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Research Article

SPEED CONTROL OF AN INDUCTION MOTOR USING FED PI

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ABSTRACT

The speed control of an induction motor using FED PI is proposed in this paper. The name of the FED is quoted from the feedback to the integrator of PI control. The integral part of the PI control is fed by the differential feedback gain, this feedback for the integral part of the PI control is proposed in this paper named as FED PI. It gives a better results when compare with the conventional PI control.

INTRODUCTION

Classical controllers (PI, PID) are widely used in industry while more advanced techniques of control, such as adaptive controllers are less used in industry. This is due to the fact that:

1. Classical controllers are simpler to implement and their algorithms are easier.
2. Parameter tuning of classical controllers is not a hard task for manipulators.

In spite of the fact that these controllers present an attractive solution for many industrial applications, they have some limitations. Indeed, optimal tuning of parameters, sometimes, leads to unacceptable results in practice. Ziegler - Nichols method, for example, may provoke a high oscillatory transitory state, which explains that 50% of controllers in industry are used in open loop and in manual mode because operators are unsatisfied with the obtained performance of this method. Furthermore, in the case of important variations of the system parameters, classical controllers cannot self-adapt optimally. Self-adaptation capability and robustness of this class of controllers are limited. This can explain the fact that the obtained performances are unsatisfactory without being optimal and that additional tuning may be necessary. The main cases where classical controllers become under optimal can be explained by:

1. Presence of large non-linear dynamics in the system makes the classical controller incapable to compensate for this important non linearity.
2. Important variation of noise in the regulation loop, for example: sensors noise.
3. Operating domain (point) variation which makes necessary the controller gain re-adaptation.

Due to minimum overshoot period and steady state error, we proposed a new concept called FED PI. This proposed scheme is a new concept used in this paper and gets a better result when compare with conventional PI controller.

In this paper enhance the concept of FED PI applied to an induction motor with the help of vector control. Under the simulation, it shows the better result. The performance analysis held between FED PI and PI controller using the vector control. By modelling the induction motor with the vector control, the speed of these two controllers can be obtained. The result shows that the speed controller of an induction motor performs a better performance when compare with PI controller[2].

Controller

PI Controller: PI controllers are the feedback controller which makes the system less sensitive to changes in the surrounding environment and small changes in the system. They offer the simplest and yet most efficient solution too many real world control problem. These controllers are generally designed on the basis of linear control theory, even though the system is non-linear in nature. It is a type of feedback controller whose output, that is a control variable is generally based on the error (e), between user defined set point and measured process variable. Each element of the PI controller refers to the

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particular action taken on the error. It consists of two types of control such as Proportional and Integral control. Normally the parameters of these controllers are tuned either by the empirical method or analytical method. There are several other methods are used for tuning the PI controllers.

But this controller produces the response with more overshoot, more steady state error and more settling time with less accuracy. Hence it requires the proper tuning of the controller parameters to produce the control output according to the change in error with respect to time. Figure 2.1 shows the block diagram of PI Controller.

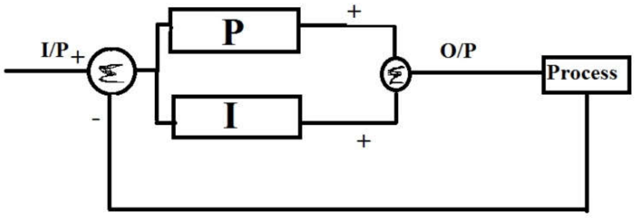

Figure 1 Block Diagram of PI Controller

FED PI Controller: The name of the FED is quoted from the feedback to the integrator of PI control. The integral part of the PI control is fed by the differential feedback gain, this feedback for the integral part of the PI control is proposed in this paper named as FED PI. It gives a better results when compare with the conventional PI control. One can ask why the differential feedback gain does not act on Proportional (P) or Derivative (D) terms of the PI controller. Under the experiment on MATLAB simulation the step response shoes the positive response for the differential feedback that acts as on the integrator[1]. Figure 2 shows the block diagram of FED PI Controller.

