Simulation of Solar Power Fed SPWM Inverter For Domestic Lighting

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Abstract- *This paper describes the details of fully automatic system for continuous power supply for domestic load in which solar power, supply mains and diesel generator used as source. System gives output on the predefined priority. First priority is set on solar power, second priority is set on supply mains and last one is on diesel power. For converting solar DC power into AC power, SPWM based voltage source inverter is used. For designing SPWM voltage source inverter, IGBT bridge is used and for generation of SPWM gate pulses, reference sine waves compared with triangular wave. The performance of single phase SPWM inverter fed domestic load is described in detail .*

Keywords- SPWM inverter, domestic lighting, Solar power.

I. INTRODUCTION

Solar power is renewable and environmental pollution free energy source. Solar power battery charged system provides power supply for a day irrespective of bad weather. By adopting the appropriate technology for the concerned geographical location, we can use large amount of power from solar radiations. More over solar energy is expected to be the most promising alternate source of energy. The global search and the rise in the cost of conventional fossil fuel is making supply-demand of electricity product almost impossible especially in some remote areas. Generators can be used as alternative supply source but it can also be used for certain hours of the day and the cost of fueling them is increasing become difficult if they are to be used for commercial purposes. Normally in remote areas domestic lighting is done by either supply mains or by solar power but in bad weather condition solar power is not sufficient for domestic lighting, So other option is supply mains but if both sources are unavailable at a time, so diesel powered generation system is alternative choice.

Table -01. Priority Selection For Load With Different Cases.

	Solar Power	Supply Mains	Diesel Generator	Output Priority
01	0	0	0	No source
02	0	0	1	D/G set
03	0	1	0	Supply mains
04	0	1	1	Supply mains
05	1	0	0	Solar power
06	1	0	1	Solar power
07	1	1	0	Solar power
08	1	1	1	Solar power

Presently domestic lighting system is done by manual system so there is problem with continuous lighting system at remote location. In which load is automatic shifted from one source to another source on the basisof predefined priority and also controlled by battery charging and discharging process. Solar power is first priority for load because it is renewable, non-polluted energy source, second priority is on supply mains and last priority is on diesel powered generator .Table 01 shows output priority of supply for load within different cases. In this table, '0' represent unavailability of source and '1' represent availability of source. For converting DC power into AC power, output IGBT based SPWM inverter is used.

1.1 SOLAR PANELS

Converting solar energy into electrical energy by using PV cells is the most recognized way to use solar energy. Since PV cells are semiconductor device, they have a lot in common with processing and production technologies of other semiconductor devices such as diodes, computers and memory chips. As it is well known, the requirements for purity and quality control of semiconductor devices are quite large and for solar cells purity is at least 99.9999 %. With today's production, which reached a large range, the whole industry production of solar PV cells has been developed and, due to low production rate, it is mostly located in the Far East. Crystalline silicon are used as semiconductor material to produced Photovoltaic cells by the majority of today's most large producers. Solar photovoltaic modules, which are a

result of combination in series of photovoltaic cells to increase their power, are highly reliable, durable and low noise devices to produce electricity. The fuel for the PV cell is free. The light energy of sun is the only resource that is required for the operation of PV systems, and its energy is almost endless.

