A CURRENT-SOURCE-INVERTER-FED INDUCTION MOTOR DRIVE SYSTEM WITH REDUCED LOSSES

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ABSTRACT

This project explores a high-power CSI-fed induction motor drive. The main problems with VSI(Voltage Source Inverter) and VSR(Voltage Source Rectifier) is that they don't have advantages like energy saving, reduction of cost and loss, improvement of line side and motor side waveforms, reduction of dc-link current and driver current rating. But all these overcome with CSI(Current Source inverter) and CSR(Current Source Rectifier) which are proposed in our project. We use CSI maximum modulation index control scheme and a flux control scheme .With the proposed dc current minimization strategy, the losses in the semiconductor devices and the drive's dc link can be reduced, and the drive current rating could be lowered and efficiency of the motor is improved .

Keywords: VSI, VSR INDUCTION MOTOR

I INTRODUCTION

Power electronics combine power, electronics and control. Control deals with the steady-state and dynamic characteristics of closed-loop systems. Power deals with the static and rotating power equipment for the generation, transmission and distribution of electrical energy. Electronics deal with the solid-state devices and circuits for signal processing to meet the desired control objectives. Power electronics may be defined as the applications to meet the desired control objectives. Power electronics may be defined as the applications of solid-state electronics for the control and conversion of electric power. Provides a (FSIG), which lack the adequate system fault ride through capability on their own. The study also provides a guideline of choosing the rating of UPQC in accordance to the demanded level of fault-ride-through capability. Power electronics have already found an important place in modern technology and now used in a great variety of high-power products, including heat controls , light controls , motor controls , power supplies , vehicle propulsion systems, and high-voltage direct-current(HVDC) systems. It is difficult to draw the flexible ac transmission (FACTs) boundaries for the applications of power electronics especially with the present trends in the development of power devices and microprocessors.

II INVERTERS

Dc-to-ac converters are known as inverters. The function of inverter is to change a dc input voltage to a symmetric ac output voltage of desired magnitude and frequency. The output voltage could be fixed or variable at a fixed or variable frequency. A variable output voltage can be obtained by varying the dc input voltage and maintaining the gain of the inverter constant. On the other hand, if the dc input voltage is fixed and it is not controllable, a variable output voltage can be obtained by varying gain of the inverter, which is normally accomplished by PWM(pulse width modulation) control within the inverter. The inverter gain may be defined as the ratio of the ac output voltage to dc input voltage. Inverters are widely used in industrial applications such as variable-speed ac motor drives, induction heating, standby power supplies and uninterruptible power supplies. Inverters can be classified as voltage source inverters(VSIs) and current source inverters(CSIs). A voltage source inverter is fed by a stiff dc voltage, where a current source inverter is fed by a stiff current source. A voltage source can be converted to a current source by connecting a series inductance and then by varying the voltage to obtain the desired current.

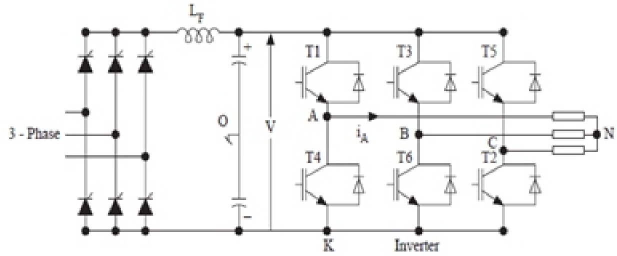
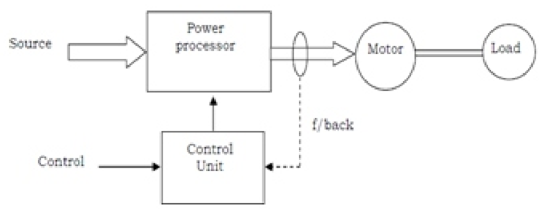


Fig. 1 Three Phase Converter and Voltage Source Inverter Configuration

III ELECTRICAL DRIVES

Drives can be defined as systems employed for motion control –e.g transportation, fans, robots, pumps etc. Prime movers are required in drive systems to provide the movement- can be diesel engines, petrol engines, hydraulic motors, electric motors etc. Drives that use electric motors as the prime movers are known as electrical drives.



