PERFORMANCE EVALUATION OF SINGLE-PHASE AC-DC CONVERTER USING VERSATILE POWER BALANCED CONTROL METHOD

N.Vengadachalam[1], Dr. R.Karthigaivel[2], V.Subha Seethalakshmi[3]
[1&3]Assistant Professor, SRM TRP Engineering College, Tiruchirappalli, TN, India
[2]Associate Professor, PSNA College of Engineering and Technology, Dindigul, TN, India
Corresponding Author[1] email ID: punniyamme@gmail.com +91-9944950505

Abstract-

The enormous application of converters in the electrical system, the power quality at input mains affected extremely. So, to enhance the system power quality, innovative techniques can be used. This paper contains advanced AC to DC converter technique that not only provides better DC output but also stabilizes the input AC power source. It also provides advantages like lower production costs and reduced component count. In this AC to DC conversion system, the combined circuit of both bridge rectifier and buck-boost converter are used for the proposed model, and it also provides stable output power for a load demand up to 1000 Watts. In this system, continues and discontinues modes of operation will be performed for buck-boost converters. The additional advantages of this system are transformerless AC to DC conversion provides high efficiency with less power absorbing capability. This paper proposes a Versatile Power Balanced Control (VPBC) based controller derived for the Buck-Boost converters in the single-phase single stage AC to smaller weight, size, reduced components, and better output voltage regulation. This paper also concentrates on the input source power factor stabilization. The circuit components are well designed according to different operating conditions with various loads and different source voltage.

Keywords:- Buck-Boost Converter, Versatile Power Balanced Control (VPBC), Transformerless AC to DC conversion, AC to DC converter.

1. Introduction

A common rectification process, a Full wave bridge rectifier with filter capacitor or smoothing circuit are usually connected between the input AC (Alternating current) mains and the DC (Direct current) output load. However, they result present with a high line current harmonics, and low power factor occurs in an AC source. According to this Concern, the proposed model a full Bridge rectifier and the pulse width control based buck-boost converter is implemented towards improving the High power factor correction in the input mains. The single stage converter has a lot of benefits mainly transformerless AC/DC conversion and controlled buck-boost converter, can exhibit high power factor modulation and reduce the ripple voltage in the DC-DC converter.

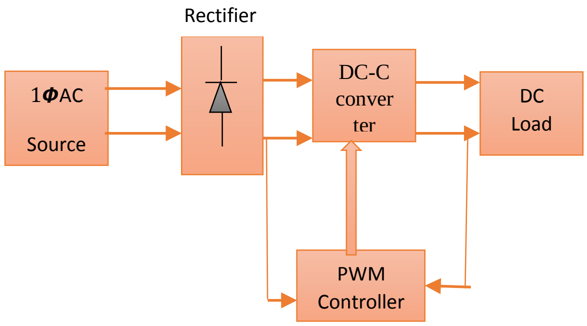

Figure 1: Functional Block diagram for single Phase AC/DC converter

To minimize the system cost and component usages, a proposed converter system is implemented with an advanced control modulation technique with a consideration of input power and the output load variation. The Bridge rectifier, Buck-Boost converters, and PWM modulation are used in the present module are shown in **Figure-1.** For the stabilization of the input power and the load system a suitable pulse width modulation (PWM) based controller is required for the Buck-boost converter. Therefore, the duty ratio of MOSFET is continuous in the average operating condition, during the discontinuous working condition, the buck-boost inductor current is not persistent in the entire duty ratio, and it also reaches Zero level earlier even before the end of the duty cycle. This design model is called the voltage-follower power factor control technique or the self- power factor control property. While using non-linear load, the input power factor is varied for its stabilization purposes the DC-DC converter supplies the required harmonics current to the converter circuit. Thus producing a nearly sinusoidal current at a unity power factor. In such a process, PFC and their subsequent effect on the current and voltage waveforms sinusoidal by regulating circuit to enable advanced techniques, i.e., to improve the input voltage and current waveforms, looking forward to better results. The operating modes, dynamics review and a design factor of the advanced AC-DC converter with the soft-switching technique are introduce in this system. The simulation results should be validate with the theoretical analysis.

2. Literature Survey

Some of the recent research works have been discussed below for an AC to DC single-phase converter.

The conventional models are analysis the reactive and active power flow in the transformer and also analysis the working condition and implement the model of the system using soft commutation [1]. For the various DC Application a DC-DC converter is it helps to converter specific operating ranges of the input power without induced losses in the electrical system. [2-3]. In this converter, the model aims to decrease the leakage current and improve performance of the system. In this proposed model develop the two-stage transformer less AC to DC converter [4]. The designed control system of the model currents makes it possible to reduce converter error and increase the PFC of the input. In this model is characterized by a small number of active switches is used in the power circuit due to the use of a direct-conversion principle [5]. Multi-objective optimization (MOO) strategy is used to improve the converter switching performance the noise is decreased in the output and increase the efficiency of the system [6-7]. DSB-AM (Double-Sideband Amplitude Modulation) equations are used to develop the system model and improve the performance of the converter is also discussed [8].

For analyzing the performance of the converter using a Space vector based closed-loop control system is implemented in this system. In this model, output power is nearly stable when different connected types of loads in the converter model and also the input power has varied the quality of the power is attained [9]. Some studies have been replaced by the LLC's resonance tank with a model, two incremental circuits, and in the inductor. By implementing a protective relay on the differential side of the circuit, the performance of the controller will be in two types: initial one is a bridge rectifier, and the further operation is Full bridge circuit voltage [10]. The resonant capacitor and inductor is the main part of this model to get the better zero switching voltage in both primary and secondary switches. This operated switches will share the same PWM, and the modifier it's easy to perform is the current mode control function no need to feel the input voltage [11]. The converter function is explained, and the new modification has been discussed in their processing stability properties. System conduction loss is reduced in the new control technology is designed to reverse are rejected for a full rectifier of the system [12-15].

The operation of the AC to DC rectifier model and the output is not a pure DC, and also it contains the harmonics of the output voltage in this boost converter circuit. Active, using PFC, however, because the overall two-step converter will have to implement an additional change conversion and working cost and implemented circuit component needs [16]. In this model, the proposed converter design is a full bridge rectifier, and the switching pulse is standard PWM it converts AC to DC single stage power and also the system is achieved the improved power factor. This converter model gives a noiseless input supply and improves the effectiveness of the system, and a stabilized Load voltage of the system can be operated, and the system decrease the converter switches the cost of the converter model [17-18]. The alternating control of power factor is associated with the matrix controller; one of these is that two separate frequencies are operated and establish the output frequency of the converter [19]. A unity power factor in the converter's discontinuous mode of transmission provides and reduces the deviation of total synchronization and give pure sinusoidal input power of this system [20-21].

