A New Power Factor Correction Technique using PFC Boost Converter

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ABSTRACT

The utilization of power is based on the power quality and ideally our power quality should be 1.0 for better efficiency and the qualitative power should be send from the sending end to the receiving end. By qualitative power it means that the transmission of the power has negligible losses. In electrical system the harmonics are present due to the nonlinear loads which includes rectifiers, variable speed drives etc. that use switching mode power supply (SMPS).They are typically found in the blade servers. By power factor correction, in this paper, would be able to exterminate the harmonics up to a greater extend or the problem of low power factor can greatly improve. The power converter i.e., here the boost converter with power factor correction draws a sinusoidal AC current which is in phase with the voltage i.e., AC input voltage. The main objective of the paper is how the power factor is corrected up to greater extend by using of the boost converter and get the desired results of the AC current which will be in phase with the voltage and by using the technique like tunning PI controller. By tuning the PI controller in the PFC boost simulation circuit, PI controller shows minimum crossover distortion of the input current . It also shows low distortion of harmonics and very low tracking error when compared to the PI controllers which are conventional in nature. Furthermore, in this paper by using the PI controller technique, keeping the voltage and load variable during the simulation and will check the results of the graph that if there is any variation in the output voltage. Large amounts of currents are to be drawn if the power factor of the system is poor so, power factor correction helps us to achieve the good power. There are many converters that are used in the PFC but mainly Boost converter is used because it is simple and it gives excellent performance of Power factor.

KEYWORDS: *Bridge boost ac-dc converter, Continuous Conduction Mode, Power Factor Correction (PFC)*

INTRODUCTION

Rectification is a process in which electric power is converted from AC to DC. It is widely used in many applications as most of electronics appliances nowadays require DC power[1]. Conventional AC-DC converters, such as Bridge rectifiers, have been developed for this purpose but there are few factors to be controlled in this regard. The No sinusoidal current drawn at the input side results in lower distortion as well displacement factors. Commanding the line current to follow the line voltage in a sinusoidal manner can gives higher efficiency with improved power factor and lower THD[2]. AC side power factor (PF) is needed to be improved along with lowering of Total Harmonic Distortion of input line current. Tight regulation of the output voltage even in the case of dynamic loads is also a stringent requirement of DC-DC converters. A controller that simultaneously controls both the input as well as the output parameters is the choice. .To gain a high power factor, different power factor correction (PFC) techniques have been introduced which can be divided into two parts, passive and active. Passive techniques consist of passive components such as inductors and capacitors that are used as input filter to

reduce line current harmonics[3]. However, improvements are not significant and another drawback is the relatively large size of these passive elements. Moreover, these techniques may not be able to handle dynamic loads[4]. On the other hand, active PFC techniques more efficient solution, having a combination of switches and passive elements. Due to presence of switches, controllers can be implemented on active techniques of PFC[5]. At the cost of complexity, the controlled active techniques can increase Power factor and reduce THD in the input AC current. Along with it active techniques can also bring precise DC regulation for variable loads.Fig-1 represent the Schematic diagram of booost PFC converter[6].
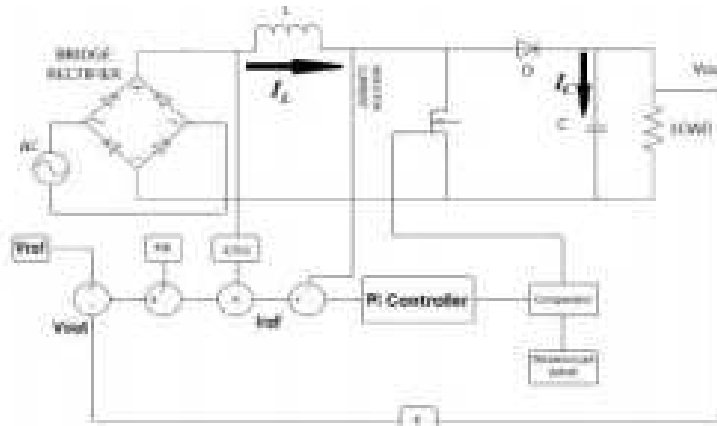
Fig-1 Schematic diagram of booost PFC converter

