IMPROVEMENT OF POWER FACTOR AND EFFICIENCY OF THREE PHASE INDUCTION MOTOR BY EXTINCTION ANGLE CONTROL

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***Abstract*—-** *In this paper an attempt is made to investigate the performance of power electronic semiconductor switch like IGBT by giving extinction pulses of three phase induction motor. The extinction pulses is generated through control circuit is attach to power circuit which consist IGBT and diode. In this project three power circuit are fed to induction motor one in each phase of induction motor drive is presented. The general study of power converters is to improve the overall efficiency of the power system by some advanced methods of control techniques. Forced commutation of the power semiconductor switches leads to improved power factor in dc converters. Similar techniques may be applied to improve the performance of ac controllers. For example, an ac controller can be used to adjust the stator voltage of an induction motor running under variable load in order to maintain better efficiency. With the present semiconductor technology (MOSFET's, IGBT's, GTO's and improved bipolar transistors), many solutions exist to alter the power factor of dynamic ac loads through an ac controller. In this paper, the performance evaluation of the extinction-angle control technique has been illustrated as applied to a single-phase voltage converter by examples of static load and the widely used single-phase induction motor to verify the feasibility of the proposed technique. Observations on power factor, displacement facto rand motor efficiency make up the results of this work.*

Keywords— Efficiency, Power Factor, AC Voltage controller, Static load. Extinction angle, Three Phase Induction Motor.

I. INTRODUCTION

AC voltage converters are widely used as one of the power electronics systems to control an output ac voltage; where a variable ac voltage is obtained from a fixed ac voltage, for power ranges from few watts (as in light dimmers) up to fraction of megawatts (as in starting systems of large induction motors). Phase-angle control (PAC) line commutated voltage controllers and integral-cycle control of thyristors have been extensively employed in this type of regulators for many applications. Such techniques offer some advantages as simplicity and the ability of controlling large amount of power economically. However, they suffer from inherent disadvantages such as; retardation of the firing angle causes lagging power factor at the input side especially at large firing angles and high low order harmonic content in both of load and supply sides Most of the drives used in the industrial motor control are electrical. Depending on the application, some of them are fixed speed and some are variable speed. The variable speed drives had various limitations such as poor efficiencies, larger space, lower speed, etc. Induction motor is the widely used motor for 24 hours running motors such as the pump and blower. As they are continuous running motor hence they require continuous power for their operation. Thus the power consumption is more as the current drawn by this motor is higher. Due to the higher stator current the copper Losses are more, and hence power factor and efficiency are reduced. By controlling the undesired oscillation in the operation of motor the efficiency can be improved .But for this an automatic compensation is required. Four switch three phase inverter operation can also be used instead of six-switch three phase inverter. Unbalance in phase currents because of the DC link voltage occurs this is the drawback with four switch three phase inverter. For efficiency improvement optimal efficiency technique is used but with this the efficiency is improved up to a certain optimal point after that point the efficiency decreases whereas the power factor increases continuously. Three switches for improvement in power factor of three phase induction motor using the stator current which induces rotating air gap flux for running of motor can be used. The change in material dimension is also responsible for the changes in operating parameters such as current, power factor and efficiency of motor. Pulse width modulator as well as the sinusoidal pulse width modulator are also the most important factor developed for the efficiency improvement but in this case the problem of harmonics arises which again restrict the performance of the drive . All above techniques can improve either efficiency or power factor of motor but they are unable to improve the power factor and efficiency simultaneously.

II. BASIC BLOCK DIAGRAM

In this block diagram three AC switches are connected in series with per phase of induction motor and three capacitor are connected in parallel with each stator winding of induction motor.. It shows the simple flow of current from supply end to the load end. During this it also supply current to the capacitor connected across stator winding of the three phase induction motor. Charging of capacitor is done during the time when the switch is on. Thus extra power and time is not required for charging of capacitors. The stored power inside the capacitors is used during the freewheeling mode when the switches are off and the current from the supply end is cut off. So continuous running of motor is possible without disturbance and the power required for its operation is also reduced. The current from the supply side is provided only when the switches are ON whereas during OFF time supply will not provide current.

