Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 9 Issue 08, August-2020

PID Control based Boost Converter for Renewable Power Source

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***Abstract*:- In this proposed paper, a single phase AC/DC Boost Converter is presented for good transfer of energy from an irregular input power source to a battery storage device or for the DC link. Simulation model for a single-phase boost converter is developed using the method of trial and error, followed by a derivation of the conditions under which the pulse width modulated switching circuit exhibits a resistive behavior from the input. Depending on the circuit model obtained, the range of the duty cycle can be determined. The gate pulse can be generated with respect to the switching states of MOSFETs. Feedback control is used to regulate the phase-to-phase input resistances of the circuit to desired values. The optimized power can be given from irregular input source to battery or dc link, so this method can be used for low speed wind turbines, stand alone or PV grid power supply , wave energy converter & for different application which having time-varying profiles.**

***Keywords*:- AC–DC power converters, power conversion, pulse width modulation.**

INTRODUCTION

Many distributed generators use renewable energy sources such as wind, solar and hydro. These DG systems require energy conversion as most renewable energy resources are inherently variable. For example, in a variable speed wind turbine system, the output of a variable voltage variable frequency generator needs to be converted to a fixed voltage fixed frequency AC output that feeds the grid. Photovoltaic (PV) systems need to convert the variable DC output of a photovoltaic panel into a fixed voltage, fixed frequency AC output that powers the grid. Power converters have been used to achieve this power conversion function. Electric converters are an important component of distributed generation systems, especially for distributed generators based on renewable energy.

In this paper, we are using single phase boost converter to develop the method of trial and error, to determine resistive behavior with the pulse width modulation switching circuit's derivation of the condition. We can then be able to determine duty cycle. MOSFET's switching state will give gate pulses. PID controllers are used for the optimal control of AC –DC boost converter which is used as the voltage controller in PV systems. This proposed controller maximizes the range to operate by varying PID parameters for different loading situations. This controlled boost converter is a bridge between PV panels and the load connected to them. This can convert any input voltage given within the specific range. The proposed controller takes the duty cycle of the boost converter which depends on input voltage and loading condition which in return gives constant output voltage. The prototype system has been developed to verify the proposed PID controller. Also, both simulation and experimental results confirms its authenticity as an effective and reliable controller for boost converter in PV system which in return can be used in different application. Within rapid demand of distributor generators system, power converters have revolutionized traditional power conversion device to system integrators.

Boost converter is an AC DC converter where output voltage is greater the input voltage as energy stored in induction is send to load, so the output is addition of voltage across induction and input voltage. The output voltage regulation in the AC-DC converter is gained by adjusting the duty cycle with the help of PID controller

I. METHODOLOGY

A. Operation od AC-DC Boost converter

Traditionally, diode rectifier or thyristor bridge converters were used to connect DC voltage from AC utilities. But rectifier disturbs the utility end with the low order harmonics, which is difficult to filter. That is why Pulse width Modulation is used to solve these problems.

Advantage of Boost Topology

i. High efficiency
ii. High power density
iii. Power quality improvement at the input and output

As the same time it also provides regulated DC output voltage maintain unity power factor

B. Design of Converter

The block diagram of single phase ac-dc boost converter is shown in following figure.

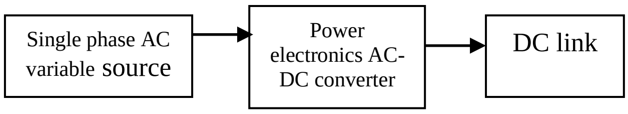

Fig.1. Block Diagram of single phase AC/DC Converter

In the single phase AC DC boost converter, this works in two stages specifically.

In the first stage , single phase AC to DC rectifier consisting of input filter , a boost converter , single phase diode rectifier and active power factor correction stage with a DC link filter capacitor .Whereas in second stage, any type of load requiring a regulated or unregulated DC bus single phase or three phase inverters is used. The boost switch is turned ON at constant frequency and the duty cycle is verified.

Given below are following assumption made

i. Components are ideal , capacitors, inductors and resistors
ii. Switching frequency is greater than line frequency thus input voltage considered to constant within switching periods.

