Self-commissioning of induction motor drives-A critical review

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Abstract:
Now days efficient performance of machinery is must need especially in industry. Variable speed drives are used to drive the motor efficiently. Control strategy of variable speed drive plays an important role in it. So, it should be selected carefully according to the application. For controlling of motor encoders are used generally, but due to some disadvantages estimation techniques are used in recent time. Also estimation techniques having too types online and offline. For accurate estimation online parameter estimation technique is used, but they are little bit complex. That is also called self-commissioning of the motor. Here in this paper two techniques for self-commissioning of induction motor from different manufactures are compared. For Danfoss frequency injection method and for Rockwell voltage current lag angle method is used. Review on both these methods is presented in this paper.

1. Introduction
In recent decades, much progress has been created in connecting the drives to the industries. The industrial drives, which are a combination of source, power modulator, control unit, motor and load, are strongly correlated with the economic development of any Nations. Every industry needs the technology of motion control to regulate the speed of the machine according to their application as a key part of the next generation of factory automation. Conventionally, commutator motors are utilized in industries, and then brushless motors incorporated with the drive system, which is operated with phase-controlled rectifiers, DC choppers [1]. In recent decades, induction motors are widely adopted in industrial applications, since it has high robustness and consistency with low cost [2]. Variable Frequency Drives (VFD) is specifically designed for permanent magnet motors but it also can be used for all type of AC speed control operations especially induction motors. When an induction motor operates with VFD, it runs at high power factor that avoids overheating of coils due to increase in current. VFDs start induction motor quickly with less inrush current of 100% to 150% of full load current. The VFDs are mainly designed in two types, they are voltage source inverter based VFD and current source inverter based VFD [3]. New VFD technologies mainly focus on improving the controllability and enhancing the efficiency of the system through advancing the adaptive control parameter estimation and energy optimization [4]. Thereby, 11 to 18 per cent of the energy usage of VFD could be reduced [5]. Precise prediction and analysis of machine's parameter are mandatory in controlling the VFD to counterpoise the load output. Hence, it is inevitable to conduct the test on the drive motor under mechanically decoupled state, conventionally known as offline parameter determination method [7]. On the other hand, mechanical decoupling of the load from drive motor is not feasible on every industrial drive systems. Online parameter estimation techniques are Recursive Least square technique, Model reference adaptive system, Signal Injection technique, Sliding mode Observer, Heuristic or Meta-heuristic algorithms [8].

During acquire the parameters of the motor in offline, the effects of the ascent in skin effect, flux saturation, temperature, will certainly cause variations in the parameters. The heat produced by the motor creates the temperature change in machine and thus distressing the stator and rotor resistance. Besides, there are variations in rotor resistance due to variations of skin effect caused by changes due to rotor frequency and temperature. Finally, the magnetizing inductance is affected due to the saturation of magnetizing flux. Therefore, parameters of a motor are diverged from the nominal values during
To certify the performance of the IM systems, it is necessary to provide real-time parameters using online parameter identification. Only certain parameters among all the essential motor parameters have an important impact on overall control performance in operation. Thus, online identification usually aims at one or several parameters [8, 9]. The invention of online identification encompasses a method for automated measurement of Ohmic Resistance of Stator, the Main Inductance and Leakage Inductances of the IM by applying a direct Signal which is predetermined by test signal Superimposed with an alternating Signal to a stator winding of the IM [10].

Stage Recursive Least Squares (RLS) is also one of the commonly used algorithms for online parameter estimation. For applying this technique, some of the necessary details are stator current, voltages and their derivatives. On the process of measuring, the voltages modified by switching of DC inputs which may introduce harmonics and noises at the input. So, the filters included with the necessary compensating device because adding filters may delay the output. The basic Induction Motor model is written in regressive form for applying RLS algorithm. The data obtained from the system gives initially estimated parameter. From that, the covariance matrix is formed. It is updated for each step based on the error value. The errors lumped in the single scalar term, which show larger error value than the estimated parameter, which may not give accurate results. To overcome this inaccuracy The Forgetting factor is added which decompose the past parameter so that algorithm can prioritize the recent data rather than old one. The error percentage of the estimated parameter is less than 5% [9]. The major drawback of RLS algorithms is that the motor parameters vary slowly concerning time, that is, their time derivatives are approximately zero [11]. Two-Stage Recursive Least Squares Algorithm (TSRLS) in this the system is decoupled into two subsystems and then to find parameters of each subsystem using the RLS estimation. Compared to the conventional RLS this algorithm is effectively save computational cost [12].

