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Steady State Analysis of Self Excited Induction Generator using Artificial Neural Network Technique

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Abstract-Due to increasing demand of energy and limitation of non-renewable energy sources, the need of efficient use of renewable energy sources is increasing. An Induction Generator with its various advantages such as low cost, simplicity, robust construction, inherent protection against short circuit and absence of dc source for excitation makes it very useful in the renewable energy industry. By connecting capacitors to the stator terminals makes it feasible for Induction Machine to be used as a Self Excited Induction Generator. The ability of an Induction Generator to work as a standalone generator makes it very useful in the generation of electrical energy in remote areas. The main drawbacks of SEIG are poor voltage and frequency regulation. The thesis gives the analysis o Self Excited Induction Generator using artificial intelligence. The proposed ANN model is trained by different set of data obtained from simulation of machine by using MATLAB®/SIMULINK® software. The comparison of calculated and predicted data confirms the validity and accuracy of the proposed work.

Keywords- SEIG, Artificial Intelligence, ANN, MATLAB/SIMULINK

SYMBOLS USED

a	per unit frequency
b	per unit speed
Rs,Rr	per phase stator & rotor resistance
Xm	magnetizing reactance
X1s	per phase stator leakage reactance
X1r	per phase rotor leakage reactance
Xc	per phase capacitance reactance
Rl	per phase load resistance
f, v	per unit frequency & speed
s	slip, *(a-b)/a*
N	speed

I. INTRODUCTION

The essential component needed in the advancement of a nation is its energy limit. The majority of the electric energy today utilizes fossil fuels. The fossil fuels as we probably are aware are constrained in nature and are going to vanish, we require another sources of energy which are less expensive and are likewise solid when contrasted with the customary wellsprings of energy requirement. This has pressurized scientists to consider non-routine wellsprings of energy. Non-ordinary sources incorporate solar energy, wind energy, tidal energy, and geothermal energy, hydro and so on. Another reason or adaption of non-conventional sources of energy is that they are anything but difficult to handle eco-accommodating and require less upkeep. The fundamental element of non-routine wellsprings of vitality is that they make less measure of contamination.

Induction Generators are progressively utilized with the non-conventional sources of energy. The primary explanation for the prevalence of Induction Generator for utilizing it with renewable sources of energy are low unit expense, small size, roughness, brushless development, nonappearance of DC power supply, simplicity of support and so forth. Such generators may be utilized for the jolt reason as a part of remote territories. The operation of Self Excited Induction Generator (SEIG) is helpful under variable rate operation; in this manner it turns into the obligation of an analyst to examine the conduct of particular issue related issues of Induction Generator.

A fitting circuit representation and precise scientific demonstrating is vital in assessing the consistent state execution of SEIG for distinctive working conditions. To compute the unfaltering state execution of Self Excited Induction Generator, examiners received distinctive models, a few specialists [3]-[4] embraced the impedance model while some utilized the induction based model for such estimations. It was found that most specialists utilized the displaying which came about as a part of a solitary polynomial comparison of higher request in obscure created recurrence and polarizing reactance. A dynamic force source based new comparable circuit model was proposed by. In [5], an iterative strategy has been utilized to get the created recurrence of the Self-energized Induction Generator. To process the non direct polarization qualities of Induction Generator it is fundamental to add to a numerical model, terminal voltage can likewise be figured with such demonstrating. Scientists have received different methods to gauge the execution of SEIG, for example, piecewise straight rough guess, hereditary calculation and so forth. However in this setting Artificial Neural Network strategy can turn out to be a straightforward and proficient technique for demonstrating the SEIG.

In this paper ANN displaying to investigate the enduring state execution of SEIG has been proposed through the customary circuit. The ANN model is prepared by distinctive situated of information got from the reenactment of machine. The correlation of the information gives the legitimacy and exactness of the proposed model.

