DEVELOPMENT AND IMPLEMENTATION OF A HYBRID MODEL FOR REDUCING ELECTRICAL POWER CONSUMPTION AND COST

By

MD. SHAZZAD HASAN

MD. ABDULLAH AL MASUM

MOHD. EHSANUL HOQUE

BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONIC ENGINEERING

Department of Electrical and Electronic Engineering
INTERNATIONAL ISLAMIC UNIVERSITY CHITTAGONG

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CERTIFICATE OF APPROVAL

The thesis/project entitled as "**Development and Implementation of a hybrid model for reducing electrical power consumption and cost**" submitted by **Md. Shazzad Hasan** (Metric ID. **ET151003)**, **Md. Abdullah Al Masum** (Metric ID. **ET151004)** and **Mohd. Ehsanul Haque** (Metric ID. **ET143052R)** of the Department of Electrical and Electronic Engineering, International Islamic University Chittagong, has been accepted as satisfactory in partial fulfilment of the requirements for the degree of Bachelor of Science in Engineering and approved for the examination held on **24 December, 2021**.

Supervisor
Engr. Mohammad Faisal
Assistant Professor,
Department of Electrical and Electronic Engineering
International Islamic University Chittagong.

DECLARATION OF CANDIDATES

We hereby pronounce that, in this project, except some specific references, all the information, knowledge and equipment's are used by following the academic rules and ethical code and conduct which includes collection, process and present. We are announcing and promising about not sharing about any portion of this research for any other qualification of this University or institute as well as others.

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Name of Student 1

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Name of Student 2

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Name of Student 3

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ABSTRACT

Renewable energy is the most valuable term in the modern world. Every year so much fuel is wasted in power generation. Energy resources are reducing massively. The most important fact is that we are fully dependent on fuels. Between 1971 and 2019 world total energy supply (TES) increased 2.6 times (from 230 EJ to 606 EJ) and its structure changed markedly. Oil fell from 44% to 31% of TES between 1971 and 2010; its share has held steady since then and it remains the most important fuel in 2019. The aim of our project is the development of a hybrid model that utilizes renewable energy for residential usage that synchronizes and switches with the supply grid depending on load demand. Our model is designed to work like a hybrid system where solar energy will be used during the daytime and the stored battery-powered energy will be used during the blackout. The method that is involved in our project is the effective coordination of converters for synchronization and switching of the connected energy sources. The addition of a storage element ensures uninterrupted power supply to meet the load demand in times of blackout or solar energy unavailability. We are promising such a solution that will help us to reach the desired destination of reducing utility electrical power consumption and cost. The proposed system will be proved beneficial to the nation's current grid infrastructure as the generation and consumption of energy is seemingly out of balance and it gives rise to the problem of cost of electricity. The developed model will be a feasible solution to the problems at hand.

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CHAPTER 1

INTRODCUTION

1.1 Introduction

The sun produces a large amount of energy to supply the requests of the entire total populace, and, dissimilar to petroleum derivatives, it isn't relied upon to run out very soon. It is difficult to transmit ozone harming substance discharges into the climate when power is created utilizing sunlight-based charger frameworks. Since solar energy is a sustainable wellspring of energy, the main requirement to its utilization is our ability to change over daylight into power in a practical and productive way. Usually, solar energy has many advantages than fossil-based coal and oil due to reduce carbon emissions, clean the air, and can generate again within our lifetimes [1]. Since the sun creates substantially more energy than people will at any point require, power produced by solar energy is an extremely fundamental wellspring of energy in the progress to clean energy creation. When contrasted with different wellsprings of energy creation, the working costs of solar chargers are very modest later they have been introduced. Since no fuel is required, solar energy might produce tremendous amounts of power without the vulnerability and cost of getting a solid fuel supply. Solar energy is turning out to be more feasible.

Environmentally friendly power is energy that is gotten from sustainable assets that are recharged normally on a human timescale, for example, carbon-nonpartisan sources like daylight, wind, downpour, tides, waves, and geothermal hotness. Environmentally friendly power is energy that is gotten from sustainable assets that are recharged normally on a human timescale. According to the sustainable future scenario of the International Energy Agency, by renewable energy resources, 57% of world electricity supply will be provided by 2025 [2].

Hybrid inverter (sometimes referred to as a multi-mode inverter) is an all-in-one solution that contains three totally different functions. It has an integrated solar charge controller that connects to the solar panel(s) and serves to regulate the voltage from the output of the solar panel to the loads and/or batteries.

As of late, worldwide energy utilization has expanded significantly, with arising countries representing the huge main part of the development. In 2014, the total global primary energy consumption was about 160310 million MWh, and this value had been projected to be increased to 240318 million MWh in 2040[3].

Despite the fact that sustainable power represents scarcely 3% of complete energy in Bangladesh, the nation has effectively contrived a ground breaking strategy for the environmentally friendly power area[4]. Currently, there are 111 working power plants in Bangladesh. The grid capacity is 15, 821 MW and per capita electricity generation is as low as 433 kWh. However, the current demand (12644 MW) is so high and alarmingly, the demand from both industries and households is constantly increasing day by day [5]. A decrease in the present and future basic energy emergency situation is conceivable with the mix of sustainable power sources into the power producing process. To accomplish its present sustainable power level headed, the Bangladeshi government is constraining the specialization of sustainable power creating financial plans. The point is to lessen worldwide contamination through the utilization of biomass, sun oriented, hydro, wind, and flowing power. The electricity for all citizens of Bangladesh by 2021 will confirm the government's plan by IDCOL. The company is a Bangladeshi government establishment owned by a non-banking financial institute that financed the installation of 4.13 million SHS (Solar home system) in rural areas in 2019[6]. As per this review, the more prominent probability of sustainable power assets is likewise analyzed and presented in this examination, also.

1.2 Motivation

33% of Bangladesh's power usage is dependent on exorbitant imported petroleum derivative energy sources, while 65% depends on the country's flammable gas saves, which are relied upon to be depleted eventually soon [7]. Although Bangladesh's introduced electrical producing limit has expanded quickly to 13265 MW, this is lacking to satisfy the country's energy interest, as per the World Bank [8]. Besides that, the country's de-industrialization has been exacerbated by an absence of satisfactory electrical result. Our proposed model will provide a viable solution of the energy consumption issue and cut down on overall cost.

1.3 Research problems

Bangladesh's overall power generation has fallen to 40% in 2019-2020 down from 43% in the prior years due to excess energy consumption. This excessive consumption is putting a strain on the balance of country's current energy distribution.

Cost of grid energy is increasing due to installation and maintenance of country's grid infrastructure. In lieu of the current GDP of the country, the increased cost of electricity is a major issue for its citizens.

1.4 Objectives

The objectives of this research are

i) To develop a model for grid connected energy storage system integrated with renewable energy sources.

ii) To implement the proposed model to reduce electrical energy consumption and cost.

1.5 Organization of the report

Six chapters are covered in the course of design and development of this project. The chapters and their contents are as follows:

Chapter one is the introductory chapter. The background, research problems, objectives, motivations are described in this chapter. This chapter gives the brief idea of the problems and motivations that led to the conduction of this research.

Next chapter is titled Literature review. All previous work related to this project are discussed in this chapter. In this chapter the reference material that have been used in the project and the corresponding researches have been briefed in detail.

In the next chapter, descriptions about the hardware used in the project is discussed. All the main components used in this project are described elaborately.

The next chapter deals with system design of the project. In this chapter block diagram, flow chart, circuit description is elaborately described.

Chapter five describes about the system implementation and results. The graphical and numerical result of the project is explained in brief.

The next and final chapter discusses about the conclusion, advantage, limitations and future work of this system.

1.6 Summary

The background, obstacles and motivations leading to the conduction of the research has been explained elaborately in this chapter. For the readers, this chapter works as the gist of the project that we have done.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter the discussion of the previous works based on hybrid inverters are provided. The review gives the reader insight about the vital background to better comprehend the research by referring to the investigations and findings of past researchers and documents the researcher's knowledge and planning the problem.

2.2 Review of previous works

Some previous works related to hybrid inverter models in different ways are given below.

2.2.1 80 kW hybrid solar inverter for standalone and grid connected applications

In 2012, Luis Amedon chipped away at a cross breed sun-oriented inverter with a result of 80 kW that could be utilized both unsupported and, in a matrix, associated application. During independent activity, the proposed framework is equipped for providing constant ability to key burdens while likewise progressing flawlessly between independent and matrix associated modes, guaranteeing supply security. In this review, the production of a sun oriented photovoltaic creating framework dependent on a customary power hardware cell for use in microgrid applications is the essential objective. Depiction of the equipment, recommended control procedures, and framework recreation models are completely remembered for this work. At the point when the age and burden request are erratic, a cutting-edge lithium-particle battery with a limit of 20 kWh is used to adjust the power stream in the framework, lessening the effect of this change [9].