To attain high control performance of IM drives, some of the classic control strategies are used like field-oriented induction motor, Torque controller or Vector controllers (VC), Hysteresis current controller etc. Here VC is a widely used control technique in induction machine drives systems to accomplish high performance in induction machine applications. Direct Field Orientation controller (DFOC) and Indirect Field Orientation controller (IFOC) are the two various types of VC. DFOC estimates parameters thru terminal measurements. This controller is sensitive to Rotor resistance and Inductance. One of the problems is low speed operation and rotor flux cannot be measured directly. Low speed problem is not inherited by IFOC, it utilize the rotor flux positioning data's for the operation. However, the problem is open circuit time constant, which may often vary to flux and temperature changes. Incorrect time constant leads to wrong calculation of slip frequency and rotor flux positioning [6].

So finding the accurate parameters of IM drives is essential to control the speed of Induction machine. Two methods i.e. Offline Parameter estimation and Online Parameter Estimation can evaluate the Parameters of motors. In Offline Parameter estimation, No load and Blocked rotor test has to be done. Otherwise, parameters are calculated by applying Ac voltage to the motor windings [7].

2. System modelling

In this study a 3 phase balanced symmetrical winding for squirrel cage induction motor with a sinusoidal flux distribution (magneto motive force) and dynamic modelling circuit was performed.

2.1. Modelling of Induction motor

Fig. 1 represents a schematic diagram of the modelling of IM with alternating signal injection method [16], to estimate the motor parameters. The squirrel cage IM dynamics is modelled using stationary reference frame dq0. Various quantities are used in their normalized form in this paper and that normalized quantities of the rotor are referred to the stator circuit. An IM parameters are listed in Table 1. Stator and rotor voltages equations [14] in terms of abc transformation

\[ v_{abcs} = r_i s_{abcs} + p \lambda_{abcs} \]  (1)
The measurement of voltage is very important in estimating the online parameter for which the sensor is generally used to measure the voltage for estimation of other different parameters. The estimation process starts when induction motor reaches to steady state condition, the detailed measurements of steady-state parameters are collected primarily. For accurate control of drives, it is necessary to know exact flux variation in dq0 axis. The fundamental reason is that computations are much easier by transforming the 3-φV instantaneous values of voltages and currents within the synchronously rotating reference frame dq0 make calculations much simpler and the second thing is it provides the individual control for both the active current component (on d-axis) and reactive current component (on q-axis). The dq0 frame can be found from the Parks transformation. Similarly, in the machine, the torque and flux can be independently controlled. By this way, the coupling effect can be minimized to a certain extent. Additionally, in the dq0-frame, mutual inductance is constant. Thus, it allows to achieve the desired output as the inductance dependent quantities are constant. The online parameter estimation technique requires these quantities to estimate the parameter values. Employing the different estimation techniques resistance, inductance, flux linkage and the angular frequency of the induction motor can be estimated.

\[ v_{abcs} = r_{abcs} \frac{d}{dt} + p\lambda_{abcs} \]  

Figure 1. Modelling diagram of the IM with alternating signal injection approach.

Applying these estimated parameters values to induction motor modelling gives Vdq0, Idq0 and Te value which is given as a reference to the controller along with D-axis reference currents are injected into the drive system one by one, making sure that results obtained are gathered on each incident when a steady state is reached. This should be observed that the injected d-axis current will produce additional torque reluctance which causes torque ripples for IM. To overcome this situation, the alternating signal injection strategy is performed. The torque ripple caused due to alternating signal injection can be minimized by
this compensation strategy. The controller produces controlling signals that are given to the dq0 to abc transformation block and applied to the converter which drives the machine as per the requirement. The following equations are used to construct the model and estimate the parameter of IM. The mechanical part of the motor is modelled through electromagnetic torque as:

\[ T_e = J \left( \frac{2}{P} \right) Pw_r + T_L \]  \hspace{1cm} (3)

Where \( J \) is the rotor inertia, \( T_L \) is the load torque which is positive for a torque load on the shaft of the induction machine.

