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The Control of Voltage and Frequency of Self-excited Three-Phase Induction Generator

In this work it is presented the control of voltage and frequency of three-phase induction generator in autonomous regime. It is adjusted the intensity of voltage and frequency at the terminals of the consumer by means of frequency converter, in conditions of driving the induction generator at constant speed. System testing and measurements were carried out by the Laboratory for Designing and Testing of Equipment Excitation and Automation of the Center for Research in Hydraulics, Automation and Thermal Processes (CCHAPT) within "Eftimie Murgu" University of Resita.

Keywords: *voltage, frequency, bank of capacitors, induction generator, frequency converter.*

1. Introduction

The scientific importance of the theme proposed arises from the stringent reality of the problems related to generation of electricity using renewable energy systems like micro-hydro power plants, especially in isolated areas which are not connected to the national electricity network.

The problem proposed for solving is the development of a control system destined to the micro-hydro power plants (MHC) endowed with induction generators, system which is destined to improve their performances and to make possible the efficient use of the hydroenergetic potential from isolated areas.

Due to multiple advantages that they have, the asynchronous machines have been spread on a large scale within economy. The practical applications of the induction machine, in generator regime, were limited only due the difficulties to control the voltage and frequency. The development of power electronics thus improved the possibilities to adjust the parameters of induction generators, connected or not to a network, particularly in case of generator with lower power with hydro or wind drives.

2. Configuration of generator system – frequency converter – load

It is known the fact that an induction machine may remain excited even after it was disconnected from network. The condition necessary to maintain excitation is to connect a sufficiently high capacity to terminals while the speed is maintained from external mechanical power source. The voltage generated depends on capacity, speed, load current and by the power factor and thus it was born a new generator system.

During this time, few things have been written about the autonomous induction generators due to the reduced practical importance of the subject, because of the reduced capacity to control voltage and frequency.

Lately, the fact that induction generators may convert the mechanical energy in electric energy, within a broaden field of rotor speeds, made them to be regarded as alternatives to synchronous machines.

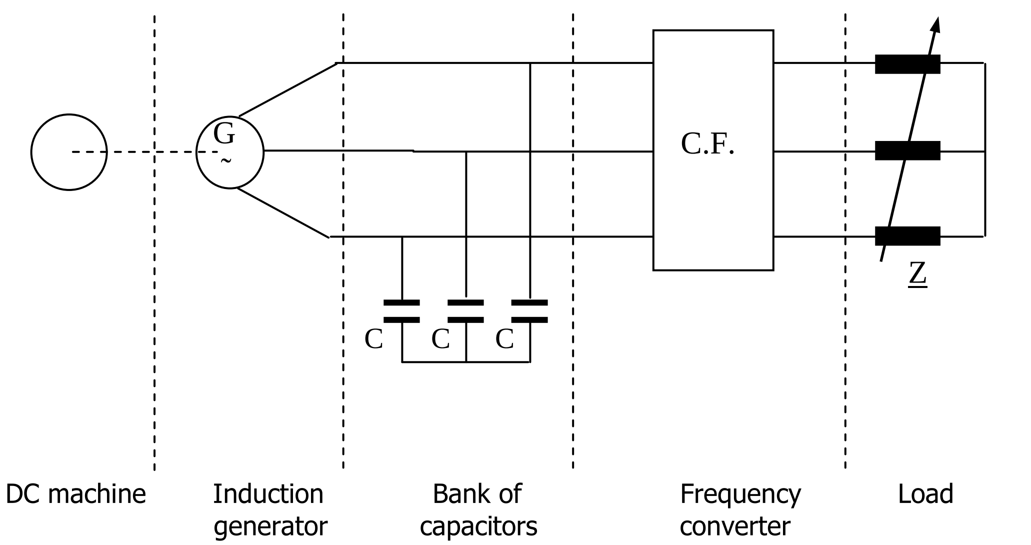

Figure 1. System configuration

In figure 1 it is presented a system composed of primary drive (turbine), induction generator, bank of capacitors necessary for excitation of generator, frequency and load converter.

System testing and measurements were carried out in the Laboratory for Designing and Testing of Equipment Excitation and Automation of the Center for Research in Hydraulics, Automation and Thermal Processes (CCHAPT) within "Eftimie Murgu" University of Resita.

The nominal parameters of the induction generator are the following:

P_n= 1.5 kW
U_n= 220/380V (Δ/Y)
I_n= 6.56/3.8 A
n_n= 1410 rpm
cosφ= 0.79
R_1= 4.2Ω

The bank of capacitors was sized at 3x33.75μF.

For voltage and frequency control we used a Sinamics G120 frequency converter, manufactured by Siemens Company.

The measurements were performed for active (resistive) three-phase load, in seven equal stages, up to 0.8 of the generator rated power.

3. Results of measurements

Table 1.

