iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 Issue: VII Month of publication: July 2020

DOI: https://doi.org/10.22214/ijraset.2020.30347

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue VII July 2020- Available at www.ijraset.com

Grid Connected Solar Powered Water Pumping System utilizing SRM Drive

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Abstract: Despite the focus on industrialization, agriculture remains the dominant sector of the Indian economy, both in terms of contribution to the gross domestic product (GDP) as well as the source of employment for millions across the country. Over 70% of the rural households depend on agriculture as their principal means of livelihood. Renewable energy sources are beginning to play more of a role in urban areas such as building integrated photovoltaic's, as well as in rural areas where wind, solar, biomass, and geothermal are gaining in popularity. When it comes to replacing the mass energy production of fossil fuels, renewable energy has not yet proven to be practical. However, renewable energy sources do excel in local applications where there is limited or no access to an electricity grid, or where access to conventional energy is prohibitively expensive. They are most efficient in local applications because the energy production is at the same location as the end-use, hence minimizing the need for energy storage and transport. Of the energy consumers within agriculture, the timing of irrigation requirements conveniently coincides with an increase in insolation/intensity of solar radiation, creating great potential for the union of irrigation and solar energy, specifically photovoltaic systems

The use of PV technology varies considerably, from PV cells in calculators and watches, to PV modules in telecommunications equipment and highway signs, to PV arrays for water pumping and generating electricity in agricultural and rural areas (Kabade 2013).An important aspect of the PV system is the energy storage capacity. A method of storing energy is to use the solar power to pump water to a higher elevation, thus transferring the electrical energy to potential energy .Water pumps used depend greatly on the type of application .Positive displacement pumps offer low volume with high lift capabilities, whereas rotating pumps are best for large water requirements over any lift. Floating and surface suction pumps offer a range of volumes at low lift only. Submersible pumps are the most efficient for use in a PV pumping system, as they eliminate the suction line.

I. RELATED WORK

The focus of this article is on the use of conventional energy to produce non-existent energy. This article focuses on the application of floating fertilizer for solar power plants. The main theme of this article is the use of solar power. Since hydropower is a non-power source, with the help of solar PV panels, we can produce energy all year round. We can use the renewable source of electricity to generate electricity. Solar energy is a source of energy. Solar energy is converted into solar energy by alternative energy sources. The use of solar energy has some limitations, as well as the benefits of using solar energy.

S.V. Mitrofanov et al. (2019) This article provides the experience of producing solar power stations through Orenburg's (Russia) two-axis solar system in winter 2019. Comparative analysis the "green" energy produced by solar panels and the solar models with control systems. The data of the camp measurement system is used as data to investigate the operation of photovoltaic power stations. Difficulty is developing a development scheme for isolatedintensive care and testing of solar farms and automatic life stations. The author examines in detail the structure and operation of the common site, the nature of the pipeline during the period above, and proposes to improve the efficiency of photovoltaic power plants in 'of the Orenburg area.

II. PRPOSED SYSTEM

The SRM drive has been chosen for proposed system due to its highly inductive nature, which makes it most appropriate for single stage system. The other benefits such as low cost, high efficiency and requirement of simple power converter for phase energizing, make it suited for the grid interactive solar powered water pump

The manifold benefits and contributions of proposed system are enlightened here.

1) It is first time that SRM is being used as a drive for the grid connected solar powered water pumping system either for double stage or single stage. A high-efficiency SRM drive substantially reduces the size of PV array and hence its installation cost.
2) The proposed system has low losses due to absence of DC-DC conversion stage. Thus, the system becomes compact and efficient.
3) Since the proposed topology is single stage, it has additional advantage of variable DC link voltage depending upon the PV power. It helps to reduce the power loss in the system. The semiconductor and ohmic losses in the interfacing inductor, are dependent on dc link voltage. The ripple content in the interfacing inductor can be reduced by variable dc link voltage.
4) An improved generalized integrator based grid side control algorithm is presented for a single-phase grid interfaced solar energy conversion system, which has good DC offset and harmonic components rejection capability. This controller has incorporated a PV feed forward approach to enhance the dynamic performance of overall system and to minimize the size of DC link capacitors with improved MPPT performance. It also overcomes the oscillations present in grid voltage and PV output voltage.
5) The seamless power streaming is facilitating the system to work in all possible conditions without using a battery or any other storage device by just maintaining the DC link voltage.
6) The switched reluctance motor (SRM) drive is highly inductive and so it is the most suited for single stage PV fed system as it is able to mitigate the ripple in PV output current and minimizes a need of high DC link capacitors.

A number of configurations have been reported in the literature to integrate the utility grid to solar PV array to offer uninterrupted power to the motor-pump arrangement so that a continuous water supply can be obtained. However, most of the configurations involved are the double stage arrangement with unidirectional power flow [11-13]. Although, these are able to provide continuous water supply, the proposed systems suffer from high converter losses, control complexity, unable to mitigate and overcome the harmonics and oscillations in the grid voltage and provides only unidirectional power flow from the grid to load side

