way that commute means to travel back and forth.) In its simplest form, the commutator is a metal ring divided into two separate halves and its job is to reverse the electric current in the coil each time the coil rotates through half a turn. One end of the coil is attached to each half of the commutator. The electric current from the battery connects to the motor's electric terminals.

These feed electric power into the commutator through a pair of loose connectors called brushes, made either from pieces of graphite (soft carbon similar to pencil "lead") or thin lengths of springy metal, which (as the name suggests) "brush" against the commutator. With the

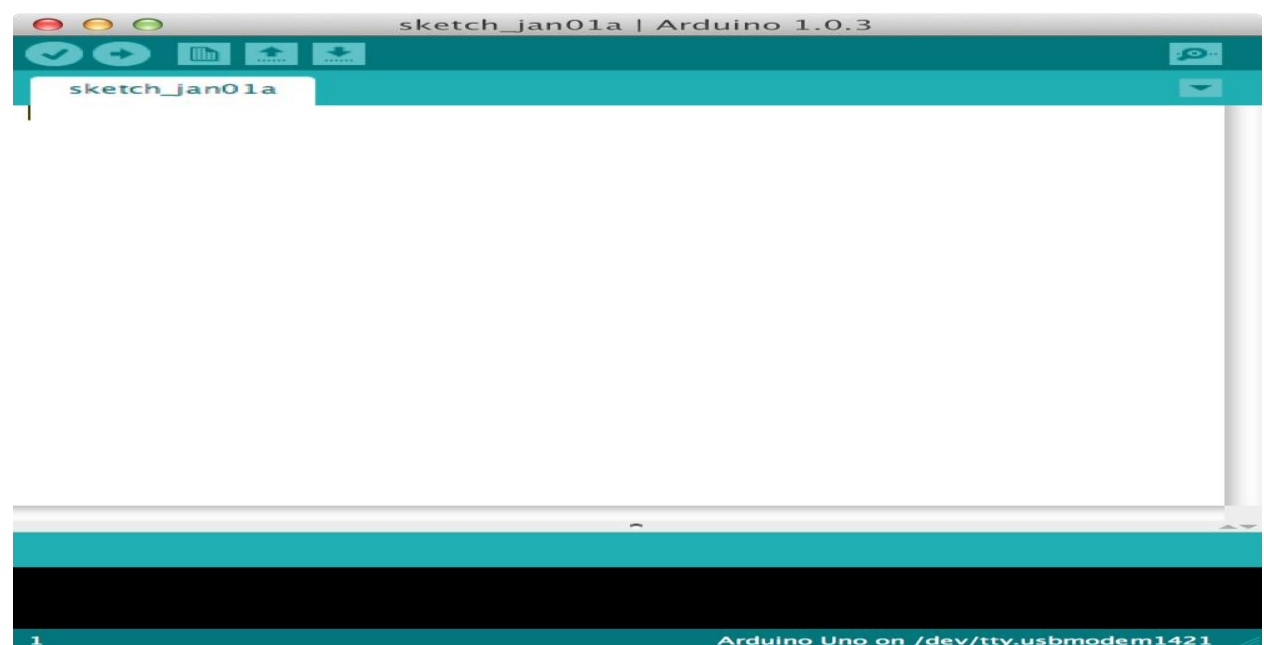
commutator in place, when electricity flows through the circuit, the coil will rotate continually in the same direction.

Software requirements:

Download Arduino Software

You'll need to download the Arduino Software package for your operating system from the Arduino download page.

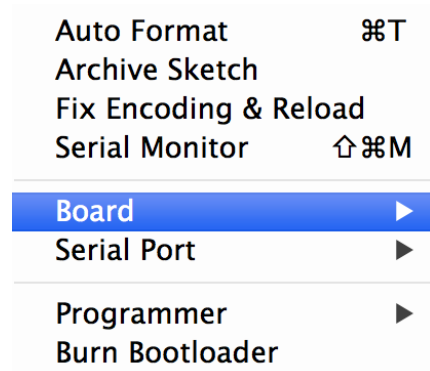
When you've downloaded and opened the application you should see something like this:



This is where you type the code you want to compile and send to the Arduino board.

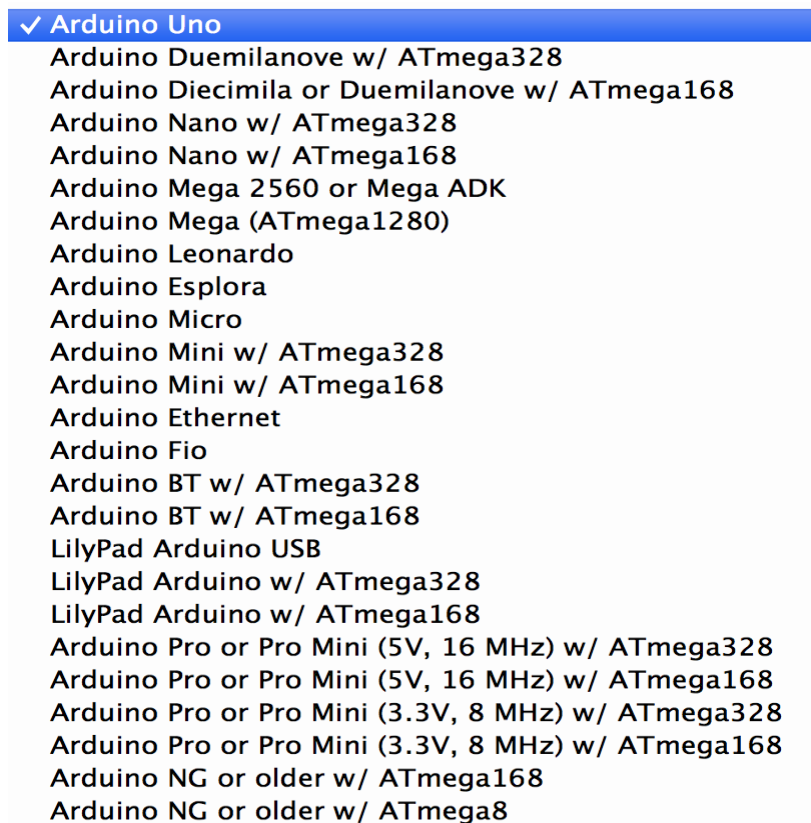
The Initial Setup

We need to setup the environment to **Tools** menu and select **Board**.



Tools Menu < Board

Then select the type of Arduino you want to program, in our case it's the **Arduino Uno**.



Arduino Uno

The Code

The code you write for your Arduino are known as **sketches**. They are written in **C++**.

Every sketch needs two *void type functions*, `setup()` and `loop()`. A void type function doesn't return any value.

The `setup()` method is ran once at the just after the Arduino is powered up and the `loop()` method is ran continuously afterwards. The `setup()` is where you want to do any initialization steps, and in `loop()` you want to run the code you want to run over and over again.

So, your basic sketch or program should look like this:

```
1
2
3 void setup()
4 {
5 }
6
7 void loop()
8 {
9 }
```

If you notice on the top edge of the board there's two black rectangles with several squares in. These are called **headers**. Headers make it easy to connect components to the the Arduino. Where they connect to the board is called **pins**. Knowing what pin something is connected to is essential for programming an Arduino.

The pin numbers are listed next to the headers on the board in white.

The onboard LED we want to control is on pin 13.

In our code above the `setup()` method let's create a variable called `ledPin`. In C++ we need to state why type our variable is before hand, in this case it's an integer, so it's of type `int`.

```
int ledPin = 13;
void setup()
{
}
void loop()
{
}
```

Each line is ended with a semicolon (;).

