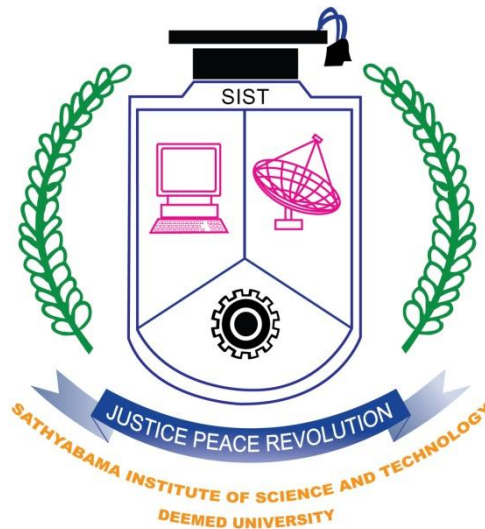


**An Efficient Energy Management Approach for
a Solar-Powered EV Battery Charging Facility
to Support Distribution Grids**

submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering Degree in
Electrical and Electronics Engineering

by

**SUBHASHINI.A(Register No. 38140051)
KARTHIGA SRI.RS(Register No. 38140017)**



**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING
SCHOOL OF ELECTRICAL AND ELECTRONICS ENGINEERING**

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of
Subhashini.A (Reg. No. 381400577) and **Karthiga sri.RS** (Reg. No. 38140015) who
carried out the project entitled
**"An Efficient Energy Management Approach for a Solar-Powered EV Battery
Charging Facility to Support Distribution Grids"**
under my supervision from November 2021 to May 2022.

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Submitted for Viva voce Examination held on_____

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DECLARATION

We **SUBHASHINI.A** (Reg. No. 38140051) and **KARTHIGA SRI.RS** (Reg. No. 38140017) hereby declare that the Project Report entitled “**An Efficient Energy Management Approach for a Solar-Powered EV Battery Charging Facility to Support Distribution Grids**” done by us under the guidance of **DR.V.Sivachidambaranathan** 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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Abstract

The home photovoltaic (HPV) system integrated with energy storages can supply power to the distribution grid which may be reliable and free from HPV intermittency effects. However, this is always associated with the high cost of energy storages. On the other hand, the growth of electric vehicles (EV) in the market has a potential to place the distribution grid in a high risk as the EV owners may charge the EV battery on demand which may cause an unexpected increase in the evening and power quality problems. This paper proposes an efficient energy management approach for the HPV systems to power the electric vehicle battery (EVB) charging facility while utilizing the EVB as an energy storage system (ESS) that can mitigate the HPV impacts and allow the growth of HPV systems in power grids. This research is aimed for electric vehicles (EVs) that are compatible with the dc fast charging CHAdeMO standard. The operation strategy of the HPV-EVB charging system is designed in such a way that the EVB is either charged efficiently by the HPV or by the distribution grid. The proposed energy management strategy will help to reduce the unexpected peak power demand, and can help in the implementation of the vehicle-to-grid (V2G) to improve the stability of the grid during peak load. In addition, the EVB can provide power to the critical loads in the home when there is a loss of power supply from the grid. In the proposed system, the HPV, the grid, and the EVB converters share a common dc bus. Both the simulation and experimental results show that the proposed energy management of the HPV-EVB system can reduce the impacts of the high penetration of EVs and HPVs on power distribution grids and can effectively improve the self-consumption of the HPV systems.

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CHAPTER 1

INTRODUCTION

1.1 GENERAL INTRODUCTION

Electric vehicle (EV) has become increasingly attractive in recent years after the intensive efforts by the governments, automakers and environmental activists. EVs can provide a holistic solution to achieve a zero consumption of fossil fuels and consequently can reduce the air pollution and global warming. However, by nature, EVs need to be charged frequently using the grid power, and there are still many issues that need to be tackled. First, if the grid power is generated using the traditional methods, such as from the coal fired power plants, the emission reduction by adopting EVs is not obvious. Second, the growing use of electric vehicles may have detrimental consequences for the local distribution system. The high possibility of the EVs are plugged to get charged at the same time when EV owners arrive home from work will draw a huge amount of electricity from the local distribution power system, which can cause various technical issues, such as voltage regulation, harmonic contamination and frequency variations. These bring significant challenges to the traditional load growth planning and management of the power utilities. Uncontrolled and unregulated charging can result in an unexpected peak load at a specific time, which may exceed the capacity of the distribution grid. Therefore, the distribution grid needs to be upgraded to increase its capacity to meet the new demand from EV charging. In addition, the distribution grid is also facing an increasing penetration of the home photovoltaic (HPV) systems.

CHAPTER 2

LITERATURE SURVEY

Nupur Saxena et al, "Implementation of a Grid-Integrated PV-Battery System for Residential and Electrical Vehicle Applications", *IEEE Trans. Ind. Electron.*, vol. 65, no. 8, pp. 6592-6601, Aug. 2018

A single-phase grid is given with a unique control strategy for integrating solar photovoltaic (PV) with battery storage for residential and electric car applications. The planned work's major goal is to provide continuous power to the grid, hence improving the feasibility of the system's battery energy storage support. The charging and discharging of the battery achieves power and load equalisation, as well as better system reliability. The multifunctional voltage-source converter serves as an active power filter, reducing harmonics and compensating for reactive power. In the proposed system, a unique control is designed for grid resynchronization during grid reconnection after a failure is mitigated. The system's overall control is adaptive to a variety of real-world scenarios, such as disconnecting the PV array, battery, and grid from the system. The suggested system's comprehensive design and control are provided. The suggested system's validity is tested using a laboratory prototype with a power rating of 2.2 kW that is connected to the utility grid. The system's performance under various disturbances has been found to be satisfactory, and the recorded results have been demonstrated.

"Optimal Energy Management of EV Parking Lots Under Peak Load Reduction Based DR Programs Considering Uncertainty," *IEEE Trans. Sustain. Energy*, vol. 10, no. 3, pp. 1034– 1043, July 2019. Sengor et al., "Optimal Energy Management of EV Parking Lots Under Peak Load Reduction Based DR Programs Considering Uncertainty," *IEEE Trans. Sustain. Energy*, vol. 10, no. 3, pp. 1034

Those who are concerned about the future of energy have a lot of options with demand response (DR) programmes. The notion of expanding electric vehicles (EVs) excites researchers all over the world because DR techniques make it easier for new technologies to participate in power systems. In this paper, an optimal energy management approach for EV parking lots is created in a stochastic programming framework using peak load reduction based DR programmes, referred to as EV parking lot energy management (EV-PLEM). The proposed EV-PLEM aims to maximise the load factor during the daily operation of an EV parking lot while taking into account the unpredictability of EV behaviour, such as arrival and departure times, as well as the stochasticity of the EVs'

remaining state-of-energy when they arrive at the parking lot. A series of case studies are done to validate the efficacy of the proposed EV-PLEM idea, and credible results and relevant findings are given for the cases where the EV-PLEM is used.

F. Marra et al., “EV charging facilities and their application in LV feeders with photovoltaic’s,” *IEEE Trans. Smart Grid*, vol. 4, no. 3, pp. 1533–1540, Sep. 2013

Low-voltage (LV) grid feeders with high penetration of photovoltaic’s (PVs) are often affected by voltage magnitude problems. To solve such issues, previous research has shown that reactive power methods, active power curtailment and grid reinforcement can be used for voltage support, yet showing several limits. We present the usage of public charging stations for electric vehicles (EVs) with energy storage systems (ESS) as a method for voltage management in LV feeders with PV. To determine the ESS charging load required for voltage regulation, a unique approach is proposed, and the results are compared for different places in the feeder. We quantify the energy size required for a station ESS using time-series simulations. The case study is a Belgian LV home grid that was modelled using real PV generation and load characteristics. The approach and simulation results demonstrate the value of employing public EV charging stations with the added benefit of voltage regulation in PV feeders.

"Energy management system with PV power forecast to optimally charge EVs at the workplace," *IEEE Trans. Ind. Inf.*, vol. 14, no. 1, pp. 311-320, Jan. 2018. D. Meer, G. R. C. Mouli, G. M. Mouli, L. R. Elizondo, and P. Bauer, "Energy management system with PV power forecast to optimally charge EVs at the workplace," *IEEE Trans. Ind. Inf.*

The architecture of an energy management system (EMS) capable of anticipating photovoltaic (PV) power generation and optimising power flows between the PV system, the grid, and battery electric vehicles (BEVs) at work is presented in this study. The goal is to reduce charging costs while reducing grid energy demand by increasing PV self-consumption and, as a result, increasing the BEV fleet's sustainability. The developed EMS is made up of two parts: A mixed-integer linear programming framework with an autoregressive integrated moving average model to predict PV power generation. An autoregressive integrated moving average model to estimate PV power output and a mixed-integer linear programming framework to efficiently allocate power to minimise charging cost make up the developed EMS. The findings suggest that the proposed EMS can greatly

cut charging costs while improving PV self-consumption and minimising grid energy usage. Furthermore, when compared to an uncontrolled charging policy, the EMS reduces charging costs by 118.44 percent and 427.45 percent in case of one and two charging points, respectively, in a case study similar to one frequently considered in the literature, i.e., dynamic purchase tariff and dynamic feed-in tariff.

Z. Wei, Y. Li, Y. Zhang, and L. Cai, "Intelligent parking garage EV charging scheduling considering battery charging characteristic", IEEE Trans. Ind. Electron., vol. 65, no. 3, pp. 2806-2816, 2018.

This paper studies the electric vehicle (EV) charging scheduling problem under a parking garage scenario, aiming to promote the total utility for the charging operator subject to the time-of-use (TOU) pricing. Unlike most previous work, we create a multicharging system that incorporates practical battery charging characteristics and an intelligent charging management mechanism to maximise the interests of both customers and charging operators. To begin, we develop an admission control method to ensure that all accepted EVs' charging requirements are met prior to their departure, in order to ensure the quality of service for each client. Second, we formulate the charge scheduling process as a causal scheduling problem with a deadline constraint. Then, we propose an adaptive utility-oriented scheduling (AUS) algorithm to optimize the total utility for the charging operator, which can robustly achieve low task declining probability and high profit. The charging operator can also apply the discussed reservation mechanism to mitigate the performance degradation caused by the charging information mismatching with vehicle stochastic arrivals. Finally, using realistic EV charging conditions and TOU pricing, we run comprehensive simulations. Simulation results exhibit the effectiveness of the proposed AUS algorithm in achieving desirable performance compared with other benchmark scheduling schemes.

"Autonomous energy management technique for solid-state transformer to integrate PV-assisted EV charging station participating in auxiliary service," Q. Chen, N. Liu, C. Hu, L. Wang, and J. Zhang, IEEE Trans.

Photovoltaic-assisted charging station (PVCS) is expected to be one of the important charging facilities for serving electric vehicles (EVs). In this paper, a type of solid-state transformer (SST) is introduced to the PVCS design and an autonomous energy management strategy (EMS) for SST is proposed. This study aims to develop an effective real-time EMS for PVCS participating in ancillary service of smart grid, and the rule-based decision-making method is utilized. An energy-bound calculation (EBC) model is suggested to discover the top and lower boundaries of flexible resources, taking into account the dynamic classification of EVs. Moreover, considering the EBC results and power command from the aggregator, a charging power allocation algorithm is designed for power distribution of flexible EVs. The proposed EMS is effective in real-time energy management and suitable for practical applications, according to case study and experiment analysis.

CHAPTER 3

3.1 AIM OF THE PROJECT

In our system we going to hybrid the two sources solar panel and grid to charge the electrical vehicle efficiently .and maintain the power quality. .