MATLAB simulink: The circuit consists of an internal current loop and an external voltage loop, and the two loops are connected together by a multiplier. There are two input ports of the multiplier. One is the AC sinusoidal half wave signal, which is the rectified given AC sinusoidal wave signal; the other one is the difference of the output DC bus sampling voltage and the reference voltage, and the difference will go through a first order process and the amplitude will be limited. The output of the multiplier is also an AC sinusoidal half wave signal, whose amplitude is regulated by the output DC bus voltage. The multiplier output works as the reference value of the current loop, and it is compared with the inductor sampling current and outputs the result to the PI controller and get adjusted, and at last PWM drive signal can be generated and control the operation of the MOSFET (shown in fog-2).
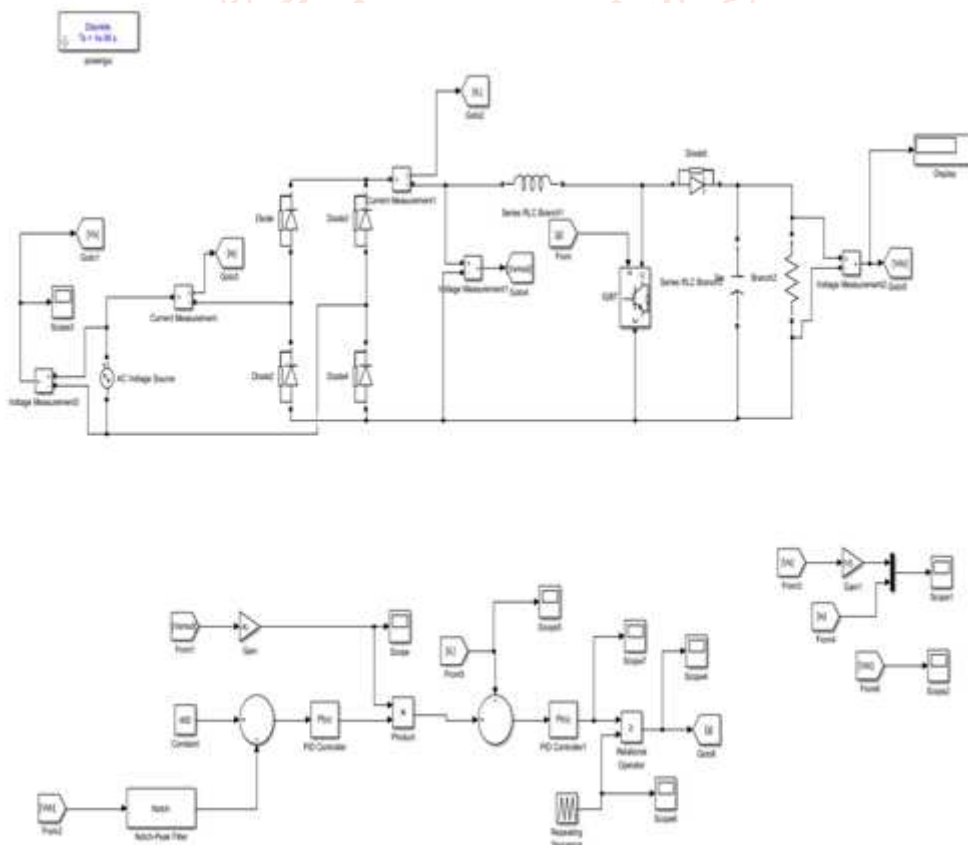

Figure 2.Simulink model for proposed PFC Boost by using PI controller

PFC circuit has the both the function of rectification and voltage stabilization, that is, the rectification requires the input power factor to be 1, and the voltage stabilization requires stable output voltage. Therefore, PFC circuit must be applied voltage feedback and current feedback simultaneously to form a dual loop control system. The outer loop is to keep the output voltage stable, and the inner loop shape the input current to make it a standard sinusoidal waveform with the same phase of the input voltage[7].

Sr. No.	Parameters	Values
1	AC Voltage Source	230*sqrt (2)
2	Frequency	50Hz
3	Inductance Value	$10e^{-3}$
4	Capacitance Value	$10e^{-3}$
5	Load	20Ω
6	Proportional value (P)	0.5
7	Integral (I)	3
8	fsw (switching frequency)	10kHz

