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Implementation of Integrated DC-DC Converter for Cellular Phones

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***Abstract*— The paper demonstrate an integrated small size buck dc–dc converter for cellular phones.At nominal conditions, the converter produces a 3.7-V output from a 12-V input. Both open loop and closed loop systems are introduced. A simple technique to reduce the ripple is also presented. A converter efficiency of approximately 91 % is achieved.The major advantages and disadvantages are highlighted and the field of application is found. The Circuit will be simulated using MATLAB Simu-link. The converter has less harmonics and its THD value is good. Finally, numerical simulation and experimental results are presented to validate the theory. Experimental results are shown for a synchronous buck converter with 12 Vinput voltage, and3.3-4V and0.02–0.05A output.**

Keywords- Buck converter; Efficiency;DC-DC converter

I. INTRODUCTION

Recently, most mobile equipments used batter as power source. The efficiency of DC/DC converters becomes an important issue, in order to maintain long working times for batteries in mobile devices such as mobile phones, laptop computers and so on. A general conventional buck type DC/DC converter uses an inverting chopper or a combination chopper. The inverting chopper stores output energy in storage device, such as reactor or capacitors. Therefore, the converter efficiency is decreased since the power loss occurs in the storage devices. On the other hands, because the combination chopper has two stages for conversion process, the converter efficiency decreases. Many circuit topologies of DC/DC converters have been studied in order to obtain high efficiency

In this paper, we present a small size DC-DC converter with the high efficiency over a wide range of load conditions for cellular phones. DC/DC converter requires high switching frequency in order to realize downsizing and high speed output voltage response. However, the number of parts in the circuit increases, because resonant converters require an additional inductor or capacitor. Moreover, the voltage and current rating of the DC/DC converter are dominated by the output voltage rating and the output current rating in conventional DC/DC converters. From the viewpoint of the battery application, the input voltage i.e. battery voltage, is almost constants under normal operation. Therefore the efficiency for voltage at normal condition is very important. In some battery applications, the output voltage is regulated by the DC/DC converter . The proposed circuit provides only differential voltage between the input voltage and the output voltage command. As a result, the power rating of the DC/DC converter is reduced drastically.

Firstly, this paper introduces an approach that uses series compensation converters to obtain high efficiency and a reduction of power rating. Two new types of buck converters and their control methods are proposed based on this new concept. Finally, simulation and experimental results are shown in order to demonstrate the advantages of the proposed converters in comparison with a conventional buck converter.

In Section II, a conventional type DC-DC converter is described . In Section III, the simulation result and in section IV the parameters of the newly developed DC-DC converter circuit and in section V presents measurement results of the converter, and compares with small size converters that we reported previously. Conclusions are presented in Section VI.

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II. CONVENTIONAL DC-DC CONVERT

A. Circuit diagram and key waveforms

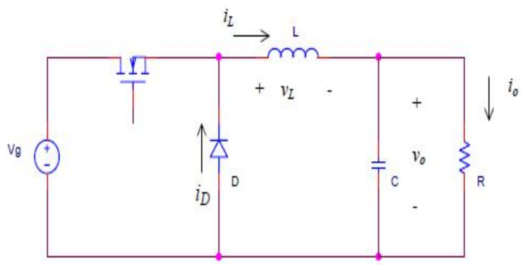

Fig1-Buck converter

B. Circuit description and operation

The three basic dc-dc converters use a pair of switches, usually one controlled (eg. MOSFET) and one uncontrolled (ie. diode), to achieve unidirectional power flow from input to output. The converters also use one capacitor and one inductor to store and transfer energy from input to output. They also filter or smooth voltage and current.

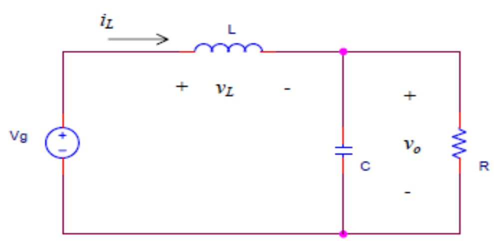

Fig2-switcch on for a duration DT

The dc-dc coverters can have two distinct modes of operation: Continuous conduction mode (CCM) and discontinuous conduction mode (DCM). In practice, a converter may operate in both modes, which have significantly different characteristics. Therefore, a converter and its control should be designed based on both modes of operation. However, for this course we only consider the dc-dc converters operated in CCM.

