SIMULATION OF AN ASYNCHRONOUS GENERATOR WITH REACTIVE POWER COMPENSATOR IN AN ISOLATED POWER GENERATION SYSTEM WITH RLC SERIES CIRCUIT

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Abstract- This paper expounds a simulation model of a self-excited asynchronous generator (SEASG) feeding R L load in conjunction with an AC/DC/AC converter fed RLC series circuit connected at the point of common coupling (PCC). Simulation model of the proposed system have been developed by using Matlab/Simulink. The result shows that the effect of RLC series circuit when operated at variable frequency affects the generation voltage profile. This reflects that an additional capacitance or inductance effect is possible to inject when the RLC is operated at frequency lower than the resonance frequency or the higher than the resonance frequency. This simulation model validates the injections of capacitance in a SEASG is possible to match the lagging reactive power of the RL load to maintain a constant voltage at the load bus.

Keywords- Asynchronous generator, Rectifier-inverter, Simulation model;

I. INTRODUCTION

The use of non-conventional energy sources has become eminent due to fast depletion of conventional energy sources. The recent trend to tap solar, wind and tidal energy are becoming popular amongst the renewable energy sources. At present, to decentralize the power generation system, attempts have been in the direction of generating small power and distributing it locally. This prompted the use of wind and solar energy to cope with the present day energy crises. Self-excited asynchronous generator has emerged as a possible alternative for isolated power generation from renewable energy sources because of its low cost, less maintenance and rugged construction [1]-[3]. However, it requires a suitable controller to regulate the voltage due to variation of consumer loads. From the characteristics of voltage generation in a SEASG, it is essential to have a variable capacitance at the machine terminals to maintain constant voltage with variable load.

II. SYSTEM CONFIGURATION

The schematic arrangement of the proposed system is shown in Fig.1. It consists of an SEASG, rectifier – inverter fed RLC series circuit with RL load. SEASG is driven at a constant speed along with static capacitor at the stator terminals of the SEASG. The effect of changing load on the generated voltage was found to be drooping with an increase of load. To compensate this drooping voltage, an R L C series resonance circuit fed from an AC/DC/AC converter is connected at PCC.

D-Q Axis Modelling of Asynchronous Generator

The d-q axis equivalent circuit model of a SEASG is shown in Fig. 5.20 (a) and Fig. 5.20 (b) respectively.

From Fig. the loop equations of the d-q axis equivalent circuit of SEASG could be written as

\[ R_s i_{qs} + L_{ls} \frac{di_{qs}}{dt} + \frac{1}{C} \frac{di_{qs}}{dt} + L_m \frac{di_{qr}}{dt} = V_{dc} \]

\[ R_r i_{qr} + L_{lr} \frac{di_{qr}}{dt} + L_m \frac{di_{qs}}{dt} = \omega r \lambda_{dr} \]

\[ R_s i_{ds} + L_{ls} \frac{di_{ds}}{dt} + L_m \frac{di_{dr}}{dt} = -V_{dc} \]

\[ R_r i_{dr} + L_{lr} \frac{di_{dr}}{dt} + L_m \frac{di_{ds}}{dt} = V_{qc} \]

The dynamic characteristic behaviour of SEASG in d-q axis equivalent circuit model is used for simulation. The magnetizing current \( i_m \) and generated air gap voltage can be calculated using equations and respectively.

\[ |i_m| = \sqrt{(i_{qs} + i_{qr})^2 + (i_{ds} + i_{dr})^2} \]

\[ V_g = \omega L_m |i_m| \]

It should be noted that \( L_m \) is not constant but a function of the magnetizing current \( i_m \) given as

\[ L_m = f(|i_m|) \]

The developed electromagnetic torque and the torque balance equations are written as
\[ T_e = \left( \frac{3}{2} \right) \left( \frac{P}{2} \right) L_m (i_{dr} i_{qs} - i_{qr} i_{ds}) \]

\[ T_{\text{shaft}} = T_e + J \left( \frac{2}{P} \right) \frac{d\omega_r}{dt} \]

