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A Streamlined Boost Converter Design and Modelling Process for Photovoltaic Systems

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Abstract*: This project shows a simplified design and modelling process of Boost Converter specific to photovoltaic (PV) systems. Boost Converter is necessary to upgrade the low, variable output voltage of the PV panels to one compatible with application to the load or energy-storage systems. The proposed technique is applicable in ensuring a successful voltage regulation and optimum flow of power by integrating analytical modelling, simulation and real practical design issues. Inductors and capacitors are optimized precisely to meet critical parameters in the case of solar electricity applications such as duty cycle, switching frequency, and inductors and capacitor sizes. Simulation results verify the performance of the converter to a number of different load conditions and irradiance conditions. The process offers a simple yet effective basis of designing power converters that are high efficient in renewable energy systems.*

Keywords*: Snubber, Knee point, Converter, Fuzzy, Irradiance*

I. Introduction

Photovoltaic (PV) systems as clean and sustainable sources of energy are gaining relevance. Nevertheless, due to the fluctuations in temperature and irradiance, the electrical yield of solar panels is fundamentally random and often in form of low voltage, unsuitable to operate most equipment. To resolve this a boost converter is often employed to increase the voltage to a value suitable to DC loads or energy storage devices. The principal aim of this study is a streamlined structure and modelling practice of a Boost Converter designed specifically to PV systems. Targets at streamlining the development process by maintaining high performance and efficiency of the multiple input conditions. Relevant components include analytical modelling, component selection (e.g. capacitors and inductors) and simulation such as using the MATLAB/Simulink. Using this approach it is even possible to develop reliable and cost-effective power conditioning systems to renewable energy using small adjustments in the converter parameters and verifying how the converter performs under real sun light conditions.

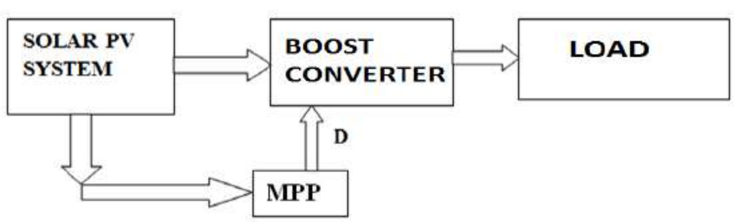

Fig 1: Block diagram of PV

II. Boost Converter Fundamental Principle

A boost DC-DC power converter is a power converter that increases an input voltage to a higher output voltage. It is made up of using an inductor, switch (typically a transistor), diode and capacitor, and operates by means of storing and releasing energy. The diode prevents the flowing of current to the output and the inductor accumulates energy of the input source as the current flows through the inductor. There is increase in the output voltage due to the energy stored in the inductor being released to the output capacitor and the load and the diode. This method makes feasible effective voltage boosting in battery driven and solar systems among others.

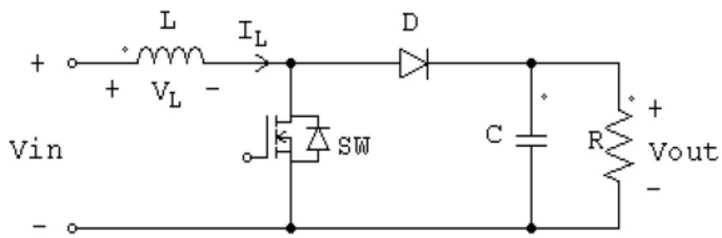

Fig 2: Boost converter schematic diagram

III. Boost Converter Operation Analysis

A boost converter raises the input voltage by switching the storage and transfer of energy between an inductor [2-4]. The operation of it is usually analysed in two modes. The switch is usually closed, usually a MOSFET. As the input voltage applies across the inductor, the inductor current increases linearly. The load is driven when the diode is reverse-biased, with output capacitor. When the switch closes, the inductor reacts and gives the stored energy to the load and output capacitor through the diode.

