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Performance Analysis of Long Shunt Self Excited Induction Generators

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Abstract
The Subject of this paper is to analyse the Self Excited Induction Generators operating in long Shunt configuration. A simulink model of long shunt self excited induction generator (SEIG) has been developed using Matrix Laboratory (MATLAB) (R2010a) user friendly toolbox. The results are verified by conducting experiments on the same SEIG. Different results are taken for different loading conditions.The values of Shunt and Series capacitance is also changed for different loads and the performance is analysed.

Keywords: *Self excited induction generators, shunt capacitance, series capacitance*

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INTRODUCTION

The Wind Energy systems are becoming more and more popular nowadays due to environmental considerations.

The Self Excited Induction Generators (SEIG) mainly driven by wind turbine. The SEIG are nothing but Induction Generators excited by capacitors. The rating of capacitance should be greater than the minimum value (Cmin) of capacitance which has to be calculated using different algorithm.

If capacitance value is below Cmin the the SEIG will fail to excite and voltage will be zero[1].

The SEIG suffers from problem of Voltage Regulation. Both Long shunt and Short shunt configurations are used to regulate the voltage but the long shunt can maintain lower voltages while short shunt has better higher voltage regulation[2].

Paper[5] shows that the optimum value of shunt capacitance Csh for both shunt and short shunt configuration are same while for long shunt it is different.

In this paper the performance of Long shunt is carried out with different values of shunt capacitance.

SIMULINK MODEL

In this model the Induction Generator is excited by Shunt capacitance Csh as well as Series capacitance Cse.

In this model commonly known as long shunt configuration, three set of resistive loads 400 Ω, 350 Ω, 300 Ω are taken. The SEIG is made to operate under these three different loads using different values of Csh, Cse and rotor speed W.

Results for the experimental and simulated are compared.

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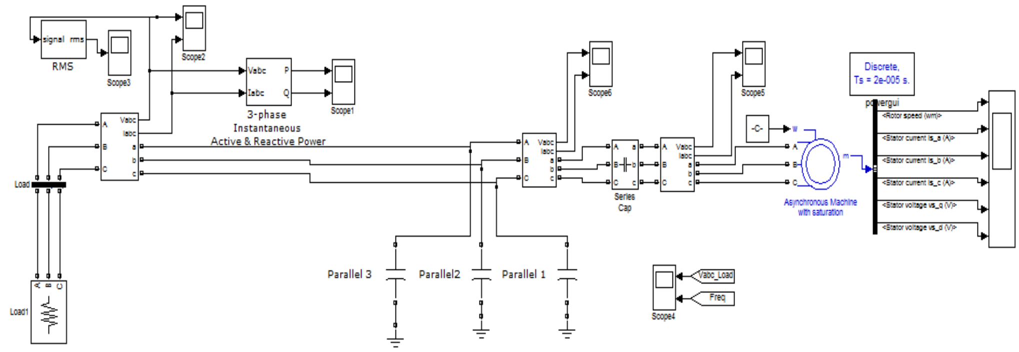

