# Direct Torque Control and Field Oriented Control of VSIs Fed Three Phase Induction Motor Providing Variable Switching Frequencies

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***Abstract*: In this control schemes, two control methods along variable switching frequencies are proposed and examined for the paralleled voltage source inverters (VSIs) fed three phase induction motor drive. This control schemes can be applied to high power drive systems where the high frequency modulation index is high. Firstly, DTC is broadly used control method for three phase induction motor providing variable switching frequencies where torque and flux are controlled by using SVPWM method. Hence, along with fast dynamic response of torque control also speed of motor is controlled. Secondly, FOC with pulse width modulation using hysteresis controller under stationary frame are proposed for parallel fed induction motor. While designing these two schemes, the withdrawal of inherent circulating current is also considered. Apart from the advantages of DTC, the output currents of paralleled inverters are kept balanced.**

***Keywords – Voltage source inverter (VSI), Space vector pulse width modulation (SVPWM), Pulse width modulation (PWM), DTC, FOC***

## I. INTRODUCTION

The paralleled inverters fed electric drives have the benefits of simple modular design, high current ratings, high fault withstanding ability and good current waveforms [1]. Hence, they are used broadly in high control applications where at least two power converters are required for the important power limit, for example, the powerful compressor trains for melted common gas, high control gas or steam turbine [2]- [4]. They are additionally utilized for generation of power by wind [5].

For paralleled inverters encouraged electric drives, a few inverters are paralleled at their output of
ac sides resulting in increased output current ratings. Hence, this kind of paralleled inverters can share one normal dc link. This construction helps to save the cost as well as makes the control of dc connection voltage less demanding. In any case, the circling current may happen because of the familiarity in exchanging moments and contrast in parameters of paralleled inverters [6], [7].

In paralleled voltage source inverters, harmonics can be reduced by using the pulse width modulation (PWM) which in turn improves the harmonic performance of paralleled converters [8]. This PWM technique can be applied to sinusoidal PWM (SPWM), where SPWM is obtained and as a result switching harmonics is reduced for paralleled inverters [9]. These techniques results in the speed regulation of induction motor.

Generally most of the works on control method of the paralleled inverters fed induction motors are based on synchronous frame reference. The transformation of three phase currents into q-axis and d-axis under the synchronous frame. Using PI controllers, the q-axis and d-axis currents are controlled. And also control of paralleled inverters fed motors is proposed under stationary frame where the transformation of three phase currents into α-axis and β-axis. To control these currents, a proportional constant is used.

In this concept we generally concentrated on direct torque control (DTC) and field oriented control (FOC) of VSIs fed three phase induction motor providing variable switching frequencies.

Firstly, DTC is broadly used control method for three phase induction motor providing variable switching frequencies where torque and flux are controlled by using SVPWM. Hence, along with fast dynamic response of torque control also regulation of speed is obtained. Secondly, FOC with pulse width modulation using hysteresis controller under stationary frame are proposed for parallel fed induction motor. The proposed schemes such as chaotic SVPWM and generation of PWM using hysteresis current controller make the speed control of induction motor. While designing these two schemes, the withdrawal of inherent circulating current is also considered. Apart from the advantages of DTC, the output currents of paralleled inverters are kept balanced.

## PROBLEM FORMULATION

In this paper mainly concentrated on DTC and FOC technique of VSIs fed three phase induction motor providing variable switching frequencies. These control schemes which is proposed mainly based on the chaotic phase width modulation technique. This control schemes can be applied to high power drive systems where the high frequency modulation index is high. Generally, these controls are used for industrial purpose and also can be used in Traction purpose.

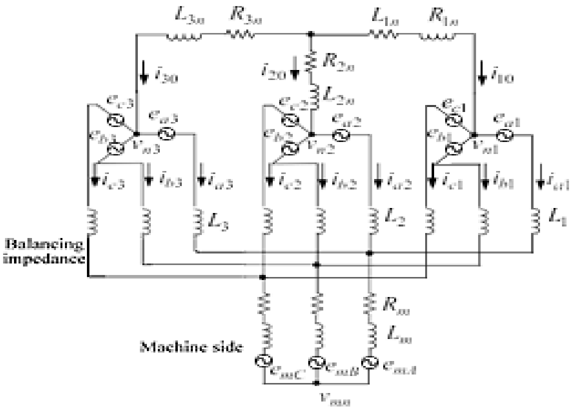


Fig.1 Equivalent circuit of three inverters fed PMSM drive.

Using phase shifted chaotic SVPWM with DTC and FOC with hysteresis controller schemes under stationary frame are proposed for the paralleled VSIs fed three phase Induction motor. The suggested control schemes such as SVPWM and hysteresis controller results in speed regulation of induction motor. Finally, the speed control of induction motor can be achieved with the proposed hysteresis controller under stationary frame and the DTC with interleaved SVPWM respectively. It can be observed that the low-order harmonics of currents using the three proposed schemes are similar, and they are also related to the low-order harmonics in back EMF of induction motor.

