Preface

Millions of Electronic Devices join hands together to work as Personal Computer, Mobile Telephone, Satellite Communication Link, Landline Telephone, DVD Player and so on. The list is almost without an end.

Developments in the field of Electronic Devices are leading to Nano-technology. Applications of Nano-technology in the field of medicine are expected to eradicate even chronic diseases.

THE BOOK

The elementary functional unit of any Integrated Circuit (IC) is an Electronic Device. A question often raised is—Why study discrete devices when everything is designed with ICs? The learned answer is that understanding these devices is crucial in understanding terminal behavior of ICs. The aim of this book is to make reader comprehend thoroughly the construction, characteristics, data sheet specifications, applications and limitations of basic electronic devices.

The need to write one more text was sensed after noting that majority of textbooks on the subject tend to give only a partial story about devices. The construction and characteristics of devices are explained nicely, but there is no link between the theory and its practice. This is where most designers are somewhat "stuck" in the process of completing the design. Translation of theory into practice to address a given application is the job of a designer.

The motivation to write this book was provided by difficulties the author faced himself, when he was a *practicing* electronics engineer for one and a half decades. There were a number of situations where the design worked, but (in few cases, probably with God's grace!) the logic (or magic?) behind several "Thumb rules" was not known. They were taken "as told by seniors". Needless to say, this is against a good design practice. The idea of writing a book that will overcome this difficulty of designers then became more concrete. Subsequently, in the course of teaching, it was noticed that many important circuit analysis and design concepts were not getting registered on to student's mind. There was a need to reduce the *overemphasis on ideal treatment* everywhere, keeping an initiated, enthusiastic student deprived of knowing (or keep on wondering about) what exactly happens with "real" devices. This book attempts to present the "ground" reality about the use of "real" devices. Using ideal treatment with device's characteristic and circuit analysis is all right in the beginning, but it is certainly not very practical and, hence, not the universal one.

The author is aware of the fact that whatever is taught first to students has a profound and long-lasting impact on the student's mind. This is all the more reason for including sections on interpretation of device data sheet specifications and effect of non-ideal characteristics on performance. These sections immediately follow a *brief* coverage of devices' ideal behaviour. The author believes that such a quick changeover from "ideal-to-real" will go a long way in developing correct understanding of subject matter and related design issues. In trying to achieve this objective, there is, of course, no compromise made on coverage of theory.

The material presented here is a compilation of the author's class notes for Electronic Devices and Circuits (EDC), Electronic Circuit Design and related subjects for the last nine years.

TARGET AUDIENCE

This book is intended for undergraduate students of second year engineering (in four year engineering degree course) as first textbook on Electronic Devices. It is particularly useful for budding engineers who wish to study Electronic Devices from the view of adopting them in design or pursue research on devices. The material provided is self-sufficient to be covered in two consecutive semesters. It covers over 90% of the syllabus for the related subject followed by most of the universities in India. The review questions are designed to help students face many competitive examinations conducted on this subject.

Practicing engineers can refer to this text occasionally to revise their understanding and find some finer theoretical aspects.

SALIENT FEATURES

- All required network theorems, laws of linear circuit analysis included
- All newly introduced concepts supported by numerical examples
- Generic problem solving techniques
- Answers to all solved examples supported by comments
- Uniformity in treatment for all introduced devices
- End of the chapter summary of formulae
- Device Data sheet interpretation
- Bridges the gap between theory and practice
- Large number of review questions to enhance subject understanding
- Useful compilation of reference data in the form of nine Appendices.

CONTENTS AT A GLANCE

Chapter 1 is essentially a useful compilation of basic definitions and linear circuit analysis, theorems and laws. Also included is the useful application information on discrete components. Their correct choice is equally important in a design. The chapter also covers basics (from usage view point) of most commonly used instruments in Laboratory. Standard methods of measurements with oscilloscopes are also presented. Finally, all varieties of Printed Circuit Boards (PCBs) and their peculiarities are covered.

Chapter 2 on Semiconductor Physics covers intrinsic and extrinsic semiconductors. The main focus is on modulation of conductivity of a semiconductor with doping. Energy band theory of crystals and classification of materials based on band gap is presented. The chapter covers different mechanisms and laws that govern conduction in the semiconductor. Discussion of direct and indirect band gap semiconductors is included to facilitate primary understanding of Opto-electronic devices.

Chapter 3 is split into three parts. Part I covers characteristics of different types of diodes and their data sheet specifications. Part II covers basic application circuits with diodes. These include Wave shaping circuits, Rectifier circuits and Voltage multiplier circuits. A systematic method of analyzing circuits containing diodes and other passive components is presented. This is to strengthen the ability of circuit analysis. Third part of this chapter covers special purpose diodes. The treatment on individual diode is deliberately limited. It is assumed that these special diodes will be studied in further detail in textbooks specifically meant for respective subject.

