

Next-Generation Wearable Antenna on Cotton Substrate for BAN and IoT Applications

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Abstract: Wearable antennas play a pivotal role in enabling next-generation wireless systems for healthcare monitoring, fitness tracking, and bright clothing. This paper presents a compact wearable antenna designed and fabricated on a cotton substrate, suitable for applications that require flexibility, a low profile, and efficient performance. The antenna features a square patch of $14.5 \times 14.5 \text{ mm}^2$ connected to a coplanar waveguide (CPW) feed line. It achieves a simulated -10 dB impedance bandwidth of 3 GHz over the frequency range of 1.9 to 5 GHz, encompassing critical wearable system applications such as body area networks (BAN) at GSM (1.9 GHz), medical telemetry and health monitoring via Bluetooth and Wi-Fi (2.4 GHz), and high-data-rate communication for wearable IoT devices at WiMAX and 5 GHz Wi-Fi. The antenna exhibits a simulated peak gain of 3.74 dB, a directional radiation pattern, and a high radiation efficiency of 90%. The fabricated prototype was tested, and results showed excellent agreement with simulations, demonstrating its viability for real-world wearable applications. This work highlights the potential of cotton substrates in achieving sustainable, flexible, and high-performance wearable antennas.

The length of the patch in an antenna indirectly affects the resonant frequency, with increasing the patch size generally lowering the resonant frequency, as the longer path of the signal leads to a lower frequency. The dimensions of the ground plane, specifically its length and width, directly influence the antenna's bandwidth; increasing the ground plane size improves efficiency and increases bandwidth, while reducing its size narrows the frequency range. The width of the dielectric layer directly affects the impedance and, in turn, the S11 characteristics. Increasing the dielectric layer width improves impedance matching and reduces reflection losses, whereas a thinner layer may lead to a more significant mismatch and higher reflection. Modifying slot dimensions, like logo patterns, impacts antenna performance by changing current distribution, radiation pattern, bandwidth, and resonant frequency. While adjustments can optimize performance, larger or complex designs may reduce efficiency.

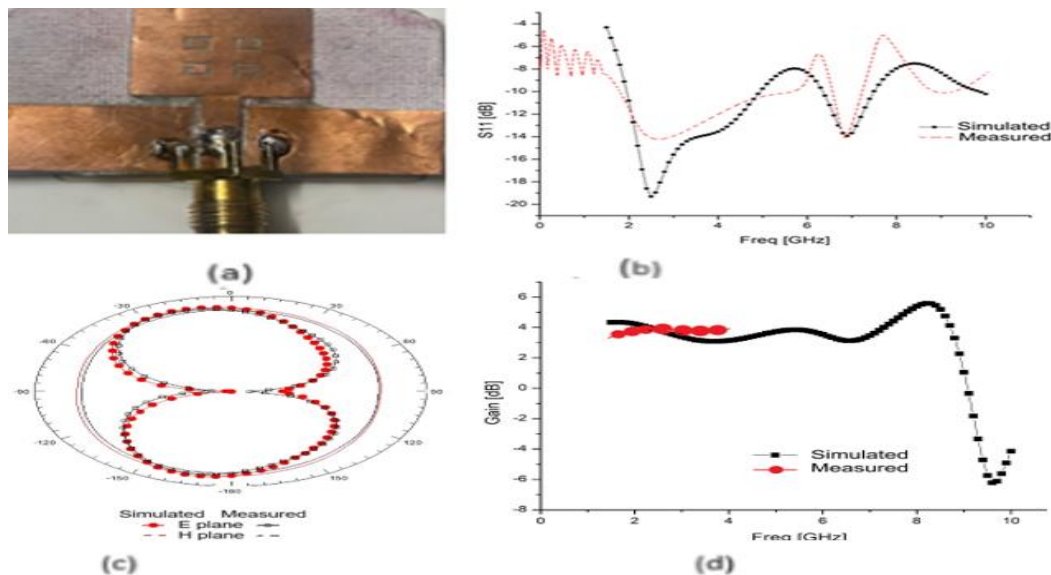


Figure 1. (a) Fabricated antenna Design (b) Simulated and Measured Return Loss (right) (c) Simulated and measured radiation Pattern (d) Simulated and measured gain of proposed antenna.