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Advanced MPPT Controller PVA Connected Grid System for BLDC Motor Drive

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ABSTRACT
This paper proposes a solar photovoltaic (PV) fed water pumping system driven by a brushless DC (BLDC) motor. A promising case of interruption in the water pumping due to the intermittency of PV power generation is resolved by using a power grid as an external power backup. The power is drawn from the grid in case the PV array is unable to meet the required power demand; otherwise the PV array is preferably used. A unidirectional power flow control for the same is developed and realized through a power factor corrected (PFC) boost converter. The proposed system and control enable a consumer to get a full volume of water delivery throughout the day and night regardless of the climatic condition. The utilization of motor pump at best is thus made possible in addition to an enhanced reliability of the pumping system. The power quality standards required at the utility grid are met by the developed control A grid interface PVA source is used for running a BLDC motor water pumping system. The PVA is connected to booster converter for constant voltage generation during solar irradiation change. The booster converter is controlled using MPPT controller which is updated to beta method from conventional incremental conductance method. The reaction time and power output of the PVA are compared with these two MPPT methods. The graphs of voltages and powers of PVA and grid are generated with respect to time using MATLAB Simulink environment. The MATLAB/Simulink based simulations and the performance analysis are carried out to demonstrate the applicability of the system.

Keywords:- Solar photovoltaic; Brushless DC motor; Unidirectional power flow control; PFC boost converter; Power quality conventional Beta MPPT Technique, Incremental MPPT .

INRODUCTION

As the energy demand increases, the need for energy saving measures have been rapidly increasing. The brushless DC (BLDC) motors play a vital role, being an energy efficient motor, in this trends [1]. In comparison with an induction motor which is widely used in a solar photovoltaic (PV) based water pumping, the BLDC motors have a high power density, high efficiency, high torque/inertia ratio and a high power factor . Besides these, unlike an induction motor, the speed of a BLDC motor is not limited by power frequency. This leads to a reduced size and an increased capacity of the motor [3]. Among the most promising and significant renewable energy sources, the development of a solar PV technology is reaching its mature stage [4]. Towards an energy saving, this technology plays an increasingly important role. Therefore, the solar PV fed BLDC motor drive indeed emerges as a worth combination of source and drive for an application such as water pumping. Despite an innumerable encouraging aspects, being an intermittent in nature, is the serious issue with PV generation technology. This demerit results in an unreliable

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water pumping with a PV based pumping system. In the course of bad climatic condition, the water pumping is severely interrupted. Moreover, the system is underutilized as the pump is not operated at its full capacity. Furthermore, an unavailability of sunlight (at night) leads to shutdown of an entire water pumping system. To overcome these shortcomings, an external power backup in the form of a battery storage is provided in a PV-BLDC motor-pumping system However, a battery storage reduces the service life, and increases the installation cost and maintenance requirements [8]. To get over this complications with a battery technology, an alternate solution is reported in [9-11] wherein a utility grid is used as the backup source in a PV based induction motor driven water pumping Brushless dc (BLDC) motors are preferred as small horsepower control motors due to their high efficiency, silent operation, compact form, reliability, and low maintenance. However, the problems are encountered in these motor for variable speed operation over last decades continuing technology development in power semiconductors, microprocessors, adjustable speed drivers control schemes and permanent-magnet brushless electric motor production have been combined to enable reliable, cost-effective solution for a broad range of adjustable speed applications. Household appliances are expected to be one of fastest-growing end-product market for electronic motor drivers over the next five years [4].

The major appliances include clothes washer's room air conditioners, refrigerators, vacuum cleaners, freezers, etc. Household appliance have traditionally relied on historical classic electric motor technologies such as single phase AC induction, including split phase, capacitor-start, capacitor–run types, and universal motor. These classic motors typically are operated at constant-speed directly from main AC power without regarding the efficiency. Consumers now demand for lower energy costs, better performance, reduced acoustic noise, and more convenience features. Those traditional technologies cannot provide the solutions.

