I J C T A, 9(5), 2016, pp. 2545-2551

Implementation of Buck-Flyback Converter for improving power factor in Switched Reluctance Motor

M. Nagaraj*, S.S. Sivaraju and T. Sivarama Sumbramani*****

ABSTRACT

This paper provides the power quality improvement of a integrated buck-flyback Power Factor Correction (PFC) Converter. This converter is an inherent integration of a buck-flyback converter, the function of it provides to operate in both buck-flyback mode according to the input voltage variations. Whether lower or higher than output voltage. By using simple conventional bridge rectifier the mid-point converter based switched reluctance motor drive gives low power factor at AC mains and provides high harmonics. Therefore proposed integrated buck-flyback power factor correction converter achieves high power factor, reduces total harmonic distortion and its input current harmonics within its limit. Detailed analysis and optional design consideration are presented in this paper. The switched reluctance motor drive with input buck-flyback converter is modeled and the performance is simulated in MATLAB.

Index Terms: Power Factor Correction (PFC), Power Quality, Switched Reluctance Motor (SRM), Integrated buck-flyback converter, Constant On-Time (COT) control.

1. INTRODUCTION

Switched Reluctance Motor (SRM), become a most preferable competitive motor for many application of electrical drive system due to its relative simple and rugged construction, reliability, fast response and low cost. Due to this features it is going on increasing attention in electric drive system industry. Switched reluctance motor employs power converter for its operation and they need to a stable dc supply. Conventional switched reluctance motor drive usually includes simple rectifier circuit with a diode, filter capacitor as a front end converter. But the main draw back in employing conventional converter is that it draws or pulsating ac line current resulting in poor power quality and high harmonic content.

Therefore appropriate method that is power factor correction converter is used for AC-DC because it needs almost sinusoidal input current. The AC/DC power converters can meet IEC61000-3-2 limit. The buck-flyback power factor correction converter can achieve a relatively high efficiency particularly at low input voltage due to low average input current and rms current, which makes buck power Factor Correction converter has drawn much important an improved constant on time control can helps improve the power factor of buck-flyback converter[1]. The conventional bridge rectifier as front end converter fed switched reluctance motor drive. The purpose of the converter in this switched reluctance motor is to improve the power factor in various operating conditions. The converter employded in this paper presents a combination of two classical type converters, in which one is buck converter which is a basic type and the other type of

* PG Scholar, Department of Electrical and Electronics Engineering, RVS College of Engineering and Technology, Coimbatore, Tamilnadu, *Email: nagarajmuthumanickam06@gmail.com*

** Head of the Department, Department of Electrical and Electronics Engineering, RVS College of Engineering and Technology, Coimbatore, Tamilnadu, *Email: sssivaraju @gmail.com*

*** Scholar, Department of Electrical and Electronics Engineering, RVS College of Engineering and Technology, Coimbatore, Tamilnadu, *Email: sivaramasubramani@gmail.com*

converter includes here is flyback converter. The main advantage of this converter is it provides the power factor to an optimum level. The main merit includes the power factor range under various operating conditions.

Due to the reliable and rugged construction of the switched reluctance motor the drive motor found its implementations in various sources. When the power factor range of the machine is improved it becomes an important source drive for many major industrial applications. This turns to the formation of a hybrid converter. Here a non isolated type buck flyback type converter is modulated as a hybrid converter. A form of vector control is used in the implementation of this converter. The main advantage of using the vector form of control is its accurate control parameters when compared to other form of classical types.

2. PROPOSED TOPOLOGY FOR SRM DRIVE

In Switched Reluctance Motor (SRM), the buck-flyback converter is used as front end converter to improve the power quality at ac mains and Figure1shown in Conventional Bridge Rectifier as front end converter fed Switched Reluctance Motor drive. The proposed system consist of diode rectifier and buck-flyback converter fed mid-point converter based SRM drive connected in cascade configuration.

