Comparison of Single Phase and Four Phase Boost Converter for Closed Loop Model

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Abstract— The objective of this paper deals on analysis and implementation of single phase and four phase boost converter. The input ripple current and output ripple voltage, steady state capacitor current are observed using MATLAB Simulink.

Key words: Battery, Boost Converter, Capacitor, PI controller

I. INTRODUCTION

A. Overview

Boost dc-to-dc converters have very good source interface properties. The input inductor makes the source current smooth and hence these converters provide very good EMI performance.

One of the issues of concern in these converters is the large size of the storage capacitor on the dc link. The boost converter suffers from the disadvantage of discontinuous current injected to the load. The size of the capacitor is therefore large. Further, the ripple current in the capacitor is as much as the load current; hence the ESR specification of the tank capacitor is quite demanding. This is especially so in the emerging application areas of automotive power conversion, where the input voltage is low (typically 12V) and large voltage boost (4 to 5) are desired.

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. DIGITAL CONTROL OF POLYPHASE BOOST CONVERTER

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. Generation of the four phase shifted PWM signals can be done in two ways:

– Method A: Programming general purpose timers with period of switching frequency and initializing four different counter registers with 0, 90, 180, 270 degrees phase shift respect to the timer period register.
– Method B: The switching pattern of different switches for different values of duty cycles which is stored as lookup table in memory has been shown in table II. On time duration of the switch is determined by ***D′*** and similarly (1-***D′***) determines the off time duration.

Where, ***D′*** is given by ***D′***=ND−floor(ND)

B. Design of PI Controller

1) Converter parameters

Po = 35 W, Vin = 12 V, Vo = 32 V

Fs = 100 KHz, D= 1-Vin/Vo = 0.625

ΔIin = 0.2(20%),ΔVo = 0.01(1%)

R = Vo*Vo/Po = 29.257 Ω

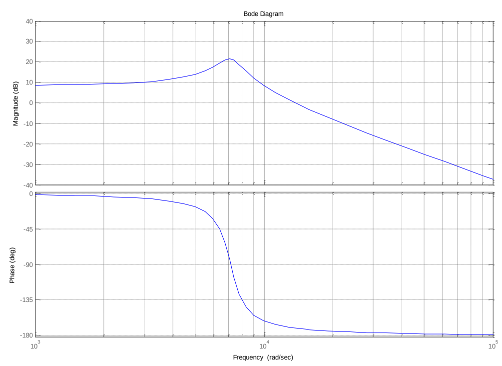
L = (Vin*D*Ts)/ΔIin = 128.5714µH

C = (D*Ts*Vo)/(R*ΔVo) =21.3623µF

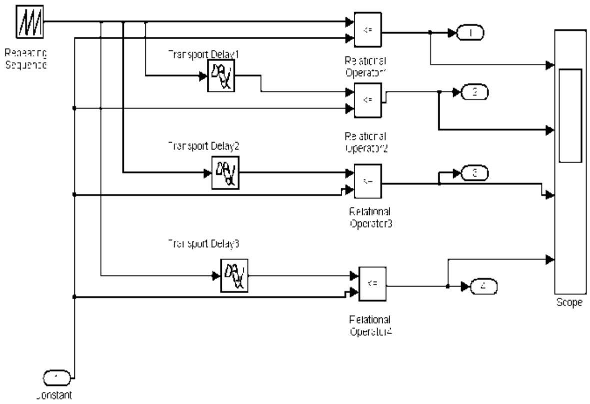
2) MATLAB program for bode plot of the Boost Converter

```
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;
```

