Analysis and Experimentation of Photo - Voltaic (PV) Based Negative Output Super lift Luo Converter (NOSLC)

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***Abstract*— Photovoltaic system (PV) seems to be a good alternative for conventional sources, but it exhibits a non-linear characteristic due to various environmental factors like temperature, shadowing, dirt etc., to overcome this, a suitable power electronic circuit has to be developed. In this paper, a negative output elementary superlift luo converter (NOESLLC) integrated with the PV system is proposed. To enhance the tracking power of the PV system, MPPT (maximum power point tracking) technique is implemented with an analog MPPT charge control circuit. The maximum power transfer takes place with this implementation of MPPT that employs an integrated circuit model. The modeling of PV cell and the MPPT is carried out using MATLAB/SIMULINK.A prototype of the proposed converter powered by PV source is built to validate the experimental results.**

Keywords. NOESLLC, Photovoltaic system, Equivalent circuit of PV cell, PV module, PV model with NOESLLC.

I. INTRODUCTION

The increase in the demand for electricity and changes occurring in environment has led to a need for development of new source of energy that proves to be less hazardous. In this search, solar energy using PV modules has provided a sustainable solution. This paper presents the PV based design of NOESLLC.NOESLLC is a type of Dc-Dc converter that employs superlift technique in which the output voltage increases in geometric progression. Here the PV cell is modeled using equations and the MPPT technique is also developed to track the maximum power ,then integrated with NOESLLC and simulated using MATLAB.A prototype of this integrated circuit is developed and the output power is measured and verified with the simulation results obtained.

The section II deals with the overview of the proposed work. Section III represents the modeling of PV cell with its I-V and P-V characteristics. The modes of operation of NOESLLC have been dealt in section IV. Section V depicts the MPPT technique with its simulation results and finally sectionVI portrays the hardware implementation of PV based system followed by conclusion in section VII.

II. OVERVIEW OF THE PROPOSED CONVERTER WITH PV MODULE

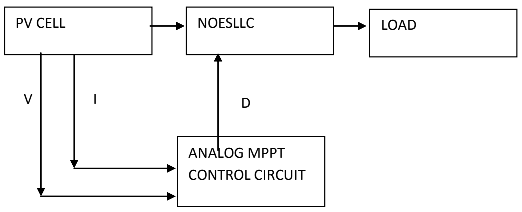

Fig 1**.** Block diagram of the proposed system

The fig.1 represents the overall view of the proposed work [6]. It shows the sensing of the voltage and the current of the PV cell, with which the duty ratio of the switching pulse of NOESLLC is varied.

III. MODELLING OF PV CELL

Solar panels use light energy from the sun to generate electricity through the photovoltaic effect. The module of a PV consists of number of solar cells connected in series and parallel. Each cell is basically a p-n diode. When sunlight falls on a solar cell, the light energy incident is converted into electrical energy.

The current source Iph represents the cell photocurrent. Rsh and Rs are the shunt and series resistances of the cell. Usually the value of Rsh is very large and that of Rs is very small. The fundamental parameters related to solar cell are short circuit current (Isc), open circuit voltage (Voc), Maximum Power Point (MPP).

III.1 Equations of PV cell

Module photo-current (Iph)

$$Iph = [Iscr+ki\ (T-298)]*\ \lambda/1000 \qquad (1)$$

Where, Iscr = short circuit current at 25^{0}C and 1000W/m2.

ki = is the short circuit current at 25^{0}C and 1000W/m2.

λ is the PV module illumination (W/m2).

Let the reference temperature be 25^{0}C or 298K.

Let the cells operating temperature be 50^{0}C or 323K.

Module reverse saturation current (Irs)

$Irs = Iscr/ [\exp (qVoc/NskAT)-1]$ (2)

Where,

q = electron charge in coulumbs.

Voc = open circuit voltage in volts.

Ns= total number of cells in series.

K=Boltzmann constant.

A=B is an ideality factor.

Module saturation current (Io)

$Io=Irs [T/Tr]3 \exp [q*Ego/BK \{1/Tr-1/T\}]$ (3)

Where,

Ego=band gap for silicon.

Photovoltaic current (Ipv)

$Ipv = Np*Ipv-Np*Io[\exp \{q*(Vpv+Rs)/(NsAkT)\}-1]$ (4)

III.2 Development of Simulink model for PV Cell

Being illuminated with radiation of sunlight, PV cell converts part of the photovoltaic potential directly into electricity with both I-V and output characteristics. Fig 2 depicts the characteristics setup of PV module.[8],[11]. Fig 3 and Fig 4 shows the P-V and I-V characteristics at different illumination. With 1000w/sqm, the maximum power of the module comes to 36 watts and the current obtained as 2.5A.[9,10].