Fig 2.2.1 shows the systematic diagram of the model.

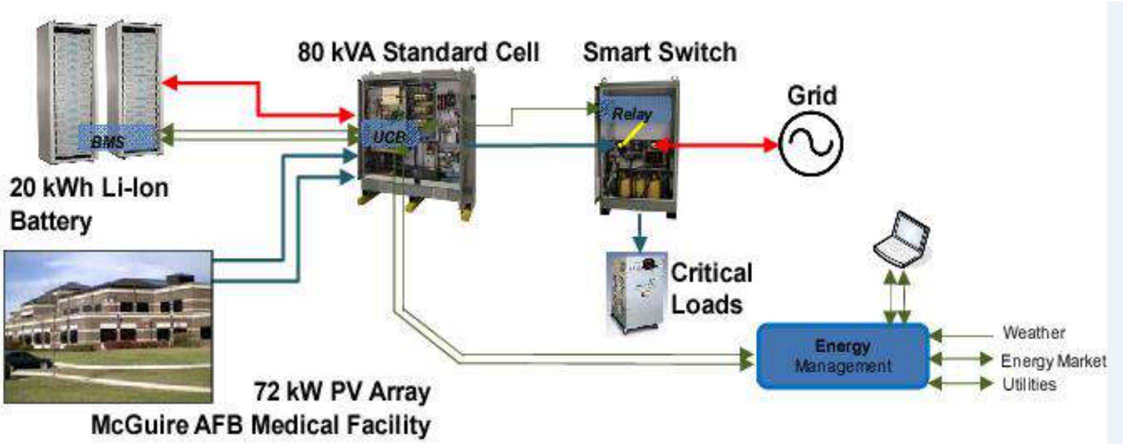

Fig 2.2.1: 80 kW hybrid solar inverter for standalone and grid connected applications [9]

2.2.2 Novel single-stage solar inverter using hybrid active filter

In 2014, Mariappan delivered a paper on A special single-stage sun-oriented converter using a half and half dynamic channel to build power quality, which depended on his examination. With framework taking care of inverters, one of the difficulties is the interest for a high DC-connect voltage, which might be testing. Network associated photovoltaic (PV) frameworks with power electronic interfaces are turning out to be more well-known because of the way that they don't add to contamination of the climate. A solitary power stage, with a dc interface voltage that is more modest than the pinnacle line-line voltage, is utilized in the inverter, which assists with diminishing power misfortunes and circuit intricacy by improving on the circuit [10].

Figure 2.2.2 shows the systematic diagram.

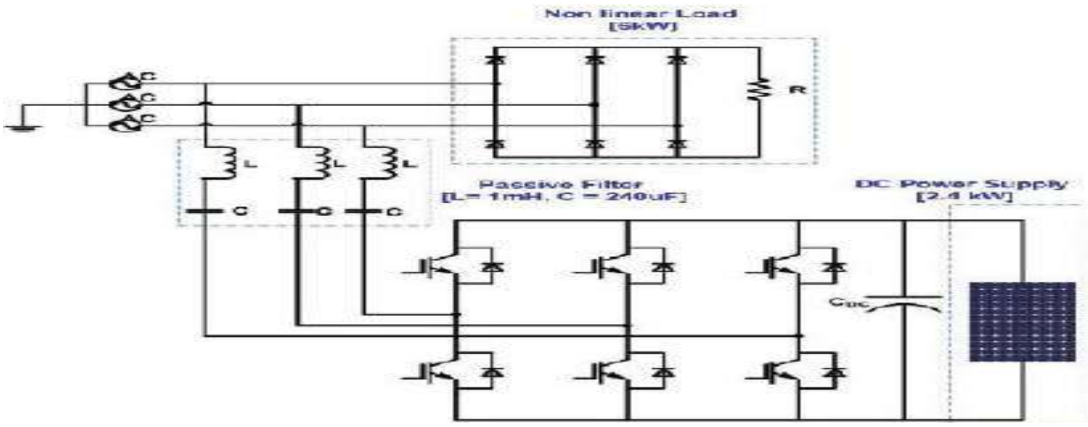

Fig 2.2.2: Novel single-stage solar inverter using hybrid active filter [10]

2.2.3 Hybrid isolated generating system based on PV fed inverter-assisted wind-driven induction Generators

Craig R Bush delivered a review on sun-oriented inverters in 2021, which should be visible here. A solitary stage current-source sun-oriented converter with a DC association of diminished size is displayed here. Coming up next are the remarkable elements of the proposed geography in contrast with existing PV inverter innovation: a) the low recurrence (twofold of line recurrence) swell that is normal to single-stage inverters has been killed; b) the shortfall of low recurrence swell permits fundamentally decreased size detached parts to accomplish vital firmness; and c) further developed greatest power guide following execution is effortlessly accomplished due toward the fixed current wave even with r = 0. An imaginative current source converter design is introduced in this work, which is chiefly focused on single-stage photovoltaic (PV) applications.

S.A. Daniel shared his contemplations on PV inverters in 2019. Sustainable power frameworks dependent on crossover wind-sun based sources are accepted to be more feasible and reliable than wind-diesel frameworks when contrasted with different types of environmentally friendly power [11].

Fig 2.2.3 shows the schematic diagram of the proposed generating system

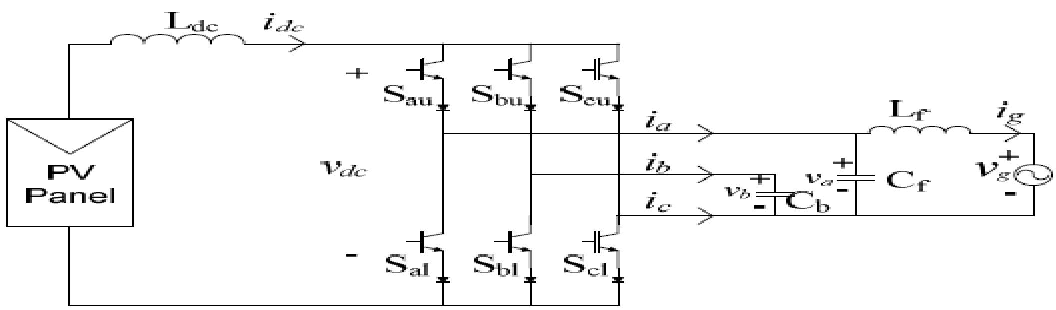

Fig 2.2.3: Schematic diagram of Hybrid isolated generating system based on PV fed inverter-assisted wind-driven induction Generators [11]

2.2.4 A novel grid-tied, solar powered residential home with plug-in hybrid electric vehicle (PHEV) loads

The design and analyses of a grid-connected residential photovoltaic (PV) system containing a plug-in hybrid electric vehicle (PHEV) load is presented in this paper. In this system, PV arrays and battery packs are cascaded to supply power to the load.

Solar energy is harvested by PV arrays, the terminal voltage of PV arrays is regulated by a DC/DC converter to track maximum power point (MPPT) using the incremental conductance method. Battery packs work as the energy storage system and the current controlled bi-directional DC/DC converter regulates the power flow between grid and battery. The interfaced inverter is also a bidirectional inverter [12].

Fig 2.2.4 shows the schematic diagram of the system.

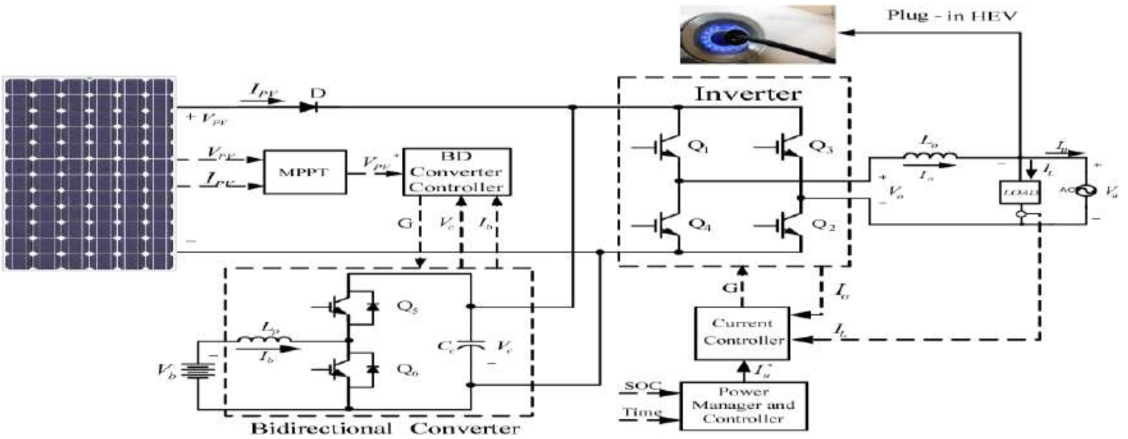

Fig 2.2.4: Schematic Diagram of a novel grid-tied, solar powered residential home with plug-in hybrid electric vehicle (PHEV) loads [12].