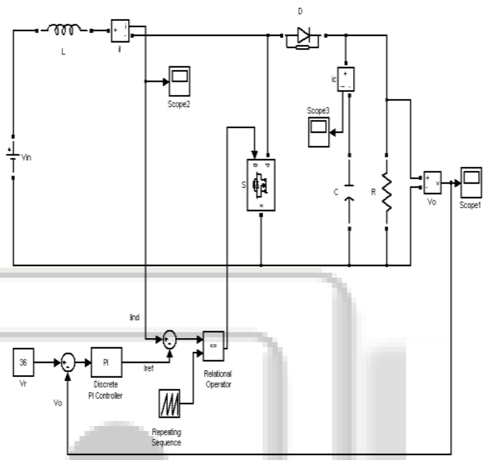
a) Bode plot of the boost converter



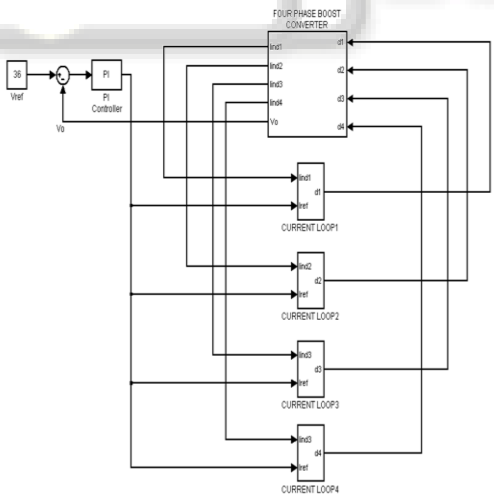
3) Generation of Four Phase Shifted Pulses using Simulink



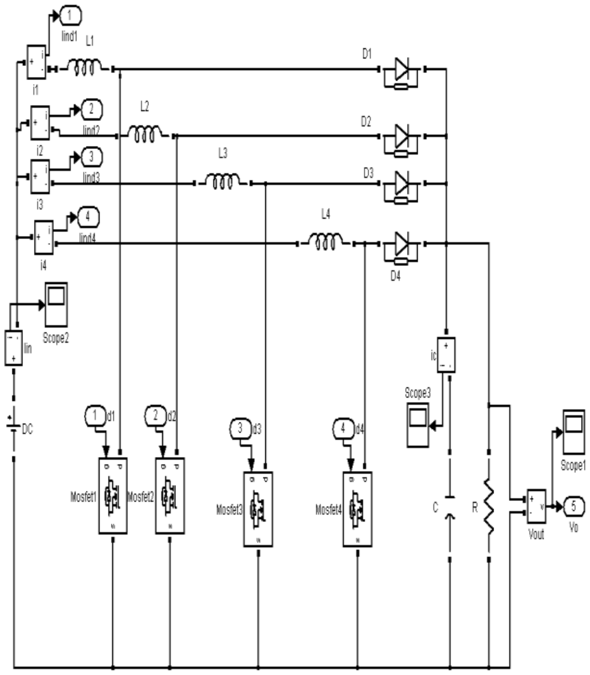
C. Simulink Model for Single Phase Boost Converter (Closed loop)



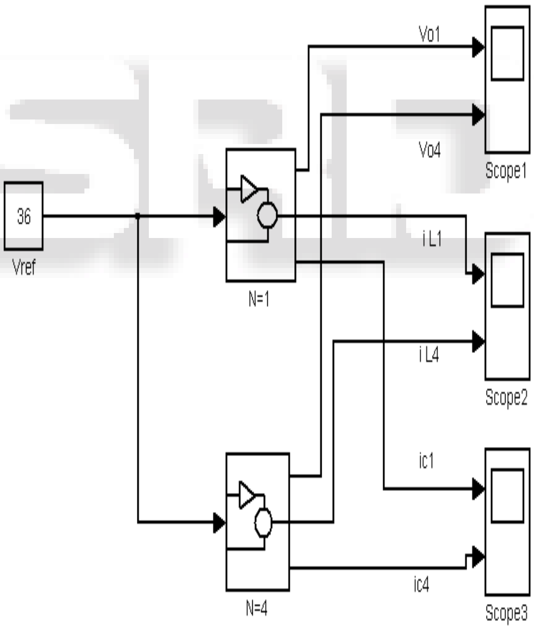
D. Simulink Model for Four Phase Boost Converter (Closed loop)



