

Multi level Inverter for improving efficiency of PV System using Luo Converter

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Abstract—The proposed framework manages implementation and modelling of a multilevel inverter with dc-dc converter outline. This framework is primarily expected to be utilized for solar panel applications in which the photovoltaic boards are associated with string structure. The whole recreation configuration incorporates photovoltaic module, Luo converter at the dc input and multilevel inverter at the yield of Luo converter. The PV module is requisite to send dc input. The dc input is given to Luo converter where it all the while working to control photovoltaic voltages.

In Hardware, we have implemented 5-level multi-level inverter. The input voltage is supplied from the transformer with rectifier at 12V to Luo Converter. Luo converter is used to convert to DC-DC voltage and boost the voltage with the less distortion. The output voltage of Luo converter is boosted to 43V. Luo Converter has connected to H-Bridge Multi-level inverter. The waveform of the multi-level is in a staircase form.

Index Terms— Photovoltaic(PV) Cell, Luo Converter, Cascaded H-bridge inverter, Multilevel Inverter, MOSFET(Metal Oxide semiconductor field).

I. INTRODUCTION

Photovoltaic or sunlight-based vitality frameworks are by and large widely examined in conveyed age region attributable to its effectively versatile structure. The PV modules that are involved arrangement and parallel association of indistinguishable PV cells give same qualities. The present voltage (I-V) and power-voltage (P-V) qualities of every cell in a PV module draw similar esteems and yield general yield for each PV module. The PV strings are regularly incorporated arrangement association of PV modules keeping in mind the end goal to build the string voltage.

The yield of the sun oriented board isn't looked after consistent, so in our undertaking the Luo converter is utilized to keep up the steady DC voltage over the yield of the Luo converter. Positive yield Luo-converters play out the voltage transformation from positive to positive voltages utilizing Voltage Lift strategy. This converter performs positive to positive DC-DC voltage expanding transformation with high

power, high effectiveness and shabby topology in straightforward structure. They work in the first quadrant with vast voltage amplification. A relative basic controller will be utilized as a part of the recreation model to control exchanging

of Luo converter. The inductor exchanges the vitality from source to capacitor within turn off, and afterward, the put away vitality of a capacitor is conveyed to stack amid switch-on. In this way, if the voltage is higher the yield voltage ought to be high. At the point when the turn is finish, the current flows through the free-wheeling diode. This current bars in entire turn off period. In the event that Current does not end up zero preceding switch turned on once more, this working state is defined as the constant conduction mode. In the event that current ends up zero preceding switch turned on once more, this working state is defined as the intermittent conduction mode.

A multilevel inverter will be required for changing over dc yield of Luo converter into air conditioning voltage. We will utilize a multi-level fell H-connect inverter in our project. This inverter utilizes a few H-connect inverters associated with an arrangement to give a sinusoidal yield voltage. Every cell contains one H-connect and the yield voltage created by this multilevel inverter is really the total of the considerable number of voltages produced by every cell i.e. on the off chance that there are k cells in an H-connect multilevel inverter at that point number of yield voltage levels will be $2k+1$. In Simulink, we are proposing 9- level H-bridge Multi-Level inverter, where in hardware we are designing 5- Level H-bridge Multi-Level inverter. This sort of inverter has an advantage over the other two as it requires less number of parts when contrasted with the other two kinds of inverters thus its general weight and cost is additionally less.

A multilevel inverter accomplishes high power appraisals, as well as empowers the utilization of sustainable power sources. Sustainable power sources, for example, Photovoltaic, wind, and energy components can be effortlessly interfaced to a multilevel inverter framework for a powerful application. The most imperative advantage of Multistring is to create expanded yield levels and to diminish the dv/dt weight on switches.

In Hardware, we have implemented 5-level multi-level inverter. The input voltage is supplied from the transformer with rectifier at 12V to Luo Converter. Luo converter is used to convert to DC-DC voltage and boost the voltage with the less distortion. The output voltage of Luo converter is boosted up to 43V. Luo Converter has connected to H-Bridge Multi-level inverter. The waveform of the multi-level is in a staircase form.

