THE FASTEST AND HIGH POWER POINT DETECTION SYSTEM FOR A PV ARRAY OF AIR CONDITIONING SYSTEM USING BLDC MOTOR DRIVE

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Abstract - *Solar energy is a sole form of renewable energy source that has a high demand of utilization for numerous environmental benefits. A DC microgrid with EMS system is designed and validated using MATLAB/SIMULINK. It majorly consists of three sources(namely solar, wind and diesel generator), EMS block, DC microgrid and multilevel inverter. The EMS monitors the output of all three sources. Based on the load requirement, EMS supplies the power to the load by controlling all the three sources. Solar system is designed and controlled using MPPT algorithm. Wind system is controlled using normal pulse width modulation controller. Genetic Algorithm is used to designed an Optimized energy management system. Optimization is introduced to maximize the usage of renewable resources as well to reduce the cost. The Maximum Power Point Tracking (MPPT) systems are employed in Photovoltaic systems for enhancing the solar PV panels and for maximum power extraction. A Brushless DC motor is proposed rather than the conventional DC motor which is driven by the power delivered by the solar panel and extracting this power proficiently. A Tesla coil is a radio frequency oscillator that drives the air-core double-tuned resonant transformer to generate high voltage with low current. The construction of windings of the tesla coil would be substantial effect in order to deliver the electricity to supply a load without wires in distances. We induce this tesla coil technology in dc grid as the battery power is one of the major power resources in the micro-grid which we use everyday.*

***Key Words*: Brushless DC motor (BLDC), DC microgrid EMS Block, Maximum power point tracking (MPPT), Multilevel Inverter, Photovoltaic (PV) System , Tesla coil.**

1.INTRODUCTION

On generation side, nearly 75% of electricity is produced from thermal power plant. There are 15 coal reserves in India producing 319 billion metric tons of coal every year. India's coal consumption was stated at 452.221 TOE mn in Dec 2018. In future the demand will increase more. As the demand increases the last thermal power plant in India will be closed by 2050. On other hand there are some significant disadvantages in coal fired power plant they are greenhouse gas emissions, mining destructions, generation of million tons of waste and emission of harmful substances. So India need's to work on generating electricity from renewable resources. Micro grids are used for integrating the renewable resources such as solar and wind along with the power from grid.

Renewable energy are the ones whose sources come with an unlimited supply. Nonrenewable sources of energy constitute around 75% of the worldwide energy which will gradually deplete, these sources include fossil fuels like natural gas, petroleum, oil and coal.

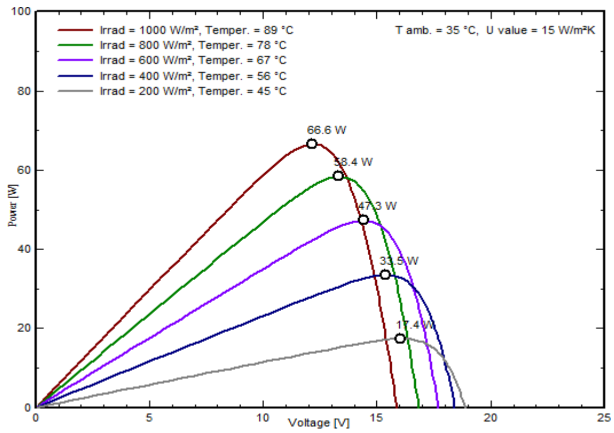


Figure.1. Solar Characteristics for Dissimilar Temperature and Irradiance Values.