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C. Simulation circuit of AC DC boost converter

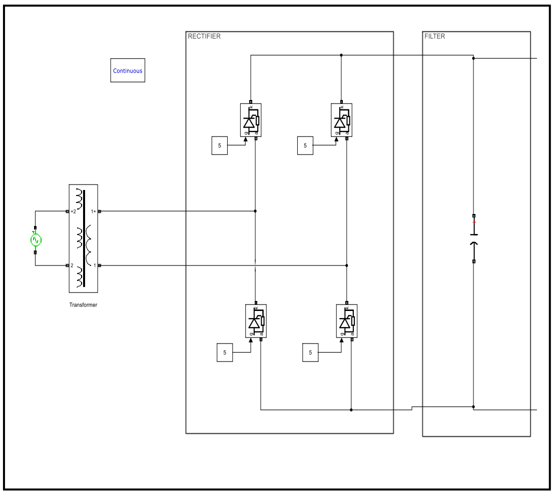

Fig.2. Simulation Diagram of single phase AC/DC Converter

In the given proposed model we have taken AC power supply and which is then connected to the transformer. Further the rectifier is used along with capacitor as the filter which is then connected to Inductor and diode where the current direction should be always positive. Maximum voltage to minimum voltage it varies. After that resistors are connected to IGBT for switching and we can get required duty cycle for tuning of PID .

II. PRINCIPLE AND CIRCUIT ANALYSIS

The single phase boost converter is shown in the figure. Compared to a traditional boost rectifier, one diode is removed from line – current path, which results in conduction losses.

In the single phase boost converter the Scotty diodes and MOSFETS are used. To reduce switching losses only one MOSFET is operated every single instant of time, while the other is kept ON/OFF, depending on the relative voltage on the respective phases.

A PID controller is unique device often used in industrial applications to check temperature, flow, pressure, speed and other process variables. PID (proportional integral derivative) controllers use a control loop feedback mechanism to control process variables working are the most accurate and stable controller. A PID controller continuously calculates an error value. As the difference between a desired set point (SP) and a measured process variable (PV) and applies a correction based on proportional, integral, and derivative terms (denoted P, I, and D respectively), hence the name. There are several methods for tuning of PID controller and get desired. In this paper Trail and Error Method is used specifically.

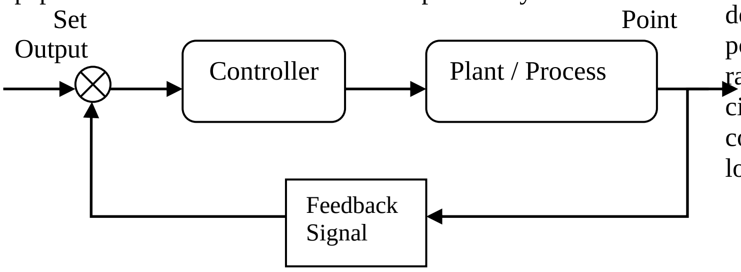

Fig.3. Block Diagram of closed loop system for controller.

DERIVATION OF BOTH THE MODES

Vin (min) = 100
Vin (max) = 120
Vout (expected) = 200
I = 300
Fs = 1000…………………………..……Switching frequency
n = 0.9……………………90 % tolerance in input voltage
Duty cycle,
D = 1 – {Vin * n ⁄ Vout (expected) }
Duty cycle is there to adjust the output voltage.
Inductor ripple current,
Il = { 0.2 * I * Vout (expected) / Vin}
Inductor,
L = Vin (min) * { Vout - Vin (max)}/ *Il* * Fs * Vout
Output Capacitor value, C = I * D / Fs * 0.5
Output Resistor, R = Vout / I
PID controller, $c(s) = (0.001\ s^2 + 0.02\ s + 0.6) / s$
For, Pulse generation

The pulse generation is based on the switching frequency. In the trial and error method, which is one of the easiest methods, initially by increasing value of Kp until the proposed system reaches to oscillating response without making system unstable and by maintain the value of Kd and Ki zero. Thus by changing the value of Ki in a manner that oscillation of the system stops. At the final stage setting the value of Kd for fast response.

A. MODE 1

This mode is also named as rectifying mode. In MOSFET the voltage increase when capacitor are fully charged and convert it low voltage and high current.

B. MODE 2

This mode is also named as inverting mode. In MOSFET the current decreases when inductor is used and converts it in low current and high voltage.

C. Simulation and experimnetal resluts

According to switching states of the gate pulse can be generated. The time duration like ON and OFF time can be determined and controlled by this given circuit. In the mode 1 situation all the switching done in ON state, where we can observe. In this case, the energy drawn from the input source is stored in the magnetic fields of the inductors. In mode 2 switches is ON at a time, where the stored energy in the inductor together with the energy drawn from the input sources is fed to the battery. In mode 3, the remaining stored energy in L along with the energy coming from C charge the battery until the inductors is totally discharged.

