

DESIGN & DEVELOPMENT OF SOLAR ELECTRIC BOAT

Submitted in partial fulfillment of the requirements for the award of

Bachelor of Engineering Degree in
Electrical and Electronics Engineering

By

S.SANTHOSH (Register No. 37140072)

G.PANDIARAJAN (Register No. 37140061)



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

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

**Accredited with Grade "A" by NAAC
JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119**

APRIL 2021



SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited "A" Grade by NAAC | 12B Status by UGC | Approved by AICTE

www.sathyabama.ac.in

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of
S.SANTHOSH (Reg. No. 37140072) and **G.PANDIARAJAN** (Reg. No. 37140061)
who carried out the project entitled "**DESIGN & DEVELOPMENT OF SOLAR
ELECTRIC BOAT**" under our supervision from December 2020 to April 2021.

Dr. M.S.SANGEETHA
Internal Guide

Dr. V. SIVACHIDAMBARANATHAN
Head of the Department

Submitted for Viva voce Examination held on _____

Name:

Signature:

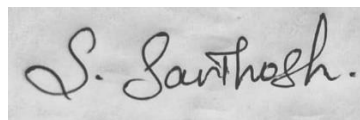
Internal Examiner

External Examiner

DECLARATION

We **S.SANTHOSH** (Reg. No. 37140072) and **G.PANDIARAJAN** (Reg. No. 37140061) hereby declare that the Project Report entitled “**DESIGN & DEVELOPMENT OF SOLAR ELECTRIC BOAT**” done by us under the guidance of **Dr. M. S.SANGEETHA** is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Electrical and Electronics Engineering.

1.



2.



DATE:

SIGNATURE OF THE CANDIDATES

PLACE:

ACKNOWLEDGEMENT

We are pleased to acknowledge our sincere thanks to the Board of Management of **SATHYABAMA** for their kind encouragement in doing this project and for completing it successfully. We are grateful to them.

We convey our thanks to **Dr. N. M. Nandhitha., Dean, School of Electrical and Electronics Engineering** and **Dr. V. Sivachidambaranathan, Head of the Department, Dept. of Electrical and Electronics Engineering** for providing us necessary support and details at the right time during the progressive reviews.

We would like to express our sincere and deep sense of gratitude to our Project Guide **Dr. M.S.SANGEETHA** for his valuable guidance, suggestions and constant encouragement paved the way for the successful completion of our project work.

We wish to express our thanks to all Teaching and Non-teaching staff members of the Department of Electrical and Electronics Engineering who were helpful in many ways for the completion of the project.

ABSTRACT

Using solar energy to your own advantage is a very old concept and goes back millions of years. All life on earth depends on the sun in some way. Using sun energy to create electricity is also not such a new concept. Research on it began as early as 1839 when Alexandre Edmond Becquerel observed a photoelectric effect when an electrode in a solution of conductive liquid became charged when in sunlight¹. In this project I am going to explore the possibility of making a boat that is powered solely from the sun. I will then design and make a working model. It is generally thought that solar power is limited to sunny locations. However, contrary to what most people think, solar panels still can get energy if the sky is overcast but they do not absorb as much energy. Therefore, designing a solar powered boat for use in The Netherlands is not that farfetched. Currently, there is a huge amount of research going into solar power and many new technologies are being discovered. Over the past few years new flexible and light solar panels have been invented and because of those it will be much easier to make a solar powered boat.

I have absolutely no previous knowledge of solar power however I do know a fair bit about model boats. Therefore, I am hoping to build on my knowledge of model boats and learn more about using solar energy. Furthermore, by presenting my work I am also hoping to raise awareness in the school about possible alternative energies and the great potential that solar energy has.

TABLE OF CONTENTS

CHAPTER NO	TITLE	PAGENO
	ABSTRACT	V
	LIST OF FIGURES	VI
	LIST OF TABLES	IX
1	INTRODUCTION	
	1.1 INTRODUCTION	1
	1.2 LITERATURE SURVEY	2
	1.3DRAWBACKS OF EXISTING SYSTEM	4
	1.4 ADVANTAGE OF PROPOSED SYSTEM	4
2	PROJECT DESCRIPTION	
	2.1 PROPOSED SYSTEM	5
	2.1 PV BOAT	5
		6
	2.3 PV MODULES	
	2.4 BLOCK DIAGRAM	7
	2.4.1 MPPT	8
	2.4.2 DEVELOPMENT OF MPPT IN SOLAR BOAT	8
	2.4.3 BATTERIES	8
	2.4.4 CHARGE AND DISCHARGE CONTROLLER	9
	2.4.5 MANAGEMENT CONTROL	9
	2.5 SUSTAINABLE DESIGN METHODS	9
	2.6 DESIGN CRITERIA	10

SOFTWARE DESCRIPTION

3.1 SIMULATION	12
3.1.1 MATLAB\SIMULINK	12
3.1.1.1 MATLAB DESCRIPTION	12
	12
3.1.2 SIMULINK	
3.1.3 Maximum Power Point Tracking Algorithms	12
3.1.3.1 Perturb and observe	13
3.1.3.2 MPPT ADVANTAGES	15
3.2 SIMULATION CIRCUIT AND RESULTS	
3.2.1 SIMULATION CIRCUIT	15
3.2.2 SIMULATION CIRCUIT FOR BATTERY CHARGING	16
	17
3.3 SIMULATION RESULTS	
3.3.1 OUTPUT PARAMETERS OF SIMULATED D DC	17
CONVERTER	18
3.3.2 OUTPUT PARAMETERS OF SIMULATED CHARGE OF BATTERY	
	19
3.3.3 OUTPUT PARAMETERS OF SIMULATED CHARGE OF CURRENT	
3.3.4 OUTPUT PARAMETERS OF SIMULATED BATTERY OUTPUT VOLTAGE	20

4	HARDWARE DESCRIPTION	
	4.1 HARDWARE	21
	4.1.1 DC MOTOR	21
	4.1.2 DC TO DC BOOST CONVERTER	21
	4.1.3 DC MOTOR DRIVE	22
	4.1.4 BLUETOOTH MODULE	23
	4.1.5 LEAD ACID BATTERY	24
	4.1.6 SOLAR PANEL	24
	4.1.7 ARDUINO	25
	4.1.8 PROPELLER	26
	4.2 HARDWARE RESULT	27
5	5.1 CONCLUSION & FUTURE SCOPE	
	5.1.1 CONCLUSION	28
	5.1.2 FUTURE SCOPE	29
	REFERENCES	30

LIST OF FIGURES

FIG NO	TITLE	PAGE NO
2.4	Block diagram of proposed method	7
3.1.3.1	Fig Perturb and observe	13
3.1.3.2	Incremental conductance	14
3.2.2	Simulation circuit for battery charging	16
3.3.1	Output parameters of simulated DC-DC converter	17
3.3.2	Output parameters of simulated charge of battery	18
3.3.3	Output parameters of simulated charge of current	19
3.3.4	Output parameters of simulated battery output voltage	20
4.1.1	Dc motor	21
4.1.2	DC to DC boost converter	21
4.1.3	DC motor drive	22
4.1.4	Bluetooth module	23
4.1.5	Lead Acid battery	23
4.1.6	Solar panel	24
4.1.7	Arduino	25
4.1.8	Propeller	26
4.2	Hardware kit	27

CHAPTER 1

1.1 INTRODUCTION

In modern society fossil fuels are the most commonly used primary energy sources. Which are used for various applications, such as transport, lighting and heating. At least 70% of the electrical energy is generated by using fossil fuels, from this coal is the most important one. In 2010, the International Energy Agency (IEA) stated that the need for fossil fuels to generate electrical energy has increased 67% from 1990 to 2007.

Transport is a large consumer of the petroleum products which gives various emissions such as Volatile Organic Compounds (VOCs) and in particular CO₂ worldwide. The report from the IEA in 2009, estimated that 25% of CO₂ emissions originated by transportation. All over the world fossil fuel is the most important source for transportation. The VOCs, CO₂, NO_x and CH₄ are emitted by the type of fuel, contamination and combustion process. Whether we can reduce these emissions that can extend the lifespan of our resources and provide benefits to the natural environment.

In order to reduce the use of non-renewable energy like fossil fuel in the transport, we have to make use of renewable energy. Photovoltaic (PV) solar power, wind power, hydro power and other renewable energy sources can generate electrical energy that can provide for almost all of our energy needs with negligible CO₂ emissions. In this framework, particular building and retrofitting boats with electric propulsion is a topic of interest for the province. While operating the boat there is no sound and there is no pollution are considered advantages for keeping large lake areas green, silent and clean. One example is whether or not boats can be powered through renewable energy technologies, such as PV.