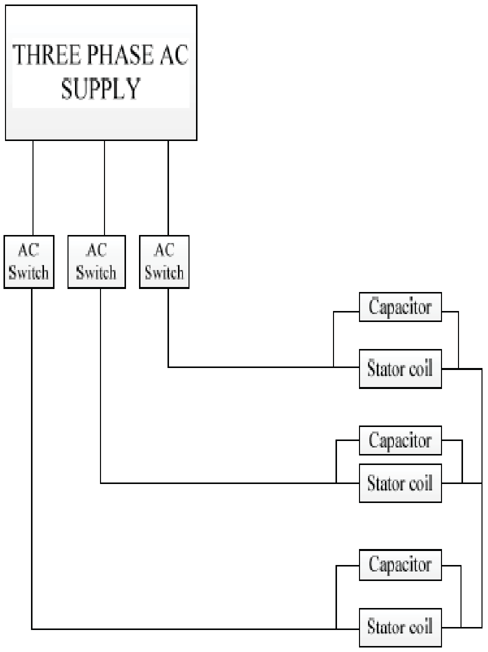


Fig1. Basic Block Diagram of Circuit.

III. CONTROL CIRCUIT

A. CONTROL TECHNIQUE PULSE GENERATION

Fig.2 shows the control circuit. For converting the sine wave into the square wave the negative zero crossing detector has been used. After this the square wave has been given to the ramp generator through Op-amp. Three synchronized ramp wave had been generated from the three phase supply. This ramp waves are compared with the reference voltage in the comparator IC and the required gate pulses for switching on the IGBT are generated. These generated pulses are given to the gate of IGBT for turning ON and the supply voltage is given to the drive. The time up to which the switches are ON is known as the conduction time. After switching OFF the AC switch supply voltage is not given to the drive from source side it will be provided from the freewheeling side. Fig. 3 is shows the sequential change from the supply voltage wave up to the required gate pulse. The aim of this gate pulse generation circuit is to provide the required value of voltage for turning on the IGBT switch .

B . CIRCUIT DESCRIPTION AND PRINCIPLE OF OPERATION OF PER PHASE OF THREE PHASE INDUCTION MOTOR

Fig shows the schematic representation of the power circuit configuration which consists of a three-phase induction motor connected to an ac source through an ac voltage controller. The forward switch SI is used periodically to connect and disconnect the load to the supply in the EAC technique, i.e. regulates the power delivered to the load. The parallel switch S2 provides a freewheeling path for the load current to discharge the stored energy of the load inductance when the forward switch SI is turned off. Switch SI is turned on at wt =0 and is turned off by forced commutation at (wt = 180 – B as shown in Fig. I to supply power to the load during the active mode. For an inductive load, a freewheeling path for the load current must be provided for the period from wt =180 –B to wt =180 by the freewheeling switch S2 to discharge the load inductance stored energy during the freewheeling mode. The fundamental component of the input current leads the input voltage, and the displacement factor (and hence the power factor) is leading. The switching pulses shown in Fig are synchronized with the supply voltage and the output voltage is controlled by varying the extinction angle B from 0 to 180 to vary the rms value of the output voltage from rated input voltage to zero. The gating pulses of the freewheeling switch S2 are the complement of the gating pulses B of the forward SI. Due to non ideality of the switching devices, a dead time is requisite to avoid commutation problem. A by-pass capacitor Cb is added parallel to the load in order to provide a path for the current during the dead time when both switches are opened. The operation is divided into three modes: active, dead time and freewheeling modes. The current flows through the input and output sides, providing energy to the load during the active mode, freewheels through the freewheeling path during the freewheeling mode and bypasses during the dead time mode. Detailed analysis of the operation modes and circuit description can be found in

