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INDUCTION GENERATOR WITH ROTOR WINDING AND STATIC FREQUENCY CONVERTER FOR MICRO HYDROELECTRIC POWER PLANTS OR WIND POWER STATION WITH VARIABLE SPEED

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Abstract – **The paper presents the production of electric energy from regenarate sources, to variable rotation, utilizing an induction generator with coil rotor and a frequency static converter.**

Keywords: *regenerate energy, induction generator, frequency static converter, variable speed.*

1. INTRODUCTION

The classical hydraulic or wind turbine must keep a constant speed value for the generator. For the an induction generator this speed must be higher than the speed of the magnetic induction rotating field. For this purpose the hydraulic turbines are provided with entrance buckets on the stator and adjustable blades on the rotor and the wind turbines are provided with adjustable blades [1,2].

For the micro hydroelectric power plants where the flows can vary in a wide range from one season to another and the filling are of small capacity, there are intervals when the flow is too low and the power plant can not operate, as well as intervals when the flow is too high, thus an significant amount of power is wasted. The same situation occurs in the wind power stations located in areas with relatively wide variations of the wind speed [3].

This paper proposes a solution which eliminates these drawbacks [8,9].

2. THE METHOD PRINCIPLE

Starting from the slip formula:

$$s = \frac{\Omega_1 - \Omega}{\Omega_1} \quad (1)$$

where:

- Ω_1 is the stator rotating magnetic field angular speed;
- Ω is the rotor angular speed, and from the relation between the stator voltage frequency f_1 and rotor voltage frequency f_2.

$$\pm f_2 = s \cdot f_1 \quad (2)$$

where the + or - symbol corresponds to a particular succession of the supply voltage in the induction machine rotor with rotor winding, the following relation results:

$$f_1 = \pm f_2 \cdot \frac{\Omega_1}{\Omega_1 - \Omega} \quad (3)$$

To keep a constant output voltage frequency f_1 during angular speed Ω wide range variations, modifying the rotor supply voltage frequency f_2 is required [6,7].

Relation (3) can be expressed as follows:

$$f_1 = \pm f_2 + \frac{p \cdot \Omega}{2 \cdot \pi} \quad (4)$$

where p is the number of generator pole pairs. The output frequency f_1 automatic control concept is based on this relation.

3. THE INVERTER POWER SOURCES TYPES

Figure 1 below presents the principle drawing of the frequency automatic control when the angular pulling speed Ω is variable.

Abbreviations:

- T - hydraulic turbine or wind turbine;
- IG - induction generator with rotor winding;
- BMP - measurement and protection unit;
- K - grid circuit breaker
- R - fully controlled rectifier
- C - condenser from the frequency static converter (FSC) d.c. intermediary circuit
- I - inverter
- R.I. - charging regulator
- B - charger battery, with buffer function during the cold startup
- Cons. c.c. – d.c. consumers for grid blackout until the generator is braking to shut down;
- PLC - the programmable logic controller which supervises and controls the entire system;
- SUCD - remote monitoring and control system.

Regardless the angular speed Ω value the system forces a constant value for the generator output frequency f_1, equal with the grid frequency.

We present a comparison of the experimental results against simulations results.

