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Research

Mobile Solar Photovoltaic Water Pumping System

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Abstract:
Solar photovoltaic (PV) water pumping systems are a good alternative to traditional water pumps powered by electricity or diesel because of their low cost and environmental friendliness. These gadgets are suitable for remote places where there is no access to the power grid. Sun PV system output varies with environmental factors such as solar irradiation and temperature. This paper presents a low-cost photovoltaic water pumping system with maximum power point tracking for water harvesting in distant areas. To extract the greatest available power from PV panels, the MPPT P & O algorithm is employed. MPPT charge controller technology boosts efficiency. To increase the PV module voltages for the needed load, an MPPT DC-DC boost converter is used.

Keywords: Photovoltaic system, Mobile water pumping System, modelling, simulation, MATLAB, pumps, MPPT

Introduction:

A water pumping system needs electricity to run. An AC powered system is more economical and needs less upkeep When AC electricity is available from a neighboring power grid. However, electricity lines are few, and water supplies are dispersed over many kilometers of land in many rural locations. It is frequently too expensive to establish new transmission line and transformers at location. These areas have historically been home to windmill construction, however many of them are currently inoperable due to age and inadequate maintenance. In today's world, internal combustion engines power a large number of standalone water pumping systems.

These systems are portable and simple to set up. They do, however, have some important limitations, such as the need for frequent site visits for maintenance and fuel refills as well as the fact that diesel fuel may be occasionally expensive and difficult to come by in rural areas of developing nations. Because they have the shortest life cycle cost and are very dependable, photovoltaic systems are typically chosen in applications where electricity is not accessible and IC engines are expensive to operate.

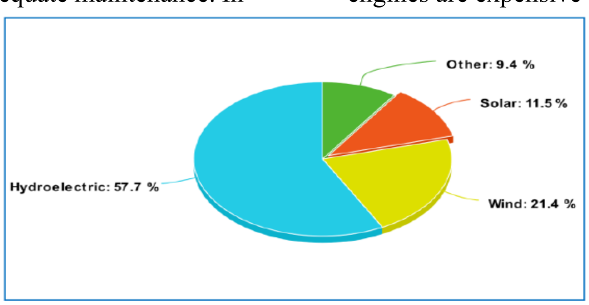

Fig. 1. Global generation of Renewable Energy 2020

Table 1. Remote Water Pumping Technique Comparison

Technology	Advantages	Disadvantages

PV Power System	• Low Maintenance • Reliable Long Life • No fuel & no fumes • Low recurrent cost • Modular system matched to need	• High capital cost • Low output during gloomy season • Low flow rate
Diesel or Gas Power System	• Moderate capital cost • Easy to install • Portable • Extensive experience available • Higher flow rate	• Needs maintenance & replacement • Frequent site visits • Noise and fumes • Fuel expensive & supply issues
Wind Mill	• No fuel and no fumes • Long lasting • Works well at windy sites	• High maintenance • Seasonal drawbacks • Difficult spare parts • Labour-intensive installation

Surface water pumping system selection is usually influenced by cost, dependability, and environmental concerns. When producers cannot afford grid electricity, they frequently use ram, diesel, wind, or solar powered pumps. When these alternatives are considered, solar pump systems are typically the best choice due to the operational conditions that exist in Maharashtra, allowing them to function successfully and economically. Portable solar water pumping systems for surface sources or wells are appealing because of many producers want systems that can move from one location to another.

Portable photovoltaic (PV) systems are even being used by some users to power broken windmill pump jacks. The best option for water pumping from subterranean aquifers via wells is to use existing AC power connections. For drinking water & many irrigation purposes, PV water pumping systems, on the other hand, constitute a highly appealing, long-term, cost-effective alternative to carrying water, diesel pumps and even traditional windmills. Because of their vast and diversified benefits, PV systems are appealing in a number of environments.

Proposed System

An induction motor powered by a solar photovoltaic array is used in the pumping system for water suggested in this paper. The system is relatively simple, as shown in fig., and consists of solar P_V Module, a Boost converter, an SPWM inverter, a single-phase induction motor coupled pump, and a water storage tank.

