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UWB Antenna Design Incorporating a Combination of an Ellipse Shaped Radiating Patch and a Slot

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Abstract - An ultra-wideband (UWB) antenna is proposed using a combination of an elliptical-shaped patch and a slot structure. The antenna employs a coplanar waveguide (CPW) feeding technique, consisting of a central signal strip, two rectangular ground planes. The signal strip is directly connected to the elliptical patch and slot, which together function as the primary radiating elements responsible for achieving wideband operation. This integrated geometry enhances impedance matching and supports efficient radiation across the UWB spectrum, making the design suitable for compact and high-performance UWB applications. The antenna achieves a wide impedance bandwidth ranging from 3.44 to 11.17 GHz, as verified through return-loss analysis. Surface current distribution confirms that the elliptical radiating patch plays a dominant role in efficient radiation. The proposed design attains a peak gain of 4.40 dBi, making it suitable for UWB communication and sensing applications. The VSWR remains below 1.75 throughout the operating band, indicating superior impedance matching and reduced reflection losses. Additionally, the E- and H-plane polarization characteristics reveal low cross-polarization levels, ensuring stable and clean radiation patterns. Overall, the antenna demonstrates robust UWB performance with desirable attributes in bandwidth, gain, matching, and polarization purity.

Keywords - UWB antenna, elliptical patch, CPW feeding and good radiation.

I. INTRODUCTION

A CPW-fed UWB antenna is a compact and efficient radiating structure that uses a coplanar waveguide feeding technique to achieve wideband performance suitable for modern high-speed wireless applications. In this configuration, the signal line and ground planes are printed on the same side of the substrate, which minimizes parasitic effects, simplifies fabrication, and offers excellent impedance matching over a broad frequency range.

This feeding method also supports flexible integration with various radiating geometries, such as elliptical patches, slots, and tapered structures allowing designers to achieve stable radiation patterns, low loss, and consistent performance across the ultra-wideband spectrum. As a result, CPW-fed UWB antennas are widely used in portable devices, radar imaging, short-range communication, and sensing systems where compactness and wide bandwidth are essential. UWB antenna with CPW feeding are detailed in [1-6] and which shows good radiation in the UWB range.

Coplanar Waveguide (CPW) feeding is a planar transmission-line technique in which the central signal strip and the ground planes are printed on the same side of the substrate, separated by narrow gaps. This configuration provides a low-loss, wideband feeding mechanism that is easy to fabricate and integrate with various antenna geometries. CPW feeding offers several advantages, including excellent impedance matching, reduced radiation loss, and minimal dispersion over a broad frequency range.

It also supports compact designs by eliminating the need for vias, improves mechanical flexibility, and simplifies integration with active and passive microwave components. These features make CPW feeding highly suitable for UWB antennas, where wide bandwidth, stable performance, and simple fabrication are essential. CPW radiator are suitable for flexible antenna design [7-11] and which is important for nanocomposite coating for enhancing radiation characteristics.

II. ANTENNA DESIGN

An UWB antenna is designed by the combination for elliptical shaped patch and slot structure as shown in Fig. 1. The design introduce a CPW feeding and which consists of central signal patch with two rectangular ground plane. The signal strip is united to elliptical shaped patch and slot, which act as radiating elements for UWB band. The 2D and 3D structure of the proposed antenna is detailed in Fig.1.

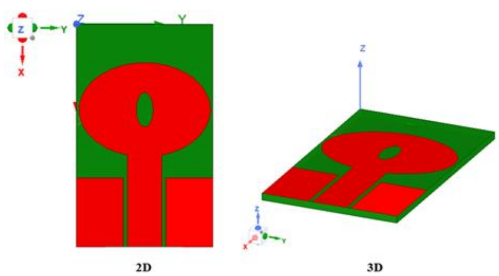


Fig. 1 Proposed antenna structure.

Return loss (S(1,1)) provides a direct indication of how efficiently an antenna accepts power across a range of frequencies, and it is closely used to determine the antennas bandwidth. When the return loss is low (-10 dB), it means most of the input power is radiated instead of being reflected back to the source.

By identifying the continuous frequency range over which the antenna maintains this acceptable return loss level, designers define the antenna bandwidth.

