# A NOVEL TECHNIQUE OF EFFICIENCY AND POWER FACTOR IMPROVEMENT OF THREE PHASE INDUCTION MOTOR WITH EXTINCTION ANGLE CONTROL HAVING THREE SWITCHES

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*Abstract :* Efficiency and Power Factor improvement of three phase induction motor drives which are continuously running motor for pump and blower applications is the need of present industries. In the proposed drive an Extinction Angle Control (EAC) technique has been used having three switches. Continuous unidirectional flow of current takes place in this. Extinction angle variation has been done to change the speed of motor and to reduce the current drawn by motor which will control the power factor of the motor without disturbing the other operation of motor.

***IndexTerms* - Power Factor, Efficiency, Current Reduction, Extinction Angle control, Induction Motor.**

## I. INTRODUCTION

Power saving is the most important criteria in designing of any equipment. The electric drive manufacturers are interested to design drives which having more efficiency and power saving capability as compared to old ones. They are also trying to increase the input power factor of AC motors suitable for all classes of industrial drives and single phase as well as three phase systems. The purpose of selecting the squirrel cage induction motor is because of is because of its simple operating characteristic and the self starting operation. Squirrel cage induction motor is more superior to the slip ring induction motor as it has easy operating characteristics. Most of the technique are capable of providing efficiency improvement as the need of era is to save the required energy.

Pump, Fans and Blowers are the continuous running motor which require the continuous power for their working. Induction motor is the most commonly used AC motors and it is used for pump, fan and blower application. Current drawn by this motor is more as this motor has the lagging power factor. Hence power factor improvement must be done which will reduce the current drawn by motor and increase the efficiency of the motor. Change in the stator winding connection (Delta or Star) according to the load condition will increase the power factor [2]. Power factor is nothing but the phase difference between the voltage and current supplied to the motor for its working. As the power factor increment is difficult to achieve hence most of the researcher tried to increase the efficiency of motor for energy or power saving rather than improving the power factor. Development of Line-Start Permanent Magnet Synchronous Motor is one of the example in which the copper wire size and number of turns for coil of stator are reduced to maximize the efficiency of motor [3]. Instantaneous power theory is also used for the efficiency improvement of three phase induction motor [4]. PWM, SPWM, torque control, speed control and many more techniques of efficiency improvement or power factor improvement are proposed and implemented for efficient operation of motor [5-8]. Power factor and efficiency improvement is done by using the extinction angle technique for single phase induction motor having two switches [1].

In the proposed technique the control over the power factor and its improvement is being done by the extinction angle control technique. In this one switch is for per phase. Thus the control of three phase IM is possible with only three switches. In this the power factor of lagging to leading range is obtained. As only one switch per phase is used hence there is no chance of short circuiting during operation of switches.

## II. CONTROL TECHNIQUE

The extinction angle control technique is to be employed in this. The extinction angle control technique is the one in which the supply to the drive is started at zero degree and it is forced commutated at $\omega t = (\pi-\beta)$ radian, where $\beta$ is the extinction angle. After forced commutation the current through drive is not dropped to zero suddenly but it is allowed to freewheel in the circuit so that the drive will run continuously. The phase difference between the windings of three phase induction motor is 120 degree each between the two consecutive winding. Because of this there is considerable change in the displacement power factor of the motor it will become $[\cos(\beta/2)-\phi]$ By using the PWM control method power factor of the induction motor cannot be increased beyond a certain limit and it will also not capable of providing a leading power factor but the proposed extinction angle technique is able to do so. Thus, this control technique has the power of increasing the power factor which will ultimately lead to increase the efficiency of the drive. Generation of gate pulses will takes place through the ZCD and ramp wave generator. Synchronized gate pulse generation is needed for turning ON all the switches at the same time. Forced commutation is the phenomenon of turning of the switch before going its normal commutation. Controlling of the whole drive with only three switches and controlling that switches with only one pot provided. Speed reduction done during this operation is not much it is near about 10-20% of the rated speed. And energy saving done during this operation is 20-30%. ON and OFF timing of the switches depend on the gate pulses provided to it. Uniqueness about this control is only three switches. The system is of 3-phase and 4- wire, neutral is fourth wire needed for this particular operation of drive.

