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An Extinction Angle Control of Three Phase Induction Motor Drive for High Power Factor Operation

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ABSTRACT

To achieve independent control on speed and power factor, six semi controlled switches are used in a three phase AC to AC voltage controller using medium frequency extinction angle control technique. This technique has been realized using AC freewheeling. In industries and power station variable voltage variable frequency drives are widely used for cooling purpose. VVVF drive improves power factor (PF) of earlier used phase angle controlled induction motor drive. Through proposed drive it is expected to provide higher efficiency and higher power factor as compared to phase angle controlled and variable voltage variable frequency drive with much simplicity and much more economical.

Keywords: Extinction Angle Control(EAC), Extinction Angle(β), Power Factor (PF), High power Induction Motor(IM), AC-AC.

I. INTRODUCTION

In Today's era power conservation is an issue across the globe. This project mainly deals with the minimum power consumption by enhancing the efficiency and offering AC freewheeling of three phase induction motor (IM) drive, which mostly used in industries and power stations for controlled cooling purpose. Three phase induction motor is most widely used in industries than other machines due to their advantages such as simplicity in construction, reliability in operation, and cheapness. The speed control of such motors can be achieved by controlling the applied voltage on the motor by the use of power electronic devices [1]. AC phase angle voltage controllers are also used for induction motor soft starter and economic running at reduced speed. But this suffers from several disadvantages such as retardation of power factor due to increase in firing angle at lower speeds, complex control techniques and more number of switches [2-3]. In [5], voltage control strategy for three-phase ac voltage regulator has been studied. In [7] one of the major drawbacks inverter is that it has more harmonics distortion in its output voltage and current as compared to conventional four switch , three phase inverter. Variable voltage variable frequency (VVVF) drives are used to minimize the above drawbacks of phase angle controlled drives. With VVVF drive, power factor (PF) and efficiency of induction motor improves as compared to previously used phase angle controlled drive. In order to further improve the efficiency and power factor the proposed drive scheme is presented. The proposed drive can operate induction motor with high PF ranging from lagging to leading or even at near unity for speed range required for fans and blowers. This could have been achieved with the help of three phase extinction angle control with AC freewheeling. If number of motors are driven using the proposed drive, plenty of power conservation is possible. The control circuit for the drive is simple and economic. The power circuit of the drive consists of six semiconductor controllable switches, out of which three are main switches and three freewheeling switch. Simulation results of power factor, displacement factor and total harmonic distortion factor are described and discussed. In order to further improve the efficiency and power factor the proposed drive scheme is presented. The proposed drive can operate induction motor with high PF ranging from lagging to leading or even at near unity for speed range required for fans and blowers. This could have been achieved with the help extinction angle control of three phase

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II. CONTROL TECHNIQUE

This is a technique that is introducing a extinction angle (β) control for three phase induction motor drive. In EAC control the conduction is started at zero crossing of the supply voltage, forced commutated at the (wt= π - β) and also a freewheeling path is provided for the load current to discharge the stored energy of input voltage. In the conduction period from (wt=0) to *(wt = π-β)*, i.e. in this conduction period output voltage waveform is in the form of single pulse in each half cycle. EAC technique is to provide leading power factor. By using the technique advantages of extinction angle control are employed for controlling induction motor drive, thus results in achieving any power factor from lagging to leading or even at unity power factor for any speed and induction motor is expected to draw comparatively less current, thus stator copper losses of three phase induction motor are reduced. If losses are reduced efficiency of motor is improved. In this technique six semiconductor switches are used. So, complexity of circuit is also reduced.

III. POWER CIRCUIT OF THE PROPOSED DRIVE

The power circuit of the proposed technique is shown in Figure1. In this diagram 3-phase supply is connected to stator winding of 3-phase induction motor through single phase Diode Bridge along with semiconductor switch (IGBT) in each phase, whereas three more switches used for providing freewheeling path to each phase current. This switch is connected in parallel to the 3-phase stator winding of induction motor. Across each of the stator winding capacitor are connected to provide dead time in between the operation of the main and freewheeling switches.

IV. MODES OF OPERATION

The operating modes of proposed drive are divided into four modes

1. Active mode
2. Dead time-I mode
3. Freewheeling mode
4. Dead time-II mode

1. Active mode (mode-I)

The active mode corresponds to the ON-state period of the main switches S1 S2 S3 and during this mode of operation switch S4 S5 S6 remains OFF. When switches S1 S2 S3 are made ON, the current flows from the three phase supply to the three phase stator winding through the switches S1 S2 S3 simultaneously along with forward biased diagonally opposite diodes of the bridge as shown in Figure2. The supply voltage appear across the terminals of star connected stator winding during mode-I.

