Chapter 2
Cutting-Edge Methodologies for Low Power Design in VLSI Circuits

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ABSTRACT

The rapid advancements in Very Large Scale Integration (VLSI) technology have been driven by the increasing demand for high-performance and energy-efficient electronic devices. Low power design has emerged as a critical focus area in modern electronic systems to address these demands. The chapter categorizes design approaches into conventional methods, such as static and dynamic CMOS technologies, and non-conventional techniques, including FinFET, Carbon Nanotube Field Effect Transistors (CNTFET), and Floating Gate MOSFET (FGMOS). A comparative analysis of XOR/XNOR circuits highlights their design characteristics, performance trade-offs, and challenges. The findings indicate that FGMOS technology offers superior power efficiency, while CNTFET technology significantly improves circuit speed at lower technological nodes. However, the adoption of non-conventional technologies is constrained by the lack of robust simulation models and the complexity of fabrication processes.

1. INTRODUCTION

In today's scenario, the demand for efficient, high-performance electronic systems is continuously expanding. VLSI circuits are the core of these systems, which serve as the backbone for advancements in areas such as communication, computing, healthcare, and consumer electronics (Bellaouar and Elmasry,

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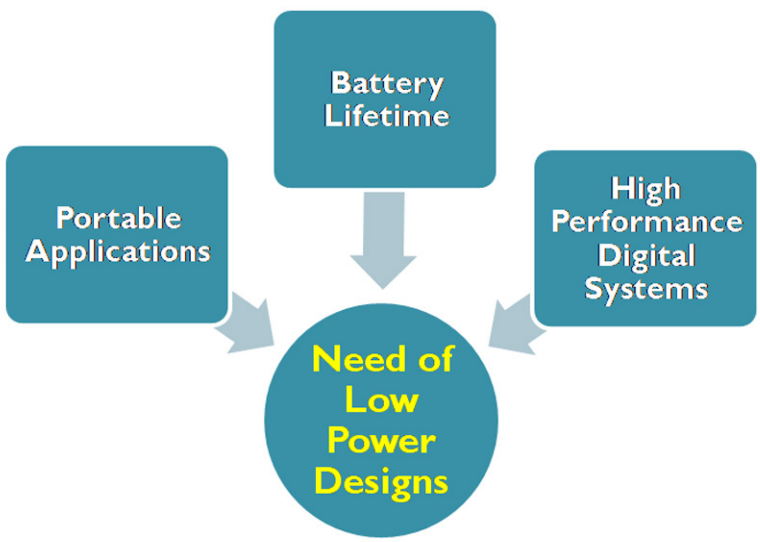
2012). However, the increasing complexity and functionality of these circuits have led to significant challenges in power consumption. Low-power applications have become the main focus of attention in the field of VLSI system design (Zimmermann and Fichtner, 1997). Early in the new millennium, analog media, primarily analog video cassettes like VHS, preserved about 75% of all information (Kang and Leblebici, 1999). This was a time when physical media was important. By 2007, things had changed dramatically, with an incredible 94% of our collective technological memory being stored as digital bits and bytes. The speed at which technology is evolving is demonstrated by the change from analog to digital technology in just seven years. By 2024, most of the information in the world is stored digitally, which is influencing how we communicate, exchange, and store knowledge. Therefore, digital circuits have had a great run when it comes to making things smaller and more efficient in the technological world. Fig.1 depicts the need of low power design in present scenario.

Figure 1. Need of low power design



The key roles and benefits of low power design are as follows:

i. **Extended Battery Life:** Low power design enhances the ability of electronics devices such as mobiles, smart watches, and IoT gadgets to operate for longer duration by optimizing the power consumption.
ii. **Heat Reduction:** For the proper functioning of compact devices, it is essential to lower the power consumption and lower power consumption translates into less heat generation. Electronic circuits and component's damage can be reduced by reducing the excessive heat using low power circuit design.
iii. **Sustainability:** By lowering the overall energy demand, VLSI circuits with less power consumption contribute significantly to environmental sustainability. The overall demand for electricity is decreased by reducing the energy consumption of electronics on a large scale. As a result, power generation emits fewer greenhouse gases, which helps to reduce carbon footprints. These develop-