RESEARCH OF PSCAD SOFTWARE SYSTEM OPPORTUNITIES FOR ADEQUATE SIMULATION OF AUTOMATIC VOLTAGE REGULATORS WITH FORCED CONTROL OF SYNCHRONOUS GENERATORS

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Introduction

The basis of this work is the research of automatic excitation regulators with forced control (AER FC). The distinctive features of AER FC is that it responds to change several regime settings and their derivatives, has large gain ratio and high speed, and also used on generators with high-speed excitation systems – thyristor or ion [1]. For excitation control are generally used the following parameters:

1. the value and the rate of change of voltage fluctuation;
2. the value and the rate of change of frequency fluctuation;
3. the rate of change of the excitation current.

Taking into consideration the value and first derivative of the change regime settings allows to predict the trend of the process and to provide the best impact on the excitation system in the beginning of regime changes.

Description of mathematical models of AER FC

The basis of the research is the mathematical model of AER FC, present in [2]. As mentioned earlier, AER FC is used on generators with thyristor excitation system. The AER model that was simulated in the software package PSCAD is shown in Fig. 1.

This scheme corresponds to one of the latest versions of AER FC. The measured signals ΔU, ΔU\`, $\Delta f$, $\Delta f$ \` and i_{ex}\` are enhanced with gain ratio k_{0U}, k_{1U}, k_{0f}, k_{1f} and k_{1iex} respectively, and are provided to the summator with transfer function $W_{\Sigma}(p)$. In the end, the resulting signal AER (E_{qe}) is provided to the input of the exciter.

Also in this article was used blocks of independent thyristor excitation system (ST1A) and system stabilizer (PSS1A & DEC1A) which are included in the software package PSCAD and presented their mathematical models, conforming to standards IEEE [3], because the IEEE model of AER from the library of PSCAD does not contain the frequency channel, so for opportunity to compare Russian and IEEE models is required the same controlled value.

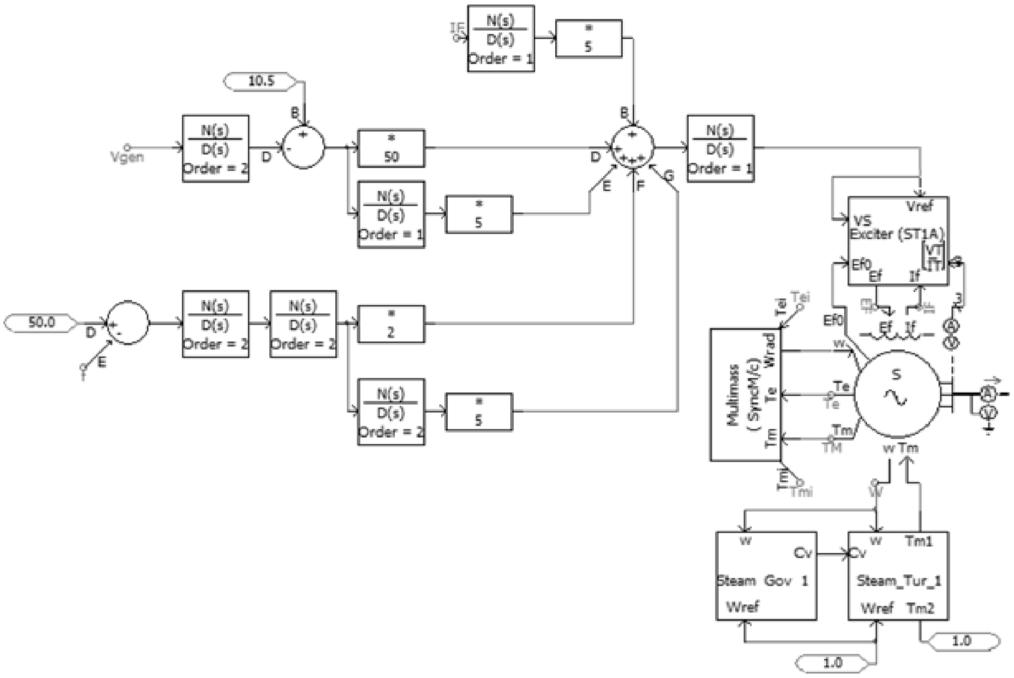

Fig. 1. The model of Russian AER FC simulated in the software package PSCAD

Research of AER FC models

The basic scheme for research was part of the power district of the Tomsk region. As the research of engineered Russian and IEEE AER FC models was used the generator with rated power 200 MW, located on the thermal power plant («TPP-3»).

As a check of the correct operation of the AER FC simulated in PSCAD program were used test disturbances, according to the standard «SO UPS» [1]. In this sheet, the check is performed by the following disturbances:

1. two-phase short circuit (duration 0.5 s) on bus of power station where installed test generator, and unsuccessful auto-reclosing of one of the lines connecting «TPP-3» and the other substation, leading to loss of dynamic stability of power system;
2. emergency load shedding in power system – disconnection of the load on buses 110 kV «TPP-3», leading to increase in frequency of the network.

The results of these researches are shown in Fig. 2. From the resulting oscillograms in Fig. 2 for the first disturbance, could be said that in both cases AER systems are forcing the excitation of the synchronous generator to maintain the nominal voltage at the generator terminals, however, due to the resulting power unbalance value of voltage is somewhat reduced. Also there are differences in the values of excitation current and voltage, which is associated with different imposed limits – the Russian model provides a short-term doubling of the excitation current and the maximum voltage increase up to $2U_{f*}$; while the IEEE model has limitations to $6.4U_{f*}$ and has no limits on the excitation current. For the second disturbance (Fig. 2) it could be said that in both cases occurs blocking of the stabilization channels due to emergency load shedding and increase in frequency to 50.12 Hz – there are short-term fluctuations in excitation voltage and current, which returned to the nominal values after a short time, i.e. the automatic excitation regulators does not interfere in this regime, because in this case should work automatic regulation of frequency and active power.