2.2.5 An Off-Grid Solar System for Rural Village in Malaysia

This article aims to discuss the sustainability of a stand-alone AC Bus Configuration solar system for a rural village in the state of Sarawak, East Malaysia, based through a community-based project. The project was implemented via installation of photovoltaic system to supply electricity to the rural village. Different coupling configurations are shown in this paper. Actual load profile for four consecutive days and average monthly solar irradiation is studied. Analysis of the daily consumption is shown between the PWD center, church and housing infrastructure. Average monthly solar radiation is also shown here, with the daily load profile discussed. The project has brought certain benefits for the local villagers such as free electricity. Further studies on the load growth are needed to ensure system sustainability [13].

Fig 2.2.5 shows the block diagram of the model

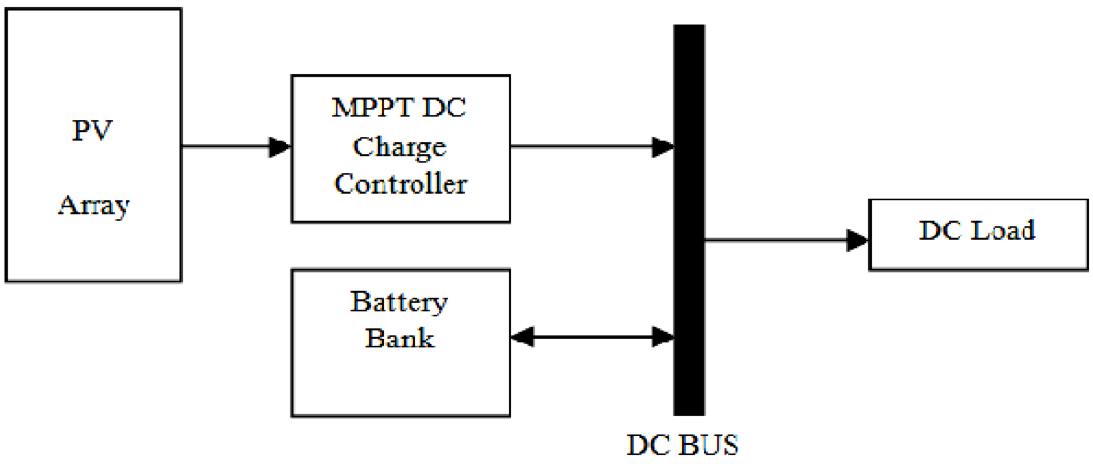

Fig 2.2.5: Block Diagram of An Off-Grid Solar System for Rural Village in Malaysia [13].

2.3 Summary

The description, summary and evaluation of the previously done researches on hybrid models are well described in this chapter. For a compact assessment of the novelty of a research, literature review is immensely useful.

CHAPTER 3

HARDWARE DESCRIPTION

3.1 Introduction

In this chapter, we are going to relate the components used for this system. The main major fact in a project is the hardware. Selecting the required hardware is also not an easy task. Here is also a discussion about the function of the chosen hardware and their parts. The reason behind choosing the used components and also their function of this project will be understood by the end of this chapter.

3.2 Component list

In this project, we have used several converters to ensure an effective coordination of the system. We use AC to DC converters to convert the grid supply to our desired DC supply, Schottkey diode to ensure effective switching, LM7805 voltage regulator for effective voltage regulation, 16X2 LCD for showing system status etc.

The list of components is given below.

- AC to DC converter,
- LM 2576 DC-DC converter,
- 100mH inductor
- Schottky diode 1N 5822
- Switching transistor TIP,
- PIC 16F703,
- 16 MHz Crystal oscillator
- Lcd 16x2
- Variable resistor 5K
- 7805 regulator Diode IN 4007
- CTB 34 (Schottky diode)
- TL494 PWM generator

- C4145 MOSFET
- DG4N60 MOSFET
- 12V-7.5A Lead-Acid Battery
- 20W Solar Panel

All of them have now been described in detail below.

3.3 AC-DC converter

The electrical circuits that transform alternating current (AC) input into direct current (DC) output are known as AC-DC converters. They are used in power electronic applications where the power input a 50 Hz or 60 Hz sine-wave AC voltage that requires power conversion for a DC output.

Fig 3.1 shows an AC-DC converter module.

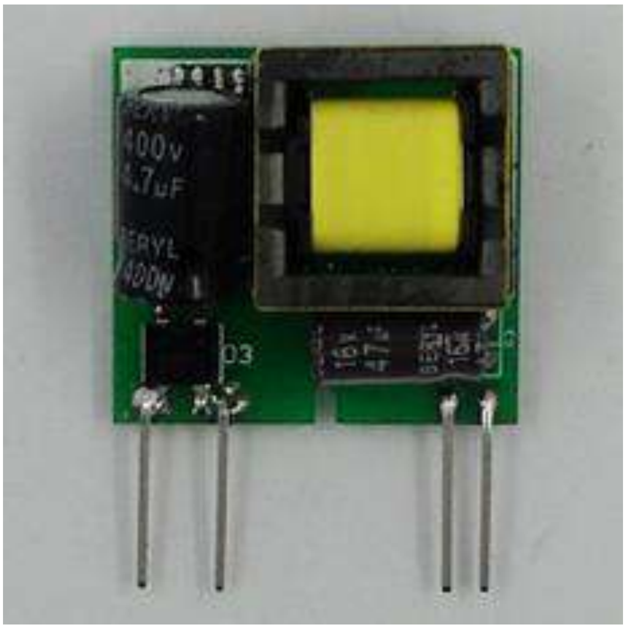

Fig 3.1: AC to DC converter. Input voltage:AC85~265V 50/60HZ or DC100v-370v [14]

AC-DC converters have an output voltage of 12V DC (±0.1V) and output current of 400mA. Its power rating is 5W and the printed circuit boards dimension is 3*2*1.8cm [14].

3.4 LM2576 DC-DC converter

LM2576 series of regulators are monolithic integrated circuits that provide all the active functions for a step-down (buck) switching regulator, capable of driving 3-A load with excellent line and load regulation. Fig 3.2 shows an LM2576 DC-DC converter.

Fig 3.2: LM 2576 DC -DC converter [15]

Output voltage for fixed voltage regulator is: 3.3V, 5V, 12V or 15V and the maximum input voltage is 40V. The output current is rated 3A. Some of the other features of LM2576 are the in-built thermal Shutdown and current limit protection. It is available in TO-220 and TO-263 packages. The output voltage for variable type regulator is 1.23V to 37V. The internal Oscillator frequency is fixed at 52-kHz [15].

3.5 100 mH Inductor

This is a multifunctional product, which can be used for various household appliances, meters, instruments and equipment. The inductor has a large number of small sizes, and the base with high power. Generally used as an energy saving device for linear motion and high performance [16]. Fig 3.3 is shown a 100 mH inductor.

Fig 3.3: 100mH inductor [16]

This inductor contains high frequency ferrite and has a comparatively large rated current. Some of its applications include usage in TV, Power supplies, Computers, PC peripherals, telephones, electronic toys and games.

3.6 Schottky diode

A Schottky diode (also known as the hot-carrier diode or Schottky barrier diode) is a semiconductor diode formed by the junction of a semiconductor with a metal. Schottky diodes have a low forward voltage_drop (0.15 to 0.45 V) and a very fast switching action [17].

Just like a regular diode, a Schottky diode will conduct a current in the forward direction when sufficient forward voltage is applied.

Fig 3.4 shows a Schottky diode.

Fig 3.4: Schottky diode [17]

The most prominent physical parameter of this diode is their fast-switching rate and less forward voltage drop. It is a metal-semiconductor junction that does not have the capacity to store charges at their junctions.

The Schottky diode (named after the German physicist Walter H. Schottky), also known as Schottky barrier diode or hot-carrier diode, is a semiconductor diode formed by the junction of a semiconductor with a metal. It has a low forward voltage drop and a very fast switching action.

