

Preface

Nowadays, “Power Electronics,” basically deals with conversion and control of electrical power using electronic converters based on semiconductor power switches. Historically, the evolution of power electronics has generally followed the semiconductor power device evolution. Power solid-state devices are the heart and soul of modern power electronics equipment. Therefore, the age of power solid-state electronics is often called the second electronics revolution. Development of microelectronic controllers has made revolutionary advances in power electronics.

Power electronics circuits are an integral part of all electronics equipments. Power supply is the heart of all electronic circuits. For low-power consumption units or for portable operation, a battery is often used. For example, in a power supply system for a laptop computer, DC/DC converter converts lithium battery voltage into the output voltages required by the load. AC mains supply is generally used as a primary power supply for high power circuits. In almost all cases, this power requires conversion to the appropriate DC voltage by AC to DC converters. Besides DC to DC and AC to DC converters, typical applications of power electronics include conversion of an unregulated DC voltage to a regulated one, conversion of DC to AC, and conversion of an AC power source from one amplitude and/or frequency to another amplitude and/or frequency.

DC to DC converters and DC to AC inverters provide natural interfaces with direct energy sources such as solar cells, thermoelectric generators, fuel cell uninterruptible power sources. Commercial applications of power electronics include industrial motor drives, electrical vehicle power and drive system, as communications equipment, off-line power systems for computers, robotic technology, inverter systems for renewable energy generation applications, etc. In the twenty-first century, power electronics will have a large impact on industrial automation, energy conservation, utility systems, transportation, and environmental protection.

Power electronics includes application from ranges less than one watt (battery-operated portable equipment) to more than a few 100 or 1,000 W in motor drives or in rectifiers and inverters that interface DC transmission lines to the AC utility power system. In view of the fact that high efficiency is essential in all power processing applications, the key element is the switching converter. A small power

loss and hence high energy efficiency cannot be met by linear electronics where the semiconductor devices are operated in their active (linear) region. That is the reason that switched mode of semiconductor devices (transistors or thyristors) are used in switching converters. When a switch operates in the off state, its current is close to zero, and when it operates in the on state, its voltage drop is very small. In either state, its power dissipation is low. If the switching device is ideal, either the device voltage in on state or the device current in off state is zero so that power dissipation is also zero. Efficiency depends on switching frequency because real devices absorb some power when transition between on and off states and vice versa. Efficiency is improved by use of new switching devices, new circuit topologies, modern control techniques, and new ways of manufacture.

The book “Power Electronics: Converters and Regulators” is structured into ten chapters.

Chapter 1 is “Introduction,” and briefly reviews parts of signals and systems theory as used in power electronics, as well as some circuit theory and basic components used in power electronics.

Chapter 2 covers “Diodes and Transistors,” and particularly covers their use as switches in power electronics circuits. Power MOS transistors, IGBT and some standard driver and snubber circuits are also described in this chapter.

Chapter 3 is still focused on devices, “Regenerative Switches.” The most important regenerative switches are covered including new powerful devices such as the Emitter Turn-Off Thyristor (ETO) and Insulated Gate Bipolar Thyristor (IGCT).

Coverage of topics specific to power electronics starts with Chap. 4, “PWM DC/DC Converters.” All basic topologies are analyzed in both Continuous (CCM) and Discontinuous Current Mode (DCM). This chapter also includes discussion of loss mechanisms in these converters.

“Control Modules” are presented in Chap. 5. Basic principles and characteristics of PWM control modules are covered. The chapter describes a number of circuits used to control power electronic systems, and illustrates their application.

Chapter 6 covers “DC/AC Converters,” i.e., inverters. One-phase and three-phase bridge inverters are presented. Also, the most used control techniques are discussed, unipolar and bipolar PWM and space vector modulation.

Chapter 7 is followed by its natural complement, AC/DC Converters, i.e., rectifiers. The coverage starts from uncontrolled rectifiers, progressing toward phase controlled rectifiers and high power factor PWM rectifiers. The most commonly used control techniques are presented, as well as some application with the PWM rectifiers.

Chapter 8 covers “AC/AC Converters.” This chapter describes single-phase and three-phase AC/AC voltage converters and both direct and indirect frequency converters. Also, an overview of matrix converters and their applications is presented in this chapter.

Chapter 9 contains description of “Resonant Converters.” Many topologies are covered: series resonant converter, parallel resonant converter, class E resonant

converters, zero voltage and zero current switching converters, and some control circuits used in resonant converters.

Chapter 10 covers “Multilevel Converters.” Basic topologies of DC/DC and DC/AC multilevel converters are presented. Also, some widely used control techniques, such as multilevel PWM, space vector modulation and selective harmonic elimination, are briefly discussed in this chapter.

The book “Power Electronics: Converters and Regulators” is primarily intended for students of electrical engineering. A significant part of the book was created from authors’ teaching materials for the subjects *Pulse Electronics* and *Power Electronics* at the Faculty of Electrical Engineering, University of Banja Luka in the last 15 years. This is third revised and updated edition. In relation to the two previous issues from 2000 and 2007, which were intended for Serbian and Croatian language readers (ex-Yugoslavia countries), this issue has have more than one third of the content altered. The alterations are in the form of: completely or partially new chapters, such as Multilevel Converters, Space Vector Modulation, Active Rectifier, PWM Rectifiers, Matrix Converters, Power Factor Correction, and number of problems at the end of every chapter.

For the design of power electronic converters, different knowledge from electrical engineering fields is required, such as theory of electrical circuits, electronics, electromagnetics, theory of control systems, and heat transfer. In addition, semiconductor elements in switched mode are highly nonlinear, and analysis of the circuits is quite complex. Therefore, simplified models are used in this book with explanation of the basic processes and essential phenomena. This is followed by waveforms of characteristic voltages and currents, which should complete understanding of electrical circuits operation. Numerous solved examples in each chapter should help students better understand the book material. Besides, we used examples to introduce ways of thinking about the problems, methods of analysis, and use of approximations. For some problems the results obtained by PSPICE simulation are presented. At the end of each chapter, unsolved problems are given, which should help the students to test their knowledge and stimulate thinking about the material presented in the chapter.

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