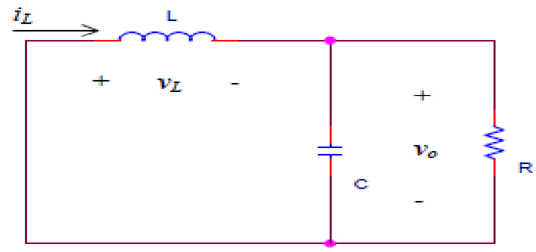

Fig3- switch off for a time duration (1-D)T

When the switch is on for a time duration DT, the switch conducts the inductor current and the diode becomes reverse biased. This results in a positive voltage $v_L = V_g - V_o$ across the inductor. This voltage causes a linear increase in the inductor current i_L. When the switch is turned off, because of the inductive energy storage, i_L continues to flow. This current now flows through the diode, and $v_L = -V_o$ for a time duration (1-D)T until the switch is turned on again

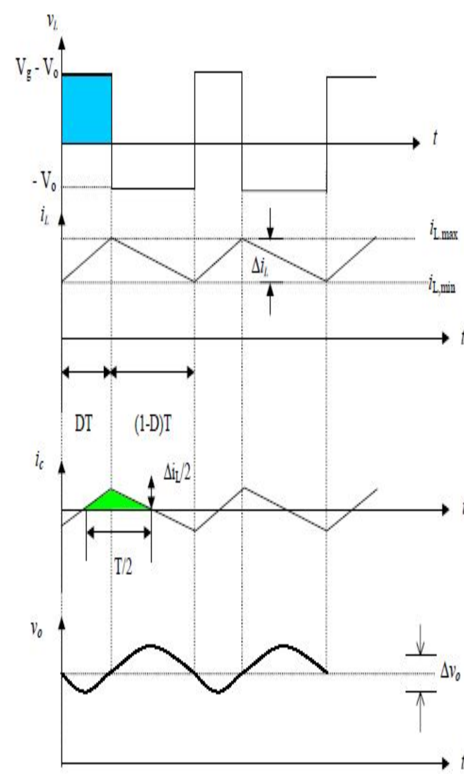

Fig4-Key waveform

C. Analytical expressions

Assumptions made about the operation of the converters are follows

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- The circuit is operating in the CCM
- The capacitor is large enough to assume a constant output voltage
- The component are ideal

Assuming a lossless circuit, $P_g = P_0$

Therefore $V_g I_g = V_0 I_0$

And $I_0 / I_g = V_g / V_0 = 1/D$

For a buck converter ,it is obvious that

$I_L = I_0$

$\Delta i_L = 1/L \int_0^{DT} V_L dt = 1/L$ [shaded area under

$= 1/L(V_g - V_0) \times DT$

waveform V_L (Area A)]

From Δi_L we can obtain $i_{L\min}$ & $i_{L\max}$

$i_{L\min} = I_L - (\Delta i_L / 2)$

$i_{L\max} = I_L + (\Delta i_L / 2)$

To obtain the average inductor current, we can use the relationship

$$I_L = I_0 = V_0 / R$$

The peak-peak output voltage ripple, Δv_o. From the information of the capacitor current, i_c, we can

obtain $\Delta V_0 = \Delta V_C = 1/C \int i_C dt = 1/L$ [

$$= 1/C \times 1/2 \times T/2 \times \Delta i_L / 2$$

Therefore $\Delta V_0 = \Delta i_L / 8 fc$

D .CCM/DCM boundary condition

Being at the boundary between the continuous and the discontinuous mode, by definition, the inductor current i_L goes to zero at the end of the off period. At this boundary, the average inductor current is

