P.438153 Electric generator with internal frequency transformer

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The present invention makes it possible to increase the efficiency of the machine in a purely electric way, i.e. without the need for a double external propulsion of a two-rotor generator or a mechanical transmission. Replacing the second rotor of the generator together with the drive unit based on a mechanical transmission used to transmit mechanical power, with a solution defined as a rotating field unit with increased rotation speed, which is based on a frequency transformer, results in the reduction of unfavorable phenomena, including backlash and energy losses in the mechanical transmission, especially when multiplying the speed, also losses of both ventilation resistance and bearings of the second rotor rotating at a different rotational speed, and simplifies the construction of a generator equipped only with rotors rigidly mounted on a common drive shaft, i.e. rotating at the same rotational speed.

The aim of the project is to develop a construction of an electric generator with an internal frequency transformer having higher efficiency compared to conventional AC generators. The higher values of the generated voltage and frequency without the need to increase the rotational speed of the shaft or the same voltage and frequency at a lower shaft speed define this higher efficiency, which is obtained by a different method than in two-rotor generators known from descriptions of patents. Another goal is to develop a compact electric machine that is economical to manufacture.

The electric generator with an internal frequency transformer, which is the subject of the invention, is a multi-structure electric machine with one shaft, one generator structure and one frequency transformer structure. The generator structure is an alternating current electric generator, for example a synchronous generator, an asynchronous generator or an induction generator.

The essence of the invention is to obtain higher values of the generated voltage and frequency in relation to the voltage and frequency of conventional AC electric generators without the need to increase the rotational speed of the shaft.

An electric generator with an internal frequency transformer (hereinafter referred to as the machine) can be made as three-phase or with any number of phases. In addition, it can act as a generator or motor.

The synchronous generator (Fig. 1) consists of a laminated rotor core 9 with a three-phase winding 10, mounted on a shaft 8, and a solid stator core 5 with permanent magnets 6 mounted in the machine body 11. The internal frequency transformer consists of a laminated core 2 with a three-phase winding 1, mounted in the body 11, and a laminated core 12 with a three-phase winding 13, mounted on the shaft 8.

The laminated rotor core 9 is separated by an air gap from the solid stator core 5 with permanent magnets 6. In the three-phase winding 10, rotating in a stationary magnetic field excited by permanent magnets 6, voltages are induced with the frequency f1 = p1n1/60, where n1 – rotational speed of the machine shaft 8, p1 – number of pole pairs of the synchronous generator. The value of the voltage induced in the winding 10 is proportional to the speed n1. The three-phase winding 10 is electrically connected by three connecting wires 4 with the three-phase winding 13. The voltage from the three-phase winding 10 is supplied through these wires to the three-phase winding 13, which produces a magnetic field rotating relative to the stator with the speed n1 + n2, where n2 - field rotation speed relative to shaft, n2 = 60f1/p2, p2 – number of pole pairs of the frequency transformer. The laminated core 12 with the three-phase winding 13 is separated by an air gap from the laminated core 2 with the winding 1. The rotating field induces voltages in the three-phase winding 1 with the frequency f2 = p2(n1 + n2)/60 = (p1 + p2)n1/60. The value of the voltage induced in winding 1 is proportional to the sum of the speeds n1 + n2. In the case of p1 = p2, the frequency f2 of the voltage at the output of the frequency transformer doubles in relation to the frequency f1 of the synchronous generator. This is the case of the frequency doubler, while the voltage at the output of the frequency transformer depends on both the sum of speeds n1 + n2 and the transformer ratio. In the case of a unitary ratio, the voltage also doubles compared to the voltage of the synchronous generator.

In the case of a 4-pole synchronous generator and a 4-pole frequency doubler, the machine's rotor must be driven at 750 rpm to obtain an output frequency of 50 Hz. This is half the speed at which the rotor of the standard synchronous generator should be driven in order to obtain the voltage of the same frequency. Depending on the speed required, you can save on a mechanical transmission or install a transmission with a lower ratio and therefore higher efficiency. This is important in the case of low-speed drives, e.g. wind power turbines.

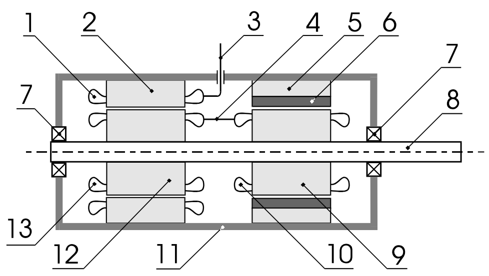

Fig. 1. Electric generator - variant with a synchronous generator, where: 1 - three-phase stator winding of the frequency transformer placed in slots, 2 - laminated stator core of the frequency converter, 3 - power cables, 4 - connecting cables, 5 - solid stator core of the synchronous generator 6 – permanent magnet fixed to the rotor of the synchronous generator, 7 – generator shaft bearings, 8 – generator shaft, 9 - laminated generator rotor core, 10 – three-phase generator armature winding embedded in slots, 11 – generator body, 12 – laminated rotor core of the frequency transformer, 13 – frequency transformer rotor's three-phase winding placed in slots

By replacing the electric generator with an internal frequency transformer, which is the subject of the invention, with two electric machines, optimal operation of the electric generator thus formed cannot be achieved due to the significant disadvantages of its construction, in particular: greater volume and weight, higher costs and greater complexity of construction and more frequent maintenance. In the present invention, for example, there are no slip rings and brushes that complicate the design, wear out relatively quickly and require frequent maintenance.

