Load Voltage Control for a Self-Excited Induction Generator using GA & ANN

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Abstract**—** This paper presents a terminal voltage control of a wind turbine Self Excited Induction Generator (SEIG). The wind turbine operates over a wide range of operating conditions, which means that the terminal voltage of the induction generator is not constant. Changing the value of excitation capacitance by controlling the firing angle of SVC under different operating conditions can handle this problem. It is proved that SVC in the form of Fixed Capacitor – Thyristor Controlled Reactor (FCTCR) is used not only provide capacitive excitation for the isolated induction generator, but also it controls its terminal voltage at all different loads with variable speeds of the windmill prime-mover. The terminal voltage had been regulated by adapting the value of the excitation capacitance from Static VAR Compensator (SVC) using Artificial Neural Network (ANN) controller and Genetic Algorithm (GA) Approach. Artificial Neural Networks (ANN) and Genetic Algorithm (GA) Approach with a very simple objective function is proposed to meet the control requirements

Keywords**—** self-exited induction generator, load voltage, artificial Neural Network (ANN) and Genetic Algorithm (GA).

I. Introduction

An externally driven induction machine with an appropriate value of capacitor bank can be used as a generator[1]. This system is called self-excited induction generator (SEIG). The SEIG has many advantages over the synchronous generator: brushless (squirrel cage rotor), reduced size, rugged and low cost. But the induction generator offers poor voltage regulation and its value depends on the prime mover speed, capacitor bank and load[2]. Murthy et al [3] has shown that excitation capacitance must be varied over a wide range to maintain the generator voltage constant. Switched capacitor scheme is cheap and simple solution for providing variable reactive power. It is proposed by Singh et al [4] for SEIG while variation in the load voltage is kept within tolerable limit.

SVC are widely used in power systems for several applications. They are mainly used in voltage control purposes and in stability problem solutions. They are used for solving machine operation problems such as induction motor starting and induction motor short circuit problems solutions [5]. The use of an adaptive excitation capacitance value is motivated by the fact that the wind turbine generator operates over a wide range of operating conditions, and hence no single capacitance value is sufficient for regulating the terminal voltage.

In back propagation control scheme, learning is divided into general and specialized learning. In general learning makes the input space of the plant with training samples so that the network can interpolate for intermediate points [6]. The specialized learning learns directly evaluating the accuracy of the network which is given by the error between the actual and desired outputs of the plant. The error evaluation updates the corrective weights in the network. In this sense, the controller learns continuously and hence it can control plants with time varying characteristics. Over the past few years real-coded evolutionary algorithms, particularly for solving real-world optimization problems is used by researchers. Genetic Algorithm (GA) [7, 8] is one of them.

II. System Configuration

A SEIG driven by prime mover. The generator supplies an isolated three-phase four-wire load. The voltage and frequency control of the system is achieved by Static VAR Compensator (SVC) using Artificial Neural Network (ANN) controller and Genetic Algorithm Approach (GAA).

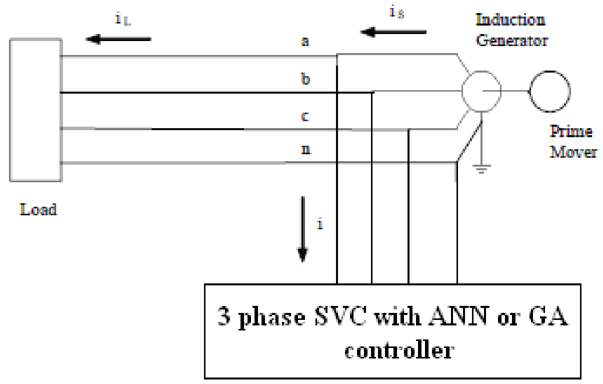

Fig 1 Schematic diagram of proposed system

III. Genetic Algorithm Based Solution

The genetic algorithm (GA) is an optimization technique that performs a parallel, stochastic and directed search to evolve the fittest (best) solution. Different from conventional optimization methods, GA employs the principles of evolution, natural selection and genetics, as inspired by natural biological systems, in a computer algorithm to simulate evolution. Three main operators comprising GAs are: reproduction, crossover, and mutation.

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A. Reproduction

Evolution is, in effect, a method of searching among an enormous number of possibilities for solutions.

B. Crossover

The crossover operator exchanges genetic information between strings. There are a number of commonly used crossover operators: such as blend crossover (BLX), simulated binary crossover (SBX), unimodal normal distribution crossover (UNDX) and simplex crossover (SPX) and parent centric recombination operator (PCX).

C. Mutation

Real coded mutation (RCM) operator has been used to protect the irrecoverable or premature loss of important notions.

GA IS used to control the load voltage of SEIG for any variation in its operating condition. In order to obtain the desired voltage regulation. GA is applied with following objective function

$OF = V_T + V_{err}$

Where

$$Verr = \left(\frac{V_{ref} - V}{V_{ref}}\right)^2$$

Application of GA model results in to the appropriate selection of α. Objective function as given above is minimized using GA to maintain the power quality. Bounds on firing angle, 'α' are 0 to 90 degrees.