Electrical Drives is multi-disciplinary field. Various research areas can be sub-divided from electrical drives.

3.1 Components of Electrical Drives:

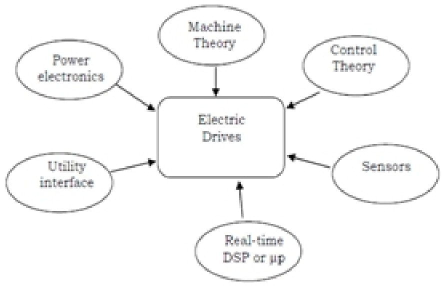


Fig. 2 Various Research Areas For Electrical Drives

IV COMPONENTS OF ELECTRICAL DRIVES

Motors obtain power from electrical sources. They convert energy from electrical to mechanical- therefore can be regarded as energy converters. They are several types of motors used in electric drives- choice of type used depends on applications and electrical sources available. Broadly, they can be classified as either DC or AC motors. DC motors (wound or permanent magnet)- DC voltage AC motors Induction motors- squirrel cage, wound rotor- AC voltage Synchronous motors- wound field, permanent magnet- AC voltage etc Electrical sources or power supplies provide the energy to the electrical motors. For high efficiency operation, the power obtained from the electrical sources need to be regulated using power electronic converter Since the electrical sources are normally uncontrollable, it is therefore necessary to be able to control the flow of power to the motor- this is achieved using power processor .Converters are used to convert and possibly regulate the available sources to suit the load i.e. motors DC-AC, AC-DC, DC-DC, AC-AC are efficient because the switches are operate in cut-off or saturation modes. Complexity depends on drive performance Analog to noise , nonflexible, infinite bandwidth Digital immune to noise ,configurable, bandwidth depends on sampling frequency.

V OVERVIEW OF A.C AND D.C DRIVES

AC drives used for fixed speed operation. This is because it is not easy to obtain variable frequency supply. The efficiency of the drive is low when fixed frequency and variable voltage supply is used to control the speed of the motors. However, variable DC supply can be easily obtained. Consequently, DC drives are widely used for variable speed operation. Speed control is achievable in AC drives because variable frequency can be obtained using voltage source inverter (i.e power electronic converter). Dc drives were replaced with AC in variable speed applications which do not require high performance operations. AC drives use AC motors hence require less maintanence e.g squirrel cage induction motors require minimum maintanence since no contact brushes are used. With the advancement of power semiconductor devices and powerful microprocessors, it is possible to control the AC motors that will give comparable performance to that of DC drives.AC drives utilizing control techniques such as field-oriented control(F.O.C) and Direct Torque Control(DTC) are now gradually replacing Dc drives in high performance applications.

VI VOLTAGE-FED INVERTER INDUCTION MOTOR DRIVE

The front-end diode rectifier converts 60 Hz ac to dc, which is then filtered to remove the ripple. The dc voltage isthen converted to variable-frequency, variable-voltage output for the machine through a PWM bridge inverter. Among a number of PWM techniques, the sinusoidal PWM is common. The stator sinusoidal reference phase voltage signal is compared with a high-frequency carrier wave, and the comparator logic output controls switching of the upper and lower transistors in a phase leg. The phase voltage wave shown refers to the fictitious center tap of the filter capacitor. With the PWM technique ,the fundamental voltage and frequency can be easily varied. The stator voltage wave contains high-frequency ripple, which is easily filtered by the machine leakage inductance. The voltage-to-frequency ratio is kept constant to provide constant air gap flux in the machine. Up to the base or rated frequency wb, the machine can develop constant torque. Then, the field flux weakens as the frequency is increased at constant voltage. The speed of the machine can be controlled in a simple open-loop manner by controlling the frequency and maintaining the proportionality between the voltage and frequency. the motor will act as a generator and the inverter will act as a rectifier, and energy from the motor will be pumped back to the dc link. The dynamic brake shown is nothing but a buck converter with resistive load that dissipates excess power to maintain the dc bus voltage constant.

