EXPERT SYSTEM FOR STATIC POWER CONVERTER

Assoc. Prof. Eng. **Virginia IVANOV** PhD, Prof. Eng. **Maria BROJBOIU** PhD,
Prof. Eng. **Sergiu IVANOV** PhD

University of Craiova, Faculty of Electrical Engineering

REZUMAT. În proiectarea convertoarelor statice de putere, experienţa unui expert este absolut necesară pentru a obţine o soluţie performantă. Evoluţia metodelor de proiectare asistată de calculator a condus, în ultimii ani, spre sisteme expert care conţin module cu tehnici de inteligenţă artificială. În această lucrare se prezintă un sistem dedicat pentru monitorizarea şi diagnoza elementelor unui invertor.

Cuvinte cheie: sistem expert, diagnoză, defecte, tranzistoare, invertoare

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 monitoring and diagnosis for the switches of a static converter.

Keywords: expert system, diagnosis, faults, transistors, inverters

1. INTRODUCTION

In order to achieve a satisfactory reliability, the static converters must use high reliable components and/or redundant topologies.

One of the most important characteristic of an electric system is the availability. The availability of a system represents its capacity to fulfill the function for which it was designed.

Redundancy is a general term which is used when an equipment or a component can substitute another equipment or component which fell in fault. Particularly, the redundancy is a technique to improve the reliability which consists in the use of two or more parallel components, substructures or complete equipment [3].

Technically, the redundancy can be achieved in three different ways: time, power and number of element respectively.

Time redundancy means that the operations are performed more times and the results are compared in order to make a decision. Power redundancy means is similar with the over design. Redundancy by number of elements can be with active or passive reserves.

The diagnosis process links the commands applied to the semiconductors and the bridge state, respectively the system for monitoring and diagnosis of the transistors state within an inverter is related based on an algorithm which establishes a correlation between the ON command signals and signals on the DC bus of the inverter.

2. PASSIVE REDUNDANCY IMPLEMENTATION FOR A SEMICONDUCTOR BRIDGE

The redundancy can be seen at the entire bridge level (Fig. 1), where, in case of fault, the whole bridge is replaced, or at the level of devices, where, in case of fault detected by the diagnosis system, only the device in fault is replaced (Fig. 2).

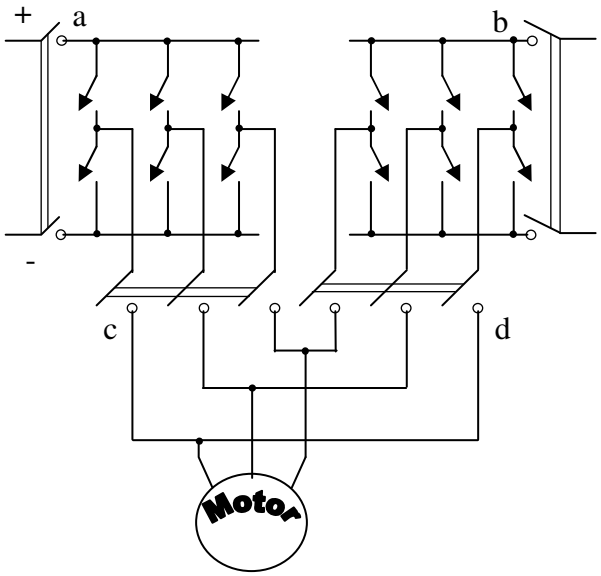


Fig. 1. The redundancy obtained by doubling the structure with identical equipment.

Concerning the Fig.2, when a fault occurs within the static converter, the diagnosis device identifies the lag which contains the device in fault. The device in fault is then replaced with a reserve, by the proper configuration of the switches $K_1 \ldots K_{10}$. During the normal operation, three of the switches $K_1 \ldots K_4$ and three of the switches $K_5 \ldots K_{10}$ will be ON.