In simple terms, the bandwidth is the span of frequencies where the antenna performs well, and this region is determined by the portion of the return-loss curve that stays below the chosen threshold. The return loss of the proposed antenna is detailed in Fig. 2 and which shows that produce 3.44 – 11.17 GHz bandwidth for covering most of the UWB range.

III. RESULTS AND DISCUSSION

Surface current distribution is important in antenna analysis because it reveals how currents flow over the radiating structure, which directly determines the antenna radiation pattern, gain, impedance, and overall performance.

By studying the current distribution, designers can identify the active radiating regions, understand how different parts of the antenna contribute to resonance, and detect unwanted effects such as current crowding, mutual coupling, or losses.

It also helps in optimizing antenna size, shape, slot placement, and feed location to achieve desired frequency behaviour and bandwidth. In summary, surface current distribution is a powerful diagnostic tool that guides both the design and improvement of antennas for efficient and predictable radiation.

The surface current distribution of the UWB antenna is displayed in Fig. 3 and which shows that elliptical shaped patch has major role in the radiation process.

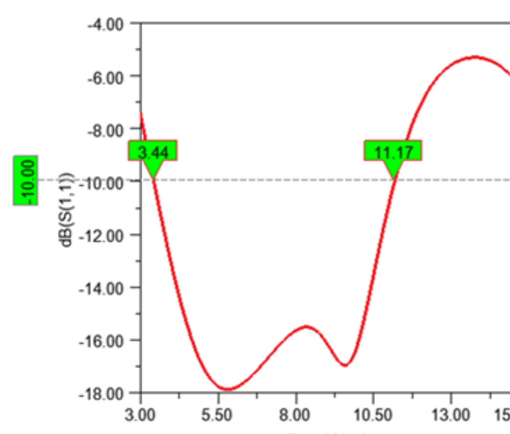


Fig. 2 Simulated return loss of proposed antenna.

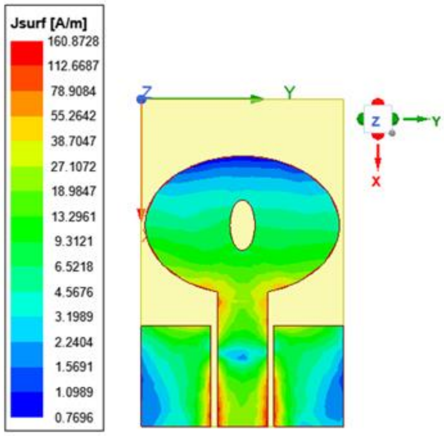


Fig. 3 Simulated surface current distribution of proposed antenna.

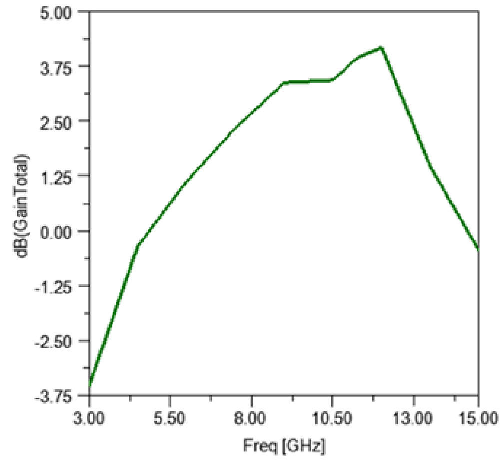


Fig. 4 Gain of the proposed UWB antenna.

The gain of a CPW-fed UWB antenna represents how effectively the antenna converts input power into radiated energy in a particular direction across its ultra-wide operating band. In CPW-fed designs, the ground and feed are on the same plane, providing better impedance matching, reduced parasitic effects, and stable current flow, all of which help maintain consistent gain over a wide frequency range.

Typically, UWB antennas aim for moderate gain because they prioritize wide bandwidth and omnidirectional radiation rather than high directional gain. The gain variations across the band are mainly influenced by the antenna geometry, surface current paths, ground structure, and slot or notch features used for enhancing bandwidth or rejecting interference. Overall, a CPW-fed UWB antenna offers stable, usable gain across a broad spectrum, making it suitable for portable, sensing, and short-range communication applications. Simulated gain of this UWB antenna is detailed in Fig. 4 and which implies that a peak gain of 4.40 dBi obtained.