Figure 1.3.1.1 Photovoltaic cells

A typical photovoltaic cell efficiency is about 15% to 20%, which means it can convert 1/5 to 1/6 of solar energy into electricity. PV systems produce no noise as there are no moving parts and they do not emit pollutants in to the atmosphere therefore we get clean energy from solar cells. Taking into account the energy consumed in the production of photovoltaic cells, they produce several tens of times less carbon dioxide per unit as compare to the energy produced from fossil fuel technologies. Photovoltaic cell has a lifetime of more than twenty five years and is one of the most reliable semiconductor products. Most solar cells are produced from silicon, which is non-toxic and is found in abundance in the earth's crust in major form of sand. PV modules require minimal maintenance. PV modules bring electricity to remote areas especially to rural areas where there is no electric power grid, and thus increase the life value of these areas. PV systems will continue the future development in a direction to become a key factor in the production of electrical energy for households and buildings in general. The systems are installed on existing roofs and/or are integrated into the facade (BIPV panels). These systems contribute to reducing energy consumption in buildings. Also, PV technology, as a renewable energy source, contributes to power systems through diversification of energy sources and security of electricity supply. By the beginning of incentives for the energy produced by renewable sources in all developed and developing countries, photovoltaic systems have become very affordable, and timely return of investment in photovoltaic systems has become less and constantly decreasing. In recent years, this industry is growing at very fast rate and the photovoltaic technology creates thousands of jobs at the local level.

II. LITERATURE REVIEW

[1]. Piyush Choudhary, Rakesh Kumar Srivatava and Somnath De, are proposed "Solar Powered Induction Motor Based Water Pumping System: A Review of Components, Parameters and Control Methodologies"

Author presented comprehensive review of solar energy based water pumping system and technology including its historical background and principle of its functioning, various physical components and classification, parameters, such as environmental conditions and photovoltaic materials that has an effect on the overall performance of the system. Emphasis has been made on induction motor based solar pumping systems and their control methodologies including their advantages as well as disadvantages and future scopes in solar water pumping systems[4].

[2]. Archan P. Parikh, P. N. Tekwani and Vinod Patel are proposed "Design and Implementation of Solar Pumping System with Induction Motor and Submersible Pump"

This paper proposed , induction motor along with submersible pump of 1.5 kW is used. On the basis of motor rating, solar panel rating is decided to be 1.8 kW considering losses in the system. In this system the main focus is to design boost-converter which boosts the voltage obtained from solar panel. This boost voltage acts as a dc-link voltage for three-phase inverter. Three-phase inverter is developed to convert dc voltage into ac voltage. This ac voltage generated is given to induction motor which runs the submersible pump. Maximum Power Point Tracking (MPPT) algorithm is implemented to obtain maximum power from the solar panel under different solar irradiation and temperature. In this topology, incremental conductance method is used to obtain maximum power from solar panel. Modulation index of inverter is controlled by Sine-Triangle Pulse Width Modulation (SPWM) technique[5].

[3]. V r.balaji and M.sudha are proposed "Solar Powered Auto Irrigation System"

In this system moisture sensor and PIC microcontroller based automatic irrigation system proposed in which soil moisture sensor use to detect the moisture level and 4X4 keypad for various crops control. When the moisture content of the soil is reduced then the sensor sends detected value to the microcontroller. Then the water pump is automatically ON according to the moisture level[6].

[4]. Er.Upendra Singh,MohitVyas, Gaurav Sharma, Surender Pal Singh and SulemanKhan present "Solar Based Smart Irrigation System"

Proposed system deals with design of solar system to collect maximum solar energy that is converted into electrical energy which in turn is used to power the irrigation system. This system consists of solar powered water pump along with an automatic water flow control using a moisture sensor. In Automatic mode the water pump is switched on and off automatically based on moisture sensor value. In Manual mode the farmer has to go to the field where the system is installed to ON and OFF the water pump[7].

III. PROPOSED SYSTEM

3.1 Block diagram of proposed system-

Complete block diagram of proposed system is shown in figure3.1.1. In which solar panel is connected to charging current controller. Output of charging current controller is connected to battery voltage controller, which controls battery charging process as battery voltage reaches atpreset maximum value so controller automatically turn off battery charging process. For better performance of battery and inverter, charging voltage controller automatically disconnect the load, as battery voltage is low.Battery level indicator also used for indicating the battery voltage level.

