International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-6, August, 2019

A Novel Power Factor Corrected Converter for Solar Pv Emulator

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Abstract: ***This Paper Presents A Pfc Converter Design For A Solar Pv Emulator. A Boost Converter Is Proposed As A Pfc Converter. The Photovoltaic Modules Are Connected In Series As An Array. The Pfc Buck-Boost Converter Circuit Provides The Compensated Voltage To The Pv Panel. The Pfc Converter Circuit Has Been Simulated In Simulink/Matlab. The Simulation Results Shows The Single Phase And Three Phase Output Voltages Along With The Pfc Correction.. The Pv Panel Compensates The Voltage Provided By The Power Source After Conversion From Ac To Dc.***

Keywords: - Photovoltaic Module, Buck-Boost Converter, Pv Emulator, Pic Microcontroller

I. INTRODUCTION

Renewable energy is a vital area of development in recent years. Renewable sources are increasing rapidly. Solar system, Wind energy, fuel cell are the recent trends of development in the field of renewable energy [1]. Availability of solar is abundant, but when compared with wind energy, the wind sources are erratic in nature. Solar power generation is used in all the industries. Now days, industrialist generate their own power by erecting the solar panels in the industries [6]. The power required for usage of industry is generated and the remaining power is fed to the grid for the consumers. Each solar panel consists of an array of solar cells, which is fabricated by using aluminium material [2]. Solar power taken by the PV panel depends on the radiation of sunlight. But a minimum of 25degree Celsius is required for the PV cell to generate solar power. The solar power generated is DC power. The generated DC is fed to the DC panel through the diodes [5]. The generated power from DC is fed to the inverter for the conversion of DC to AC. The AC power is fed to the AC panel for the distribution to the industrial usage. The excess of AC power is fed to grid for the consumers.

II. DC CHOPPER BASED SYSTEM

The DC Chopper based PV emulator emulates the output characteristics of the PV modules [8]. The output characteristics of the simulator are similar to those of an actual PV module. The simulator has a very good dynamic response.

Revised Manuscript Received on October 30, 2019.
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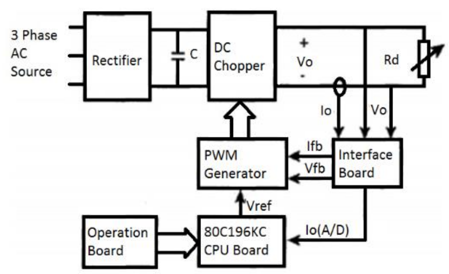

Fig 1:DC Chopper system circuit diagram

III. BUCK-BOOST CONVERTER BASED SYSTEM

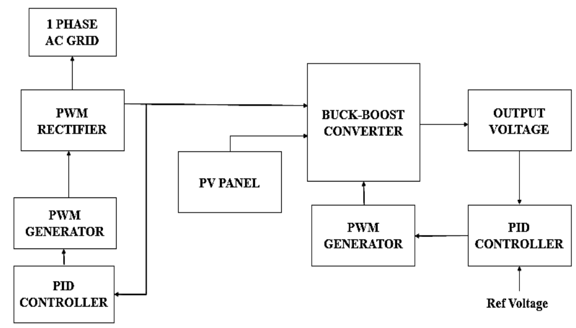

Fig 2: Buck-Boost Converter system block diagram

IV. MODES OF OPERATION OF BUCK BOOST CONVERTER

The Buck Boost converter has two modes of operation, when switch is ON and OFF.
Mode I: Switch is ON, Diode is OFF

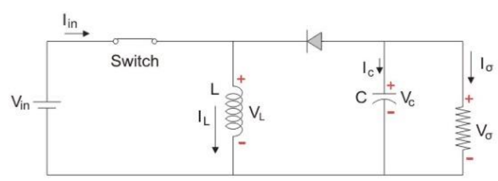

Fig 3: Buck-Boost converter switch on mode

When the switch is ON, the current flows in the closed circuit. The inductor stores its energy during the instant switch is ON. The PV emulator is connected across the load terminals [13]. At an instant of time period t_1, the diode is in the reverse biased state. The capacitor is charged with upper plate positive. The power factor correction is done by switching the switches at different instant of time period.

Mode II: Switch is OFF, Diode is ON

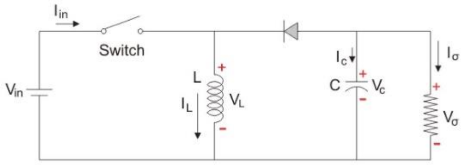

Fig 4: Buck-Boost converter switch off mode

When the switch is turned OFF, the polarity of terminals across the inductor is interchanged. The diode is forwards biased [14]. The capacitor is charged with upper plate positive and lower plate negative. The current freewheels through the closed circuit.

