STATOR RESISTANCE ESTIMATION OF INDUCTION MOTOR USING GENETIC ALGORITHM

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ABSTRACT

Nowadays, induction motors are mainly used in all industrial especially in plant industrial. In general, this motor is widely used because it is cheaper, easy to maintenance, no friction by brushes and their speed are easy to control compared to the direct current (DC) motor. But, the stator resistance changes continuously with the temperature of the machine. The changes can cause an error between the actual and estimated motor torques which leads to motor break down in worst cases. In order to solve this issue, a genetic algorithm method is designed to estimate the variation of stator resistance. This project is about to design genetic algorithm estimator using MATLAB software, and builds an actual induction motor using Newcastle University Drives Simulation Library. Finally these parts of Simulink diagram will be combined to estimate the variation of stator resistance.

ABSTRAK

Pada masa kini motor induksi kebanyakannya digunakan dalam semua industri terutama di loji perindustrian. Secara amnya, motor ini digunakan secara meluas kerana ia lebih murah, mudah dengan kerja penyelengaraan, tiada geseran oleh berus dan kelajuan mereka mudah dikawal berbanding dengan motor arus terus. Tetapi rintangan menukar secara berterusan dengan suhu mesin. Perubahan boleh menyebabkan ralat antara daya kilas motor sebenar dengan anggaran yang akan menyebabkan motor rosak teruk. Dalam usaha untuk menyelesaikan isu ini, satu kaedah algoritma genetik telah direka untuk menganggarkan perubahan rintangan pemegun. Projek ini adalah untuk merekabentuk algoritma genetik penganggar menggunakan perisian MATLAB dan membina sebuah model motor induksi menggunakan pemacu simulasi perpustakaan Universiti Newcastle. Akhirnya semua simulasi ini akan digabungkan untuk menganggarkan perubahan rintangan pemegun.

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CHAPTER 1

INTRODUCTION

1.1 OVERVIEW

Induction motor is a type of alternating current (AC) motor where power is supplied to the rotor by electromagnetic induction. This motor is widely used in domestic, commercial and various industrial applications. Particularly, the squirrel cage type is characterized by cheaper, easy to maintenance, no friction by brushes and their speed are easy to control compared to the direct current (DC) motor, which has always its attractions and it has therefore captured the leading place in industrial sectors [1]. Resistance of stator is an important criterion of dynamical model of induction motor which changes due to the temperature variations [2]. The changes can cause an error between the actual and estimated motor torques which leads to motor break down in worst cases. In induction motor, power loss generated temperature escalation inside the motor which the major cause come from the current flowing throughout the stator winding. Basically, the losses in the machine contribute to stator winding temperature rise, and those losses classified as stator copper loss, rotor copper loss, stator iron loss, rotor iron loss, and some amount of stray loss.

Most symbolic artificial intelligence (AI) systems is very static. Most of them can usually solve one given specific problem. In recent years, genetic algorithm (GA) has been recognized as potent tools in design optimization of electrical machinery [1]. A genetic algorithm is a random global optimization method principles inspired that of evolution found in nature. It is gaining popularity in improvement of system design , parameter identification, and solving non linear equations [3]. One of the most important advantages of GA compared with other numeric methods such as newton Raphson is that it is able to find the global minimum instead of local minimum and that the initial attempts with different starting point need not be close actual values. Another advantage it does not require the initial estimates and use of any derivative a function, which is not always easily obtainable or may not even exist [1-2]. GA differs from conventional non- linear improvement techniques as by preserving a population of the solutions, they search for better ones. The key features of such algorithms characterized by possessing a chromosome. The significance of this approach lies in number manipulation and natural selection. The key operators in the computation consist of reproduction, crossover, and mutation. Generally, the GA is implemented by firstly assigning each unknown parameter a random binary code (string). A population of strings can be generated through repeating this procedure. Reproduction involves a process that each string is assessed against predetermined criteria of fitness (fitness function). The fitters are more likely to survive and to produce offspring in the next generation. Crossover represents mating and swapping of some information of the two strings that are also randomly selected from the survivors of the selection process. Mutation occurs to one randomly selected string to invert its binary code from 0 to 1, or vice versa. By manipulating the degree of each process involving the three operators, some global best solutions from the population can be achieved [3].