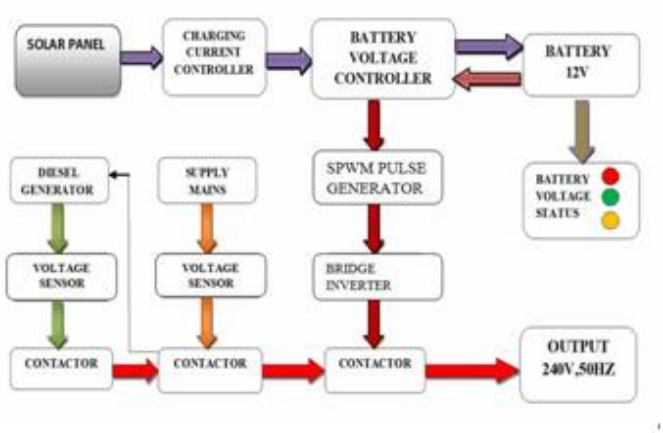


Fig.- 3.1.1 Block diagram of the system

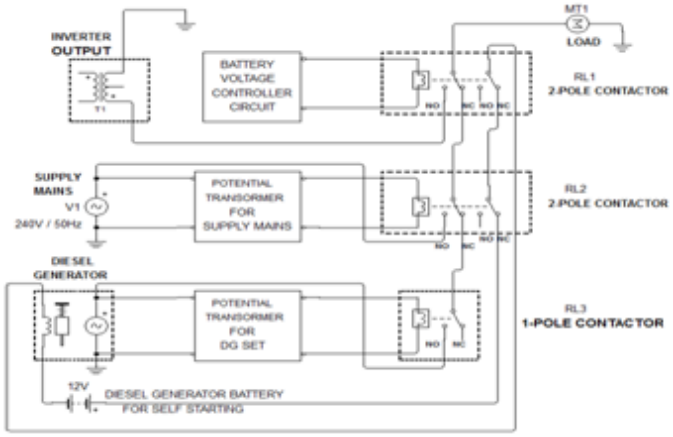


Fig.- 3.1.2 Contactor connection for priority selection

Main function of system isto maintain continuity of output supply. For continuous power supply 3 different electrical sourcesare used. These sources are solar panel, supply mains and diesel generator. With the help of switching setting of contactors first priority set on solar based SPWM inverter, second priority set on supply main and last priority set on diesel generator. IGBT based voltage inverter gated through SPWM gate pulses, The gating signals are produced by comparing a sinusoidal reference wave with a high frequency triangular signal.

The rms ac output voltage

$$V_{rms} = V_s\sqrt{\frac{p\delta}{\pi}} \rightarrow V_s\sqrt{\frac{\sum_{n=1}^{p} \delta_n}{\pi}}$$

Where,
p =number of pulses
δ= pulse width

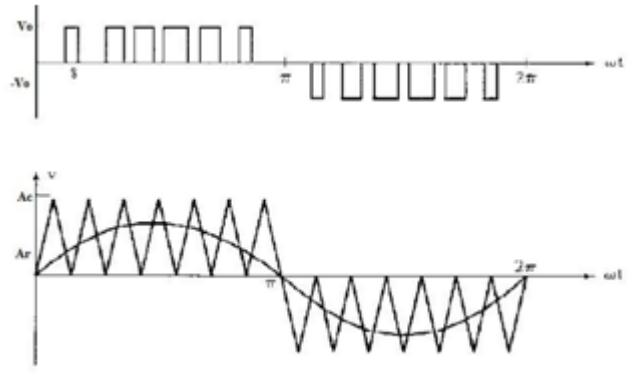


Fig.- 3.1.3Sinusoidal Pulse Width Modulation

voltage sensor are used for sensing voltage level of supply mains and diesel generator, as the voltage comes is in normal range (200-240). So,contactor is operated on the

basis of priority setting source when connected to domestic load system. For inverter and supply mains system DPDT contactor is used , one part of contactor used for priority selection and other part of contactor is used for diesel generator operation, supply mains and inverter side contactor are connected to each other with particular setting for automatic turn on/off diesel generator.

