EXPERT SYSTEM FOR POWER RECTIFIERS DIAGNOSIS

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***Abstract* – In designing of the static power converters, the experience of an expert is absolutely necessary in order to obtain a competitive solution.**
The evolution of the CAD methods has brought in the last time expert systems which contain artificial intelligence modules.
This paper deals with an expert system dedicated to the diagnosis of an uncontrolled bridge rectifier. This system dedicated to the functional testing and diagnosis of bridge rectifiers was developed based on the effects noticed during the operation, respectively anomalous behaviors and the faults which determine these. The expert system was developed by using the CLIPS 6.0 language (C Language Integrated Production System). The inference mechanism was developed by using the faults tree method applied to the bridge rectifier. The corresponding database is comprehensive and takes into account the most frequent faults specific to the power semiconductor devices. The paper presents at the end the results and the conclusions which follow the execution of the expert system algorithm. The diagnosis system of the bridge rectifier analyses and identifies the causes of the faults which occur during the operation and reduces the displayed results if two sets of values of the sources which determine the same answer, differ by a single input.

***Keywords*:** *expert system, diagnosis, diodes bridge rectifier*

1. INTRODUCTION

An expert system is a program which uses knowledge and inference procedures for solving quite difficult problems which normally require a human expert for finding the solution. On brief, the expert systems are software which stores dedicated knowledge programmed by the experts for solving problems difficult to be revealed manually.

1.1. Characteristics of the expert systems

The expert systems are often used when there are not available clear algorithmic solutions. The main characteristic is the presence of a knowledge database together with a searching algorithm proper with the reasoning type.
Often, the knowledge database is quite large. For this reason it is very important the way how the knowledge is represented.
The knowledge database must be separated by the software which at its turn must be as stable as possible.
The operations of these systems are then controlled by a simple procedure whose nature depends by the knowledge nature.
As different artificial intelligence software, when other techniques are not available, the searching method is used. The different expert systems differ from this point of view [1].

1.2. Structure of an expert system

The systems based on knowledge can be applied for any area of knowledge. Expert systems must contain three main modules [2]:
a) The knowledge database is done from the sum of specific knowledge specified by the human expert. The knowledge loaded here is mainly the description of the objects and of the relations between them.
b) The inference devices consist in the sum of the algorithms for determining solutions for the expertise problems, similarly to the human expert.
c) The base of facts (Factual knowledge) contains a dynamic collection of information which changes itself during the call of the expert system. It depends on the practical expertise problem.
Besides these modules, an expert system contains also several modules which offer the ability to communicate with the user and the human expert.
The user interface is the one which performs the dialogue between the user and the system, by using a quasi-natural language. It generally contains the systems of menus and the graphical user interfaces specific to the men-machine communication.
Knowledge acquisition module performs the task of acquiring the specialized knowledge offered by the human expert or by the knowledge engineer. It verifies the validity of the knowledge and generates a knowledge base specific to the expert system.
Explanations module allows tracing the way followed during the ration activity by the expert system. It outputs arguments for the resulted solutions.

2. EXPERT SYSTEM FOR DIAGNOSIS OF A DIODE BRIDGE RECTIFIER

An expert system for static power converters diagnosis and functional testing is developed starting

from the anomalous behaviors, noticed during the operation, and the faults which determine these.
The notion of "fault" of a certain device has a different significance if the fault is analyzed taking into account the effects of the fault on the other components of the system. Therewith, a complete fault of device within a bridge rectifier can be the cause of a partial fault of the subsystem which contains the device.
As example, is considered the diode bridge rectifier whose functional scheme is depicted in Fig. 1.

