The Analysis of Harmonics and Conduction of Electro Magnetic Interference in Step-down Chopper

B.N.Choukimath
Department of Electronics and Communication Engineering
K.L.E College of Engg & Tech, Chikodi, Karanataka , India.

Abstract- This paper investigates the harmonics and the negative effects of electromagnetic interference (EMI) due to the fast switching power device used in the step-down chopper. The work of this paper focuses on measurement of total harmonics and simulation of EMI in electronic devices which is one of the major challenges in the design of high-speed electronic devices. A filtering method is used to mitigate the Harmonics as well conducted EMI due to the operation of power electronic converter. A step-down chopper is used as an example for analyzing of harmonics and conducted EMI. The effectiveness of these interference suppression techniques is investigated by using Multisim 12.0.

Keywords – EMI, Chopper,THD,

I. INTRODUCTION

The chopper converter converts fixed DC to variable DC. For last past six decades and as per incomplete statistics, there were 500 more prototypes of DC to DC converter [1]. As per the functions of choppers, they are called buck converter, boost converter and Buck-boost converter etc… The buck converter (step-down) is the simplest topology. The output is always less than input with the same polarity, this property use in the design of the power stage.

The chopper uses switching action in power conversion. The performance of power electronics devices enhanced by an increase in switching speed and frequency. But these advantages having increased levels of harmonics and interference. This harmonics and EMI consideration is one of the major tasks for circuit designers. These chopper circuits, use the fast switching power semiconductor switches. Fastest switching speed of converter has the capacity to cause harmonics, EMI and high dv/dt.

Mitigation techniques are classified in two groups. The first group includes filtering, snubbing, grounding and Printed Circuit Board (PCB) or layout considerations. In the second group, effects of switching characteristics such as frequency, duty cycle, speed and control strategies on EMI level are considered. The most common way to minimize conducted EMI by using EMI filters, PWM and random PWM [2]. The frequency modulation also employed to mitigate EMI [3]. The filtering is the most common technique which uses a capacitor and inductor as a filter element. But these passive elements limited with frequency. They become bulky, expensive and sometime more worse with respect to frequency.

In this paper organized in the following way, section II proposes mitigation method of harmonics and EMI using filtering method. Section III explains experimental results and this paper concluded in section IV.

II. PROPOSED METHOD TO MITIGATE HORMONICS AND CONDUCTED EMI

In this paper buck converter were used to analyze and measuring the EMI. Step – down chopper is the integral part of the power circuit in the modern electronic circuit They can convert a voltage value of 8 V to 30 V into a lower regulated voltage level approximately 0.5 V to 5 V. Buck converters convert small packets of energy using a switch along with a diode, an inductor and a capacitors. This converter gives higher efficiency in utmost cases.

Figure1. shows schematic of the buck converter. A DC battery Vd, supplies a lower voltage to a load, R. The vital component of the converter is the switching device and its duty cycle. When the switch is closed, the current passes through the inductor and to the load, the inductor creates a voltage drop by absorbing energy. Once the switch opens the battery disconnect from the load and inductor acts as a power supply due to stored energy. The diode is biased into active state, it allows the indicator to discharge stored energy and energy absorbs by the load. But the output voltage will not be a smooth DC signal it contains a ripple which will slightly distort the output voltage.

As the switch unfailingly alternates states, there is a very slight delay time between the supplies to the load. This upshot in the creation of harmonics of the switching frequency in the switch. The delay times and harmonics can momentously cause ripples in output. The output of the converter has a distortion magnitude of 1.2V and SNR of 18dB. To counteract this ripple and harmonics is to connect a capacitor in parallel with the load.

