# Comparative Analysis of Different Speed Synchronization Techniques of Induction Motors

**Project Advisor**

Mr. Muhammad Shoaib

**Co-Advisor**

Mr. Asif Hussain


**Submitted by**

Nawaz Rafique 091420139

Sajjad Hussain 091420150

Muhammad UsmanZafar091420094

Department of Electrical Engineering

School of Engineering

**University of Management and Technology**

# Comparative Analysis of Different Speed Synchronization Techniques of Induction Motors

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**Advisor Name: -**Mr.Muhammad Shoaib

**Advisor Signature: - ____________**

Nawaz Rafique 091420139

Sajjad Hussain 091420150

Muhammad UsmanZafar 091420094

Abstract

In this Research work a comparative analysis of different speed synchronization techniques for multiple induction motors is presented. Synchronization of multiple induction motor is the among the core processes used in different industries like drug production line, paint mixing, paper industries, textile industries to ensure the reliability and efficiency of the process involved. So these techniques are becoming much popular in industries and these are replacing the conventional mechanical coupling systems for synchronization. Various techniques to synchronize the speed of multiple induction motor during load change, acceleration and declaration are drafted and explicitly delineated. Comparative analysis of Direct Torque Control, Total Sliding Mode Control method, Adjacent Cross Coupling Control method and Speed - Sensor less Vector Control is carried out. It has been concluded that the selection of the synchronizing technique is application and process dependant. The limitations and advantages of these methods and the selection of the optimal method for synchronization are discussed and the analysis developed is validated using Simulation techniques.

# Dedication

First of all we are very thankful to ALLAH ALMIGHTY who has given us enough courage to complete this project.

Dedicated to

Our loving Parents

&

Mr. Muhammad Shoaib

Mr. Asif Hussain

Who enlightened our minds with Knowledge, tried

To include the spirit of hard work and dedicational us

So that we could have a BRIGHT FUTURE in terms

Of being good human and turn out to be competent

Engineers with powers to take challenging.

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# Chapter 1

## Introduction

### 1.1 Introduction

In industries more than 80 present of motors used are induction motors due to its reliability, low cost, simple construction, maintenance and high power capability.[1] In much of industrial applications speed synchronization of multiple induction motors is required. Many methods were proposed to achieve this requirement of speed synchronization and due to advancement in variable frequency drive the synchronization techniques become much easier and these techniques are replacing the old technologies for speed synchronization. However these techniques are application specific and extension and advancement in these techniques are difficult to fulfil the new synchronization requirement.

The purpose of this paper is to analyses the different techniques on base of their efficiency and effectiveness. These techniques are Adaptive Time Delayed Feedback Control (ATDFC) technique using stator flux regulation based on Direct Torque Control (DTC)[2], tracking error control and synchronization error control using total sliding mode control [3], speed tracking using adjacent cross coupling control [4], and Master Slave Speed Control[5].

## 1.2 Synchronization techniques

### 1.2.1 Direct torque control

In this proposed technique the speed synchronization of multiple induction motors is achieved using the adaptive time delay feedback control (ATDFC). It produces reference torque for SFR-based DTC. The parameters of ATDFC speed controller is selected on the base of trial and error approach such that its performance is acceptable according to our requirement. SFR-based DTC controller estimates the stator flux and calculates the torque using current and voltage. This current and voltage is obtained using Clarke Transformation of the three phase voltage source. The control signal to the three phase inverter is realized by selecting proper voltage space vector which is determined by the regulation in stator torque.

Master slave approach as shown in fig3.1 is adopted to apply ATDFC which produce reference torque for SRF based DTC which produce the control signal to the inverter to drive the slave induction motor according to the chaotic speed of master induction motor. To achieve speed synchronization the chaotic speed change should be according to reference flux and chaotic error of speed between master and slave must varies synchronously.

To analyse the model of induction machine, its controlling parameters and speed synchronization approach Lyapunov function and Riccati polynomial matrix is used.

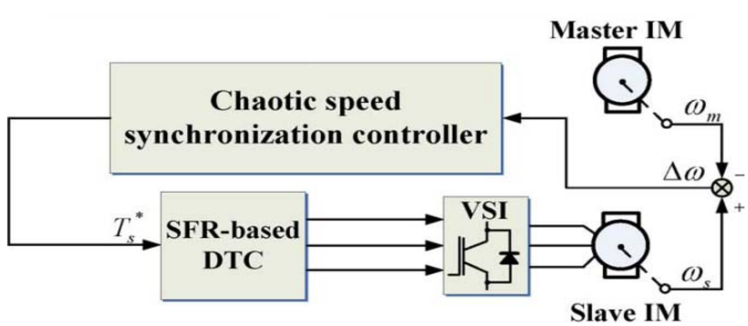


Fig 1.1. Chaotic speed synchronization scheme using master-slave approach.