3.7 Switching transistor TIP217

Transistor switches are circuit-building blocks; they're used to make logic gates.Fig 3.5 shows a switching transistor.

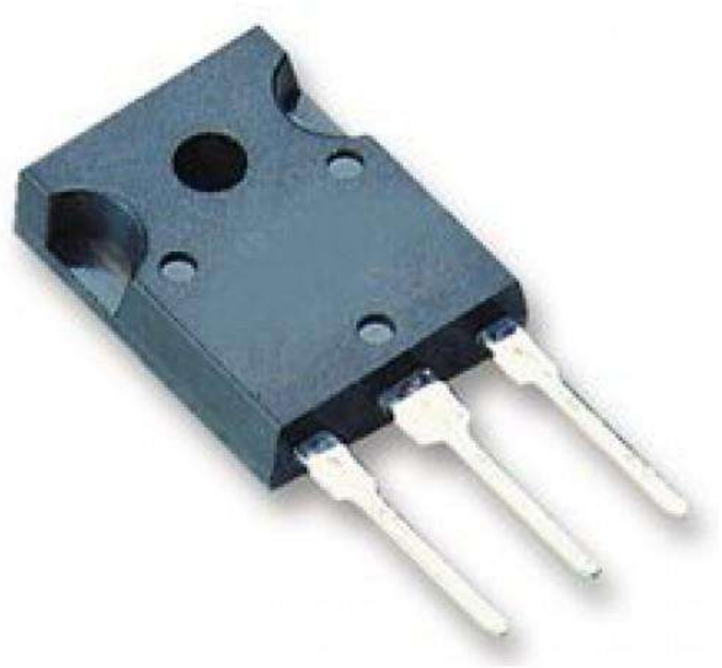

Fig 3.5: Switching transistor TIP217 [18].

The TIP127 is a silicon PNP Darlington transistor in a TO−220 type package designed for general purpose amplifier and low−speed switching applications. It has a high DC current gain of 25009(Typ) at Ic=4 A. The Collector−Emitter Sustaining Voltage: VCEO (sus) = 100V (Min) at IC = 100mA and the Emitter Saturation Voltage: VCE(sat) = 2.0V (Max) at IC = 3A [18].

3.8 PIC16F73 controller

Micro processor's solid PIC engineering is pressed into a 28-pin bundle, making it both strong (200 millisecond guidance execution) and clear to program (only 35 single word directions). It is upwardly viable with the PIC16C5X, PIC12CXXX and PIC16C7X gadgets, just as with the PIC16C5X. Offbeat sequential port that can be designed as either a 3-wire Serial Peripheral Interface (SPITM) or a 2-wire Inter-Integrated Circuit (I2CTM) transport just as a Universal Asynchronous Receiver Transmitter are completely remembered for the PIC16F73. The PIC16F73 likewise incorporates two extra clocks, two catch/look at/PWM capacities, and a Universal Asynchronous Receiver Transmitter (USART). These qualities make it especially appropriate for more elevated level A/D applications in the auto, modern, apparatuses, and shopper markets, among different regions [19].

Fig 3.6 and 3.6.1 shows a PIC16F73 microcontroller unit and its pinout arrangement.

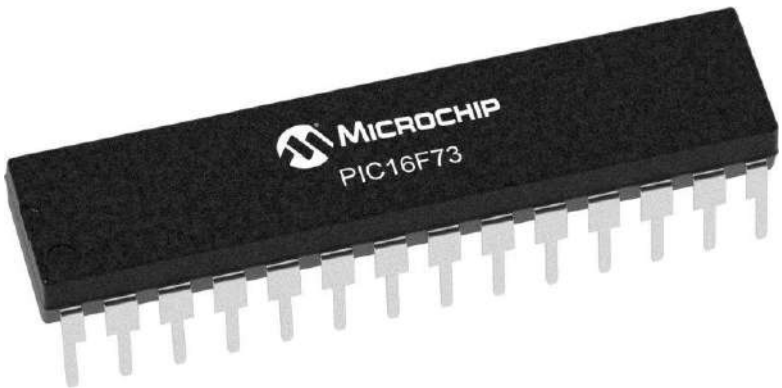

Fig 3.6: PIC16F73[19]

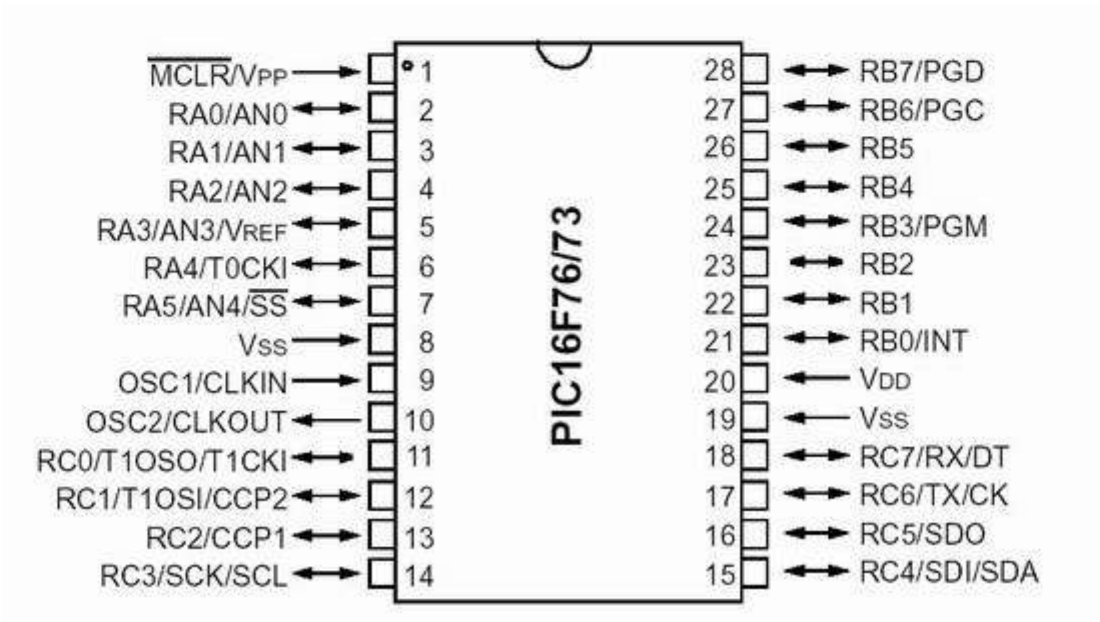

Fig 3.6.1: Pic controller pinout [19]

3.9 16 mHz Crystal Oscillator

One of the most important features of any oscillator is its frequency stability, or in other words its ability to provide a constant frequency output under varying load conditions[15].

Fig 3.7 represents a 16 mHz Crystal Oscillator.

Fig 3.7:16 mHz Crystal oscillator [20]

Table 3.1: Crystal Oscilloscope specifications

Specification	Value
Type	Crystal
Frequency	16 MHz
Tolerance	50 ppm
Power Max	5 mW

3.10 16x2 LCD

The end result of our venture was displayed on a 16x2 LCD. There are two lines and sixteen segments in this table. This permits us to just run two string lines on it as an outcome. We used a 16x2 LCD to show the area of a wire issue deep down. By far most of our estimations are introduced in this module, with only a couple of result capacities showed in drove units on the opposite side of the screen. A 16x2 LCD is found in the figure beneath [21].

LCD display module with Blue Back light has a size of 20X4 (2 Rows and 16 Characters Per Row).

Fig 3.8 shows a 16x2 LCD unit.

