Evaluation of various converters for decreased total harmonic distortion and progressed Power Factor

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Abstract—energy electronics is a enormous region in electrical engineering for research which incorporates different switching gadgets to manipulate and switching of electrical machines and drives for his or her output, velocity and torques and so forth. it has many programs in our ordinary life together with motor drives, and energy resources for pc. the 'modern' drawn by means of those devices is distorted so there is a need to use electricity element correction converter. on this paper a comparative evaluation of different topologies of ac–dc converter is completed for total harmonic distortion and enriched energy factor. the model is simulated in matlab and their outcomes are proven.

Keywords—THD; PFC; PFC Boost Converter; PFC Double Boost Converter.

I. INTRODUCTION

For the domestic cause of strength, we especially use 230 v and 50 hz deliver source that's in appropriate sinusoidal shape with time. But, to control the present day because of the impact of substation transformers and transmission traces through the magnetic flux impedance in energy device. This technique consequences in to the distinction of voltage among consumer end factor and substation supplying power end (less voltage on the client give up). Because of the boom in electronic devices results in to the mains driven digital devices which have mostly rectification circuits, creates the harmonic distortion. there are loads of inductive loads which attracts reactive energy from source. This consequences in reactive modern float and creates harmonic problems. these consequences in to the decrease electricity issue for loads and transmission system.

The active power principally depends upon the power factor mainly so it is better to have better power factor which upsurges the utilization of power. Hence, we always try to reduce the harmonic distortion and make better power factor [1, 2]. Here in this paper a method of power factor correction is discussed which compares the conventional rectifier, PFC boost and PFC double boost converter topologies for power factor improvement and to reduce the THD in the circuit. These are the different technologies which used to enhance the power factor in circuit and to reduce the THD. The simulation is carried out on MATLAB platform.

II. POWER FACTOR

The term Power factor [2-6] can be defined as the angle cosine between current flowing in to circuit and terminal voltage in any electrical AC (Alternating Current) circuit. The angle difference entirely depends on the nature of load if the load is inductive in nature then current lags the voltage by some angle and termed as lagging power factor load. Whereas capacitive load results in to the current leads voltage however, for the capacitive network, current goes ahead to the voltage so it is characterized as the leading power factor. In simple terms it can be defined as the proportion of real power to the apparent power.

A. Behavior of linear load

At the point when the heap takes absolutely sinusoidal molded current and the voltage frame the supply source then it is said to be the direct load. The term of the power factor in any system can be accounted by the cosine point distinction of the stage voltage esteem and the present an incentive in that system.

B. Non-linear load

Commonly, arc discharge devices like electric welding machines, arc furnaces, fluorescent lamps are the nonlinear loads and different power supplies constitutes the rectifier circuit's leads to nonlinearity of loads in power system, which contributes current other than fundamental frequencies of different multiplies of fundamental frequencies through them. Due to the switching action of rectifiers consistent disturbance of current takes place. The shape of current waveform gets deteriorate due to the harmonics present in flowing current in nonlinear loads which is not in sinusoidal nature. The amplitudes of different odd harmonics of the line current are substantial according to the fundamental frequency and these cannot be ignored.

III. VARIOUS FORMS OF POWER FACTOR

There are two basic components of power factor principally:

- Distortion power factor
- Displacement power factor

The second one is associated with phase angle while the first one is the part of the shape of waveform of current and voltages.

Power factor can be given by:

$$PF = \frac{I1rms}{Irms} COS\boldsymbol{\phi}$$

$$Kp = \frac{I1rms}{Irms}$$

$$Kd = COS\boldsymbol{\phi}$$

$$PF = Kd * Kp$$

Where I1rms is the fundamental component of current and *Irms* is the RMS (root mean square) value of the current itself.

Phase angle movement between the waveform of voltage and the waveform of current can be given by $\boldsymbol{\phi}$.
Distortion power factor is symbolized as Kp.
Displacement power factor is symbolized as Kd.