$(\Delta i_L)_{open}=(V_0/L)(1-D)T$

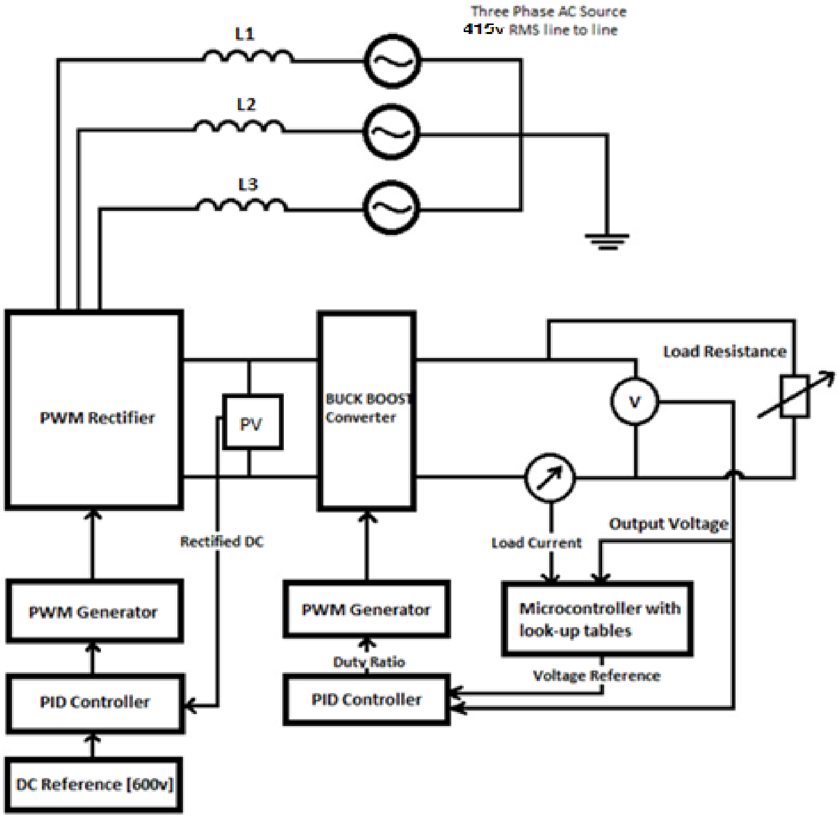

Fig 5: Buck-boost Converter Circuit diagram

V. SIMULATION RESULTS

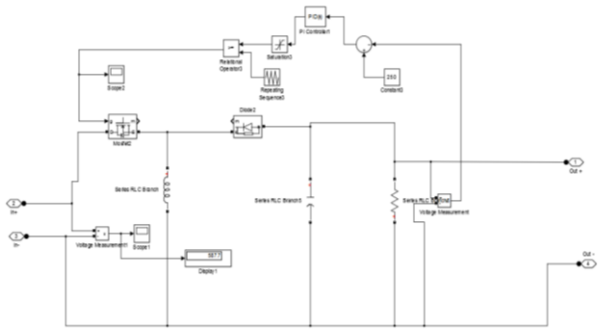

Fig 6: Closed loop Buck-Boost converter

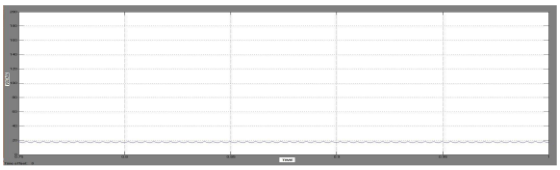

Fig 7: Output voltage for the single phase model made for hardware

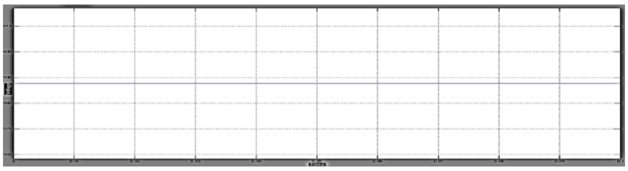

Fig 8: PV Panel output of 585 volts

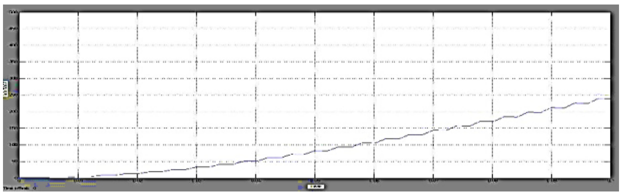

Fig 9: Output for buck boost converter at 238.9 volts

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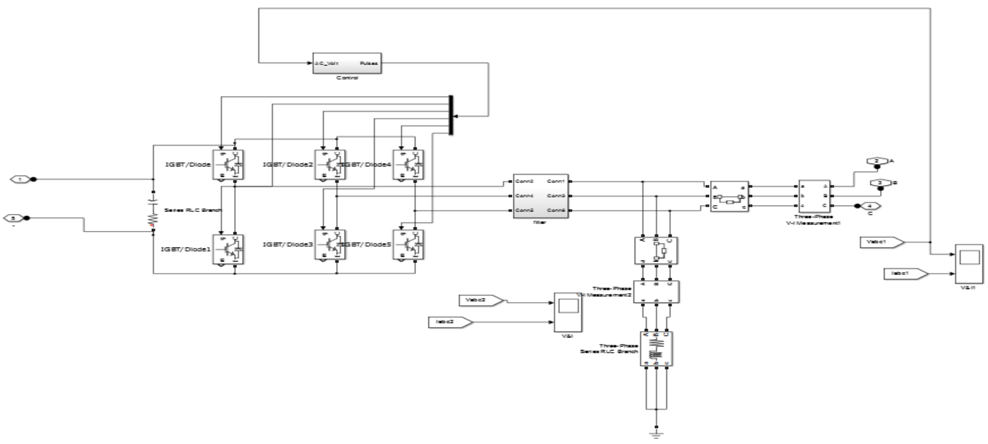
VI. THREE PHASE SIMULATION