II SRTUCTURE GRID INTERFACED SOLAR PV WITH BLDCMOTOR DRIVE

The schematic of proposed grid interfaced PV fed brushless DC motor driven water pumping system is shown in Fig.1. A PV array, possessing a sufficient power to run the water pump at its full capacity under the standard climatic conditions, feeds a BLDC motor via a boost converter and a VSI. The DC-DC boost converter and the VSI respectively carry out the MPPT of PV array and an electronic commutation of the motor. Three Hall Effect sensors are used to generate the commutation signals. A BLDC motor which has a rated speed of 6000 rpm at 410 V (DC), is used to run the water pump. A single phase utility grid support is provided, via a bridge rectifier and a PFC boost converter, at the common DC bus of VSI. The power transfer is controlled by operating the PFC converter through a unidirectional power flow control. The developed control enables a power transfer from utility grid to the DC bus if a PV generated power is insufficient to meet the power demand otherwise no power is transferred from the utility.

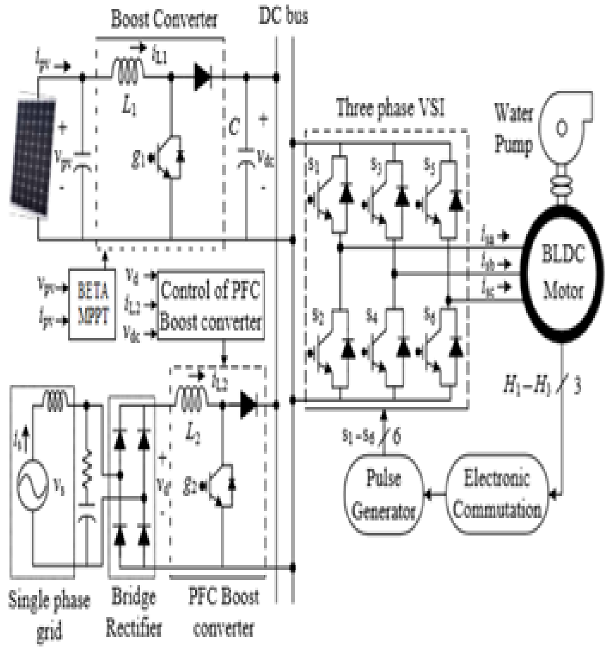

Fig 1: Proposed grid interfaced PV fed brushless DC motor.

III BRUSHLESS DC MOTOR

Brushless dc motor background BLDC motor drives, systems in which a permanent magnet excited synchronous motor is fed with a variable frequency inverter controlled by a shaft position sensor. There appears a lack of commercial simulation packages for the design of controller for such BLDC motor drives. One main reason has been that the high software development cost incurred is not justified for their typical low cost fractional/integral kW application areas such as NC machine tools and robot drives, even it could imply the possibility of demagnetizing the rotor magnets during commissioning or tuning stages. Nevertheless, recursive prototyping of both the motor and inverter may be involved in novel drive configurations for advance and specialized applications, resulting in high developmental cost of the drive system. Improved magnet material with high (B.H), product also helps push the BLDC motors market to tens of kW application areas where commissioning errors become prohibitively costly. Modeling is therefore essential and may offer potential cost savings.

A brushless dc motor is a dc motor turned inside out, so that the field is on the rotor and the armature is on the stator. The brushless dc motor is actually a permanent magnet ac motor whose torque-current characteristics mimic the dc motor. Instead of commutating the armature current using brushes, electronic commutation is used. This eliminates the problems associated with the brush and the commutator arrangement, for example, sparking and wearing out of the commutator-brush arrangement, thereby, making a BLDC more rugged as compared to a dc motor. Having the armature on the stator makes it easy to conduct heat away from the windings, and if desired, having cooling arrangement for the armature windings is much easier as compared to a dc motor.

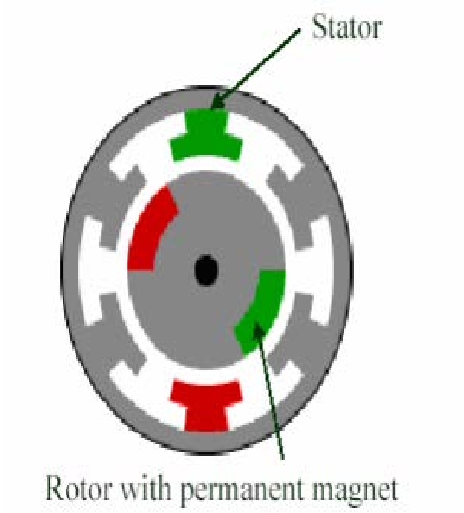

Fig 3.1: Cross-section view of a brushless dc motor.