In the last 50 years, the energy demand around the world has tripled due to the increasing number of innovations in technology and developing countries and is projected to triple in the next 30 years. With the advancement in power electronic technology DC microgrids are more preferred than AC microgrids including high efficiency, reliability and stability. In this paper, the optimized energy management system is designed using genetic algorithm. Optimization is performed in order to increase the usage of renewable resources as well as to reduce the cost of electricity. While in recent years, the price of solar panels are decreasing which is increasing the attention to use more solar based applications. Applications working on renewable energy sources are gaining more popularity in industries and hometown application. Aiming at the expanding agricultural requirements in a wide range of areas from the need for more efficiency, reliability, less maintenance and precise control in various agricultural equipment. Therefore, for a tropical country like India, Solar powered BLDC motor will be most suitable with the profuse solar energy available throughout the year. The Brushless DC motor is one of the best possible choices for applications that require better efficiency, enhanced reliability and impressive power to volume ratio. For solar PV based application, BLDC motor is neck and neck with any other motor used in applications such as pumping as it delivers superior performance of motor while in action in addition to a soft starting. The inclination angles of the Solar Panel can be seen in the Table

TABLE I

INCLINATION OF PV PANEL AS PER TIMING

Time	Angle
Before 9:00	0
9:00 to 10:00	15
10:00 to 11:00	30
11:00 to 12:00	45
12:00 to 13:00	58
13:00 to 14:00	68
14:00 to 15:00	78
15:00 to 16:00	88
16:00 to 17:00	99
17:00 to 18:00	113

1.1 FLOW DIAGRAM

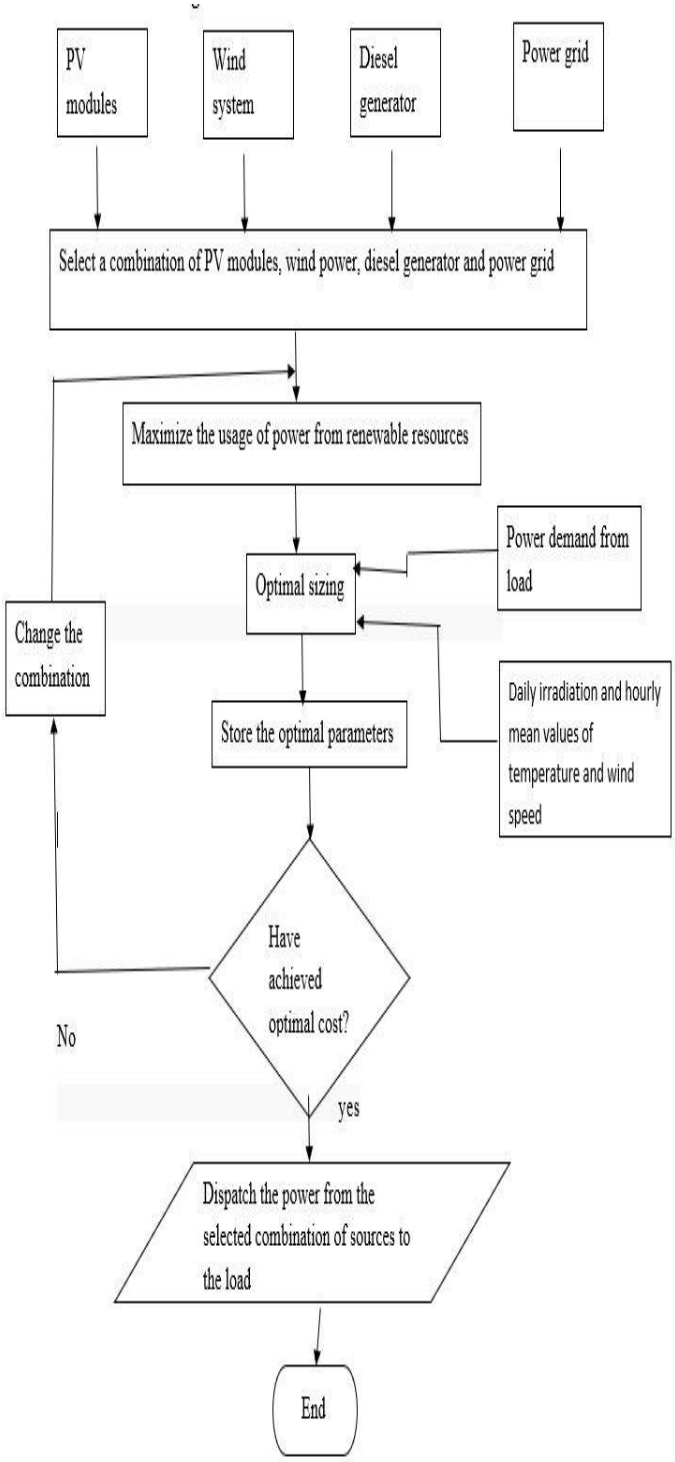


Figure 2: Flow diagram

The above flow chart illustrates the step by step process of the system. This chart is an activity chart which consists of initial user node and final destination node.

