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BLDC Motor Drive by the Interaction of GRID and Solar PV Array for Reduction of Power Quality Aspects by ANN Technique

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Keywords:
Power Flow Control, Solar Photovoltaic Array, BLDC Motor, Voltage Source Converter, Unit Vector Template Generation, Voltage Source Inverter, Maximum Power Point, Power Quality, Power Factor, Total Harmonic Distortion.

ABSTRACT

Integration of Renewable Energy into the GRID leads to reducing losses but improves power factor issues. The usage of non-linear loads leads to harmonics in the current waveform. In this paper Solar Photovoltaic with MPPT and Boost Converter is integrated to DC link of three phase Inverter with three phase BLDC Motor with an aim of reliability in Water Pumping system for both grid and Islanding Condition. Bi-directional flow of power between the single-phase grid source to solar photovoltaic system is done by using Unit Vector Template (UVT). In this work, Artificial Intelligence-based Controller (Artificial Neural Network ANNCs) were considered with the objective of reduction of THD and improving empower factor. To show the performance of proposed techniques or controllers comparison analysis is carried out with the methods available in the literature. The proposed techniques give superior performance. The proposed system is simulated by using the MATLAB R2016a version.

1. INTRODUCTION

Due to the heavy usage of electricity, now a days power saving is a real challenge. BLDC Motor is an electro-mechanical system, it is better than compared to induction motor and DC motors. It possesses low noise pollution and power density is high and efficiency is high.

Now-a-days solar power consumption is reached to its peak level by installing new plants across all over India, by implementing new techniques for less space needed by more energy consumption. The power produced by the solar is occurred by the nature sources. Thus, this proposed system Solar Photovoltaic array feeds BLDC Motor water pumping system is familiar for irrigation purpose. Moreover, by implementing the motor, it is clear that system is economically related when the system installation process is done on the point view of maintenance operation. In this system water pumping process is going on day and night, because of single-phase utility grid is implemented for supply of power for water pumping system. In this proposed system, by the literature survey the main drawback of this system is by placing the battery for storage of power from solar photovoltaic array system. It may occur for heavy expenditure and also life span of the overall system is reduced in months and it increase the installation price and also a maintenance charges of the proposed system. For that purpose, to maintain the system in clear point of view without any discontinuous power flow single-phase grid system is implemented.

A Bi-directional power flow control is proposed in this system, by implementing the phased locked loop among the unit vector template generation technique for flow of power from solar photovoltaic array to single phase grid source when water pumping system is not required and also for when solar power is less for motor to run in below its rated

speed, i.e., on the movement single phase grid will supply power to run the motor in rated speed.
A single-phase grid source is interactive with solar photovoltaic array to feed water pumping system by using BLDC Motor is proposed in this system. The implementation system techniques and the control methodologies are used in this system. The technique Incremental Conductance Algorithm (InC) used here for Maximum Power Point Tracking (MPPT), for consuming the power in its high point of tracking power at different radiation levels in solar photovoltaic system. It is interacted with the Boost Converter, for step up the voltage which is generated by the solar system.
For the adjustment of speed in the motor current sensors are not required in this proposed system. And the motor works on the hall signals which are electronic signals i.e., gates signals are used in this signal's techniques. Three phase Voltage Source Inverter is used in this system to run the motor.

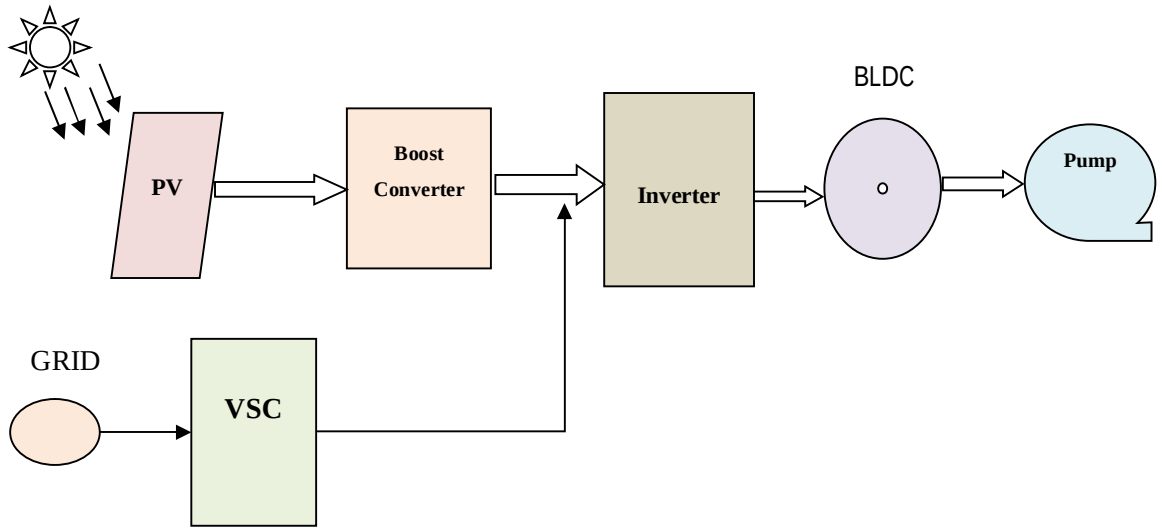


Fig.1. Block representation of the Single-phase Grid supply interactive with Solar Photovoltaic Array based water pumping system by using a BLDC Motor.

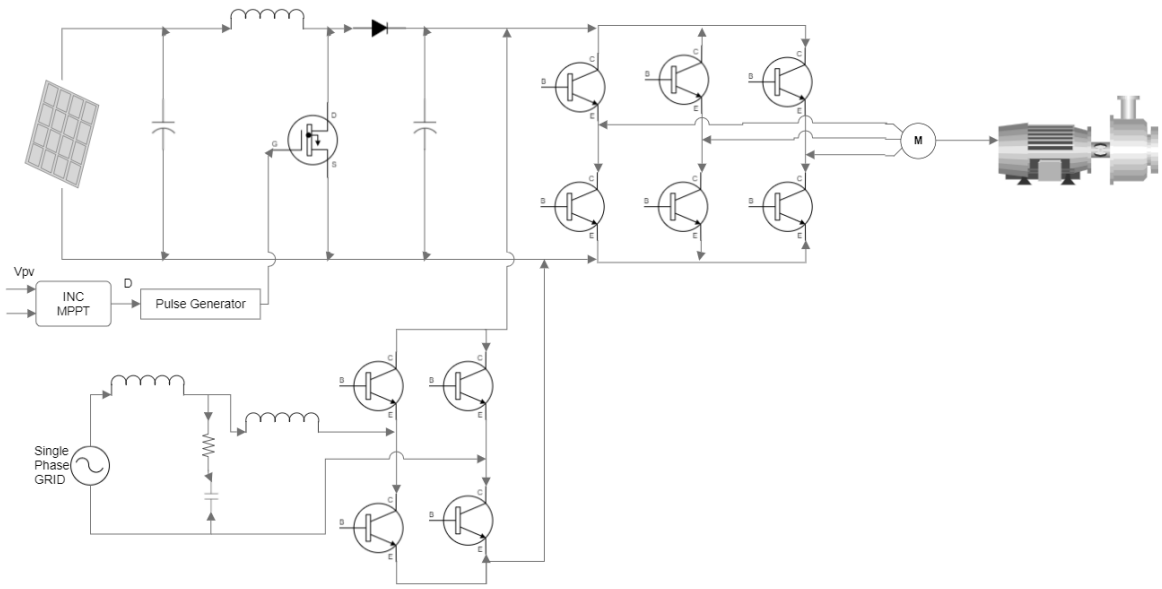


Fig.2. Schematic diagram representation of the proposed system

2. EXSISTING PI CONTROLLER

In this system PI controller are used in the power flow control of the bi-directional way of power, it is also used for the reduction of harmonic distortion and the control of power quality aspects. The required value is obtained by the between actual and the output is derived from the controller.
The noticeable method is Proportional Control: Current value of the motor is set to be proportional to the error value of

existing system. However, if the proportion method fails or if proportion method couldn't operate. Immediately other methods among Integral or Derivative terms will active to find the error in the proposed system if proportion integral derivative controller is implemented in the system.

