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# Methods for Determining the Available Working Resources of Power Electronic Devices

Vladislav Danchev Veselinov and Dancho Veselinov Grigorov

*Abstract* - **The present article reviews the suggested by the authors methodology for determining the current working resource of power electronic devices compared to this of the semiconductor switches. The possible break-down situations in the internal electric circuits of power converters were analyzed. The main task is a theoretical report of the developing processes during the occurrence of internal short circuits under a failure of one or several switches and their influence upon the rest of them. The available possibilities for an optimal defense and the methods of their registering and measuring are considered. They are applied in the digital complex introduced in the laboratory LAMAR designed for research and control of the working process of power electronic devices.**

*Keywords* – **IGBT device, Power converters, Power Semiconductor, Digital complex, break – down process.**

## I. INTRODUCTION

For determining the exploitation overloading and short circuits in the load are used electronic current and heat protection devices, which give a signal for a blocking in the converter control. In most cases they can not defend the integrity of the devices in the schematic when a failure of one of them occurs. The worst case of a break-down in the converter seems to be the internal short circuit, associated with a device failure. One of the stages of the development of a strategy for an optimal defense of power electronic device (PED) is connected with determination of the working resource of the components that build up the system.

### *A. Main topics*

The working process of the converter is associated with the available resource of the power semiconductor that build up the system. The main reason for a break-down are the semiconductors and in most cases according to statistics [1] it happens because of overheating in the structure of the element [2] and because of reaching the maximum amount of switching cycles, which are specified by the manufacturer (fig.1). The methodology consists of determining that to this two parameters of the devices can be judged on all available resources of the system. As a base we use the break-down schematic in which the temperature is the last critical factor.

Eng. V. Veselinov is with the Department of Power Electronics, Faculty of Electronic Engineering and Technologies, Technical University - Sofia, 8 Kliment Ohridski blvd., 1000 Sofia, Bulgaria, e-mail: wdw_mania@abv.bg
PhD. D. Grigorov is with the Department of Power Electronics in LTD “Elit-Neo” – Sofia, 16 Slatinska reka str., 1574 Sofia, Bulgaria, e-mail: elit_neo@abv.bg

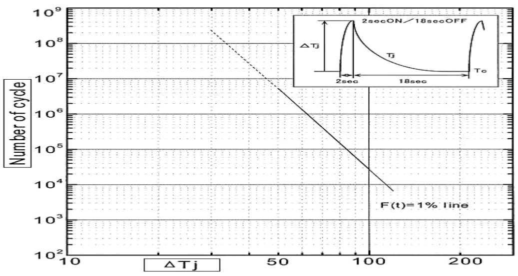


FIG.1. SWITCHING CYCLES OF POWER FOR CONVERTER MODULE.

### *B. Basic principles for construction of the methodology*

For the building up of the methodology we focused upon the work of PED that use IGBT modules, but it can be applied with success for all the other devices classified in [3].

By now in the literature there are not enough investigations for the work of this elements for a long period of time. The investigation of the methodology by a particular scheme decision in the structure of converter purchases the following tasks:

1. To analyze the assurance of the converter and to prognoses the possibility of failures and resource of work.
2. To eliminate the devices which have changed there working parameters in the working process before reaching the break-down process.
3. To report the real thermal processes in the scheme of the converter and the behavior of the devices after two years of exploitation.
4. To make un analyses of the reasons for the change in the parameters.

The structural of the worked out scheme decision (DSM-D3) for the realization of the principles of the method is shown in fig.2.

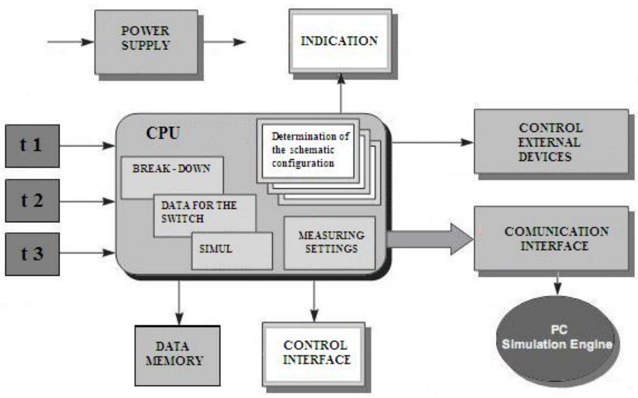


FIG. 2. FIG. 2. STRUCTURAL SCHEME OF THE SYSTEM FOR DETERMINING EXISTING WORK RESOURCES OF POWER ELECTRONIC DEVICES – DSM-D3.

