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PV Power Generation System is Improved by Bidirectional Dc-Dc Converter and Energy Storage System Interfaced to Three Phase Grid and used for Water Pumping Application

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Abstract: This paper deals with the energy management in solar photovoltaic power generation for the stability of the system and to increase economic benefits. Photovoltaic panels are integrated to improve the output power and it is interfaced to the three phase grid to feed the generated solar PV power, where the harmonics are reduced. and energy storage system is controlled by using power conditioning system (PCS). The PCS consist of VSI and bidirectional DC-DC converter. The DC-DC converter used here is cuk converter where it can be used in all climatic conditions. Two inverters are connected in parallel to the three phase grid. PCS stops its operation when the absorption of solar energy is low. The PCS restarts if the solar radiation recovers. Therefore, energy storage system is connected between PV panel and PCS. The maximum power from the PV source is observed by perturb and observe (P&O) scheme. By increasing the DC bus voltage, it reduces line loss and efficiency is improved. Higher DC voltage and efficiency will be achieved. By integrating the photovoltaic panels its application is used for water pumping system. Permanent Magnet Synchronous Motor (PMSM) drive is used for water pumping application.
Keywords: solar photo-voltaic systems, Energy management scheme, Bidirectional DC-DC Converter, voltage source inverter (VSI), maximum power-point tracking, perturb & observe scheme,, PMSM drive.

I. INTRODUCTION

Photovoltaic power generation system can improve energy crisis and reduce environmental pollution, it can be used to generate electric power to compensate the electricity demand. From last few decades, solar PV energy generation system (SPEGS) is one of the focused areas of research community as it is pollution-free, renewable, inexhaustible, and has a lot of other advantages. An energy management scheme is proposed and t is aimed to improve the reliability of power supply and to increase the economic benefits of the system.

Energy storage system is involved in the proposed system by connected between PV panel and power conditioning system to deliver power continuously and can easily achieve higher DC voltage gain and higher efficiency. There are some potential dangers for batteries when the load changes suddenly without current control. So, it is necessary to insert a bidirectional DC-DC converter between the DC bus and batteries to control the discharging current.

For nonlinear relation between solar PV array voltage and its current, which depend on climatic condition, there is a need of maximum power point tracking (MPPT) scheme for harnessing the crest energy from the solar source. The initial expenditure of solar PV installation is also very high. Hence, this is also one of the reasons for harnessing the maximum power from total installed capacity.

Various MPPT schemes are reported in the literature. However, due to simplicity and easy implementation, perturb and observe (P&O) scheme is more preferred. Grid-integrated SPEGSs are the systems, which connects the maximum power from the PV array and it feeds to the three phase grid. The control methods employed in this paper used for harnessing the maximum power from SPEGSs and also work for grid synchronization. This paper deals with the distributed adaptive control approach for dual mode SPEGS integrated to the local three phase grid.

Its application is used for solar water pumping in hilly areas. For solar pumping systems below 5 kW DC motors are generally used for high efficiency. PMSM motor gives better performance than induction motors and DC motors as they provide optimal efficiency, high torque to size ratio and dynamic response.

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II. PROPOSED SYSTEM

The Fig.1 shown below gives the detail about the proposed system. Integrated solar panels are connected and feeds the ESS and PCS and then to the three phase grid and its application is used for water pumping system.