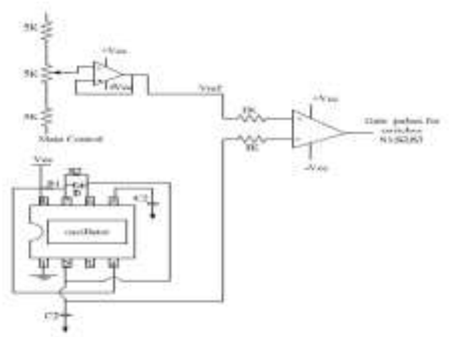
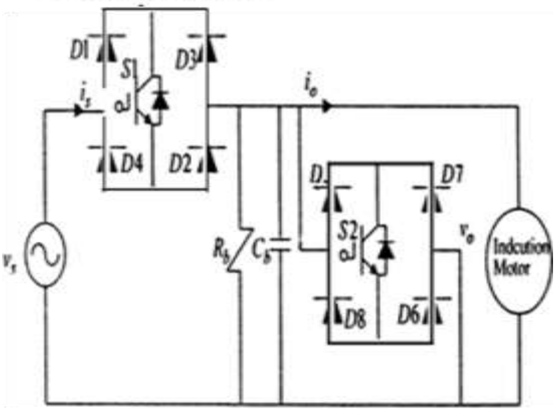


Fig.2 Control pulse generation circuit.



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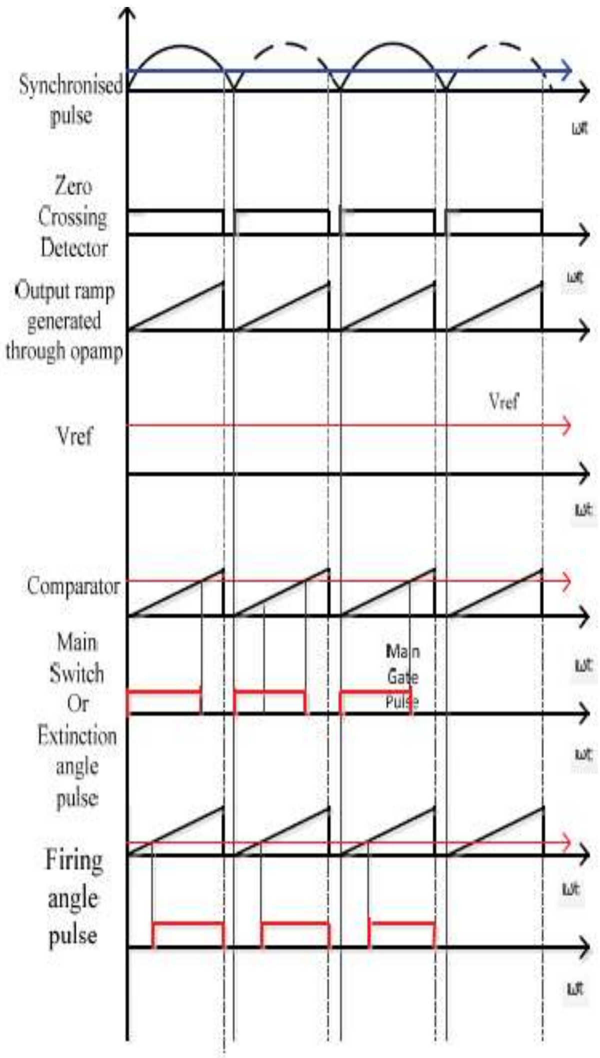

Fig. 3 Gate pulse generation

IV. POWER CIRCUIT

There are two types of operation which can be included

in the working of proposed drive.

A. Active mode: operation of main switches.

B. Freewheeling mode: operation of Capacitor.

A. ACTIVE MODE

This includes the ON- state period of semiconductor switches. The switches S1, S2, S3 will turn on during this operation. A gate pulse had been given to each of the switch and allowed to turn on which will conduct up to a certain period of time as assign by us. As the switches remains active during this mode hence it is called as the Active mode of operation. The current will be supplied from the AC source to the windings of the motor as well as it will be supplied to the capacitor across winding thus charging of capacitor will also takes place in this mode without disturbing the operation of induction motor. Fig shows the conduction mode of operation.