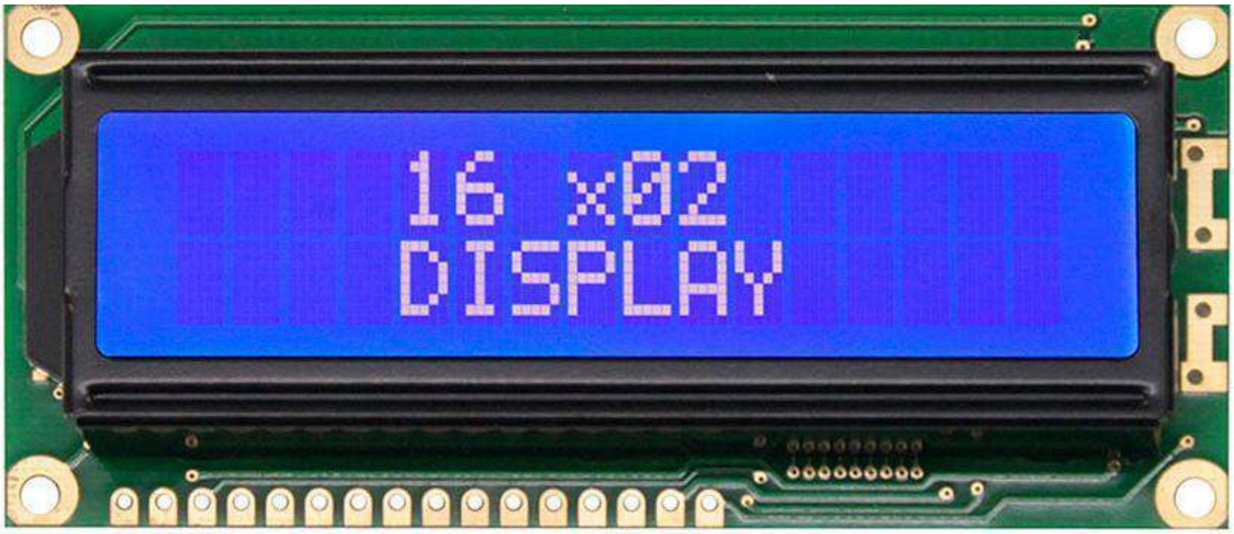

Fig 3.8: 16x2 LCD module.[21]

3.11 Variable resistor

A variable resistor can be used mainly in two different ways. When one end of resistance track and wiper terminal is connected with circuit then current through the resistor limits according to the position of the wiper contact on the resistance track. As the wiper contact slides away from the connected end of the resistance track, the resistive value of the resistor increases and current goes down through the circuit. That means the variable resistor behaves like a rheostat. In this case the two ends of resistance track are connected with a voltage source. Hence voltage drop across the resistance track is equal to the value of voltage source [22]. Fig 3.9 shows a unit.

Fig 3.9: Variable Resistor [22]

3.12 LM7805 voltage regulator

The LM7805 is a voltage regulator that outputs +5 volts. Like most other regulators in the market, it is a three-pin IC; input pin for accepting incoming DC voltage, ground pin for establishing ground for the regulator, and output pin that supplies the positive

5volts. It has 3-Terminal Regulators. And its Output Current is up to 1.5A. It has Internal Thermal-Overload Protection and High Power-Dissipation Capability [23].

Fig 3.10 shows an LM7805 voltage regulator IC.

Fig 3.10: LM7805 IC [23]

3.13 Solar panel (12v/20w)

A solar cell panel, solar electric panel, photo-voltaic (PV) module or just solar panel is an assembly of photo-voltaic cells mounted in a framework for installation. Solar panels use sunlight as a source of energy to generate direct current electricity. A collection of PV modules is called a PV panel, and a system of PV panels is called an array. It has a maximum power rating of 20W. It’s voltage at maximum power is 18 V and current at maximum power is 1.04 A The rating for Open Circuit voltage is 21.78 V and Short Circuit current is 1.15 A [24].

In Fig 3.11 a Solar panel is shown.

Fig 3.11: Solar panel (20w) [24]

3.14 Diode 1N4007

The 1N4007 belongs to a sort of 1 A general-purpose silicon rectifier diode, commonly used in AC adapters for common household appliances. It is fairly low-speed rectifier diode, being inefficient for square waves of more than 15 kHz. The 1N4007 diode is a standard recovery rectifier with a molded plastic case. The maximum current carrying capacity is 1A and it withstands peak up to 30A. So, we can use this diode in circuits that are designed for less than 1A. The reverse current is 5uA which is negligible but it can withstand reverse voltage peak up to 1000V [25].

Figure 3.12 shows a Diode 1N4007

Fig 3.12: Diode 1N4007 [25]

According to its datasheet**,** 1N4007 diode specs list as following: Reverse Voltage, 1000 V Forward Current, 1 A, Standard Recovery Rectifiers Configuration; Single Forward Voltage, 1 ,Max Surge Current, 30 A Reverse Current, 5 uA, Minimum Operating Temperature, – 65 C, Maximum Operating Temperature, + 150 C.

3.15 TL494 PWM Generator

The TL494 device incorporates all the functions required in the construction of a pulse-width modulation (PWM) control circuit on a single chip. Designed primarily for power-supply control, this device offers the flexibility to tailor the power-supply control circuitry to a specific application. n-chip adjustable oscillator, a dead-time control (DTC) comparator, a pulse-steering control flip-flop, a 5-V, 5%-precision regulator, and output-control circuits. The error amplifiers exhibit a common-mode voltage range from –0.3 V to VCC – 2 V. The dead-time control comparator has a fixed offset that provides approximately 5% dead time. The on-chip oscillator can be bypassed by terminating RT to the reference output and providing a sawtooth input to CT, or it can drive the common circuits in synchronous multiple-rail power supplies. The uncommitted output transistors provide either common-emitter or emitter-follower output capability. The TL494 device provides for push-pull or single ended output operation, which can be selected through the output-control function. The architecture of this device prohibits the possibility of either output being pulsed twice during push-pull operation [26]. Fig 3.13 shows a TL494 PWM Generator.

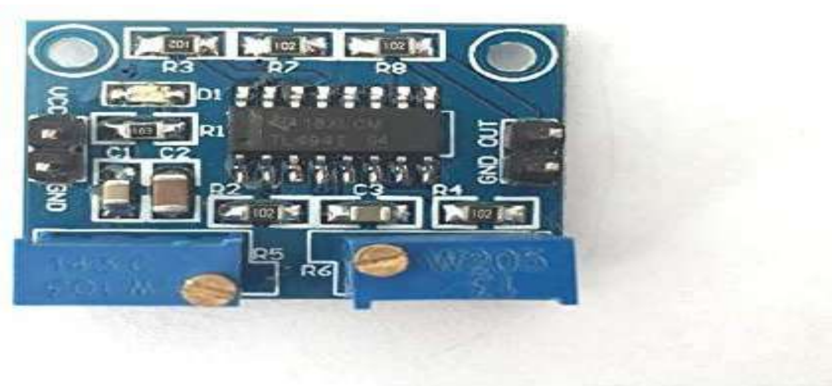

Fig 3.13: TL494 PWM Generator [26]

3.16 DG4n60 MOSFET

G4N6 0 is an N-channel enhancement mode MOSFET, which is produced using Micro-electronics.

The self-aligned planar process and improved terminal technology reduce the conduct ion loss, improve switching performance and enhance the avalanche energy. The transistor can be used in various power switching circuit for higher efficiency and system miniaturization [27].

Fig 3.14 shows a DG4n60 MOSFET.

Fig 3.14: DG4n60 MOSFET [27]

3.17 Lead Acid battery (12V-7.5A)

Alpha power maintenance-free sealed lead-acid battery represents a 12V 7.5AH power supply, 13.5 - 13.8V standby use, 14.4 - 15.0V cycle use, < 2.1A initial current and 150 x 67 x 100mm dimensions. The total weight of this battery is 2Kg and made in Taiwan [28].

Fig 3.15 shows a Lead Acid battery (12V-7.5A).

Fig 3.15: Lead Acid battery **(**12V-7.5A) [28]

3.3 Summary

In this chapter, the necessary components required for the construction of the project has been explained carefully. The component's features, physical parameters, pinout, applications etc have been explained in brief. This chapter provides a complete overview of the components that we have used in building this project.

CHAPTER 4

METHODOLOGY

4.1 Introduction

In this chapter the project's structure, circuit diagram, flow-chart, block diagram, and other operational details are explained in brief. It describes the main key features of the system and the methodology to develop the prototype.

4.2 Project workflow

Hybrid inverter work as a multiple source inverter system. It takes power from three source: solar power source, battery power source and PDB (Power development Board) provided power sources.

Now our hybrid inverter can be operated into four modes. During day light we can set the PBD plus solar mode. So that PDB provided power combines with the solar power and generate a hybrid power to the sources. We can set them solar only mode. By this our system will take power only from solar panel.

During Night time only PDB provided power source will work. We have an alternative battery storage system used, in case of power losses. So that’s the fourth power source mode. If solar power battery power does not work then battery used power will work.

4.3 Project Block Diagram

This is a PIC based hybrid inverter system. As a result, the controller is used to link all of the components. The output was shown on a 16x2 LCD display, and system data such as power unit, inverter unit are connected through the switching unit. The block diagram of the system incorporates all the operations of the project at different conditions.

Fig 4.1 shows the block diagram of the proposed model.