3.2 SCOPE OF THE PROJECT

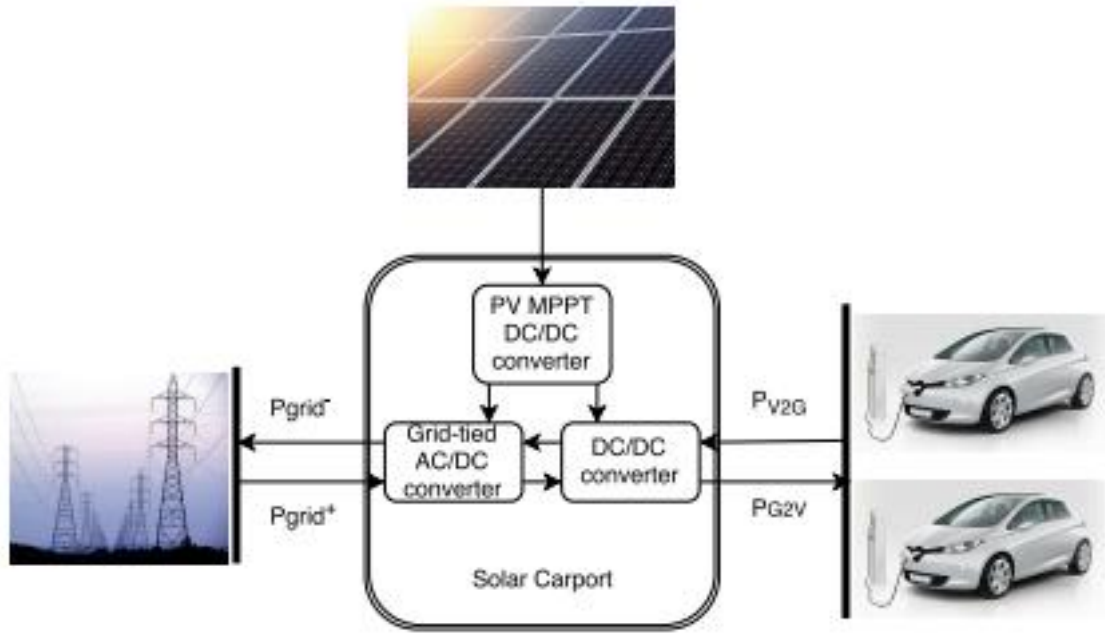
Ev s can provide a comprehensive solution for achieving zero fossil fuel usage and, as a result, reducing air pollution and global warming. The project we can use in mini e-vehicle charging station .and auxiliary battery charging. The proposed system with its control algorithm will have a great potential for the future smart grid and ev applications.

The ev battery can be connected to or disconnected from the pv system at any time. The ev battery can be used as an uninterruptible power supply whenever there is a blackout. The efficiency of the ev battery can be improved. The impacts of a high penetration of both residential pv system and evs can be mitigated. The integrated ev and pv system can provide grid support during the peak demand.

CHAPTER 4

EXISTING SYSTEM AND PROPOSED SYSTEM

4.1 EXISTING SYSTEM

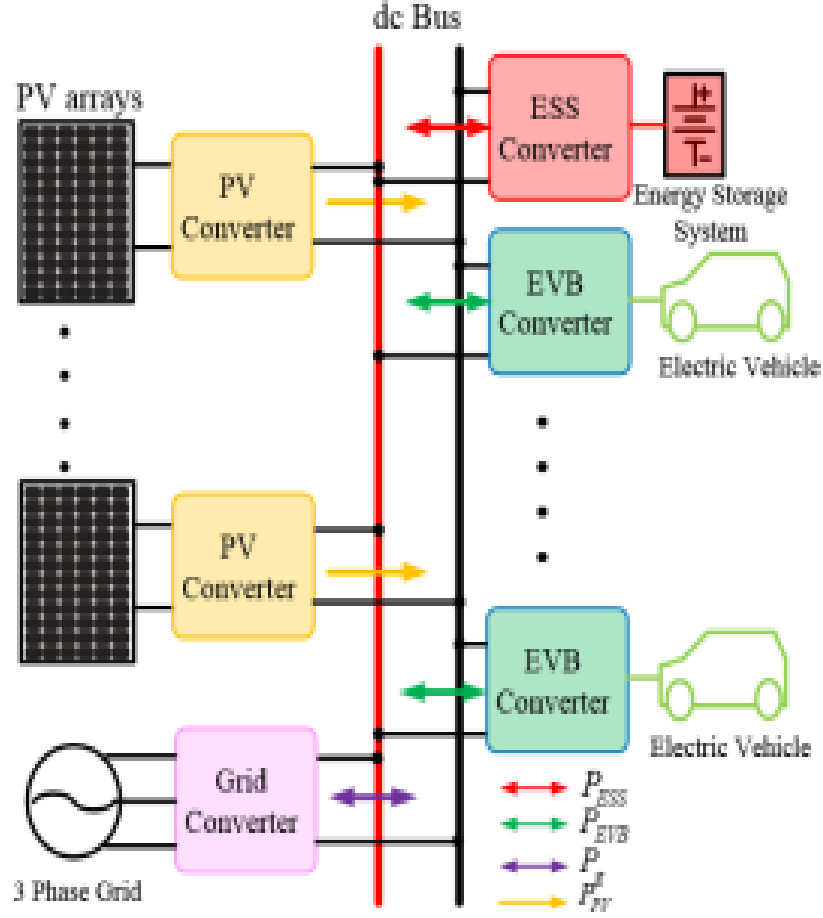


Existing system presents the design of an energy management system (EMS) capable of forecasting photovoltaic (PV) power production and optimizing power flows between PVsystem, grid and battery electric vehicles (BEVs) at the workplace. The goal is to reduce charging costs while reducing grid energy demand by increasing PV self-consumption and, as a result, increasing the BEV fleet's sustainability. The proposed EMS is made up of two parts: an auto regressive integrated moving average (ARIMA) model for predicting PV power generation and a mixed-integer linear programming (MILP) framework for allocating electricity optimally to reduce charging costs. The findings suggest that the proposed EMS can greatly cut charging costs while improving PV self-consumption and minimizing grid energy usage.

4.2 PROPOSED SYSTEM

The proposed system entails the creation of a bi-directional power flow control system that allows power to flow from a PV array to a single phase utility grid when no water pumping is required, and from the grid to a BLDC motor when PV array power is insufficient (or at night) to run the pump at full capacity. By selling electricity to the utility, this practise provides a source of income for users. To achieve a bi-directional power transfer, a unit

vector template (UVT) generation is used because of its simplicity and ability to accomplish the goal.



4.3 Boost Converter

An inductor is linked to the input voltage source. The switch-functioning solid-state gadget is linked across the source. A diode is utilised as the second switch. As indicated in the diagram, the diode is connected to a capacitor, and the load and the two are connected in parallel. The constant input current is caused by the inductor linked to the input source, hence the Boost converter is referred to as a constant current input source. The load can also be thought of as a constant voltage source. Pulse Width Modulation is used to turn on and off the controlled switch (PWM). PWM can be based on time or frequency. The use of a wide range of frequencies to accomplish the desired control of the switch, which in turn gives the desired output voltage, is a disadvantage of frequency-based modulation. Time-

based Modulation is mostly used for DC-DC converters. It is simple to construct and use. The frequency remains constant in this type of PWM modulation. The **Boost converter** has two modes of operation. The first mode is when the switch is on and conducting.

4.4 Buck Converter

In SMPS circuits, the Buck Converter is utilised when the DC output voltage must be lower than the DC input voltage. Any DC source or rectified AC can be used as the DC input. When electrical isolation between the switching circuit and the output is not required, but the input is from a rectified AC source, a mains isolating transformer can provide isolation between the AC source and the rectifier.

The Buck Converter's switching transistor between the input and output is constantly on and off at a high frequency. During the on periods of the switching transistor, the circuit taps into the energy stored in the inductor L to maintain a constant output. The circuit leverages the energy stored in the inductor L during the on phases of the switching transistor to continue providing the load during the off periods to maintain a continuous output. The operation of the circuit is dependent on what is known as a Flywheel Circuit. This is because the circuit functions similarly to a mechanical flywheel, which spins smoothly (and outputs energy) at a constant rate when given regularly spaced pulses of energy.

4.5 SOLAR PANEL MODULE

Solar panel refers either to a photovoltaic module, a solar thermal energy panel, or to a set of solar photovoltaic (PV) modules electrically connected and mounted on a supporting structure. A PV module is a packaged, connected assembly of solar cells. Solar panels can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential applications. The DC output power of each module is rated under standard test conditions (STC) and normally ranges from 100 to 320 watts. Given the same rated output, the efficiency of a module affects its size: an 8 percent efficient 230 watt module will have twice the area of a 16 percent efficient 230 watt module. There are a few solar panels on the market that are more efficient than 19 percent.

A single solar module can only provide a certain quantity of energy; therefore, most setups use numerous modules. A photovoltaic system consists of a panel or array of solar modules, an inverter, and, in certain cases, a battery and/or solar tracker, as well as interface cables.

Solar modules use light energy (photons) from the sun to generate electricity through the photovoltaic effect. Wafer-based crystalline silicon cells or thin-film cells based on cadmium telluride or silicon are used in the majority of modules. A module's structural (load-bearing) element can be either the top layer or the back layer.

Mechanical and moisture damage to cells must also be avoided. The majority of solar modules are rigid, but semi-flexible modules based on thin-film cells are available. The first usage of these early solar modules in orbit was in 1958.

To obtain a desired output voltage, electrical connections are formed in series, and/or in parallel to offer a desired current capability. Silver, copper, or other non-magnetic conductive transition metals may be used in the conducting wires that take the current away from the modules. The cells must be electrically connected to one another and to the rest of the system.

The cells must be connected electrically to one another and to the rest of the system. Externally, popular terrestrial usage photovoltaic modules use MC3 (older) or MC4 connectors to facilitate easy weatherproof connections to the rest of the system. In the case of partial module shading, bypass diodes may be included or utilized externally to maximize the output of module areas that are still lighted. Concentrators, in which light is focused by lenses or mirrors onto an array of smaller cells, are one of the most current solar module designs. This enables the cost-effective usage of cells with a high cost per unit area (such as gallium arsenide).

4.6 EFFICIENCY

Depending on construction, photovoltaic modules can produce electricity from a range of frequencies of light, but usually cannot cover the entire solar range (specifically, ultraviolet, infrared and low or diffused light). As a result, solar modules squander a significant amount of incident sunlight energy, and they can achieve significantly better efficiency if illuminated with monochromatic light. As a result, another design notion is to divide the light into multiple wavelength ranges and guide the beams to different cells tuned to those wavelength ranges.

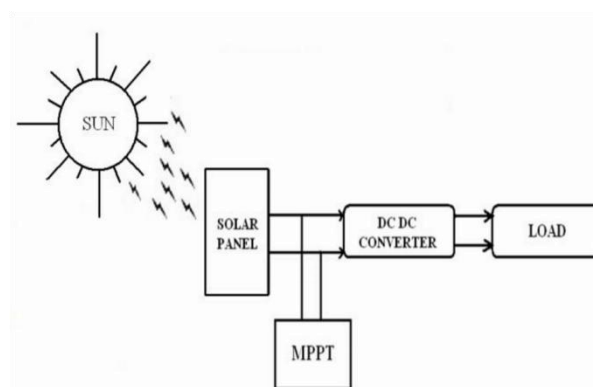
It has been estimated that this might increase efficiency by 50%.

currently the best achieved sunlight conversion rate (solar module efficiency) is around 21.5% in new commercial products typically lower than the efficiencies of their cells in isolation. Power density ratings of up to 175 W/m² (16.22 W/ft²) are found in the most efficient mass-produced solar modules. The efficiency of a solar panel can be enhanced by studding the light-receiving semiconductor surface with aluminium nanocylinders akin to the ridges on Lego blocks, according to Imperial College London research. Because the scattered light travels a longer journey through the semiconductor, more photons can be collected and converted into electricity. Although light scattering occurred in the near infrared area and visible light was significantly absorbed, similar nanocylinders were previously employed in which aluminium was preceded by gold and silver.

The ultraviolet component of the spectrum was absorbed by aluminium, while the visible and near infrared sections of the spectrum were scattered by the aluminium surface. Aluminum is more abundant and less expensive than gold and silver, according to the study, which might save costs and enhance efficiency. The research also noted that the increase in current makes thinner film solar panels technically feasible without "compromising power conversion efficiencies, thus reducing material consumption".