This technique is developed for liquid mixing and it operates below 300 rpm. The limitations of this method is as mention in the paper that direct torque control is good for torque control but not good for speed control so DTC is not good for proposed speed synchronization. The DTC might be preferred for high dynamic applications, but, shows higher current and torque ripple. The slave follow the speed change in master motor and change in slave motor has no effect on speed of master induction motor. However this method is very effective in those applications where controlling of fast-changing chaotic motion is required. This technique requires more advancement for highly precise speed synchronization.

### 1.2.2 Total sliding mode control

In this proposed technique the speed synchronization of multiple induction is achieved by total sliding mode method incorporated with adjacent cross coupling which is consist of tracking error controller and synchronizing error controller.

To get fast response for synchronization the induction motor is divided into two sub systems i.e. electromagnetic and mechanical system. The electromagnetic system is fast in response while mechanical system is slow. So for fast response we control the electromagnetic parameters like electromagnetic torque, current and electromagnetic flux to its desire value.

Sun [6] has proven that if every pair of motor is in synchronize manner then all motor in the system are synchronized. To achieve synchronization the tracking error controller use error value to track the reference speed. This error value is the difference between the reference speed given to all motors and the speed of motor itself while synchronizing error controller make the error zero between controlled motor and it adjacent motors and synchronizes the output speed of all motors in the system.  This strategy requires number of controller double the number of motors. The adjacent cross coupling strategy is show in figure 3.2.

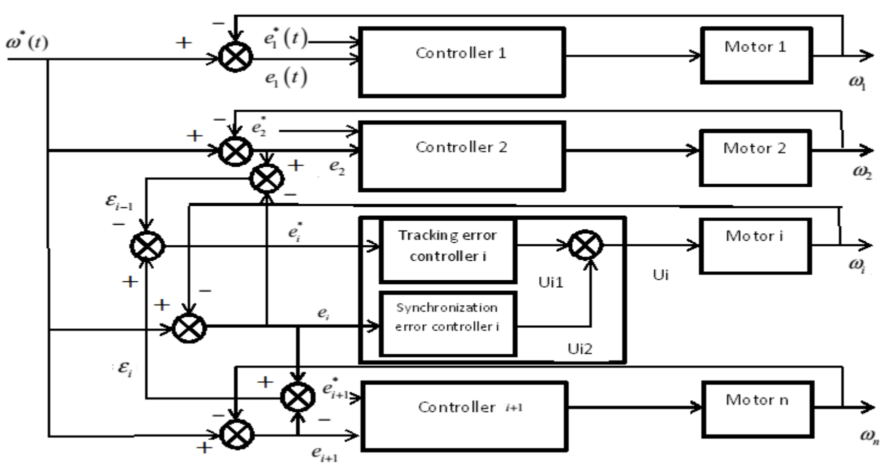


Fig. 1.2 adjacent cross coupling control

Theoretically the system is proven using different phenomena's which are to analyse the stability and control of the whole system Lyapunov phenomena is used and in design of speed controller sliding mode theory is used and chattering phenomena is used around this sliding mode surface.

### 1.2.3 Adjacent cross coupling

In this proposed technique asymptotic convergence of both speed tracking controller and speed synchronization controller is guaranteed and to implement direct field orientation sliding mode flux observer is used. This method is symmetry of Total Sliding Mode Method for speed synchronization is same. The only difference is in the applied theory of modelling and construction of speed synchronizing controller and tracking error controller. The theory applied on these controllers gives more precise result and its performance is better than the total sliding mode control method.

### 1.2.4 Master-slave

Master Slave approach is used to synchronize the speed of only two motors. In this paper for controlling of motors field oriented controller (FOC) and proportional integral (PI) controller is used. The transformed voltage components from (abc) coordinate to (qs-ds) cordinate to feed the pulse width modulator (PWM). PWM inveter is used to genrate the controlling signal for induction motor.

The speed of master motor is used as refrence spped by the slave motor and it track this speed to achive speed  synchronization. The speed change in master motor is reflected in  slave but any change in slave have no effect on master. This technique is not good for speed synchronization but for fast controlling it is batter. this method has low dynamic synchronizaation performance and asymetric responce. Speed and angle synchronization of this method is lower than other techniques [7]. The master slave strategy is shown in figure 3.3.

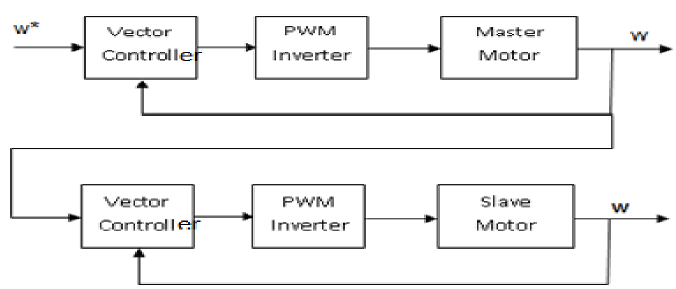


Fig. 1.3 Master-Slave scheme