Fig. 1: *Simulink Model of Long Shunt SEIG.*

RESULTS AND DISCUSSIONS

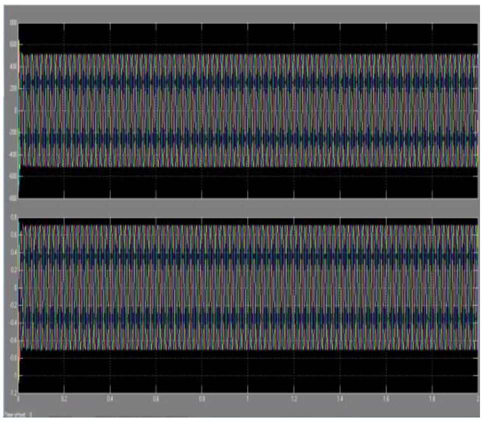

Fig. 2: *Plot of V Vs Time and I Vs Time.*

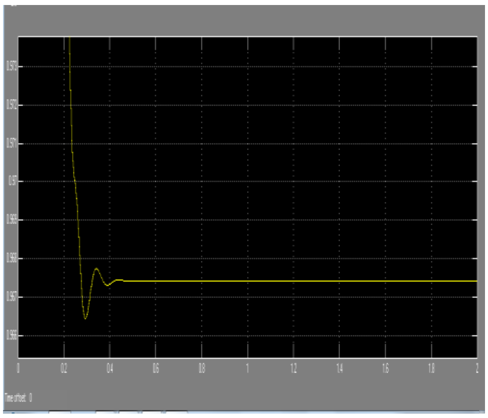

Fig. 3: *Plot of Vabc Vs Time and Iabc Vs Time.*

In Figure 4 the graph shows voltage and current generated by the SEIG. It can be seen that the voltages and currents generated in all the three phases are balanced.The graph shows the frequency which is maintained at 0.9675 pu for the same value of load.

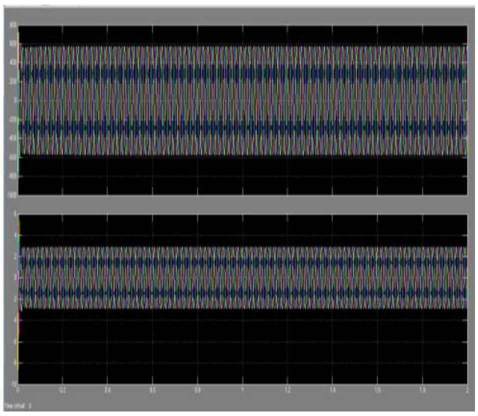

Fig. 4: *Plot of Freq Vs Time.*

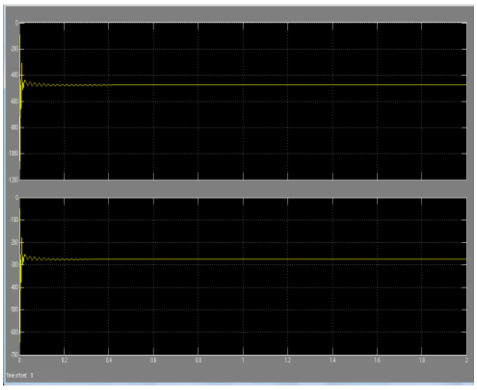

Fig. 5: *Plot of P Vs Time and Q Vs Time.*

Graph shows that Active Power P is equal to 476 Watts and Reactive Power is equal to 275 Watts. Comparisons for the varoius experimental and simulated results are listed in table mentioned below.

Table 1: *Comparison for Load Voltages and Load currents.*

					Load voltage pu		Load Current pu	
	Csh μf	**Cse μf**	**Load Ω**	**Speed pu**	**Exp**	**Sim**	**Exp**	**Sim**
1	29	268	400	0.976	1.0023	0.9354	0.2895	0.2266
2	29	268	350	0.9898	1	0.9592	0.3579	0.2643
3	29	268	300	0.983	1.0024	0.9252	0.2947	0.2977
4	29	280	400	0.9458	1.0002	0.8703	0.3368	0.2103
5	29	280	350	0.9518	1.0018	0.8749	0.2737	02419
6	29	280	300	0.9585	1.0078	0.87495	0.3158	0.2902
7	29	230	400	0.97	1.0015	0.8936	0.3789	0.2169
8	29	230	350	0.975	0.998	0.9122	0.2947	0.2456
9	29	230	300	0.9906	1	1.1076	0.3474	0.2977
10	27	206	400	1.018	0.9957	0.9606	0.3895	0.2326
11	27	206	350	1.0032	0.9981	0.9122	0.2737	0.2512
12	27	206	300	1.0314	1.0018	0.968	0.3263	0.3126
13	25.6	200	400	1.028	1.0013	0.9494	0.3895	0.2307
14	25.6	200	350	1.0316	1.0018	0.9494	0.2842	0.2624
15	25.6	200	300	1.036	1.0002	0.9429	0.3158	0.304
16	24.6	200	400	1.0434	1.0031	0.9662	0.3895	0.2345
17	24.6	200	350	1.0488	1.0026	0.968	0.2737	0.2605
18	24.6	200	300	1.0436	1.0005	0.9401	0.3263	0.3015

Table 1 shows Effect on Load Voltage and Load current as the value of Csh, Cse and speed is changed. The performance is checked by applying three set of loads.

