POWER ELECTRIC SYSTEM TRANSIENT SIMULATION USING MATLAB-SIMULINK

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ABSTRACT

This paper deals with using the Matlab Simulink components to solve transients in power systems in an advanced form. This means the elements of power system don't have to be simulated by effective impedances and solved like the simplified substitute circuit. Matlab-Simulink with the use of SimPowerSystems Blockset gives the utilities to simulate every element of the power system with the appropriate function block. In this work system of two machines and load is solved and described.

1 INTRODUCTION

In the power system it is important to keep required quality of electricity. This means, we have to keep constant frequency and voltage for consumption nodes. Both of this is close connected with the generator operation. The rotating speed of the alternator rotor affects the frequency in the power system and the terminal voltages regarding the network topology and loads affects the voltage in the consumption nodes. While there are some fast changes happening like faults or switching of the big loads the balance between production and consumption of electricity is corrupted. Basically this is mostly affecting the speed of rotor and this leads to changing frequency in the power system. While there is a loss of the load, rotor speed is increasing. Power system has an inertia of the transients, so it leads to difference in the rotor speed, which represents rotating speed of rotor electromagnetic field, and the rotating speed of the electromagnetic field in stator windings. If this imbalance lasts too long, the difference could grow up so much, that the magnetic coupling of the stator and rotor magnetic field could be broken. This could lead to further changes in the power system, in the worst event to power cut or blackout. That’s why it is important to solve different situations, load dropouts and faults and its effects to power system operation.

2 SITUATION DESCRIPTION

If there are two machines producing power in one system, not connected to the parent power system, these machines are “cooperating” in covering the production of electricity for consumption. In case of some fast changes in power system, these machines react due to their time constants of inertia and change their rotor speed. The differences between magnetic fields rotating speeds could be described by so-called “power angle”. If the generator stays in stable state the power angle curve steadies down after couple swings. In the other way the angle still grows up and the generator is acting as it is working without the load.

The model consist of two generators 500 MVA operating at 20 kVrms line-to-line rating voltage both working to the 570 MVA transformer, primary 20 kVrms Yg, secondary 420 kVrms D. These transformers are followed by power lines. There is a difference between power lines. One is single line, the other is double. There is a block for simulation of fault on the power line, so the line is supplemented with the breakers on both sides. This way it is possible to simulate fault and automatic reclosing. The power lines end on the bus connected to transformer 630 MVA, 430 kVrms Yg on primary side, 231kVrms Yg on secondary. After transformer there is a load S = 1000+300i MVA.

