INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN: 2278 – 0211 (Online)

Performance Of 3-ϕ Self Excited Induction Generator

V. Samson Devakumar
Software Development and training Centre, South Central Railways, WWO, VIjayawada, India
Elika Jahnavi
Department Of Electrical Engineering, Kluniversity, Vaddeswaram, Guntur District, India
B. Kiran Babu
Assistant Professor, Department Of Electrical Engineering, Kluniversity, Vaddeswaram, Guntur District, India

Abstract:

Induction generators are increasingly being used in nonconventional energy systems such as wind, micro/mini hydro, etc. The advantages of using an induction generator instead of a synchronous generator are well known. Some of them are reduced unit cost and size, ruggedness, brushless (in squirrel cage construction), absence of separate dc source, ease of maintenance, self-protection against severe overloads and short circuits, etc. In isolated systems, squirrel cage induction generators with capacitor excitation, known as self-excited induction generators (SEIGs), are very popular. This paper presents the process of self-excitation and voltage buildup, characteristics of RLC load.

1.Introduction

The increasing rate of the depletion of conventional energy sources has given rise to an increased emphasis on renewable energy sources such as wind, mini/micro-hydro, etc. Generation of electrical energy mainly so far has been from thermal, nuclear, and hydro plants. They have continuously degraded the environmental conditions. An increasing rate of the depletion of conventional energy sources and the degradation of environmental conditions has given rise to an increased emphasis on renewable energy sources, particularly after the increases in fuel prices during the 1970s. Use of an induction machine as a generator is becoming more and more

popular for the renewable sources. Reactive power consumption and poor voltage regulation under varying speed are the major drawbacks of the induction generators, but the development

Of static power converters has facilitated the control of the output voltage of induction generators. This paper presents an overview of three-phase self-excited induction generator (SEIG). This paper presents the classification of induction generators. A literature review on the process of self-excitation and voltage buildup. Performances of load characteristics of SEIG have been presented.

2.Historical Background

Induction generators were used from the beginning of the 20th century until they were abandoned and almost disappeared in the 1960s. With the dramatic increase in petroleum prices in the 1970s, the induction generator returned to the scene. With such high-energy costs, rational use and conservation implemented by many process of heat recovery and other similar forms became important goals. By the end of the 1980s, wider distribution of population over the planet, as improved transportation and communication enabled people to move away from large urban concentration, and growing concerns with the environment led to demand by many isolated communities for their own power plants. In the 1990s, ideas such as distributed generation began to be discussed in the media and in research centers. Traditionally, synchronous generators have been used for power generation but induction generators are increasingly being used these days because of their relative advantageous features over conventional synchronous generators. These features are brush less and rugged construction, low cost, maintenance and operational implicitly, self-protection against faults, good dynamic response, and capability to generate power at varying speed. For its simplicity, robustness, and small size per generated kW, the induction generator is favored for small hydro and wind power plants. The need of external reactive power, to produce a rotating flux wave limits the application of an induction generator as a stand-alone generator. However, it is possible for an induction machine to operate as a self-excited induction generator (SEIG) if capacitors are connected to the stator terminals to supply sufficient reactive power.

3.Induction Generator

The induction generator has the very same construction as induction motor with some possible improvements in efficiency. There is an important operating difference; the rotorspeed is advanced with respect to stator magnetic field rotation. For prime mover speedabove synchronous speed, the rotor is being driven at a speed more than synchronously rotating magnetic field. The rotor conductors are now being cut by the rotating flux in adirection opposite to that during motoring mode. This shows that rotor generated emf, rotor current and hence its stator components change their signs. As the speed during induction generator operation is not synchronous; it is also called an asynchronous generator.

