# What is power electronics engineering essay

Power electronics involves the study of electronic circuits intended to control the flow of electrical energy. These circuits handle power flow at levels much higher than the individual device ratings.

It has been said that people do not use electricity, but rather they use communication, light, mechanical work, entertainment, and all the tangible benefits of both energy and electronics. In this sense, electrical engineering is a discipline very much involved in energy conversion and information. In the general world of electronics engineering, the circuits engineers design and use are intended to convert information, with energy merely a secondary consideration in most cases. This is true of both analog and digital circuit design. In radio frequency applications, energy and information are sometimes on a more equal footing, but the main function of any circuit is that of information transfer.

What about the conversion and control of electrical energy itself? Electrical energy sources are varied and of many types. It is natural, then, to consider how electronic circuits and systems can be applied to the challenges of energy conversion and management. This is the framework of power electronics, a discipline that is defined in terms of electrical energy conversion, applications, and electronic devices. More specifically, Rectifiers are probably the most familiar example of circuits that meet this definition. Inverters (a general term for dc-ac converters) and dc-dc converters for power supplies are also common applications. As shown in Fig. 1. 1, power electronics represents a median point at which the topics of energy systems, electronics, and control converge and combine [1]. Any useful circuit design for the control of power must address issues of both devices and control, as well as of the energy itself. Among the unique aspects of power electronics are its emphasis on large semiconductor devices, the application of magnetic devices for energy storage, and special control methods that must be applied to nonlinear systems. In any study of electrical engineering, power electronics must be placed on a level with digital, analog, and radio-frequency electronics if we are to reflect its distinctive design methods and unique challenges.

FIGURE 1. 1 Control, energy, and power electronics are interrelated.

All power electronic circuits manage the flow of electrical energy between some sort of source and a load. The parts in a circuit must direct electrical flows, not impede them. A general power conversion system is shown in Fig. 1. 2. The function of the power converter positioned at the middle is that of controlling energy flow between a given electrical source and a given load. For our purposes, the power converter will be implemented with a power electronic circuit. As a power converter appears between a source and a load, any energy used within the converter is lost to the overall system. A crucial point emergesâ€” to build a power converter, we should consider only lossless components. A realistic converter design must approach 100% efficiency. A power converter connected between a source and a load also affects system reliability.

FIGURE 1. 2 General systems for electric power conversion

A circuit built from ideal switches will be lossless. As a result, switches are the main components of power converters, and many people equate power electronics with the study of switching power converters. Magnetic transformers and lossless storage elements such as capacitors and inductors are also valid candidates for use in power converters. The complete concept, shown in Fig. 1. 3, illustrates a power electronic system. Such a system consists of an energy source, an electrical load, a power electronic circuit, and control functions. The power electronic circuit contains switches, lossless energy storage elements, and magnetic transformers. The controls take information from the source, load, and designer and then determine how the switches operate to achieve the desired conversion. The controls are usually built up with conventional low-power analog and digital electronics.

FIGURE 1. 3 a basic power electronic system

Trends in Power Supplies :

As costs of electronics decline, the power supply becomes a larger fraction of system cost and design effort. One major manufacturer estimates that power supply cost will soon reach 50% of the total cost of a typical electronic product such as a cordless telephone or personal computer. Thus, new technology developments in power supplies are critically important.

In the past, bulky linear power supplies were designed with transformers and rectifiers from the ac line frequency to provide low-level dc voltages for electronic circuits.

Late in the 1960s, use of dc sources in aerospace applications led to the development of power electronic dc-dc conversion circuits for power supplies. In a typical power electronics arrangement today, an ac source from a wall outlet is rectified without any transformation; the resulting high dc voltage is converted through a dc-dc circuit to the 5V, 12 V, or other level required. These switched-mode power supplies are rapidly supplanting linear supplies across the full spectrum of circuit applications. A personal computer commonly requires three different 5V supplies, two . 12 V supplies, a Ã¿12 V supply, a 24 V supply, and perhaps a few more.

This does not include supplies for 1 Introduction 3 video display or peripheral devices. Only a switched-mode supply can support such complex requirements without high costs. The bulk and weight of linear supplies make them infeasible for hand-held communication devices, calculators, notebook computers, and similar equipment. Switched-mode supplies often take advantage of MOSFET semiconductor technology. Trends toward high reliability, low cost, and miniaturization have reached the point at which a 5 V power supply sold today might last 1, 000, 000 hr (more than 100 yr), provide 100Wof output in a package with volume <15 cm3, and sell for a price of <$0: 30 watt.

This type of supply brings an interesting dilemma: the ac line cord to plug it in actually takes up more space than the power supply itself. Innovative concepts such as integrating a power supply within a connection cable will be used in the future.

Device technology for power supplies is being driven by expanding needs in the automotive and telecommunications industries as well as in markets for portable equipment. The automotive industry is making a transition to 42 V systems to handle increasing electric power needs. Power conversion for this industry must be cost effective, yet rugged enough to survive the high vibration and wide temperature range to which a passenger car is exposed. Global communication is possible only when sophisticated equipment can be used almost anywhere.