In effect, a BLDC is a modified PMSM motor with the modification being that the back-emf is trapezoidal instead of being sinusoidal as in the case of PMSM. The “commutation region” of the back-emf of a BLDC motor should be as small as possible, while at the same time it should not be so narrow as to make it difficult to commutate a phase of that motor when driven by a Current Source Inverter. The flat constant portion of the backemf should be 120° for a smooth torque production. The position of the rotor can be sensed by using an optical position sensors and its associated logic. Optical position sensors consist of phototransistors (sensitive to light), revolving shutters, and a light source. The output of an optical position sensor is usually a Logical signal.

3.1.1Principle operation of Brushless DC (BLDC) Motor

A brush less dc motor is defined as a permanent synchronous machine with rotor position feed back. The brushless motors are generally controlled using a three phase power semiconductor bridge. The motor requires a rotor position sensor for starting and for providing proper commutation sequence to turn on the power devices in the inverter bridge. Based on the rotor position, the power devices are commutated sequentially every 60 degrees. Instead of commutating the armature current using brushes, electronic commutation is used for this reason it is an electronic motor. This eliminates the problems associated with the brush and the commutator arrangement, for example, sparking and wearing out of the commutator brush arrangement, thereby, making a BLDC more rugged as compared to a dc motor.

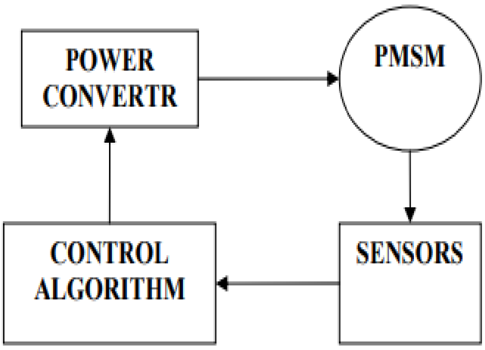

Fig 3.2: Basic block diagram of BLDC motor.

The basic block diagram brushless dc motor as shown Fig.3.2 The brush less dc motor consist of four main parts power converter, permanent magnet-synchronous machine (PMSM) sensors, and control algorithm. The power converter transforms power from the source to the PMSM which in turn converts electrical energy to mechanical energy. One of the salient features of the brush less dc motor is the rotor position sensors ,based on the rotor position and command signals which may be a torque command ,voltage command ,speed command and so on the control algorithms determine the gate signal to each semiconductor in the power electronic converter.

IV SIMULATION RESULT AND DISCUSSION

The complete design related to the project is created in Matlab & Simulation using Sim Power System Toolbox and thereby analysisthe different MPPT Technique. .This designing is conducted in two satge stages:-

1 .Grid interfaced PV-INC MPPT system with BLDC Motor Drive

2. Grid interfaced PV-BETA MPPT system with BLDC Motor Drive

1.1.1 4.1 SYSTEMPARAMETERS

PARAMETERS	VALUES
Irradiation	1000
Temperature constant	30°
PWM Switching frequency	1000
Inductance	1mh
Capacitance	47 micro farad
AC Voltage source	180V
Stator phase resistance of BLDC	0.41
Stator phase inductance of BLDC	2.13

