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Diagnosis System for Elements Power Rectifiers

The diagnosis of the electric systems is an actual item for the specialists in domain. The direction is interesting due to the multitude of the measuring points and large number of possible faults to be analyzed. The algorithms used for determining the normal/fault operation use new concepts and automatic systems as the expert systems. The proposed diagnosis system based on the analytic model investigates the output waveforms of a rectifier for two types of possible faults of the switches: interrupted and short circuit. For identifying the elements in fault, the waveforms corresponding to different faults are stored in an information database and compared with the ones corresponding to normal operation.

Keywords: Fault diagnosis, Rectifiers, Expert systems

1. Introduction

For analyzing the complex electrical systems, new concepts related to the artificial intelligence are applied. In industrial applications area, new techniques and methodologies lead to the development of the expert systems. Thanks to the decreasing of the IT costs, during the last period, the expert systems became more familiar, with large applicability as systems engineering, architecture, financial system, education etc.

In what concerns the artificial intelligence, two directions can be mentioned:

- in the field of expert systems, for diagnosis matters, robots command, inteligent use of the databases, development of intelligent programming media;
- in the field of shape recognition, understanding and voice synthesis, image processing, knowledge representation and natural language learning.

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2. Faults diagnosis methods

The faults detection and diagnosis methods can be:

- based on signals;
- based on knowledge;
- based on analytic models.

The methods based on signals select the signals which contain information and data specific to the fault operation from the multitude of the signals measured from the process. By analyzing the selected signals, possible symptoms of the faults are defined, the faults are located, the moment of occurrence and possible causes are identified [1].

For these methods, the technology based on the shape recognition is used for sorting the objects whose aspect varies from the specific objects. This operation is performed automatically thanks to the strong algorithms and methods for shape recognition developed lately.

Another direction for using the diagnosis method based on signals is by applying the neuronal networks. Difficulties occur when the analyzed signal is incomplete or it is jammed by noise. The tendency is to use the artificial neuronal networks for signals pre-processing and expert systems to be used for analyzing the information.

The methods based on knowledge are used when complex systems must be diagnosed. In these cases, the knowledge about process can be sometime incomplete. The behavior of the system is qualitatively described by using knowledge about the system grouped in rules and facts, as results of human empiric observations. For the complex systems, the qualitative models can be used for defining the relationship cause-fault-symptom by using the tree of faults concept [3].

The methods based on analytic models consist in comparing the system behavior with the results of the mathematical model which reproduce the normal operation. If the analytic model is available, this method proves to be more efficient than the methods based on signals.

For diagnosis purpose, the system model must be developed in order to analyze the fault propagation in different monitoring points. Thus, it is enough to model the system for the most probable faults. The diagnosis starts with the observation of the behavior in normal operation and continues with the analysis of the behavior in faults conditions.

The static power converters are essential equipment for adapting the type and parameters of the electric energy, placed between sources and loads. During the exploitation of the static power converters, the experience of an expert is absolutely necessary for competitive operation. Minor faults or defects of this equipment can lead to ravaging effects [2]. The effects can be propagated in the power system if the protection system does not operate properly.

3. Possible faults of a controlled three phase rectifier and their simulation

Using Simulink of Matlab® has been developed the model of a phase controlled three phase rectifier (Fig. 1) [4].