From the above analysis, some of the drawbacks identified are switching noises, voltage ripples, phase angle shifts and the time required for stability recovery are high. They can be rectified in a developed AC to DC converter using Versatile Power Balanced Control (VPBC).

3. MATERIALS AND METHODS

This work describes the operation of the proposed single phase AC to DC converter for the stabilization of the output power with improve the Power factor on the source side, and also decreasing the number of required active switches using in a buck-boost converter. The transformerless converter considerably less in weight and are less costly to build for the system. Then additional advantage of this system is VPBC control technique provides a sophisticated duty ratio for the DC-DC converter switch which will stabilize the output voltage and also compensate the input power factor with higher efficiency. The combined operation of both Bridge rectifier and buck-boost converter has a benefit of system safety and reliability for the proposed model. A comprehensive study of AC to DC converter is conducted in simulation, and its performance is verified. The simulation outcomes confirm the efficiency of the suggested **Versatile Power Balanced Control (VPBC)** controller algorithm.

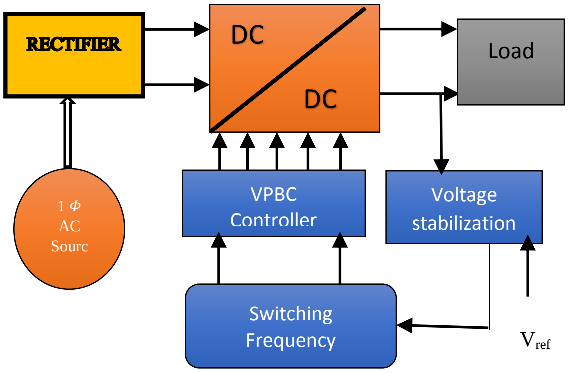

Figure 2: Proposed Block diagram for the single Phase AC-DC converter

Figure 2 demonstrates the proposed block diagram for VPBC control technique for the proposed converter model. There are different closed-loop control blocks are used in this system. They are Voltage stabilization, and switching pulse generator are present in the control block. All these controllers are mainly used for analyzing the input power and output load variation in the given converter circuit and provide a signal to the controller. Based on the signal **Versatile Power Balanced Control (VPBC)** controller generate a duty cycle to the switch. Due to this switching operation, the DC to DC converter will provide the desired power to the load. It is represented that the VPBC control technique can balance the output voltage for line and load variations. The inherent capacity of the overall system is maintained for high power factor correction for any variation in input power and load. The simulation of the AC-DC converter and its operating values are presented; its accuracy will be validated with the theoretical analysis.

3.1 Modeling DC-DC converter

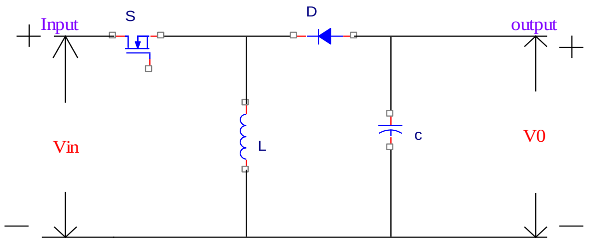

Figure 3: Circuit diagram for the DC-DC converter

Figure-3 describes the working principle proposed DC-DC converter system. During the continuous conduction mode of operation buck -boost converter, $V_L = V_{in}$ while the MOSFET is ON state, when the MOSFET is off state it can be expressed as $V_L = V_o$. For Zero net current changes over a period, the average voltage across the inductor is zero.

$$V_{in}t_{on} + V_o t_{off} = 0 \ldots (1)$$

Which gives the voltage ratio,

$$\frac{V_o}{V_{in}} = -\frac{Dt}{(1-Dt)} \ldots . (2)$$

And the corresponding current rate,

$$\frac{I_o}{I_{in}} = -\frac{(1-Dt)}{Dt} \ldots . (3)$$

Where,

$V_{in}t_{on}$=Input voltage and on time duration
$V_o t_{off}$= output voltage and OFF time duration
Dt=Duty cycle ratio of the PWM modulation
V_L = Line voltage

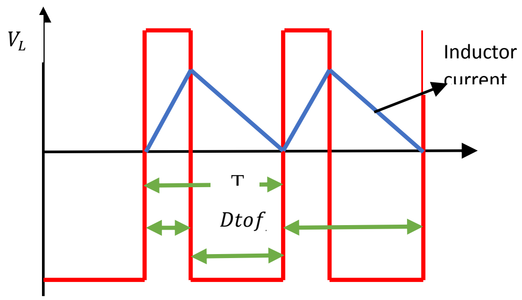

Figure 4: Inductor voltage and current waveform

Figure 4 presents the waveform for the buck-boost converter under different time duration. Since the MOSFET duty ratio "Dt" is between 0 and 1, during this time the voltage of the converter is varied from low to higher magnitude. Mainly operating ranges of the inductor describe the limitation between the continuous and discontinues conduction modes which is given by,

$$L_1 = \frac{(1-Dt)^2}{2Dt} \ldots (4)$$

3.2 Modes of operation for a proposed DC-DC converter

The cascade connection of buck converter and boost converter its circuit are illustrated in **Figure 5.** The circuit will clearly describe the operating modes of the buck converter and boost converter under different switching condition, due the system needs this converter topology will be operated in buck mode.

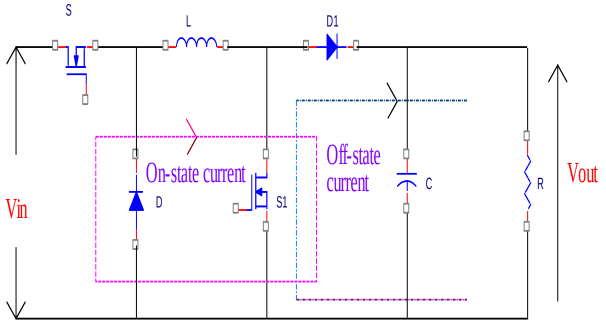

Figure 5: cascaded Buck-Boost converter Circuit

This combined buck and boost converter circuit is reduced the component usage, but the working and operation of this modified converter will perform the ideal characteristics of buck-boost converter.