4.7 MPPT (MAXIMUM POWER POINT TRACKING)

For any PV system, the output power can be increased by tracking the MPP (Maximum Power Point) of the PV module by using a controller connected to a dc- dc converter (usually boost converter). Due to the nonlinear nature of PV modules, the MPP varies with insolation level and temperature. Each sort of PV module has its own distinguishing features. In general, there is a single point on the V-I or V-P curve, called the Maximum Power Point (MPP), at which the entire PV system operates with maximum efficiency and produces its maximum output power. This point can be located with the help of MPPT (Maximum Power Point Trackers). PV system with MPPT controller



4.7.1 PV SYSTEM WITH MPPT

The Maximum Electricity Point Tracker, or MPPT, is an electronic system that controls the operation of photovoltaic (PV) modules so that they can produce all of the power they are capable of. MPPT is not a mechanical tracking system that “physically moves” the modules to make them point more directly at the sun. MPPT is a fully electronic system that varies the electrical operating point of the modules so that the modules are able to deliver maximum available power.

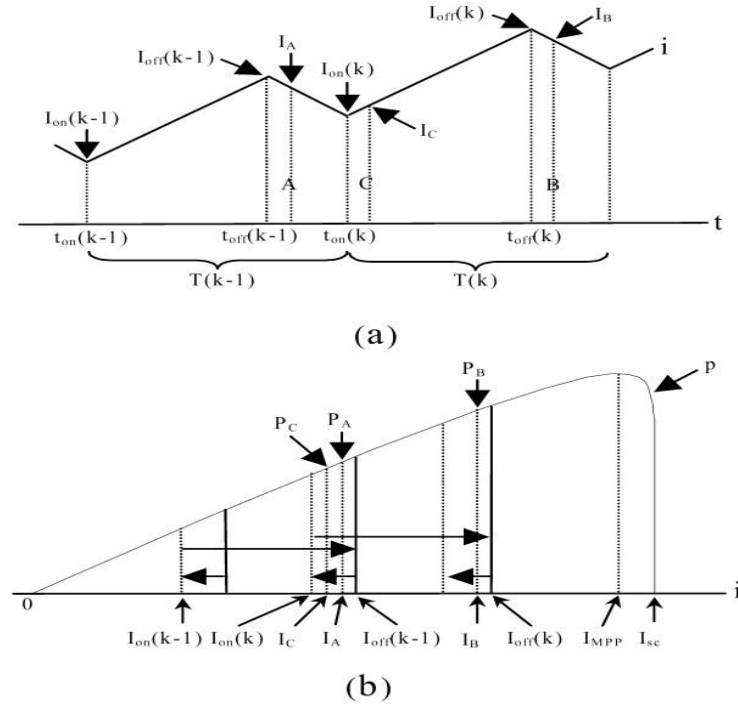
4.7.2 MPPT ALGORITHMS

In the past, various algorithms for tracking MPP have been proposed. Perturb and observe, incremental conductance, constant voltage, constant current, and other algorithms are commonly utilised. The P&O approach stands for "perturb and observe." The PV array's voltage or current is changed in this approach to reach the MPP. For instance, the voltage is increased until the power is increased. One of the most basic MPPT algorithms is the constant voltage technique. The ratio of the array's maximum power voltage, V_{MPP} , to its open-circuit voltage, V_{oc} , is essentially constant, hence this method works. Constant current and constant voltage methods are comparable.

4.7.3 METHOD FOR MPPT TRACKING

Usually MPPT algorithms are based on the comparison of average values of I_{pv} and V_{pv} . *A peak current regulated boost dc-dc converter is used in this MPPT method [7]. The current reference for the peak current controller is the output of the MPPT algorithm.* By comparing instantaneous values of PV voltage and current at two different sampling instants, the variation of the reference current that would result in an increase of PV output power can be obtained.

The basic principle for the operation of the MPPT algorithm can be explained as follows based on Figure 4. Let us suppose the system is operating on the left side of the MPP and the average value of the PV current rises due to an increase in the reference current. In every switching cycle, I_{pv} increases during switching on and decreases during switching off because of the boost converter. The instantaneous current at A, I_A , is less than the instantaneous current at B, I_B , if the sampling time instant in switching cycle $T(k-1)$ is at point A and the sampling time instant in switching cycle $T(k)$ is at point B. The instantaneous power at A, P_A , is less than the instantaneous power at B, P_B , as shown in Figure 4(b). As a result, the reference current I_{ref} should be increased since a positive fluctuation of the instantaneous current resulted in a positive variation of the instantaneous PV power. The MPPT algorithm also indicates that the operating point is on the left side of the MPP and that the reference current I_{ref} should be raised to move the operating point towards the right side.



Operating point on left side of MPP a) I_{pv} wave form in two switching cycles (b) I_{pv} locus on PI curve

The instantaneous samples reveal that I_C is smaller than I_A and P_C is less than P_A if the sampling time instant in switching cycle $T(k)$ is at point C instead of point B. It is obvious

that as the current value decreases, the power decreases, hence the reference current I_{ref} should be increased.

4.8 METHOD OF CONTROL

4.8.1 Control using the proportional-integral (PI) method

It's critical to use a combination of proportional and integral terms to improve response speed and eliminate steady-state inaccuracy. The PID controller block is reduced to P and I blocks only as shown in figure 1.

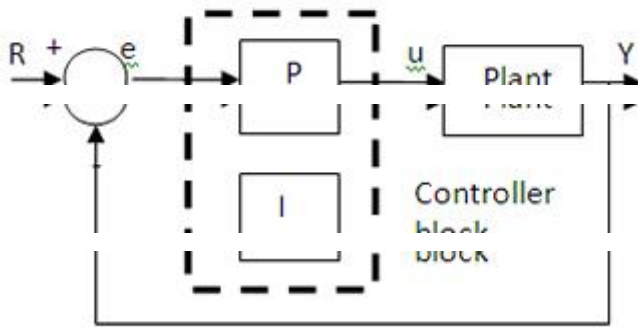


Figure 1: Proportional Integral (PI) Controller block diagram

The proportional and integral terms is given by:

$$u(t) = K_p e(t) + K_i \int e(t) dt$$

K_p and K_i are the tuning knobs, are adjusted to obtain the desired output. The following speed control example [3] is used to demonstrate the effect of increase/decrease the gain, K_p and K_i . A DC motor dynamics equations are represented with second order transfer function,

$$G(s) = \frac{\dot{\theta}}{V} = \frac{K_t}{(Js + b)(Ls + R) - K_e K_t}$$

Where

$K_t = K_e$ = electromotive force constant = 0.01Nm/Amp

b = damping ratio of the mechanical system = 0.1Nms

J = moment of inertia of the rotor = 0.02kgm²s⁻²

R = electric resistance = 1Ω

L = electric inductance = 0.5H

After we include the PI controller, the closed-loop transfer function become:

$$G_P(s) = \frac{Y}{R} = \frac{K_t K_p}{(Js + b)(Ls + R) - K_e K_t - K_t K_p}$$

Figure 2 shows the effects of closed-loop response as we vary the integral gain K_i . The response yields that as K_i increasing, the response reaches the steady state faster with steady state error approaching to zero. The proportional controller and the PI controller are compared in Figure 3.

The result obviously shows with PI controller, we are able to eliminate the steady state error. In summary with small value of K_i ($K_i = 0.01$), we have smaller percentage of overshoot (about 13.5%) and larger steady state error (about 0.1). As we increase the gain of K_i , we have larger percentage of overshoot (about 38%) and manage to obtain zero steady error and faster response. With the response depicted in figure 2 and 3, P-I-D controller can be introduced in order to reduce the overshoot and to ensure the response converge to the specified design objectives.

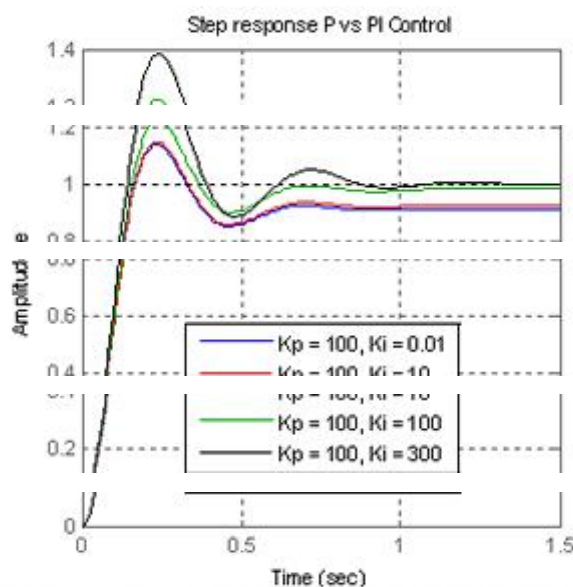
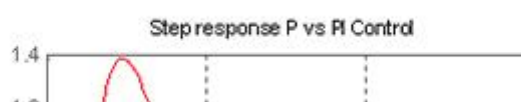


Figure 2: Closed-loop response of PI controller



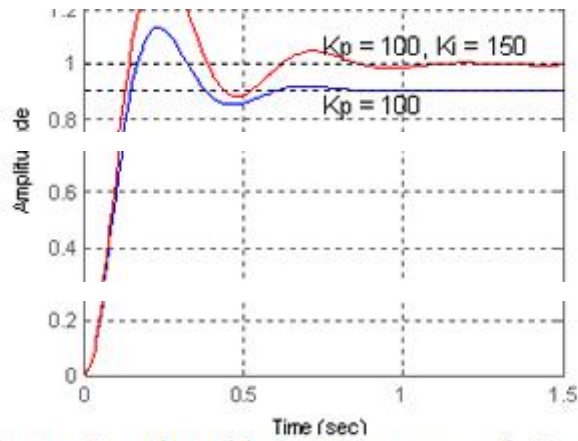
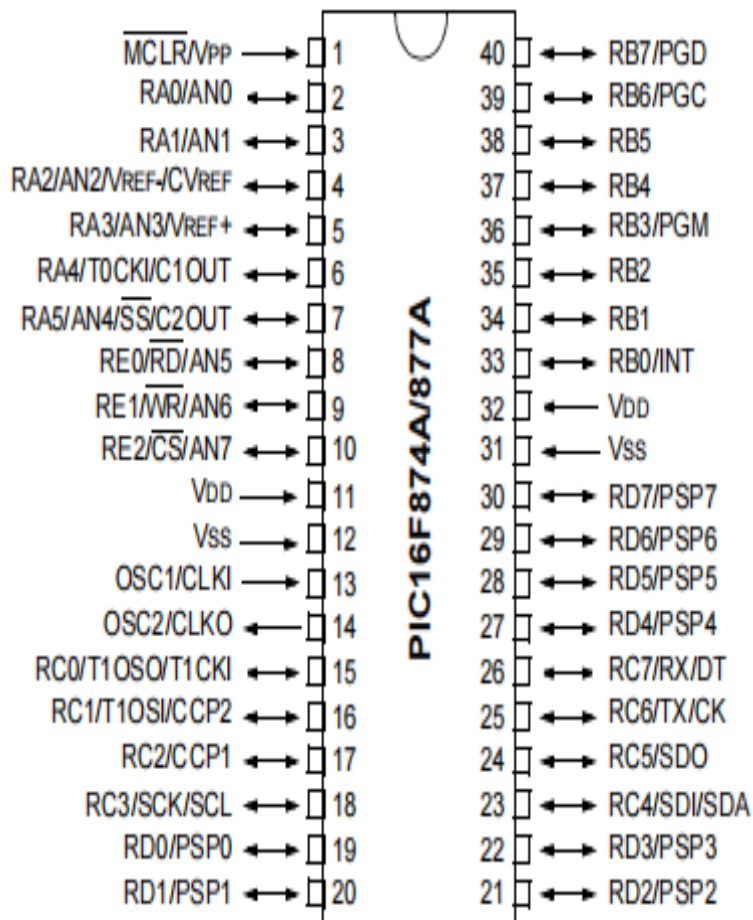