Calculation of power factor is completed as cosine angle amongst the current and voltage waveform if the waveform of the both current and voltage is totally sinusoidal, but most commonly non-sinusoidal current flows in reality from different power supplies. Distortion power factor comes in to the picture when current waveform is not in proper sinusoidal wave shape and the shape of voltage wave is sinusoidal which the ordinary case is and the displacement power factor comes into picture by phase displacement between the voltage and current waveform. This is mainly caused by the inductive reactance's presence in the power system and the distortion of harmonic is liable for other type of power factor which is distortion power factor. In reality, the value of RMS gets improved without any change in the power drawn from the source which is responsible for reduction of power factor in the power system. The other parameter which measures the distortion in the power supplies is the total harmonic distortion $(THDi)$[1] which is defined as follows:

$$Kp = \frac{1}{\sqrt{1 + (THDi)^2}}$$

$$THDi = \frac{\sqrt{\sum_{n=1}^{\infty} In\ rms^2}}{I1rms}$$

IV. CONVENTIONAL RECTIFIER

The chief objective of the rectifier is to transform the AC voltage supply into DC voltage supply. It can be connected directly to the loads as DC motors, furnaces; heater coils *etc.*, or for other conversion as in the point of UPS system, switched mode power supplies (SMPs), variable frequency AC drives (VFD), induction type of heating inverters *etc.*

There are two types of rectifiers are named as controlled type and uncontrolled type rectifiers. Various power electronics devices including the AC and DC drive uses the rectifiers at the input to change the different controllable parameters of the power supply.

Modeling, simulation and result of conventional rectifier:

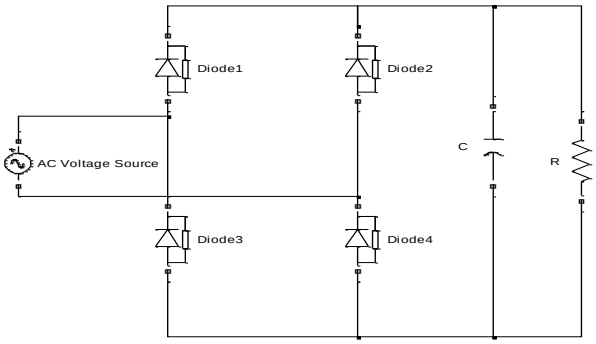

Fig 1. Conventional rectifier Simulink model

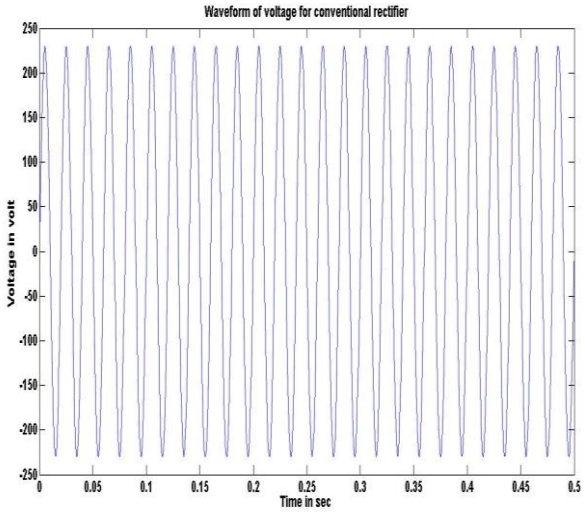

Fig. 2.Waveform of voltage for conventional rectifier

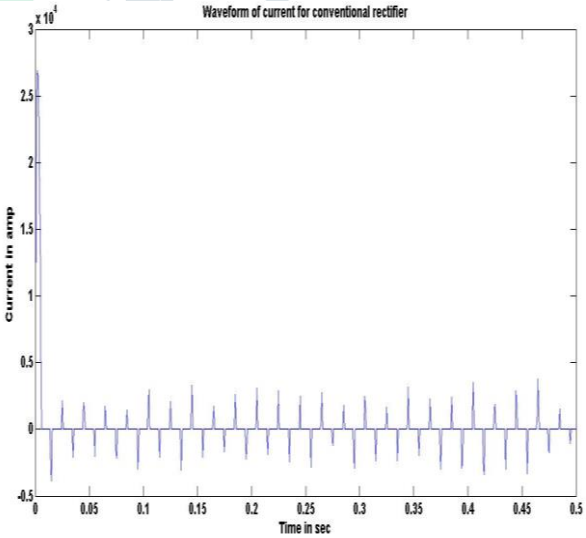

Fig. 3.Waveform of current for conventional rectifier

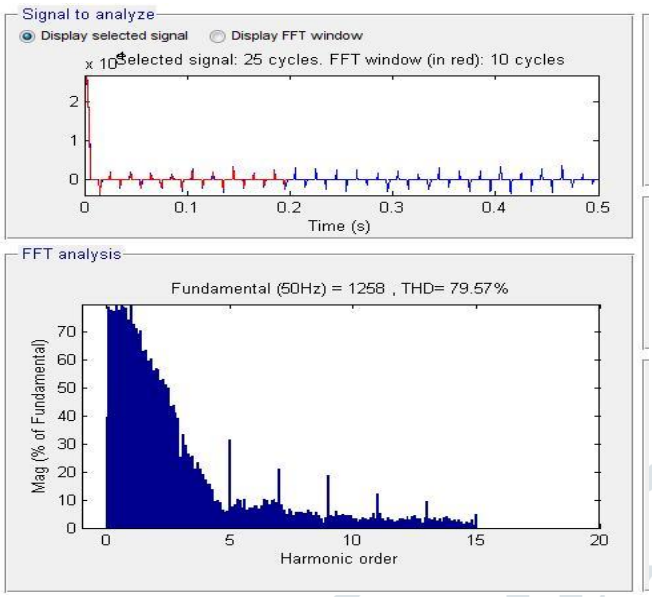

Fig. 4.FFT Analysis of input current

V. POWER FACTOR CORRECTOR (PFC)

With the aid of the usage of external tools reduced electricity component of deliver may be up surged or stepped forward in used power system. there are various methods to upsurge the energy thing of circuit via passive and active topologies. the passive topology carries the exercise of tuned lc circuit filters, which characterizes a strong and strong decision of it, however the elevated weight, length and results. whereas, the other type of topology (passive topology) won't solution again effectively if there are deviations inside the electricity aspect of load deliver takes place.

This is a modern concept for the power factor correction topologies. It can be understood as to make the power system to look like a totally resistive system means, to get restored power factor for the load supply. When the circuit is resistive and the power factor is 1.0 the ratio between current and voltage is also constant if it differs then it can be understood that the supply contains harmonic distortion and phase displacement or may be both and they will cause to worsen the power supply.

Types of PFC:

This can be classified as:

- Active Power Factor Correction (APFC)
- Passive Power Factor Correction (PPFC)

A. Active Power Factor Correction

Power electronic hardware's game plan that is intended to have charge over the amount of energy depleted by a heap and in returns it obtains a power factor which is most likely as close as to solidarity, this course of action is entitled as a dynamic PF adjustment. Ordinarily any PFC configuration capacities to make to take after the present waveform by the voltage waveform nearly by controlling the input current supply and it may be a sinusoidal waveform. To increase the line current shaping and to obtain the controllable output voltage supply a combination of reactive components and some active switches are used.

B. Passive Power Factor Correction

To improve the wave form of line current only passive factors are used with diode bridge rectifier by using this technique the price of strength issue may be elevated as much as 0.8 approx.

Advantages of Active Power Factor Correction:

- This type of system contains less weight.
- It lowers the harmonic content in the supply to very truncated values.
- The power factor better than 0.95 can be obtained by this means but has smaller dimension.
- Automated correction of electricity issue is likewise viable on this approach for ac input voltage.
- Can be operated on any range of voltage level.

