“Mircea cel Batran” Naval Academy Scientific Bulletin, Volume XVI – 2013 – Issue 1
Published by “Mircea cel Batran” Naval Academy Press, Constanta, Romania

INDUCTION GENERATOR WITH CAPACITIVE EXCITED USED AS A SOURCE OF ELECTRICITY GENERATION IN WIND INSTALLATIONS

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Abstract: *Asynchronous generators are the most robust types of generators. They are used in the vast majority in suprasincron regime, coupled power network. They cover power range between tens of kW and 2-3 MW. Since the network has constant frequency, resulting asynchronous generators operate with constant speeds. Asynchronous generators that operate at constant speeds is a disadvantage because they will not be able to extract the full power available aerodynamics, which would require the increasing speed. Another disadvantage is that their starting made as engine for to bring the aerodynamic rotor at the operation speed. That advantage can mention is stable operation over the network. Conversion efficiency of asynchronous generators are generally than lower synchronous generators.*
Key-words: *wind energy, asynchronous generator, excitation frequency.*

1 INTRODUCTION

Asynchronous generators are the most robust types of generators. They are used in the vast majority in suprasincron regime, coupled power network. They cover power range between tens of kW and 2-3 MW. Since the network has constant frequency, resulting asynchronous generators operate with constant speeds. Asynchronous generators that operate at constant speeds is a disadvantage because they will not be able to extract the full power available aerodynamics, which would require the increasing speed. Another disadvantage is that their starting made as engine for to bring the aerodynamic rotor at the operation speed. That advantage can mention is stable operation over the network. Conversion efficiency of asynchronous generators are generally than lower synchronous generators.

2 GENERAL CONSIDERATIONS OF WIND ENERGY CONVERSION INTO MECHANICAL ENERGY

Theoretical maximum conversion efficiency of wind energy into mechanical energy is 0.5926.

For most improved propeller actual maximum output not exceeding 80% of the theoretical maximum efficiency. The relationship between power generated by a wind turbine and wind parameters is as follows:

$$P = 0,5\rho A C_p v^3 \eta_g \eta_b \qquad (1)$$

where:

ρ - is the air density;

A - is area described by the rotor and governable to wind action

C_p - coefficient of performance which depends on the type turbine;

v- is wind speed

η_g - is generator efficiency

η_b - is coupling efficiency.

A fraction of about 60% of this power can be recovered. Basically it is considered used only 70% of the maximum theoretical power. Considering mechanical efficiency (90%), electrical efficiency (85%) and that of the electricity transmission network (98%), wind energy conversion efficiency in electrical energy resulting to be approximately 30%. If considered generator coupling efficiency at wind turbines, resulting overall efficiency of about 24%.

Note that wind turbine power is proportional to the cube of wind speed. So even a small increase in wind speed will result in a noticeable increase of power generated by the turbine.

For electricity generated by wind turbines have a price as low, and considering the direct dependence of wind speed and power cube generated, the turbines are designed to match their maximum efficiency at wind speeds around 15 m/s. It is not profitable for maximum turbine efficiency correspond to higher wind speeds because, for most locations, according to statistical data, the time of year when the wind is registered with speeds above 15 m/s is low or very low (wind speed 15 m/s correspond to storms).

Moreover, at high wind speeds, there is danger that the turbine, so it is provided with a control system that limits the rotor speed when it reaches extreme values

3 CAPACITIVE EXCITED INDUCTION GENERATOR

Capacitive excited induction generator used in the present in composition different of sources of power generation capacity low: hydro, wind, sources with internal combustion engines.

Generator mode depends also by the character of variation of the load. Therefore the generation system requires a regulator required for stabilizing the number of revolutions of the rotor in case of external disturbances. Known example is the routing device mode capacitive excited induction generator used in hydro power plants and wind turbines.

The drawback of this technical solution is the high technical complexity of achieving constructive device, the reduced frequency adjustment and instability generator voltage and current at varying wind speed. Another solution excitation and voltage stabilization squirrel cage induction generator is proposed for autonomous wind turbines supply electricity to consumers.