β – It is the extinction angle which varies between 0 to 180$^o$ .

## III. POWER CIRCUIT OF THE PROPOSED DRIVE

The power circuit which is required for the proposed drive is as shown in the figure1. It is consist of three main switches and three capacitors for freewheeling. Main switches operate during conduction mode. When the main switches are forced commutated then capacitors are going to act. The main switches are connected in series whereas the freewheeling switches are connected in parallel with the winding of the drive. Diode Bridge is also provided along with each switch to avoid the reverse flow of the current.

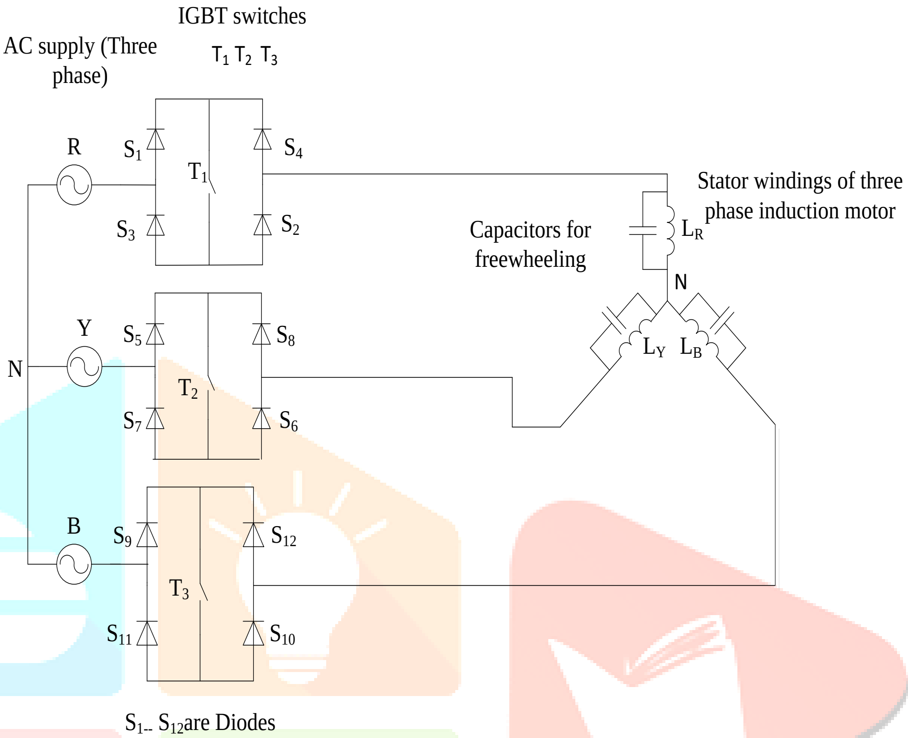


Fig.1 Circuit Diagram (Power Circuit)

## IV. MODES OF OPERATION

The proposed system works into two modes of operation.

1) Conduction Mode
2) Freewheeling Mode

Conduction Mode:

This mode of operation needed for conducting the supply current from source end to the destination end. The three AC switches which are connected across the three phase supply are going to turn on during this mode and they will conduct up to (π-β) radian. The switches are force commutated at β radian. The flow current in this mode is as shown in fig.2 switches T1, T2, T3 are ON during this mode of operation.

Freewheeling Mode:

This is the second phase of operation during which the AC switches will be turned off but the three phase induction motor connected as a load will remain turn on. The energy required to keep the motor on will be provided by the small value ceramic capacitors across it during this mode. There is no requirement of charging these capacitors separately they will be charged at the time when the main switches T1, T2, T3 are on. The current flow during this mode is as shown in dig. 3.

In this working of drive continuous current conduction is not there hence the saving of energy during the freewheeling mode of operation without interrupting the performance of the drive. Unidirectional current flow is there in this proposed scheme from source end to load end no reverse flow from load to source end. Charging of capacitors are done during the conduction mode and discharge during freewheeling mode.

