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A Novel Auto Transformer Space Vector Controlled Strategy of an Induction Motor Drive near The 12-Step Mode of Operation

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Abstract - This work give a novel autotransformer a lessened kilovolt-ampere rating is exhibited for harmonic current decrease in twelve-pulse ac-dc converter-fed vector-controlled induction motor drives (VCIMDs). Diverse transformer arrangements for 12-pulse-based operation are additionally considered and a novel field weakening applied for improvement in torque of the induction motor based drive system. The design methodology for the proposed autotransformer is presented to demonstrate the flexibility in the design for making it a cost-effective replacement suitable for previous applications. The impact of load minor departure from VCIMD is likewise concentrated to exhibit the viability of the proposed field mitigator. Space Vector Pulse Width Modulation(SVPWM) is a standout amongst the most utilized methods to maintain the machine voltage and current because of its productivity. This algorithm is exceptionally utilized as a part of power electronic applications. This work describes simulation algorithm of SVPWM utilizing MatLab/simulink simulation environment. The primary algorithm of this work is to keep up current control regardless of whether the inverter output voltage is saturated, i.e., it enters the 12 stage method of operation. Below base speed, the drive will work as a typical rotor-flux-oriented vector-controlled drive. In field debilitating locale, when the inverter terminal voltage gets soaked and enters the six-advance method of operation, the q-pivot current controller adjusts the transition current reference rather than straightforwardly producing the q-hub voltage reference.

Keywords - Auto Transformer, Space Vector, IMD, VCIMD.

I. INTRODUCTION

Nowadays, in electrical vehicle drives AC motors are commonly used. It is because of theirs known advantages like reliability, simplicity, lack of mechanical commutator and brushes, ability to work under unfriendly conditions (dust, humidity, etc.) and low cost. Rated power of these drives varies from hundreds watts up to mega watts (high power applications). The most popular AC machines are induction motors IM and permanent magnet synchronous motors PMSM. These machines can be supplied from power electronics converters (like VSI inverters) and hence are used in various applications like electric vehicles EV, public transport, tools drives, etc. Some of them have to work above rated speed. This is essential in EV, including public transport. High speed operation can be achieved either by increasing supply voltage (not always possible) or by field weakening. In PMSM, where field is produced by magnets, field weakening algorithm is not profitable (high current is needed for permanent magnets flux reduction). Moreover, field weakening current has to be controlled precisely to not reach critical current magnitude and not demagnetize the PMSM magnets. Therefore, the field weakening is effective only in special constructions like buried magnet synchronous machines. Hence, the most common AC motors are IM, where the field weakening can be easily achieved by appropriate control algorithm. Therefore, operation above nominal speed is possible without additional losses (no need for demagnetization current like in PMSM). The standard IM are also far cheaper than PMSM motors.

Electrical machines are the most vital component in traction applications as they provide the electromechanical energy conversion. Propulsion applications require drive systems that can operate on high torque, power density while reducing maintenance costs and operational losses. Since the beginning of the 20th century, induction machines (IMs) have remained a popular choice in industrial practices owing to high ruggedness and reduced cost (absence of commutators and slip rings). Despite the merits, IMs are still less efficient than another class of AC machines the permanent magnet synchronous machines (PMSMs). In IMs a part of the rotor flux is produced by the currents flowing in rotor windings while in PMSMs the rotor flux is actually the permanent magnet flux generated by the permanent magnets (PMs) mounted on the rotor structure. Elimination of the rotor cage reduces the rotor mass thus PMSMs have a lower inertia and faster torque response compared with IMs of the same size. Additionally, absence of rotor currents eliminates the rotor losses leading to more efficient operation. Therefore, PMSMs are a more suitable candidate for traction applications.

The type of waveforms that the electric drive system deals with is ac waveforms, so the main objective of power converters needed in adjustable speed drives (ASDs) should produce an ac output waveform from a dc power supply. The magnitude, frequency, and phase of the sinusoidal ac outputs should be controllable. According to the type of ac output waveform, the power converter topologies can be considered as voltage source inverters (VSIs) and current source inverters (CSIs). The voltage source inverters, where the ac output voltage waveform can be controlled independently, is the most widely used power converters in ASDs and many industrial applications because they naturally behave as voltage sources as required in these applications. The output of the VSI is fed to the three phase induction motor which is finally connected to the load of the drive system.