Here two combined buck-flyback converter were introduced, in which the criteria's of input current can be eliminated with auxiliary flyback converter. In this paper a novel integrated buck-flyback non-isolated power factor correction converter is proposed. The structure of the proposed converter is formed by summing two diode rectifier's one winding of inductor and one switch into conventional buck power factor correction converter [3]. When the supply voltage is less than output voltage the proposed converter operates in flyback it and operates in a buck mode when input voltage is higher than output voltage. This proposed topology integrates buck-boost input current shapers with a quadratic buck converter to eliminate the harm zones of the current input and then achieve high power factor. However, the topology makes it unsuitable for actual applications because of complex structure of it. Two combined buck-flyback converters are introduce, in the input current can be eliminated with the

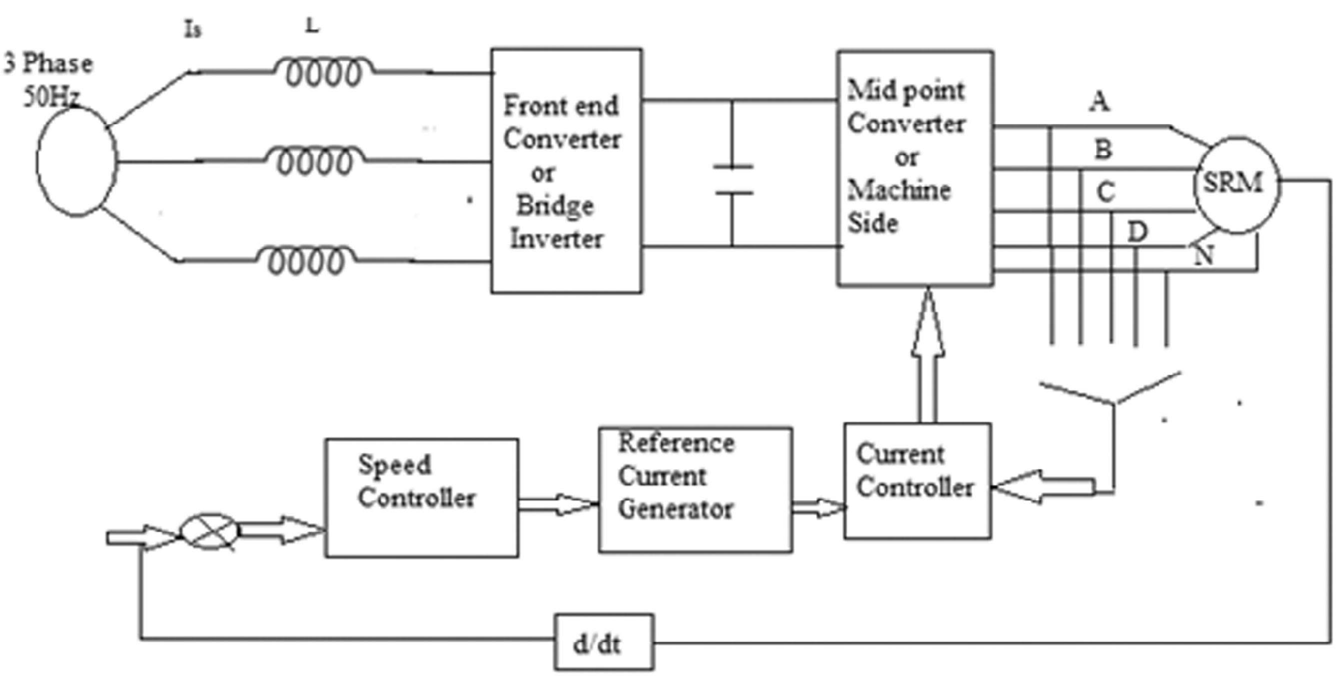
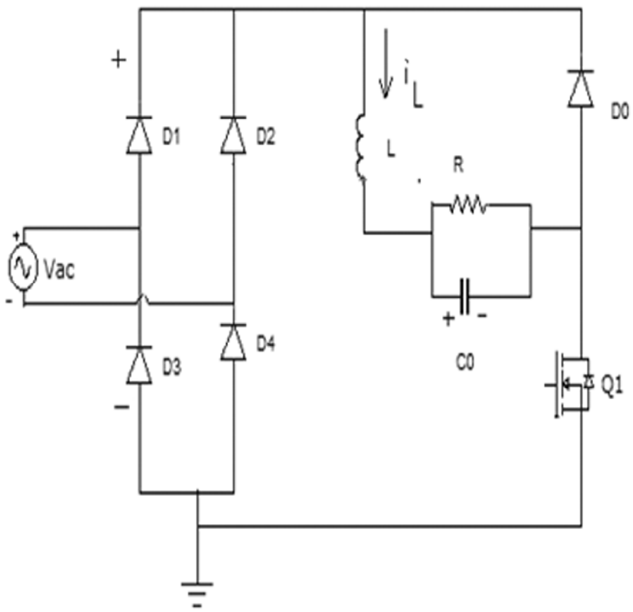
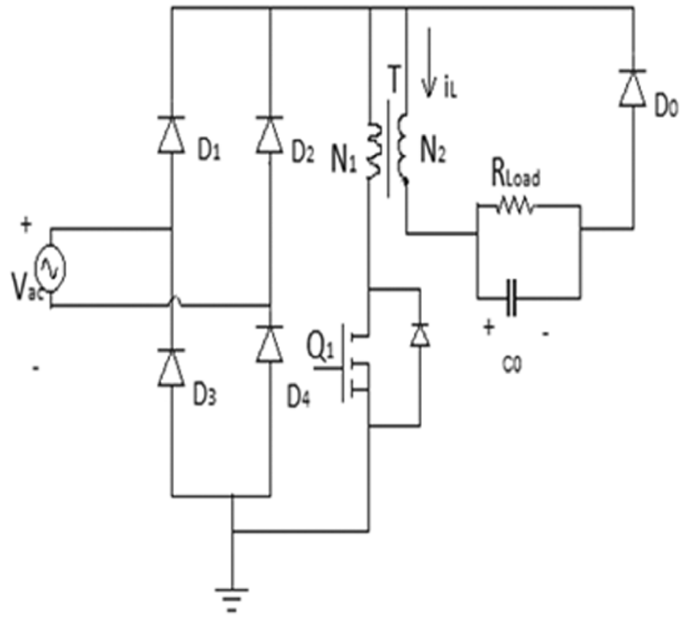