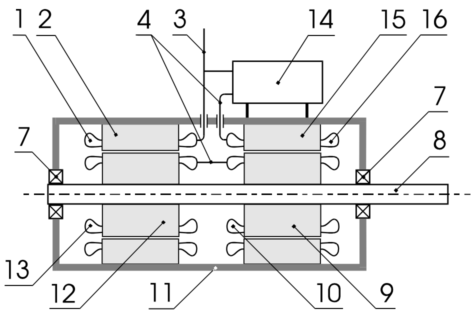

Fig. 2. Electric generator - variant with an asynchronous generator, where: 1, ..., 13 - as in Fig. 1, additionally: 14 – electronic frequency converter, 15 - laminated stator core of an asynchronous generator, 16 - three-phase stator winding of an asynchronous generator

The asynchronous generator (Fig. 2) consists of a laminated rotor core 9 mounted on the shaft 8, a three-phase rotor winding 10, a laminated stator core 15 mounted in the machine body 11, and a three-phase stator winding 16 fed from the frequency converter 14 . The internal frequency transformer consists of a laminated core 2 fixed in the stator, a three-phase stator winding 1, a laminated core 12 mounted on the rotor shaft 8 and a three-phase rotor winding 13 .

The laminated rotor core 9 is separated by an air gap from the laminated stator core 15. In the three-phase winding 10, rotating in a rotating magnetic field excited by the winding 16 supplied from the frequency converter 14, voltages with the frequency $f_1 = p_1n_1/60 \pm f_{inv}$ are induced, where n_1 – rotational speed of the machine shaft 8, p_1 – number of pole pairs of the asynchronous generator, f_{inv} – generator supply frequency from the frequency converter. The value of the voltage induced in the winding 10 is proportional to the frequency f_1. The three-phase winding 10 is electrically connected by three connecting wires 4 to the three-phase winding 13. The voltage from the three-phase winding 10 is supplied through these wires to the three-phase winding 13, which generates a magnetic field rotating relative to the stator at a speed of $n_1 \pm 60f_{inv}/p_1 + n_2$, where n_2 - field rotation speed relative to the shaft, $n_2 = 60f_1/p_2$, p_2 – number of pole pairs of the frequency transformer. The laminated core 12 with the three-phase winding 13 is separated by an air gap from the laminated core 2 with the winding 1. The rotating field induces in the three-phase winding 1 voltages with the frequency $f_2 = f_1(1 + p_2/p_1)$. The value of the voltage induced in winding 1 is proportional to the frequency f_2. In the case of $p_1 = p_2$, the frequency f_2 of the output voltage of the frequency transformer doubles in relation to the frequency f_1 of the asynchronous generator. This is the case of the frequency doubler, and the voltage at the output of the frequency doubler depends on both the frequency f_2 and transformer ratio. In the case of a unitary ratio, the voltage also doubles in relation to the voltage of the asynchronous generator.

The induction generator (Fig. 3) consists of a laminated rotor core 9 mounted on the shaft 8, a three-phase rotor winding 10 , a laminated stator core 17 embedded in the machine body 11, and a squirrel-cage winding 18 . The internal frequency transformer consists of a laminated core 2 embedded in the stator, a three-phase stator winding 1, a laminated core 12 mounted on the rotor shaft 8, and a three-phase rotor winding 13.

The laminated rotor core 9 is separated by an air gap from the laminated stator core 17. In the three-phase winding 10, rotating in a rotating magnetic field excited by this winding and supplied from the winding 13, voltages with the frequency $f_1 = p_1n_1/60(1 + s)$ are induced, where n_1 – rotational speed of the machine shaft 8, p_1 – number of pole pairs of the induction generator, s – slip. The value of the voltage induced in the winding 10 is proportional to the frequency f_1. Simultaneously, due to the action of the same rotating field, voltages are induced and currents flow in the closed circuits of the squirrel-cage winding 18, which generates its own rotating field. As a result of the action of the magnetic fields, an electromagnetic torque is produced which counteracts the drive torque applied to the shaft 8 of the machine. The three-phase winding 10 is electrically connected by three connecting wires 4 to the three-phase winding 13. The voltage from the three-phase winding 10 is applied through these wires to the three-phase winding 13, which generates a magnetic field rotating relative to the stator at a speed $n_1/(1 + s) + n_2$, where n_2 – field rotation speed relative to the shaft, $n_2 = 60f_1/p_2$, p_2 – number of pole pairs of the frequency transformer. The laminated core 12 with the three-phase winding 13 is separated by an air gap from the laminated core 2 with the winding 1. The rotating field induces in the three-phase winding 1 voltages with the frequency $f_2 = f_1(1 + p_2/p_1)$. The value of the voltage induced in winding 1 is proportional to the frequency f_2. In the case of $p_1 = p_2$, the frequency f_2 of the voltage at the output of the frequency transformer doubles in relation to the frequency f_1 of the induction generator. This is the case of the frequency doubler, and the voltage at the output of the frequency doubler depends on both the frequency f_2 and transformer ratio. In the case of a unitary ratio, the voltage also doubles compared to the voltage of the induction generator.

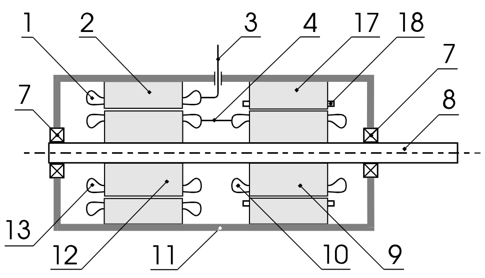

Fig. 3. Electric generator - variant with a squirrel-cage induction generator, where: 1, ..., 13 - as in Fig. 1, additionally: 17 - laminated stator core of the induction generator, 18 - squirrel-cage winding of the induction generator