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DYNAMIC PERFORMANCE IMPROVEMENT OF INDUCTION MOTOR USING RADR CONTROLLER

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Abstract

Induction Motors are widely used in Industries, because of the low maintenance and robustness. Speed Control of Induction motor can be obtained by maximum torque and efficiency. Apart from other techniques Artificial Intelligence (AI) techniques, particularly the neural networks, improves the performance & operation of induction motor drives. This paper presents dynamic simulation of induction motor drive using neuro controller. The integrated environment allows users to compare simulation results between conventional, Fuzzy and Neural Network controller (NNW).The performance of fuzzy logic and artificial neural network based controller's are compared with that of the conventional proportional integral controller. The dynamic Modeling and Simulation of Induction motor is done using MATLAB/SIMULINK and the dynamic performance of induction motor drive has been analyzed for artificial intelligent controller.

1.Introduction

Three phase Induction Motor have wide applications in electrical machines. About half of the electrical energy generated in a developed country is ultimately consumed by electric motors, of which over 90 % are induction motors.For a relatively long period, induction motors have mainly been deployed in constant speed motor drives for general purpose applications. The rapid development of power electronic devices and converter technologies in the past few decades, however, has made possible efficient speed control by varying the supply frequency, giving rise to various forms of adjustable-speed induction motor drives. In about the same period, there were also advances in control methods and Artificial Intelligence (AI) techniques. Artificial Intelligent techniques mean use of expert system, fuzzy logic, neural networks and genetic algorithm. Researchers soon realized that the performance of induction motor drives can be enhanced by adopting artificial-intelligence-based methods. The Artificial Intelligence (AI) techniques, such as Expert System (ES), Fuzzy Logic (FL), Artificial Neural Network (ANN or NNW), and Genetic Algorithm (GA) have recently been applied widely in control of induction motor drives. Among all the branches of AI, the NNW seems to have greater impact on power electronics & motor drives area that is evident by the publications in the literature. Since the 1990s, AI-based induction motor drives have received greater attention. Apart from the control techniques that exist, intelligent control methods, such as fuzzy logic control, neural network control, genetic algorithm, and expert system, proved to be superior. Artificial Intelligent Controller (AIC) could be the best controller for Induction Motor control [1-6]. Since the unknown and unavoidable parameter variations, due to disturbances, saturation and change in temperature exists; it is often difficult to develop an accurate system mathematical model. High accuracy is not usually of high importance for most of the induction motor drive. Controllers with fixed parameters cannot provide these requirements unless unrealistically high gains are used. Therefore, control strategy must be robust and adaptive. As a result, several control strategies have been developed for induction motor drives within last two decades. Much research work is in progress in the design of hybrid control schemes. Fuzzy controller conventionally is totally dependent to memberships and rules, which are based broadly on the intuition of the designer. This paper tends to show Neuro controller has edge over fuzzy controller. Sugeno fuzzy controller is used to train the fuzzy system with two inputs and one output [10-12].The performance of fuzzy logic and artificial neural network based controllers is compared with that of the conventional proportional integral controller

A proportional–integral–derivative controller (PID controller) is a generic control loop feedback mechanism (controller) widely used in industrial control systems – a PID is the most commonly used feedback controller. A PID controller calculates an "error" value as the difference between a measured process variable and a desired set point valve. The controller attempts to minimize the error by adjusting the process control inputs. In the absence of knowledge of the underlying process, a PID controller is the best controller. However, for best performance, the PID parameters used in the calculation must be tuned according to the nature of the system – while the design is generic, the parameters depend on the specific system. The main disadvantage of PID controller is PID can lead to the overshoot of output, and derivative of PID is not realized physically. The PID controller is often used in control of inductor motor; however, it is easily affected by the changes of the parameters of a system. To overcome this problems this paper presents a new concept called Linear Active Disturbance Rejection Controller (LADRC).