That is, multiple PV panels are connected serial and in parallel to share one inverter having maximum point tracker. One major drawback for such system is the shading effect. Small percentage of shading area can result in a tremendous amount of energy loss. Similarly, panel aging effect caused

mismatching within the system also reduces total energy output. One of the solutions to the problem is called the 'Distributed' photovoltaic system which involves using a dedicated DC/DC converter attached to each of the PV panels. For such a setup, one can control every PV panel independently in order to minimize the effect caused by panel shading or mismatching. Our team focuses on the development of a new generation of the distributed system including various MPPT algorithms, award winning design of the DC/DC converter and the patented controller system for PV application. After successfully testing on a grid-connected PV application, attention is focused on the application of a standalone PV system.

A solar powered boat demonstrates a complicated standalone system application, since it not only produces rolling, pitching motion, and ship stability problems, but also the PV panels on board encounter fast change of solar insolation intensity. Previously, we reported a special technique called dynamic MPPT process that is especially suitable for marine application. By integrating the patented hardware and the firmware, the latest design and rework on a solar boat is presented. Some review on the ship design, space requirement for PV panel installation, DC/DC power optimizer, the quadratic MPPT algorithm and central controller, and system integration with propulsion motors will be given. This methodology has been realized in a solar boat running at Love River in Kaohsiung City, Taiwan. This work provides a framework to help the domestic leisure yacht builder adopting the renewable solar energy technology and promoting the new solar ship design with higher percentage green energy penetration. This dissertation explains what PV technology comprises and what PV boats are. This chapter concludes with previous research and therefore the research questions addressing bottlenecks of the mixing of PV into boats

1.2 LITERATURE SURVEY

1.2.1 Photovoltaic dynamic MPPT on a moving vehicle, Solar Energy

In addition to the conversion efficiency of a photovoltaic panel, the Peak Point Tracking (MPPT) method also plays a central role in getting the most energy from the sun. The MPPT unit in a moving vehicle must maintain high tracking accuracy to compensate for the rapid change in insolation due to the dynamic movement of the vehicle. In this article, some problems of a

photovoltaic system related to a moving vehicle are addressed and a modified quadratic maximization MPPT algorithm is proposed. Theoretical PV performance is linked to the experimental test followed by the Sandia dynamic test protocol to verify the proposed MPPT method. Finally, the experimental result on a ship model is discussed.

1.2.2 Solar-powered boat design optimization, procedural engineering

This article presents a strategy for designing a solar-powered boat to calculate the dimensions of a photovoltaic (PV) system with minimal cost. Two-stage optimization procedures have been proposed. The first stage can be a simplified ship size optimization supporting the prevailing ship design to obtain the minimum propulsion power using the gold panning section algorithm. The second stage is the optimization of the size of the photovoltaic system to obtain the quantity of photovoltaic module (PV) and battery with a minimum cost by using the Simplex algorithm. A pleasure passenger catamaran operated in Taiwan with a capacity of 42 people is chosen as a case study. The service speed of the boat is 5 knots with a total cruise duration of around 5 hours. In this case, a 280-watt multi-crystalline photovoltaic module and a 12-volt, 90-Ah lead-acid accumulator are chosen. From the simulation, it is obtained that the optimal ship has 32 photovoltaic modules (8.96 kW), 32 batteries (34.56 kWh), 14.44 meters of waterline length, 4.37 meters of width, 0.852 meters of the draft, and 16,258 tons of total displacement with photovoltaics. The annual capital cost of the system around USD3, 557.

1.2.3. Topology study of the photovoltaic interface to monitor the point of maximum power

This article analyzes the performance of PV modules under non-ideal conditions and proposes topologies to mitigate performance degradation caused by these conditions. It is found that the height point of a module is significantly reduced thanks to the less shading of the module, which this effect spreads through other non-taxable modules connected in series with the shading.

1.3 DRAWBACKS OF THE EXISTING SYSTEM

The use of fossil fuel engines in ships causes environmental pollution. It needs more maintenance compared to solar-powered boats. Today, the daily increase in the price of petroleum products makes it expensive to travel by boat not only in boats but also in all the fossil fuel engine transport used. In the normal engine, boats produce a huge noise when accelerating and it can irritate the life of boat trips. The fuel-powered boat burns the fuel and emits greenhouse gases into the atmosphere and is harmful to the land. Using fuel engines takes more space and there will be some oil leaks that will make the boat look like it is not clean and it will also need more maintenance.

1.4 ADVANTAGES OF THE PROPOSED SYSTEM

They are environmentally friendly, reducing carbon emissions, lowering noise levels, and eliminating the cost of fuel. This boat saves more fuel costs. We are not saying that it is completely silent while driving, but solar boats produce less sound when traveling. Whether we are not using the boat, the solar panels continuously charge the batteries. So the stored energy can be at any time when we do not need to load the boat urgently. Solar panels can also restore a boat's batteries, helping you hold the boat as a backup in case the batteries require an additional charge. And also act as an additional energy source to existing electrical sources. At an equivalent time, solar energy is often stored for later use. Almost anything is possible with a solar boat. You can charge all your devices, such as mobile phones and laptops while browsing. These devices never run out of battery while the panels are charged. Almost anything can be possible in a solar boat, as we can charge all devices such as mobiles, laptops, and any other electronic device that is carried for shipping..

CHAPTER-2

PROJECT DESCRIPTION

2.1 PROPOSED SYSTEM

In this project, we have proposed an innovative battery charge/discharge management. With this management, we have optimized battery life, and during navigation, we have real-time control of the navigation autonomy. Also, we have designed ships with zero pollution and really low operating costs; all the energy required for navigation comes from renewable sources. The electricity produced by photovoltaic energy is safer and more benign for the environment than conventional sources of energy production. However, there are health, safety, and environmental concerns associated with the manufacture, use, and disposal of photovoltaic equipment. Manufacturing electronic equipment consumes a lot of energy. The electricity produced is higher than that required to manufacture the photovoltaic modules, and therefore the energy break-even point is typically reached over three to 6 years.

2.2 PHOTOVOLTAIC BOAT

A photovoltaic boat is a boat that sails solely on photovoltaic energy generated in daylight conditions. The energy in a photovoltaic boat is generated solely through solar means and is stored in batteries. This energy is used primarily for propulsion. Navigation, security, lighting, and housing are the secondary loads or Hotel Electric Energy (HEP) loads. According to Waechter, boats are much more feasible to navigate with photovoltaics compared to, for example, cars, since at lower speeds photovoltaic boats consume less energy. However, with increasing size, PV boats are becoming less and less feasible, even at lower speeds. Also, PV boats that are equipped with a wide variety of electrical appliances may not be suitable to be powered by PV alone. In that case, combinations of photovoltaics with other energy sources are an option. Photovoltaic systems do not contain moving parts, so their maintenance demand is relatively low. Photovoltaic systems can consist of photovoltaic modules, one or more maximum power point trackers (MPPT), a battery management system (BMS), energy storage, and typically DC / DC converters.

2.3 PV MODULES

Photovoltaic modules convert solar radiation into electrical energy. There are various configurations of photovoltaic modules and, in general, photovoltaic modules generate low voltage direct current (DC) power. Most photovoltaic modules have an efficiency in the range between 10% and 20%. As a general rule of thumb, the higher the efficiency of the PV modules, the more expensive they are. A photovoltaic module consists of photovoltaic cells connected in parallel, in series, or a combination of both. There are several photovoltaic cell technologies, of which c-Si is the most widely used. Other technologies include amorphous silicon (a-Si), cadmium telluride (CdTe), and copper indium gallium selenide (CIGS) in thin-film photovoltaic modules and various combinations of materials such as gallium arsenide (GaAs). and the phosphorus of indium and gallium (in spaces) in multifunction cells. In general, thin-film PV modules, such as those based on CdTe and CIGS, are cheaper in the range of 0.80 e / Wp to 2.00 e / Wp [26]. However, the efficiency of your PV module is in the range of 7% to 13%. Multi-function PV modules are the most expensive, but have module efficiencies in the 25% to 30% range. Under concentrated irradiation, the cost range of multifunction photovoltaic modules is between e 2.50 / Wp and e 4.50 / Wp. Some PV module technologies offer a useful life of more than 25 years. During this period, production typically decreases by 10-20%. The cost of the photovoltaic module and the efficiency ranges of the photovoltaic module for common photovoltaic technologies.