I. MODELLING OF SEIG

The per phase equivalent circuit of SEIG for the analysis of steady state operation is shown in fig.1

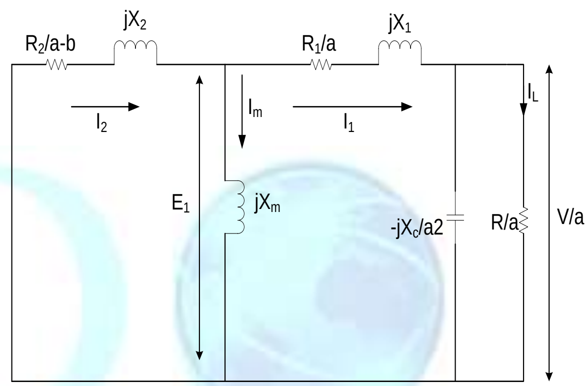

Fig.1 per phase circuit representation of SEIG

In this circuit, all the parameters are thought to be independent of immersion besides polarizing reactance. Examination of equal circuit brings about the accompanying mathematical statements for the relentless state operation.

$$\frac{\left(R_L+\frac{R_1}{a}\right)}{(X_1-X_L)^2+\left(R_L+\frac{R_1}{a}\right)^2}+\frac{\frac{R_2}{a-b}}{{X_2}^2+\left(\frac{R_2}{a-b}\right)^2}=0$$

$$-\frac{1}{X_m}-\frac{X_2}{{X_2}^2+\left(\frac{R_2}{a-b}\right)^2}-\frac{(X_1-X_L)}{(X_1-X_L)^2+\left(R_L+\frac{R_1}{a}\right)^2}=0$$

With low operating slips, above equation can be written as

$$s=-\frac{R_2(aR_L+R_1)}{a^2(X_1-X_L)^2+(aR_L+R_1)^2}$$

Where generated frequency is

$$a=\frac{b}{1-s}$$

Omitting stator impedance and rotor reactance by using approximate equivalent circuit gives the operating slip as

$$s = -\frac{R_2}{R}$$

Initial value of frequency a_o will be

$$a_o = \frac{b}{1+\frac{R_2}{R}}$$

From above, the value of magnetizing reactance can be calculated as

$$X_m = -\frac{1}{\frac{X_2}{X_2^2+\left(\frac{R_2}{a-b}\right)^2}+\frac{(X_1-X_L)^2}{(X_1-X_L)^2+\left(R_L+\frac{R_1}{a}\right)^2}}$$

The proposed model of the Self Excited Induction Generator has been indicated in fig.2

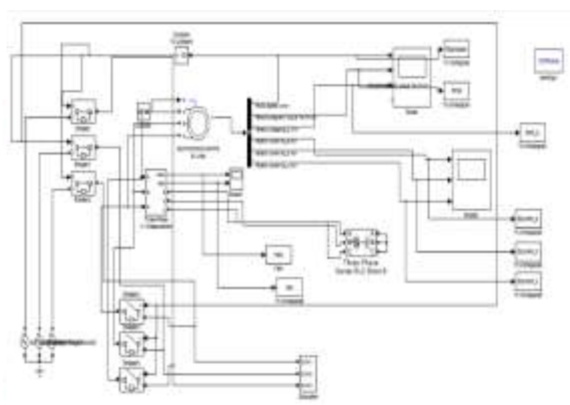

Fig.2 Proposed model of SEIG

II. ANN BASED MODELLING

Fake Neural Network additionally called parallel disseminated handling frameworks and connectionist are by and large utilized for the non-straight displaying, framework distinguishing proof and example affiliation and so forth. In this paper, the multilayer back engendering nourish forward neural system is utilized that gives a decent close estimation of polarization qualities. The structure of ANN is demonstrated in fig 3.