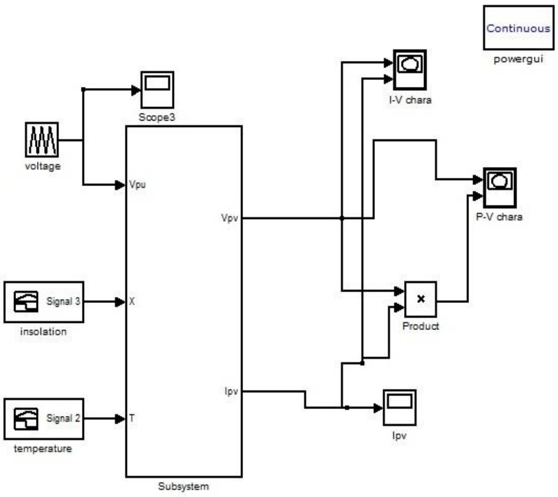

Fig.2 I-V and P-V characteristics setup of PV Module

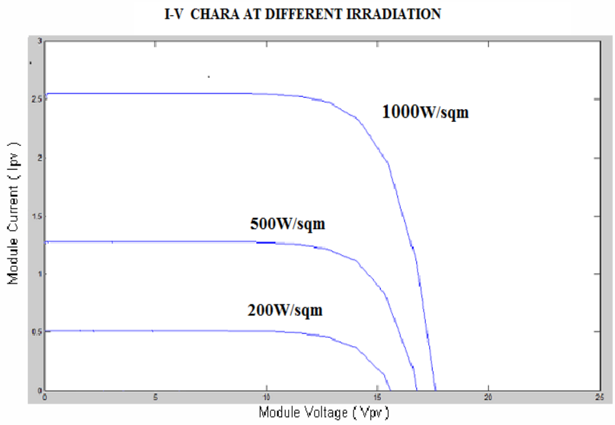

Fig.3 I-V characteristics at different Ilumination

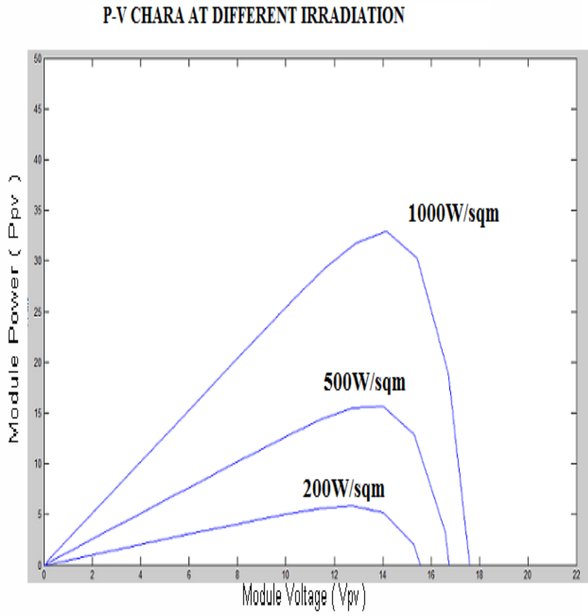

Fig.4 P-V characteristics at different Illumination

IV. OPERATION OF NOESLLC

NOESLLC is a type of DC-DC converter possessing high-voltage transfer gain, high power density, high efficiency, reduced ripple voltage and current. The modes of operation have been explained with the following diagrams.

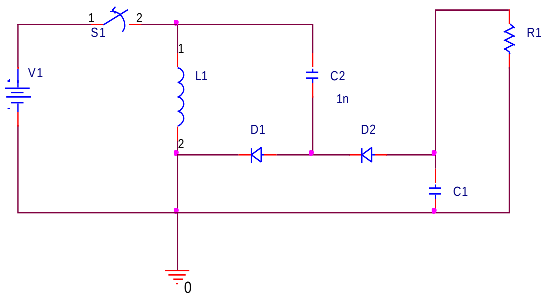

Fig.5 Circuit diagram of NOESLLC

Fig.5 shows the elementary circuit of NOESLLC.It consists of DC supply voltage in, capacitors C1 and C2, inductor L1, power switch S, freewheeling diodes D1 and D2 and the load resistance R.[2,3]. The working principle is explained with the switch 'S' on and off as two modes of operation. During the on period of the switch 'S' i.e. DT interval, voltage across capacitor C1 is charged to Vin. Current flowing through inductor L1 increases with slope Vin /L1 and decreases with slope – (Vo –Vin)/L1 during switch-off (1-D) T. During mode-1, the switch 'S' is closed and the supply flows through the inductor L1 and C1 charges during this time ,the capacitor C2 produces a load voltage. During mode-2, the switch is open and the inductor L1 and capacitor C1 discharges through the load which gives the boosted output Voltage .

