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Simulation and Analysis of Parameter Identification Techniques for Induction Motor Drive

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Abstract

For induction motor drive the accuracy of the motor parameters has an important impact on the performance of the whole system. In this paper the method of identification for motor parameters like stator resistance, rotor resistance, and total leakage inductance for inverter fed induction motor drive. This test is based on the inverter switching for avoiding then the locked rotor and no-load test. The proposed algorithm can be implementing in standard motor drive to automatically perform parameter identification.

Index Terms— parameter identification, induction motor, equivalent circuit

1. Introduction

In practice, full use of the well-known advantages of modern Induction motor drives with field oriented control shows excellent utilization, dynamic performance, higher accuracy in the servo applications and highly reliable operation, If during commissioning the control system has been accurately adapted to the motor connected, In many applications, however, e. g. when inverter and motor are not sold as a unit, the parameters of the motor are not known beforehand [1].

In this, paper parameters identification method for induction motor driven by voltage source PWM inverter is presented. In this method, all tests and parameter estimation procedures are performed by the PWM inverter and its own controlling computer without aids of any extra equipment. The proposed scheme can be implemented on an existing controller by just adding software program only. Also, the parameters can be effectively estimated under any mechanical loading condition. With this parameter identification scheme on the controller, an inverter can be utilized for any induction machine although whose parameters are unknown. [5].

2. Principle of Parameter Identification

A. Motor model

The single phase equivalent circuit of the induction motor is shown in Fig. 1. Where, R_s, L_{ls} are the stator resistance and leakage inductance, respectively; R_r, L_{lr} are the rotor Resistance and leakage inductance, respectively; L_m is the Magnetizing inductance. The test structure with a PWM Inverter supply is shown in Fig. 2. By changing the on-off state of IGBT (VT1 to VT6), two types of excitation (DC or single Phase AC) will be injected into the motor [3].

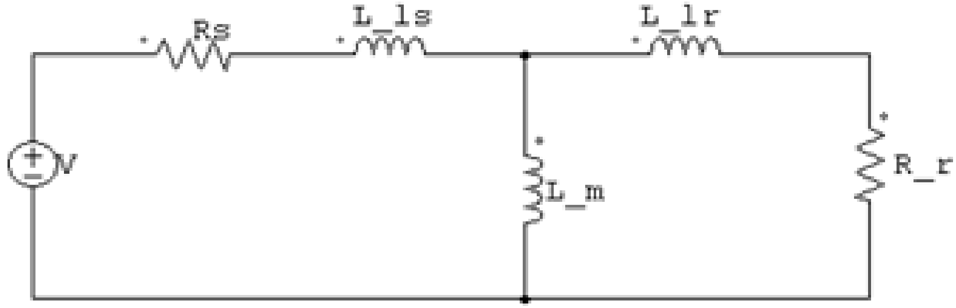

Fig-1 Single phase equivalent circuit

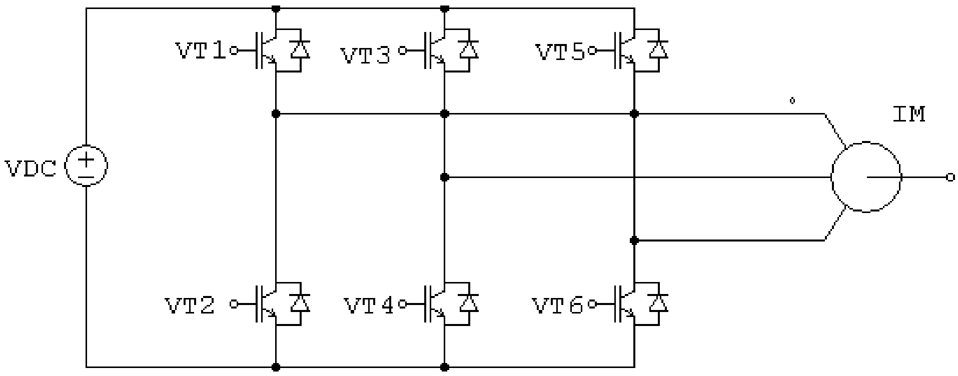

Fig-2 Inverter Topology

B. Stator Resistance measurement R_s

The value of R_s can be measured by an impressing different values of direct current on the induction machine. For example, this could be performed by a current controller and a pwm modulator. The current controller can be implemented by software [1].

