International Journal of Science, Engineering and Technology Research (IJSETR)
Volume 7, Issue 3, March 2018, ISSN: 2278 -7798

PERFORMANCE ANALYSIS OF SELF EXCITED INDUCTION GENERATOR USING MATLAB

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***Abstract-*.The steady state analysis of self excited induction generator (SEIG) is vital for proper implementation of induction machine operation as a generator in a stand alone mode through appropriate modeling. This project presents a user friendly software based solution for complete evaluation of steady-state behavior of SEIG under different operating conditions. The mathematical modeling of the machine is carried out and then simulated in MATLAB's Graphical User Interface (GUI) environment. The simulation results obtained through the presented methodology are analyzed .**

Key words;- SEIG, GUI

1) INTRODUCTION

The induction generators are externally driven machines. The construction and working is very simple and requires less maintenance. The dynamic characteristics of IG are excellent allowing the machine for use of both grid connected and standalone generation. The constant need of reactive power is the only demerits of IG. Reactive power flow can be managed by using simple capacitors or some power converters. In grid connected system the reactive power can be taken from the grid for real power generation via slip control when the machine is rotated above the synchronous speed. The operation of grid connected system is simple and autonomous as the voltage and frequency are controlled by the grid. Power generation for far flung areas can be done using self excited induction generators. The SEIG system uses capacitor for voltage build up. The reactive power from the stator capacitor are shared by load and the machine for self excitation. SEIG is very sensitive to wind speed change. Also load impedance governs the voltage regulation of the overall system. So some intermediate systems must be used to improve the voltage and frequency regulation. Power converters and FACTS devices can be used to make SEIG operate in steady condition.

2) SEIG System Configuration

Self-excited induction generator is simply an induction machine coupled with a prime mover. For generator action the magnetization field is created by the use of capacitor bank at the stator terminals. The detailed configuration of the SEIG system is shown in the Fig. 2. The active power required by the load is supplied by the induction generator by extracting power from the prime mover.

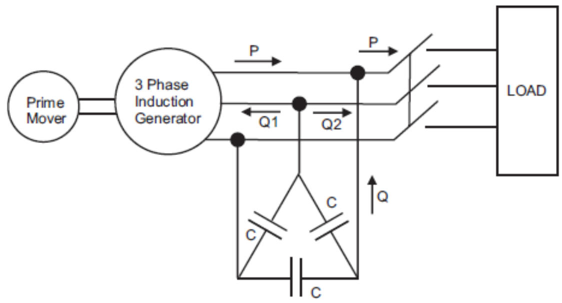

Fig.2 Schematic diagram of self-excited induction generator

The capacitors bank for self-excitation must be connected to the stator terminals of the induction machine to generate sufficient amount of reactive power so as to fulfill the reactive power requirement of the load as well as the induction generator.

The excitation capacitor must be well calculate in accordance to load to avoid the excitation failure. If the load or wind speed varies then the excitation process is directly disturbed so excitation failure occurs. If the load impedance is increased the reactive power demand goes beyond the capability of excitation capacitor as the reactive power is mutually shared between load and the generator itself. Therefore, increased impedance of the load creates drop in generating voltage resulting poor voltage regulation. Due to change in wind speed the slip is changed which causes poor frequency regulation. For constant load application capacitor excited system is suitable.

3) The Self-excitation Process

Self excitation process allows the induction generator to work as SEIG when the rotor is running at a speed greater than the stator magnetic field. For self excitation the rotor core must have sufficient residual magnetism and capacitor connected with the stator should have some initial magnetizing current. Capacitor bank having suitable capacitance values are necessary at the stator terminals of an externally driven induction machine to develop e.m.f. For self excitation the machine windings must possess some residual magnetism. If there is a loss in residual magnetism then it can be regained by connecting a charged capacitor across the winding terminals or by simply driving the IM at no load for few minutes. The

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e.m.f. which is induced will cause a leading current to flow through the capacitor. Flux produced due to the current will help to gain more residual magnetism. So the machine flux will increase constantly inducing larger e.m.f. Therefore the current and flux increases. The SEIG works closer to the saturation limits. The value of excitation capacitance, magnetization characteristics, prime mover speed and electrical load are the factors governing the steady state operation of SEIG. The value of excitation capacitor for voltage build up mainly depends on rotor speed, load parameters and magnetising characteristics of the machine.

4) Mathematical modelling of SEIG

By the help of mathematical transformations the complexity for analysis of SEIG is solved. Three axes to two axes transformation gives simplified mathematical expression for the generator and helps in developing machine model in MATLAB. More clear understanding of different circuit parameters and its importance can be visualised by observing the equation obtained from axes transformation. Let us consider a three phase symmetrical machine and the three axes are separated at120 degree from each other. The real three phases of the supply are represented by the three axes. d and q are the two imaginary phases in tangent to each other. For the analysis it is assumed that all the axes are in a stationary reference frame. The abc to dq0 transformation by the help of Kron’s primitive machine mode is discussed. The Fig.4(a) shows the three axes and two axes representation of SEIG. The per-phase equivalent circuit representation from conventional analysis is helpful for steady state analysis. For dynamic analysis d-q modelling is used to represent the SEIG. The transformation makes a systematically changes in variables to obtain a desired reference frame. Transforming SEIG to rotating reference frame is simple.