More about this source text Source text required for additional translation information send feedback Side panels

2.4 BLOCK DIAGRAM OF PROPOSED METHOD

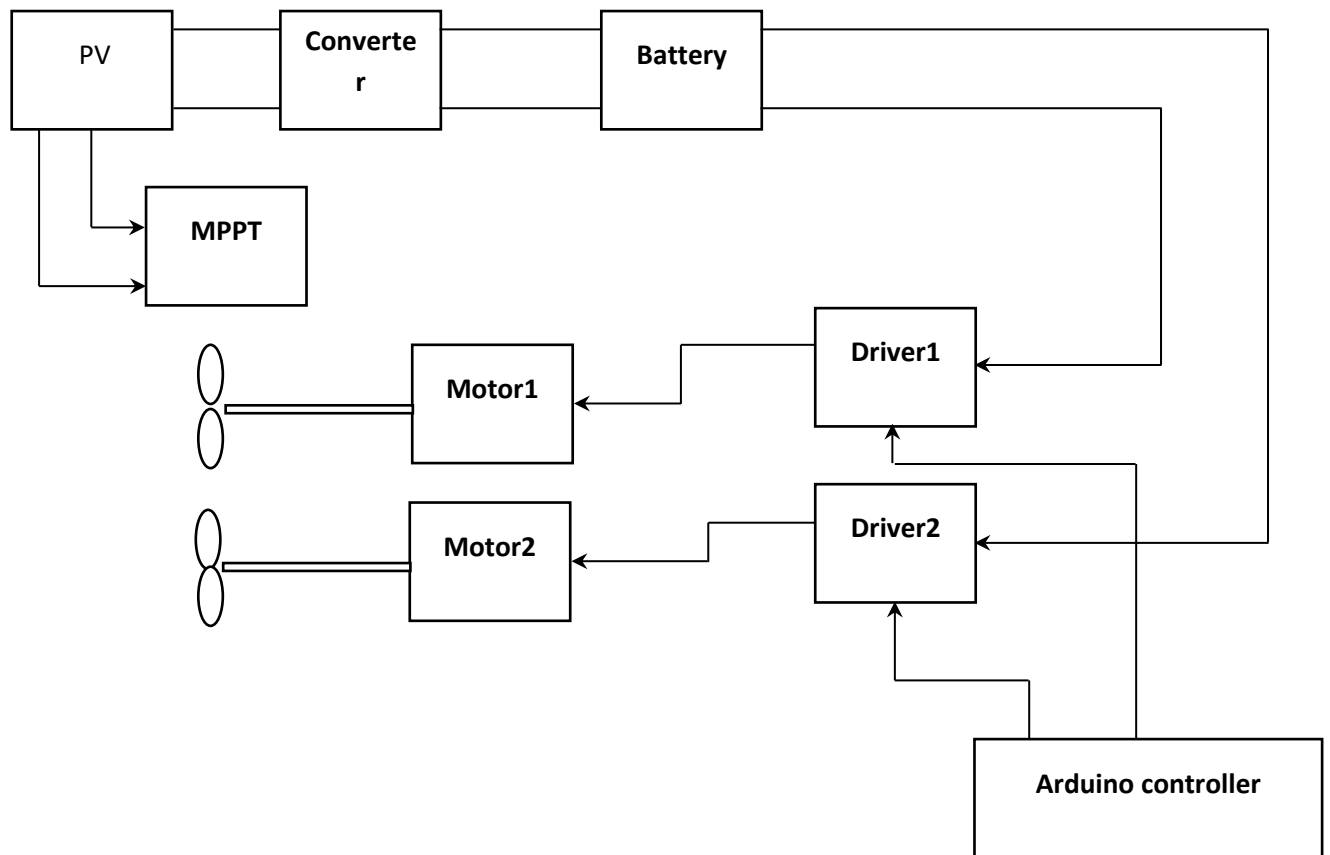


Fig2.4 BLOCK DIAGRAM PROPOSED METHOD

2.4.1 MPPT

MPPTs let the PV module operate in its Maximum point (MPP). Electronics in the MPPT vary the electrical load which is applied to the PV module. With search algorithms, the combination of voltage and current is found which delivers the most power.

2.4.2 DEVELOPMENT OF MPPT IN SOLAR BOAT

Maximum power point tracking is a method to increase PV systems efficiency by maximizing PV output power at every weather condition. PV modules have different maximum power at each weather condition, especially at different solar irradiation. The value of PV maximum power at each weather condition can be obtained if the PV output voltage is at a certain value, called Maximum Power Point (MPP) voltage. MPPT features a role to get optimum voltage reference for DC-DC converter in order that PV can produce its maximum power at every different condition. There are dozens of PV MPPT methods that have been developed. Some of them are non-artificial intelligent techniques while some are artificial intelligent based. The examples of non-artificial intelligent MPPT methods are Perturb & Observe, incremental conductance, and fractional open circuit method. The most well-known artificial intelligent MPPT methods are fuzzy logic and neural networks. Specifically develop MPPT for solar-powered boat application.

MPPT in moving objects like boats must have fast response because the sun irradiation may change rapidly. Both of those references use modification of the Quadratic Maximization algorithm to track PV maximum power. Quadratic Maximization algorithm works by approximate correlation between PV power and converter duty cycle through quadratic curve function. The limitations of Quadratic Maximization algorithms for moving objects are duty shafting, re-tracking and convergence. This algorithm is validated through comparing simulation results with the P & O algorithm under change of either sun irradiation or temperature condition. The results show that the proposed algorithm has fast response and better efficiency than P&O. The proposed method has also been applied in model ships and shows good results. It can be concluded that the proposed MPPT method is very suitable for a solar-powered boat system.

2.4.3 BATTERIES

Batteries are chemical systems during which electric energy are often stored temporarily. Most cells from batteries work at a low voltage, in a range between 1.2 V and 3.7 V. By connecting these cells in series, more useful voltages can be achieved. Various rechargeable battery technologies exist, such as lead-acid, Lithium-ion (Li-Ion) or Nickel-Cadmium.

2.4.4 CHARGE AND DISCHARGE CONTROLLER

Charge controller, through the information received by the management control, sends the energy that comes from the photovoltaic array, to the fully discharged battery bank. During the charge process, the charge controller measures the flow of incoming energy in the battery bank. When the battery bank is totally charged, the energy flow is shipped to a different fully discharged battery bank. In the eventuality that there are not any fully discharged battery banks the energy flow is shipped to the hundreds through the discharge controller; in alternative, the energy flow is sent to the grid if it's connected. The discharge control carries to discharge fully one battery bank at a time. During the discharge process the discharge control measures the energy flow and management control compares this with one memorized during the preceding charge. Through this comparison it is possible to establish the aging of the battery and to determine the real storable energy.

2.4.5 MANAGEMENT CONTROL

The principal assignment of the management control system is to determine the real available energy for the navigation and to furnish information on the ship's autonomy. To realize this assignment, the system preserves information of the flows of energy and manages the entire discharge/charge of the battery banks. The performances of all electrical systems are monitored by the management control. It manages the discharge of the single battery bank one at a time. With this management strategy we check the battery life and limit the number of charges/discharge. In our system, the sizing of battery capacity has been selected in such a way that, with an opportune control, at most only one cycle of charge/discharge could be done during the navigation. Considering that our batteries bear 2000 complete discharges with a loss within the 20% the time life of the batteries will be greater than 10 years.

2.5 SUSTAINABLE DESIGN METHODS

Opportunities can be identified with respect to increasing the energy efficiency of PV boats, reducing the cost and increasing the usability and aesthetics of PV boats. From a technical point of view, many opportunities for and applications of sustainable energy technologies exist. The success of sustainable energy solutions in products can be increased by applying IDE methods. Common practice up until the early 2000s was to design products with sustainable energy technologies from a technical point of view: the main focus was to increase the technology's energy yield.

This is also the case for PV boats, which show since 1975 advances in maximum speeds and sailing autonomy. However, advances in

cost, usability and aesthetics stayed behind. Reindeers point out that not only advances in technology are key to the success of sustainable energy solutions. They state that the success of an energy solution for PV boats is dependent on five key factors:

- Technical aspects.
- Financial aspects.
- Social aspects.
- User aspects.
- Design Styling.

Assume that interdisciplinary design methods can create better solutions compared to methods which focus only on optimizing energy solutions. This is illustrated in Figure 1.9. Naturally, the end user plays an important role in the acceptance of new forms of energy and energy efficiency, also at the level of use of energy systems. User interaction with an energy system can affect the quality of the system's functions and the corresponding perception of usefulness and comfort by the end user. The practical use of good technologies and also by good technologies and also by using new technologies, opportunities exist in creating better performing PV boats. For example, recent developments in new battery technologies, such as lead acid made it possible to develop better performing PV boats. However, such technologies also find their way in other areas. Battery technology developed for PV boats were used in solar cars which participated in the World Solar Challenge 2013. Two of these cars reached 1st and 3rd place as a result. In the case of PV boats, marketing can play an important role to emphasize on the benefits of PV boats over other, more common, forms of transport on the water with IC engines. The societal context must be identified to find opportunities in PV boat design and the way these opportunities are often translated to successful PV boat design. Human factors play a crucial role within the design of PV boats. Design Styling can be a means to make PV boats more attractive, or distinctive compared with other more conventional boats. Therefore, in product development such as PV boats, IDE plays an important role. IDE can be seen as a crossover between industrial design and design engineering. Both fields try to solve design problems, however industrial designers tend to focus on the life styling features of a product, whereas design engineers focus on the technological features of PV boats.