II. SYSTEM MODEL

The two phases of each induction motor is connected to each leg and the third phase is connected to the series capacitor combinations. There are two modes of operations, Variable frequency mode and Constant frequency mode as shown in the Figure 2.1. The conducting switches supplies current for the two phases of motor. The capacitor is used to supply current for the third phase.

The closed loop system consists of carrier signal and reference signal. The carrier signal is generated from the difference between running speed and set speed. The reference signal is generated from the supply voltage. Reference signal is an constant signal where, the carrier signal varies according to the speed changes in the motor. The reference signal and carrier signal is compared to generate the PWM signal. These signals are used to control the ON/OFF period of switch by which the inverter output is varied and the speed is controlled for any load changes.

Closed loop system is fully automatic control system. The control depends on the output of the motor. Based on the speed of the motor the control signal is varied. By doing closed loop system the result is more accurate and more reliable. The result is not disturbed in the presence of non linearities because it consists of feedback mechanism. The closed loop system clears the error between input and output signals and hence the system remains unaffected to any load variations. The complexity is reduced and the efficiency is increased.

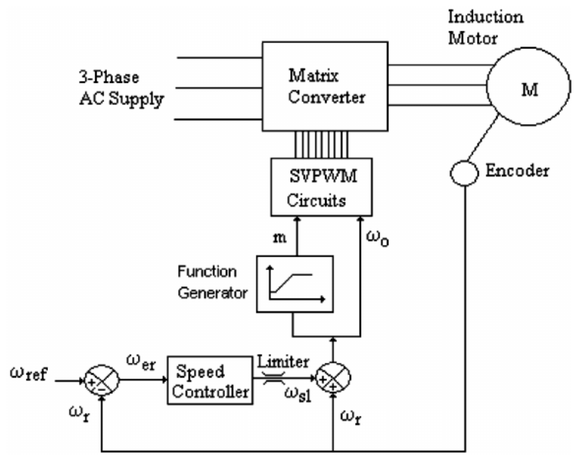

Figure 2.1 General Closed Loop Drive System Induction Motor

III. PROPOSED METHODOLOGY

The proposed system is designed to have a efficient drive system with the concept of field weakening to improve the torque of the induction motor drive. The strategy involved the synchronous machine generator as a three phase supply source which will be coneected to the load through treansmission line. The load is quipped with the squirrel cage induction motor drive with the RLC load. To improve the efficiency of the system or to improve the torque of the induction motor drive the field should be weakened, which can be achieved by reducing the flux procuced. The reduction in the flux weaken the field which directly improved the torque of the system.

In this work to reduce the flux control strategy is applied in the parallel of the system. The control strategy consists of autotransformer which would lead to different mode of operations. These different mode of operations are possible with the help of switch which turns on the different modes of operations. The switch is operated with the pulses generated using the phase difference of the phase B and phase c and signal generator. The load connected to the transmission line is through circuit breaker. Which is operated by the timer. This arrangement is nothing but the vector contolled arrangement.

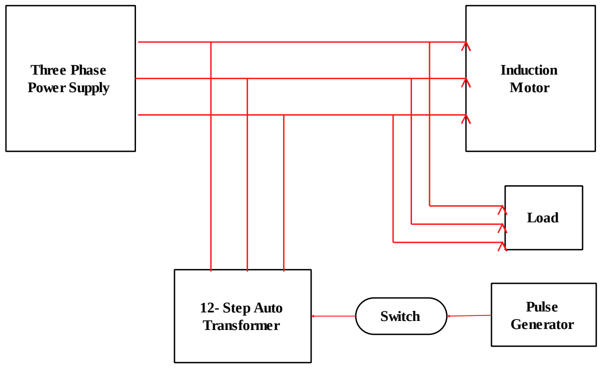

Fig.3.1 System Block Diagram

The design procedure for the proposed auto transformer is presented to show the flexibility in the design for making it a cost-effective replacement suitable for retrofit applications. Implementation of proposed work with auto transformer with 6 + 6 pulse converter has been shown in figure 3.2. The transformer is used to provide the galvanic isolation to the drive power supply form the AC grid. The converters are supplied by three phase auto transformer.

