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DIFFERENT TYPES OF POWER ELECTRONICS CONVERTERS TO ENHANCE THE PERFORMANCE OF ADVANCE POWER SYSTEM

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ABSTRACT

As we prepare to enter the 21st Century we stand on the threshold of a Power Electronics Revolution. The last 50 years have seen the growth of power conversion to the point at which today about 15% of the electric power produced undergoes some form of electronic conversion. However, most of this occurs at the "consumer end" of the supply chain from battery chargers to locomotives. Although HVDC transmission has exploited line-commutated power electronics for the past three decades, it is the 1990s which have witnessed the commissioning of self-commutated power electronics at the transmission level. Developments in semiconductors and their packaging technology will drive power electronics into distribution applications as device efficiency and reliability increases whilst the cost of the switched megawatt falls. The key semiconductors enabling this predicted transition will be reviewed and the anticipated demands of system builders on device suppliers discussed.

Keywords*-Threshold, Power Electronics, HDVC, IGBTs and IGCTs etc.*

I. INTRODUCTION

Power electronics is introduced in areas where its benefits are cost effective. Early applications were power supplies, battery chargers and motor drives. The'60 saw the introduction of line commutated control (thyristor and diodes) in traction applications followed, in the '70s, by fast thyristors and diodes in self-commutated applications (choppers and inverters). The '80s saw a rapid expansion of industrial motor drives thanks to the development of the bipolar-power transistor in the form of Darlingtons and "Triplingtons" and that of the GTO (Gate Turn-off -Thyristor) and the IGBT (Insulated Gate Bipolar Transistor).

II. APPLICATIONS

Industry and Traction

During the early '80s the transistor-based structures pushed the thyristor-based structures (fast thyristors and GTOs) towards higher powers such that by the early'90s GTOs had become "very high power devices "suitable for traction and high power (> 1MW) or medium voltage (>2.3 kV) industrial drives. IGBTs with their simple drive requirements (voltage control)displaced Darlington transistors (current control) as the device of choice Low Voltage Drives (LVDs) up to480 Vrms and by the mid '90s they had displaced GTOs in LVDs up to 690 Vrms thanks to the widespread availability of devices with ratings of up to 1800VThis availability (low cost) has turned the LVD industry into a B$3 market with a growth rate of about 7% p.a. The emergence of the IGCT (Integrated Gate-Commutated Thyristor) [S. Klaka et al, 1] in the late'90s has given a new impetus to the drives industry by doing to Medium Voltage Drives (MVDs) up to6900 Vrms what IGBTs did for LVDs up to 690 Vrms. This market represents B$0.5 with a growth rate of about 15% p.a. due to the large number of MV motors in the field, 95% of which operate without torque and speed control due to the absence, until now, of cost effective drives solutions at these voltage levels.

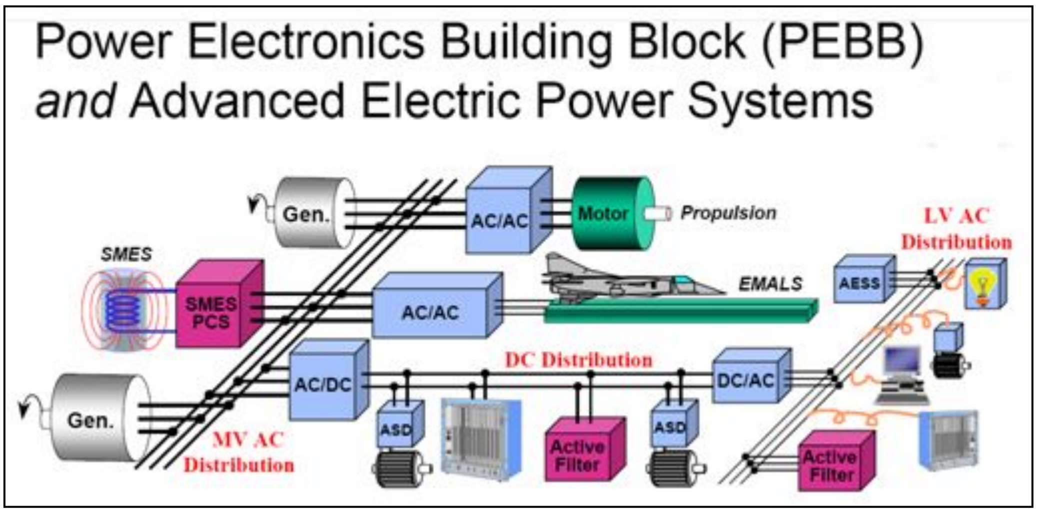
Generation, Transmission and Distribution

The above illustrates that over the last 30 years the driving forces behind power electronics lay in the cost-effective implementation of control at the user level either to stabilise voltages (power supplies) or to control motor speed, acceleration and torque (industrial processes or transportation). The transmission and distribution industry also has its problems to solve but has traditionally not had cost-effective solutions for them. Notable exceptions have been High Voltage DC (HVDC) to transmit DC power over large distances atop to 1MV and Static VAR Compensators (SVC) to control inductors or capacitors for voltage stabilization. All these have relied on Phase Control

Thyristors(PCTs) to control power primarily because these devices offer the highest power control and hence the most cost-effective (though not necessarily the best)solutions. The generation industry has had little call for power electronics at the output stage since the powers are typically very large (250 MW) and generators operate in synchronism with the infinite grid.