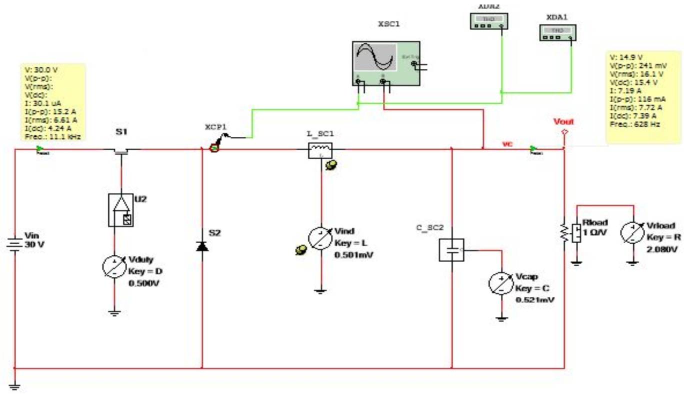


Figure 1. Standered buck conveter

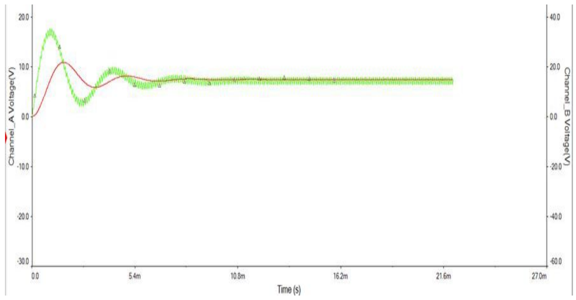


Figure 2. Output waveform for buck converter

By referring the output waveform as shown in Figure 2 and 3 the shunt capacitor not capable to remove the harmonics and EMI in the output. In the proposed circuit has been modified wherein the diode in parallel with the supply is removed and a diode is placed between two capacitors, after the switch as shown in Figure 4. The ripples generated by a switch pass through the diode which is then diverted to ground via capacitors. The resulting output is illustrated in the Figure 5 and Figure 6.The magnitude of the distortion present in the output signal and SNR is 0.1mV and 47.627dB respectively

Figure 3. Spectrum Analysis for standerd buck converter

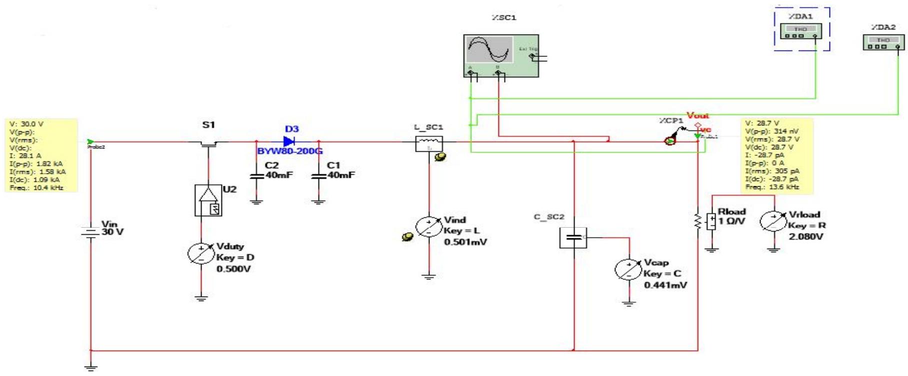


Figure 4. Modified buck converter

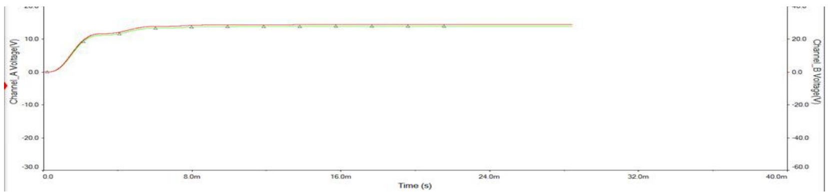


Figure 5. Output waveform of modified buck converter

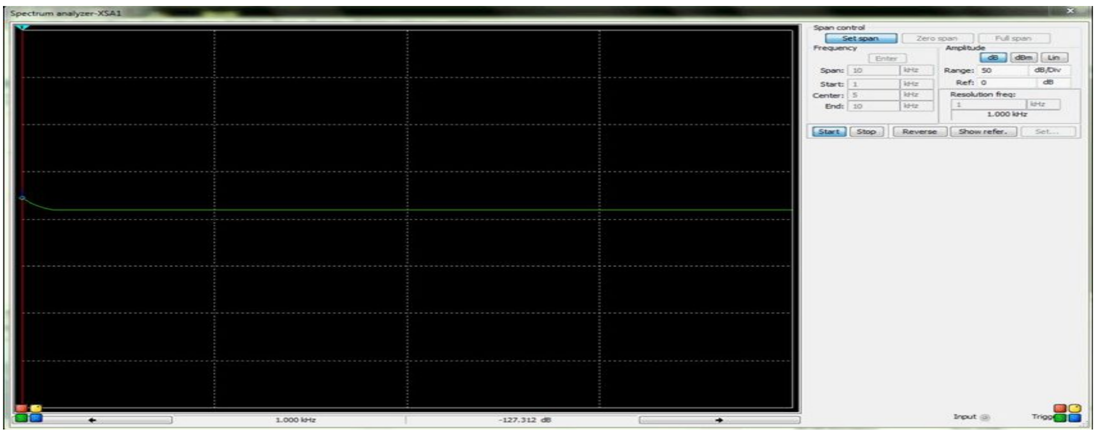
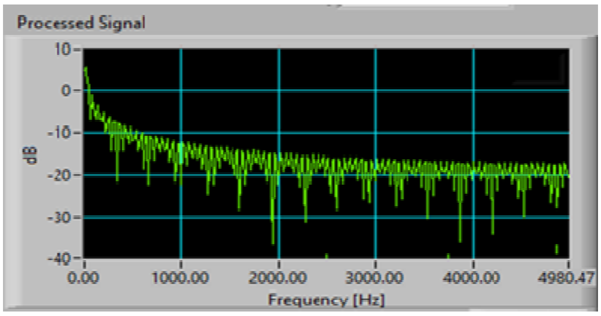