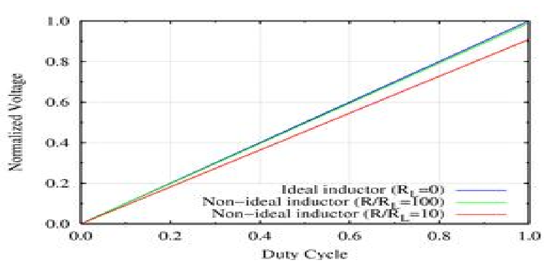

Fig a

$I_L = \Delta i_L / 2$

The minimum inductor current, $i_{L,\min} = 0$

And the maximum inductor curren $i_{L,\max} = \Delta i_L$

We know that for buck converter

$$I_L = I_0 = V_0 / R$$

and

$$\Delta i_L = 1/L(V_g - V_0)DT = [V_0(1-D)T]/L$$

If the desired switching frequency and the value of the inductor L are established, the minimum load resistance required for CCM is

$$R\min = 2fL/(1-D)$$

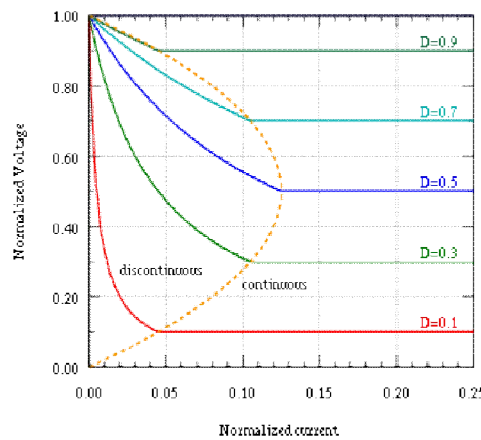

Fig b

III . SIMULATION AND DISCUSSION

The importance of simulation is apparent for the preliminary design of any system. System behavior and performance can be predicted with the help of the simulation The response of the buck converter in the open loop and closed loop condition for various input voltages has been obtained using the MATLAB7.0 Simulink and shown in the following figures.