A set of power-quality indices on input ac mains and on a dc bus for a VCIMD fed from different 12-pulse ac-dc converters is given to compare their performance. The use of vector controlled induction motor drives VCIMD provides several advantages over DC machines in terms of size, robustness, lack of brushes, and maintenance and reduced cost.

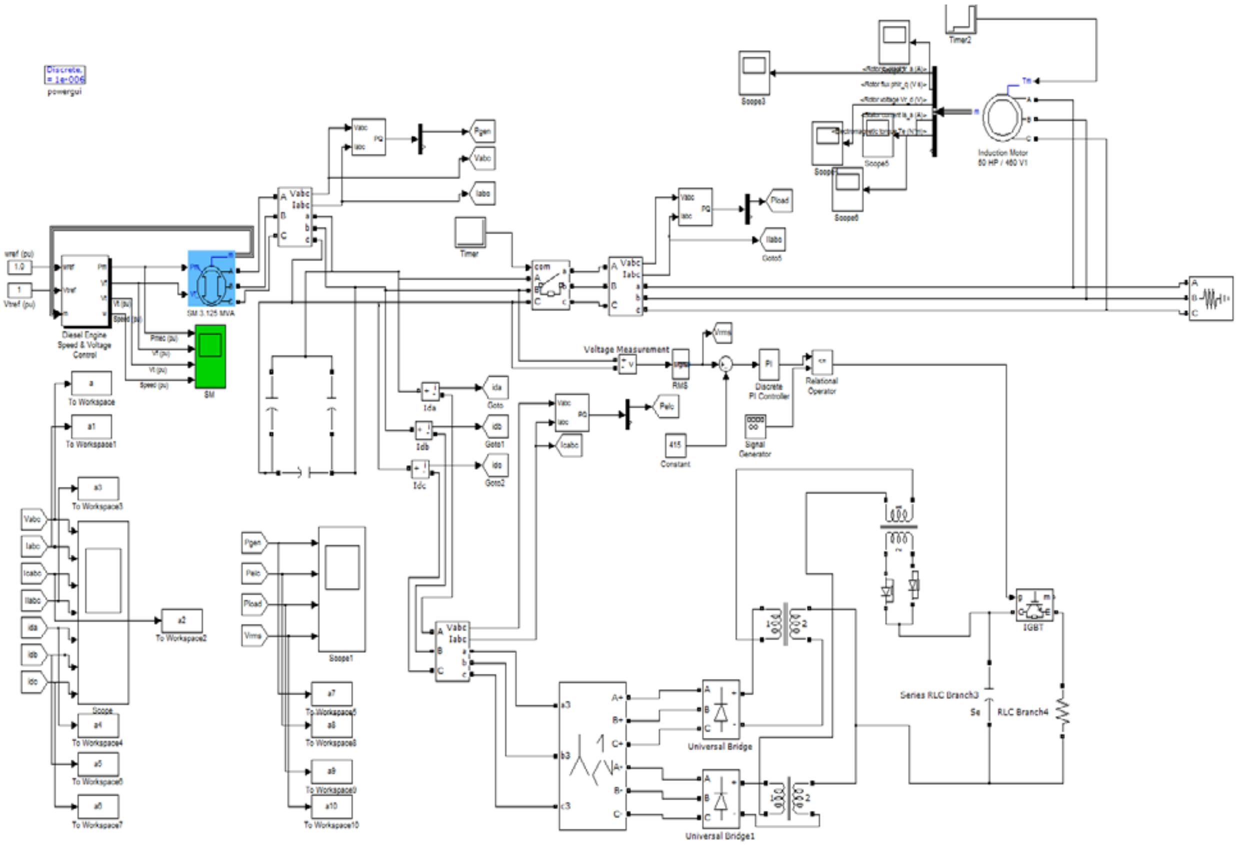

Figure 3.2 Proposed System with Auto transformer with 6 + 6 pulse converter.