1.1 OBJECTIVES

The proposed project seeks to fulfill the following objectives:

I. To design an actual induction motor by using Newcastle Drives Simulation Library (NUDSL).

II. To estimate the variation of the stator resistance based on an error between actual and estimated stator current using genetic algorithm estimator.

III. To design a genetic algorithm estimator by using MATLAB.

1.2 SCOPES OF PROJECT

The scope of this project are as follows:

I. To build a system to measure the stator resistance between the actual and estimated induction motor.
II. To monitor the effect of stator resistance changes due to the changes of temperature of induction motor.
III. To estimate stator resistance using the Genetic Algorithm.

1.3 PROBLEM STATEMENT

When stator resistance becomes higher, it also affects the stator current that finally makes the induction motor become malfunction. This case can cause the flux vector, speed and frequency become inaccurate. The problem of this can become error of flux magnitude, phase angle which finally affects the drives and all electronic equipments. By using genetic algorithm because it is capable to perform functions normally associated with human intelligence.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

While doing this project there are many aspects that must be involved and one of that is the literature review. These literature reviews are getting from past journals or research that have been done. All the literature review includes about induction motor, genetic algorithm and stator resistance estimation by using another method which is fuzzy logic, neural network and Neuro fuzzy. From this literature review, it can be known that genetic algorithm is used for another application, it cannot be just for stator resistance estimation. There are many various ways can be used to estimate the variation of stator resistance and application of genetic algorithm.

2.1.1 Estimation of stator resistance of induction motor for direct torque control scheme using adaptive Neuro fuzzy inference systems.

"Direct torque control (DTC) is a relatively induction motor control method. That is relatively easy to implement and that enables high performance to be achieved. However, the conventional DTC techniques has some drawbacks such as large torque ripple in the low speed region according to the change of motor parameters. The sensitivity of DTC to temperature variations, leading to stator resistance changes, is eliminated by online stator estimation of stator resistance. An estimator is designed through Adaptive Neuro-Fuzzy Inference Systems (ANFIS) for stator resistance estimation with reference to the temperature" [3].

The temperature variations leading to the stator resistance changes. The stator resistance can be estimated by using Adaptive Neuro-Fuzzy Inference Systems with the reference of the temperature. This application uses for direct torque control.

2.1.2 A fuzzy logic approach for stator resistance estimation of an induction motor.

"During the operation of an induction motor an accurate estimation of stator resistance is so important especially due to variation in the stator resistance and the temperature working machine. A fuzzy technique uses for an online estimation of the stator resistance under steady state operating conditions of an induction motor. The fuzzy technique considers two inputs and one output, in which the inputs are current error and change in the current error whereas the output is the change in stator resistance" [7].

The changes of stator resistance in an induction motor because of the variation of temperature working machine. Afuzzt technique was use to estimate the changes of stator resistance. The fuzzy technique need two input to make it can be function well to estimate stator resistance.

2.1.3 Resistance estimation for temperature determination in PMSMs through signal injection.

"Real time thermal management of electrical machines relies insufficiently accurate indicators of temperature within a machine. One indicator of temperature in a permanent magnet synchronous motor (PMSM) is the stator winding resistance. Detection of PMSM winding resistance in the literature has been made on machines with relatively high resistances, where the resistive voltage vector is significantly under load. A technique applied to sense the winding resistance where the resistance is low and hence the resistive is voltage difficult to detect. A current injection method is applied which enables the resistance to be determined, and hence the winding temperature in non-salient machines. This method can be applied under load and in a manner that does not disturb shaft torque, or speed. The method is able to distinguish between changes in the electro-motive force (EMF) constant and the resistive voltage" [5].