B. FREEWHEELING MODE

During this mode of operation the switches will be turned off. And the freewheeling mode of operation will start. In this the capacitors which are connected in parallel across the winding comes into operation. The motor will not stop as the supply from the source is turned off whereas it will run continuously by using the energy which is stored in the capacitor. So motor will not get turn off. It will continue to run. Fig shows the freewheeling mode of operation.

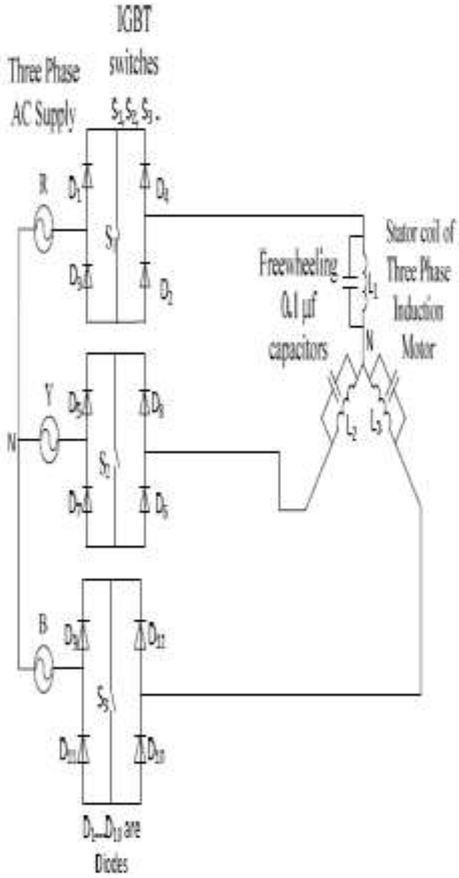

Fig 4 . Basic Circuit Diagram

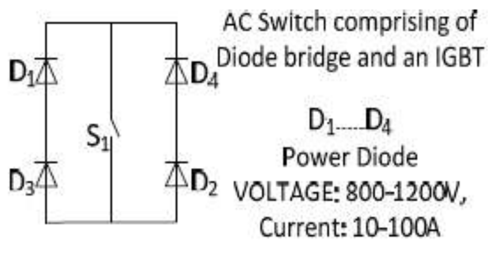

Fig. 5 AC switch

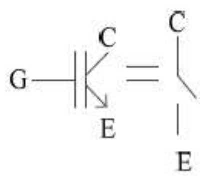

Fig. 6 Symbol of IGBT

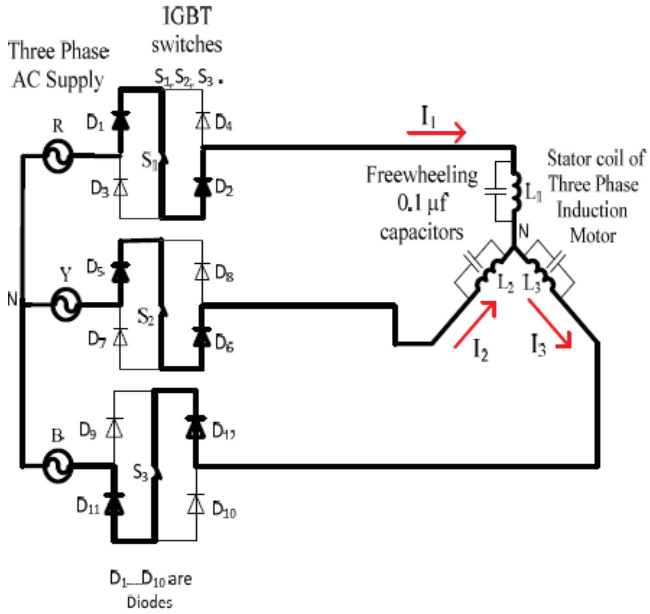

Fig. 7 Conduction mode of operation

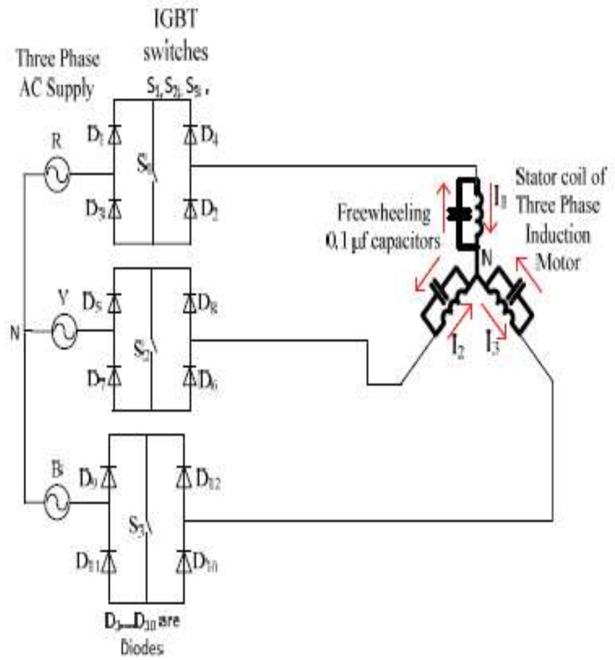

Fig. 8 Freewheeling Mode of Operation

V. CONTROL TECHNIC

Extinction angle: - The angle at which semiconductor controlled switches are turned off before reaching their natural commutation which is also known as the forced commutation of the switches is nothing but the extinction angle for that switch. The extinction angle control technique allows the switch to be forced commutated. Fig.1 shows the changes in the output voltage and input current with the implementation of extinction angle control