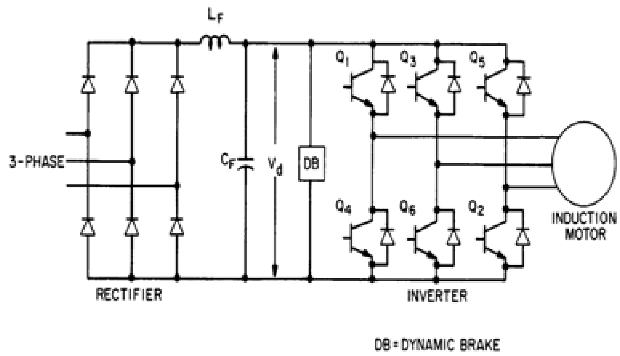


Fig.3 Diode rectifier PWM inverter control of an induction motor

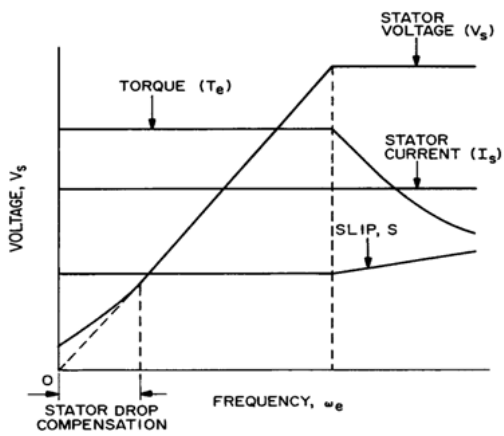


Fig.4 Voltage-Frequency Relation Of Induction Motor

VII Current-Fed Inverter Induction Motor Drive:

The speed of a machine can be controlled by a current-fed inverter as shown in Fig. The front-end thyristor rectifier generates a variable dc current source in the dc link inductor. The dc current is then converted to six-step machine current wave through the inverter. The basic made of operation of the inverter is the same as that of the rectifier, except that it is force commutated , the capacitors and series diodes help commutation of the thyristors. One advantage of the drive is that regenerative braking is easy because the rectifier and inverter can reverse their operation modes. Six-step machine current, however, causes large harmonic heating and torque pulsation, which may be quite harmful at low-speed operation. Another disadvantage is that the converter system cannot be controlled in open loop like a voltage-fed inverter. also increases considerably. Therefore it is not possible to bring back the generator terminal voltage to its pre-fault value unless over speeding of the generator is prevented. This triggers protection circuit to disconnect the wind turbine from the network

[2,3].

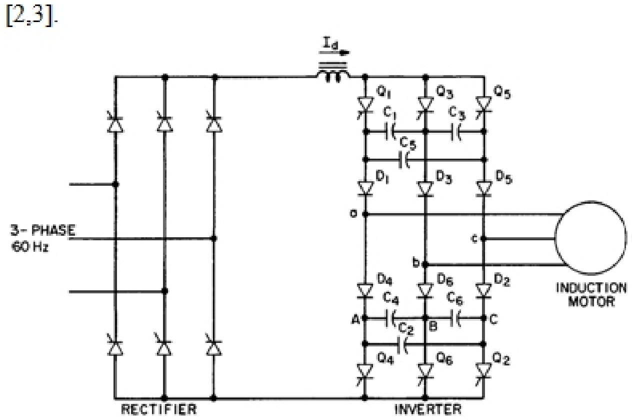


Fig.5 Force-commutated current-fed inverter control of an induction motor

STATOR EQUIVALENT CIRCUIT FOR A POLYPHASE INDUCTION MOTOR

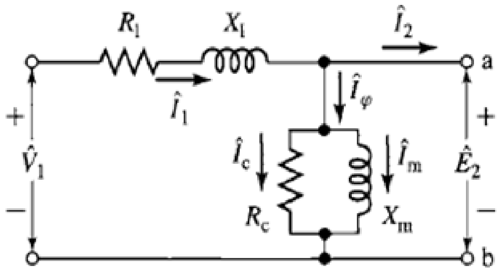


Fig. 6 Equivalent Circuit Of Induction Motor as Referred To Stator

Equation,

$$Z_2 = \frac{\hat{E}_{2S}}{\hat{I}_2}$$

Slip-frequency leakage impedance Z_{ROTOR} of the actual rotor must be

$$Z_{2S} = \frac{\hat{E}_{2S}}{\hat{I}_{2S}} = N^2{}_{EFF}\left(\frac{\hat{E}_{ROTOR}}{\hat{I}_{ROTOR}}\right) = N^2{}_{EFF}.Z_{ROTOR}$$

