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DEVELOPMENT OF SYNCHRONOUS GENERATOR PROTECTION METHOD AGAINST TURN-TO-TURN SHORT CIRCUIT ROTOR WINDING

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Introduction. A synchronous generator turn-to-turn short circuit rotor winding is common [1] and difficult to control [2]. Detection of turn-to-turn short circuit, using standard equipment, is a challenging task due to a number of reasons. Methods, based on turbine generator internal and applied magnetic field analysis, are considered promising, because there is a symmetric configuration of magnetic field in the air gap, iron and around the iron. This configuration is directly-proportional to turbine generator rotor winding technical state.

A magnetic field sensor setting is necessary to control turn-to-turn short circuit rotor winding based on magnetic field symmetry analysis. A rating of spatial pattern magnitude of disturbance is more important than magnetic field components magnitude for relay protection objects. It means that it is necessary to rate the current poles field changes relative to each other.

A new method for protection of a synchronous generator turn-to-turn short circuit rotor winding, based on the unipolar signal analysis, which is obtained from the magnetic stray field sensor output, is suggested. A device for this method implementation was developed and tested. In addition, protection values were set.

Problem statement: to receive the turn-to-turn short circuit rotor winding characteristic, to develop the method and protection device based on dispersion field magnetic sensor installed in the synchronous generator end zone.

The experimental data. *Fig. 1* shows the EMF experimental waveforms from the induction sensor output installed in the synchronous generator end zone with 30% short-circuit breaking coils in one out of two no-load (*Fig. 1.a*) and on-load poles (*Fig. 1.b*).

The waveform with the availability turn-to-turn short circuit marks Curve 1, the waveform without it - Curve 2.It is obvious that positive and negative EMF half-waves are not symmetrical when coupling to one rotor pole. These half-waves are different in amplitude and in form. Therefore, positive and negative EMF half-waves discrepancy in the induction sensor output may serve as turn-to-turn short circuit sign.

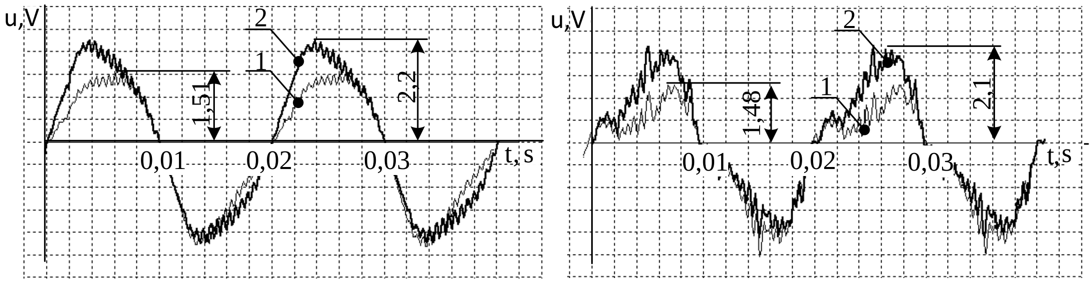

Fig.1 EMF experimental waveforms from the induction sensor output
a –the idle (open-circuit); b – under the nominal load

The protection method. The EMF asymmetry value from the induction sensor output is necessary to find the turn-to-turn short circuit rotor winding. The EMF is provided to convert the unipolar electric signal. If one of the poles turns part abridges, MMF and consequently field density will decrease in the end zone. Then one of the 2 p half-waves will be smaller value in the unipolar electric signal under each complete rotor rotation. The harmonic quantity with f_v=f_s/p frequency, where in f_s is line frequency, is turning up under the response analysis. At that, f_v value is equal to the asymmetry value which is proportional to coupled pole rotor turns number. If f_v value is higher than set value, the rotor winding damage signal or the synchronous generator disconnection from network is formed.

The device. For the method realization, there was designed a device which block scheme (structure) is shown in *Fig.2*. The block scheme includes: S – sensor; R1, R2 – blocks of the unipolar signal shaping (rectifiers); HPF – high-pass filter for the constant component suppression in the unipolar signal; LPF1 – low-pass filter for the periodic component isolation by; LPF2 – low-pass filter for the input signal magnitude formation on Schmitt trigger; LPF3 – low-pass filter forming the reference voltage (set point); ST – non-inverting Schmitt trigger.