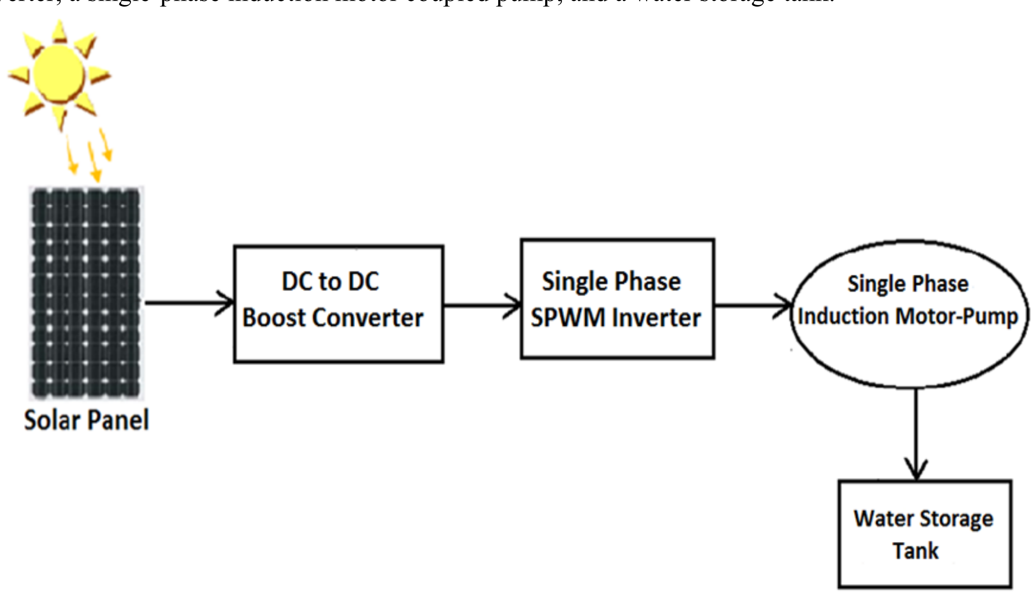

Fig. 2. Block diagram

A solar water pumping system consists of following components.

Solar Array: A series of PV modules and maybe strings of modules connected in tandem.

Controller: An electrical device that converts P_V electricity to motor power and controls operation, starting & stopping of the PV pump. Controller is typically situated on surface, while some P_V pumps include controller into a submersible motor-pump set.

I] Solar Array:

A single module can't possibly supply enough electricity to power a house or a business. To convert dc power into alternating current, which can power motors, loads, lights &other devices, most PV arrays use an inverter. A P_V array modules are normally connected in series to attain necessary voltage before being connected parallel to increase system current o/p.

II] Boost Converter:

A DC-to-DC power converter known as a boost converter generates an o/p voltage larger than i/p voltage. It is a particular kind of switched mode power supply with at least 2 semiconductors diode & transistor and at least 1 energy storage component, like capacitor, inductor, or both. To lessen output voltage ripple, filters made of capacitor are frequently added to the converter's output (often in conjunction with inductors). Any appropriate DC source, such as batteries, solar panel and DC generator, can be used to power boost converter. One DC voltage to another is converted in a process known as DC-DC conversion. boost converter is an output-voltage converter that converts direct current to direct current.

A boost converter is also referred to as step-up converter since which "steps up" source voltage. Because power must be saved, o/p current is less than source current. Battery power systems commonly stack cells in series to generate a high voltage. However, extensive cell stacking is impractical many high voltage applications due to a lack of available area. Boost converter enable voltage to be increased while fewer cells are required.

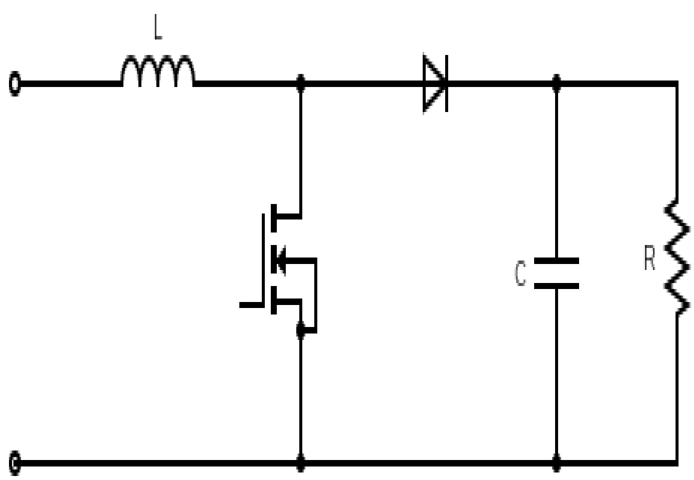

Fig. 3. Boost converter circuit

Selection of Inductor (L):

$$L = \frac{V_{in} * (V_{out} - V_{in})}{\Delta I * f_s * V_{out}} \quad (1)$$

where,

Vin = typical Input Voltage

Vout =Desired output Voltage

Fs= Min. switching frequency of converter
ΔI= estimated inductor ripple current

Selection of Capacitor (C):

$$C = \frac{I_{out} * D}{f_s * \Delta V_{out}} \quad (2)$$

where,
Cout = Min. output capacitance
Iout = Max. output current
D= duty cycle
fs= min. switching frequency of converter
ΔVout= Desired output voltage ripple