Neff -> is the effective turns ratio between the stator winding and that of the actual rotor winding E2s-> it is the voltage induced in the equivalent rotor by the resultant air gap fluxI2s-> it is the corresponding induced currentThe slip-frequency leakage impedance of the referred rotor

$$Z_{2S} = \frac{\hat{E}_{2S}}{\hat{I}_{2S}} = R_2 + jsX_2$$

Where

R_2 =referred rotor resistance

sX_2 =referred rotor leakage reactance at slip frequency

ROTOR EQUIVALENT CIRCUIT FOR A POLYPHASE INDUCTION MOTOR AT SLIP FREQUENCY

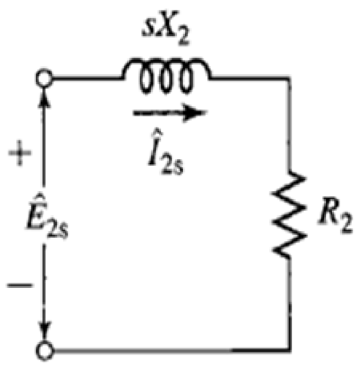
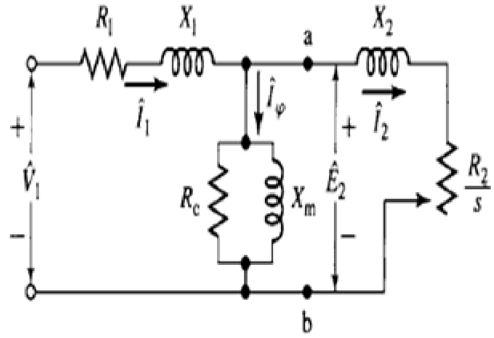


fig. 8 Equivalent Circuit Of induction Motor(referred to rotor).

I2s is defined as the current in an equivalent rotor with same number of turns per phase as the stator. The relative speed of the flux wave with respect to the rotor is s times its speed with respect to the stator, the relation between these emfs is given by the Equation

