Simulation and Design of Three Phase AC-DC Buck-Boost Converter

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Abstract— **Generally AC to DC Regulated Converter are Designed For Generator and also used telecommunication Industry and Data Servers and DC Motor and for Generators. They need Continuous DC supply for their Proper Working. There we cannot tolerate the input Variation. So we have to design such converter that gives Constant DC output under the input Variation. Here we Design and Develop commercial power supply that allows a user to have a wide range of output voltages. In this application, a user would be able to obtain stepped up and stepped down output dc voltages from the same three-phase ac supply. Many three-phase ac-dc converters that perform PFC with a reduced number of switches are variations of the converter and their output voltage is always higher than their input voltage because they are boost-type converters. This is a drawback if there is a need for a converter that needs to operate for a wide range of input ac voltages and/or produce a wide range of output dc voltages. We will design and simulate converter with above features**

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I. INTRODUCTION

A front-end rectifier for a Telecommunication and Data server product that must require certain fix voltage. While with several ranges of ac voltages, such as a product that must work with the following two ranges of ac supply voltages: 200- 415V,rms and frequency Range 50Hz to 400Hz

Since the dc output of a front-end rectifier is typically fed to a "back-end" converter like a dc-dc converter or an inverter, a buck-boost front-end rectifier allows for the optimal design of the "back-end" converter since the dc output can be made fixed, regardless of the input voltage. If a buck or boost front-end converter is used, then the back-end converter would have to be designed to operate with a wide range of input dc voltages.

A rectifier for a permanent magnet synchronous generator (PMSG) wind energy system. Since the output voltage of a PMSG in the wind energy system varies considerably due to the speed of the wind, a buck-boost rectifier can be used as the interface converter to produce a fixed output voltage for back-end converters.

There are two topologies that we can use for DC conversion. that are Single Phase topologies and Three phase Topologies. Under that Single phase topologies are difficult to Synchronize Switching of Each phase. While Using three phase six-switch converter, however, is costly and complicated given the number of active switches that must be used and the sophisticated control needed to ensure a good power factor .Cheaper and simpler methods of performing three-phase active input PFC have been developed using converters with less than six switches.[3]

One such converter, first proposed, is the Two-switch boost converter. This converter is designed to operate so that its phase currents are discontinuous and bounded by a sinusoidal envelope. this converter will also control the input variation.[1]

II. DESIGN AND POWER CIRCUIT

Necessary Parameters of the Power Stage

The following four parameters are needed to calculate the power stage:

1. Input Voltage Range: VIN(min) and VIN(max)
2. Nominal Output Voltage: VOUT
3. Maximum Output Current: IOUT(max)
4. Integrated Circuit used to build the boost converter. This is necessary, because some parameters for the calculations have to be taken out of the data sheet. If these parameters are known the calculation of the power stage can take place.

- *Calculate the Maximum Switch Current*

The first step to calculate the switch current is to determine the duty cycle, D, for the minimum input voltage. The minimum input voltage is used because this leads to the maximum switch current.

Equation 1 Duty Cycle Equation

$$D = 1 - \frac{V_{in(min)} \times \eta}{V_{out}}$$

$V_{in(min)})$ = minimum input voltage

V_{out} = desired output voltage

h = efficiency of the converter, e.g. estimated 80%

Equation 2 Calculation Of Duty Cycle

$$D = 1 - \frac{300 \times 0.8}{750}$$

$$D = 0.68$$

The efficiency is added to the duty cycle calculation, because the converter has to deliver also the energy dissipated. This calculation gives a more realistic duty cycle than just the equation without the efficiency factor. The next step to calculate the maximum switch current is to determine the inductor ripple current.

Equation 3 Inductor Ripple Current Equation

$$\Delta I_L = \frac{V_{in(min)} \times D}{F_s \times L}$$

$V_{IN(min)}$ = minimum input voltage

D = duty cycle calculated

f_S = minimum switching frequency of the converter

L = selected inductor value

$$\Delta I_L = \frac{300 \times 0.68}{8000 \times L}$$

- *Inductor Selection*

Often data sheets give a range of recommended inductor values. If this is the case, it is recommended to choose an inductor from this range. The higher the inductor value, the higher is the maximum output current because of the reduced ripple current. The lower the inductor value, the smaller is the solution size. Note that the inductor must always have a higher current rating than the maximum current because the current increases with decreasing inductance. For parts where no inductor range is given, the following equation is a good estimation for the right inductor:

Equation 4 Inductor Equation

$$L = \frac{V_{in} \times (V_{out} - V_{in})}{\Delta I_L \times F_s \times V_{out}}$$

Equation 5 Calculation Of Inductor Value

$$L = \frac{300 \times (750 - 300)}{7.5 \times 8000 \times 750}$$

$$= 3.50 \times 10^{-3} H$$

V_{in} = =typical input voltage

V_{out} = desired output voltage

F_s = minimum switching frequency of the converter

ΔI_L = estimated inductor ripple current, see below

A good estimation for the inductor ripple current is 20% to 40% of the output current.

