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# Contemporary Progresses in Power Integrated circuit Technology for Industrialized and Traction Machine Determinations

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**Abstract**

**This paper presents a review of the state of the art of power electronics technology in both industrial and traction drive application. Key development trends include the dominance of ac adjustable-speed drives in new applications, with the squirrel-cage induction machine as the preferred machine in most cases. Particularly striking has been the rapid ascendance of the insulated-gate bipolar transistor (IGBT) as the predominant power switch in both industrial and traction applications ranging from fractional kilo-watts to multimegawatts. Key current issues such as industrial drive input power quality and the effects of fast IGBT switching transients on the machines and electromagnetic interference (EMI) production are reviewed. Recent developments in electric traction for both rail and road vehicles are discussed, including the increasing modularity of new traction inverters in all sizes and the market intro-duction of new hybrid vehicles using advanced power electronics. The paper concludes with a discussion of expected future trends in power electronics technology that will likely expand the markets for industrial and traction drives during coming years.**

**Key words: traction drive, hybrid vehicles, industrial drives**

## I. INTRODUCTION

Power electronics has a far longer history than other people in the field are aware of. As can be said, its development and success have not been gradual or well-organized. The "life-changing" events that prompted the most significant changes in the practice were completely unexpected. It is helpful to accept the following working term in order to provide a foundation for both looking back to our beginnings and, at the same time, a better view of the world in which power electronics engineers function today.

Power electronics is a field of study that deals with the efficient conversion, control, and conditioning of electrical power from its functional input form to the desired electrical output form using static means.To accomplish the following goals, this technology involves the effective use of electrical and electronic components, the application of linear and non-linear circuit and control theory, the use of skilled modelling techniques, and the development of sophisticated analytical methods.

The aim of power electronics is to control how much energy is transferred from an electrical source to an electrical charge. High efficiency, high availability, high reliability, small scale, light weight, and low cost are all important factors. We'll start by identifying the key technical characteristics that distinguish electronic power systems from other electrical systems. In addition, we highlight characteristics that help differentiate four different forms of power electronic systems. In this sense, we look back at the history of electrical engineering to try to identify some of the people and events that have had a significant impact on some of the most important developments in the ever-changing field of power electronics. "Beauty is in the possession of the beholder," as we've always heard. "History is in the eye of the historian," one might say. For this reason, it must be stated right away that the author is not a historian nor even what might be considered a competent student of history. The speaker is a serious engineer with more than forty years of experience in government, private enterprise, and teaching, concentrating most of his scientific energies in the area that we now classify as power electronics. As a result, he had the good fortune to see all of the events firsthand and to know all of the people who had and would have a significant impact on the profession's prospects in the second half of the twentieth century and the twenty-first century. The author has tried to be as meticulous in recounting historical experiences as he is in describing a laboratory experiment in planning the material for this paper. The reader should be aware, though, that some of the events reported are based on people's memory rather than hard facts.

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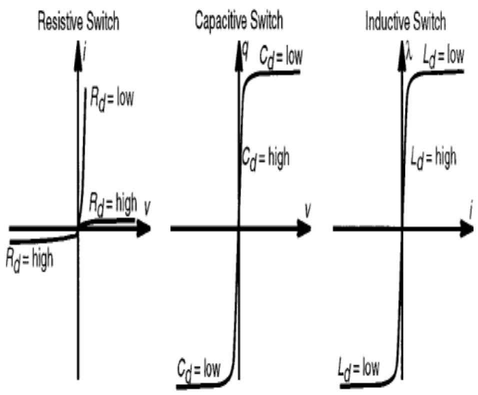


Figure 1: Various types of switching characteristics.

First, we define some features that are typical of power electronic systems in general, and then other features that help to differentiate one class or form of power electronics device from another. Of the various interchangeable names assigned to power electronics equipment such as electronic power processor, static power generator, power conditioner, and so on, the almost ubiquitous inclusion of the term power connotes the crucial reality that the primary objective of this equipment is the capacity to handle large quantities of electrical power, preferably, as required by any device load. Power electronics monitor the transfer of electrical energy between the alternating or direct current source and one or more electrical loads requiring alternating or direct current. The flow of power is balanced and governed to satisfy the load(s) specifications by changing the electrical impedance of one or more elements internal to the power converter located between the source and the load(s).