An Integral term is the speed procedure action compare to proportion term controller. Its action posses not only on error but also on time process. So, if the functional force in the system is not sufficient to convey the error to zero stage, then the applied force will be improved as time going on. A pure Integral "I" Controller can clear the error to zero stage, but time taking process is depend upon the error and cruel at the end.

If the oscillations in the amplitude is increases by means of time, the system is said to be unstable. Then if its time reduced, system is stable.

Proposed ANN Controller

An Artificial Neural Network (ANN) is implemented in this proposed system, it is working as neuron system in the human brain in biology sector. ANN is also named as Neural Network, which falls below the coverage of Artificial Intelligence or AI.

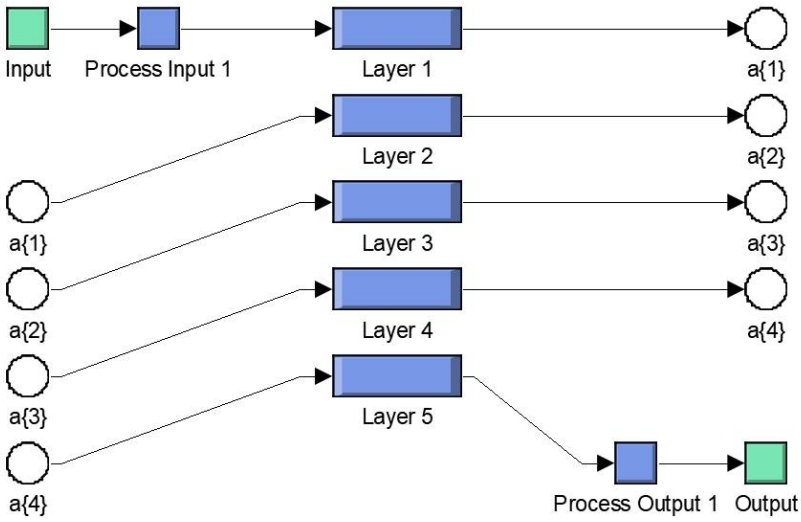


Fig.3. Block Diagram for representation of ANN Technique

In early days of computing, Artificial Neural Network technique is used for storing of data. Artificial Neurons are seemed to be nodes of the network. ANN receives signals received by the membrane of neuron and signal referred to membrane of the neural network or neuron.

The complication of real neurons is highly inattentive when artificial neuron modelling process. Activation of the neurons are done by the inputs of the system, which are reproduced by the weights and mathematical function calculation process is implemented for the formation of required output.

In this proposed system, Artificial Neural Network (ANN) is used for the improvement in power quality aspects and to store the data in the system and by comparison of input signals with the reference signals by that procedure so many numbers of references have been done and there are thousands of or lakhs of references signals were provided to compare the input with the reference signals not to overcome with the output required data.

The fields where it is related to work is to process information by the functions of Artificial Neural Network ANNs. It is used in recognition of pattern; compression of data and forecasting are in engineering purposes. There are wide varieties of ANNs which are interactive to design or modulate the real neural networks in the system.

3. Proposed Simulation Results

A study of the proposed system under various operating conditions is carried out through the Simulated results in MATLAB R2016a Simulink software platform. The advanced system and its control are tested for starting, dynamic and steady state operations. The water pumping system may be operated with Solar Photovoltaic system, with single phase grid supply, with both connection of solar photovoltaic and single grid supply, or may not be operated for any climatic or sudden change in climate reason. All these possible operating conditions are considered for the demonstration of proposed system.

Case A BLDC Water pumping system is fed by only Solar system:Various solar photovoltaic array and BLDC water pumping system characteristics in this proposed case are implemented and shown in the figure 4 given below. Solar photovoltaic array is operated at its maximum power point under the radiation of 1000 W/m2 and the BLDC motor is operated at full capacity and motor runs at rated speed is shown in the figure 5. In this case single phase grid supply is not implemented because the sufficient rated required power was produced by the solar system by implementing

Incremental Conductance technique in the MPPT Algorithm. The various specifications are stator back-emf, stator current, speed of the motor, electromagnetic torque and load torque are shown in this case without any disturbance in the power supply.

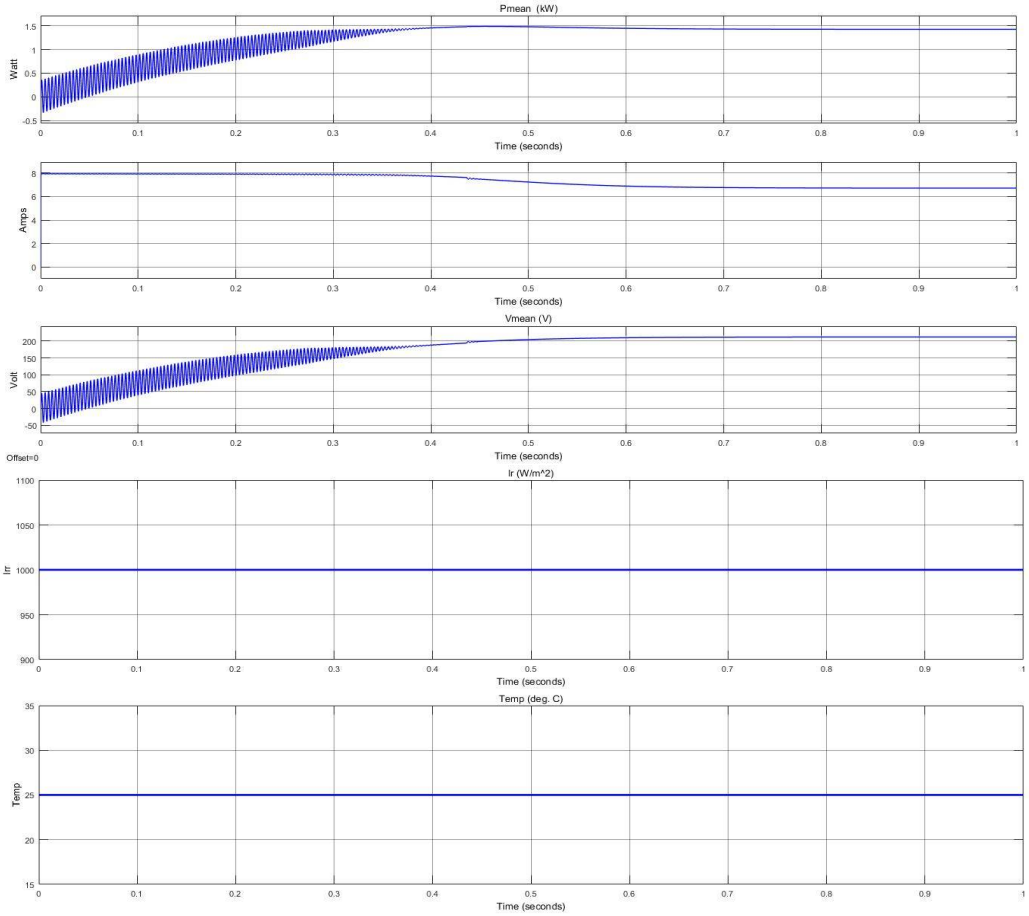
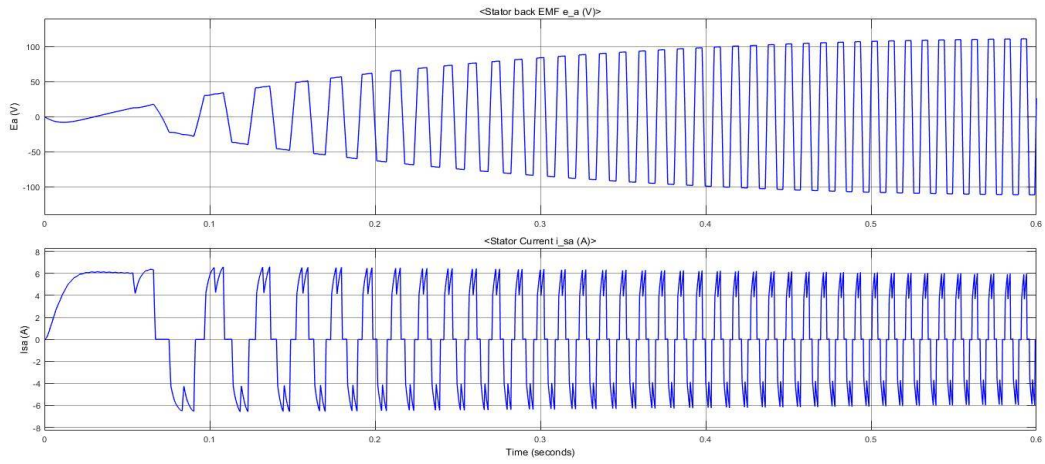