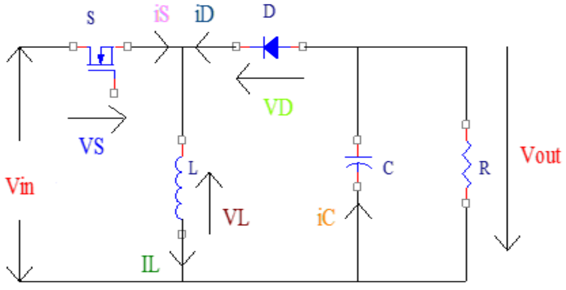

Figure 6: Modified Buck-Boost converter circuit

Figure-6 describes this combined dual operation in the DC-DC conversion process.

3.2.1 Continues inductor current operation

The differential circuits of the proposed converter for on-state and off-state of MOSFET are shown in **Figure 7(a) and 7(b)**. During the “on condition” of switch ‘S' the voltage passing through inductor becomes $\mathrm{V_{in}}$ and current across the inductor increases. The diode is reversed biased with the voltage $\mathrm{V_{in}} + \mathrm{V_{out}}$. Hence the entire load current is delivered by the capacitor C. During the time that switch ‘S’ is ‘off condition’, the inductor current becomes flat to passing the diode, and a breakdown voltage of V_{out} is developed across the inductor it will be causing a linear decrease in the current. In this condition the MOSFET voltage is $\mathrm{V_{in}} + \mathrm{V_{out}}$.

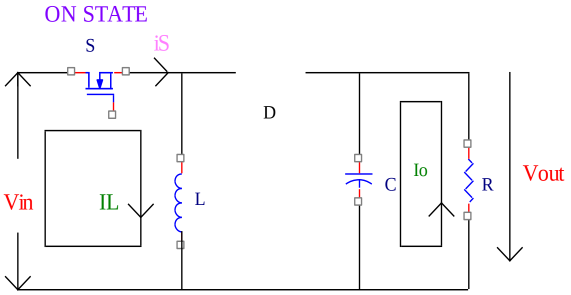

Figure 7(a): MOSFET ‘on’ state

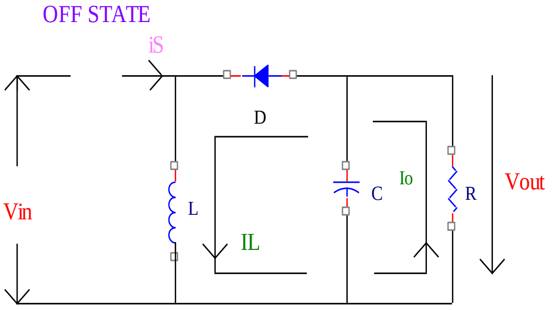

Figure 7(b): MOSFET ‘Off’ state

3.2.2 Inductor current

Inductor peak to peak ripple current is represented in Figure 7(a)

$$\Delta i_L = \frac{V_{in} D S_W}{L} = \frac{V_{out}(1-D) S_W}{L} \ldots (5)$$

The above equation 5 describes the average inductor current i_L which is capable of deriving the average working condition of MOSFET with a diode current.

Average diode current =output current

$$I_o = \frac{V_{out}}{R} = \bar{\iota}_L (1 - D) \ldots (6)$$

Average MOSFET current =input current

$$I_{in} = \bar{\iota}_L D \ldots (7)$$

Hence Average inductor current =input current +output current, i.e.

$$\bar{\iota}_L = \mathrm{I_{in}} + \mathrm{I_O} = \frac{\mathrm{I_o}}{1-\mathrm{D}} \ldots (8)$$