III] MPPPT (Maximum Power Point Tracker):

To track the MPP, the P&O technique is often employed. In this technique, perturbation is introduced to cause power variation of P_V module. The P_V o/p power regularly measured & compare to previous power. The operation is repeated if o/p power increases; else, perturbation is reversed. PV array voltage is perturbed by technique. To assess if power is raised or decreased, voltage of the P_V module may increase or decrease. When voltage increases, power increases, and the PV modules operating point moves to left of the MPP. As a result, greater rightward disruption is necessary to approach MPPT.

IV] SPWM Inverter:

DC-to-AC power conversion was performed using rotary converters or motor-generator sets from the late nineteenth century through the middle of the twentieth century (M-G sets). Vacuum tubes and gas filled tubes were first utilized as switches in inverter circuit in the early twentieth century. D. Prince was the first to create an inverter device in 1925. He thinks that the name inverter was given to this device because its operational characteristics are the inverse of rectifiers; instead of AC to DC voltage translation, DC to AC voltage transformation. Textiles are said to be the first practical application of single-phase inverters. However, inverters were not widely used until the invention of contemporary power electronic switches.

RESULTS AND DISCUSSION

MATLAB Simulation:

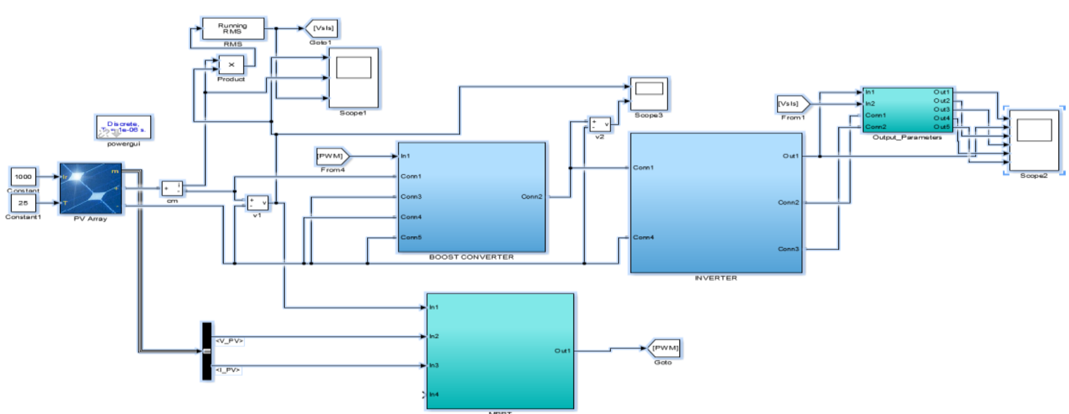

Fig. 4. MATLAB SIMULATION

The above diagram is a simulation of a solar photovoltaic system that includes an MPPT, boost converter, and inverter. The input from panel is up to 48 volts, which is then increased by the MPPT and boost circuit to 230 volts and then converted to AC by the inverter. Finally, using the appropriate LC filter, the square wave is converted to pure sine wave.

Solar Panel:

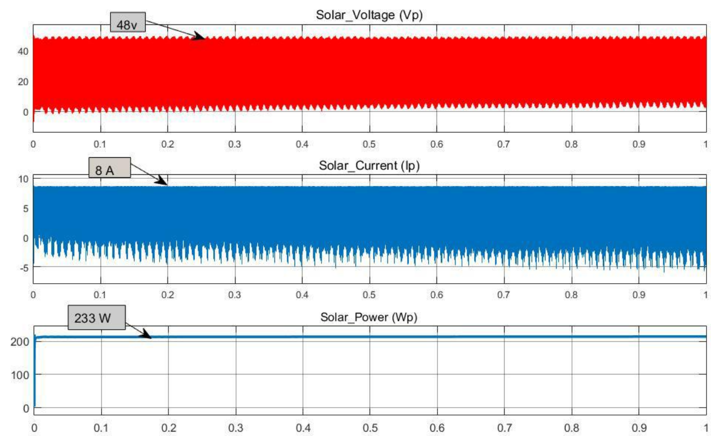

Fig. 5. Solar Panel Output

The diagram depicts the output of the solar panel we created for our system, which has the specifications shown below.

