MODELING AND SIMULATION OF VARIOUS LUO CONVERTER TOPOLOGIES FED BLDC DRIVE USING SOLAR PV ARRAY

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Abstract: *The Conversion technique is one of the vast research areas in the field of power electronics. The equipments which are used in the conversion technique are found to have many applications in industry, research and development. All the existing DC/DC converters are designed to meet the requirements of certain applications only. The voltage lift technique is the most popular technique widely used in electronic circuit design. Since the effect of basic circuit elements limits the output voltage and power transfer efficiency of DC-DC converters, the voltage lift technique is an efficient technique to improve circuit characteristics. This paper deals with the analysis from the types of Luo converter such as (positive output LUO converter, negative output LUO converter and double output LUO converter) is connected with Brushless DC motor. The Main objective of this paper is to justify the suitable DC-DC converter for the BLDC Motor based upon application. The Solar Photo Voltaic Array is used to get the source and in which we using the MPPT technique (incremental conductance method) for getting the maximum power. The source is given to the Developed DC-DC converters used separately and given to the BLDC motor. The Voltage source inverter is used to get rotor supply in which 120 degree is used. The result is obtained by using the MATLAB software and the result is compared*.

Keywords: *DC-DC Converters, Developed Converters, MPPT Algorithm, Solar PV Array, BLDC Motor, Lifting technique*

1. Introduction

Now-a-days the increasing need for electrical energy and by reducing getting the electrical energy from conventional sources, the renewable energy gets more importance. The renewable energy generation such as solar energy and wind energy get more importance than other renewable energy system. By considering the solar energy it has several advantages such as eco-friendly and most inexhaustible in nature. But it has low efficiency and high costs of solar photovoltaic panels. The increase in technology that improves the efficiency of solar photovoltaic system makes more confidence to use.

The DC motor can be directly connected to the solar panel and voltage source converter can be avoided. Hence the DC-DC converter is used for tracking the maximum power point. A DC-DC converter can be implemented to produce the constant output voltage from solar panel to load. Thus the output voltage can be controlled by using switching concept. In this paper developed DC-DC converter can be used between the solar panel and BLDC motor and a comparative study of two stage systems is done. The developed DC-DC converters are positive output LUO converter, negative LUO converter and double output LUO converter is operated in both buck and boost modes [15] and it does not have any restrictions on using MPPT technique, but the buck and boost converters can have the bounded region. This feature makes to soft start the motor and it has low switching losses and high efficiency [6]. Developed DC-DC converters are using the capacitor and inductor as power storing device. As a result it has a continuous current at input and output. In order to eliminate the ripples the capacitor has been used to eliminate in both input and output side. There is no need of external filter is used. The inductor on the output side is used for better output current characteristics and on input side is used for boost the voltage level [3] [5].

However a DC motor is not preferred because the frequent maintenance is required for commutation and brushes are used. Now-a-days Brushless DC motor becomes more popular by the advantages of high efficiency, high power density, compact size, high ruggedness, low maintenance requirements, long life, high reliability, low radio frequency interference and because of low inertia and friction brushless dc motor can run at high speed.

The electronically commutated brushless dc motor is supplied by voltage source inverter is operated in fundamental frequency used to reduce the switching losses [7] [8]. It has a three phase winding on the stator which are excited by a voltage source inverter and it is electronically commutated the power electronic switches are used in the stator part which get pulses from hall sensor, Which is used to sense the rotor position. By using these the problems are sparking, electro- magnetic interference, noise interference can be eliminated.

2. Proposed System Configuration

A. Solar PV Cell

A photovoltaic system converts sunlight into electricity. The basic device of a photovoltaic system is the photovoltaic cell. Cells may be grouped to form panels or modules. Panel scan be grouped to form large photovoltaic arrays. The term array is usually employed to describe a photovoltaic panel. It focuses on modeling photovoltaic modules or panels composed of several basic cells [4]. The term array used henceforth means any photovoltaic device composed of several basic cells. In the photovoltaic arrays composed of several panels connected in series or in parallel.