**Table1. Parameters and their values of the simulink model**
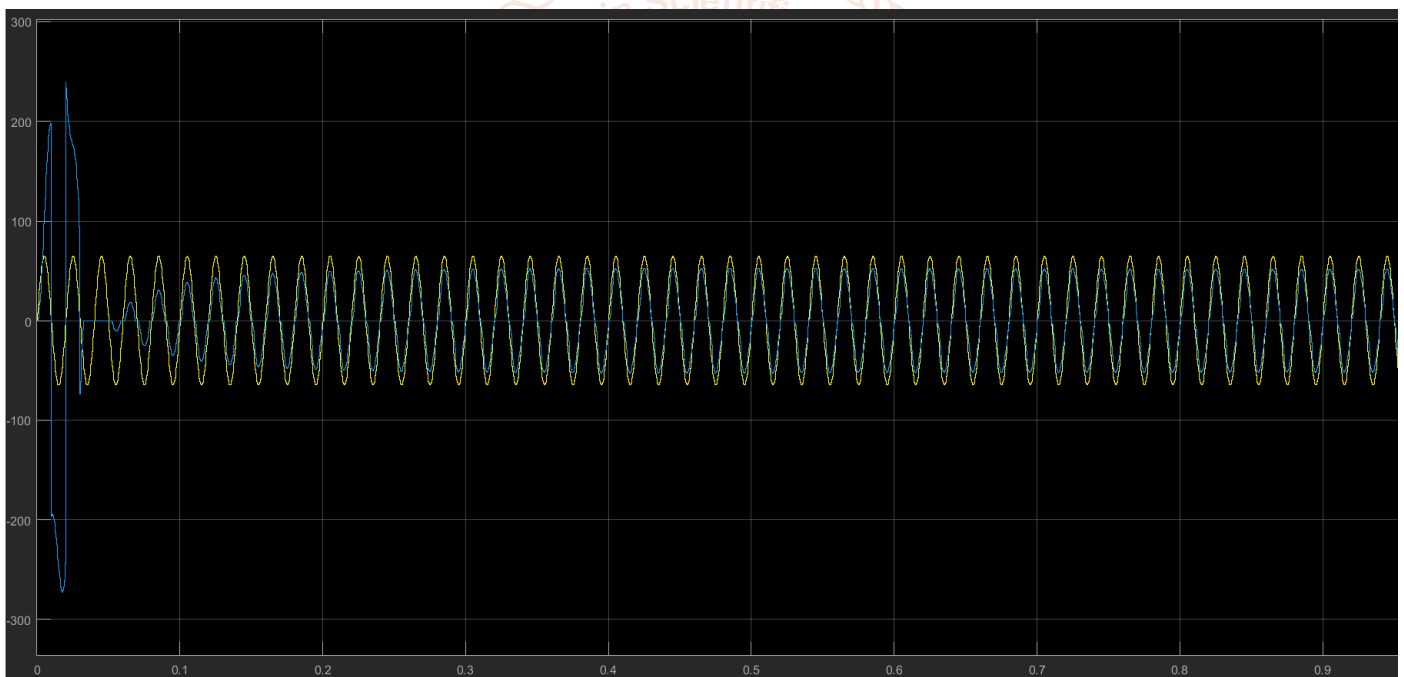
Figure 3 Simulation graph of current and voltage

Here from the graph, the current and the voltage are in phase with each other which shows the idea of power factor correction technique and the harmonics present in the input voltage gets corrected and the harmonics are reduced. Now zooming into the Vs and Is we see that the current and voltage is in phase with each other, the variations in the graph are because of the switching present in the boost operation during the simulation.
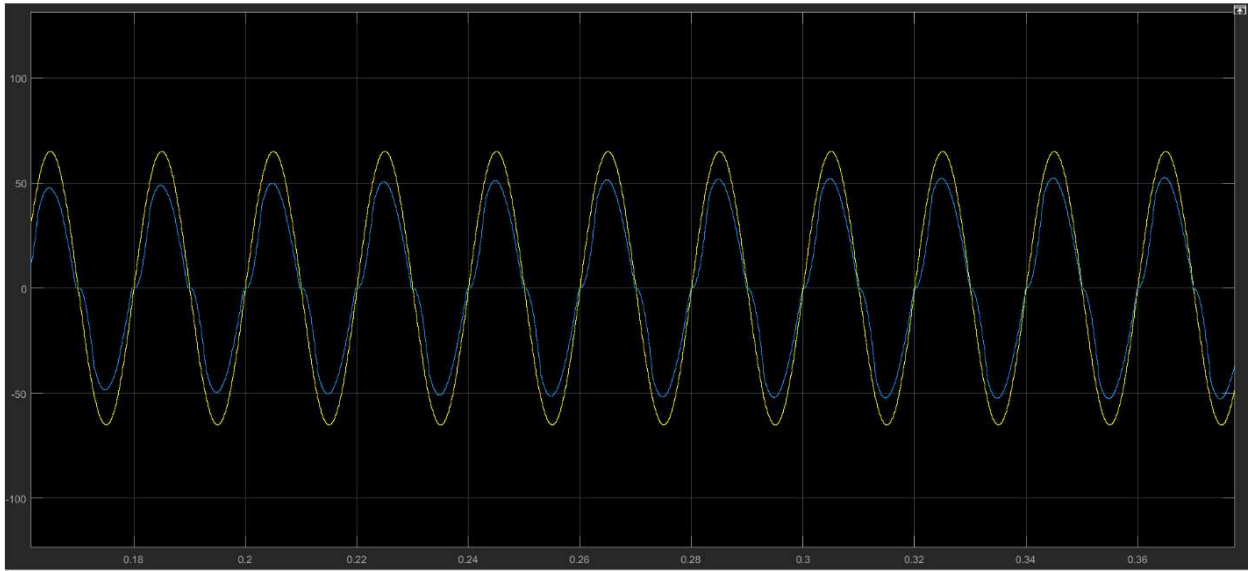
Figure 4.Zoomed-in view of the graph of current and voltage.