Figure 3: Closed-loop response of P vs PI controller

4.9 CONTROLLER

4.9.1 PIC16F877A



4.9.2 High-Performance RISC CPU:

- Only 35 single-word instructions to learn
- All single-cycle instructions except for program branches, which are two-cycle
- Operating speed: DC – 20 MHz clock input DC – 200 ns instruction cycle
- Flash Program Memory up to 8K x 14 words, Data Memory (RAM) up to 368 x 8 bytes, and EEPROM Data Memory up to 256 x 8 bytes
- Pinout compatible to other 28-pin or 40/44-pin PIC16CXXX and PIC16FXXX microcontrollers

4.9.3 Peripheral Features:

- Timer0: 8-bit timer/counter with 8-bit prescaler
- Timer1: 16-bit timer/counter with prescaler, which can be incremented by an external crystal/clock during Sleep.
- Timer2: 8-bit timer/counter with prescaler and postscaler, as well as an 8-bit period register.
- Two modules for capture, comparison, and PWM - Capture is 16-bit, with a maximum resolution of 12.5 nanoseconds; compare is 16-bit, with a maximum resolution of 200 nanoseconds; and PWM has a maximum resolution of 10-bit.
- SSP (Synchronous Serial Port) with SPITM (Master mode) and I2CTM (Master/Slave mode)
- 9-bit address detection on the Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI)
- 8-bit wide Parallel Slave Port (PSP) with external RD, WR, and CS controls (40/44-pin only)
- Brown-out Reset circuitry with brown-out sensing (BOR)

4.9.4 Analog Features:

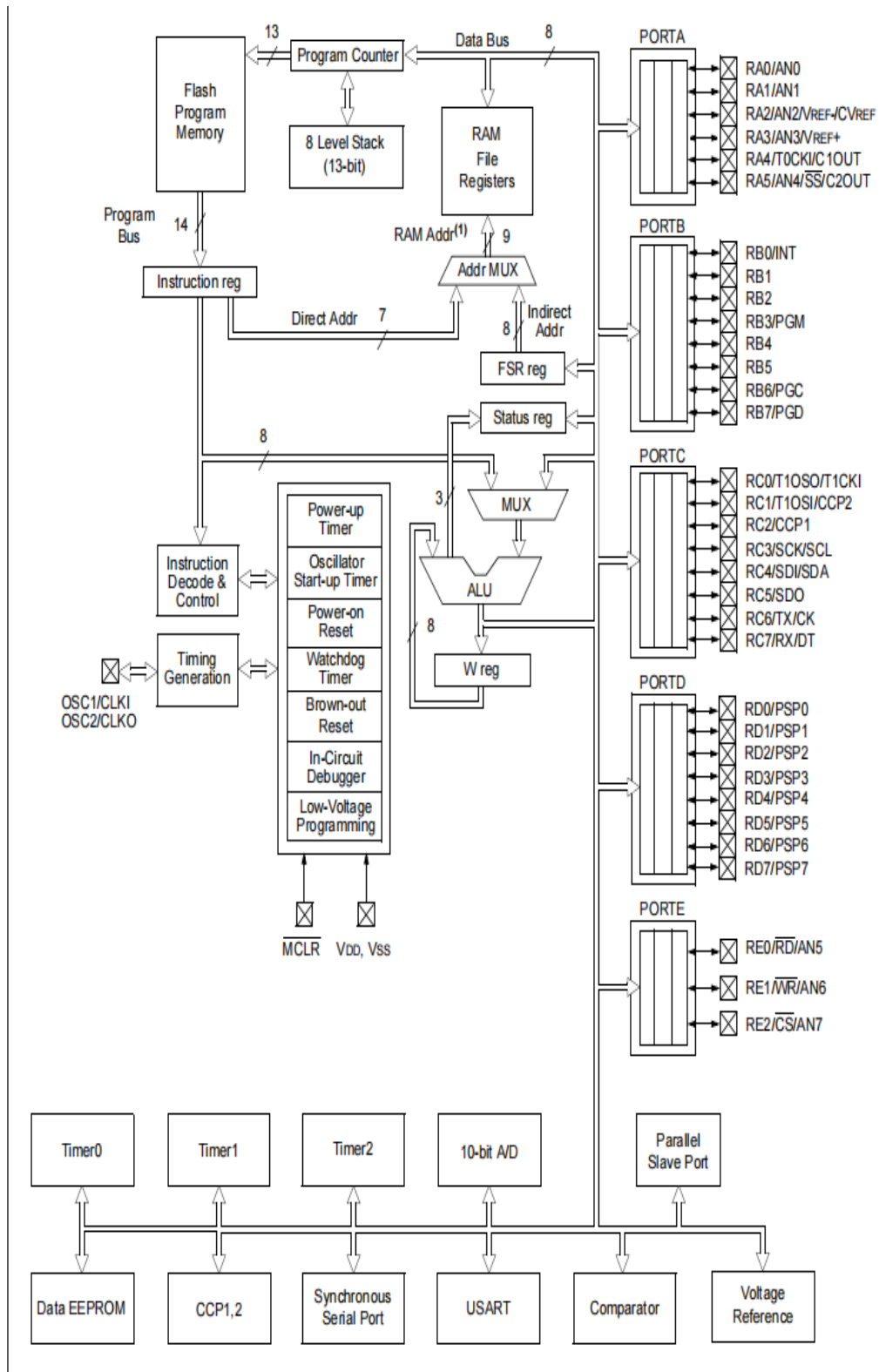
- Analog-to-Digital Converter (A/D) with 10-bit resolution and up to 8 channels
- Reset the brown-out (BOR)
- Analog Comparator module has the following features: - There are two analogue comparators. - On-chip voltage reference (VREF) module that may be programmed - Programmable input multiplexing from device inputs and an internal voltage reference- Comparator outputs are externally accessible

4.9.5 Special Microcontroller Features:

- 100,000 erase/write cycle Enhanced Flash program memory typical
- 100,000 times erase/write Memory for Flash programmes is typically increased.
- 1,000,000 times erase/write Typical data EEPROM memory
- Retention of data in EEPROM > 40 years
- Software-controlled self-reprogramming
- Two-pin In-Circuit Serial Programming™ (ICSPTM)
- In-Circuit Serial Programming with a Single 5V Supply
- For dependable operation, the Watchdog Timer (WDT) has its own on-chip RC oscillator.
- Code protection that can be programmed
- Sleep mode saves energy
- Oscillator options that can be changed
- CMOS Technology: In-Circuit Debug (ICD) through two pins
- Flash/EEPROM technology with low power and high speed

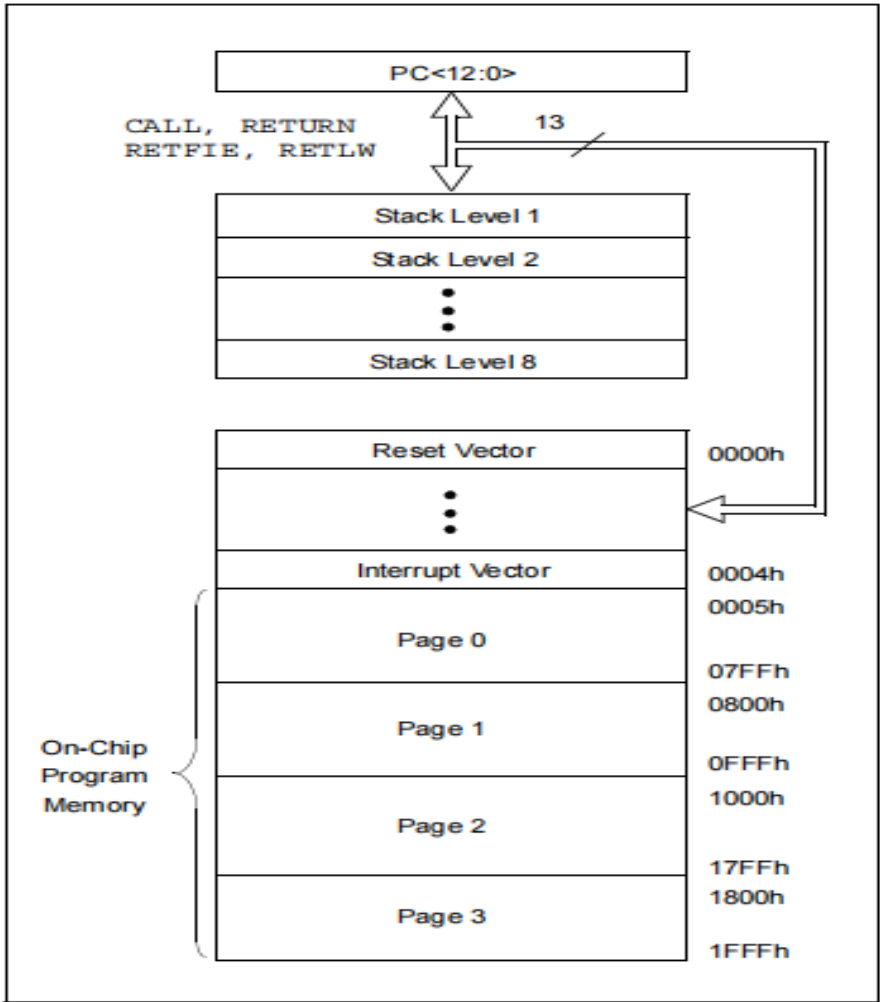
- Design is completely static.
- Wide range of operating voltages (2.0V to 5.5V)
- Commercial and Industrial temperature ranges
- Low-power consumption

4.9.6 877A BLOCK DIAGRAM:



4.9.7 MEMORY ORGANIZATION

Each of the PIC16F87XA devices has three memory blocks. This section describes how the programme memory and data memory have distinct buses to allow for parallel access. Section 3.0 "Data EEPROM and Flash Program Memory" delves into the EEPROM data memory block. The PICmicro® Mid-Range MCU Family Reference Manual has more information on device memory (DS33023)



4.9.8 Program Memory Organization:

The PIC16F876A/877A devices have a Flash programme memory of 8K words x 14 bits, while the PIC16F873A/874A devices have 4K words x 14 bits. A wraparound will occur if you access a location that is above the physically implemented address.

4.9.9 Data Memory Management:

The General Purpose Registers and Special Function Registers are divided into numerous banks in the data memory. The bank select bits are RP1 (Status) and RP0 (Status). Each bank has a 7Fh limit (128 bytes). The Special Function Registers are kept at the lowest regions of each bank. General Purpose Registers, implemented as static RAM, are located above the Special Function Registers. Special Function Registers are present in all installed banks. Some of a bank's frequently utilised Special Function Registers may be replicated in another bank for coding purposes. All implemented banks contain Special Function Registers. For code reduction and faster access, some commonly used Special Function Registers from one bank may be duplicated in another bank.

(4.9.10) I/O PORTS

Some I/O port pins are multiplexed with an alternate function for the device's peripheral features. When a peripheral is enabled, it cannot be utilised as a general-purpose I/O pin in most cases. Additional information on I/O ports may be found in the PICmicro™ Mid-Range Reference Manual (DS33023).

4.9.11 PORTA and the TRISA Register

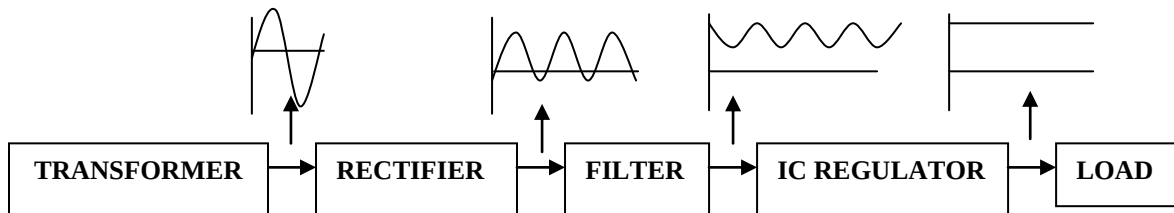
PORTA is a 6-bit wide, bidirectional port. The corresponding data direction register is TRISA. When a TRISA bit (= 1) is set to 1, the accompanying PORTA pin becomes an input (i.e., put the corresponding output driver in a High-Impedance mode). When a TRISA bit is cleared (= 0), the corresponding PORTA pin becomes an output (i.e., put the contents of the output latch on the selected pin). Writing to the PORTA register will write to the port latch, while reading it will read the status of the pins. Read-modify-write operations are used in all write operations. As a result, writing to a port entails reading the port pins, changing the value, and then writing to the port data latch. The Schmitt Trigger input and open-drain output of the RA4/T0CKI pin is a Schmitt Trigger input and an open-

drain output. TTL input levels and full CMOS output drivers are available on all other PORTA pins. For both the A/D converters and the comparators, other PORTA pins are multiplexed with analogue inputs and the analogue VREF input. Clearing/setting the necessary control bits in the ADCON1 and/or CMCON registers selects the operation of each pin.