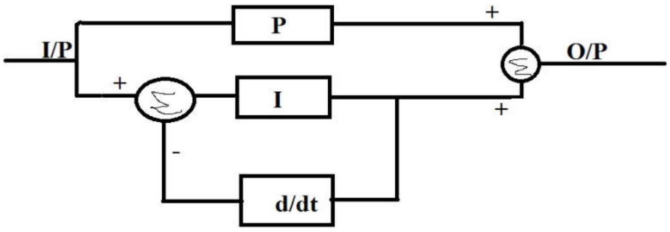

Figure 2 Block Diagram of FED PI Controller

The mathematical description of FED PI is shown in the equation as

$T(s)=K_p+(K_i/K_{i+1})(1/s)$ 1

The block diagram shows the proposed scheme from PI controller. The input is divided into proportional and integral part. In that integral output gets the feedback to the input by means of differential feedback gain. By subtracting the input values to the integral part from the output of differential feedback gain.

This type of the proposed scheme is to decrease the steady state error as well as overshoot.

Mathematical Model of an Induction Motor

In modelling of an induction motor, both the stator and rotor windings carry alternate currents. The stator produced flux rotates at synchronous speed with respect to stator. The currents induced in the rotor also produce a field that rotates at synchronous speed with respect to stator. Thus under steady state conditions, the relative speed between stator and rotor field is zero. Note that the rotor receives energy from stator by electromagnetic induction. The object of the induction machine analysis under dynamic, transient and steady state conditions [3]. The mathematical models of induction motor equations are as follows as:

The voltage supply for an induction motor is

$$V_a=[V]\sin(wt+\theta) \tag{2}$$
$$V_b=[V]\sin(wt-2\pi/3+\theta) \tag{3}$$
$$V_c=[V]\sin(wt-4\pi/3+\theta) \tag{4}$$

The voltage equation from three phase to two phase is

$$V_{ds}=\sqrt{2}/3(V_a-\frac{1}{2}V_b-\frac{1}{2}V_c) \tag{5}$$
$$V_{qs}=\sqrt{2}/3(\frac{\sqrt{3}}{2}V_b-\frac{\sqrt{3}}{2}V_c) \tag{6}$$

These voltage equation written from the matrix form as

$$V_{ds}=R_{ds}I_{ds}+L_{ds}I_{ds}P+L_{md}PI_{dr} \tag{7}$$
$$Vqs=R_{qs}I_{qs}+L_{qs}I_{qs}P+L_{mq}PI_{qr} \tag{8}$$
$$V_{dr}=L_{md}I_{ds}P-L_{mq}wrI_{qs}+R_{dr}I_{dr}-L_{qr}wrI_{qr} \tag{9}$$
$$V_{qr}=L_{mq}I_{ds}P+L_{md}wrI_{ds}+R_{qr}I_{qr}+L_{dr}I_{dr}wr+L_{qr}I_{qr}P \tag{10}$$

The equation for the electrical model as

$$\text{Induced EMF } e=L\frac{di}{dt} \tag{11}$$
$$e.L^{-1}=\frac{di}{dt} \tag{12}$$
$$\int e.L^{-1}=\text{i(t)} \tag{13}$$
$$\text{i(t)}=L^{-1}.\int e \tag{14}$$
$$\text{i(t)}=L^{-1}.\int(V-Ri) \tag{15}$$

Matrix equation of Inductance:

Table 1 Matrix Equation of Inductance

L=	**L_s**	**0**	**L_m**	**0**
	0	**L_s**	**0**	**L_m**
	L_m	**0**	**L_r**	**0**
	0	**L_m**	**0**	**L_r**

Table 2 Matrix Equation of Voltage

V=	**V_{ds}**
	V_{qs}
	V_{dr}
	V_{qr}

Table 3 Voltage Equation of Resistance

R=	**R_S**	**0**	**0**	**0**
	0	**R_s**	**0**	**0**
	0	**$P/2w_oL_m$**	**R_r**	**$P/2w_oL_r$**
	$-P/2w_oL_m$	**0**	**$-P/2w_oL_r$**	**R_r**