II. PROPOSED SYSTEM

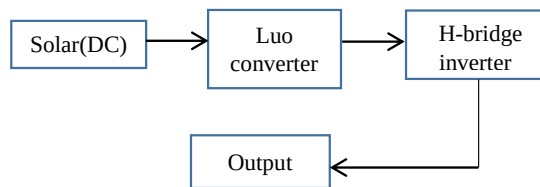


Fig. . Proposed System Block Diagram

In Solar module, there are 20 number of Solar Cells where each cell carries 0.6 volts. The input is supplied at 11.67V. The DC output voltage is supplied to Luo converter which boosted the voltage up to 33.27 V. To get the voltage in AC load we have connected H –Bridge inverter in which explained model is proposed to have a 9 level staircase waveform. The semiconductor device is used in inverter is MOSFET transistor which is highly used for amplifying and switching electronic signals in the electronic devices.

III. PV MODULE

Photovoltaic cells are connected in series and parallel to form PV module. When various PV modules are connected electrically with each other, it is referred as PV array. In solar plants and high power requirement system, solar arrays are used. Due to the prototypic nature involved in our project model, PV modules are used. Here, four PV modules are used as input sources at the input terminals of the converter.

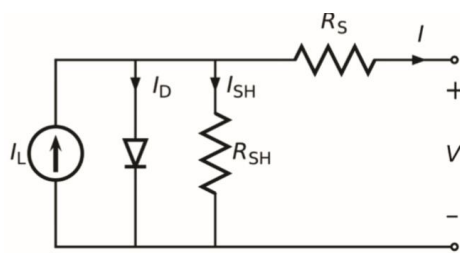


Figure I. Equivalent circuit of PV panel

In this Figure, I_d is a diode current, R_s means the series resistance of PV cells, R_{sh} represents the PV battery parallel resistance

Equation

$$I_o = I_{pv} - I_D(V) - I_{sh}(V)$$

$$I_D = I_R(e^{VD/n} - V_r - 1)$$

$$I_{sh} = \frac{V_o + I_o R_s}{R_{sh}}$$

$$I_o = I_{pv} - I_D(V) - \frac{V_o + I_o R_s}{R_{sh}}$$

$$I_o = I_{pv} - I_R(e^{V_o + I_o R_s / n V_r} - 1) - \frac{V_o + I_o R_s}{R_{sh}}$$

$$I_D = I_{ph} - I_o \left[\exp\left(\frac{q \cdot v}{A \cdot k \cdot T}\right) - 1 \right] - \frac{V + R_s \cdot I}{R_p}$$

The characteristics of PV module are absolute non-linear by their nature. A single cell equivalent circuit is considered for model implementation.

TABLE I. Parameters of Solar Modules

Rated Power of each module	120W
Short Circuit Current(I_{sc})	7.34A
Temperature	25degC
Open Circuit Voltage(V_{oc})	0.6 V
Number of Modules	4
Number of PV cells in each module	20

The output of solar panel changes throughout the day, i.e. it is variable. In order to get a constant output voltage waveform, Luo converter is implemented. Proposed model contains positive output elementary circuit of Luo converter.

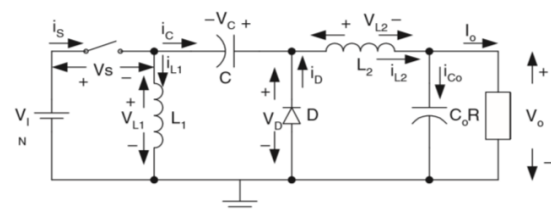


Figure III. circuit of positive output Luo converter

The above figure represents the elementary circuit of positive output Luo converter. The circuit contains a switch (MOSFET), a tank circuit and a LC filter. It has two modes of operation which are discussed below along with their analysis.

Mode I: Switch is in ON state, the L_1 is supplied by V_{IN} , source and the capacitor C transfers charge to inductor L_2 . capacitor C_0 supplies the load

$$\frac{dV_{C1}}{dt} = \frac{I_{L0}}{C}$$

$$\frac{dV_{C0}}{dt} = \frac{I_{L0}}{C} - \frac{V_o}{RC_o}$$

$$L_o \frac{dI_{L0}}{dt} = V_{in} - V_{C1} - V_o$$

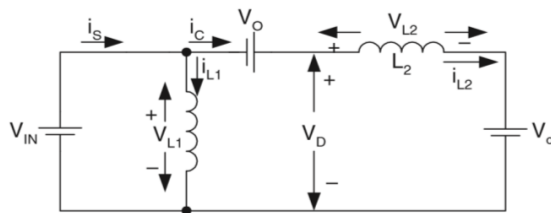


Figure IV. Equivalent circuit of mode I

Mode II: Switch is turned OFF. The source current becomes zero. The capacitor C is charged by the Current I_{L1} and current I_{L2} flows through C_0 and R circuit and diode D to make itself a continuous.