Fig.4. Starting Performance of a Solar Photovoltaic array, when only Solar system feeds water pumping system



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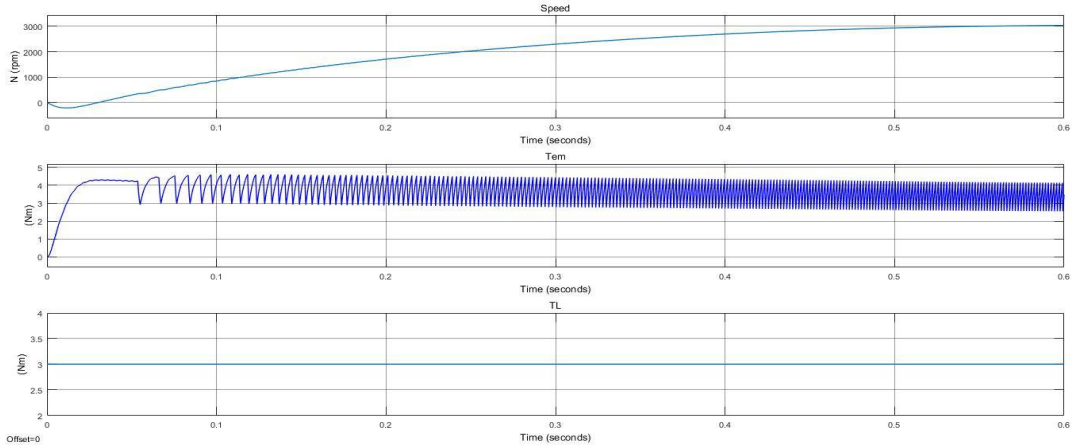

Fig.5. Steady State performance of BLDC Motor – Pump, when solar system feeds BLDC Motor water pumping system

Case B BLDC Water pumping system is fed by the only utility grid supply:This operation is implemented by using a single-phase grid voltage supply without any occurrence of solar power supply generation i.e., this case is done in the night climatic condition. A single-phase 180V, 50Hz utility grid is used for generating the required amount of power to run the motor at rated speed all specifications characteristics are shown in the figure 6 and figure 7 given below.

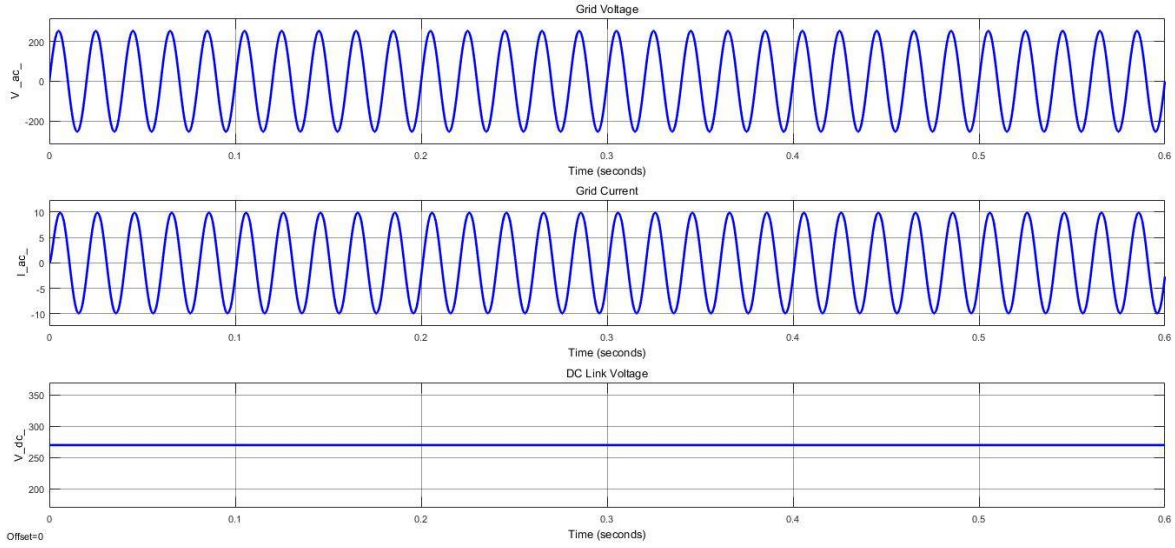

Fig.6. Starting Performance of Single-Phase Grid, when only single-phase grid source feeds BLDC water pumping system

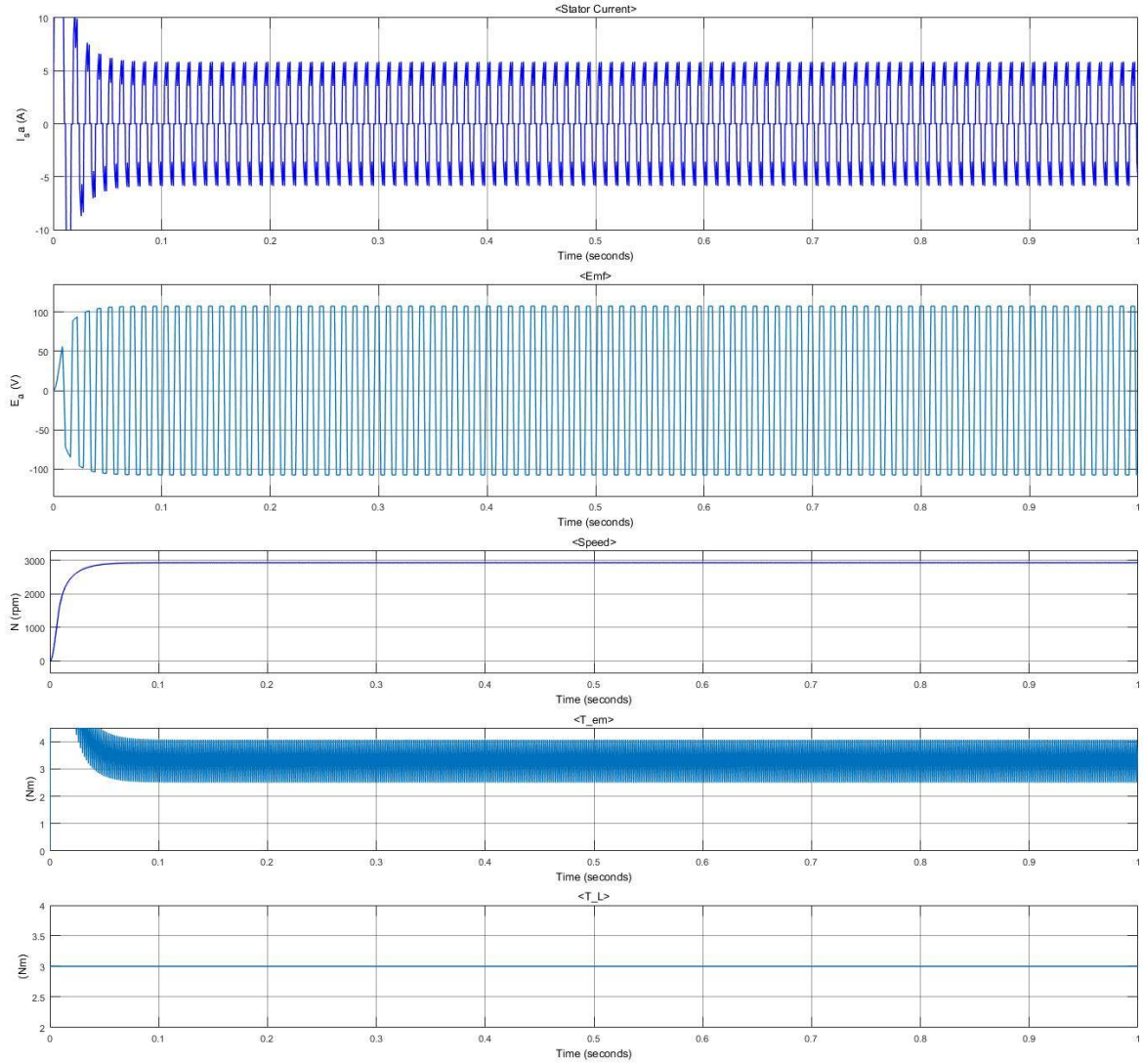

Fig.7. Steady State performance of BLDC Motor-pump, when only utility single-phase grid is connected to feed water pumping system