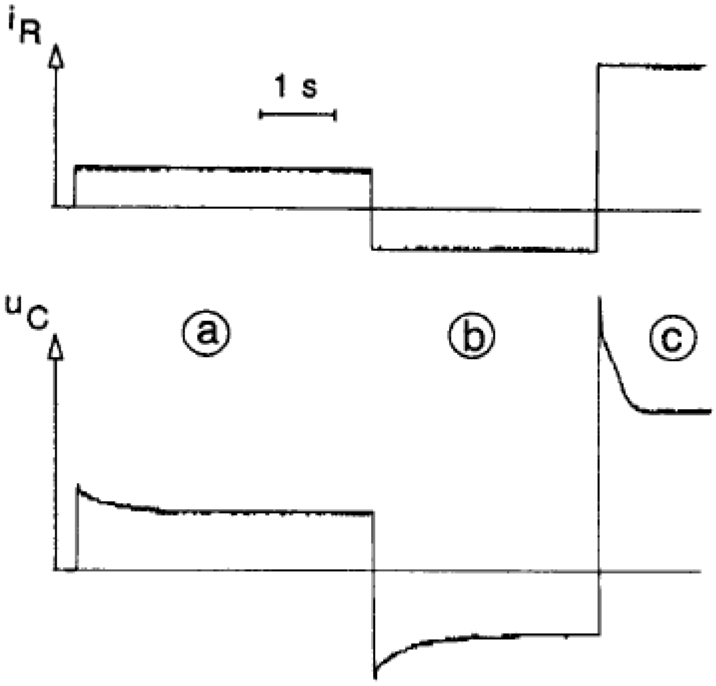

Fig-3 Measured stator current (I_r) and output of current Controller (U_c)

In interval c the current is the peak value of the rated current, in a and b, it is about 30 percent of this value. In steady state the terminal voltage is

$$U_c = R_s I_s \tag{1}$$

The average value of the terminal voltage is proportional to the voltage on the output of the current controller and can be determined if the d. c voltage is known however, the voltage drops due to semiconductor devices cause a small deviation. to obtain a correct value of the stator resistance, it can be estimated by using following expression.

$$R_s = \frac{U_s(c) - U_s(a)}{I_s(c) - I_s(a)} \tag{2}$$

C. Total leakage Inductance L_σ

In this method the appropriate short voltage impulse are generated inverter itself. Which supply the induction machine for this method induction machine is disconnected from the inverter for some time interval. This time interval decided based on the rotor time constant. The rotor time constant depends on the rating of the motor, higher the rating higher the time constant. Fig 4 describes the measuring procedure. By giving appropriate gating signal to IGBT S1and S4 at instant t_1, the direct voltage V_{dc} is applied across Phase A and Phase B and then firing of S1 and S6, V_{dc} is applied across Phase A and Phase C of the motor. At time t_2 the stator current i_s reaches to the peak value of rated motor current and then IGBTs are triggered in such a way that short circuit the motor. Similarly at t_3 V_{dc} is applied and at t_4 the motor remain short circuited. The leakage inductance can be calculated by taking differentiation of current which is replaced by differences of current and time. [5]

