Theory of operation single phase induction generator at load state ,

Engineering

2. Theory of single phase generators The use of an induction motor as a generator requires a magnetizing current for excitation and a prime mover to maintain the rotor speed above the synchronous speed. In a self-excited induction generator the excitation is provided by the capacitor connected across the stator winding as shown in Fig 1.

Fig1 – Capacitor connected induction generator

Before a generator can be applied to supply power to a specific electrical load, it is important to understand the voltage and frequency of power that will be generated. This is discussed in the sections below.

2. 1 Factors that determine the generator voltage and frequency

a) In the single phase induction generator, the excitation voltage and frequency vary depending on the rotor speed, the values of the capacitance and the winding inductance and the load current. For any value of capacitance, there is a minimum rotor speed at which self-excitation would occur [1].

It is difficult to measure the self inductance of the generator winding directly. An approximation can be made by driving the rotor at synchronous speed and measuring the stator voltage and current. At the rotor synchronous speed, no current is induced in the rotor and it is a virtual open circuit. The measured impedance (V/I) can be approximated for the winding self-inductance.

The resonant frequency is given by

$\omega 0 = 1/\sqrt{LC}$

From the above relationship, the value of the capacitance required for resonance at 50 Hz is calculated by

$C = 1/ \omega_0^2 L$

From the above equations, it is clear that the self-inductance of the winding would vary with the voltage induced in the winding. The variation of magnetizing inductance with voltage for a specific induction generator is shown in Fig 2.

Fig 2- Variation of self-inductance with voltage

The inductance increases from (A) to (E) on the curve with an increase in voltage and then falls from (E) to (C) as the machine begins to saturate.

b) For a given speed of the rotor, the voltage generated in the winding would vary with the value of the connected parallel capacitor. The relationship between the terminal voltage and the value of the capacitor for a specific induction generator is shown in Fig 3.

Fig 3 – Variation of terminal voltage with value of capacitance at constant speed

One requirement in any electrical generator is for the terminal voltage to remain constant when the connected load varies. Most electrical loads operate satisfactorily only in a narrow range around their rated voltage. The value of capacitance needed to maintain constant terminal voltage at a given rotor speed is shown in Fig 4 for a specific induction generator. The graph shows that the variation is linear.

Fig 4- Capacitance value to maintain constant terminal voltage with change in load

In addition to the constant voltage, an alternating current generator also needs to supply power at a constant frequency. For the single phase self-excited generator, we know from induction motor theory that as the load

current changes, the slip between the rotor and the stator would vary and cause the induced stator frequency to vary. This relationship for a specific induction generator is shown in Fig 5.

Fig 5- Variation of output frequency with load at constant rotor speed

The controls needed to maintain the voltage and frequency of a single-phase induction generator would therefore be very complex and defeat the objective of using the simple machine as a generator.

The solution is therefore to use the single-phase induction generator to charge a battery and then to feed the connected load through an inverter.

Reference :

1. Robinson, L. and Holmes, D. G., (2006). “ A Single-phase Self-excited Induction Generator with Voltage and Frequency Regulation for use in a remote area Power Supply”, Proceedings of the Australasian Universities Power Engineering Conference (AUPEC ’06), Melbourne, Australia, 10-13 December 2006, pp 1-6. Web. Retrieved from < http://educypedia. karadimov. info/library/207. pdf >