2.1.4 Design optimization of induction motor by genetic algorithm and comparison with existing motor.

"The genetic algorithm is used for optimization and three objectives namely torque, efficiency, and cost are considered. The motor design procedure consists of a system of non-linear equations which imposes induction motor characteristics, motor performance, magnetic stresses and thermal limits. The optimally designed motor is compared to an existing motor having the same ratings" [1].

2.1.5 Electrical energy consumption estimation by genetic algorithm and analysis of variance.

"The using of GA with variable parameters to forecast electricity demand in agricultural, low energy consuming and energy intensive sectors uses stochastic procedures. Three kinds of models; linear logarithmic, exponential and quadratic are used to find which leads to minimum error for the related sector. The GA applied has been tuned for all its parameters and the best coefficients with minimum error are identified, while all parameter values are tested concurrently. The estimation errors of genetic algorithm models are less than that of estimated by regression method. Finally, analysis of variance (ANOVA) is applied to compare the genetic algorithm (three models), regression and actual data. It is found that at $\alpha = 0.05$ the five treatments are not equal and therefore the Duncan test is applied to see which treatment pair has lead to the rejection of the null hypothesis. Furthermore it is shown that genetic algorithm estimation is closer to actual data with less MAPE (Mean Absolute Percentage Error) error than that of an estimated by regression" [6].

The genetic algorithm is used to tune all the parameter of the electricity demand in agricultural. The economic indicators used are price, value added, number of customers and consumers in the last periods for agricultural and low energy consuming sectors and price, value added, number of customers, price of the substitute fuel and energy intensity in energy intensive sector. From the experiment, it can prove that genetic algorithm is accurate because the result is close to the actual data.

2.1.6 Application of genetic algorithm to the optimization of a roll type electrostatic separation process.

"GA is used for the development of a procedure for optimal control of electrostatic separation process in the recycling industry. The target of this development is to maximize the conductor product, with the control variables being the high voltage that supplies the electrode system of roll-type corona-electrostatic separator and the inclination of the splitter between the two compartments in which are collected the conductor product and the middling. The effectiveness using GA is tested against a situation of dysfunction that can occur in industrial practice" [8].

Another using of genetic algorithm, as the optimal control of separation process in recycling industry. The using of a genetic algorithm is more as to find optimization in the project or process. From all of the artificial intelligence, it tested that the accuracy of the genetic algorithm. Also, if the genetic algorithm is suitable for industrial practice.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

In this project, the designing process will be divided into three parts:

I. Design actual induction motor by using Newcastle University Drives Simulation Library (NUDSL).
II. Design a simple proportional integral (PI) estimator using MATLAB.
III. Design a genetic algorithm estimator by using MATLAB.

Therefore, a genetic algorithm estimator method is design to estimate the variation of stator resistance. So, in this thesis genetic algorithm estimator is designed by using MATLAB Simulink to estimate the variation of stator resistance based on error between the actual and estimated stator current of the induction motor. The actual motor is developed using NUDSL while the estimated motor was developed by using MATLAB Simulink that can be obtained by using two equations state below:

$$ids(k) = W1Vds(k-1) + W2\lambda_{dr}^{im}(k-1) + W3\lambda_{qr}^{im}(k-1) + W4ids^{*}(k-1) \quad (1)$$

$$iqs(k) = W1Vds(k-1) + W2\lambda_{qr}^{im}(k-1) + W3\lambda_{dr}^{im}(k-1) + W4iqs^{*}(k-1) \quad (2)$$