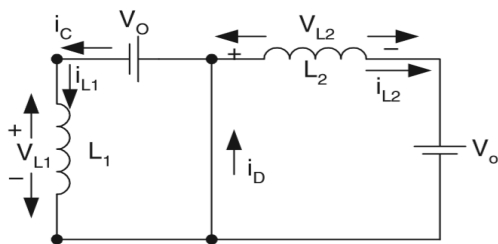


Figure V. Equivalent circuit of mode II

$$V_{C1} = -L_1 \frac{dI_{L1}}{dt}$$

$$L_o \frac{dI_{L0}}{dt} = -V_{C0}$$

$$C_o \frac{dV_{C0}}{dt} = I_{L0} - \frac{V_o}{R}$$

IV. MULTILEVEL INVERTER

An Inverter is used for the purpose of converting signal from DC to AC. Although, inverter output is in AC form but it is not a sinusoidal wave. In order to get a wave which is more similar to sine wave and whose distortion is less, a 9 level inverter is used.

Calculation of Number of Switches for 9 Level Inverter
N=9

$$\text{Number of Switches} = 2(N-1)$$

$$= 2(9-1)$$

$$= 16$$

Switching angle interval

$$T = \frac{360}{16} = 22.5$$

TABLE II: Switching Angle of Inverter Switches

Similarly,

For 5 Level Inverter

N=5

$$\text{Number of Switches} = 2(N-1)$$

$$= 2(5-1)$$

$$= 8$$

$$T = \frac{360}{16} = 45$$

angle ↓	switch	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Voltage
0.0																		0
22.5	✓		✓															1
45	✓		✓		✓			✓										2
67.5	✓		✓		✓		✓	✓		✓		✓						3
90	✓		✓		✓		✓	✓		✓		✓		✓		✓		4
112.5					✓		✓	✓		✓		✓		✓		✓		3
135									✓		✓		✓		✓		✓	2
157.5													✓		✓		✓	1
180																		0
202.5		✓		✓														-1
225		✓		✓		✓		✓										-2
247.5		✓		✓		✓		✓		✓		✓						-3
270		✓		✓		✓		✓		✓		✓		✓		✓		-4
292.5						✓		✓		✓		✓		✓		✓		-3
315									✓		✓		✓		✓		✓	-2
337.5														✓		✓		-1
360																		0

V. SIMULATION RESULTS

The energy supplied by PV modus depends mainly on two factors temperature and irradiance. As the temperature increases there is increase in the intensity of sunlight, which results in an increment in power as well as voltage.

The changes in Irradiance also get reflected in the output voltage and power with a slight variation.

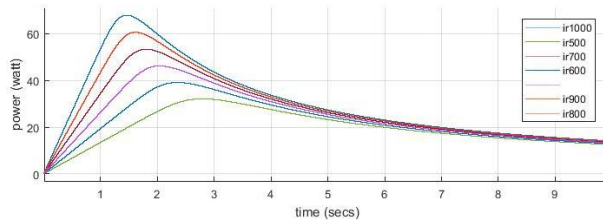


Figure VI. Power at different values of irradiance

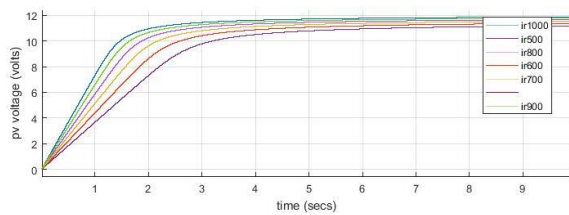


Figure VII. Voltage at different values of irradiance

The power and voltage at six different values are observed. It is to be noted that power and voltage both are directly proportional to temperature and irradiance

Simulation model consists of four PV modules as input, luo converter and a symmetrical 9 level inverter.