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A.Conventional circuit

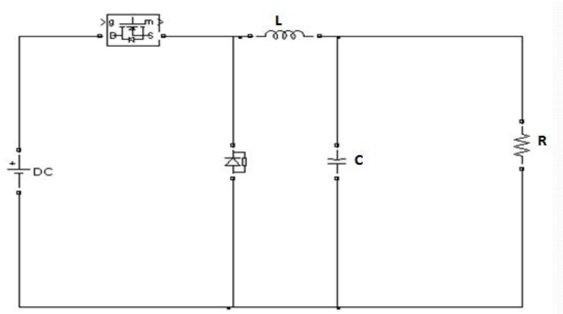

Fig6- Conventional model

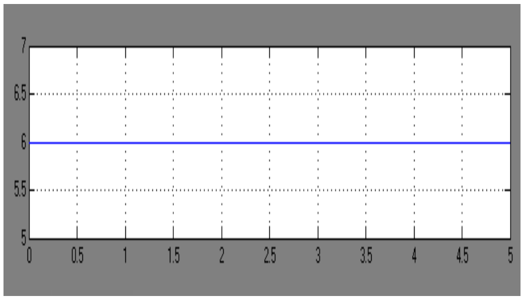

Fig7-DC input voltage

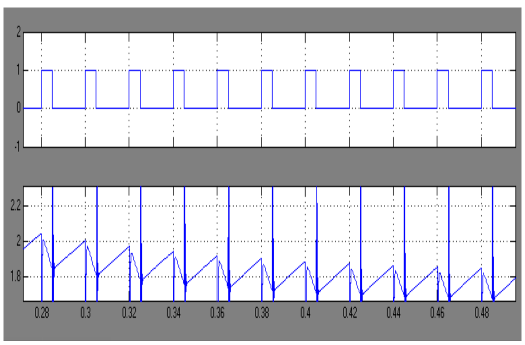

Fig8- Switching pulse and Vds

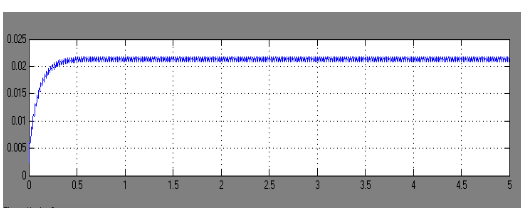

Fig9-Output current

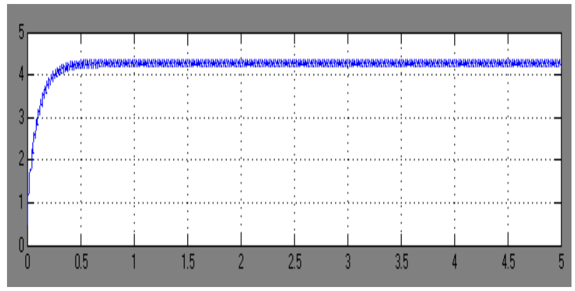

Fig10-Output voltage

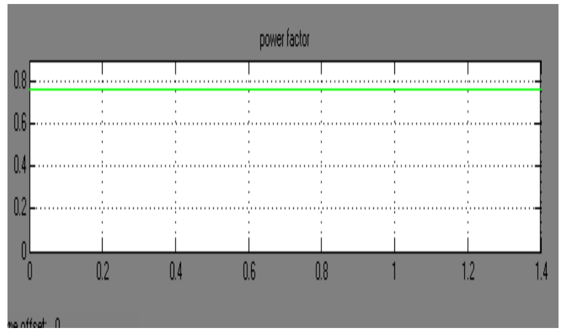

Fig 11-Power factor for conventional circuit

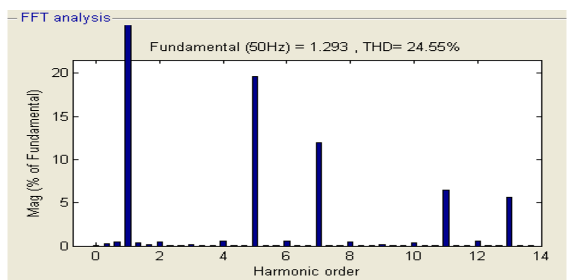

Fig12-FFT analysis

B.Proposed circuit

From fig:13 it is noted that for obtaining better we introduced the proposed circuit thus the conventional converter shows the response of the PI controlled Buck converter. To verify the design and performance of the buck converter, a simulation study of the same in open loop is performed for input DC voltage of 12V at 50Hz and output DC voltage of 3.7V and 1W output power rating with a switching frequency of 20KHz,with RL load. Power circuit of buck converter with open loop is shown in figure13.AC input voltage is shown in figure14.

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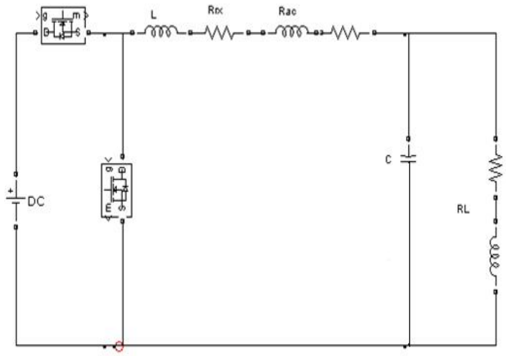