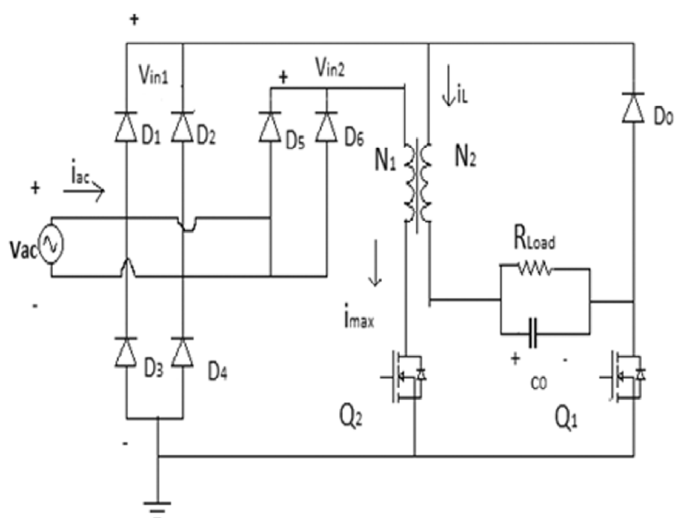
Figure 1:Conventional Bridge Rectifier as front end converter fed SRM drive



(a) Buck Converter



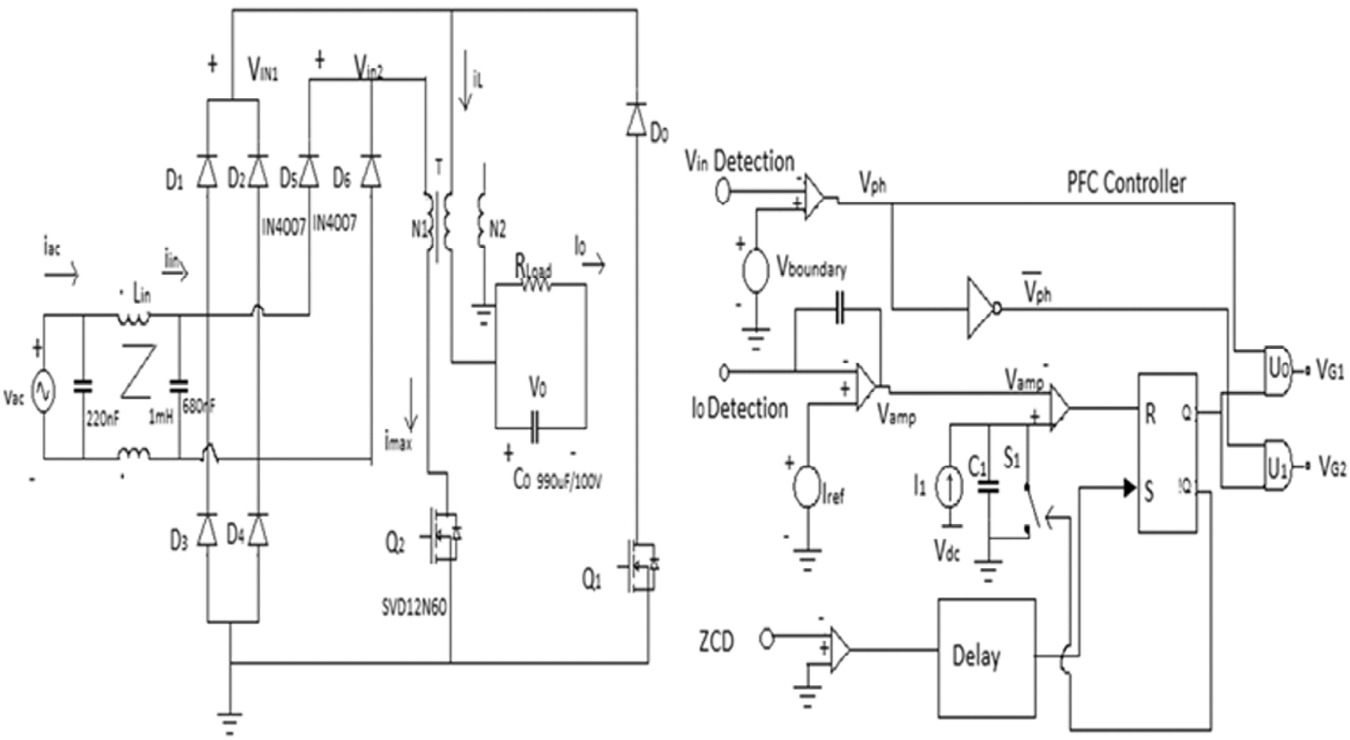
(b) Flyback Converter



(c) Buck-Flyback PFC converter

Figure 2: Proposed integrated buck flyback nonisolated PFC converter

converter. However, an additional diode leading to some losses. In this paper a novel non isolated power factor buck-flyback converter is proposed, as shown Figure 2. The structure of proposed converter is very simple. Two rectifier diodes involved forming and one switch into the conventional buck PFC converter. The switch Q2 source nodes of the added and the buck switch Q1 are connected to the ground. This reference current is then sending to MOSFET and the power switching is operating at 142 kHz frequency. When the supply voltage is less than output voltage the proposed converter operates in flyback it and operates in a buck mode when input voltage is higher than output voltage. Therefore, it can achieve in high PF and pass the IEC61000-3-2 class C limits to simple. Moreover, the power loops of the buck mode are separated, and no additional losses in power loops. Obviously, the innovated integrated buck-flyback converter introduced and the proposed buck flyback converter with an improved COT control schematic diagram shown in Figure 3. The detailed operation principle will be illustrated in section III. Experimental results based on a 100-W prototype will be given in section V. Finally, a conclusion section is used to summarize this paper.



(a) Buck-flyback converter with COT **(b) Buck PFC converter with COT control**

Figure 3: Schematic of the proposed buck PFC converter with an improved COT control.