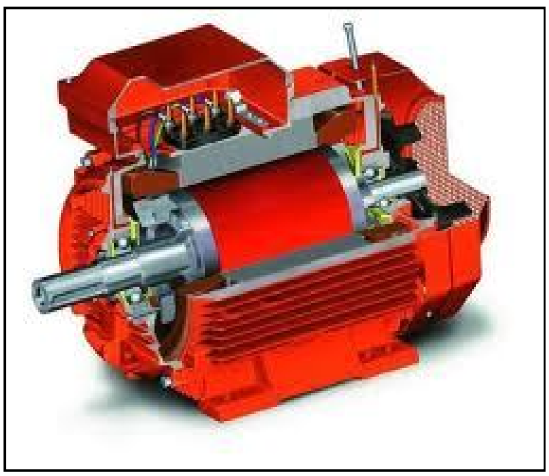

Figure 1

4.Classification Of Induction Generators

The induction machine offers advantages for hydro and wind power plants because of it's easy operation as either a motor or generator, it has different application in different areas and depending upon them it has many classifications.

Induction generators can be classified on the basis of excitement process as

- Grid connected induction generator
- Self-excited induction generator

Further induction generators are classified on the basis of rotor construction as

- Wound rotor induction generator
- Squirrel cage induction generator

Depending upon the prime movers used and their locations, generating schemes can be broadly classified as under

- Constant speed constant frequency [CSCF]
- Variable speed constant frequency [VSCF]
- Variable speed variable frequency [VSVF]

5.Grid Connected Induction Generator

The grid connected induction generator takes its reactive power for excitement process from the grid supply, so it is called grid connected induction generator. It is also called autonomous system. In this system generator is driven by a prime mover above its synchronous speed and hence the slip is negative in case of grid connected induction generator.

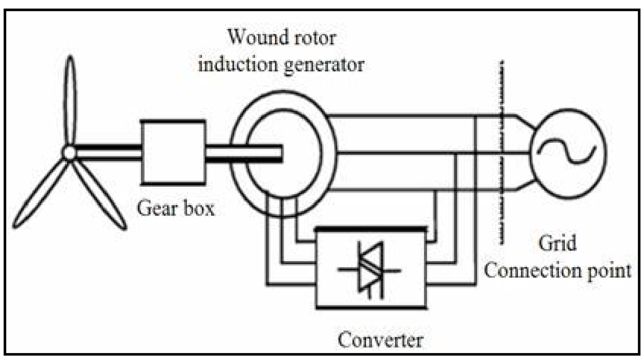

Figure 2: Grid connected induction generator

The power factor of the grid connected induction generator is fixed by its slip and its equivalent circuit parameters and not affected by the load.

6.Self-excited Induction Generator

By self-excited induction generator (SEIG), we 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). SEIG may be built with single phase or three phase output and may supply AC loads or AC rectified autonomous loads.

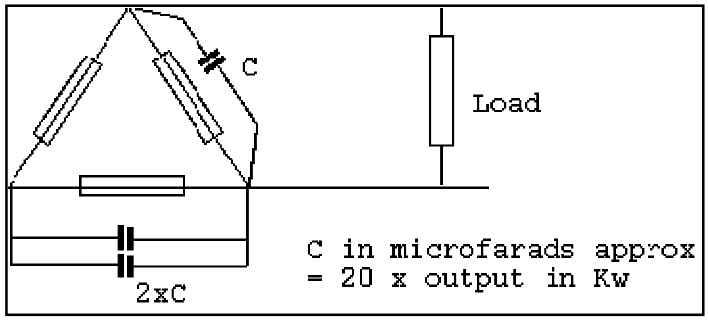

Figure 3.: Self-excited induction generato

In figure 1.2 a capacitor bank is connected across the stator terminals 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.

7.Clasification On The Basis Of Primeovers

7.1.Constant Speed Constant Frequency [CSCF]

In this scheme, the prime mover speed is held constant by continuously adjusting the blade pitch and/or generator characteristics. An induction generator can operate on an infinite bus bar at a slip of 1% to 5% above the synchronous speed. Induction generators are simpler than synchronous generators. They are easier to operate, control, and maintain, do not have any synchronization problems, and are economical.

7.2.Variable Speed Constant Frequency [VSCF]

The variable-speed operation of wind electric system yields higher output for both low and high wind speeds .This results in higher annual energy yields per rated installed capacity. Both horizontal and vertical axis wind turbines exhibit this gain under variable-speed operation. Popular schemes to obtain constant frequency output from variable speed are as shown.