Max Power: 250.205 SW Open Circuit Voltage: 37.3v

Voltage at Max power point Vamp: 30.7 v

Short-circuit Current Isc: 8.66 A

Current at Max power point Imp: 8.15 A

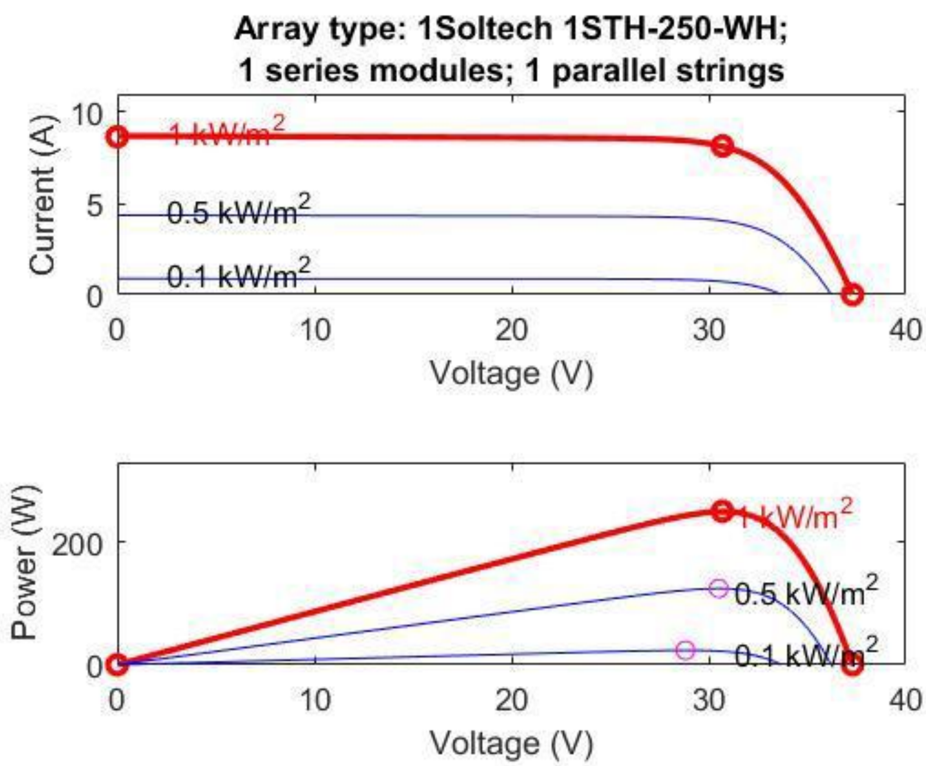

Fig. 6 VI & VP Characteristics of Solar Panel

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MPPT & Boost Converter:

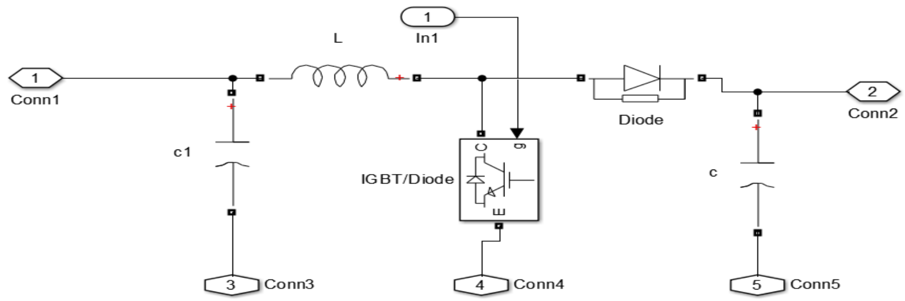

Fig. 6. Boost converter Simulation

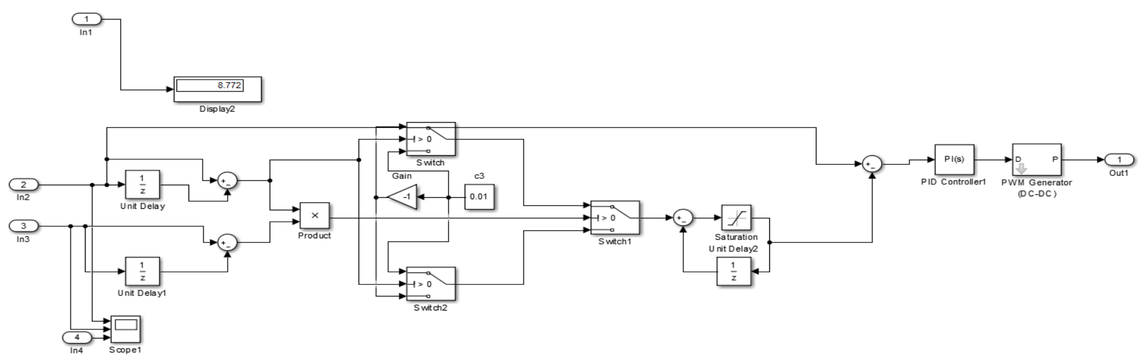

Fig. 7. MPPT Simulation

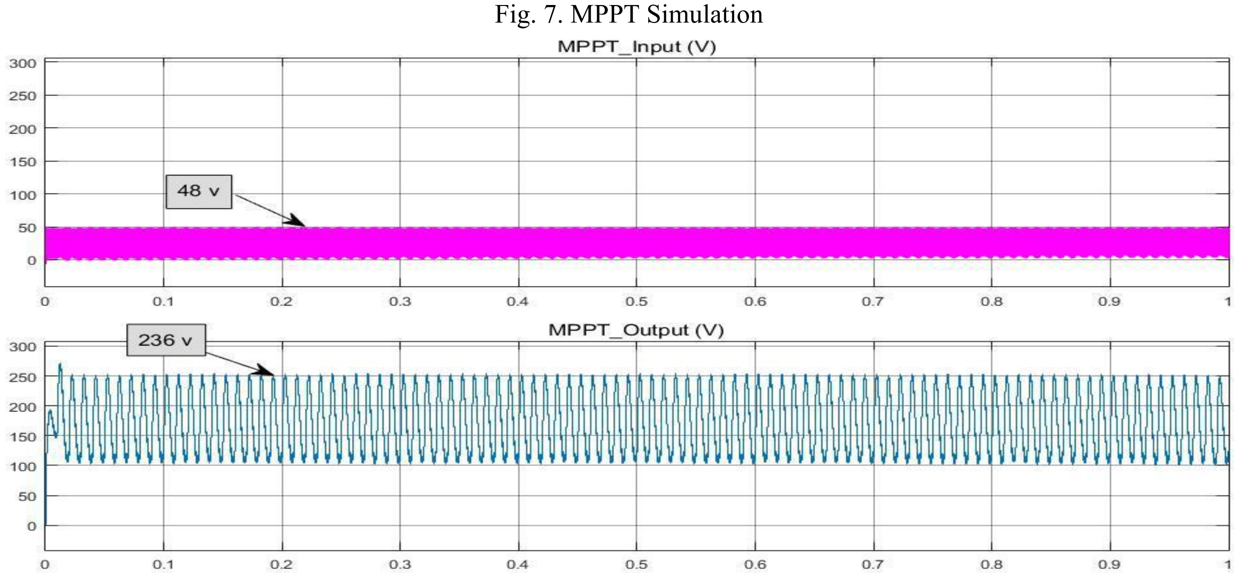

Fig. 8. MPPT Input & Output

We have shown the output of the MPPT and BOOST converters, and we can plainly see that the input side has voltage up to 48 volts dc only from the solar panel, which we converted to 230 volts dc using the DC-DC Boost converter.