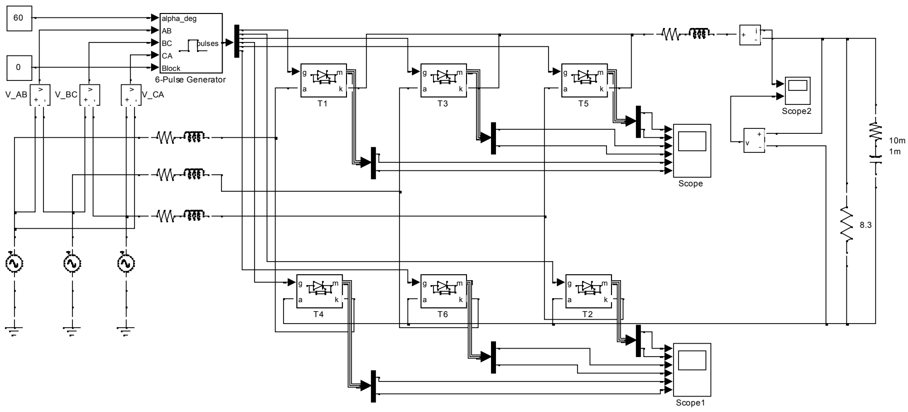


Figure 1. The Simulink model of the phase controlled three phase rectifier.

The proposed diagnosis system based on the analytic model investigates the output waveforms of a rectifier for two types of possible faults of the switches: interrupted and short circuit.

For the beginning, the fault consisting in interruption of one device, T_4, is analyzed and the consequences of this fault on the other switches and on the rectifier operation.

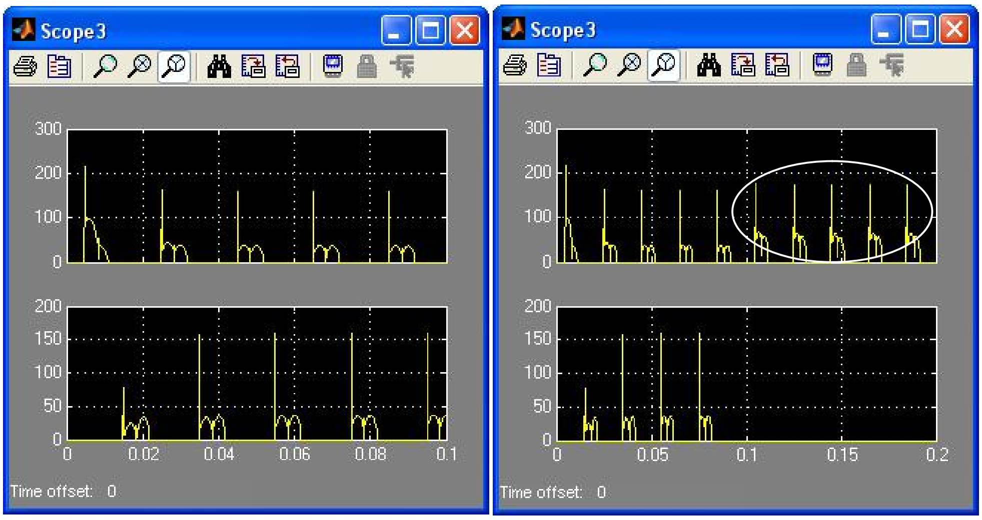
By using the model in Fig. 1, in Fig. 2 are plotted the waveforms of the devices currents corresponding to the leg in fault (T_1 and T_4).

Fig. 2.a plots the waveforms for normal operation and Fig. 2.b when the T_4 is interrupted at the instant 0.1 s. An increasing of the current in the health switch (T1) is noticed.

Fig. 3 plots the output current and voltage waveforms: Fig. 3.a for normal operation and Fig. 3.b for fault operation (T_4 interrupted at 0.1s). Important oscillations occur, both in current and in voltage.