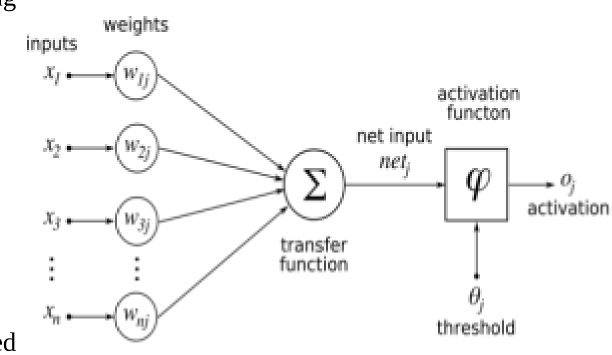

Fig.3 non-linear model of Artificial Neuron

The quantity of information and yield neurons relies on upon the fashioner and the sort of issue. In this paper two layer nourish forward back spread neural system has been utilized. The outline of system and determination of ideal preparing parameters are performed by experimentation. Further, Levenburg Marquardt preparing capacity is utilized which causes less ages when contrasted with other preparing capacity. Accordingly rough results will be delivered when an info is connected to the system. This Training strategy has been found to be especially capable for figuring the non direct attributes of the Induction Machine

III. RESULTS AND DISCUSSIONS

Table 1 demonstrates the examination of proposed ANN system and results got from the reenactment model of Induction Generator (36µF & 160ω). To test the general abilities of the neural system, preparing is finished with 100 specimens, out of which 70% examples are utilized for preparing reason, 15% are utilized for testing and 15% specimens are utilized for approval purpose

Speed N (rpm)	Voltage , ,V (volts)		Frequency , f (Hz)		Magnetizing Reactance , X_m (ohm)	
	V (calculated)	V (predicated)	f (calculated)	f (predicated)	X_m (calculated)	X_m (predicated)
1440	126.95	126.99	46.22	46.24	113.50	113.45
1420	136.87	137.25	46.91	46.60	112.46	112.82
1440	149.29	149.45	47.59	47.58	113.78	113.59
1460	165.42	165.14	48.27	48.29	113.88	113.84
1480	180.49	180.22	48.84	48.89	113.20	113.39
1500	192.80	192.68	49.53	49.5	113.39	112.37
1520	204.36	204.34	50.21	50.22	113.50	113.61
1540	216.31	215.72	50.89	50.90	113.61	113.60
1560	226.8	227.34	51.56	51.59	113.64	113.53
1580	239.05	239.56	52.53	52.25	113.67	113.52
1600	251.99	252.8	52.87	52.96	113.48	113.51

Table 1 Comparison of Results of data set calculated and predicated

The closeness of the results indicates the accuracy of the proposed ANN technique.

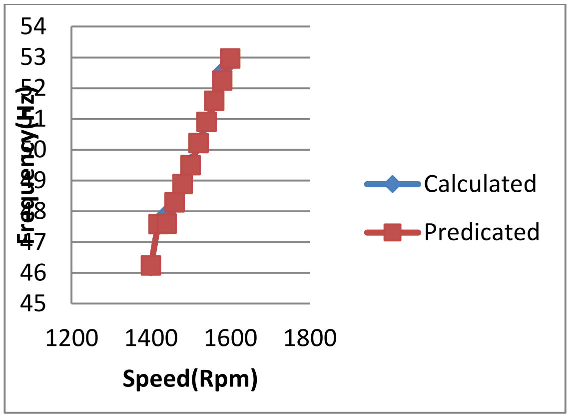

Fig.4 Comparison of simulated and neural network data of generated frequency

Figure 5 shows the comparison of experimental magnetizing reactance data obtained and neural network generated magnetizing reactance data and point out the closeness of the two sets of data.