Inverter

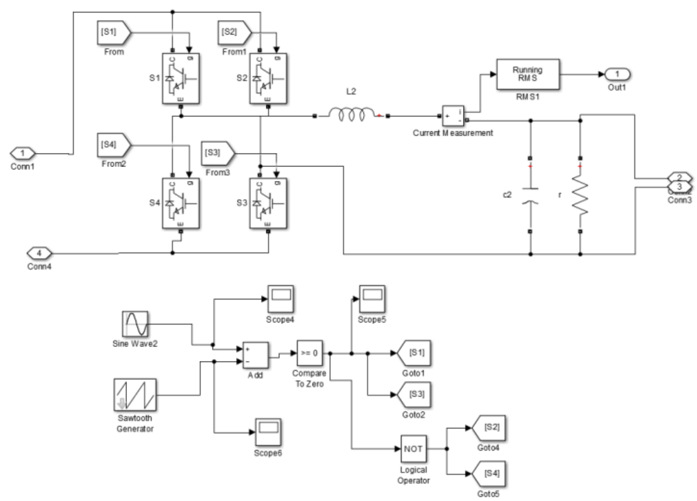

Fig. 9. Inverter Simulation

We designed the single-phase inverter using a bridge of four switches to which we designed the PWM signal through the sine wave and fed to respective switches, resulting in ac at the output side in the form of a square wave, so we used the Lc filter with appropriate values to obtain the pure sine wave.

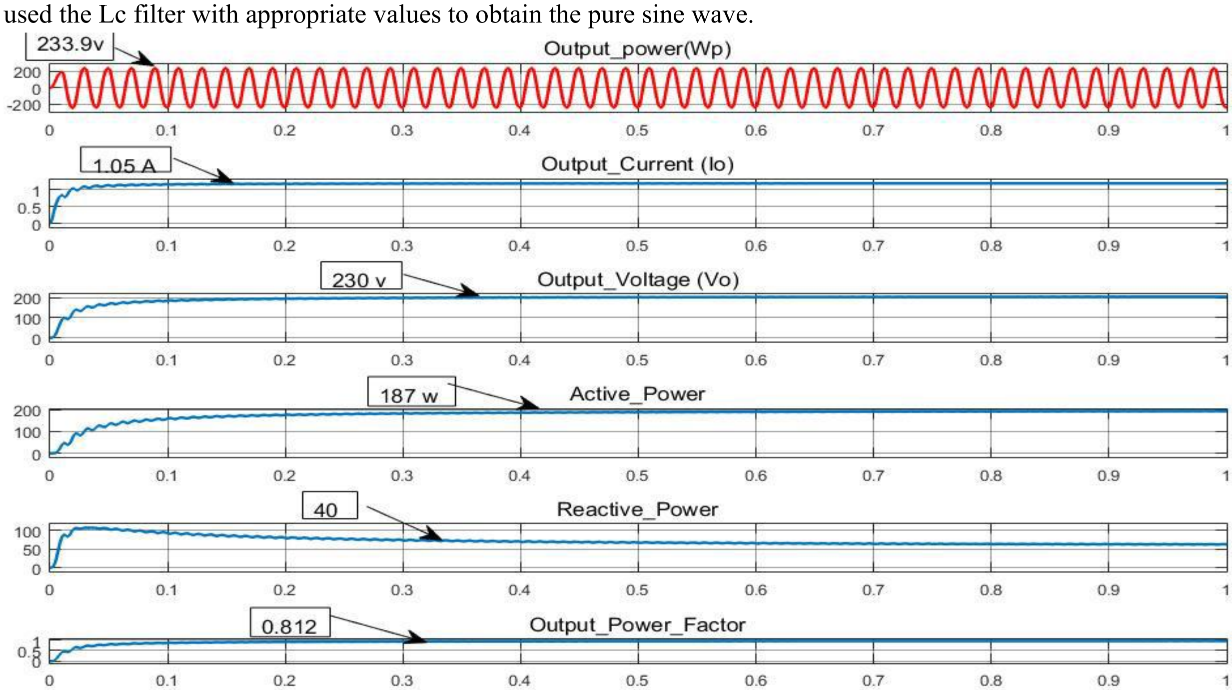

Fig. 10. Inverter Output

As a result, we displayed the final output of our solar photovoltaic system. The load is on the output side. We connected the LC filter before this since the inverter output is square wave, therefore we converted it to pure sine wave by applying the appropriate L and C values. We also displayed the active and reactive powers, as well as the output power factor.

CONCLUSION

This project describes a PV system for water pumping that uses a single-phase boost SPWM inverter and a single-phase induction motor-pump. The boost converter used to increase low input voltage generated by the PV. The inverter converts the direct current voltage to alternating current voltage, which is then utilized to power the single-phase induction motor-pump. As a result, the proposed technique successfully used to power single phase induction motor. The SPWM approach is employed to regulate the IGBT inverter and effectively eliminate lower order harmonics, while the proposed LC filter eliminates higher order harmonics. To validate the suggested system, the experimental results on MATLAB/Simulink are shown.

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