A review on voltage control of single-phase self-excited induction generator

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***Abstract*—Electrical energy from renewable energy resources can be cheaper compare to grid connection in remote locations or hilly areas. 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. But the Induction generator has a greatest disadvantage of poor voltage regulation as it depends on the consumer load when run in self-excited mode. The aim of this paper is to develop induction generator controller (IGC) to regulate the voltage of single phase self-excited induction generator (SEIG), suitable for stand-alone power mode. MATLAB Simulation of SP-SEIG is carried out to get performance characteristics for different parameters.**

***IndexTerms*—self-excited induction generator,voltage control, renewable energy, MATLAB.**

I. INTRODUCTION

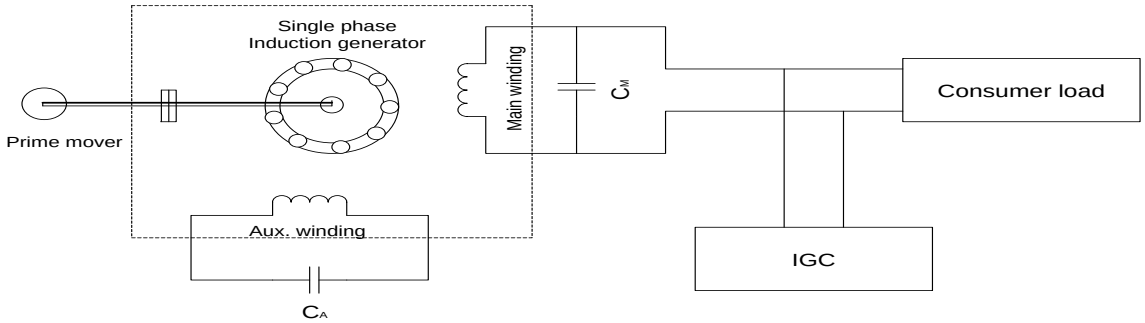
Today energy consumption has been increasing due to population growth, economic and industrial development. The energy supply is far less than our increasing demands, so continues to face serious energy shortages problem. To overcome this energy problem, we have to look towards non-conventional (renewable energy) energy sources like wind, micro-hydro etc.

Induction generators are widely being used these days to extract energy from renewable energy resources because of their relative advantageous features. These features include operational and maintenance simplicity, lower unit cost, good dynamic response, brushless and rugged construction, self-protection against faults and ability to generate power at varying speed. Electrical energy from renewable energy resources can be cheaper compare to grid connection in remote locations or hilly areas. A micro-hydro system which maintains almost constant input power due to fixed head coupled with self-excited induction generator may be one of the most suitable options. In remote locations or hilly areas a single phase power supply is preferred over three phase in order to make the distribution system simple and cost effective. Single-phase induction motors can be used as single phase self-excited induction generators for single phase power generation for supplying smaller loads in sparsely distributed area.

The generated voltage depends on the prime mover speed, excitation capacitances, load current and power factor of the load. Thus, self-excited induction generator has a major disadvantage of a poor voltage regulation. These issues are addressed by several researchers and develop an induction generator controller (IGC) to regulate the voltage and frequency of single phase self-excited induction generator.

II. BASIC CONCEPT

A schematic diagram of the SP-SEIG with IGC is shown in Figure 1.1. It consist of a single phase squirrel cage induction motor working as induction generator with main and auxiliary winding, which is driven by a constant power prime mover (typically, an unregulated micro-hydro turbine). The excitation capacitors are connected across the main (CM) and auxiliary winding (CA) as shown in Figure 1.1, which have a fixed value to result in rated terminal voltage at rated load. Consumer load and induction generator controller (IGC) are connected in parallel at generator terminals. Induction generator controller consist a control circuit in series with dump load.



The SP-SEIG provide power to the consumer and dump load connected in parallel such that the total power Pout=Pc+Pd is constant, Where, Pout is the generated power of the generator which must be kept constant, Pc is the consumer load power and Pd is the dump load power. This dump load power (Pd) may be used for the load which, dissipate power as heat such as heating, battery

charging, cooking etc. The amount of dump load power is controlled by induction generator controller (IGC) to regulate voltage of single phase self-excited induction generator.