In the `setup()` method we want to set the `ledPin` to the output mode. We do this by calling a special function called `pinMode()` which takes two variables, the first the pin number, and second, whether it's an input or output pin. Since we're dealing with an output we need to set it to a constant called `OUTPUT`. If you were working with a sensor or input it would be `INPUT`.

```
1
2   int ledPin = 13;
3
4   void setup()
5   {
6     pinMode(ledPin, OUTPUT);
7   }
8   void loop()
9   {
10  }
11
```

Next we want to compile to machine code and deploy or *upload* it to the Arduino.

Compiling the Code

If this is your first time you've ever compiled code to your Arduino before plugging it in to the computer go to the **Tools** menu, then **Serial Port** and take note of what appears there.

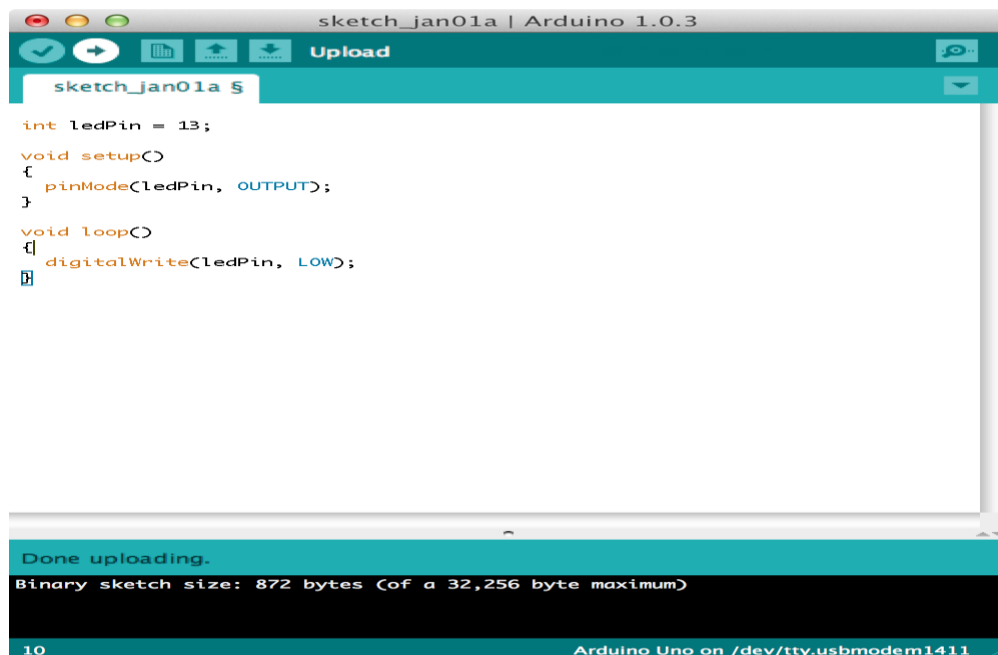
Here's what mine looks like before plugging in the Arduino UNO:

```
/dev/tty.Bluetooth-PDA-Sync  
/dev/cu.Bluetooth-PDA-Sync  
/dev/tty.Bluetooth-Modem  
/dev/cu.Bluetooth-Modem
```

Plug your Arduino UNO board in to the USB cable and into your computer. Now go back to the **Tools > Serial Port** menu and you should see at least 1 new option. On my Mac 2 new serial ports appear.

```
/dev/tty.Bluetooth-PDA-Sync  
/dev/cu.Bluetooth-PDA-Sync  
/dev/tty.Bluetooth-Modem  
/dev/cu.Bluetooth-Modem  
✓ /dev/tty.usbmodem1411  
/dev/cu.usbmodem1411
```

They *tty* and *cu* are two ways that computers can talk over a serial port. Both seem to work with the Arduino software so I selected the *tty.** one. On Windows you should see *COM* followed by a number. Select the new one that appears.



Once you have selected your serial or COM port you can then press the button with the arrow pointing to the right.

Once that happens you should see the **TX** and **RX** LEDs below the **L** LED flash. This is the communication going on between the computer and the Arduino. The **L** may flicker too. Once this dance is complete your program should be running. And your LED should be off. Now let's try and switch it on using the **HIGH** constant.

CHAPTER 6

Existing System And Proposed system

6.1 Existing System

renewable energy sources are also used, whose power is variable in nature. The micro-grid has one demerit that voltage profile is highly distorted due to small generating capacities along with fluctuating loads. These fluctuations in load affect the quality of power as well as the voltage profile. So, maintaining a flat voltage profile with fluctuating power demand is a big challenge for power engineers.

6.2 Proposed system:

Aiming at the voltage stability problem of wind power grid-connected systems, a cooperative control scheme of Thyristor Controlled Series Compensator (TCSC) and Static Synchronous Compensator (STATCOM) is proposed in this study. The proposed scheme is applied in the wind power grid-connected system, a combined control strategy based on STATCOM double closed-loop feedback control and TCSC device is used to ensure that the system has enough reactive power to maintain its normal work during operation. The corresponding simulation model of wind power grid-connected system. Proposed that a cooperative control of TCSC and STATCOM is applied to improve the voltage stability of wind power grid-connected systems when the reactive power compensation is carried out under three-phase short-circuit fault.

6.3 Control scheme of TCSC-STATCOM

Asynchronous wind turbine without an excitation circuit is different from the synchronous generator, the excitation can only be done with an external power supply. In the case of constant speed, the electromagnetic torque of the asynchronous generator is proportional to the square of the unit outlet voltage. The asynchronous wind generator is connected to the grid and the grid provides its own required excitation and reactive power which is the reactive power load of the grid. If the mechanical torque remains unchanged, when the power grid is a failure, the terminal voltage of wind farm will decrease, which will reduce the electromagnetic torque of the generator and then cause the rotor to accelerate. After the power grid fault is cut off, the generator needs to absorb a large amount of reactive current from the grid to rebuild the internal electromagnetic field of the generator during the system voltage recovery, which will cause a large voltage drop on the bus of grid-connected wind farm, and further reduce the terminal voltage of wind farm. Under normal circumstances, the required value of the wind farm terminal voltage needs to be adjusted frequently to maintain the rated voltage value. Therefore, it will be taken into consideration that the STATCOM device is put into the system to provide the required reactive power for the wind turbine, thus it is not necessary to frequently reset the required value to maintain the wind farm terminal voltage at the desired value. However, while asynchronous wind turbine injects a variable output current into the grid, at the same time it also will increase the damping. If there is no excitation controller in the wind power grid-connected system, the system will not be able to operate stably only with STATCOM device. Therefore, it will be taken into consideration that the cooperative control of TCSC and STATCOM in Fig. 5 is applied in a wind power grid connected system. STATCOM is connected in parallel with the wind power access point, and TCSC is connected in series with the transmission line of the grid.

6.4 STATCOM

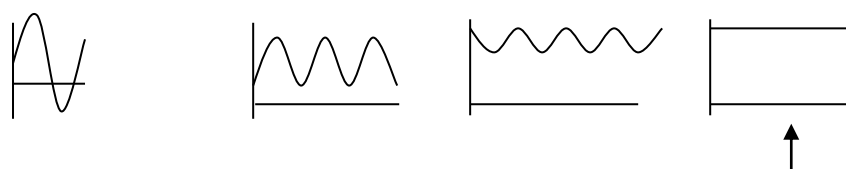
The dynamic reactive current output range is symmetrical (during normal disturbed network conditions); however, non-symmetrical designs are possible by introducing mechanically or thyristor switched shunt elements with unified control systems to cover most conventional applications.