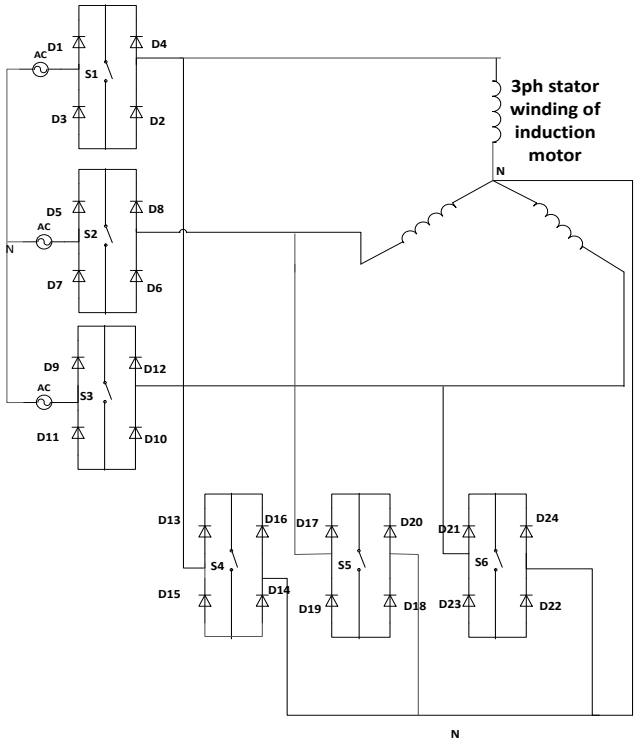


Figure 1. Power Circuit of Extinction Angle Control of Three phase Induction Motor Drive.

