

CHAPTER

6

CIRCULARLY POLARIZED IMPLANTABLE ANTENNA FOR BREAST APPLICATIONS

*Faishal Adilah Suryanata, Maria Alessandra Sabiniano Florida,
Mohamad Kamal A. Rahim, and Mohd Fairus Mohd Yusoff*

6.1 INTRODUCTION

In the healthcare industry, biomedical telemetry has seen a growing demand as it allows the condition of patients to be remotely monitored. As a result, antennas have become a crucial component of implantable medical device (IMD) due to their ability to wirelessly receive and send information. Among specific medical applications, the use of antennas for breast imaging is drawing increasing interest in electromagnetic research. Implantable antennas can operate in microwave frequencies which range from 300 MHz to 300 GHz (Cheng & Fu, 2018). Operation within such frequency range offers the advantage of a safer breast screening method due to the absence of non-ionizing radiation. Antennas implanted in the breast transmit signals and collect the backscattered signals from the breast tissue. Owing to the varying dielectric characteristics of breast tissue, differentiation of tissue type therefore becomes possible in both healthy and pathological cases.

This chapter discusses the development of an implantable antenna for breast application. Succeeding sections cover the design and

fabrication process of the antenna and breast phantom. Furthermore, it also includes the performance analysis of the antenna design.

6.2 COPLANAR WAVEGUIDE DESIGN

This section discusses the design and refinement of a coplanar waveguide (CPW) fed antenna developed with a focus on biomedical applications. Within this field, multiple categories of implantable antennas have been introduced to address diverse functional requirements. Among the most widely implemented configurations are the planar inverted-F antenna (PIFA), slot antenna, conformal antenna, wire antenna, and planar antenna. Across these designs, the commonly desirable features include compact physical size, straightforward implementation, and ability to sustain efficient electromagnetic performance.

Among the different antenna configurations, CPW structure stands out as a highly suitable option for implantable antenna design because of its distinct advantages. In this approach, all metallic traces are patterned on a single surface of dielectric substrate which classifies the geometry as coplanar. The layout typically includes a central conducting strip positioned between two parallel ground planes separated by a narrow slot. As illustrated in Figure 6.1, this arrangement results in a compact form factor, an essential requirement for implantable devices where the antenna must be sufficiently miniaturized to fit within biological tissue. In contrast, microstrip antennas require metallization on both sides of the substrate, making it more susceptible to fabrication inaccuracies caused by misalignment between top and bottom layers. CPW antennas overcome this drawback since both signal line and ground planes are realized on the same substrate surface, thereby minimizing alignment errors during manufacturing process.

Coplanar waveguide (CPW) antennas demonstrate efficient performance at high operating frequencies offering wide impedance bandwidth and reduced transmission losses. In comparison, with conventional microstrip designs, CPW structures provide several notable advantages including minimal radiation leakage, low dispersion,

and effective control over characteristic impedance. These attributes are particularly beneficial for implantable use as it not only ensures reliable operation within biological tissue but also facilitate seamless incorporation with biomedical telemetry systems. Considering to the advantages, CPW antennas have emerged as a strong candidate for implantable antenna in biomedical applications. Since CPW feeding technology has a simple structure, wide bandwidth, low loss, and high anti-interference ability, it not only effectively realizes antenna low profile and wide bandwidth characteristics but also guarantees high-quality signal transmission and stable communication performance.

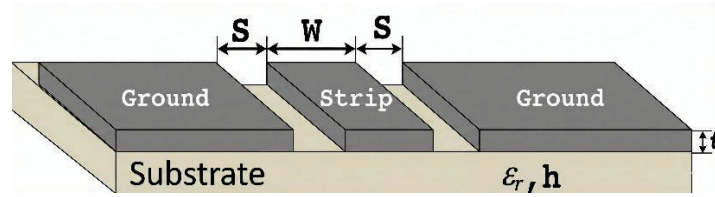


Figure 6.1 Coplanar waveguide antenna structure (Source: Xia et al., 2007)

6.3 CIRCULAR POLARIZATION

Other than CPW, polarization of an antenna may also need to be consider in designing any antenna. Polarization refers to a fundamental characteristic of electromagnetic waves that describes orientation and temporal evolution of electric field vector. Among various polarization types such as linear, elliptical, and others, circular polarization is distinguished by electric field vector tracing a circular trajectory at a fixed point in space over time. This constant magnitude and a rotating direction of electric field is illustrated in Figure 6.2.

Circular polarization (CP) is realized by combining two orthogonal electric field components of equal amplitude, offset in phase by 90 degrees. Unlike linearly polarized antennas, CP antennas do not require precise alignment between transmitting and receiving units during design or fabrication process. This characteristic provides polarization diversity, as electric field vector maintains a constant amplitude while rotating in a