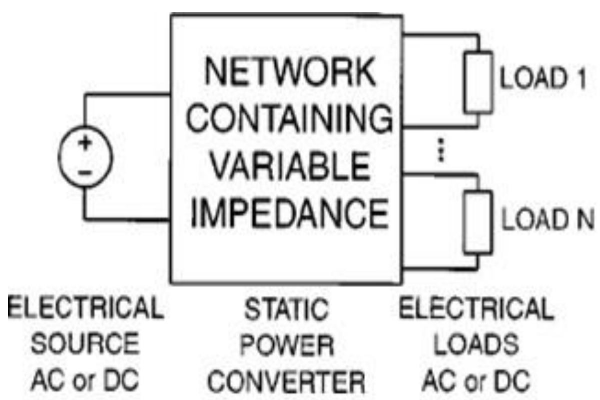


Figure 1 : General Structure of power electronic circuit

The asserted goal of high longevity necessitates the avoidance of parts with known low and volatile life-time limits, such as heater and filament tubes and certain electrolytic capacitors. Because of the goal of high availability, moving parts that need to be repaired or removed on a regular basis are always unwelcome. This is particularly true since these components are part of the key power flow path and are responsible for theregular establishment and interruption of current as part of the power transfer process. As a result, the word "static" exists in our definition of power electronics. Most power electronic circuits may be accurately modelled using an electrical network made up of controlled sources and pure resistive, capacitive, and inductive elements, in which the current entering one terminal of each two-terminal part is immediately transferred to the other terminal.

## II. LITERATURE REVIEW

H.M.B. Metwally et. al [16] suggested new control strategy for speed control of induction motor with field orientation. The proposed model is tested for 2 HP induction motor. A comparison between the characteristics for three different methods namely v/f, direct torque control and field orientation are presented. The comparison showed that better performance characteristics are obtained using the proposed speed control strategy.

Ragu Balanathan et. al [17] modelled the loads of induction motor to carrying out voltage stability analysis in calculating real and reactive power as well as slip. The Generic Dynamic Load Model (GDLM) is modified and proposed model has been used to evaluate transient and steady state stability of induction motor loads.
The simulated approach was suggested and furthers the challenges and advances in simulation tool for complex power electronics system and drives were explained byP.Bauer et. al [18].

An improved mathematical model for variable speed single phase induction motors including motor losses is presented by S.Vaez-Zadeh et. al [19]. A single phase variable frequency supply and an advanced motor test setup are developed to evaluate the machine model under different supply and operating conditions. The machine characteristics obtained by the model are in good agreement with experimental results. It proves the validity of the proposed steady state model in predicting the motor performances under a wide range of voltages, frequencies and operating conditions with slightly better results at the frequencies close to the nominalone.

Derek N. Dyck et. al [20] simulated an induction motor driven with a Pulse Width Modulation (PWM) techniques. The Induction Motor Modeling (IMM) was validated by comparison to a time-stepping FE transient simulation of a 12-slot, 13-bar, four-pole induction motor at 1000 rpm and driven with sinusoidal voltages and PWM techniques.

V.S.S.P.K. Hari et. al [21] developed a hybrid PWM technique employing five switching sequences. The developed technique is a combination of continuous PWM, Discontinuous PWM (DPWM) and advanced bus clamping PWM methods. Performance of the developed PWM technique has been evaluated and compared withexisting techniques on a constant volts per hertz induction motor drive. It proves that hybrid PWM is superior in terms of total harmonic distortion in the line current, as compared to conventional space vector PWM (CSVPWM) and DPWM over a fundamental frequency range of 32–50 Hz at a given average switching frequency. The reduction in harmonic distortion is about 42% over CSVPWM at the rated speed of the drive.

## III. POWER ELECTRONICS FOR TRACTION APPLICATIONS

Electric drive is required in such applications, such as goods or equipment that require motion. Nowadays, there are a plethora of applications that require motion that we can findall around us. Trains, locomotives, trams, and metros, for example, all use a traditional traction service nowadays. The traction car has at least one traction bogie, as shown in Fig. 3, where traction forces are induced on the traction wheels by a unique combination of mechanical transmissions and electric motors. The longitudinal travel of the entire train over the track is caused by the traction effort on the wheels. The user's comfort-related features such as rpm, pull, and slip-to can all be controlled thanks to a specially engineered electrical drive.

