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ASSORTED TRENDS IN POWER ELECTRONICS

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Abstract

Power electronics is widely used in many major industrial applications, power supply, battery management system, smart grid etc. Huge demand emerges in the major industrial applications for power , electronics expertise, which requires the theory of power electronics and the real industrial needs to be combined tightly. Most renewable energy resources tend to be geographical dependent and clustered in certain areas due to availability of natural resources. This paper illustrates basic history of power electronics including various trends in this industry with its certain prime applications.

Keywords*: Power electronics, Ecodesign, Smart grid, Efficiency.*

Introduction

Power electronics is the application of solid-state electronics to the control and conversion of electric power. It also refers to a subject of research in electronic and electrical engineering which deals with the design, control, computation and integration of nonlinear, time-varying energy-processing electronic systems with fast dynamics.Power electronics started with the development of the mercury arc rectifier. Invented by Peter Cooper Hewitt in 1902, it was used to convert alternating current (AC) into direct current (DC). From the 1920s on, research continued on applying thyratrons and grid-controlled mercury arc valves to power transmission.

Uno Lamm developed a mercury valve with grading electrodes making them suitable for high voltage direct current power transmission. In 1933 selenium rectifiers were invented. In 1947 the bipolar point-contact transistor was invented by Walter H. Brattain and John Bardeen under the direction of William Shockley at Bell Labs. In 1948 Shockley's invention of the bipolar junction transistor (BJT) improved the stability and performance of transistors, and reduced costs. By the 1950s, higher power semiconductor diodes became available and started replacing vacuum tubes. In 1956 the Silicon Controlled Rectifier (SCR) was introduced by General Electric, greatly increasing the range of power electronics applications. By the 1960s the improved switching speed of bipolar junction transistors had allowed for high frequency DC/DC converters. In 1976 power MOSFETs became commercially available. In 1982 the Insulated Gate Bipolar Transistor (IGBT) was introduced. Automotive electronics is a wide area It is clear that they will become more integral has the years progress. In the 1950s, for instance, "luxury" meant power steering and rollup windows. Now a common $15000 car has these features. Auto manufacturers are going to strive to introduce new features. Cars today are now electromechanical machines, instead of being just mechanical machines. It is good to have an electrical background for the future.The primary trends present in almost all power supply market segments are: increased efficiency; higher power density; and cost reduction. Andrew Skinner looks at how these trends

Ecodesign

Thanks to governmental legislation and widespread media pressure, it's fair to say that we are all mindful of how the environment is being affected by the products we use; it's influencing consumer choice and every buying decision we make, whether it's the fuel efficiency of a car or the energy rating of a washing machine. Similarly, power supply efficiency is a key selection criterion and this is supported by legislation such as the Ecodesign Directive 2009/125/EC. Although the scope of the Ecodesign Directive is currently targeted at higher volume consumer related products, many manufacturers of professional electronic products are following the same guidelines voluntarily. These also mandate low power standby operation – similar to the tighter standby power consumption restrictions put on tv and Freeview boxes a few years ago. There are several methods to improving efficiency and these include: developing new topologies; improved power devices, control ics and magnetic component designs entering the market; the availability of new materials; and the application of digital control loops. Depending on the type of power supply and its end use, some or all of these methods will be used. To illustrate this, a low power (150W or less) power supply aimed at high volume, cost sensitive applications would still use a low-cost conventional flyback circuit with one of the newer control ics that helps simplify compliance to the minimum efficiency standards of the Ecodesign legislation. In contrast, a high power (>1000W), high density power supply for redundant data centre applications meeting 80 PLUS efficiency requirements of up to 96% or more, will use most of the methods noted above. For lower power applications, it's all about high power density with more and more power being claimed on industry standard pc board sizes, such as 2 x 4in and 3 x 5in. For cost reasons, a flyback circuit is commonly used but this has its limitations in terms of achieving efficiency improvements.