The speed derivation of torque balance equation is expressed in equation

\[ \frac{d\omega_r}{dt} \left( \frac{P}{2J} \right) = \left( T_e - T_{\text{shaft}} \right) \]

The generated phase voltage and the stator currents derived from d-q axes values using equation

\[ v_a = v_1 \cos \theta_1 + i_2 \sin \theta_1 \]

\[ v_b = v_1 \cos \left( \theta_1 - \frac{2\pi}{3} \right) + i_2 \sin \left( \theta_1 - \frac{2\pi}{3} \right) \]

\[ v_c = v_1 \cos \left( \theta_1 + \frac{2\pi}{3} \right) + i_2 \sin \left( \theta_1 + \frac{2\pi}{3} \right) \]

\[ i_a = i_1 \cos \theta_1 + i_2 \sin \theta_1 \]

\[ i_b = i_1 \cos \left( \theta_1 - \frac{2\pi}{3} \right) + i_2 \sin \left( \theta_1 - \frac{2\pi}{3} \right) \]

\[ i_c = i_1 \cos \left( \theta_1 + \frac{2\pi}{3} \right) + i_2 \sin \left( \theta_1 + \frac{2\pi}{3} \right) \]

Modelling of Bridge Diode Rectifier

The diode bridge model is developed with ideal switches and the total loss of the bridge is represented by a lumped resistor \( R \) which is added to the dc resistance \( R_{dc} \) with the help of three Heaviside functions. These Heaviside functions determine whether the diode is in conducting state (or) in blocking state. The functions \( g, k \) (where, \( k = 1, 2, 3 \)) are defined from the graph shown in Fig.5.21. The three phase voltages are expressed through the equation

\[ e_1 = g_1 V_{dc} ; e_2 = g_2 V_{dc} \quad \& \quad e_3 = g_3 V_{dc} \]

Using the above equation (5.81) the phase voltages are computed through the equation

\[ u_1 = f_1 V_{dc} ; u_2 = f_2 V_{dc} \quad \& \quad u_3 = f_3 V_{dc} \]

Where,

\[ f_1 = \frac{2g_1 - g_2 - g_3}{3} ; f_2 = \frac{2g_2 - g_3 - g_1}{3} \quad \text{and} \quad f_3 = \frac{2g_3 - g_1 - g_2}{3} \]

From the above equation (5.81) and (5.82) the dc side current is given by

\[ i_{dc} = g_1 i_1 + g_2 i_2 + g_3 i_3 \]
The simulated results are as follows.

Carrier Frequency = 1000 Hz

- For carrier frequency 1000Hz, the waveform clearly shows that the frequency lower than the resonance frequency the input side current is leading.

- This phenomenon of drawing leading and lagging current also observed at PCC shown in below results.

Carrier Frequency = 1000 Hz
For carrier frequency 1000Hz, the simulation results of the d.c side input current of the inverter is shown for inverter frequency lower than the resonance frequency.

Carrier Frequency = 2000 Hz

For carrier frequency 2000Hz, the simulation results of the d.c side input current of the inverter is shown for inverter frequency higher than the resonance frequency.

CONCLUSION & FUTURE SCOPE

1. CONCLUSION:
Simulation of the proposed system with AC/DC/AC inverter fed RLC series circuit in open loop has been studied. This concludes that the characteristics impedances of series circuit changes due to frequency changes that reflect into the system at PCC. This reveals that the power factor has been changed. Therefore a conclusion is made that impedance changes at PCC is a similar to the phenomenon of capacitive VAR injection or consumption. Since, the rectifier circuit has been constructed using diodes; it is not possible to make the current to lead the voltage at PCC. But it is possible to adjust the power factor of the system up to certain limits.

From the simulation results of currents at the input side of the inverter and at PCC as shown in above figures it is evident that the RLC series circuit when operated either at a frequency lower or higher than the resonance frequency the system power factor gets affected. This characteristics phenomenon can be implemented in controlling the leading VAR requirements for constant voltage operations of the SEASG.

2. FUTURE SCOPE:
Control strategy of the proposed system can be strengthened by artificial intelligence technology for further development of operating process.

REFERENCES

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