3.2Model of Complete System-

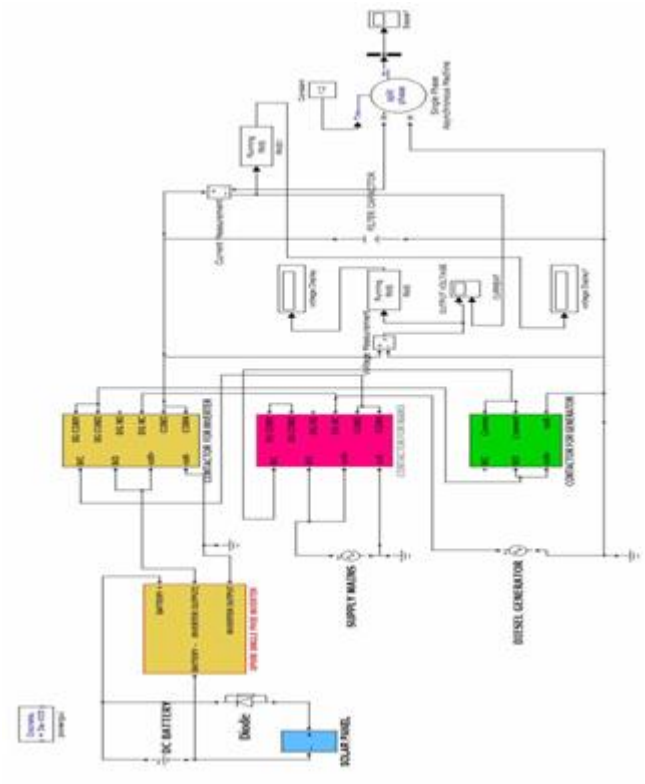


Fig.- 3.2.1 Model of complete system

Main model of system shows in figure 3.2.1, it consist of solar panel for charging battery bank. Battery bank DC Supply is connected to SPWM based voltage source inverter and inverter output connected to the inverter side DPDT contactor. Solar based SPWM inverter have first priority and next one is supply mains. Supply is connected to DPDT supply mains contactor through voltage comparator system , in which supply mains voltage is compared with preset voltage level. As the voltage comes in normal range so, contactor coil is activated and contactor is turn on. Similarly diesel generator supply is connected to D-G side SPDT contactor through voltage comparator system, in which D-G voltage is compared with preset voltage level, as the voltage comes in normal range so contactor coil is activated and contactor is turn on. Single phase split phase type induction motor is used as a load, motor output parameters like speed, stator current,torque can be shown in scope 1 and for load variation constant block is used.

3.2.1 Model of SPWM Inverter Sub- System-

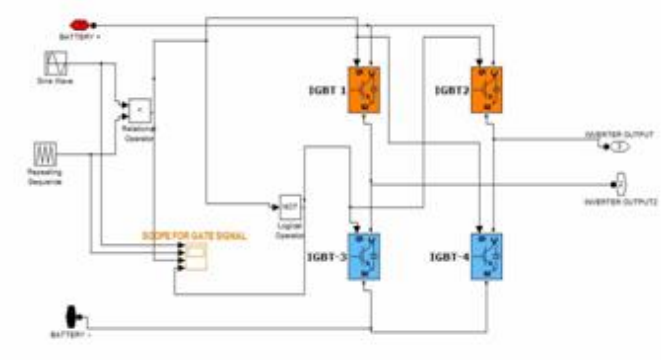


Fig.- 3.2.1.1Model Of SPWM Inverter

Fig. 3.2.1.1 shows sub system of SPWM inverter block diagram, in which gating signals are produced by comparing a sinusoidal reference wave with a high frequency triangular signal with the help of relational operator block, 4 IGBT with feedback diode are used for Bridge inverter, IGBT-1 & IGBT-4 works at same time and IGBT-2 & IGBT-3 works for next cycle. IGBT output of inverter collect from the terminal no. 2 and 3.

