Modeling, Analysis and Simulation of Poly-Phase Boost Converter

Abhishek Kumar[1] Gajendra Singh Rawat[2] Rituraj Singh Thakur[3]
[1,2]Assistant Professor [3]M.Tech(Power System and Electric drives)
[1,2]Electrical Department
[1,2]Faculty of Engg. & Technology, Gurukula Kangri Vishwavidyalaya [3]Disha Institute of Management and Technology

Abstract— The objective of this paper is to design Poly-phase boost converter which overcomes the problem of high input ripple current and output ripple voltage Digital control is more convenient for such a topology on account of the requirement of synchronization , phase shift operation , current balancing etc. This paper deals on analysis and implementation of four phase boost converter, each is a 35W unit and switched at 100 KHz. The waveforms are observed using MATLAB Simulink.

Key words: Boost Converter, Capacitor

I. INTRODUCTION

A. Overview

The poly-phase operation of boost converter to overcome the disadvantages of large size storage capacitor in boost converter and off-line UPF rectifiers and a small signal analysis of N converters in parallel to an equivalent second order system in such converters.

During the on state of the switch, the capacitor has to supply the load current in the boost converter and this discontinuity of current in the capacitor increases the rms value of current and also increases the amount of capacitor which is needed for correct operation of the circuit and therefore it results in more dissipation due to ESR of capacitor. In standard designs it is not uncommon to see tank capacitors one or two orders of magnitude higher than the ideally required capacitance A way to overcome this problem is using poly-phase operation with appropriate phase shift in the control circuit of main switches.

II.

A. Boost Converter

A boost converter regulates the average output voltage at a level higher than the input or source voltage. For this reason the boost converter is often referred to as a step-up converter or regulator. The DC input voltage is in series with a large inductor acting as a current source. A switch in parallel with the current source and the output is turned off periodically, providing energy from the inductor and the source to increase the average output voltage. The boost converter is commonly used in regulated DC power supplies and regenerative braking of DC motors.

III.

A. Poly-phase operation

In poly-phase boost converter each stage has an independent current mode control loop, which uses the same reference current. The reference current in turn is generated by the outer voltage control loop. For correct operation of poly-phase boost converter each PWM gate signal is required to have 90 degrees phase shift respect to the previous one. In order to generate these signals a synchronization circuit is needed. Though practicable, the analog realization leads to certain limitations.

B. Matlab Program For Bode plot of the Boost Converter

```
Vi=12; Vo=32; Po=35; Fs=100e3; deli=0.2; delv=0.01; D=1-Vi/Vo; Ts=1/Fs; R=Vo^2/Po; L=D*(1-D)^2*R*Ts/deli; C=D*Ts/(R*delv); num=[1/(1-D)]; den=[L*C/(1-D)^2 L/(R*(1-D)^2) 1]; H=tf(num,den); bode(num,den); grid on;
```

