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Solar Powered Smart Agriculturing

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ABSTRACT
The greater usage of fossil fuels and increasedcarbon emissions, which hasten their rapid depletion, inducesconsumers to switch to renewable energy. Traditional irrigationtechniques may be expensive or environmentally harmful. Inlight of this, conversion to renewable energy sources, like solarenergy, can resolve this problem. Solar energy is widely usedin a wide range of applications since it is user-friendly andenvironmentally friendly. Yet, many rural areas of India continueto use conventional irrigation systems, such as diesel pumps,for irrigation. They are neither economical nor environmentally favourable. It releases a significant amount of hazardous gases,such as carbon dioxide. Farmers can operate a water pumpeffectively and sustainably by adopting a solar photovoltaic-based water pumping system. With the use of moisture sensors,scientific irrigation methodology is implemented, makingirrigation more efficient. In comparison to current technologies,this system is reliable, economical, and capable of increasingagricultural productivity levels. The requirement for labour is also decreased by irrigation automation and wireless control.In this, a permanent magnet DC (PMDC) motor-drive powersthe water pump. Outside in the field plains, moisture sensorsare being installed to keep track of the wetness in the soil. Themicrocontroller uses the information from the sensors to regulatethe pump's operation.
Keywords—solar photovoltaic, moisture sensors, permanent magnet DC (PMDC) motor-drive

1) Introduction

The agricultural economy in India is primarily reliant onmonsoons for natural irrigation. Pumps are used to providewater for farming. Farmers rely on grid electricity or dieselgenerators to power the pump, causing significant delays andeconomic stress. As a result, an efficient irrigation system likethe Solar Water Pump is a huge help to farmers. A stable andclean water supply is a basic requirement, but many peopledo not have it.

Solar water pumps are water-supply device that is both sociallyand environmentally appealing. Solar power is frequently themost cost-effective option, especially in isolated locationswhere power lines are inaccessible. Solar water pumps can replaceexisting pump systems, resulting in both socioeconomicand climate-related benefits. The water supplied by the solarwater pump can be used to irrigate crops, water livestock, orsupply potable drinking water. A solar water pump systemis simply an electrical pump system that is powered by oneor more photovoltaic (PV) panels. The continuous emissionof carbon and increased use of fossil fuels which is leadingto its faster depletion encourage instant consumers to adoptrenewable energy.

Conventional methods for irrigation can either be expensive orcan lead to environmental damage. Considering this, switchingto renewable energy sources such as solar energy can resolvethis situation. Because of its simplicity and environmentalfriendliness, solar energy is utilized widely in many diverseapplications. Other than the traditional irrigation system usedin rural areas diesel pumps are used for irrigation in manyparts of India. They are neither cost-effective nor ecofriendly.It emits a huge amount of carbon dioxide and other toxic gases.A solar photovoltaic-based water pumping system enablesfarmers to run a water pump energy efficiently usingsustainable technology. Scientific irrigation methodology isincorporated with the help of a moisture sensor. Comparedwith the existing technologies this system is reliable, cost-effective,and can raise levels of agricultural productivity.

Irrigation automation and wireless control also decrease the demand for labor. A permanent magnet DC (PMDC) motor drive powers the water pump in this case. Moisture sensorsare being deployed outside on the field plains to monitorsoil moisture. The pump's operation is controlled by themicrocontroller using information from sensors. A basic solarpumping system is made up of a solar panel array that powersan electric motor, which in turn powers a bore or surface pump.Because water is frequently pumped from the ground or streaminto a storage tank that offers a gravity feed, these systems donot require energy storage. Water pumps that run on fossilfuels are commonly used to irrigate fields and crops.