2. EXISITING SYSTEM

2.1 Green Energy Corridor

POWERGRID evolved a complete plan for integration of renewable capacity addition envisioned in the 12th plan as part of "Green Energy Corridors" report. In the 12th plan, around 43GW of capacity is envisaged, mostly from wind and solar, in eight renewable-rich states. Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, Gujarat, Rajasthan, Himachal Pradesh and Jammu and Kashmir. The idea includes Intra State as well as Inter-state transmission strengthening and other related infrastructure like dynamic reactive compensation, energy storage, smart grid applications, forecasting of renewable generation, real time monitoring, formation of renewable energy management Centre, electric vehicles, investment etc. It also covers the outlook plan for integration of renewables by 2030.

2.2 Physical Structure

Wind and Solar generation by its inherent features are variable in nature and poses severe challenge to Grid security and system solidity. To enable the renewable integration into the Grid, transmission and balancing reserves are mandatory. Balancing reserve requirements, sources of balancing reserves, and the impact on system stability due to intermittent and variable generation were investigated in the report "Renewable Energy Integration Transmission as an Enabler".

3. PROPOSED SYSTEM

A DC microgrid with EMS system is designed and validated using MATLAB/SIMULINK. It majorly consist of three sources (namely solar, wind and diesel generator), EMS block , DC microgrid and multilevel inverter. The EMS monitors the output of all three sources. Based on the load requirement, EMS supplies the power to the load by controlling all the three sources. Solar system is designed and controlled using MPPT algorithm. Wind system is controlled using normal pulse width modulation controller. Similarly, diesel generator is controlled. Genetic Algorithm is used to designed an Optimized energy management system. Optimization is introduced to maximize the usage of renewable resources as well to reduce the cost. The step by step process of genetic algorithm is already described above.

- Solar system is designed with MPPT algorithm in order to maximize the output of solar panels by tracking the maximum power point. The output is DC so the output power is directly given to EMS .

- The output of wind is AC but it is fluctuating in power as well as the frequency . so, it is converted into DC and fed to the grid. the output power is also given to the EMS.

- The output of diesel generator is also converted into DC and fed into microgrid.

EMS performs the economic load dispatch model by monitoring all the outputs of power sources as well as the power grid.

DC power from the microgrid is converted into AC using five stage multilevel inverter. By using multilevel inverter total harmonic distortions are reduced.

3.1 Solar Charge Controller

A charge controller, also known as a charge regulator is basically a voltage and current regulator, to prevent batteries from overcharging due to solar arrays. It . A solar charge regulator is very crucial and is needed to prevent overcharging of the battery. Most of the 12-volt panels always supply 17 volts because if it was 12 volts, then it works under the perfect conditions, which does not happen in all places. The extra voltage supplied by the panel caters to when the sun is low or when covered by heavy clouds so as to ensure output voltage to the battery. The charge controller prevents deep discharge by protecting the battery from overcharging and disconnecting the load. Preferably, charge controller directly controls the state of the battery.. This technique allows the current to be effectively tapered and the result is corresponding to constant voltage charging . Without the charge controller, the current from the PV panel will flow into a battery proportional to the irradiance, whether the battery needs to be charging or not. If the battery is fully charged, the unregulated charging will cause the battery voltage to reach tremendously high levels, causing electrolyte loss, internal heating and rapid grid corrosion. Therefore, charge controller maintain the health and extend the life time of the battery.