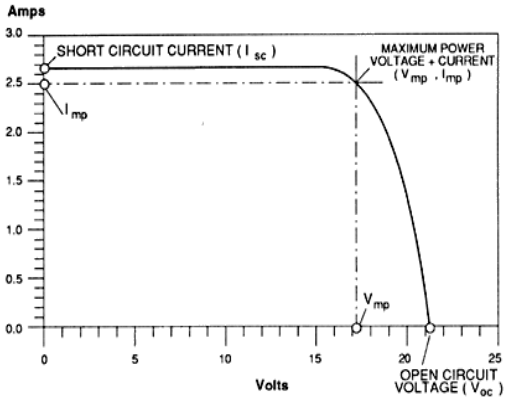

Fig.1 V-I characteristics of Solar PV

B. Maximum Power Point Tracking

Maximum Power Point Tracking, frequently referred to as MPPT, is an electronic system that operates the Photovoltaic (PV) modules in a manner that allows the modules to produce all the power they are capable of. MPPT is not a mechanical tracking system that "physically moves" the modules to make them point more directly at the sun. MPPT is a fully electronic system that varies the electrical operating point of the modules so that the modules are able to deliver maximum available power [9]. To track the maximum power in the proposed system configuration the Incremental Conductance algorithm are used. This method exploits the assumption of the ratio of change in output conductance is equal to the negative output Conductance Instantaneous conductance

C. Incremental Conductance Method

The time complexity of perturb & observe algorithm is very less but on reaching very close to the MPP it doesn't stop at the MPP and keeps on perturbing on both the directions. When this happens the algorithm has reached very close to the MPP and we can set an appropriate error limit or can use a wait function which ends up increasing the time complexity of the algorithm

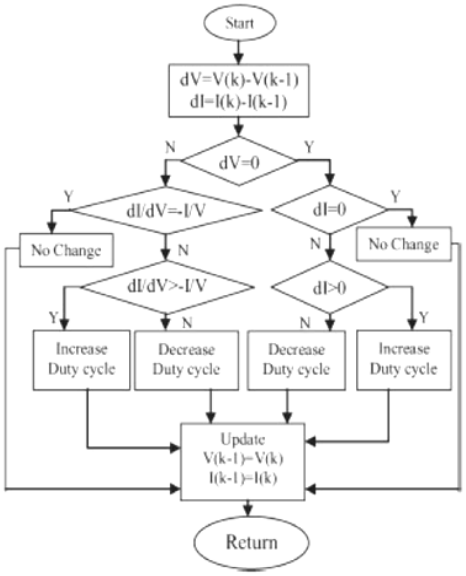

Fig.2 Flowchart of Incremental Conductance Method

However the method does not take account of the rapid change of irradiation level (due to which MPPT changes) and considers it as a change in MPP due to perturbation and ends up calculating the wrong MPP. To avoid this problem we can use incremental conductance method [10][12].

3. Proposed Circuit Operation:

A. Positive Output Luo Converter:

The positive output LUO converter is derived from the buck-boost converters in which it contains the power storing device the inductance and capacitance when the switch is off the stored energy should be dissipated. The advantage is it eliminates the ripples from input and output side [1][2].

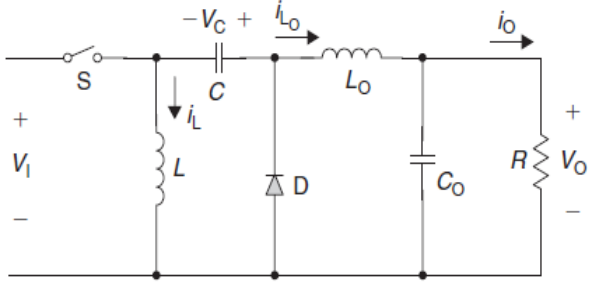

Fig.3 Positive Output Luo Converter

Mode-1: When the switch is closed (ON condition) the path flow should be $+V_1 - S - C - L_0 - V_0 - -V_{in.}$

Mode-2: When the switch is open (OFF condition) the inductance and capacitance will dissipate the energy and the output will be ripple less due to filter and the path flow is L – D – L_0 – V_0 –L.