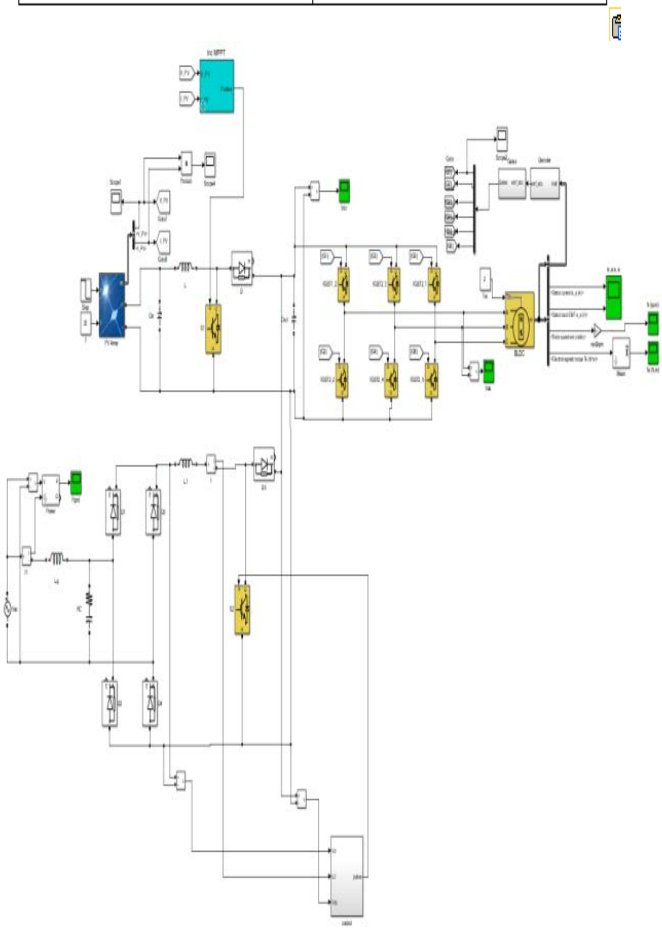

Fig 4.1: Grid interfaced PV-INC MPPT system with BLDC Motor Drive.

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In the above proposed system the utility grid is connected to a diode bridge rectifier for AC to DC conversion and the variable DC voltage is stabilized using booster converter. A feedback loop controller is connected to control the booster converter of the utility grid.

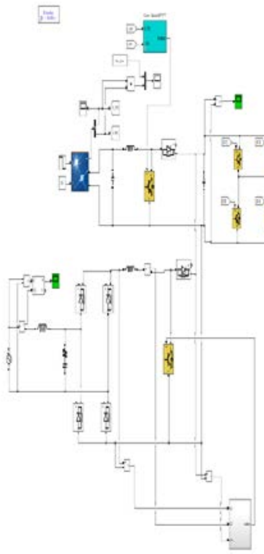

Fig 4.2: Grid interfaced PV-BETA MPPT system with BLDC Motor Drive.

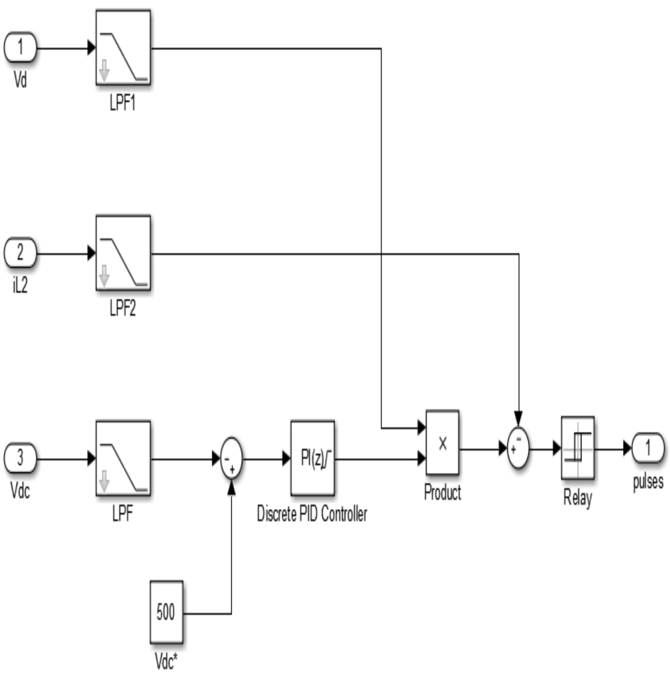

Fig 4.3: Booster converter controller of utility grid module.