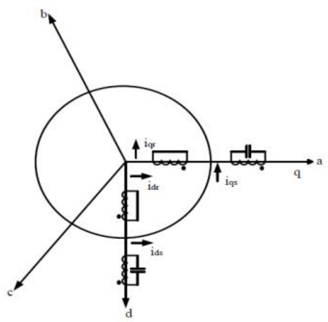

Fig.4(a).Axes transformation of induction generator

A rotating reference frame come to be stationary if the rotational speed of the reference frame is zero. If the angular speed of reference frame is equal to excitation frequency, the variables will seems as constant instead of time-varying values after transformed into the rotating reference frame. d-q axes of SEIG are shown in Fig.4(b).

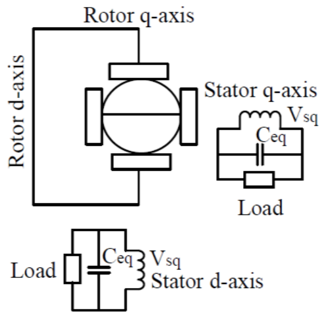

Fig.4(b).d-q axes presentation of self-excited induction generator

The current direction and voltage polarities are shown in the d-q equivalent circuits.

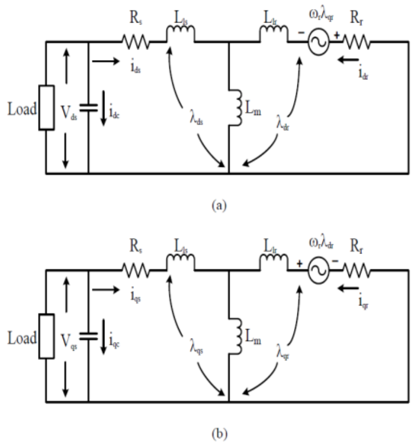

fig.4(c).Equivalent circuit of SEIG in d-q stationary reference frame (a) d-axis (b) q-axis

From the d-q equivalent circuit the differential equations are derived which helps for mathematical analysis to determine the final expressions. Mathematical analysis are done by taking several books and journals as references [7]-[8].

5) MATLAB

MATLAB is a product of the MathWorks, Inc. and is an advanced interactive software package specially designed for scientific and engineering computation. It is an advance is a high level language & interactive environment that enables us to perform computationally intensive tasks faster than with traditional program language such as C, C++ and FORTRAN.

An optional extension of the core of MATLAB called SIMULINK is also available. SIMULINK means Simulating and Linking the environment. SIMULINK is a MATLAB toolbox designed for the dynamic simulation of linear and non linear systems as well as continuous and discrete time systems. MATLAB has proven to be a very flexible and useful tool for solving problems in many areas [17] [18].

6) SOFTWARE OR SIMULATION /MODELLING APPROACH

The simulation models has developed using MATLAB/Simulink with SimPowerSystems. It is then used to simulate SIEG with various loads and observe how power system sinusoidal waveform distort and variation of P and Q with variation in V and f. The models has developed with minimum number of blocks in mind and use their default settings whenever possible. The developed models present in the thesis also serve as basic building blocks to a larger power system. The voltage level used in the models is based on the India grid code.

First of all the MATLAB simulation model of SIEG with different electrical loads is designed using MATLAB (R2013a) and their performance has to be analyzed.

Simulink model:

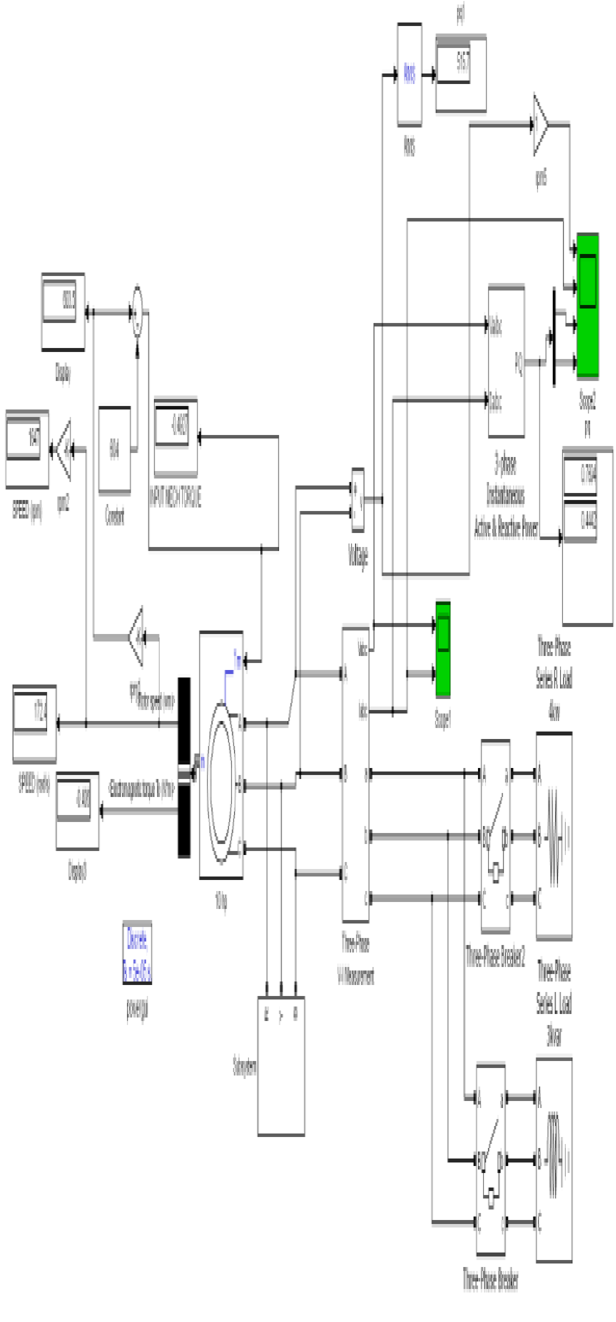

Fig.6.Simulink model of Stand alone SEIG

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7) RESULT & DISCUSSION

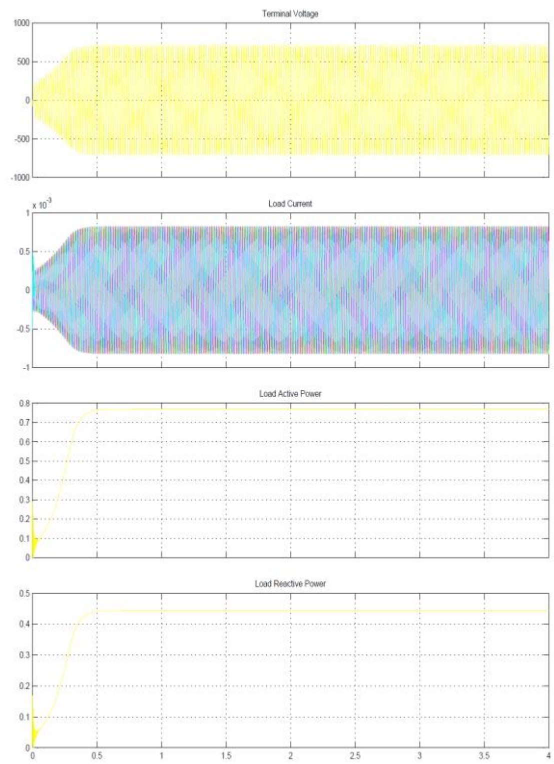

Fig.7(a) Simulation result of system without load

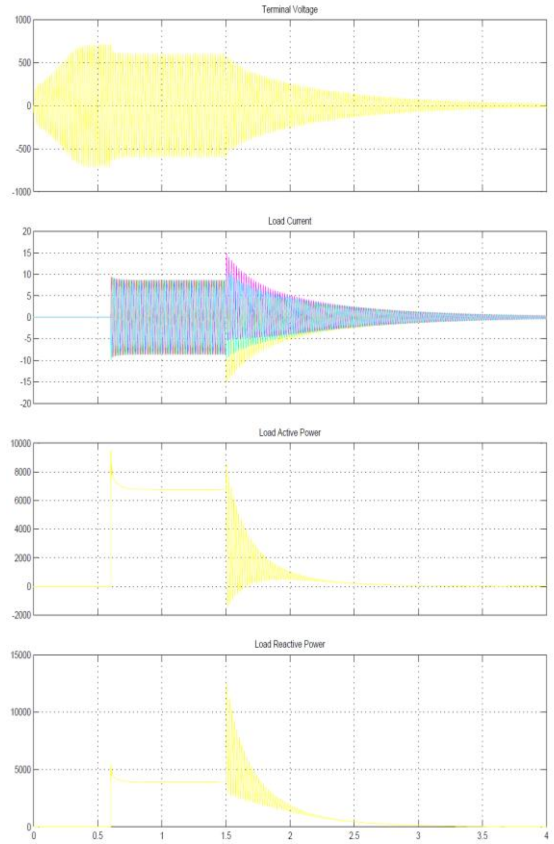

Fig.7(b). Simulation result of system with load

8) CONCLUSION

IGs are enormously used in Wind farms because of their ability to supply power. Characteristics of IG are studied in MATLAB environment. Control techniques of IG have been analyzed. Magnitude and Frequency control has to be studied and a Simulink model for the same has been proposed.. This simplifies the design of the control system and improves system reliability.

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