Table 2: *Comparison for Stator Voltages and Stator Currents.*

					Stator current pu		Stator voltage pu	
	Csh μf	**Cse μf**	**Load Ω**	**Speed pu**	**Exp**	**Sim**	**Exp**	**Sim**
1	29	268	400	0.976	0.9474	1.02344	0.152632	1.04249
2	29	268	350	0.9898	0.9737	1.0718	1.078947	1.070418
3	29	268	300	0.983	0.9474	1.03833	1.065789	1.032255
4	29	280	400	0.9458	1	0.968	1.052632	0.968
5	29	280	350	0.9518	1	0.9602	1.039474	0.9736
6	29	280	300	0.9585	1	0.9787	1.078947	0.9739
7	29	230	400	0.97	1	0.975	1.021053	1.01457
8	29	230	350	0.975	1	0.9974	1.026316	1.01643
9	29	230	300	0.9906	0.9474	1.04205	1.026316	1.046217
10	27	206	400	1.018	1	1.0234	1.131579	1.09834
11	27	206	350	1.0032	1.0562	0.9676	1.105263	1.0387
12	27	206	300	1.0314	1.0562	1.079	1.105263	1.1
13	25.6	200	400	1.028	1.0562	0.9713	1.105263	1.0797
14	25.6	200	350	1.0316	1	1.1755	1.118421	1.0726
15	25.6	200	300	1.036	0.9474	0.9936	1.118421	1.07228
16	24.6	200	400	1.0434	1	0.9862	1.118421	1.09462
17	24.6	200	350	1.0488	0.9474	0.9974	1.128947	1.09834
18	24.6	200	300	1.0436	0.9474	0.97134	1.118421	1.0648

Table 2 shows Effect on Stator Voltage and Stator Current as the value of Csh, Cse and speed is changed.

Table 3: *Comparison of Frequency.*

					Frequency pu		Stator voltage pu	
	Csh μf	**Cse μf**	**Load Ω**	**Speed pu**	**Exp**	**Sim**	**p**	**q**
1	29	268	400	0.976	0.9325	0.956	400	228
2	29	268	350	0.9898	0.935	0.9675	476	275
3	29	268	300	0.983	0.9387	0.958	520	300
4	29	280	400	0.9458	0.9162	0.922	343	200
5	29	280	350	0.9518	0.92	0.93	400	220
6	29	280	300	0.9585	0.9262	0.9341	470	270
7	29	230	400	0.97	0.9312	0.951	362	210
8	29	230	350	0.975	0.935	0.952	414	240
9	29	230	300	0.9906	0.9425	0.965	513	300
10	27	206	400	1.018	0.9512	0.9981	414	240
11	27	206	350	1.0032	0.97	0.982	428	250
12	27	206	300	1.0314	0.9687	1.005	568	325
13	25.6	200	400	1.028	0.9875	0.008	410	237
14	25.6	200	350	1.0316	0.98	1.01	466	269
15	25.6	200	300	1.036	0.9887	1.012	537	310
16	24.6	200	400	1.0434	0.9925	1.0236	425	245
17	24.6	200	350	1.0488	0.99	1.0265	488	280
18	24.6	200	300	1.0436	0.995	1.0192	534	307

Table 3 shows the changes in the frequency as the value of Csh, Cse and speed is changed.

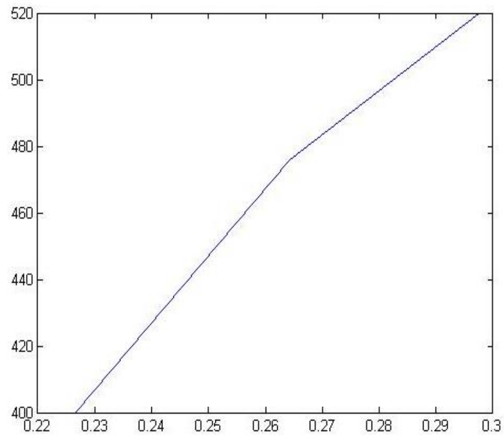

Fig. 5: *Plot of Active Power Vs Load Current.*

Figure 5 Shows the changes in the Active Power P in Watts with respect to load current I in pu for the first three set of load values as mentioned in the Table 3. It is seen that the graph is linear.

