Analysis of Different Approach of Speed Control Methods of Induction Motor

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Abstract:

Induction motor has wide application in industries nowadays because of their low maintenance and robust nature. In recent years control of induction motor drive is in active research area. Also electric vehicle are looking forward to replace BLDC completely with induction motor as BLDC consist of permanent magnet, needs commutator, bulky size, weight etc. which are eliminated in induction motor. In order to achieve maximum torque and efficiency speed control of induction motor is important. Generally control and estimation of ac drives are significantly more complex than dc drives and when high performance are demanded this complexity increases to greater extent. So this paper presents the analysis of some of the advance speed control methods of induction motor and compared further.

Keywords: *vector control, scalar control, EV (electric vehicle)*

1. Introduction:

Speed control of induction motor is more important to achieve maximum torque and efficiency. In number of industries motor must satisfy very strict speed characteristics requirements, both w.r.t ranges, smoothness of control and also w.r.t economical operation. In recent years, the control induction motor drive is an active research area. And technology has further advances in this field.

2. Conventional methods of speed control:

As speed is given by N= (120f/p)(1-s), so there are three factors, supply freq f, number of poles and slip, to change the speed of IM motor any of these can be changed to change the speed of the IM. Based on these, conventional method can be classified as

- From stator side

a. Variation of supply frequency (v/f method)

b. Variation of applied voltage

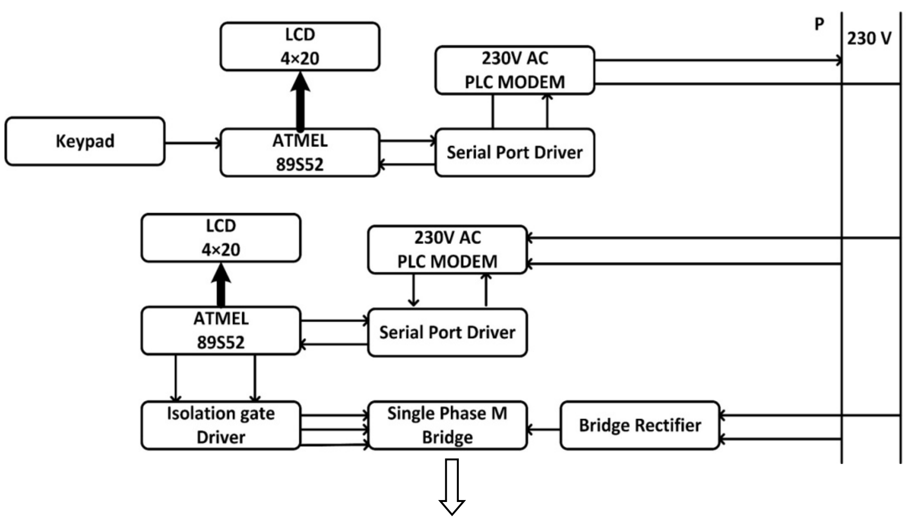
c. Changing number of poles

2. from rotor side:

- Changing resistor in rotor circuit
- Introducing into rotor circuit additional emf of same frequency

3. Advancement in speed control methods:

3.1. Microcontroller based speed control of IM using PLC technology



To induction motor

Fig: 1 proposed block diagram [2]

In this IM speed control method, speed is controlled by variable frequency method using PLCC technology by ATMEL 89S52 microcontroller [2]. Fig. 1 shows the part of speed control technology i.e. Induction motor, LCD screen, ATMEL microcontroller, 230V AC power line modem. Whenever the key is pressed, PLCC generate the specific output. The generated signal is given to PLCC transmitter; it is initially tuned to work in the 125 kHz frequency. The frequency varies depending on PLCC receiver. Two frequency combination is given by PLCC, i.e. carrier and analogue frequency of the specific key is pressed. After picking the tuned signal from PLCC receiver it accordingly produce BCD code and the digital output that is generated is given to ATMEL microcontroller which is parallelly connected to PC.

