*Proceedings IRF2018: 6th International Conference Integrity-Reliability-Failure*
*Lisbon/Portugal 22-26 July 2018. Editors J.F. Silva Gomes and S.A. Meguid*
*Publ. INEGI/FEUP (2018); ISBN: 978-989-20-8313-1*

PAPER REF: 7155

# METHODOLOGICAL FRAMEWORK FOR IMPLEMENTATION OF A PREDICTION RELIABILITY MODEL FOR IGBT POWER MODULI USED IN RAILWAY APPLICATIONS

**E. Dabla[1,2], F. Pérès[1(*)], C. Martin[1], C. Fournier[2], M. Piton[2], F. Andrianoelison[2]**
[1]INPT ENIT, France
[2]Alstom Transport, France
[(*)]*Email:* francois.peres@enit.fr

## ABSTRACT

The control of critical electronic components reliability is one of the great issues in railway traction applications. Insulated Gate Bipolar Transistors (IGBTs) are part of these components. They are subjected to high stresses resulting in the severe conditions of use of the train. The increase of requirements in term of reliability and safety impose to answer the question how to improve them. This short paper presented a methodological framework for predicting reliability of IGBT based on Bayesian approach.

***Keywords:*** railway traction application, reliability prediction, Bayesian networks.

## INTRODUCTION

Insulated Gate Bipolar Transitors (IGBTs) modules are power switching components that equip converters used in railway applications. The harsh environmental conditions encountered in railway operation and the stringent requirements in terms of system availability and maintainability impose high reliability levels to IGBT modules. The key issue of the work conducted in this PHD research is the need to increase the reliability prediction of IGBT modules.

Railway operators are today faced with the lack of a failure rate model during useful life of the IGBTs: in the first instance, the failure rate is computed based only on return from field; in the second instance the lifetime is calculated taking into account only thermal cycling stress performed at design stage. This last calculation does not give a good visibility with the real life of the component. The calculation contains a lot of variability and uncertainties and must be characterize. A probabilistic approach, Bayesian network is proposed to quantify these uncertainties and variability.

IGBT modules (see Figure 1) are power semi-conductors devices providing switch function. Used in traction applications, they combine high efficiency and fast switching. In the form of a package, they are composed inside of lot of sub-components made with different materials and each ensuring several functions. Due to the difference of properties of materials inside, IGBTs modules are subjected to different failure mechanisms that can induce failure and affect greatly their reliability. In traction systems, the requirements for 30 years and more of fault-free operation lead to undergo lots of work to improve the reliability of IGBT Modules. In the literature, different

Fig. 1 - IGBT Module

programs have been devoted to the reliability and lifetime prediction of IGBTs Modules: LESIT program (Held *et al.*, 1997), RAPSDRA (Reliability of advanced power semi-conductor devices for railway traction applications) (Ciappa, 2002). Other works also have been undertaken especially (J. Due *et al.*, 2011; R. Amro, J. *et al.*, 2004; U. Scheuermann, 2013) to predict the lifetime of IGBTs Modules. The main particularity of these studies is the fact that they take into account only thermal cycling. The first research question is addressed: what is the impact of other failure mechanisms on the reliability of the IGBT?

All these studies involve also lot of assumptions, uncertainties and variability, for example, different criteria of failure result in different values of lifetime predicted. To quantify all these uncertain data, a probabilistic approach is proposed. The advantage of using this Bayesian approach, is to take into account not only all the operating environment of the IGBTs, but also all known phenomena that could have influence on their reliability.

## RESULTS AND CONCLUSIONS

The proposed approach integrates the definition of a "U" cycle. Currently, it is difficult to collect data on the evolution of the operating variables directly at the level of the IGBT. This leads to carry out analyzes at different levels. These analyzes will be nested later to build the model. Functional analysis consists of knowing the functions realized by the system or the component. The dysfunctional analysis is used to complete the first one in order to take into account dysfunctions.

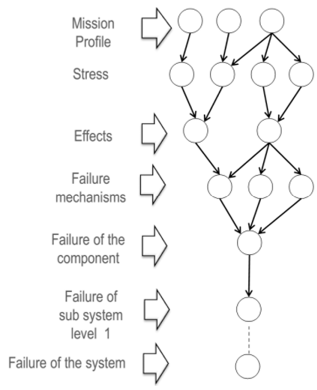


Fig. 2 - Bayesian model

Knowledge gathered from different analysis will feed the bayesian model, Figure 2. The mission profile describes the mission profile of the train namely the set of environmental conditions. The stresses represent the impact of this mission profile in terms of constraints for the component (IGBT). The effects, Failures and Failure mechanisms are induced by the stress of the component.

A methodological framework is proposed to set up a prediction model of IGBT modules used in traction applications. It results in different analysis functional and dysfunctional at IGBT modules level and train level. All this analysis will feed the Bayesian model with the goal to to predict the reliability of IGBT Modules

## REFERENCES

[1] Ciappa, M. (2002). Selected failure mechanisms of modern power modules. Microelectronics Reliability 42, pp. 653-667.

[2] M. Held, P. Jacob, G. Nicoletti, P. Scacco, M.-H. Poech: "Fast Power Cycling Test for IGBT Modules in Traction Application", IEEE 1997 and business Media, LLC.

[3] J. Due, S.M. Nielsen, and R. Nielsen. Lifetime investigation of high power IGBT modules" in Proc. 14th Europe Conference Power Electronics, Aug-Sept. 2011, pp. 1-8.

[4] R. Amro, J. Lutz. Power Cycling with high Temperature Swing of Disrete Components based on Different Technologies, IEEE, 2004.

[5] Uwe Scheuermann. Pragmatic Bond wire Model, ECPE Workshop 'Lifetime Modelling and Simulation', July, 03-04, 2013, Dusseldorf, Germany.