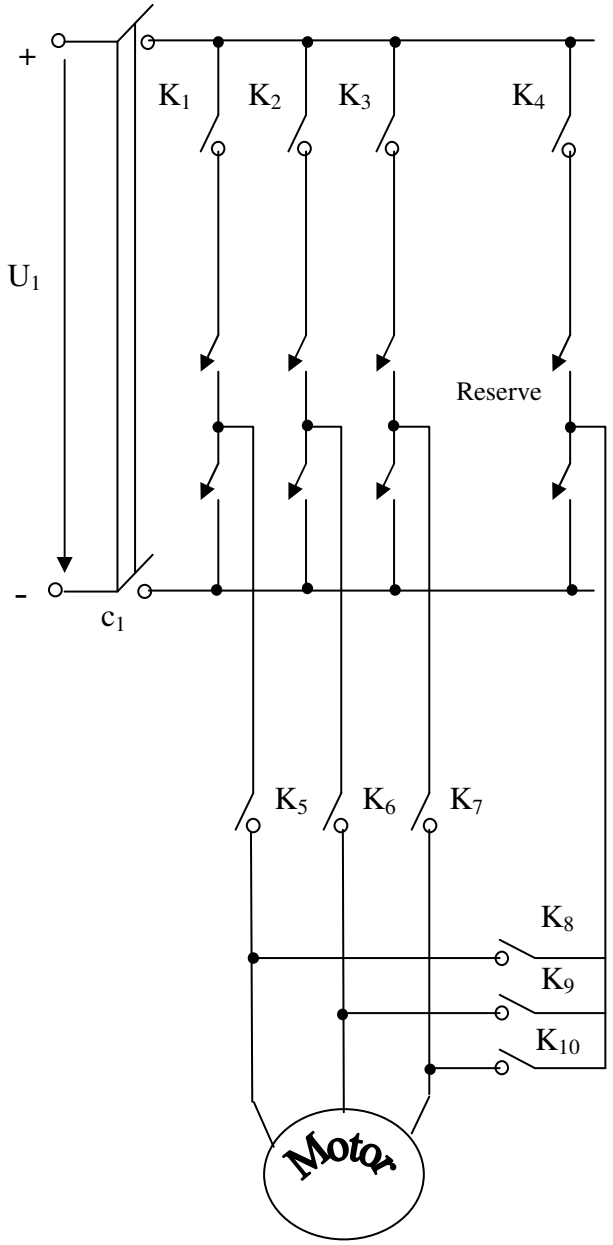


Fig. 2. The redundancy obtained by doubling the elements of the structure.

If we analyse the reliability of the resulted systems, one can conclude that the redundancy is more efficient at devices level that at the level of substructures. Concerning the redundancy at the devices level, from the point of view of the reliability of the resulted system, it is an advantage to double the less reliable component [1].

A diagnosis system is necessary both for the redundant systems and for non redundant ones, being a support for the maintenance activity [2].

3. DIAGNOSIS SYSTEM FOR THE POWER DEVICES OF A STATIC CONVERTER

In order to obtain high performance equipment to meet present requirements, both in terms of reliability and availability, we performed an experimental system which is based on an algorithm for online verification of each component of the inverter.

Block diagram corresponding to this system is shown in Fig. 3 [3].

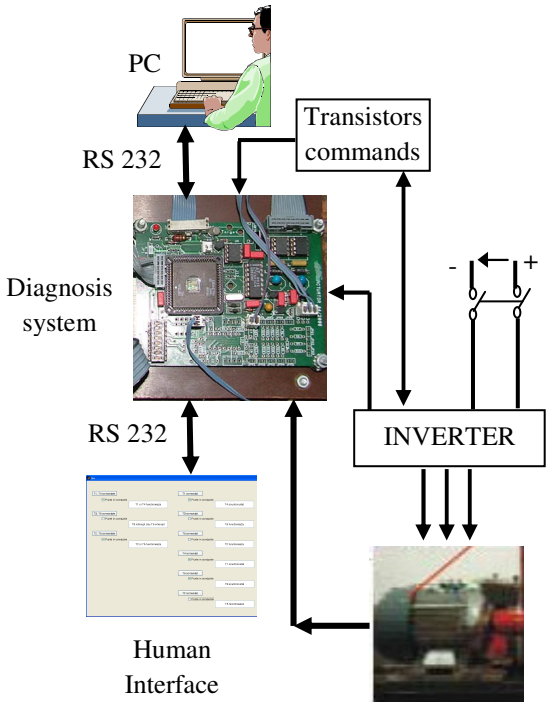


Fig. 3. The general structure of an experimental system.