II. MODELLING OF INDUCTION MOTOR

In the control of any power electronics drive system(say a motor), to start with a mathematical model of the plant is required. This mathematical model is required further to design any type of controller to control the process of the plant. The induction motor model is established using a rotating (d, q) field reference (without saturation) concept. The power circuit of the 3-φ induction motor is shown in the Fig. 1. The equivalent circuit used for obtaining the mathematical model of the induction motor is shown in the Fig. 2. An induction motor model is then used to predict the voltage required to drive the flux and torque to the demanded values within a fixed time period[9]. This calculated voltage is then synthesized using the space vector modulation. The stator & rotor voltage equations are given by

$$u_d = R_1 i_d + \frac{d\psi_d}{dt} - \omega_1 \psi_q$$

$$u_q = R_1 i_q + \frac{d\psi_q}{dt} - \omega_1 \psi_d$$

$$u_{dr} = R_2 i_{dr} + \frac{d\psi_{dr}}{dt} - (\omega_1 - \omega)\psi_{qr}$$

$$u_{qr} = R_2 i_{qr} + \frac{d\psi_{qr}}{dt} - (\omega_1 - \omega)\psi_{dr}$$

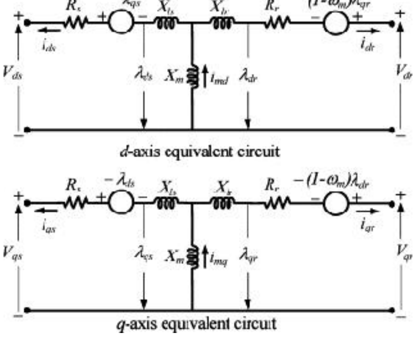


Fig.4 Equivalent circuit of induction motor in d -q farm

where u_{sd} and u_{sq}, u_{rd} and u_{rq} are the direct axes & quadrature axes stator and rotor voltages. The squirrel-cage induction motor considered for the simulation study in this paper, has the d and q-axis components of the rotor voltage zero.

By superposition, i.e., adding the torques acting on the d-axis and the q-axis of the rotor windings, the instantaneous torque produced in the electromechanical interaction is given by

$$T_e - \frac{3}{2}\left(\frac{P}{2}\right)\frac{L_m}{L_r}\left(i_{qs}\lambda_{dr} - i_{ds}\lambda_{qr}\right).$$

III. Radr Controler

RADR control is Han's way out of the robust control paradox [14-16]. The term was first used in [17] where his unique ideas were first systematically introduced into the English literature. Originally proposed using nonlinear gains, RADR control becomes more practical to implement and tune by using parameterized linear gains, as proposed in [18]. Although the RADR control method is applicable, in general, to n^th order, nonlinear, time-varying, multi-input and multi-output systems (MIMO), for the sake of simplicity, its basic concept is illustrated here using the second-order motion control problem in (1).

The RADR Concept :

At this juncture, a more specific answer to (Q1) is that the order of the differential equation should be known from the laws of physics, and the parameter b is should also be known approximately in practice from the physics of the motor and the amount of the load it drives. Adopting a disturbance rejection framework, the motion process in (1) can be seen as a nominal, double integral, plant

$$\ddot{y} = u$$

Scaled by b and perturbed by $f\left(y, \dot{y}, w, t\right)$. That is, $f\left(y, \dot{y}, w, t\right)$ is the generalized disturbance, as defined above, and the focus of the control design. Contrary to all existing conventions, Han proposed that $f\left(y, \dot{y}, w, t\right)$ as an analytical expression perhaps is not required or even necessary for the purpose of feedback control design. Instead, what is needed is its value estimated in real time. Specifically, let $\hat{f}$ be the estimate of $f\left(y, \dot{y}, w, t\right)$ at time t,

$$u = \left(-\hat{f} + u_0\right)/b$$

reduces (1) to a simple double-integral plant

$$\ddot{y} \approx u_0$$

which can be easily controlled.