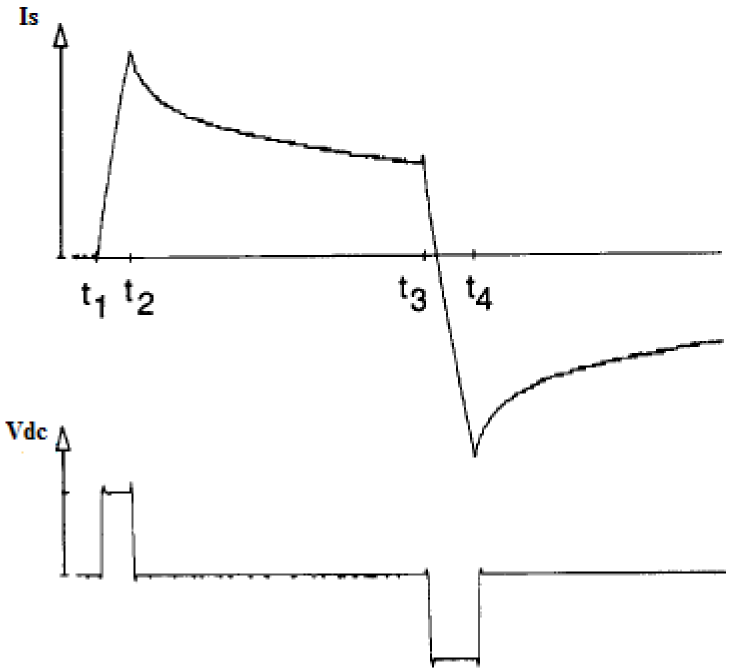

Fig-4 stator voltage and current for determining leakage inductance

$$L_\sigma = \frac{2}{3}\frac{V_{dc}(t_4 - t_3)}{I(t_3) - I(t_4)} \tag{3}$$

Evaluating time interval t_3 - t_4 rather than $t_1 - t_2$ has many advantages. As the differences of current and time are greater, the result is more accurate.

D. Rotor resistance measurement R_r

The d-axis equivalent circuit of the induction machine at standstill can be drawn as Fig. 2. In order to identify the rotor resistance, the d and *q* axis currents are controlled in the stationary reference frame according to the following relationships [2].

$$i_{ds} = i_{ds} + i_h \sin \omega_h \tag{4}$$

$i_{qs} = 0$ (5)

On the d-axis, a sinusoidal current with DC bias is applied while the q-axis current is controlled to be zero. The DC bias current I, is determined as the nominal current value given on name plate. The sinusoidal current term has a constant frequency ω and amplitude I, When the frequency is high enough, most of the DC current I, flows through the L branch while the sinusoidal current I_h sinwht flows through the rotor branch.

The mutual inductance L_m rotor leakage-inductance L_{lr} , And rotor resistance R_r , can be approximately obtained from Name plate data. With these values, the frequency is determined using the following condition:

$$\frac{R_r + j\omega_h L_{lr}}{j\omega_h L_m} \leq 0.05 \tag{6}$$

$$V_{ds} - R_s I_{ds} = \left(R_s + R_r\right) I_h \sin \omega_h t + L_\sigma I_h \omega_h \cos \omega \omega_h t \tag{7}$$

$$= C I_h \sin\left(\omega_h t + \alpha_h\right) \tag{8}$$

$$C = \sqrt{\left(R_s + R_r\right)^2 + \left(\omega_h L_\sigma\right)^2} \tag{9}$$

$$\alpha_h = \tan^{-1} \frac{\omega_h L_\sigma}{R_s + R_r} \tag{10}$$

From the above relationship, the phase difference α_h between I_h sinwht and V_{ds} - $R_s I_s$ includes the information of the rotor resistance. In other words, from the equation (10), R_r is obtained a

$$R_r = \frac{\omega_h L_\sigma}{\tan \alpha_h} - R_s \tag{11}$$

Therefore, the rotor resistance can be uniquely determined by detecting the corresponding phase difference α_h. For Identifying R_r , the stator resistance R_s , and the stator transient inductance L_σ need to be known.