The proposed diagnosis system monitors, analysis and transmits a result concerning the state of the devices of a transistors bridge within an inverter. The diagnosis system can access the command terminals of the transistors and the DC bus bars (+, -).

The diagnosis links the commands of the devices by the state of the bridge (ON or OFF), Fig.4.

The faults which can occur to the devices level can be of two types: the device can be interrupted or the device can be in short circuit.

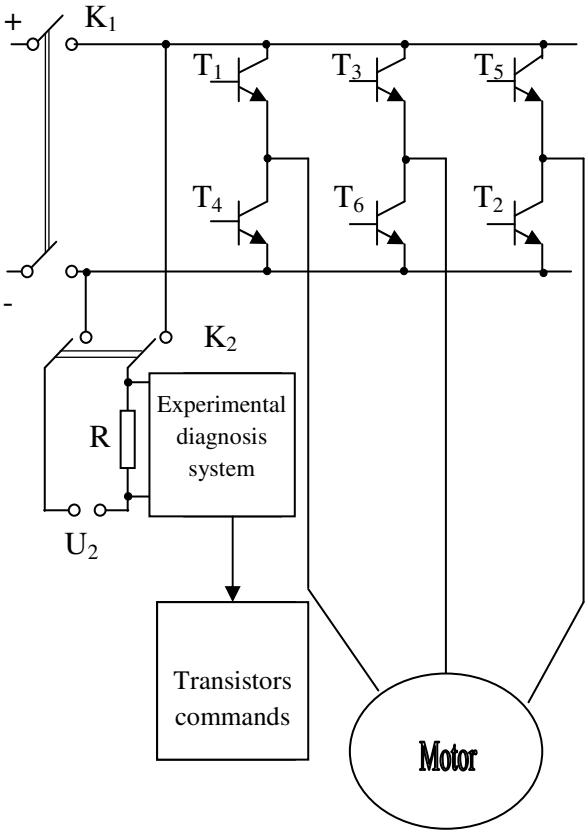


Fig. 4. Diagnosis system for the devices within an inverter.

The operation algorithm of the diagnosis system follows step by step the verification of the state of the inverter's devices. There are checked all the devices on every leg to be not interrupted.

Then, the short circuit fault of the semiconductor devices is controlled, by commanding ON each device on the bridge and controlling the state of the bridge ON or OFF.

The diagnosis system interacts with the user by the mean of a graphical interface made with GUI from Matlab [5], [6].

For explaining the diagnosis algorithm, will be considered as example, the fault of short circuit of the transistor T_4 (Fig. 7). The fault detection can be performed by commanding the ON state of the transistor T_1, and observing the ON state of the bridge due to the short circuit of the transistor T_4, even is was not commanded to be ON. If the transistor T_4 would be in good condition, when only T_1 is commanded ON, the state of the bridge would be OFF.

This program sequence is repeated for the other phases pair of elements (T_3 and T_6, T_5 and T_2 respectively) (Fig. 5).

Another type of fault which can occur is the interruption of the transistor. For the considered transistor (T_4) this fault can be detected by commanding simultaneously only T_1 and T_4 to be ON. In normal operation, the bridge must be ON. If the bridge is OFF, one, or both transistors (T_1 and T_4) are interrupted (Fig.6).

This type of fault highlights one of the limitations of the diagnosis system, in the sense that the fault can not be anytime located with high precision.

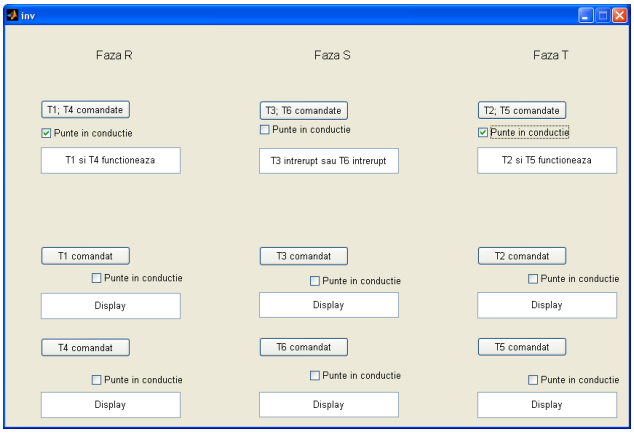


Fig. 5. Fault detection of the semiconductor devices interruption.