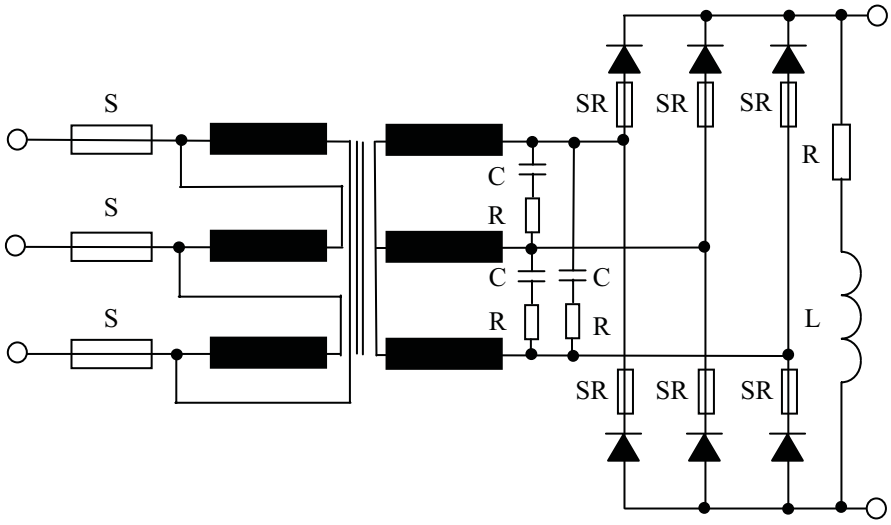

Figure 1: Functional scheme of a diodes bridge rectifier

The expert system used for the diagnosis of the analyzed system is based on the faults tree method.
This method implies to fulfill several steps, as follows: defining the analyzed system (Fig. 1); the development of the faults tree of the system; quantitative evaluation of the faults tree.
For the proposed system, diodes bridge rectifier respectively, the different faults and their possible causes are analyzed [3], as are presented in Fig. 2.

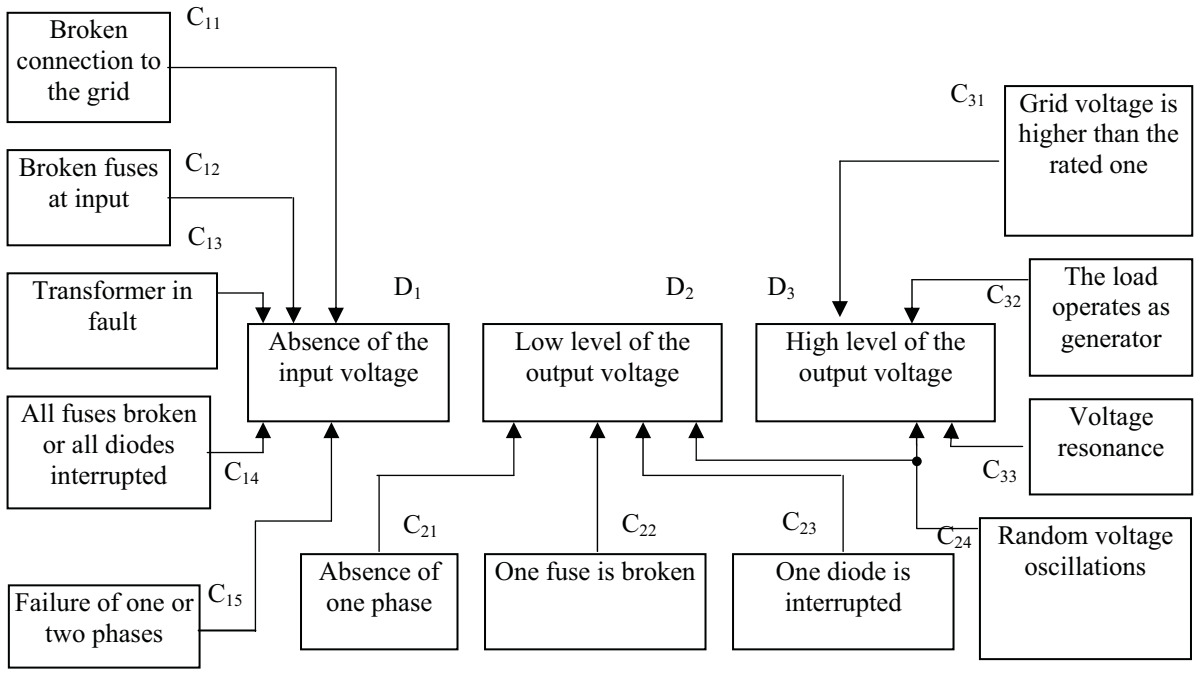

Figure 2: The faults and possible causes for the diodes bridge rectifier.