2.6 DESIGN CRITERIA

The design of a product is good if it's certain criteria. A good set of criteria important to reach a good design. Testing of the criteria is determining which criteria are acceptable and which are not. In a design process of a posh product, like a PV boat, different people with different disciplines work

together. Their goal is to conceive a good design. Therefore, criteria are needed to make it clear for everybody what the design should be. The design criteria formulated in this section are helpful to improve the technical performance of PV boats. Societal aspects are not considered in this dissertation, because clear indicators showed the need for a theoretical model with which PV boats' performance could be evaluated in an early design stage. Performance related to a number of physical parameters such as speed and power are easily measurable and thus used as performance indicators in this dissertation. The design criteria act more as directives or guidelines and should not be considered as design constraints. In that way, the design process of new products is more open for innovation, which is also needed in the design and development of PV boats. A list of criteria is usually the result form a creative process, since this list of criteria is the first step in product design. One of the threats of design criteria is that the list of criteria can grow long. As a result, too many criteria can lead to difficulties in evaluation. First it is important to focus on the main items and not to get into much detail. In a later stage, such as the embodiment phase, the more detailed criteria will be evaluated. Furthermore, it is impossible to state all the design criteria in the first phase.

Usually, design criteria are adapted as a result from findings in later phases of the design process. Research in 2006 described the developments of PV boats. From this research, four key functions were identified where PV brings additional value to boats. These four functions are:

1. Propulsion.
2. Navigation, safety and lighting.
3. Living.
4. Battery charging.

More or less, these four functions can be merged into two functions for the PV boat. First, the energy needed for the propulsion (1) can be identified and secondly the energy need for other load such as navigation (2) and living (3), which are called HEP loads. The last function, battery charging (4) can be neglected, since a (partially) charged battery is always needed to provide for the energy needed for the propulsion and HEP loads on a PV boat. It is therefore not a function which brings additional value to a PV boat but it's mandatory on a PV boat. In the research from some design criteria have been stated, which might lead to better design of PV boats. However, PV has been considered more as an add-on than being part of the boat. Their findings were that if PV boats should come successful, the relatively high capital cost of PV boats should be tackled. Secondly, the aesthetic appearance of PV boats should be increased. Subsequently, more surface area for PV modules needs to be created. Furthermore, the energy density of batteries needs to increase. And finally, the energy efficiency of the PV boat needs to increase. A complete overview of design criteria for PV boats.

CHAPTER-3

3.1 SOFTWARE DESCRIPTION

3.1.1 MATLAB\SIMULINK

3.1.1.1 MATLAB DESCRIPTION

MATLAB may be a software package for computation in engineering, science, and applied math. It offers a strong programming language, excellent graphics, and a good range of expert knowledge. MATLAB is published by and a trademark of the math's Works. Developed by MATHWORKS, MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages. An additional package, SIMULINK, adds graphical multi-domain simulation and Model-Based Design for dynamic and embedded systems.

3.1.2 SIMULINK

Simulink (Simulation and Link) is a MATLAB extension of Math works Inc. It works with MATLAB to provide modeling, simulation, and analysis of dynamic systems in a graphical interface (GUI) environment. Building a model is simplified with a mouse click and drag operations. Simulink includes a complete block library of toolboxes for linear and nonlinear analysis. Models are hierarchical, allowing both top-down and bottom-up approaches to be used. Because Simulink is an integral part of MATLAB, it is easy to modify back and forth during the analysis process, and therefore the user can take full advantage of the features offered in both environments. This tutorial introduces the essential features of Simulink and focuses on control systems because it has been written for college students on my control systems.

3.1.3 Maximum power point tracking algorithms

As explained above, MPPT algorithms are necessary for photovoltaic applications because the MPP of a solar panel varies with irradiance and temperature, thus requiring the use of MPPT algorithms to obtain the maximum power from a solar battery. Over the past decades, many methods for searching for MPP have been developed and published. These techniques differ in many aspects such as required sensors, complexity, cost, range of effectiveness, and speed of convergence, correct monitoring in case of irradiation and/or natural process, the hardware necessary for implementation or popularity, among others. A full review of 19 different MPPT algorithms is often found.

Among these techniques, the P&O and In Cond algorithms are the most common. These techniques have the advantage of being simple to implement but even have

drawbacks, as will be seen later. Other techniques that support different principles are mathematical logic control, neural network, circuit fractional voltage or short current, current sweep, etc. an approximate MPP, not the precise one. Under normal conditions, the V-P curve has only one maximum, so it is not a drag. However, if the PV field is partially shaded, there are multiple maxima on these curves. To alleviate this problem, some algorithms are implemented.

3.1.3.1 Disturb and observe

The P&O algorithm is also called "hill-climbing", but both names refer to the same algorithm depending on how it is implemented. Acceleration involves a disturbance in the duty cycle of the power converter and P&O a disturbance in the

More about this source text Source text needed for additional translation information send feedback to the Side panels

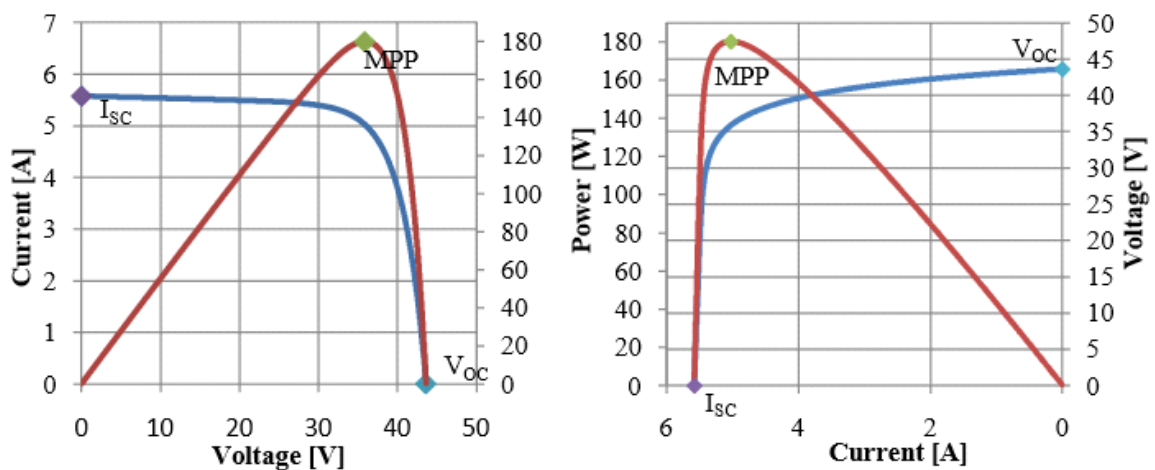
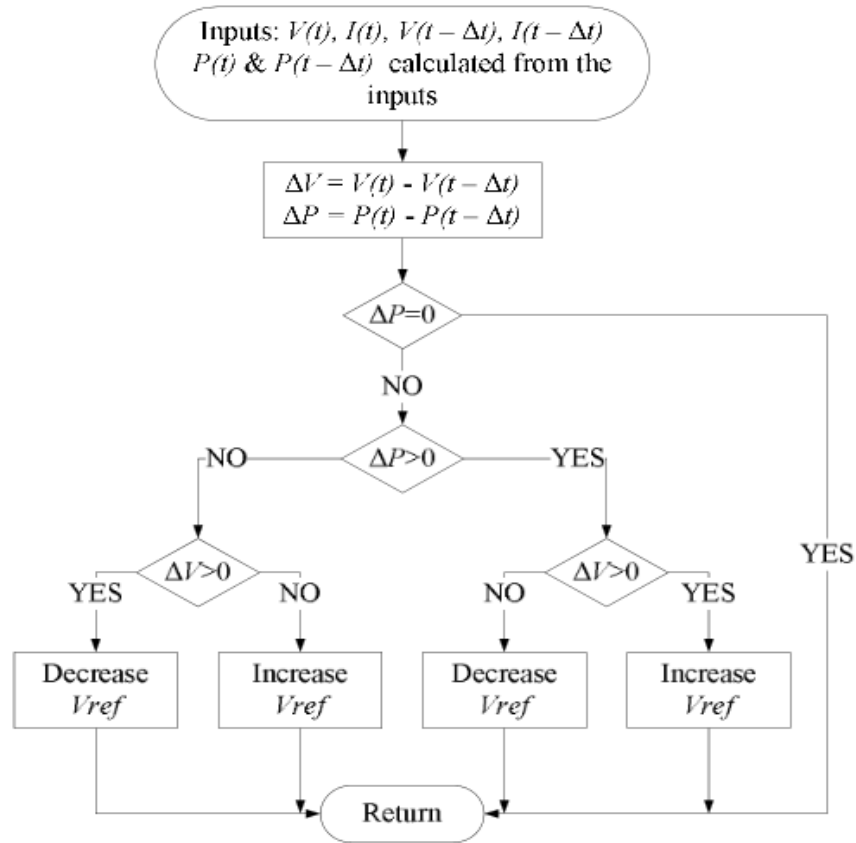


Fig 3.1.3.1 Perturb and observe

Operating voltage of the DC link between the PV array and the power converter. In the case of the Hill-climbing, perturbing the duty cycle of the power converter implies modifying the voltage of the DC link between the PV array and the power converter, so both names refer to the same technique. In this method, the sign of the last perturbation and the sign of the last increment in the power are used to decide what the next perturbation should be

If there is an increment in the power, the perturbation should be kept in the same direction and if the power decreases, then the next perturbation should be in the

opposite direction. Based on these facts, the algorithm is implemented. The process is repeated until the MPP is reached. Then the operating point oscillates around the MPP.