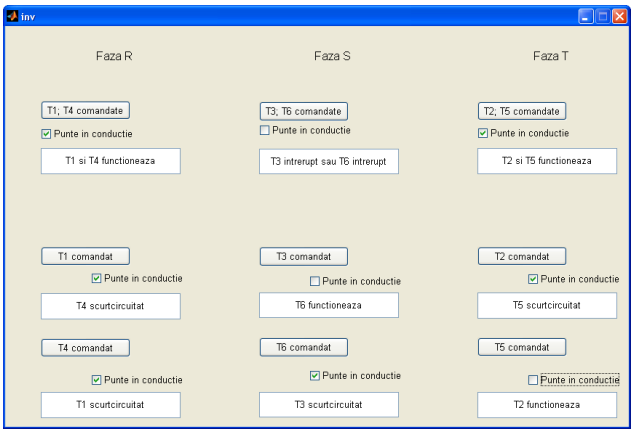
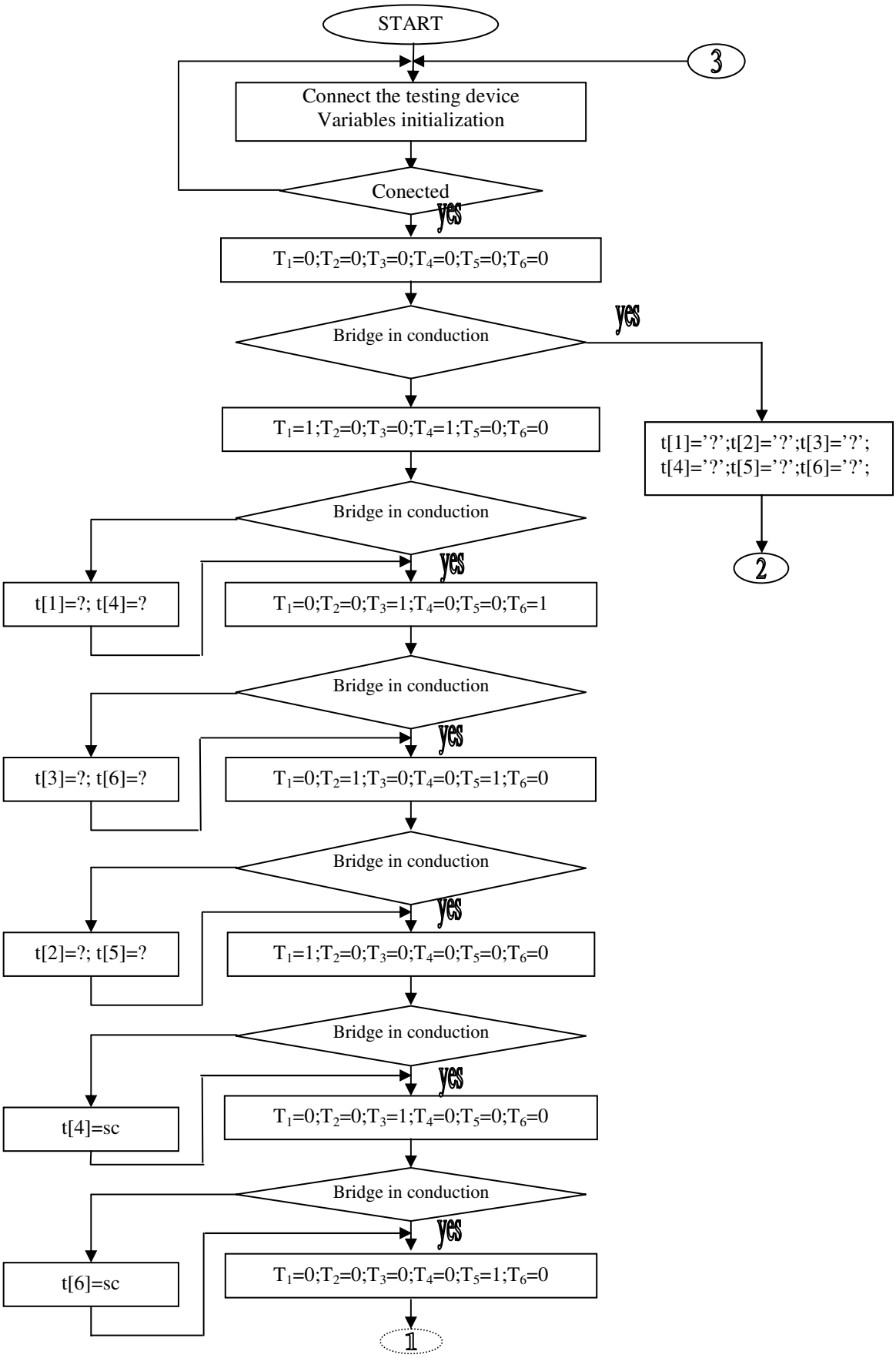