Equation 6 Inductor Ripple Current Equation

$$\Delta I_L = 0.2 \text{ to } 0.4 \times I_{out(max)} \times \frac{V_{out}}{V_{in}}$$

Equation 7 Calculation of Inductor Ripple Current

$$\Delta I_L = 0.3 \times 10 \times \frac{750}{300}$$

$$\Delta I_L = 7.5$$

$\Delta I_L =$ = estimated inductor ripple current

$I_{out(max)} =$ = maximum output current necessary in the application

4 .4 Rectifier Diode Selection

To reduce losses, Schottky diodes should be used. The forward current rating needed is equal to the maximum output current:

Equation 8 Forward Current equation

$$I_F = I_{out(max)}$$

I_F = average forward current of the rectifier diode

$I_{out(max)} =$ maximum output current necessary in the application

Schottky diodes have a much higher peak current rating than average rating. Therefore the higher peak current in the system is not a problem. The other parameter that has to be checked is the power dissipation of the diode. It has to handle

Equation 9 Power Dissipation Equation

$$P_D = V_F \times I_F$$

I_F = average forward current of the rectifier diode

V_F =forward voltage of the rectifier diode

- *Output Capacitor Selection*

  Best practice is to use low ESR capacitors to minimize the ripple on the output voltage. If the converter has external compensation, any capacitor value above the recommended minimum in the data sheet can be used, but the compensation has to be adjusted for the used output capacitance. With internally compensated converters, the recommended inductor and capacitor values should be used or the recommendations in the data sheet for adjusting the output capacitors to the application should be followed for the ratio of L × C. With external compensation, the following equations can be used to adjust the output capacitor values for a desired output voltage ripple:

Equation 10 Capacitor Equation

$$C_{out(min)} = \frac{I_{out(max)} \times D}{F_s \times \Delta V_{out}}$$

Equation 11 Calculation of Capacitor Value

$$C_{out(min)} = \frac{10 \times 0.68}{8000 \times 7.5}$$

$$= 1.13 \times 10^{-3} \text{ farad}$$

$C_{out(min)}$ = minimum output capacitance

$I_{out(min)}$ = maximum output current of the application

D = duty cycle

F_s = minimum switching frequency of the converter

ΔV_{out} = desired output voltage ripple. It is 1 to 3% of Out Put Voltage.

It can Also calculated Another Way. The ESR of the output capacitor adds some more ripple, given with the equation:

Equation 12 Output Voltage Ripple Equation

$$\Delta V_{out(ESR)} = ESR \times \left(\frac{I_{out(max)}}{1-D} + \frac{\Delta I_L}{2} \right)$$
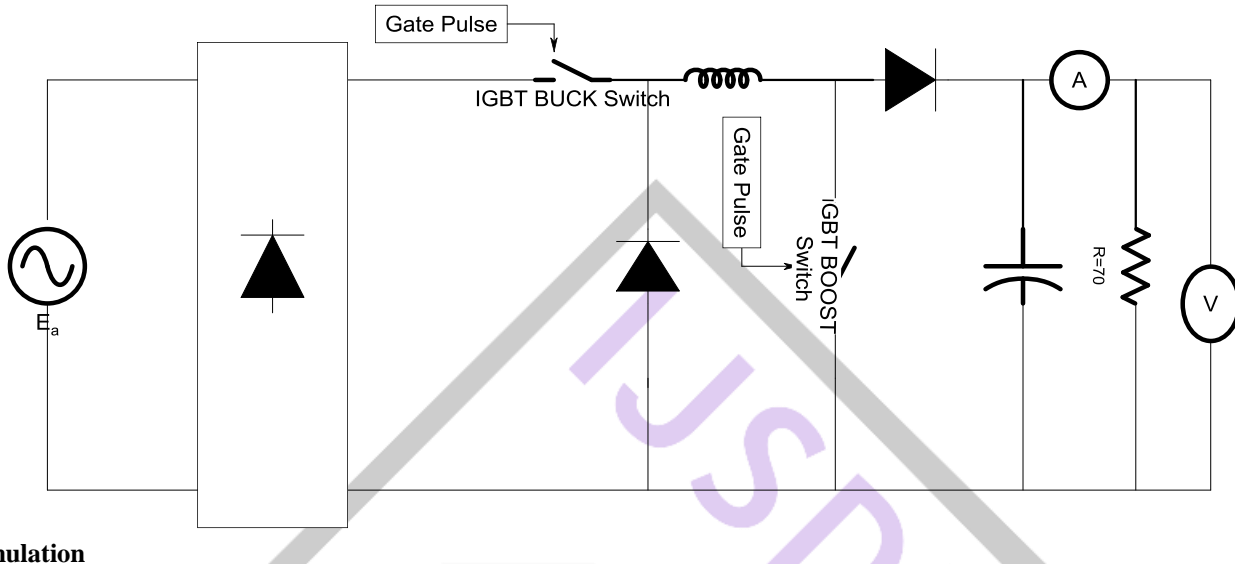
$\Delta V_{out(ESR)}$ = additional output voltage ripple due to capacitors ESR