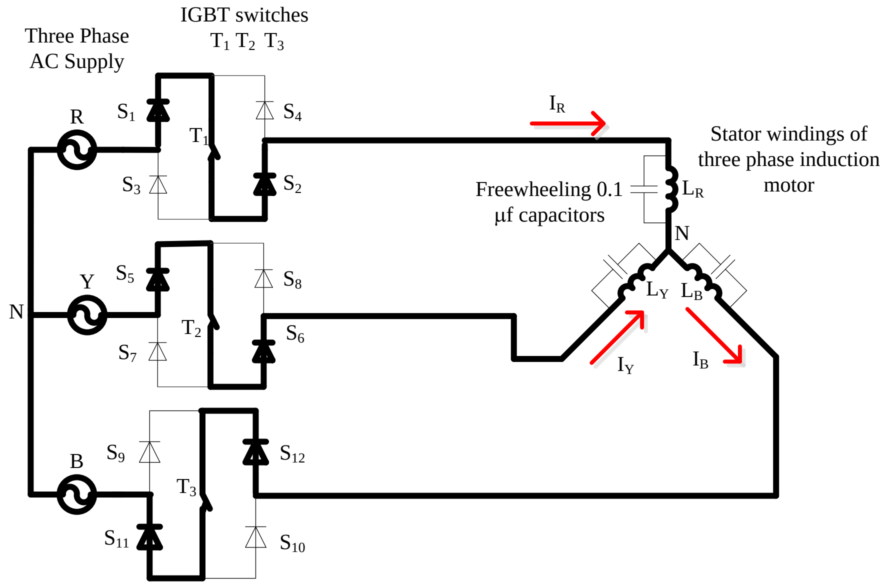


Fig.2. Conduction Mode

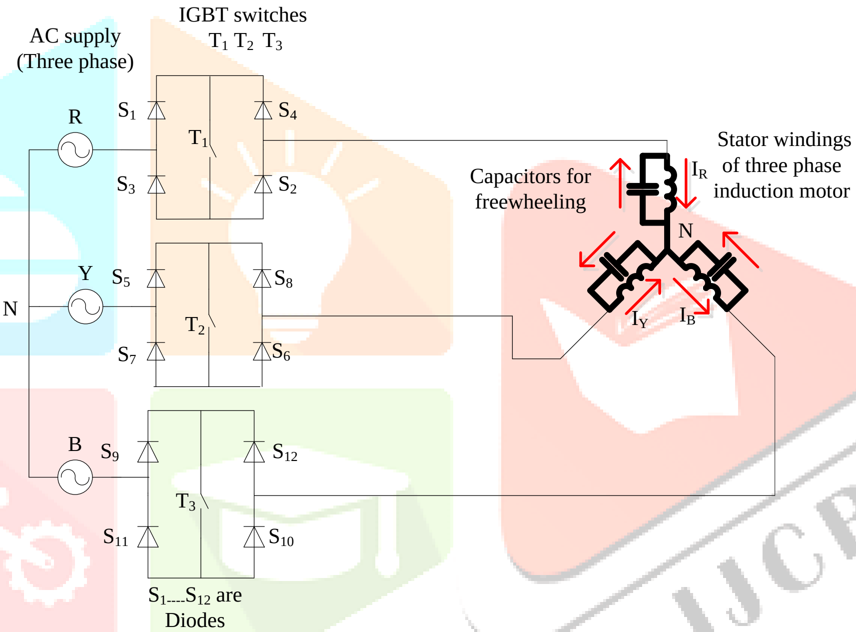


Fig.3. Freewheeling Mode

## V. MATLAB SIMULATION RESULTS

Fig. 4 indicates the MATLAB simulation model for the proposed circuit in which the three phase load had been attached across the proposed scheme. It consist of three switches T1, T2, T3. These switches are connected across the supply side through the diode bridge rectifier. Capacitors are connected across the winding of load. The various simulation parameters are given by the table as shown below.

Table No. 1 Simulation Parameters

| Simulation Parameters | Ratings |
|---|---|
| Supply Voltage | 100V |
| Supply Frequency | 50Hz |
| Capacitor | 0.1µF |
| Resistor | 50Ω |
| Inductor | 25mH |

Testing of the whole module tested in the MATLAB environment. Gate pulses required for turning ON the switches is provided by the combination of pulse generator and sine wave. The outputs of gate pulses are taken across scope 1. And the final output of voltage and current is obtained across scope 2. The switches used here are IGBT switches as the forced commutation is needed in this operation. Gain block is given across the current measurement block for enhancing the magnitude of current.