3.2 Types of Solar Charge Controllers

Pulse Width Modulation (PWM) and Maximum Power Point Tracking (MPPT) are the two types of charge controllers most widely used in today's solar power systems. Both regulates the charging rates depending on the battery's maximum capacity as well as monitor the battery temperature to prevent overheating [8].

3.3 Pulse Width Modulation (PWM) Charge Controller

By adjusting the duty ratio of switches(MOSFET), Pulse width modulation charge controller is the most effective to attain the constant voltage battery charging. In Pulse width Modulation charge controller, the current from the solar panel tapers in line with the battery condition and recharging needs. When a battery voltage reaches the regulation set point, the PWM algorithm gradually decreases the charging current to avoid overheating and yet charging continues to returning the maximum amount of energy to the battery in the shortest amount of time.

The PWM controller (Pulse Width Modulation) is a switch that connects the solar panel to the battery. The panel and the battery will be nearly at the same voltage when the switch is closed. For a discharged battery, the initial charge voltage will be about 13volt, and a voltage drop of 0.5V through the wiring and controller, the panel will be at =13.5 volt. The voltage will be gradually increases with increasing the state of charge of the battery. When the absorption of voltage is attained, the PWM controller will starts to disconnect and reconnecting the panel to prevent overcharging[9].

3.4 Maximum Power Point Tracking (MPPT) Charge Controller

Nowadays, Maximum Power Point Tracking is the most progressive solar charge controller. It is more complicated and costly. It has several advantages over the Pulse width modulation charge controller. At low temperature, it is 30 to 40% more effective. The Maximum power point tracking is based around a synchronous buck converter circuit. It will adjust its input voltage to yield the maximum power from the solar panel and then renovate this power to supply the varying voltage requirement of the battery and load. It is generally accepted that MPPT will outstrip PWM in a cold temperature climate, in a subtropical to tropical climate, both controllers will show approximately the same performance. The MPPT charge controller is a DC to DC transformer that can transform power from higher voltage to power at lower voltage [9]. The amount of power doesn't change, therefore, if the output voltage is less than the input voltage, the output current would be greater than the input current, so that the product P=VI remains constant. As a result, in order to get the maximum out of a solar panel, a charge controller must be able to choose the best current-voltage point on the current-voltage curve; the Maximum Power Point.

3.5 Component Selection for Controller Design

In light of the prior appraisal of design styles, the following components will be an important part of design and hence, their importance and working principles are deliberated. A list of essential components required to carry out the design on this project are as follows.

(i) Diodes: These are simply blocking diodes which ensure that the current flow in only one direction, so that the battery does not discharge when the output from the solar panel is low.

(ii) Zener Diodes: This part of the circuit guarantees that once the charging cut off voltage is reached by the battery, the charging stops. The breakdown voltage of the Zener diode is rated as 6.8 volts.

(iii) MOSFET: The metal-oxide-semiconductor field effect transistor is used to amplify or switching the electronic signals. It protections to cut off the load in low battery level or an overload conditions.

(iv) Transistor: It is used to circumvent the solar energy to a dummy load although the battery gets completely charged. Once the batteries are fully charged, it illustrate all the current and thus shielding the battery.

(v) Indicators : Indicators are provided by a green LED indicates that the battery is fully charged, while a set of red LED are used to indicate under charged, overcharged and profound discharge conditions.

(vi) LM317: It's a three terminal modifiable voltage regulator which can supply an output voltage ranging from 1.2volts to 37 volts. It will supply more than 1.5 amps of load current to the load. We can modify the voltage by changing the value of the resistor connected to a pin of the voltage regulator. These resistors administrate the voltage that the voltage regulator adjusts to an outputs.