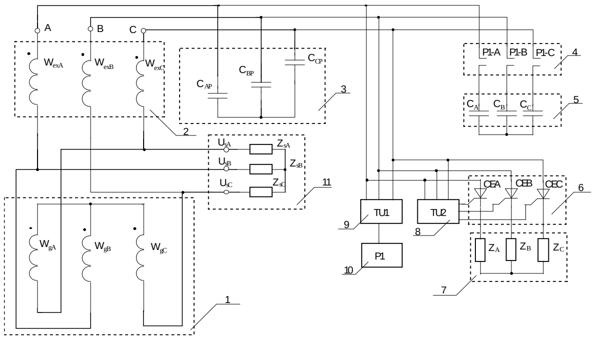

Fig. 1 Equivalent circuit of asynchronous generator voltage stabilization by regulating the flow of fundamental pulse of the machine

The essence of the proposed technical solution is to stabilize the output voltage of the generator by adjusting time and space fundamental magnetic flux of the machine by connecting consecutive and simultaneous short output terminals of the capacitor winding and the neutral excitation winding by a electronic key ordered separately depending on the current value of the respective phase voltage amplitude.

Winding neutral connection can be made through active resistance, what leads to a change slower regulate impulse flow and improve the quality indices of the output voltage of the generator.

The purpose of the proposed solution is achieved by changing the connection scheme of the two capacitor banks, one of which is permanently connected with the output terminals of the generator and battery second capacitor is connected to the generator terminals after his arousal and reaching a specified goods output voltage of the generator with a switch with normally open contacts. On reaching the specified goods voltage change occurs by jumping ability of the capacitors and switching to operating frequency. This ensures stable operation broadening the scope of the generator.

At divert blood flow generator after changing wind speed and load control system automatically seeks voltage amplitude deviation from the nominal value half-wave first half of the positive and negative error value form after opening command to switch to electronic key common point connection outlet excitation winding and the capacitors to the stator winding neutral.

For the three-phase generator is possible to obtain the adjust the machine’s fundamental magnetic flux at least six times during the voltage generated.

The opening angle $\varphi = n\pi - \alpha$ is a function of exceeding the specified value of the amplitude of the alternating voltage, for example nominal voltage, where:

Φ - opening angle for electronic key close to the value π or 2π

n=1 for positive alternation

n=2 for the negative alternation of voltage in common point of connection between terminals of the generator excitation winding and capacitors.

α - angle for phase shift or electronic conductivity is a function key value generator voltage amplitude deviation from specified goods.

The angle α cannot exceed the value of π /2.

It can obtains high flexibility due to fundamental flow control of the machine and during this action does not go beyond time T/2, where T-period generator voltage. Formation conductivity angle electronic key can be based on deflection winding excitation voltage amplitude, or the output voltage of the generator, or the voltage derivative crossing through zero and switching control system can provide any keys which is near the zero crossing regime during the given circuit voltage amplitude decrease.

This also increases the flexibility of the fundamental flow stabilization of the machine and the output voltage of the generator. Fast switching phase excitation winding of the generator at least six times the current period based assures the exclusion of amplitude modulation of the voltage generator at varying wind engine installation.

In Figure 1 element 1 is working winding of the generator excitation and element 2 is excitation winding. At excitation winding terminals 2 in permanent connection is switched capacitors 3 and through normally open contacts 4 by relay 10 is coupled capacitors 5. Electronic keys 6 output terminals connected to the excitation winding 2 and the input block 7 consists of impedances ZA, ZB, ZC, the outputs of which are connected to the neutral of the generator winding. The voltage transducer 8 provides key action CEA, CEB CEC and for switch 6 to overcome the generator voltage over value.

Power translator 9 provides the transition from high frequency excitation mode to mode under the operating frequency excited by ordering the relay 10 and switching the capacitors 5 in parallel with capacitors 3 by closing contacts 4. Load generator 11 is connected to the output terminals of the generator winding 1 which have galvanic connection with the excitation winding.

Subsystems of elements 3, 4, 5, 9 and 10 form the capacitive excitation generator block. Subsystems of items 6, 7, and 8 form the stabilizer output voltage of the generator.

Diagram is shown in Figure 2 working electronic key control function consists of voltage transducer 8.

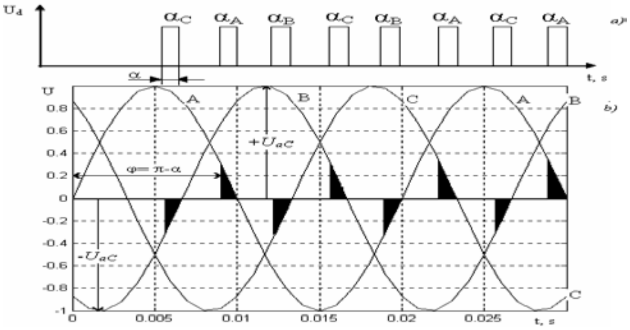

Fig. 2 Timing diagram of operation of the voltage regulator asynchronous generator

Figure (2-a) shows the variation in time for intervals electronic conductivity keys and control of impulses generated by the stabilizer for each particular circuit.