ESR = equivalent series resistance of the used output capacitor
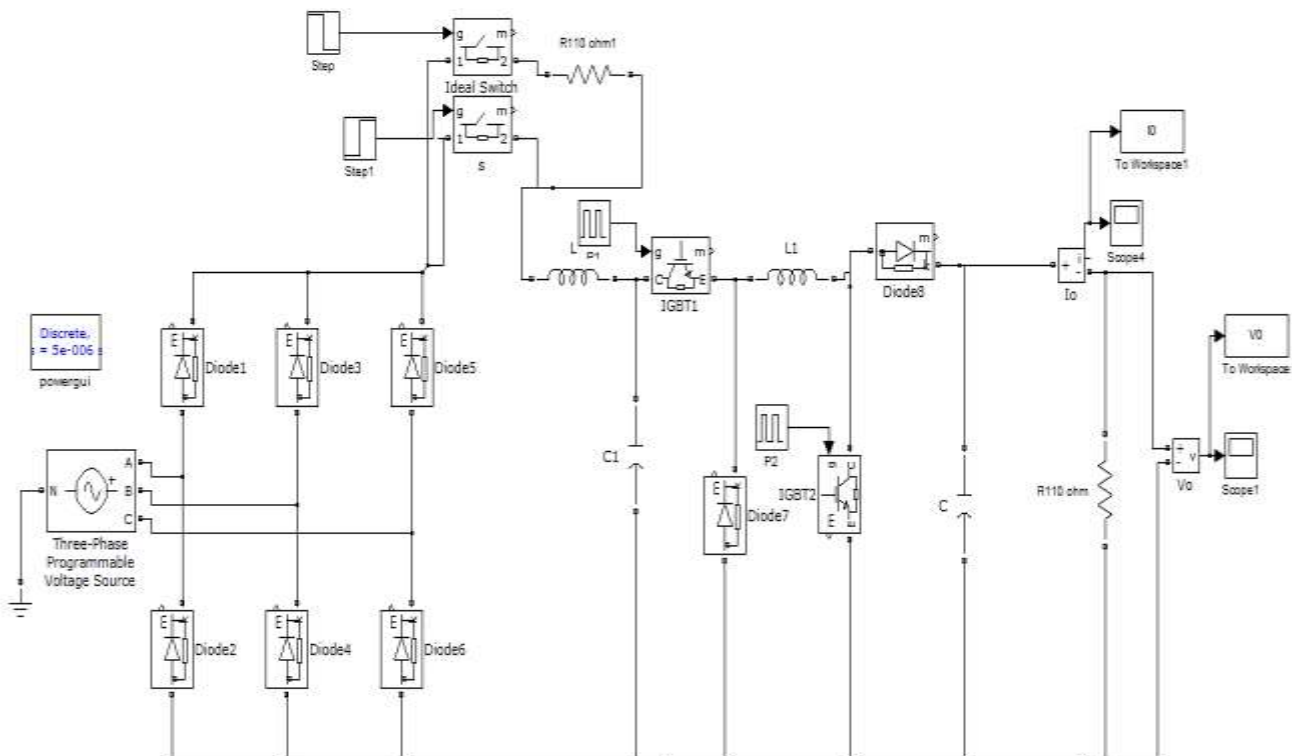
$I_{out(max)}$ = maximum output current of the application