Now as we see the dc voltage should be maintained constant at 400v as seen from the simulation circuit,so from this graph or the simulation result that our voltage is maintained constant at 400V which shows that the simulation results are right.
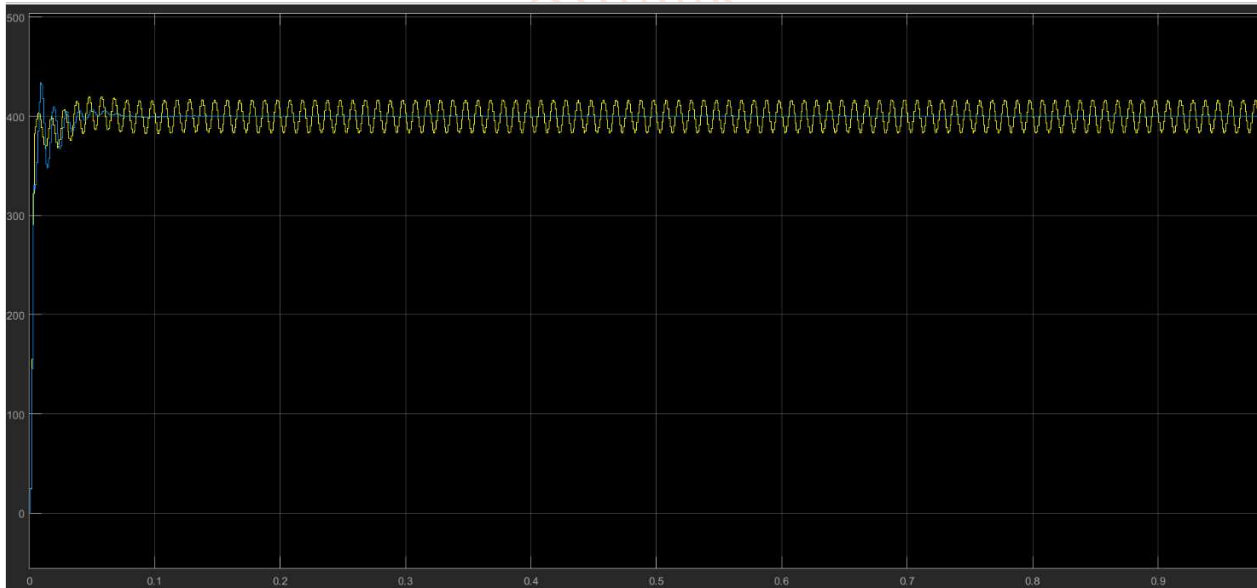