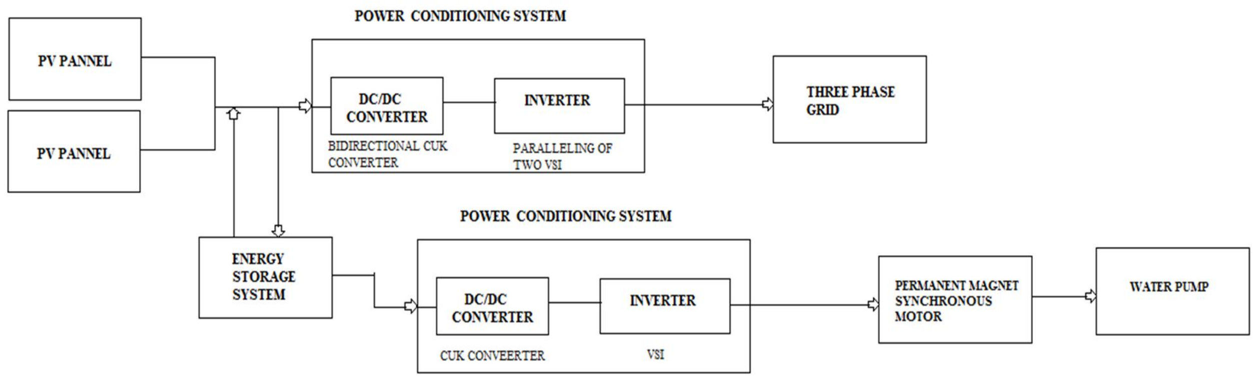

Fig.1 Block Diagram of the proposed system

A. PV System And Energy Management Scheme

By considering the MPPT technique a two-stage grid-connected PV system is proposed with an adjustable dc-link voltage, wherein MPPT is realized by DC-DC converters and great performance is achieved. The irregularity and randomness of solar irradiation will lead to the frequent interaction between the system and power grid. In a PV system with an energy management scheme based on the DC bus signaling is given. The system can achieve higher resource utilization and higher reliability. PV system interfaced to grid-tied three phase converter is presented and an optimized energy management scheme is proposed.

B. Power Conditioning System

Power conditioning system is composed of DC-DC converter and Inverter. Cuk converter is used as DC-DC converter. Voltage source inverter used to convert DC power to AC power and sent it to the three phase grid. An isolated bidirectional DC-DC converter is involved in the system.

1) *DC-DC Converter:* A DC-DC converter is needed between PV panels and inverter to avoid too much number of series connected PV panels and to achieve MPPT. The phase difference between voltage and current will be larger, which limits the further improvement of efficiency and power density. Cuk converter is used as bidirectional DC-DC converter and it will result in low ripple in input and output current. By using only one auxiliary switch in the circuit, soft switching condition is achieved for all semiconductor elements regardless of the power flow direction and without any significant additional voltage or current stresses. The Fig.2 shows the circuit diagram of cuk converter.

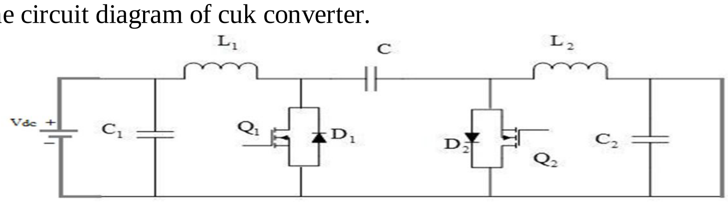

Fig.2: Circuit diagram of bidirectional cuk converter

The estimated parameters of the converter are which are calculated at 1000W/m2 irradiance. With change in irradiance the converter duty cycle will be changed such that maximum-power is extracted from the SPV system. The Duty cycle is calculated using the expression

D= vdc/(vdc+vmpp)

The Cuk converter parameters capacitance C1, inductance L1 and L2 are expressed as

C1= [Impp(1-D)]/(fsw.del vc1) where Vc1=vmpp/(1-D)

L1=DVmpp/fsw.del L1where ΔIL1=8% of IL1

L2= Dvmpp/ fsw.del L2where ΔIL2=8% of IL2

2) *DC-AC Converter:* For three phase grid-tied system, traditional two-level inverters have been used in the system for their simplicity. The magnitude of dc link current often changes in step as the inverter switches are turned on and off. The net power-flow is from dc bus to ac load then the average magnitude of the dc link current remains positive and if the direction is reversed if the ac load connected to the inverter is regenerating. The capacitor of the dc link should be close to the switches so that it provides a low impedance path to the high frequency component of the switch currents. Two inverters are connected in parallel to the three phase grid in the proposed system. The main inverter operates at a low switching frequency, transfers active power to the grid. For the compensation of the ripple current of grid the auxiliary inverter processes a very low power. Thus, no active power is processed by the auxiliary inverter does not process active power. The proposed system is to produce a grid current with a low total harmonic distortion and to obtain the highest efficiency from the inverter system. The Fig.3 shows the circuit diagram of inverter which is connected parallel.

