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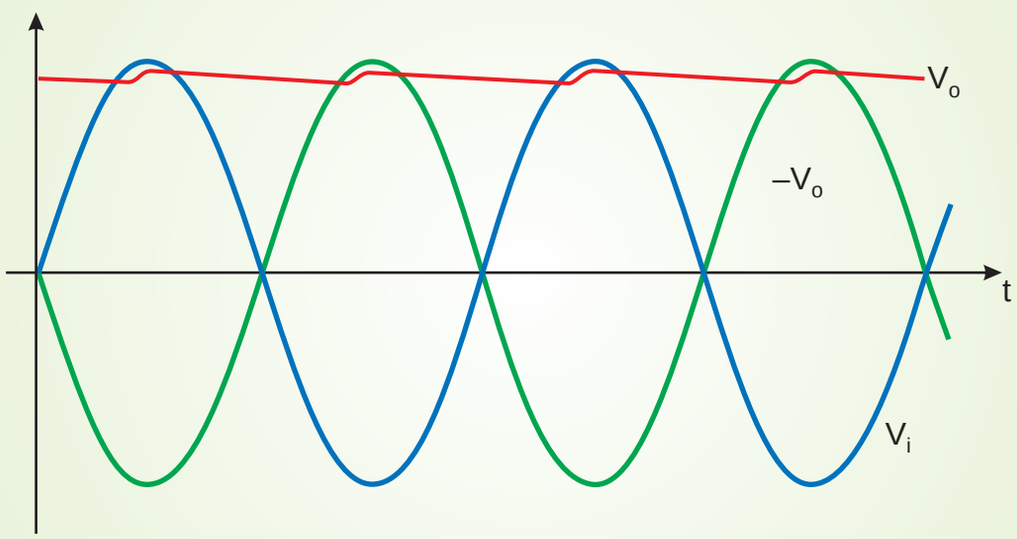
Basic Electronic Devices and Circuits



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Basic Electronic Devices and Circuits

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BASIC ELECTRONIC DEVICES AND CIRCUITS
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To students
who care to think
beyond exams and marks

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Preface

Yet another book? Aren't there some excellent books on the topic already? Indeed, there is no convincing explanation for writing another book on semiconductor devices. Perhaps, it is the urge to tell the story (at least the parts one believes one knows well) in one's own words. On a more mundane note, the present book, unlike many others, also includes basic electronic circuits, a topic that is now getting clubbed in the first course on semiconductor devices in several engineering colleges, apart from IIT Bombay.

We start with a chapter (Chapter 1) on numbers from all walks of life, in order to put things in perspective. This will hopefully make the student sit up and wonder whether the answer s/he has got, e.g., 58.2 A, for the current through a MOS transistor in an inverter circuit, has the correct order of magnitude. After that begins the actual technical content.

We cover in Chapter 2 the "nuts and bolts," viz., semiconductor structure, band diagrams, electron and hole statistics, carrier transport (drift and diffusion), and Poisson and continuity equations, sprinkled with numerical examples which will help to fix the scale in the student's mind. We then embark on a journey (Chapter 3) to find the not-so-short answer to the question—Why does a *pn* junction rectify? A qualitative description of breakdown of *pn* junctions is also included. Metal-semiconductor (M-S) junctions are briefly discussed in the same chapter since the I–V relationship of a rectifying M-S junction closely resembles that of a *pn* junction.

In the following chapter (Chapter 4), we look at switching of a *pn* junction between conducting and non-conducting states and the small-signal model of a *pn* junction. Some of the optical devices based on *pn* junctions are taken up in Chapter 5. Simple diode circuits are covered in Chapter 6.

A natural extension of *pn* junctions, the bipolar junction transistor (BJT), is discussed in Chapter 7 which includes the structure and basic operation of a BJT, its regions of operation, and breakdown phenomena. The performance advantage of a heterojunction bipolar transistor (HBT) over a BJT is explained.

The use of a BJT for amplification is discussed in Chapter 8, starting with biasing and signal coupling issues. Different amplifier configurations are presented, and the gain, input resistance, and output resistance are discussed in each case. Switching behaviour of a simple BJT inverter is also described in Chapter 8.

Junction field-effect transistors (JFETs) are covered in Chapter 9, starting with low-voltage operation and then moving to current saturation at higher drain voltages. Simple JFET amplifier circuits are presented. Metal oxide semiconductor field-effect transistors (MOSFETs) are discussed in a separate chapter (Chapter 10). First, the MOS capacitor is described in detail, and its charge-voltage relationship is used subsequently to derive the current-voltage equation for the MOS transistor. The most basic digital circuit—the inverter—is discussed, followed by a few other logic gates.

The book is expected to serve as a complete text for an introductory course on basic devices and circuits. Several solved examples are included, and review questions are given at the end of the chapters for students to test their understanding. Instructors may obtain a solution manual by contacting the publisher. Additional reading material is listed after the last chapter.

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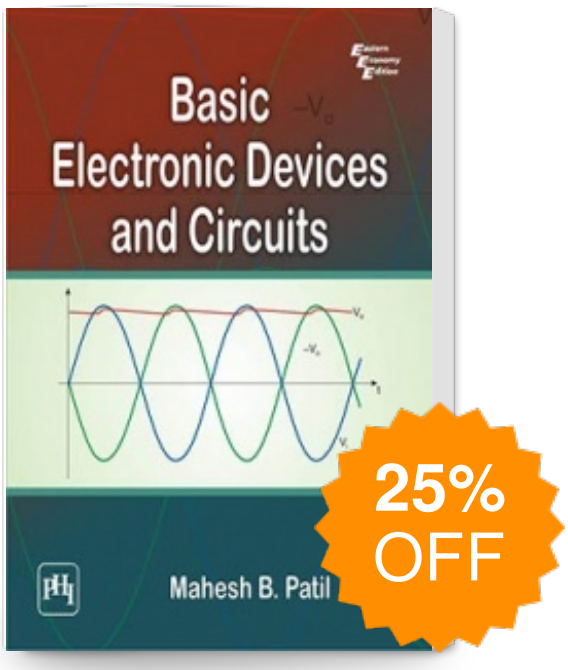

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