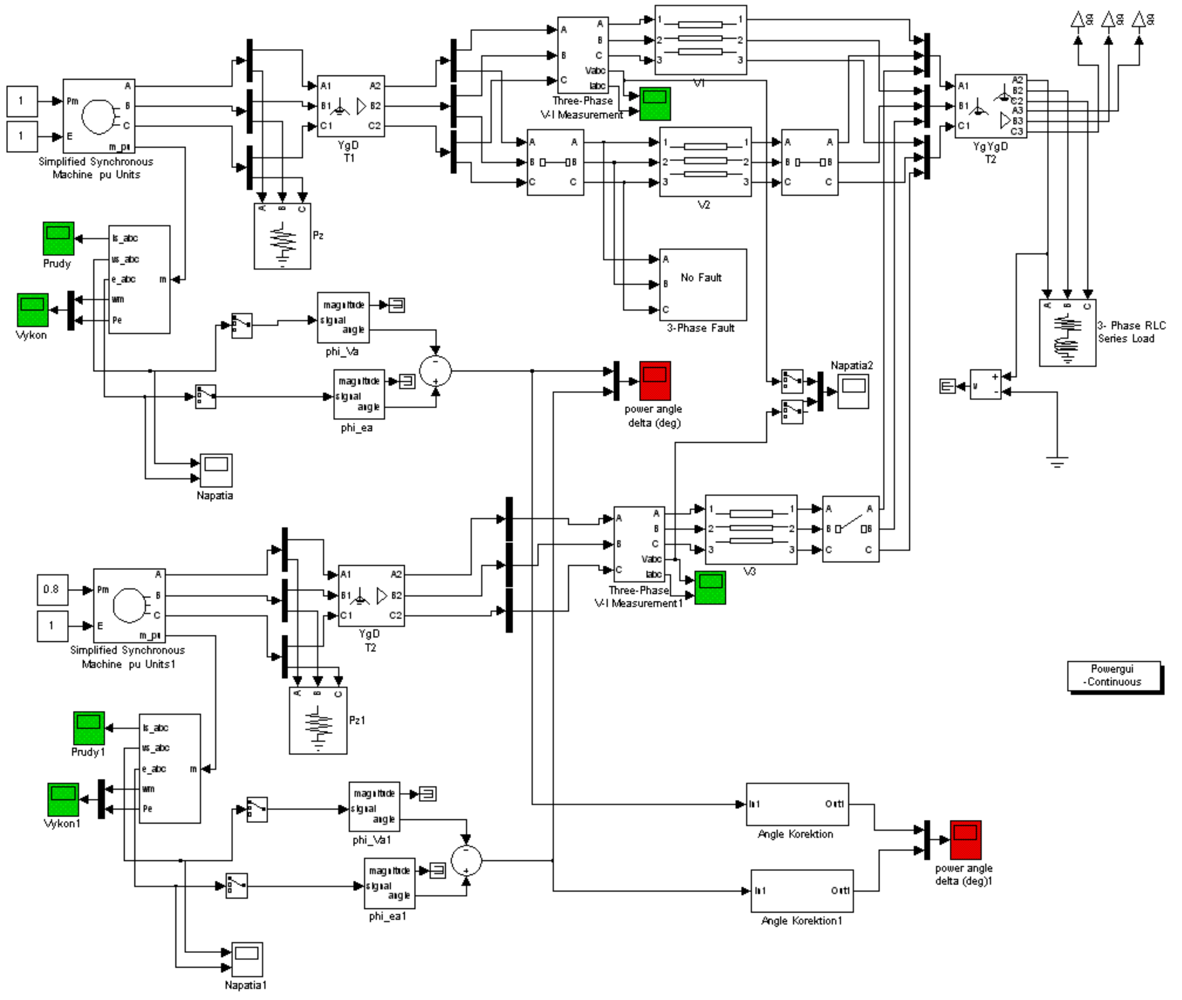

Fig. 1: *Simulation scheme*

3 POSSIBLE SIMULATIONS

There are different possibilities of simulation very easy accessible by setting up the parameters of different function blocks.

3.1 FAULT

By setting up specifications of the fault it is possible to solve, how the system is going to react on different types of faults. Block “Fault” gives the possibilities to simulate 1, 2 or 3-phase fault which could last specified time. It is possible to set up repeated faults.

3.2 FAULT AND AUTOMATIC RECLOSING

If we use the breakers at the beginning and at the end of the power line affected by fault we could simulate reaction of the automatic reclosing system, which is the most used for protecting of the aerial power lines.

3.3 DROPOUT OF THE GENERATOR

Setting up the breakers in power line two to switch off in specified time it is possible to dropout generator number 2 and solve reaction of the generator number 1 to the overload.

3.4 SIMPLE SWITCHING MANIPULATION

In some cases there appears switching off one of the parallel lines. This leads to small change in the network topology so we could solve how much this manipulation affects power system.

4 MEASURMENT AND PLOTTING

There are several ways how the important values are measured. First of all it is a regular measurement of voltage and electric current in the nodes and branches. For this purpose SimPowerSystem Blockset uses blocks “Voltage” and “current” measurement. Both types have output in number format. This could be connected to the scope with time base.

Another system of measurement is used for both generators. Generator block has multiplexed output of possible measured values like terminal voltages, terminal current, internal voltage, rotor speed, rotor deviation etc. To plot these values the “machines measurement demux” block is used. By simple selecting of required values, block changes number of outputs. Outputs are all of number type, depending on generator block type in SI or pu units. It is useful to connect them with the scope with time base.

5 EXAMPLES

It is not possible to show and describe all parameters and settings of the simulation as well as the results because of too big amount of pictures, which exceeds the length of this paper, so I’ll try to show some important results.

5.1 FAULT

Both machines are connected to the system, in one parallel line of the doubled line is 3-phase fault in time 0,6 s.The line and the fault is switched off in time 0,63 s.

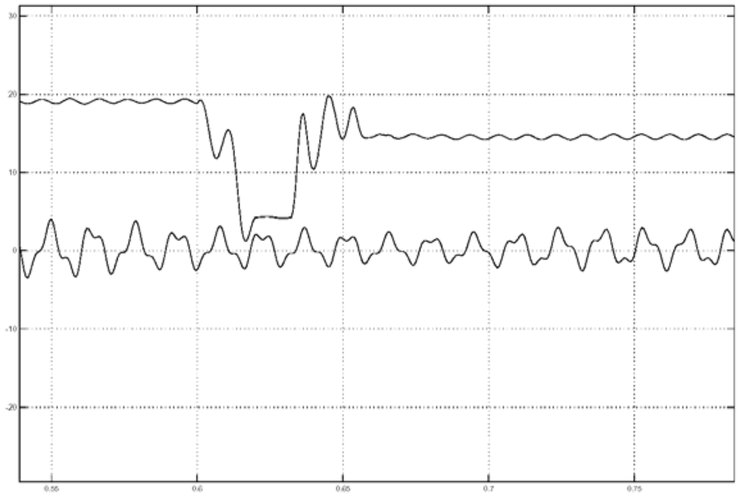

Fig. 2: *Power angle of both machines*

In this picture there are shown a few swings of the first machine power angle when the fault starts and then few swings when it is switch of with the one of parallel lines. It could be seen, that the machine steadies down in the stable state. On the other hand next picture shows, that it is not good state, because rotor speed is growing up, and it leads to the power system frequency increase.