Fig13-Proposed circuit

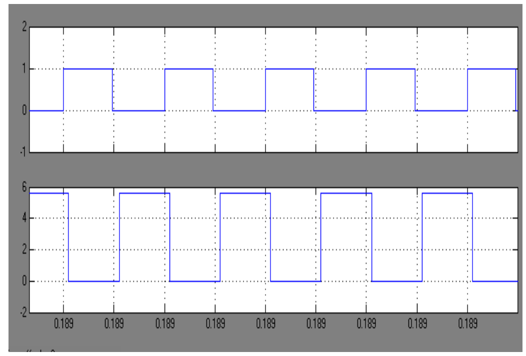

Fig17-Switching pulse and Vds for M2

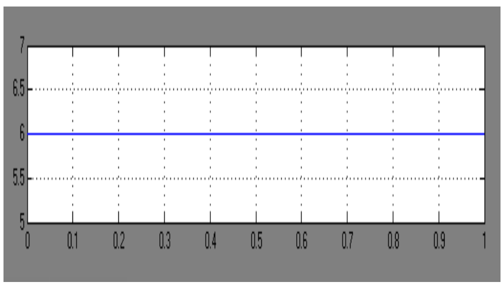

Fig14-DC Input voltage

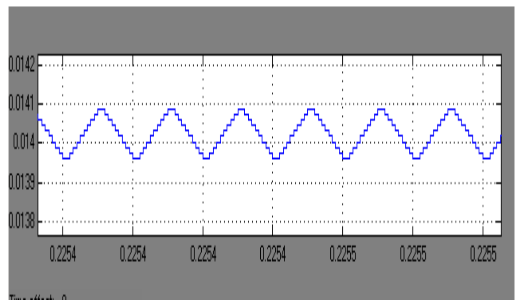

Fig18-Inductor current

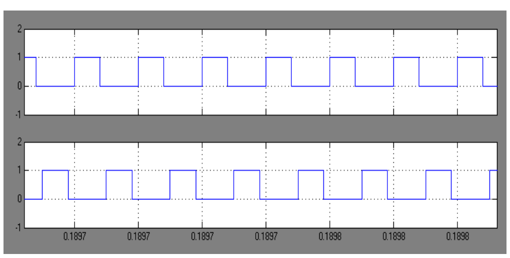

Fig15-Switching pulse M1&M2

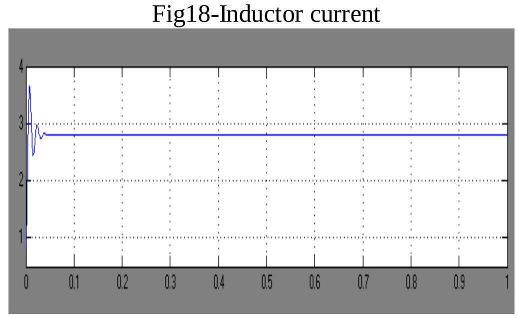

Fig19-Output voltage

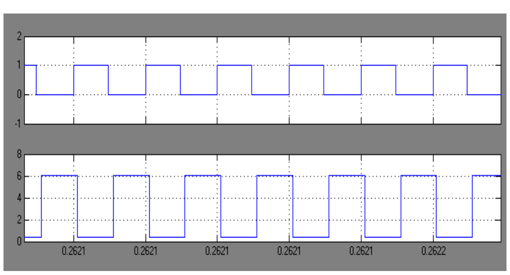

Fig16-Switching pulse and Vds for M1

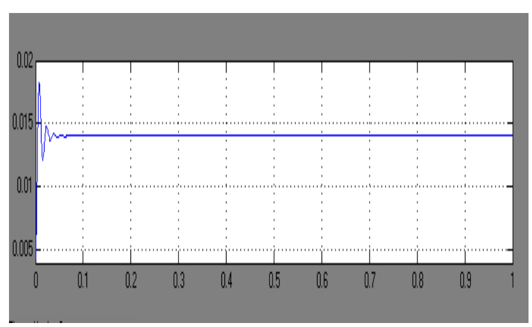

Fig20-Output current

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C.Proposed modified circuit with open loop

In the circuit of modified open loop converter, 6V is given in the input side. Input voltage,output current and output voltage of the circuit is shown in fig 22,23&24 respectively..

