Preface

Wireless Capsule Endoscopy (WCE) technology stands at the forefront of advancements in medical diagnostics and healthcare. Leveraging the integration of cutting-edge technology and medical science, WCE offers a promising avenue for non-invasive exploration of the human gastrointestinal (GI) tract. This miniature ingestible capsule equipped with a camera embarks on a journey through the digestive system, capturing high-resolution images for crucial insights into GI health. WCE has the potential to revolutionize the early detection and management of GI diseases.

This PhD thesis, titled "Design and Development of Dual-Band Antenna and RF Rectifier System for Wireless Capsule Endoscopy," recognizes the pivotal role of WCE technology in healthcare. While the technology holds immense promise, challenges remain in realizing its full potential. Key among these challenges is the need for compact, efficient, and reliable components for communication and power harvesting within the capsule's confined space. This thesis is driven by the unwavering determination to address these challenges.

Thesis Contributions:

- Design of a novel dual-band ingestible antenna using Characteristic Modal Analysis (CMA) for optimal performance in WMTS and ISM bands. This antenna exhibits exceptional bandwidth, a compact footprint, and a near-isotropic radiation pattern, making it ideal for high-resolution GI tract imaging.
- Development of a compact and efficient dual-band RF rectifier employing a modified T-section matching network. This design achieves impressive rectification

efficiencies exceeding 50% across a wide range of input power levels, making it a promising candidate for powering WCE systems and implantable medical devices.

- Introduction of a dual-band, dual-sense (DBDS) high-gain circularly polarized suspended plate antenna for biotelemetry applications. This antenna operates effectively in WMTS and ISM bands, featuring specific design elements for each band to ensure optimal impedance and circular polarization characteristics. The design exhibits impressive bandwidths, peak gains, and axial ratio bandwidths, while minimizing polarization mismatch for reliable communication links.

Chapter 1 of this thesis serves as the gateway to the research. It introduces wireless capsule endoscopy, elucidating its potential to disrupt traditional medical diagnostics. The chapter charts the course by uncovering the motivations that underpin this research. It highlights the limitations that must be addressed to enable wireless capsule endoscopy to reach its zenith. Furthermore, it defines the research objectives, providing a roadmap for the reader to navigate the journey that unfolds. This chapter, in its essence, is a compelling invitation for readers to join us in exploring the captivating universe of wireless capsule endoscopy.

Chapter 2 illuminates the path forward through a comprehensive literature review. We delve into the existing work on dual-band ingestible antennas, dual-band RF rectifiers, and dual-band dual-sense circularly polarized antennas, carefully scrutinizing their strengths and limitations.

Chapter 3 introduces a novel wide band-with dual-band ingestible antenna designed using Characteristic Mode Analysis (CMA). This powerful technique unlocks the antenna's resonant mechanisms, enabling optimal performance. The proposed antenna exhibits impressive dual-band capabilities, operating efficiently in both the Wireless

Medical Telemetry Services (WMTS) and Industrial, Scientific, and Medical (ISM) bands. Its compact footprint, exceptional bandwidth, and near-isotropic radiation pattern make it a promising candidate for high-resolution imaging within the gastrointestinal tract.

Chapter 4 focuses on the RF rectifier, responsible for converting harvested RF energy into usable DC power. Here, we introduce a compact and efficient dual-band rectifier leveraging a modified T-section matching network. This design achieves impressive efficiencies exceeding 50% across a wide range of input power levels. Its remarkable performance and reduced footprint make it a potential candidate for powering WCE systems, particularly in implantable medical devices.

Chapter 5 introduces a dual-band dual-sense (DBDS) high gain circularly polarized suspended plate antenna for bio-telemetry. The antenna operates in both WMTS and ISM bands, featuring specific design elements for each band to ensure optimal impedance and circular polarization characteristics. The chapter presents extensive simulation and measurement results, demonstrating impressive bandwidths (12.85% for WMTS and 34.6% for ISM), peak gains (8.9 dBi at 1.4 GHz and 10.15 dBi at 2.45 GHz), and axial ratio bandwidths (5.7% for WMTS and 11% for ISM). Validation with a dual-band ingestible antenna showcases the effectiveness of the proposed antenna in reducing polarization mismatch and maintaining reliable communication links.

Chapter 6 concludes our journey by summarizing the key findings of the preceding chapters, highlighting the contributions made to the field of WCE antenna design. It also lays out the future directions for this research, outlining potential avenues for further exploration and refinement.