**Figure 5.DC voltage graph that is maintained at 400V**

Now, here keeping the model same as before, we will apply a variable load in the Simulink model during the simulation and will check the variation in the graph if we change the load values during the simulation. Keeping all the parameters as same as the above model only changing the values of load during simulation.
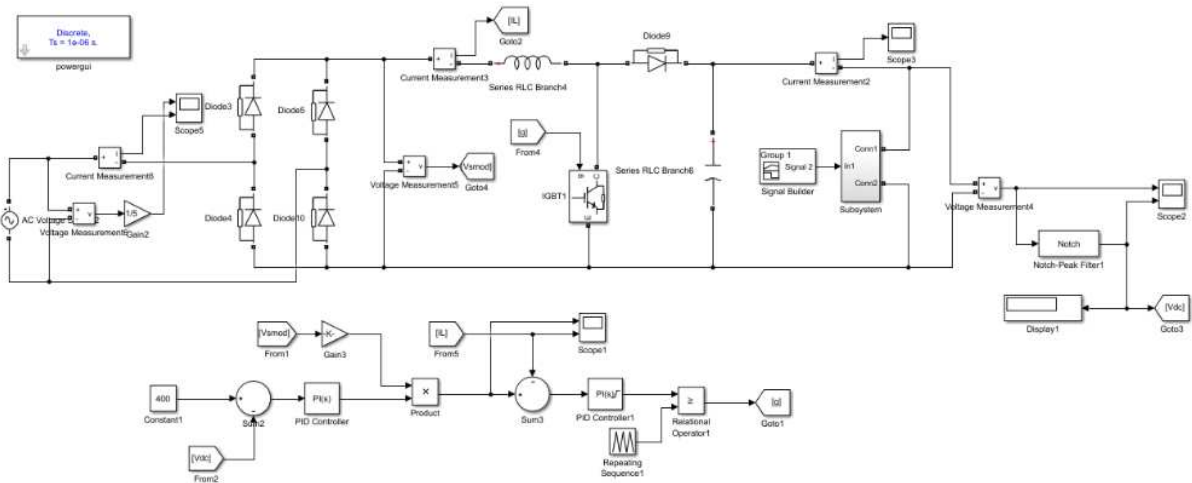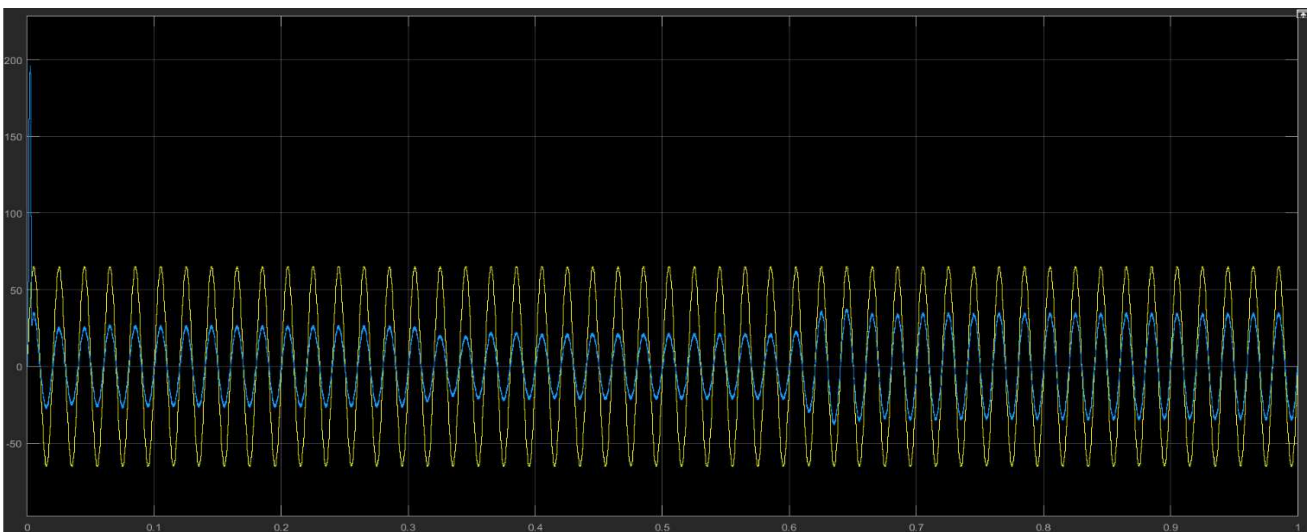