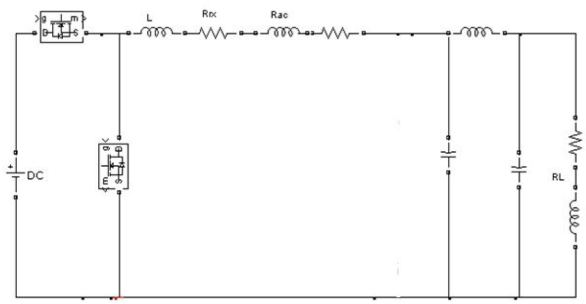

Fig21-Proposed modified circuit

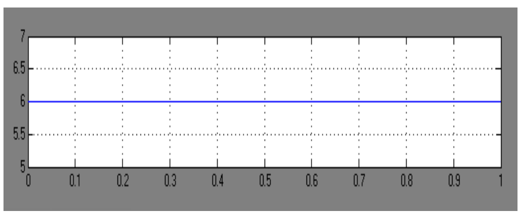

Fig22-DC input voltage

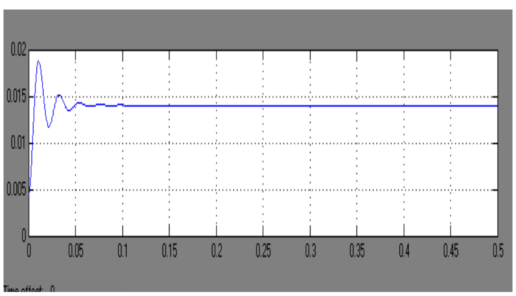

Fig23-Output current

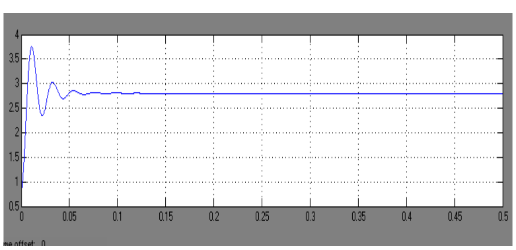

Fig24-Output voltage

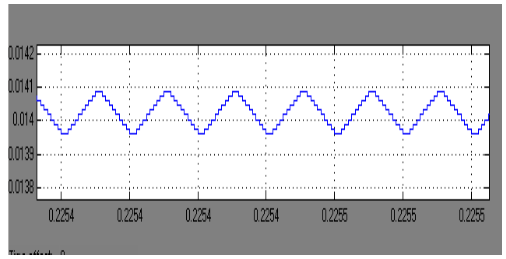

Fig25-Inductor current

D. Proposed open Loop Converter with Disturbance in the Input Side

In the circuit of proposed open loop converter, a step disturbance is given in the input side. Input voltage, output current and output voltage of the circuit is shown in fig25, 26&27 respectively.

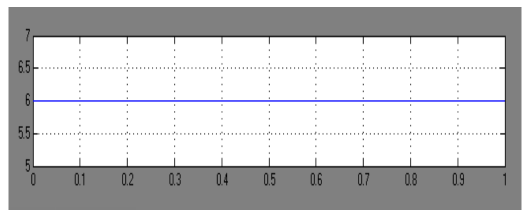

Fig25-DC input voltage

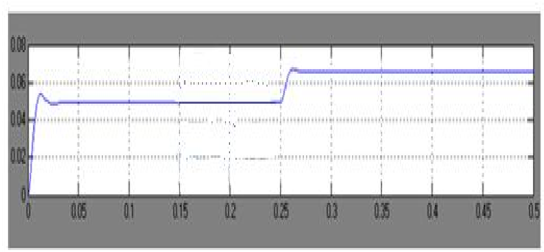

Fig26-Output current

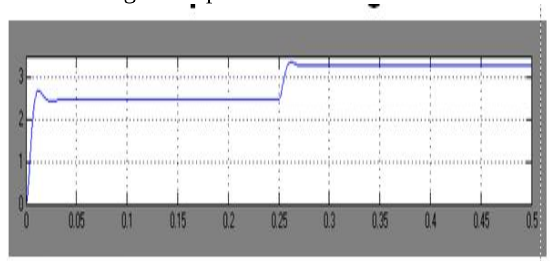

Fig27-Output voltage

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E.Proposed closed loop circuit with RL load

Fig 28 shows the closed loop converter for better efficiency and THD with RL load. It uses a very simple control feedback, which only requires output voltage sensing. At the input side an inductor and capacitor combination is using. Now, a small value of output voltage, compared to the reference value and resulting value, passes through the proportional integral (PI)controller , which generates the PWM output and is used for switching the MOSFET(M_1).It has inherent power factor correction characteristics with constant duty ratio and switching frequency, offering an attractive solution for lower power applications.