7.2.1.AC-DC-AC Link

With the advent of high-powered thyristors, the ac output of the three-phase alternator is rectified by using a bridge rectifier and then converted back to ac using line-commutated inverters. Since the frequency is automatically fixed by the power line, they are also known as synchronous inverters.

7.2.2.Double Output Induction Generator (DIOG)

The DOIG consists of a three-phase wound rotor induction machine that is mechanically coupled to either a wind or hydro turbine, whose stator terminals are connected to a constant voltage constant frequency utility grid. The variable frequency output is fed into the ac supply by an ac–dc–ac link converter consisting of either a full-wave diode bridge rectifier and thyristor inverter combination or current source inverter (CSI)-thyristor converter link. One of the outstanding advantages of DOIG in wind energy conversion systems is that it is the only scheme in which the generated power is more than the rating of the machine. However, due to operational disadvantages, the DOIG scheme could not be used extensively. The maintenance requirements are high, the power factor is low, and reliability is poor under dusty and abnormal conditions because of the sliding mechanical contacts in the rotor. This scheme is not suitable for isolated power generations because it needs grid supply to maintain excitation.

7.3.Variable- Speed Variable Frequency [VSVF]

With variable prime mover speed, the performance of synchronous generators can be affected. For variable speed corresponding to the changing derived speed, SEIG can be conveniently used for resistive heating loads, which are essentially frequency insensitive. The basic theme of this paper is to present an overview of SEIG in isolated applications. This scheme is gaining importance for stand-alone wind power applications**.**

8.Process Of Self-Excitation And Voltage Buildup In Seig

Self-excitation phenomenon in induction machines although known for more than a half century is still a subject of considerable attention. The interest in this topic is primarily due to the application of SEIG in isolated power systems. Physical background of the self-excitation process has been described in considerable depth in. When an induction machine is driven at a speed greater than the synchronous speed (negative slip) by means of an external prime mover, the direction of induced torque is reversed and theoretically it starts working as an induction generator. From the circle diagram of the induction machine in the negative slip region, it is seen that the machine draws a current, which lags the voltage by more than 90. This means that real power flows out of the machine but the machine needs the reactive power. To build up voltage across the generator terminals, excitations must be provided by some means; therefore, the induction generator can work in two modes (i.e., grid connected and isolated mode). In case of a grid-connected mode, the induction generator can draw reactive power either from the grid but it will place a burden on the grid or by connecting a capacitor bank across the generator terminals. For an isolated mode, there must be a suitable capacitor bank connected across the generator terminals. This phenomenon is known as capacitor self-excitation and the induction generator is called a “SEIG.” The process of voltage buildup in an induction generator is very much similar to that of a dc generator. There must be a suitable value of residual magnetism present in the rotor. In the absence of a proper value of residual magnetism, the voltage will not build up. So it is desirable to maintain a high level of residual magnetism, as it does ease the process of machine excitation. The operating conditions resulting in demagnetization of the rotor (e.g., total collapse of voltage under resistive loads, rapid collapse of voltage due to short circuit, etc. should be avoided). When an induction generator first starts to run, the residual magnetism in the rotor circuit produces a small voltage. This small voltage produces a capacitor current flow, which increases the voltage and so forth until the voltage is fully built up. The no-load terminal voltage of the induction generator is the intersection of the generator’s magnetization curve with capacitor load line. The magnetization curve of the induction generator can be obtained by running the machine as a motor at no load and measuring the armature current as a function of terminal voltage. To achieve a given voltage level in an induction generator, an external capacitor must be able to supply the magnetizing current of that level.

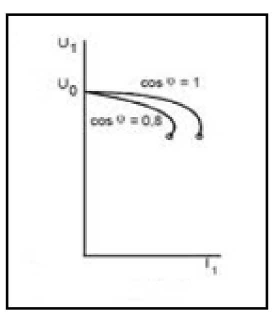

Figure 4: V-I characteristics

9.Merits And Demerits Of Induction Generator

Several types of generators can be coupled to the rotating power turbines; DC and AC types, parallel and compound DC generators, with permanent magnetic or electrical fields, synchronous or asynchronous, and, specially, induction generators. The right choice of generator depends on a wide range of factors related to the primary source, the type of load, and the speed of the turbine, among others.