3. PRINCIPLE OF OPERATION OF CONVERTER

The integrated buck-flyback converter operating in critical conduction mode will be analyzed on details. An improved Constant ON Time control is applied to the proposed converter and forces it to operate in critical conduction mode. The output current is detected for constant output current control of the load LED. The proposed integrated hybrid non-isolated PFC converter operates in buck mode when Vph is in high logic level, while it operates in flyback mode when Vph is in low logic level. Transition process between those two modes are natural [6].

1) *Positive Half –Cycle of AC input*: When the input voltage Vac is positive and magnetic of Vac is smaller than Vo, the proposed converter operates in flyback mode. In this mode, switch Q1keeps off, Q2 keeps switching. There exist three stages when the proposed converter operates in this mode.
2) *Negative Half-Cycle of AC input*: When the input voltage Vac is negative, the proposed converter also operates in fly-back mode and buck mode in different input voltage regions. The operations of proposed converter in the negative half-cycle of ac input are similar to those of the positive half-cycle. For simplicity, these operation processes are not dedicated in detail in this paper.

4. ANALYSIS AND DESIGN CONSIDERATIONS

The design consideration of the hybrid converter buck-flyback converter power factor correction converters is discussed in this paper.

1. Harmonics analysis of converter
2. Inductor design

4.1. Harmonics analysis of converter

The harmonic spectrum of the input current waveform can be achieved by Fourier decomposition. The harmonic current contents of the input current are affected by the turns ratio of the transformer and the output voltage Vo. The output Voltage out of the range of 70-100 V will cause unacceptable low efficiency, as analyzed in the following part. Therefore, several output voltage within the range of 70-100 V are selected for harmonic current contents[10]. All the four harmonic current contents under almost all the output voltage except 90V can achieve much margin when turns ratio is equal to two. In other words, $n = 2$ is an optimal turns ratio for most of the output voltages [9].

4.2. Inductor design

The value of duty cycle, for a zeta ac-dc converter operating in continuous conduction mode is

$$D = Vo / (Vin + Vo) \tag{1}$$

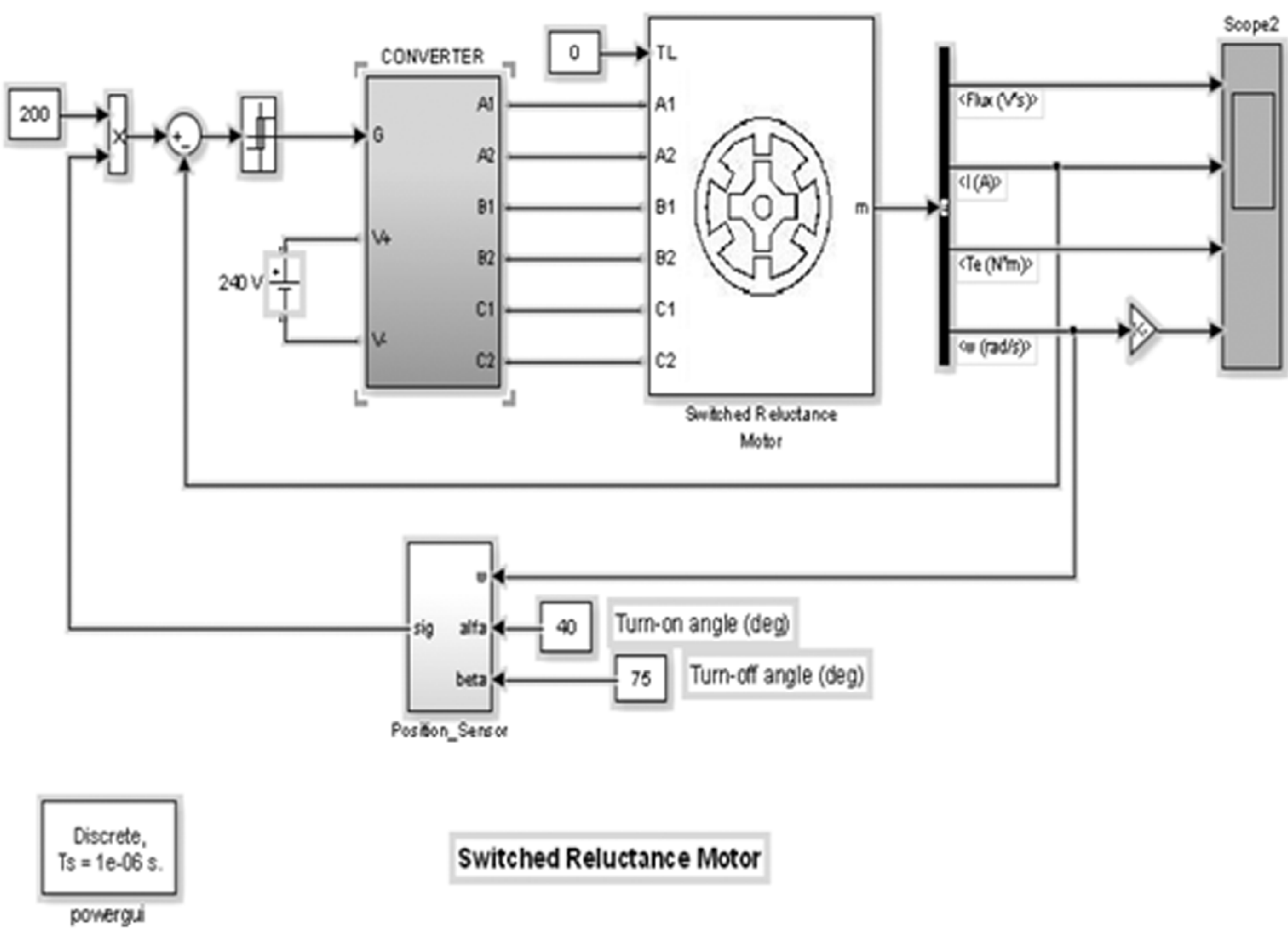
Where, D is the duty cycle, VO is the output voltage at dc link and Vin is the rms value of input ac voltage. To determine the value of inductance $L1$ and $L2$ the peak-to-peak ripple current is taken approximately 10-20% of the average output current[11].