3.1.3.2 Incremental conductance

The incremental conductance algorithm is based on the fact that the slope of the curve power vs. voltage (current) of the PV module is zero at the MPP, positive (negative) on the left of it and negative (positive) on the right

- $\Delta V / \Delta P = 0$ ($\Delta I / \Delta P = 0$) at the MPP
- $\Delta V / \Delta P > 0$ ($\Delta I / \Delta P < 0$) on the left
- $\Delta V / \Delta P < 0$ ($\Delta I / \Delta P > 0$) on the right

By comparing the increment of the power vs. the increment of the voltage (current) between two consecutive samples, the change in the MPP voltage can be determined.

3.1.3.3 MPPT ADVANTAGES

MPPT ensures that you get the most power possible from your solar panels at any point in time. It is particularly effective during low light level conditions. These calculations result in an output that delivers maximum current at the required voltage at any point in time. During low light level situations it will compensate for the low light level and find the new point at which the solar cell delivers its maximum power output.

3.2 SIMULATION CIRCUIT AND RESULTS

3.2.1 SIMULATION CIRCUIT

The simulation of the project was carried out in the mat lab. Closed loop control of the motor with respect to speed and torque was achieved. Simulation Circuit Diagram for Modified Isolated Step up- DC to DC Converter and MPPT is also shown the figures in the subsequent pages show the following output parameters of the simulation setup

- PV panel is connected to DC – DC to converter and MPPT.
- PV panel is given solar energy for input of DC – DC to converter.
- The simulated value of DC Output voltage of the voltage measurement.
- DC to DC converter connected in a battery.
- The simulated closed loop for battery charging.

3.2.2 SIMULATION CIRCUIT FOR BATTERY CHARGING

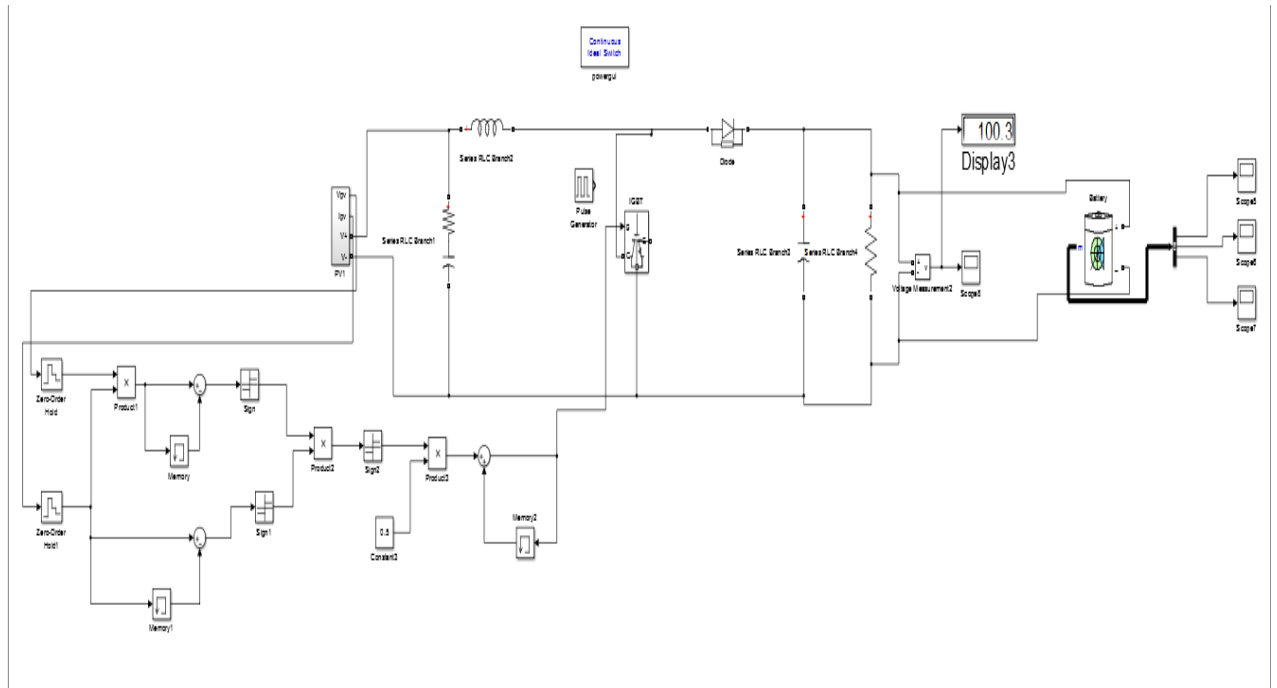
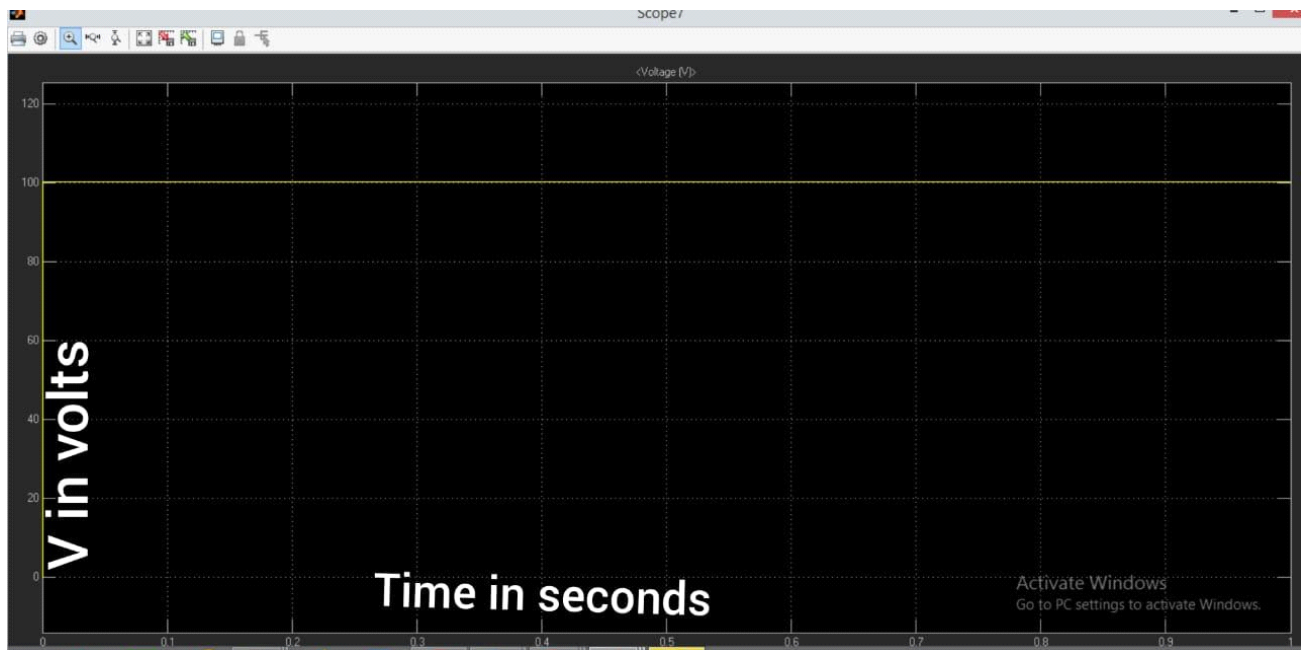