The system can be advanced in the future by providing smartirrigation technology such as drip irrigation. Sensors can beprovided for monitoring the growth of the plant and detectingcrop-damaging micro and macro-organisms in plants alongwith watering systems. In addition to this various other sensorsuch as humidity, light detection, plant growth, etc also canbe integrated with the circuit. To reduce reliance on traditionalagricultural irrigation methods, the agriculture sector can successfullyapply recent breakthroughs in renewable energy byapplying these techniques.

Moisture sensors and Free Cloud are set upin order to wirelessly and automatically control irrigation.Providing smart irrigation technologies, such as drip irrigation,will allow the system to advance in the future. Together with irrigation systems, sensors can be installed to monitor plantgrowth and find organisms in plants that can harm crops.Moreover, a variety of different sensors, including those thatmeasure humidity, light, plant growth, etc., can be added to thecircuit. By implementing these techniques, the agriculture sectorcan successfully reduce reliance on traditional agriculturalirrigation methods

2) PROPOSED SYSTEM

a) Existing System

In the irrigation of grasslands and farms, diesel-poweredpumps are often employed as the conventional methodologyof water pumping. However, if fuel supply is expensive andunpredictable, maintenance is costly, and life expectancy islow, there may be problems withaccessibility and reliabilitylimited. These problems underscore the necessity for a practicalalternative energy source for irrigational water pumping,together with more recent environmental concerns regardingdiesel engines. Diesel-powered water pumping systems have alarger detrimental effect on ecosystem quality, human health,climate change, and the depletion of natural resources.Contribution analysis was used to determine the primarycontributors to each category of environmental effects. The effects of diesel fuel pumps are 65% on natural resources,20% onhuman health, 5% on climate change, and 3% onecosystem health. On the other side, solar pumping systemshave a negative influence on ecosystem quality by 0.5%,human health by 2%, and climate change by 3.0%.

b) Proposed System

The agricultural purpose makes use of a solar-poweredwater pump. PV (photovoltaic) panels or radiant heat createdby gathered sunlight are used to power solar water pumps. Itis made up of a solar charge controller (MPPT), an array ofsolar panels, a DC water pump, electrical wires, and a waterstorage tank.PV systems capture radiant solar energy during the operationof a solar pump and convert it into electricity. The highestpossible voltage for the buck converter from the 50W PV array is 17V. In accordance with the range that the DC motor neededto operate, which was employed inthis project, the convertersteps down the voltage to 12V water. Pumping is done usinga PMDC motor. A solenoid valve maintains the flow of waterfrom the water tank. When sunlight is present during peakhours, the PV array produces power and fills the water tank.Later, the water is

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removed from the tank in accordance withthe needs. Potential energy is employed to water the crops viapipeswhile the tank is positioned overhead. Data from the fieldis transmitted through a sensor network to a microcontrollerand displayed on an LED screen. Free Cloud may be accessedby a handset (mobile)and records the power, energy, andcurrent produced by the circuit. Blynk IoT is used to displaythe data on mobile.