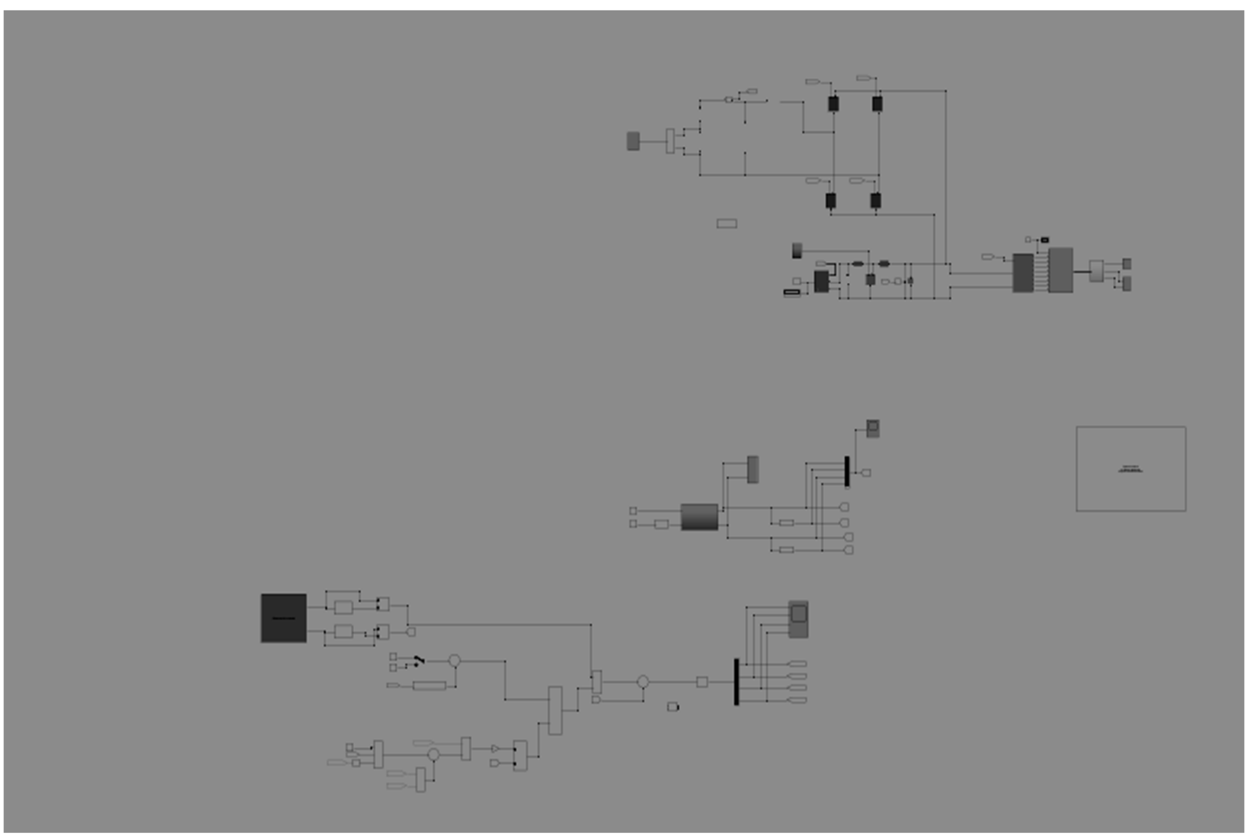

Fig 1 proposed simulink model

However, the system discussed in [14] has bidirectional power flow capability utilizing a bidirectional converter and the transformer. The presence of isolated transformer and its noisy operation, make the system unreliable and inefficient. The another system discussed in [15], is able to acknowledge most of the constraints of conventional systems but the incapability to handle the disturbance generated in the grid side and inefficient MPPT controller, make system unsuitable. Moreover, the limited operating area for MPPT execution, losses due to boost converter and large DC link capacitor, make the system impractical for solar powered water pumps. Such, a hybrid arrangement including PV array, a battery and utility grid, is discussed in [16]. In this system, PV array charges the battery and then water pump is run with the discharging of the battery. The utility grid is connected with an optional switch. The complete system becomes costly due to presence of a battery. All these abovementioned topologies are double stage, need large size DC link capacitor and have no provision to handle the disturbance in the grid parameters. So, a single stage system without DC-DC converter and having the capabilities to handle all these issues yet to be developed. Therefore, the present single stage PV array powered SRM driven water pumping system with proposed controller, has multiple intents such as DC offset rejection, harmonic components removal, efficient MPPT tracking and DC link current compensation.

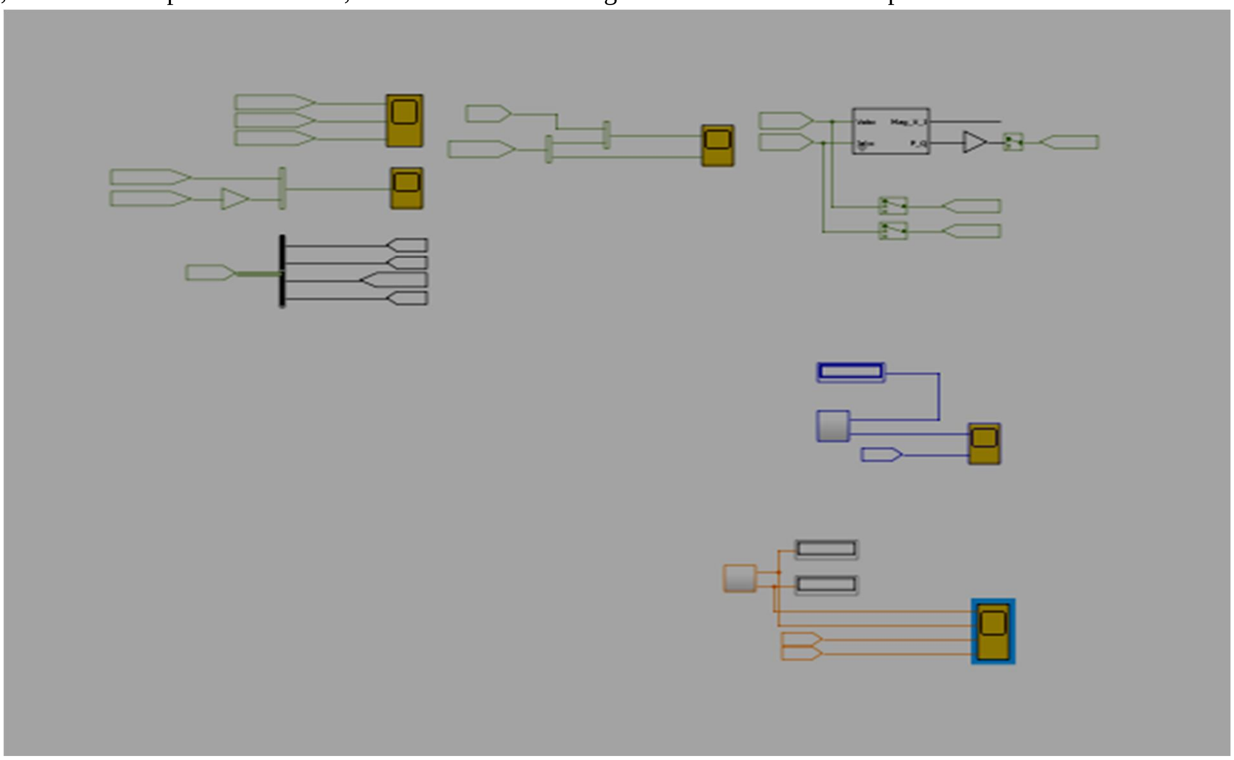

Fig 2 proposed simulink model subsystem

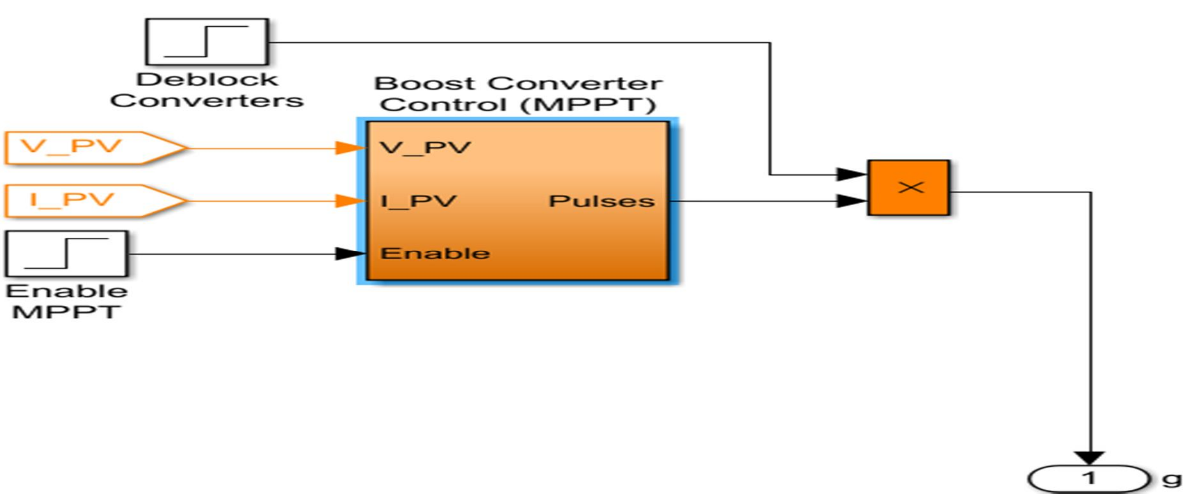

Fig 3 boost converter simulink model

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Emotional conversion is a DC-to-DC converter whose output volume is larger than the output volume. Also called pulse converter. The uploaded got its name, because, like the promotion converter, it goes up at a higher rate than the cable reinforcement cable. According to the law of conservation of energy, the input power must be equal to the energy of the energy (assuming there is no line loss).