Case C Water Pumping is not required: In this case, implemented flow of power from solar photovoltaic system to single-phase grid voltage source without use of BLDC Motor water pumping system, in this case total amount of power generated by the solar energy with 1000 W/m2, operated at its MPP is consumed by the single-phase grid, figure 9 shows sinusoidal supply current is reversed at a movement when the power is flowing from Solar Photovoltaic Array to single-phase grid voltage source.

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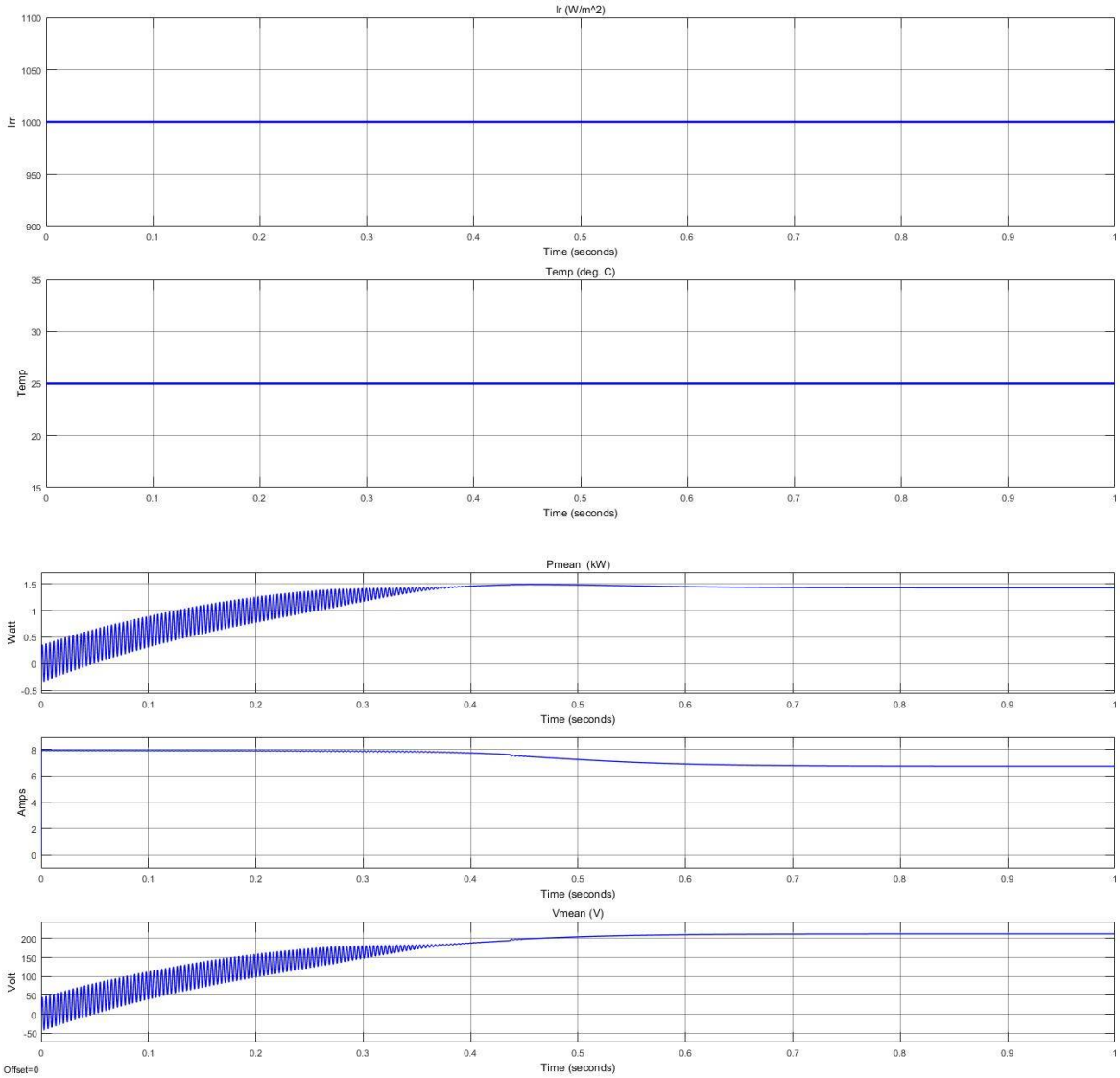

Fig.8. Starting performance of solar photovoltaic array, when water pumping system is not required

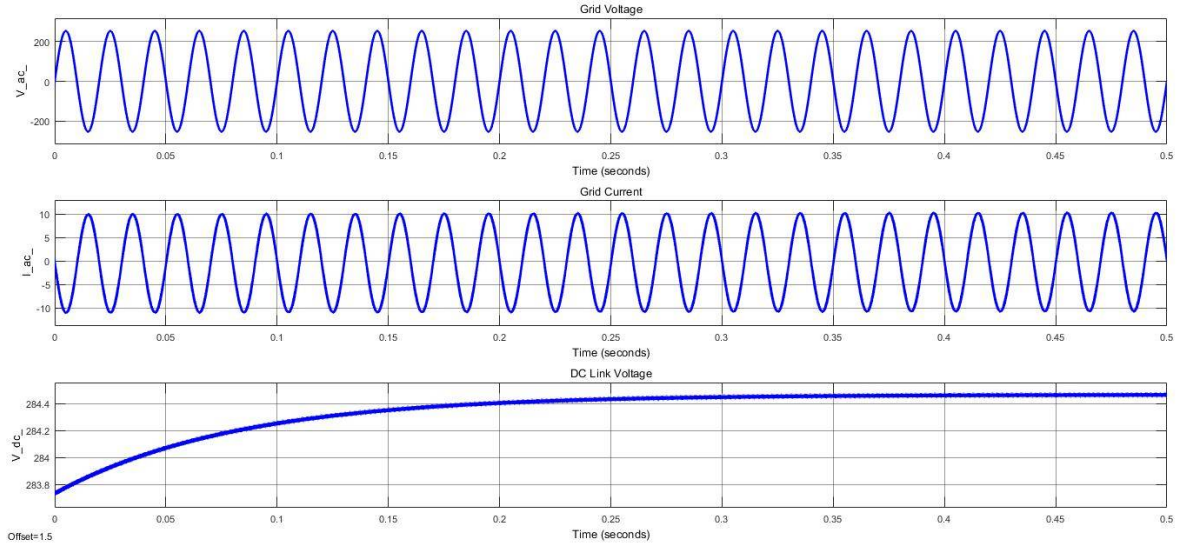

Fig.9. Performance of single-phase Grid source, when BLDC water pumping is not required (solar power flow to single-phase grid source)

Due to sudden change in climatic condition or sudden change in the direction of power flow are treated as Dynamic response or Dynamic performance of the proposed system, several cases are implemented in this performance based on the climatic conditions or sudden change in the nature disasters.

Case D Grid feeding Water Pump to Solar Photovoltaic Array feeding Grid:In this proposed case, water pumping system is initially operated through the single-phase utility grid system, when solar power is not available in this system. This mode of operation is sudden change in climate condition i.e., by considering that water pumping system not required when solar power is available in this system. Therefore, it is proposed system is implemented as feed of utility grid by solar array after 0.3 seconds of time duration which is shown as dynamic condition or dynamic response of the system. The figure 10, 11 & 12 shows the solar photovoltaic array characteristics and single-phase grid source characteristics and BLDC Motor water pump characteristics for this proposed dynamic case of the system. In this case before 0.3 sec of time duration Utility grid is feds water pumping system procedure is going on, when BLDC Motor water pumping not required then power generated by Solar Photovoltaic array is flow through the VSI implemented the unit vector template generation technique for the bidirectional flow of power from the solar array system to single-phase grid source system.