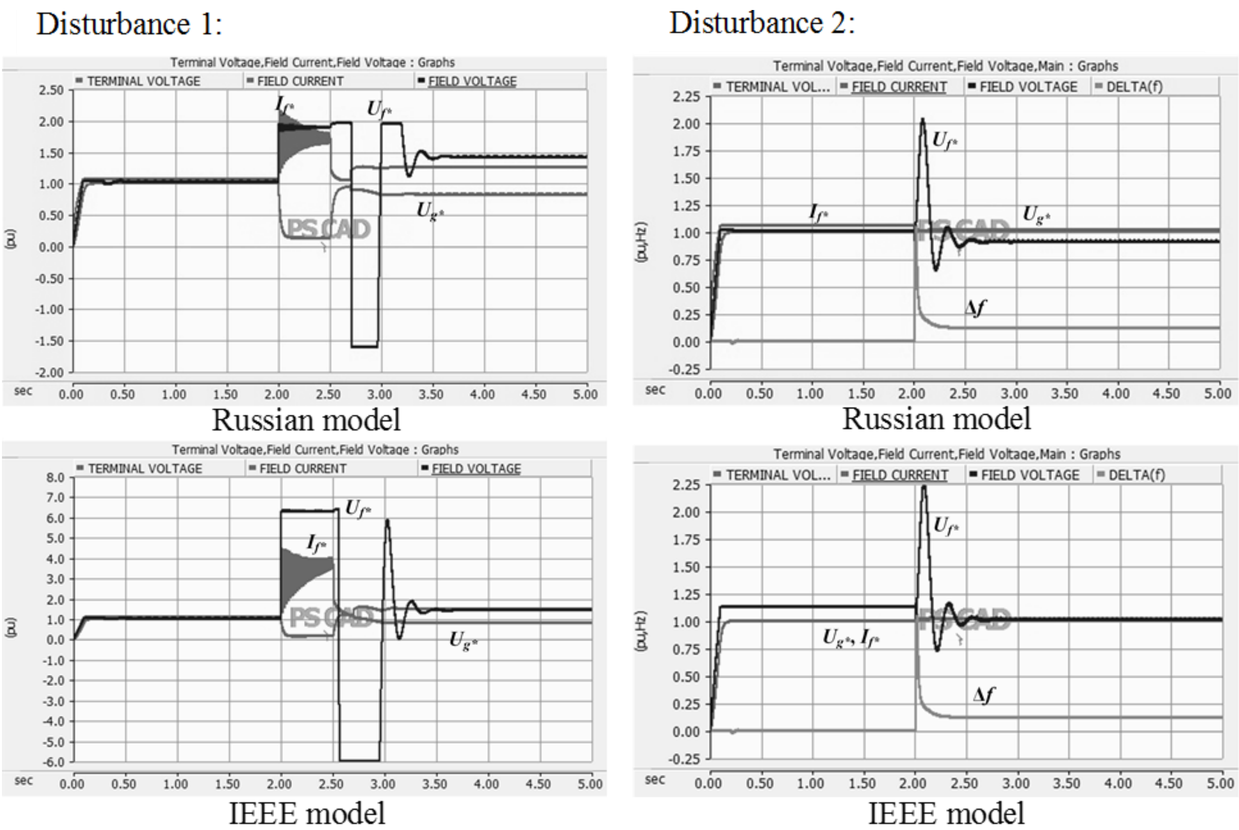

Fig. 3. Oscillograms of Russian and IEEE simulated models of AER FC

Also in this work was researched another disturbance – single-phase short circuit (duration 0.03 s) on buses of power station where installed test generator «TPP-3» (buses 110 kV). In this experiment the decay time of the electromechanical transients should be reduced when the stabilization channels or power system stabilizer are activated in comparison with the time and amplitude of damping when they are disabled. From the research results it can be said that in the presence of stabilization channels or power system stabilizer resulting oscillations at single-phase short circuit damped faster (≈ 0.5 sec) after the short-circuit turning-off than in their absence.

Conclusion

As a result of the work, there was simulated an adequate Russian and IEEE models of AER FC of synchronous generator in the software package PSCAD and also the influence of regulator parameters on the operation of the generator upon the occurrence of disturbances was reviewed. The differences in the systems of Russian and IEEE developments AER was determined – one of the main differences is in the gain ratio of excitation current and voltage, while both models maintain the nominal voltage at the terminals of the generator and work correctly, according to the specified parameters; the second important difference is the implementation of this automation models – Russian model contains channels for the analysis of frequency change in power system that makes it easier to create a model of AER, while when working with foreign analogues it is necessary to use an additional unit in the form of system stabilizer PSS to ensure the algorithm of the AER FC, which leads to additional complication of the circuit, to increase the error margin of the regime analysis and to reduce high-speed performance.

This work contributed to the consolidation and acquisition of practical skills in configuring of automatic devices. The synthesized model allows to accurately analyze the performance of the automatic excitation regulators, that is especially actual in connection with appearance of new devices in the power system, such as flexible alternating current transmission systems (FACTS), high voltage direct current (HVDC) devices, etc., that can have an impact on the parameters of the power system as a whole. Using the PSCAD program allows for detailed modeling of the elements of the power system, including Russian model of AER FC, which, in turn, allows to identify errors in the design of new facilities of the electrical network and takes steps to eliminate them.

Acknowledgment:

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