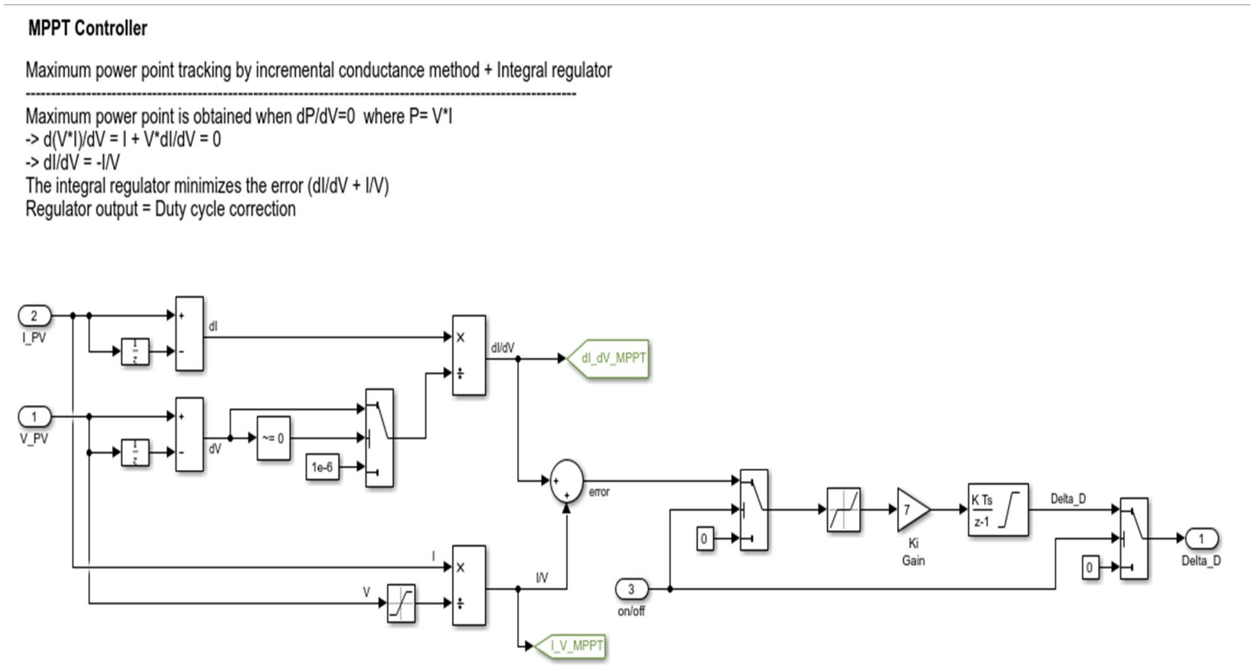

Fig 4 MPPT simulink model

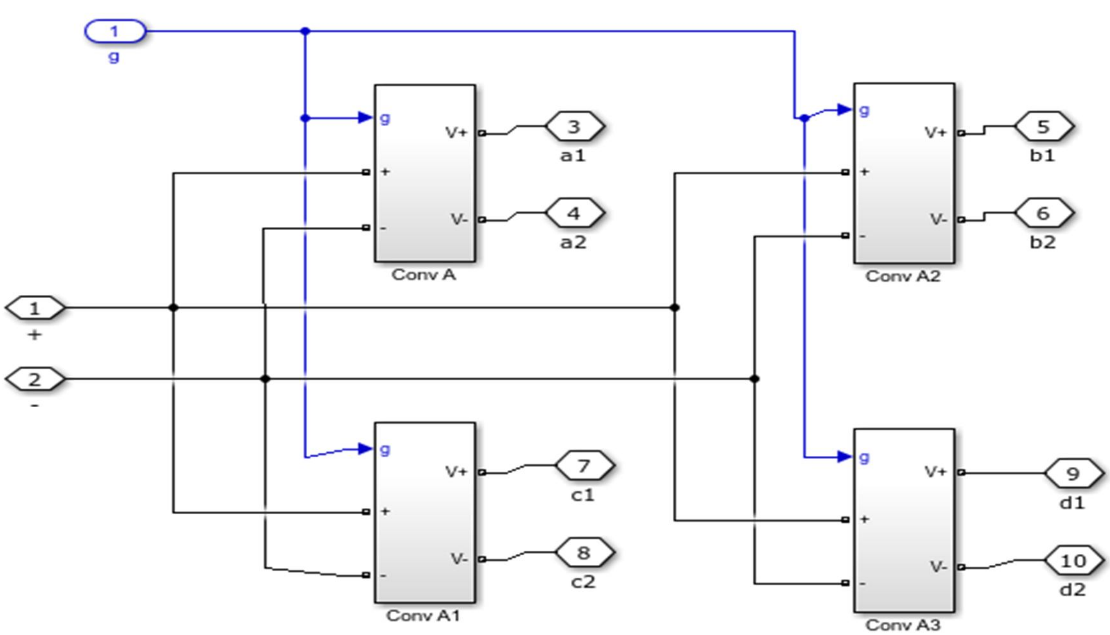

Fig 5 convertersimulink model

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III. BIDIRECTIONAL DC-DC CONVERTER

When buck or boost converters are related together in an antiparallel fashion, the resulting circuit basically has same construction as the basic buck or boost structure, but with the additional bi-directional power flow function. The following figure shows basic structure of a non-isolated half-bridge bidirectional DC-DC converter