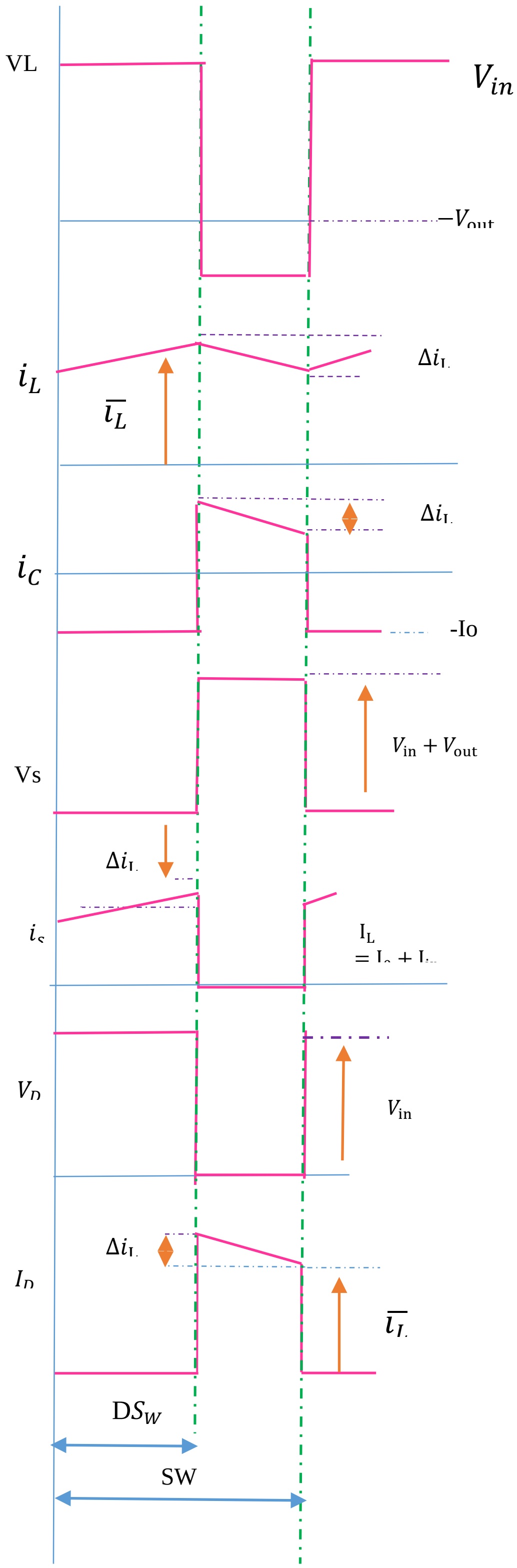

Figure 8: Continuous mode for DC-DC converter

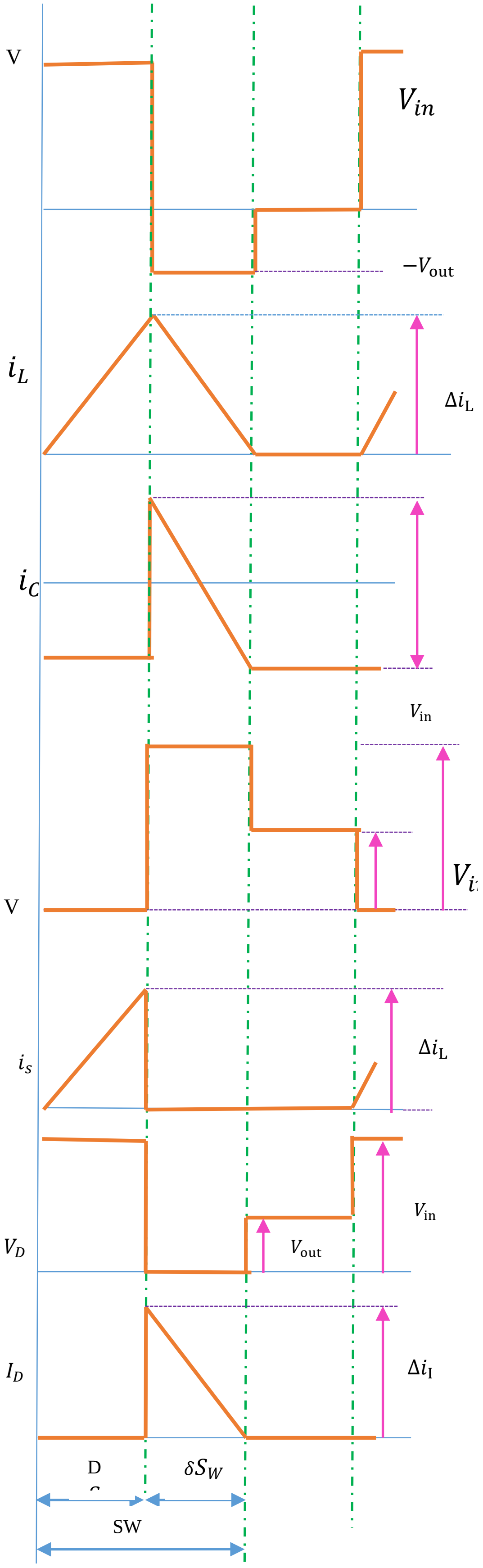

Figure 9: Discontinuous mode for DC-DC converter

3.2.3 Voltage conversion ratio

The voltage conversion of a buck-boost converter may be obtained from equation 5, which gives as,

$$V_{in} D S_W = V_{out}(1-D) S_W \dots (9)$$

$$\frac{V_{out}}{V_{in}} = \frac{D}{1-D} \dots (10)$$

Alternatively, the same expression (10) is used for equating the voltage variation of the inductor during on-state and off-state of the MOSFET.

Where,

S_W = MOSFET Pulse width modulation

The buck-boost converter under continuous and Discontinues modes of operation and its waveforms are represented in Figure 8 and Figure 9. The modes of operation are obtained from the inductor current i_L, inductor voltage V_L, the capacitor ripple I_c and the circuit voltage and current.

3.3 Discontinuous inductor Current operation

The discontinuous inductor current waveform is shown in **figure 9.** A supplementary mode appears the following the inductor current i_L, falls to Zero, and the inductor current turns out discontinuous mode. During this state, MOSFET and diode do not conduct any current. Figure 10 denotes the proposed converter circuit diagram under discontinues modes of operation. Let δs to be the time taken for the inductor to fall zero after MOSFET is turned off.

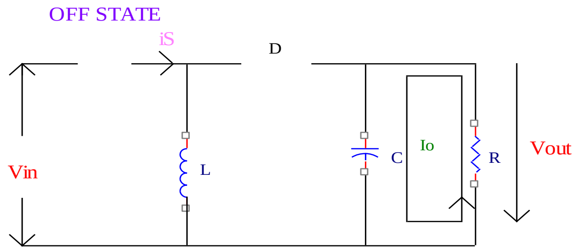

Figure 10: Discontinuous mode circuit diagram for the converter

3.3.1 Voltage conversion for the converter

The voltage conversion ratio of a DC-DC converter may be obtained by equating the input and output power:

$$V_{in} I_{in} = V_{in} \frac{\Delta i_L}{2} D = V_{in} \frac{V_{in} D S_W}{2L} D = \frac{V_{out}^2}{R} \dots (11)$$

$$\frac{V_{out}}{V_{in}} = \frac{D}{\sqrt{k}} \dots (12)$$

Where $k = \frac{2L}{RS}$, is the output voltage during discontinuous mode which greater than the continuous mode output level from the same duty cycle, and the conversion ratio varies linearly D.

3.3.2 Boundary condition for discontinuous conduction mode

During Discontinuous operating mode, the inductor ripple current $\frac{\Delta iL}{2}$ is larger than its average current

$$\frac{\Delta iL}{2} > \overline{\iota_L} \ldots (13)$$

Hence,

$$\frac{(1-D)V_{out}S_W}{2L} > \frac{I_{out}}{1-D} \ldots. (14)$$

And gives;

$k < (1-D)^2$ For the discontinues operation.

Where,

K is the duty ratio

The stabilize output voltage is achieved when the buck-boost converter is operated in dual modes of operation.

3.4 Modeling and Analysis of Single phase AC-DC converter

The coordinated synchronous operation of the single phase AC to DC converter are described in this section. The objective of the proposed converter is increasing the power quality in terms of power factor stabilization at the source side and also regulate the DC voltage for the load system. The transformer less conversion takes a major advantages to have less weight and cost of the system, additionally an advanced switching strategy makes a balancing output voltage under varying the load and the source power.