Induction generator having the following merits:

- Simple and robust construction
- Can run independently
- Inexpensive
- Minimal maintenance
- Inherent overload protection
- At high speed ~400 Hz, reduces size and weight of machine (roughly 0.33 m long, 0.5 m diameter) and filter components
- Stand-alone applications, no fixed frequency

Induction generator has the drawback that it requires significant reactive energy and it have poor power factor.

10.Applications

Application of an induction generator can be classified as:

10.1.For The Electrification Of Far Flung Areas

(Extension of national grid is not economical)

- Remote family
- Village community
- Small agricultural applications
- Lighting and heating loads

10.2.For Feeding Critical Locations

- Library
- Computer centres
- Hospitals

- Telephone exchange
- Cinema Hall
- Auditorium
- Marketing complex

10.3.As A Portable Source Of Power Supply

- Decorative lighting
- Lightings for projects and constructional sit

11.Practical Results

11.1.No Load

Speed(rpm)	**Wattmeter-1(MW)**	**Wattmeter-2(MW)**	**Current(amp)**	**Voltage(v)**
1488	160	-160	3	400
1504	80	-280	3.4	400
1530	-20	-380	4.2	400

Table 1

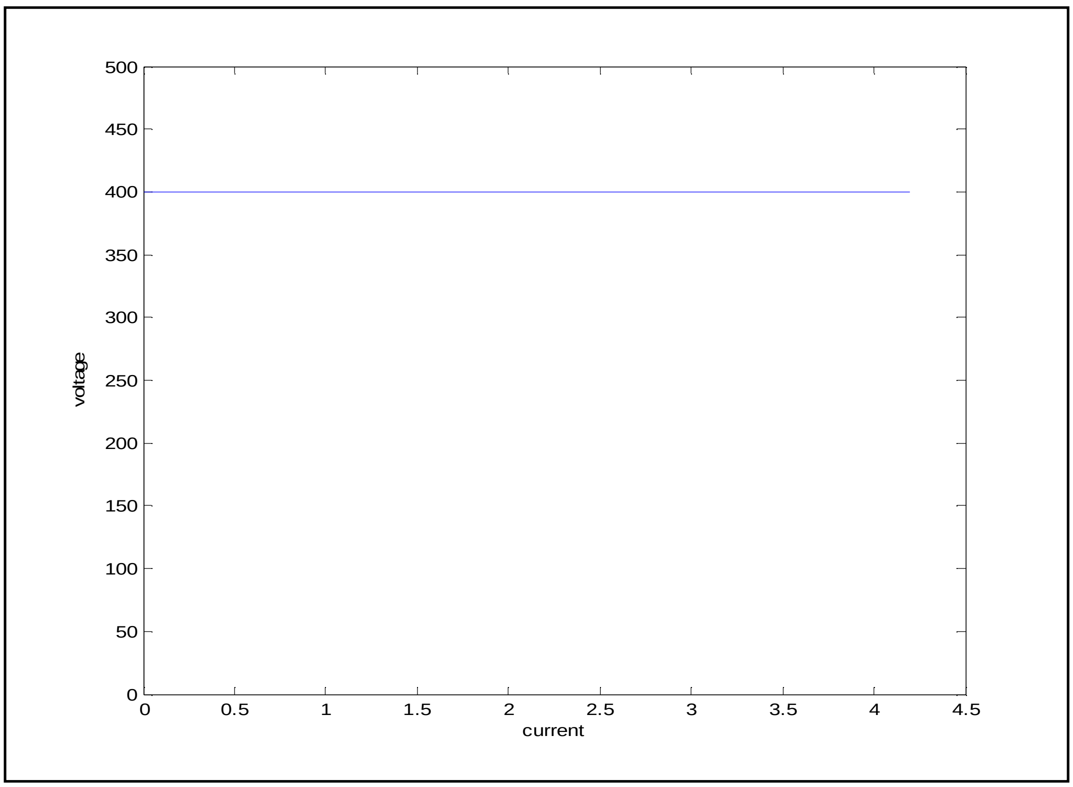

Figure 5

11.2.RC LOAD

Speed(rpm)	Wattmeter-1(MW)	Wattmeter-2(MW)	Current(amp)	Voltage(v)
1496	0	180	3	380
1500	-10	90	3.1	380
1474	0	170	4	375
1486	40	200	4.6	365