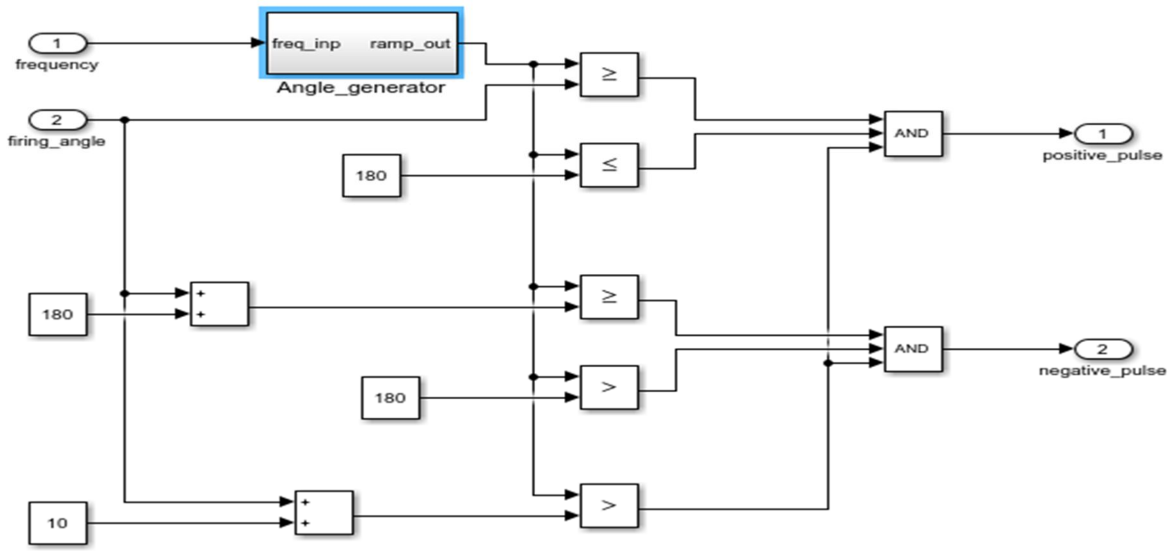

Fig 6 motor subsyem

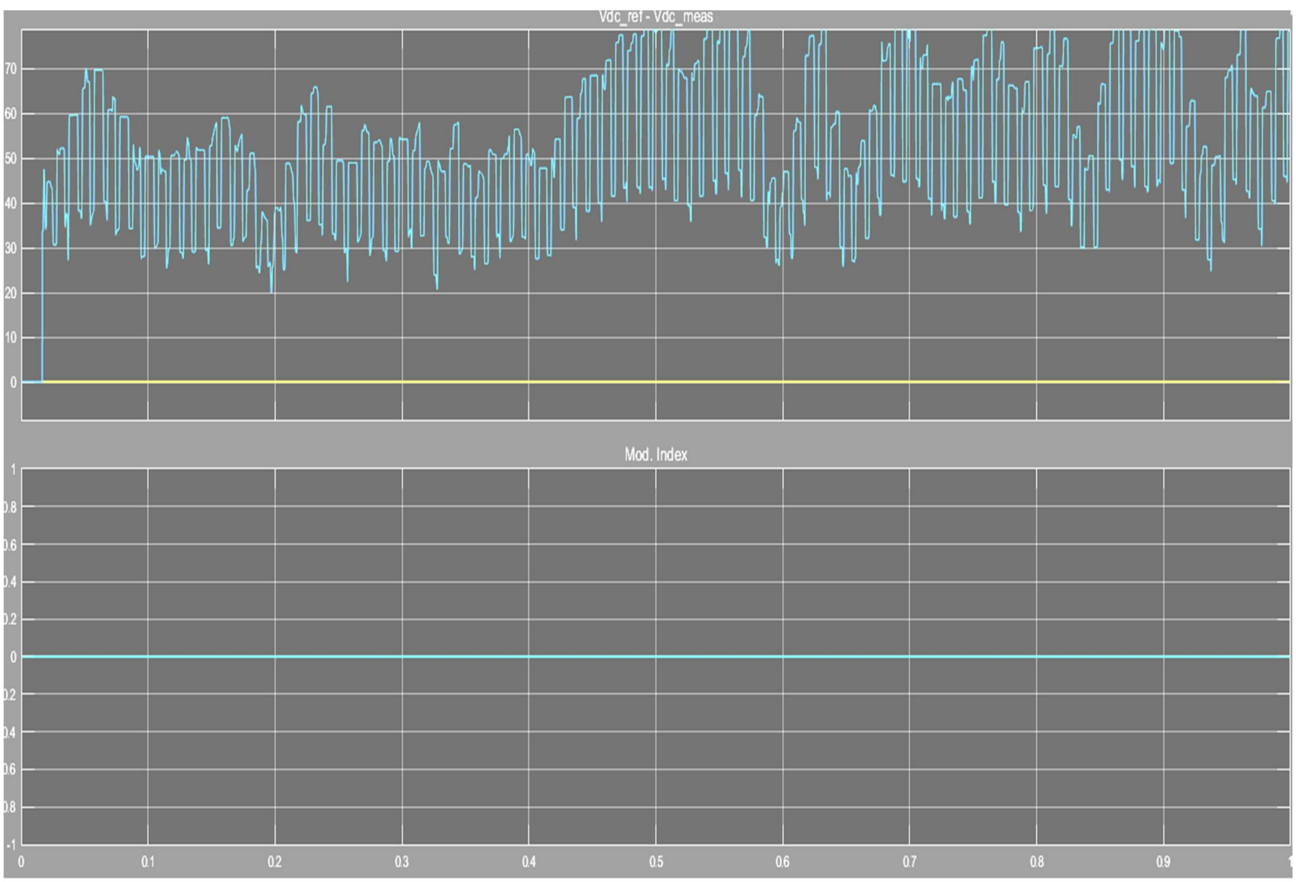

Fig 7 output mode index and voltage source converter

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The logic to commutate the SRM converter at fundamental frequency while doing the MPPT tracking through VSC has enhanced the efficiency of overall system.

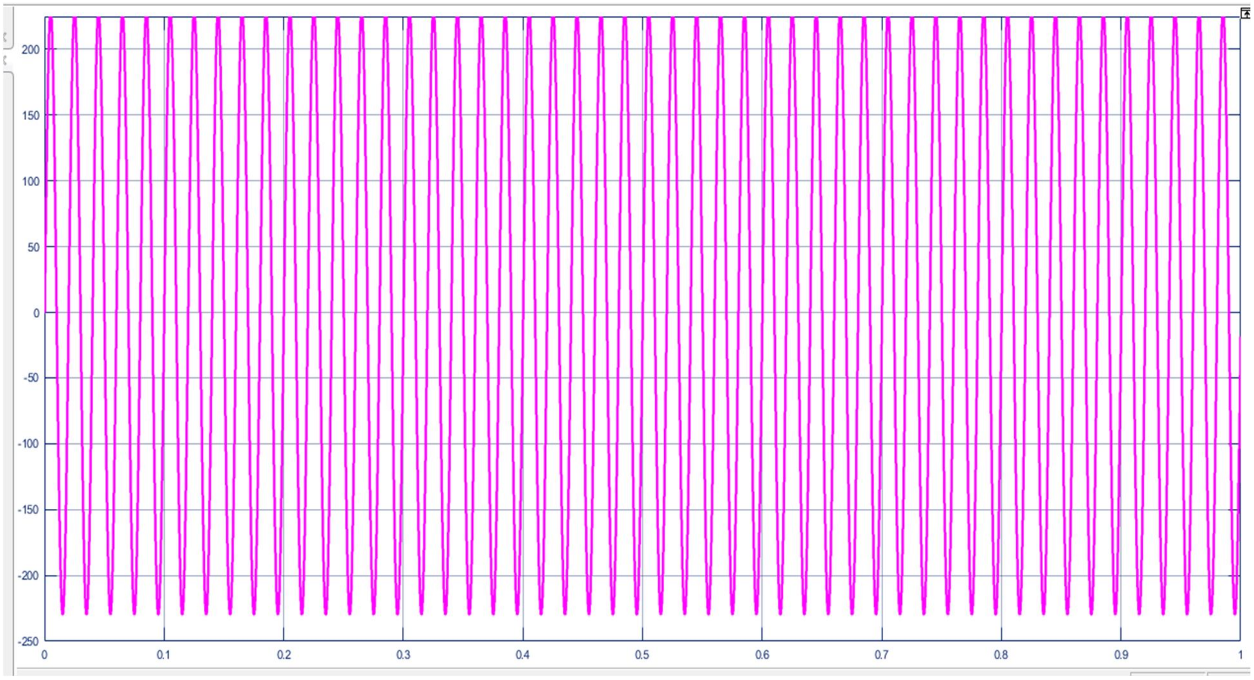

Fig 8 grid power demonstrate the behaviour of system

Under situation when the solar power is completely absent and the pump is driven only through the grid power.illustrates the grid components, 'vg', 'ig', and SRM indices 'ipha' and speed. Both 'vg' and 'ig' are in phase and govern the supply of grid power to the load illustrates the system operation, when only grid is feeding the pump. The developed control technique has merits of eliminating the effect of grid voltage imbalance as well as DC offset,