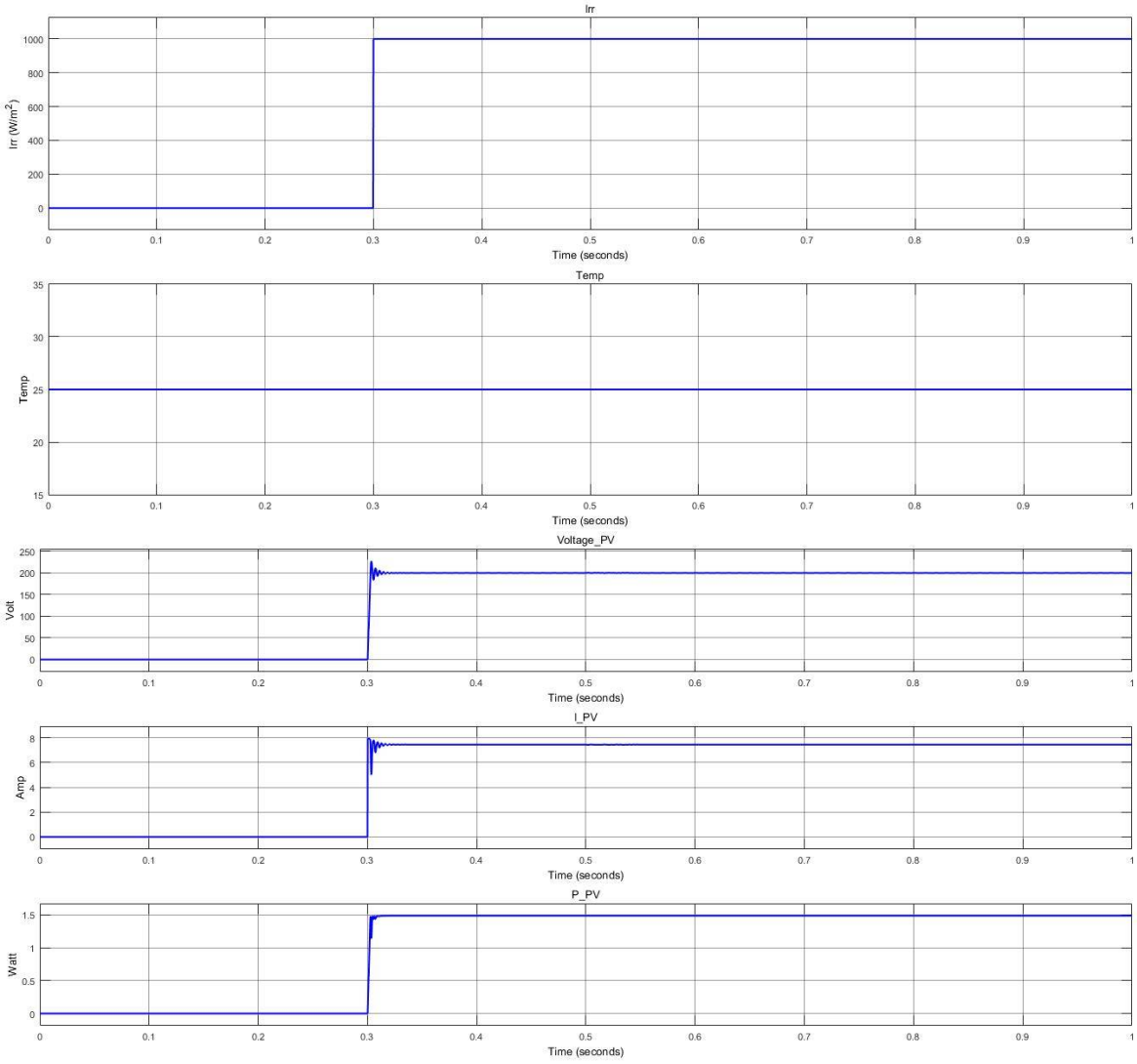

Fig.10. Dynamic performance of the solar system, when Grid Feeding water pumping system to solar system feeding grid.

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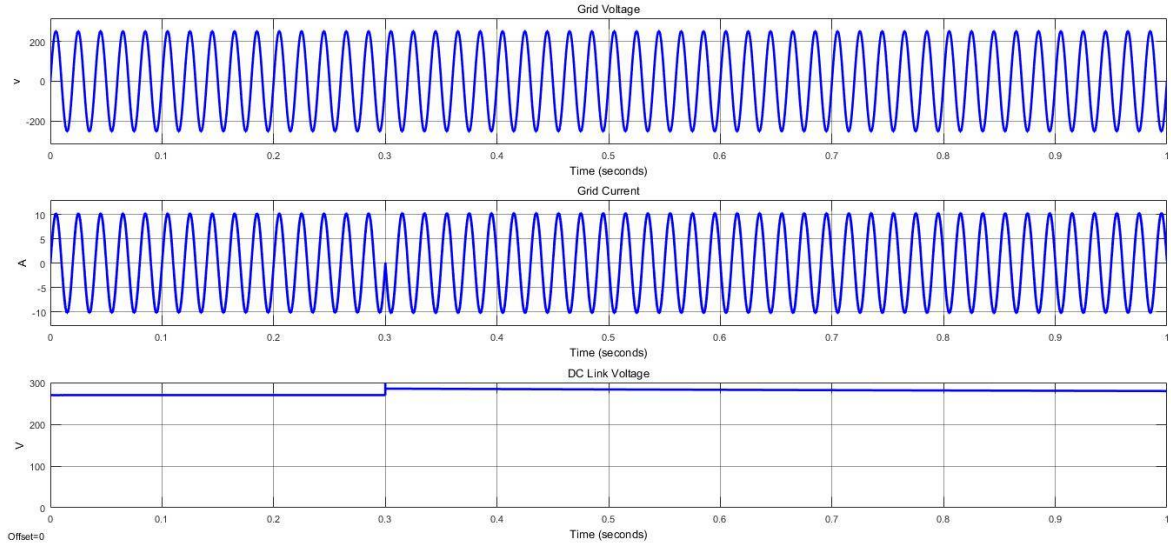

Fig.11. Dynamic response of the Single-Phase Grid System, when Grid Feeding water pumping system to solar system feeding grid.