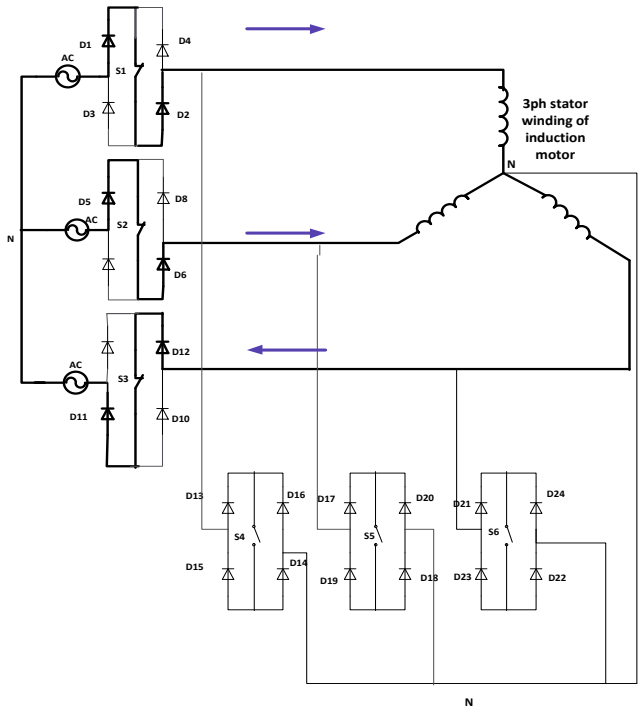


Figure 2. Active Mode

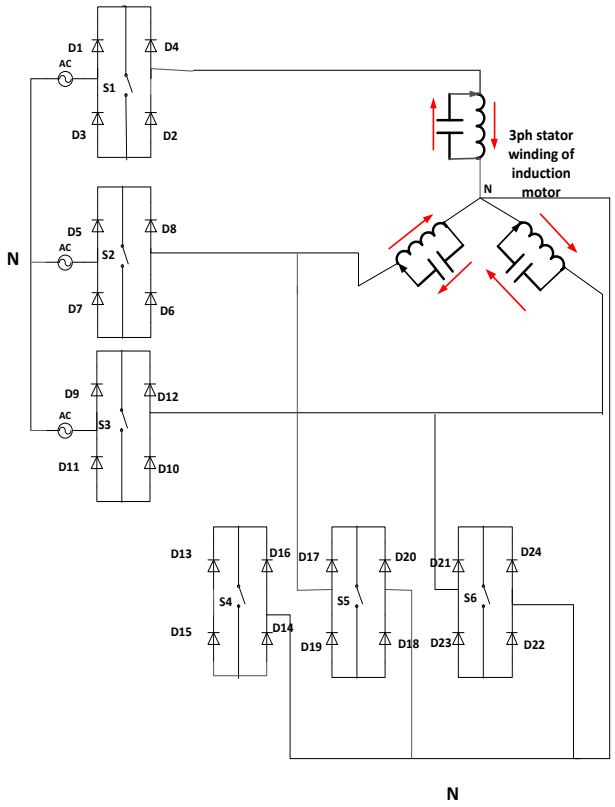
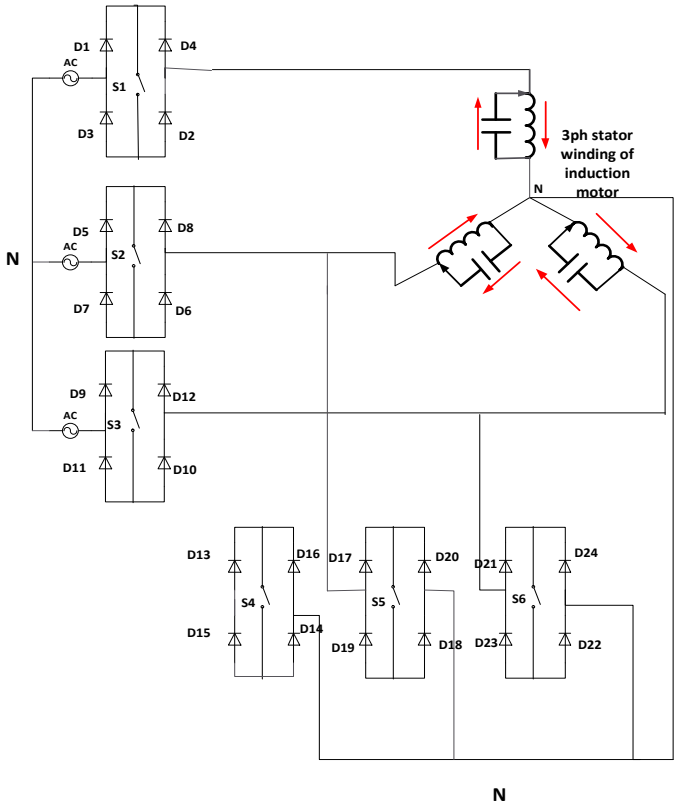


Figure 3. Dead time I mode



Figue 5. Dead time II mode

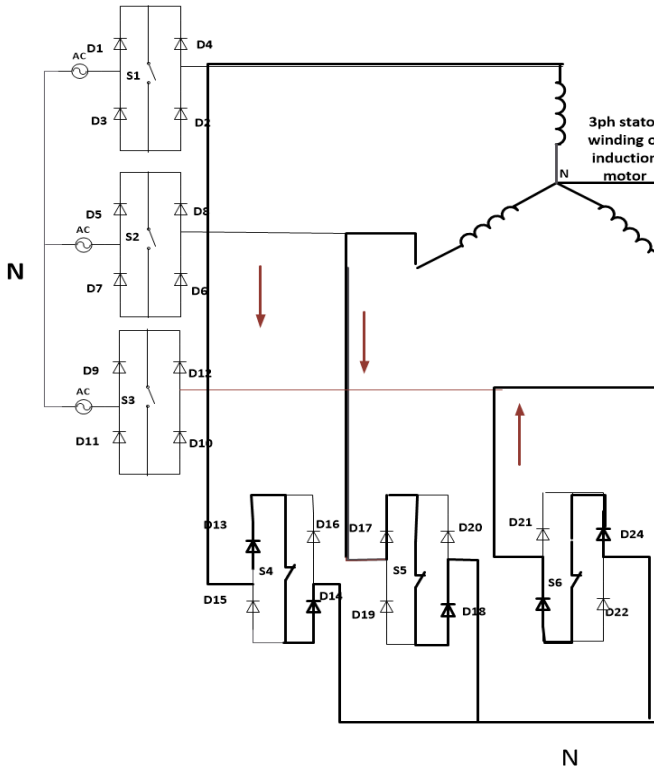
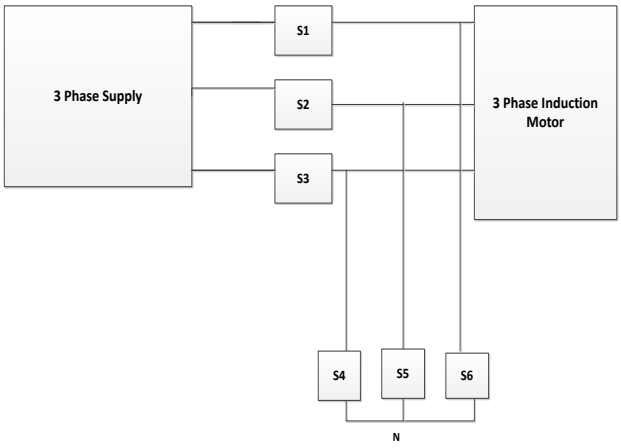