If a synchronous generator rotor winding has a damage, the signal from S after R1 contains a useful signal in the form of subfrequency, ripple frequency and dc component which is necessary to be suppressed. The dc component after R1 is used as the ST base voltage because it is balanced to the signal from S. The set values can specify changing the gain on LPF3.

The subfrequency isolation is made by the analog band-pass filter, which consists of HPF and LPF1. The asymmetric band-pass filter was used because of decibel-log frequency characteristic distance on the frequency axis was a single octave.

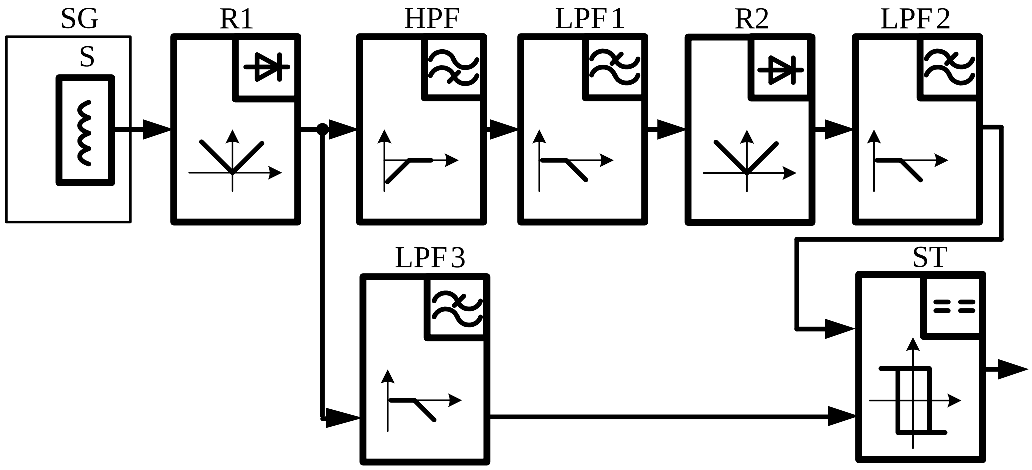

Fig.2 The structure of the relay protection device

The test signal, wherein the half-waves asymmetry (4%) was created, was modeled for the device setting. The ST functioning was tuned on the reference voltage 0,9U_{fv} set value under the 4% half-waves asymmetry.

After tuning by the test signal the device was tested on the experimental synchronous generator. The device detected of short-circuit of coils in winding under the 4% pole's coil short circuit accurately. Besides there were no deceptive actuation during power surge and drop modes, initiation, non-symmetrical phases loading, earth fault in the one excitation circuit point and earth fault of stator's phase. The device actuation is restarted in 3-phase short-circuit mode on the outputs of synchronous generator, which should be switched off immediately by its protection system. Introduction of the time setup would except the deceptive performance of the developed protection.

Conclusion

1. The synchronous generator turn-to-turn short circuit rotor winding causes a disturbance of the stray magnetic fields symmetry. The turn-to-turn short circuit can be diagnosed by a specialized sensor measuring.

2. The EMF conversion from the sensor output in a unipolar signal, followed by the separation of the subfrequency equal to the rotor frequency allows to determine turn-to-turn short circuit rotor winding.

3. The experiments have shown the developed device is able to determine the closure of the synchronous generator 4% rotor windings.

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SMART METER

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First, let's talk about the main disadvantages of the traditional meters. Traditional meters measure the total amount of consumed electricity and do not provide information about what happened when consumption was. With the transition from state regulation to market relations in the field of electric power production and other community resources, government inspection have looked for a means to match consumption and production of electricity and other resources. One of these solutions became the smart meters.

A smart meter is usually an electronic device that records consumption of electric energy in intervals of an hour or less and communicates that information at least daily back to the utility for monitoring and billing purposes. Smart meters enable two-way communication between the meter and the central system. Unlike home energy monitors, smart meters can gather data for remote reporting. Such an advanced metering infrastructure differs from