Implementation of Solar PV Array Fed EASPO Super-Lift Converter for PMBLDC Motor Drive

T.Santhana Krishnan[1],V.Venkatesh[2],P.Thirusenthil Kumaran[3],P.Ragupathy[4],P. Marishkumar[5],G.Soorya Priya[6]
Assistant Professor (SG)[1], Assistant Professor[2], Assistant Professor (SS)[3], Assistant Professor (SS)[4]
Department of EEE, Rajalakshmi Engineering College (Autonomous), Chennai
[5]Associate Professor, Department of EEE, Easwari Engineering college, Chennai
[6]Associate Professor, Department of EEE, Loyola Institute of Technology, Chennai

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Abstract:

Solar Photo Voltaic (SPV) arrays are used in diverse packages consisting of irrigation fields, family packages, and also for industrial packages. The performance and the running conditions of the SPV array are managed with the assist of an Elementary Additional Series Positive Output Super-lift Converter (EASPOSC). voltage output produced for this remarkable carry converter are expanded with the aid of geometric progression and similarly it enhances the voltage switch gain in strength series. Normally, it produces high frequency switching losses. An Electronically Commutation based PMBLDC motor along a input Voltage Source Inverter (VSI) operating at base-fundamental switching frequency is carried out. An superior method of duty cycle for the energy transfer is being generated to gain over the switching losses. The maximum output extremely produced by POSC converter is then related to a Permanent-Magnet Brushless DC (PMBLDC) motor in this case. Then assessment of the converter under special working situations were examined in MATLAB/Simulink environment.

Keywords: *Elementary Additional Series Positive Output Super-lift Converter (DC-DC converter), permanent magnet brush less DC motor (PMBLDC), Solar Photo Voltaic (SPV), voltage source inverter (VSI), Power Factor Correction (PFC).*

I. INTRODUCTION

In these current days, most of the international locations inside the global are facing problems in using traditional assets in electricity technology due to the eradication of fossil fuels as well as few socio-environmental issues. In herbal resources, solar energy is one of the non-traditional power resources, that could be a clean and an considerable herbal aid. By the use of the Solar Photo Voltaic (SPV) Cells, the energy is generated for diverse applications. Although several kind of researches are performed within the source of SPV arrays feeding water pumps, adding diverse DC–DC converter topologies and motor powered drives, the quality output tremendous-lift converter , associated with a PMBLDC motor is analysed. The maximum electricity can be acquired from the sun panel, which is essentially operated by using high quality output first-rate-EASPOSC converter. The shunt Active Power Factor Filter used is being activated to yield the reactive current that nullifies the voltage harmonics inside the converter DC-side and also compensates not directly the harmonics by load current. It will improve voltage ripple content of load voltage and current permitting use of low configuration converter DC-link inductor.[2] Solar panel absorbs solar rays as a source of input electricity for producing power. Under some suitable test conditions, the power produced by every SPV board is rated and hence the performance of a module is decided as 8% more efficient with a 230-watt board module..

A desirable DC-DC converter should yield a high DC voltage for the given DC voltage to acquire an excessive voltage transfer benefit. The high-quality output high-quality-lift converter consists of high voltage transfer benefit, and it also meets all the important necessities of DC-DC converter. The converter proposed here suggests voltage improvement technique that makes the tremendous to tremendous conversion voltage with larger percentage of power and voltage transfer gain benefit. The subtype of EASPOSC is the Positive Output Super-lift Converter which goes on both continuous and discontinuous conduction modes. The capacitors are charged with the aid of the input DC electricity supply while the switch is ON, and the capacitor discharges when the switch is OFF. The PMBLDC motor has high efficiency, torque reliability, low radio frequency interference, improved cooling and also it has practically no renovation. A right most power monitoring algorithm may be done, even though the tracking system may additionally fail, unless choice of an suitable notable DC-DC converter taken into consideration, supporting aid of the burden-type.[10] The EASPOSC has several benefits over different DC-DC converters, it include single semiconductor switch transfer thereby minimizing switching losses inside the circuit and the performance is progressed in this gadget.