IV. SIMULATION RESULTS

The simulation of proposed model has done on MATLAB SImulink. The simulation waveform of proposed work has been given in figure 4.1 and figure 4.2. Figure 4.1 shows three different waveforms for different power (Source,) and load voltage. There are about to 12 steps mode of operation are applied to achive desired controlled output wavefrom on matlab simulink simulation enviroment.

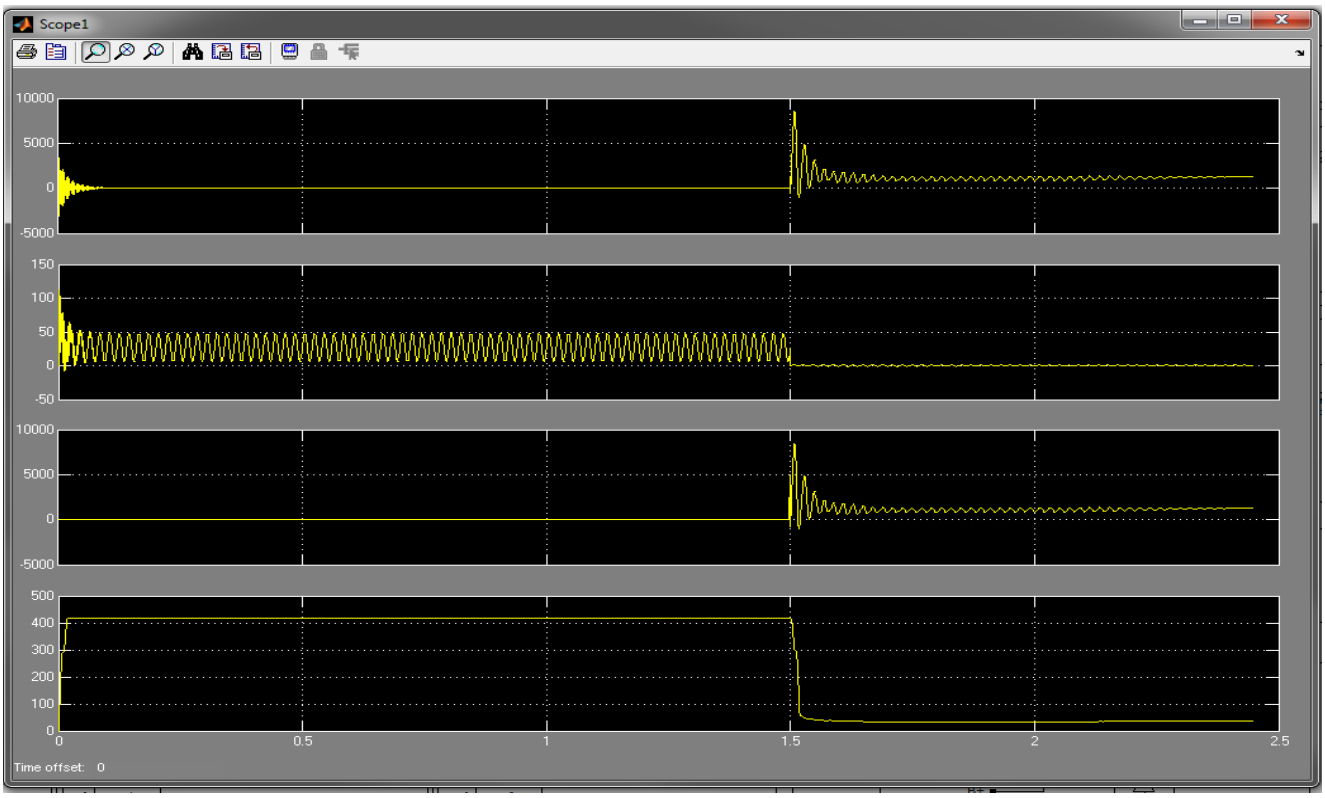

Figure 4.1 Different Power (Source, Controlled, Load) and Load Voltage.

