An Implementation for Speed Control of Three Phase Induction Motor by V/F Technique

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ABSTRACT

This paper presents the design and physical layout implementation of constant v/f method for speed control of an AC induction motor using MATLAB technology. This method falls under the category of VVVF drives, The V/f technique is therefore a better solution so that the control on flux and torque become independent from each other and the induction motor is transformed from a non-linear to linear control plant. With the advent of field oriented control; the induction motor has become an attractive option. The main advantage of this technique lower Different type of loss in induction motor. In this report we will come to know the concept of V/F and different types of V/F techniques available.

Keywords: MATLAB, V/F, Pulse Width Modulation Converters, AC motor.

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I. INTRODUCTION:

Induction motors are commonly used in industrial applications, automotive control and in appliances.

The efficiency of these motors can be improved by the effective drive and control of speed of induction motor. Few applications of Induction motors are mechanical drives and automotive management. Traditional methods for speed control of induction motors are electromechanical switching, speed controllers using micro controllers and Digital Signal Processors. Few drawbacks of these methods are complex circuitry, application and component specific, no circuit modification etc. In earlier days, DC motors were used in cases where the load demanded variable speed. The commutator or carbon brush gear in the DC motor made it less dependable for speed control and required higher maintenance. Speed control techniques have evolved from these traditional methods to high speed digital controllers. The challenge in speed control is to strike the balance between speed, power factor and efficiency. This thesis develops the physical level implementation of steady V/f system for rate control of 3 AC Induction Motors (ACIM). The proportion between v/f is maintained constant keeping in mind the end goal to have an extreme torque for a given working condition. This strategy goes under Variable Voltage Variable

Frequency (VVVF) drives focused around sinusoidal pulse width modulation (SPWM). The VVVF output of the electrical converter is so used as source to a 3 induction motor to regulate its speed. SPWM technique helps in reducing the lower order harmonics and switching power loses of the converters.

II. BACKGROUND OF STUDY

A. Speed control of Three phase Induction Motor

A three phase induction motor is classified in to two types based on their construction of the rotor:
i. Squirrel cage Induction motor
ii. Wound rotor or Slip ring induction motor

AC IM starts rotating with a synchronous speed when it is fed by a balance 3 sources. A rotating magnetic field with constant magnitude is produced in the stator, which cuts the rotor winding and induces a voltage in the rotor winding and there by a current. This induced current creates a magnetic field in the rotor. Because of the collaboration between these two attractive fields, a torque is created. The torque created is specifically relative to the proportion of supply voltage and the frequency of supply. Two control algorithms to control the speed of an ACIM are open loop control scheme and closed loop control scheme. Various methods of speed control under these control algorithms are speed control by changing the number of poles, supply frequency, rotor resistance, changing supply voltage, constant V/f control and Vector control. Variable rotor resistance method of speed control is appropriate just to wound rotor motor to which an external resistance can be included using the slip rings. Steady V/f strategy is the most common open loop control scheme for ACIM as it minimizes the cost and provides accurate speed control. Scalar and Vector control using sensor or sensor less feedback are the closed loop control methods.

B. Pulse Width Modulation

PWM is a methodology in which the width of the pulses in a train of pulses is modified with respect to a control signal to attain a target low frequency output voltage or current. The width of the pulses depends on the amplitude of the control voltage. Sinusoidal Pulse Width modulation is the most common form of PWM, where a sine wave is contrasted with a saw tooth wave of high frequency. Switching in this method happens at the convergence of a target waveform and a high frequency triangle carrier wave. The triangle carrier wave is basic to every one of the three phases. Due to the switching, the potential difference of all three phases is equivalent and the voltage between lines is 0. A constant V/f ratio is maintained by varying the width of these zero voltage intervals while the frequency is adjusted. The sinusoidal control wave is compared to a triangular carrier wave of desired frequency to obtain a PWM signal.