Fig 3.2.2 SIMULATION CIRCUIT FOR BATTERY CHARGING

3.3 SIMULATION RESULTS

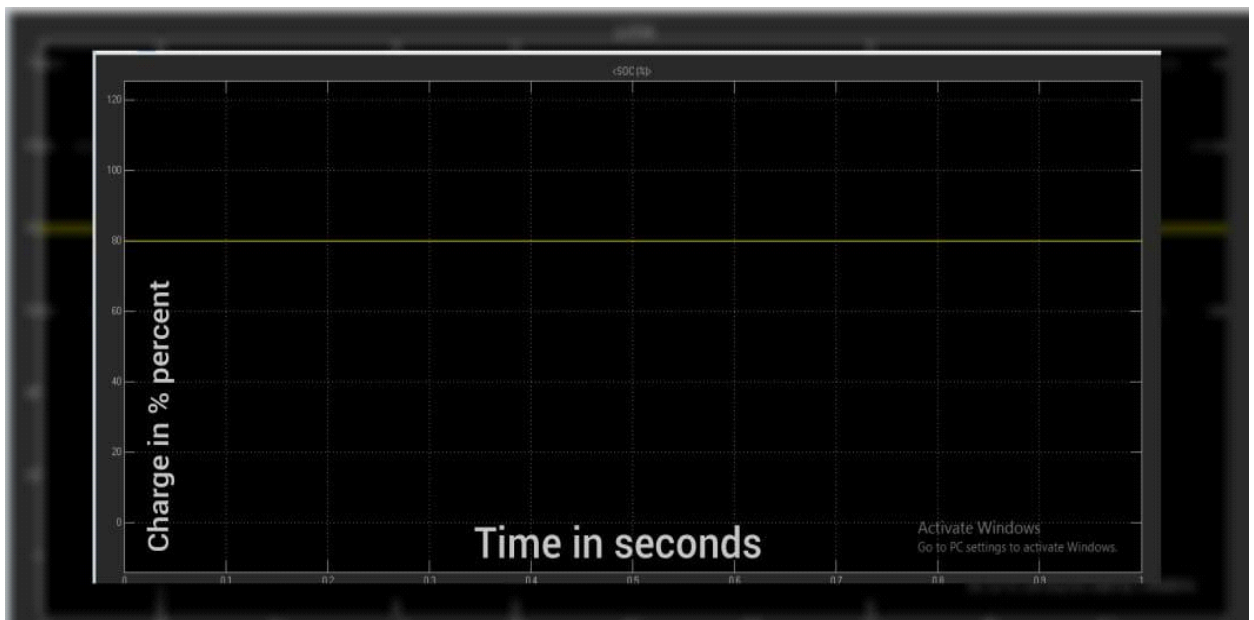
3.3.1 OUTPUT PARAMETERS OF SIMULATED DC-DC CONVERTER



Boost converter output = 100v

Fig 3.3.1 OUTPUT PARAMETERS OF SIMULATED DC-DC CONVERTER

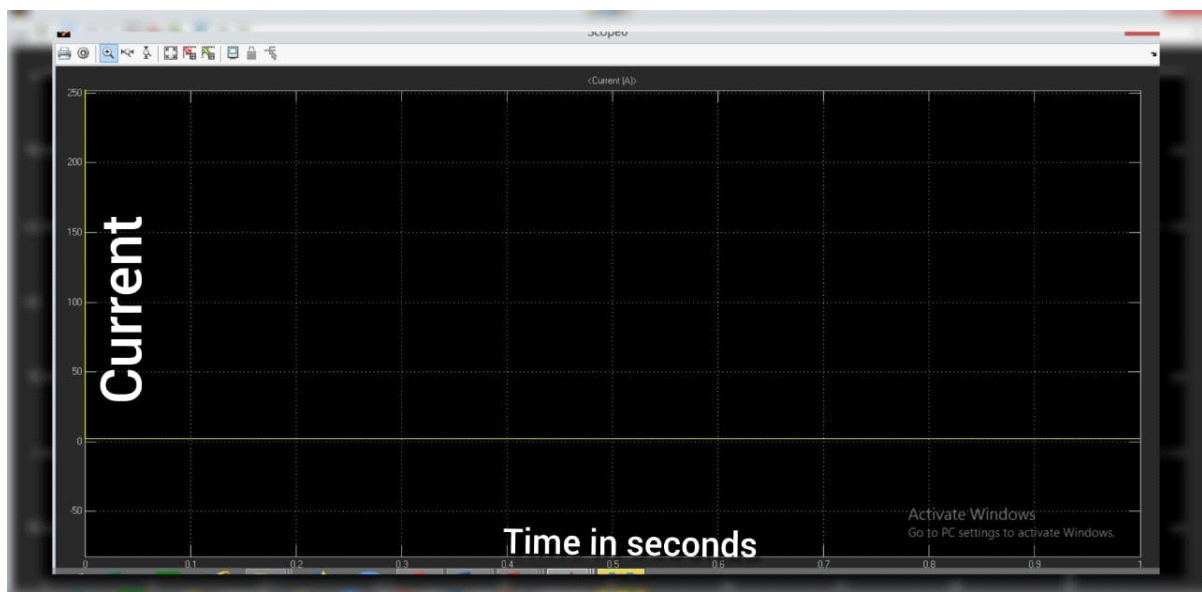
3.3.2 OUTPUT PARAMETERS OF SIMULATED CHARGE OF BATTERY



State of charge in% = 80%

Fig 3.3.2 OUTPUT PARAMETERS OF SIMULATED CHARGE OF BATTERY

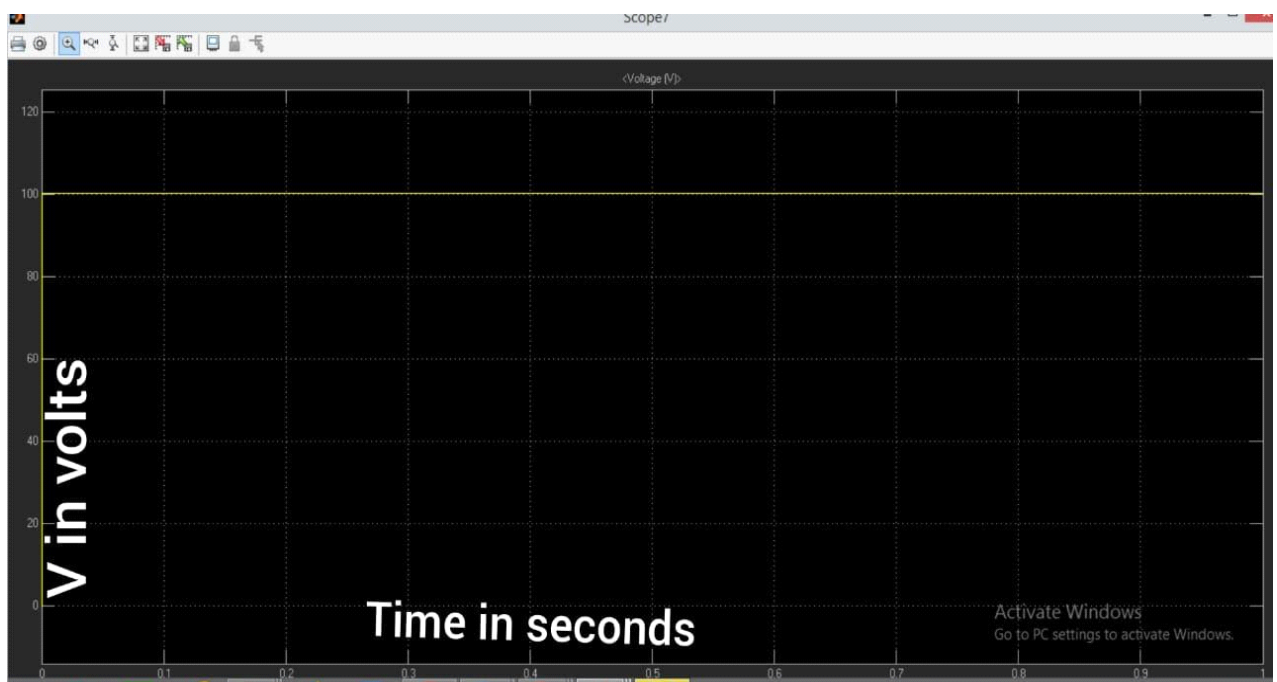
3.3.3 OUTPUT PARAMETERS OF SIMULATED CHARGE OF CURRENT



Charge of current = 5.4A

Fig 3.3.3 OUTPUT PARAMETERS OF SIMULATED CHARGE OF CURRENT

3.3.4 OUTPUT PARAMETERS OF SIMULATED BATTERY OUTPUT VOLTAGE



Battery of voltage = 100v

Fig 3.3.4 OUTPUT PARAMETERS OF SIMULATED BATTERY OUTPUT VOLTAGE

CHAPTER-4

4.1 HARDWARE DESCRIPTION

4.1.1 DC MOTOR



Fig 4.1.1 DC motor

In this project we are using the 12 volt DC motor of 500 RPM. Which is used as propulsion of the boat. That makes the boat move front, back, left and right direction. Each motor is controlled by a motor driver and it is regulated by Arduino.

4.1.2 DC TO DC BOOST CONVERTER

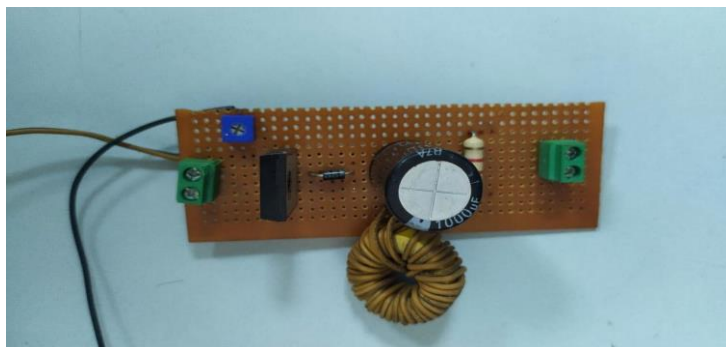


Fig 4.1.2 DC TO DC BOOST CONVERTER

The dc to dc converter input is connected to the solar panel and the output is boosted and connected to the Arduino which makes the constant voltage is given to the motor by using his maximum power point tracking algorithm.