Fig. 9 switching pulses

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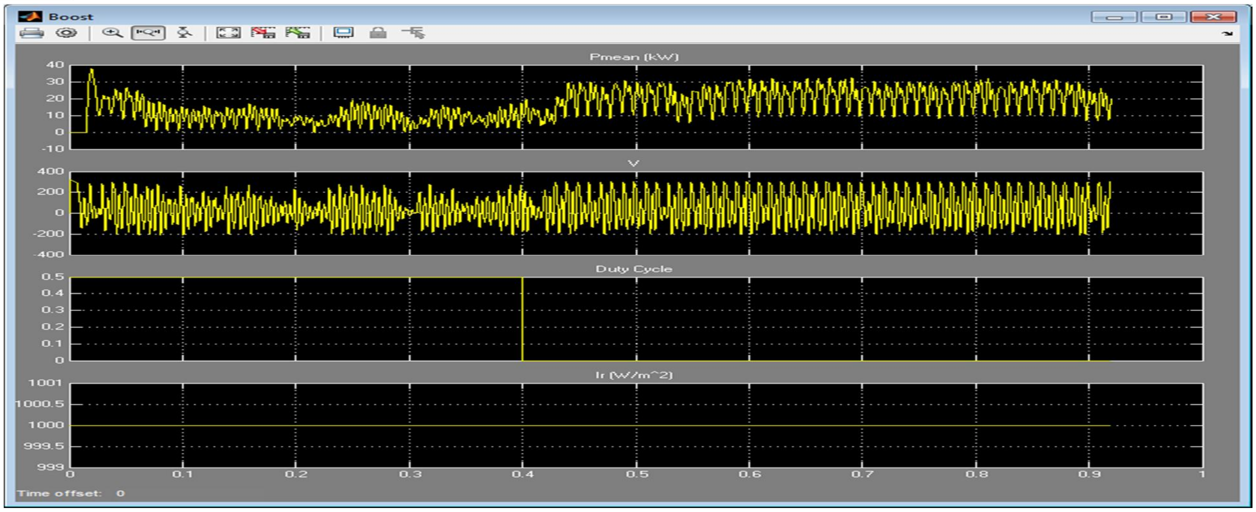