Table 2

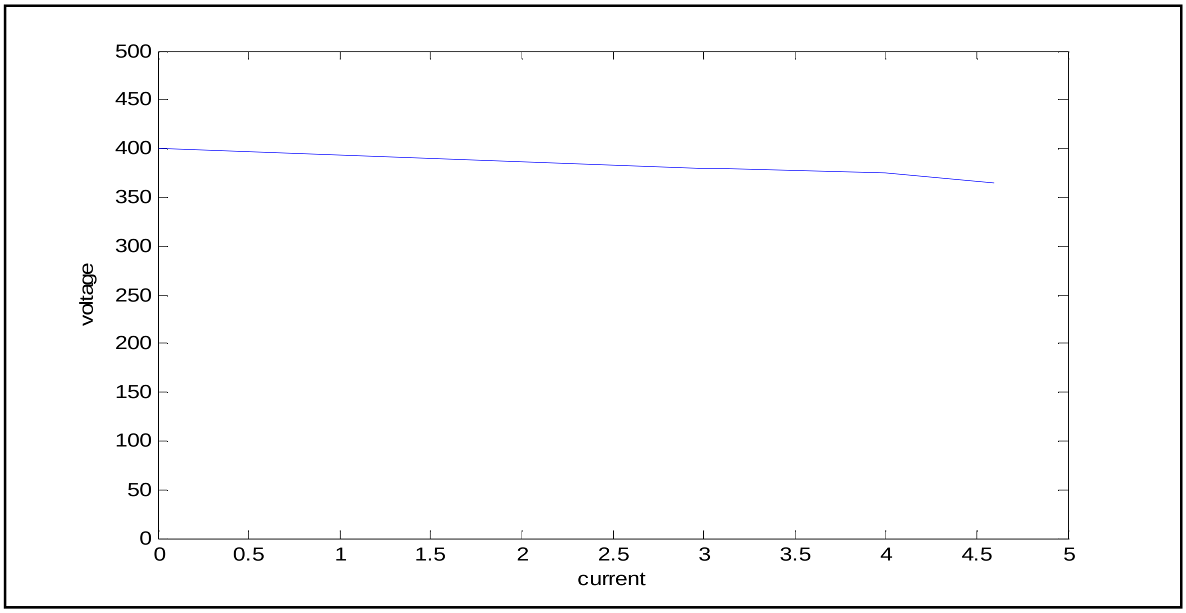

Figure 6

11.3.RL LOAD

Speed(rpm)	Wattmeter-1(MW)	Wattmeter-2(MW)	Current(amp)	Voltage(v)
1454	360	-120	3	180
1456	380	-125	3	160
1474	380	-115	2.7	150

