Chapter 12
State-of-the-Art Review on Power Electronics

During 1991-2004 years, International Workshop on the Future of Electronic Power Processing and Conversion (FEPPCON) held four times with the support of IEEE Power Electronics Society. The main purpose is to outline the possibilities of development in different fields during the next period as a result of the discussions. At the last meeting held in Italy, the tendency to increase the role of Power Electronics during the next 25-30 years in the processes of energy conversion has been confirmed (Blaabjerg, 2005). Special attention is paid to the role of Power Electronics at a system energy conversion level, because it is not in the position to dictate the trends in the development of this level. Nevertheless, without the power electronics tools, future serious achievements in power processing are impossible. Therefore, the power electronics implantation at a system level at a system energy conversion level is an issue of the efforts of the specialists in this field (Agrawal, 2001). This, of course, imposes also some changes and adaptation towards Power electronics role also in the process of schooling of specialists paying attention mainly to multidisciplinary of Power Electronics. For example, a necessity of further tuition in electrochemistry, mechanics, physics (especially electromagnetic and thermal processes), etc, is outlined. Remote access to complex power electronics laboratory equipment and the possibility of remotely driving experiments and measurement is represented (Rodriguez, 2009). Power Electronics takes a significant part in the following systems: Generic Systems; Energy Storage; Power Systems, including Alternative Energy Supply; Automotive Systems (Bose, 2009).

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In this chapter, some of the latest achievement in the three basic levels in the Power Electronics – components, circuits and systems, are consecutively studied. To prepare and write this chapter, mainly survey papers in the different fields are used. In these papers the reader may find a lot of additional references in certain filed of interest.

**CONTEMPORARY STUDY IN THE FIELD OF COMPONENTS FOR POWER ELECTRONICS**

Thyristors (SCRs) dominated as power switches in the period 1958-1975 years. Their implementation in controlled rectifiers causes problems connected with the worsen power factor. Because of that, the rectifiers with phase control are displaced step by step by these with PWM based on fully-controlled power switches – see Chapter 4. The capabilities of a standard thyristor regarding the commutation of high voltages and currents at low frequencies outline its dominant use in the coming future in the following fields – high voltage DC transmission of energy (HVDC); cycloconverters and some drivers with very high powers. The creation of high-power gate turn-off thyristor (GTO) in 1980 year and its upgrading especially by Japan companies make preconditions for the displacement of a standard thyristor from some of the power electronics converters with high powers. The possible variations of GTO with or without blocking capability in the reverse bias, as well as the borders reached (6kV, 6kA), make its implementation in multimegawatt converters the most probable one. The problems for wider implementation of GTO-s are connected with its slow turning on and off, complicated structure of the control drivers, the required snubbers group. Thus, the implementation is in the field of low frequencies – to several hundred Hz. In the field of power MOSFET it has to be mentioned the creation of CoolMOS by Infineon Technology, characterized by a high fast reaction and decreased losses compared to the rest MOSFET structures. For the present, the CoolMOS voltage capabilities are to 800V. With the creation of IGBT in 1983, its development during the following period and its parameters, it may be considered that IGBT fully displaces power bi-junction transistor (BJT). Till now, the IGBT voltage and current capabilities reached are 6.5kV and 700A, respectively. Recently, the attention towards integrated gate-commutated thyristor (IGCT) the first one demonstrated by ABB in 1996 is quickened. It is probable to be used in high powers – values for single devices reached are 6.5kV and 4kA. In these powers, the capabilities of IGCT are commensurate to those of IGBT regarding the switching frequency, while in high voltages IGCT has lower voltage across it in ON state compared to IGBT. Step by step, IGBT and IGCT displace GTOs in the whole ranges of frequencies and powers. The static induction transistor (SIT) is a normally ON state device with a high voltage in forward bias. This limits its implementation possibilities but its development will permit its use in high frequencies. Notes of other semi-conductor devices, at an experimental level for the time being as MOS-controlled thyristor, static induction thyristor, MOS turn-off thyristor, etc, exist.

In the field of creation of new power devices, the attention is paid towards so-called wide bandgap semiconductors. The aim is basically to increase breakdown voltage, to achieve higher operational temperatures of the junction, as well as to achieve lower values of the resistance in the ON state. Also, better temperature conductivity is searching for to facilitate the integration of several power devices if it is possible together with control drivers in a common body. The researches are towards material close to silicon (1.12 eV) – GaN (3.44eV); GaP(2.26eV), SiC (2.36-3.25eV) C (diamond) (5.46-5.6eV).
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