4.10 HARDWARE

4.10.1 Power Supply

The ac voltage, which is usually 220V rms, is linked to a transformer, which reduces the ac voltage to the desired dc output level. A full-wave rectified voltage is then produced by a diode rectifier, which is first filtered by a simple capacitor filter to produce a dc voltage. There is frequently some ripple or ac voltage change in the resulting dc voltage. Even if the input dc voltage varies or the load attached to the output dc voltage changes, a regulator circuit removes the ripples and maintains the same dc value. One of the most common voltage regulator IC modules is used to provide this voltage regulation.



Block Diagram of Power supply

4.10.2 Transformer

The power supply voltage (0-230V) will be reduced to (0-6V) using the potential transformer. The secondary of the potential transformer will then be connected to an op-amp-based precision rectifier. Precision rectifiers have the advantage of providing peak voltage output as DC while the remainder of the circuits only provide RMS.

4.10.3 Rectifier Bridge

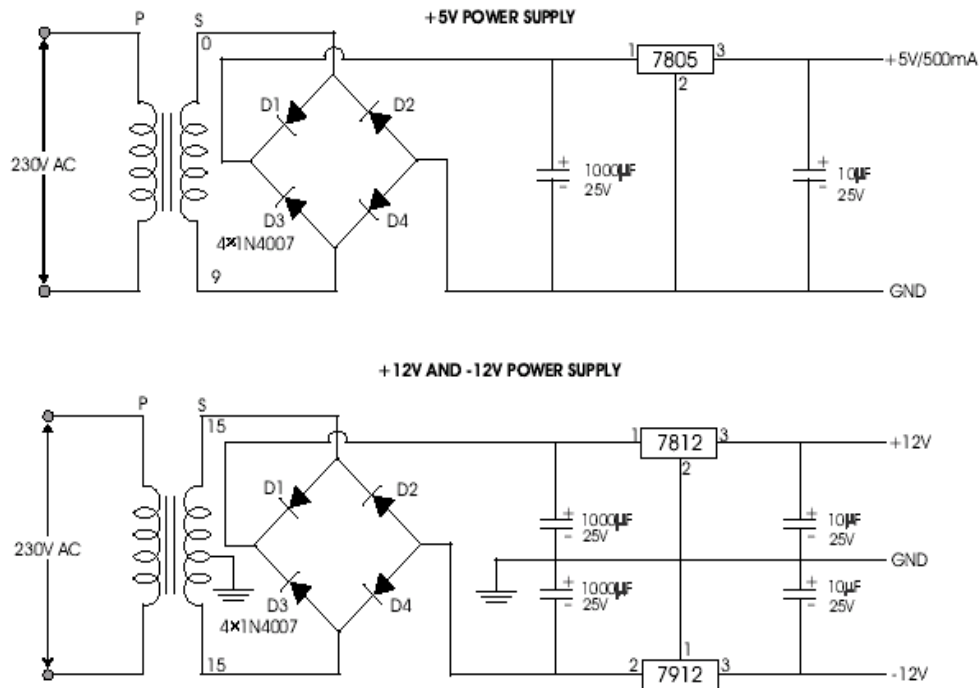
A bridge rectifier is a circuit in which four diodes are linked as indicated in the diagram. The circuit's input is applied to the network's diagonally opposed corners, while the output is drawn from the remaining two. Assume the transformer is operational, with a positive potential at point A and a negative potential at point B. 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. D3 and D1 are forward biased at this time, allowing current to flow through them; D4 and D2 are reverse biased, blocking current passage. Current flows from point B through D1, up through RL, through D3, and back to point B via the transformer's secondary. The solid arrows point in the right direction. Across D1 and D3, waveforms (1) and (2) can be seen. The polarity across the secondary of the transformer reverses one-half cycle later, forward biasing D2 and D4 and reverse biasing D1 and D3. The current flow is from point A to D4, up via RL, through D2, through T1's secondary, and back to point A. The broken arrows point in the right direction. The current in RL always moves in the same direction. This current creates a voltage that corresponds to the waveform depicted when it flows through RL (5). This bridge rectifier is a full-wave rectifier because current flows through the load (RL) during both half cycles of the supplied voltage.

One advantage of a bridge rectifier over a normal full-wave rectifier is that it provides a voltage output nearly twice as high as the typical full-wave circuit with the same transformer. Assigning values to some of the components in views A and B can demonstrate this assume that the same transformer is used in both circuits. In both circuits, the peak voltage created between points X and y is 1000 volts. The greatest voltage that can be rectified at any given time is 500 volts since only one diode can conduct at any given time. Because of the modest voltage drop across the diode, the maximum voltage that appears across the load resistor is nearly-but never exceeds-500 volts. During both half cycles of the supplied voltage, current flows through the load. The greatest voltage that can be rectified in the bridge rectifier illustrated in image B is the whole secondary voltage. As a result, the output voltage across the load resistor reaches approximately 1000 volts at its peak .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. Current flows from point B through D1, up through RL, through D3, and back to point B via the transformer's secondary. The solid arrows point in the right direction. Across D1 and D3, waveforms (1) and (2) can be seen. The polarity across the secondary of the transformer reverses one-half cycle later, forward biasing D2 and D4 and reverse biasing D1 and D3. The current flow is from point A to D4, up via RL, through D2, through T1's secondary, and back to point A. The broken arrows point in the right direction. The current in RL always moves in the same direction. This current creates a voltage that corresponds to the waveform depicted when it flows through RL. (5) This bridge rectifier is a full-wave rectifier because current flows through the load (RL) during both half cycles of the supplied voltage.

4.10.4 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 configured to operate with load currents ranging from hundreds of milliamperes to tens of amperes, and power ratings ranging from milliwatts to tens of watts. From 5 to 24 volts, the series 78 regulators provide fixed positive regulated voltages. From 5 to 24 volts, the series 79 regulators give set negative regulated voltages. An unregulated dc input voltage, V_i , is applied to one input terminal, a regulated dc output voltage, V_o , is applied to a second terminal, and the third terminal is connected to ground. From 5 to 24 volts, the series 78 regulators provide fixed positive regulated voltages. The series 79 regulators, on the other hand, provide fixed negative regulated voltages ranging from 5 to 24 volts. For ICs microcontroller, LCD - 5 volts. For alarm circuit, op-amp, relay circuits -12 volts.

4.10.5 Driver Circuit

A driver is an electrical circuit or other electronic component in electronics that is used to control another circuit or component, such as a high-power transistor or a liquid crystal display (LCD).

They are typically used to regulate current flowing through a circuit or to control other parameters in the circuit, such as other components and devices. A specialised integrated

circuit that controls high-power switches in switched-mode power converters is sometimes referred to as a high-power switch controller.

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.

The properties of the driver stage(s) of a circuit are typically different from those of the other circuit stages. To avoid or minimise distortion in a transistor power amplifier, the driver circuit normally requires current gain, the capacity to rapidly discharge the following transistor bases, and low output impedance.

In semiconductor devices, driver circuits are most typically used to amplify signals from controllers or microcontrollers in order to regulate power switches. Driver circuits frequently provide extra roles such as separating the control and power circuits, detecting malfunctions, storing and reporting failures to the control system, and acting as a relay precaution against failure, analyzing sensor signals, and creating auxiliary voltages.

4.10.6 Thyristor Driver Circuits

To trigger the thyristor, appropriate control signals are used to generate gate current pulses in thyristor driver circuits. A transformer is used to separate the control circuit from the power circuit's high voltages.

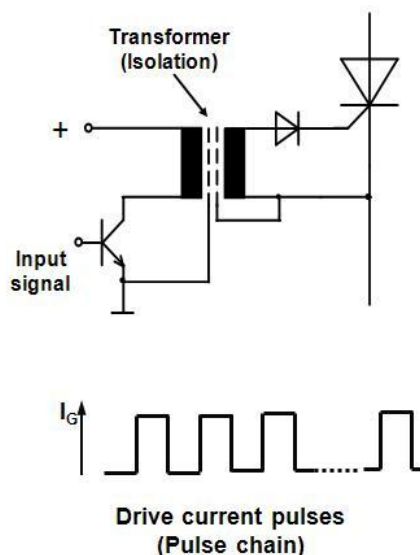


Figure 1 shows the workings of a thyristor driver circuit.

The firing pulses are repeated multiple times to ensure that they surpass the latching current of the thyristor. The latching current is the thyristor's minimal gate current necessary to activate it. The gate pulse must continue until the current flowing through the thyristor reaches the holding current, which is the minimum current required to keep the thyristor in the on state

4.11 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 gate and emitter are separated by a thin layer of silicon oxide. A maximum voltage of 20V to 25V must never be exceeded in order to ensure that the oxide layers remain intact.

4.12 FUNCTIONS OF TYPICAL DRIVER CIRCUITS

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

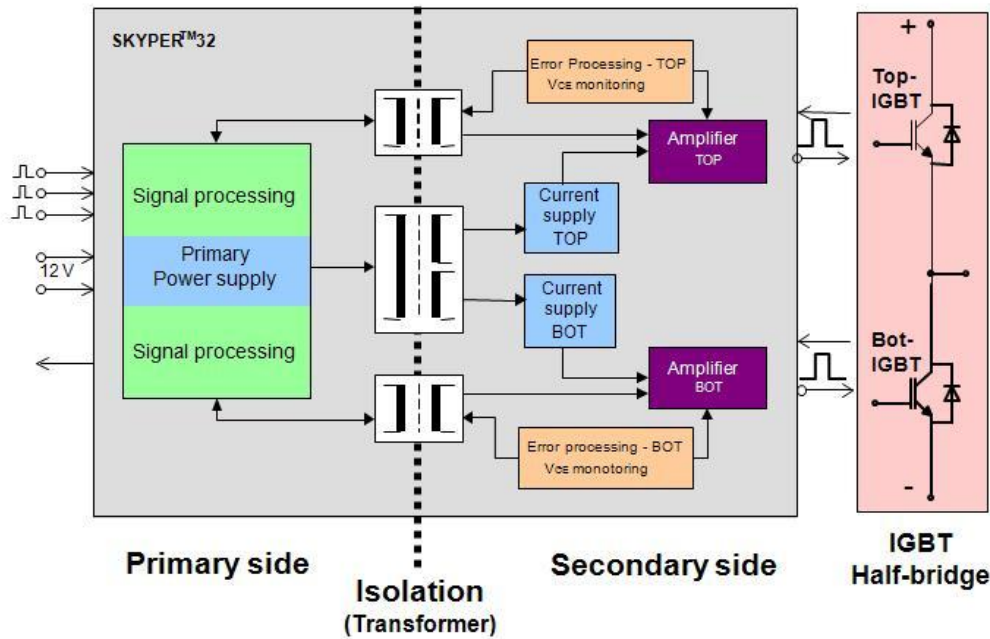


Figure 2. Outline of IGBT half-bridge driver circuit

Primary side of driver circuit

Input signals are received on the primary side of the IGBT half-bridge driver circuit above, and error signals are delivered back to the controller.

Signal processing on the primary side of the driver circuit allows for short pulse suppression to reduce glitches, the prevention of both IGBTs in the half-bridge turning on at the same time to avoid short circuits, and temperature and undervoltage monitoring.