When Vcontrol > Vtri, V_o = Vdc/2

When Vcontrol < Vtri, V_o = -Vdc/2

The PWM waveforms are designed to have a certain switching frequency (fs), modulation index (ma) and modulation frequency (mf)

Modulation index is the ratio between the amplitude of the control wave and amplitude of the carrier wave. Modulation frequency is given by the ratio of carrier signal frequency to control signal frequency. The intersection of carrier wave the signal happens only when the modulation index is less than 1.

III. PROPOSED WORK

DIRECT V/FMETHOD:

In direct V/f method we have seen that it determines the magnitude and position of the rotor flux vector by direct flux measurement or by a computation based on terminal conditions. It also called flux feedback control is method in which required information regarding the rotor flux is obtained by means of direct flux measurement or estimation. The flux is measured by the sensors like Hall Effect sensor, search coil and this is a part of the disadvantages. Because fixing of number of sensors is a tedious job and this increases the cost factor. The V/f algorithm is based on two fundamental ideas. The first is the flux and torque producing currents. An induction motor can be modeled most simply (and controlled most simply) using two quadrature currents rather than the familiar three phase currents actually applied to the motor. These two currents called direct (Id) and quadrature (Iq) are responsible for producing flux and torque respectively in the motor. By definition, the Iq current is in phase with the stator flux, and Id is at right angles. Of course, the actual voltages applied to the motor and the resulting currents are in the familiar three-phase system. The move between a stationary reference frame and a reference frame, which is rotating synchronous with the stator flux, becomes then the problem.

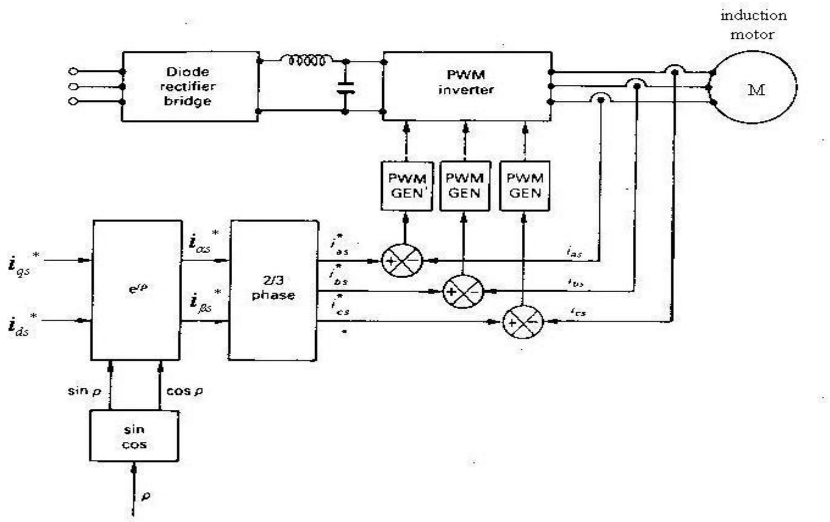

Fig 1: Basic field oriented control system for an induction motor with a current controlled PWM

IN-DIRECT V/FMETHOD:

Fig shows the basic block diagram of induction motor operating in indirect V/f mode. The motor speed is used as feedback signal in the controller. The controller calculates reference values of the two decoupled components of stator current space vector in the SRRF which are iqs* and ids* for the control of torque and flux respectively. The two components of the currents are transformed into three phase currents which are ias*,ibs*,ics* in the stationary reference frame of reference. Now as a balanced load, two of the phase currents are sensed and the third one is calculated from the two sensed currents.

SIMULINK MODELLING OF V/F TECHNIQUE:

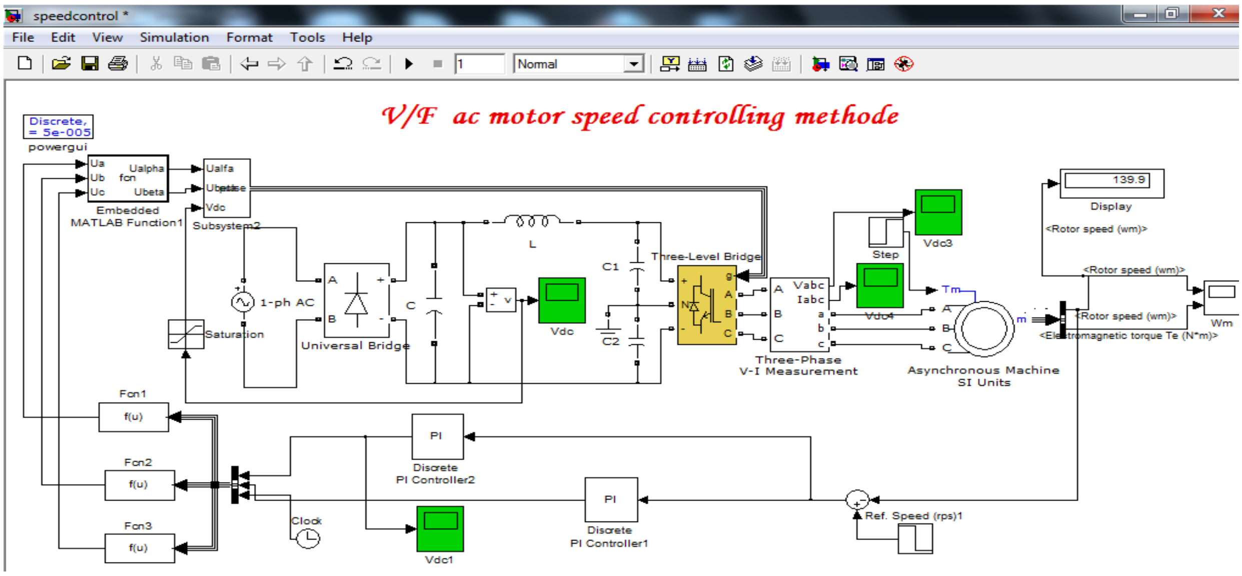

Fig 2: Simulink Modeling of V/F controlling induction Motor

OUTPUT WAVEFORM IN V/f CONTROLING INDUCTION MOTOR:

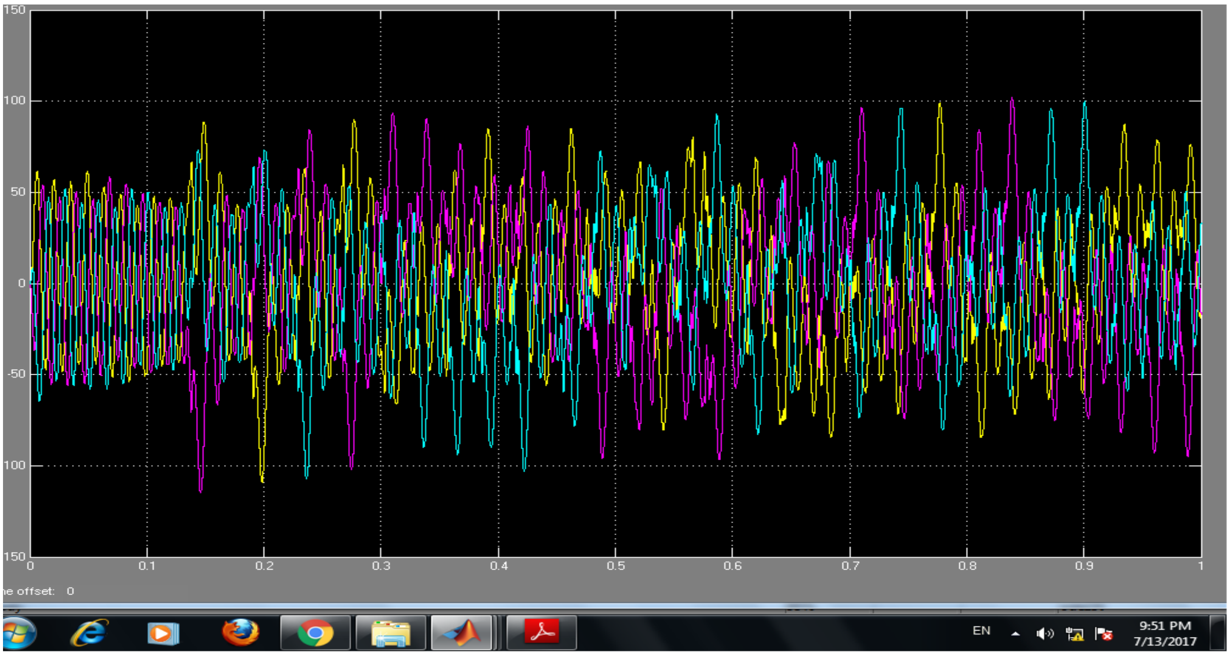

Fig 3: Stator Current Characteristics for Uncontrolled Induction

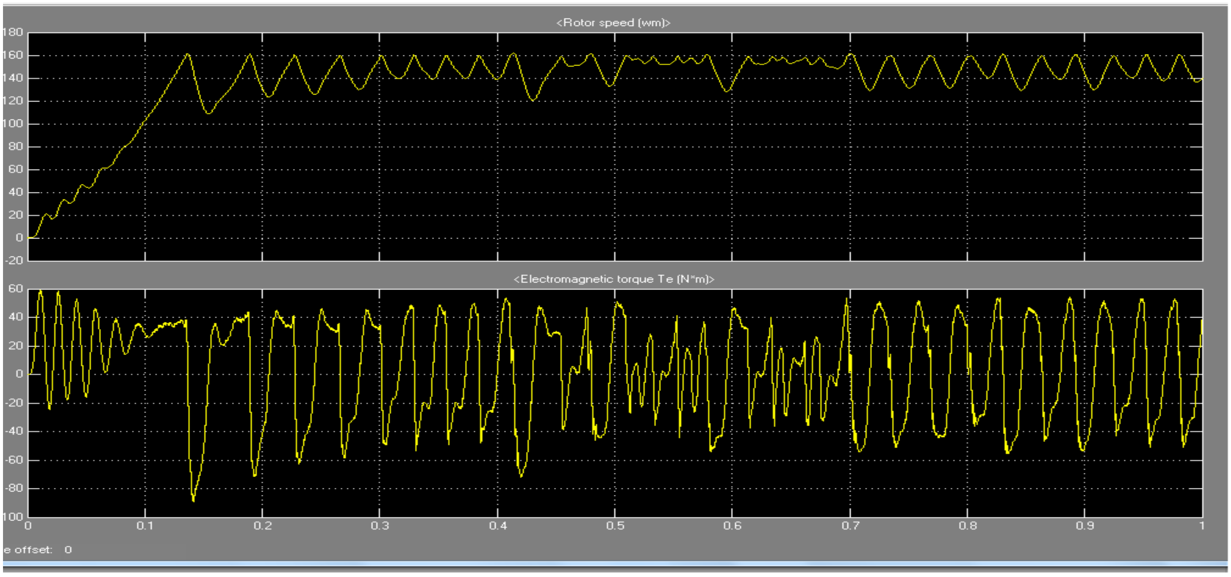

Fig 4: Torque characteristics for Uncontrolled Induction Motor

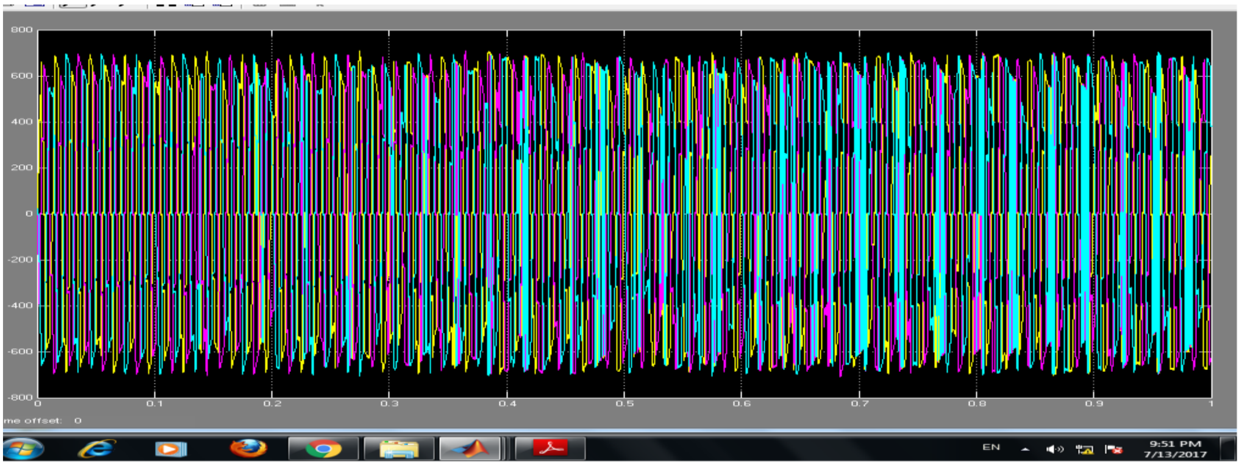

Fig 5: Three phase voltage variation

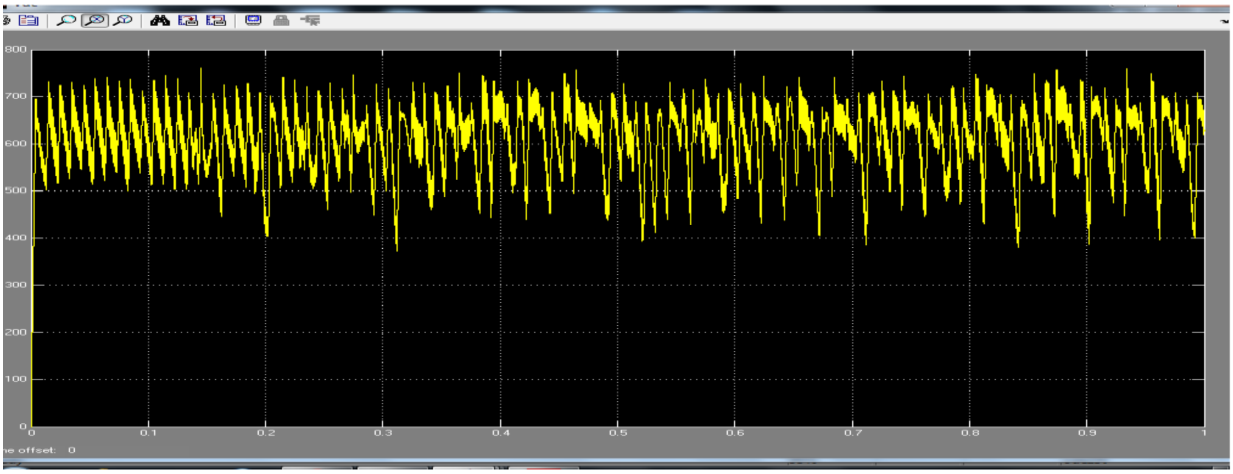

Fig 6: DC voltage fluctuation

Table 1: Parameters for Asynchronous Machine block

RMS value of supply voltage (line-to-line)	415 Volts*
Number of poles	4
Stator resistance	0.075 ohm
Rotor resistance	0.1 ohm**
Frequency	50 Hz***
Stator leakage reactance at 50 Hz frequency	0.45 ohm
Rotor leakage reactance at 50 Hz frequency	0.45 ohm
V/f ratio (ONLY FOR CONTANT V/f CONTROL)	8.3

OPEN-LOOP V/F CONTROL USING MATLAB:

In this method, the stator voltage was varied, and the supply frequency was simultaneously varied such that the V/f ratio remained constant. This kept the flux constant and hence the maximum torque while varying the speed.

A MATLAB code was developed which asked the user to input different frequencies and then varied the voltage to keep the V/f ratio constant. The different synchronous speeds corresponding to the different frequencies were calculated and the torque characteristics were plotted as the rotor speed was incremented from zero to the synchronous speed in each case. The resulting Torque vs Speed graph was plotted.