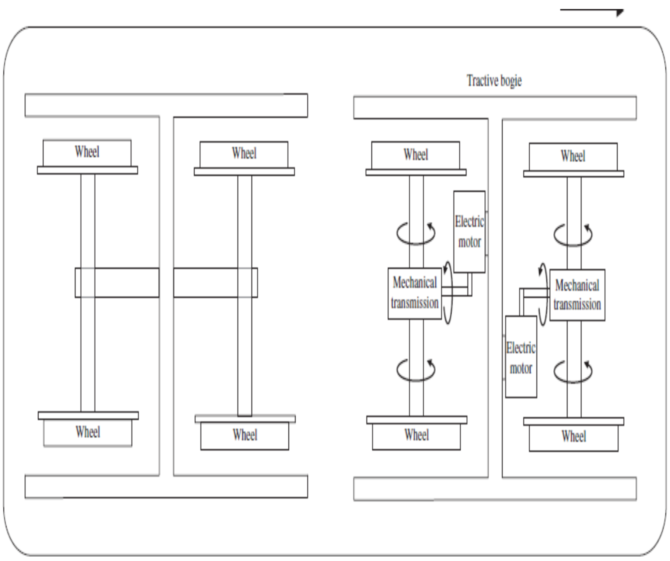


*Figure 3 : Traction System.*

It's also worth noting that, as with most applications that require movement to be generated and controlled, the movement is provided by an electric motor. The rotational movement produced by the engine's shaft is then translated into the movement required by the application, which in the case of the train is the train's longitudinal movement. It should also be noted that the train's movement must be monitored to ensure basic functions such as quick and relaxed deliveries and accelerations, reduced energy consumption, and reduced noise levels. The movement is generated by what is known as the electric drive in order to accomplish this. The electrical drive will be discussed in greater detail later in the chapter, but in a nutshell, it is made up of an electrical drive. The rotational movement is generated byan electric motor.

An Electronic Power Converter, which supplies the electric motor with energy from a specific energy source, enabling the regulated rotation of the electric motor; a Control Algorithm, which is responsible for controlling the Electronic Power Converter to achieve the desired power output of the electric motor; and an Energy Source, which in some cases is part of the Electric Power Converter;
As a result, there are two ship applications to consider. A thruster or propeller controls the forward motion of a modern ship. The thruster accelerates the blades by rotating them, displacing the water behind it and causing the ship to move forward. The electric motor, once again, is the component that allows the blade to rotate. The thruster is powered by an electrical drive that was specially engineered and adapted for that ship in order to achieve stable and controllable travel. This allows

the ship to shift at varying speeds, under various sea conditions, or to conduct dynamic positioning (DP) while conducting a specific mission.

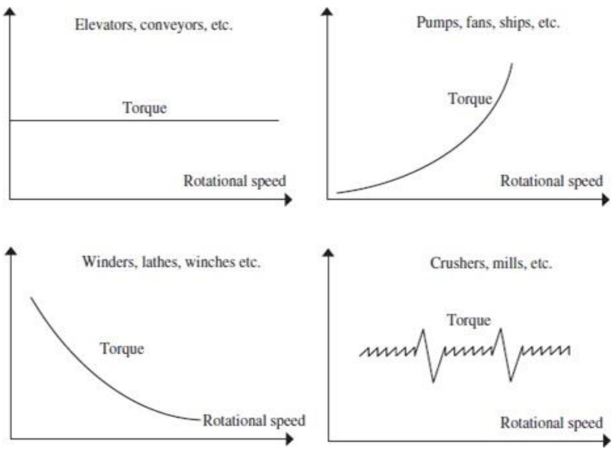


*Figure 4 Torque Speed Curves of Various Applications.*

The movement that is produced in both of these applications necessitates the resolution of force or torque. This torque is detected by the electric motor, specifically the electric motor, which requires an opposition torque for proper machine operation. In the case of elevators, for example, the electric drive must be able to provide the necessary and continuous torque on the engine shaft in order to generate an equal force to lift the vehicle, regardless of the number or weight (within reason) of the passengers to be transported. For example, if a train must travel at a constant speed, the torque delivered by the electric drive will be determined by the force of the air in the opposite direction, the angle, the weight of the passengers, and other factors. As a result, the opposition torque that the electric drive must produce is always predetermined, depending on the type of operation and the working conditions of the machine. Figure 4 depicts some common torque vs. rotational speed trends in various applications. For example, for a given number of passengers in the vehicle, the elevators can be shown to run at a constant torque (constant mass). For example, in ships, the electric torque ensures that the thruster moves at various rotational speeds and, as a result, the ship moves at various longitudinal speeds, and that the rotational speed has an exponential relationship with the longitudinal speed.

## IV. ELECTRIC DRIVES FOR TRACTION APPLICATIONS

Following are the various machines that will be used in traction applications.

Induction motors (IM)

Synchronous motors (SM)

Brushless motors (BLDC)

Reluctance motors (RM)

**4.1 Induction Motors:**

Induction motors are commonly used in commercial settings. Their success stems from their ease of use, ruggedness, and low construction costs, as well as their ease of maintenance, high power performance, and high durability. However, they are not immune to electrical or mechanical defects. Thorsen [11] gives a very helpful survey of industrial system failures utilising various categorizations such as machine capacity, enclosure design, safety scheme, era, operating hours, repair regime, number of poles, and so on. He pinpoints the originators, contributors, and root causes of stator and bearing failures, which account for more than 75% of all failures. These flaws result in sudden motor breakdown, which results in a manufacturing halt and financial loss. As a result, induction motor condition control is important.