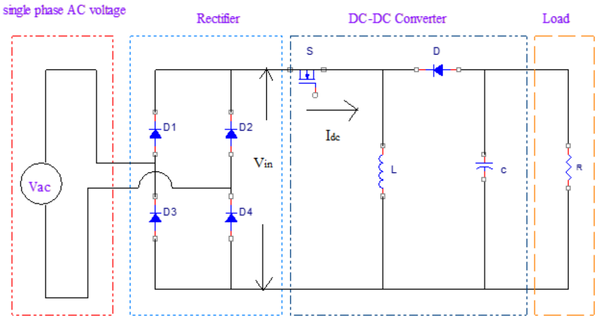

Figure 11: Modeling of single phase AC to DC converter system

Figure 11 illustrates the circuit diagram for the proposed AC/DC converter. In above circuit diagram it clearly shows that the proposed converter will be performed with similar components only they are D1, D2, D3 and D4 for the Full bridge rectifier and buck-boost converter MOSFET 'S' and inductor L, Filter capacitor C, diode D and the load resistance R.

The input power V_{ac} is directly connected to the rectifier diodes (D1, D2, D3 and D4) .The rectification process of these diode is depend upon the positive and negative cycle of the AC source. During the positive half cycle the voltage will passing through the diode D1 and D4.For the negative half cycle the voltage will flows through D2 and D3. Hence this part of the circuit effectively provides continuous value of the DC output voltage.

The rectified DC output voltage is given as,

$$V_{in} = \text{Idc R} = \frac{2\text{Imax R}}{\pi} \ldots (15)$$

$$= 2\, V_{ac} \text{ max } \frac{R}{\pi[R_F+R]} \ldots (16)$$

$$= [\,\frac{2\ V_{ac}\text{ max}}{\pi}] - \text{Idc } R_F \ldots (17)$$

Where,

V_{in}=voltage Flow in dc circuit

I_{dc}=current flow in dc circuit

R_F= diode forward resistance

R=load resistance

V_{ac} = Input source voltage

A non-isolated transformer less DC-DC converter is presented in **Figure 11.** The buck-boost consists of, controlled Switch (MOSFET) 'S', DC source voltage V_{in}, Inductor L , diode D, Filter capacitor C, and the resistive load R. For the switching characteristics of the buck-boost converter it performs will be verified. During the on state of the MOSFET'S' the current passing through the inductor is high. When OFF state of the MOSFET 'S' the inductor current flows through a diode D. From this condition represents the divergence of the diode and the inductor current will drop from the output.

The determination of Zero-volt for the inductor in the normal state is represented as,

$$V_{ac}DS_W = -V_{out}(\text{1-D})\, S_W \ldots (18)$$

Hence, the voltage of the converter is,

$$\text{MV} = \frac{V_{out}}{V_{ac}} = -\frac{\text{D}}{(1-\text{D})} \ldots (19)$$

The output voltage of the converter V_{out} negative sign with respect to ground. The present magnitude can be varied with the limit of (D=>0.5) for the source voltage.

The inductor value that will limit the continuous and discontinues modes of operation is

$$\text{L} = \frac{(1-\text{D})\text{R}}{2\text{F}} \ldots (20)$$

3.5 Versatile Power Balanced Control (VPBC) Technique for synchronizing the AC-DC converter

For the synchronizing the power quality improvements of the proposed AC-DC converter, a **Versatile Power Balanced Control (VPBC)** based controllers and the operations are analyzed in this section. **Figure 12** shows the proposed converter with VPBC controller which effectively optimize the error present in the AC-DC conversion system.

In this section, the proposed model has examined the dynamical performances of the proposed Converter. By enhancing the AC-DC conversion in the model, the dc values, phase angle shifts, voltage ripples and stabilize voltages of the buck-boost converter are stabilized using VPBC optimization technique.

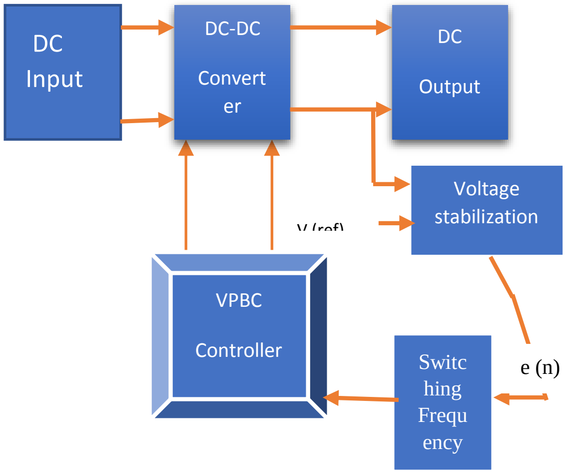

Figure 12: Versatile Power Balanced Control (VPBC) optimization technique

3.5.1 Optimization of single state AC-DC converter using Versatile Power Balanced Control (VPBC) Technique

The **Versatile Power Balanced Control (VPBC)** technique presented here is logical, and a step by step process is explained by considering a single Phase AC-DC converter as a model.

Step 1: Determine the AC/DC converter parameters concerning the stability converter design. Circuit topology: Full-bridge, Buck-boost converter Power Output.

Step 2: For analyzing the power conversion of the AC/DC converter, various parameters like Voltage stabilization, Reference Error calculation, and its run time signal are obtained and evaluated.

For evaluating the e (n) error signal and its equation are given below,

For the change in load voltage the different signal is produced like e (k), e (k-1)…e (k-∞). With the reference signal e(r).

By obtain this above equation the error signal is verified by below equation (21),

$$\mathrm{e(n)} = \frac{\mathrm{e(k-1)-e(r)}}{\mathrm{e(k+1)-e(r)}} \ldots (21)$$

Step 3: The obtained error signal e (n) is given as the feedback signal to the proposed controller VPBC.

Step 4: The proposed VPBC controller will compensate the error signal e (n) to make it more adjustable to external factors, and then it sends the compensated signal p (n) to the DC-DC converter.

The compensation of the error signal e (n) and gain value of P (n) is calculated below,

$$\mathrm{P(n)} = \int_{t_0}^{t} u(n)dt + p_o \ldots (22)$$

Where,

$\mathrm{P(n)} = \mathrm{Gain\ pulse\ generator}$

$\mathrm{u(n)dt} + \mathrm{p_o}$

$= \mathrm{is\ the\ vector}$

$- \mathrm{valued\ function\ of\ the\ current\ simulation}$

time t.

Step 5: At last, the controlled p (n) and the state signal determine the duty ratio with least switching Frequency, to control the converter switch (s) with the regular variation of the I/O.

Step 6: Due to the proper switching pulse, the regulated output power is given to the load. The load may be varied with slight variation during the execution period.