In order to characterize the system, starting from the functional diagram, the subsystems and devices are identified and their functional inter-connections.

The development of the faults tree is a laborious step, when the human expert must demonstrate high ability in knowledge and understanding of the analyzed system. The faults tree is developed in a hierarchal manner, starting from the upper level towards the lower levels. The level of detail is given by the requested deep of the analysis.

The faults tree of the expert system corresponding to the diodes bridge rectifier, developed based on the faults and possible causes presented in Fig. 2, is depicted in Fig. 3.

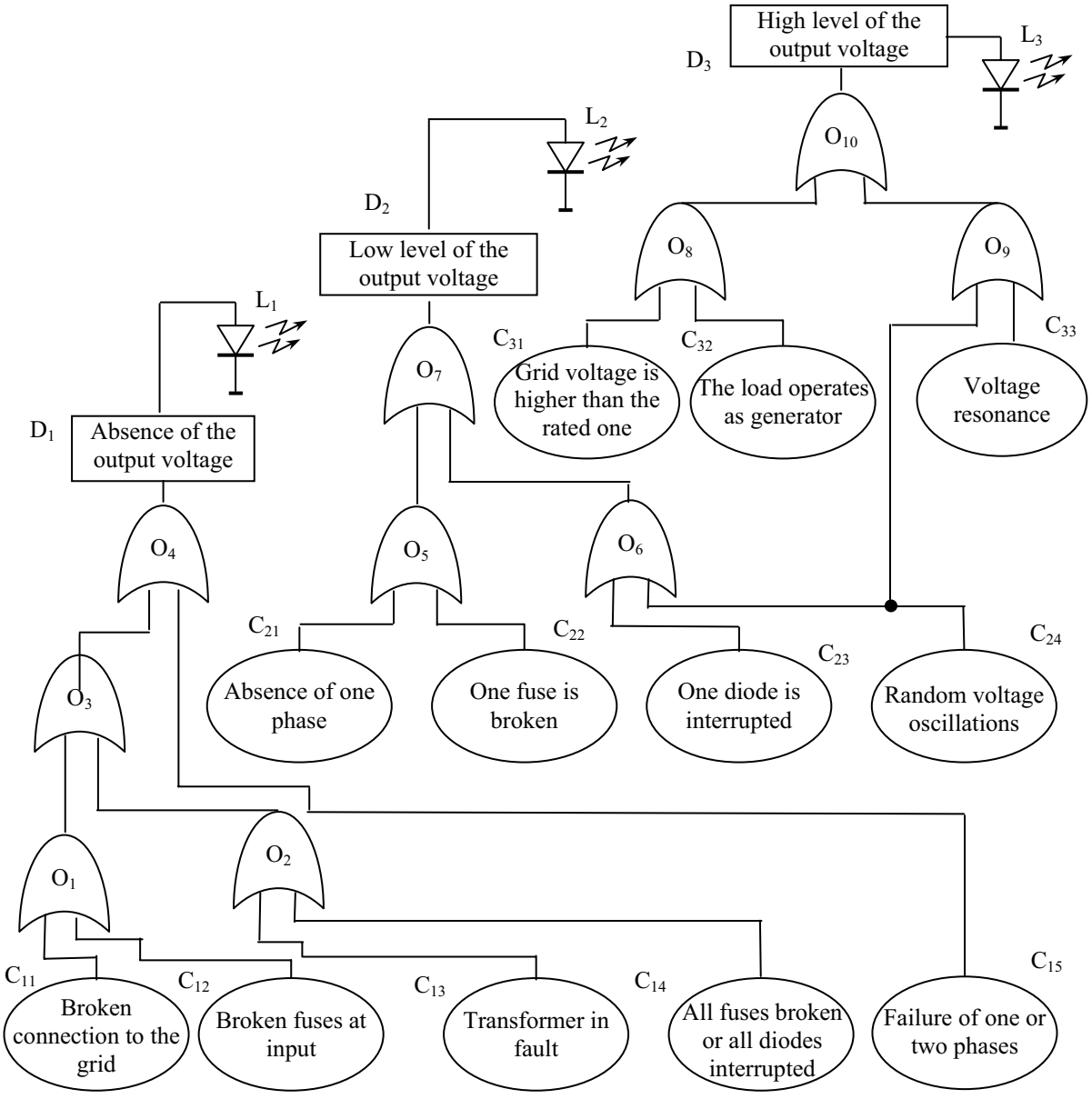

Figure 3: The faults tree corresponding to the diodes bridge rectifier.