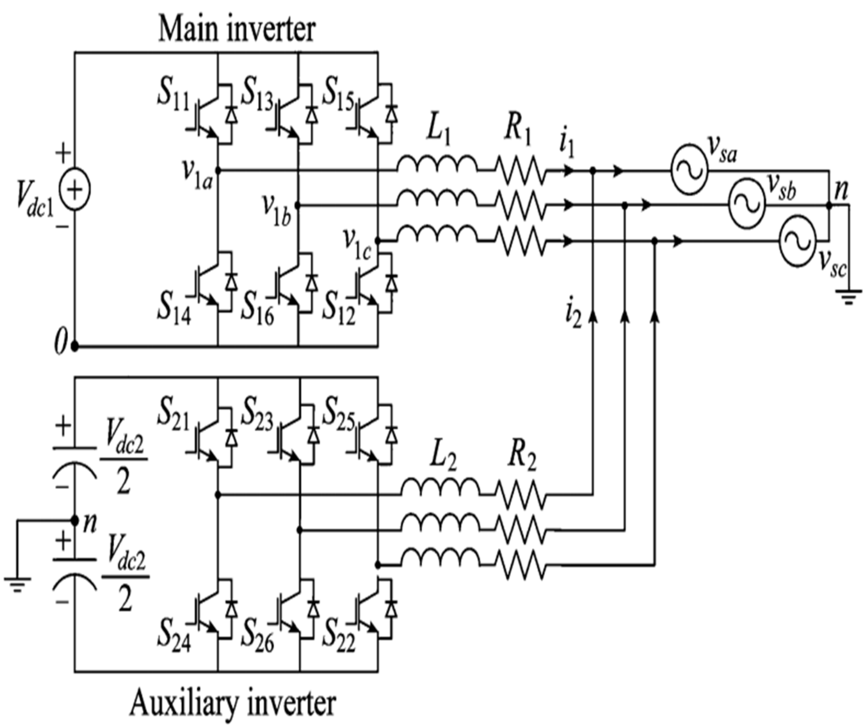

Fig.3: Circuit diagram of parallel connection of Inverter

C. Solar Photo Voltaic Application

Solar photo voltaic application is used for water pumping scheme. Solar pumping systems is used for agricultural operations in remote areas or where the use of an alternative energy source is desired. The natural use aligns with solar radiation as water demands typically increase during the summer when solar radiation is at a maximum. By designing the water pumps properly it increases agricultural productivity. Permanent Synchronous Motor is used in the proposed system used for high efficiency, PMSM motor gives better performance than induction motors and DC motors as they provide optimal efficiency, high torque to size ratio and dynamic response.

1) *Permanent Magnet Synchronous Motor:* Permanent magnet synchronous motors (PMSM) are used for high-performance and high-efficiency. The high-The performance of motor is controlled by smooth rotation, full torque control at zero speed, and fast acceleration and deceleration. For PMSM, vector control techniques are employed and it can generate torque at zero speed using permanent magnets. A centrifugal-pump is attached with PMSM shaft which pumps the water which is designed to operate at its rated power and speed in a way that full volume of water is pumped at STC.

Torque of centrifugal pump is $Tm=c1\omega 2+sign(\omega).(c2e-c3|\omega|)+c4$

$Pm=k1\omega 3-k2\omega 2+k3\omega$ in which lower order terms are neglected then

$Pm=k1\omega 3$ $k1=Pm/\omega 3=1.94e-4$

The rated torque is given as $Tr=Pm/\omega=6000/(2*pi*3000/60)=19$ N-m

D. Circuit Diagram For The Proposed System

The circuit diagram of the proposed system is shown in the Fig.5. Two PV panels are integrated to feed the power conditioning system and the energy storage system. The DC\DC converter in the PCS is the bidirectional Cuk converter and paralleling of inverter is done in the PCS. The output power is given to the three phase grid.