C. Bode plot of the Boost Converter

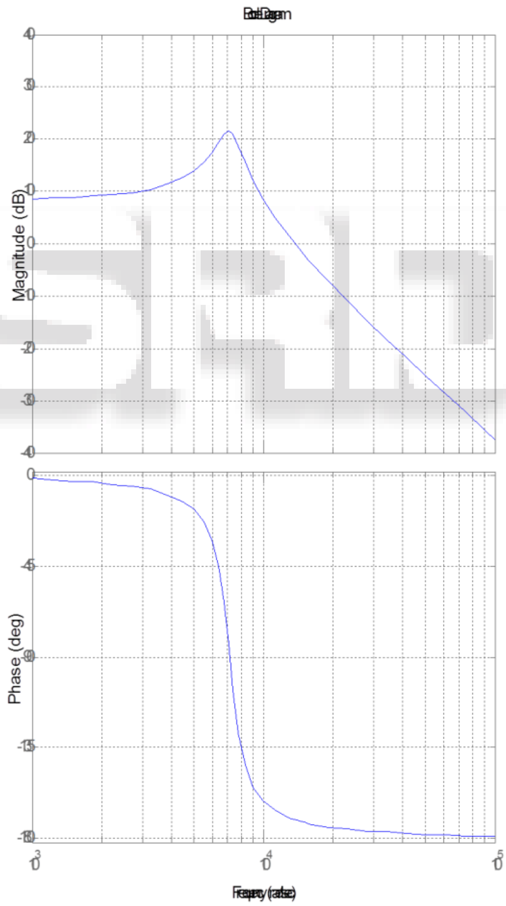


Fig 3.3

D. Calculation Kp, Ki from bode plot

$$K_P = \frac{\cos\theta}{A} = 2.3792e\text{-}3 \quad (3.16)$$

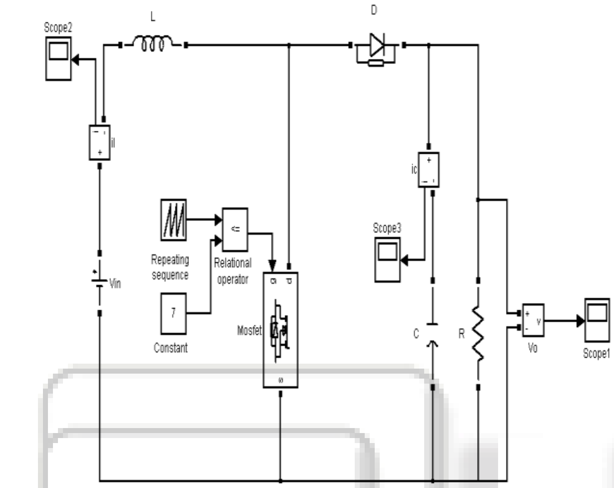
$$K_i = -\frac{\omega \sin\theta}{A} = 397.3783 \quad (3.17)$$

$$\theta = \gamma_d - \gamma_u = 60°\text{-}87.6°$$

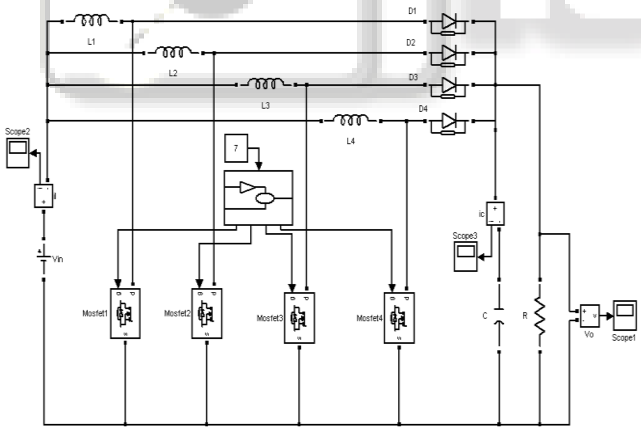
where, γ_d = desired phase margin, γ_u = phase margin of uncompensated system

IV.

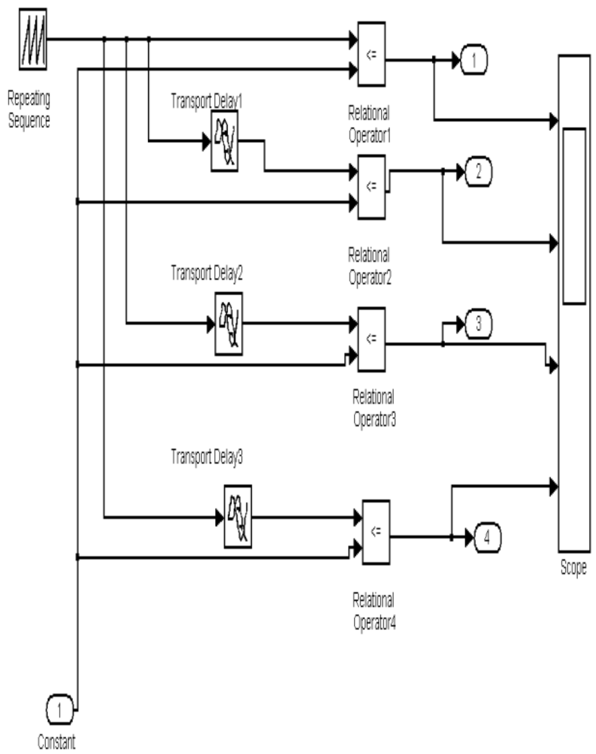
A. Simulink Model For Single Phase Boost Converter (open loop)



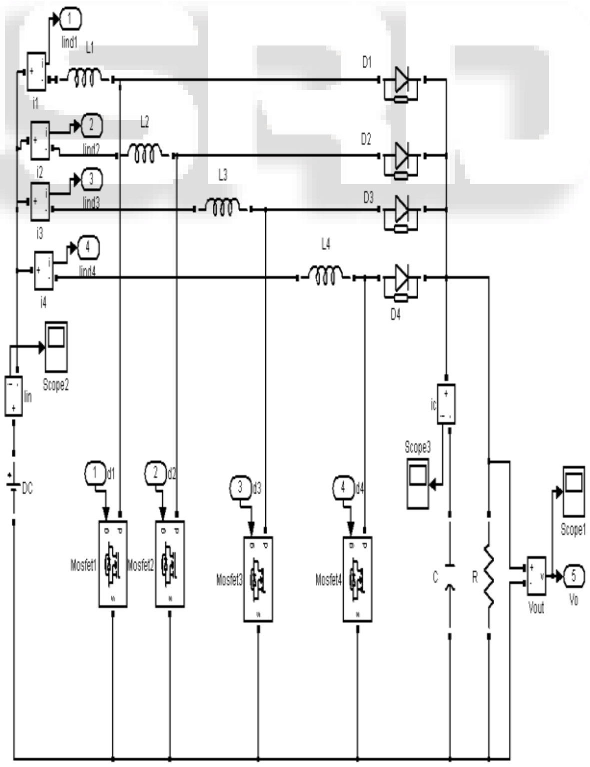
B. Simulink Model for Four Phase Boost Converter (open loop)