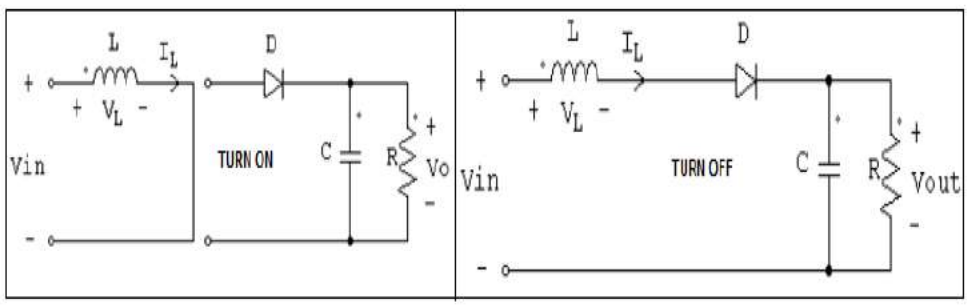

Fig 3: ON / OFF Boost converter

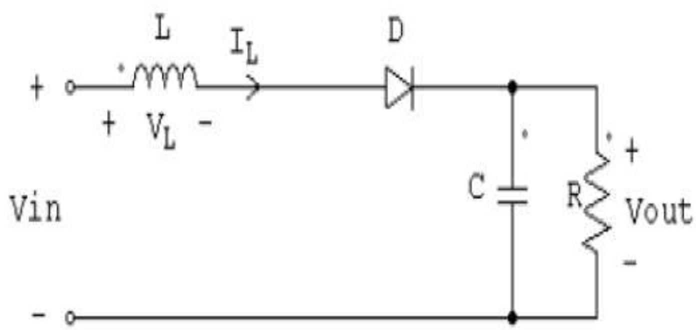

Fig 4: OFF operation of boost converter

Consequently, the output voltage is increased. DCM In DCM, the inductor current is zero in part of the switching cycle, typically when the load is light. This mode is harder to analyze and will have three steps. This voltage depends upon the frequency and the load. When constructed well, they are usually efficient (more than 85 per cent). Performance is affected by the control technique, the inductor resistance and switching losses. Policies towards regulating output voltage and duty cycle using pulse width modulation or PWM are often found.

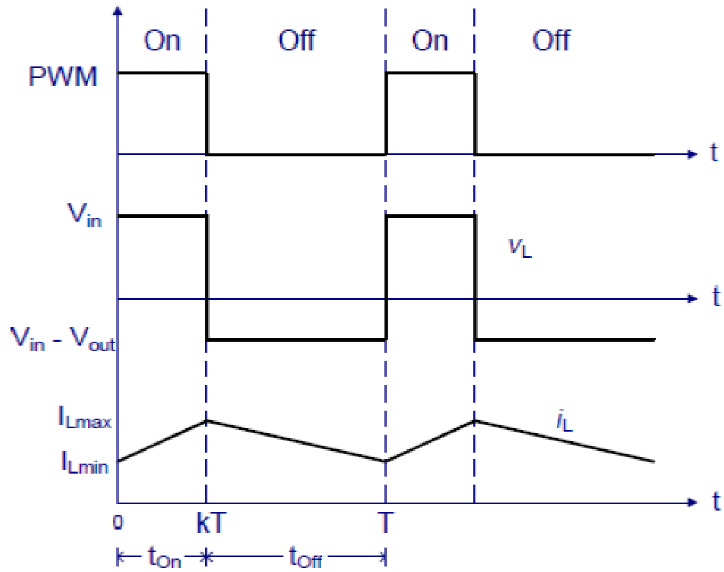

Fig 5: Waveform of boost converter in conduction mode

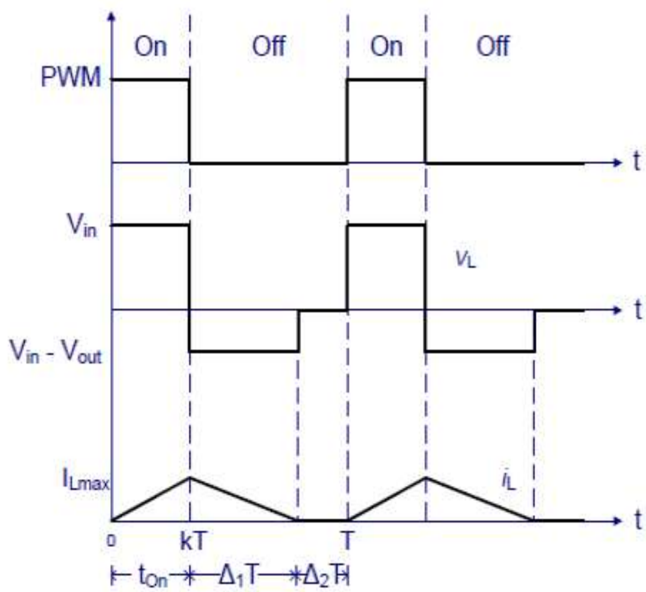

Fig 6: Waveform of boost converter in discontinuous conduction mode

IV. Proposed System

The proposed system is based on the Boost Converter that is intended to operate in photovoltaic (PV) whereby a simple yet powerful design and modelling approach is applied. It aims to regulate the low and variable DC voltage that is being provided by a solar panel and convert them into a higher constant response that could be used as a DC load or in storage. an optimized boost converter which consists of switching and capacitor and inductor elements. The duty cycle is varied based on input conditions in pulse width modulation or PWM. The approach simplifies the design of renewable energy systems and increases the reliability of the system [1-4].