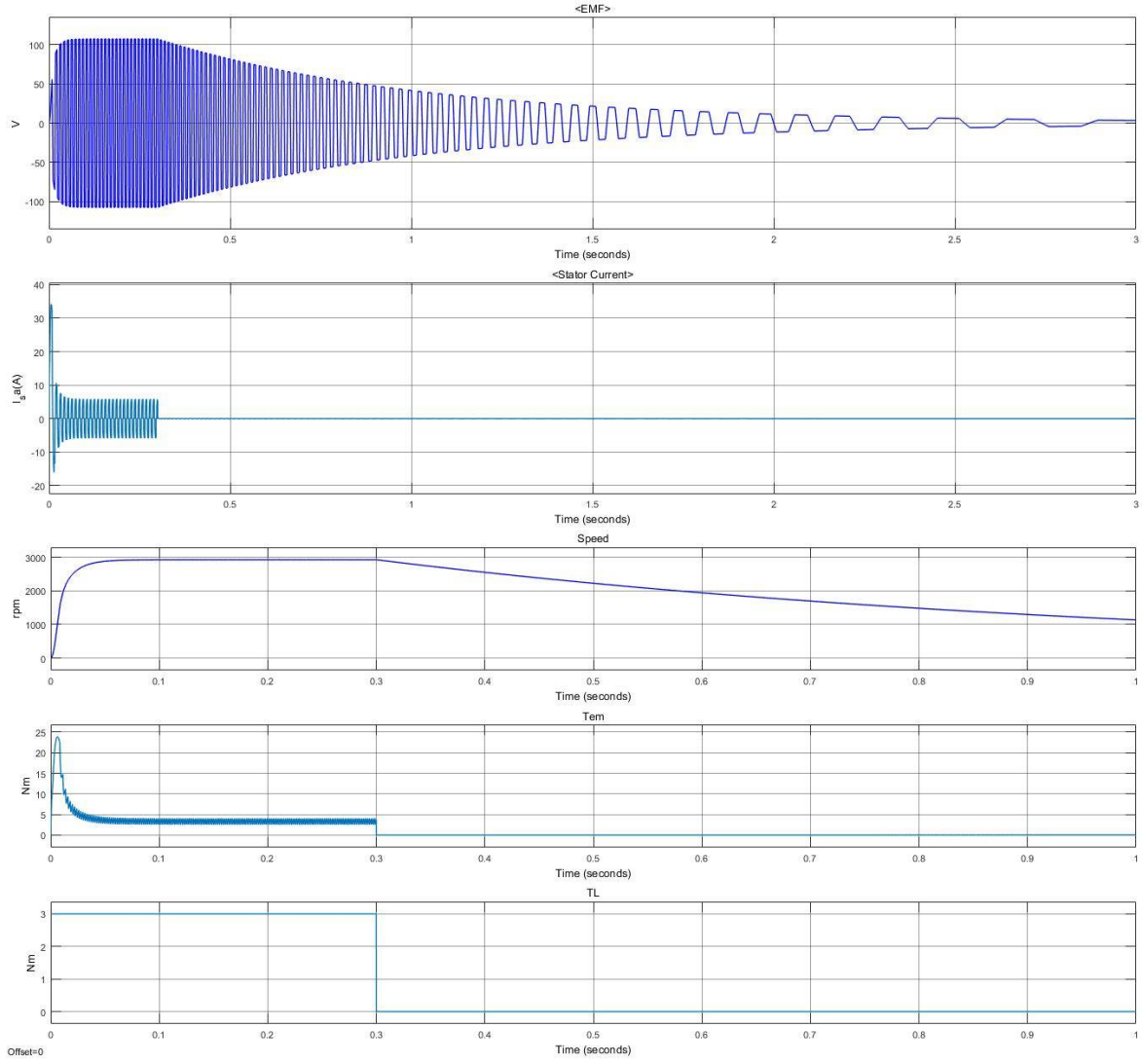

Fig.12. Dynamic Response of the BLDC Motor Water pumping system, when Grid Feeding water pumping system to solar system feeding grid.

Case E : Solar Photovoltaic array feeds Water Pump to Both Solar array and Utility grid feeds pumping system: In this case it is supposed that solar photovoltaic array system is enough to run BLDC water pumping system at a rated speed and rated output with the radiation of 1000W/m2, but due to the climate change or sudden of cloudy condition, radiations have been changed from 1000 W/m2 to 500W/m2, then at the sudden movement or immediately single-phase grid supply is flow through dc link capacitor to run the specified motor at rated speed. Solar system characteristics and single-phase grid supply characteristics and motor water pumping system characteristics are shown in the figure 13, 14 & 15.

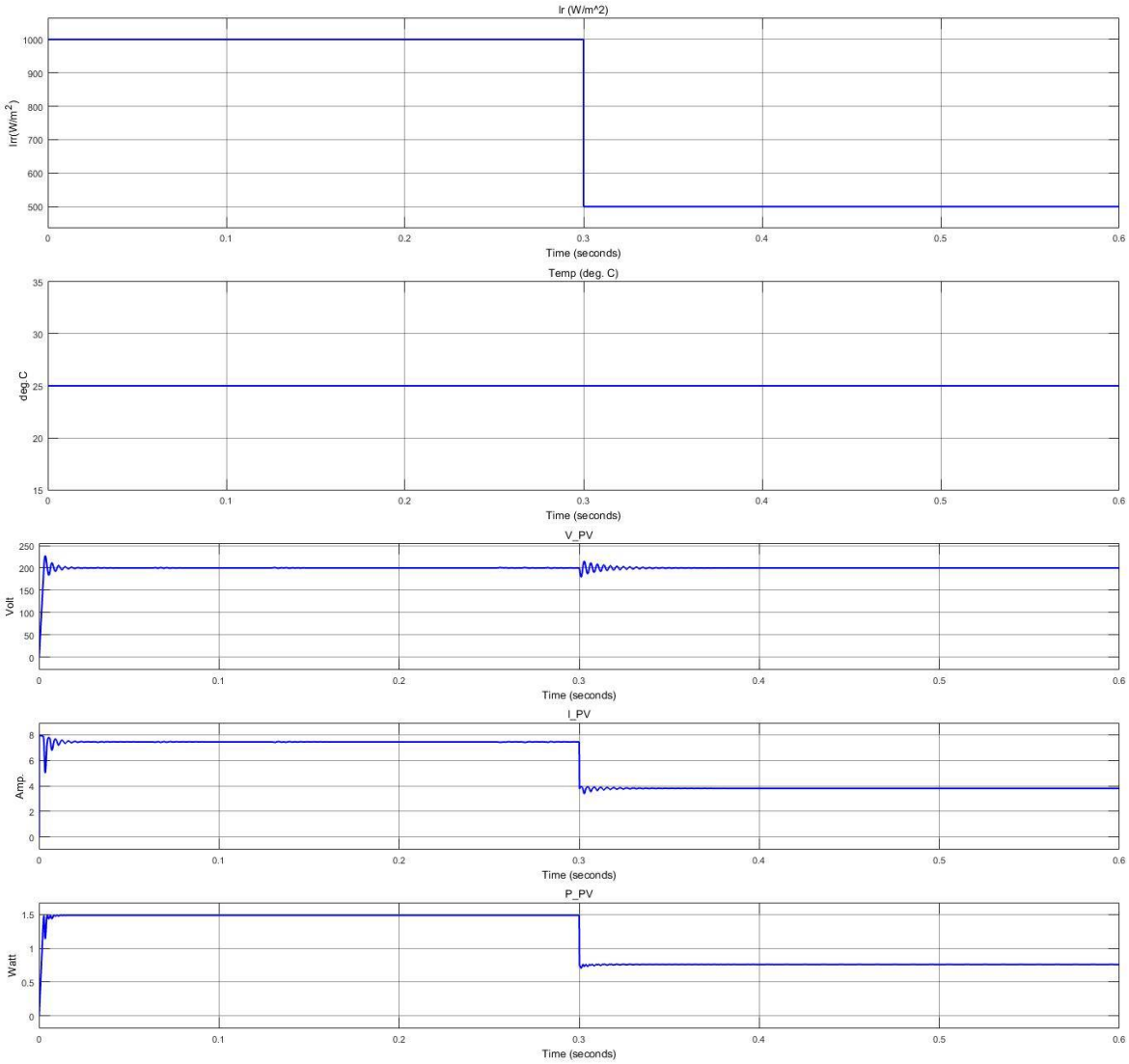

Fig.13. Dynamic Response of the Solar system, when radiation fall from 1000W/m2 to 500W/m2

