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SIMULATION OF MERS CIRCUIT AS PHYSICAL MODEL WITH SIMSCAPE

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Abstract: *This paper describes simulation of magnetic recovery switch in Simulink's toolbox Simscape. Magnetic energy recovery switch is electronic circuit whitch can be used for power factor correction. In the first part is explained magnetic energy recovery switch, ih the second part is described toolbox Simscape and physical modeling. Simulation of magnetic energy recovery switch is desribe at the third part*

Key words: *power factor correction, physical modeling, Simscape, power transmission*

1. INTRODUCTION

Increasing of power transmission efficiency is a one of today task at power engineering. Improving of power factor is one of way. There are some possebilities to improve power factor. Static compensator with capacitor and power factor corection circiut are using for this. Power factor circuit is usually build as active PWM rectifier. Magnetic energy recovery switch (MERS) is another way for improving of power factor.

MERS circuit consists from four semiconductor switching devices (transistor of tyristor) with free-wheeling diode (bypass diode) and capacitor. Circuit is connected in series with RL load (for example induction machine) and AC power supply (Fig.1).

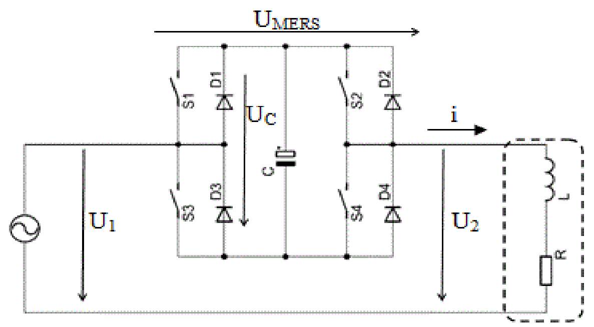

Fig. 1. MERS circuit (Huzlik, R; Ondrusek, C; Vetiska V, 2011)

For three phase network three separate MERS circuit can be used.

Toshiba started with development of MERS at 80's years. First patent was given at 1999, and until this day, this circuit is protected by many patents (Shimada, R.; Usuki, K. 2008) (Igarashi, S.; Uchida, Y.; Shimada, R. 2005).

MOS-FET transistor, IGBT transistor, GTO thyristor or IGCT thyristor can be used as a switching device.

MERS control is based on switching sequence, witch consist from four parts – on the base of switch-on transistors. This switching sequence will be explained at chapter 3.

2. SIMSCAPE AND PHYSICAL MODELING

Physical modeling approach is based on creating of simulated model from parts, which represents basic physical part of complex system. Simulation base on algebraic or differential equation is classical approach. Physical modeling approach divide model on several basic parts (for example armature resistance, armature inductance etc.) and these parts has their own models. These models are connected together and form complex model.

Simscape is one of Simulink toolbox and is preferably assigned for the simulation of multidomain systems. The software is able to deal with real physical units (amper, Newtonmeter etc.) and with circuit models which enable easier simulation of specified states such as faults. Simscape enables to connect its own blocks with Simulink blocks use transfer blocks and therefore one part of the model is able to be solved out in Simscape and the other one in Simulink. Simscape has its own programmable language for creation of new blocks.

Simscape and physical modeling can be used for example for creating of controlling system and testing of system in many different states.

3. SIMULATION OF MERS CIRCUIT

Simscape for simulation of MERS circuit was choosen for several reasons:

- Shorter time to provide simulation. Simulation based on diferential equations would be very complicated.
- Possibilities to test in-correct switching sequence.
- Possibilties to test different control algorithms on one model of MERS circuit.
- Possibilities to test various types of load.
- Possibilities to test fall state on transistors on one model of MERS

Simulation of MERS was mentioned in some article (Isobe, T.; Wiik, J.A.; Wijaya, F.D.; Inoue, K.; Usuki, K.; Kitahara, T.; Shimada, R. 2007) (Takaku, T.; Isobe, T.; Narushima, J.; Shimada, R.), but in these article wasn't not mentioned program.

Simulation was created for two models of switching device components – switch (Fig. 2) and transistor (Fig. 3). Simulation simulates mode with non-continuous current via capacity.

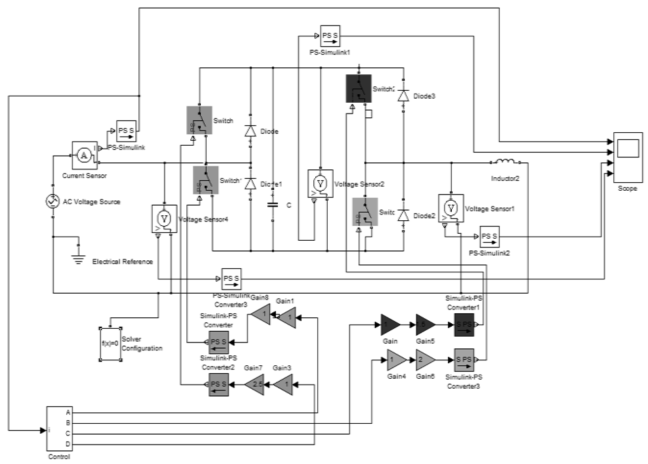

Fig. 2. SIMSCAPE model of MERS circuit with switch

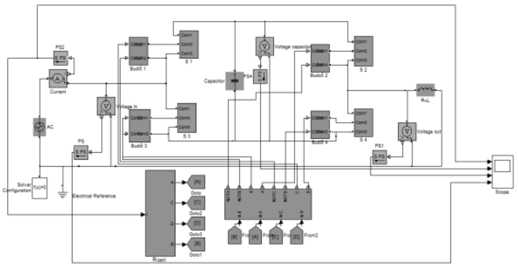

Fig. 3. SIMSCAPE model of MERS circuit with models of transistors

Results of simulation for both types of switching parts were very similar.