3. Simulation Result

In this section, simulation results of the proposed method are presented. The proposed method for the parameter identification of an induction motor has been tested by computer simulations using PSIM 9. 0 software. The specifications and parameters of the simulated induction motors are listed in Table I

Rated power P	0. 75 kW	7. 7kW
Supply voltage V_s	380V	380V
Rated current I_s	1. 8A	
Frequency f	50 Hz	50Hz
Stator resistance R_s	9. 313Ω	0. 81Ω
Rotor resistance R_r	*11. 651Ω*	*0. 57Ω*
Magnetising inductance L_m	401. 6mH	
Leakage inductance L_σ	35. 85mH	1. 80mH

For stator resistance the DC test will be performed at two different rating of motor in fig 6 shows the arrangement of Stator resistance measurement.

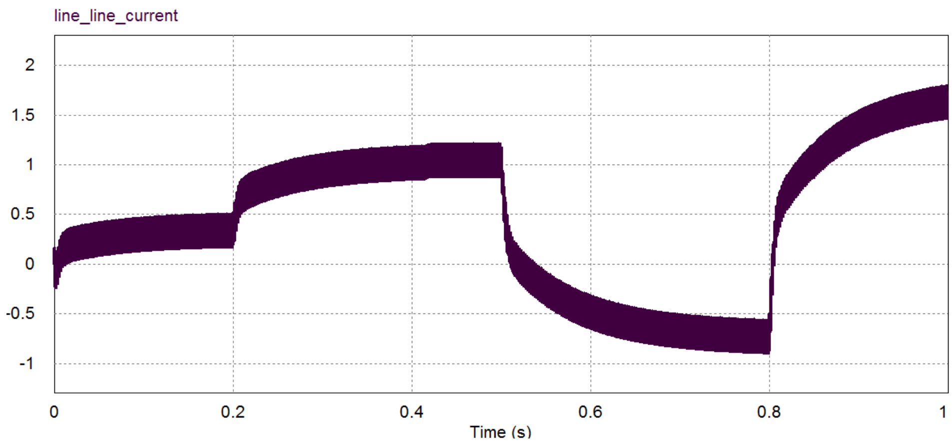

Fig-6 Measured stator output line-line current

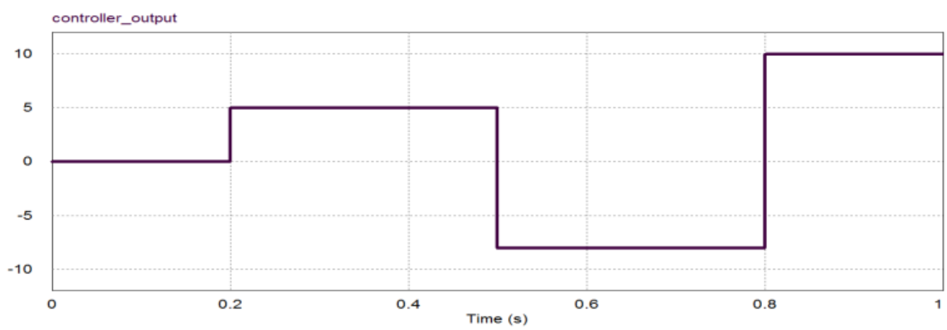

Fig-7 Measured output of current controller

For identification of leakage inductance the same system is adapted. Only change is in the firing scheme of the inverter. The stator current and voltage waveforms are shown in