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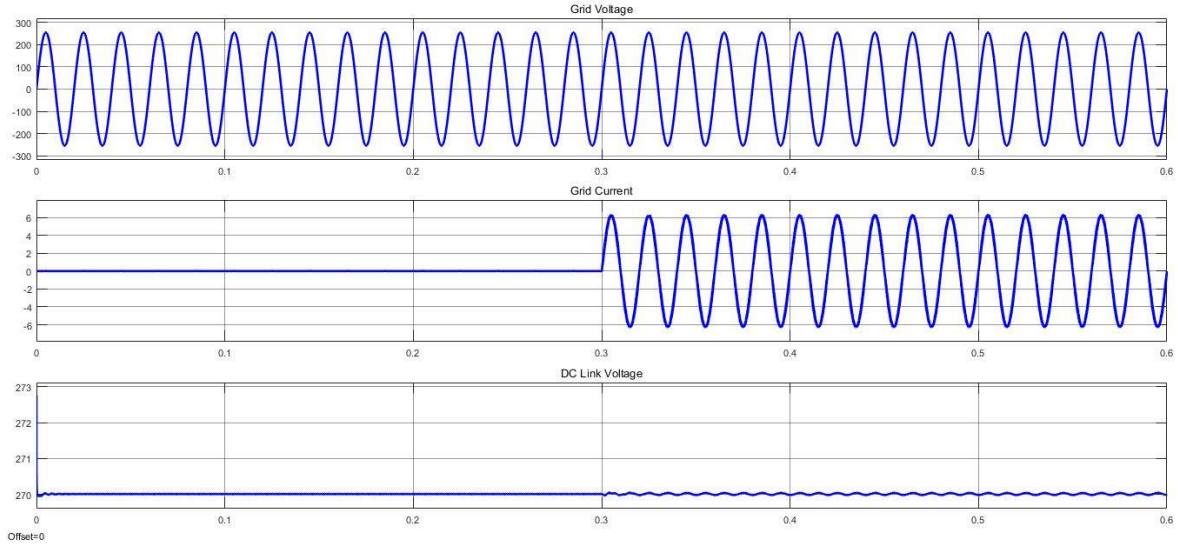
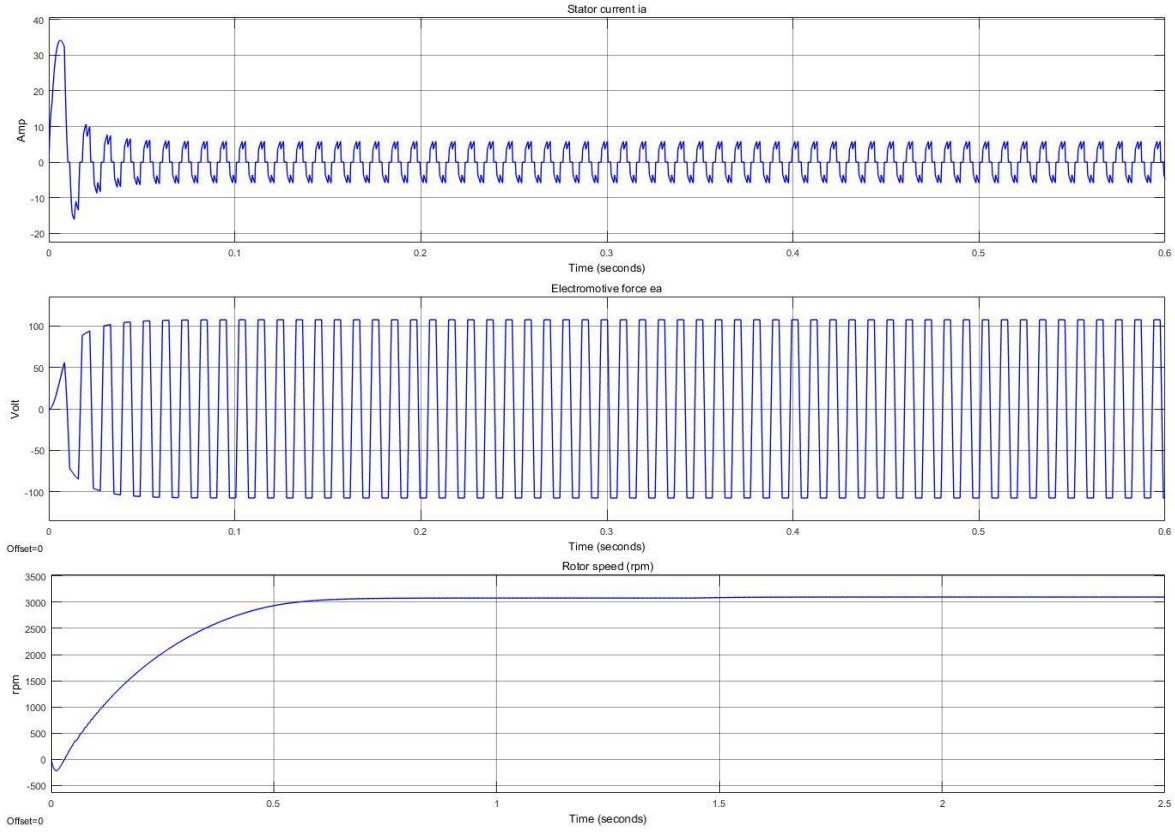


Fig.14. Dynamic Response of Single-Phase Grid System, when sudden fall of radiation from 1000W/m2 to 500W/m2



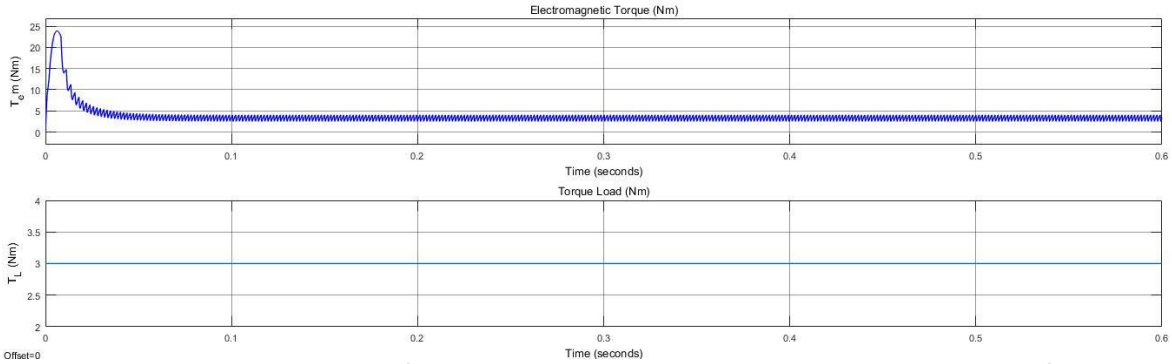


Fig.15. Dynamic Response of BLDC Motor Pumping System, when Solar system feeds Water pumping system to single phase grid system feeds water pumping system.

Power Quality with PI controller

In the designed implemented system establishes an improves of power quality aspects when single-phase grid supply is connected in this system in terms of power factor and Total Harmonic Distortion (THD). The figure 16 represents the total hormonic distortion and the harmonic spectrum of the supply grid current which is explained in case 2, when single phase grid supply is feeds water pumping system without solar photovoltaic array during night condition, in absence of sunlight this specific case is done.

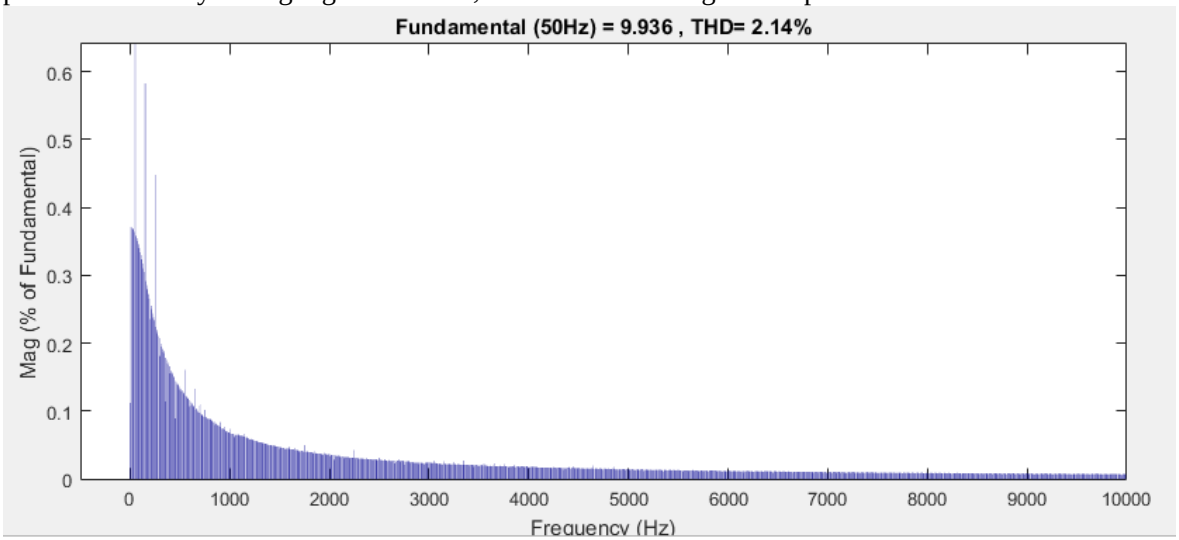


Fig.16. THD and Harmonic spectrum of the supply current, when only Utility Grid feeds water pumping system through PI Controller

The figure 17 shows the Total Harmonic Distortion and the harmonic spectrum of the supply current, when suddenly radiation is reduced from 1000W/m2 to 500W/m2 condition, in that particular case grid is supplying power to the load to run motor in rated speed immediately when solar array is generating power less than the rated amount which is mentioned in the specifications of the BLDC Motor.