The pulse generator is also optimized to control an ON/OFF state of switches in the PWM switching circuit to gain a desired resistance in the PWM circuit. In this design input power factor is good at any given frequency. A wider speed range that is below rated frequency is also possible. The circuit can be designed to provide purely active power conversion of a band-limited input voltage source to a DC load.

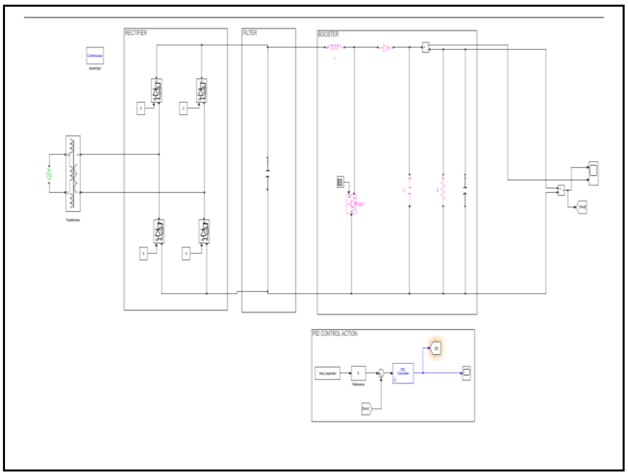

Fig 4. Simulation of AC- DC boost converter with PID

The above figure shows the gate pulse, among the switches exactly one switch is on at a time. The main simulation diagram of three phase ac-dc boost converter is shown in fig. In given above gate pulse generating circuit, the duty cycle can be adjusted in pulse generator.

D. Wave forms

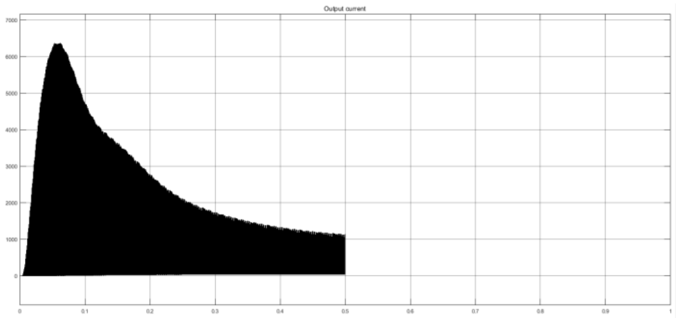

Fig 5 : Output current waveform

The output voltage waveform and control pulses using PWM control are given in the above waveform.

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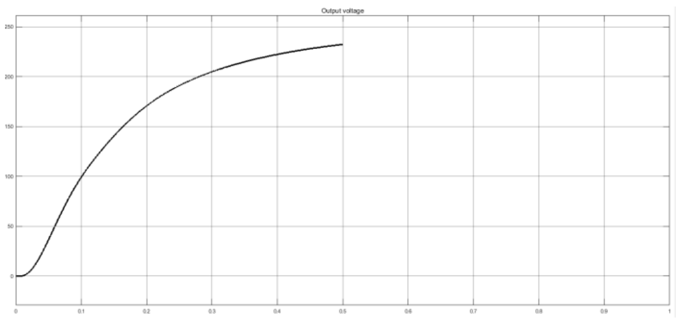

Fig 6. Output voltage waveform

As the above figure shows , thi increase in voltage drop in ver small.

CONCLUSION

In this paper, analytical expressions describing the input characteristic of a single -phase boost-type converter were derived, based on that the range of the duty cycle can be obtained. According to the switching states of modes, the gate signal can be generated. With respect to gate signal & range of duty cycle, the boost converter charges the battery. In this proposed paper IGBT is the preferred device because of its ability to work on high blocking voltage and lower operating frequencies. The resistive input behavior can heavily reduce harmonic and improve power quality. This equation is not based on the sinusoidal steady state conditions, so this can be applicable to low speed, wave energy converters and mechanical vibrations for converting mechanical energy into stand-alone or grid connected electricity. The trial and error method in the Simulation helps to determine the required output. This feature is good in many natural source energy conversion systems such as low speed wind, wave energy conversion, and regenerative suspension. Further we can use this method for three phase boost converter. Thus according to the switching we can determine gate pulse respectively. With the stable high voltage also is one of the applications. In future the control system and switching scheme can be used for extension to high power converters.

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