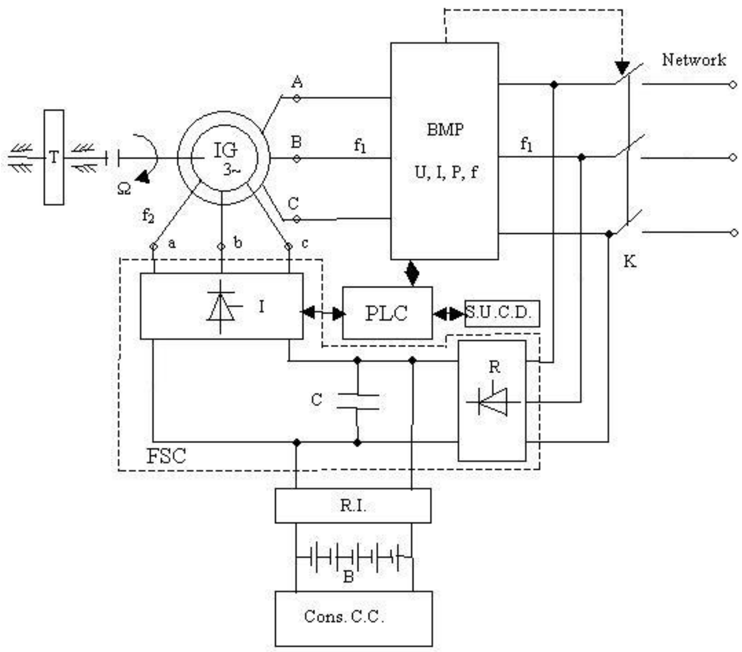

Figure 1: The electrical scheme.

4. THE OPERATING SIMULATION

In figure 2 is presented scheme of simulation with the Matlab Simulink. They represented graphic dependencies on time of angular speed, of the output voltage of FSC, of the generator voltage and output voltage frequency (figure 3 a, b, c, d). The simulation results are presented in figure 3 [3,4].

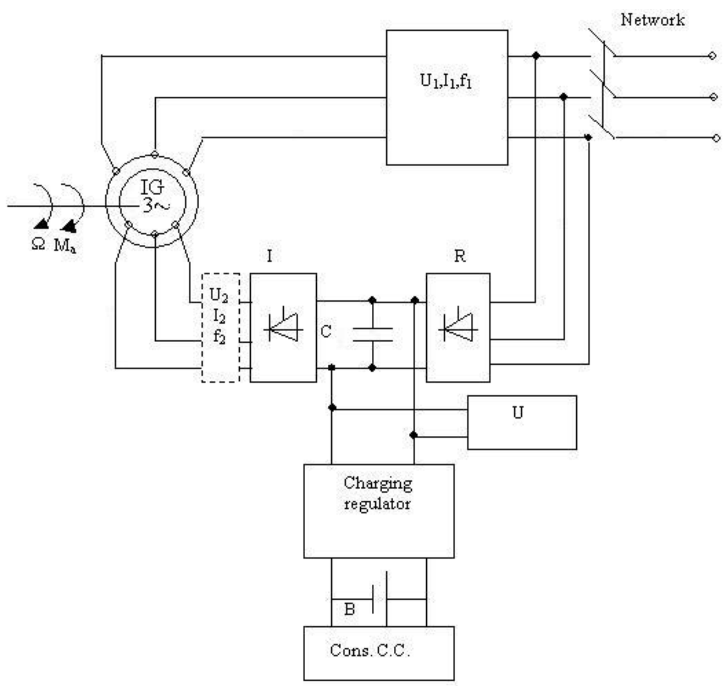

Figure 2: The simulation scheme.