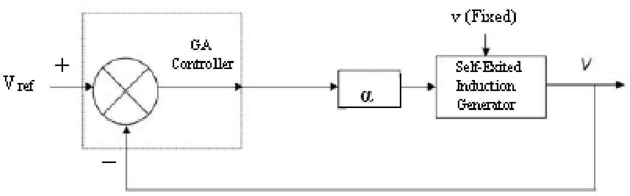

Fig. 2 Voltage control of SEIG for fixed speed operation.

IV. ARTIFICIAL NEURAL NETWORKS BASED SOLUTION

Artificial Neural Networks are considered as a relatively new information processing technique. They can be defined as "a computing system made up of a number of simple, highly interconnected processing elements, which process information by its dynamic state response". A neural network consists of a number of very simple and highly interconnected processors called neurons, which are the analogy of the neurons in the brain. The neurons are connected by a large number of weighted links, over which signals can pass. three layers neural network (having an input layer, a hidden layer and an output layer) with a sigmoidal activation function and supervised training via a back-propagation technique, as shown The well known enhancement of introducing a momentum term in the weight updating formula has also applied to reduce training times and to help in avoiding premature convergence.

The weights of neural network are adapted effected by error signal comes from the difference between desired and actual values. The error function E is calculated as

$$E = \frac{1}{2}\sum\left(\alpha_r(m) - \alpha_L(m)\right)^2 = \frac{1}{2}\sum \overline{e(m)}^2$$

The back propagation algorithm is used to update the connective weights w according to the relation

$$w_{ij}(n+1) = w_{ij}(n) - \lambda \frac{\partial E}{\partial w_{ij}(n)} + \mu \, \Delta w_{ij}(n-1)$$

A three-layer (input, hidden, and output) network is shown

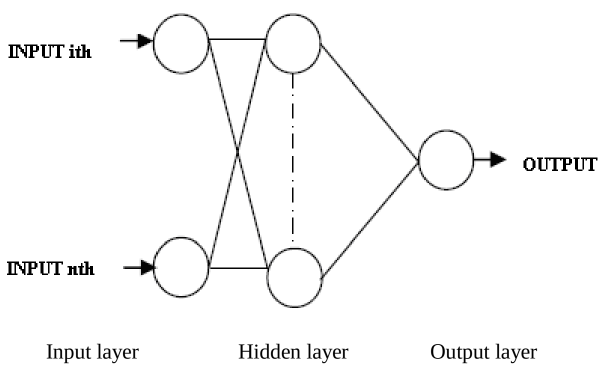

Fig 3 Schematic diagram of neural network model

V. RESULTS AND DISCUSSIONS

These techniques give smooth voltage control over conventional method. It gives better flexibility in operation. And also improve the power factor by controlling the reactive power requirement. It provides remote operation of self exited induction generator with wind mill and as a small water turbine generator. This technique check small change in parameter and necessary corrective action take i.e. change in firing angle take place. Which is better control by ANN and GA based controller over conventional firing angle control circuit. Table and figures showing the variation operating voltage and the value of capatiance and firing angle.

Sr.no.	C	Voltage Value Using GA	Voltage Value Using ANN
	μF	V, volts	V, volts
1.	36	216.58	217
2.	37	226	227
3	50	224	223
4.	51	232	231.5
5.	52	237	238

Table1 different value of captiance and terminal voltage using GA & ANN

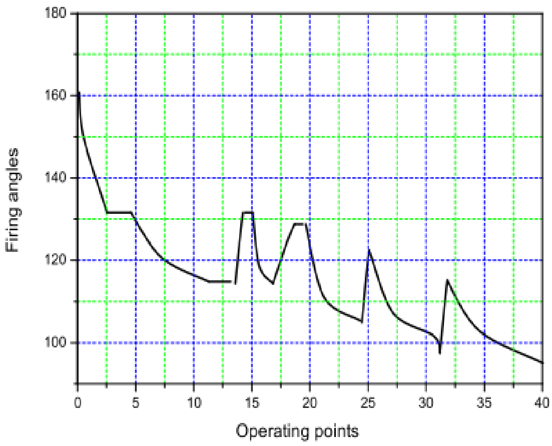

Fig 4Variation of firing angle with different terminal voltage Using Ga

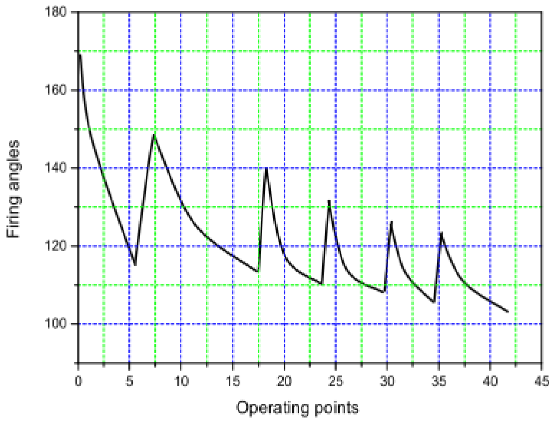

Fig 5 Variation of firing angle with different terminal voltage Using ANN

VI. Conclusion

Self excited induction generators seems to be the right choice for remote windy locations provided terminal voltage is maintained with load. In this paper a new GA and ANN based modeling is discussed to improve the voltage profile of SEIG. Genetic Algorithm artifical nural network is proposed for estimation and selection of shunt capacitance. Analysis proposed may be helpful for researchers to think over the implementation of such generators successfully in windy remote locations.

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