A Review on Voltage Stability of Low Capacity Three-Phase Self-Excited Induction Generator

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***Abstract*— Power is extremely fundamental infrastructure on the whole extension of many nations in the world. Electrical energy from renewable energy resources can be cheaper compare to grid connection in hilly areas or remote locations. Induction generators are widely used to extract energy from renewable energy as it gives synchronized electrical power at variable speed of its prime mover turbine. . Unfortunately the Induction generator, when run in self excited mode, has poor voltage stability. Output voltage of SEIG increase, when we decrease the load on it from the full load. We don't have any control over consumer load. This results in voltage problem on connected consumer load. This project aim to develop controller for an SEIG to keep SEIG output voltage constant by developing ELC (Electronic Load Controller) for low capacity SEIG. MATLAB simulation for low capacity SEIG power generation unit is carried out for the reliability of low capacity SEIG power generation facility for the remote area.**

***Index Terms*—self-excited induction generator, voltage control, capacitor bank, renewable energy, MATLAB.**

I. INTRODUCTION

Our country and the whole world are passing through a severe energy crisis. Even after 14 years of entering in to the 21st century, in India, we have lacs of villages which are still waiting for the supply of electricity. It is not feasible for our government to supply electrical power to each and every interior village because of, mainly, shortage of electrical power. The energy supply is far less than our increasing demands, so continues to face serious energy shortages problem. To overcome this energy problem, we have to look towards non-conventional (renewable energy) energy sources like wind, micro-hydro etc.

This problem can be solved to some extent if we install small power generation units in all the villages and urban areas. Non convention sources of energy like wind power, power of small streams in hilly areas and tidal power can be explored for the small capacity local power generation units. The only problem with such energy sources is the speed consistency.

Induction generator is the best solution for the irregular speed turbine because it gives synchronized electrical power at all the speed of its prime mover turbine. When Induction generator is run in self excited mode, has poor voltage stability. Output voltage of SEIG (Self Excited Induction Generator) increase, when we decrease the load on it from the full load. We don't have any control over consumer load. This results in voltage problem on connected consumer load.

This project work tries to develop controller for an SEIG to keep SEIG output voltage constant. This can be done by developing proper ELC (Electronic Load Controller) for low capacity SEIG. This project work will be useful to develop a village level micro grid to overcome the energy crisis to some extent.

II. BASIC CONCEPT

The induction generator construction is same as the induction motors with some possible improvements in efficiency. There is an important operating difference; the rotor speed is faster with respect to the stator magnetic field rotation. An induction generator consists of a rotating element i.e. rotor and a stationary element i.e. stator. The rotor consists of an aluminum or copper "squirrel cage" within the rotor laminations.

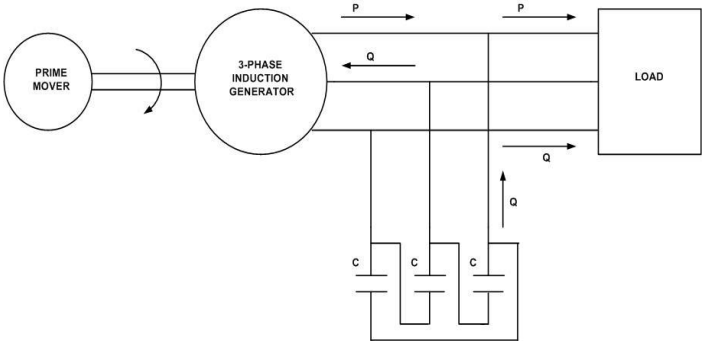

Figure 1: Self-excited Induction Generator (SEIG)

Induction machines work on induction principle, in other words it depends on Faraday's law of induction (i.e. when a conductor moves in a magnetic field, it gets some induced voltage.) In this case it should be noted that moving in a magnetic field actually makes the magnetic flux changing to the moving conductor and this changing magnetic field causes voltage and current to be induced on the moving body.

By self-excited induction generator, which mean cage rotor induction machines with shunt capacitors connected at their terminals for self-excitation. The shunt capacitors may be constant or may be varied through power electronics (or step wise). The self-excited induction generator may be built with single phase or three phase output and may supply AC loads or AC rectified autonomous loads. In figurer a capacitor bank is connected across the load of a 3-phase induction machine which supply the reactive power to the induction generator for self-excitement process and as well as to the load.

III. SIMULATION OF 3-PHASE-SEIG WITHOUT ELC

The MATLAB simulation of 3-PHASE-SEIG without ELC is done with parameters as shown below in table.

Table 1 Equivalent circuit parameters

Sr. No.	Parameter	Value
1	Stator resistance R_s	10.1 Ω
2	Stator inductor L_{ls}	0.05032 H
3	Rotor resistance R'_r	9.8546 Ω
4	Rotor inductor L'_{lr}	0.05032 H
5	Mutual inductor L_m	0.782709 H

Table 2 Parameters used in simulation model

Sr. No.	Quantity	Value
1	Supply Voltage	415 V
2	Supply frequency	50 Hz
3	Capacitors	5μF
4	Induction machine	1 HP (0.746 kw), 415 V, 1440 RPM

Effect of variable load on induced voltage and actual speed for,

$$P = \frac{2\pi NT}{60}$$

$$T = \frac{750*60}{2\pi*1500} = 4.77\,n.m$$

$$P = \sqrt{3}*VI*\cos\phi$$

$$750 = \sqrt{3}*415*I*0.8$$

$$I = 1.3A$$

$$I = \frac{V}{R}$$

$$R = \frac{415}{1.3} = 320\Omega$$

Rated torque = -4.77

CASE 1- Variation of the voltage and speed,when load impedance is **320** ohms.