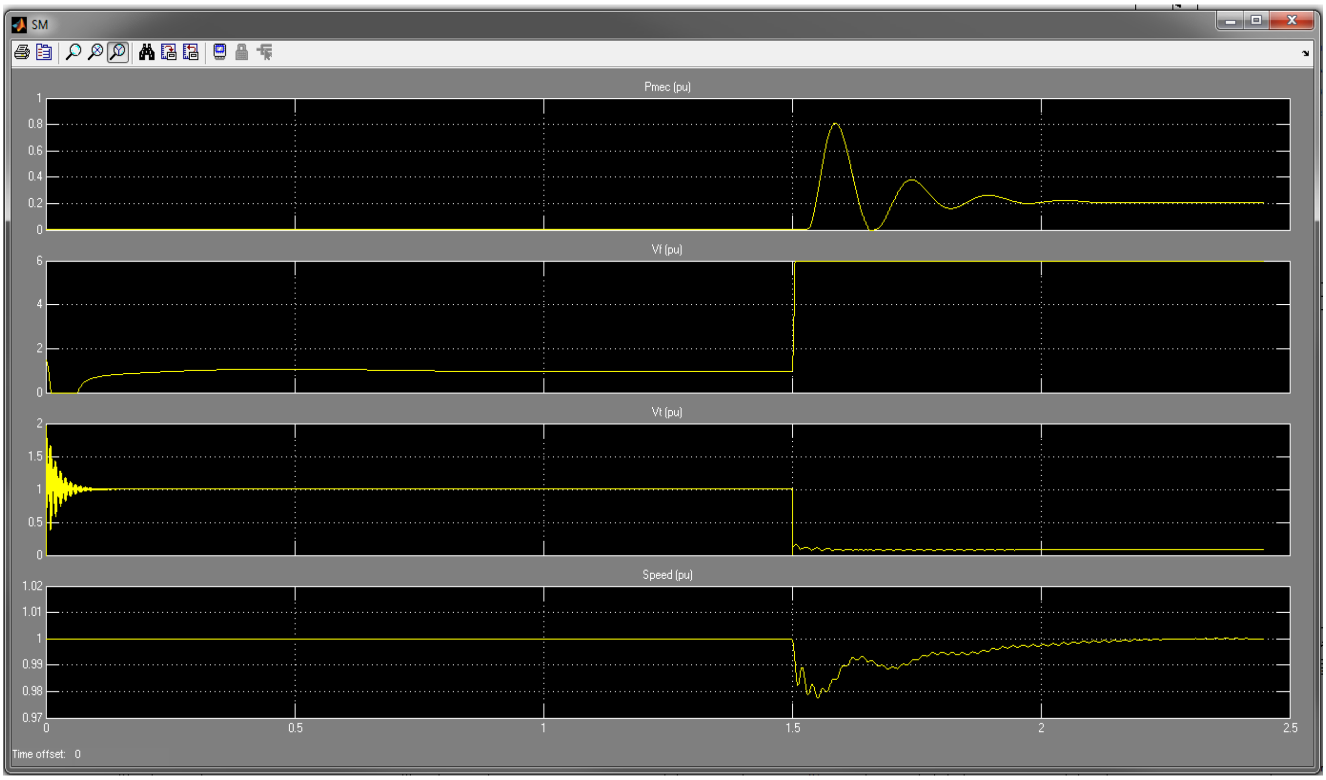

Figure 4.2 Governer Power, Field Voltage, Vt and Speed.