Distribution in time for pulse control and conductivity ranges are as follows: αA→αB→αC→αB→αA→αC, if the first control pulse was formed positive alternation of phase A.

In fig.2b is shown sinusoidal voltage curves are phase A, B, C and specified intervals switching output terminals excitation winding capacitor banks 2 and capacitors 3 and 5 in the neutral winding impedances ZA, ZB, and ZC , where:

α-angle electronic conductivity key

φ = π-α is a opening angle α electronic key for phase A for alternating positive voltage

-UaC, +UaC is amplitude of negative alternating and positive alternation of voltage phase C.

4 DEVICE OPERATION

In no excited state generator voltage is near zero. Capacitors 5 is disconnected by the contacts 4 of the commutator 10 from generator.

Increasing the number of rotations of the rotor cage generator, such as driven by the engine, due to increased wind speed, generator excitation passes under residual magnetic flux produced by the asynchronous machine.

Generator excitation frequency is determined in this case by the phase work winding inductance 1 and excitation winding 2 connect in the autotransformer diagram and capacity of the capacitors phase 3.

On reaching the setpoint voltage, eg Unom nominal, voltage sensor 9, which has a hysteresis characteristic type reaction generates output signal which activates relay 4 relay 10 and contacts provide connection of the capacitors 5 in parallel with battery capacitors 3. This was put into operation constructive device subassembly which provides excitation regime and pass to generator operating frequency. Switching capacitors 5 in parallel with capacitors 3 provides the conditions for the function for systems 6, 7, 9, voltage stabilization system, of increasing generator rotor slip in generation mode of the synchronous rotation to stator rotating field and increase voltage than the nominal value.

Upon reaching the threshold voltage value of each alternation amplitude Upr.c>Unom, voltage transducer 8 form control signals (Fig. 2-a) for electronic key opening 6 (CEA, CEB, şi CEC), where Upr.a.- is phase amplitude threshold that is reference signal stabilization system; Unom- voltage rating of the generator. Voltage transducer 8 has a characteristic hysteresis type and help ensure a more stable operation of the control system and decrease the output voltage modulation depth. The transducer hysteresis loop 8 is narrower as the transducer hysteresis loop 9. Keys form a new circuit for the winding excitation current, which provides direct flow of work winding neutral 1 by impedances 7. Impedances 7 may have the value zero. The winding connection terminals 2 lead to a regime of low load or short circuit in stator winding machine during conductivity range for open electronic key and machine demagnetization. Also is decreasing occurs fundamental magnetic flux generator and voltage reduction. Because switching interval is relatively small for each phase and this short circuit regime for that phase occurs at low voltages, near the zero crossing point voltage phase connected and repeated at least six times on period get slow reaction for control fundamental flux value and diminishing modulation output voltage work winding of the generator 1.

When passing through zero phase voltage connected to one of the electronic keys 6 this voltage changes sign and therefore electronic key closes automatically disconnecting terminal phase excitation winding 2 from neutral winding 1. Using this principle stabilizer control with electronic keys simplifies its design. The same thing will happen to random variation the value of electric charge generator and if concomitant deviation of the load and wind speed.

5. CONCLUSIONS

Technical result of the proposed solution consists in expanding stable operating range of the generator and increase power quality indices products by the wind turbine at variable speed wind and random variation of the load supplied including minimizing amplitude modulation of the voltage generator.

Efficiency and technical solution proposed device was verified in laboratory conditions for sample asynchronous generator electrical output power of 0.3 to 1.5 kW in equivalent schemes for wind speed of 3-8 m / s.

It has been established experimentally the excitation capacitor battery is useful to divide in report $C_{11} \approx C_{21} \approx 0,5C$ where C is total capacity of the battery.

The frequency of excitation and work is in report $f_{ex} \approx 1,4f$ and nominal active power generated in wind speed will be minimal (7-10)% of rated installed. There is ensures stable operation under asynchronous generator generating at all wind speeds in the range of prescribed work.

Adjustment for known devices power reserve capable of generation at minimum wind speed is zero. Voltage stabilizer was conducted as laboratory sample based electronic keys made of thyristor for research robust stabilization principle under laboratory conditions.

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