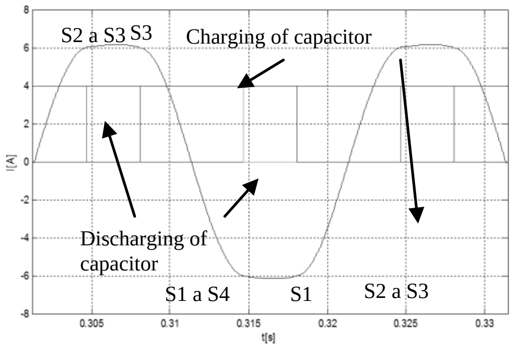

Fig. 4. Switching sequence of MERS (Huzlik, R; Ondrusek, C; Vetiska V, 2011)

Switching sequence is explained in Fig.3. Let us suppose that all switches are opened and supply voltage is connected. Capacitor is charged to maximum voltage of source. Now all switches will be closed. This state is called as double bypass. Capacitor is going to be fully discharged (Uc=0) During negative half wave, after negative maximum, the switches S2 and S3 will be switched “ON” at a given time. Capacitor is connected by its positive terminal to the load and its negative terminal is connected to the supply. Capacitor becomes to be charged via diodes D2, D3. A current cross zero and becomes positive. At a given time S3 is opened and S1 and S4 are closed. Capacitor is connected by its positive terminal to the supply and by negative terminal to load. Capacitor is charged to Uc via diodes D1 and D4. Current crosses zero and becomes negative; capacitor is discharging through switches S1, S4 which are closed. When the capacitor is discharged, S1 is opened and S4 remains closed. The current flows through S4 and D3. If the current crosses zero, the whole cycle is repeated. The above described operation is illustrated on Fig.2.

One of simulation was made for input voltage U_1=12 V RMS, inductance L=20mH, resistance R= 2Ω, capacity C=253 µF and switching level X=4A.

Fig. 5 shows capacitor voltage. The voltage is increasing due to charging and after current crossing zero capacitor is discharging and voltage is decreasing.

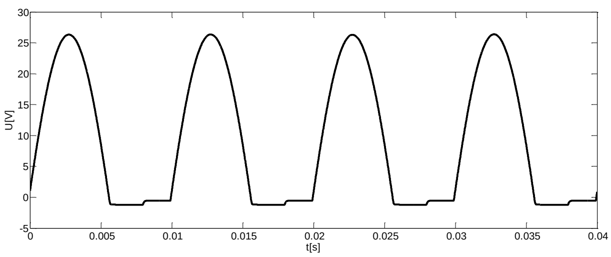

Fig. 5. Simulated waveform of capacitor’s voltage (Huzlik, R; Ondrusek, C; Vetiska V, 2011)

Fig. 6 shows waveforms of input and output voltage. MERS increases output voltage, because capacitor voltage is added to input voltage. Output voltage is quasi-sinusoidal.

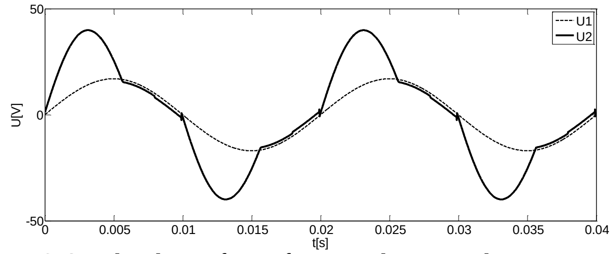

Fig. 6. Simulated waveform of input and output voltage (Huzlik, R; Ondrusek, C; Vetiska V, 2011)

Fig. 7 shows waveform of current. Current is not sinusoidal, but there is very small total harmonic distortion.

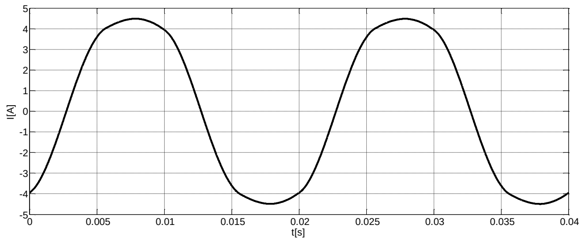

Fig. 7. Simulated waveform of current (Huzlik, R; Ondrusek, C; Vetiska V, 2011)

4. CONCLUSION

Main characteristics of magnetic energy recovery switch were described in this article. This single-phase circuit is able to correct power factor in alternating current power network. MERS characteristics were introduced and confirmed by simulation. Main problem of our experiment was controlling of MERS circuit. We are using controlling on the base of compression of current with demand value. Using of phase locked loop for controlling will be better.

5. ACKNOWLEDGEMENT

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