4.1.3 DC MOTOR DRIVE

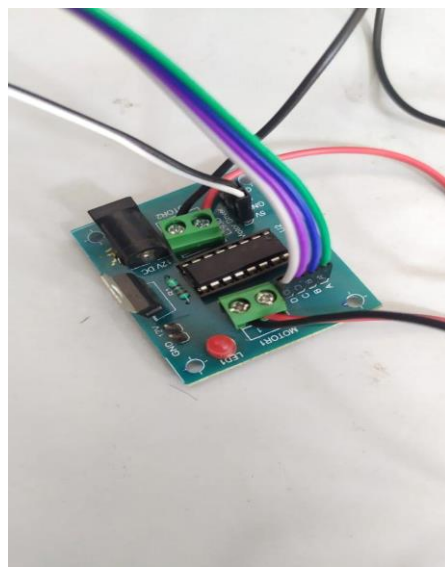


Fig 4.1.3 DC MOTOR DRIVE

The **DC motor** drive is a type of amplifier or power modulator that integrates between the **controller** and a **DC motor**. It takes the low current and then converts it into a high current which is appropriate for the **motor**.

Driver circuit plays two function in this project,

- One is an auto coupler which gives constant input to the Arduino of 5 to 9 volt.
- Second one is to boost the Arduino output of 5v to 12v to the MOSFET which makes it work.

4.1.4 BLUETOOTH MODULE

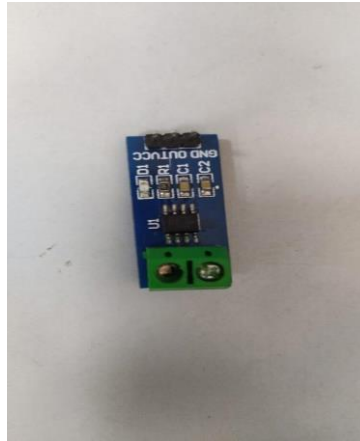


Fig 4.1.4 BLUETOOTH MODULE

The Bluetooth module acts as a wireless control of the boat using a simple mobile application. The range of the Bluetooth module is 5 to 10 meter range.

4.1.5 LEAD ACID BATTERY



Fig 4.1.5 LEAD ACID BATTERY

A 12v lead acid battery is used to power the components which are used in this project. These types of batteries are easy to charge and discharge. This is a high performance sealed maintenance free battery with constant Voltage Charge (12V/1.3Ah). These lead acid batteries are sealed maintenance free batteries. The output current of a constant voltage charger will reduce as the battery charges. So the battery will take around 8 hours to reach 80% capacity. There will be no loss in power output over the battery life. Low self-discharge of about 2-3% per month compared with 20-30% for more common battery systems. Quality construction with no compromise on materials to ensure a long service life. Low internal resistance means a high discharge rate. Wide operating temperature range operating between -15°C to $+50^{\circ}\text{C}$ when fully charged.

4.1.6 SOLAR PANEL

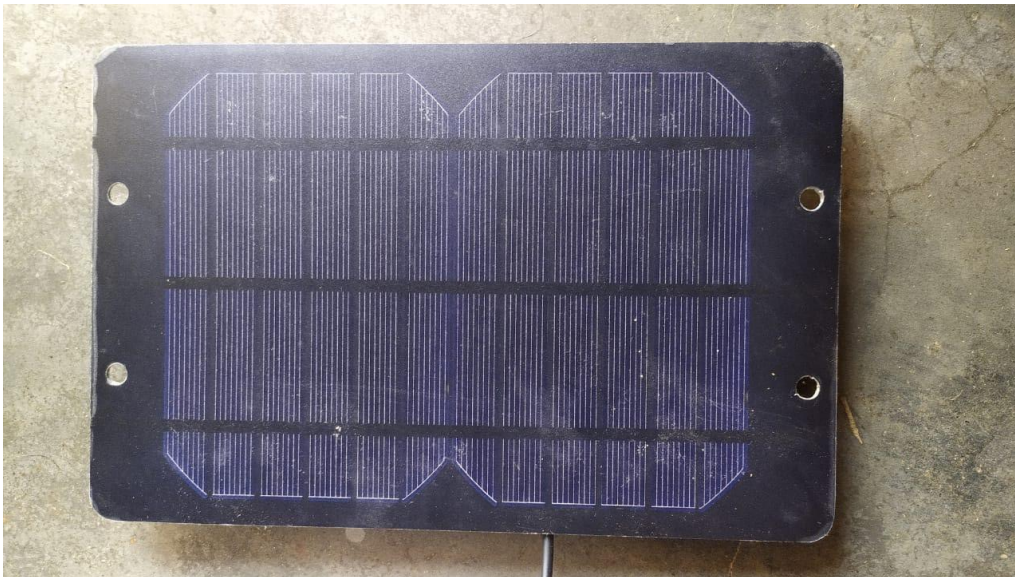


Fig 4.1.6 SOLAR PANEL

The solar panel of 5 v/500mah is used in this project which gives the power to the boat and charges the battery for backup power. This is the main power source of the boat and also a renewable source.

4.1.7 ARDUINO

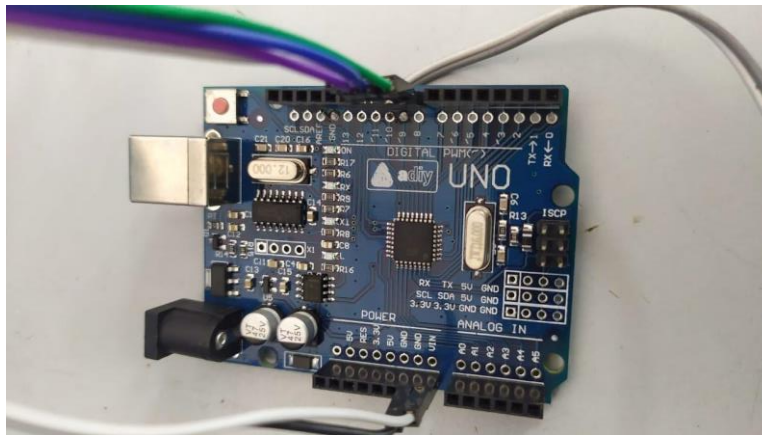


Fig 4.1.7 ARDUINO

In this prototype, two Arduino are used controlling, one Arduino is used to maintain the PWM pulse which is connected to the MPPT circuit to ensure constant output. Another Arduino is used to control the motor driver circuit and also for the Bluetooth module to control the direction of the motor by using the mobile application. Arduino is an open source electronics platform based on easy to use hardware and software. It is used to control the sensors and other hardware devices. In this project we are using two Arduino.

- One of the Arduino is used to maintain the PWM pulse which is connected to the MMPT to ensure that the constant output is getting or not.
- Second one is used to control the motor drive which makes the boat to navigate in all the directions and also Bluetooth module is connected to the Arduino which can be controlled by a mobile application which makes it as a wireless control of the boat to turn and front, back movement.

4.1.8 PROPELLER



Fig 4.1.8 PROPELLER

The purpose of the propeller is to provide a method of propulsion so the aircraft is able to move forward through the air. The propeller itself consists of two or more blades connected together by a central hub that attaches the blades to the engine shaft.