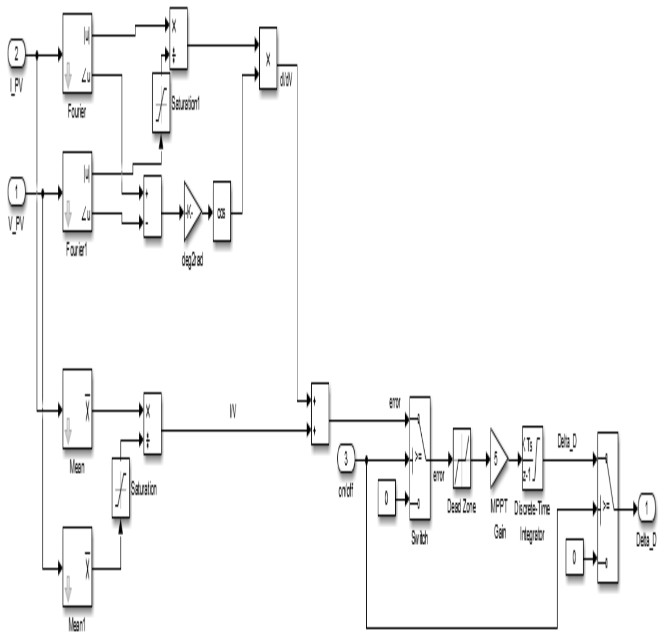

Fig 4.4: Incremental conductance MPPT method.

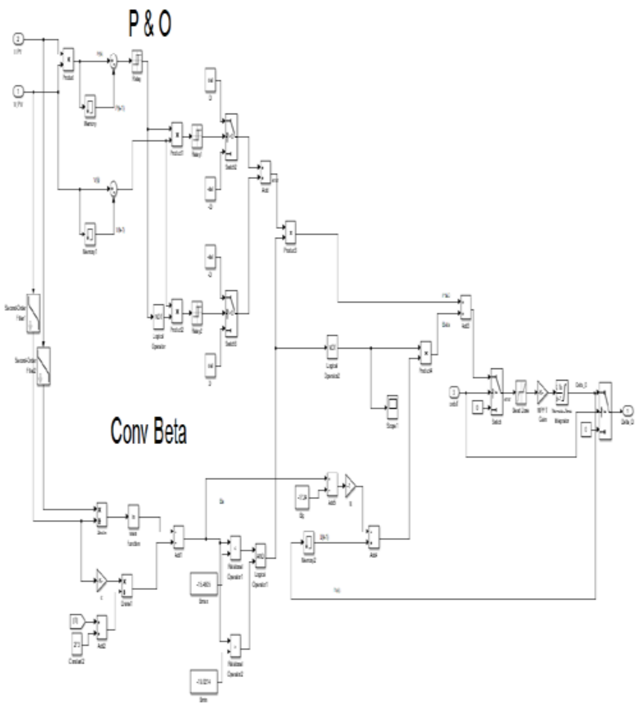

Fig 4.5: Beta method MPPT method.

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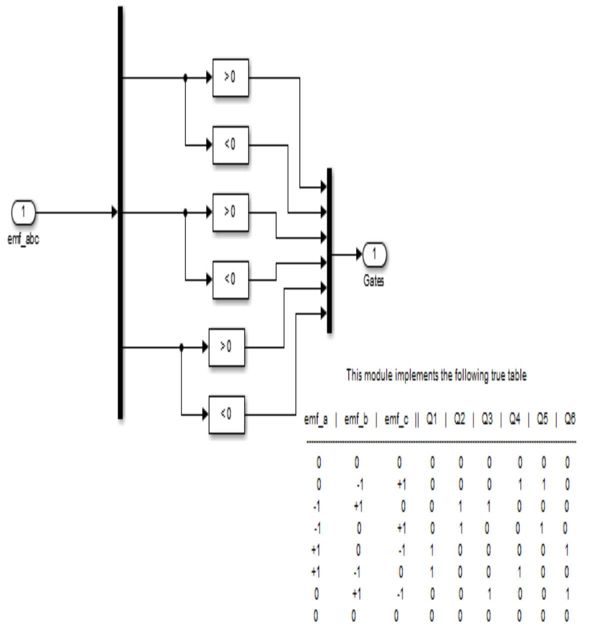

Fig 4.6: Commutation signals for six switch VSC for BDLC motor drive.

The above test system is run for 1sec with solar irradiation drop from 1000W/mt2 to 200W/mt2 at 0.5sec and powers of PVA and grid are recorded.