4. Design of Solar Charge Controller

Based on the circuit diagram of Figure. 3, the design is as follows

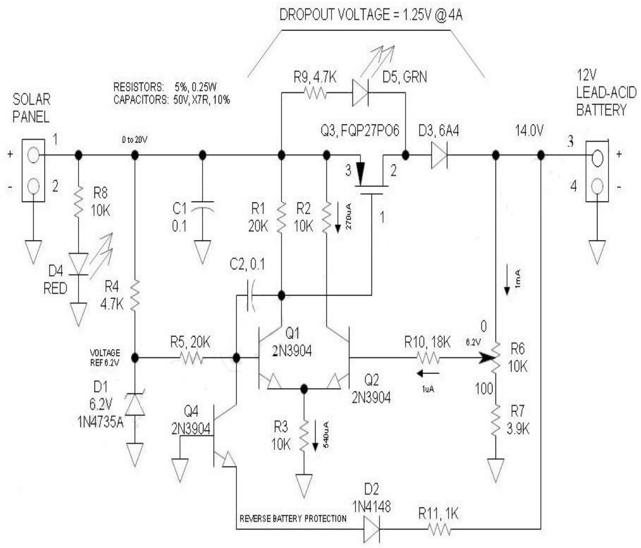


Fig.3. Circuit design of Solar Charge Controller

solar charger controller circuit using transistors makes use of a basic differential amplifier along with series P channel MOSFET linear regulator. Voltage output is flexible. It will be primarily intended for charging the 12volt lead-acid battery.

4.1 Observations

The appropriate connection of the solar panel and battery leads to their respective terminals on the solar charge controller, the power and undercharging LED turned ON to specify the battery charging. The optimal charge LED turns ON indicating full charge and undercharge LED turns OFF indicating that no current is getting to the battery. This work has produced a low cost, consistent and functional solar charge controller, using locally sourced and available components. This proposed system worked satisfactorily and can be used in a solar home system to solve problems of power supply.

5. Tesla Coil Working

Tesla coil uses a specialized transformer called a resonant transformer or radio-frequency transformer, or an oscillation transformer. The principle behind the Tesla coil is to attain a phenomenon called resonance. Tesla coil is a high frequency oscillator that drives in air core doubled tunned resonant transformer to generate high voltage at very low current for producing the oscillation. The tesla coil can yield the output voltage from 50kv to several million volts.

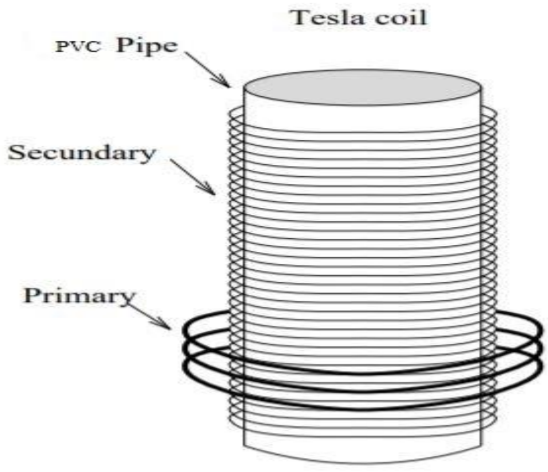


Fig.4. The Tesla Coil

The primary coil is connected to the power supply and the secondary coil of a transformer is coupled loosely to ensure that it resonates. The capacitor connected in parallel with the transformer circuit acts as a tuning circuit or LC circuit to produce signals at a specific frequency. With the accumulation of enormous amounts of charge in the capacitor, eventually, breaks down the air of the spark gap. The capacitor emits a enormous amount of current through the Tesla Coil (L1, L2), which in turn generates a high voltage at the output.

5.1 Oscillation Frequency

A tuned circuit is formed by the combination of a capacitor and the primary winding'L1' of the circuit. This finely tuned circuit ensures that both primary and secondary circuits are resonate at the identical frequency. The resonant frequency of the primary 'f1' and secondary circuits 'f2' and are given by,

$$f1=1/2\pi\sqrt{L1C1}$$

$$f2=1/2\pi\sqrt{L2C2}$$

As the secondary circuit cannot be adjusted, the moveable tap on 'L1' is used to tune the primary circuit till both the circuits resonate at the identical frequency. Therefore, the frequency of the primary is same as the secondary.