IV.1 Parameters of NOESLLC

The circuit parameters for NOESLLC is calculated with the conduction duty ratio k, switching frequency f, switching period T, and the load resistance R. The input voltage and current are Vi and Ii, output voltage and current are Vo and Io respectively. [5], [7].

Considering the modes of operation as by above figures, the variation of the inductor current during on and off modes are given by,

$\Delta iL1 = (Vin/L1)\ KT = (V_O\ -Vin/\ L_1)\ (1-K)\ T$ (5)

Thus the output voltage V_O is given by,

$Vo/\ Vin = 1/\ (1-k) = [(2-k)/\ (1-k) - 1]^n\ Vin$ (6)

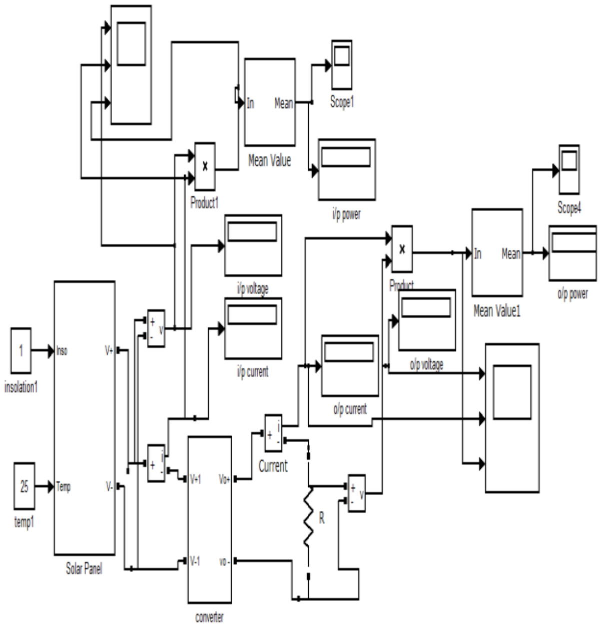

Fig.6 NOESLLC fed with PV without MPPT

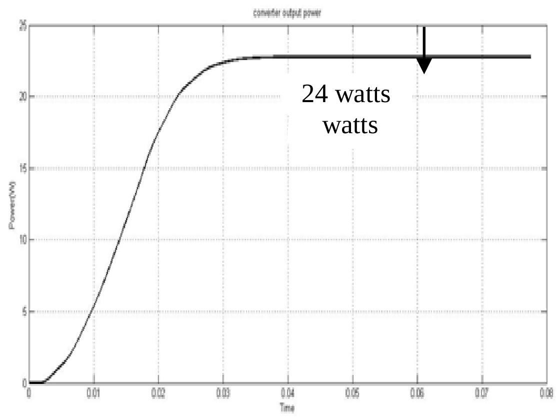

Fig.7 output power of NOESLLC

The NOESLLC is fed with PV system as shown in the Fig 6. The output power of PV panel is 26watts and without MPPT, the power transferred to NOESLLC is 24watts which is again shown in the Fig 7.

V. IMPLEMENTATION OF MPPT CONTROL

The above sections have been dealt with the modeling of PV cell and the operation of NOESLLC. This section deals with the concept of trapping of maximum power with the analog MPPT technique employed. This provides a fast track of maximum power with the sense of voltage and current at the input section. It shows the variation in the duty cycle with the prediction of change in voltage and current [4],[1].

5.1 NOESLLC fed with PV cell with MPPT

This section reveals the concept of NOESLLC fed with PV with the implementation of analog MPPT control.