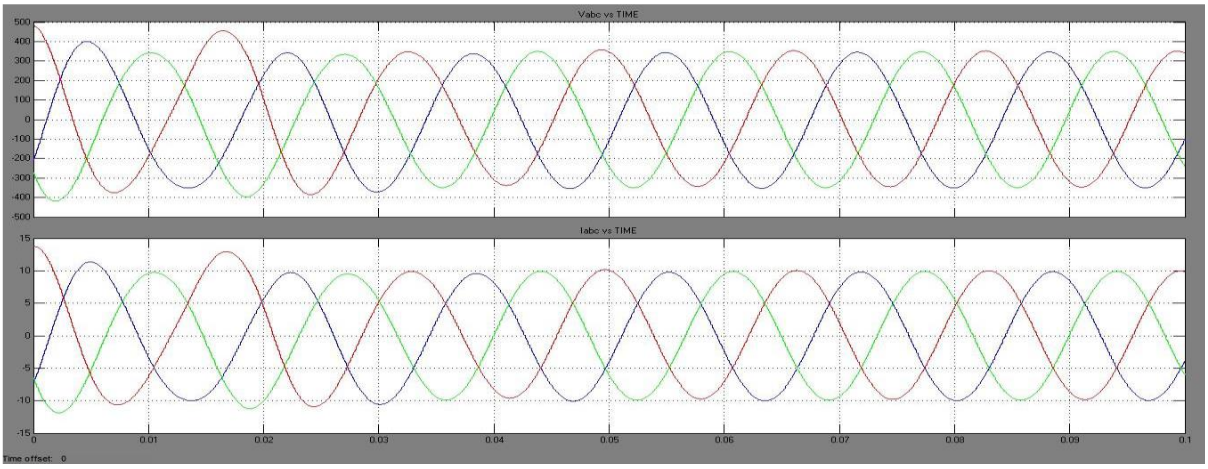


Fig 10: Three phase simulation

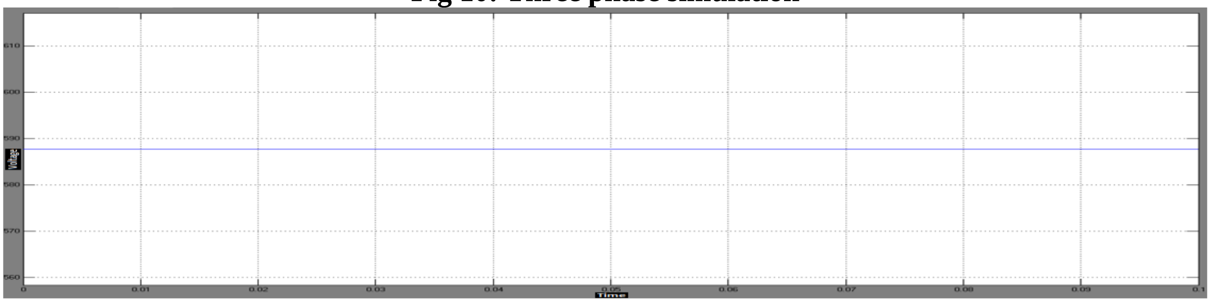


Fig 11: PV panel output for three phase model

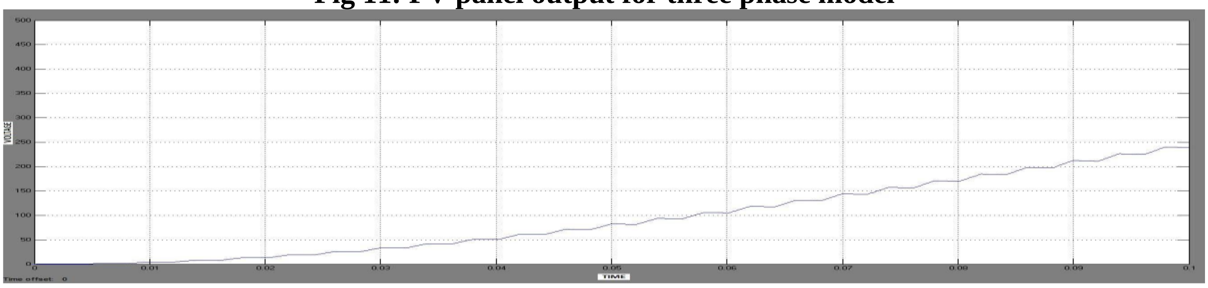


Fig 12: Load output for three phase

VII. HARDWARE OPERATION

The transformer steps down the voltage from 230 V to 12V. The 12v supply is given to bridge rectifier made using IN4007 diodes and the converted from pulsating DC to actual DC current.IC7805 voltage regulator reduces the voltage to 5v for PIC microcontroller to be operable. A PIC microcontroller of PIC 16F series is used which provides the reference voltage to the driver circuit operating the MOSFETs present in the converter circuit. The microcontroller uses a crystal oscillator to provide the voltage signal and grounding is handled by 10pF 1V ceramic capacitors. The Driver circuit amplifies the voltage using opto-coupler and provides pulses to the MOSFETs. The rectified voltage from the transformer as DC voltage is given as an input to the converter circuit along with the PV panel compensation.

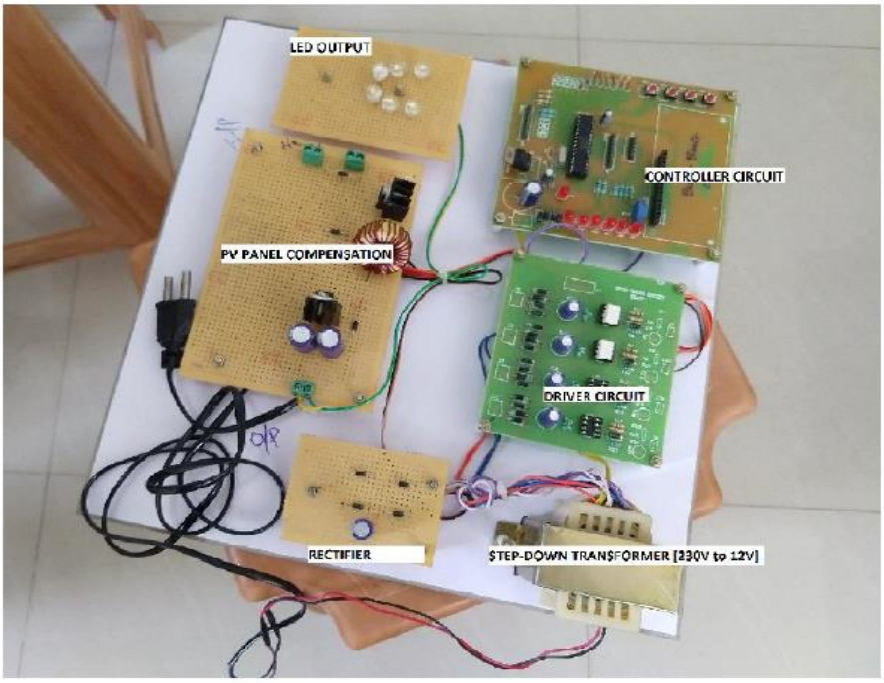


Fig 13: Hardware circuit

COMPARISON TABLE

DC-DC Chopper	Buck-Boost
Output voltage is about 44v	Output voltage is about 238.5v
Higher voltages cannot be reached easily.	Higher voltages can be reached
Spike in voltage is lower(about 5v)	Spike in voltage is higher(about 15v)
Steady State Error is higher(about 4v for 44v)	Steady State Error is reduced(about 1.5v for 238.5v)
Power Factor Efficiency is lower(about .82)	Power Factor Efficiency is higher(about .9)
Operation in variable Temperatures can lead to losses (about 20v variation)	Operation can be done at variable temperatures (about 10v variation)

VIII. CONCLUSION

In this paper, a power electronic circuit based photovoltaic (PV) simulator with power factor correction converter is proposed. An array of photovoltaic modules connected in series. A power factor corrected buck-boost converter circuit is presented which is able to reduce the temperature of the PV panel at different condition. The designed circuit has been modelled and simulated in Simulink MATLAB environment. The simulation results has been compared with the designed hardware. Thus, the proposed power factor corrected converter can be used in laboratory environments for research purposes.

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