The three phase current is converted to two phase current, When θ=0 the equation are as

$$Ia=\sqrt{\frac{3}{2}}*Id \tag{13}$$

$$Ib=\sqrt{\frac{3}{2}}*[\left(-\frac{1}{2}\right)Id-\left(\frac{\sqrt{3}}{2}\right)Iq] \tag{14}$$

$$Ic=\sqrt{\frac{3}{2}}*[\left(-\frac{1}{2}\right)Id+\left(\frac{\sqrt{3}}{2}\right)Iq] \tag{15}$$

Similarly for the torque equation to model for an induction motor are as follows as

$$Te = [Iqr[LdrIdr + MdIds] - Idr[LqrIqr + MqIqs] \tag{16}$$

$$Te = (Iqr\varphi dr - Idr\varphi qr) \tag{17}$$

The relations between torque and speed equations are

$$Te = J\frac{d2\theta}{dt2} + B\frac{d\theta}{dt} + K + Tl \tag{18}$$

$$Te - Tl = J\frac{d2\theta}{dt2} + B\frac{d\theta}{dt} \tag{19}$$

$$Te - Tl = J.S.\omega r + B\omega r \tag{20}$$

$$Te - Tl = [J.S + B]\omega r \tag{21}$$

$$\frac{Te-Tl}{[J.S+B]} = \omega r \tag{22}$$

$$\frac{Te-Tl}{[J.S]} = \omega r \tag{23}$$

The voltage, current and torque equation which is controlled by the vector control of an induction motor.

Scalar control of ac drives produces good steady state performance but poor dynamic response. This manifests itself in the deviation of air gap flux linkages from their set values. This variation occurs in both magnitude and phase[4].

Vector control (or field oriented control) offers more precise control of ac motors compared to scalar control. They are therefore used in high performance drives where oscillations in air gap flux linkages are intolerable, e.g. robotic actuators, centrifuges, servos, etc.

Why does vector control provide superior dynamic performance of ac motors compared to scalar control ?

In scalar control there is an inherent coupling effect because both torque and flux are functions of voltage or current and frequency. This results in sluggish response and is prone to instability because of 5th order harmonics. Vector control decouples these effects[5]. In this paper, direct vector control is used.

The direct vector control depends on the generation of unit vector signals from the stator or air gap flux signals. The air gap signals can be measured directly or estimated from the stator voltage or current signals. The stator flux components can be directly computed from stator quantities. In these systems, rotor speed is not required for obtaining rotor field angle information. Here, the actual motor currents are converted to synchronously rotating frame currents using park transformation. The resulting dc quantities are compared with the reference d-axis and q-axis components. The output of the controllers are used to generate the pulse width modulated signals for switching the devices in the inverter bridge feeding the motor. Hence in this paper the direct vector control is used for the speed control by FED PI concept.

Simulation Models

In this simulation model, the induction motor is fed by a current controlled PWM inverter with six semiconductor switching devices. The PWM current controllers are widely used. The switching frequency is usually kept constant. They are based in the principle of triangular carrier wave of desire switching frequency and is compared with the error of controlled signal. The error signal obtained from the sum of reference signal generated in the controller and the negative of the actual motor current feedback from the motor. The voltage signal obtained triggers the gates of the voltage source inverter to generate the desire output. If the error command is greater than the carrier, the inverter leg is held switched to the positive polarity. When the error command is less, the inverter leg is switched to negative polarity. This will generate the PWM signal and the output voltage of the inverter is proportional to the current error command.

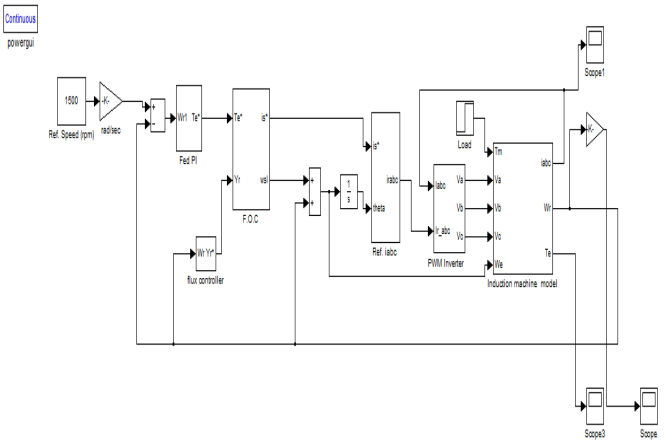

Figure 1 Simulation circuit for the speed control of an induction motor using FEDPI.

