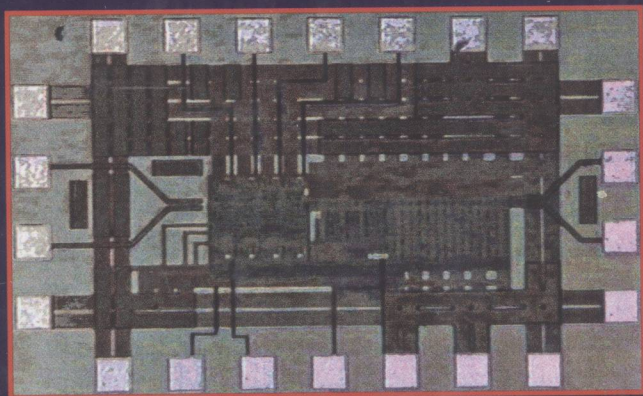


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Advanced Integrated Communication Microsystems



JOY LASKAR, SUDIPTO CHAKRABORTY,
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and ANH-VU PHAM

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Advanced Integrated Communication Microsystems

Preface

This book introduces readers to the implementation of miniaturized communication systems, which have matured significantly over 10 years. The GSM standard became popular around the early 1990s. Its implementation in silicon technology made it a mainstream focus of the semiconductor industry, and it remains an area of interest for major business even today. Over the years, semiconductor technologies have matured significantly, and slowly, integration of communication system blocks has reached maturity since their inception. Today, multiple radios are integrated on the same die, along with integrated circuit (IC) components for performance optimization and miniaturization. This process is motivated by our ever increasing need for improved mobile computing and connectivity. Wired connections are preferred for high bandwidth communications, and they carry much of the backbone traffic in communication systems. In practice, wired and wireless communication systems coexist in a synergistic manner to provide the overall communication system solution. Many communication standards have been developed, in both the wired and the wireless space to facilitate this coexisting aspect. In addition, there are several scenarios in which a wireless communication system is inevitable: (1) connectivity with the remote geographical areas, (2) satellite communication, and (3) implanted electronic devices.

One needs to appreciate the foundations of such systems. Although many communication systems are developed and deployed, very little has changed in the fundamentals of electromagnetic wave propagation, communication systems, and the basic functionality blocks. Integration of diverse functionality blocks in a system on chip and system on package are continuously evolving, which leads to innovative system solutions.

Between these two thought patterns, a gap exists. Although the foundations are a mature area of study led by early inventions in the 1900s, the integration and feasibility of miniaturized microsystems is only two decades old. Thus, while looking at the complexity of these miniaturized systems, “relating back” to the fundamentals becomes a difficult task for newcomers. At the same time, the reverse situation is

true for experienced professionals and academicians. In this book, we make an attempt to provide a wholistic picture in the simplest possible manner to bridge the gap.

The book is organized into nine chapters, as outlined below.

Chapter 1 illustrates all the relevant fundamental concepts that need to be understood in order to appreciate various aspects of integrated microsystems. These aspects include (1) electromagnetics, (2) communication systems, (3) circuit fundamentals, and (4) semiconductor devices. These topics are all vast and very much mature areas today. We do not intend to make an attempt to perform a classic treatment of the individual disciplines. Our aim is to select a few principles in order to illustrate the different aspects of integrated communication systems. Hence, only a few selected basis functions are illustrated. Applications of these functions are shown in the chapters.

Chapter 2 illustrates wireless communication architectures. Wireless architectures are essentially the derivatives of Armstrong's original works related to superheterodyne architecture and the like. Because of the specific requirements of implementation, one architecture is preferred over the others. This choice is also dependent on communication standard, semiconductor process, and level of integration. For example, one approach could include the implementation of superheterodyne radios using continuous-time signal processing in the front end. In this respect, one may enjoy the benefits of advanced semiconductor technologies (up to a certain extent). In the other extreme, one may also incorporate "mostly digital" schemes such as sampling architecture. These choices differ in the requirements of dynamic range, power, and form factor. In this chapter, we make an attempt to emphasize these tradeoffs.

Chapter 3 illustrates the various aspects of wired communication systems. Several architectural considerations are illustrated. Recently, there has been much discussion regarding the speed bottleneck of wired communication systems in the backplanes. To address these issues, development of equalizers demands specific attention. A fundamental aspect in the design of wired communication systems includes high-speed signal processing, which consumes significant power.

Chapter 4 illustrates the various basis functionalities in terms of circuit techniques. Both wired and wireless communication systems use similar building blocks or at least the same basis functionalities. We make an attempt to illustrate these similarities to the readers. The idea is to illustrate the versatility of the circuit blocks as they appear multiple times in any communication systems. We have covered various unique basic circuit topologies to illustrate this concept with specific implementation issues.

Chapter 5 provides practical examples of both wired and wireless communication systems. It illustrates the design methodology, building circuits, and a few architecture choices. One of these examples is in the second generation BiCMOS process, whereas the other is in deep submicron CMOS. Circuit designs, as well as layout considerations, have been illustrated.

Chapter 6 provides some advanced concepts. It includes the discussions from previous chapters to illustrate the developments of low-voltage, low-power circuits and systems. In this chapter, we focus on architecture, as well as on circuits. Critical aspects of low-power radios are illustrated, and the fundamental determinants of these requirements are also emphasized. Many modern applications such as medical

electronics require ultra-low power in their implementations. Our approach, again, is to cover the few fundamental principles, and to put them in relevance, to build integrated systems.

Chapter 7 focuses on aspects that are inherent to passive components, packaging, and the like. Often, the growth of packaging technologies is underestimated; however, their importance needs to be kept in mind. No radios can even be feasible without integrating passive, discrete components. Such components include antenna, matching network, resonators, and so on. Although semiconductor scaling and extrapolation of Moore's law is often emphasized, this domain deserves special attention, and often it is a key to the success of smaller form factor, optimized, multichip solutions.

Chapter 8 illustrates various developments in the area of compact antennas. The success of any integrated communication system is involved in optimizing power and form factor. Although power consumption can be mostly related to judicious choices of architecture, circuits, available passive components, and so on, a major challenge lies in realizing small form factor antennas, which are mostly governed by electromagnetic principles. This chapter illustrates a few approaches in order to achieve small antennas.

Chapter 9 illustrates the simulation and test methodologies to build communication systems and to characterize them. Although understanding fundamental principles and their relevance to understand complex systems are important, it may fail to develop design confidence and enthusiasm in beginners. This chapter covers a few simulation techniques to analyze circuits in an intuitive manner. Various aspects of test calibrations are also covered in greater detail.

All in all, we have tried to maintain a good balance of theoretical foundation, design procedures, and practical implementation. Many textbooks are already available, and this attempt is, in no way, exhaustive. However, we hope that we can cover the seemingly complicated aspects in a simplistic manner. Since this discussion is an attempt to introduce the interdisciplinary approaches to realizing integrated systems, we have assumed a basic knowledge of electromagnetics, circuits, and architecture. Based on this assumption, we have provided the next level of details to the readers.

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