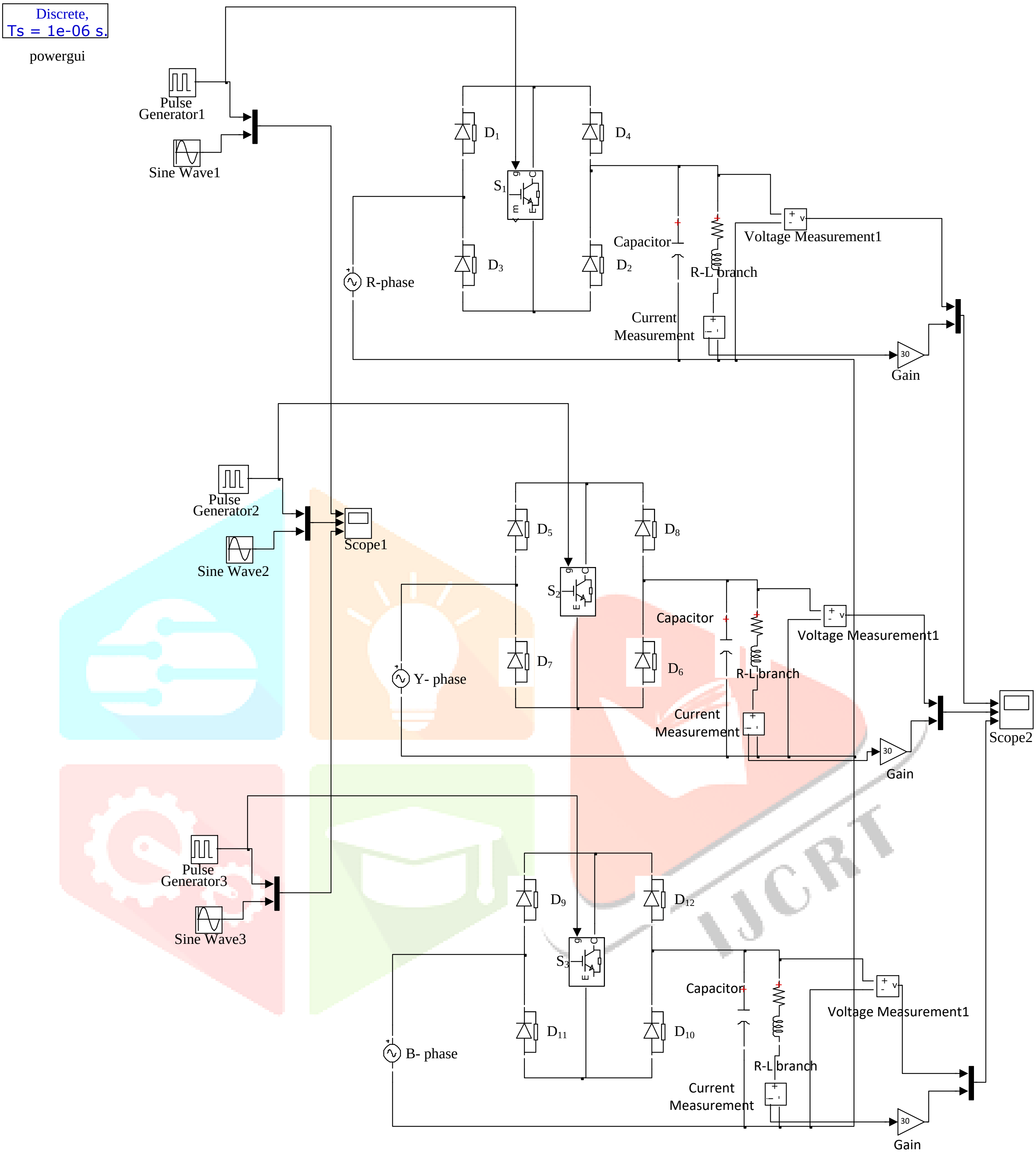


Fig. 4 MATLAB model

Fig. 5 and Fig. 6 are the results of the simulation model taken across scope 2 and scope 1 respectively. All the three phase have the same model except there is a phase-shift across their supply voltages. By observing Fig. 5 it is clear that the voltage and current are in phase with each other which also means that they are operating at a unity power factor. The operation of any drive at unity power factor is the most desirable characteristic. Hence with the help of this proposed scheme improvement of power factor is done which will lead to the efficiency increment. As the current drawn by the load is less hence the copper losses encountered in the system are also decreased.