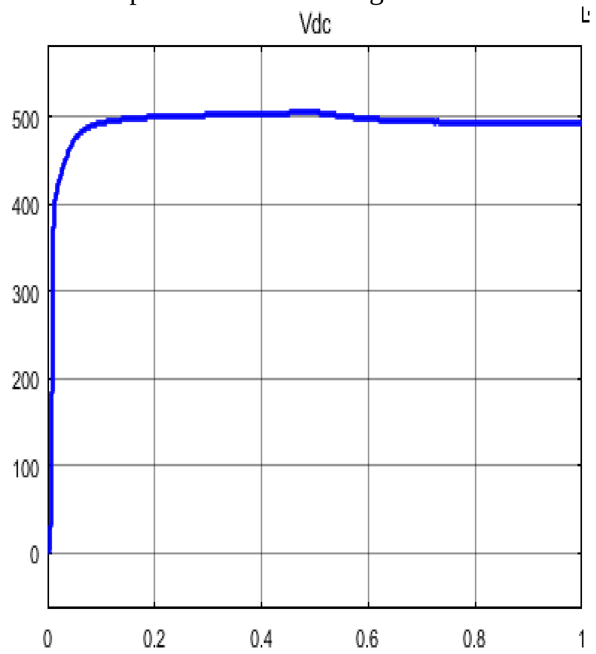

Fig 4.7: DC voltage at PCC.

The DC voltage is maintained at 500V even during drop in solar irradiation, which is maintained by the MPPT controller and the feedback loop controller of the utility grid.

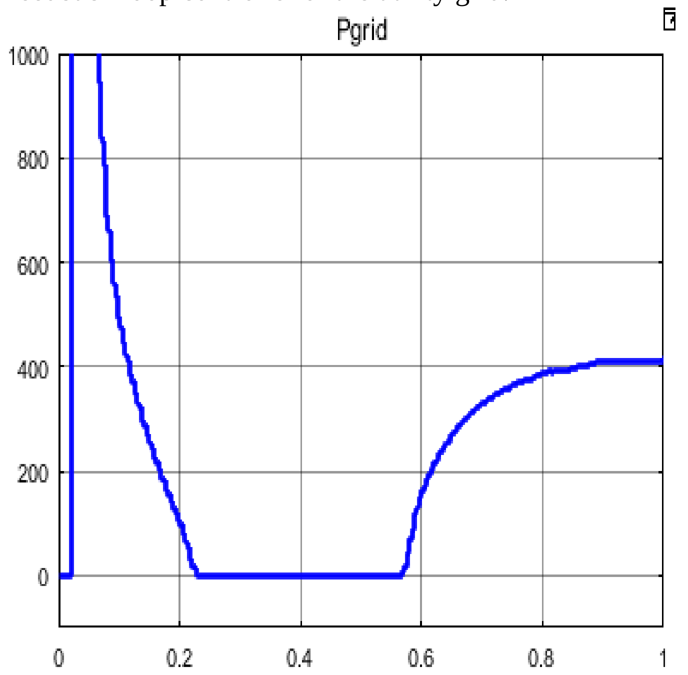

Fig 4.8: Grid power injected.

Increase in power of grid from 0W to 400W during drop in solar irradiation. From 0 to 0.2sec is the transient time for the system to settle which is neglected as we consider only steady state period.

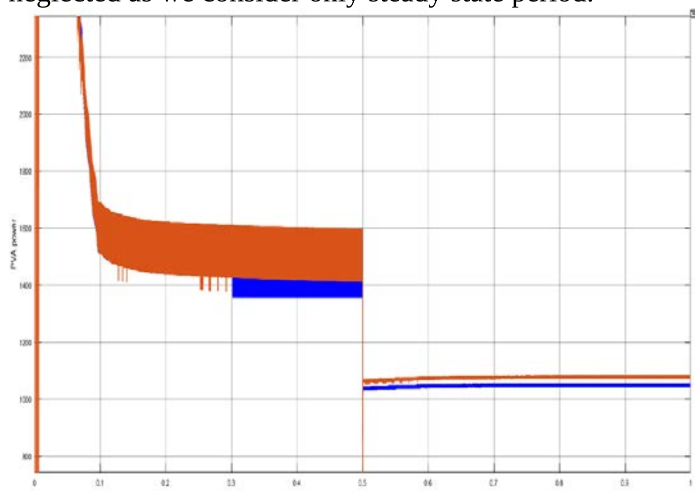

Fig 4.9: PVA power comparison for incremental conductance MPPT and beta method.