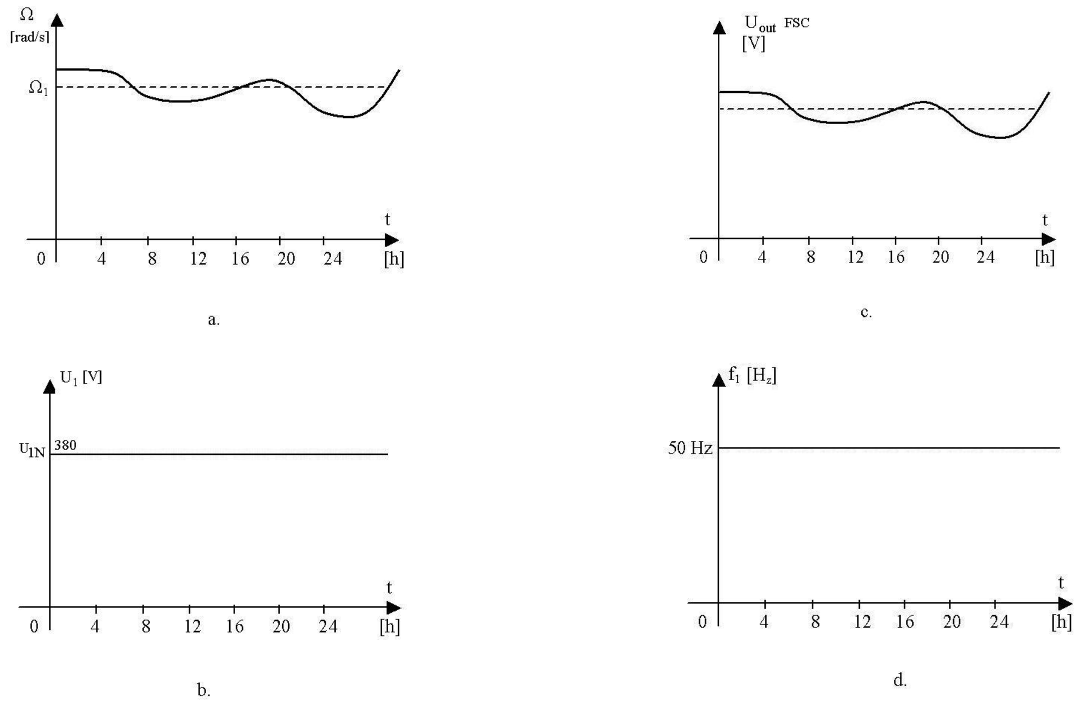

Figure 3: Simulation results.

5. EXPERIMENTAL RESULTS

For used-up experimentation scheme presented in THE figure 4. For the rally generator with variable speed it is used an d.c. motor having: P_N = 4 kW, U_N = 220 V, I_N = 20 A, n_N = 950 rot/min.

The induction generator coil rotor has the date: S_N = 3 kVA, U_{1N} = 380 V, I_N = 6A, cosφ = 0.87 , U_{2N} = 80 V, n_1 = 1000 rot/min, n_n = 920 rot/min. The frequency static converter is ACS 800 with the features: P_N = 1.5 kW, I_N = 3 A, U_N = 380V [5]. The results obtained are presented in the table 1.

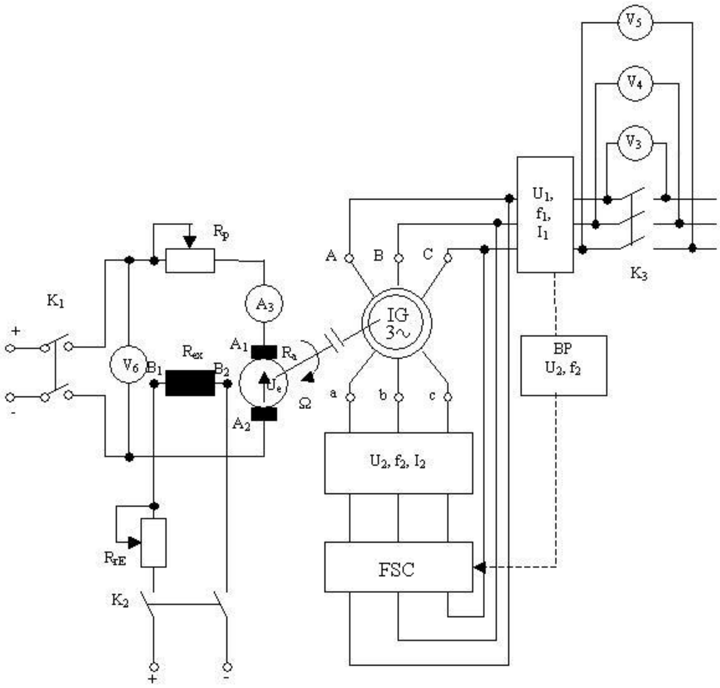

Figure 4: Measure scheme.

n [rot/min]	Ω [rad/s]	U_1 [V]	I_1 [A]	f_1 [Hz]	f_2 [Hz]
1200	125.6	382	6.20	50	-10
1100	115.06	381	6.10	50	-4.96
1020	106.69	380	6.00	50	-0.96
980	102.5	380	5.90	50	1.03
960	100.41	380	5.85	50	2.03
940	98.32	379	5.80	50	3.03
930	97.27	379	5.76	50	3.53
920	96.23	378	5.72	50	4.03
900	94.14	378	5.70	50	5.02

Table 1: The experimental results.

6. CONCLUSIONS

The system enables a high flexibility of the angular speed. Thus the employed turbines are less complicated, without entrance buckets and rotor blades adjustments. In this way electric power is generated at angular speeds in the range of (0 … 1.2 Ω_N) in island mode or with the generators connected to the grid.

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