

Preface

Radio Frequency Identification (RFID) technology has gained significant popularity due to its wide range of applications across various industries, including logistics, healthcare, retail, and security. Its ability to automatically identify and track objects without the need for line-of-sight communication has made it an indispensable tool in modern inventory management, asset tracking, and supply chain optimization. The technology's capability to streamline operations, reduce human error, and enhance efficiency has driven its rapid adoption and continued evolution. At the heart of RFID technology lies a simple yet powerful working principle. RFID systems consist of three primary components: a reader (or interrogator), a tag (or transponder), and a backend database. The tag, which is typically attached to the object being tracked, contains a microchip and an antenna that are energized by the electromagnetic waves emitted by the reader. Upon activation, the tag transmits its stored data back to the reader, which then forwards this information to the backend system for processing. Depending on their design, tags can be passive, relying solely on the reader's signal for power, or active, containing an internal power source to boost signal transmission.

Despite the success and versatility of RFID technology, challenges remain in optimizing the size, detection range, and communication reliability of RFID tag antennas, particularly in the Ultra-High Frequency (UHF) band. The present work addresses these challenges by focusing on the development of compact, high-performance RFID tag antennas that are suitable for a variety of applications, including those in environments with metallic surfaces.

This thesis is organized into seven chapters, each contributing to the overall goal of

advancing RFID tag antenna technology. Chapter 1 provides an introduction to RFID technology and the motivation behind this research. It outlines the importance of developing smaller, more efficient antennas with extended detection ranges. Chapter 2 delves into the design principles of UHF RFID antennas, exploring the factors that influence their performance, including impedance matching, radiation efficiency, and material selection.

In Chapter 3, a planar UHF RFID tag antenna with dimensions of $120\text{ mm} \times 60\text{ mm} \times 1.6\text{ mm}$ is proposed. This antenna operates at 865 MHz with a reflection coefficient bandwidth of 12 MHz, achieving a detection range of 13.9 meters, making it suitable for applications requiring long-range identification.

Chapter 4 introduces a more compact planar tag antenna with a volume of $60\text{ mm} \times 16\text{ mm} \times 1.6\text{ mm}$. Operating at 866 MHz, this antenna achieves a detection range of 12.6 meters, offering a balance between size and performance, making it ideal for space-constrained environments.

In Chapter 5, a planar tag antenna with dimensions of $76\text{ mm} \times 30\text{ mm} \times 1.6\text{ mm}$ is presented. This antenna, designed for operation at 902 MHz, attains a detection range of 14.1 meters with a radiation efficiency of 37%. The combination of compact size and high radiation efficiency makes this antenna highly effective for various UHF RFID applications.

Chapter 6 proposes a circularly polarized tag antenna designed to operate at 915 MHz, specifically for use on metallic surfaces. This antenna achieves a maximum detection range of 8.4 meters and offers a 10-dB reflection coefficient bandwidth of 17 MHz and an axial ratio bandwidth of 13 MHz. The circular polarization enhances its performance in challenging environments where traditional antennas may struggle.

The final chapter, Chapter 7, draws conclusions from the research and outlines the future scope of RFID tag antenna development. It discusses potential advancements in antenna miniaturization, cost reduction, and the expansion of RFID technology into new applications.