The demerits of the use of zeta converter as a DC-DC converter are such that, it turns into nonlinear model while it is in fourth order.[16]. To overcome this, the fine output remarkable-lift converter is used. EASPOSC converters provide a nice output voltage for any required level of fine source supply voltage.

PMBLDC motor drive likewise contributes besides in building up a basic, productive, savvy, and increasingly dependable framework. In light of the preferences and remarkable highlights referred to above, Solar PV cells along with EASPOSC Converter is utilized here. A PFC based Bridge Less-Luo converter-took care of PMBLDC motor drive is made for a wider scope of speeds and supply voltages. An electronically commutated PMBLDC motor has been utilized for using a low-recurrence activity of VSI to lessen switching losses.[8] The PMBLDC motor is utilized to drive with EASPOSC and because of its super drive framework it is being utilized proficiently. The voltage follower control technique is utilized for a Bridge Less-Luo converter working in DCM inductor current mode. The speed of the PMBLDC motor is constrained on utilizing a methodology of changeable DC-interface voltage, that allows a low-recurrence exchanging of a VSI for an electronical commutation of the PMBLDC motor, subsequently delivering limited losses due to switching.[6] This framework comprises of a solar based PV panel, an EASPOS Converter, a voltage source inverter and a PMBLDC motor drive.

II. Operation Of THE Proposed System

The practical block chart of PMBLDC motor drive took care of by solar oriented PV array utilizing a POSC is appeared in Figure 1. The significant segments utilized in the circuit are solar based PV panel, POSC DC link capacitor, VSI, PMBLDC motor pump and electronic commutator. An improvised controller of DC-DC boost converter depends on the evaluation of a wide range of the switching losses that happen in the converter.[11] The solar oriented PV array produces the electrical power and is taken care of into the motor pump by means of an EASPOS Converter alongside a voltage source inverter.

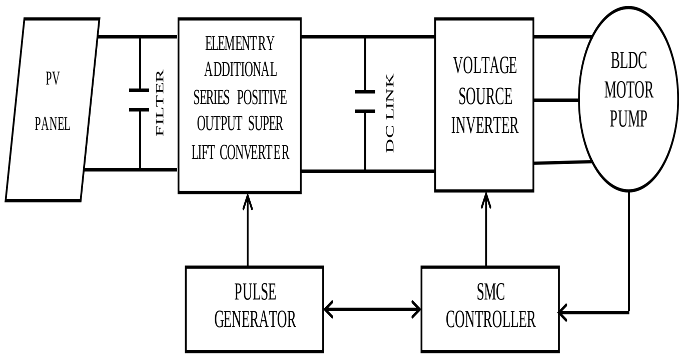

Fig.1 Functional block diagram of the proposed system

The PV cell is known as a Photo Voltaic gadget considered as the essential structural block of the PV module, here there are a lot of PV cells interconnected in parallel and series combinations. The PV array is a gathering of panels that involves total direct current PV producing units which will be the essential basic gathering module of the solar powered panel.

Thereof the maximum power accessible through the SPV cell module is removed with the help of our Proposed lift Converter. This

May – June 2020
ISSN: 0193-4120 Page No. 9930 - 9936

Super lift converter expands the output voltage in the form of geometric progression and furthermore improves the voltage transfer gain in power series [14]. An EASPOS Converter is appeared in Fig. 2.