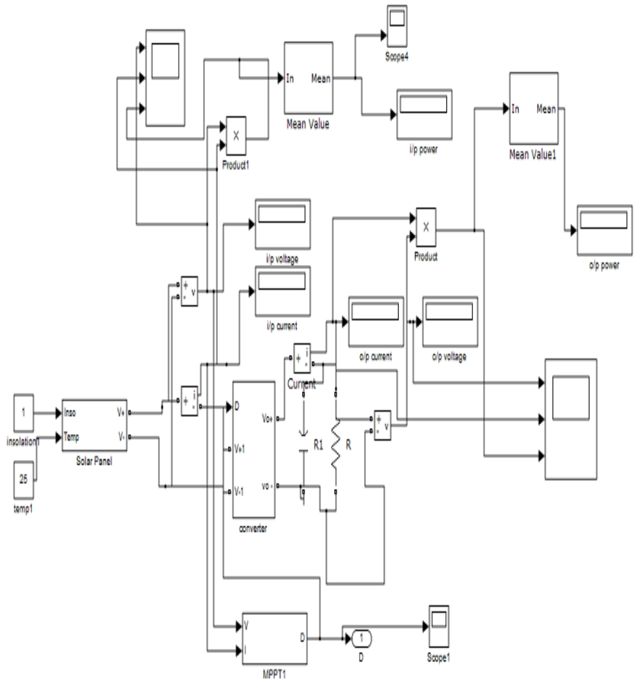

Fig. 8 NOESLLC fed with PV with MPPT

Fig.8 shows the NOESLLC fed with PV with the MPPT block. The output power of PV panel with MPPT is 35watts and seems to be very high compared to PV power without MPPT which was found to be only 26watts.fig.9 shows the transfer of power from PV to NOESLLC which is depicted as 26watts and fig 10 shows the comparative output of PV power with and without MPPT and predicts the tracking of power is high only in MPPT concept.

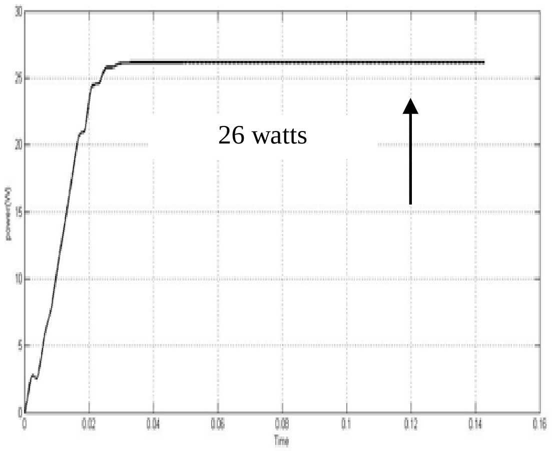

Fig.9 Output power of NOESLLC with MPPT

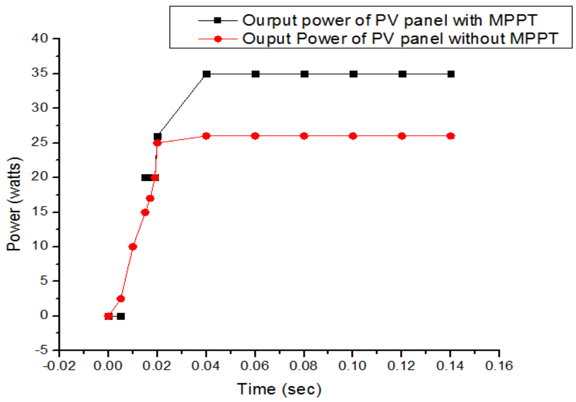

Fig.10 Output power of PV panel with and without MPPT

VI. HARDWARE IMPLEMENTATION OF PV BASED NOESLLC WITH MPPT

The hardware implementation of PV based NOESLLC is explained in this section. The fig 11 depicts the duty ratio of 0.7 generated. This shows analog mppt circuit brings a change in the duty ratio by sensing the panel voltage and current and thereby maintaining the steady state output with a value of -36V.

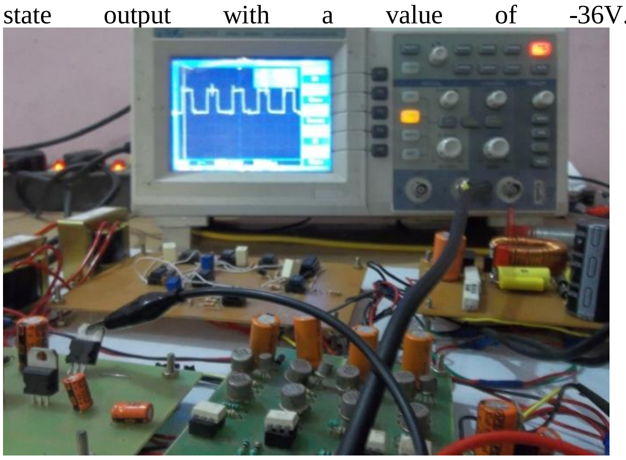

Fig.15 Generation of Pulse for a load of 80Ω with D=0.7

Fig.16 Steady Output voltage of -36V with a change in duty ratio

Thus the regulation in the output voltage is obtained effectively with the change in duty ratio from 0.8 to 0.7.

VII. CONCLUSION

This paper has implemented an analog MPPT controller at the input section to track the maximum power. Here the PV system is modeled and the parameters are measured. This developed model is simulated and integrated with NOESLLC and the output power is measured with and without employing MPPT.It proves that the maximum power is tracked only by using an MPPT concept. Thus a prototype of this model is developed and the results are verified with the simulation results.

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