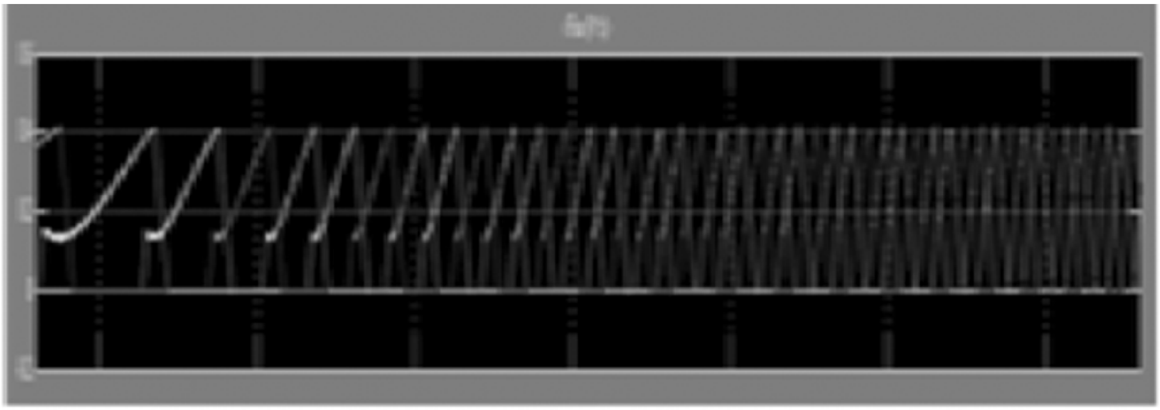
5. SIMULATION RESULTS

5.1. Simulation

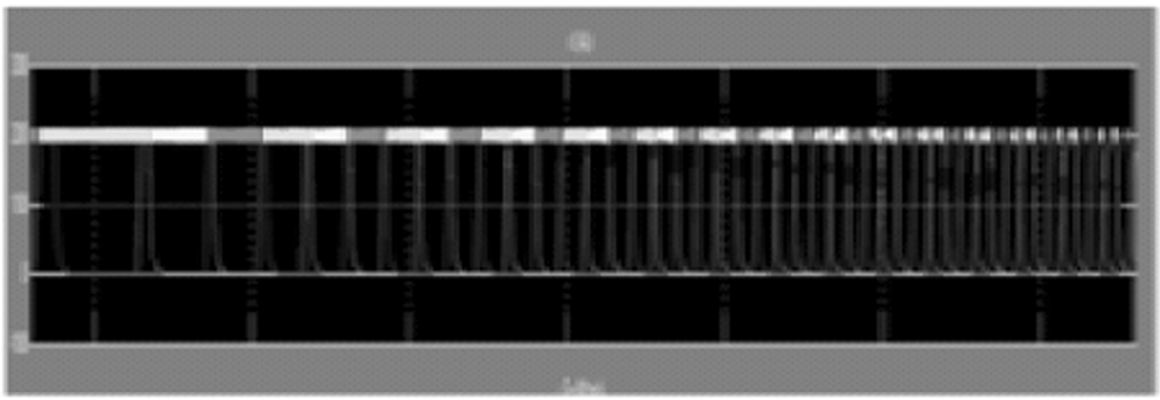
5.2. Output waveforms

The main purpose of the modeling and simulation is to declare the design of proposed power factor correction buck-flyback converter based SRM drive is valid which has power factor nearly at unity and low THD of ac mains current. The voltage at dc link is maintained almost constant that is 240V and Switched Reluctance Motor output waveforms are shown in Figure 4. Under steady state operation, the input voltage(Vs),