Step 7: Finally the stabilized output DC voltage with an improved power factor is obtained through Versatile Power Balanced Control (VPBC).

4. Results and discussion

The simulation result of the proposed single phase AC-DC converter with closed-loop control of versatile power balanced control (VPBC) technique is presented in this section. The overall system is developed in MATLAB 2017 b Simulink environment.

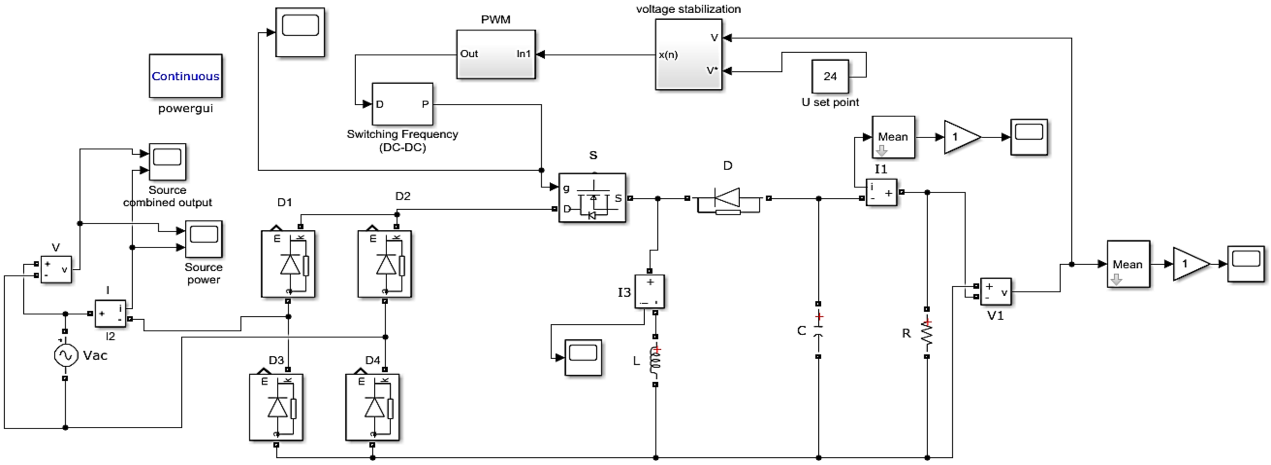

Figure 13: Simulation Model of the Proposed AC to DC converter

Figure 13 represents the proposed simulation for a single phase AC/DC converter using Versatile Power Balanced Control (VPBC) optimization which effectively improves the performance of the overall Model.

Table 1: Design Parameters Ranges for proposed AC/DC Converter

Parameters	**Values**
V_{in} (RMS)	230 ±10 % V
V_{out}	24V
Maximum Load	1000W
MOSFET Switching Frequency	5kHz
Input power factor	0.9715
Inductor	100e-4 H
capacitor	400e-8 Farad
Diode(forward voltage)	0.8V
MOSFET(internal diode resistance)	1e-6 ohms

Table 1 describes the Design parameters and its ranges for the proposed converter model. In this system lesser components are used to make energy efficient operation during the power conversion process.

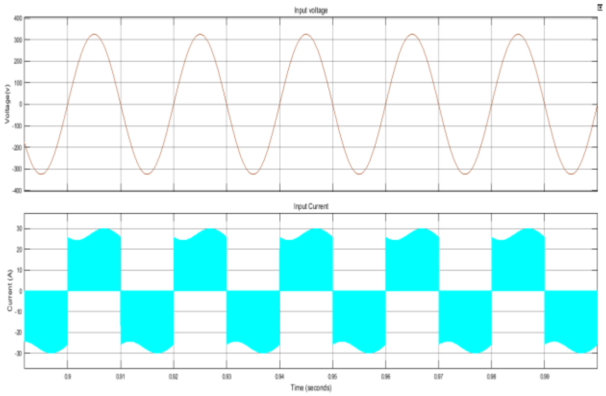

Figure 14: Source Voltage and Current Waveforms

Figure 14 illustrates source current and voltage waveform both are in phase with each other under the differential time period. The waveforms confirm the power factor is unity with respect to any load.

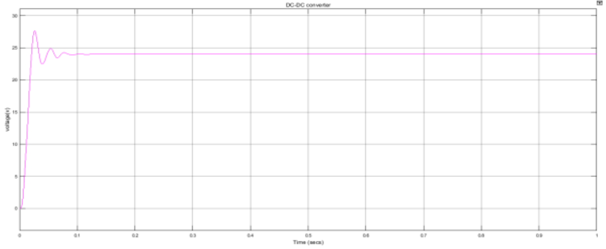

Figure 15: DC-DC converter output voltage

Figure 15 shows the DC-DC converter output voltage from the conversion of the source voltage. The y-axis shows the converted DC voltage =24V with respect to time.

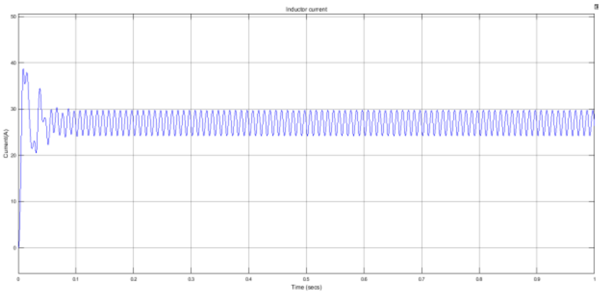

Figure 16: Inductor current waveform

Figure 16 represents the waveform of the saturated current limit of the Inductor during Buck-boost converter operation. During the power stabilization process, the inductor current ripple is maintained between the lowest possible limits.

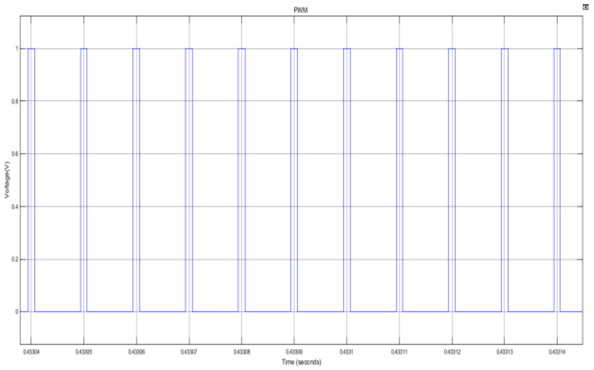

Figure 17: Switching frequency For the converter

Figure 17 shows the switching Frequency of the proposed converter system the waveform that represents the Y-axis shows the voltage =1V for the Pulse Width is 4 $\mu s/\mathrm{div}$.