$$V_1 = \frac{2 - k}{1 - k} V_{in} \qquad (1)$$

$$V_{L1} = \frac{k}{1 - k} V_{in} \qquad (2)$$

$$V_0 = V_{in} + V_{L1} + V_1 = \frac{3 - k}{1 - k} V_{in} \qquad (3)$$

$$G = \frac{V_0}{V_{in}} = \frac{3 - k}{1 - k} \qquad (4)$$

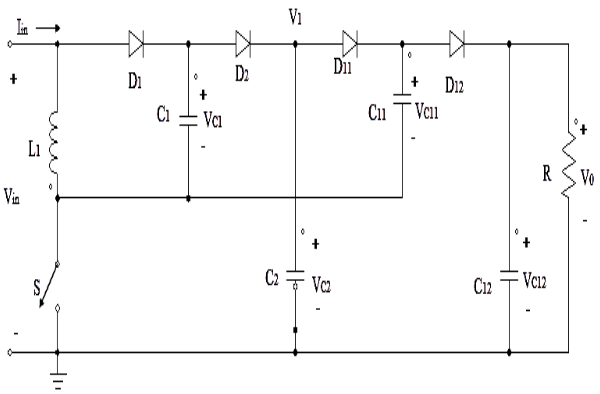

Fig.2 EASPOS converter

A. MODE I:

Whenever power semiconductor switch S is turned - ON , then the diodes I, D are at off state, the supply voltage passes through the inductor the current passes through the inductor is , then the capacitor and C are charged by voltage and voltage appeared across capacitor C is charged to $V_0 = 2$. The Fig.3 represents the ON state switching circuit diagram for an elementary additional series positive output super-lift DC-DC converter.

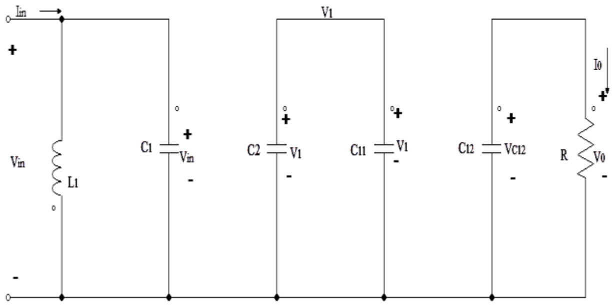

Fig.3 ON state switching circuit diagram for EASPOS Converter

The State Space model equation of mode I operation is given below. It consists of five state equations due to the presence of five energy storing elements in the circuit.

$$\frac{di_{L1}}{dt} = \frac{1}{L_1} V_{in} - \frac{1}{L_1} V_{c1} \qquad (5)$$

$$\frac{dV_{c1}}{dt} = \frac{1}{C_1} I_{L1} - \frac{1}{R_{in} C_1} V_{in} \qquad (6)$$

$$\frac{dV_{c2}}{dt} = -\frac{1}{C_2} I_{L1} - \frac{C_1}{C_2} V_{c1} - \frac{1}{R_{in} C_2} V_{in} \qquad (7)$$

$$\frac{dV_{c11}}{dt} = -\frac{1}{C_{11}} I_{L1} - \frac{C_1}{C_{11}} V_{c1} + \frac{C_2}{C_{11}} - \frac{1}{R_{in} C_{11}} V_{in} \qquad (8)$$

$$\frac{dV_{c12}}{dt} = -\frac{C_2}{C_{12}} V_{c2} + \frac{C_{11}}{C_{12}} V_{c11} - \frac{R}{C_{12}} V_0 \qquad (9)$$

The following will be the state space matrix given for mode I .

$$\frac{d}{dt}\begin{pmatrix} i_{L1} \\ V_{C1} \\ V_{C2} \\ V_{C11} \\ V_{C12} \end{pmatrix} = \begin{pmatrix} 0 & -\frac{1}{L_1} & 0 & 0 & 0 \\ \frac{1}{C_1} & 0 & 0 & 0 & 0 \\ \frac{-1}{C_2} & -\frac{C_1}{C_2} & 0 & 0 & 0 \\ \frac{-1}{C_{11}} & -\frac{C_1}{C_{11}} & \frac{C_2}{C_{11}} & 0 & 0 \\ 0 & 0 & -\frac{C_2}{C_{12}} & -\frac{C_{11}}{C_{12}} & 0 \end{pmatrix} \begin{pmatrix} i_{L1} \\ V_{C1} \\ V_{C2} \\ V_{C11} \\ V_{C12} \end{pmatrix} + \begin{pmatrix} \frac{1}{L_1} \\ -\frac{1}{R_{in} C_1} \\ -\frac{1}{R_{in} C_2} \\ -\frac{1}{R_{in} C_{11}} \\ 0 \end{pmatrix} (V_{in}) + \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ -\frac{R}{C_{12}} \end{pmatrix} (V_0)$$

B. MODE II:

Whenever the power semiconductor switch S

May – June 2020
ISSN: 0193-4120 Page No. 9930 - 9936

is at OFF state, then the diode gets forward biased and will start conducting such that the inductor starts supplying the stored energy to the circuit and when the energy starts decreasing with a voltage ($V_1 -$) during the switching OFF instant (1 – k)T. The Fig.4 represents the OFF state switching circuit diagram for EASPOS DC-DC Converter.