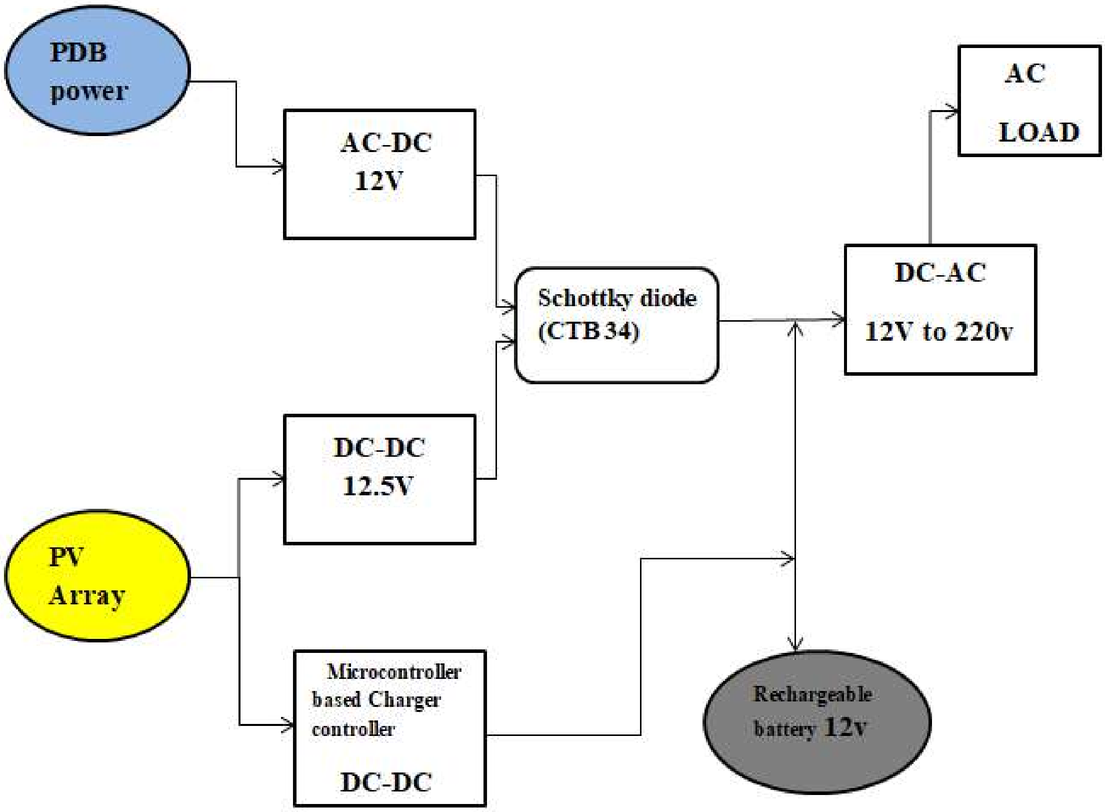

Fig 4.1: System block diagram.

4.4 Circuit Diagram

This framework schematic was made with the assistance of the express pcb online plan program. It is an online circuit configuration, circuit test system, and printed circuit board (PCB) plan program that works altogether inside our program. One of the objectives of this device is to monitor both electrical association and the plan objective.

The result of the schematic apparatus is a netlist, which will be brought into a PCB instrument, which might be equivalent to the schematic device. This sort of framework might incorporate printed circuit sheets (PCBs), just as coordinated circuits (ICs) (ICs). When utilized as an executable, a schematic catch instrument, for instance, will regularly work as its own program.

Fig 4.2 depicts the Circuit diagram of the system.

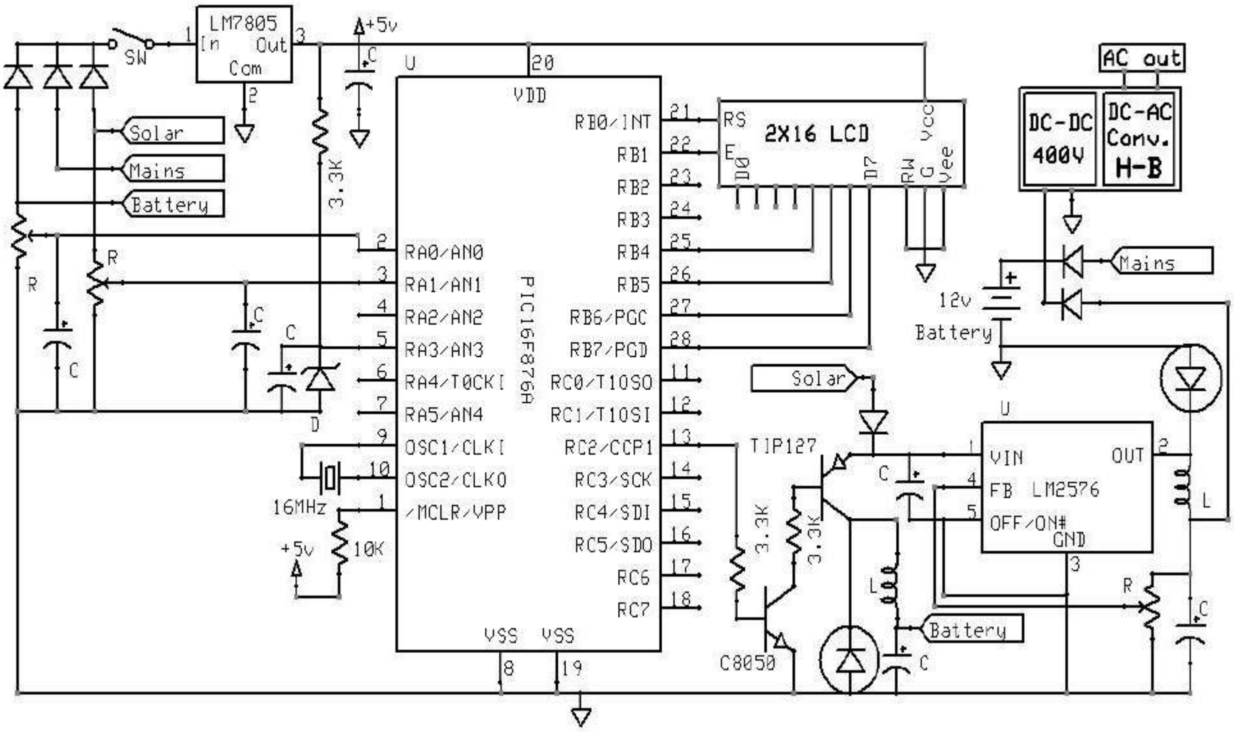

Fig 4.2: Circuit diagram.

4.5 System Architecture

The system architecture segment represents the effective co-ordination of the components used in order to develop the system.

Fig 4.3 shows the system architecture.

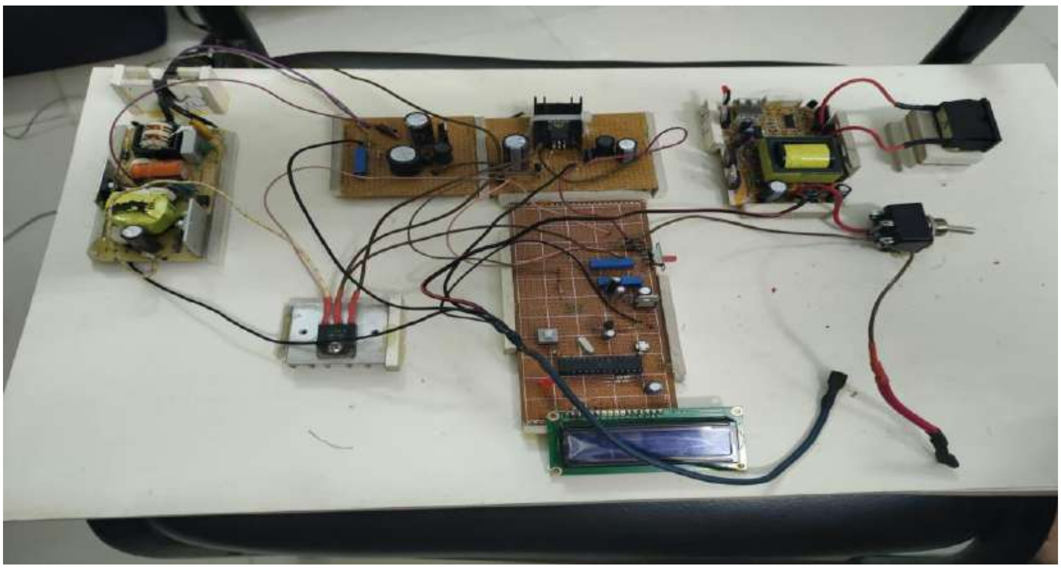

Fig 4.3: System architecture

4.6 Algorithm of the charging arrangement

One of the major concerns of the project is the charging arrangement of the battery. For ensuring the effective shift of energy from the sources to the battery, we have used a microcontroller unit (PIC16F73), in the system. The algorithm of the charging arrangement and the corresponding operations have been explained in detail below.