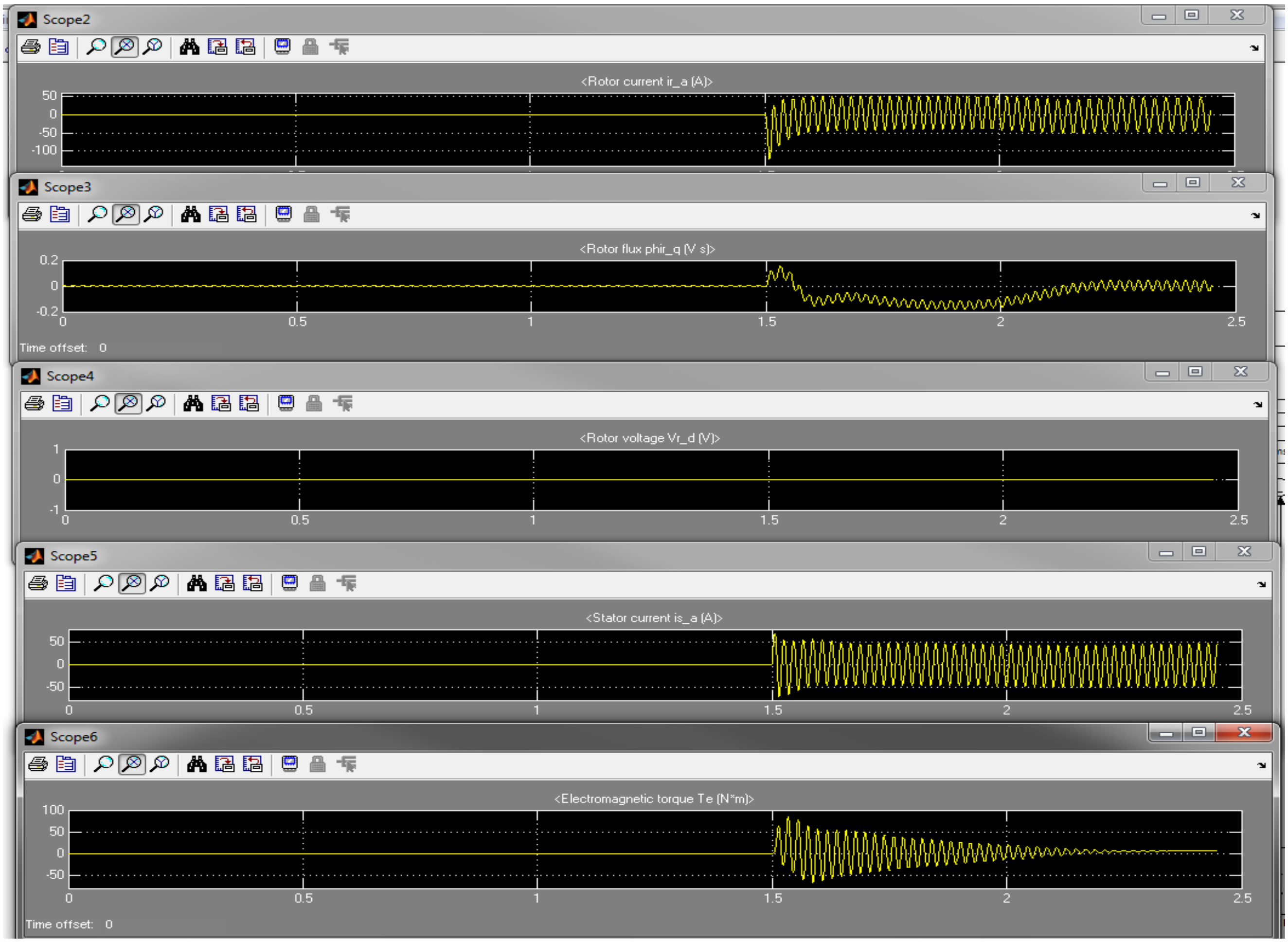

Fig. 4.3 Induction Motor Parameters

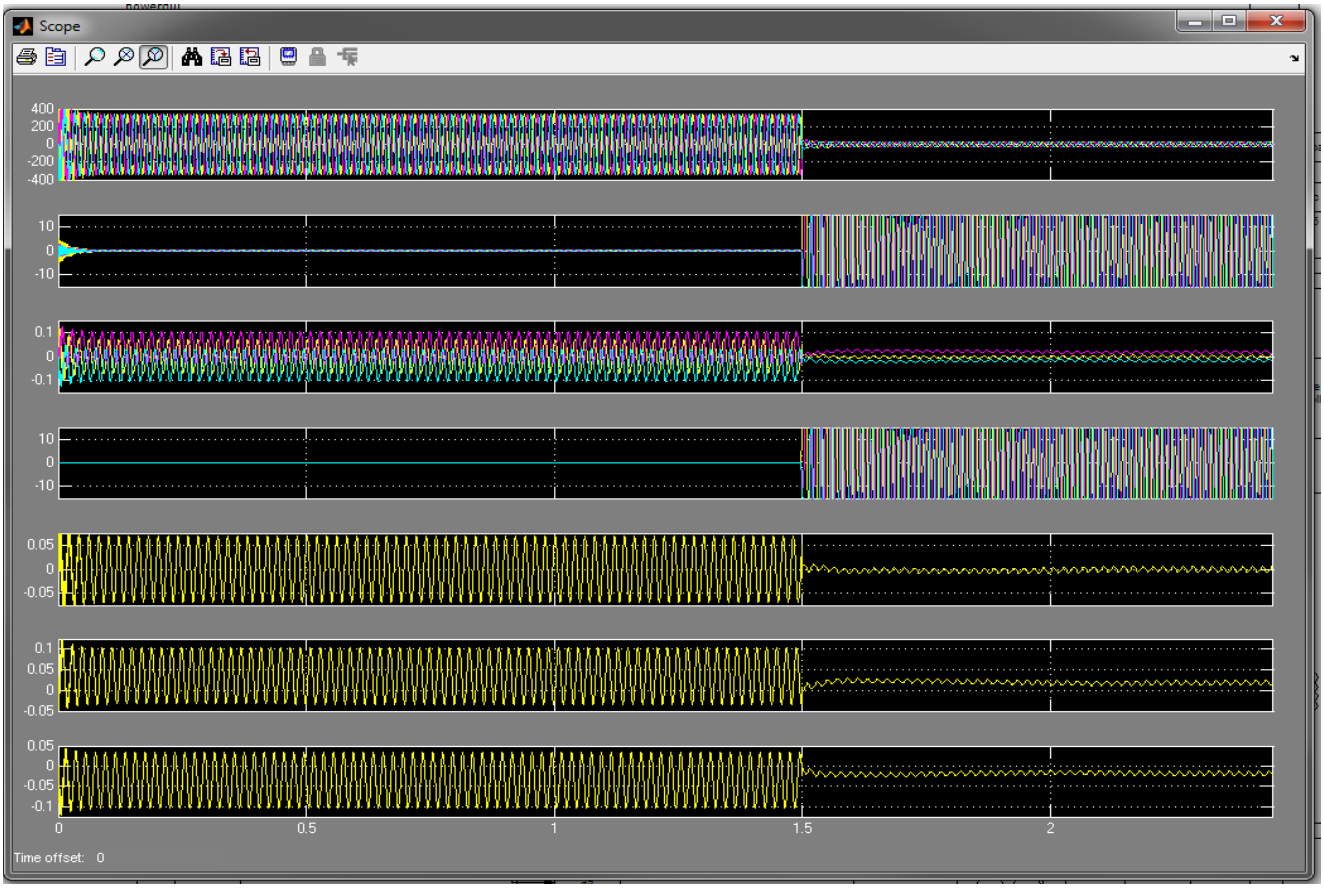

Fig. 4.4 Voltage, Controlling Current, Load Current and Three Phase Controlling Currents

Fig. 4.3 shows the induction motor parameters like Rotor current, Rotor flux, Rotor Voltage, Stator Current, and Electromagnetic torque. From the waveforms it is clear that the induction motor flux reduction increases the motor torque, which needs to be increased for better system operations.

Fig. 4.4 shows the system voltage, three phase control currents and load current along with single phase control currents and its variations.

V. CONCLUSION

This work presents control strategies, based on autotransformer space vector controlled strategy of an induction motor drive near the 12-step mode of operation are implemented and evaluated in MATLAB. From the simulation results it is clear that the proposed approach is effciently working towards the weakening of the field, which would lead to increment in the torque level. The future enhancement can be done in the advancement of vehicles, because in the future every vehicle need electric motors to run. In this case our proposed model will benefits the future technology to improve efficiency of the motor and torque with the optimum controlling while maintaining speed. Other future work consists of application in many hardware and industrial machines with the real-time implementation of proposed work to controlling different induction motor derives applications.

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