There are several methods for condition management that have been released. Motor current signature analysis (MCSA), electromagnetic torque analysis, noise and vibration control, acoustic noise tests, and partial discharge are some of the methods that have historically been used in industry [12]. Understanding the electric, magnetic, and mechanical behaviour of the system in a safe state and under fault conditions is the foundation of every reliable condition control technique [13]. These techniques are usually designed and verified using complex mathematical models that enable for detailed machine simulation, prediction of motor activity, and detection of fault signatures [12–15]. Models of motor activity in normal and abnormal circumstances may be used to look at the mechanical features of defective motors without having to measure them destructively. Multiple-coupled circuit (MCC) models, updated d-q models, magnetic equivalent circuit (MEC) models, and finite-element system (FEM) models are among the control on the IM performance.

subcategories. The aim of this paper is to provide an overview of these four fault models. Model definition, parameter estimation, faults modelled, model scale, and

Numerical intensiveness are also addressed with each category of model. At the end, a variety of description tables are providedfor easy linking of templates to relevant works

## V. SIMULATION RESULTS OF INDUCTION MOTOR DRIVES

Dynamic simulation has been arranged in MATLAB/SIMULINK to evaluate the effects of drive

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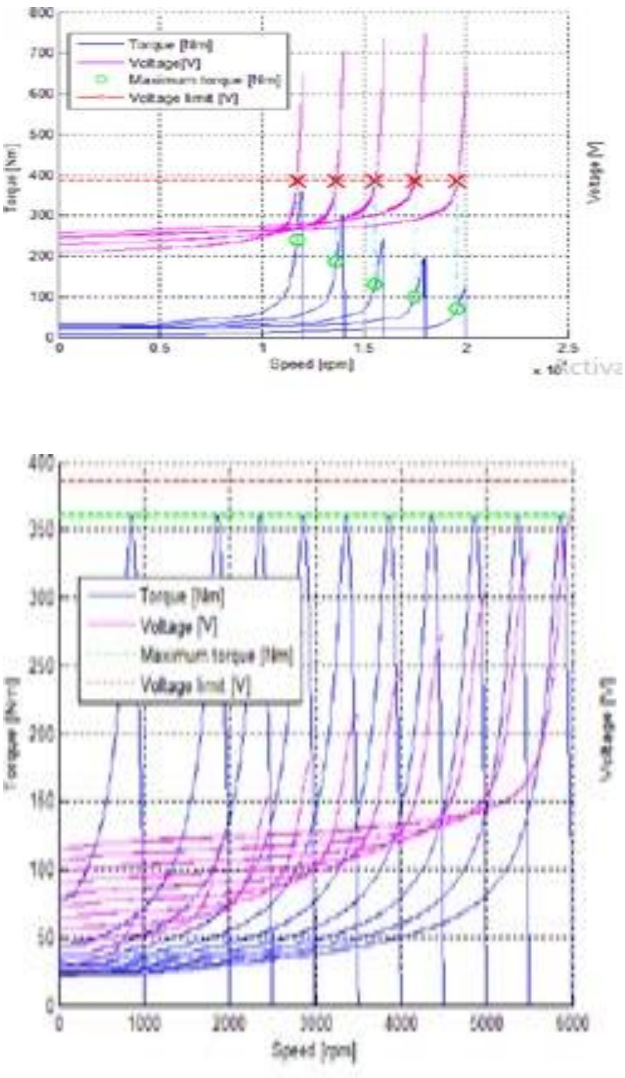


Figure 6. Characteristics of IM Drive.

## V. CONCLUSION

The latest advances discussed briefly in this paper attest to the significant strides made in adapting modern control electronics technologies to automotive and traction drives in recent years. While technological experts employed in the sector every day may perceive advances asrelatively slow and laborious, the pace of technical advancement is really very remarkable whenone consider show much technology has advanced over the last 25 years.

What are our options now? The future of both industrial and traction drives is determined not just by advancements in the fundamental technology, but also bythe economic and regulatoryenvironment in which they are being developed. Against the inherent dangers of forecasting potential developments, there are numerous reasons to believe that in the coming years, global concerns regarding effective electrical energy use, transportation fuel economy, pollutant pollution levels, and electrical power quality would grow. In terms of the surgent challenges, new developments in power electronics tec hnologies will almost definitely continue to be prioritized in the search for more significant changes in automotive and traction drives.

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