The microcontroller gives PWM signal which is then fed to driver circuit, which in turn provides the desired speed with the help of required frequency.

Advantages:

- Speed control is possible in wide range
- Speed control based on V/f
- Can be smoothly controlled down to zero.
- Multiple motors can be controlled at a time.

3.2. Speed control using PID controller

- Here speed of the induction motor is controlled by PID controller using vector control. PID controller has overcome the PI controller due its fair advantages.

PID controller (proportional integral derivative controller) is widely used in industrial control system. In this an error value is determined as distinction between the ideal set point and the deliberate procedure variable. It involves three separate constant integral, derivative and proportional. It gives steady state error performances and frameworks additionally keeps running with typical speed as previously.

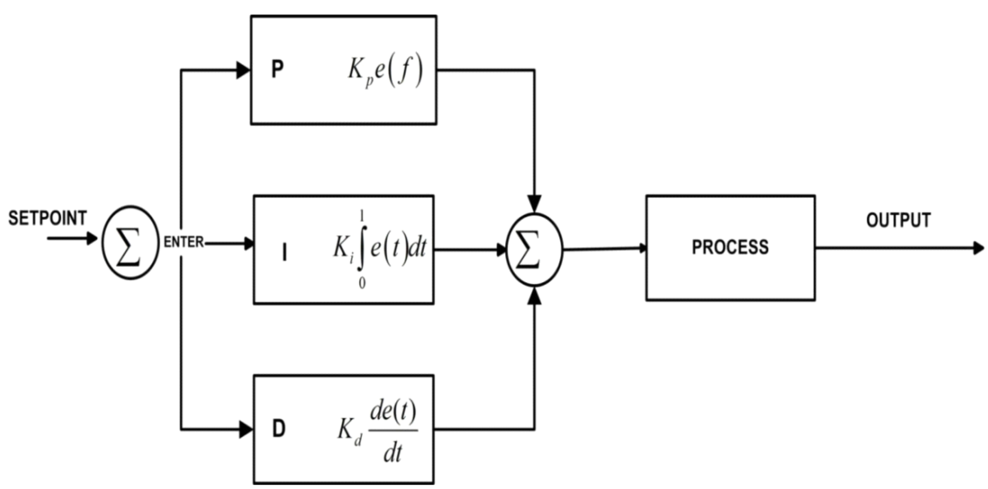


Fig.2 Basic block of PID controller [1]

Advantages:

- The presence of derivative action may take system steadier in steady state in the case of noisy data. This is due to derivative action which is more sensitive to the higher frequency terms in input.[1]

- Improves damping and reduces maximum overshoot. It also decreases the bandwidth and improves the rise time.[1]

- System is less responsive to real(non-noise) in absence of derivative action.[1]

3.3. Real time speed control using new generation DSP processor

This strategy is ongoing usage of v/f method with the help of DSP processor. In various load condition, high resolution, speed and precise control of IM is provided by DSP processor.

It include hardware device such as induction motor, rectifier, inverter, eddy current load setup, torque indicator and DSP board with sensing unit[4]. By comparing carrier signal and modulated signal PWM signal is generated. The switching frequency of PWM signal is decided by carrier signal frequency. Hence the one which controls the speed of the motor is modulated signal and carrier signal looks after the switching frequency and power quality issues. According to the speed feedback and control algorithm PWM signal are generated.

Quadrature encoder pulse speed detector sense the actual speed of the motor. V/Hz control is utilized in this plan, so by stator voltage and frequency the speed of the motor is controlled keeping air gap flux at desired steady state [4].