Fig. 10 boost converet output

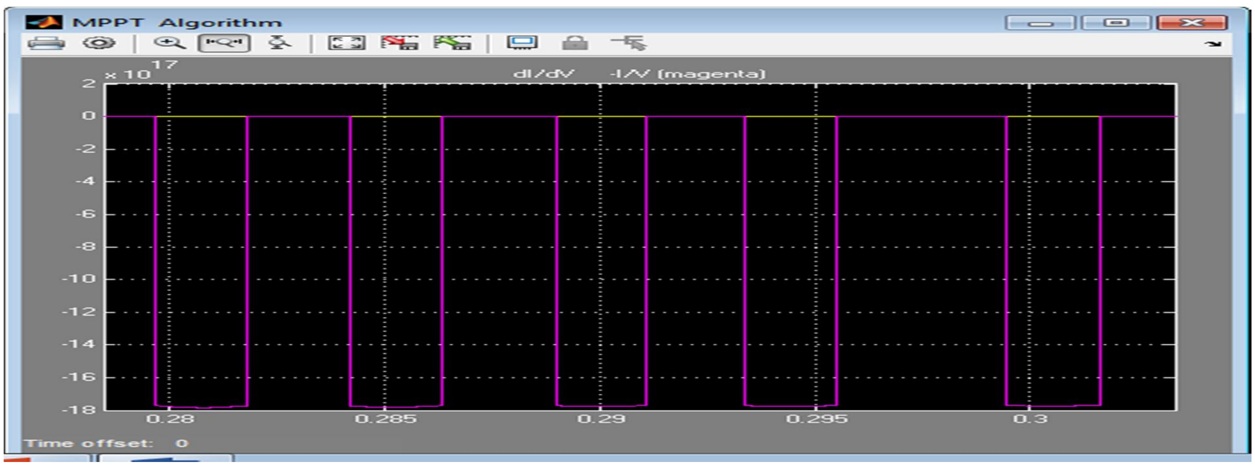

Fig. 11 MPPToutput

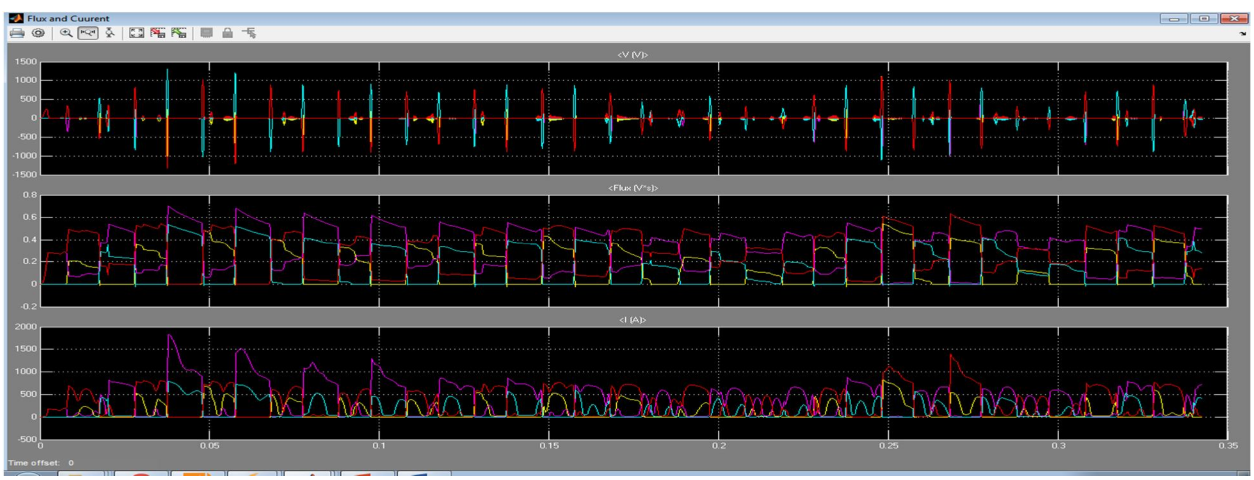

Fig.12 flux and motor current

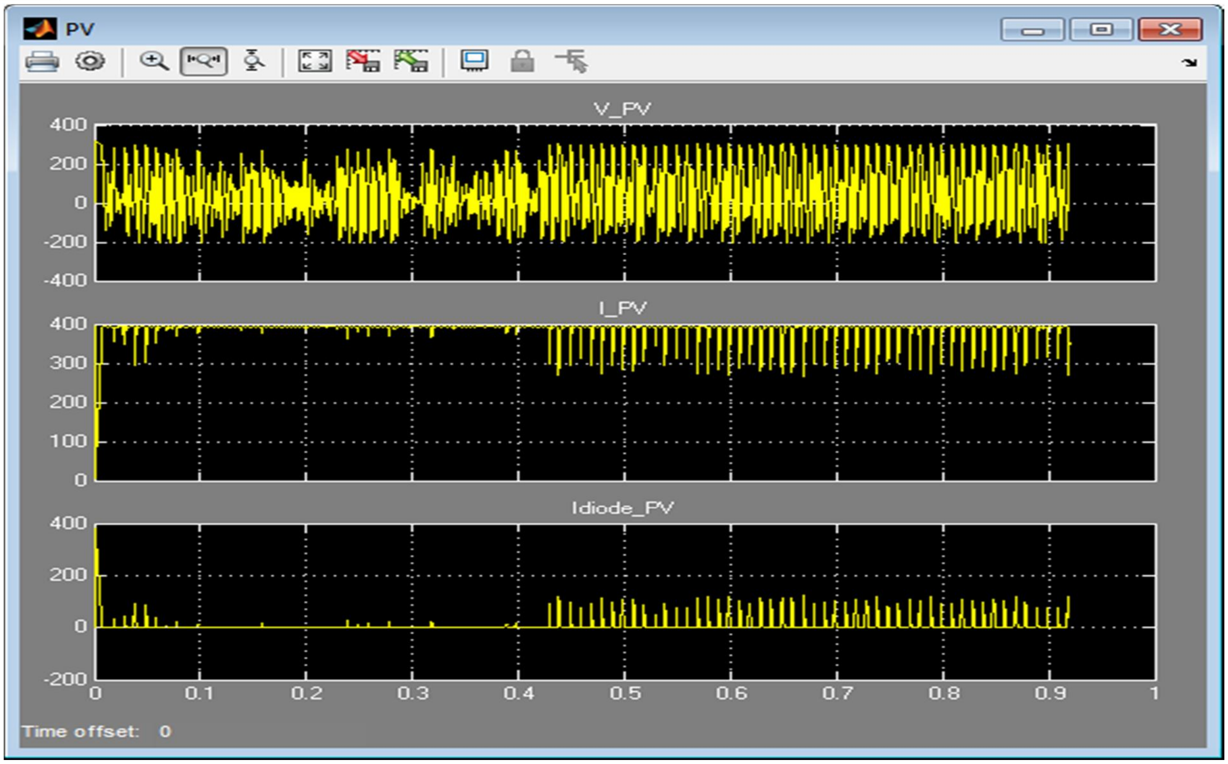

Fig .13 solar panel output

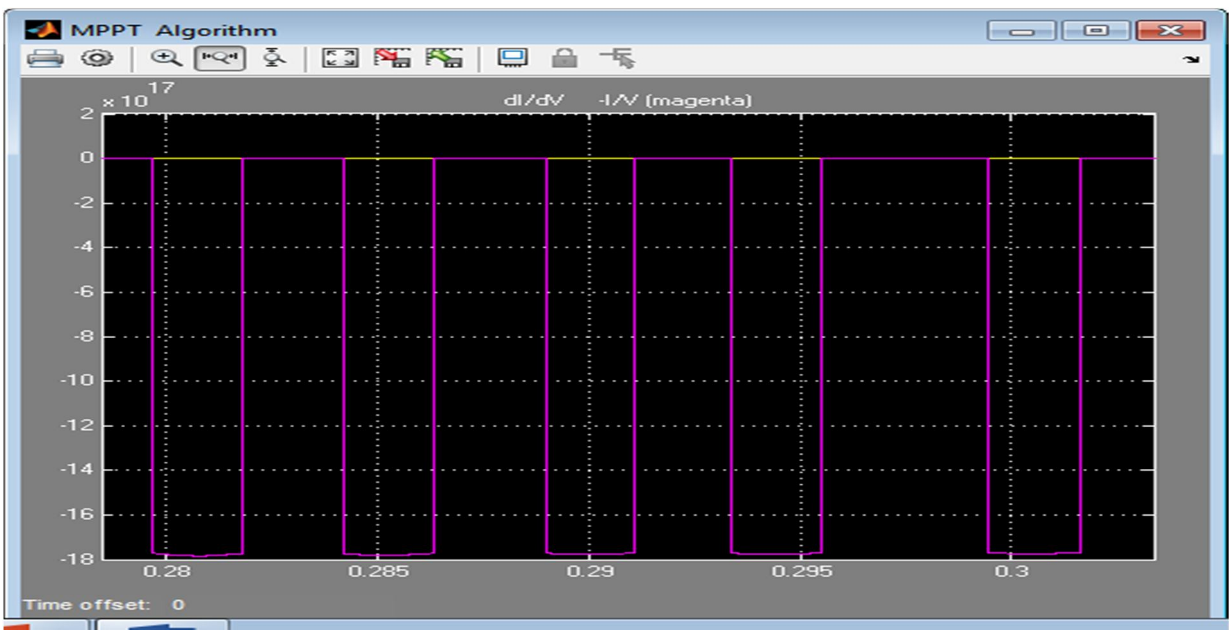

Fig. 14 MPPT output

As far as the condition of rapid change of insolation, the proposed system with proposed MPPT controller, has proficiently handle the rapid change of insolation by quickly adjust the DC link voltage and therefore speed of the motor drive as the logic The drive speed remains constant under variation in solar irradiance and DC link voltage tracks the 'Vpvref' value at all irradiance levels. The magnitude of 'ig' is increasing under decrease in insolation levels to meet the power demand of the pump. Besides, when Ppv=0, the total power needed by motor-pump system is supplied by the grid while maintaining the PQ of utility grid. Moreover, the smooth variation in the grid current under change in irradiance governs the effectiveness of PV feed-forward term incorporated in proposed control