Chapter 4 covers a family of devices whose working is based on what is known as Field Effect. Different family members are introduced along with their construction, characteristics and application areas. Also introduced are important data sheet specifications for the field effect devices. Part I covers Junction Field Effect (JFET) devices' characteristics and biasing circuits. Part II covers amplifier configurations based on JFETs. JFET small signal model is useful for analyzing small signal amplifiers. The parametric model for FETs being simpler than Bipolar Junction Transistors (BJTs), the Field Effect devices are introduced first in this text. (This is contrary to the approach taken by some texts). Part III discusses characteristics of Metal Oxide Semiconductor Field Effect Transistor (MOSFET), which forms the basis of most modern digital ICs and VLSI chips. Different "flavors" of the device, like Power MOSFETs, high-speed MOSFET, are covered briefly for the sake of completeness. Part IV covers MOSFET amplifier configurations. MOSFET as a switch is discussed next followed by CMOS inverter characteristics. This circuit is the basic building block of most digital ICs. CMOS handling precautions are covered in required details. Finally peculiarities of MOSFETs as a basic element in Very Large Scale Integrated Circuits (VLSI) are covered.

Chapter 5, Part I covers Bipolar Junction Transistors (BJTs) in a traditional way. The device construction, characteristics, operating regions and models are presented. Detailed procedure to analyze BJT DC and AC circuits is presented to enhance student's ability to analyze a given circuit. Interpretation of BJT data sheet parameters is covered in details. This will help reader in understanding any semiconductor device data sheet with ease. Unique to this text is information on packaging and device terminal identification information. Part II covers BJT biasing and amplifier circuits with their analysis. This discussion naturally leads to biasing techniques used in ICs. Small signal low- and high-frequency BJT models are presented with detailed method of analysis using these models. This is followed by detailed treatment on BJT Audio Power amplifiers. A special variety of BJT used in high frequency circuits viz. Heterojunction BJT or HBT is discussed in the end.

Chapter 6 discusses Operational Amplifier (OPAMP) as the basic building block of analog signal conditioning circuits. Particular stress is given on avoiding overemphasis on OPAMP as an ideal device. A deeper understanding of this device

is absolutely essential because even "digital-pro" engineers have agreed to the fact that- Real world is full of analog quantities. Whatever may be the arguments in favor of either domain, OPAMP will retain its importance as an electronic device. Maintaining the uniformity in treatment on devices, Part I of the chapter covers different family members, their peculiarities and application areas. Internal details of the device are covered only to the extent that will facilitate understanding of terminal behaviour of the OPAMP. Part II of the chapter covers popular linear applications of the device. These circuits form building blocks of analog interfaces. A limited number of non-linear applications are covered because they are most frequently used configurations. This is followed by an introduction to Instrumentation and Isolation amplifiers.

Chapter 7 deals with frequency response characteristics of FETs, BJTs and OPAMPs. A detailed analytical treatment will enable reader to fine-tune the designs to cater to desired bandwidth (which happens to be the first consideration in design of linear amplifiers). The chapter mostly deals with low frequency amplifiers. The treatment for high frequency region is beyond the scope of this text since it calls for understanding of several concepts of distributed network components. This is a topic in itself.

In Chapter 8, Part I covers feedback theory and detailed method of analyzing feedback configurations. Different circuit configurations based on FETs, BJTs and OPAMPs are presented with step-by-step analysis. Part II covers different RC and LC oscillator configurations with three possible devices, viz. FETs, BJTs and OPAMPs. Oscillator start-up mechanism and need for amplitude limiting in low distortion oscillators are discussed in detail.

Chapter 9 deals with Linear regulator circuit configurations. Both discrete and integrated implementations are covered with emphasis on interpretation of relevant data sheets of regulators. Discussion on more advanced switched mode power supplies requires deeper understanding of power switching devices. Hence, these configurations are not covered. Voltage references are briefly discussed in the end.

Appendices 1 to 9 are a useful compilation of different constants. Information provided on discrete devices will be useful for designers. Appendix 7, covering grounding and shielding, will be particularly useful to analog designers.

WEB SUPPLEMENT

The dedicated web site at http://www.mhhe.com/deshpande/edc for the book contains resources both for the students and teachers.

The teacher would have access (password protected) to the Solutions Manual for the book and PowerPoint Slides that will aid them in the preparation of their lectures and teaching notes.

Students' resource would have sample question papers and related links for extra reading.

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I will be glad to receive any comments, suggestions and corrections on my e-mail ID deshapande_nandkishor@yahoo.co.in

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