Figure 6: Simulink block of the boost PFC by Varying its load.
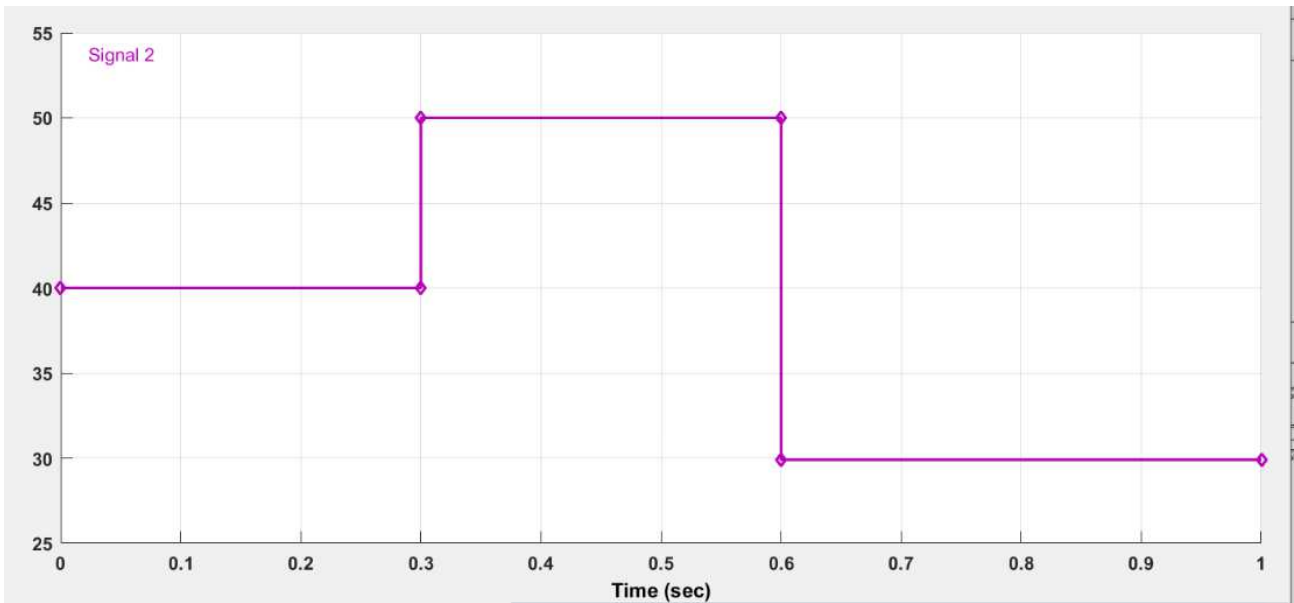
**Figure 7: Varying values of resistance applied with respect to time.**
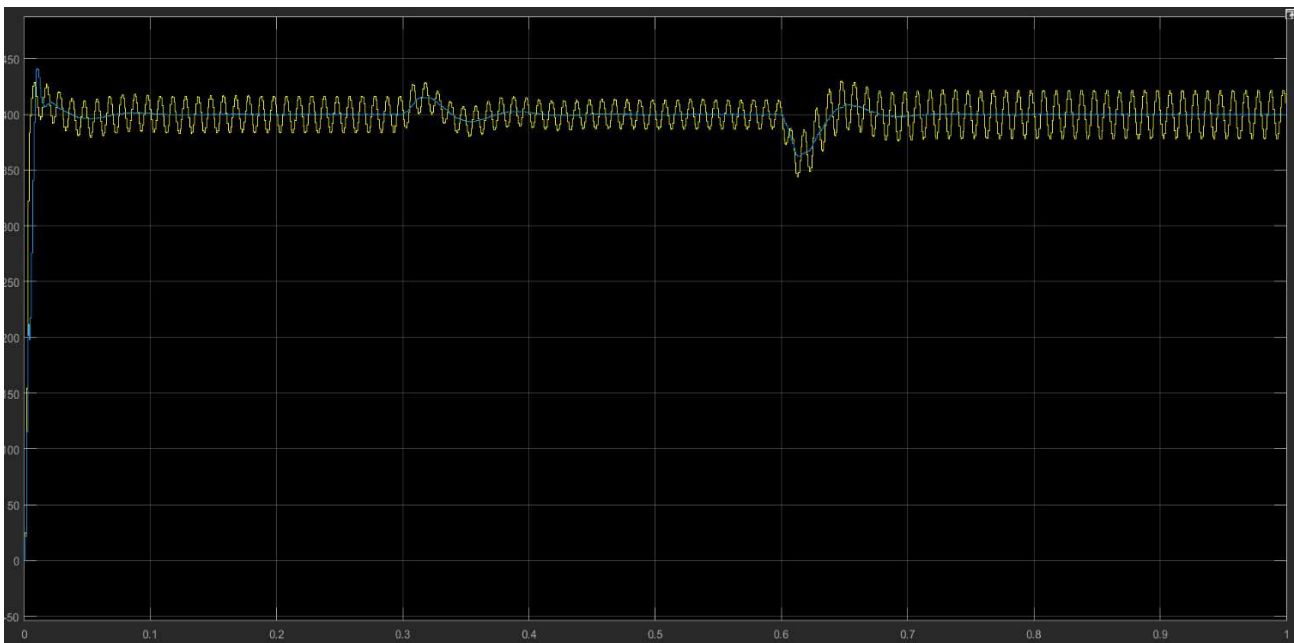
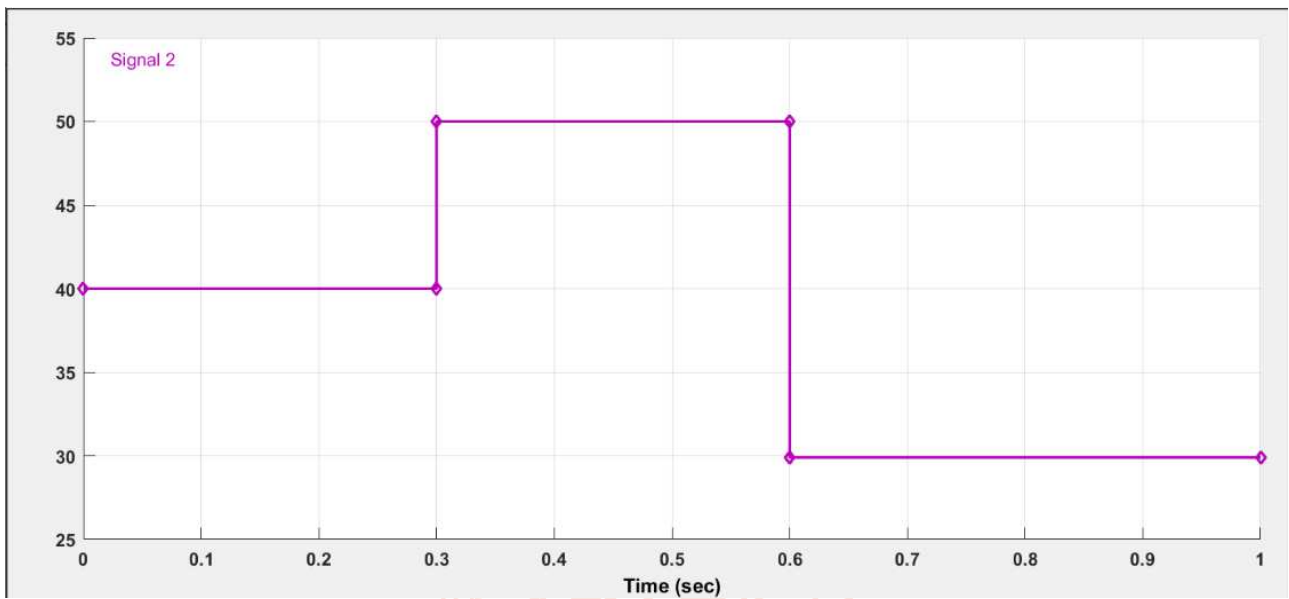**Figure 8: Graph showing voltage maintained at 400V**

