A Review on power electronics in India

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Abstract:

The purpose of this paper is to review the state of the art of power electronics technology appearing in the latest generation of industrial and traction drives, including a discussion of technology trends that are likely to be reflected in future systems. An effort has been made to highlight both the areas of commonality and the important differences among the wide ranges of specific applications and power ratings that fall within the broad boundaries of industrial and traction drives. Attention is concentrated on recent developments affecting ac adjustable-frequency drives that have been growing in market importance while acknowledging that dc drives continue to evolve and thrive in some sectors of the industrial and traction drive markets

I. INTRODUCTION

In this paper a three phases four wire dynamic voltage restorer (DVR) with bidirectional power electronic transformer structure is proposed to inject required compensating series voltage to the electronic power system in such a way that continuous sinusoidal voltage is seen at load side ever at heavy fault occurrences at utility side .the proposed structure is composed of three-phase four leg inverter, three single-phase high frequency transformer , three cycloconverters and high frequency harmonic filter that are connected to the utility. Three dimensional space vector modulation (3DSVM) methods are used for pulse generation. Fourth added wire enables the DVR to compensate unbalance voltage disturbance that are custom power problems in electrical utility. The performance of the structure and applied switching scheme are verified under both balanced and applied switching scheme are verified under both balanced and unbalanced disturbances via simulation study in MATLAB software.

Power quality (PQ) problems have obtained increasing attentions as they can affect lots of sensitive end-users including industrial and commercial electrical consumers. Studies indicate that voltage sags, transients, and momentary interruptions constitute 92% of all the PQ problems occurring in the distribution power system. In fact, voltage sags have always been a huge threat to the industry, and even 0.25s voltage sag is long enough to interrupt a manufacture process resulting in enormous financial losses. Voltage sags are generally classified according to its depth and duration time.

Typical sag can be a drop to between 10% and 90% of the rated RMS voltage and has the duration time of 0.5 cycles to 1 min. According to the data presented in majority of the sags recorded are of depth no less than 50% but deeper sags with long duration time obviously cannot be ignored as they are more intolerable than shallow and short-duration sags to the sensitive electrical consumers. Many customer power devices have been proposed to mitigate such voltage sags for sensitive loads. The most studied voltage regulator topologies can generally categorized into two groups: the inverter-based regulator and direct ac–ac converters. In several ac–ac converter-based regulators are introduced. Series-connected devices (SD) are voltage-source inverter-based regulators and an SD compensate for voltage sags by injecting a missing voltage in series with the grid. There are lots of SD topologies, and key features related to the evaluation of a certain SD topology are the cost, complexity, and compensation ability. Dynamic voltage restorer (DVR) is a commonly used SD and has been widely studied. Consumer's equipment need pure balanced sinusoidal voltage with constant root mean square (RMS) value to have their satisfying operation

Based on the aforementioned discussions, this paper proposes a PET based three-phase four-wire DVR to inject required compensating series voltage to the power system in such a way that continuous sinusoidal voltage is seen at load side ever at heavy fault occurrences at utility side. The proposed structure is composed of a three-phase four-leg inverter, three single-phase high frequency transformers and a three-phase high frequency harmonic filter that are connected to the utility.

coming years the scope of this paper. In particular, advances in the development of high-performance ac machine control algorithms [3] and the high-speed digital processors to implement them [4] have been major factors in the improved controllability of modern industrial and traction drives. Similarly, continuing improvements in the material properties and cost of neodymium–iron (Nd–Fe) permanent magnets is having a significant impact on development trends in several classes of industrial and road vehicle traction drives [5].

Background

1) Applications:

a) Industrial drives: Prior to the availability of electronics, clever electromechanical solutions involving combinations of dc and ac machines (e.g., Krämer and Scherbius systems) were developed early in the 20th century to control the speed of electric machines in industrial processes. The emergence of mature triggered-arc power switch technology (e.g., grid-controlled mercury-arc rectifiers, thyratrons, ignitrons) in the 1920s and 1930s provided a major boost to dc commutator machines as preferred prime movers for industrial drive applications [6]. This situation persisted for several decades until solidstatethyristors finally provided the crucial power switch breakthrough needed to build practical adjustable-frequency ac machine drives in the 1970s. Since that time, new generations of gate-controlled power switches have successively improved the performance and cost-effectiveness of ac drives in comparison to their dc drive counterparts. Although most of today's growth in the worldwide industrial drive market can be ascribed to ac drives, modern generations of dc drives continue to hold a significant share of the total industrial drive market