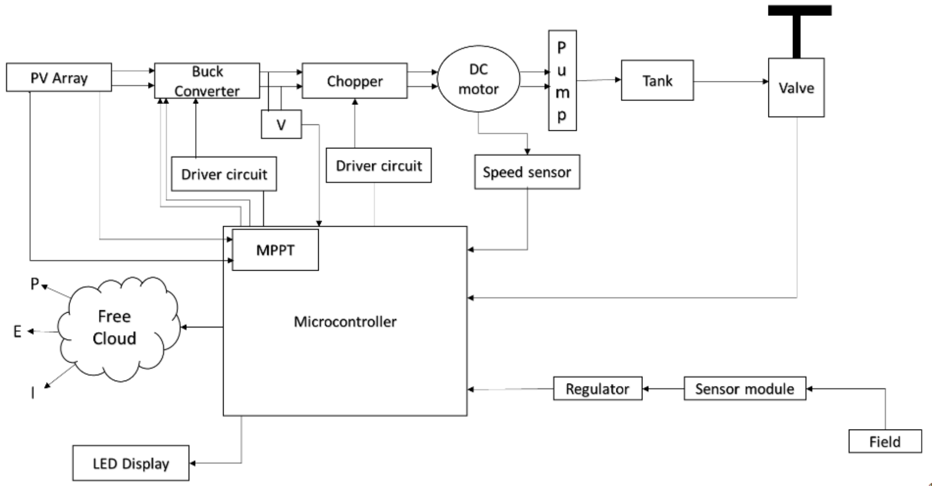

Fig 1. Block diagram

c) Simulation

A solar-powered water pump with a PMDC motor is simulatedusing MATLAB. The input to the buck converter is 17V is taken from the PV array. The buck converter bucks theinput to 12 V. The MPPT of the PV array is achieved by thePO algorithm using a DC-DC buck converter. PMDC motordrives the pump using a chopper circuit to maintain a constantload.

The simulation phases consist of 4 phases:

Phase 1: Simulation of Buck Converter

Phase 2: Simulation of Buck Converter with PV array.

Phase 3: Simulation of Buck Converter with PV array andMPPT.

Phase 4: Simulation of DC Motor Speed Control.

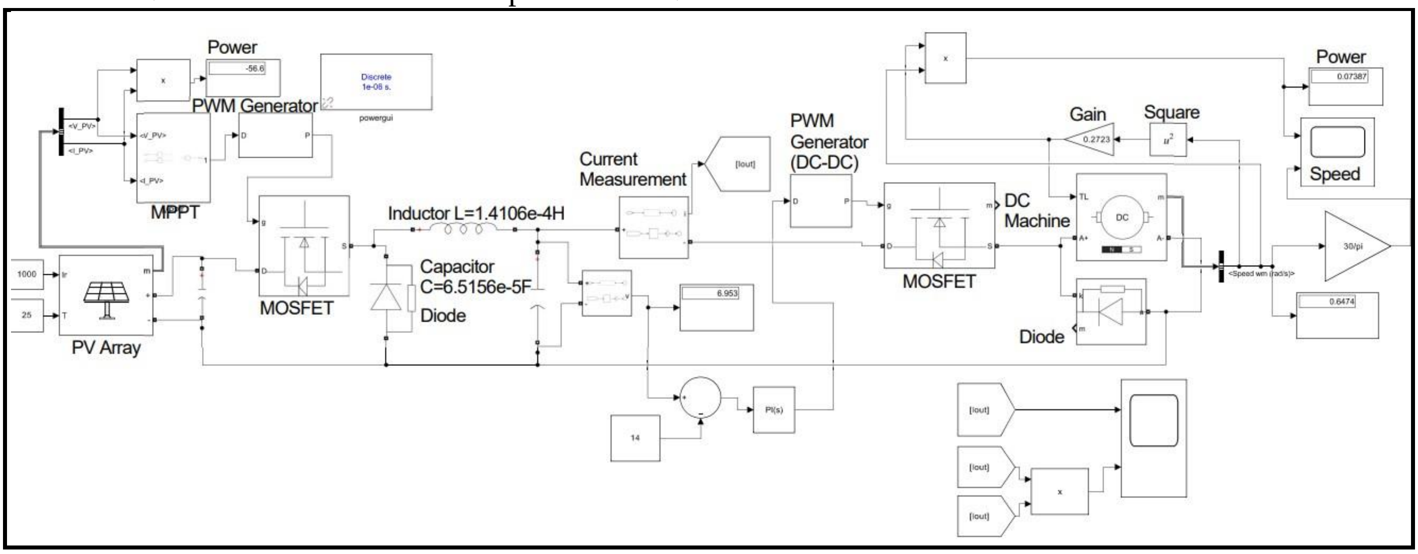

Fig. 2. Simulation Circuit

- **Phase 1**: Phase 1 is the simulation of a basic buckconverter. The required circuit parameters were obtained bydesigning the buck converter and simulating the circuit as perthe design using MATLAB Simulink. An input voltage of17V is given which gives the required output of 12V with aduty ratio of 0.705.