III. SIMULATION OF SP-SEIG WITHOUT IGC

The MATLAB simulation of SP-SEIGB without IGC is done with parameters as shown below in table.

Table-1

SR NO.	PARAMETER	VALUE
1	Nominal power	1.492 kw
2	Phase Voltage	220 volt
3	Fundamental Frequency	50 Hz
4	Main winding resistance	2.02 Ω
5	Main winding leakage inductance	0.0074 H
6	Auxiliary winding resistance	7.14 Ω
7	Auxiliary winding leakage inductance	0.0085 H
8	Rotor resistance	4.12 Ω
9	Rotor leakage inductance	0.0056 H
10	Mutual inductance	0.187 H
11	Inertia	0.0146 kg/m^2

Effect of variable load on induced voltage, induced current and actual speed for,
Main winding capacitance (C_M) =75 µF
Auxiliary winding capacitance (C_A) =36 µF
Torque = -5 Nm

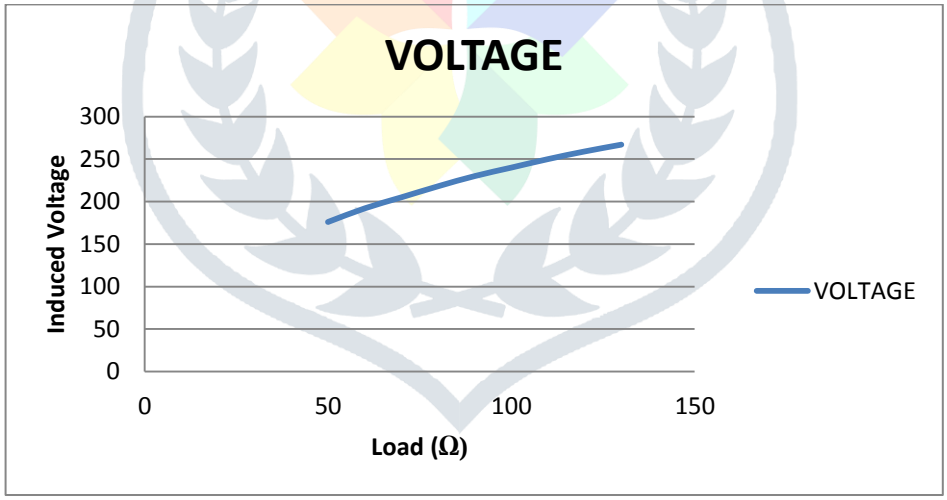


Figure 1

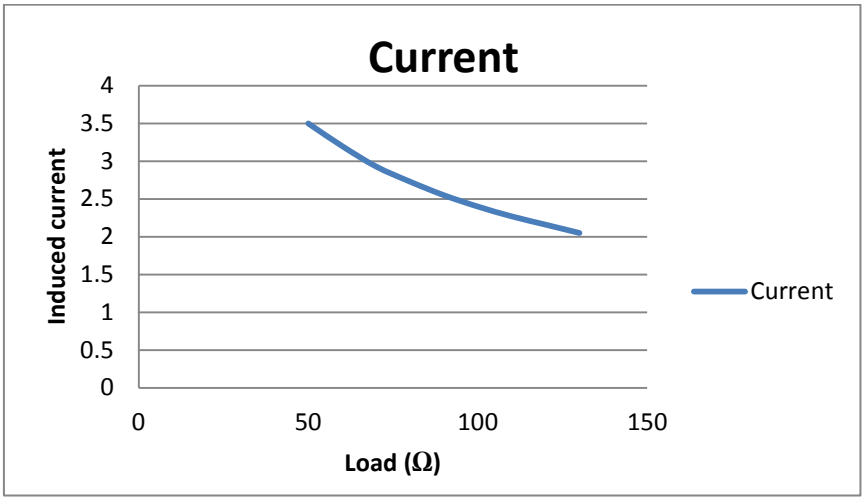


Figure 2

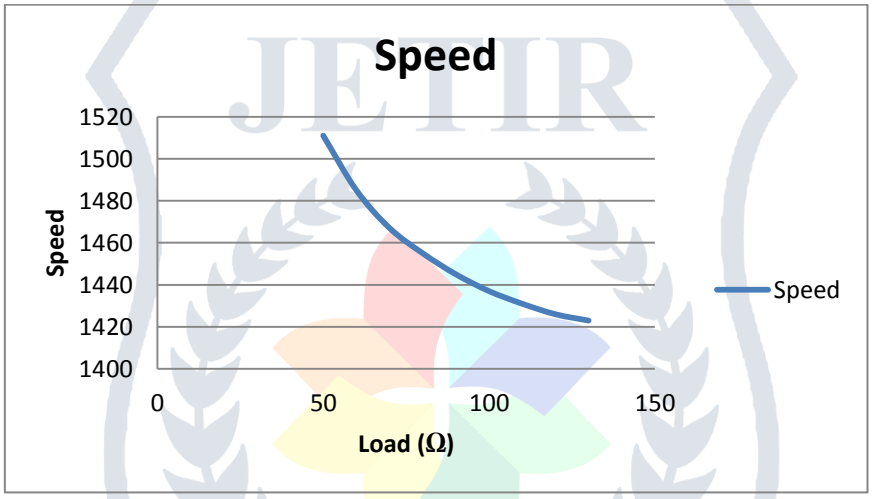


Figure 3

As seen from the graph we can say that the when load impedance of induction generator increases i.e. loading decreases the induced terminal voltage increases and current decreases. SEIG must be fully loaded. So when consumer load decreases, voltage is regulated by injecting dump load through IGC.

IV. CONTROL STRATEGY