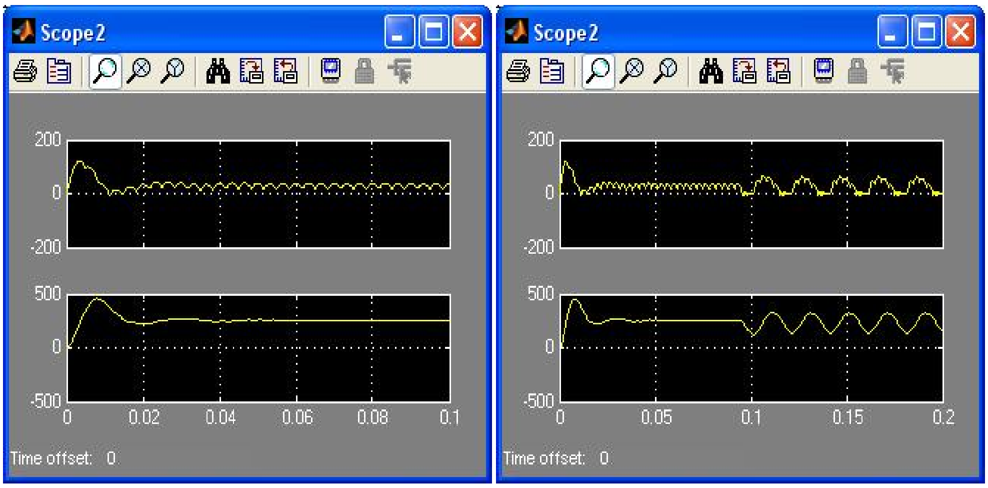
Following the short circuit of the T_4 switch and its consequences on the other switches and on the rectifier will be analyzed.

Fig. 4 plots the currents waveforms of the devices corresponding to the leg in fault (T_1 and T_4) when the T_4 is short circuited at the instant 0.1 s. On the right hand it is a zoom after the fault occurrences.



a) b)

Figure 2. Currents flowing in T_1 and T_4.



a) b)

Figure 3. Output current and voltage.