$$E_{2S} = sE_2$$

SINGLE-PHASE EQUIVALENT CIRCUIT FOR A POLYPHASE INDUCTION MOTOR



VIII SIMULATION BLOCK DIAGRAM

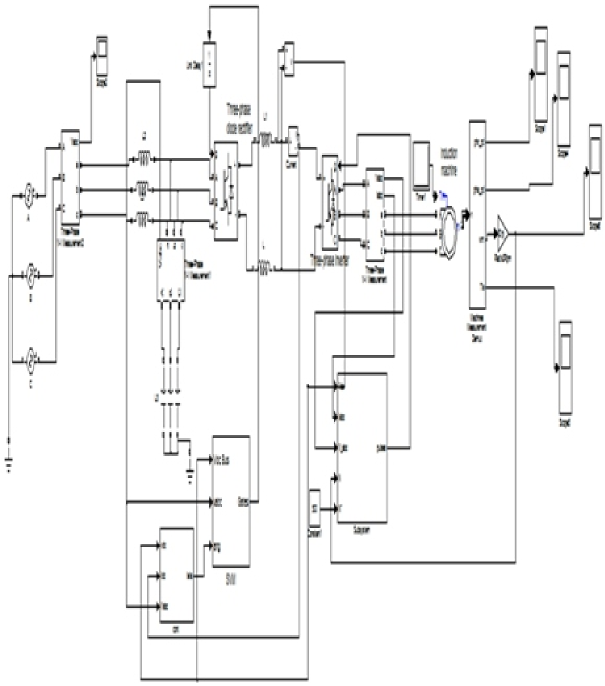


Fig. 9 simulation diagram for current source inverter fed induction motor

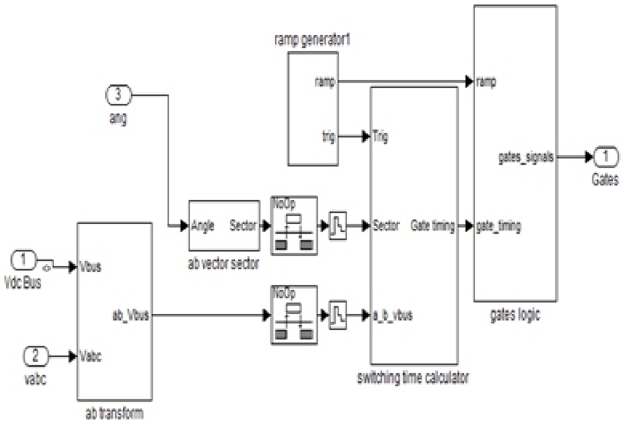


Fig. 10 svm block

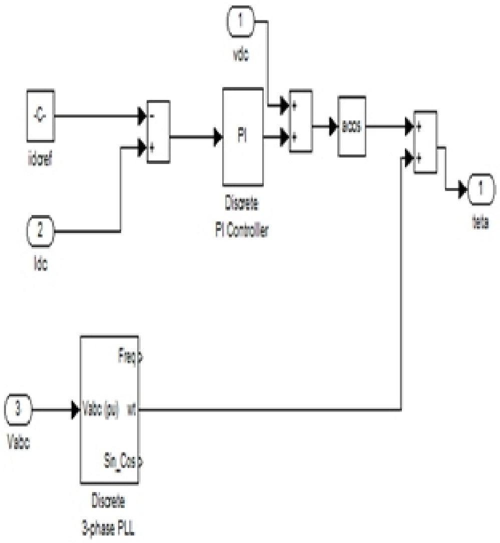


Fig. 11 csr(current source rectifier) block

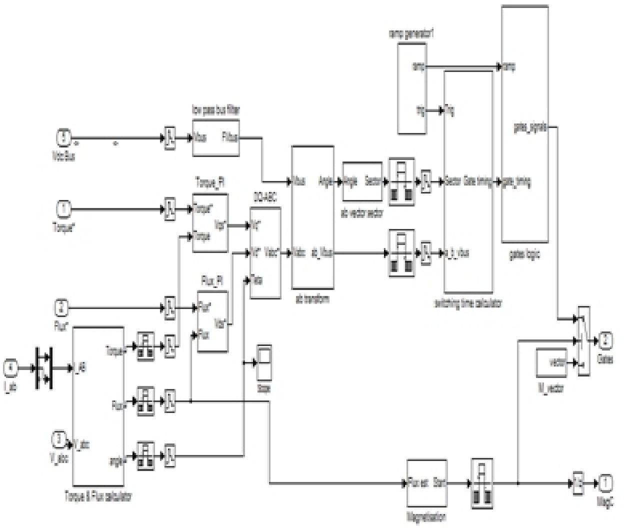
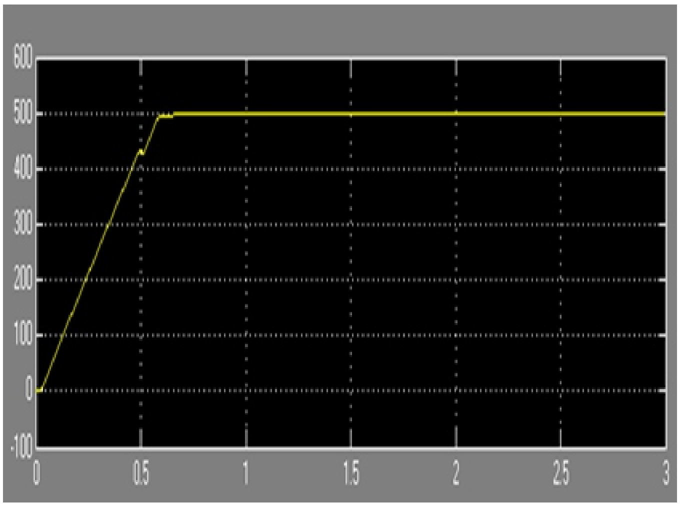
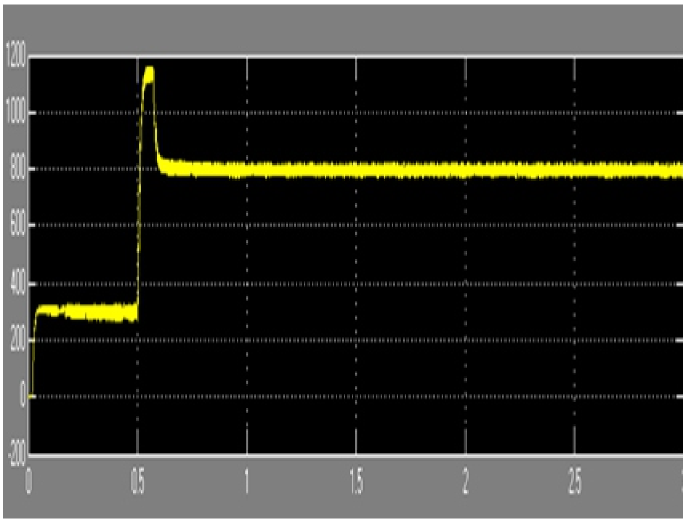