The Voltage Standing Wave Ratio (VSWR) of a CPW-fed UWB antenna indicates how well the antenna is impedance-matched to the feed line across its ultra-wide bandwidth. A good UWB antenna is expected to maintain a VSWR below 2 (or return loss better than −10 dB) over the entire operating range, ensuring minimal reflection and efficient power transfer.

The CPW feed structure helps achieve this by offering a planar, low-parasitic path for the signal, providing smoother impedance transitions and wider tuning flexibility. As a result, CPW-fed UWB antennas typically show a broad, continuous region of low VSWR, which is essential for stable radiation performance, reduced distortion, and reliable operation in high-speed, multi-band communication or sensing systems. The magnitude of VSWR plot of the proposed antenna is shown in Fig. 5. This magnitude plot implies that a low value (less than 1.75) of VSWR is produced in the operating band.

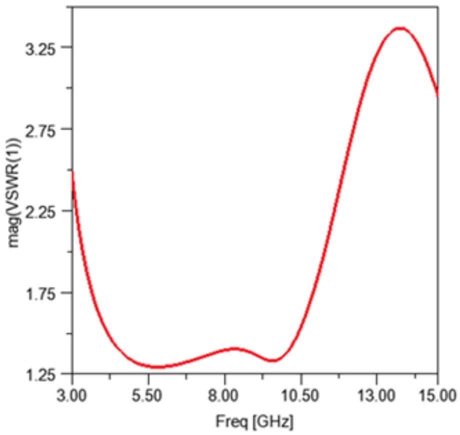


Fig. 5 Magnitude of VSWR plot of UWB antenna.

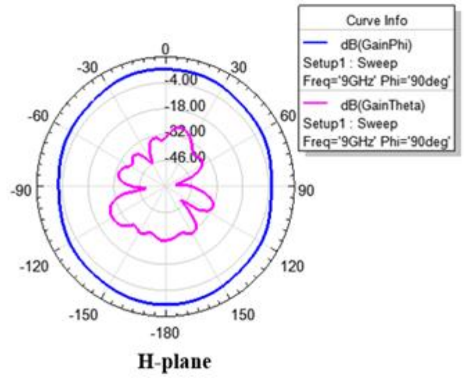
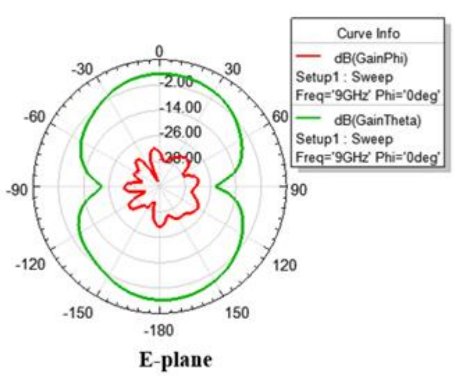


Fig. 6 Polarization plot of the antenna.

The polarization plot of a CPW-fed UWB antenna illustrates the orientation and behaviour of the radiated electric field over its wide operating frequency range. Since most CPW-fed UWB antennas are designed for linearly polarized operation, their polarization plot typically shows a dominant vertical or horizontal electric field component with relatively low cross-polarization levels. The CPW feed helps maintain stable current flow and symmetric field distribution on the same plane as the ground and radiator, which supports consistent polarization performance across the entire UWB band.

The plot also helps verify that the antenna maintains its intended polarization despite frequency changes, ensuring reliable data transmission, reduced polarization mismatch losses, and robust performance in communication, imaging, or sensing applications. The E and H-plane polarization plot of the proposed UWB antenna is shown in Fig. 6 and which shows that a low value of cross polarization is obtained.



IV. CONCLUSION

In summary, the proposed UWB antenna demonstrates strong performance across all key parameters. The return-loss characteristics confirm a wide operating bandwidth from 3.44 to 11.17 GHz, effectively covering most of the UWB spectrum. Surface current analysis highlights that the elliptical patch is the primary radiating element, ensuring efficient energy radiation. The antenna also achieves a reasonable peak gain of 4.40 dBi, suitable for UWB communication and sensing applications. Furthermore, the VSWR remains below 1.75 throughout the band, indicating excellent impedance matching and minimal signal reflection. Finally, the E- and H-plane polarization plots reveal low cross-polarization levels, confirming stable and clean radiation characteristics. Overall, the antenna exhibits robust UWB performance with good bandwidth, gain, impedance matching, and polarization purity.

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