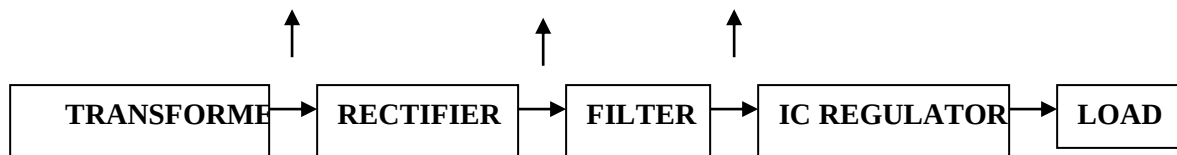
The STATCOM design and fast response makes the technology very convenient for maintaining voltage during network faults (as STATCOMs are capable of providing fast fault current injection limited to the rated current), enhancing short term voltage stability.

In addition, STATCOMs can provide power factor correction, reactive power control, damping of low-frequency power oscillations (usually by means of reactive power modulation), active harmonic filtering, flicker mitigation and power quality improvements.

6.5 POWER SUPPLY

The ac voltage, typically 220V rms, is connected to a transformer, which steps that ac voltage down to the level of the desired dc output. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation. A regulator circuit removes the ripples and also remains the same dc value even if the input dc voltage varies, or the load connected to the output dc voltage changes. This voltage regulation is usually obtained using one of the popular voltage regulator IC units.





Block Diagram of Power supply

6.6 TRANSFORMER

The potential transformer will step down the power supply voltage (0-230V) to (0-6V) level. Then the secondary of the potential transformer will be connected to the precision rectifier, which is constructed with the help of op-amp. The advantages of using precision rectifier are it will give peak voltage output as DC, rest of the circuits will give only RMS output.

6.7 BRIDGE RECTIFIER

When four diodes are connected as shown in figure, the circuit is called as bridge rectifier. The input to the circuit is applied to the diagonally opposite corners of the network, and the output is taken from the remaining two corners. Let us assume that the transformer is working properly and there is a positive potential, at point A and a negative potential at point B. The positive potential at point A will forward bias D3 and reverse bias D4. The negative potential at point B will forward bias D1 and reverse D2. At this time D3 and D1 are forward biased and will allow current flow to pass through them; D4 and D2 are reverse biased and will block current flow. The path for current flow is from point B through D1, up through RL, through D3, through the secondary of the transformer back to point B. this path is indicated by the solid arrows. Waveforms (1) and (2) can be observed across D1 and D3. One-half cycle later the polarity across the

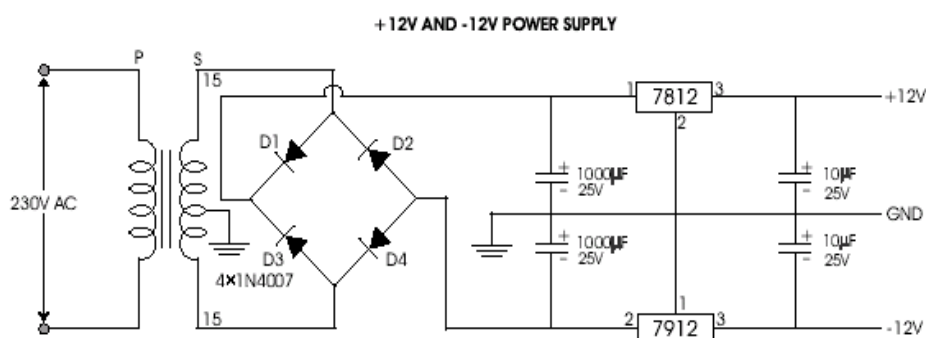
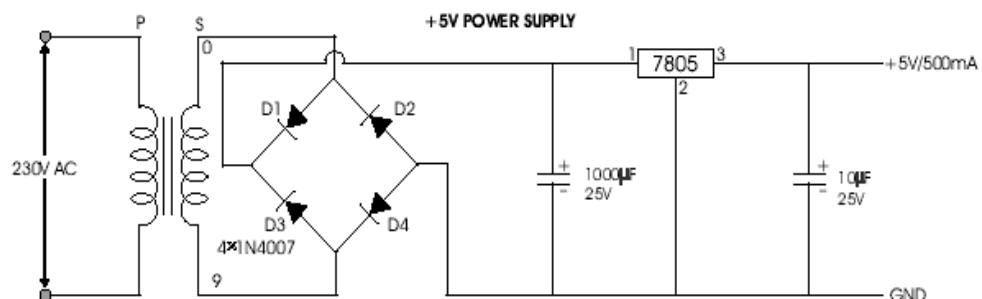
secondary of the transformer reverse, forward biasing D2 and D4 and reverse biasing D1 and D3. Current flow will now be from point A through D4, up through RL, through D2, through the secondary of T1, and back to point A. This path is indicated by the broken arrows. The current flow through RL is always in the same direction. In flowing through RL this current develops a voltage corresponding to that shown waveform (5). Since current flows through the load (RL) during both half cycles of the applied voltage, this bridge rectifier is a full-wave rectifier.

One advantage of a bridge rectifier over a conventional full-wave rectifier is that with a given transformer the bridge rectifier produces a voltage output that is nearly twice that of the conventional full-wave circuit. This may be shown by assigning values to some of the components shown in views A and B. assume that the same transformer is used in both circuits. The peak voltage developed between points X and y is 1000 volts in both circuits. Since only one diode can conduct at any instant, the maximum voltage that can be rectified at any instant is 500 volts. The maximum voltage that appears across the load resistor is nearly-but never exceeds-500 volts, as result of the small voltage drop across the diode. Current flows through the load during both half cycles of the applied voltage. In the bridge rectifier shown in view B, the maximum voltage that can be rectified is the full secondary voltage. Therefore, the peak output voltage across the load resistor is nearly 1000 volts. With both circuits using the same transformer, the bridge rectifier circuit produces a higher output voltage than the conventional full-wave rectifier circuit. In the conventional full-wave circuit, the peak voltage from the centre tap to either X or Y is 500 volts. The path for current flow is from point B through D1, up through RL, through D3, through the secondary of the transformer back to point B. this path is indicated by the solid arrows. Waveforms (1) and (2) can be observed across D1 and D3. One-half

cycle later the polarity across the secondary of the transformer reverse, forward biasing D2 and D4 and reverse biasing D1 and D3. Current flow will now be from point A through D4, up through RL, through D2, through the secondary of T1, and back to point A. This path is indicated by the broken arrows. The current flow through RL is always in the same direction. In flowing through RL this current develops a voltage corresponding to that shown waveform (5). Since current flows through the load (RL) during both half cycles of the applied voltage, this bridge rectifier is a full-wave rectifier.

6.8 VOLTAGE REGULATOR

Regulator IC units contain the circuitry for reference source, comparator amplifier, and overload protection all in a single IC.



The regulators can be selected for operation with load currents from hundreds of milli amperes to tens of amperes, corresponding to power ratings from milli watts to tens of watts. The series 78 regulators provide fixed positive regulated voltages from 5 to 24 volts. The series 79 regulators provide fixed negative regulated voltages from 5 to 24 volts. A fixed three-terminal voltage regulator has an unregulated dc input voltage, V_i applied to one input terminal, a regulated dc output voltage, V_o , from a second terminal, with the third terminal connected to ground. The series 78 regulators provide fixed positive regulated voltages from 5 to 24 volts. Similarly, the series 79 regulators provide fixed negative regulated voltages from 5 to 24 volts. For ICs microcontroller, LCD - 5 volts. For alarm circuit, op-amp, relay circuits -12 volts.

6.9 DRIVER CIRCUIT

In electronics, a **driver** is an electrical circuit or other electronic component used to control another circuit or component, such as a high-power transistor, liquid crystal display (LCD), and numerous others.