Fig. 6. Fault detection of the semiconductor devices short circuit.

The whole diagnosis system operates by tracking the algorithm presented in Fig. 7.

The algorithm verifies each element of the inverter for the two analyzed faults: short circuit and i9nterruption respectively.

First time, the transistors of each arm are tested for the short circuit fault. Possible elements in fault are indicated. Following, the transistors of each arm are tested for the interruption fault. Depending on the information received concerning the bridge state, the algorithm is restarted.


START
3
Connect the testing device
Variables initialization
Conected
yes
T1=0;T2=0;T3=0;T4=0;T5=0;T6=0
Bridge in conduction
yes
T1=1;T2=0;T3=0;T4=1;T5=0;T6=0
t[1]='?';t[2]='?';t[3]='?';
t[4]='?';t[5]='?';t[6]='?';
2
Bridge in conduction
yes
t[1]=?; t[4]=?
T1=0;T2=0;T3=1;T4=0;T5=0;T6=1
Bridge in conduction
yes
t[3]=?; t[6]=?
T1=0;T2=1;T3=0;T4=0;T5=1;T6=0
Bridge in conduction
yes
t[2]=?; t[5]=?
T1=1;T2=0;T3=0;T4=0;T5=0;T6=0
Bridge in conduction
yes
t[4]=sc
T1=0;T2=0;T3=1;T4=0;T5=0;T6=0
Bridge in conduction
yes
t[6]=sc
T1=0;T2=0;T3=0;T4=0;T5=1;T6=0
1