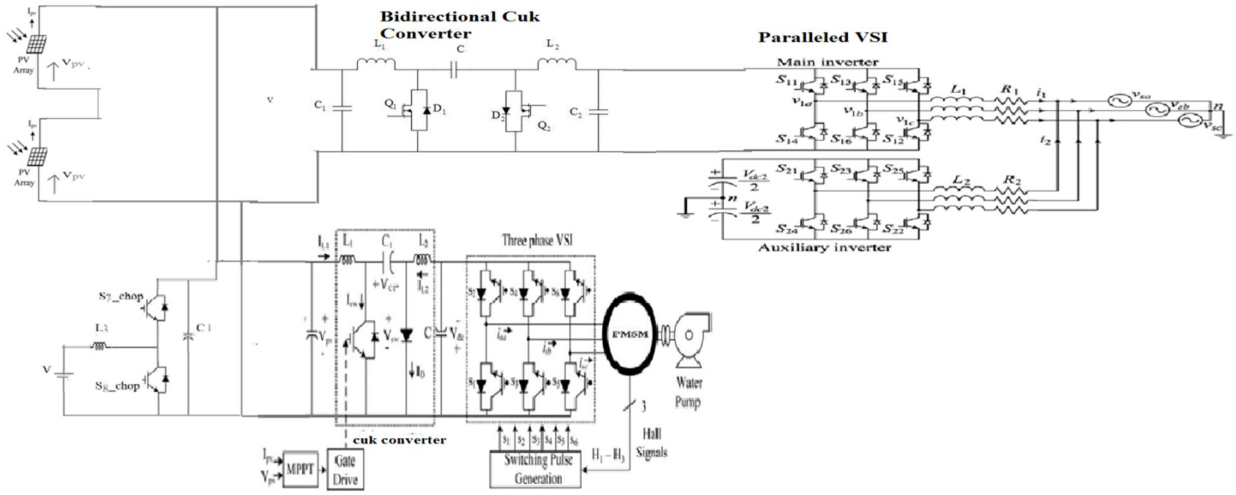

Fig.5: Circuit Diagram of the proposed system

III. SIMULATION RESULTS

Waveform for various results are shown in the below figures. Various values for temperature and frequency are given in PV array. In PV array the temperature is kept at 500 degree Celsius and frequency 50 Hz and the following graphs are taken.

A. Output of Energy Storage System

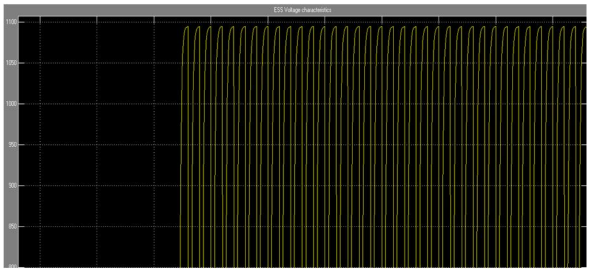

Fig.6: Waveform of energy storage system

Fig.6, shows the voltage of energy storage system at 500 degree Celsius and frequency of 50Hz, where y-axis denotes the voltage in volts and x-axis denotes the time in seconds.

B. Output of Cuk Converter

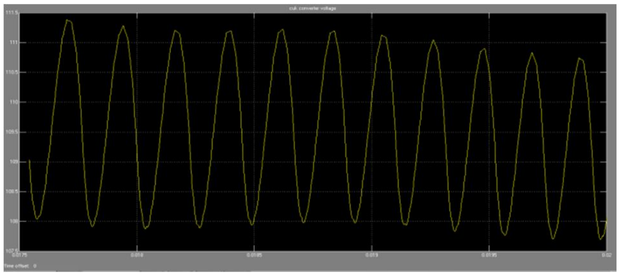

Fig.7: Waveform of cuk converter

Fig.7, shows the voltage of cuk converter, where y-axis denotes the voltage in volts and x-axis denotes the time in seconds.