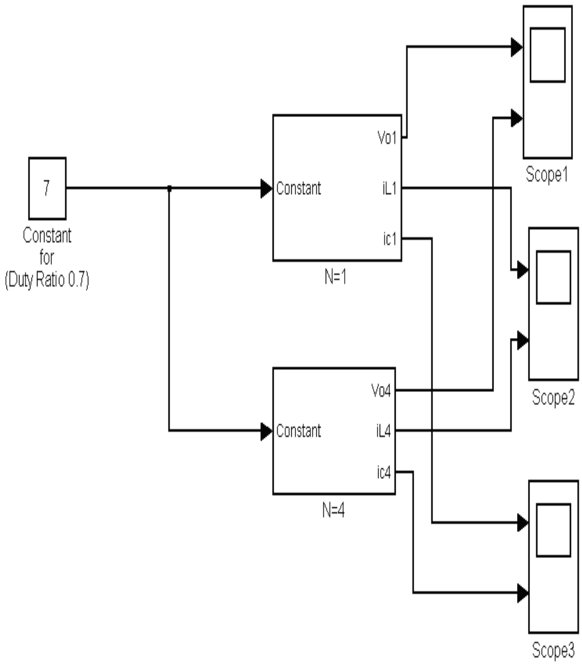
1) Generation of Four Phase Shifted Pulses using Simulink



C. Sub System For Four Phase Boost Converter



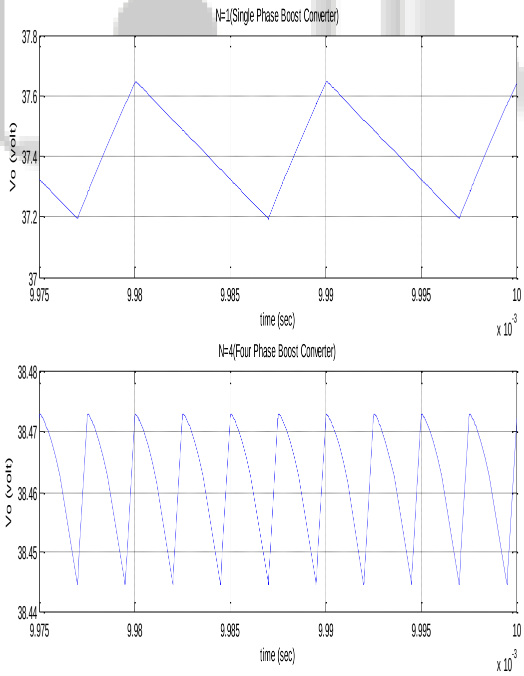
D. Simulation Model For Comparison of Single Phase and Four Phase Converters (in open loop)