4.2 HARDWARE RESULT

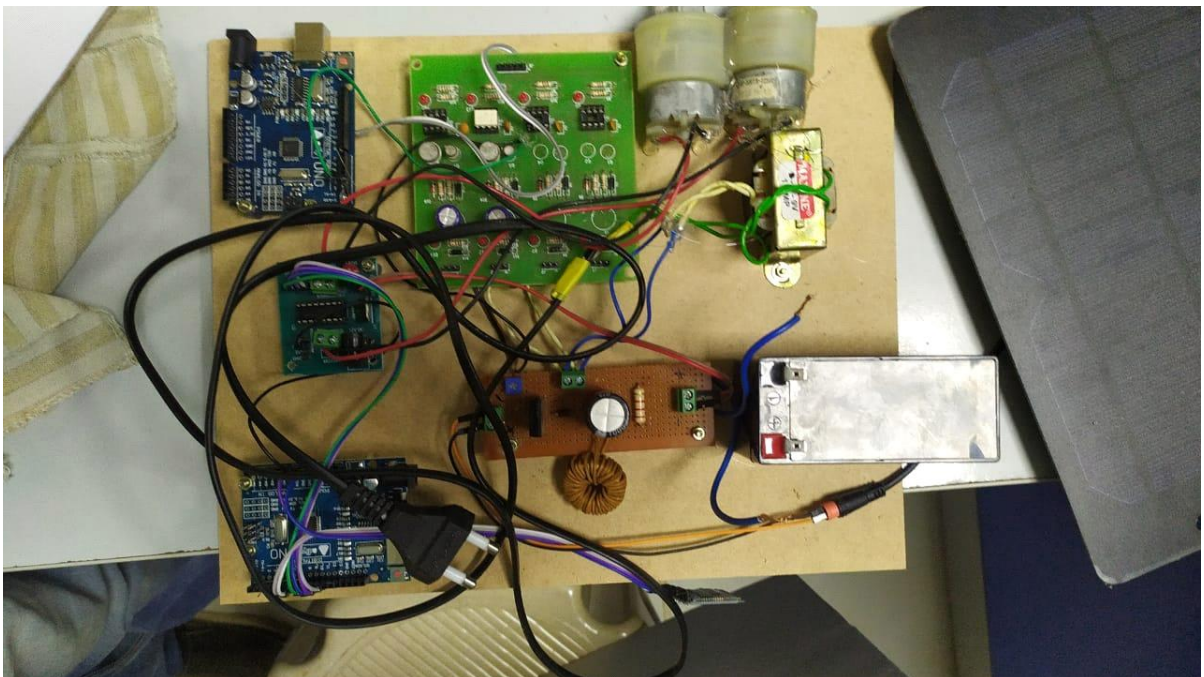


Fig 4.2 HARDWARE RESULT

CHAPTER-5

5.1 CONCLUSION & FUTURE SCOPE

5.1.1 CONCLUSION

My overall goal on this project was to research, design, build and test a solar powered model ship. I achieved all of these goals. I found out that solar panels work by using a semiconductor material like silicon to absorb energy from the sun and then two metal contacts built into the panel create an electrical circuit to use the energy from the solar panel. If I had used the first set of hulls I made, the ship probably would have sunk. The second hulls I made kept the boat high in the water and were definitely a huge improvement. The ship remained afloat during all the tests. The motor ran, it spun the shaft which in turn spun the propeller that was propelling the boat forward at about 1 meter per second (~ 3.6 km / h) .I have tested the boat working directly from the solar panels and it was even more fast though when the ship sailed in the shade and slowed down. The reason the boat was faster when in sunlight was because solar panels can produce more voltage (more than 8 volts), which means more power when in sunlight than the battery you have a maximum voltage of 6. And give the boat a good look, the rest of the boat is not really "attractive" to the eye. So in that sense, I didn't fully achieve my goal, which was to design an attractive model ship. However, after many tests, I can definitely conclude that the solar boat works.

With no power loss due to battery charging / discharging, the new design instantly improves energy efficiency by almost 28% (assuming 85% charge / discharge efficiency). Considering that 40% of the operating energy comes directly from the solar system, the new system can provide more than 50% of the energy required for daily operation on a sunny day. In addition, the cost of lithium ion battery is at least 3 times higher than AGM lead acid battery, and the large capacity lithium ion battery management system is very sensitive and vulnerable during the charging process. / download. For every five years, the ship-owner struggles to replace a new battery system due to the extremely high cost. An independent study shows that after an optimal design of a solar boat, the total cost of the solar system for a 45 foot with a lithium-ion battery can be six times more compared to the new design with

the lead-acid battery- acid. However, a weight reduction of 1000 kg is necessary for a competing vessel of this type. The mission-based design of the solar boat can accurately assess the energy balance between the battery system and the photovoltaic system. By reducing the total cost, it will definitely help to promote the solar system applied to the recreational type solar boat. Hopefully, it won't be long before we see a sustainable eco-friendly vessel operating in a beautiful landscape like Sun Moon Lake in Taiwan.

A very important part of this project was learning how I approach learning (Approaches to Learning). During this project I learned many things, not only about solar energy and information related to boat design, but I also learned more about myself. The technical things I learned through this project are: how solar panels work and how to connect them together; on battery charging and amp hours; about different types of helmets, their characteristics and effects; on electric motors and different types of propeller shafts. This technical learning was pretty easy for me.

4.1.2 FUTURE SCOPE

In the future, it is interesting to take a closer look at how to design a hardtop in such a way that it is adaptable to a wider range of boats. Since the chosen grid connection components are not common in this thesis, a detailed economic analysis of the complete powertrain, including the hardtop, must be performed for a large-scale production scenario. In addition, some future improvements could be made such as some aerodynamic elements, the design of a structure for the solar panels or the greater movement capacity of the orientation system (which in this thesis has been designed conceptually). Finally, it would be of interest to design the different components (for example, motor and batteries) to obtain product specifications that can better satisfy the market demands.

In the future, it will be used for ocean freight instead of fuel-powered ships. This makes it free from contamination and makes maintenance easier compared to More about this source text Source text required for additional translation information Send feedback Side panels History Saved Contribute 5,000 character limit. Use the arrows to translate more.

REFERENCES

- 1) Aldous, Scott. How Solar Cells Work.<http://science.howstuffworks.com/solar-cell.htm>, 2007.
- 2) B. Liu, S. Duan, F. Liu, and P. Xu, "Analysis and improvement of maximum power point tracking algorithm based on incremental conductance method for photovoltaic array," in Proc. IEEE PEDS, 2007, pp. 637–641.
- 3) Boulder, CO, Pecan et al, "Renewable Energy Based Capstone Design Applications for an Undergraduate Engineering Technology Program", Proceedings of 33rd ASEE/IEEE Frontiers in Education Conference, November 5-8, 2003.
- 4) G.C Hsieh, C.Y. Tsai, and H.I. Hsieh, "Photovoltaic Power-Increment Aided Incremental Conductance Maximum Power Point Tracking Controls," in Proc. IEEE PEDG, pp. 542-549, Aalborg, Denmark, 2012.
- 5) G.C.D. Sousa, D.S.L. Simonetta, and E.E.C. Norena. Efficiency optimization of a solar boat induction motor drive. In Industry Applications Conference, 2000. Conference Record of the 2000 IEEE, volume 3, pages 1424–1430 vol.3, 2000. Doi: 10.1109/IAS.2000.882071
- 6) G. Louis, F. P H Wouters, G. M. Koerts, and T. C J Van der Widen. Monitoring results of PV for electric propulsion in recreational boating. In Conference Record of the 24th IEEE Photovoltaic Specialists Conference, volume 1, pages 1157–1160 vol.1, 1994.doi: 10.1109/WCPEC.1994.520168.
- 7) G. Schirripa. Spagnolo, D. Papalillo and A. Martocchia, "Eco friendly Electric Propulsion Boat," 10th International. Conference on Environment and Electrical Engineering, Rome, 8-11 May 2011, pp. 1-4. doi:10.1109/EEEIC.2011.5874699
- 8) Kruschandl, Nelson. Solar boats.http://www.solarnavigator.net/solar_boats.htm, 2007.
- 9) K. Hochkirch and V. Bertram, "Options for Fuel Saving for Ships," Mare Forum 2010: Maritime Transportation of Energy, Houston, and 19 February 2010.

- 10) Letellier, "High Power Permanent Magnet Machines for Electric Propulsion Drives," Proceedings of 3rd International Symposium on All Electric Ship, Paris, 27 October 2000, pp. 126-132.
- 11) McKinney M.L., Scooch R.M., Environmental Science: Systems and Solutions, Jones and Bartlett Publishers, 1998, pp.446-447.
- 12) R. A. Dunstan, http://www.solarnavigator.net/transatlantic_21.htm "Smart Battery Providing Battery Life and Recharge Time Prediction," US Patent No. 5565759, 1996.
- 13) R. Leiner. Research solar power boat - data management and online visualization. In AFRICON 2007, pages 1–5, 2007. Doi: 10.1109/AFRCON.2007.4401548
- 14) R. A. Dunstan, "Smart Battery Providing Battery Life and Recharge Time Prediction," US Patent No. 5565759, 2019
- 15) S. D. Shroff, "Currents of Change Electric Ship Propulsion Systems," IEEE Power & Energy Magazine, Vol. 9, No. 4, 2011, pp. 30-37. doi:10.1109/MPE.2011.941319
- 16) S. H. Koi and R. M. Chao, Photovoltaic dynamic MPPT on a moving vehicle, Solar Energy, v. 86, no. 6, 2012, pp. 1750 – 1760.
- 17) Shi, J., Lee, W.-J., Liu, Y., Yang, Y., & Wang, P. (2012). Forecasting Power Output of Photovoltaic Systems Based on Weather Classification and Support Vector Machines. IEEE Transactions on Industry Applications, 48(3), 1064–1069.
- 18) Spangle G S, Papalillo D, Martocchia A and Makara G 2012 Solar-Electric Boat Journal of Transportation Technologies 02 144–9.

Geotagged photos