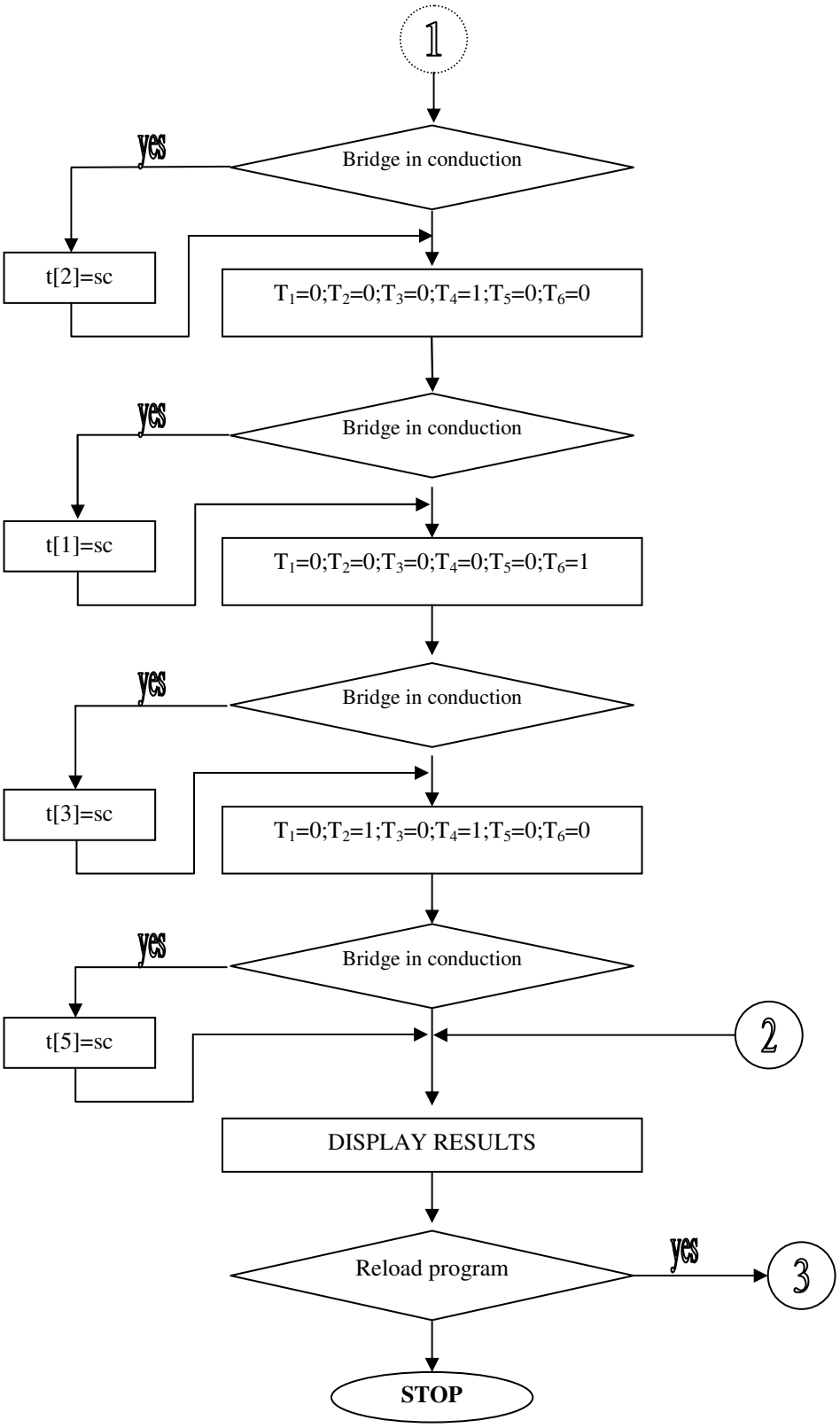


Fig. 7. The diagnosis algorithm.

5. CONCLUSIONS

✓ The full availability of a system can be achieved only by redundancy of its components. A partial availability can be achieved by activating systems partially doubled.

✓ The faults which can occur to the devices level can be of two types: the device can be interrupted or the device can be in short circuit.

✓ The proposed diagnosis system monitors, analysis and transmits a result concerning the state of the devices of a transistors bridge within an inverter.

✓ The diagnosis system can access the command terminals of the transistors and the DC bus bars (+, -).

✓ The diagnosis links the commands of the devices by the state of the bridge (ON or OFF).

✓ The diagnosis system interacts with the user by the mean of a graphical interface made with GUI from Matlab.

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About the authors

Assoc. Prof. Eng. **Virginia IVANOV,** PhD
University of Craiova, Electrical Engineering Faculty.
email:vivanov@elth.ucv.ro

Graduated at the University of Craiova, Electrical Engineering Faculty, Romania, in 1986 and Doctor in Electrical Engineering in 2004. From 1986 to 1998 she worked as researcher with the Researching Institute for Motors, Transformers and Electric Equipment Craiova. In 1998 she joined the Faculty for Electrical Engineering, Department of Electrical Equipment and technologies.

Prof. Eng. **Maria BROJBOIU**, PhD.
University of Craiova, Electrical Engineering Faculty.
email: mbrojboiu@elth.ucv.ro

She is currently working as Professor at the University of Craiova, Electrical Engineering Faculty, Department of Electrical Equipment and Technologies since 1981. Before that, she worked as design engineer at the Electroputere holding the Research and Development Center. She is Doctor in Science Technique – Electrical Engineering.

Prof Eng. **Sergiu IVANOV**, PhD. ,
University of Craiova, Electrical Engineering Faculty.
email:sivanov@em.ucv.ro

Went to the University of Craiova, where he studied electrical engineering and obtained his degree in 1986. He worked for the Institute for Research in Motors, Transformers and Electrical Equipment Craiova before moving in 1991 to the University of Craiova. He obtained his PhD in 1998 with a topic in the field of the control of the electric drives systems. He is involved in modelling of the electromechanical systems.