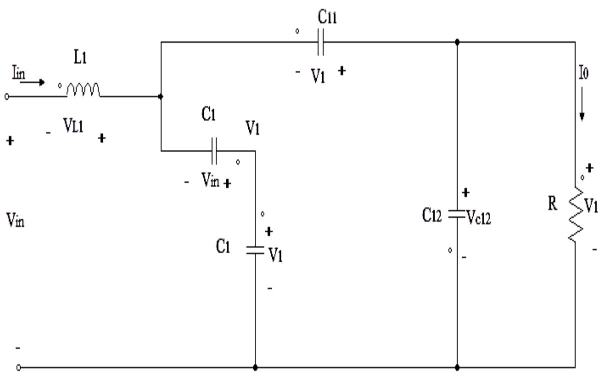

Fig.4 OFF state switching circuit diagram for An EASPOS DC-DC Converter

The state space model equations for mode II operation are given below. It consists of five state equations due to the presence of five energy storing elements in the circuit.

$$\frac{di_{L1}}{dt}=\frac{1}{L_1}V_{C1}-\frac{1}{L_1}V_{in} \tag{10}$$

$$\frac{dV_{c1}}{dt}=\frac{1}{C_1}I_{L1}-\frac{C_{11}}{C_1}V_{c11}-\frac{1}{R_{in}C_1}V_{in} \tag{11}$$

$$\frac{dV_{c2}}{dt}=\frac{1}{C_2}I_{L1}-\frac{C_1}{C_2}V_{c1}-\frac{1}{R_{in}C_2}V_{in} \tag{12}$$

$$\frac{dV_{c11}}{dt}=\frac{1}{C_{11}}I_{L1}-\frac{C_{12}}{C_{11}}V_{c11} \tag{13}$$

$$\frac{dV_{c12}}{dt}=\frac{C_{11}}{C_{12}}V_{c11}-\frac{R}{C_{12}}V_0 \tag{14}$$

The matrix of state space for mode II is written as

$$\frac{d}{dt}\begin{pmatrix} i_{L1}\\ V_{C1}\\ V_{C2}\\ V_{C11}\\ V_{C12}\end{pmatrix}=\begin{pmatrix} 0 & \frac{1}{L_1} & 0 & 0 & 0\\ \frac{1}{C_1} & 0 & 0 & -\frac{C_{11}}{C_1} & 0\\ \frac{1}{C_2} & \frac{C_1}{C_2} & 0 & 0 & 0\\ \frac{1}{C_{11}} & 0 & 0 & 0 & -\frac{C_{12}}{C_{11}}\\ 0 & 0 & 0 & \frac{C_{11}}{C_{12}} & 0\end{pmatrix}\begin{pmatrix} i_{L1}\\ V_{C1}\\ V_{C2}\\ V_{C11}\\ V_{C12}\end{pmatrix}+\begin{pmatrix} -\frac{1}{L_1}\\ -\frac{1}{R_{in}C_1}\\ -\frac{1}{R_{in}C_2}\\ 0\\ 0\end{pmatrix}(V_{in})+\begin{pmatrix} 0\\ 0\\ 0\\ 0\\ -\frac{R}{C_{12}}\end{pmatrix}(V_0)$$

An AC electric signal drives the PMBLDC motor which is also called an Electronically Commutated Motors (ECMs, EC engines) which are energized by a DC electric source by aid of a coordinated inverter/exchanging power source unit. PMBLDC motor is fundamentally an electrical gadget which changes over electrical energy into mechanical energy. PMBLDC is of two categories, one is external rotor motor and other is internal rotor motor. The fundamental contrast between the two motors is the plan design, their working standards are same. It has main two significant parts rotor and stator. [15]. Rotor is a rotating element and has rotor magnet and accordingly, the stator is a stationary element and it contains stator winding. The Voltage equations of BLDC engine are as per the following.