4.12.1 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.

4.12.2 Secondary side of driver circuit

Input signals are amplified and used to control the switching of the IGBTs on the secondary side of the driver circuit. Overcurrents are monitored to detect power circuit

shorts. This is accomplished by comparing the collector-emitter voltage V_{CE} to a predetermined threshold or by monitoring the current sensor signal.

If there is an overcurrent condition, the secondary side of the driver turns off all IGBTs and sends an error signal to the primary side.

4.12.3 Using an optocoupler to isolate the triggering signal

To isolate signals, optocouplers are frequently used instead of transformers. An optocoupler is a device that combines a light-emitting diode (LED) and a light-sensitive transistor (phototransistor) into a single chip. 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.

4.12.4 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.

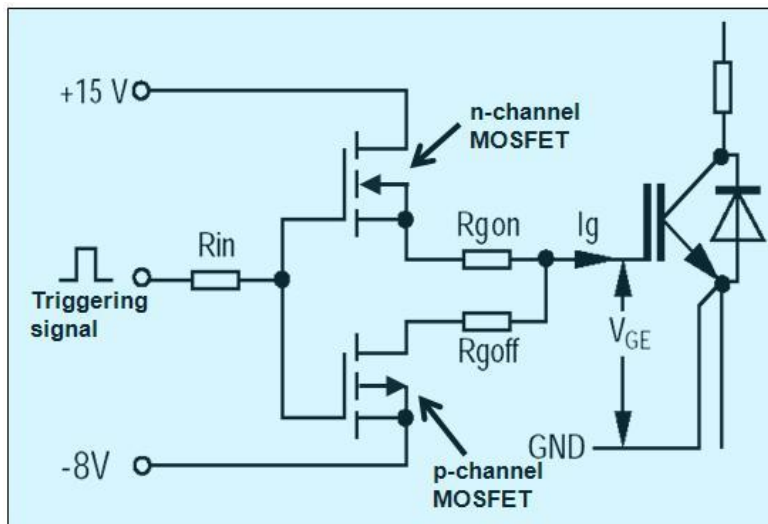


Figure 3. Output stage of a gate driver

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

4.12.5 Soft turn off

When a short circuit occurs in several driving circuits, a switch to a greater R_{goff} is made, resulting in a slower, or soft, turn-off. Overvoltages, which can result in high currents and parasitic inductances, which could otherwise harm the module, are avoided in this method.

4.12.6 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.

When choosing a driver circuit for a certain application, it's important to consider both the maximum and average gate currents.

(4.13)Battery

Batteries are used to store excess solar energy turned into electrical energy in isolated systems distant from the grid. Only isolated sunlight loads, such as irrigation pumps or drinking water supplies for storage, are exempt. In fact, for small machines with less than a kilowatt of output. Batteries appear to be the only storage option that is both technically and economically feasible. Due to the high capital costs of both the photovoltaic system and the batteries. It is critical to optimise the overall system in terms of available energy and local demand patterns. Solar energy storage requires a battery with a specific capacity to be economically viable combination of properties:

- (1) Low cost
- (2) Long life
- (3) High reliability
- (4) High overall efficiency
- (5) Low discharge
- (6) Minimum maintenance

- (A) Ampere hour efficiency
- (B) Watt hour efficiency

We utilize lead acid batteries to store electrical energy from solar panels for street lighting, and more information about lead acid cells may be found below.

4.13.1 Wet Lead-Acid Cell:

The lead-acid cell is the most popular type utilized when high load currents are required. A dilute solution of sulfuric acid (H_2SO_4) serves as the electrolyte. The load current to the starter motor of an automobile, for example, is normally 200 to 400A when using battery power to start the engine. Although a single lead-acid cell provides a nominal output of 2.1 volts, lead-acid cells are frequently used in series combinations of three for a 6-volt battery and six for a 12-volt battery. A secondary cell or store cell that may be recharged is a lead acid cell. As long as the cell is in good physical condition, the charge and discharge cycle can be repeated several times to restore the output voltage. Heat from high charge and discharge currents, on the other hand, reduces the useful life of an automotive battery to 3 to 5 years. The lead-acid type of secondary cell provides the highest output voltage of the several varieties, allowing for the use of fewer cells for a given battery voltage.

4.13.2 Construction:

The positive and negative electrodes in a lead-acid battery are made up of a series of plates welded to a connecting strap. The plates are submerged in an electrolyte made up of eight parts water and three parts concentrated sulfuric acid. Each plate is made up of a lead-antimony alloy grid or framework. The active ingredient, lead oxide, may be pasted onto the grid thanks to this design. A forming charge is used to make the positive and negative electrodes in the cell. The active substance in the positive plate is converted to lead peroxide (PbO_2) during the manufacturing process. A spongy lead serves as the negative electrode (Pb). The majority of automobile batteries are sent dry from the manufacturer. The electrolyte is added during installation, and the battery is subsequently charged from the plates. With maintenance-free batteries, little or no water need be added in normal service. Some types are sealed, except for a pressure vent, without provision for adding water.

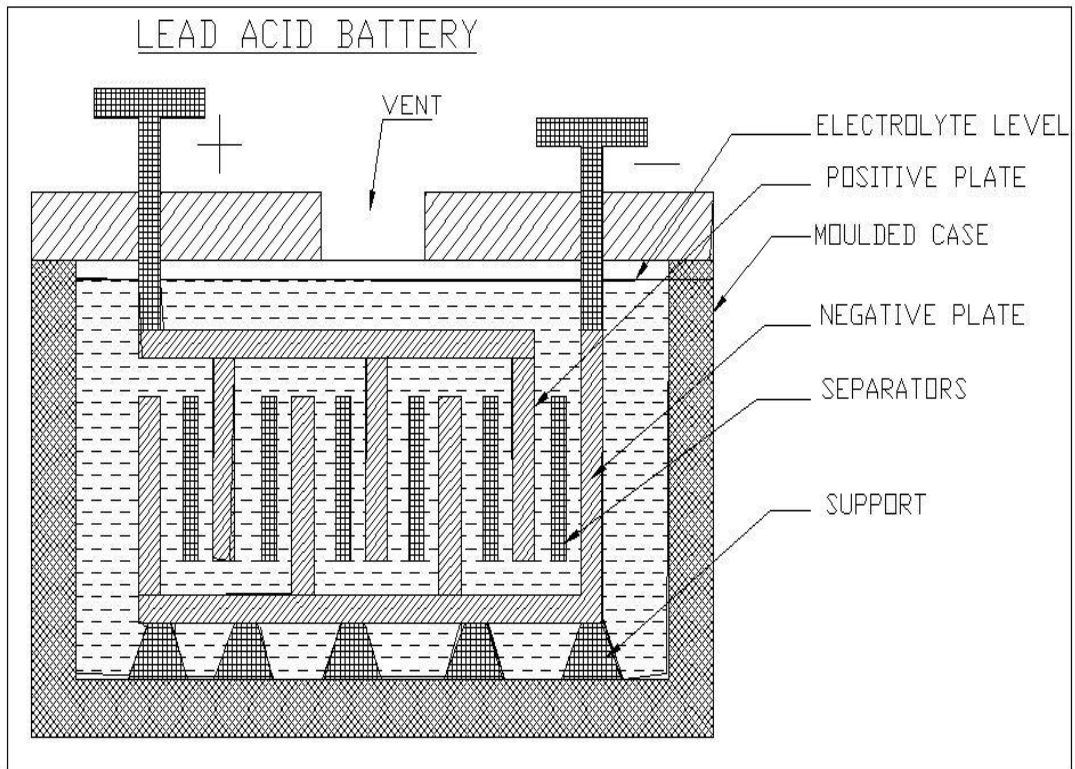


Fig 5.1 Layout of Battery



Fig 5.2 Battery

4.14 THYRISTOR

A thyristor 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 thyristor 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 thyristor 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.

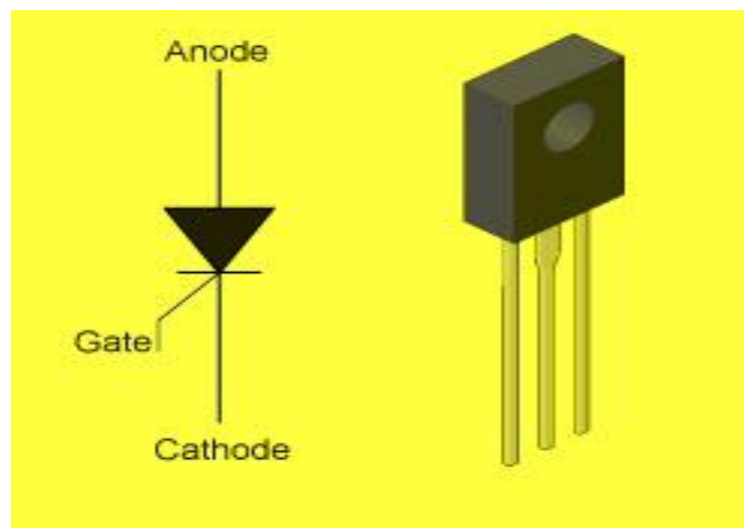


Fig 4.4 Thyristors Diagram

4.15 MOSFET

The MOSFET (metal–oxide–semiconductor field–effect transistor) is a type of transistor that can be used to amplify or switch electronic signals. Despite the fact that the MOSFET has four terminals: source (S), gate (G), drain (D), and body (B), the body (or substrate) of the MOSFET is frequently linked to the source terminal, making it a three-terminal device like other field-effect transistors. Only three terminals appear in electrical

schematics because these two terminals are generally connected to each other (short-circuited) inside.

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 include electrons (an n-MOSFET or n-MOS) or holes (a p-MOSFET or p-MOS), which are of opposite type to the substrate, therefore n-MOS is made with a p-type substrate and p-MOS is made with an n-type substrate (see article on semiconductor devices). The channel in the less common depletion mode MOSFET, described later, is made up of carriers in an opposite-type surface impurity layer, and conductivity is reduced by applying a field that depletes carriers from this 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. Because it is difficult to enhance the speed of operation of transistors without metal gates, they are regaining favour. Similarly, the word "oxide" in the name can be misleading, as many dielectric materials are employed to achieve robust channels with lower applied voltages. A related name, insulated-gate field-effect transistor, or IGFET, is practically synonymous with MOSFET. Because many "MOSFETs" have a gate that is not metal and a gate insulator that is not oxide, the word may be more comprehensive. MISFET (metal–insulator–semiconductor FET) is another synonym.

Though the bipolar junction transistor was once far more widespread, the MOSFET is by far the most common transistor in both digital and analogue circuitry.

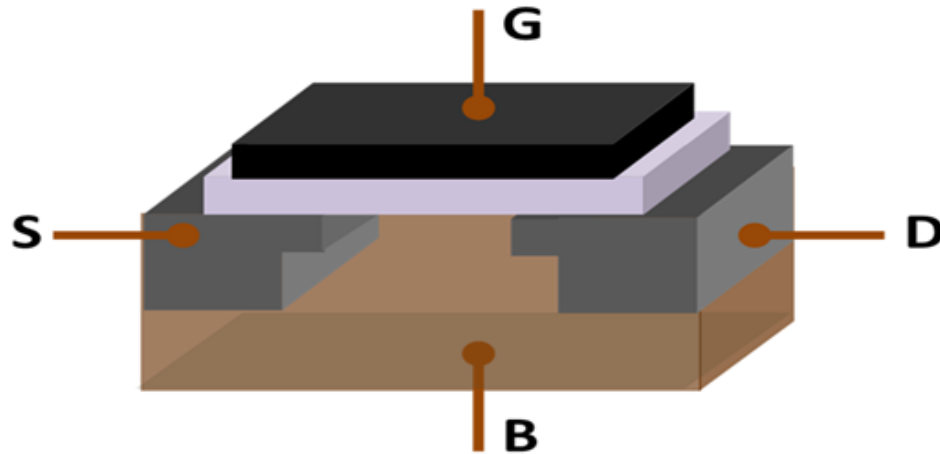


Fig 4.5 MOSFET Construction Diagram

4.15.1 OPERATION OF MOSFET

Growing a layer of silicon dioxide (SiO_2) on top of a silicon substrate and applying a layer of metal or polycrystalline silicon results in the classic metal–oxide–semiconductor (MOS) configuration (the latter is commonly used). Because silicon dioxide is a dielectric material, its construction is similar to a planar capacitor with a semiconductor replacing one of the electrodes. When a voltage is placed across a MOS structure, the charge distribution in the semiconductor is changed. When a voltage is applied across a MOS structure, it modifies the distribution of charges in the semiconductor. A positive voltage applied from gate to body (see figure) creates a depletion layer by forcing positively charged holes away from the gate-insulator/semiconductor interface, leaving a carrier-free region of immobile, negatively charged acceptor ions exposed (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 In the depletion region, there are carrier production and recombination centres. The threshold voltage is the gate voltage at which the volume density of electrons in the inversion layer is equal to the volume density of holes in the body. Overdrive voltage occurs when the voltage between the transistor gate and source (V_{GS}) surpasses the threshold voltage (V_{th}).