Fig.12 foc-svm block speed(rpm)



time(sec)

fig. 13 speed of the induction motortorque(n-m)



time (sec)

fig.14 electromagnetic torque (te) output wave form

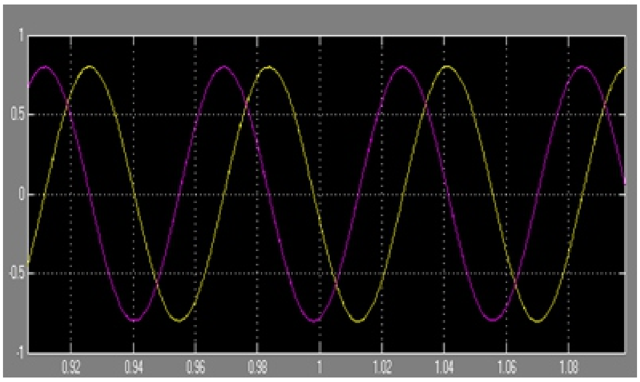


Fig 15 waveform for stator flux

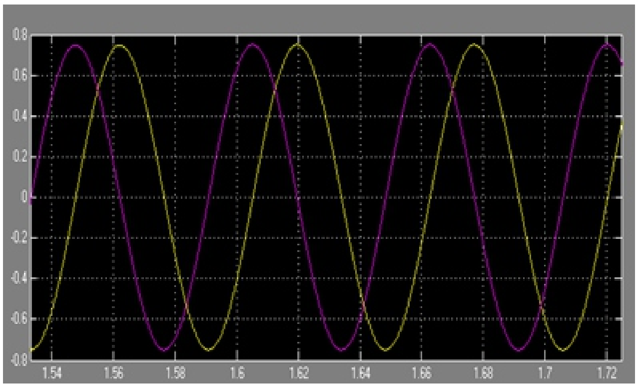


Fig 16 waveform for rotor flux

CONCLUSION

This report has presented the losses that are associated with the motor-drive system and to improve the efficiency of the motor. The SVM (Space Vector Modulation)technique used for the motor-drive system to reduce the drive current rating and improve the motor side waveforms. The FOC(Field Oriented Control) of Induction Machine is used to control the speed and torque of the induction motor. The simulations carried out show that dc-link current is minimized. It is also observed that motor current magnitude and efficiency of the motor is improved.

The performance of induction motor is observed using MATLAB/SIMULINK.

REFERENCES:

1. Yun Wei Li, Member, IEEE, Manish Pande, Member IEEE, Navid R Zargari, Senior Member IEEE and Bin Wu, Fellow, IEEE " DC-LINK CURRENT MINIMIZATION FOR HIGH-POWER CURRENT-SOURCE MOTOR DRIVES", IEEE transactions on Power Electronics , vol.24, no.1,JANUARY 2009.

2.. Jose R. Espinoza, member IEEE Geza Joos, senior Member IEEE "A CURRENT-SOURCE INVERTER FED DRIVE SYSTEM WITH REDUCED LOSSES", IEEE transactions on Industry Applications, vol.34,no.4AUGUST 1998

3. Mr.G.Pandian and Dr.S.Rama Reddy "IMPLEMENTATION OF MULTILEVEL INVERTER-FED INDUCTION MOTOR DRIVE" VOL.24,NO.1,JUNE 2008

4. Thesis on "ACTIVE HARMONIC ELIMINATION IN MULTILEVEL CONVERTERS" Submitted by Zhong Du.

5. Thesis on "SPACE VECTOR MODULATION AND CONTROL OF MULTILEVEL CONVERTERS", Submitted by Nikolae Celanovic