$$f = 1/2\pi\sqrt{L1C1} =1/2\pi\sqrt{L2C2}$$

The state for primary and secondary to resonate at the identical frequency is,

$$L1C1= L2C2$$

The output voltage in the resonant transformer doesn't depend on on the number-of-turns ratio as in ordinary transformer. As soon as the cycle commences and as the spark sets up The primary capacitor 'C1' stores the primary circuit energy, and the voltage at which the spark breaks down is 'V1'.

$$W1=1/2C1V1^2$$

Similarly, the energy in the secondary coil is given by,

$$W2=1/2C2V2^2$$

Consider if there is no loss of energy, W2 = W1. Simplify the above equation, we get

$$V2 = V1\sqrt{C1/C2} = V1\sqrt{L2/L1}$$

In the above equation, the peak voltage can be attained when air break down does not occur. The peak voltage is the voltage at which the air break down and starts to conduct.

5.2 Applications of Tesla Coil

At present, these coils doesn't require large complex circuits to produce high voltage. However, small Tesla coils find their applications in a range of sectors.

•It is used in Aluminum welding.

•Cars use the tesla coils for the spark plug ignition.

•Created Tesla coil fans, used to produce artificial lighting, sounds like music Tesla coils in Entertainment and Education industry are used as attractions at electronics fairs and science museums.

• High voltage generation with relatively high power level.

6. RESULTS AND DISCUSSION

6.1 TESLA COIL TESTING

Fig.6. Tesla coil testing using Fluorescent Bulb

Fig. 6. shows the fluorescent bulb was light up with full brightness after several troubleshoot has been done to the driver circuit and primary coil. The troubleshooting stage consists of correcting the tap point of the primary coil.

6.2 SIMULATION RESULTS

A DC microgrid with EMS system is designed and validated using MATLAB/SIMULINK. It majorly consist of three sources (namely solar, wind and diesel generator), EMS block , DC microgrid and multilevel inverter. The EMS monitors the output of all three sources. Based on the load requirement , EMS supplies the power to the load by controlling all the three sources. Solar system is designed and controlled using MPPT algorithm. Wind system is controlled using normal pulse width modulation controller. Similarly diesel generator is controlled. Genetic Algorithm is used to designed an Optimized energy management system. Optimization is introduced to maximize the usage of renewable resources as well to reduce the cost. The flow process of genetic algorithm is already described above.

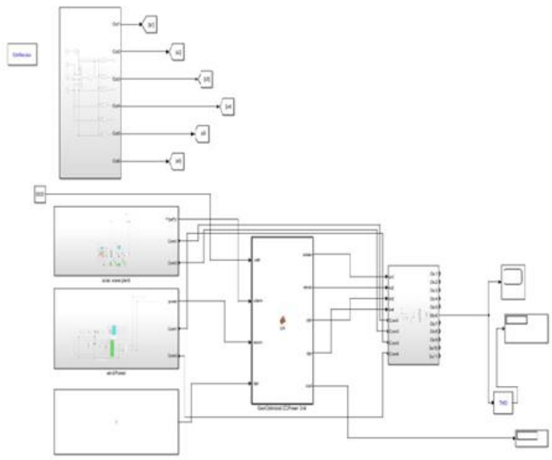
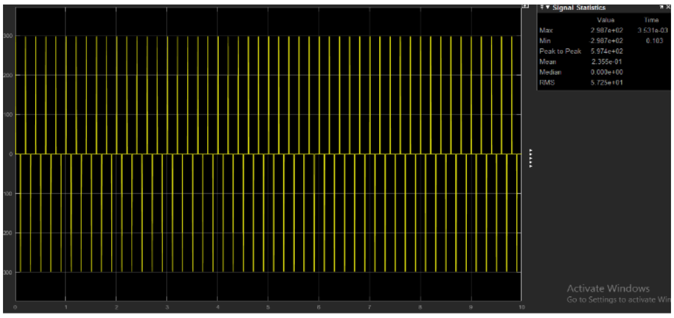