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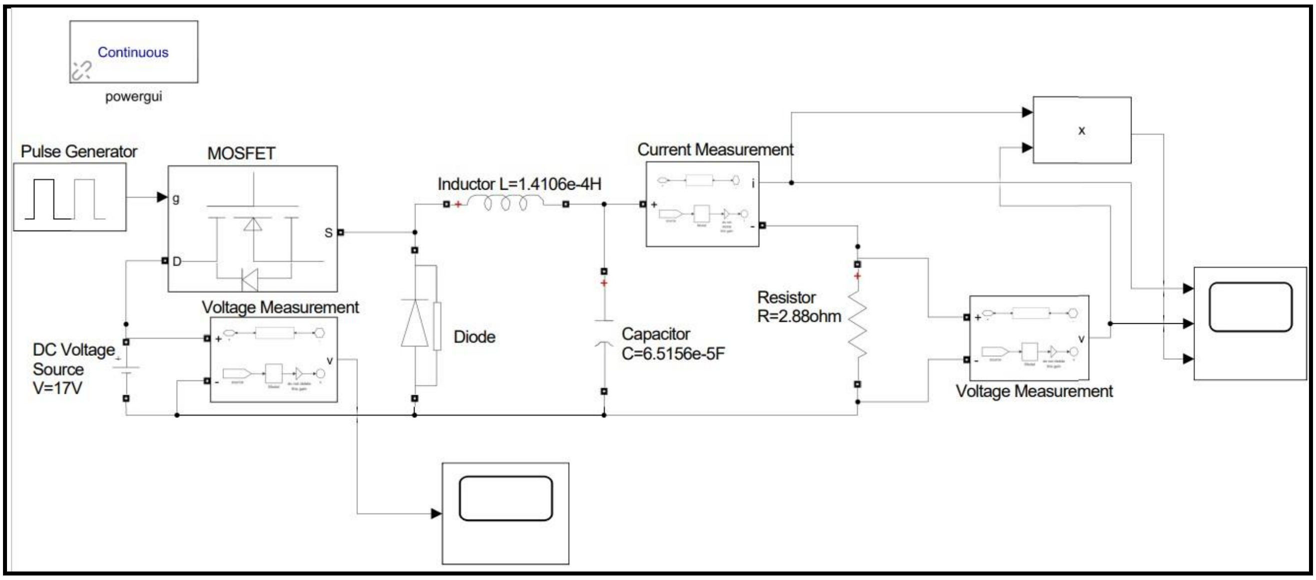

Fig. 3. Buck Converter

$$D = \frac{V_{out}}{V_{in}(max)} = \frac{12}{17} = 0.705$$

Where D is the duty ratio

$$I_{out} = \frac{P}{V_{out}} = \frac{50}{12} = 4.1667A$$

$$\Delta I_L = (0.2to0.4) \times I_{out} = 1.25$$

$$L = \frac{V_{out} \times (V_{in} - V_{out})}{\Delta I_L \times f_s \times V_{in}} = \frac{12 \times (17 - 12)}{1.25 \times 20 \times 1000 \times 17} = 141\mu H$$

f_s: Supply frequency
L : Inductance
ΔL : Inductor ripple current

$\Delta V_{out} = ESR \times \Delta I_L \; or \; 1\% V_{out}$
=1% of 12 = 0.12

$$C = \frac{\Delta I_L}{8 \times f_s \times \Delta V_{out}} = \frac{1.25}{8 \times 20 \times 1000 \times 0.12} = 65.156\mu F$$

$$R = \frac{V^2}{P} = 2.88\Omega$$

$ESR : Equivalent\ series\ resistance$

- **Phase 2**: A PV array is connected to the buck converterin the second phase. We take an average of 1000 W/m^2 ofirradiation and 25◦C. PV array provides 17 V input voltage, 12V output voltage, and 4 V output current of the buck converterwas seen. 50 W was obtained as the buck converter's

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outputpower. The maximum power point of the PV array is reached as the simulation's outcome, and PV attributes are presented. A maximum output of 50.7W and 17.67V has been attained.