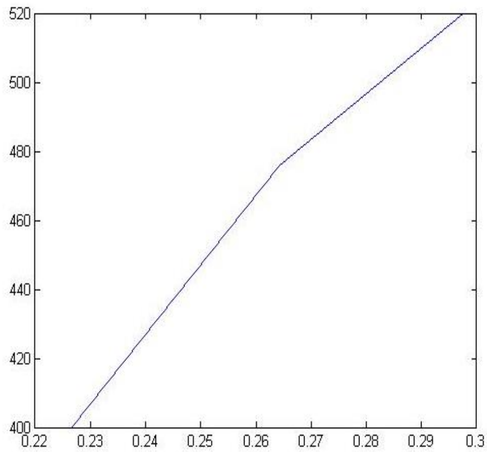

Fig. 6: *Plot of Reactive Power Vs Load Current.*

Figure 6 shows the variation in Reactive Power Q as the load is changed.This graph is also plotted for the first three set of values as mentioned in Table 3. This graph is also linear.

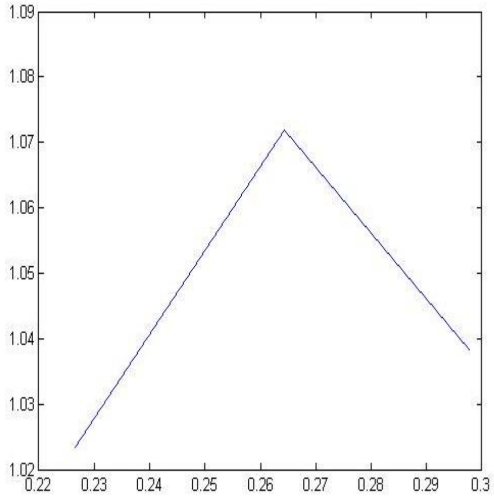

Fig. 7: *Plot of Stator Current Vs load Current.*

This graph is plotted for as per the values mentioned in Table 1 and Table 2 for the first three set of values.

CONCLUSION

In this paper the anaysis for the long shunt confiruration is carried out. Due to the series compensation the voltage of SEIG can be regulated for a wide range. The results are verified by changing simultaneously the value of load, Csh, W and the value of Cse changes correspondingly. Experimental results and Simulated results are verified.

APPENDIX

The specification of the machine are taken from[6] SEIG 3-phase, 4-pole, 50 Hz, Star connected, squirrel cage induction machine 75 W/1 HP, 380 V, 1.9 A

PARAMETERS

$$R_1 = 0.0823, R_2 = 0.0696, X_1 = X_2 = 0.0766$$

Base values
Base voltage =219.3 V
Base current =1.9 A
Base impedance =115.4 Ω
Base frequency =50 Hz
Base speed =1500 rpm

The variation of magnetizing reactance with air gap voltage at rated frequency for the induction machine is given below.

$$X_m < 169.2 \quad E_1 = 512.69 - 2.13X_m$$
$$179.42 > X_m \geq 169.20 \quad E_1 = 891.66 - 4.37X_m$$
$$184.46 > X_m \geq 179.42 \quad E_1 = 785.79 - 3.78X_m$$
$$X_m \geq 184.46 \quad E_1 = 0$$

NOMENCLATURE

Csh: Shunt capacitance
Cse: Series capacitance
V: Load Voltage in pu
I: Load current in pu
Vabc: terminal voltage of SEIG in pu
Iabc: Current generated by SEIG in pu
Freq: Frequency in pu
P: Load active power in Watts
Q: Load reactive power in Vars
W: Rotor speed in pu
Sim: Simulated value in pu
Exp: Experimental value in pu

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