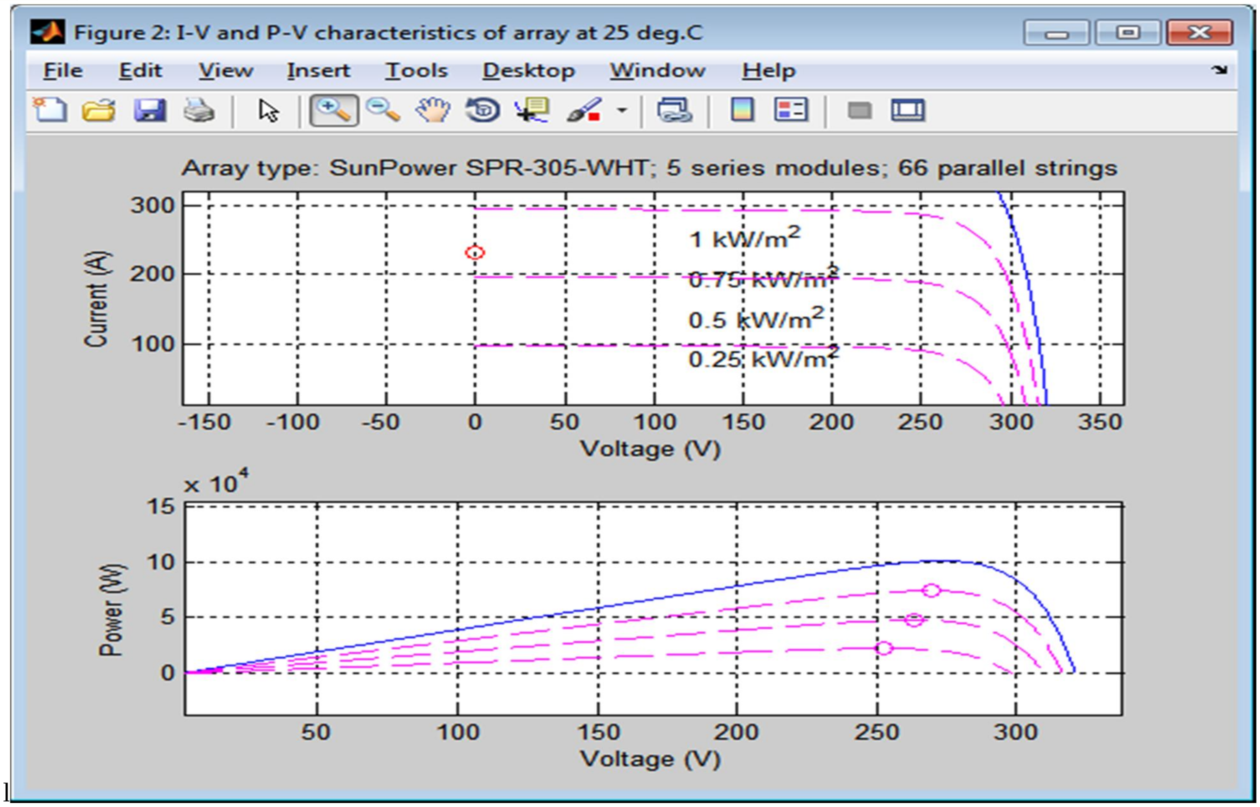

Fig 15 solar voltage at different irradiance level

Demonstrates the performance under both the conditions when there is change in insolation from 1000W/m2 to 200W/m2 and then when PV power is totally unavailable. Fig. 9(a) shows the insolation, 'Vpv', 'Ppv', 'ig', 'vg' and 'N'. The drive speed remains constant under variation in solar irradiance and DC link voltage tracks the 'Vpvref' value at all irradiance levels. The magnitude of 'ig' is increasing under decrease in insolation levels to meet the power demand of the pump. Besides, when Ppv=0, the total power needed by motor-pump system is supplied by the grid while maintaining the PQ of utility grid. Moreover, the smooth variation in the grid current under change in irradiance governs the effectiveness of PV feed-forward term incorporated in proposed c

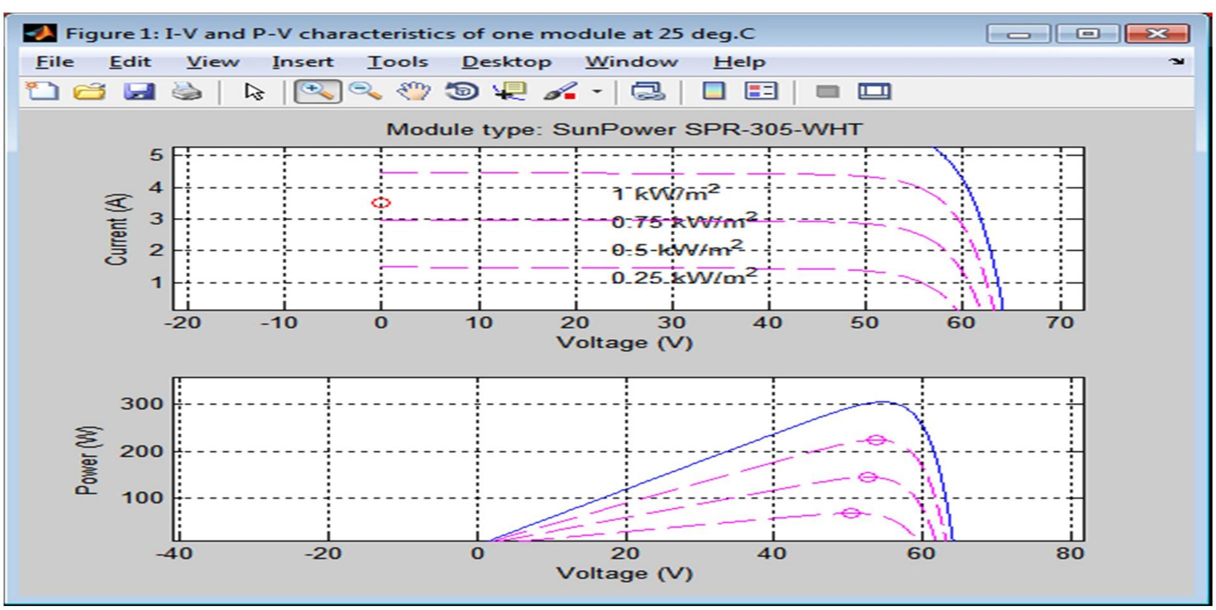

Fig 16 solar power and voltage at different irradiance level

As far as the condition of rapid change of insolation, the proposed system with proposed MPPT controller, has proficiently handle the rapid change of insolation by quickly adjust the DC link voltage and therefore speed of the motor drive as the logic given in Fig.1. So, the technique to control the speed of SRM drive via PWM control is highly effective in continuously changing insolation levels. The characteristics of motor speed and one of the winding current under the change in PV power due to variation in insolation level from 1000W/m2 to 600W/m2 and from 600W/m2 to 1000W/m2 are shown in Figs.12 (a) and (b). Both the figures governs the smooth performance of proposed system even when the PV power is less than motor power and grid is absent

