Chapter 6
Embedded Systems and Microcontrollers in Wearables

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ABSTRACT

Smart wearables and e-textiles are transforming personal technology by combining materials science, embedded computing, and wireless communication. At their core, embedded systems and microcontrollers (MCUs) enable sensing, data processing, connectivity, and user interaction within strict limits of size, power, and comfort. This work reviews the fundamentals of embedded design, including processors, memory, sensors, actuators, and architectures, while addressing challenges such as miniaturization, textile integration, durability, and data security. Popular MCU platforms are analyzed for energy efficiency, processing power, and connectivity. Power management strategies, including low-power modes and energy harvesting,

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are emphasized for extending battery life. The chapter also highlights emerging directions such as on-device machine learning, hybrid architectures, and flexible electronics. By integrating research and practical insights, it underscores the central role of embedded systems in enabling next-generation, intelligent, and user-centric wearable technologies.

INTRODUCTION

Overview of Smart Wearables and E-Textiles

In recent years, smart wearables have gained more attention at the intersection of electronics, textiles, and computing. These devices blend smoothly into garments and accessories. They allow real-time monitoring, data processing and wireless communication. E-textiles play a key role in driving this technology forward. By embedding conductive materials and flexible electronics into fabrics, they support applications ranging from health monitoring to environmental tracking and feedback systems.

Embedded systems and microcontrollers have played a crucial role in enhancing the functions of smart wearables. Microcontrollers deliver processing power, efficiency, and network access. As the core of smart wearables, they give the devices autonomy and the ability to react in real time. As materials science advances and power management improves, e-textiles and embedded computing are working together in new ways. This synergy is driving the development of next-generation wearables that are lightweight, durable, and highly functional.

This chapter explores the role of embedded systems and microcontrollers in the development of smart wearables. It also provides a comprehensive overview of design principles, hardware components, and emerging trends in wearable electronics.

Role of Embedded Systems in Wearables

Embedded systems play main role in enabling the core functionalities of modern wearable devices. These compact systems are designed to perform given tasks efficiently and reliably within constrained environments like limited size, weight and power available in wearable technology.

In wearables, embedded systems act as brain. It connects with sensors to collect physiological or environmental data. Also, executing onboard data processing algorithms, managing communication protocols (e.g., Bluetooth Low Energy, Wi-Fi) and controlling actuators, feedback mechanisms. This integration gives wearables