Table 2: Comparison of Power factor variation with an existing controller for single stage AC/DC converter

S. No	**Controller Used**	**Power factor (P.F)**	**Load(W)**
1	ANFIS	0.9908	0
		0.9889	200
		0.9814	400
		0.9789	600
		0.9705	800
		0.9675	1000
2	VPBC	0.9989	0
		0.9910	200
		0.9886	400
		0.9823	600
		0.9775	800
		0.9715	1000

Table 2 demonstrates the comparison of power factor variation esteems got from AC/DC single stage

converter with a conventional technique like Adaptive Neuro-fuzzy (ANFIS) and proposed Versatile Power Balanced Control (VPBC) technique.

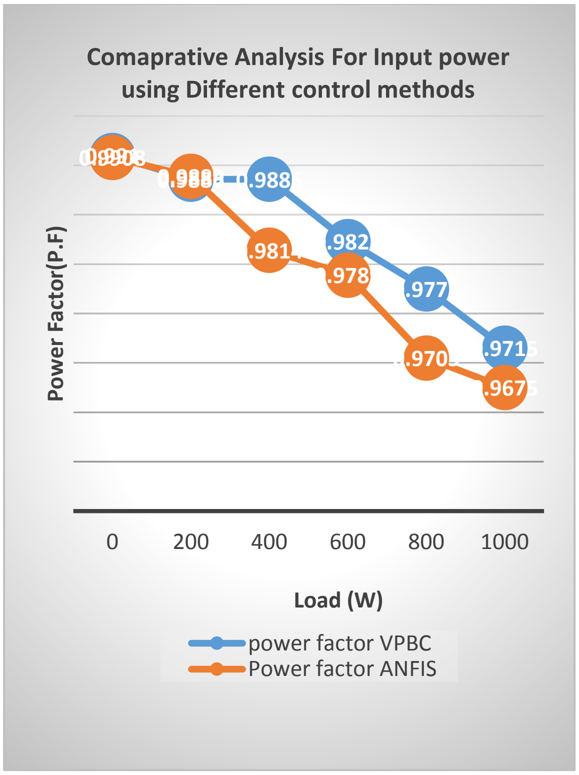

Figure 18: power factor analysis for the existing and proposed technique

Figure 18 describes the comparative study for the proposed Versatile Power Balanced Control (VPBC) technique and the conventional Adaptive Neuro-fuzzy (ANFIS) technique. In that waveform, Y-axis shows the power Factor values, and the X-axis shows the Load variation up to (0-1000) watts. The proposed VPBC method provides Effective result in the comparative analysis.

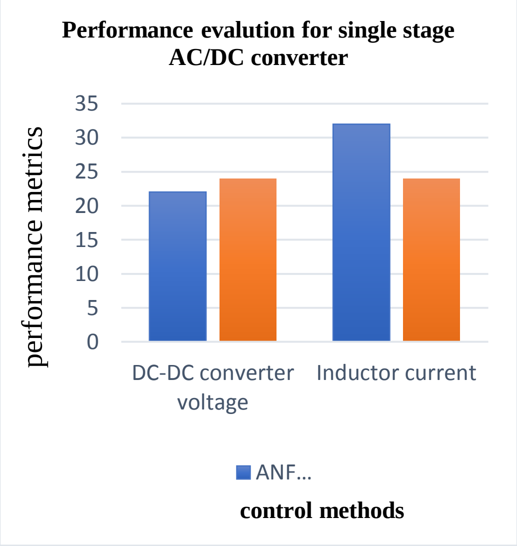

Figure 19: Performance evaluation of the proposed model

Figure 19 represents the performance Evaluation for proposed power conversion model with various parameters like 1.DC-DC converter voltage, 2.inductor current Based on the chart the proposed Versatile Power Balanced Control (VPBC) controller produce better results compared with the Adaptive Neuro-fuzzy (ANFIS) control technique.

Table 3: Efficiency calculation for AC/DC converter

Load(watts)	Efficiency
0	0
100	55.55%
200	67.69%
300	73.88%
400	77.27%
500	80.08%
600	85.00%
700	85.55%
800	85.71%
900	90.69%
1000	91.11%

Table 3 describes the Efficiency analysis of the proposed model for different load power in watts. The proposed Versatile Power Balanced Control (VPBC) controller produced an effective result of 91.11% of efficiency for Full load condition.

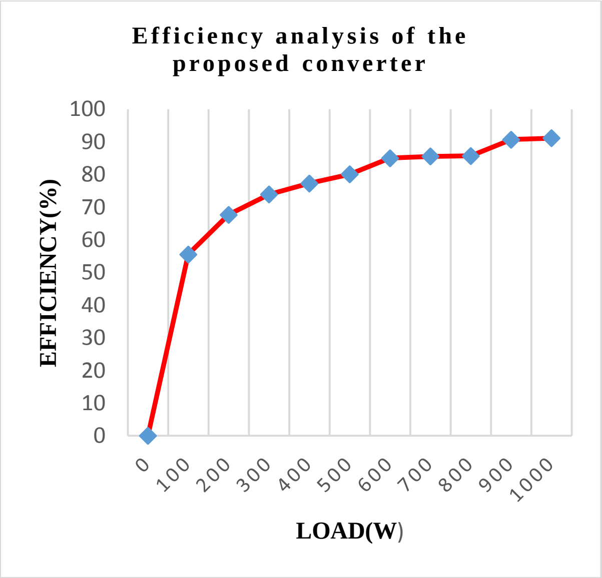

Figure 20: Efficiency analysis of the proposed system

Figure 20 shows Efficiency analysis of the proposed converter model**.** The waveform clearly describes the Efficiency improvement of the proposed model for the load power (0-1000) watts.