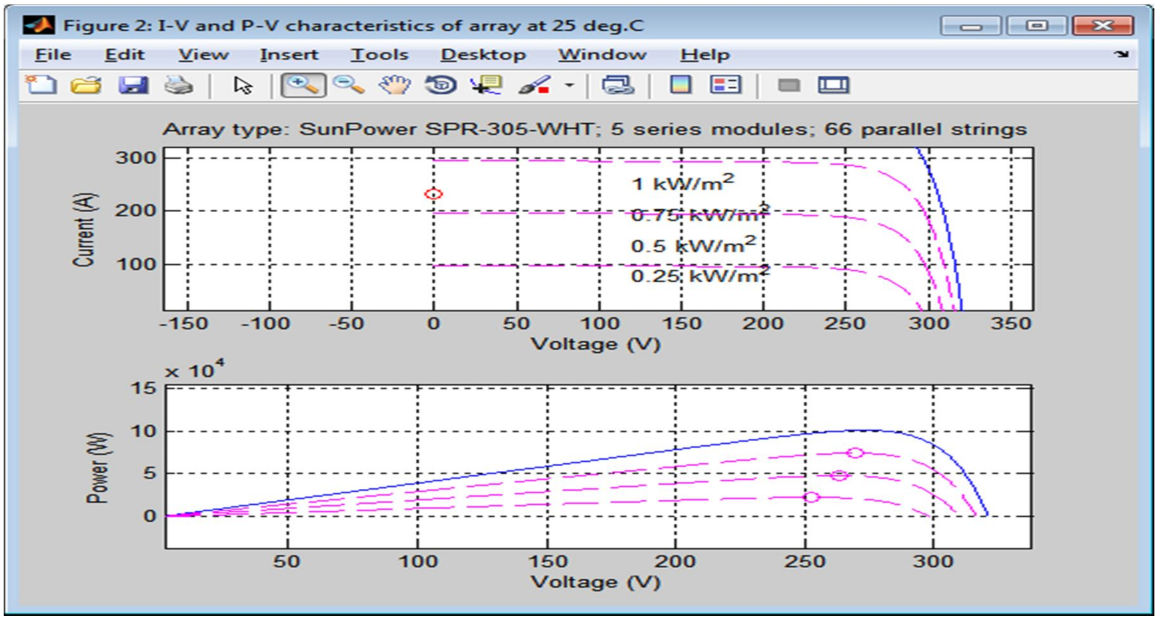

Fig 17 solar power and voltage at different irradiance level

IV. CONCLUSION

Here, PV pumping system has been analyzed with its scope and limitations. Photovoltaic systems are especially designed to supply water and irrigation in areas where there is no mains electricity supply. Their main advantages over hand pumps or internal combustion engine pumps are their practically zero maintenance, their long useful life, that they do not require fuel, that they do not contaminate, and finally that they are straightforward to install. Another important characteristic is that, as they use the sun as their energy source, the periods of maximum demand for water coincide with the periods of maximum solar radiation. When compared to diesel powered pumping systems, the cost of solar PV water pumping system without any subsidy works out to be 64.2% of the cost of the diesel pump, over a life cycle of ten years. Solar pumps are available to pump from anywhere in the range of up to 200m head and with outputs of up to 250m³/day. In general photovoltaic pumps are economic compared to diesel pumps up to approximately 3kWp for village water supply and to around 1kWp for irrigation. Solar Photovoltaic (SPV) sets represent an environment-friendly, low-maintenance and cost effective alternative to irrigation pump sets which run on grid electricity or diesel. It is estimated that India's potential for Solar PV water pumping for irrigation to is 9 to 70 million solar PV pump sets, i.e. at least 255 billion lit/year of diesel savings. A solar irrigation pump system methods needs to take account of the fact that demand for irrigation system water will vary throughout the year. Peak demand during the irrigation system seasons is often more than twice the average demand. This means that solar pumps for irrigation are under-utilized for most of the year. Attention should be paid to the system of irrigation water distribution and application to the crops. The irrigation pump system should minimize water losses, without imposing significant additional head on the irrigation pumping system and be of low cost.

A new configuration of efficient and reliable single stage grid interactive solar powered SRM driven water pump with an efficient controller, has been proposed. A new control technique to extract the fundamental of grid voltage has worked diverse objectives such as power factor correction, harmonics mitigation, DC offset rejection and the MPPT tracking. The new PV feed-forward unit is also incorporated in developed control technique to improve the dynamic performance of system and to minimize the burden on current and voltage controllers, which has successfully demonstrated by both Simulink and test results. All the power quality aspects in each possible case, have been met as per the IEEE- 519 standard. The logic to commutate the SRM converter at fundamental frequency while doing the MPPT tracking.

System can be indorsed as a basis of ecological growth and of course as an earning source through the trade of electricity to the utility grid.In the current research, all efforts have been made to present the problem related to power fluctuations of DGs on a grid without taking the transmission losses in considerations. In future, the transmission losses may also be considered for a more rigorous analysis. The analyses may also be strengthening by considering the plants which are at close proximity and at extreme distance separately. Distance of geographical location may be given importance for determination of fluctuations due to cloud. A more robust analysis may be carried out for voltage, transient and 143 dynamic stability of the system influencing the power fluctuations. In future, the reactive power may also be considered for loss reduction on different standard test system like meshed or ring mains with better soft computing techniques. The analysis of proposed grid management technique provides an effective solution for maintaining a flat load curve. The analysis has been done considering the load of water pumping system alone. In future, more versatile loads such as electric vehicle or more urban loads may be included and studied for proposing a generalised acceptable solution. The reach of the research may be increased by considering a wider area such as a city or even states having large population and versatile load conditions.

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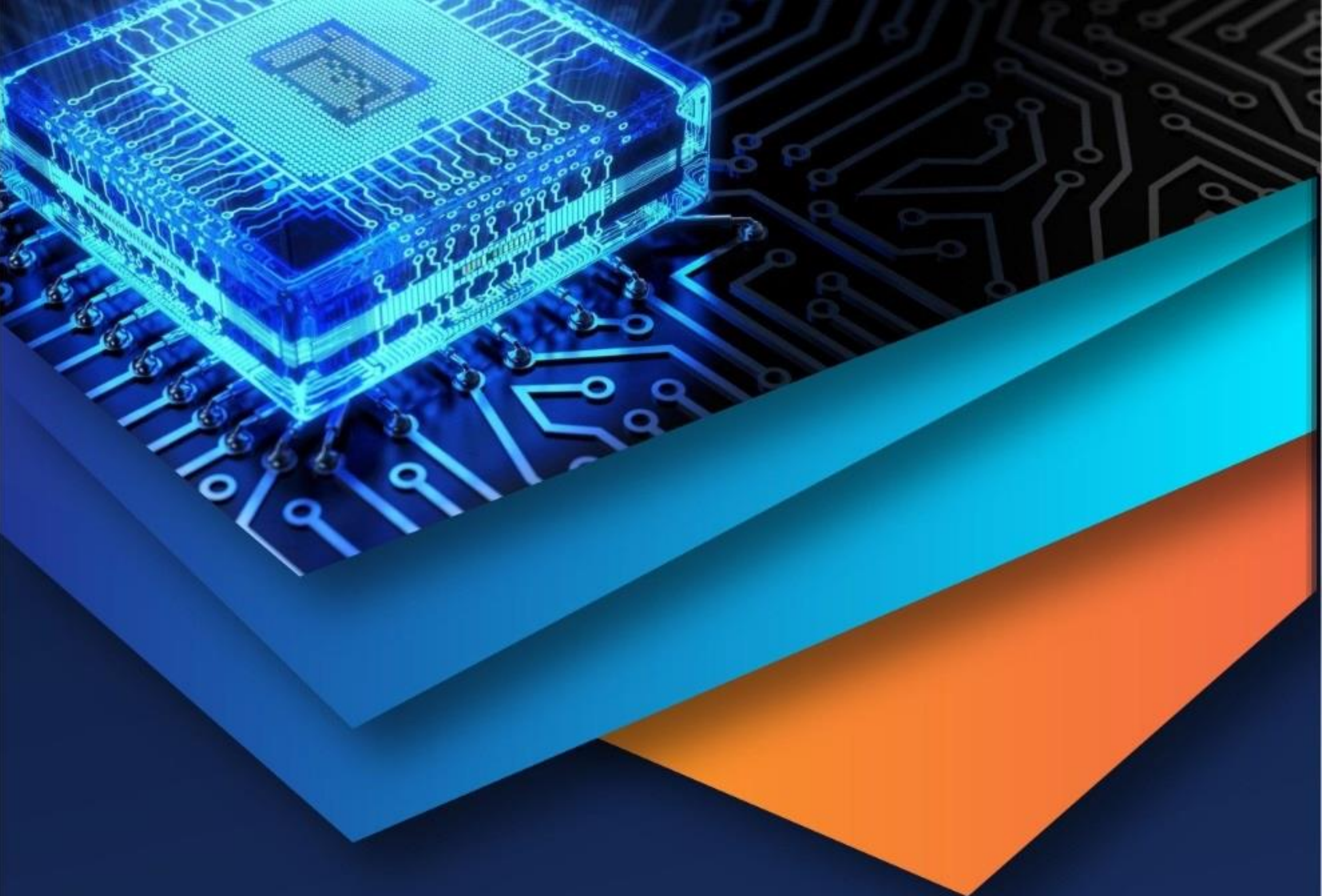

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