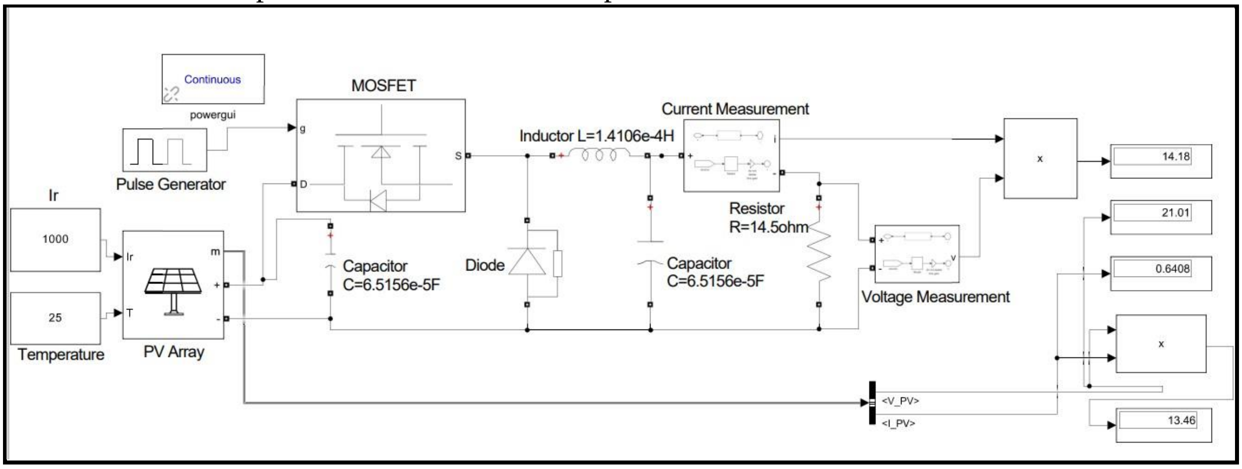

Fig. 4. Buck Converter with PV array

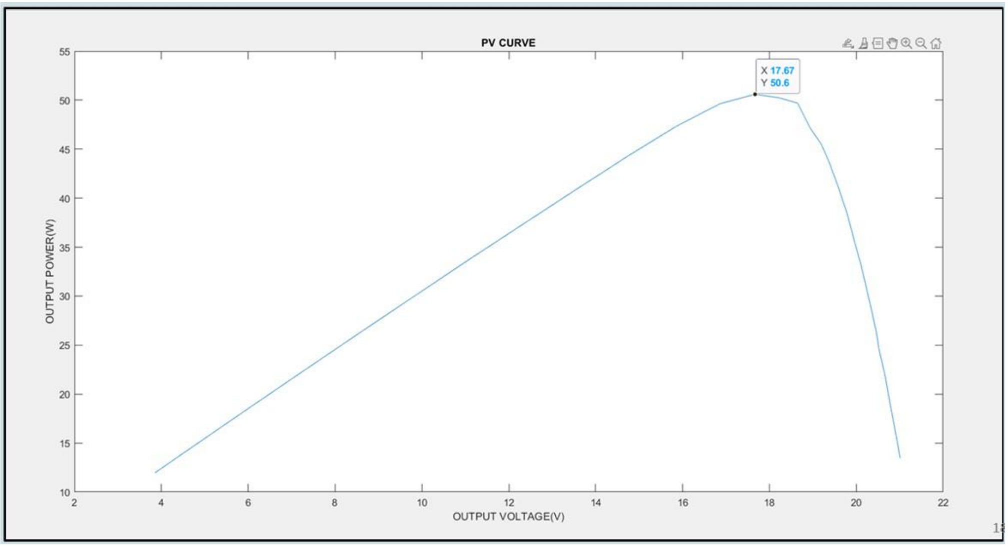

Fig. 5. MPPT-PV Curve

- **Phase 3**: The phase 2 circuit is expanded with an MPPTcontrol utilizing the Perturb and Observe algorithm. Throughthe application of this method, voltage incrementing resultsin an increase in power when an operation is performed onthe left side of the MPP and a decrease in power when theoperation is performed on the right side of the MPP. MPPTmeasured a maximum power of 50.7W at a 17.67V inputvoltage. The PV array is connected to the buck converter,and the requisite output of 50W, voltage of 17V, and current of 3A has been effectively generated.