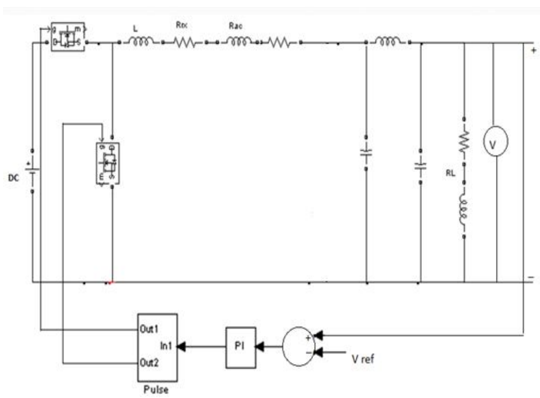

Fig28- Proposed closed loop circuit

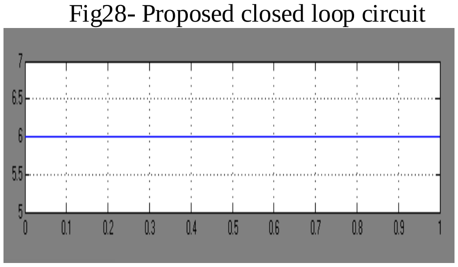

Fig29-DCinput voltage

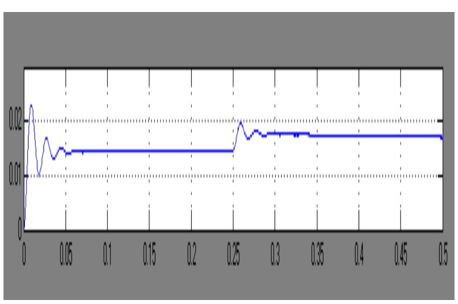

Fig30-Output current

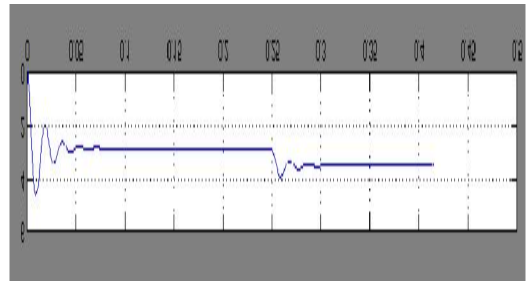

Fig31-Output voltage

The output voltage regulation is provided by the feedback loop as shown in Fig28, where the output sensed voltage Vo is compared with a reference Vref value and the error is amplified in a proportional integral (PI) controller thus providing the pulse to power switch.Therefore, this circuit is controlled by the differencein the on- time interval and the constant switching frequency . Input voltage, output voltage,and output current are shown in figure29,30&31 respectively. Power factor for closed loop converteris shown in fig32.Total Harmonic Distortion is shown in fig3

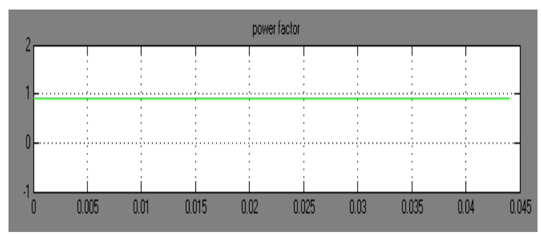

Fig32- Power factor for Proposed circuit

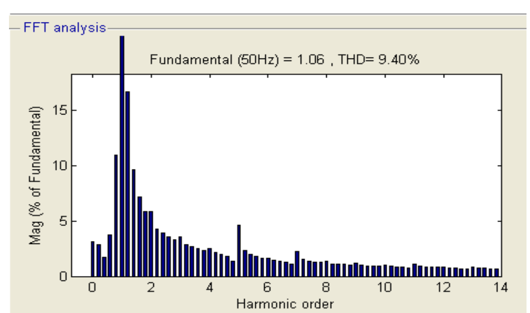

Fig33-FFT analysis

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IV. PARAMETERS OF A BUCK CONVERTER EXAMPLE

.

TABLE 1

Input voltage	12V
Output voltage	3.7V
Switching frequency	20KHz
Efficiency	91%

V . PERFORMANCE

TABLE 2

Input voltage	**Output voltage**	**Conventional efficiency**	**Proposed efficiency**
6V	2.8V	60	90
12V	3.7V	62	91
24V	4.2V	68	92.5
48V	4.8V	70	93

V IV CONCLUSION

The objective of analysing the efficiency and robustness of conventional and proposed buck converter has been success fully done and the simulation results and performance indices are determined for 3.7V, 1W output. Pi filter is used to reduce the harmonics. The closed loop converter has a good efficiency of 91% .The total harmonic distortion of the closed loop converter is good.From the results it is evidently proved that the converter with closed loop PI controller is highly efficient, robust and dynamic in stabilizing the system over the other controllers.

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