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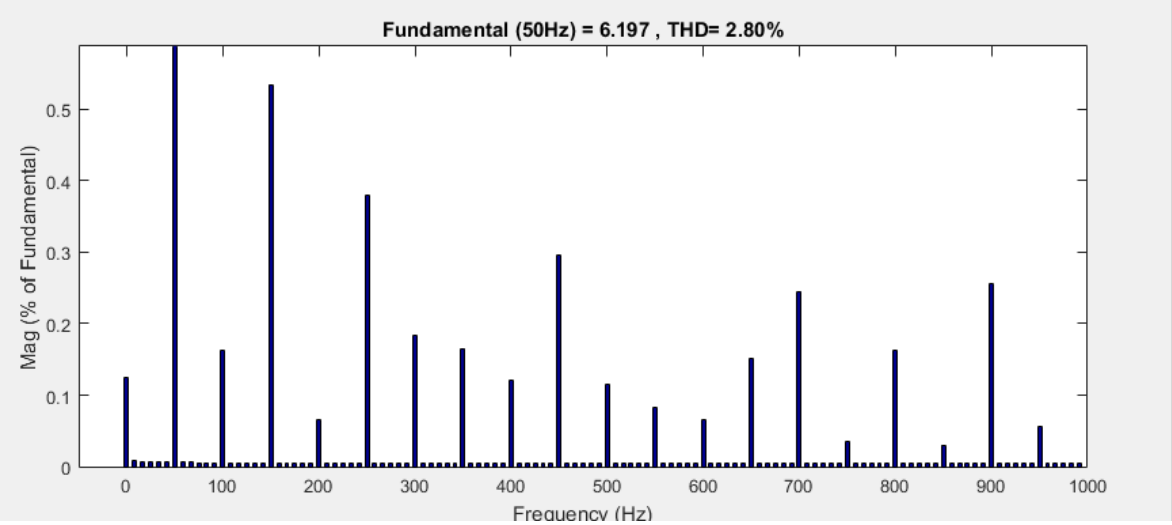

Fig.17. THD and Harmonic spectrum of the supply current, when Solar system and Single-Phase Grid Supply feeds water pumping system through PI Controller

Power Quality with ANN Technique:

In this proposed system in presence of PI Controller, Artificial Neural Network (ANN) is implemented in this system for the power quality improvement reduction of total harmonic distortion in this system, where the utility grid is proposed in this system for water pumping process. The solar, utility grid, BLDC motor characteristics are shown in the figure 18 & 19.

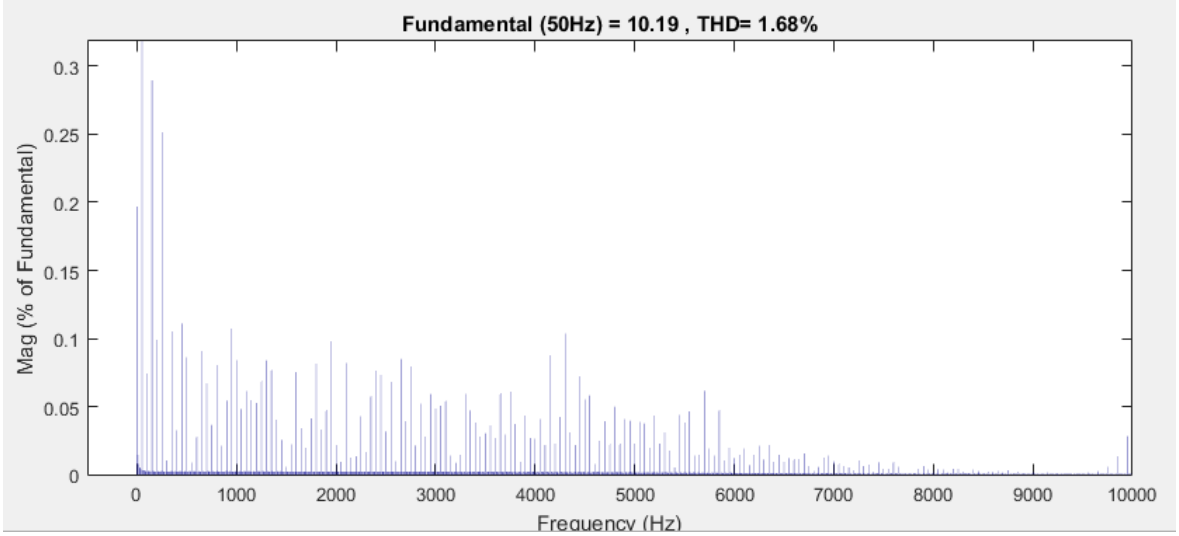

Fig.18. THD and Harmonic spectrum of the supply current, when only Utility Grid feeds water pumping system through ANN Controller

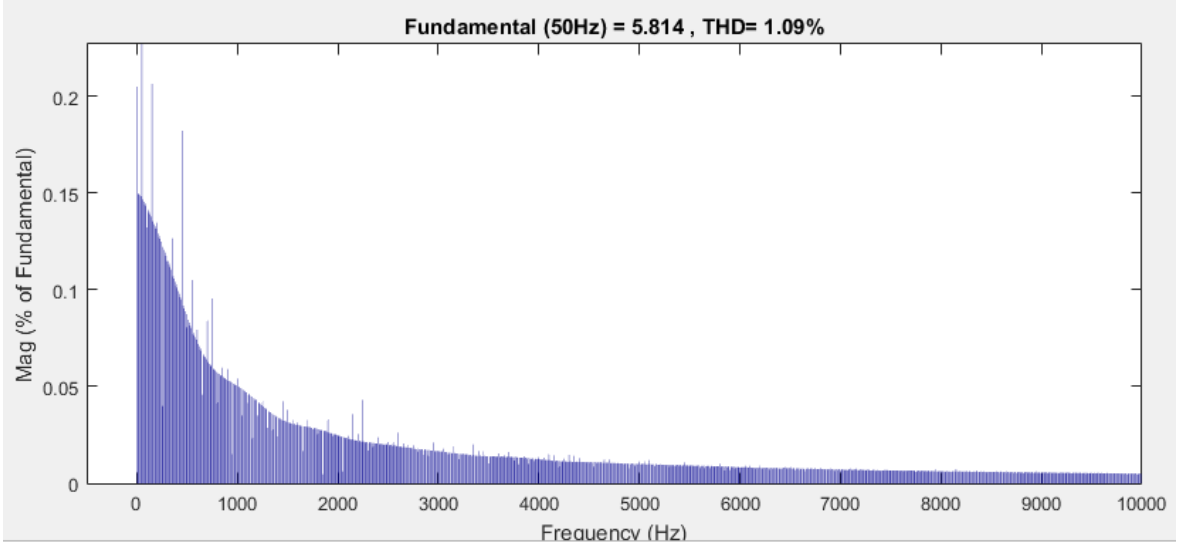

Fig.19. THD and Harmonic spectrum of the supply current, when Solar system and Single-Phase Grid Supply feeds water pumping system through ANN Controller

5. CONCLUSION:

In this study, we provide an innovative technique for reduction of total harmonic. A single-phase grid system is interactive with Solar Photovoltaic array power based on BLDC motor water pumping system by implementing with ANN technique in Phase Locked Loop for bidirectional control of power flow has been implemented in this designed system. A simple unit vector template generation technique has been implemented and proposed in this system. In this proposed system we had shown the better results and Total Harmonic Distortion reduction and unity power factor correction in this proposed system. Power Quality aspects has been mentioned as per IEEE-519 standard.

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