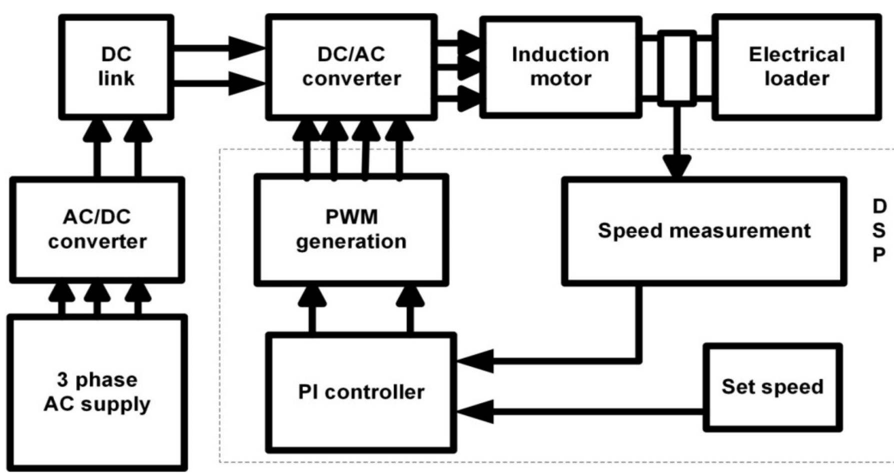


Fig 3. Block diagram of DSP based IM control system [4]

Advantages:

As mentioned in [4] advantages can be observed as

- The DSP based system is found to be compact
- User friendly
- Reduces complexity
- It has good performance, higher control processor made the speed control of motor most effective as compared to other conventional techniques

3.4. Direct torque control using sliding mode

SMC provides robust and fast dynamic performance of induction motor drive. It enforces system to slide over the pre-defined sliding surface by adjusting the structure of the controller [3].

The drive include a PI speed controller and stator flux, torque and speed observer, and the goal of the drive is to control stator flux magnitude and the torque of machine. The assembly of controllers are in such way that it make the stator flux and the torque to follow their command values. To impose sliding mode operation with first order dynamics, the sliding surfaces of stator flux magnitude and electromagnetic torque are designed accordingly [3].

The switching signals which are given to switching logic (in fig) are used to select proper voltage for VSI.

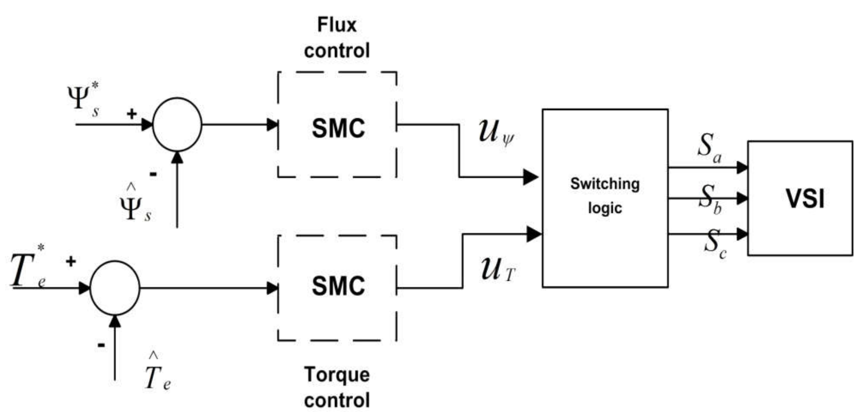


Fig.4 SM based control scheme for DTC [3]

Here, $\hat{\psi}_s$ is stator flux, T_e^* $\hat{T}_e$ is electromagnetic torque and u_ψ , u_T are the switching logic as mentioned in [3].

Advantages:

Reduces ripple in torque and steady state and Provides better steady state characteristics [3].

3.5. Direct torque control using fuzzy logic methods

Following [3] Fuzzy controllers are designed to have one input and two outputs separately. Input to flux control loop is absolute value of error between command stator flux and estimated stator flux, similarly for torque control loops too [3]. Based on defined fuzzy rule controller produces gain values. Gains are adjusted then finally outputs of the both loops together with sector number are used to obtain the best voltage vector for VSI [3].

According to [3] here ψ_s^* , $\hat{\psi}_s$ are stator flux, T_e^*, $\hat{T}_e$ are electromagnetic torque and u_ψ , u_T are the switching logic.