New Trends

New chips are now available that enable efficiencies of up to 92%, although one must appreciate that at an efficiency of 92%, a 200W power supply will still dissipate 27% more excess power than a previous generation 100W product at 88% efficiency. Indeed, many components will be larger for the 200W power supply so, if both are designed to be the same size, then the parts are packed much more tightly and significant thermal challenges arise. Reducing the value and size of electrolytic output capacitors is a common way to save space and cost. However, the risk is that since flyback circuits generate high ripple current the life of the capacitor can be shortened significantly unless close attention is paid to the design. Customers are becoming increasingly aware of the difference between mtbf and design life and are now asking power supply manufacturers how a power supply will perform over the expected life of the host equipment. For medium and high power applications, the use of a digital control loop will play a major part in continued efficiency improvement. By simplifying interleaved power factor correction and enabling real-time efficiency improvement through dynamic operating algorithms, these power supplies can respond continuously to line and load conditions to ensure maximum efficiency at all times; this is commonly referred to as Intelligent Embedded Power. Certain complex topologies that were previously difficult or almost impossible to control using analogue techniques become viable with a digital approach to deliver additional efficiency gains. DSPs are now coming onto the market at attractive price points and with sufficient functionality for power supply use – as a result, digitally controlled power conversion will become increasingly common. The added advantage of an on board dsp or microcontroller is that it is easier to implement a higher level of external monitoring and control whenever the end application demands it.

Usage

A growing proportion of the market is requiring additional system monitoring and control features beyond those required of a basic power supply – especially for use in large complex installations such as data centres, as well as remote and Smart Grid related installations. For mainstream applications in the foreseeable future, digital power conversion will be a means to create power supplies with higher density and efficiency – but those offering self-monitoring and diagnostics will be attractive to customers whose products are deployed in mission critical applications. The impact of digital control and enhanced efficiency means that convection cooled medium to high power products are becoming more viable from a cost and size perspective. Whilst a convection cooled power supply will never be the same size as a fan cooled product (in the foreseeable future), many customer end products can accommodate a reasonably sized power supply and the attractions of a product that does not have fan noise or the risk of pollution ingress are substantial. New power devices using silicon carbide (SiC) and gallium nitride (GaN) will be increasingly common in ac/dc power supplies. SiC diodes are already in common usage in high efficiency products and this will expand as component prices fall further – driven by increasing volumes and device manufacturers moving to larger wafer sizes. GaN wafer costs are expected to be significantly lower than those of Si .The first SiC FETs we see on the market are 1200V devices targeted mainly at inverters and motor applications for renewable energy. At the moment, the use of a 1200V SiC FET is likely to be too expensive for most commercial ac/dc power supply applications, even though the efficiency improvement gains can be attractive. For conventional switched mode power supplies, 600 to 800V devices are sufficient and it is expected that devices targeting industrial power supplies in sub 1000V class will first come from GaN.

Targetting Maximun Efficiency

Although GaN devices suitable for low voltage dc/dc converters are now available, it is likely to be 2014 or 2015 before devices suitable for the primary side of ac/dc power supplies become commercially available and, in the early years, adoption is likely to be limited to higher end products targeting maximum efficiency. Magnetics will continue to see improvement – new ferrite materials will help to reduce core sizes and reduce losses further and squeezing out more efficiency gains means that magnetics designs will be more complex in some products to minimise core and winding losses albeit at a higher cost. Cost-effective use of ceramics will also become more common, particularly where adequate thermal design is a major constraint. The physical parameters of the power supply will continue to dominate most applications for the foreseeable future with the key driver being high efficiency, which in turn allows compactness and lower heat dissipation. The most successful companies are likely to be those that are actively developing advanced technologies, especially digital power conversion, often in collaboration with universities.

Applications

Applications of power electronics range in size from a switched mode power supply in an AC adapter, battery chargers, fluorescent lamp ballasts, through variable frequency drives and DC motor drives used to operate pumps, fans, and manufacturing machinery, up to gigawatt-scale high voltage direct current power transmission systems used to interconnect electrical grids. Power electronic systems are found in virtually every electronic device. Inverters are utilized in applications requiring direct conversion of electrical energy from DC to AC or indirect conversion from AC to AC. DC to AC conversion is useful for many fields, including power conditioning, harmonic compensation, motor drives, and renewable energy grid-integration. A smart grid is a modernized electrical grid that uses information and communications technology to gather and act on information, such as information about the behaviors of suppliers and consumers, in an automated fashion to improve the efficiency, reliability, economics, and sustainability of the production and distribution of electricity.

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