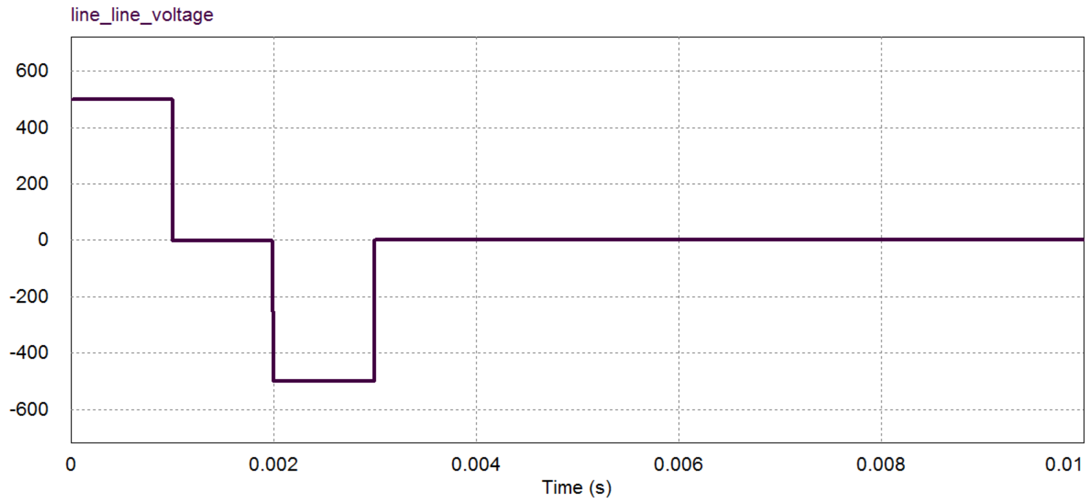

Fig-8 Measured stator output line-line voltage

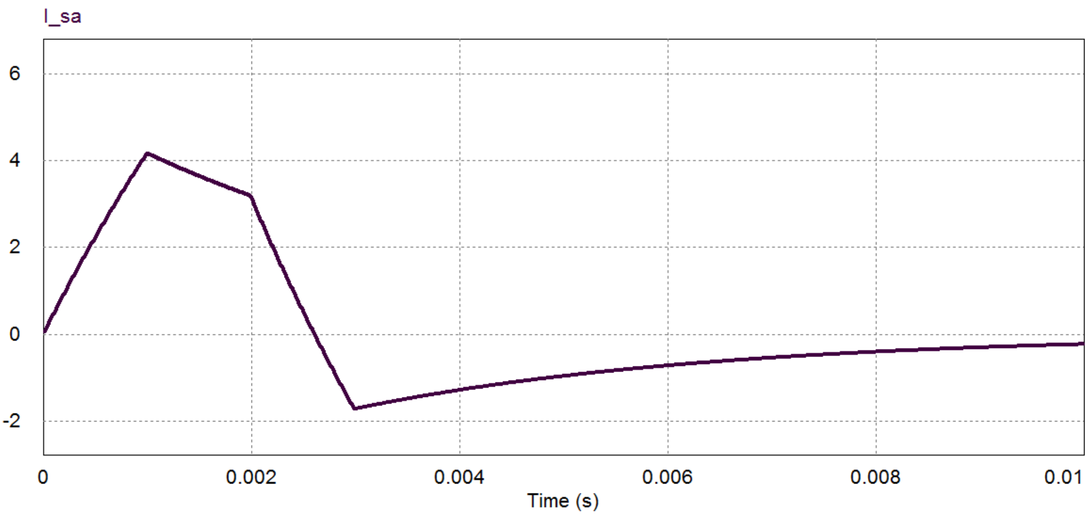

Fig-9 Measured stator output line-line current

For Identification of Rotor resistance the same system is adapted. Only change is in the firing scheme of the inverter. The stator current and voltage waveforms are shown in