The n-type MOSFET is built on this p-type body structure, which necessitates the inclusion of n-type source and drain regions.

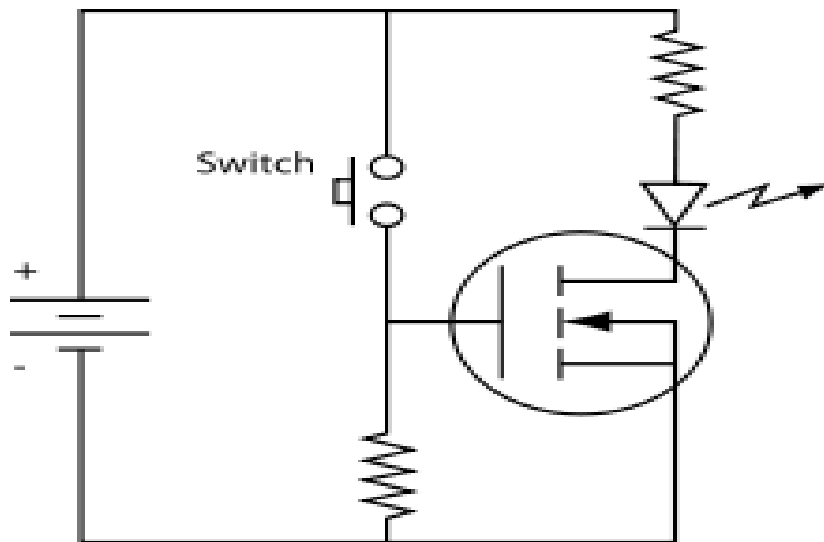


Fig 4.6 MOSFET Block Diagram

4.16 INDUCTOR

An inductor, also known as a coil or reactor, is a two-terminal passive electrical component that resists changes in the electric current that passes through it. It is made up of a conductor, commonly a wire, twisted into a coil. As long as current runs, energy is stored in a magnetic field in the coil. According to Faraday's law of electromagnetic induction, when the current flowing through an inductor varies, the time-varying magnetic field induces a voltage in the conductor. The direction of induced electromotive force (or "emf."), according to Lenz's law, is always such that it opposes the change in current that caused it. As a result, inductors constantly resist changes in current, much as a flywheel resists changes 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 Henrys (H). Inductors have values that typically range from 1 μH (10^{-6}H) to 1 H. Inside the coil of many inductors is a magnetic core made of iron or ferrite, which increases the magnetic field and therefore the inductance. Inductors are one of the three passive linear circuit elements that make up electric circuits, along with capacitors and resistors. Inductors are common in alternating current (AC) electronic equipment, especially in radio equipment. Chokes are inductors that are designed to block AC while allowing DC to pass. They're also employed in electronic

filters to separate signals of different frequencies, and in tuned circuits to tune radio and TV receivers, where they're combined with capacitors.



Fig 4.7 Inductor Diagram

4.17 CAPACITOR

A capacitor (also known as a condenser) is a two-terminal passive electrical component that stores electrical energy in an electric field briefly. Practical capacitors come in a variety of shapes and sizes, but they all have at least two electrical conductors (plates) separated by a dielectric (i.e. an insulator that can store energy by becoming polarized). Thin films, foils, or sintered metal beads, as well as conductive electrolytes, can be used as conductors. The capacitor's charge capacity is increased by the non-conducting dielectric. Glass, ceramics, plastic film, paper, mica, and oxide layers are all common dielectric materials. Many typical electrical gadgets employ capacitors as part of their electrical circuits. Unlike a resistor, an ideal capacitor does not dissipate energy. A capacitor, on the other hand, stores energy as an electrostatic field between its plates.

When a potential difference exists between the conductors (for example, when a capacitor is connected to a battery), an electric field forms across the dielectric, causing positive charge $+Q$ to gather on one plate and negative charge Q to collect on the other. No current can flow through a capacitor if a battery has been connected to it for an extended

period of time. A displacement current can flow if a time-varying voltage is put across the capacitor's leads.

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

The capacitance increases as the surface area of the "plates" (conductors) increases and the space between them narrows. In practice, the dielectric between the plates leaks a small amount of current and has a limit on the strength of the electric field, which is known as the breakdown voltage. Inductance and resistance are introduced by the conductors and leads.

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.

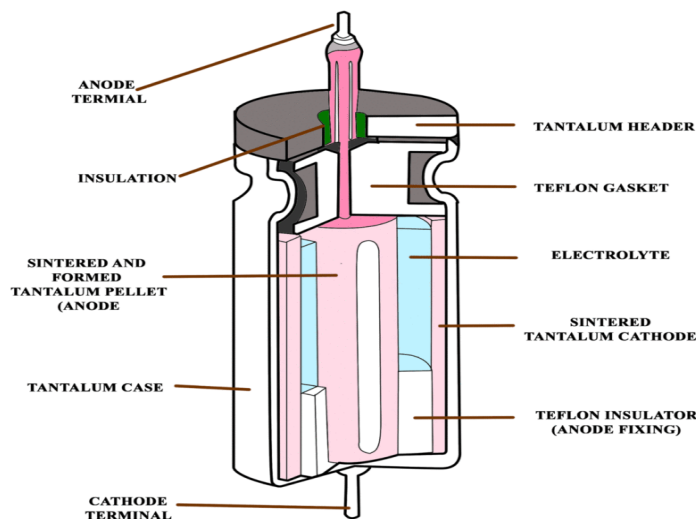


Fig 4.8 Capacitor Diagram

4.18.1 OPERATION OF CAPACITOR

Two conductors are connected by a non-conductive area in a capacitor. A vacuum or an electrical insulator substance called a dielectric might be used as the non-conductive zone. Glass, air, paper, and a semiconductor depletion area chemically similar to the conductors are all examples of dielectric media. A capacitor is thought to be self-contained and isolated, with no net electric charge and no external electric field influence. As a result, the conductors on their facing surfaces have equal and opposite charges, and the dielectric creates an electric field. A capacitance of one farad, expressed in SI units, means that one coulomb of charge on each conductor results in a voltage of one volt across the device. The ratio of charge Q on each conductor to the voltage V between them defines the constant capacitance C of an ideal capacitor.

$$C=Q/V$$

The opposite charges on the conductors (or plates) attract each other due to their electric fields, allowing the capacitor to store more charge for a given voltage than if the conductors were separated, resulting in a large capacitance. Condensers were the name given to early capacitors, and the term is still still used today, especially in high-power applications like automobile systems.

CHAPTER 5

MATLAB

In today's world, simulation has become a very powerful tool in both industry and academia. An electrical engineer's understanding of simulation and its application in numerous applications is now required. Simulation is one of the most effective ways to examine the behaviour of a system or circuit without causing damage to it. For engineering professionals, there are tools for performing simulations in a variety of sectors accessible on the market. Before creating a product, many firms invest a significant amount of time and money on simulation. Simulation plays an essential role in most research and development (R&D) projects. It's impossible to go any further without simulation. It's worth noting that computer simulation and a proof-of-concept hardware prototype in the lab are complementary in power electronics. However, computer simulation should not be used in place of a physical prototype. The goal of this chapter is to show how to use the MATLAB tool to simulate an impedance source inverter with R, R-L, and RLE loads.

5.1 INTRODUCTION TO MATLAB

MATLAB is a high-performance technical computing language. It combines computation, visualization, and programming in a user-friendly interface with problems and solutions written in common mathematical notation. Typical applications 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 with an array as its basic data element that does not require dimensioning. This allows you to solve many technical computing issues in a fraction of the time it takes to build a programme in a scalar non-interactive language like C or FORTRAN, especially ones using matrix and vector formulations. Matlab is an acronym for matrix laboratory. MATLAB was created to make matrix software developed by the LINPACK and EISPACK teams more accessible. The LAPACK and BLAS libraries are now included in MATLAB engines, putting the state-of-the-art in software for matrix computation. Many users have contributed to the development of MATLAB over the years. In university environments, it is the standard instructional tool for introductory and advanced courses in mathematics, engineering, and science. For high-productivity research, development, and analysis in industry, MATLAB is the tool of choice. Toolboxes are a type of add-on application-specific solution available in MATLAB. Toolboxes are essential for most MATLAB users since they allow you to understand and use specific technologies. 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.

5.2 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. The user interfaces of many of these tools are graphical. The MATLAB desktop and Command Window, as well as a command history, an editor and debugger, a code analyzer and other reports, and browsers for reading help, the workspace, files, and the search path, are all included. The MATLAB Programming Language Control flow statements, functions, data structures, input/output, and object-oriented programming capabilities are all included in this high-level matrix/array language. It enables "programming in the tiny" for short and filthy throw-away applications, as well as "programming in the large" for massive and complex application programs.

5.2.1 Graphics

MATLAB includes a number of tools for presenting vectors and matrices as graphs, as well as annotating and printing them. It contains high-level data visualization, image processing, animation, and presentation graphics functions in two and three dimensions. It also includes low-level utilities for extensively customizing the appearance of visuals and creating complete graphical user interfaces for your MATLAB applications. External Interfaces/API in MATLAB This is a library that allows you to interface with MATLAB using C and Fortran programs. It includes facilities for calling routines from MATLAB (dynamic linking), calling MATLAB as a computational engine, and for reading and writing MAT-files.