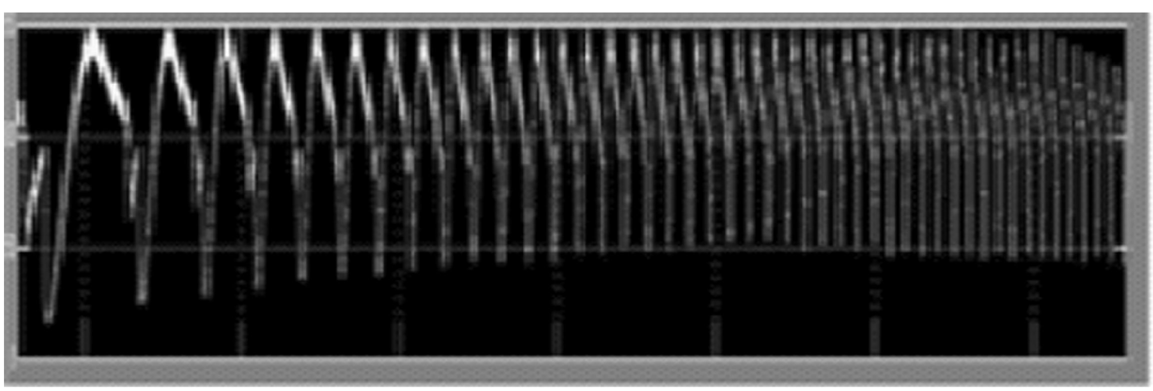




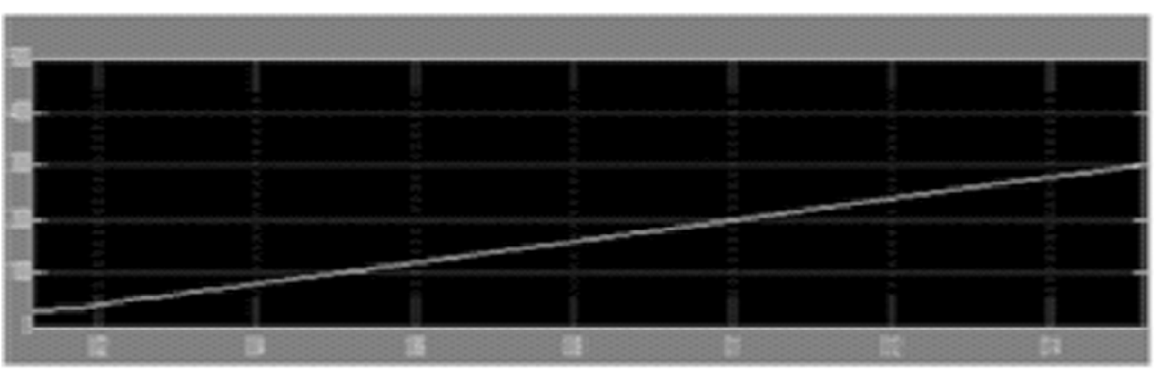
(a) Output voltage



(b) Output current



(c) Output Torque



(d) Output Speed

Figure 4: Switched Reluctance Motor output waveform

Table 1
Simulation results of buck-flyback converter fed SRM

Vs(V)	Is(A)	Vdc	PF	THD
125	0.246	237.7	0.992	0.182
140	0.293	237.8	0.9332	0.185
150	0.325	237.9	0.994	0.19
180	0.372	238.5	0.995	0.192
200	0.394	239.1	0.995	0.194
220	0.409	239.8	0.996	0.195
230	0.428	240	0.996	0.196
250	0.444	240	0.997	0.198
270	0.475	240	0.997	0.204
300	0.542	240	0.998	0.22
320	0.581	240	0.999	0.245
350	0.61	240	0.9999	0.254

current(Is) waveforms. Table-1 shows the variations of power factor of PFC hybrid converter based front end converter with the wide variations in ac mains voltage.

5. CONCLUSION

A power factor correction buck-flyback mid-point converter fed SRM drive has been designed and its performance is simulated for a 60kW.6/4 pole SRM. The proposed buck-flyback converter operating in continuous conduction mode has been shown an improved performance with nearly unity power factor of ac mains. The proposed SRM drive system helps of improve the power factor almost to unity with the low THD of supply current and balanced the dc link capacitor voltage and this converter is that it is easy to maintain the voltage across capacitor balanced at dc bus.

REFERENCES

[1] D. Gacio, J. M. Alonso, J. Garcia, L. Campa, M. J. Crespo, and M.Rico-secades,: “PWM Series dimming for slow dynamics HPF LED drivers: the high-frequency approach,” IEEE Trans. Ind. Electron., vol. 59, no. 4, pp. 1717-1727, Apr. 2012.