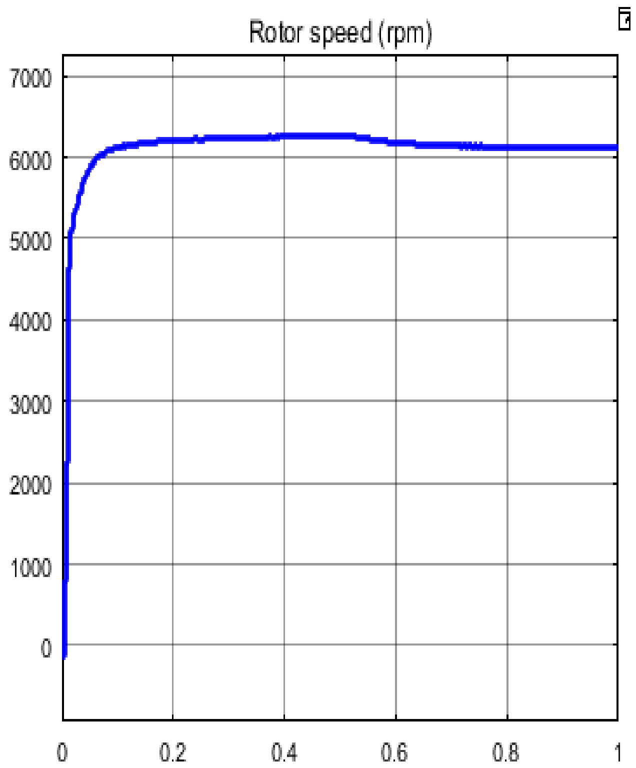

Fig 4.10: Speed of the BLDC motor.

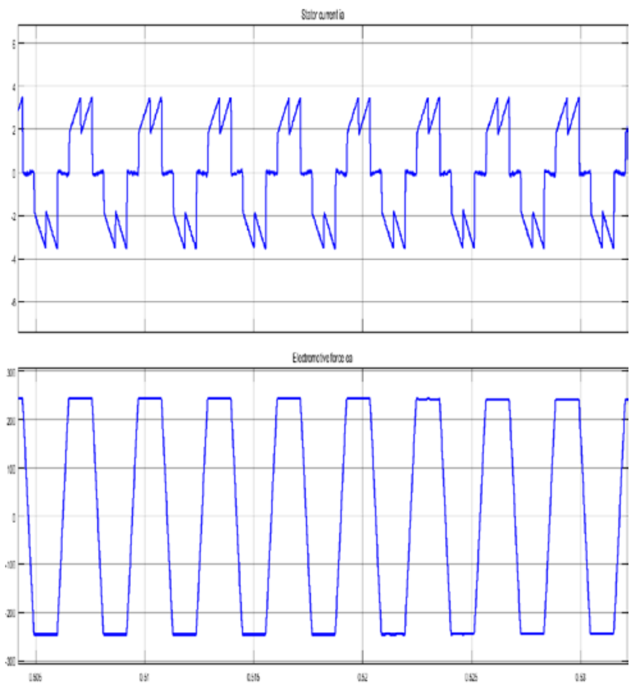

Fig 4.11: Stator current and emf of A phase of BLDC motor.

V CONCLUSION

A single phase grid interfaced solar PV-water pumping system with a brushless DC motor drive has been proposed and demonstrated through its performance evaluation using MATLAB/Simulink platform. The utility grid support as a power backup has been provided at the common DC bus. A unidirectional power flow control has been developed and realized with a PFC boost converter in order to enable a power transfer conditionally. In the above graphs the power of the PVA is dropping from 1500W to 1100W when the irradiation is changed from 1000W/mt2 to 200W/mt2 and the remaining deficit power 400W is compensated by utility grid at 0.5sec. The BLDC motor is however running at the same speed even during solar irradiation change. The power output of the PVA is improved when the MPPT is updated with beta method as compared to conventional incremental conductance method. Thus, the proposed topology has emerged as a reliable and efficient water pumping system.

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