They are usually used to regulate current flowing through a circuit or is used to control the other factors such as other components, some devices in the circuit. The term is often used, for example, for a specialized integrated circuit that controls high-power switches in switched-mode power converters. An amplifier can also be considered a driver for loud speakers, or a constant voltage circuit that keeps an attached component operating within a broad range of input voltages.

Typically the driver stage(s) of a circuit requires different characteristics to other circuit stages. For example in a transistor power amplifier, typically the driver circuit requires current gain, often

the ability to discharge the following transistor bases rapidly, and low output impedance to avoid or minimize distortion.

Driver circuits are most commonly used to amplify signals from controllers or microcontrollers in order to control power switches in semiconductor devices. Driver circuits often take on additional functions which include isolating the control circuit and the power circuit, detecting malfunctions, storing and reporting failures to the control system, serving as a precaution against failure, analyzing sensor signals, and creating auxiliary voltages.

6.10 Thyristor Driver Circuits

In thyristor driver circuits, appropriate control signals are used to generate gate current pulses in order to trigger the thyristor. A transformer often isolates the control circuit from the high voltages of the power circuit.

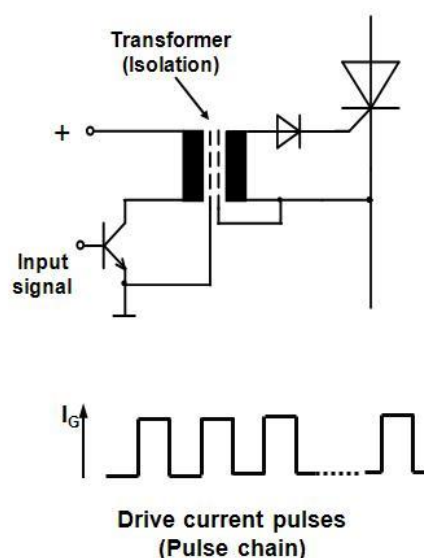


Figure 1. Principle of a thyristor driver circuit

The firing pulses are repeated several times in order to ensure that the pulses exceed the thyristor's latching current. The latching current is the minimum gate current required to trigger the thyristor. For the

thyristor to turn on, the gate pulse must continue until the current through the thyristor reaches the holding current, the minimum current required for the thyristor to remain in the on-state.

6.11 MOSFET and IGBT Driver Circuits

IGBT and MOSFET drivers are very similar in that both components are controlled by voltage (charging the gate capacitor). Table 1 below shows typical control voltages for both types of drivers:

	MOSFET	IGBT
Switch On	+10 V	+15 V
Switch Off	0 V	-8 V (-15 V)

Table 1. Typical control voltages for MOSFETs and IGBTs

The IGBT gate voltage in switch off mode is generally approximately -8V to 15V in order to prevent an undesired capacitive switch on. The insulation between the gate and the emitter is made of thin silicon oxide. A maximum voltage of 20V to 25V must never be exceeded in order to ensure that the oxide layers remain intact.

6.12 Functions of Typical Driver Circuits

The diagram below shows an example of an IGBT half-bridge driver circuit.

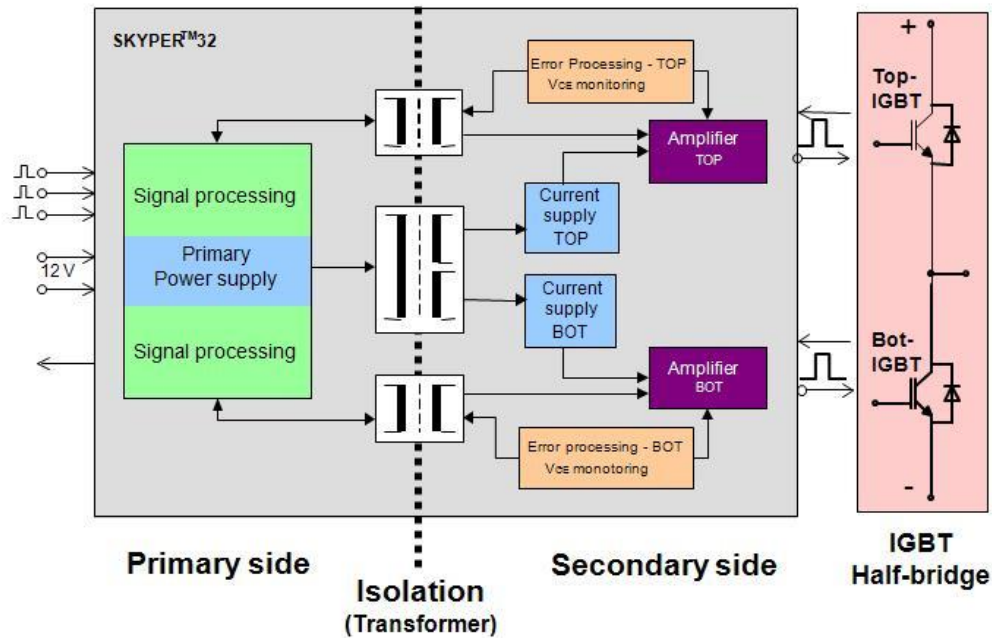


Figure 2. Outline of IGBT half-bridge driver circuit

Primary side of driver circuit

On the primary side of the IGBT half-bridge driver circuit above, input signals are received and error signals are sent back to the controller.

Signal processing that takes place on the primary side of the driver circuit enables short pulse suppression in order to minimize glitches, prevention of both IGBTs in the half-bridge turning on simultaneously so to avoid short circuits, and monitoring of temperature and undervoltages.

Isolation between primary and secondary sides

Isolation of primary and secondary sides of the driver circuit is generally accomplished by use of transformers or optocouplers (LEDs and phototransistors). Typical driver circuits can withstand voltages of 2500 V between the primary and secondary side.

Some simple driver circuits forego the isolation between the primary and secondary sides, leaving this task in the hands of the user.

Secondary side of driver circuit

On the secondary side of the driver circuit, input signals are amplified and used to control the switching of the IGBTs. Overcurrents are monitored to detect shorts in the power circuit. This is done by either comparing the collector-emitter voltage V_{CE} to a preset threshold or by monitoring the signal of a current sensor.

If overcurrent occurs, the secondary side of the driver switches all the IGBTs off and sends an error signal to the primary side.

Isolation of the triggering signal using an optocoupler

Optocouplers are often used in place of transformers to isolate signals. An optocoupler is made up of an LED (Light Emitting Diode) and a light sensitive transistor (phototransistor) all in one package.

In general, optocouplers are inferior to transformers since they display higher susceptibility than transformers, less durability, limited performance, and limited isolation voltage. These drawbacks are more apparent in low cost optocouplers.

6.13 Output Stage of Driver Circuits

The gate emitter capacitor is charged and discharged through the gate resistor by the driver. This determines the switching speed of the IGBT.

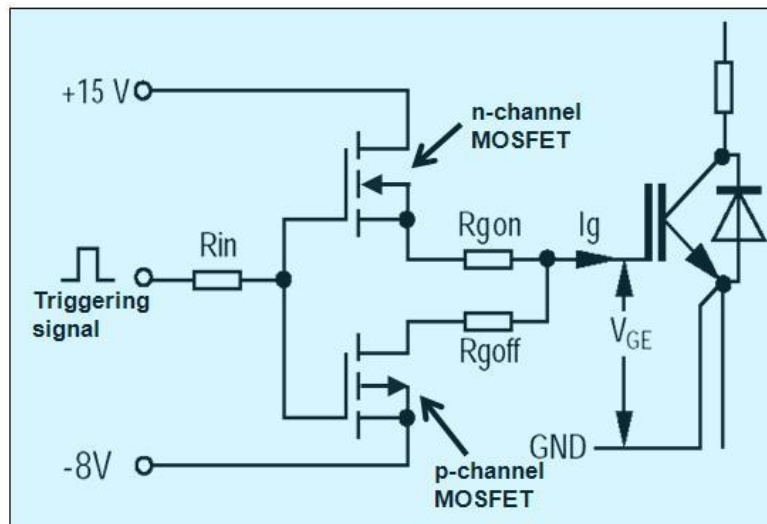


Figure 3. Output stage of a gate driver

In the diagram above, R_{gon} represents the external gate series resistance at switch-on and R_{goff} the external gate series resistance at switch-off. The higher R_g the slower the switching process.