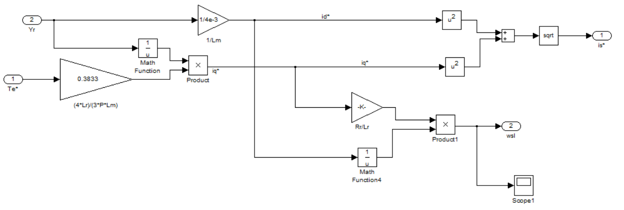

Figure 2 Simulation circuit for the direct vector control.

SIMULATION RESULT

The simulation result for the speed control of an induction motor by using FED PI is shown as

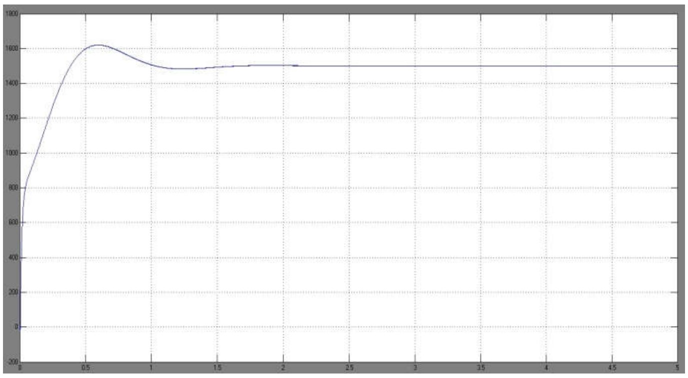

Figure 3 Result shows the speed control of an induction motor using FED PI

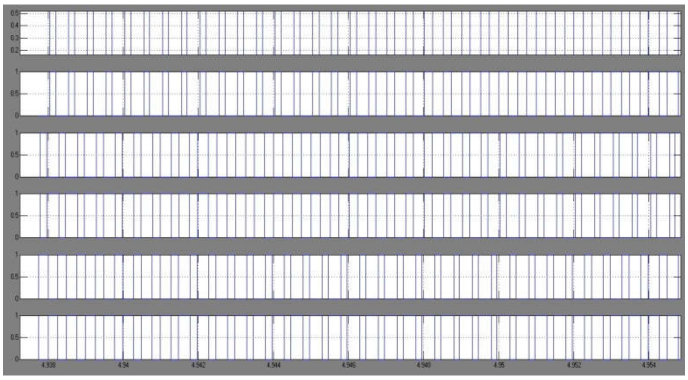

Figure 4 Result shows the PWM current pulse used in an induction machine.

CONCLUSION

This paper has presented the mathematical model of an induction motor drive. The induction motor drive system is implementing by MATLAB/Simulink. The proposed FED PI control technique is implemented to control the induction motor drive system based on current hysteresis PWM inverter. From the simulation result shows that the overshoot as well as steady state error have been decreased. This overcome the results when compare with conventional pi controller.

References

1. N.P. Ananthamoorthy, K.Baskaran "Simulation of PMSM based on Current Hysteresis PWM and Fed PI Controller", International Conference on Computer Communication and Informatics (*ICCCI -2012), Jan. 10 – 12, 2012, Coimbatore, INDIA*
2. Shaddy M. Gadoue, D. Giaouris and J.W. Finch "Tuning of PI controller in DTC of induction motor based on genetic algorithm and fuzzy logic scheme", IEEE Conference on Control Applications, IEEE Part vol.2, 2003, pp.785-90 vol.2. 'Istanbul, Turkey'.
3. Lin Feng, Zheng Hongtao and Yang Qiwen, "Sensorless vector control of induction motors based on online GA tuning PI controllers", *Fifth International Conference on Power Electronics and Drive Systems.* IEEE Vol.1, 2003, pp.222-5 Vol.1. 'Singapore'.
4. T. Sheu and T. Chen, "Self-Tuning Control of Induction Motor Drive Using Neural Network Identifier", IEEE Trans. Energy Conversion, Vol. 14, December 1999, pp. 881-886.
5. P.S.Bimbhra, "Generalised Theory of Electrical Machines", Khanna Publishers, 2002.

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