Power system as well as other machine parameters are mostly given in ohms and even fraction of base impedance per unit, it is possible to express the voltage and equation of flux connection in terms of reactance instead of inductance.

\[ v_{qd0s} = r_s i_{qd0s} - w \lambda_{dqs} + p \lambda_{qd0s} \]  \hspace{1cm} (4)

\[ v'_{qd0r} = r'_s i'_{qd0s} + (w - w_r) \lambda'_{dqs} + p \lambda'_{qd0s} \]  \hspace{1cm} (5)

\[ v_{qs} = r_s i_{qs} + \frac{w}{w_b} \psi_{ds} + \frac{p}{w_b} \psi_{qs} \]  \hspace{1cm} (6)

\[ v_{ds} = r_s i_{ds} - \frac{w}{w_b} \psi_{qs} + \frac{p}{w_b} \psi_{ds} \]  \hspace{1cm} (7)

\[ v_{0s} = r_s i_{0s} + \frac{p}{w_b} \psi_{0s} \]  \hspace{1cm} (8)

\[ v'_{qr} = r'_s i'_{qr} + \frac{(w - w_r)}{w_b} \psi'_{dr} + \frac{p}{w_b} \psi'_{qr} \]  \hspace{1cm} (9)

\[ v'_{dr} = r'_s i'_{dr} + \frac{(w - w_r)}{w_b} \psi'_{qr} + \frac{p}{w_b} \psi'_{dr} \]  \hspace{1cm} (10)

\[ v'_{0r} = r'_s i_{0r} + \frac{p}{w_b} \psi'_{0r} \]  \hspace{1cm} (11)

Where \( w_b \) is base angular velocity used to calculate the inductive reactance.

\[ \psi_{qs} = X_{is} i_{qs} - X_M (i_{qs} + i'_{qr}) \]  \hspace{1cm} (12)

\[ \psi_{ds} = X_{is} i_{ds} + X_M (i_{ds} + i'_{dr}) \]  \hspace{1cm} (13)

\[ \psi_{0s} = X_{is} i_{0s} \]  \hspace{1cm} (14)

\[ \psi'_{qr} = X'_{ir} i'_{qr} + X_M (i_{qs} + i'_{qr}) \]  \hspace{1cm} (15)

\[ \psi'_{dr} = X'_{ir} i'_{dr} + X_M (i_{ds} + i'_{dr}) \]  \hspace{1cm} (16)

\[ \psi'_{0r} = X'_{ir} i'_{0r} \]  \hspace{1cm} (17)
Where,

Table 1. List of Abbreviations

| Parameters | Terms |
|------------|-------|
| $J$ =      | Inertia of rotor (Kgm$^2$) |
| $T_L$ =    | Load Torque |
| $P_r$ =    | Poles |
| $\lambda_{abc}, \lambda_{abcr} =$ | Stator and Rotor leakage inductance |
| $\omega_r =$ | Rotor angular speed |
| $\omega_b =$ | Nominal Rotor angular speed |
| $v_{d}, v_{q} =$ | d-axis and q-axis stator voltages |
| $i_{d}, i_{q} =$ | d-axis and q-axis stator current |
| $\psi_{ds}, \psi_{qs} =$ | d-axis and q-axis stator flux linkages |
| $\psi_{ds}, \psi_{qs} =$ | d-axis and q-axis rotor flux linkages |
| $r_s, r_r =$ | Stator Resistance and rotor resistance (per phase) |
| $X_{is}, X_{ir} =$ | Stator reactance and rotor reluctance (per phase) |
| $X_M =$ | Magnetizing Reactance |

2.2. Danfoss parameter estimation model

The basic idea of the Danfoss parameter estimation is applying a testing signal to a phase winding of the IM, measure magnitude and the phase of the resulting current $I_{sa}$ (test signal), then identify the parameters of each subsystem utilizing frequency injection [13]. This parameter estimation using frequency injection save cost and time comparing with the conventional algorithm like RLS, TSRLS. Consider rotor resistance ($\Omega$) transferred to stator side, dynamic inductance, different parameter equation is given below

$$R_r' = \left| \frac{U_m'}{I_r'} \right|$$
Where,

\( R'_r \) = Stator Side Rotor Resistance.

\( U'_m \) = Main inductance voltage drop calculated using \( L'_{m} \).

\( I'_r \) = Current through rotor winding.

\[
R'_r = R'_r \cdot \frac{L'_{DM} + L'_{nr}}{L'_{DM}}
\]  \hspace{1cm} (19)

Where,

\[
L'_{DM} + L'_{nr} = L'_r
\]  \hspace{1cm} (20)

\( L'_r \) = Slip of the asynchronous machine

\( L'_{DM}, L'_{DM'} \) = Dynamic main inductances

\( L'_{nr} \) = Rotor leakage inductance.