Sarcina	U_g [V]	U_s [V]	I_g [A]	I_c [A]	I_{CF} [A]	I_s [A]	f_g [Hz]	f_s [Hz]	P [W]	n [rot/min]
C.F.	430	385	2.8	2.35	0.5		49.3	50		1500
S_1	420	384	2.82	2.32	0.7	0.2	49.05	50	180	1500
S_1, S_2	410	383	2.83	2.3	0.9	0.4	48.8	50	360	1500
$S_1÷S_3$	400	382	2.84	2.2	1.1	0.6	48.55	50	540	1500
$S_1÷S_4$	390	381	2.85	2.1	1.3	0.8	48.3	50	720	1500
$S_1÷S_5$	380	380	2.86	2	1.5	1	48.05	50	900	1500
$S_1÷S_6$	370	379	2.87	1.9	1.7	1.2	47.7	50	1080	1500
$S_1÷S_7$	360	378	2.88	1.8	1.9	1.4	47.4	50	1260	1500

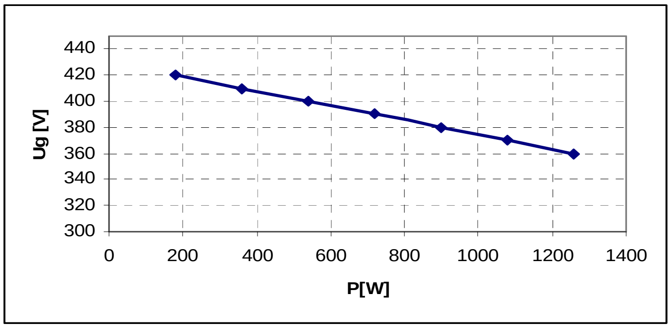

Figure 2. Variation of voltage at the generator terminal with load

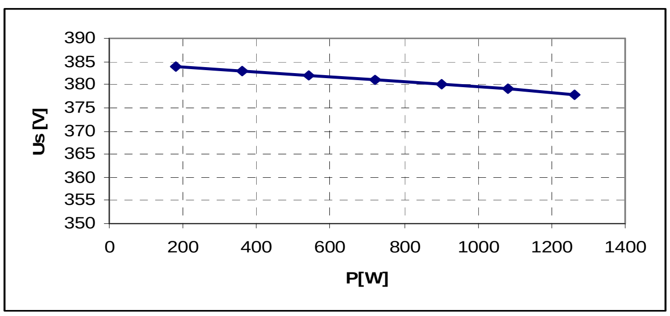

Figure 3. Variation of voltage at the load terminals with power

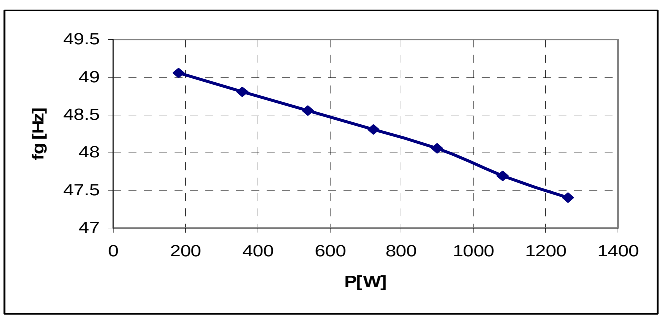

Figure 4. Variation of generator frequency with loading

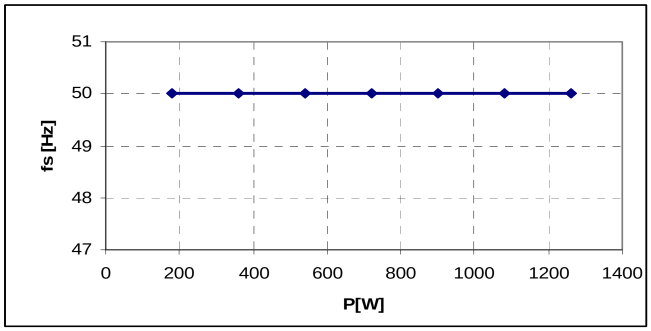

Figure 5. Variation of load frequency with power

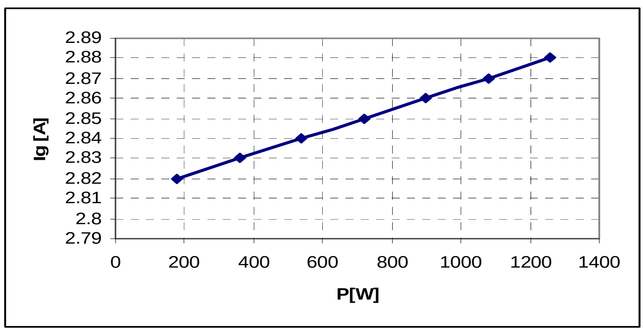

Figure 6. Variation of generator current with power

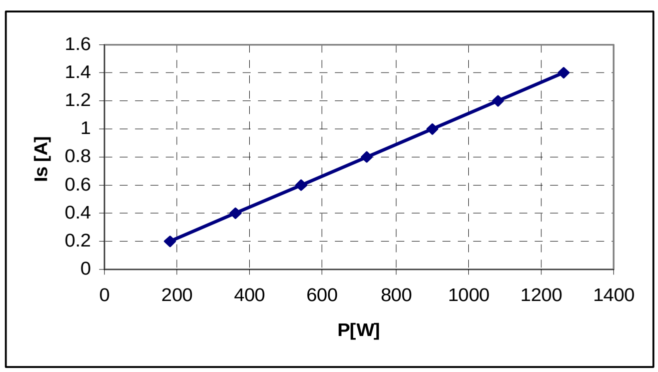

Figure 7. Variation of load current with power

4. Conclusions

As concerns the self-excited generators named in the international specialty literature SEIG (Self-excited Induction Generator), unlike the induction generators connected to network, the frequency as well as the voltage vary against the loading conditions even when the rotor speed is maintained at a constant value.

By connection of the frequency converter between generator and load we managed to control the frequency and voltage at consumers. Thus, upon the loading of generator up to 0.8 of its rated power, the frequency is maintained constantly at 50 Hz, and the voltage around the value of 380 V, the generator being driven at a constant speed.

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