This demonstrates the central idea of active disturbance rejection: the control of a complex nonlinear, time-varying, and uncertain process in (1) is reduced to the simple problem in (7) by a direct and active estimation and rejection (cancellation) of the generalized disturbance, $f\left(y,\dot{y},w,t\right)$. The key difference between this and all of the previous approaches is that no explicit analytical expression of $f\left(y,\dot{y},w,t\right)$ is assumed here. The only thing required, as stated above, is the knowledge of the order of the system and the approximate value of b in (1). The bu term in (1) can even be viewed as a linear approximation, since the nonlinearity of the actuator can be seen as an external disturbance included in w. That is, the ADRC method applies to a processes of the form $\ddot{y} = p\left(y,\dot{y},w,u,t\right)$ of which (1) is an approximation, i.e., $p\left(y,\dot{y},w,u,t\right) \approx f\left(y,\dot{y},w,t\right) + bu$ success. Obviously, the of ADRC is tied closely to the timely and accurate estimate of the disturbance. A simple estimation such as $\hat{f} = \hat{\ddot{y}} - u$ may very well be sufficient for all practical purposes, where $\hat{y}$ denotes an estimation of $\ddot{y}$.

The Extended State Observer and the Control Law

There are also many observers proposed in the literature, including the unknown input observer, the disturbance observer, the perturbation observer, and the extended state observer (ESO). See, for example, a survey in [7]. Most require a nominal mathematical model. A brief description of the ESO of (1) is described below. The readers are refered to [14,19,20] for details, particularly for the digital implementation and generalization of the ESO in [20].

The ESO was originally proposed by J. Han [14-16]. It is made practical by the tuning method proposed in [18], which simplified its implementation and made the design transparent to engineers. The main idea is to use an augmented state space model of (1) that includes f, short for $f\left(y,\dot{y},w,t\right)$, as an additional state. In particular, let x1 =, x2 = y , and x3 = f , the augmented state space form of (1) is

$$\dot{x} = Ax + Bu + Eh$$

$$y = Cx$$

With

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 0 & 0 & 0 \end{bmatrix}, B = \begin{bmatrix} 0 \\ b \\ 0 \end{bmatrix}, C = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix}, E = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$$

Note that x3 = f is the augmented state and h =f is a part of the jerk, i.e., the differentiation of the acceleration, of motion and is physically bounded. The state observer

$$\dot{z} = Az + Bu + L\left(y - \hat{y}\right)$$

$$\hat{y} = Cz$$

With the observer gain L= $[\beta 1 \ \beta 2 \ \beta 3]^T$ selected appropriately, provides an estimate of the state of (9), zi ≈xi, i=1, 2, 3. Most importantly, the third state of the observer, z3, approximates f. The ESO in its original form employs nonlinear observer gains. Here, with the use of linear gains, this observer is denoted as the linear extended state observer (LESO). Moreover, to simplify the tuning process, the observer gains are parameterized as

$$L = [3\omega, 3\omega^2, \omega^3]^T \quad (11)$$

where the observer bandwidth, ωo, is the only tuning parameter.

With a well-tuned observer, the observer state z3 will closely track x3= $f\left(y,\dot{y},w,t\right)$ The control law

u= (-z3+u0)/b

then reduces (1) to (7), i.e.,

$$\ddot{y} = \left(f - z_3\right) + u_0 \approx u_0$$

An example of such u0 is the common linear proportional-and derivative control law

$$u_0 = k_p\left(r - z_1\right) - k_d z_2$$

where r is the set point. The controller tuning is further simplified with $k_d = 2\omega_C$ and $k_p = \omega_c^2$, where ω_c is the closed-loop bandwidth [18]. Together with the LESO in (10), (14) is denoted as the parameterized linear RADR control, or LADRC.

IV.**Simulation Results**

Schematic proposed simmu link models are as shown in Figs.