IV. RESULTS AND DISCUSSION

Results are obtained with solar powered SPWM single phase 1000VA MOSFET based inverter with 230V battery bank , which is connected to 4 different loads for analysis of various electrical parameters.

4.1 SPWM Gate Pulse Wave Form

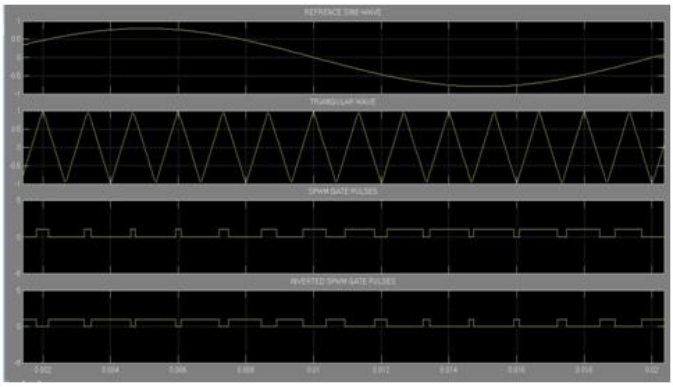


Fig .- 4.1.1 SPWM Gate Pulse Wave Form For 1 Cycle

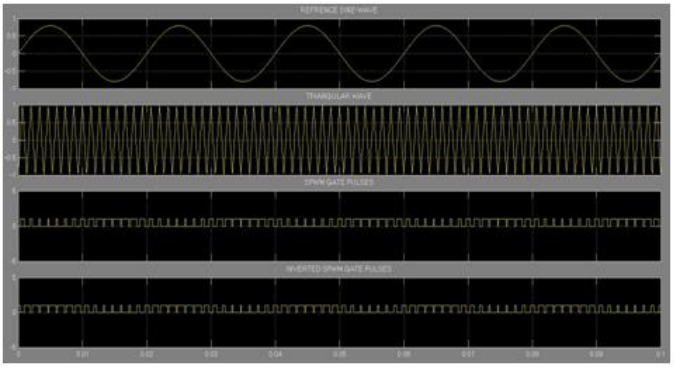


Fig. -4.1.2 SPWM Gate Pulse Wave Form in 0.1sec

CASE 1-40 ohms pure resistive load connected to inverter

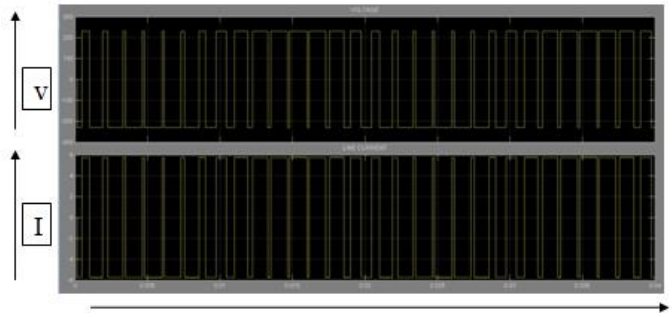


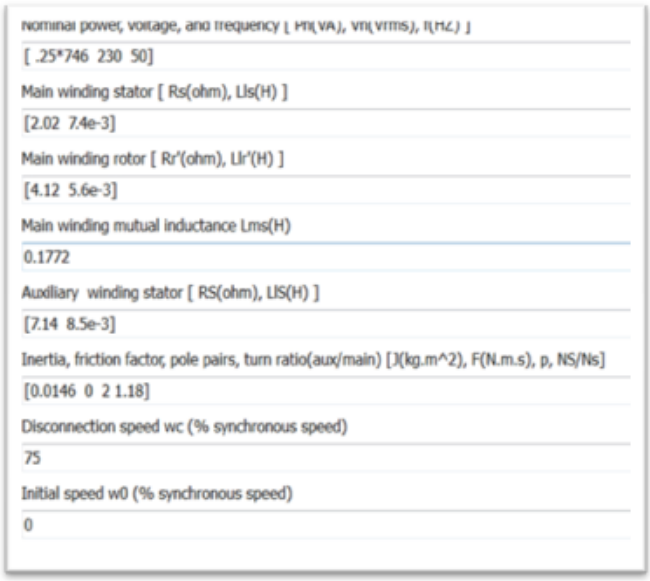
Fig.- 4.1.3 Voltage And Current Wave Form Under 40 Ohm Resistive Load