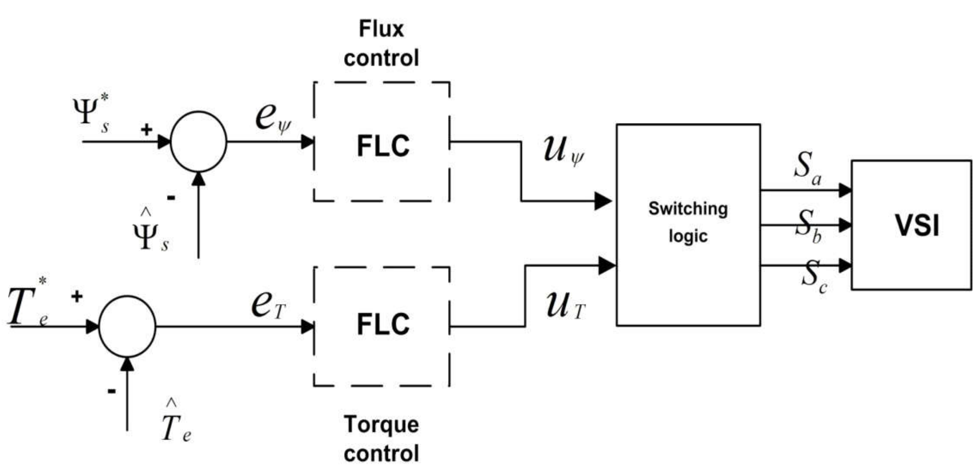


Fig.5 Fuzzy logic DTC [3]

Advantages:

Referring [3] advantages can be stated as

- Reduces ripple in torque and steady state

- Provides better steady state characteristics
- Mitigates steady states chattering problem while preserving advantages of DTC

4. Comparison of the above methods:

Using PLC technology	Using PID controller	Using DSP processor	Using SMC	Using FLC
1. V/F based speed control	1.Vector control based	1.v/F based method	1. direct torque control based method(indirect vector control)	1. direct torque control based method (indirect vector control)
2.user friendly plug and play type device	2.improves damping	2 .user friendly, reduced complexity	2. complex algorithm	2. complex algorithm
3.wireless technology	3. reduces steady state error to zero, increases efficiency	3. increased efficiency by better PWM technique	3.produces ripple free output	3.produces ripple free output
4.smooth control	4.smooth control	4.smooth control	4. smooth control	4. smooth control
5.low cost	5. costly	5.costly	5. costly	5. costly
6.high reliability	6.good performances	6.good performances	6. better dynamic performances	6. better dynamic performances
7. wide range of speed control	7. used for moderate range of speed	7. suitable where speed is required above 30% of rated speed.	7. wide range speed control	7. wide range speed control

5. Overview of different controlling schemes

1. Scalar control:

It is because of extent variety of the control variable just, and slights the coupling impact of machine. A scalar control drive is to some degree gives second rate execution yet it is anything but difficult to actualize. The framework is inclined to instability on account of higher request framework impact.

2. Vector control:

This control offers an abnormal state of elements execution and the closed loop control related with this drive gives long haul soundness.

6. Conclusion

Both control techniques have points of interest and disservices. Scalar control is a shoddy, well-implementable strategy. Due to these points of interest and its simplicity, many applications work with this control system in the business. Then again, it isn't attractive for the control of drives with dynamic conduct, since it gives ease back reaction to drifters. This is on the grounds that the V/Hz consistent technique controls the extent of voltages and recurrence as opposed to controlling the stage and size of flows. It is a stable control procedure. The field situated control strategy controls the flows so it works with quick reactions. This technique fulfills the prerequisites of dynamic drives, where quick reaction is important. Its disservice is multifaceted nature, and the high cost of the driver circuit. By and by, it is an elite control strategy. The two procedures are pertinent over the ostensible speed to the detriment of torque.

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