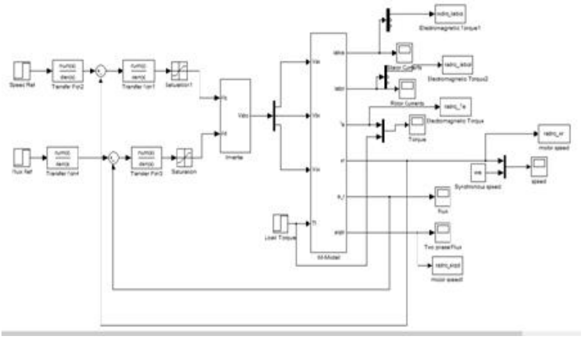


Fig.5 Proposed model of induction motor RADR controller

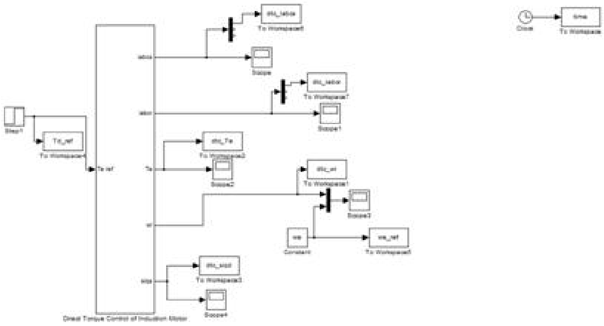


Fig.6 Proposed model of induction motor with DTC.

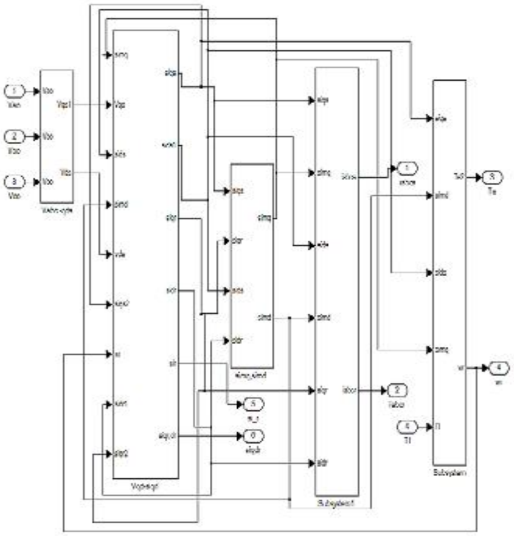
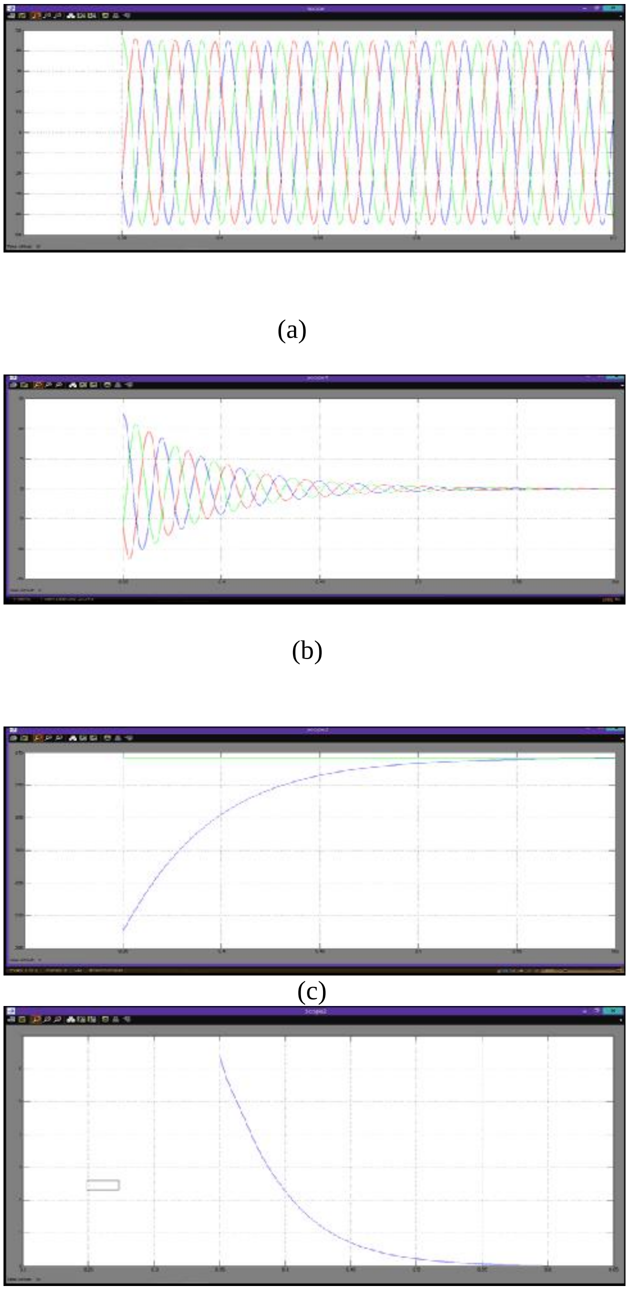


Fig.7 Simulink model of induction motor.