C. Output of Voltage Source Inverter

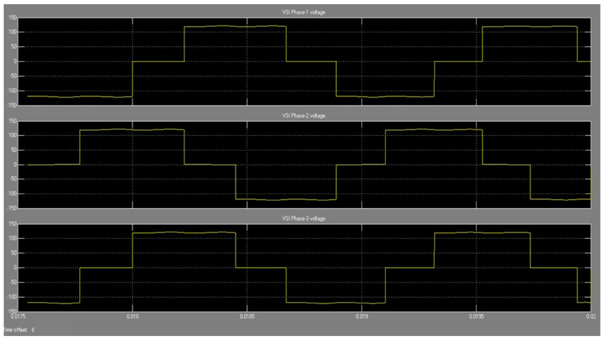

Fig.8: Waveform of voltage source inverter

Fig.8, shows the voltage of voltage source inverter, where y-axis denotes the voltage in volts and x-axis denotes the time in seconds.

D. Output of Three Phase Grid

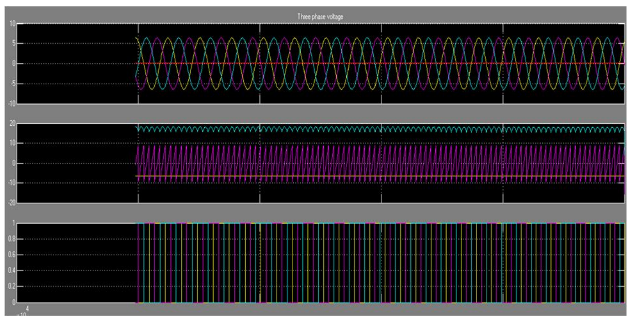

Fig.9: Waveform of three-phase grid

Fig.9, shows the three phase voltage source, where y-axis denotes the voltage in volts and x-axis denotes the time in seconds.

IV. CONCLUSION

The proposed system is simulated using MATLAB software. The paper proposes an energy storage system that improves the total PV output power. The main purpose of adding the energy storage system is to continue the operation of the PCS. The peak voltage of the dc bus reduces the line loss and the system efficiency is improved. To improve the reliability of power supply and increase the economic benefits, an energy management scheme is proposed. To optimize the performance of the converters in the system, the optimized method for the structure of bidirectional dc-dc converter is proposed. This structure can easily achieve higher DC voltage gain and efficiency to further optimize the system. The goal of main and auxiliary inverter is to produce a grid current with a low THD value and to obtain a higher efficiency. Its application provides better performance and constant output power under steady state condition and analyzed with the help of MATLAB/SIMULINK.

REFERENCES

[1] H.Haga, T.Shimao , S.Kondo , K.Kato , Y.Ito , K.Arimatsu and K.Matsuda: "High-efficiency and Cost-minimization Method of Energy Storage System with Multi Storage Devices for Grid Connection," International Power Electronics Conference, pp.415- 420(2014).

[2] V. T. Tran, K. M. Muttaqi, and D. Sutanto, "A robust power management strategy with multi-mode control features for an integrated PV and energy storage system to take the advantage of ToU electricity pricing," IEEE Trans. Ind. Appl., vol. 55, no. 2, pp. 21102120, Mar./Apr. 2019.

[3] G. Ortiz, D. Bortis, J. W. Kolar, and O. Apeldoorn, "Soft-switching techniques for medium-voltage isolated bidirectional DC/DC converters in solid state transformers," in Proc. 38th Annu. Conf. IEEE Ind. Electron. Soc., Oct. 2012, pp. 52335240.

[4] Shanmugam, Sathish Kumar, et al."Implementation of solar photovoltaic array and battery powered enhanced DC-DC converter using B4-inverter fed brushless DC motor drive system for agricultural water pumping applications," Journal of Vibro engineering 20.2 (2018): 1214-1233.

[5] Chandel, S. S., M. Nagaraju Naik, and Rahul Chandel. "Review of solar photovoltaic water pumping system technology for irrigation and community drinking water supplies," Renewable and Sustainable Energy Reviews 49 (2015): 1084-1099.

[6] Q. Jiang, M. Xue, and G. Geng, "Energy management of microgrid in grid-connected and stand-alone modes," IEEE Trans. Power Syst., vol. 28, no. 3,pp. 33803389, Aug. 2013.

[7] F. Locment, M. Sechilariu, and I. Houssamo, "DC load and batteries control limitations for photovoltaic systems. Experimental validation,"IEEE Trans. Power Electron., vol. 27, no. 9, pp. 4030–4038, Sep. 2012.