b) Rail traction: Rail transport systems have been a major application area for electric drives since the earliest days of electric machines in the 1800s. While some of the earliest applications of electric drives for rail propulsion systems were in trolley vehicles for urban transport, the adoption of electric machines for heavyrail propulsion soon followed However, the architecture of the electric rail propulsion systems evolved quite differently in various parts of the world, and these differences persist to this day (Fig. 1). In particular, rail systems in Europe and Japan took the form of catenary supply systems with electric power supplied to the locomotive propulsion drives via overhead transmission lines. In contrast, intercity rail systems in other parts of the world such as North America adopted self-powered locomotives using hybrid combinations of on-board diesel engines and electrical generators that produce electrical power which is subsequently fed to wheel-coupled motors. These differences were further aggravated in those regions adopting catenary systems by the choice of significantly different voltages (e.g., 1.5 kV, 15 kV, 25 kV) and frequencies ranging from dc to 60 Hz for the power distribution system [7]. Commutator machines designed for either dc or lowfrequency ac (e.g., 16 2/3 Hz) completely dominated electricrail propulsion systems for many decades and are still in wide use today. However, the development of rugged solid-state power semiconductors during the second half of the 20th century made it increasingly practical to introduce ac induction and synchronous machines that eliminate the need for mechanical commutators. Today, ac adjustable-frequency rail

c) Road traction: The application of electric drives to road vehicle propulsion systems has an interesting history that began promisingly in the late 19th and early 20th centuries when early electric propulsion systems handily outperformed competing equipment using immature internal combustion engine (ICE) technology of the time. However, key ICE technology advances such as the electric starter in 1915 vaulted internal combustion engines to their complete dominance in road vehicle propulsion systems that they maintain to this day Worldwide concerns about ICE emissions and the impending depletion of petroleum resources reignited interest in electric propulsion systems for automobiles in the 1970s, and active development has been continuing for the past three decades. DC commutator machines were the preferred prime mover for these electric drive systems until the 1980s when the availability of modern power semiconductors gradually shifted the spotlight to various types of commutatorless machines including induction, permanent magnet synchronous, and switched reluctance machines. 2) Technology: Since other papers in this special issue are devoted individually to each of the key components and subsystems in a modern power converter, the technology background review in this paper will be limited to relevant information not provided elsewhere. First, it is worth noting that the major types of electrical machines adopted or under serious consideration for industrial and traction drive applications include dc commutator, ac induction, ac synchronous, and switched reluctance machines. Cross sections of each of these four machine types are provided in Fig. 2. As their names imply, a major differentiator among the machine types is the form of the required electrical excitation. The switched reluctance machine is a special case, requiring pulsed phase excitation that prevents this machine from being directly connected to either a dc or fixed-frequency ac source without an intervening power converter. The degree of market acceptance of each machine type for industrial and traction drives is closely associated with the comparative availability and cost of its associated power converter technology. Since ac/dc rectifier technology has historically matured considerably earlier than the counterpart dc/ac inverter technology, dc commutator machines rose to prominence in many industrial and traction applications long before they could be effectively challenged by any ac machine Fig. 3. Basic three-phase voltage-source inverter bridge. drive technology. Nevertheless, the limitations imposed by the brushes and mechanical commutator made the dc machine vulnerable to eventual displacement by more rugged machines such as the squirrel-cage induction machine that are particularly well suited for the rigors of industrial and traction drive environments. The availability of solid-state thyristors in the 1960s marked the beginning of the induction machine's gradual rise to dominance in many industrial and traction drive applications. However, a thyristor turns off only when the power circuit forces its current to zero. As a result, self-commutated current-source inverters were widely adopted for many of the early induction machine drive systems developed during the 1970s [9], avoiding the complication and expense associated with auxiliary forced commutation circuits. Eventually, the availability of several types of newpower semiconductors that can be turned off by the gate/base terminal (e.g., bipolar transistors, IGBTs, GTOs) caused the tide to swing in favor of voltagesource inverters using pulsewidth modulation (PWM) [10]. As a result, current-source inverters are generally found today only in high-power drive applications (1 MW) where thyristors are still able to successfully compete with the various types of controlled-gate power switches

Concluding Remarks

The recent developments outlined briefly in this paper bear testimony to the major progress that has been accomplished during the past few years in applying new power electronics technology to industrial and traction drives. Although the improvements sometimes seem painfully slow and labored to technical experts working in the field every day, the rate of technical progress is actually very impressive when one takes a step back to see how far the technology has progressed during the past 25 years. Where do we go from here? The future of both industrial and traction drives depends not only on advances in the underlying technologies, but the economic and regulatory climate in which they are developing. Despite the risks of predicting future trends, there are many reasons to expect that increasing global concerns about efficient electrical energy utilization, transportation fuel economy, pollutant emissions levels, and electrical power quality will increase during coming years. In light of these pressing concerns, the desire for further major improvements in industrial and traction drives will almost certainly continue to place a high premium on new advances in power electronics technology

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