## II. METHODOLOGY PROPOSED

In this control schemes, two control methods along variable switching frequencies are proposed and examined for the paralleled voltage source inverters (VSIs) fed three phase induction motor drive. This control schemes can be applied to high power drive systems where the frequency modulation index is high. Firstly, DTC is broadly used control method for three phase induction motor providing variable switching frequencies where torque and flux are controlled by using SVPWM method. Hence, along with fast dynamic response of torque control also speed of motor is controlled. Secondly, FOC with hysteresis controller under stationary frame are proposed for parallel fed induction motor. While designing these two schemes, the withdrawal of inherent circulating current is also considered. Apart from the advantages of DTC, the output currents of paralleled inverters are kept balanced.

Connect DC supply to three parallel inverter and the output of the inverter is given to the induction motor.

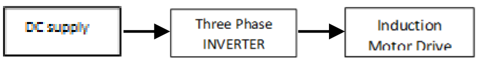


Fig.2 Block diagram of VSI fed Induction Motor

## III. SIMULATION RESULTS AND DISCUSSION

DTC is one of the control schemes for parallel fed three phase induction motor providing switching frequencies. Firstly, regulation of torque and stator flux of induction motor. Based on reference speed and current speed we need to generate flux. Each VSI is provided with traditional DTC,Hence these circulating currents are suppressed by the hysteresis current controller where each inverter currents made to track average phase currents of paralleled inverters as a result the currents of all inverters will be balanced and as a result regulation of speed for induction motor is achieved. Fig. 3 shows the simulation model using DTC method.

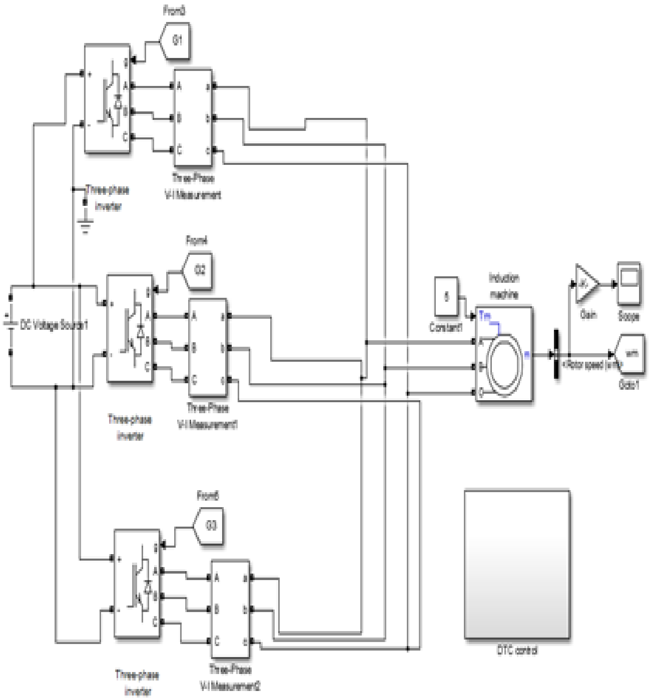

Fig. 3 simulation model using DTC

Fig. 4 shows the simulated performance of three VSIs fed induction motor drive using DTC schemes.

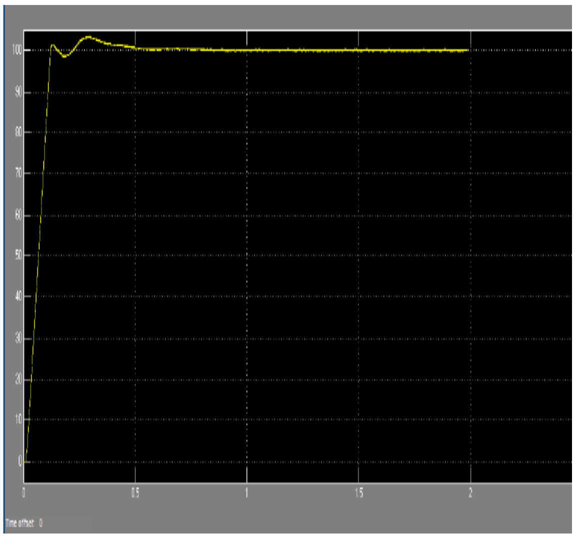

Fig.4 Speed regulation using DTC

From fig.4 it is observed that when reference speed is given as 100. Initially the speed will increase up to 100 and after settling time $t_s$ = 0.1 sec the speed will be same as reference speed. This figure indicates that good dynamic performance is given by the paralleled VSIs fed induction motor with the proposed DTC.