Soft turn off

For many driver circuits, a switch to a higher R_{goff} is made in the case of a short circuit, leading to a slower, or soft, turn-off. In this way, over voltages that can cause high currents and parasitic inductances which might otherwise damage the module are avoided.

Maximum and average gate current

High currents flowing within a short time are required in order to charge or discharge the gate capacitor. The higher the switching speed and the bigger the IGBT surface, the higher the peak gate current (up to 10A).

The average driver current depends additionally on the clock frequency, that is, the number of switching operations per second.

Maximum as well as average gate currents must be considered when selecting a driver circuit for a particular application.

6.14 THYRISTOR

A thyristors is a solid-state semiconductor device with four layers of alternating N and P-type material. It acts exclusively as a bi-stable switch, conducting when the gate receives a current trigger, and continuing to conduct while the voltage across the device is not reversed (forward-biased). A three-lead thyristors is designed to control the larger current of its two leads by combining that current with the smaller current of its other lead, known as its control lead. In contrast, a two-lead thyristors is designed to switch on if the potential difference between its leads is sufficiently large (breakdown voltage).

Some sources define silicon-controlled rectifier(SCR) and thyristors as synonymous. Other sources define thyristors as a larger set of devices with at least four layers of alternating N and P-type material.

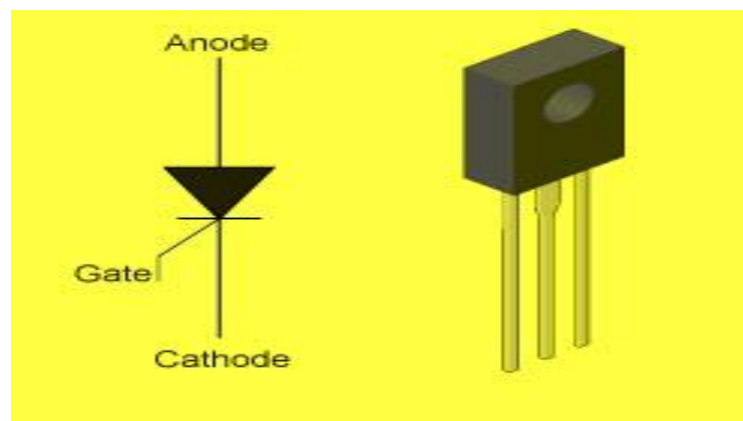


Fig 6.14 Thyristors Diagram

6.15 MOSFET

The metal–oxide–semiconductor field-effect transistor (MOSFET) is a type of transistor used for amplifying or switching electronic signals.

Although the MOSFET is a four-terminal device with source (S), gate (G), drain (D), and body (B) terminals,^[1]the body

(or substrate) of the MOSFET is often connected to the source terminal, making it a three-terminal device like other field-effect transistors. Because these two terminals are normally connected to each other (short-circuited) internally, only three terminals appear in electrical diagrams.

The main advantage of a MOSFET over a regular transistor is that it requires very little current to turn on (less than 1mA), while delivering a much higher current to a load (10 to 50A or more).

In enhancement mode MOSFETs, a voltage drop across the oxide induces a conducting channel between the source and drain contacts *via* the field effect. The term "enhancement mode" refers to the increase of conductivity with increase in oxide field that adds carriers to the channel, also referred to as the *inversion layer*. The channel can contain electrons (called an n-MOSFET or n-MOS), or holes (called a p-MOSFET or p-MOS), opposite in type to the substrate, so n-MOS is made with a p-type substrate, and p-MOS with an n-type substrate (see article on semiconductor devices). In the less common *depletion mode* MOSFET, detailed later on, the channel consists of carriers in a surface impurity layer of opposite type to the substrate, and conductivity is decreased by application of a field that depletes carriers from this surface layer.

The "metal" in the name MOSFET is now often a misnomer because the previously metal gate material is now often a layer of polysilicon (polycrystalline silicon). Aluminum had been the gate material until the mid-1970s, when polysilicon became dominant, due to its capability to form self-aligned gates. Metallic gates are regaining popularity, since it is difficult to increase the speed of operation of transistors without metal gates. Likewise, the "oxide" in the name can be a misnomer, as different dielectric materials are used

with the aim of obtaining strong channels with smaller applied voltages. An insulated-gate field-effect transistor or IGFET is a related term almost synonymous with MOSFET. The term may be more inclusive, since many "MOSFETs" use a gate that is not metal, and a gate insulator that is not oxide. Another synonym is MISFET for metal–insulator–semiconductor FET.

The MOSFET is by far the most common transistor in both digital and analog circuits, though the bipolar junction transistor was at one time much more common.

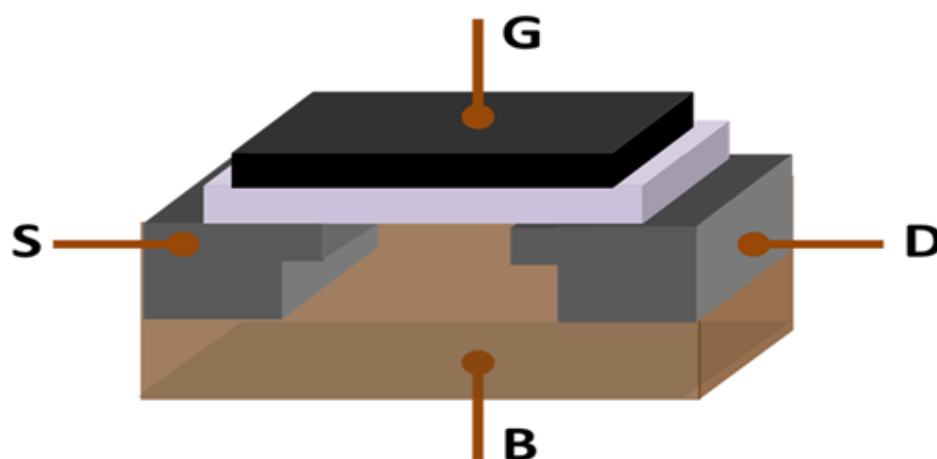


Fig 6.15 MOSFET Construction Diagram

6.16 OPERATION OF MOSFET

The traditional metal–oxide–semiconductor (MOS) structure is obtained by growing a layer of silicon dioxide (SiO_2) on top of a silicon substrate and depositing a layer of metal or polycrystalline silicon (the latter is commonly used). As the silicon dioxide is a dielectric material, its structure is equivalent to a planar capacitor, with one of the electrodes replaced by a semiconductor.

When a voltage is applied across a MOS structure, it modifies the distribution of charges in the semiconductor. If we consider a p-type semiconductor (with the density of acceptors, p the density of holes; $p = N_A$ in neutral bulk), a positive voltage, from gate to

body (see figure) creates a depletion layer by forcing the positively charged holes away from the gate-insulator/semiconductor interface, leaving exposed a carrier-free region of immobile, negatively charged acceptor ions (see doping (semiconductor)). If is high enough, a high concentration of negative charge carriers forms in an *inversion layer* located in a thin layer next to the interface between the semiconductor and the insulator. Unlike the MOSFET, where the inversion layer electrons are supplied rapidly from the source/drain electrodes, in the MOS capacitor they are produced much more slowly by thermal generation through carrier generation and recombination centers in the depletion region. Conventionally, the gate voltage at which the volume density of electrons in the inversion layer is the same as the volume density of holes in the body is called the threshold voltage. When the voltage between transistor gate and source (V_{GS}) exceeds the threshold voltage (V_{th}), it is known as over drive voltage.