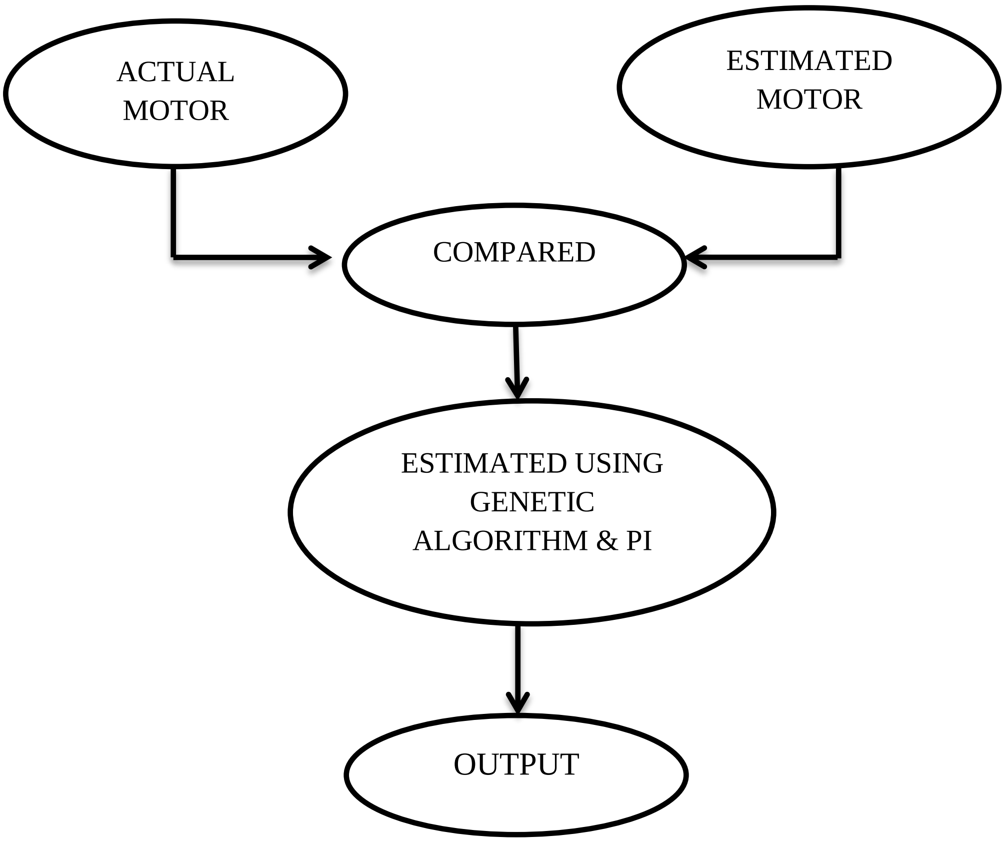

Figure 3.1 Block Diagram for Overall System

Figure 3.1 it shows that the actual and estimated stator current of induction motor is compared. The input voltages that use is the same which is both from the Newcastle university drive simulation library. After that, stator current for both machines that generated have been compared with each other. The error between the actual and the measured stator current is used to determine the variation of stator resistance through genetic algorithm estimator. The comparison as below:

$$e(k) = \Delta Is(k) = Is^{*}(k) - Is(k) \quad (3)$$

$$\Delta e(k) = e(k) - e(k-1) \quad (4)$$

The inputs to the estimator are the current error and change in current error. The incremental stator resistance continuously adds to the previous estimated stator resistance. Finally, the final estimated value of stator resistance is obtained.

3.2 Simulation Of Induction Motor Without Load By Using Newcastle University Drive Simulation Library

This section has discussed about the development of induction motor without load by using Newcastle University Drive Simulation Library. The Simulink diagram contains three phase power supply, three phase to DQ transform, three phase induction motor, DQ to three phase transform and constant rotor speed. The parameter that uses in this diagram has been shown in Table 3.1 and the diagram of the induction motor in Figure 3.2.