VI. CONTROL TECHNIQUE OF CONVERTER

Under varying loads and input voltage conditions DC output voltage can be obtained from converters. With the change in temperature, pressure and time the values for converter component are changing. Using the application of negative feedback in closed loop system the output voltage should be controlled. Current mode control and voltage mode control are the two most common methods for closed loop control [7-10] of PWM type dc-dc converters.

Hysteresis contemporary mode manage (hcmc) technique is used for controlling of the converter on this paper which is accomplished for output voltage manage. the hcmc approach activates the igbt switch. every time, errors between reference present day and line contemporary exceeds a predefined significance cost: the hysteresis band. it requires a unmarried comparator with hysteresis according to section to govern the transfer.

The HCMC method has a constant off time and turn on time control [10]. Hysteresis comparators are execute to the hysteresis band through the system everywhere from predefined reference current which gives the excellent dynamic controlling as it works quickly on demand. It also delivers an intrinsic current limiting proficiency to the system. A narrow hysteresis band must be necessary to accomplish the smaller amount of ripple content in the input current coming from the source. however, then arrowed the hysteresis band, the higher the switching frequency. Based upon the circuit apparatuses together with magnetic additives and switching gadgets the hysteresis band must be superior [11-14]. With the exchange in line voltage the frequency also varies. When, the inductor current shrinkages beneath the reference input line current then the manipulate strategies takes place, which turns on the control transfer for controlling endurance and transfer is turned off when inductor present day grows above the reference input line current. It gives rise to the available frequency control [15-17].

VII. BOOST CONVERTER

The generation of enhance converter for percent correction isn't always so complicated or normal and allows low distorted contemporary for input with the strength thing of almost team spirit with the aid of the numerous categories of dedicated techniques inside the device. these numerous techniques are employed with average contemporary mode control, peak modern control, hysteresis manage in supply. the cutting-edge technology on- cycle control and self-control are also been employed for electricity thing growth of given energy supply to any device which s the primary cause of this paper.

Boost converter is a category of power converter which gives the DC output voltage which is higher than the input supplied to the converter and it can also be considered as a category of switching mode power supply (SMPS). The increase converter can be manufactured in exclusive configurations, but the simple production should include minimum two semiconductor switches (commonly a transistor and a diode) and should also have one electricity storing issue. increase converter has true self p.c [6] assets.

Modeling, simulation and result of PFC boost converter:

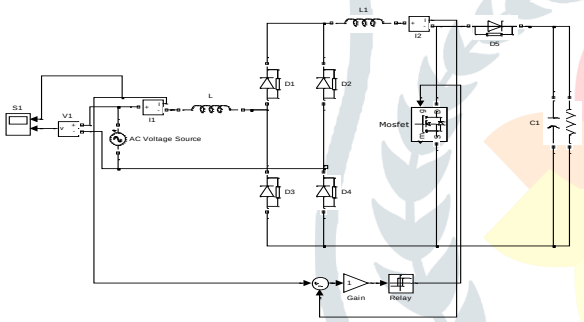

Fig. 5. Boost Converter Simulink model

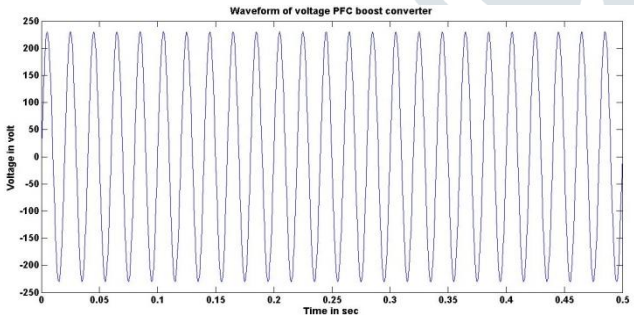

Fig. 6.Waveform of voltage for boost converter

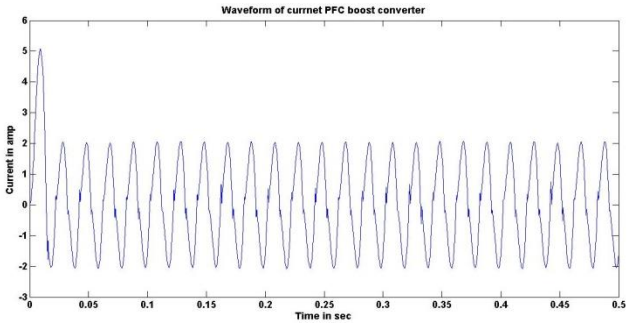

Fig. 7.Waveform of current for PFC boost converter

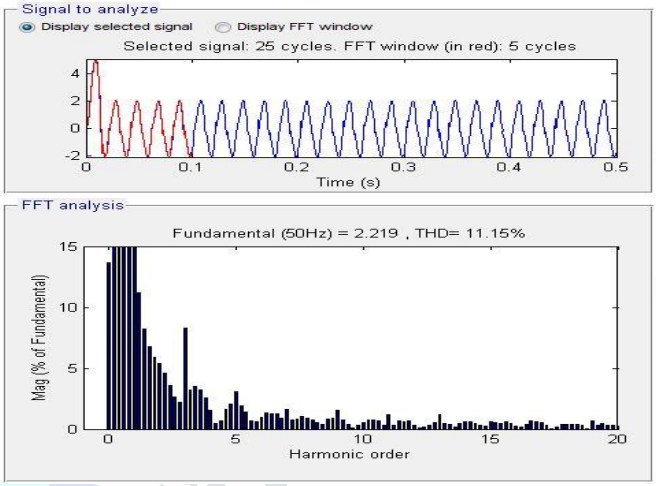

Fig. 8.FFT Analysis of inductor current

VIII. PFC DOUBLE BOOST CONVERTER

Double boost as the name suggest there must be two boost converters connected in parallel to each other, where L2 and T1 are for active filtering while L1 and T are the main switches [2-4].

Purpose of filtering Circuit

(1) Two or additional boost converters are involved in this which is associated in parallel and functions at the identical switching frequency.

(2) This Double boost converter diminishes the PFC total switching loss and increases the quality of line current. Due to the different values of switching frequency and current amplitude it diminishes the switching losses for two switches.

Modeling, simulation and result of PFC double boost converter:

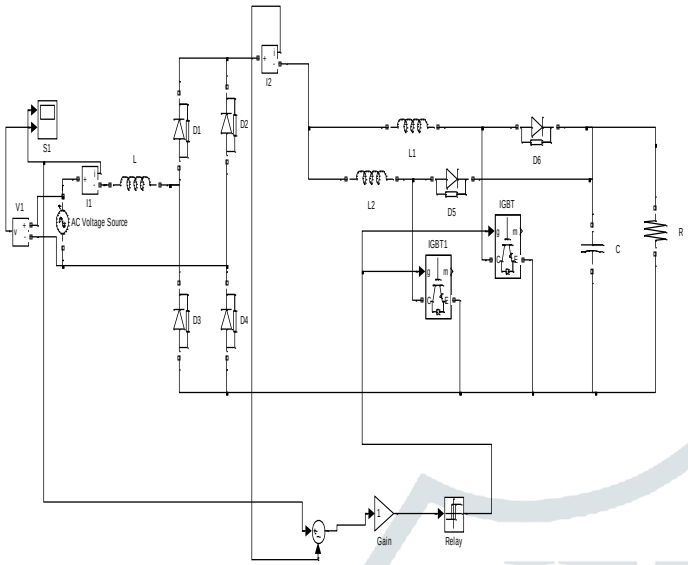

Fig. 9.PFC Double Boost Converter Simulink model

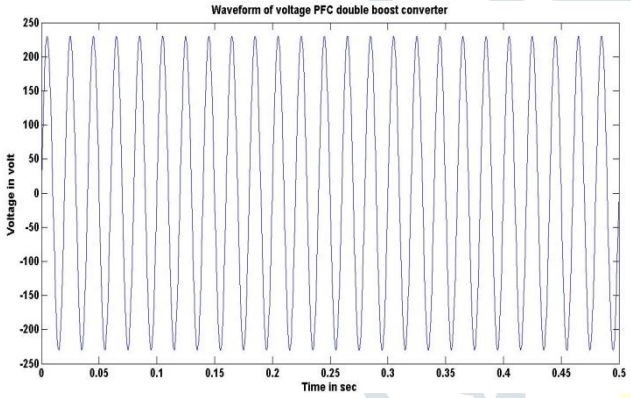

Fig. 10.Waveform of voltage for PFC double boost converter

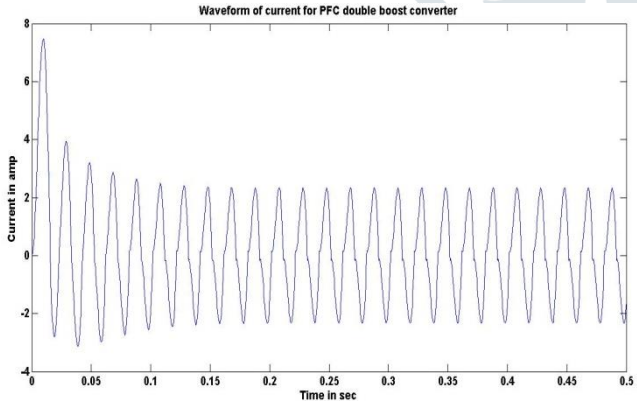

Fig 11.Waveform of current for PFC double boost converter

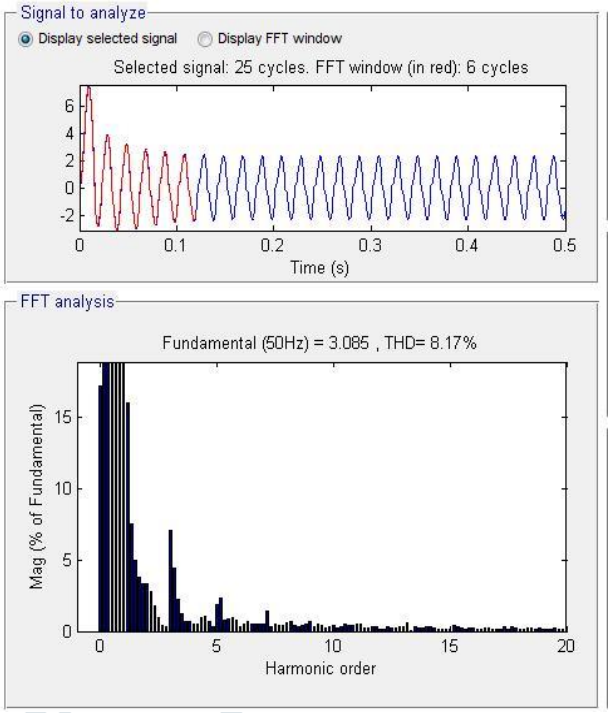

Fig 12. FFT analysis of inductor current

TABLE I. ANALYSIS OF PF AND THD

S.NO	TOPOLOGIES	THDi (%)	PF
1.	Conventional Rectifier	79.57	0.7825
2.	PFC Boost Converter	11.15	0.9938
3.	PFC Double Boost Converter	8.17	0.9966

IX. CONCLUSION

In this paper three topologies for power component correction are in comparison for the reduction in modern-day supply and to enhance the energy issue of load deliver in power device. this paper has mentioned approximately the 3 strategies to improve the strength element of load deliver that are; conventional rectifier topology, percent increase converter topology and percent double enhance converter topology. conventionally, the rectifier topology changed into in exercise to improve the strength component however now, one-of-a-kind technology are being used for the equal purposes and the % improve converter topology and p.c double raise converter topology are also one in all them.