$$V_{ab}=R(i_a-i_b)+L\frac{d}{dt}(i_a-i_b)+e_a-e_b \tag{15}$$

$$V_{bc}=R(i_b-i_c)+L\frac{d}{dt}(i_b-i_c)+e_b-e_c \tag{16}$$

$$V_{ca}=R(i_c-i_a)+L\frac{d}{dt}(i_c-i_a)+e_c-e_a \tag{17}$$

Sliding Mode Control (SMC) is a nonlinear control system with some notable features of precision, power, and simple tuning and execution. SMCs were applied on inward control loop without the utilization of any moderate carrier-based modulation techniques.[13] Sliding Mode Surface (SMS) frameworks are intended to drive the framework state conditions into a specific surface in the state space, named as a sliding surface. When

May – June 2020
ISSN: 0193-4120 Page No. 9930 - 9936

the sliding surface is reached, sliding mode control keeps the states on the nearby neighborhood of the sliding surface. Subsequently the sliding mode control has two section controller structure, the initial segment is to plan a sliding movement fulfilling the plan determinations and the subsequent part is the choice of a control law ensuring the exchanging surface appealing to the framework states.

$$X=Ax + Bu \tag{18}$$

Where

$x \in$, $u \in$, $A \in R^{I}$, and $B \in$ I

The regular form of the system should be converted into

$$X=Tx \tag{19}$$

$$D = e_v + k_v \int e_v dt \tag{20}$$

III. Simulated Performance Of The Proposed System

Above mentioned proposed framework is fundamentally structured, displayed and simulated specifying the moment and irregular changes in the solar based irradiance levels and its appropriateness is utilized to show through testing the beginning, consistent state and dynamic conduct of the framework. The performance assessment of the proposed SPV arrays, took care of by a PMBLDC motor drive utilizing an EASPOS DC-DC converter is done by utilizing the simulated outcomes. The Fig.5 shows the simulation model of PMBLDC motor driven took care by solar powered PV array.

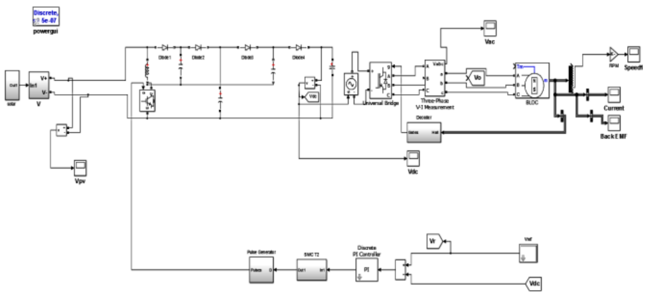

Fig.5 Simulated model of the PMBLDC motor driven fed by SPV array

A. Assessment of the SPV array

In the Fig.6, the output voltage is represented for solar PV array in a closed loop system that varies from 110V to 290V.

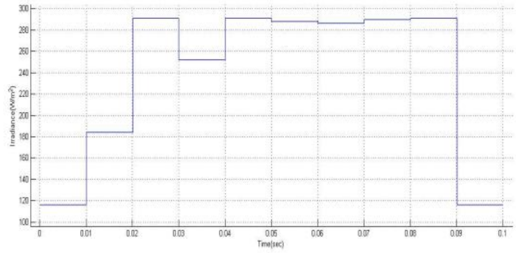

Fig.6 Output voltage for the solar PV Array

B. Assessment of the converter circuit

EASPOS DC-DC converter is used in this system as the output voltage varies from 0 to 299V and it gets saturated. The Fig.7 represents the output voltage given by converter circuit.