The value of \( R'_r \) in (19) is independent of current through winding of a stator, but referred value of rotor resistance \( R'_r \) is \( f(L'_{DM}) \), it depends upon the value of DC-offset. The referred dynamic main inductance \( L'_{DM} \), can be derived with magnetic flux and current. The following equation leads to find the value of dynamic main inductance and rotor resistance,

\[
L'_{DM} = \frac{d\phi'}{dI'_m}
\]  \hspace{1cm} (21)

Where, \( \phi' = \) magnetic flux referred to main inductance,

\( I'_m = \) Magnetizing current.

\[
\phi = L \ast I
\]  \hspace{1cm} (22)

\[
I'_{DM} = \frac{d(L'_mI'_m)}{dI'_m}
\]  \hspace{1cm} (23)

The required solution referred dynamic main inductance is:

\[
L'_{DM} = \frac{dL'_m}{dI'_m}I'_m + L'_m
\]  \hspace{1cm} (24)

\[
L'_{DM} = L'_{DM}^2/(L'_{DM} + L'_{nr})
\]

Equation 25 can be developed and from this \( L'_{DM} \) is calculated from, \( L''_{DM} \)

\[
L'_{DM} = L''_{DM} + (L''_{DM}^2 + 4L''_{DM}L'_{nr})^{1/2}
\]  \hspace{1cm} (25)

In this method, a test signal \( U'_m \) it consists of direct Voltage, superimposed with triangular Voltage is applied to the stator, and the resulting Isa (stator current) is measured. The \( L'_a \) (static transient inductance) calculated using induction motor technology, as given below:
\[ L'_s = L_m + L_{Is} - \frac{L_m^2}{L_m + L_{ir}} \]  

(26)

Moreover, \( L'_{DS} \) (Dynamic transient inductances), according to Communal understanding the field of an IM, as below:

\[ L'_{DS} = L_{DM} + L_{Is} - \frac{L_{DM}}{L_{DM} + L_{ir}} \]  

(27)

The \( R_{T1} \) value calculated at T1 it re-calculated by \( R_{T2} \) at a different temperature T2 using equation (28).

\[ R_{T2} = R_{T1} \cdot \frac{T_2 + K_T}{T_1 + K_T} \]  

(28)

Where, \( K_T \) constant (for copper material, \( K_T = 235 \)), \( T_1, T_2 \) are measured operating temperatures.

The steps involved in the Danfoss frequency injection method to estimate parameters of an Induction Motor (IM) are given below.

**Step 1:** To calculate first injection frequency, the test signal \( (U_{sa}) \), whose value depend on previously stored values in the memory. Testing voltage \( (U_{sa}) \) predetermined direct voltage applied on the phase winding of stator.

**Step 2:** To measure stator current \( (I_{sa}) \) and Ohmic Stator resistance \( R_s \), alternating triangular voltage superimposed with direct voltage of stator.

**Step 3:** Find the time constant \( L'_{s}/(R_s+R') \) and differential stator current \( dI_{sa}/dt \) using Sampled values.

**Step 4:** Main inductance \( (L_m) \) is function of magnetizing current \( (I_m) \), \( L_m = \phi_m/I_m \). Calculate \( L'_{s} \), using

\[ U_{sa} = R_s I_{sa} + L'_{s} (dI_{sa}/dt) \]

**Step 5:** Determine the correct phase voltage again by \( U_{ref} \) (reference voltage) given to the controller. Testing signal \( (U_{sa}) \) is triangular signal but can also apply square/sine wave applied till the resulting stator current \( (I_{sa}) \) and flux \( (\phi) \) stabilized.

**Step 6:** calculate a \( R_r \) (Ohmic rotor resistance) using stator Resistance \( (\Omega) \), \( L'_s \) (Leakage inductance), \( L'_{DM} \) (Main inductance R'* (Rotor resistance transferred to stator side).
2.3. Rockwell parameter estimation model

The angle between both high frequency voltage injection and the subsequent high frequency current is used to calculate the instantaneous magnitude of the stator resistance. High frequency voltage reference frame is mapped by three-phase voltage injected. In which the voltage with the higher frequency \( V_{dhv}, V_{qhv} \) must be coordinated with the direct axis and the three phase currents feedback also analysed by a current reference frame in which the higher frequency currents \( i_{dhv}, i_{qhv} \) coordinated to d or q axis, any one from the both when the estimation is perfect, the and q axis feedback related to higher frequency component ih.