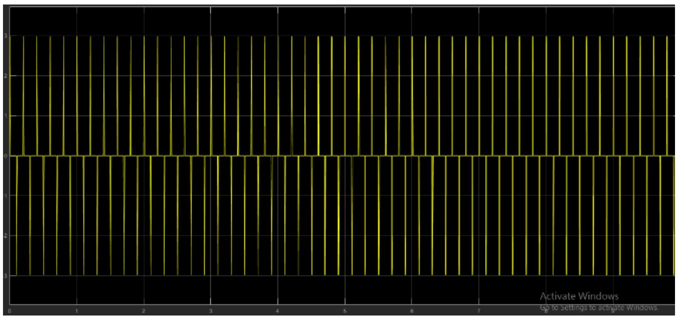
Fig.7. MATLAB Simulink For The DC Grid

EMS preforms the economic load dispatch model by monitoring all the outputs of power sources as well as the power grid. DC power from the microgrid is converted into AC using five stage multilevel inverter. By using multilevel inverter total harmonic distortions are reduced.

LOAD VOLTAGE



LOAD CURRENT



6.3 HARDWARE SETUP

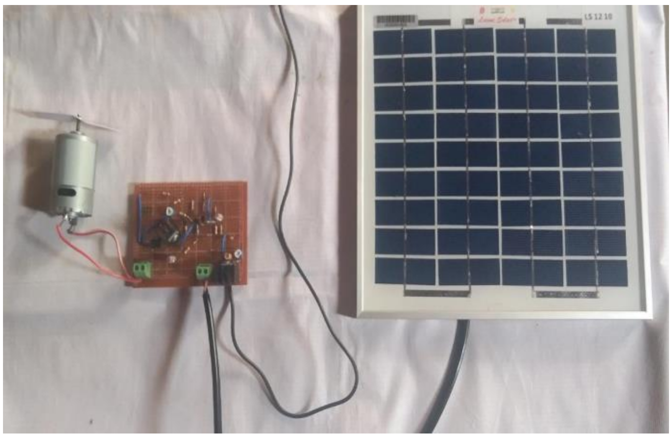


Fig.8. System Setup

7. FUTURE SCOPE

The system can be implemented for various other application purposes. Also, many modifications can be made to the system to be used to its maximum potential. The main resolution of the system is to provide for real-time applications in the field of agriculture such as for drones, land mowers, and irrigation mechanisms such as sprinklers, water pumps, electric vehicles. Depending on the application or on field requirement, the motor speed control can also prove to be a beneficial addition. With the use of more advanced technology and approach we can make the panel omnidirectional to absorb the extreme solar energy and not just capable of moving from east to west.

8. CONCLUSIONS

This paper proposes renewable based DC microgrid with an optimized energy management system. In order to support microgrid owners, cost optimization is achieved using a genetic algorithm. The main problem in DC to AC conversion involves harmonics distortion, by using five stage multilevel inverter harmonics level is reduced and power quality is improved. Increasing Electricity demand cannot be controlled in the developing nation. Renewable resources such as solar and wind are available everywhere, renewable based DC microgrids can be introduced in all companies and shopping complexes to satisfy the load demand. This system integrates technologies from diverse domains such as Renewable Power Systems, Embedded Systems and Electrical Engineering for tracking Maximum Available Power, extracting it from the grids intelligently and supply it to a load in the form of Brushless DC Motor running at maximum power keeping in mind various factors such as Durability, Efficiency and Sustainability. Tesla Coil Testing was made after the construction processes was completed. In addition, the magnifying coil is successfully capturing the flux that generated from Tesla Coil transfers the energy to the load over a 10cm of distance. Thus the objective to describe the ability of winding coils construction in order to provide electricity to supply a load without wires in distances is achieved. Moreover, it proves that the number of turn is a most significant parameter that should be considered in order to ensure the apparatus of wireless power transfer function efficiently. The number of turn affect the number of flux produce and thus, it will affect the number of flux lines that generated by the Tesla Coil.

9. ACKNOWLEDGEMENT

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