5.2.2 MATLAB Documentation

To help you learn about and use all of MATLAB's features, it provides rich documentation in both printed and online formats. Start with this Getting Started book if you're a new user. It provides a high-level overview of all of MATLAB's main capabilities, as well as several examples. The online help for MATLAB features provides task-oriented and reference information. Print and PDF versions of the MATLAB documentation are also available. To access the online documentation, go to the Help menu in MATLAB and select MATLAB Help. The MATLAB documentation is divided into the following sections:

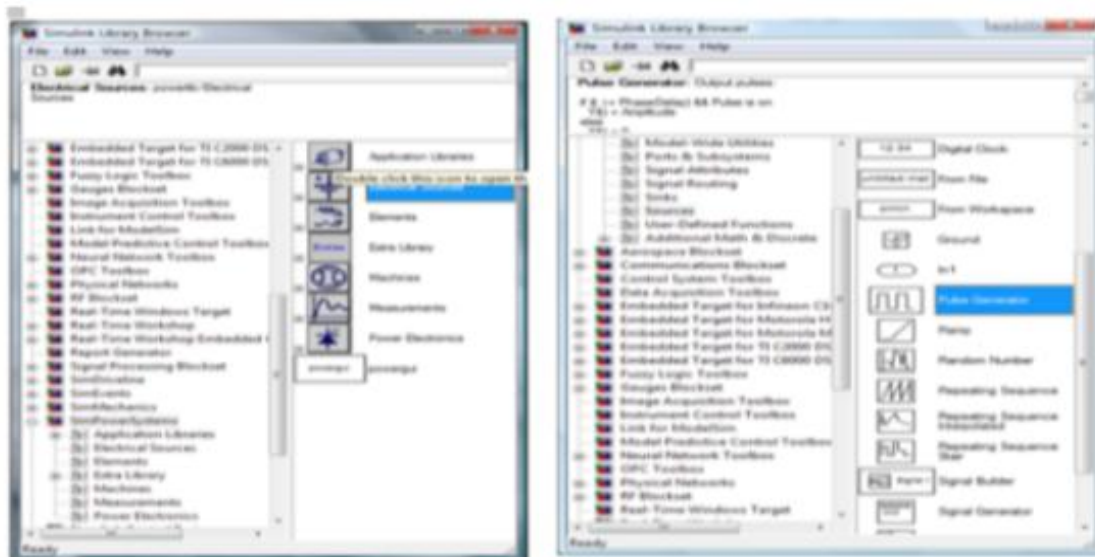
5.2.3 The Role of Simulation in Design

Electrical power systems are made up of circuits and electromechanical devices such as motors and generators. Engineers in this field are always attempting to improve the systems' performance. Power system designers have been forced to use power electronic devices and sophisticated control system concepts to meet efficiency requirements, which puts traditional analysis tools and techniques to the test. The analyst's job is made even more difficult by the fact that the system is frequently so nonlinear that simulation is the only method to comprehend it. The use of power systems is not limited to land-based power generation via hydroelectric, steam, or other methods. The employment of power electronics and control systems to meet performance goals is a typical feature of these systems. Sim Power Systems makes use of the Simulink environment, which allows you to create a model with just a few clicks and drags. Not only can you quickly create the circuit

layout, but you may also analyze the circuit's interactions with mechanical, thermal, and control disciplines. This is possible because the simulation's electrical components interface with Simulink's broad modelling library. Simulink's computational engine is MATLAB, thus designers can use MATLAB toolboxes and Simulink block sets. A specific Physical Modeling block and connection line interface are shared by Sim Power Systems and Sim Mechanics.

5.2.4 Sim Power Systems Libraries

Sim Power Systems can be put to work quickly. Models of common power equipment such as transformers, wires, machines, and power electronics can be found in the library. 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.

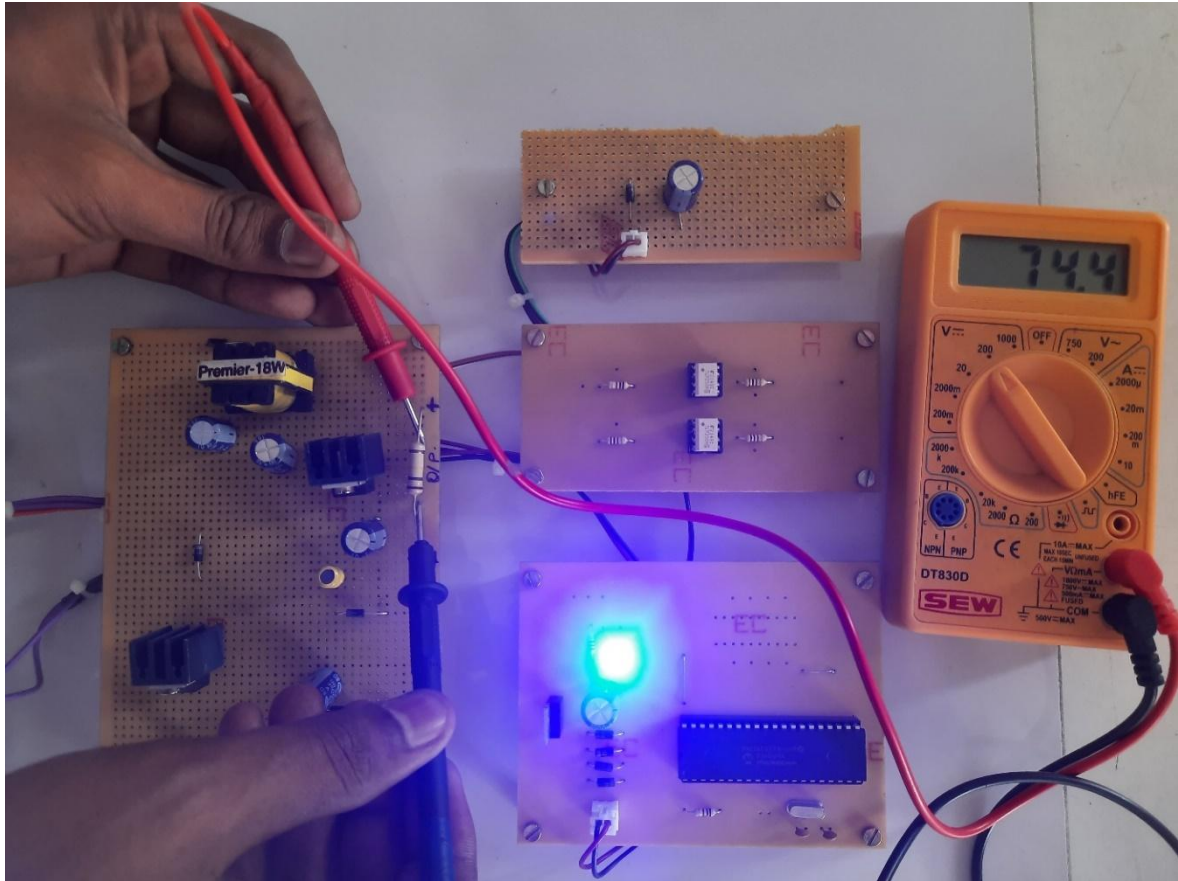


5.2.5 MATLAB Library

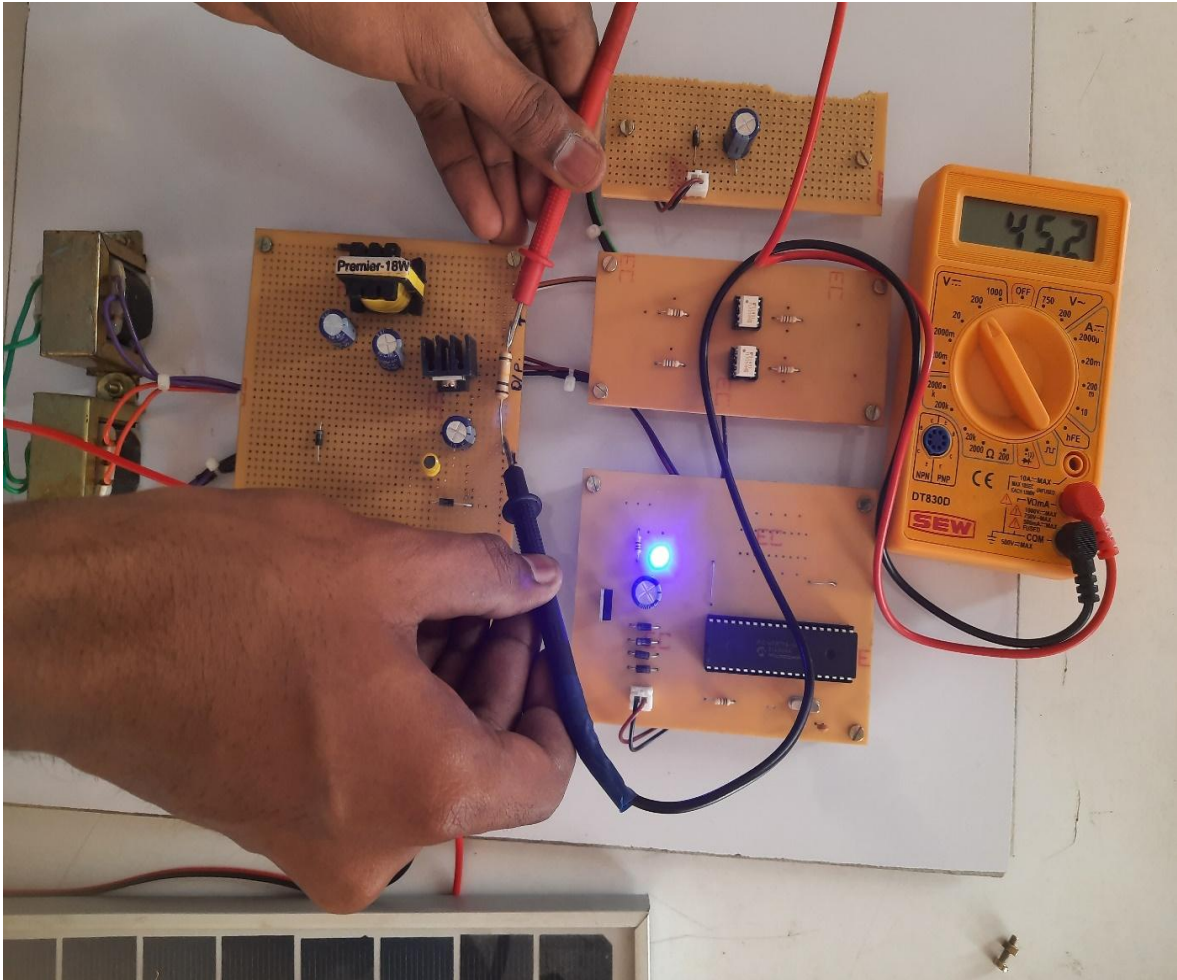
American utility located in Canada, and also on the experience of EcoLeDe Technologies superior and University Laval. The capabilities of Sim Power Systems for modeling a typical electrical system are illustrated in demonstration files. Self-learning case studies are

also available for those who want to brush up on their understanding of power system theory. The core library of Sim Power Systems, power lib, arranges its blocks into libraries based on their functionality. The block library icons and names are displayed in the power lib library window. To open the library and access the blocks, double-click a library icon. 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.

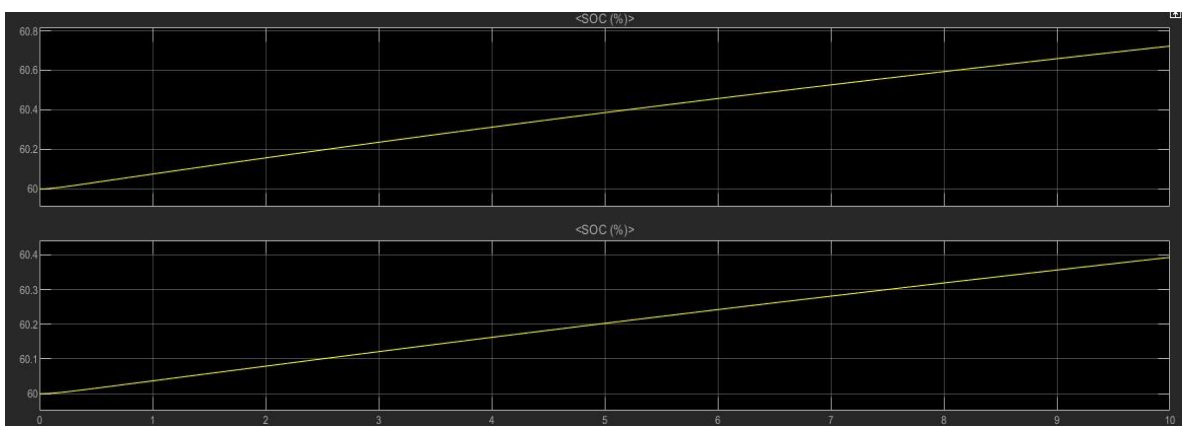
AC OUTPUT:



AC AND SOLAR OUTPUT:



SOC:



SOLAR OUTPUT:



CHAPTER 6

CONCLUSION

In this project, a novel HPV-EVB technology for the integration of the residential HPV and EV has been proposed. The power balance between the HPV source, EVB energy, the home load, and grid demands is successfully managed by the energy management system. This will help to mitigate the intermittency and uncertainty effects of the HPV and to provide a reliable power output. It is envisaged that the proposed system with its control algorithm will have a great potential for the future smart grid and EV applications. In this paper, it is considered that the home has two cars, and one is rarely used except for a short travel, which is quite common in most developed countries. For future work, the authors will investigate the proposed algorithm under a more complex network and during grid faults.

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