This structure with p-type body is the basis of the n-type MOSFET, which requires the addition of n-type source and drain regions.

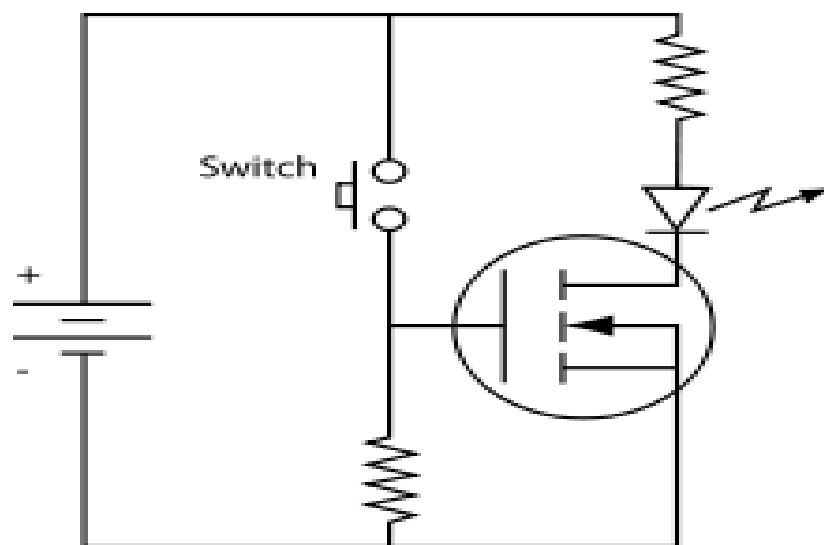


Fig 6.16 MOSFET Block Diagram

6.17 INDUCTOR

An inductor, also called a coil or reactor, is a passive two-terminal electrical component which resists changes in electric current passing through it. It consists of a conductor such as a wire, usually wound into a coil. Energy is stored in a magnetic field in the coil as long as current flows. When the current flowing through an inductor changes, the time-varying magnetic field induces a voltage in the conductor, according to Faraday's law of electromagnetic induction. According to Lenz's law the direction of induced electromotive force (or "e.m.f.") is always such that it opposes the change in current that created it. As a result, inductors always oppose a change in current, in the same way that a flywheel opposes a change in rotational velocity. Care should be taken not to confuse this with the resistance provided by a resistor.

An inductor is characterized by its inductance, the ratio of the voltage to the rate of change of current, which has units of Henries (H). Inductors have values that typically range from 1 μH (10^{-6}H) to 1 H. Many inductors have a magnetic core made of iron or ferrite inside the coil, which serves to increase the magnetic field and thus the inductance. Along with capacitors and resistors, inductors are one of the three passive linear circuit elements that make up electric circuits. Inductors are widely used in alternating current (AC) electronic equipment, particularly in radio equipment. They are used to block AC while allowing DC to pass; inductors designed for this purpose are called chokes. They are also used in electronic filters to separate signals of different frequencies, and in

combination with capacitors to make tuned circuits, used to tune radio and TV receivers.



Fig 6.17 Inductor Diagram

6.18 CAPACITOR

A capacitor (originally known as a condenser) is a passive two-terminal electrical component used to temporarily store electrical energy in an electric field. The forms of practical capacitors vary widely, but most contain at least two electrical conductors (plates) separated by a dielectric (i.e. an insulator that can store energy by becoming polarized). The conductors can be thin films, foils or sintered beads of metal or conductive electrolyte, etc. The non-conducting dielectric acts to increase the capacitor's charge capacity. Materials commonly used as dielectrics include glass, ceramic, plastic film, paper, mica, and oxide layers. Capacitors are widely used as parts of electrical circuits in many common electrical devices. Unlike a resistor, an ideal capacitor does not dissipate energy. Instead, a capacitor stores energy in the form of an electrostatic field between its plates.

When there is a potential difference across the conductors (e.g., when a capacitor is attached across a battery), an electric field develops across the dielectric, causing positive charge $+Q$ to collect on one plate and negative charge $-Q$ to collect on the other plate. If a battery has been attached to a capacitor for a sufficient amount of time, no current can flow through the capacitor. However, if a time-varying voltage is applied across the leads of the capacitor, a displacement current can flow.

An ideal capacitor is characterized by a single constant value, its capacitance. Capacitance is defined as the ratio of the electric charge Q on each conductor to the potential difference V between them. The SI unit of capacitance is the farad (F), which is equal to one coulomb per volt (1 C/V). Typical capacitance values range from about 1 pF (10^{-12} F) to about 1 mF (10^{-3} F).

The larger the surface area of the "plates" (conductors) and the narrower the gap between them, the greater the capacitance is. In practice, the dielectric between the plates passes a small amount of leakage current and also has an electric field strength limit, known as the breakdown voltage. The conductors and leads introduce an undesired inductance and resistance.

Capacitors are widely used in electronic circuits for blocking direct current while allowing alternating current to pass. In analog filter networks, they smooth the output of power supplies. In resonant circuits they tune radios to particular frequencies. In electric power transmission systems, they stabilize voltage and power flow.

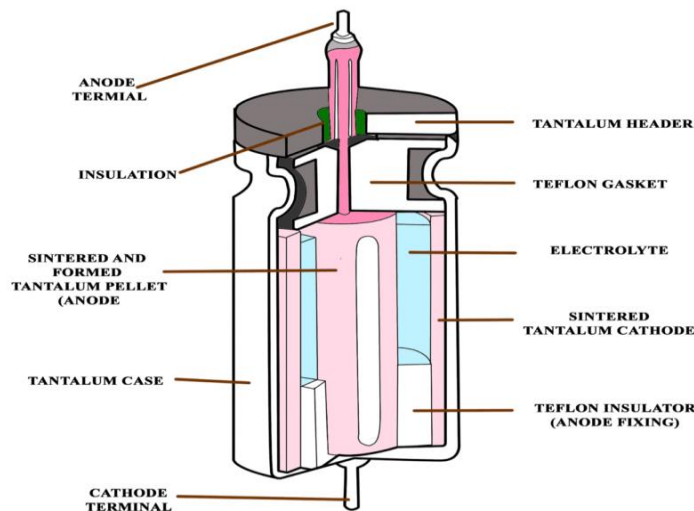


Fig 6.18 Capacitor Diagram

OPERATION OF CAPACITOR

A capacitor consists of two conductors separated by a non-conductive region. The non-conductive region can either be a vacuum or an electrical insulator material known as a dielectric. Examples of dielectric media are glass, air, paper, and even a semiconductor depletion region chemically identical to the conductors. A capacitor is assumed to be self-contained and isolated, with no net electric charge and no influence from any external electric field. The conductors thus hold equal and opposite charges on their facing surfaces, and the dielectric develops an electric field. In SI units, a capacitance of one farad means that one coulomb of charge on each conductor causes a voltage of one volt across the device.

An ideal capacitor is wholly characterized by a constant capacitance C , defined as the ratio of charge $\pm Q$ on each conductor to the voltage V between them

$$C = \frac{Q}{V}$$

Because the conductors (or plates) are close together, the opposite charges on the conductors attract one another due to their electric fields, allowing the capacitor to store more charge for a given voltage than if the conductors were separated, giving the capacitor a large capacitance. Early capacitors were known as *condensers*, a term that is still occasionally used today, particularly in high power applications, such as automotive systems.