The following machine details were used to execute the code-

- RMS Value of line-to-line supply voltage= 415 V
- No. of poles= 4
- Stator Resistance= 0.075Ω
- Rotor Resistance= 0.1Ω
- Frequency= 50 Hz
- Stator Reactance @ 50 Hz= 0.45Ω
- Rotor Reactance @ 50 Hz= 0.45Ω

CLOSED-LOOP V/F CONTROL OF INDUCTION MOTOR USING MATLAB

In closed-loop V/f Control the speed of the rotor is measured using a sensor and it is compared to the reference speed. The difference is taken as the error and the error is fed to a Proportional controller. The P controller sets the inverter frequency. The frequency is taken as input for the 34 Voltage Source Inverter which modifies the terminal voltage accordingly so as to keep the V/f ratio constant.

IV. CONCLUSION

Area and power parameters for the various modules are generated and analyzed. The main module can be further simplified by concentrating on reducing the area and power of the modules which has the highest value. The three-phase PWM generator was constructed using 5 entities namely; Interface module, Oscillator, In variable supply voltage control method of speed control, the maximum torque decreases with the decrease of supply voltage and thus the motor remains underutilized. So even this method cannot be used for good performance. In constant control, by use of rectifier and PWM inverter, we can vary the supply voltage as well as the supply frequency such that the ratio remains constant so that the flux remains constant too. So we can get different operating zone for various speeds and torques and also we can get different synchronous speed with almost same maximum torque.

REFERENCES

1. Aishanou Osha Rait., Praveen Bhosale., "FPGA Implementation of Space Vector PWM for Speed Control of 3-phase Induction Motor", International Conference on Recent Advancements in Electrical, Electronics and Control Engineering, 2011.
2. M.S.Aspalli, Veerendra.D, P.V.Hunagund, " A new generation VLSI approach for V/f control of Three- Phase Induction motor ", International Journal of Computer Science Issues, Special Issue, ICVCI-2011, Vol. 1, Issue 1, November 2011
3. Alfredo Munoz-Garcıa, Thomas A. Lipo, Fellow, IEEE, and Donald W. Novotny, Fellow, IEEE, "A new induction motor V/f control method capable of high performance regulation at low speeds", IEEE Transactions on Industry Applications , Vol. 34, No. 4, July/August 1998.
4. D. Grahame Holmes, Thomas A. Lipo, "Pulse width modulation for power converters : Principles and practice", Wiley-IEEE Press, 1st edition ,October 3,2003.
5. Vijity kinnares, B., Tranner, R. and Zwicky, R. "A rotor speed detector for Induction machine utilizing rotor slot harmonics and active three phase injection." in 2nd Proc. Euro. Con$ Power Electronic. App/. induction motor drive. (EPE), Vol. 2, (1987): pp. 599-604.
6. Xingang fu. and Naunin, D "A conception for a sensorless speed control of the squirrel cage induction motor." in Proc. Power Electron. Appl. Conf., (1985): pp. 3.51- 3.55.
7. Ieroham s. baruch, B. W., Goodfellow, J. K. and Green, T. C. "Sensorless speed measurement of inverter driven squirrel cage induction motors." in Proc. IEEE 4th Int. Con$ Power Electron. Variable Speed Drives, (1987).
8. Padikkat r. rakesh, B. K. Modern Power Electronics and AC Drives, Prentice Hall, New Jersey, 2001.
9. Mr. Aung Zaw Latt, Dr.Ni Ni Win,"Variable speed drive of single phase induction motor using frequency control method",International conference on education technology and computer 2009,pp. 30-34.
10. W.I.Ibrahim, R.M.T. Raja Ismail, M.R.Ghazali,"Development of variable speed drive for single phase induction motor based on frequency control",Proceedings of Encon 2011 4th engineering conference Kuching, Sarawak, Malaysia.
11. H.N.Hickok," Adjustable speed a tool for saving energy losses in pumps,fan blower and compressors", IEEE transaction industrial applications,Vol IA21, no.1,PP. 124-136,Jan.1985.