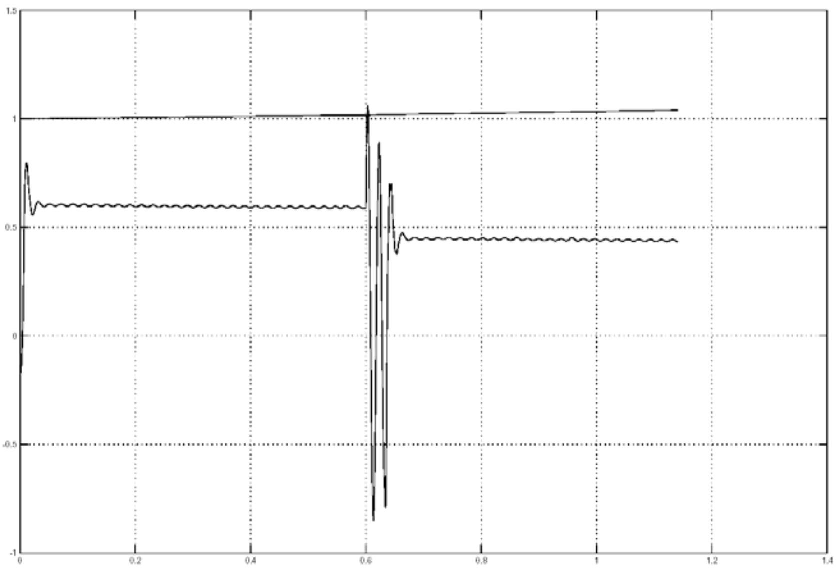

Fig. 3: *Rotor speed and power of the machine number 1*

5.2 DROPOUT OF THE MACHINE NUMBER 2

In this simulation the machine number 2 drop out in time 0,3 s. This leads to the steady state when machine number 1 steadies on the nominal frequency. Machine number 2 speeds up. Whole steady state is stable, but is not good, because the voltage in the consumption node has about 50 % rated voltage and that’s not acceptable in real power system.

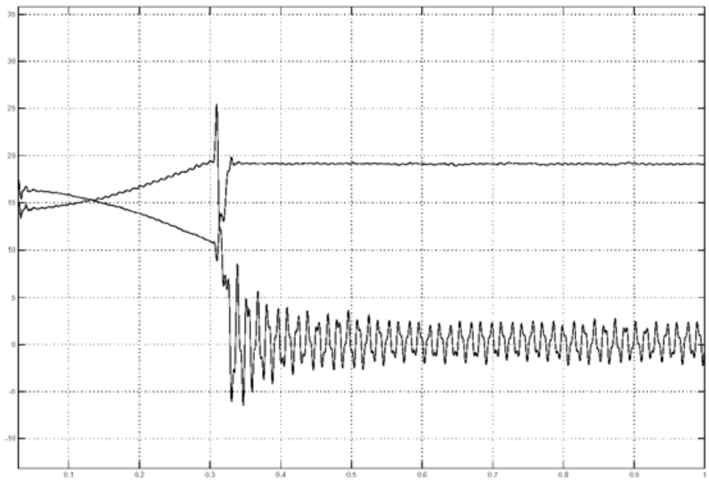

Fig. 4: *Power angle of both machines while number 2 dropout*

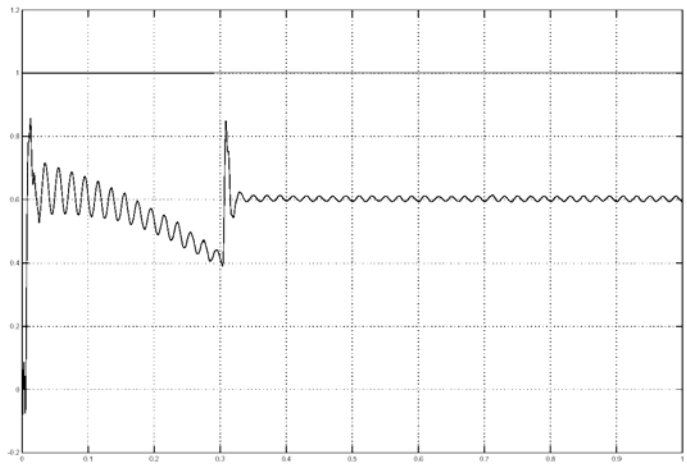

Fig. 5: *Rotor speed and power of machine1 while number 2 dropout*

REFERENCES

[1] Kolcun, M.: Riadenie prevádzky elektrizačnej sústavy, Košice, Mercury-Smékal 2001, ISBN 80-89061-57-5

[2] Haluzík, E.: Ochrany a automatiky v elektrických sítích, Brno, Ediční středisko VUT 1985

[3] Haluzík, E.: Řízení provozu elektrizačních soustav, Praha, SNTL, 1987