Emerging Markets

New applications are emerging that lie between the worlds of Traction and Industry and those of Generation, Transmission and Distribution. These applications are loosely grouped under the headings "FACTS" (Flexible AC Transmission Systems), "Power Quality" and "Custom Power". The forces driving these trends are those of the deregulation of the Power Utilities world-wide, aimed at stimulating competition (presumably born of the realisation that the standard of living of a country is inversely proportional to the relative cost of its energy); the growth of production processes requiring unperturbed sources of electric power (e.g. plastic foil or semiconductor manufacturing); environmental issues The emerging applications are listed below in Table 1. These non-traditional power electronics applications have been variously estimated to represent a world equipment market of up to B$3 in the early years of the next century and have therefore the potential of matching the importance of the traditional Traction and Industrial Drives markets.



Application	Description	Typical Power (MW)	Segment
STATCOM	Static Compensator Allows both leading or lagging power factors to be corrected seamlessly with a minimum of installed capacitance allowing Voltage stabilisation and load balancing.	100	T&D, Industrial, Traction

UPFC	Unified Power Flow Controller Converter based system which controls power flow, voltage And power factor allowing optimal stable use of existing lines.	 200	T$D
DVR	Dynamic Voltage Restorer Instantly reacts to drop in line voltage (sub-cycle) and restores the missing portion of the waveform from an energy storage Device (e.g. battery).	2-100	Power Quality
Transfer Switch	Transfers load to alternative lines.	5-30	Power Quality
Static Breaker	Interrupts faults with sub-cycle response.	5-30	Power Quality, Traction
Energy Storage/UPS	Short-term (< 1 hr) energy storage and restitution ("Peak Load Shaving") with batteries, fly-wheels, Super Conducting Magnetic Energy Storage (SMES) etc.	1-100	Power Quality, T&D, Traction, Industry
Short DC Link	Short distance HVDC (100 kV) transmission links from utility To load and from alternate power sources to the grid.	50	T$D

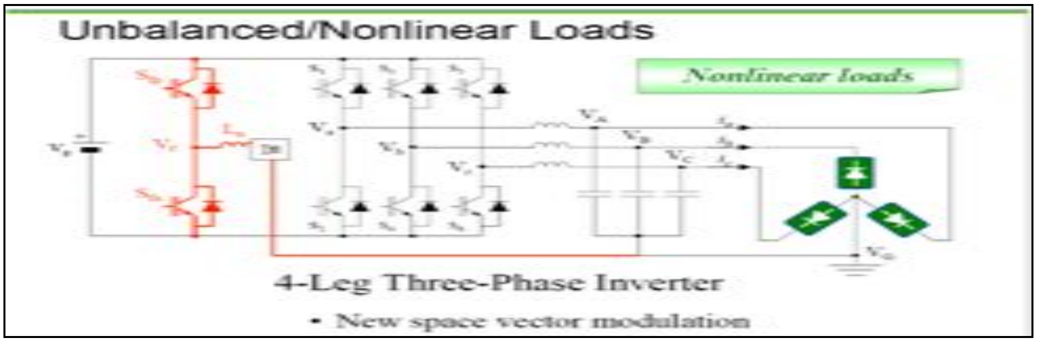
Most (all) sources and loads interfaced through power electronics converters:

• High system controllability, flexibility, and responsiveness

• Increased availability

• Reduced size and weight

• Increased efficiency.



III. CONCLUSIONS

In the multitude of emerging FACTS applications, IGBTs and IGCTs will be the principal component players in the next decade. In very high current and medium voltage applications, the thyristor structure will be the favoured approach especially where decoupling chokes are deemed desirable or mandatory. The IGBT in the choke-less configuration of greatly benefit from the rapid progress in silicon carbide diodes though commercial arrival of the latter on the FACTS scene is not imminent. Nevertheless, height will continue to be favoured in the lower cost choke-less topology where this adequately off-sets the higher cost of the component itself. An exception to this may be found in very high voltage.

Systems involving massively series IGBTs where large number of redundant devices may be used (e.g.100 devices in a 100 kV stack). Here, if the proper service intervals are respected, nothing short of a direct lightning strike would cause simultaneous failure of all redundant devices of a phase leg, such that the omission of link impedance becomes once again feasible. IGBT "press-pack module "specially designed for series connection]. Here the parallel connected IGBT and diode chips are pressure contacted with each contact designed to take full load current should a chip fail. The series operation of the stack is thus assured (with appropriate redundancy) if one chip (hence one "pack") fails short it has been shown that the circuit-specific turn-on losses are approximately given. The first two objectives are compatible because they derive from minimal component-count. Frequency however, as required by active filtering, is at odds with all the goals because switching losses increase with frequency and reduce the useful power a component may handle thus increasing component-count and reducing reliability. In the very high power applications listed in Table 1, IGCTs allow instantaneous switching powers of 16MW today but will nevertheless require series or parallel connection to fulfil those application requirements. Since these are generally for medium thigh voltages (10 kV and above), it is principally the series connection which comes into consideration

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