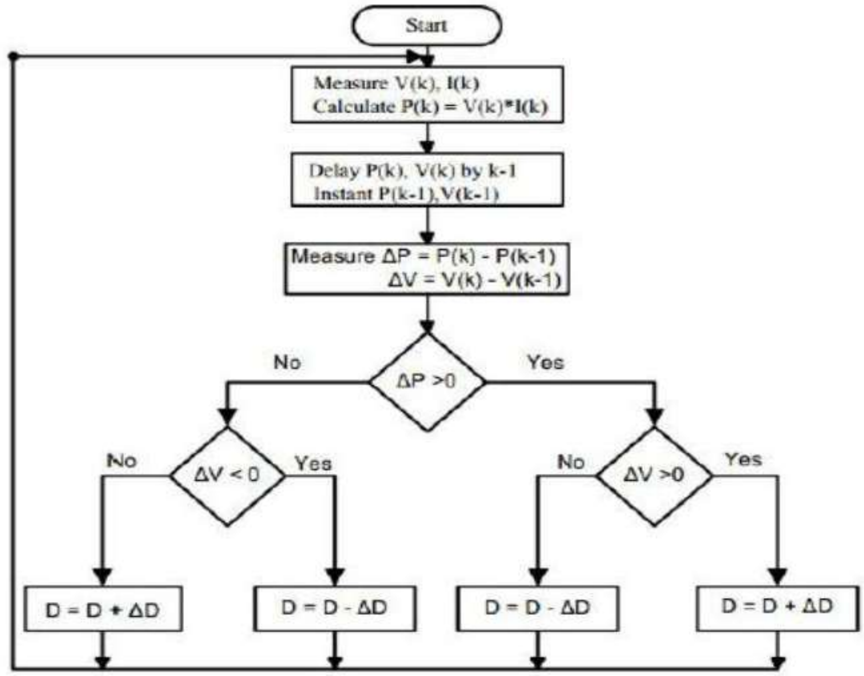

Fig 7: Algorithm of P and O method

V. Simulation Results

In order to determine the effectiveness of the proposed Boost Converter under different load and solar irradiance conditions MATLAB/Simulink was employed to simulate the proposed converter. The converter was able to raise the PV input voltage, usually at 12 18V to a constant 24V output at a variety of different irradiance levels [2-6]. The output of the system responded to changes in the input voltage with little overshoot or delay as output was controlled by the system. In most of operating conditions, the efficiency indicated in the simulation results remained higher than 90 per cent, which reassured the optimum component sizes and switching management. Such results prove that the simplified design could be applied to practical PV product line with different environmental conditions and is efficient [5].