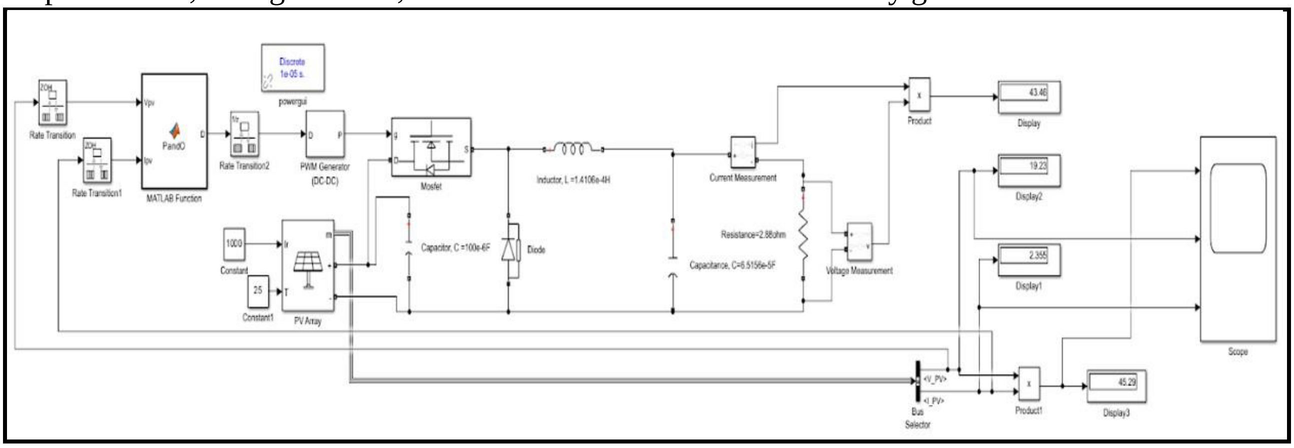

Fig. 6. Buck Converter with PV array and MPPT

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- **Phase 4**: The speed of the DC motor is varied byusing pulse width modulation (PWM). A control signal with avariable duty cycle switches the MOSFET at a fixed frequency.This enables adjustment of the average voltage across themotor, which in turn controls the rotor's angular velocity. Bycontrolling the torque characteristics of a DC motor, a speedof 4100 rpm was obtained.