Comparing with Fig. 2.a, which corresponds to the normal operation, after the fault occurrence (instant 0.1s), the waveforms change significantly for the both switches. On one hand the current in T_4 changes the waveform and on the other hand, T_1 seems that doesn't conduct anymore. The cause is the fact that the firing pulses find T_1 reverse polarized due to the changes of the voltage applied. Practically, all the time T_1 rests reverse polarized.

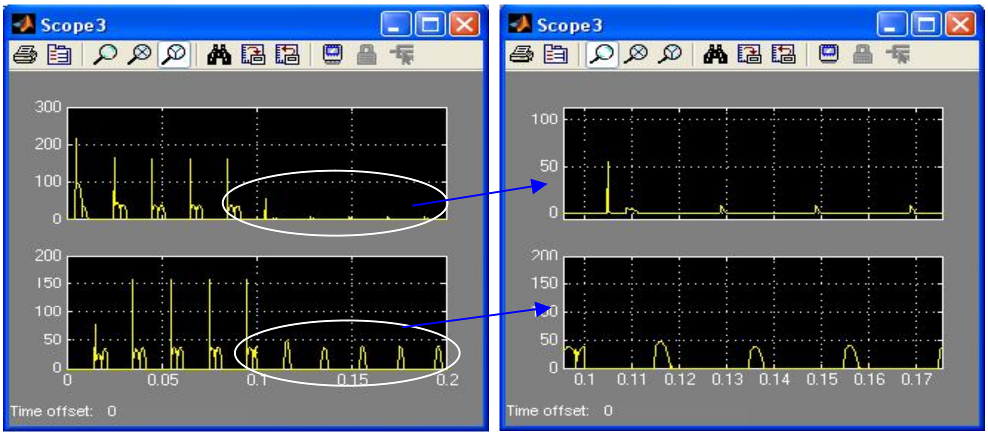
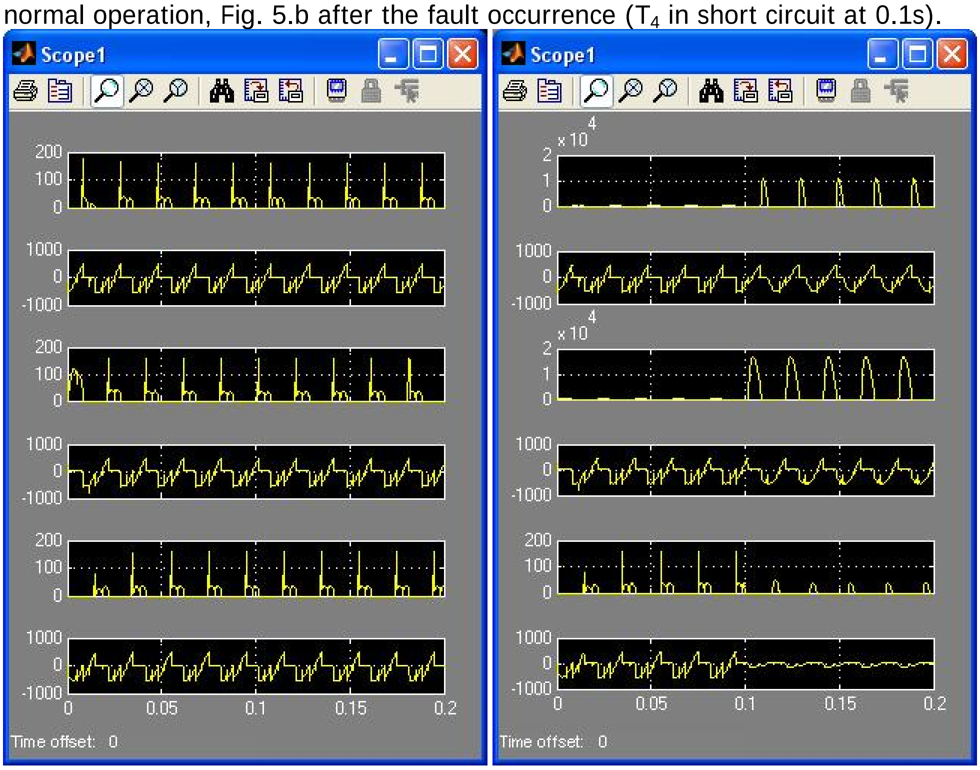