The scheme decision realizes the measuring of three different temperature points depending on the module configuration. The power IGBT modules are constructed by printed technology and the links of the crystal are realized with the help of massive copper conductors or aluminum connecters, depending on the size of the commutation currents or voltage. The requirements for short commutation times in nano or microsecond range make the construction too complicated and pliable to failures because of a lack of mechanical strength. This determines the parameter life of a device as a function of the amount of the commutation cycles as that shown in fig.1. A break-down because of an overheating of the module can occur when it is working for a long period at the edge of the maximal temperature of the junction. On the contrary, the failures of the commutation cycles are caused by the mechanical stress. On fig.3 are shown the critical changes of the temperature, which must be analyzed and monitored to achieve a max. reliability of work.

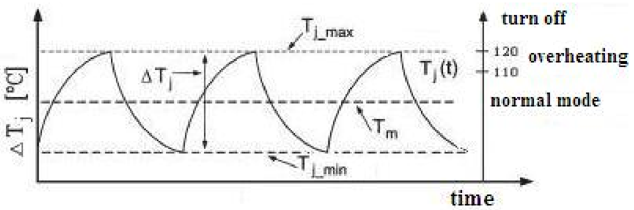


FIG. 3. TEMPERATURE PROFILE OF IGBT MODULE.

### C. Temperature profiles

For the cycle of commutation the value of ΔTj is changed in a short interval of time and is used for an estimation of the work life of the link wires of the crystal. When ΔTj ≥ 100˚C the damage connected with the difference in the coefficient of enlargement between the crystal and the aluminum or copper wire. The typical damage when ΔTj ≤ 80˚C shows the stress because of the difference between the coefficients of linear enlargement. This leads to cracks in the links and further on the temperature of the crystal grows leading to a break-down. This growth is a good indicator for determining of the device resource. At the test work cycles usually is used the average temperature of the crystal Tm, but ΔTj is t5he critical variable, which determines the levels of the thermo-mechanical stress upon the element. For the analyses we use ΔTj, which assures much punctual information. The suggested system is binded directly with the techniques for an active thermal control of PED, which make possible the regulation of the temperature in determined or transient state. When there is a possibility for a change in the system of management of the converter it is possible to set a fixed temperature of the transition by manipulating the commutation range and limiting of the current. In other words there is an active regulation of the losses in the structure of the module. Without such a possibility of a change in the scheme decision the system realizes only the function indication with reporting of the commutation cycles. This strategy improves the reliability of the power module and increases the utilization of the thermal capacitance. The algorithm for temperature modeling and processing of the reported temperature values is a main component of the system. At first are used the temperature parameters from the real working system, which are used as a standard. The calibration goes on during the process of first switching on of the system.

The method used the brought into use data for the number of commutation cycles of the type of used device and the model, which is worked out by statistic data, defined by the technical specification of the producer. On such a ground there can be registered five break-down regimes:

1.The maximal temperature of the transition is reached.
2.Overheating. (Fig..3).
3. The assigned maximal number of commutation cycles are reached.
4. The set change of ΔTj is passed over.
5. The maximal assigned temperature difference for the elements of the side of the bridge is reached.

For determining of the reported points was used a thermal analogy for IGBT devices shown in [3]. On fig.4 there is the location of the thermal sensors for the examined module.

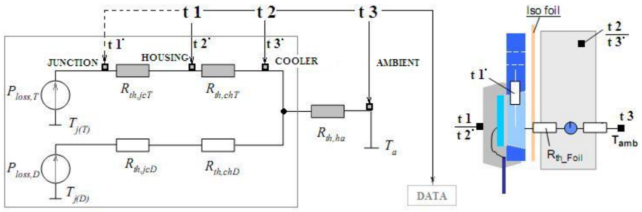


FIG. 4. LOCATION OFTHE TEMPERATURE SENSORS IN THE SYSTEM.

## II. CONCLUSION

From the information given above about the developing process and on the base of the statistical data for the failures gathered during the monitoring of the system, semiconductors are most pliable to damages provoked by thermal overloading. A failure of one of the elements by all means leads to a break - down of the others in the group. When projecting of systems for defense it is necessary the possible the break - down regimes in the inner chains to be predicted in relation with the parameters of the rectifier valves. The use of digital systems for prediction of failure of the elements in some of their parameters is a hopeful base for increase of the reliability of the rectifier converters. But the measures must be considered with the price range of the device and sometimes it could be undue when working with low powers.

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