Fig.6 shows gate pulse and sinusoidal supply voltage wave. Gate pulses are needed for the switching operation of switches. The magnitude of the gate pulses can be adjusted by adjusting the reference voltages. For generating the gate pulses first sine wave is rectified and then passed through zero crossing detector. After ZCD the op-amp triangular and ramp generator is there which is responsible for ramp wave generation. This ramp waves are then compared with the sine wave which will give the square gate pulses for turning ON switches.

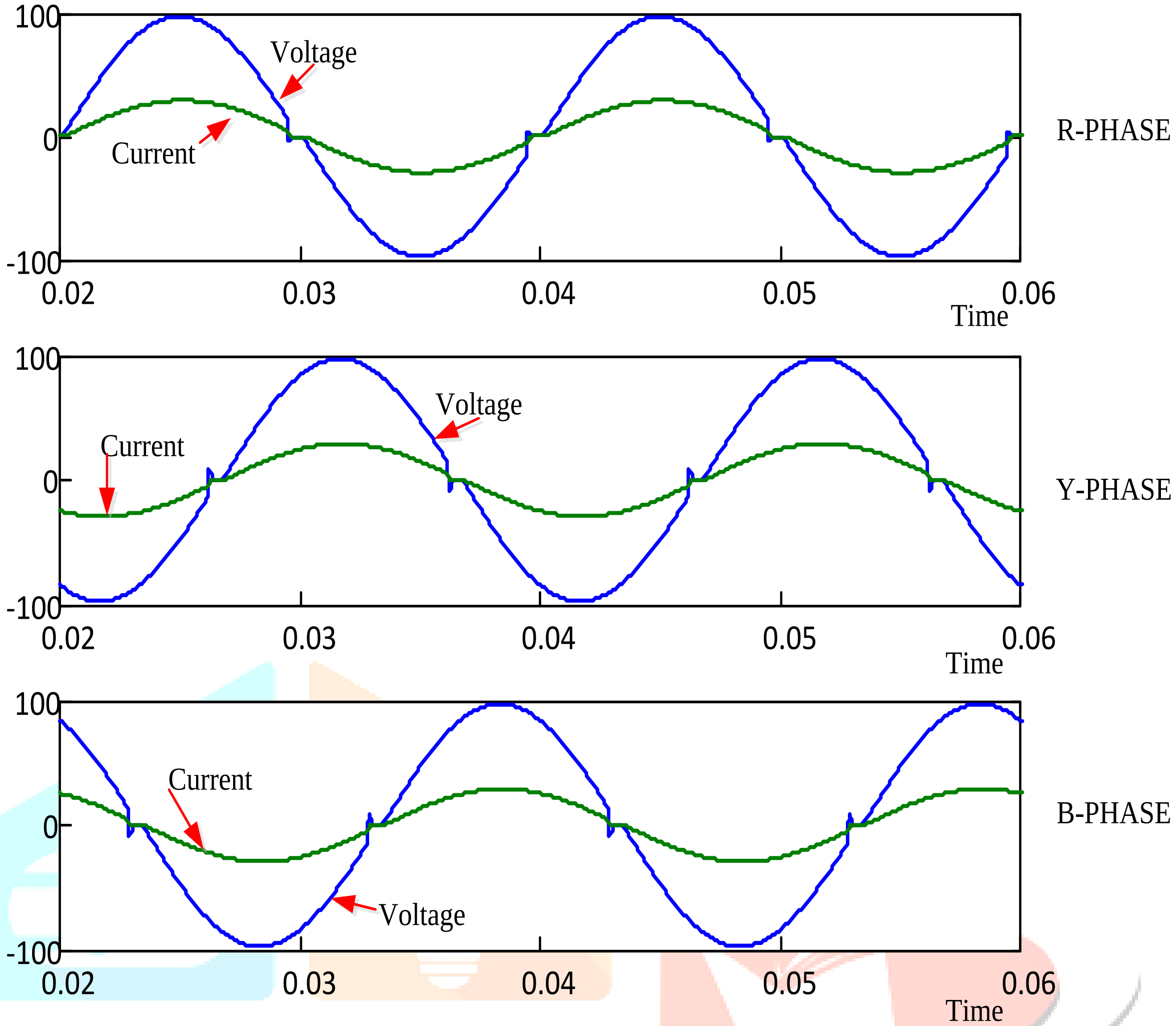


Fig.5 Voltage and current waveform.