Figure 4. Currents flowing in T_1 and T_4 with T_4 in short circuit

Fig. 5 plots the voltages and currents which flow in the switches on the same side of the bridge with the switch in fault (T_4, T_2 and T_6 respectively): Fig. 5.a for normal operation, Fig. 5.b after the fault occurrence (T_4 in short circuit at 0.1s).



a) b)

Figure 5. Currents and voltages corresponding to T_2, T_6 and T_4 respectively.

A significant increasing of the current through the health switches (T_2, T_6) is noticed after the fault occurrence (T_4 in short circuit).

Fig. 6 plots the voltages and currents which flow in the switches on the health side of the rectifier (T_5, T_3 and T_1 respectively). After the fault occurrence, the current through T_3 increases significantly.

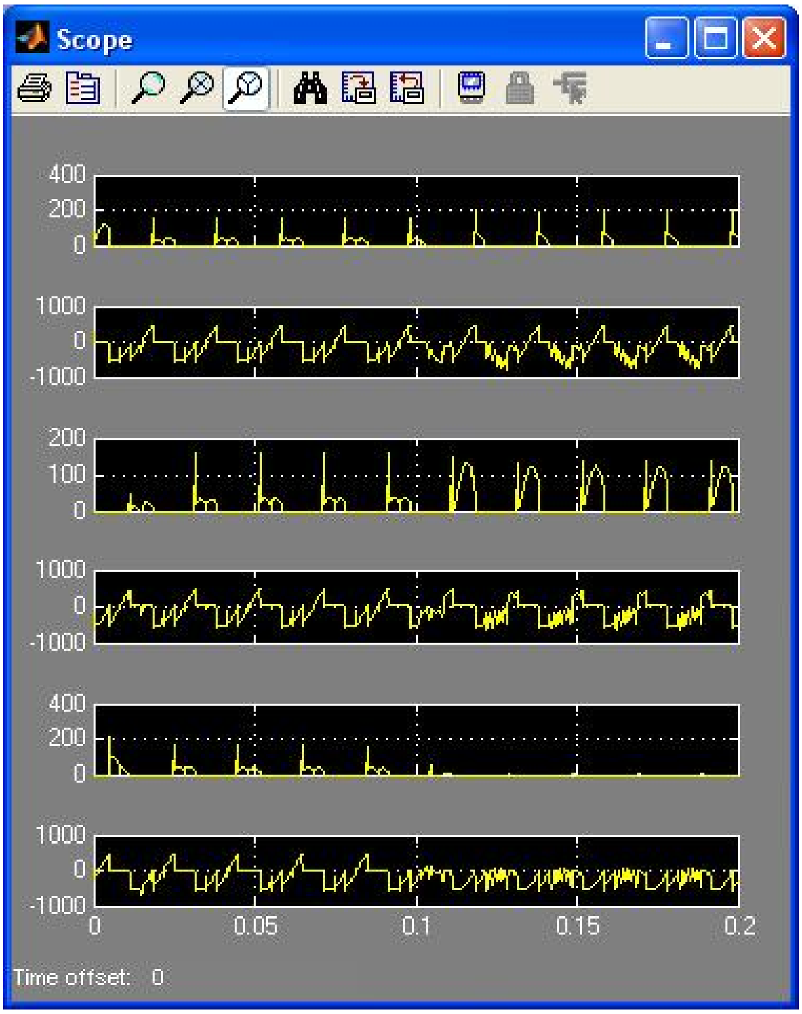


Figure 6. Currents and voltages corresponding to T_5, T_3 and T_1 respectively.

For this fault (T_4 shorted), Fig. 7 plots the output current and voltage after the fault occurrence. Important oscillations of the output voltage occur, dangerous for the load.

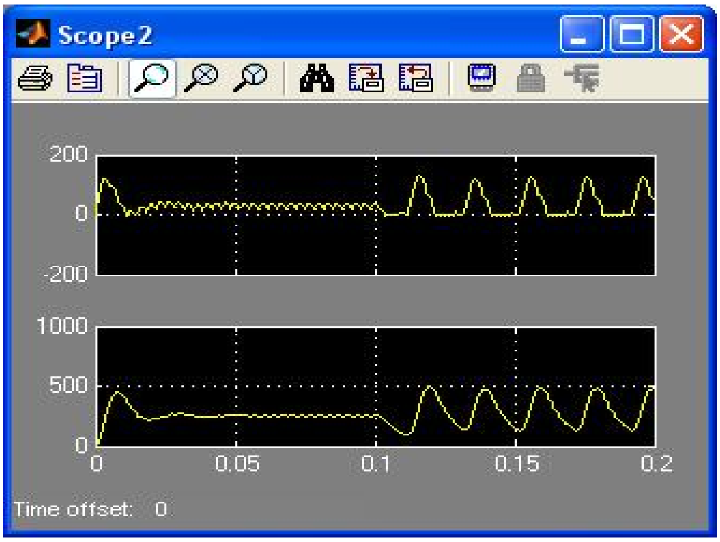


Figure 7. Output current and voltage with T_4 shorted (0.1s)

4. Conclusion

The paper presents the basis of a monitoring, control and diagnosis system of the switches within a controlled rectifier by using the analytic models method.

The diagnosis system should analyze the output waveforms resulted for two types of faults: interrupted switch and in short circuit respectively.

For the both types of faults, important oscillations of the output voltage are noticed which can damage the load, but also determine additional stress of the health switches.

The study can be detailed for different types of loads.

For identifying the elements in fault, the waveforms corresponding to different faults can be stored in an information database and compared with the ones corresponding to normal operation.

References

[1] Patterson D.W., Introduction to Artificial Intelligence and Expert Systems, Prentice-Hall International, 1999.

[2] Ivanov V., Brojboiu M., Ivanov S., Experimental System for Monitoring and Diagnosis of a Static Power Converter, Advances in Electrical and Computer Engineering, Vol.13, No.2, 2013, 113-120.

[3] Ivanov V., Brojboiu M., Ivanov S., Diagnosis System for Power Rectifiers Using the Tree of Faults Method, Annals of the University of Craiova, Serie Electrical Engineering, nr.36, 2012, 350-354.
[4] Ivanov S., Modelare si simulare - sisteme electromecanice si procese de mediu, Editura UNIVERSITARIA, Craiova, 2007.

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