This brings a special challenge, because electrical supplies are neither reliable nor consistent throughout much of the world. While in North America voltage swings in the domestic ac supply are often < _5% around a nominal value, in many developing nations the swing can be _25%â€" when power is available. Power converters for communications equipment must tolerate these swings, and must also be able to make use of a wide range of possible backup sources.

Given the enormous size of worldwide markets for telephones and consumer electronics, there is a clear need for flexible-source equipment. Designers are challenged to obtain maximum performance from small batteries, and to create equipment with minimal energy requirements.

DEVICE TYPE – CHARACTERISTICS OF POWER DEVICES

Diode: Current ratings from <1 to > 5000 A. Voltage ratings from 10V to 10 kV or more. The fastest power devices switch in <20 ns, while the slowest require 100 ms or more. The function of a diode applies in rectifiers and dc-dc circuits.

BJT (Bipolar Junction Transistor): Conducts collector current (in one direction) when sufficient base current is applied. Power device current ratings from 0. 5 to 500 A or more; voltages from 30 to 1200V. Switching times from 0. 5 to

100 ms. The function applies to dc-dc circuits; combinations with diodes are used in inverters. Power BJTs are being supplanted by FETs and IGBTs.

FET (Field Effect Transistor): Conducts drain current when sufficient gate voltage is applied. Power FETs (nearly always enhancement mode MOSFETs) have a parallel connected reverse diode by virtue of their construction. Ratings from _1 to _100 A and 30 up to 1000V. Switching times are fast, from 50 or less up to 200 ns. The function applies to dc-dc conversion, where the FET is in wide use, and to inverters.

IGBT (Insulated Gate Bipolar Transistor): A special type of power FET that has the function of a BJT with its base driven by a FET. Faster than a BJT of similar ratings, and easy to use. Ratings from 10 to > 600 A, with voltages of 600 to 1700V. The IGBT is popular in inverters from _1 to 100kW or more. It is found almost exclusively in power electronics applications.

SCR (Silicon Controlled Rectifier): A thyristor that conducts like a diode after a gate pulse is applied. Turns off only when current becomes zero. Prevents current flow until a pulse appears. Ratings from 10 up to more than 5000 A, and from 200V up to 6 kV. Switching requires 1 to 200 ms. widely used for controlled rectifiers. The SCR is found almost exclusively in power electronics applications, and is the most common member of the thyristor family.

GTO (Gate Turn-Off Thyristor): an SCR that can be turned off by sending a negative pulse to its gate terminal. Can substitute for BJTs in applications where power ratings must be very high. The ratings approach those of SCRs, and the speeds are similar as well. Used in inverters rated > 100 kW.

TRIAC: A semiconductor constructed to resemble two SCRs connected in reverse parallel. Ratings from 2 to 50 A and 200 to 800V. Used in lamp dimmers, home appliances, and hand tools. Not as rugged as many other device types, but very convenient for many ac applications.

MCT (MOSFET Controlled Thyristor): A special type of SCR that has the function of a GTO with its gate driven from a FET. Much faster than conventional GTOs, and easier to use. These devices are supplanting GTOs in some application areas.

## POWER CONVERTERS

The power processors usually consist of more than one power conversion stage where the operation of these stages is decoupled on an instantaneous basis by means of energy storage elements such as capacitors and inductors. Therefore, the instantaneous power input does not have to equal the instantaneous power output.

We will refer to each power conversion stage as a converter. Thus, a converter is a basic module (building block) of power electronic systems. It utilizes power semiconductor devices controlled by signal electronics (integrated circuits) and possibly energy storage elements such as inductors and capacitors. Based on the form (frequency) on the two sides, converters can be divided into the following broad categories:

1. AC to DC

2. DC to AC

3. DC to DC

4. AC to AC

We will use converter as a generic tenn to refer to a single power conversion stage that may perform any of the functions listed above. To be more specific, in ac-to-dc and dc-to-ac conversion, rectifier refers to a converter when the average power flow is from the ac to the dc side. Inverter refers to the converter when the average power flow is from the dc to the ac side. In fact, the power flow through the converter may be reversible.

Power Electronic Applications

**(a) Residential**

**Refrigeration and freezers**

**Space heating**

**Air conditioning**

Cooking

Lighting

**Electronics (personal computers, other entertainment equipment)**

**(b) Commercial**

**Heating. ventilating, and air conditioning**

**Central refrigeration**

Lighting

## Computers and office equipment

## Uninterruptible power supplies

(UPSs)

## Elevators

## (c) Industrial

Pumps

## Compressors

## Blowers and fans

## Machine tools (robots)

## Arc furnaces, induction furnaces

Lighting

## Industrial lasers

## Induction heating

Welding

## (d) Transportation

Traction control of electric vehicles

Battery chargers for electric vehicles

Electric locomotives

Street cars, trolley buses

Subways

Automotive electronics including engine

controls

## (e) Utility systems

High-voltage dc transmission (HVOC)

Static var compensation (SVC)

Supplemental energy sources (wind,

photovoltaic), fuel cells

Energy storage systems

Induced-draft fans and boiler

feed water pumps

## (f) Aerospace

Space shuttle power supply systems

Satellite power systems

Aircraft power systems

## (g) Telecommunications

Battery chargers

Power supplies (dc and UPS)