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Stand Alone Operation of SEIG by Using Fixed Capacitor Thyristor Controlled Reactor

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Abstract- The major aspect of this paper is to solve the off-grid operational problems of SEIG system. When the SEIG system is get directly connected with utility due to a different loading conditions and also accordingly to different prime mover conditions terminal voltage fluctuations occurred. Our main aim is to define the system voltage up to a permissible terminal voltage level by using Fixed Capacitor Thyristor Controlled Reactor.

Index terms- *Self Excited Induction Generator (SEIG), Static voltage compensator (SVC), STATCOM, Fixed Capacitor Thyristor Controlled Reactor (FC-TCR).*

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I. INTRODUCTION

In India round about 65% of the population is living in rural areas where the extension of grid is not economically viable. So to full fill their electricity demands of such residents placed in isolated areas. A micro hydro power plants or wind energy power plants are better solution whereas for such a stand-alone operational generation systems induction generator is more suitable over synchronous generator. Synchronous generator is to be synchronised before it is connected with utility whereas induction generator can be directly connected to utility without any synchronism also its compact size, simplicity, reliability, low cost and maintenance makes it more preferable over synchronous generator. But during off-grid operation of SEIG machine voltage fluctuation problems occur. In wind energy generation system when we employ an induction generator the voltage fluctuation occurs due to change in wind speed as wind speed changes continuously with respect to time and surrounding atmospheric conditions and also with respect to its loading conditions causes change in terminal voltage unacceptably. Now to solve such voltage regulation problems we have a solution i.e. FC-TCR branch. FC-TCR can be used to regulate the terminal voltage of induction generator during its stand-alone operation. FC-TCR consists of fixed capacitor connected in parallel with antiparallel thyristor connected in series with reactor where feedback control system is used to control the firing angles of antiparallel thyristor which are indirectly control the reactive power injected into the system by controlling current through the reactor Such that by using fixed capacitor thyristor controlled reactor a type of STATCOM the voltage regulation can be done to overcome problems of SEIG under the off-grid operations for controlling purpose many artificial techniques have been invented such as fuzzy logic control, microcontroller, neural networks, and genetic algorithms by using such an appropriate technique of control we can compute a switching logic for thyristor.

II. SYSTEM CONFIGURATION

A proposed work consist of SEIG directly connected to load driven by wind energy controlled by FC-TCR branch As shown in schematic system, it consists of three phase induction generator operates in a stand-alone condition The main factors which causes the voltage collapse or the output frequency fluctuation is the wind speed and the load impedance hence our main aim is to maintain the constant voltage of the system which varies with variation of consumer load and the speed of the turbine for that we are using simply FC-TCR with controller to maintain generator output power constant under varying loads and speeds.

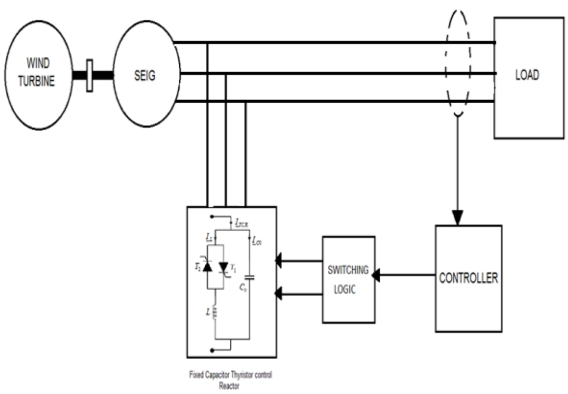

Figure I. SEIG system with FC-TCR branch

When the system is directly connected to utility under different loading conditions i.e. under reactive and resistive loading conditions the system behaviour is different and depending upon that an appropriate controlling action is to be taken by FC-TCR it has to be inject the reactive power into the system or absorbs the reactive power from the system and finally thanks the system to balanced voltage level. Also during different prime mover conditions which depend upon wind speed also causes frequency fluctuations because the rotor speed is directly proportional to frequency and hence the variable rotor

also causes the frequency fluctuation in the system the problem of frequency fluctuation also can be solved by reactive power compensation cause the rotor speed also can be varied by using FC-TCR branch.

A. Stand alone operation of induction generator

The stator of an induction generator requires to be magnetized before it can generate electricity from the utility grid. For working as standalone or off grid operational system the exciting or magnetizing current is to be injected into stator winding and this can be achieved by excitation capacitor connected across the stator terminals of the machine. It also requires being some residual magnetism in the rotors iron laminations during rotations of the turbines. The excitations capacitors are standard capacitors; they are used to provide the required reactive power for excitation which will otherwise supplied by the utility grid. If the rotor has not sufficient residual magnetism then induction generator will not get self excited even after usage of the external capacitor. But when induction generator is in self excited mode its output voltage and frequency is get affected by rotational speed so with varying rotational speed frequency fluctuation problems may arrives even though the Self-excited induction generator (SEIG) is good one for different electric generation applications especially in variable wind speed and in remote areas or in rural areas where simplicity is measure aspect so they are compatible in such areas as they don't require external supply for magnetic field generation.