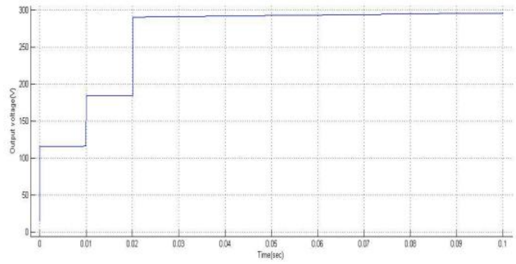

Fig.7 Output voltage for an EASPOS DC-DC converter

C. Performance of the voltage source inverter

Figure.8 shows the output voltage of the Voltage Source Inverter. The AC voltage varies from 0 to 299V and it gets saturated at 0.02sec.

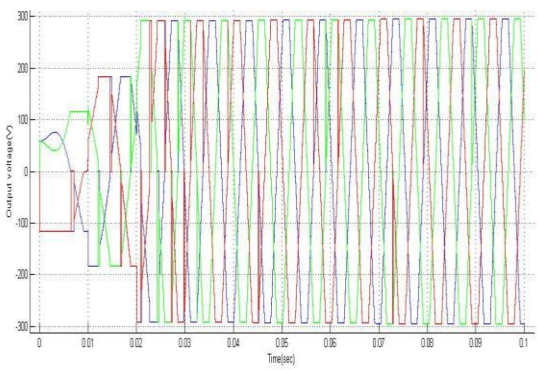

Fig.8 Output voltage for the voltage source inverter

May – June 2020
ISSN: 0193-4120 Page No. 9930 - 9936

D. Performance validation of the PMBLDC motor

The performance evaluation of the PMBLDC motor is given as follows.

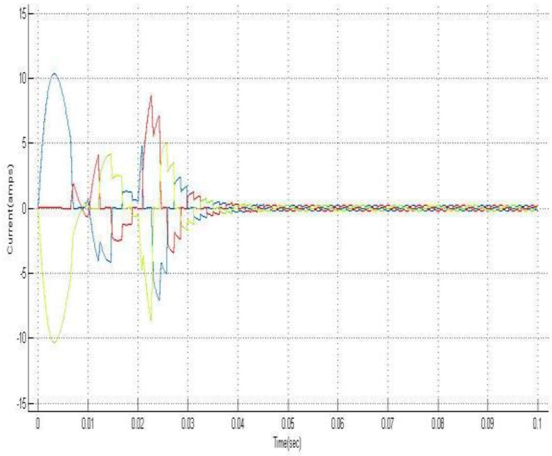

Fig.9 Current waveform for PMBLDC motor

Figure .9 represents Current waveform for PMBLDC motor as the current gradually increases during the fault occurring period of 0 to 0.3Sec, then the SMC controller controls the fault in the motor and after then the current becomes stable.

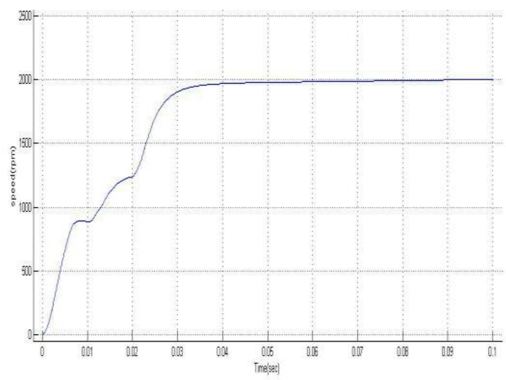

Fig.10 Speed waveform for PMBLDC motor

The Fig.10 represents the speed waveform for the PMBLDC motor in a closed loop system. The speed gradually increases during the fault occurring period of 0 to 0.3Sec and the speed becomes stable after 0.3Sec.

IV. Conclusion

Solar powered board is modeled to satisfy the power need though PMBLDC motor is worked by utilizing the supply from the SPV arrays. An Elementary extra series positive yield super-elevate DC-DC converter is modeled furnishing a more prominent effectiveness when contrasted with other DC-DC converters. The switching losses present in the circuit is limited by the SMC controller utilized. The plan of the PMBLDC motor drive took care of by solar oriented PV array utilizing an Elementary extra series Positive yield super-lift DC-DC converter is simulated utilizing MATLAB Simulink. Therefore, the conversion efficiency of the converter just as energy usage is improved in the customary DC-DC converters. The precision and unwavering quality of the framework is improved by this general framework.

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