CHAPTER 7

MATLAB

Simulation has become a very powerful tool on the industry application as well as in academics, nowadays. It is now essential for an electrical engineer to understand the concept of simulation and

learn its use in various applications. Simulation is one of the best ways to study the system or circuit behavior without damaging it. The tools for doing the simulation in various fields are available in the market for engineering professionals. Many industries are spending a considerable amount of time and money in doing simulation before manufacturing their product. In most of the research and development (R&D) work, the simulation plays a very important role. Without simulation, it is quite impossible to proceed further. It should be noted that in power electronics, computer simulation and a proof of concept hardware prototype in the laboratory are complimentary to each other. However, computer simulation must not be considered as a substitute for hardware prototype. The objective of this chapter is to describe simulation of impedance source inverter with R, R-L and RLE loads using MATLAB tool.

7.1 INTRODUCTION TO MATLAB

MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. Typical uses include

1. Math and computation
2. Algorithm development
3. Data acquisition
4. Modelling, simulation, and prototyping
5. Data analysis, exploration, and visualization
6. Scientific and engineering graphics

7. Application development, including graphical user interface building

MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. This allows you to solve many technical computing problems, especially those with matrix and vector formulations, in a fraction of the time it would take to write a program in a scalar non-interactive language such as C or FORTRAN. The name MATLAB stands for matrix laboratory. MATLAB was originally written to provide easy access to matrix software developed by the LINPACK and EISPACK projects. Today, MATLAB engines incorporate the LAPACK and BLAS libraries, embedding the state of the art in software for matrix computation. MATLAB has evolved over a period of years with input from many users. In university environments, it is the standard instructional tool for introductory and advanced courses in mathematics, engineering, and science. In industry, MATLAB is the tool of choice for high-productivity research, development, and analysis. MATLAB features a family of add-on application-specific solutions called toolboxes. Very important to most users of MATLAB, toolboxes allow you to learn and apply specialized technology. Toolboxes are comprehensive collections of MATLAB functions (M-files) that extend the MATLAB environment to solve particular classes of problems. Areas in which toolboxes are available include signal processing, control systems, neural networks, fuzzy logic, wavelets, simulation, and many others.

7.2 THE MATLAB SYSTEM.

The MATLAB system consists of five main parts: Desktop Tools and Development Environment This is the set of tools and facilities that help you use MATLAB functions and files. Many of these tools are graphical user interfaces. It includes the MATLAB

desktop and Command Window, a command history, an editor and debugger, a code analyzer and other reports, and browsers for viewing help, the workspace, files, and the search path. The MATLAB Language This is a high-level matrix/array language with control flow statements, functions, data structures, input/output, and object-oriented programming features. It allows both "programming in the small" to rapidly create quick and dirty throw-away programs, and "programming in the large" to create large and complex application programs.

Graphics

MATLAB has extensive facilities for displaying vectors and matrices as graphs, as well as annotating and printing these graphs. It includes high-level functions for two-dimensional and three-dimensional data visualization, image processing, animation, and presentation graphics. It also includes low-level functions that allow you to fully customize the appearance of graphics as well as to build complete graphical user interfaces on your MATLAB applications. The MATLAB External Interfaces/API This is a library that allows you to write C and Fortran programs that interact with MATLAB. It includes facilities for calling routines from MATLAB (dynamic linking), calling MATLAB as a computational engine, and for reading and writing MAT-files.

MATLAB Documentation

MATLAB provides extensive documentation, in both printed and online format, to help you learn about and use all of its features. If you are a new user, start with this Getting Started book. It covers all

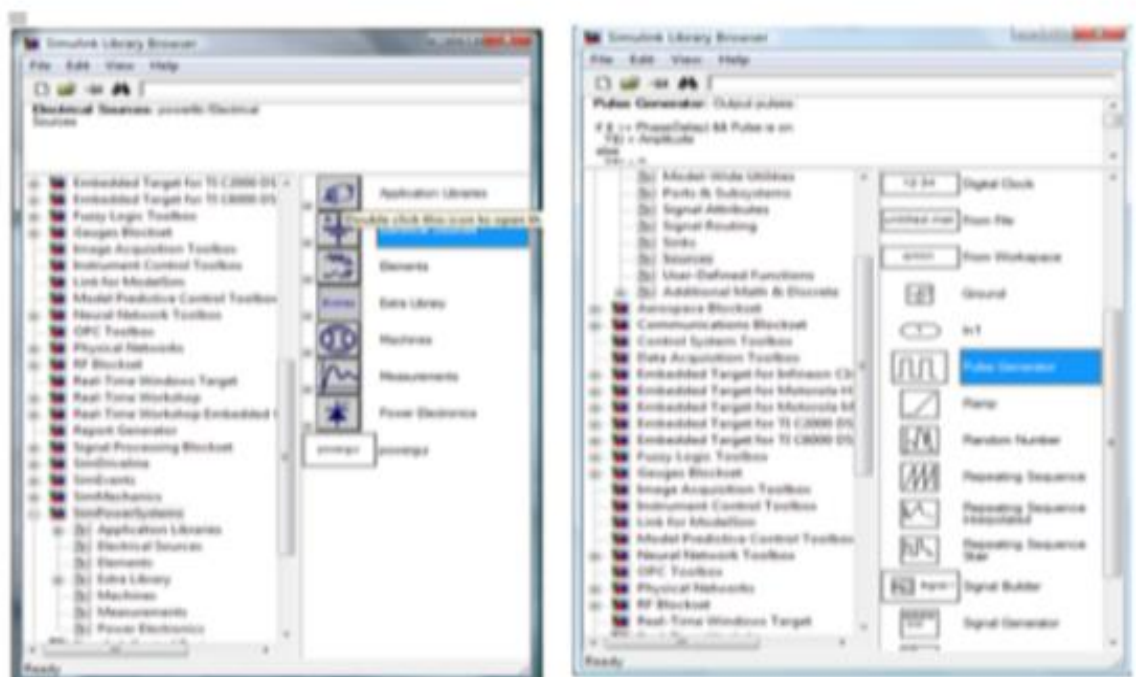
the primary MATLAB features at a high level, including many examples. The MATLAB online help provides task-oriented and reference information about MATLAB features. MATLAB documentation is also available in printed form and in PDF format. MATLAB Online Help to view the online documentation, select MATLAB Help from the Help menu in MATLAB. The MATLAB documentation is organized into these main topics:

The Role of Simulation in Design

Electrical power systems are combinations of electrical circuits and electromechanical devices like motors and generators. Engineers working in this discipline are constantly improving the performance of the systems. Requirements for drastically increased efficiency have forced power system designers to use power electronic devices and sophisticated control system concepts that tax traditional analysis tools and techniques. Further complicating the analyst's role is the fact that the system is often so nonlinear that the only way to understand it is through simulation. Land-based power generation from hydroelectric, steam, or other devices is not the only use of power systems. A common attribute of these systems is their use of power electronics and control systems to achieve their performance objectives. Sim Power Systems is a modern design tool that allows scientists and engineers to rapidly and easily build models that simulate power systems. Sim Power Systems uses the Simulink environment, allowing you to build a model using simple click and drag procedures. Not only can you draw the circuit topology rapidly, but your analysis of the circuit can include its interactions with mechanical, thermal, control, and other disciplines. This is possible because all the electrical parts of the simulation interact with the extensive Simulink modeling library. Since Simulink uses MATLAB as its computational engine, designers can also use MATLAB toolboxes and Simulink block sets. Sim Power Systems and Sim Mechanics share a special Physical Modeling block and connection line interface.

Sim Power Systems Libraries

You can rapidly put Sim Power Systems to work. The libraries contain models of typical power equipment such as transformers, lines, machines, and power electronics. These models are proven ones coming from textbooks, and their validity is based on the experience of the Power Systems Testing and simulation Laboratory of Hydro-Québec, a large north.