2) Negative Output LUO Converter:

The Negative Output LUO Converter is also derived from Buck-Boost Converter. The difference between the positive and negative output LUO converter is the flow of current to load is different in N/O the current is reversal.

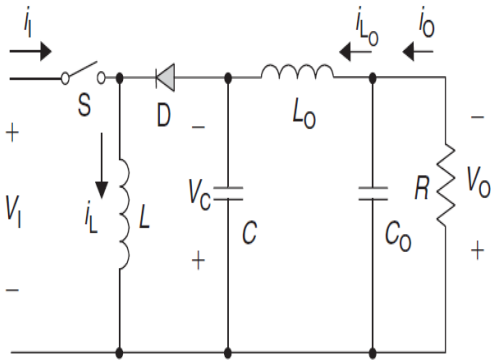

Fig.4 *Negative output LUO converter*

Mode-1: The switch is closed (ON condition) the path flow is $+V_1$ – S – L – V_0 – L_0 – C - -V_1

Mode-2: The switch is open (OFF condition) the inductance and capacitance will dissipate the energy through freewheeling diode. The path flow is given by L-V_0-L_0-D-L.

3) Double Output LUO Converter:

The Double Output LUO Converter is explained as from the single input it can be taken to two load and from the positive supply it taken another load but the same negative pin.

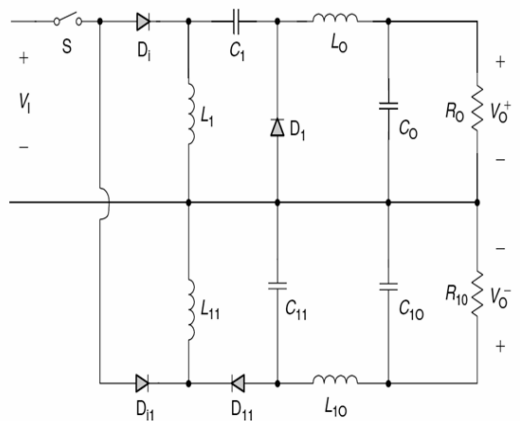

Fig.5 Double output LUO converter

4) BLDC Motor:

A brush less dc motor is defined as a permanent synchronous machine with rotor position feedback. 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 [13][14]. 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 [11].

A BLDC Motor with the trapezoidal back emf waveform and quasi square wave current is referred as BLDC motor. In the BLDC Motors, the back emf induced, has trapezoidal waveform and the stator must be supplied with a quasi square wave current waveform, whereas in the sinusoidal motors, the induced emf is sinusoidal with current fed to the stator being a sinusoidal waveform.

4. Simulation Results and Discussions

The Simulation circuit of positive output Luo, Negative output Luo and dual output Luo converters are shown in Fig.6, Fig.7 and Fig.8 respectively. Here the Luo converters are fed the dc supply input from the solar PV array. The output of the PV array is fed input to the Luo converters as shown in Fig.6, Fig.7 and Fig.8 respectively. The output of the converters is fed to the Voltage source Inverter which converts the dc voltage into AC voltage and fed to BLDC motor drive. The output voltage of the solar PV is compared with different Luo converter topologies which are shown in the comparison table.

TABLE. I COMPARISON OF DEVELOPED DC-DC CONVERTERS

Output Voltage Of Solar Panel	Positive Output LUO Converter	Negative Output LUO Converter	Double Output LUO Converter
210	246	238	241
250	250	250	250
300	253	266	260