Table-4.1.1Output Parameter under 40 ohm resistive load

S.NO.	PARAMETER	VALUE
1	V_{dc}	230V
2	V_{ac}	229.8 V
3	I_{ac}	5.745 Amp
4	LOAD	40 ohm

Case-20.25 HP, 230 volt induction motor connected to inverter with 1.2 Newton meter load.

TABLE 4.1.2Induction Motor Parameter



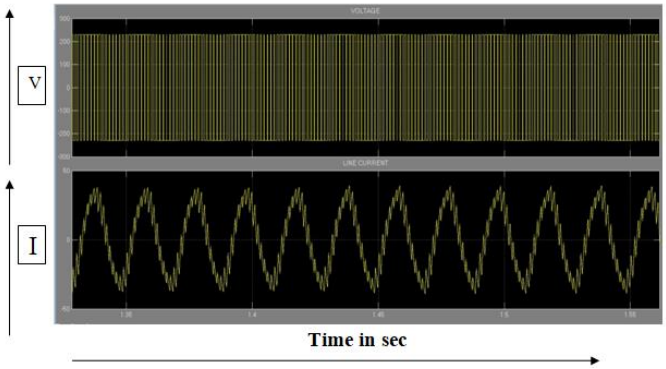


Fig.-4.1.4Voltage And Current Wave Of Induction Motor Connected To Inverter With 1.2 Newton-Meter Load.

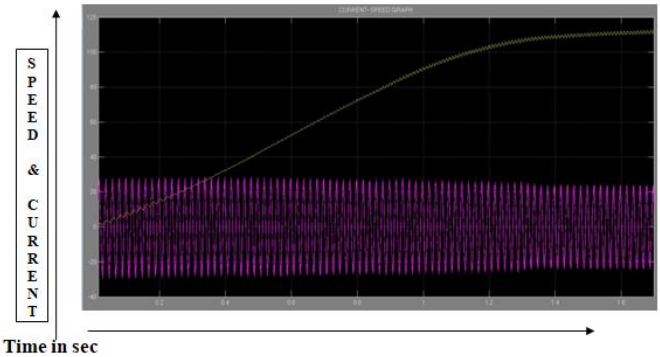


Fig.-4.1.5Speed (Rps) And Current Wave Of Induction Motor Connected To Inverter With 1.2 Newton-Meter Load

Table 4.1.3Output Parameter of 1-phase induction motor under 1.2 N-m load.

S.No.	PARAMETER	VALUE
1	V_{dc}	230V
2	V_{ac}	229.8 V
3	I_{ac}	24.65 Amp
4	LOAD	1.2 Nm
5	SPEED	114.1 rps

Case -3 1 HP, 230volt induction motor connected to inverter with 1 .5 Newton-meter load.