Table 3

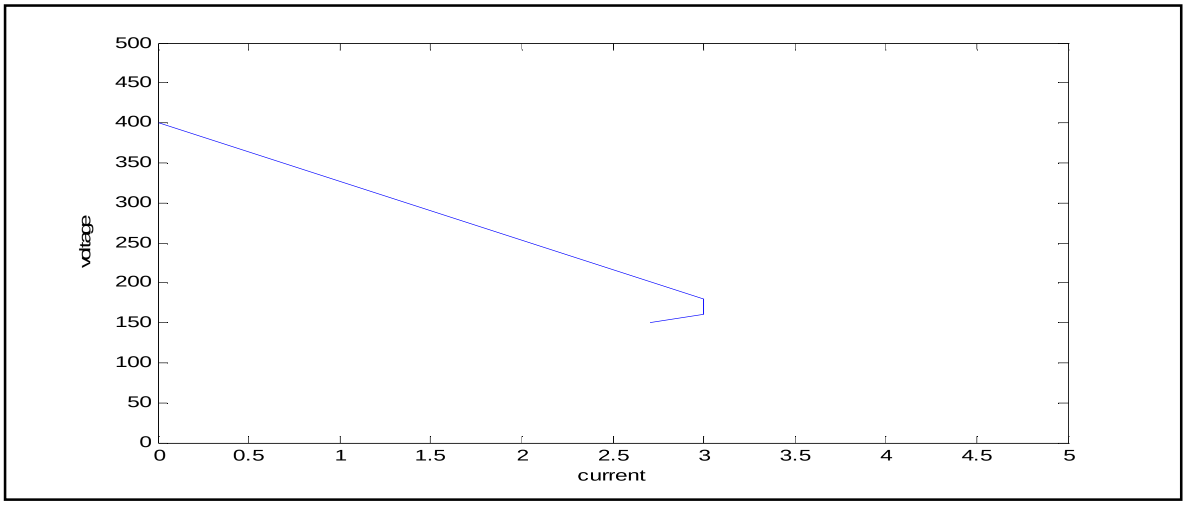

Figure 7

12.Simulation Block Diagram & Simulation Results

12.1.Simulation Block Diagram

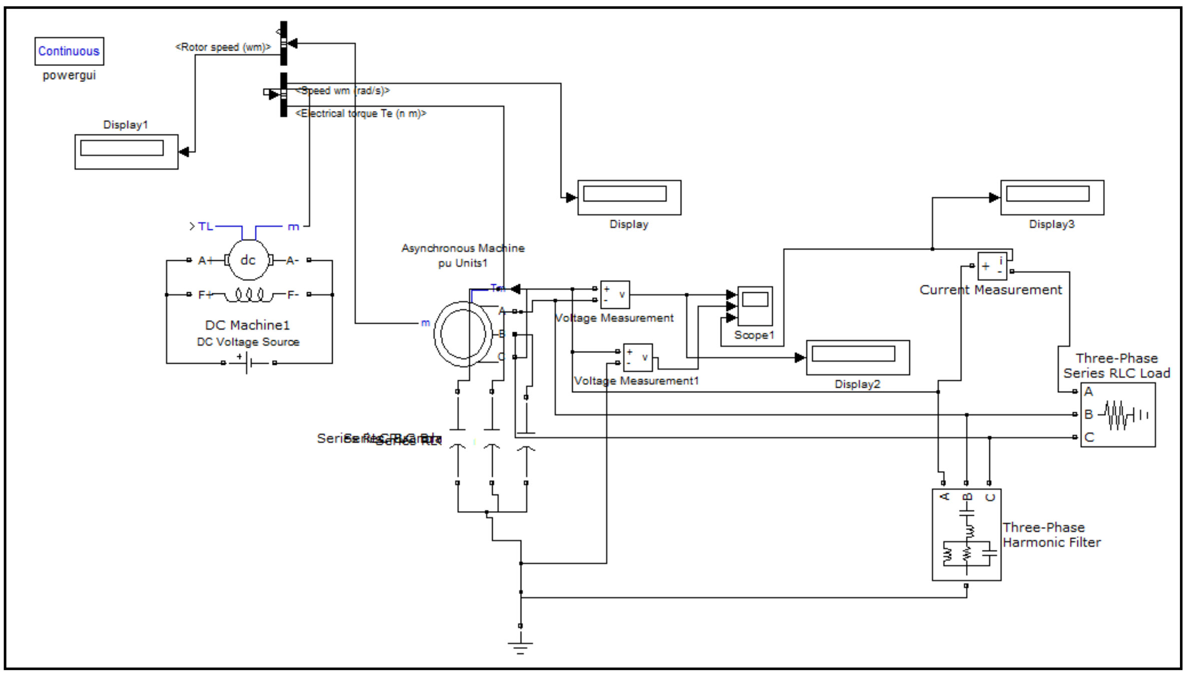

Figure 8

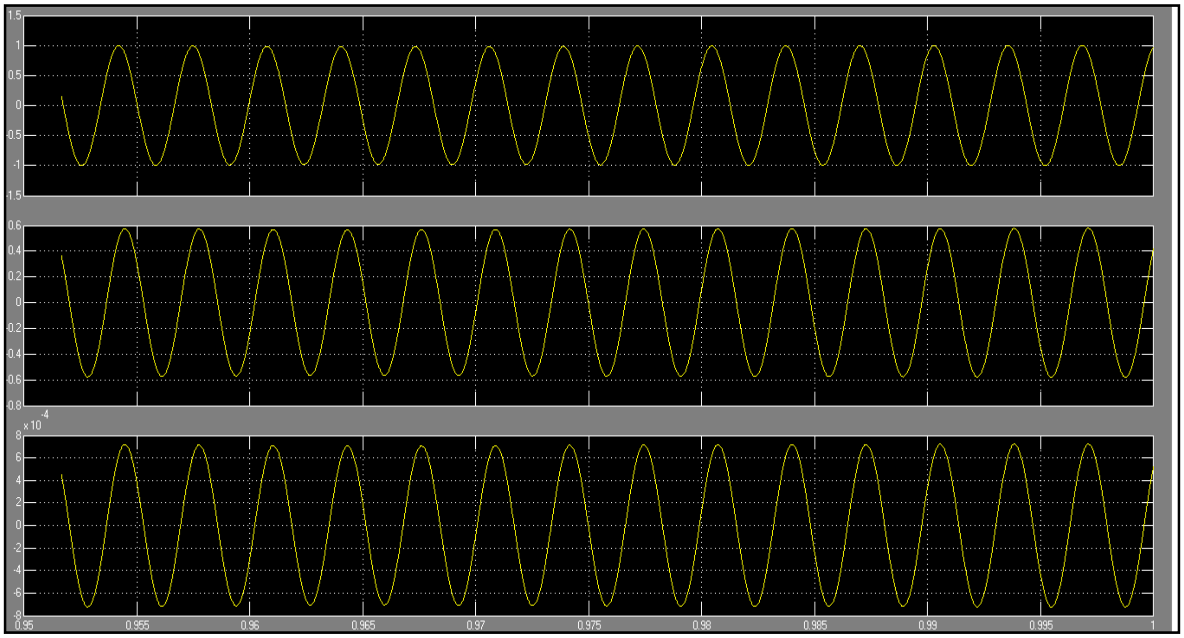

Figure 9

RESISTIVE LOAD(W)	VOLTAGE(PU)
200	1
300	0.95
400	0.85
500	0.8
600	0.7
700	0.65
800	0.6
900	0.6
1000	0.5

Table 4

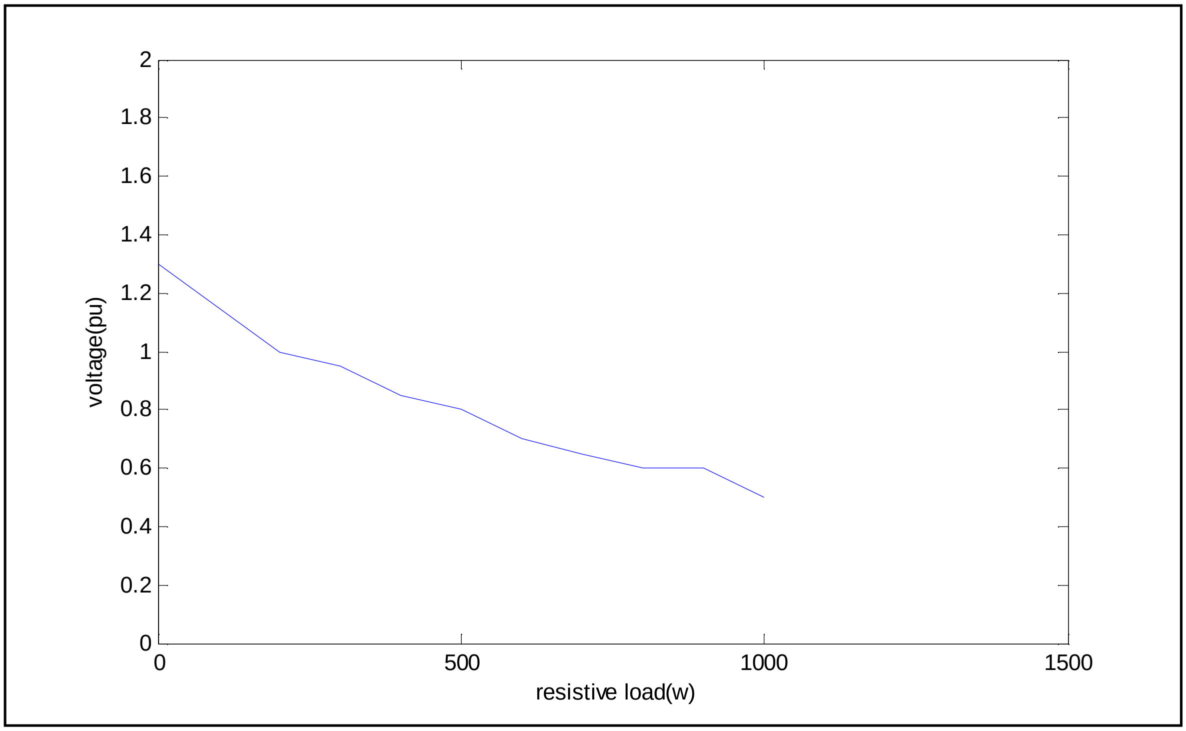

Figure 10

13.Comparision Of Induction Generator & Self Excited Induction Generator

- Induction generator has the drawback that it requires significant reactive energy and it have poor power factor.
- In SEIG the Power Factor Correction is done by using the capacitor bank which maintains good power factor not exactly equal to 1 but almost near to that.
- SEIG can be used as a portable source of power supply where as the
    - losses are more when induction generator is used for small power sources.
- Self-excited induction generators can generate power below rated speeds but induction generators are able to generate above rated speeds