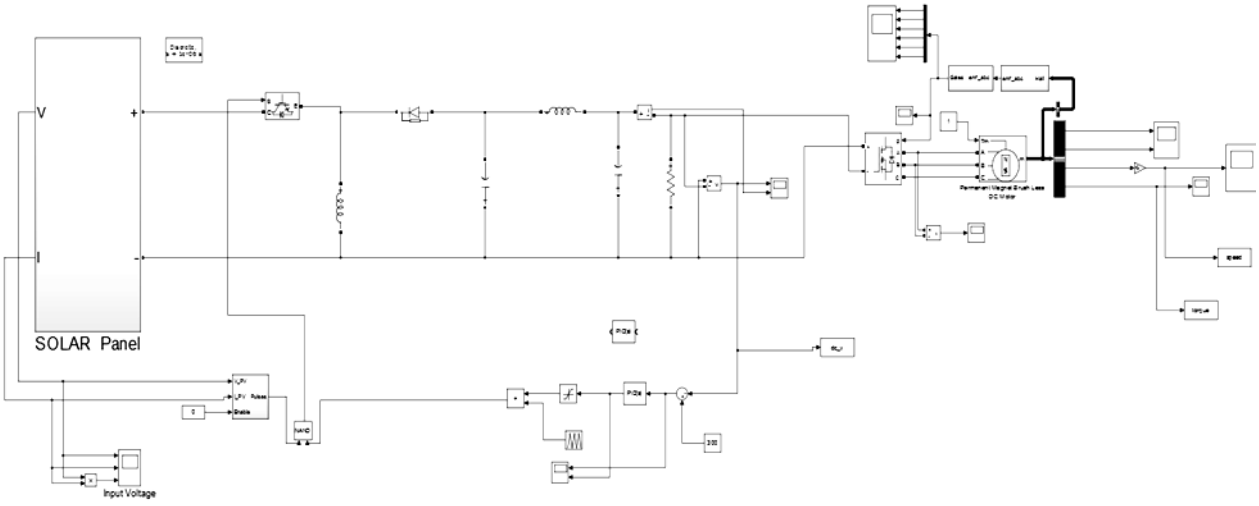

Fig.6 Positive Output LUO Converter

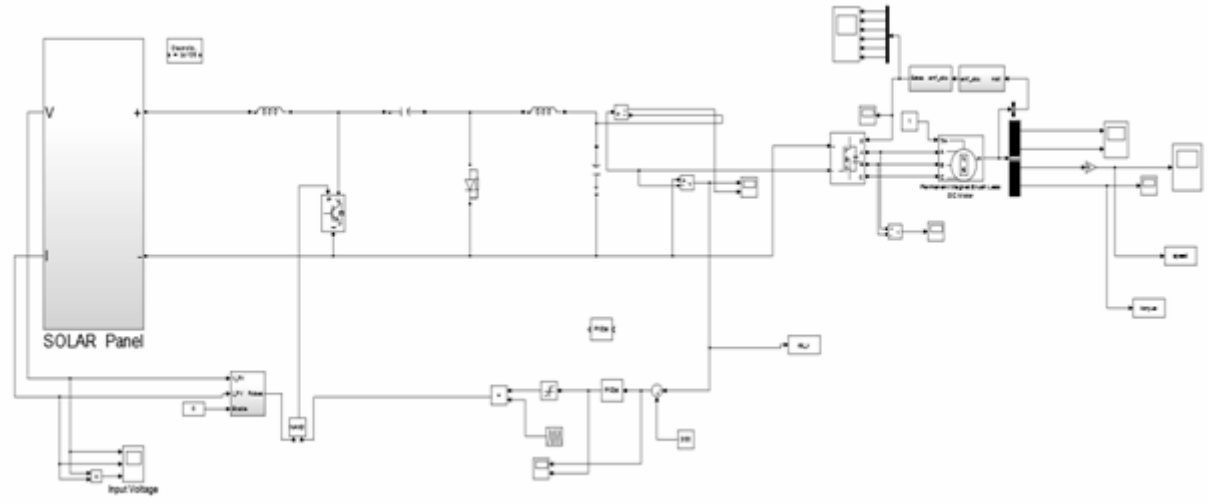

Fig.7 Negative Output LUO Converter

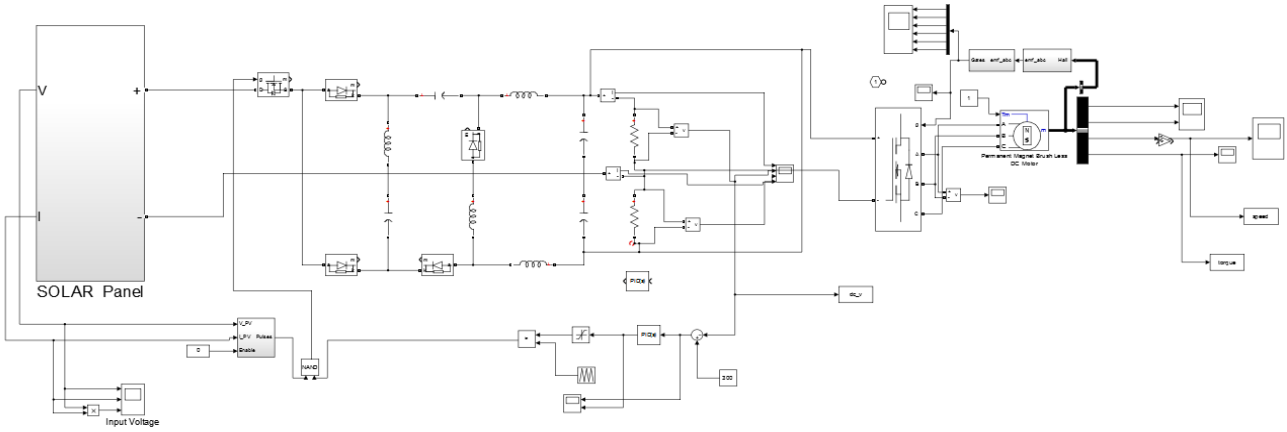

Fig.8 Double Output LUO Converter

5. Results:

A. Panel PV Characteristics

The PV Characteristic of a solar array obtained is shown in