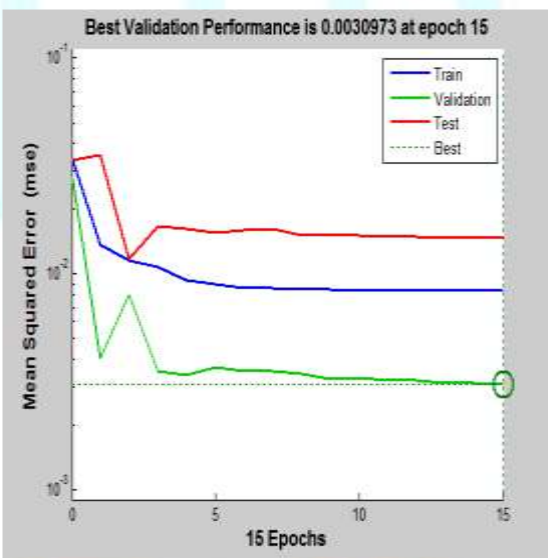

Fig.6 Performance plot of ANN for magnetizing reactance

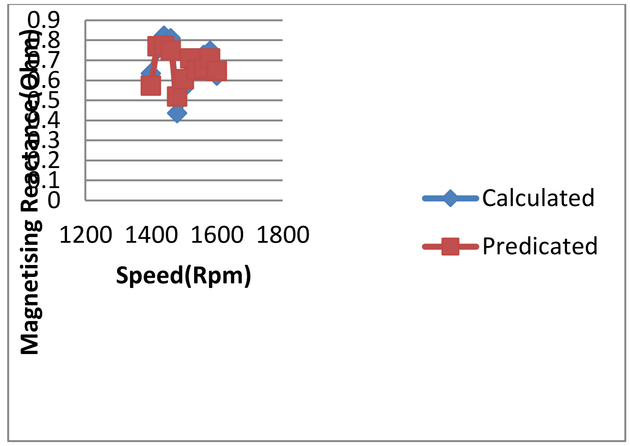

Fig.5 Comparison of simulated and neural network data of generated magnetizing reactance

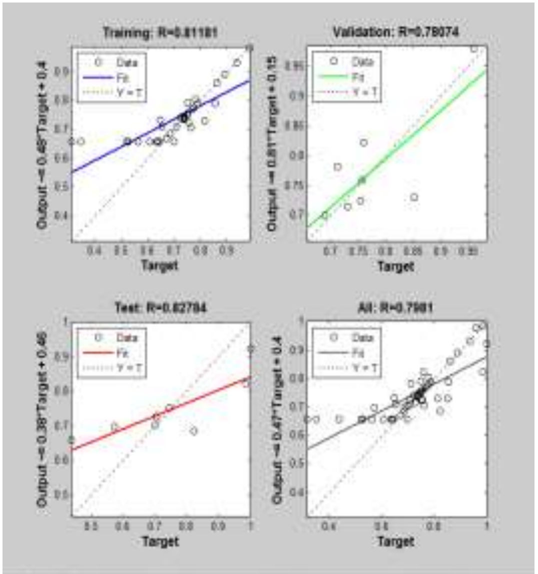

Fig.7 Regression plot of ANN for magnetizing reactance

IV. CONCLUSION

Self Excited Induction Generator are discovered to be most suitable for wind vitality change in remote and blustery ranges. This paper endeavors to utilize the given speed to produce the suitable terminal voltage, recurrence and charging reactance by the improvement of ANN model which has been prepared from the information acquired from the information got by the test performed on the reenactment model of the machine. Examination of the outcomes demonstrates a nearby understanding between the trial information and that anticipated by ANN, which demonstrates that such a basic and exact model will be helpful to dissect the conduct of Self Excited Induction Generator.

APPENDIX

Details of the machine:

- Specifications
  3-phase, 4-pole, star connected, squirrel cage induction machine
  2.2 kW/3HP, 230V, 8.6A
- Parameters
  $R_1=R_2=8.04\Omega$, $X_1=X_2=8.84\Omega$
- Base Values
  Base voltage =220V
  Base current =4.96A
  Base impedance =46.32Ω

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