FOC is another control scheme for parallel fed three phase induction motor providing switching frequencies. In this schemes PWM is generated using hysteresis current controller method and this method is applied for three phase induction motor. Fig.6 shows the simulation model using FOC method.

FOC of induction motor is implemented under stationary frame hysteresis current controller. The frequencies of the carrier signals are adjusted in disrupted manner for paralleled inverters.

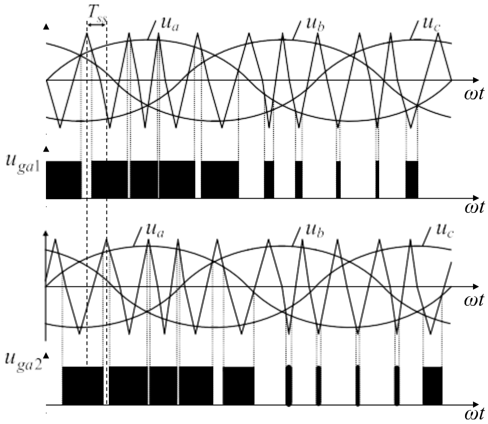


Fig.5 Principle of phase-shifted chaotic SPWM.

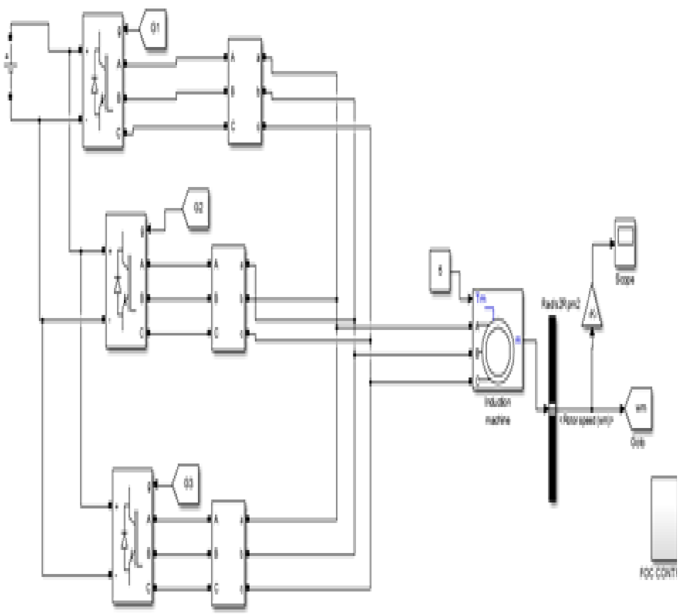

Fig.6 Simulation model using FOC

Fig.7 shows the simulated performance of three inverters fed Induction motor drive by using the proposed phase-shifted chaotic SPWM using hysteresis current controller under the stationary frame.

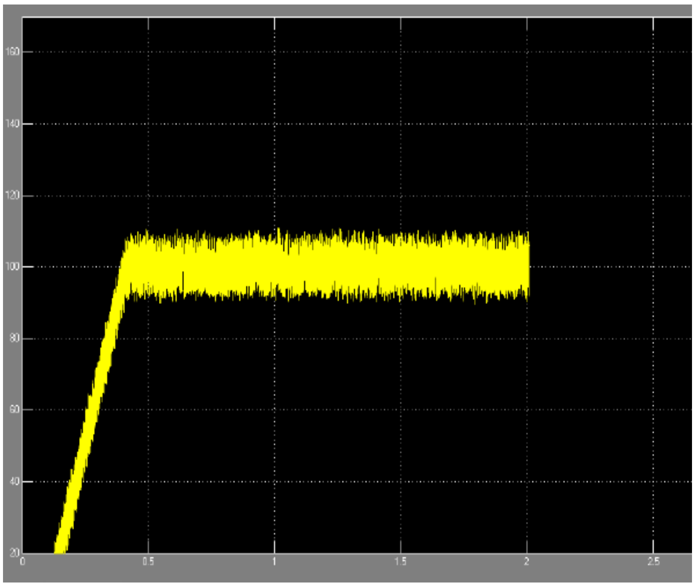


Fig.7 Speed regulation using FOC

From Fig.7 it is observed that when reference speed is given as 100. Initially the speed will increase up to 100 and after settling time ts = 0.5sec the speed will be same as reference speed.

## IV. CONCLUSIONS

A model of three paralleled VSIs fed Induction motor using DTC and FOC are proposed in this paper. As the performance of the DTC and FOC for parallel VSIs fed induction motor drive schemes has advantages of having small size, fast response in speed control. An induction motor model has been designed and its observability, controllability and stability have been shown. At present, these new techniques are alternative solution to the conventional control techniques. The outcomes of simulation have demonstrated a very high accuracy in speed control of induction motor.

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