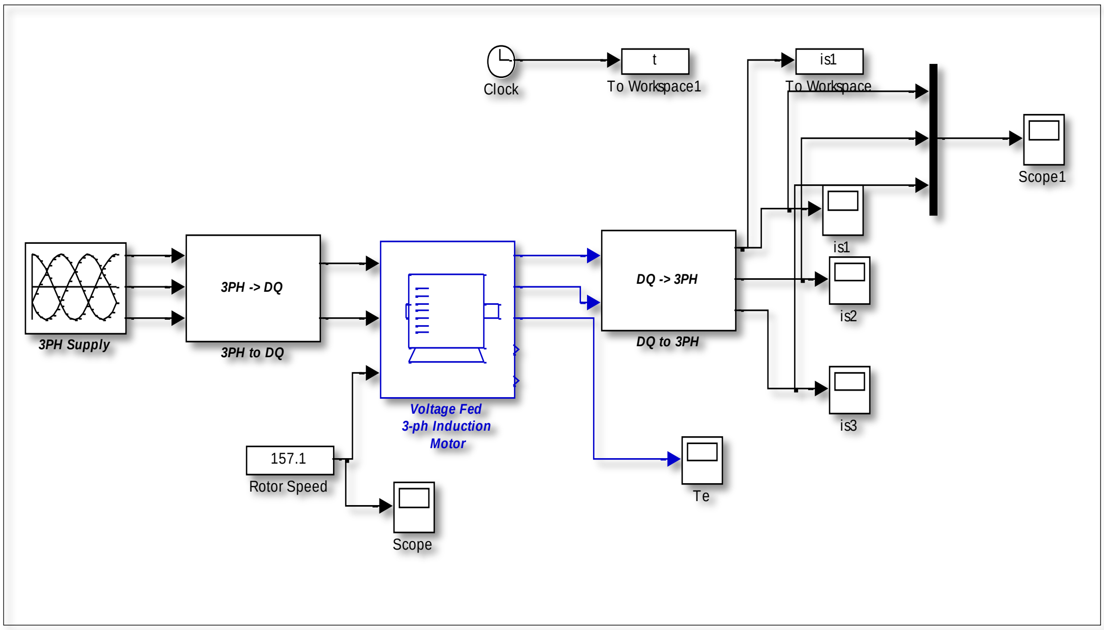

Figure 3.2 Induction Motor Models without Load Using NUDSL

Table 3.1 Parameter of Induction Motor without Load

Parameter	Value
Stator resistance, Rs	1.2Ω
Rotor resistance, Rr	1.8Ω
Stator inductance, Ls	0.156H
Rotor inductance, Lr	0.156H
Magnetizing inductance, Lm	0.143H
Voltage	311.13V
Frequency	50Hz
Rated speed	1440rpm
Rated power	4000W
Numbers pole pairs	2

The input voltage that has been injected is 311.13 V three phase supply and applied to three phase to DQ transform. The constant speed that has been injected is 157.1rad/s. The output of three phase to DQ transform and the rotor speed is by the voltage fed three phase induction motor. The the output of induction motor is the stator current. But to see the stator current clearly, it has been applied to DQ to three phase transform . After that, the graph of torque and three phase stator current is obtained by using a scope.

3.3 Simulation of Induction Motor with Load By Using Newcastle University Drive Simulation Library.

This section has discussed the development of induction motor with load by using Newcastle University Drive Simulation Library. The Simulink diagram contains three phase power supply, three phase to DQ transform, three phase induction motor, DQ to three phase transform, constant rotor speed and mechanical dynamics. The parameter that uses in this diagram has been shown in Table 3.2 and the diagram of the induction motor in Figure 3.3.