Fig.9. The XY Plot consists of Voltage in X axis and the Power is taken in the Y axis.

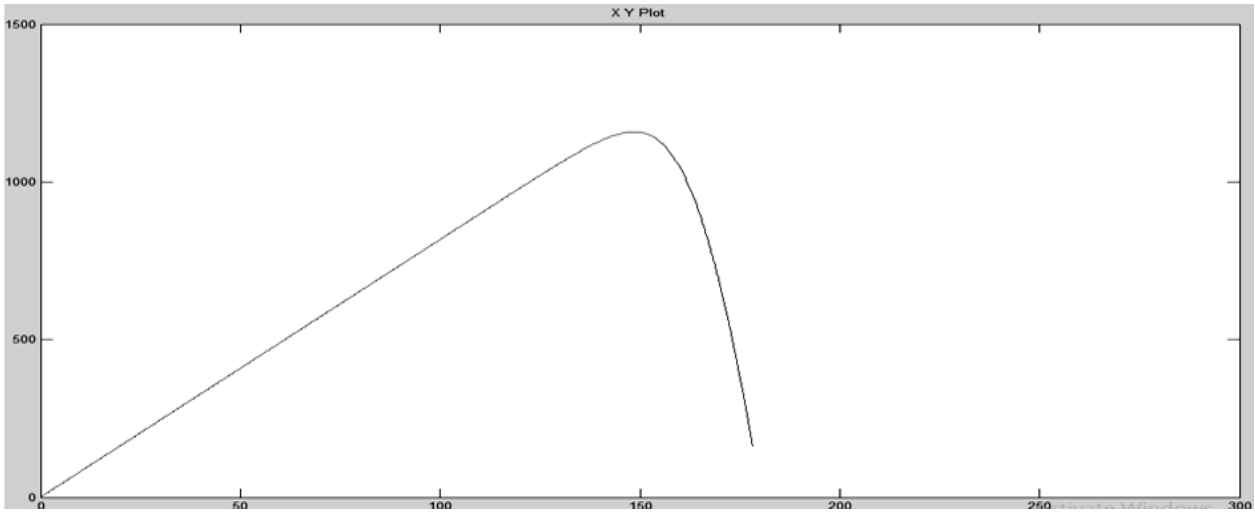

Fig.9 PV characteristics

B. Panel VI Characteristics:

The Panel IV Characteristic of a solar array obtained is shown in Fig.10. The XY Plot consists of Voltage in X axis and the Current is taken in the Y axis.