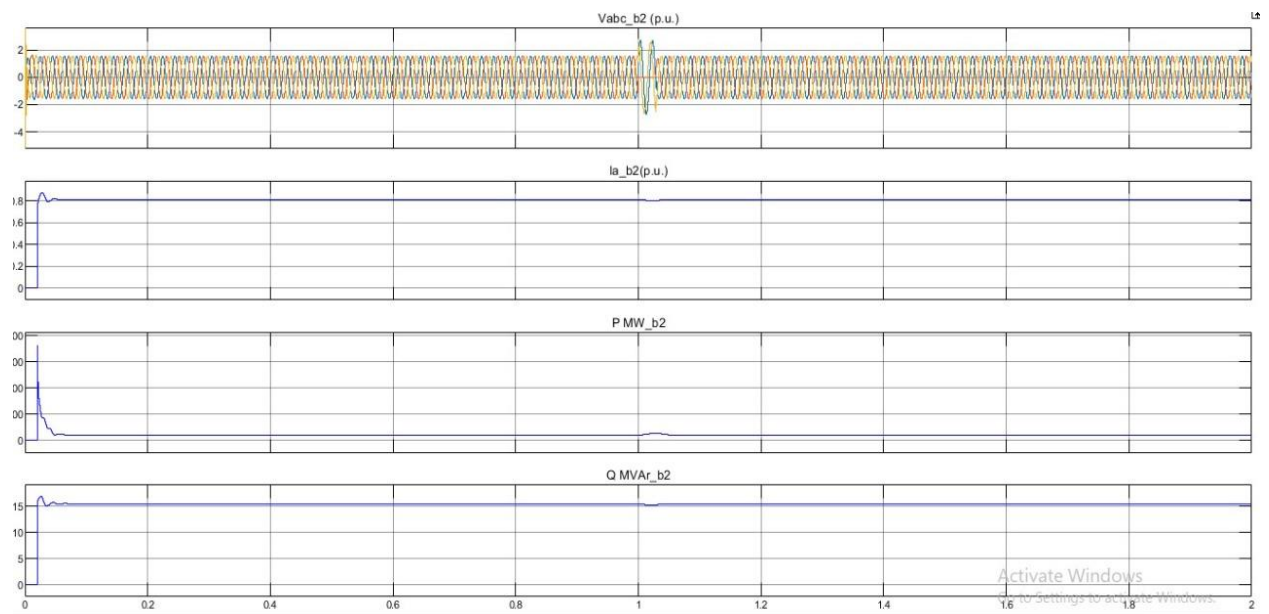


MATLAB LIBRARY

American utility located in Canada, and also on the experience of Ecole de Technologies supérieure and Université Laval. The capabilities of Sim Power Systems for modeling a typical electrical system are illustrated in demonstration files. And for users who want to refresh their knowledge of power system theory, there are also self-learning case studies. The Sim Power Systems main library, power lib, organizes its blocks into libraries according to their behavior. The power lib library window displays the block library icons and names.

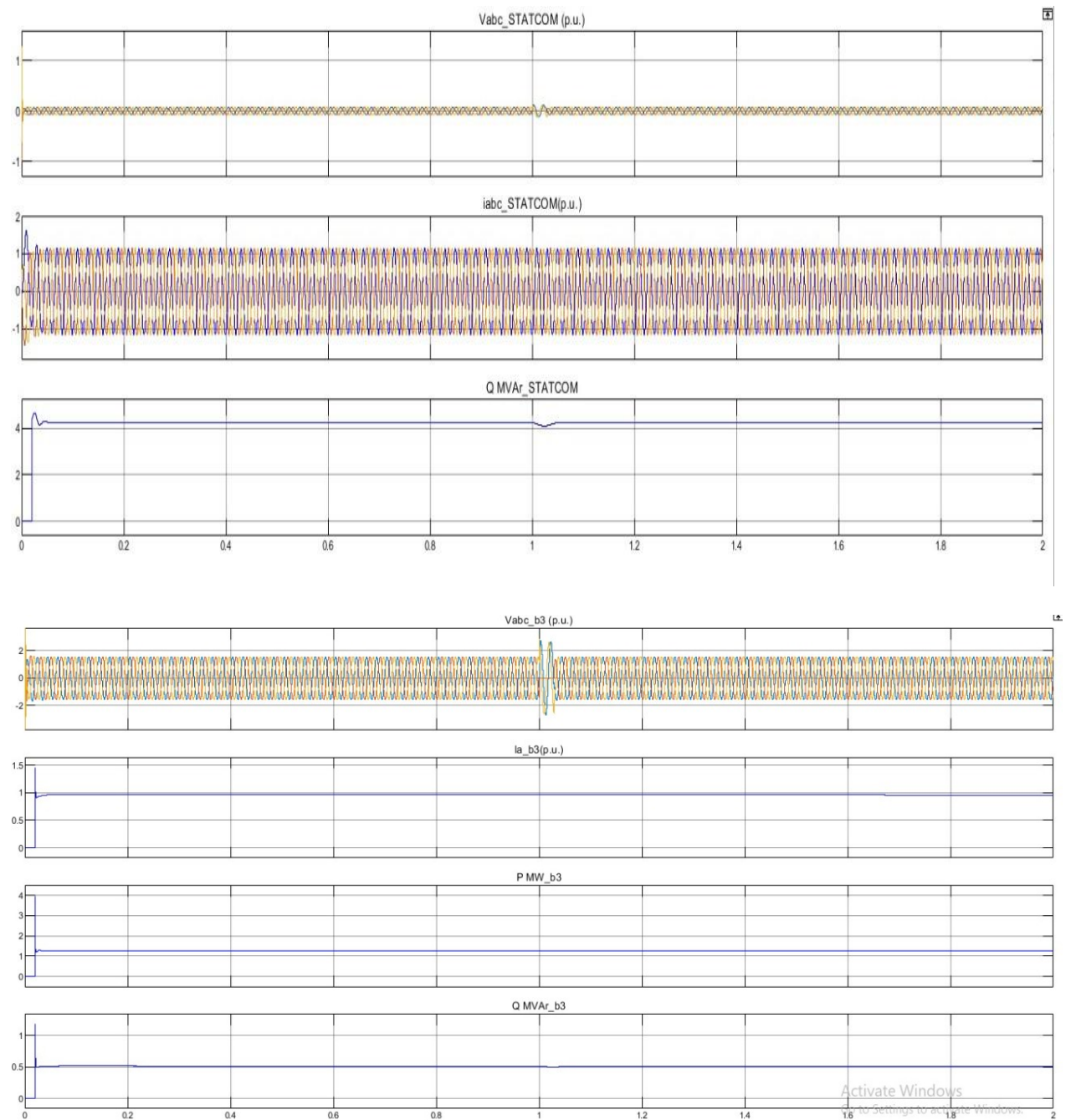
Double-click a library icon to open the library and access the blocks. The main Sim Power Systems power library window also contains the powerful block that opens a graphical user interface for the steady-state analysis of electrical circuits.

FAULT



STATCOM

OUTPUT



FAULT

Conclusion

Output:

simulation software, and the simulation of different operating conditions is carried out when there is a three-phase short-circuit fault in the system. The simulation results show that the cooperative control of TCSC and STATCOM can effectively solve the voltage stability problem of wind power grid-connected systems. The wind power grid-connected system with TCSCSTATCOM control ensures the transmission of power and at the same time ensures that the system can recover and maintain the system voltage stability quickly and effectively even if a short circuit fault occurs in a short time, and the effect of the TCSCSTATCOM cooperative control is better than only using the control of TCSC or STATCOM.

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