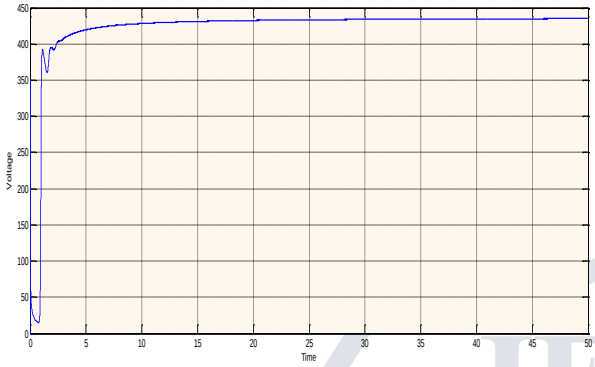

Figure 2-Characteristic of voltage verus time

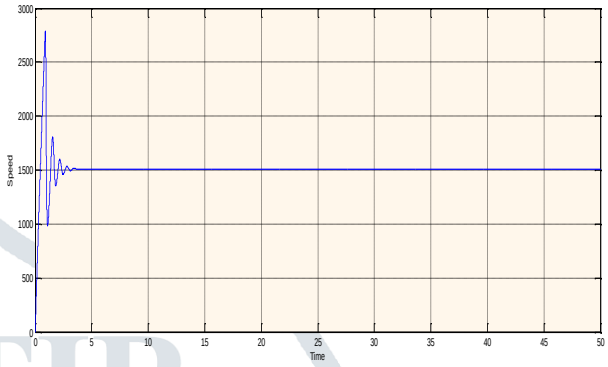

Figure 3-Characteristic of speed verus time

CASE 2-Variation of the voltage and speed,when load impedance is **500** ohms

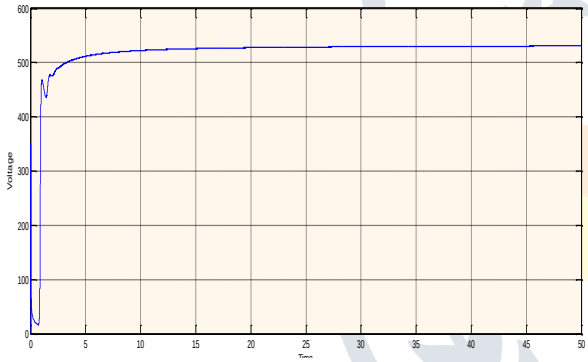

Figure 4- Characteristic of voltage verus time

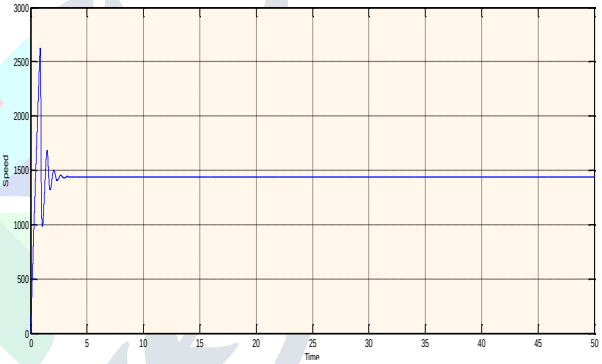

Figure 5- Characteristic of speed verus time

The graph shows that the voltage versus load impedance. In this graph load impedance increases means load on the generator decreases. So that generator terminal voltage is decrease.. SEIG must be fully loaded. So when consumer load decreases, voltage is regulated by injecting dump load through ELC.

IV. CONTROL STRATEGY

Induction generator produces electrical power when their rotor is turned faster than the synchronous speed is called an induction generator (IG). Prime mover provide mechanical torque on the motor shaft and self-excitation capacitors provide a reasonable amount of reactive power to establish the magnetic field necessary to convert the mechanical power from its shaft into electrical power. By selecting proper value of prime mover torque and excitation capacitor we can generate rated terminal voltage.

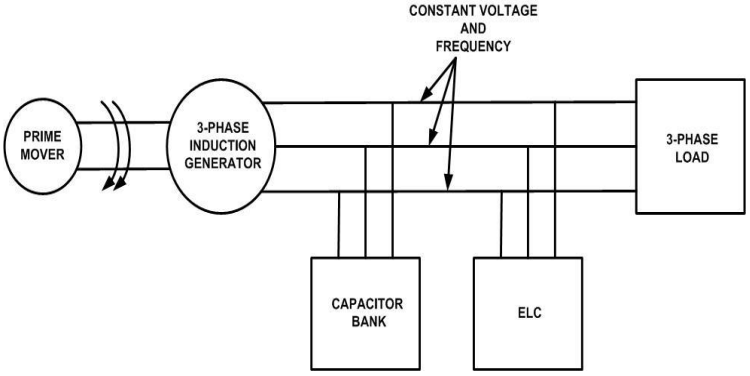

Figure 6- Block diagram of design of ELC for induction generator

But as the demand of consumer load changing the terminal voltage also changing. So that poor voltage regulation and this also proved by the MATLAB SIMULATION and show the result in graph.

In relatively to regulate the terminal voltage, we can connect dump load in across with the consumer load. The amount of power to the dump load is controlled by the induction generator controller (ELC) which is connected in series with the dump load. When consumer load changes, so SEIG on terminal voltage also changes. Controller senses this change in voltage. With the use of appropriate PI algorithm, it gives proper command to electronic switch configuration to increase / decrease proper amount of dump load. The ELC along with its dump load keeps the SEIG fully loaded all the time maintaining the terminal voltage and frequency constant.

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