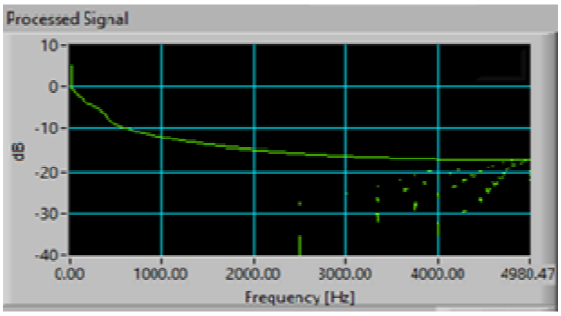
Figure 5. Spectrum Analysis of Modifed buck conveter

III. Experiment and Result

The main drawbacks are increasing EMI noise and reducing quality of power converters due to high dv/dt & di/dt and high ripple on output voltage or current. In the Figure 6 minimized the effect of electromagnetic interference was found for the chopping frequency of10 KHz and 50% of duty cycle.



(a)



(b)

Figure 6. (a) Signal Analyzer of standard buck converter (b) Signal Analyzer of modified buck converter

Table 1 shows the results of reduced harmonics of buck converter in the process of converting DC to DC. Our proceedings have resulted in an overall THD (total harmonic distortion) of 73.6291% and SNR (signal-to-noise ratio) of >=100dB.

Table -1 Experiment Result

	THD in%	THD in dB	SINAD	SNR
Standard buck converter	64.4361%	-18.355dB	18.446dB	36.801dB
Free final proposed buck converter	73.5679%	-38.058dB	38.058dB	76.118dB
Final proposed buck converter	73.6291%	<-100dB	47.627dB	>=100dB

IV.CONCLUSION

In modern power converters uses fast switching power devices and main concern is achieving high efficiency. But challenging task is to determine the exact EMI level but need to compromise with other key factors like harmonics and switching frequency. It is apparent that the increase in the switching speed and decreasing switching frequency, decreases the switching losses but the main drawbacks are increasing EMI noise and reducing quality of power converters due to high dv/dt & di/dt and high ripple on output power quantity.

In our paper have resulted in an analysis of overall THD and EMI level along with reduction. The improvement in the performance of the device influences from THD, SNR, noise, settling time and the peak harmonic amplitude level using signal analyzer. This paper effectively demonstrates for the beginner to understand harmonic analysis as well reduced EMI in step-down chopper circuit.

REFERENCES

[1] Fang Lin Luo and Hong Ye, "Advanced DC/DC Conveter", *CRC press.*

[2] Franc Mihali˘c, Member, IEEE, and Dejan Kos, "Reduced Conductive EMI in Switched-Mode DC–DC Power Converters Without EMI Filters: PWM Versus Randomized PWM", IEEE Transactions on Power Electronics, VOL. 21, NO. 6, NOVEMBER 2006

[3] G¨okhan C¸ABUK, Sel¸cuk KILINC¸, "Reducing electromagnetic interferences in flyback AC-DC converters based on the frequency modulation technique", Turk J Elec Eng & Comp Sci, Vol.20, No.1, 2012.

[4] M. Joshi, Agarwal, "Generation and Propagation of EMI Waves in Power Electronics Circuits", IEEE PESC Proceeding, Vol.2, pp. 1165-1171, May 1998.

[5] A. Farhadi, A. Jalilian, "Modeling and Simulation of Electromagnetic Conducted Emission Due to Power Electronic Converters", Proceeding of IEEE PEDES conference, India, 13-15 Dec. 2006.

[6] M. Rashid, "Power Electronics Circuits, Devices and Application", Printice Hall 1993.

[7] F. Lin, D.Y. Chen, "Reduction of Power Supply EMI Emission by Switching Frequency Modulation", IEEE Trans. On Power Electronics, Vol.9, Issue 1, pp. 132-137 Jan. 1994.

[8] M. Nave, "The Effect of Duty Cycle on SMPS Common Mode Emission: Theory and Experiment", IEEE EMC Symposium Proceeding, pp. 211-216, 23-25 May 1989.

[9] T. Williams, "EMC for Product Designer", 3rd edition, Newness 2001.