The results validate the control structure proposed in this paper. Proposed control technique for the speed control of an induction motor is compared with the performance of the DTC of induction motor. Induction motor speed response and torque response shows that the performance of the RADR control of induction motor is effective than the DTC of induction motor.

With DTC



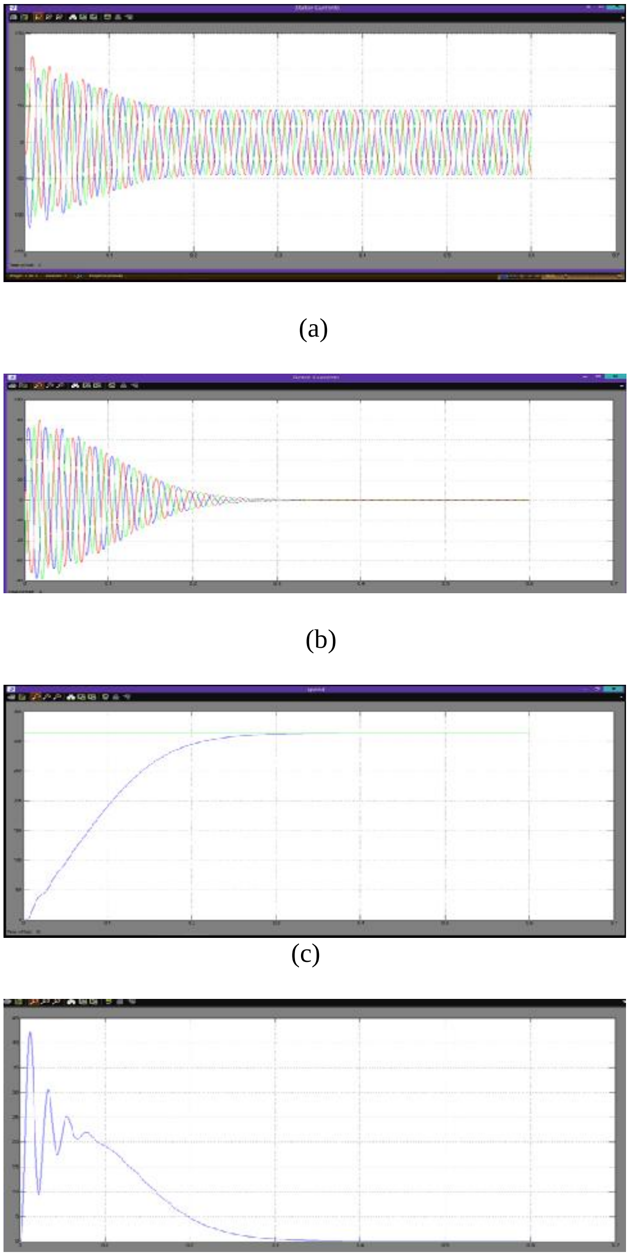
(a)

(b)

(c)

(d)

Fig.8(a)Stator currents(b)Rotor currents (c) speed (d)torque with DTC



(a)

(b)

(c)

(d)

Fig.9(a)Stator currents(b)Rotor currents (c) speed (d)torque with RADR controller

V.**Conclusions**

RADR controller maintains the advantages of PID because it is not depend on the accurate mathematical model of the induction motor [11], and it also can estimate and compensate the unknown internal dynamics and the external disturbance such as the change of the rotor resistance, so ADRC has better static and dynamic performances, strong robustness and adaptability. The main objective of this control technique is to obtain good dynamic performance.

VI.References

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