TABLE-4.1.4Induction Motor Parameter

Nominal power, voltage, and frequency [Pn(VA), Vn(Vrms), f(HZ)]
[1*746 230 50]
Main winding stator [Rs(ohm), Lls(H)]
[2.02 7.4e-3]
Main winding rotor [Rr'(ohm), Llr'(H)]
[4.12 5.6e-3]
Main winding mutual inductance Lms(H)
0.1772
Auxiliary winding stator [RS(ohm), LlS(H)]
[7.14 8.5e-3]
Inertia, friction factor, pole pairs, turn ratio(aux/main) [J(kg.m^2), F(N.m.s), p, NS/Ns]
[0.0146 0 2 1.18]
Disconnection speed wc (% synchronous speed)
75
Initial speed w0 (% synchronous speed)
0

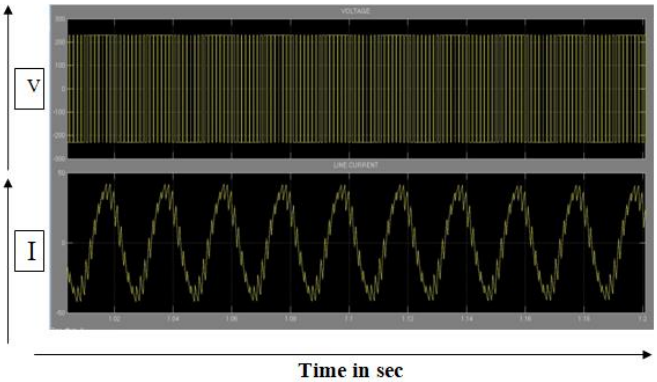


Fig.-4.1.6Voltage And Current Wave Of Induction Motor Connected To Inverter With 1.2 Newton - Meter Load.

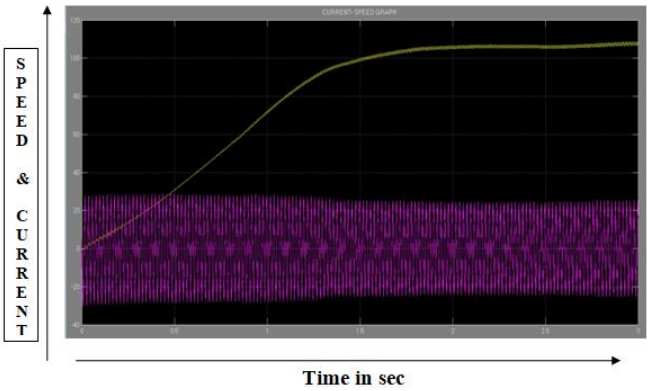


Fig.-4.1.7Speed (Rps) And Current Wave Of Induction Motor Connected To Inverter With 1.2 Newton- Meter Load

Table- 4.1.5Output Parameter of 1-phase induction motor under 1.5 N-mload.

S.No.	PARAMETER	VALUE
1	V_{dc}	230V
2	V_{ac}	229.8 V
3	I_{ac}	25.25 Amp
4	LOAD	1.5 Nm
5	SPEED	108.7 rps

V. CONCLUSION

As per my research problem " SIMULATION OF SOLAR POWER FED SPWM INVERTER FOR DOMESTIC LIGHTING " has been design in MATLAB 2010. First source priority set on solar power next one is on supply mains and last one is on diesel generator. SPWM inverter produces sine wave output, which reduces harmonics content and power losses at load side. It is found that the complete designed system working well and giving desired output results. The novelty of designed system is that, batteries are directly charged from the solar panel. So, DC power is available throughout 24 hours. Apart from irrigation some light sources can be used in night. By implementing this type system there are various benefits for the government and the farmers. For the government a solution for energy crisis is proposed. The excess energy produced using solar panels can also be feedback to the grid with small modifications in the system circuit, which can be a source of the revenue for the farmer, thus encouraging farming in India and same time giving a solution for energy crisis.

VI. SCOPE OF FUTURE WORK

This is one of the emerging fields in which lot of researchers interested to work and it has a sufficient scope to extend the work in the following area as:

1. This system can also be implemented for three phase system.
2. With the help of moisture sensor, water pump can be automatic turn on and off.
3. In this system 3 input source are used on the priority basis
   i.e. solar power, supply mains anddiesel generator but wind power also can be used as 4th input source.
4. By using GSM module system can be start and stop from the remote location .
5. By using GSM module system sent periodically live status to any particular number.

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