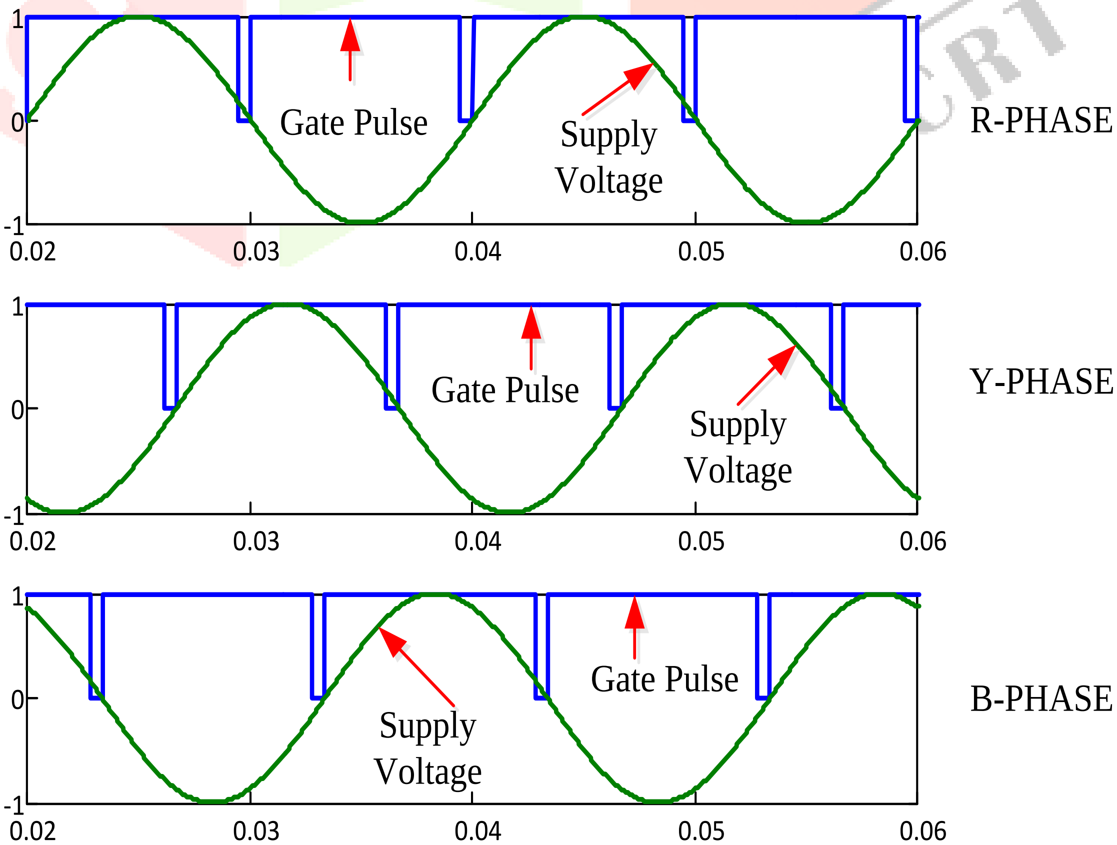


Fig. 6 Gate pulse and supply voltage waveform

## VI. CONCLUSION

The existing systems are somewhat complicated and they are not very much implemented for increasing the power factor of the system so from the suggested system there is much more possibility of increasing PF without disturbing the system performance this is better than other systems. In this the power factor is going to increase up to unity which was very difficult to obtain particularly in case of AC induction motor. But with the help of this system its somewhat become easily possible.

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