Voltage reference frame \( i_h \) decomposed into \( i_{dhv}, i_{qhv} \) using \( \Theta_h \) (high frequency command angle) in Current reference frame \( i_h \) decomposed into \( i_{dhv}, i_{qhv} \) using \( \Theta_{hi} \) (high frequency current angle)

Current lag angle \( \Theta_i = \Theta_h - \Theta_{hi} \)

Flux angle estimation:

Using feedback voltage (or current) to obtain the flux angle by injecting high frequency signal to control voltage signal to power a pulse width modulated inverter. High frequency signal in the high frequency phase angle and generates the first injection signal (the multiplication of the magnitude and sine of phase angle of high-frequency), other two phase signals are delayed by 120°, the first, the second and the third phase are shifted separately, then add to a separate one of the three-Voltage command Signals. Derivative of flux angle position (used to overcome problems not including speed sensors in it) used as estimated stator frequency (function of motor parameters). Hence estimated rotor speed calculated by deducting the slip frequency from the estimated frequency of the stator.

Stator resistance varies with temperature, temperature of Stator winding is average winding current, which increases current feedback from through analog to digital converter, these current feedbacks are converted to two-phase Rectangular currents using current angle of High-frequency, offer the close-loop system in the first of two-phase Rectangular currents to be driven, the first of two-phase Rectangular
currents to zero using the Proportional Integral controller, as the angle of lag in current can be estimated using the PI controller’s output and the current lag angle can be used to estimate as an estimate of the lag angle between voltage-current generate an estimate of the stator resistance. Estimating the stator resistance of three-phase motor is defined by an inductance of stator leakage and powered by a pulse width modulation scheme connected to the motor through three supply lines. A system operating method that gets a voltage signal having high frequency and causes high-frequency voltage injected at high frequency in each of the three-phases of motor.

\[ R_s = ctg(\varphi_d)(\omega_h)(L_{s}) \]  

Where,  
\( \omega_h \) is the injected high frequency (rad/sec)  
\( L_s \), Stator leakage inductance,  
\( I_h \) high frequency current,  
\( V_h \) high frequency Voltage  
\( \Phi_d \) voltage-current lag angle

Current vectors are present in the current reference frame include a components direct-axis and quadrature-axis. After that, the current vector of the q-axis is defined negatively and step up with the proportional-integral controller to produce angle between voltage and current. Estimation in the current \( \Phi_d \) which is equal to the lag angle estimation between voltage and current \( \Phi_d' \). Estimation, \( \Phi_d'=\Phi_d' \) is now again deducted by command angle \( \Theta_h \), to create a close-loop. With addition to that, the estimated \( \Phi_d' \) is also put into Equation for angle \( \Phi_d \) to obtain resistance estimate \( R'_d \).

\[ R'_d = \tan(90° - \varphi_d')(\omega_h)(L'_s) \]  

Rotor resistance estimation

The estimate of the lag angle used to generate estimate value of resistance of rotor. For the case, step to use lag angle estimation between voltage and current to obtain the estimation a resistance of rotor in few embodiment including a step of identification, storage of an initial lag angle estimation of voltage current, Classifying the initial value of rotor side resistance estimation, division of the initial voltage-current lag angle estimate by the estimation of voltage, current to generate a stator resistance ratio and multiplying the initial value of rotor resistance estimated with the help of Stator resistance ratio hence create an estimate of rotor resistance.

The resistance of the rotor \( R_r \) varies in proportional to the change in the estimation of a \( \Phi_d' \). Thus, if an the rotor initial resistance \( R_{ro} \) is determined and stored. Initial voltage-current lag angle estimate \( \Phi_{do}' \) is calculated, related to resistance estimation done initially. \( R_{ro} \) and stored, these values can be estimated together with the instantaneous lag angle estimate \( \Phi_d' \), which is used for estimation of the instantaneous resistance value of rotor \( R'_r \). To this end, instantaneous estimate \( R'_r \).

\[ R'_r = (R_{ro})(\varphi_{do}'/\varphi_d') = (R_{ro}) tan(90° - \varphi_{do}')/tan(90° - \varphi_d') \]  

A voltage \( V_h \), is injected in between the axis of \( d_h \), and \( q_h \) and the high-frequency current \( I_h \) results. In this case, angle between voltage and current is \( \Phi_{d'} \) can be obtained using

\[ \varphi_d' = abs(abs(\varphi_d) - abs(\varphi_v)) \]  

If the high-frequency signals were injected between direct and quadrature-axis, instead of identifying a system of co-ordinate where the current \( I_h \) coincides with the d-axis, a new system of co-ordinates can be identified where the current \( I_h \) coincides with the q-axis. Using a following equation, a lag angle estimation \( \Phi_q' \) can be obtained.
\[ \varphi_q' = \text{abs}(\text{abs}(\varphi_i) - \text{abs}(\varphi_v)) \] (33)

The steps involved in the Rockwell voltage current angle lag method to estimate the parameters of induction motor mentioned below.