The implementation of the faults tree is performed with logic gates. Each possible fault which influences the considered critical event is represented by a source. The logic 1 of each source means existence of the corresponding fault.

In order to reduce the true table of the tree corresponding to the considered fault, an expert system was developed, by using the programming language CLIPS [4].

The specific algorithm developed in CLIPS language simplifies the table of truth for a logical complex circuit with more inputs (sources) and outputs.

The simplification procedure implies the following steps:

- the connections between the circuit components are initialized;
- the response of the system when all sources are set to zero is determined;
- a single source is modified and the answer of the system is determined. By using the Gray code, all possible combinations of inputs are iterated. By using the Gray code, only one source is modified at each step, in order to determine the answer in the table of decisions (the use Gray code determines the minimization of the execution time);
- during the determination of the responses, a rule checks if two sets of inputs which are different by a single input determines the same answer. If YES, this single input can be replaced by „*" (it signifies that the value of that input has no importance for obtaining the same answer);
- once that all the answers and the simplifications were determined, the table of decisions of the circuit is printed.

This application exemplifies the use of most usual procedures available within CLIPS software and how interesting can be integrated with the rules.

The results of the program running highlight important simplification of the true table. The 2^{12} (4096) possible combinations are reduced to 102 distinct combinations (Fig. 4).

It can be seen in Fig. 4 the causes which produce one of the three analyzed faults.

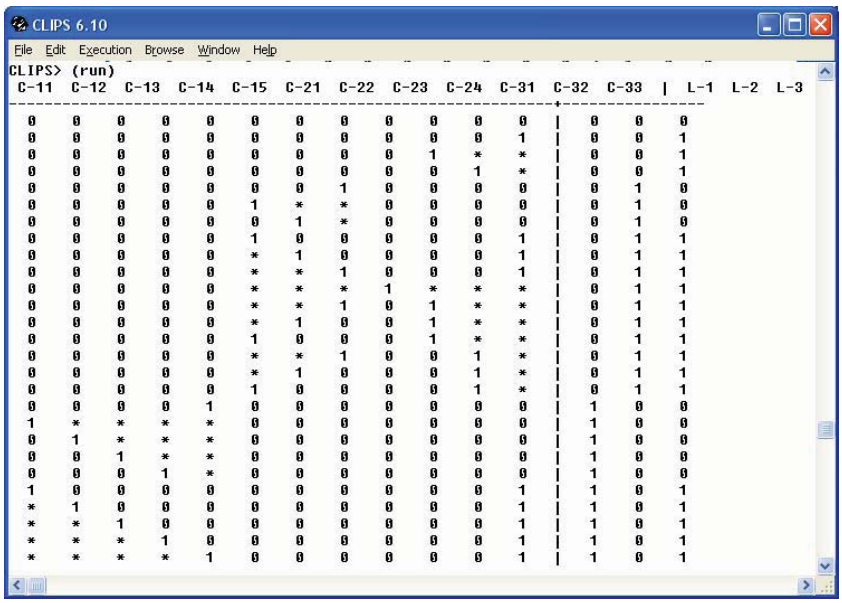

Figure 4: The results of the program running.

CONCLUSIONS

This paper presents an application of the expert systems for the diagnosis of a diodes bridge rectifier. In order to achieve the results, the faults tree method is used.

Taking into account the great number of possible faults (12 sources), the total number of possible combinations being 2^{12} (4096), the expert system performs algorithms difficult to be done manually.

This example shows how the most usual procedures available in CLIPS can be used and how interesting they can be integrated with the rules.

References

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