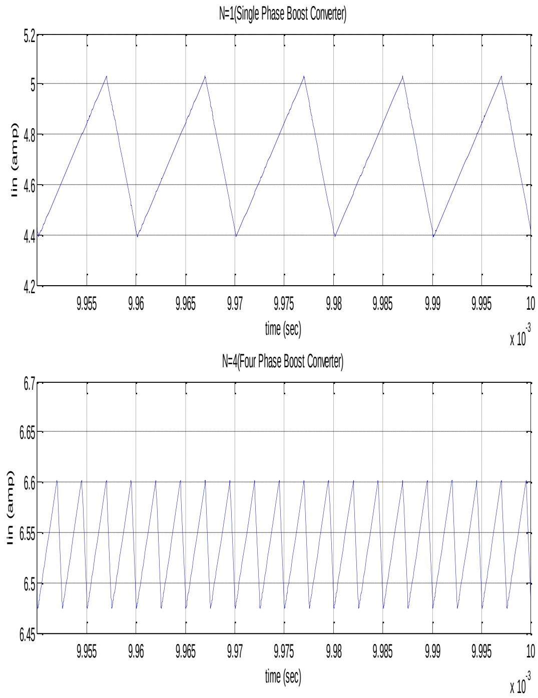
V. RESULTS

A. Comparison of Single Phase and Four Phase Converters (in open loop)

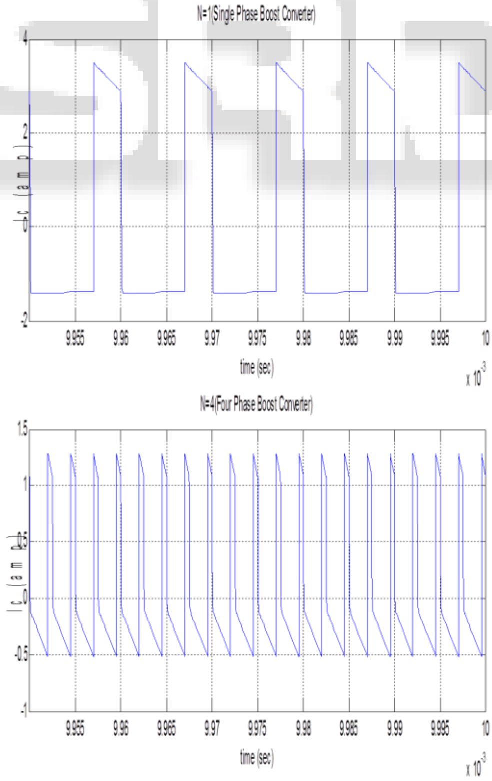
1) Output Voltage Ripple of Single Phase (N=1) and Four Phase (N=4) Converters



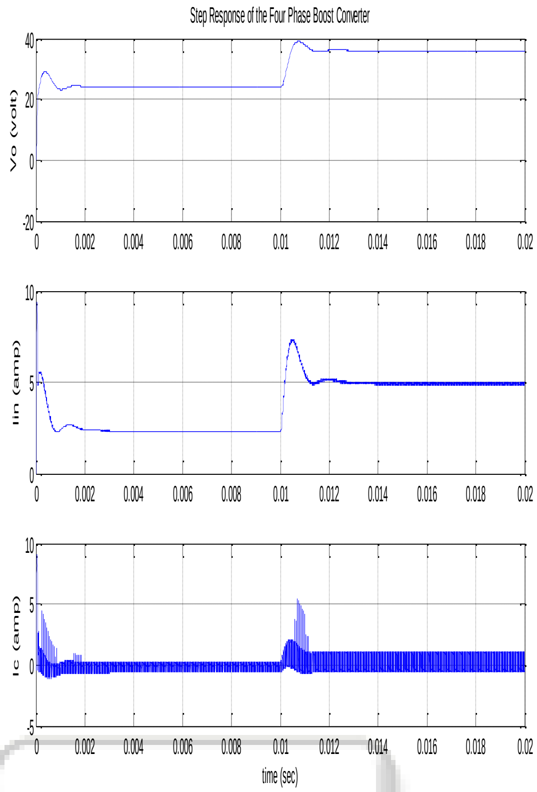
2) Input Current Ripple of Single Phase (N=1)and Four Phase (N=4) Converters



3) Steady State Capacitor of Single Phase (N=1) and Four Phase (N=4)Converters



B. Step Response of the Four Phase Boost Converter



VI. CONCLUSION

This work discusses analysis and simulation for poly-phase boost converter. A modified method for determining the duty cycle corresponds to current control has been developed. The size of N boost converters in parallel is almost same as a single boost converter of the same total power because the size of main parts-inductors-almost remains same. Smaller RMS current in the energy-storage capacitor, lower input ripple current and lower output ripple voltage or smaller size of the tank capacitor are those important points, which have been considered. Moreover digital realization in control results in better performance and advantages, which cannot be achieved by Analog method.

REFERENCES

[1] R. Mirzaei and V. Ramanarayanan, **"**Polyphase Boost Converter for Automotive and UPF Applications with Digital Control." NATIONAL POWER ELECTRONICS CONFERENCE, NPEC 2005.

[2] R.Redl and L.Balogh, "Power-factor correction with interleaved boost converters in continuous-inductor-current mode." in Proc. APEC'93, pp.168–174.

[3] R.Redl and L.Balogh, "RMS, DC, Peak, and Harmonic Currents in High-Frequency Power-Factor Correctors with Capacitive Energy Storage." in Proc. APEC 1992 pp. 533-540

[4] R. Giral, L. Martinez-Salamero and S. Singer,"Interleaved Converters Operation Based on CMC." IEEE Trans Power Electron, vol. 14, no. 4, Jul 1999.

[5] I. Cadirci, A. Yafavi and M. Ermis, "Unity power factor boost converter with phase shifted parallel IGBT operation for medium power applications." IEE. Proc.-Electr. Power Appl. Vol.149, No. 3, May 2002.

[6] D. Maksimovic, R. Zane, and R. Erickson, "Impact of Digital Control in Power Electronics." IEEE International Symposium on Power Semiconductor Devices &Ics, Kitakyushu, Japan, May 2004.