- Induction generators are often used in wind turbines and some micro hydro installations due to their ability to produce useful power at varying rotor speeds.
- In these applications SEIG is more efficient than induction generators as
    - They maintain power factor.
- Induction generators are not, in general, self-exciting, meaning they require an electrical supply, at least initially, to produce the rotating magnetic flux (although in practice an induction generator will often self start due to residual magnetism.) where as the SEIG's have a capacitor bank

14.Conclusion & Further Scope

The technical and economic viability of using induction generator for electric power generation to harness the renewable energy sources, particularly in remote and far flung areas where extension of grid is not economically feasible. The technology of induction generator, once fully developed and realized to the stage of large practical applications, has many advantages to offer over conventional systems.

In isolated systems, the use of a SEIG offers many advantages over a synchronous generator. It is desirable that the cost of an isolated system should be very low so that the cost of power produced from it can be afforded by the poor community residing in an isolated area. Use of the SEIG compared to the synchronous generator can reduce the system cost considerably.

15.Reference

1. R. C. Bansal, “Three Phase Self Excited Induction Generator: An Overview,” IEEE Trans. Energy Convers., vol. 20, no. 2, Jun. 2005.
2. M. Godoy Simoes and F.A.Farret, “Renewable Energy Systems: Design and Analysis with Induction generators,” CRC Press, Boca Raton, FL, 2004.
3. R. C. Bansal, T. S. Bhatti, and D. P. Kothari, “A bibliographical survey on induction generators for application of nonconventional energy systems,” IEEE Trans. Energy Convers., vol. 18, no. 3, pp. 433–439, Sep. 2003
4. Studies on the use of conventional Induction motors as self-excited induction generators IEEE Transaction on energy conversion,vol.3,No.4,December 1988
5. Characteristic performance of an induction generator by Johnson, A. R; Laurence, V. E; Adams, E. W
6. http://www.degruyter.com/view/j/jee.2012.63.issue-4/v10187-012-0031-9/v10187-012-0031-9.xml
7. Text-book of advanced machine work by Smith, Robert H. (Robert Henry), 1852-1916