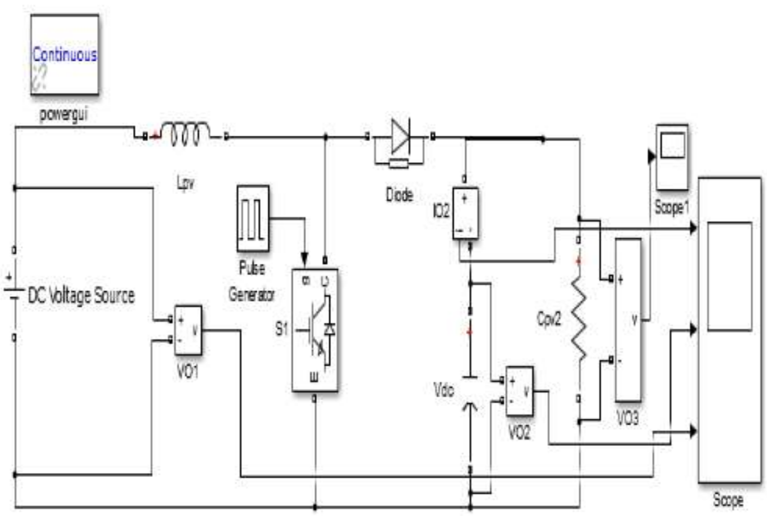

Fig 8: Simulink boost converter

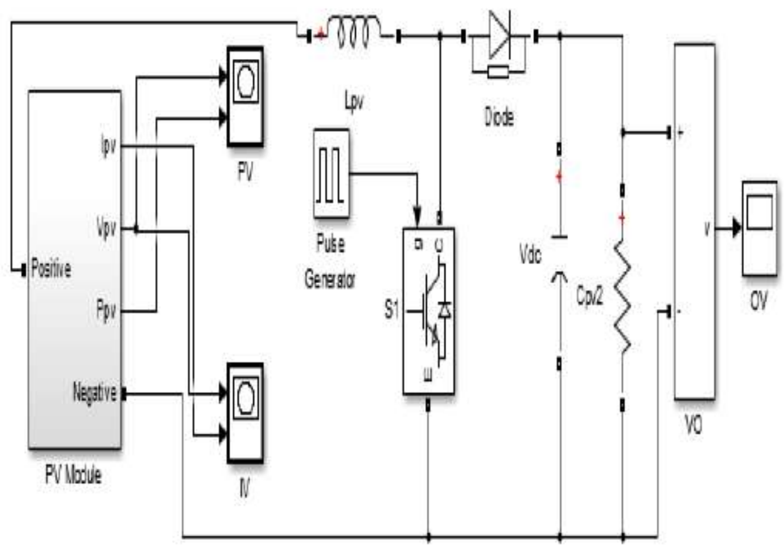

Fig 9: Simulink boost converter with PV

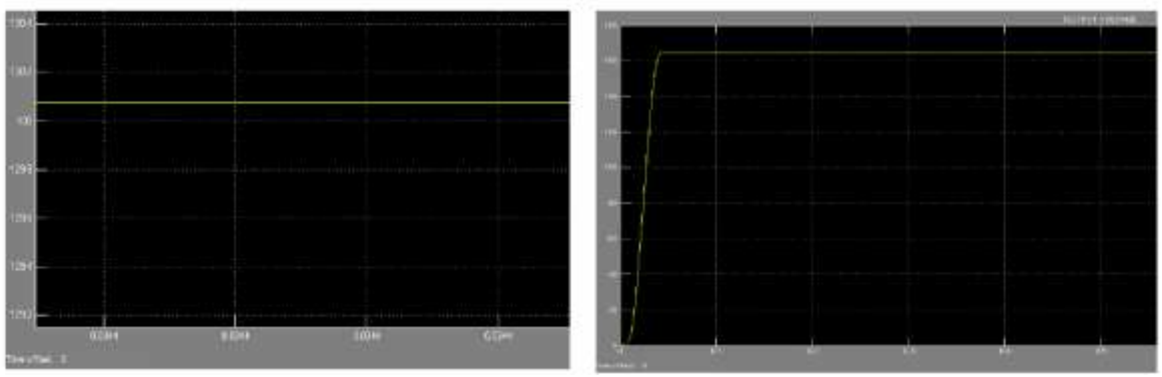

Fig 10: Output voltage waveform of boost converter

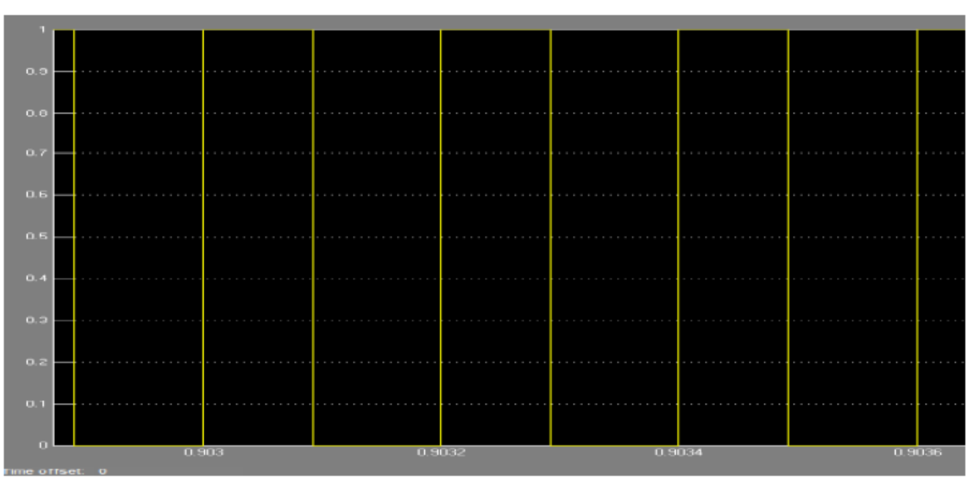

Fig 11: Output voltage waveform of boost converter with PV

VI. Conclusion

The project illustrates an effective approach of integrating power conversion in photovoltaics (PV) systems, hence simplified design and modelling of boost converter. Other power converter aspects such as duty cycle, inductor and capacitor values and control method were optimised to ensure satisfactory efficiency and low abuse output during varied solar conditions by simulation and analysis in MATLAB/Simulink. The efficiency and speed (greater than 90 percent) of the dynamic response in the system enabled the system to efficiently increase the variable input of PV panels to constant output voltage. It would be ideal in renewable applications because it simplifies the process of converter design without having to compromise its performance. The proposed design offers a practical and economical solution towards enhancing the conversion of solar power system [4].

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