Table 4: Performance analysis for AC/DC converter using features of the proposed and existing system

Comparison feature	ANFIS	VPBC
cost	High	Low
Physical structure	Large	Compact
Resistance to the work environment	Complicated	Easy
Finding fault	Hard	Because of complex circuit Finding fault is Simple
communication	Easy	Simple
Production planning	Moderate	Easier
security	Moderate	Reliable

The above **table 4** compares the features of the proposed controller with that of an existing one. From the above, various feature analysis, the proposed Versatile Power Balanced Control (VPBC) technique produce an effective result and the conventional Adaptive Neuro-fuzzy (ANFIS) technique**.**

5. Conclusion

A single phase AC to DC converter with soft-switching technique has presented in this work. The comprehensive analysis of the buck-boost converters implementation has been studied, and its performance characteristics are evaluated. The computation of the system that describes the proposed **Versatile Power Balanced Control (VPBC)** technique has several benefits. First, the proposed buck-boost converter that is charged over the off period; the current stress is across the MOSFET switch is alleviated. In a further development, the power factor is improved by 0.9715(P.F); its ranges are near with unity power factor. The advanced model AC to DC converter design will maintain a constancy input power it stability will depend on the average "charging" and "discharging" current of an inductor which will automatically compensate with the help of VPBC controller. Due to this operation, a linear connection between the line voltage and current through the normal working operation is achieved with regular intervals of time. As a result, nearly unity PF is present in the input system. The output voltage of the proposed converter model is always constant for any load condition (0-1000) watts. The proposed circuit has an excellent dynamic response. The proposed PFC circuit is valid for differential loads. From the simulation results efficiency of the proposed converter model is being higher than 91.11% at rated load.

REFERENCES

1. Bruno R. de Almedia, Jose W. M. de Araujo, 2018 'A single-stage three-phase bi-directional AC/DC converter with High-Frequency Isolation and PFC' IEEE Transactions on Power Electronics, Volume.33, No.10, PP.8298-8307.
2. Hongfei Wu, Lei Zhu, Fan Yang,2018 'Three-port-converter-based single phase bi-directional AC/DC Converter with the reduced power processing stages and improved overall Efficiency' IEEE Transactions on Power Electronics, Volume.33,No.12,PP.10021-10026.
3. Hongfei Wu, Yanfeng Zhang, & Yihang Jia, 2018 'Three-port Bridgeless PFC-based quasi single-stage, single-phase AC/DC converter for wide voltage range application' IEEE Transaction on Industrial Electronics, Volume.65, No.7, PP.5518-5528.
4. Fan Chen, Rolando Burgos, 2018 'A Bi-directional high-efficiency transformer less converter with common –mode decoupling for the interconnection of AC and DC grids' IEEE Transactions on Power Electronics, Volume.32, No.2, PP.1317-1333.
5. V.V.Burlaka, S.V.Gulakov,2017 'A three-phase high-frequency AC/DC converter with power factor correction' Russian Electrical Engineering, Volume.88,No.4,PP.219-222.
6. Szymon Piasecki, Robert Szmurlo,2014 'Design of AC/DC gird connected converter using Multi-objective Optimization' Electrical Control and Communication Engineering, Volume.5,No.1,PP.11-19.
7. Chushan Li,Yu Zhang & Zhifang Cao, 2017 'single-phase single stage Isolated ZCS current-fed Full-bridge converter for high power factor AC/DC converter application' IEEE Transaction on Power Electronics, Volume.32,No.9,PP.6800-6812.
8. Udupi R. Prasanna, Anant Kumar Singh b, 2017 'Novels bi-directional single-phase single stage isolated AC-DC converter with PFG for charging of Electric vehicles' IEEE Transaction on Transportation Electrification, Volume.3,No.3,PP.536-544.
9. Zhuang Xu, 2015 'An Indirect space-vector modulated three-phase AC-DC matrix converter for a hybrid electric vehicle' International conference on applied energy, Volume.75, PP.1968-1974, conference venue-china.
10. Nor Azura Samsudin, Dahaman Ishak, 2018 'Design and experimental evaluation of a single-stage AC/DC converter with PFC and hybrid full-bridge rectifier' Engineering science and technology, An International Journal, Volume.21, No.2, PP.189-200.
11. Zhi Zhang, Hao Zhou, and Chang Liu, 2018 'A single-stage bridgeless ZVS AC/DC converter for power-factor-correction application' IEICE Electronics Express, Volume.15, No.8.PP.1-9.
12. Mehdi Narimani, Grey Moschopoulos, 2015 'Anew interleaved three-phase single-stage PFC AC-DC converter with Fluing capacitor' IEEE Transactions on power Electronics, Volume. 30, No.7, pp.3695-3702.
13. Ae-Won yang, Hyun-Lark Do, 2013 'Soft-switching buck PFC converter for a High-efficiency AC-DC LED

drive' in International Review of Electrical Engineering, Volume. 8, No. 6.

14. Sin-Woo Lee, Hyun-Lark Do, 2016 'An isolated bridgeless AC-DC PFC converter using an LC resonant voltage doubler rectifier' in International Journal of Electronics, Volume. 103, No. 12, pp. 2125-2139.
15. Jordi Events, Florian Krismer, 2014 'Optimal ZVS Modulation of single-phase single-stage bidirectional DAB AC-DC converters' IEEE Transactions on power Electronics, Volume. 29, No. 8, pp. 3954-3970.
16. M.Narimani, G.Moschopoulos, 2013 'Anew single-phase single-stage three level power factor correction AC-DC converter with phase-shift modulation' IEEE Transactions on Industrial electronics, Volume. 60, No. 9, pp. 3731-3735.
17. Dhua, Debasis, Huang, Shaojun, 2017 'Optimal power flow modeling, and analysis of hybrid AC-DC grids with off-shore wind power plant' International conference on power and energy system Engineering, pp. 572-579.
18. Pritam Das, Majid pahlevaninezhad, 2013 'Analysis and design of a new AC-DC single-stage full bridge PWM converter with two controllers' IEEE Transactions on Industrial Electronics, Volume. 60, No. 11, pp. 4930-4946.
19. Chung-ming young, ming-hui chen & Shou-heng yeh, 2012 'A single-phase single-stage high step-up AC-DC matrix converter based on Cockcroft-walton voltage multiplier with PFC' IEEE Transactions on power Electronics, Volume. 27, No. 12, pp. 4894-4905.
20. R.Abdollahi, 2015 'Harmonics mitigation using 36-pulse AC-DC converter for direct torque controlled induction motor drives' Journal of applied research and technology, Volume. 13, No. 1, pp. 7-167.
21. L.S Yang, T.J Liang, Chen, 2008 'Analysis and design of a novel, single-stage, three-phase AC/DC step-down converter with electrical isolation' IET power Electronics, Volume. 1, No. 1, pp. 154-163.