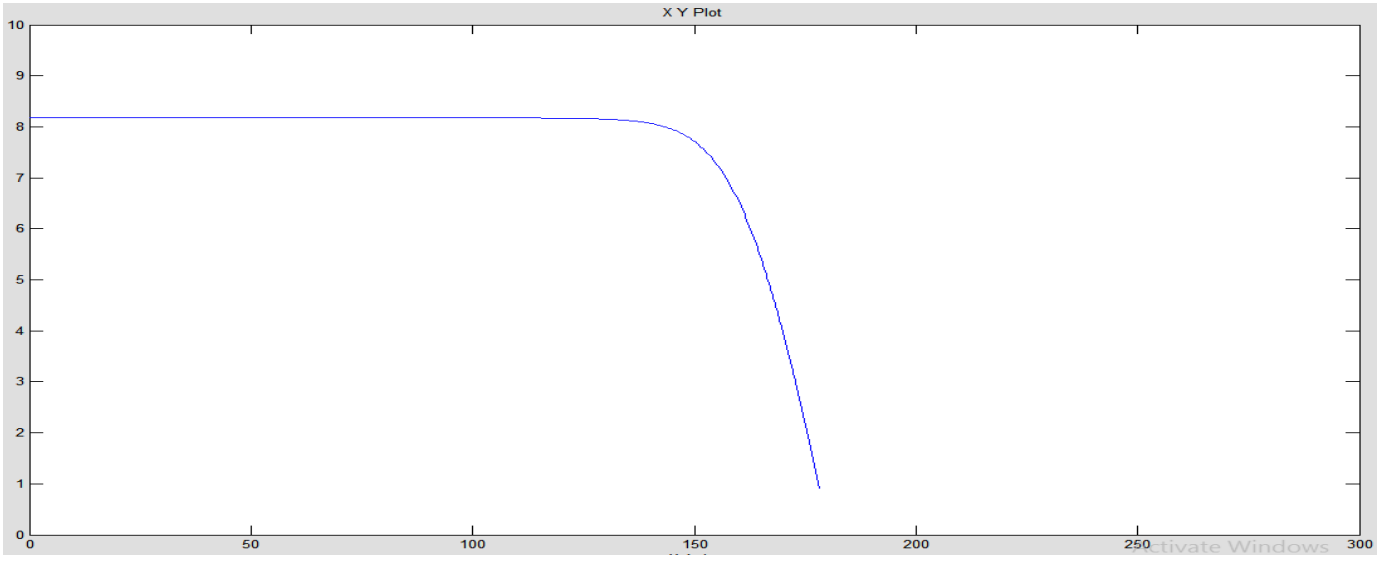

Fig.10 VI characteristics

C. Positive Output LUO Converter Output for 210V input:

For the input of 210 V in the Solar PV the output of positive output Luo converter is shown in Fig.11

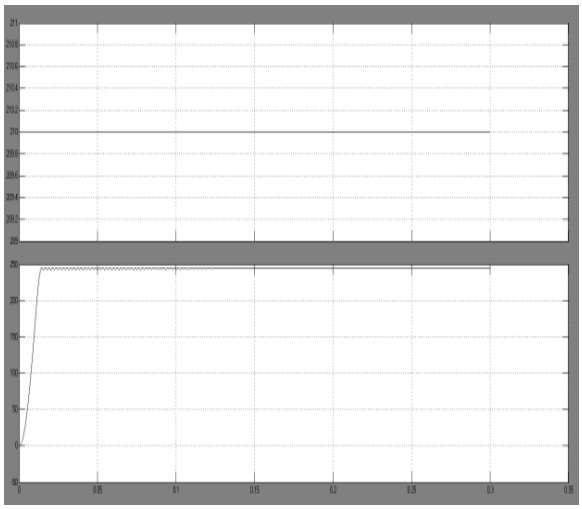

Fig.11 *Output of P/O LUO converter*

D. Negative Output LUO Converter Output for 210V Input

For the input of 210 V in the Solar PV the output of negative output Luo converter is shown in Fig.12