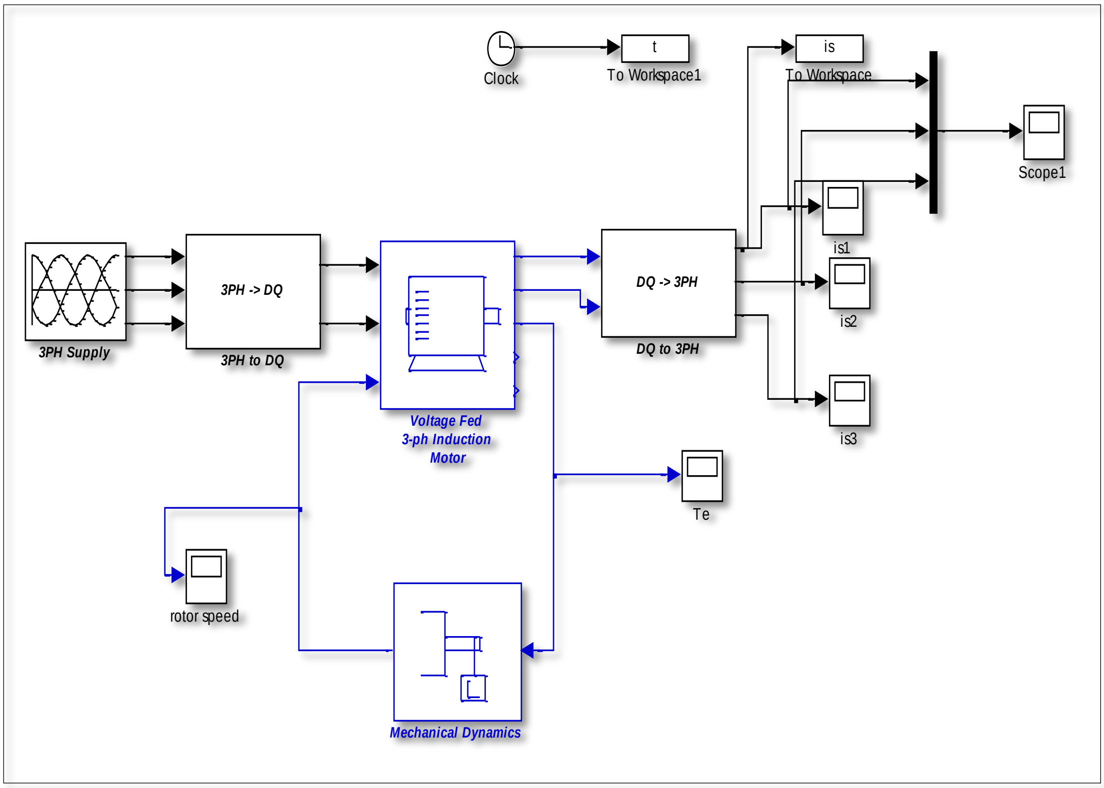

Figure 3.3 Induction Motor Models with Load Using NUDSL

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Magnetizing inductance, Lm	0.143H
Voltage	311.13V
Frequency	50Hz
Rated speed	1440rpm
Rated power	4000W
Numbers pole pairs	2
Inertia, J	$0.024kgm^2$

Firstly , the 311.13 V three phase voltage supply with the 50Hz are injected into the three phase to DQ transform. The output of the three phase to DQ transform and rotor speed enter into three phase induction motor. The outputs of induction motor are stator current in DQ form and torque. The torque is injected into the mechanical dynamic and its output is rotor speed. As mentioned before, the output of induction motor which is stator current are applied into the DQ to three phase transform and the output can be obtained by using a scope. The difference between with load and without load is the with load have the mechanical dynamic. Inside the subsystem of mechanical dynamics has one step block and the step time adjusted to become 0.4, initial value is 0 and the final value is equal to the T_{Load}.

3.4 Simulation of Induction Motor by Using Simulink MATLAB

This section will discuss on the Simulink diagram that are used to design the estimated induction motor with a load. The Simulink diagram of induction motor is designed by using d-axis and q-axis stator flux linkages, d-axis and q-axis stator current in stator reference frame and amplitude of the stator current.