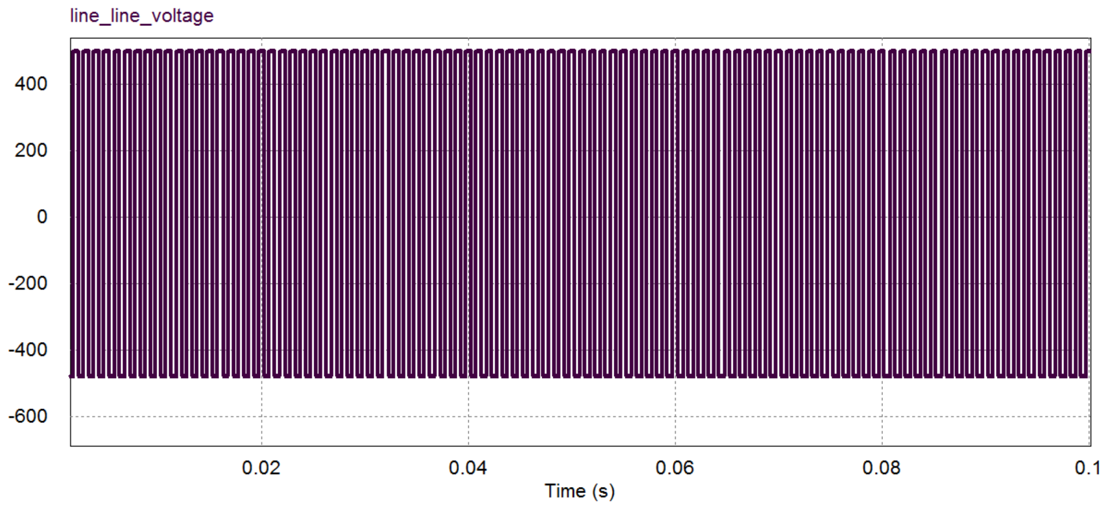

Fig-10 Measured stator output line-line voltage

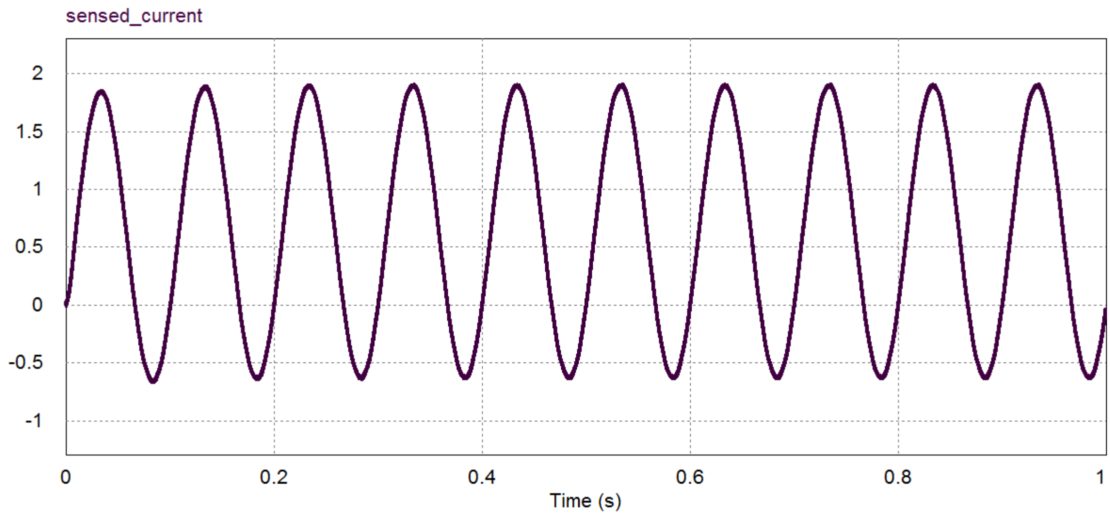

Fig-11 Measured stator output line-line current

The result obtained i. e. the derived parameter of the given motor in table which indicates that the different parameter follow the real one very closely which indicates that the proposed identification method worked successfully for induction motor parameter identification.

Table -2 Parameter Simulated Results.

	R_s			L_σ			R_r		
	Actual	Measured	Error	Actual	measured	Error	Actual	measured	Error
0. 75Kw	9. 313Ω	9. 03Ω	0. 28Ω	35. 85mH	38. 96mH	3. 11mH	11. 651Ω	10. 95Ω	0. 70Ω
7. 7 Kw	0. 81Ω	0. 80Ω	0. 10Ω	1. 82mH	1. 80mH	0. 20mH	0. 57Ω	0. 50Ω	0. 07Ω

4. Conclusion

This proposed paper demonstrates parameter estimation techniques for induction motor. This test gives result that is resonance with their theoretical values. This test eradicates the requirement of external hardware. These tests are reliable and can be used for any rating of machine. It can be performed any time before starting of the drive.

5. References

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