When 1-φ induction motor forced to run at slightly faster than the synchronous speed it generates active power and work as a 1-φ induction generator. 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. But as the demand of consumer load changing the terminal voltage also changing. Thus poor voltage regulation and this also proved by the MATLAB SIMULATION and given result in graph.

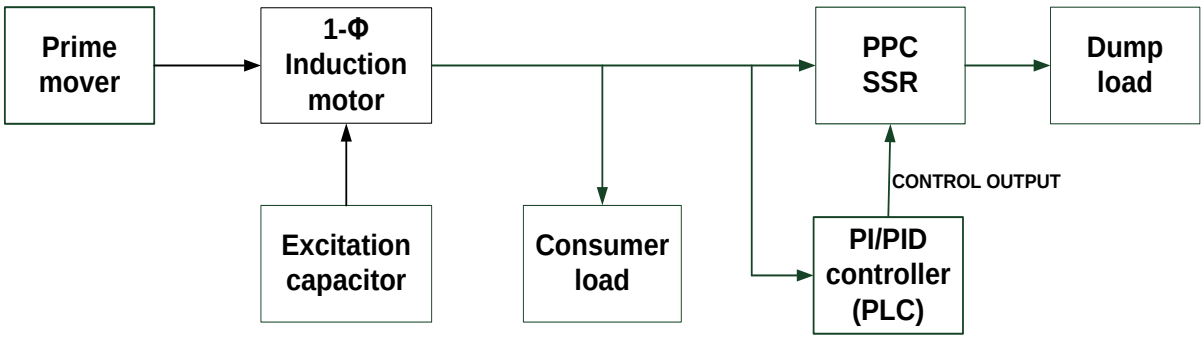


Figure 4

In accordance to regulate the terminal voltage, we connect dump load in parallel with the consumer load. The amount of power to the dump load is controlled by the induction generator controller (IGC) which is connected in series with the dump load. The IGC which is based on electronic load controller (ELC) consist the PPC SSR (proportionate power control solid state relay).When consumer load changes, terminal voltage of the SEIG also changes. Controller senses this change in voltage. With the use of appropriate PI / PID algorithm, it gives proper command to electronic switch configuration (here it is PPC SSR) to increase / decrease proper amount of dump load. The IGC along with its dump load keeps the SEIG fully loaded all the time maintaining the terminal voltage and frequency constant.

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