The system is designed to always draw power from solar input depending on load demand. The excess energy from the solar input will be sent to battery unit, which in case of solar unavailability and/or blackout situation, can be used to meet the load demand.

After the commencement of operation, the system gets supply from solar input and operates the load, but in case of solar power shortage it draws the remaining energy from grid input. The switching operation is done by the Schottky diode, which generates the system logic for power switching.

If the load demand is greater than the solar power supply, the system turns to PDB for continuing uninterrupted supply. Thus, the pressure on PDB alone is reduced and solar energy is effectively used.

If the load demand is less than the solar power input, then the remaining power is directed towards the storage unit. The PIC unit is programmed to turn the charging mode on if the battery's voltage level drops down below 11.5V. It stops the charging operation when battery reaches it's programmed value of 11.5V. Refer to the Appendix (mentioned later in the report) for the program incorporated with the charging arrangement.

Fig 4.4 shows the Algorithm of the charging arrangement.

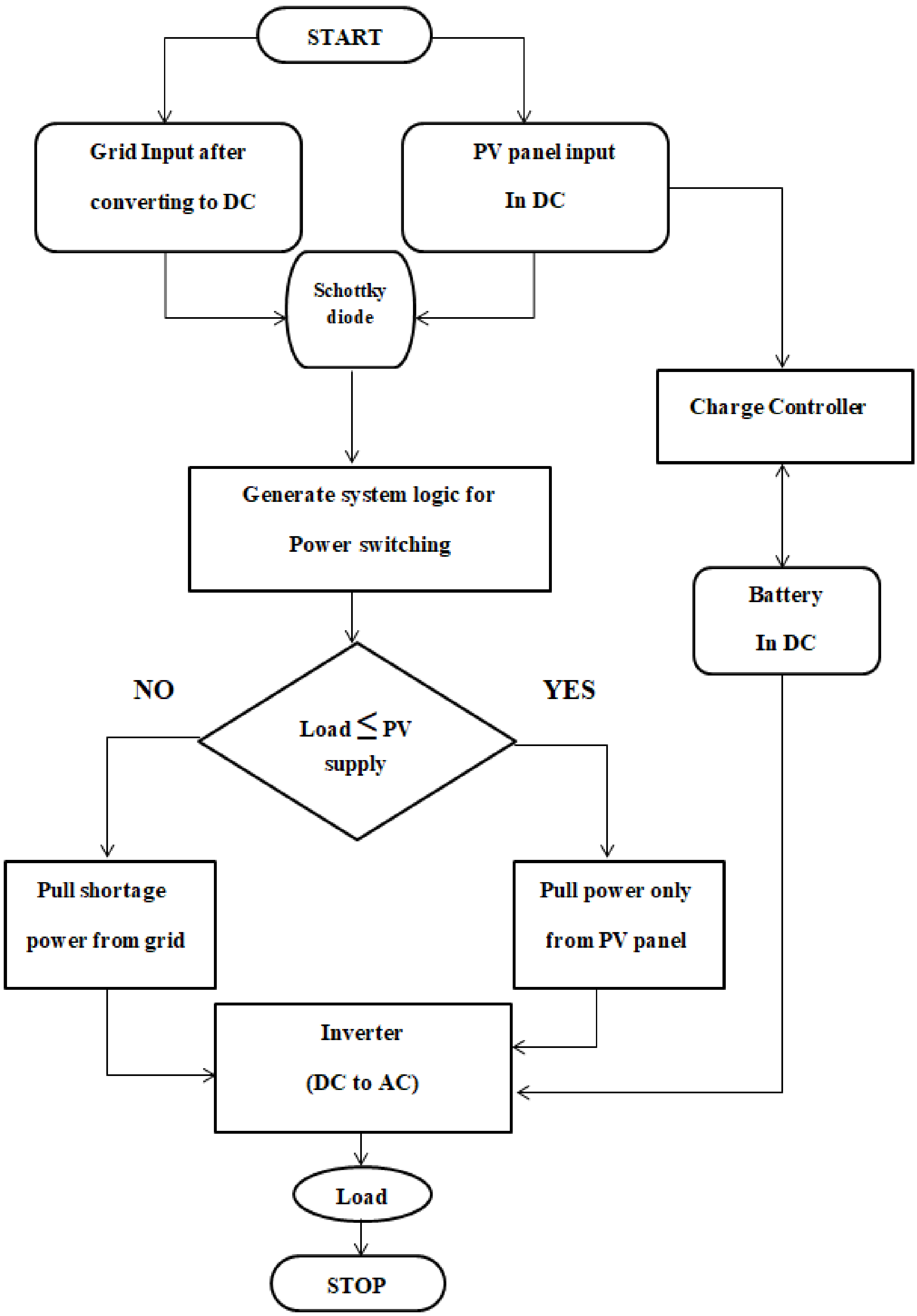

Fig 4.4: Algorithm of the charging arrangement of the system.

4.7 Summary

This chapter describes a methodology to develop the prototype and described the system design of our project. Hardware interfacing, block diagram, circuit diagram, and flow chart of the system are elaborated properly in this chapter. The development process of our has been explained step by step. A comprehensive idea about our system operation will be obtained from studying this chapter.

CHAPTER 5

IMPLEMENTATION AND RESULT

5.1 Introduction

In this chapter, the objective justification and entire implementation have been illustrated with the proper validation. The output of our system is explained in this segment. We displayed all of the output results on the LCD.

5.2 Result analysis

The model is designed to operate under different conditions. From the system architecture, it is apparent that we have used a number of converters to effectively convert the power from one state to another (AC-DC/ DC-AC). The different power sources have been coordinated by the converters to always provide AC output. Also, the microcontroller unit and the storage bank provide for the charging orientation of the system. Below, the different operating modes have been shown and explained.

i) With load

Under load operation, the system draws power from PV/ PDB depending on load demand. A signal generator has been used to provide the power supply.

Fig 5.1 shows the system operation with load.

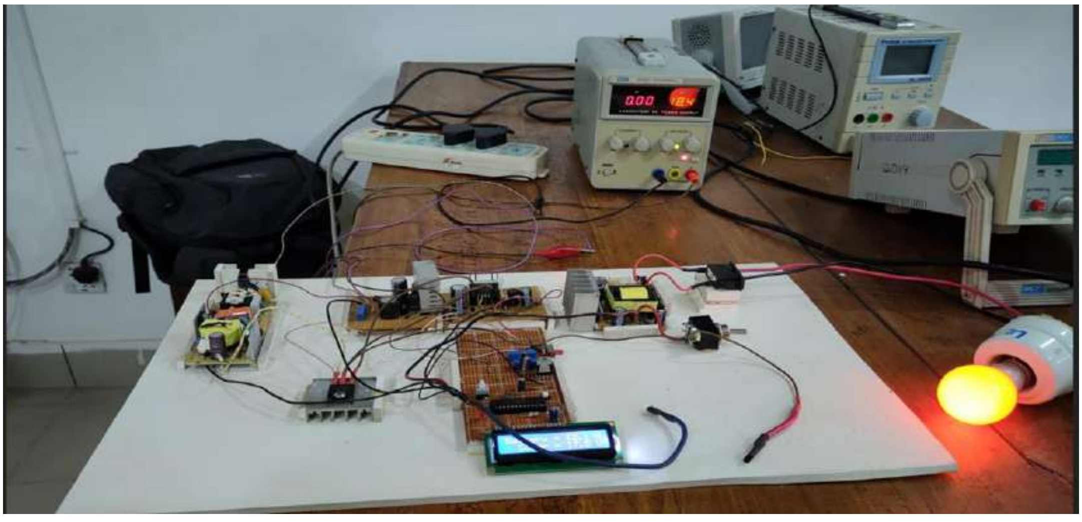

Fig 5.1: System operation with load

ii) Voltage level on LCD

The input voltage level has been visually represented through LCD. The LCD is preprogrammed to display the input voltage level after operation commencement. Here, the solar input voltage level and the battery voltage level is visible.

Fig 5.2 shows the voltage levels on LCD

Fig 5.2: Voltage level on LCD

We can see from figure 5.2 the battery outcome from the circuit. We are counting the voltage as volt unit. From figure 5.1 we have seen the battery power is 12.1 volt and the solar power is 17.5 volt.

iii) Output waveshape, power and voltage measurement on oscilloscope

A power oscilloscope is used to determine the output wave shape of the system. Also, the power and voltage rating are measured through oscilloscope.