**Figure 9: Graph showing that current and voltage in phase with each other**

Hence, by checking the graph we get the result that if the load is varied during the simulation it has no effect on the voltage or other factors. Now the same way if the voltage is varied during the simulation there will be no effect on the voltage, it will be maintained constant.
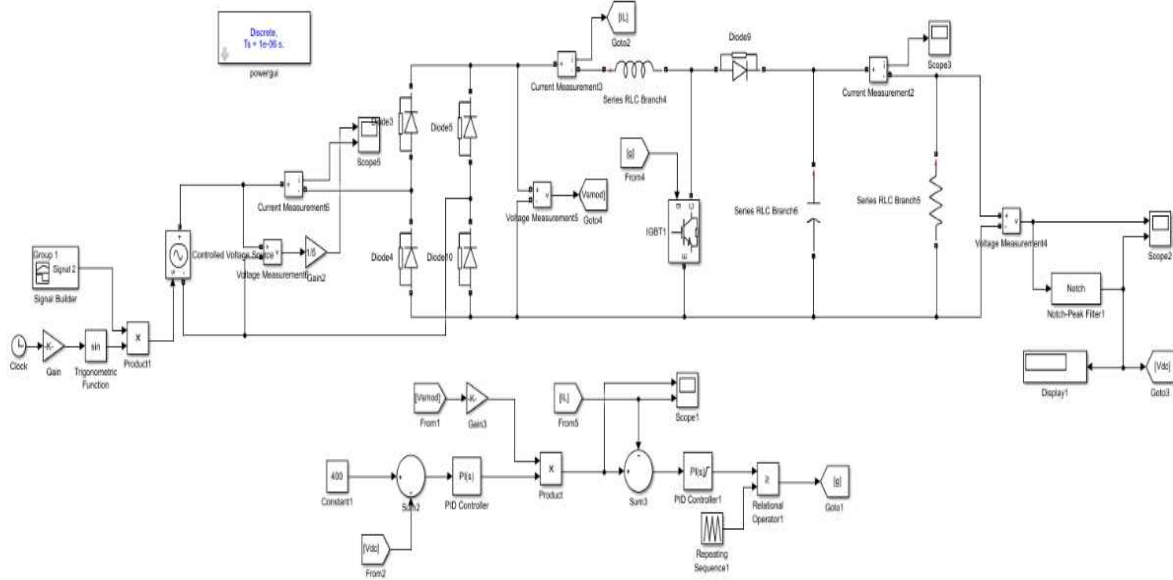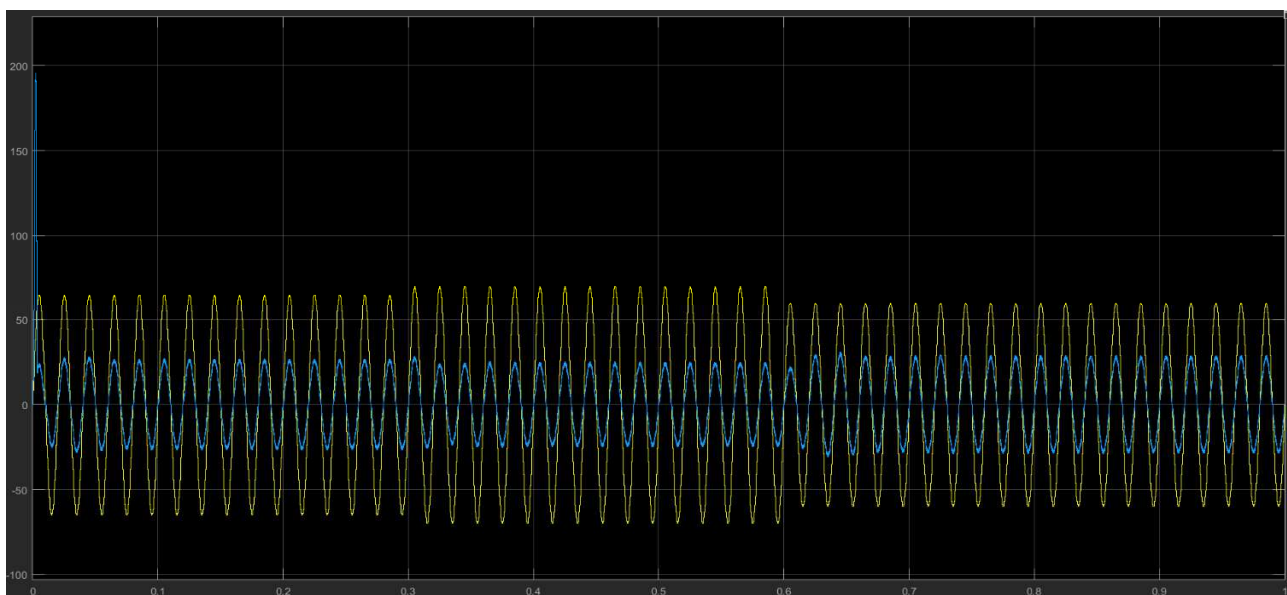
Figure 10: Simulink block of the boost PFC with varying voltage.