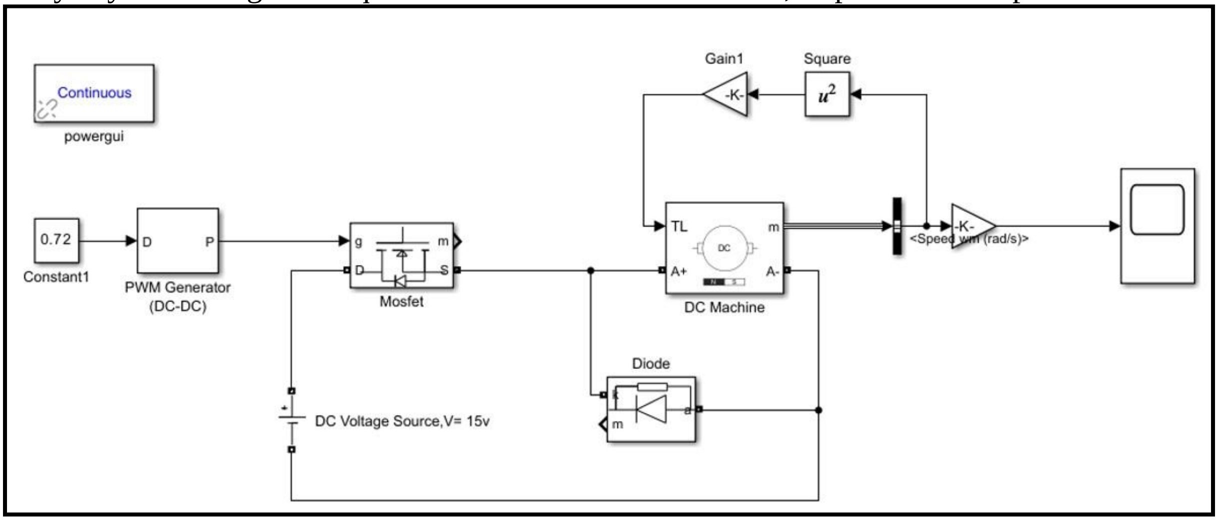

Fig. 7. DC Motor speed control

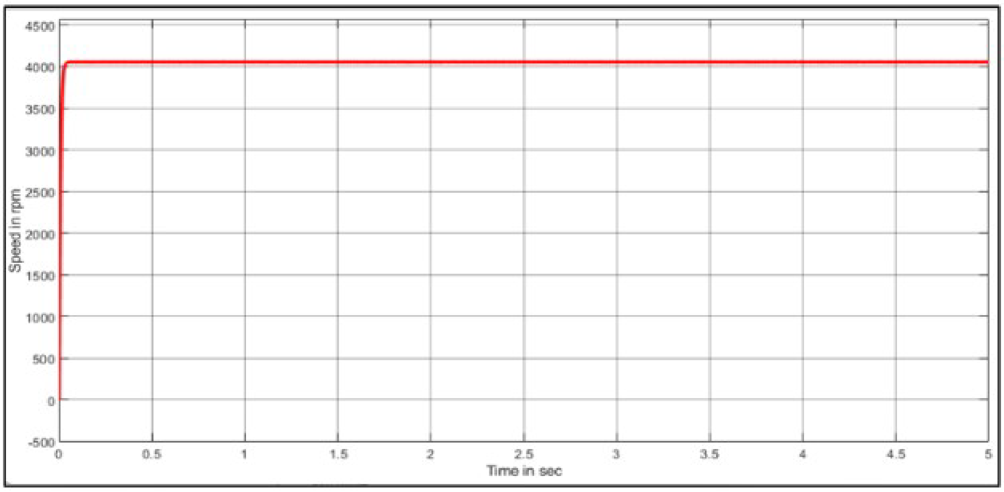

Fig. 8. DC motor output

d) Hardware

Solar water pumps are powered by either the electricitygenerated by photovoltaic (PV) panels or the radiant heatcreated by solar energy that has been captured. A solar charge controller (MPPT), a solar panel array, a DC water pump,electrical wiring, and a water storage tank make up the system.PV (photovoltaic) systems capture radiant solar energy andconvert it into electricity during the operation of a solarpump. The 50W PV array can provide the buck converter with a maximum voltage of 17V. The converter steps downthe voltage to 12V in accordance with the specifications of the DC motor utilized in this project. The circuit is linked to MPPT in order to monitor the maximum power point. In order to store water, an overhead water tank is built. The water pump is driven by a PMDC motor.