B. FC-TCR (Static VAr Compensator)

A Fixed Capacitor Thyristor Controlled Reactor is nothing but a type of STATCOM. The proposed static compensator in this work is a reactor in series with two antiparallel thyristors defined as Thyristor Controlled Reactor i.e. TCR branch.

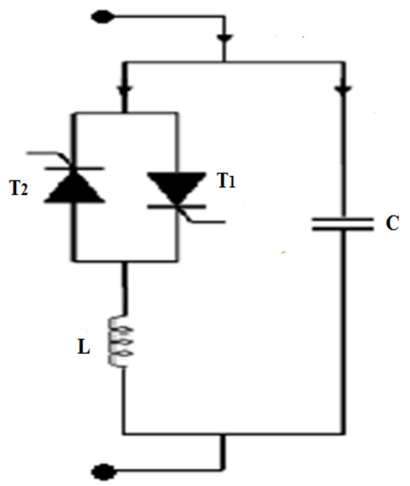

Figure II. Fixed Capacitor Thyristor Controlled Reactor

This branch is parallel with a big fixed shunt capacitor. Then, the two oppositely thyristors are gated symmetrically. They control the timing for which the reactor conducts and thus control the fundamental component of reactor current by controlling action it is shown in the equivalent circuit of the FC-TCR branch below.

C. Working of FC-TCR branch

Thyristor controlled reactors are shunt compensators that they can absorbs the reactive power. The operating principle of TCR is characterized by its operational simplicity; delay of one half a cycle and less harmonics generation. In FC-TCR fixed capacitor injects reactive power into the system whereas thyristor controlled reactor absorbs the reactive power from the system so depending upon the system requirements by adjusting the reactive power injection and absorption we can vary the system voltage. The working of FC-TCR is exactly depends upon it. The value of capacitor is fixed so reactive power injection into the system is constant whereas the effect of reactor can be controlled by controlling thyristor firing angle and hence reactive power absorption can be controlled. Such that by controlling reactive power that is to be injected or absorbed the voltage regulation can be performed. For the appropriate injection and absorption of the reactive power the analysis of the system depending upon voltage requirements is to be defined. The main work concern with it that is to control the firing angles of the thyristor connected antiparallel and switching logic computation by designing control circuit for it. Depending upon conduction period of each thyristor the current passing through the reactor depends if the conduction period of thyristor is maximum then it allows maximum current to pass through it whereas if it is minimum then its allows less current that is less reactive power injection through FC-TCR. The conduction period or angle depends upon firing delay angle by following way

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$$\S = 2\ (\pi - \alpha)$$

Where α is firing angle and § is conduction angle the above equation shows the relation between firing angle and conduction angle.

III. SIMULATION AND ANALYSIS

The proposed work of voltage regulation can be done on the basis of fixed capacitor thyristor controlled reactor which is simulated by using PROTEUS software. Depending upon different loading conditions the voltage variations are occurred hence to regulate the system voltage we can control the firing angle of thyristor which

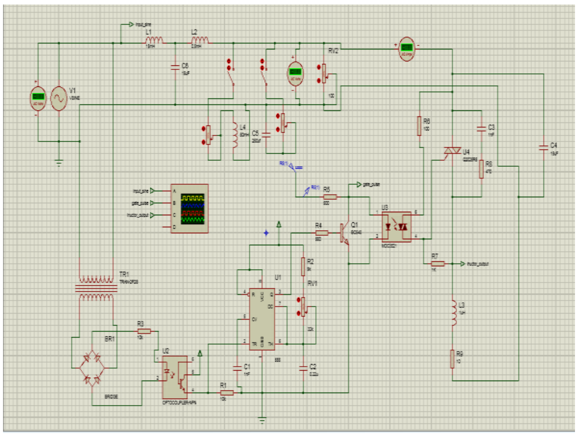

Figure III. Proteus simulation of proposed work

may control the reactor current and on the basis that we can inject or absorbs the reactive power such away we can regulate and compensate the reactive power. Following table shows the simulation results.

R%	*65*	*60*	*55*	*45*	*35*	*15*
α(degree)	*158*	*156*	*153*	*144*	*135*	*126*
§(degree)	*44*	*48*	*54*	*72*	*90*	*108*
Il (ampere)	*0.36*	*0.38*	*0.42*	*0.50*	*0.60*	*0.91*

Table I. Simulation results under different loading conditions

When the resistive load is larger one it cause voltage drop in the system where load reduction causes increase in system voltage the results shows that as the resistive load decreases it maximizes the system voltage. Now to regulate the system voltage the controller by taking an appropriate action to regulate it and depending upon that action it compute the firing logic.