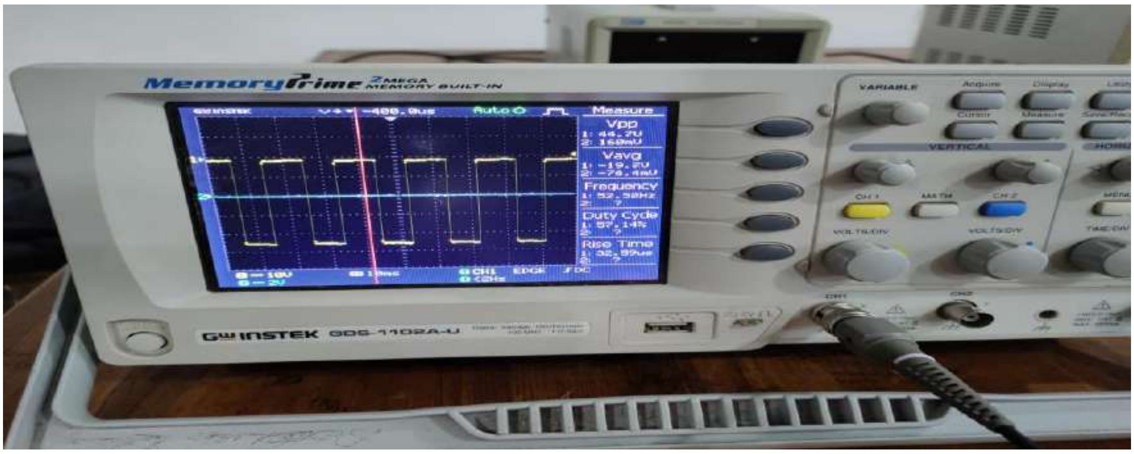

Fig 5.3: Visual output on oscilloscope

5.3 Total Cost of the system

Our prototype project cost is around 10500/-. If we implement our project in real-time or after making a custom circuit, the total system cost would be minimized. However, a detailed feasibility study is compulsory for the analysis.

Table 5.1 shows the total cost of the hardware of this project.

Table 5.1: Total Cost of the system

Name	Price	Qty
PIC 16F73	550	1
AC-DC converter	270	1
LM 2576	150	2
LCD	180	1
100 mH inductor	20	1
Schottkey diode	100	1
Switching transistor	10	1
Crystal oscillator	30	1
VR	10	1
7805	10	1
DIODE	10	10
CTB	10	10
Labor cost	5000	1
Settings and wiring	500	1
Solar Panel (12v/ 20w)	1300	1
Battery (12V/7.5Ah)	1250	1
Total		10550 BDT

5.4 Cost comparison

We have analyzed our experimental result for energy consumption and cost saving. We can get a comprehensive overview of the model’s feasibility in cost and energy consumption.

We have added separate segment and table for better understanding of the experimental values.

i) Energy consumption and energy cost on real time calculation:

Table 5.2 depicts the electrical power consumption for different loads. Also, the cost for load operation in 1 month is calculated and incorporated in the table.

Table 5.2: Grid energy consumption and cost

Appliance	Quantity	Power rating(kWh)	Running Hours per day	Energy consumption per day (kWh)	Energy consumption per month (kWh)	Cost per month (tk)
Bulb	1	.02	8	.16	4.8	28.8
Fan	1	.07	8	.56	16.8	100.8
Phone charger	1	.01	8	.08	2.4	14.4
				Total	24	144

ii) Energy consumption and cost from Solar PV

Table 5.3 measures the per month energy generation and cost using Solar energy as input.

Table 5.3: Energy consumption and cost from Solar PV

Running hours	Solar energy(kWh)	Per day energy (kWh) generated	Per month energy (kWh) generated	Cost per month(tk)
8	.015	.12	4.5	27

iii) Energy consumption and cost saving analysis

The overall study of the energy consumption and cost saving has been analysed and depicted in the table 5.4. It shows the experimental result for desired output of our model

Table 5.4: Energy consumption and cost saving

Source	Energy consumption per month(kWh)	Cost per month (tk)
Grid	24	144
Solar	4.5	27
Difference =	19.5	117

Here we can see that, after using the solar for a reasonable amount of time mentioned in the tables, we can save energy consumption and cost from utility grid supply. For a higher setup this savings will only increase as the system installation cost is one time only which is very low considering lifetime saving.

5.5 Feasibility study of the system

The proposed model will be feasible for use in rural and city areas of Bangladesh. Achieving sustainable energy target has been a major issue for the country for a long time and the government has taken necessary steps in order to address and solve the issue. Like the installation of SHS (Solar home system) in rural areas have been encouraged and a good number of such system has been already installed by IDCOL, an NGO governed by the state. As the price of solar panel and batteries are estimated to drop to 2 dollars/WP and 20% respectively, such home system will be convenient for mass-scale use. Our model will be proved an alternative as it is integrated with multiple sources to provide an all-situation energy supply.

5.6 Summary

In this chapter, the implementation of the system and the experimental result of our project are briefed in detail. The data confirm that the project is a viable solution to the energy and cost crisis of the country. Also, a feasibility study has been shared to further solidify the system’s convenience.

CHAPTER 6

CONCLUSION AND FUTURE WORK

6.1 Introduction

In this section, we'll talk about the benefits, drawbacks, future work, and conclusion. This is the final segment, and we'll go over all of the different options for this project. Hybrid inverter system is based on a controller, and sensor calibration has resulted in a well-structured project. This project's entire parameter was measured and separated into a few key aspects.

6.2 Advantages

There are a few benefits to this project. Below is a list of them.

i) We can provide alternative source of power.

ii) Energy sources are well established.

iii) It will reduce most of the national grid usage.

iv) We can incorporate another source of power during night time.

6.3 Limitations

This project does have certain restrictions. Let's have a look at the restriction below.

i) The research has been conducted in small scale.

ii) Components with higher ratings is required for a large-scale implementation which is absent in the project.

6.4 Future work

With this initiative, we have some long-term goals. We'll start by attempting to resolve all of the sensor-related issues we're currently experiencing. The system architecture will then be modified for production use. As a result, upcoming projects are listed below.

i) For a more efficient output, we will replace the power inverter into online inverter.

ii) System will be implemented in a more efficient way.

iii) This system will be developed in PLC for industrial application.

iv) We will replace the backup power source with a more efficient and reliable source.

6.5 Conclusion

Finally, we can state that the primary goal of our project was to reduce power consumption and cost, and we were significantly successful. We experienced numerous challenges during this project, but in the end, we were able to display the results. In today's world, solar energy collection is the most vital process. This is something we do nowadays to boost productivity. It is beneficial not just in the manufacturing process but also in the creation of renewable energy.

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APPENDIX

```
'PIC16F73

Define CLOCK_FREQUENCY = 16

TRISA = 255

TRISB = 0

TRISC = %01001000

RC = 0


Define LCD_BITS = 4

Define LCD_DREG = RB

Define LCD_DBIT = 4
```

```
Define LCD_RSREG = RB
Define LCD_RSBIT = 0
Define LCD_EREG = RB
Define LCD_EBIT = 1
Lcdinit 0


Lcdcmdout LcdClear
Lcdout " Welcome to IIUC"
Lcdcmdout LcdLine2Home
Lcdout "  Dept. of EEE"
WaitMs 1000
Lcdcmdout LcdClear
Lcdout "  Hybrid Solar"
Lcdcmdout LcdLine2Home
Lcdout "    Inverter"
WaitMs 1000

Dim vb As Byte
Dim vs As Byte

Dim a As Byte
Dim dt As Byte
Dim x As Word
Dim y As Word

PWMon 1, 5
Dim ch As Bit
```

```
main:
x = 0
y = 0
For a = 0 To 19
Adcin 0, vb
Adcin 1, vs
WaitMs 10
x = x + vb
y = y + vs
Next a

vb = x / 20
vs = y / 20
If vb < 115 Then
ch = 1
dt = 100
Endif

If vb > 144 Then
ch = 0
dt = 0
Endif

vb = vb + 6
vs = vs + 6
If ch = 1 Then
If vs > 170 Then dt = dt + 1
```

```
If vs < 160 Then dt = dt - 1
   PwmDuty 1,dt
Else
dt = 0
RC2 = 0
Endif


a = vb / 10
b = vb Mod 10
Lcdcmdout LcdClear
Lcdout "Battery = ", #a, ".", #b, " V"
Lcdcmdout LcdLine2Home
a = vs / 10
b = vs Mod 10
Lcdout "  Solar = ", #a, ".", #b, " V"
WaitMs 1000


Goto main
End
```