E. Sub System for Four Phase Boost Converter



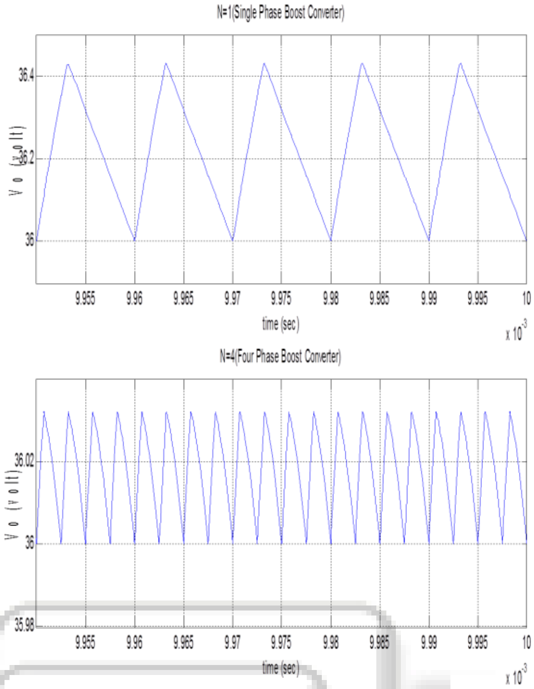
F. Simulink Model for Comparison of Single Phase and Four Phase Converters (in closed loop)



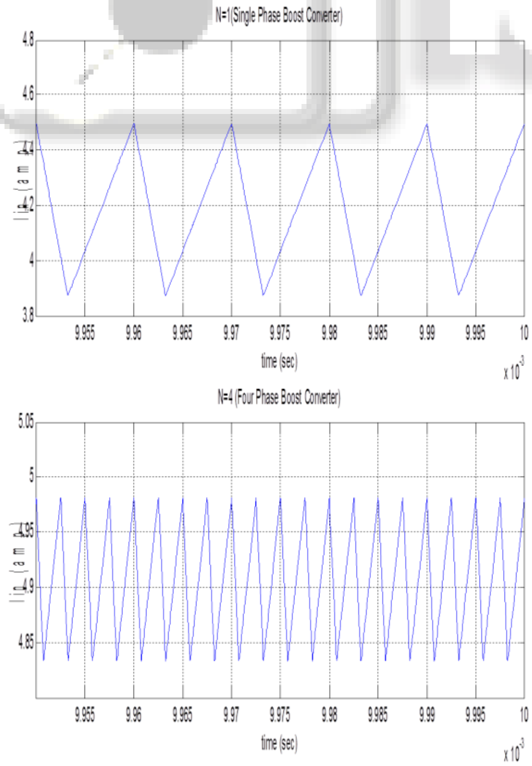
IV. RESULTS

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

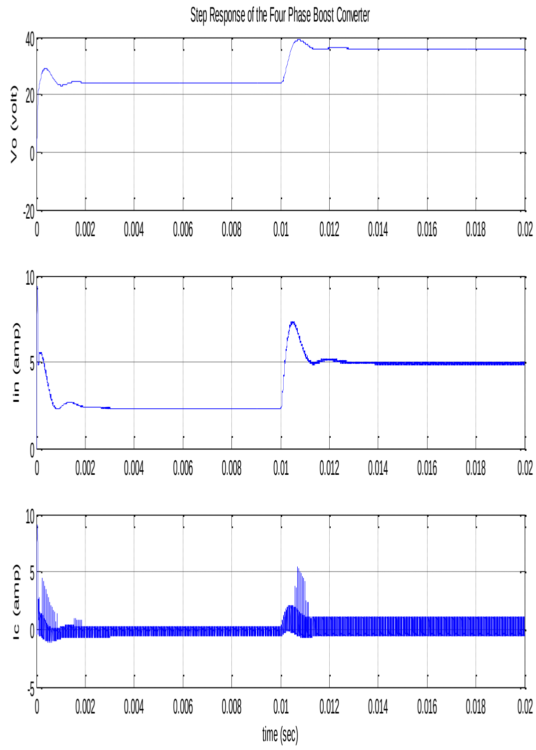
1) Output voltage ripple of single phase (N=1) and four phase (N=4)Converters



2) Input current ripple of single phase (N=1) and four phase (N=4)Converters



B. Step Response of the Four Phase Boost Converter



V. CONCLUSION

This work discusses analysis and simulation of Single phase and Four phase boost converter for closed loop.The comaparision of single phase and four phase boost are developed using MATLAB/SIMULINK. A modified method for determining the duty cycle corresponds to current control has been developed.The performance of four phase boost converter has been found to be more satisfactory as compared to single phase boost converter for closed loop.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.

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