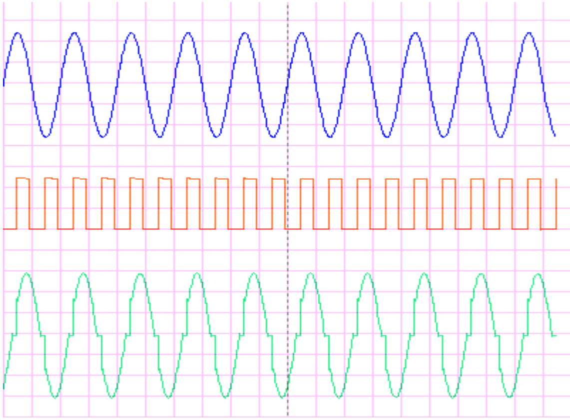

Figure IV. Reactor current and gate pulses of thyristor

As firing angle increases conduction period decreases and current through reactor reduces which reduces the voltage of the system such way that by controlling the firing angle of the FC-TCR branch the voltages

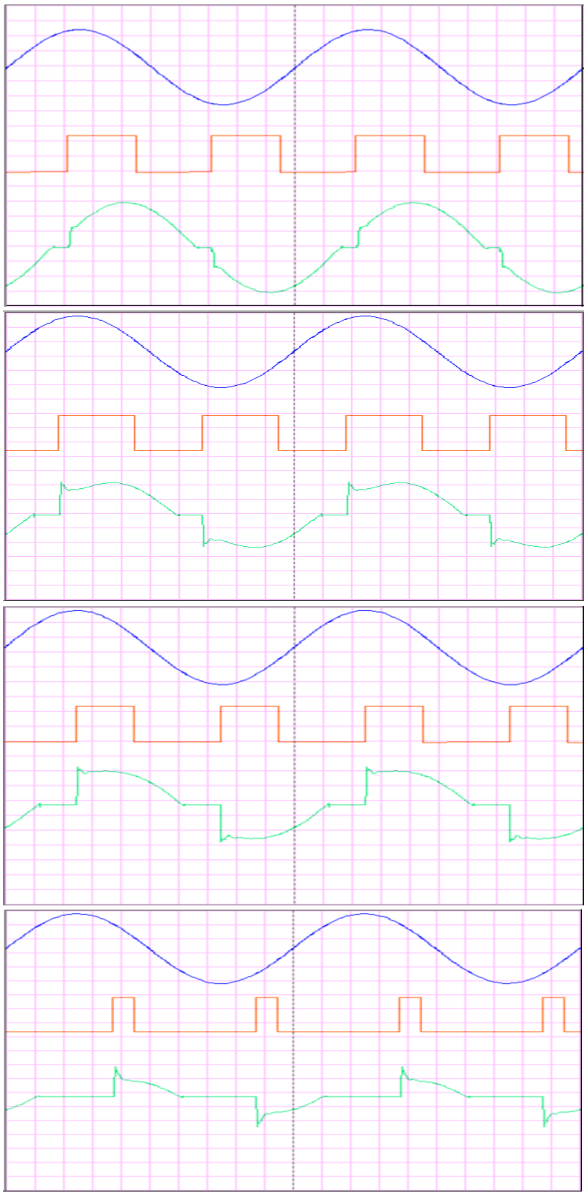

Figure V. Reactor current at different firing angles

regulation of system can be done. Anti-parallel thyristor gated simultaneously so their firing angle and their respective thyristor conduction angle depends upon system voltage requirements hence

Different firing angles can we observed on the basis of loading conditions. During reactive loading conditions the voltage is set at particular value with respect to loading condition that is at different R-L load conditions voltage drop occurs as inductive load that is type of reactive load it draws the current from the system and drops the system voltage down. As the inductive load increases the system voltage decreases and with respect to that we increased the firing angle which reduces the conduction period of thyristor indirectly drops the current through reactor so reactor current decreases hence to regulate this voltage to our set value we have to regulate the current through reactor.

IV. CONCLUSION

During off-grid operations of SEIG due to different loading and prime mover conditions the problem of voltage fluctuations occurred in the system so that to solve this problems of voltage unbalance FC-TCR is one of the simplest way. In proposed work simply by using FC-TCR branch we can regulate voltage by controlling firing angle of thyristor depending upon system requirements. By using controller switching logics are computed which control the conduction angle of antiparallel thyristors results in controlling current through the reactor in series with that thyristors. On the basis of such controlling reactive power is injected or absorbed and final voltage regulation can be done.

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