technique. The switch is turned on at T0 remained on from time T0-T1. After that from time T1-T2 the switch is turned off. The output voltage and source current also follow the same sequence. The output voltage appears across the load when the switch is on and it will be zero when switch is off. In case of input current it will be supplied to the drive when the switch is on and it is cut off when the switch is off.

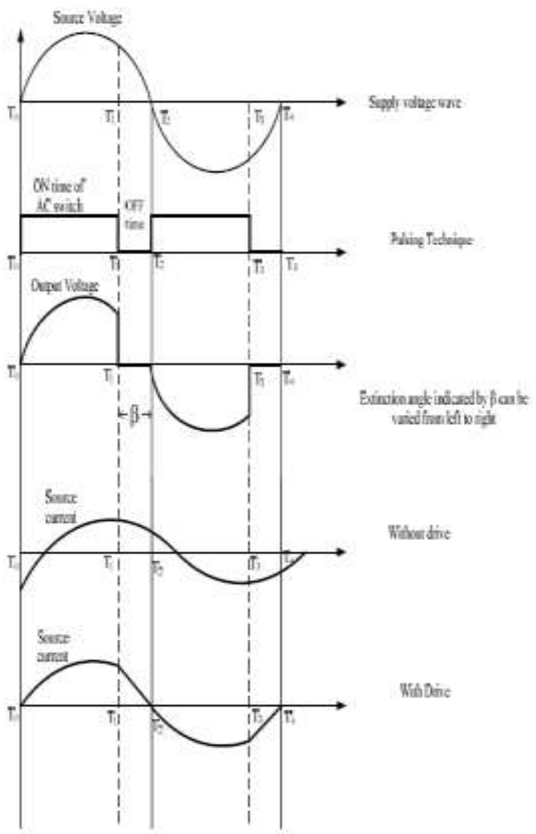

Fig 9. Waveform of source voltage, output voltage, ON and OFF time of AC switch, source current waveforms with extinction angle control.

CONCLUSION

The existing systems for improvement of performance of the Induction motor are capable for increasing the efficiency in small scale but they are unable to provide high power factor operation of drive. The proposed drive is providing the power factor improvement from lagging to leading range by compensating the lagging P.F using the extinction angle control technique. Comparison of EAC and FAC technique also proves that proposed drive is giving better power factor than FAC. High power factor operation with unidirectional flow of the current is the novelty of this drive. 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 it becomes easily possible.

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