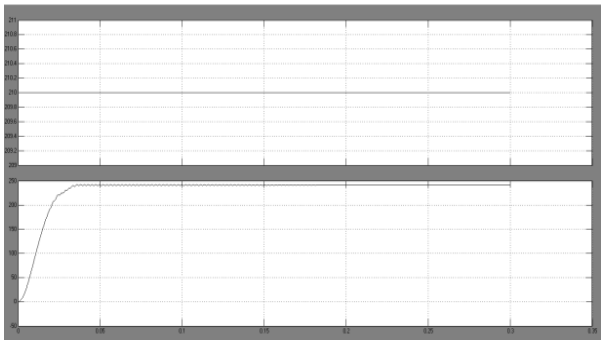

Fig.12 *Output of N/O LUO converter*

E. Double Output LUO Converter Output for 210V Input:

For the input of 210 V in the Solar PV the output of double output Luo converter is shown in Fig.13

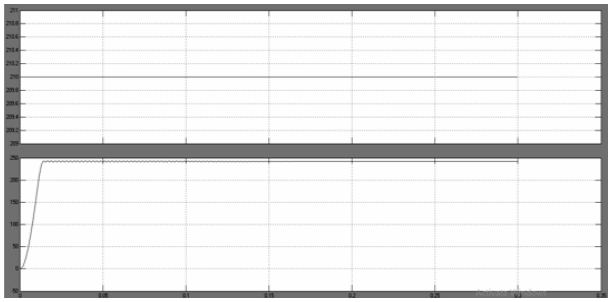

Fig.12 *Output of Double Outputt LUO converter*

F. BLDC Motor Output for 210V Input of Positive Output LUO Converter:

1) Speed Vs Time

When the output of 210 V from the Positive output Luo converter is fed to BLDC drive, the speed characteristics obtained is shown in Fig.14.

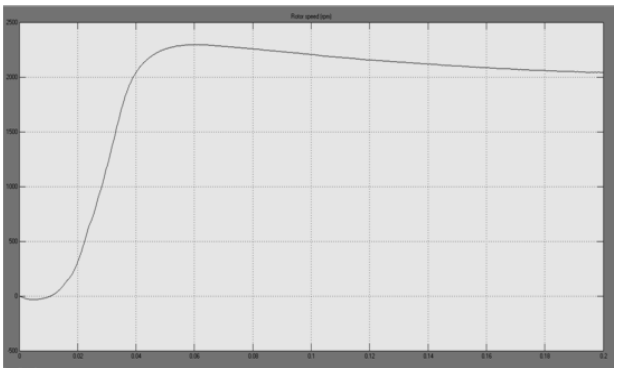

Fig.14 Output *of Speed Vs Time*

2) Back Emf Vs Time:

When the output of 210 V from the Positive output Luo converter is fed to BLDC drive, the speed characteristics obtained is shown in Fig.15.

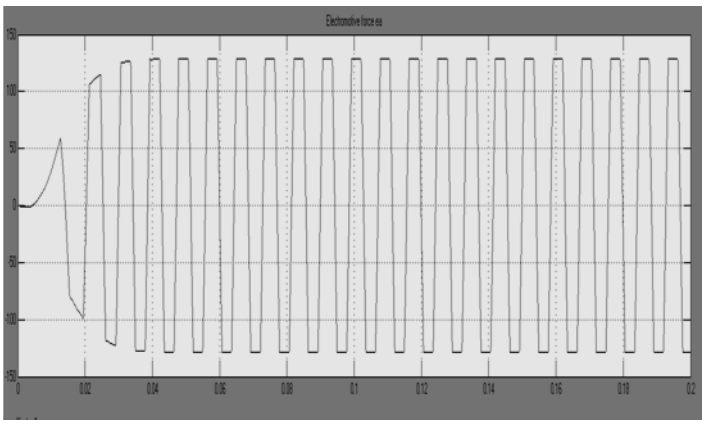

Fig.15 *Output of Back Emf Vs Time*

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300	253	266	260

The Table I shows the comparison of different Luo converter output voltages are presented.

6. Conclusion

The Solar PV fed BLDC motor is used for many applications like water pumping in agriculture, electronic equipment, fan etc. In which the efficiency of the developed dc-dc converter is analyzed to get the suitable converter has to be choose based upon the performance. Here that the P/O LUO converter is efficient than N/O and D/O LUO converter. The results are compared to get the justification and the results are obtained from the MATLAB/SIMULINK software.

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