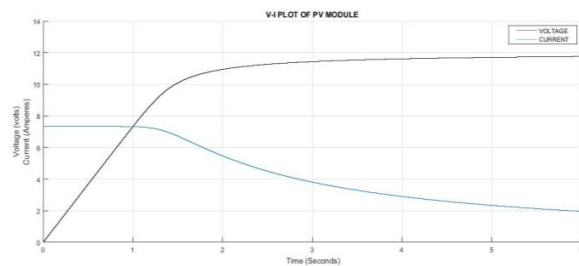
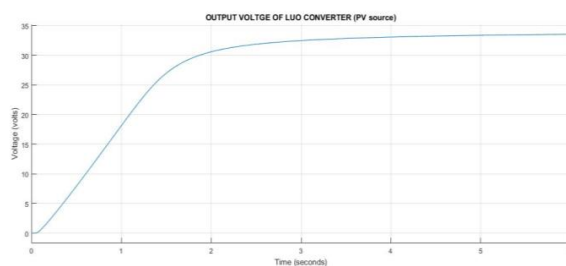


Figure VIII. VI plot of PV module

$$V_{PV} = 11.67 \text{ V}$$

$$I_{PV} = 1.996 \text{ A}$$



Output voltage of luo = 33.27 V

Figure IX. Output voltage of luo converter

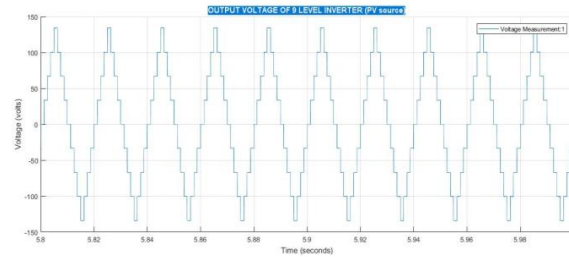


Figure X. Output voltage of 9-level inverter

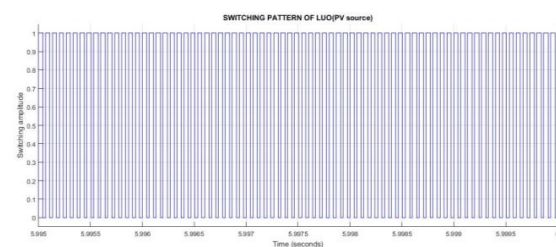


Figure XI. Switching pulses of luo

Switching frequency = 15 KHz

Duty cycle = 60 %

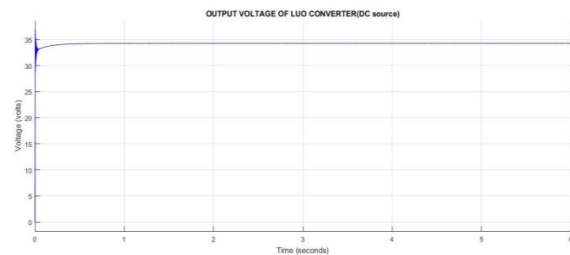


Figure XII. Output voltage of luo converter

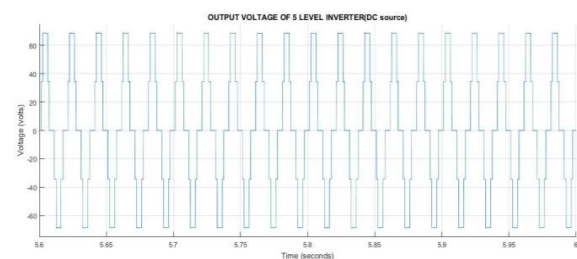


Figure XIII. Output voltage of 5 level inverter

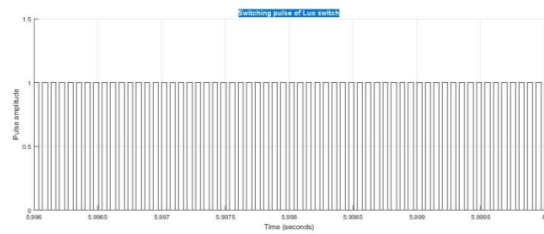


Figure XIV. Switching pulse of Luo switch