Figure 4. freewheeling mode

Block Diagram



Simulation Parameters

Parameters	Value
Max Supply Voltage	400V
Supply Frequency	50Hz
Load Resistance	100Ω
Load Inductance	10mH

V. SIMULATION RESULTS

The simulation result in Figure 6. are the gate pulses for all the switches (S1 S2 S3 S4 S5 S6) for extinction angle 10 degree is obtained. Switches S2 and S3 are phase shifted by the pulses of switch S1 by 120 degree and 240 degrees respectively. Switch S4, S5, S6 operates in complementary to all the three switches, so the pulses obtained for it are complementary to the pulses obtained for the three main switches. Result obtained is the waveform for the three phase load voltage for an extinction angle 10 degree.

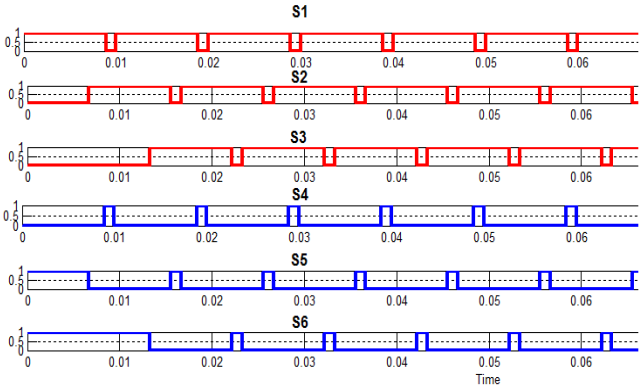


Figure 6. Gate pulses for extinction angle 10 degree

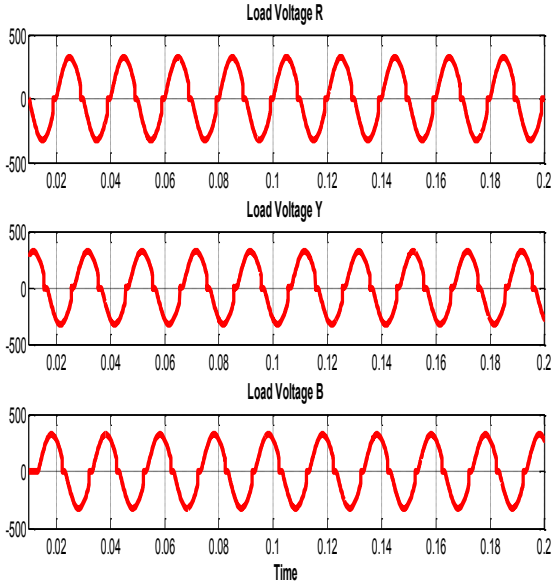


Figure 7. Load voltage waveform for extinction angle 10 degree

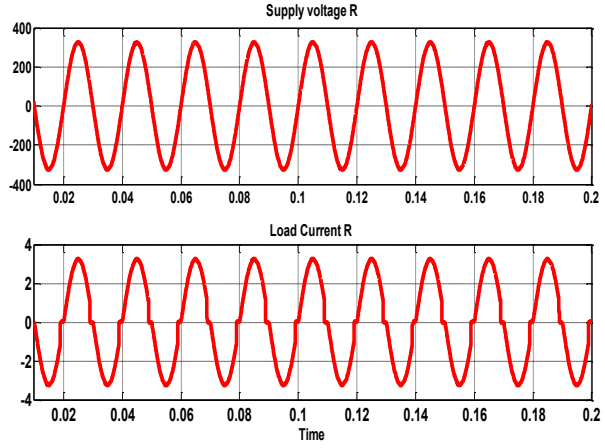


Figure 8. Load current and supply voltage waveform for extinction angle 10 degree

The result obtained in Figure8. shows the waveform of instantaneous load current for phase R, from which fundamental value of load current can be derived and it can be seen that current is leading supply voltage of phase R . Thus the obtained displacement factor will be leading.

VI. CONCLUSION

In the proposed drive desired range of voltage and high power factor control are obtainable by controlling the extinction angle. The stator copper losses are expected to reduce due to increase in power factor and reduction in magnitude of stator current.

VII. ACKNOWLEDGMENT

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