Figure 11: Figure showing varying voltage with respect to time.
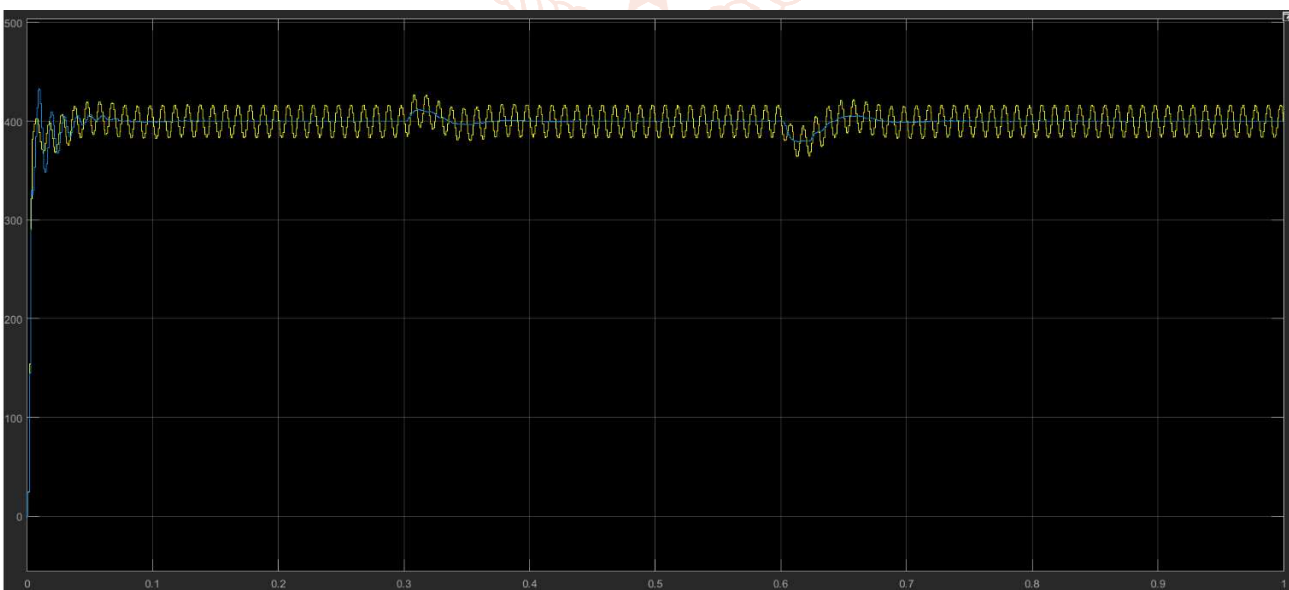
Figure 12: Graph showing the voltage maintained at 400 V.

Figure 13: Graph showing the voltage and current in phase with each other.

Conclusion:

This paper presented one new technique of the power factor correction of the boost converters using PI controllers and this paper also showed that there is no variation in the voltage output and currents if we vary the load and voltage during the simulation. The power factor correction using the boost converter could attain a decent power factor with the advantages that comes in handy for example the harmonics are reduced ,by using FFT analysis the lower order harmonics in the load current is greatly removed resulting the supply of current to reduce to 13% and can achieve the power factor up to unity and THD less than 15%.So this new power factor correction technique by using PI controllers corrected the power factor and the current and the voltage are in phase with each other.So, here in this paper the voltage and load parameters can be changed during the simulation and there will be no change in the graph of the model.

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