D = duty cycle

ΔI_L = inductor ripple current

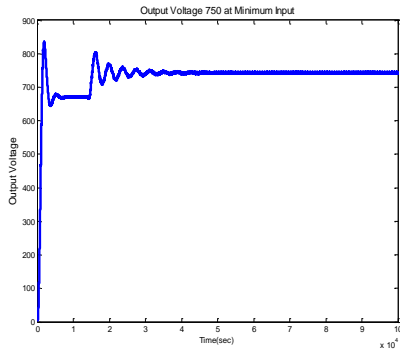**Simulation**   **Results**

Graph 1:-

INPUT VOLTAGE:-200V

FREQUENCY:-50Hz

For Out Put Voltage:-750V

Duty Cycle(%)   P1=90
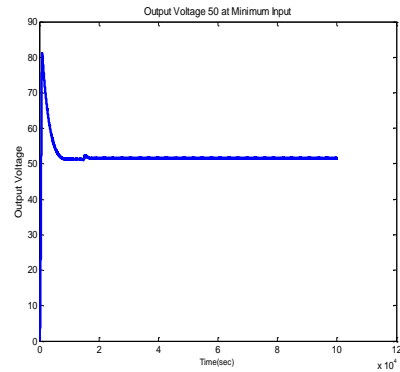
P2=62

Output Voltage 750 at Minimum Input

Graph Description:- Here We have kept Starter still we are getting spike of 800 volt in open loop and it takes time to make output stable also firing angle that we have shown here are hard to set certain fix Output manually. It is time consuming process while keeping eye on oscilloscope and output and to control variac for achieving precise Output.

Graph 2:-

INPUT VOLTAGE:-200V

FREQUENCY:-50Hz

For Out Put Voltage:-50V

Duty Cycle(%)   P1=12.5

P2=15

Output Voltage 50 at Minimum Input

Graph Description:- Here We have kept Starter still we are getting spike of 800 volt in open loop and it takes time to make output stable also firing angle that we have shown here are hard to set certain fix Output manually. It is time consuming process while keeping eye on oscilloscope and output and to control variac for achieving precise Output.

Graph 3:-

INPUT VOLTAGE:-400V

FREQUENCY:-400Hz

For Out Put Voltage:-50V

Duty Cycle(%)   P1=5

P2=15

Output Voltage 50 at Maximum Inout for Open Loop
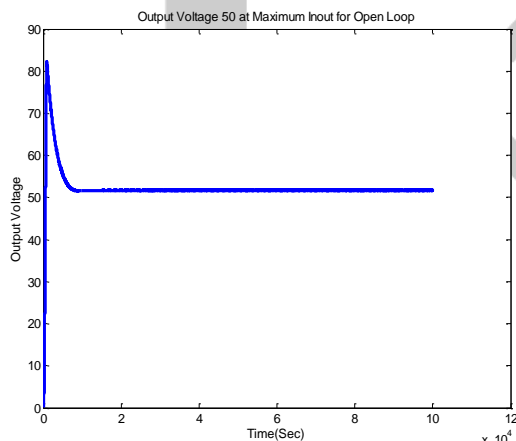
Graph Description:-At Maximum Input We need Minimum Output for that we reduced duty cycle as seen table. And Stil we have spike.we used starter for Removing it. But Stil We have it we are getting spike of 30V in open loop system which can be remove through close loop system using pi and pid respone.

Graph 4:-

INPUT VOLTAGE:-400V

FREQUENCY:-400Hz

For Out Put Voltage:-750V

Duty Cycle(%)   P1=48

P2=60

Output Voltage 750V at Maximum Input
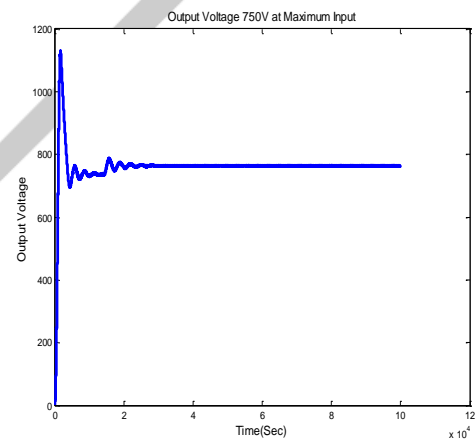
Graph Description:-Here We Increased Input Voltage 400v and Maximum Frequency 400hz.Due to Inrush Current In Inductor We have that input spike for milli Second. That must Decreased as to System Rating.   we are getting spike of 350V in open loop system which can be remove through close loop system using pi and pid respone.

III. CONCLUSION & FUTURE SCOPE:

In above work we have designed the three phase buck boost converts and simulated in open loop control mode. In further this simulation will be implemented with close control mode with P,PI,PID controller. Hardware will be prepared according to design values.

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