

# **POWER ELECTRONICS**

***CIRCUITS, DEVICES, AND APPLICATIONS***



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**M. H. RASHID**

# *Power Electronics*

## *Circuits, Devices, and Applications*

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# *Power Electronics*

To my parents, my wife Fatema  
and  
my children, Faeza, Farzana, and Hasan

# *Preface*

Power electronics deals with the applications of solid-state electronics for the control and conversion of electric power. Conversion techniques require the switching on and off of power semiconductor devices. Low-level electronics circuits, which normally consist of integrated circuits and discrete components, generate the required gating signals for the power devices. Integrated circuits and discrete components are being replaced by microprocessors.

An ideal power device should have no switching-on and -off limitations in terms of turn-on time, turn-off time, current, and voltage handling capabilities. Power semiconductor technology is rapidly developing fast switching power devices with increasing voltage and current limits. Power switching devices such as power BJTs, power MOSFETs, MOSIGTs, SCRs, TRIACS, GTOs, and other semiconductor devices are finding increasing applications in a wide range of products. With the availability of faster switching devices, the applications of modern microprocessors in synthesizing the control strategy for gating power devices to meet the conversion specifications are widening the scope of power electronics. The potential applications of power electronics is yet to be fully explored.

The time allocated to a course on power electronics in a typical undergraduate curriculum is normally only one semester. Power electronics has already advanced to the point where it is difficult to cover the entire subject in a one-semester course. The fundamentals of power electronics are well established and they do not change

rapidly. However, the device characteristics are changing continuously. *Power Electronics*, which employs the top-down approach, covers conversion techniques first, and then applications and device characteristics. It emphasizes the fundamental principles of power conversions. The book is divided into five parts:

1. Introduction—Chapter 1
2. Commutation techniques of SCRs and power conversion techniques—Chapters 2, 3, 4, 6, 7, and 8
3. Applications—Chapters 5, 9, 10, and 11
4. Devices—Chapters 12, 13, and 14
5. Protections—Chapter 15

Topics like three-phase circuits, magnetic circuits, switching functions of converters, dc transient analysis, and Fourier analysis are reviewed in the Appendixes.

*Power Electronics* is intended as a textbook for a course on “power electronics/static power converters” for junior or senior undergraduate students in electrical and electronic engineering. It could also be used as a textbook for graduate students and could be a reference book for practicing engineers involved in the design and applications of power electronics. The prerequisites would be courses on basic electronics and basic electrical circuits. The content of *Power Electronics* is beyond the scope of a one-semester course. For an undergraduate course, Chapters 1 to 9 should be adequate to provide a strong background on power electronics. Chapters 9 to 15 could be left for other courses or included in a graduate course.

Muhammad H. Rashid  
Munster, Indiana

## COMMENTS ON THE ENCLOSED FLOPPY DISK

A floppy disk has been enclosed with this text. It contains 51 programs written in Advanced BASIC and saved in ASCII characters. These programs can be used for the solutions of some worked-out examples and generating data for some figures, especially with pulse width modulation. The filenames on the disk begin with ‘EX’ for worked-out examples and ‘FIG’ for figures. For example, Figure 4-14 has a filename of ‘FIG-14’. The filenames can be listed by directory listing. The disk has a double-sided 360 kB format readable by any personal computer with a PC-DOS or an MS-DOS 2 or 3 operating system, such as IBM PC, XT or AT. Questions regarding the software may be directed to the author:

Dr. Muhammad H. Rashid  
Professor of Electrical Engineering  
PURDUE UNIVERSITY Calumet  
Hammond, Indiana 46323

**PROGRAMS ON THE DISKETTE**

EX2-16	.BAS	Ex6-12	.BAS	EX11-6	.BAS
EX3-4	.BAS	EX7-2	.BAS	EX11-7	.BAS
EX3-5	.BAS	EX8-3	.BAS	Ex11-8	.BAS
EX3-9	.BAS	Ex8-7	.BAS	Ex11-9	.BAS
EX3-10	.BAS	Ex8-9	.BAS	EX11-10	.BAS
Ex3-12	.BAS	EX8-10	.BAS	FIG11-3	.BAS
Ex4-6	.BAS	EX8-11	.BAS	FIG11-4	.BAS
Ex4-12	.BAS	EX8-12	.BAS	FIG11-9	.BAS
Ex4-13	.BAS	Ex8-13	.BAS	FIG11-12	.BAS
FIG4-14	.BAS	EX8-14	.BAS	EX12-1	.BAS
FIG4-15	.BAS	FIG8-11	.BAS	Ex12-2	.BAS
EX6-4	.BAS	FIG8-13	.BAS	Ex12-3	.BAS
EX6-5	.BAS	FIG8-15	.BAS	Ex12-4	.BAS
Ex6-6	.BAS	EX11-1	.BAS	Ex12-5	.BAS
Ex6-7	.BAS	Ex11-2	.BAS	EX15-2	.BAS
Ex6-8	.BAS	Ex11-3	.BAS	EX15-3	.BAS
Ex6-9	.BAS	Ex11-4	.BAS	EX15-4	.BAS



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