[2] Electromagnetic Compatibility (EMC), part 3-2:limits–limits for Harmonics current Emissions .Int.Std. IEC61000

[3] L. Huber, E. Brain, T. Iriving, and Jovanics, “Effect of vally switching and switching frequency limitations on Line current distortions of DCM/CCM boundary boost PFC converter,” IEEE Trans. Power Electron, Vol. 24, no. 2, pp. 339-347, Feb. 2009.

[4] Srivastava Ashish Bhim Singh “Improved power quality based high brightness LED lamp driver” International Journal of Engineering Science and Technology, Vol. 4, No. 1, 2012, pp. 135-141.

[5] M. Mahdavi and H. Farzanehfrad “Bridgeless SEPIC PFC rectifier with reduced components and conduction losses,” IEE Trans. Ind. Electron, Vol. 58, no. 9, pp. 2404-2413, Sep. 2011.

[6] T.J.E. Miller, Switched reluctancemotor and their control oxford, U.K.oxford university press, 1993.

[7] E. H. Ismail, “Bridgless SEPIC rectifier with unity power factor and reduced conduction losses,” IEEE Trans. Ind.

[8] V. Grigore and J. Kyyra, “High powerfactor rectifier based on buck converter operating in discontinuous capacitor voltage mode,” IEEE Trans. Power Electron., Vol. 15, no. 6, pp. 1241-1249, Nov. 2000.

[9] Y. Jang, J. Zhang, X. Wu, Z. Qain, and M. Xu, “Performance comparison between buck and Boost CRM Powerfactor converter,” in Proc.IEEE 13th workshop control model.

[10] E.H. Ismail, A.J. Sabzali, and M. A. Al-saffar, “Buck-boost type unity powerfactor rectifierwith extended voltage converson ratio,” IEEE Trans. Ind. Electron., vol. 55, no. 3, pp. 1123-1132, Mar. 2008.

[11] S. Vukosavic and V.R. Stefanovic, “SRM Inverter Topologies: A Comparative Industry Applications Vol. 27, no. 6, pp. 1.34-1047, Nov/Dec.1991.