**Step 1:** Identify and store the initially estimated Current Lag angle, an initial estimation of rotor resistance and inductance of stator leakage.

**Step 2:** Identify High Frequency Command Angle.

**Step 3:** A lag angle of voltage and current then subtracted from a High-Frequency Command Angle Estimate to obtain a current angle of High-Frequency.

**Step 4:** Obtain the feedback currents from sensors.

**Step 5:** Convert feedback currents to two-phase currentsto generate lag angle of voltage and current.

**Step 6:** A mathematically combine angle estimation, leakage inductance of stator and command signal with high-frequency to generate resistance of stator.

**Step 7:** A mathematically combine the initial angle estimate, the estimation of lag angle between voltage and current and the estimation of initial rotor resistance to obtain the estimate of rotor resistance.
Figure 3. Flowchart of computation of the electric parameter estimations using angle between voltage and current.
3. Experimentation

The comparison between the Danfoss electric parameter estimation method and Rockwell electric parameter estimation method with the “real” IM electrical parameters are determined from conventional No-load and Locked-rotor test in this paper. Which are shown in table 2 and ensure the reliability and accuracy of the IM electrical parameter estimation methods given by Danfoss and Rockwell.

Figure 4. Danfoss Drive and Rockwell Automated Drive from (left to right) with a motor set up.
### 4. Comparison between Danfoss and Rockwell Automation Drive

#### Table 2. Comparison of different parameters among Danfoss and Rockwell drives

| PARAMETERS | ROCKWELL AUTOMATION | DANFOSS |
|------------|----------------------|---------|
| Overview   | **Power Flex 525 drive**<br>Voltage Rating: 200V,400V<br>15 HP/11 kW<br>Overload: 150% for 60 seconds<br>frequency up to 16 kHz | **VLT Automation Drive FC 302**<br>The input power required: 90-710kw<br>Voltage=380-690V |
| Topology   | a) Parks Transformation (3Ø to 2Ø conversion)<br>b) Inverse Parks Transformation (2Ø to 3Ø conversion)<br>c) Voltage reference frame<br>d) Current reference frame | The rotor resistance $(R_s)$ of an Induction Motor is measured automatically by means of an inverter while being acted upon by a non-rotating field |
| Equivalent circuit | ![Equivalent circuit](image) | ![Equivalent circuit](image) |
| Voltage $(V_h)$ of High frequency is injected across the stator winding of motor rotates with $\Theta_h$, high frequency($\omega_h$ in rad/sec) generates high frequency current $(I_h)$ | |
| Number of sensors | • 3 voltage sensors<br>• 3 current sensors | • 3 current sensors |
| Type of filter | ➢ Band Pass Filter<br>➢ Notch Filter<br>➢ Low pass filter | ➢ Sine wave filter<br>➢ Harmonic filter<br>➢ $dU/dt$ Filters<br>➢ common-mode filter |
Parameter estimation

1. Resistance of Stator (Rs)
2. Rotor Resistance of motor (Rr)
3. Leakage inductance of stator of motor (Lsl)
4. Ohmic stator resistance of motor(Rs)
5. Ohmic resistance of Rotor (Rr)
6. Leakage inductance of rotor (Lσr)
7. Leakage inductance of Stator (Lσs)
8. Main static inductance of the Induction Motor(Lm)
9. Main Dynamic inductance(LDm)

Accuracy

More                           Low

5. Conclusion

In this paper modelling of induction motor is done for three phase squirrel cage induction motor, to obtain some important relation between parameters of induction motor and also online parameter estimation which is also called self-commissioning of induction motor is explained in detail and compare from two different manufacturers, Danfoss and Rockwell automation drives are compared for self-commissioning of the motor. Danfoss uses the frequency injection method which is comparatively less accurate than method used by Rockwell automation which is voltage current lag angle method. Also Danfoss drives uses only current sensor, numbers of estimated parameters are more so somewhat more calculative burden will be there which will in turn increases the complexity and also calculation time.

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