A solenoid valve keeps the water coming out of the tank flowing. The converter steps down the voltage to 12V in accordance with the specifications of the DC motor utilized in this project. The circuit is linked to MPPT in order to monitor the maximum power point. In order to store water, an overhead water tank is built. The water pump is driven by a PMDC motor. A solenoid valve keeps the water coming out of the tankflowing. During the peak time, when sunlight is available the PV array generates power and the water tank is filled. The water is later taken from the tank according to the requirement.As the tank is placed overhead potential energy is used to irrigate the crops with the help of pipes. The sensor network takes the data from the field to the microcontroller and isdisplayed through an LED display. Free Cloud tracks the power, energy, and current generated by the circuit and is obtained through the handset.

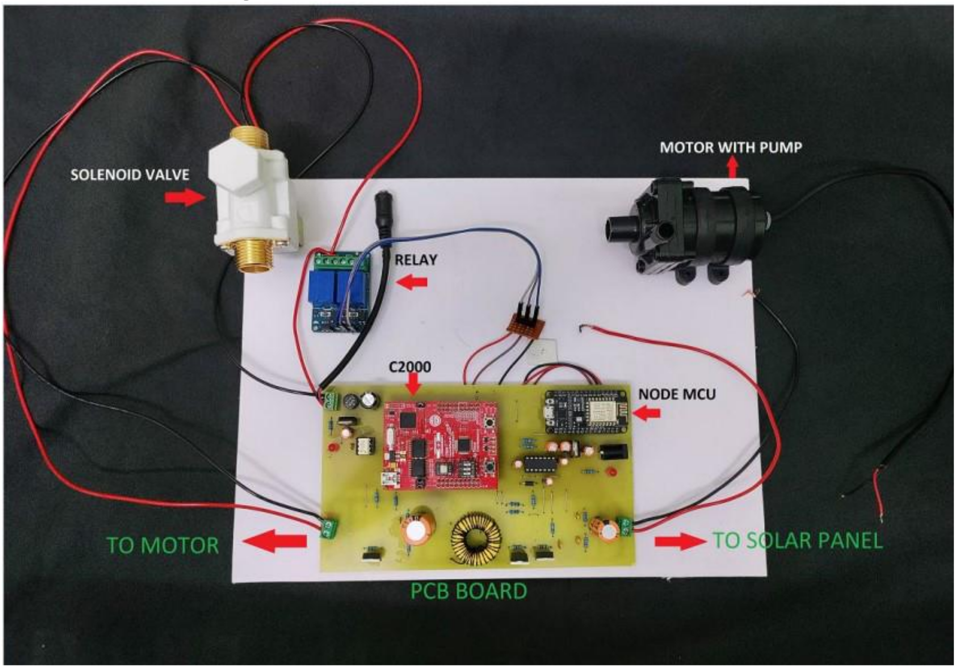

Fig. 9. Hardware Setup

3) Inference and conclusion

The primary goal of the project is to develop a waterpumping system that is sustainable, energy-efficient and supportswater conservation. Water can be pushed to the fieldeven during off-peak hours utilizing potential energy thanksto solar-powered water pumps, which allow the system to effectively use the sun's plentiful energy. The system is henceenergy-efficient. As water is the most valuable resource onearth and needs to be preserved, drip irrigation is employed inthis situation to prevent excessive water loss. A sensor module is designed inside the prototype solar-powered water pump.The system includes a moisture sensor that detects moistureand sends data to the microcontroller. Based on the detectionof moisture, the farmer gets to know about the condition ofthe soil and decides whether to turn ON the solenoid valvewith the Blynk software from the mobile. The buck converter,which reduces the 17V input voltage to 12V, is powered bythe PV array. The chopper circuit keeps the voltage out ofbalance. The intended speed is maintained via microcontrollercontrol after the speed sensor recognizes it. The MPPT isdesigned using the Perturb and Observe (PO) algorithm inorder to achieve the maximum power point. The PV generatoris managed using the MPPT method. By adjusting the torquecharacteristics, the DC motor's speed control is kept undercheck.

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