The reproduction result for these three topologies is appeared here in waveforms and the information is likewise appeared in table. Based on these waveforms and table it can be inferred that PFC twofold lift converter has magnificent power factor redress capacity The PFC boost converter technology is also better than conventional rectifier technology which also has improved the power factor and reduced the THD in current supply. The PFC double boost converter topology has best

power factor which is 0.9966, better than other topologies and THD is also less only 8.77% is also the lowest of all three topologies. These both components of power supply can also be further improved by applying other soft computing techniques.

REFERENCES

[1] P. Vijaya Prasuna, J. V. G. Rama Rao, Ch. M. Lakshmi, "Improvement in Power Factor & THD Using Dual Boost Converter," *International Journal of Engineering Research and Applications (IJERA)*, Vol. 2, pp. 2368-2376, Issue 4, July-Aug.s 2012.

[2] S. Bhattacharya, D. Divan, and B. Banerjee, "Control and reduction of terminal voltage total harmonic distortion (THD) in a hybrid series active and parallel passive filter system," *IEEE PESC*, pp. 779-786, 1993.

[3] J. Spangler and Anup Behera, "A comparison between hysteretic and fixed frequency boost converters used for power factor correction," I*EEE PESC*, pp. 281 - 286, 1993.

[4] J. Zhang, M.M. Jovanovic, F.C. Lee, "Comparison Between CCM Single-Stage and Two-Stage Boost PFC converters", *IEEE Applied Power Electronics Conference and Exposition,* Vol. 1, pp. 335-341, 1999.

[5] A. Karaarslan, I. Iskender,"The analysis of ac-dc boost pfc converter based on peak and hysteresis current control techniques" *International Journal on Technical and Physical Problems of Engineering*, June 2011, Issue 7, Vol. 3, pp. 100-105, 2011.

[6] M.H. Rashid, "Power Electronics Handbook: Devices," Circuits, and Applications", *Academic Press*, Vol. 19, pp.525-530, 2006.

[7] N.A. Rahim, J. Selvaraj, C. Krismadinata, "Hysteresis Current Control and Sensorless MPPT for Grid-Connected Photovoltaic Systems", *Proc. IEEE ISIE*, pp. 572-577, 2007.

[8] A. Karaarslan, I. Iskender, "The Analysis Of AC-DC Boost PFC Converter Based On Peak And Hysteresis Current Control Techniques", *International Journal On Technical And Physical Problems Of Engineering, Issue.* 7, Vol. 3, No. 2, Jun. 2011.

[9] G. D. Capua, S. A. Shirasavar, M. A. Hallworth, N. Femia, "An enhanced model for small-signal analysis of the phase-shifted full-bridge converter", *IEEE Trans. Power Electron.*, vol. 30, no. 3, pp. 1567-1576, Mar. 2015.

[10] D. K. Dhaked and M. Lalwani, "A Review Paper on a D-FACTS Controller: Enhanced Power Flow Controller", *International Journal of Advances in Engineering and Technology (IJAET)*, Vol. 10, Issue 1, pp. 84-92, 2017.

[11] Y. Tang, A. Khaligh, "A Multi Input Bridgeless Resonant DC-AC Converter for Electromagnetic Energy Harvesting," *IEEE Transaction on Power Electronics*, PP. 1-9, 2015.

[12] Mohd. Kashif, B. H. Khan, "Multi-input converter with regulated output voltage for series connected renewable energy systems", *Power Systems (ICPS) 2016 IEEE 6th International Conference on*, pp. 1-6, 2016.

[13] D. K. Dhaked and M. Lalwani, "Modelling and analysis of a D-FACTS device: Enhanced Power Flow Controller" *i-managers Journal on Electrical Engineering (JEE)*, Vol. 11, Issue 1, pp. 41-49, 2017.

[14] V. K. Tayal, J. S. Lather, P. Sharma and S. K. Sinha, "Power System Stability Enhancement Using Fuzzy Logic based Power System Stabilizer" *Proceedings of the Third International Conference on SocPros 2013 , Advances in Intelligent Systems and Computing 2013* ,Vol. 259, pp. 55-68, 2013.