The d-axis stator flux linkages in Figure 3.7 use equation:

$$\frac{d\lambda_{dr}^{im}}{dt} = -\frac{1}{Tr}\left(\lambda_{dr}^{im}\right) - Wr(\lambda_{qr}^{im}) + \frac{Lm}{Tr}(ids) \qquad (5)$$

The q axis stator flux linkages in Figure 3.8 use equation:

$$\frac{d\lambda_{qr}^{im}}{dt} = -\frac{1}{Tr}\left(\lambda_{qr}^{im}\right) + Wr(\lambda_{dr}^{im}) + \frac{Lm}{Tr}(iqs) \qquad (6)$$

D axis stator current in a stator reference frame in Figure 3.9 use equation:

$$\frac{dids}{dt} = \left[Vds - Rsids - \left\{-\frac{1}{Tr}\left(\lambda_{dr}^{im}\right) - Wr(\lambda_{qr}^{im}) + \frac{Lm}{Tr}(ids)\right\}\frac{Lm}{Lr}\right]\frac{1}{\sigma Ls} \qquad (7)$$

Q axis stator current in stator reference frame in Figure 3.10 use equation:

$$\frac{diqs}{dt} = \left[Vqs - Rsiqs - \left\{-\frac{1}{Tr}\left(\lambda_{qr}^{im}\right) + Wr(\lambda_{dr}^{im}) + \frac{Lm}{Tr}(ids)\right\}\frac{Lm}{Lr}\right]\frac{1}{\sigma Ls} \qquad (8)$$

The amplitude of stator current in Figure 3.5 use equation

$$Is = \sqrt{Ids^2 + Iqs^2} \tag{9}$$

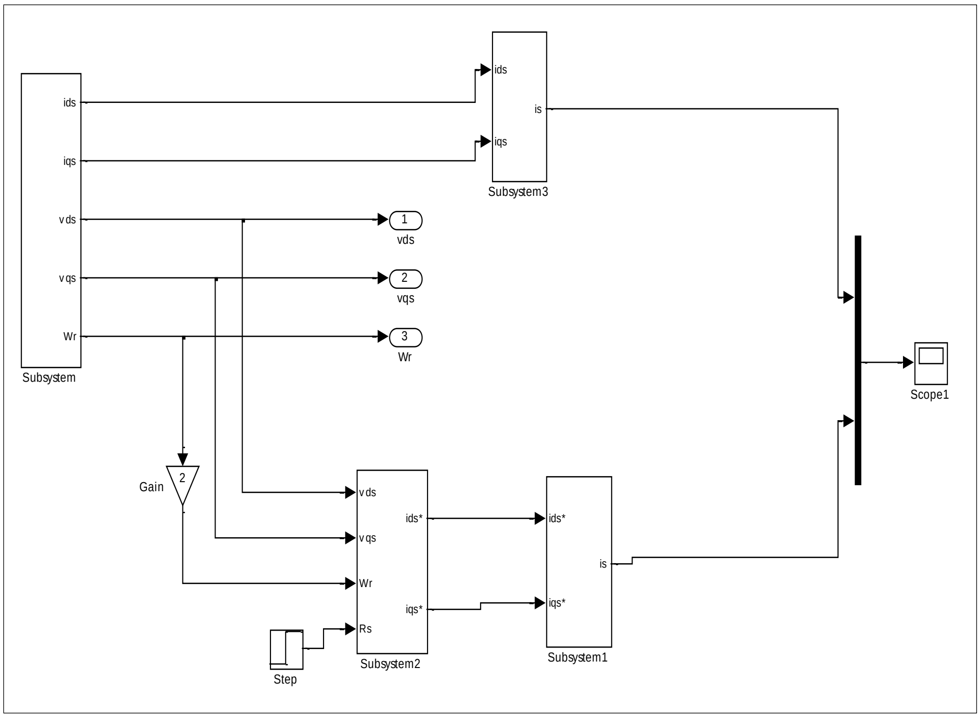

Figure 3.4 The Combination of Both Machines

Figure 3.4 shows the combination of the actual and estimated motor to compare the stator current from the both motors. The external resistance have been injected to different the resistance of the induction motor. The actual stator resistance, which is Rs=1.2Ω. While the estimate have been varied for 1.5Ω,1.8Ω and 0.9Ω.