



A COMPACT DUAL BAND RADIATOR FOR WLAN, WIMAX, WI-FI AND ISM BANDS

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Abstract

A compact radiator is formed by the combination of T shaped radiating patch and a rigid radiating element, which is fed by a coplanar wave guide structure. The lower band of the dual band radiator is generated by T shaped patch and upper band is formed by rigid element. The cross polarization of the radiators is reduced by properly decoupling of two radiating elements and the same time antenna gain, radiation efficiency are maintained in superior value for proper working of various wireless bands. The bandwidth of lower band is 2.14-2.77 GHz and upper band is 5.12-5.77 GHz. The average magnitude of radiation efficiency of lower and upper bands are greater than 90 %. The proposed radiator cover 2.4-2.484 GHz WLAN, 5.15-5.35 GHz WLAN, 2.5-2.69 GHz WiMAX, 5.25-5.85 GHz WiMAX, 2.4-2.5 GHz ISM and 5 GHz Wi-Fi bands.

Keywords: Dual Band, ISM, WiMAX and WLAN,

1. Introduction

A CPW (Coplanar Waveguide) fed microstrip patch antenna is important due to its unique advantages in modern wireless communication systems [1-4]. Unlike conventional feeding methods, CPW feeding provides a planar structure with the signal and ground on the same side, simplifying fabrication and integration with active devices. This feeding technique offers lower radiation loss and better impedance matching over a wide frequency range. CPW-fed antennas exhibit

reduced dispersion and lower cross-polarization levels, which improve overall radiation performance. They support compact and low-profile designs, making them suitable for portable and embedded applications. The open structure allows easy incorporation of tuning elements or reconfigurable features. CPW feeding enhances bandwidth and gain performance compared to traditional microstrip feeds. It also offers better isolation between feed and radiating elements, minimizing coupling effects. These characteristics make CPW-fed microstrip patch antennas ideal for high-frequency and multi-band applications like 5G, WLAN, and IoT [5-8]. Overall, they combine efficiency, compactness, and design flexibility, making them a vital component in modern antenna engineering.

A dual-band antenna is an antenna designed to operate efficiently at two distinct frequency bands. This allows a single antenna to support multiple wireless services, such as Wi-Fi and cellular, without the need for separate antennas. Dual-band operation is crucial in devices that require connectivity to different networks or standards. For example, smartphones often use dual-band antennas to connect to both 2.4 GHz and 5 GHz Wi-Fi bands. These antennas improve system compactness by reducing the number of components, which is ideal for space-constrained applications. They also minimize interference between bands by maintaining good isolation and impedance matching. Designing a dual-band antenna involves careful

tuning to ensure both bands have acceptable return loss, bandwidth, and radiation performance. Dual-band antennas are widely used in applications like GPS, Bluetooth, WLAN, 5G and wireless bands [9-13]. They improve user experience by enabling seamless communication across different frequencies. Overall, dual-band antennas are essential for achieving multifunctionality and efficiency in modern wireless systems.

This proposed design consists of CPW structure and the radiating elements are printed on the top of FR4 substrate of 0.8 mm thickness. The proper impedance matching are obtained by 50Ω transmission line. Two radiating patch radiate two resonance frequency band, which covers various wireless band.

2. Design of radiator

The proposed antenna is detailed in Fig. 1 and consists of CPW antenna design. The substrate used for this patch antenna is FR4 of 0.8 mm thickness and the radiating patch is placed on the top of FR4. The radiating patch consists of two strips for lower and upper band. The T shaped structure for lower band and the rigid patch for upper band. Since the lower band resonate with lower resonance frequency, that is longer wave length signal, which is generated by T shaped strip. But the upper band resonate with high resonance frequency, which is apt for shorter strip due to the generation of shorter wave length signal. Proposed antenna is placed inside a radiating box with medium air as showcased in Fig.2.

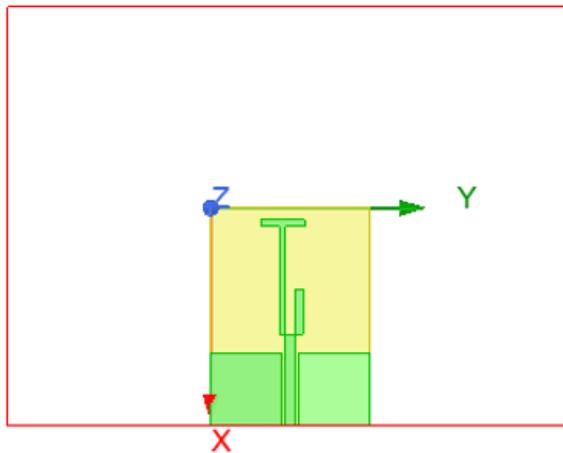


Fig. 1 Antenna structure

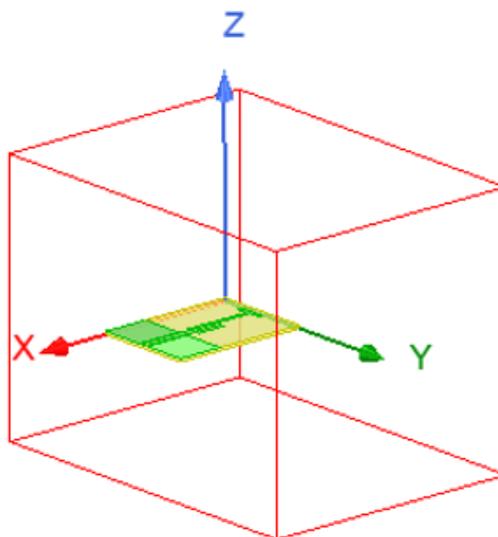


Fig. 2 Antenna placed inside a radiating box.

Return loss is a critical parameter that indicates how much of the transmitted power is reflected back due to impedance mismatch between the antenna and the transmission line. It is essential for determining the efficiency of power transfer from the source to the antenna. A higher return loss (more negative, such as -10 dB or lower) signifies better impedance matching and minimal signal reflection. When return loss is low, more power is reflected instead of being radiated, which leads to poor antenna performance. This reflection can reduce the effective radiated power, impacting the communication range and signal strength. Good return loss helps maintain a low Voltage Standing Wave Ratio (VSWR), protecting sensitive components from damage. It also improves overall system efficiency by ensuring that maximum power is radiated. Engineers use return loss measurements during design and

testing to optimize antenna performance. Monitoring return loss can also help detect faults or environmental effects on the antenna over time. Thus, return loss is vital for ensuring reliable, efficient, and high-performance wireless communication systems.

3. Results and discussion

The simulated return loss of antenna is shown in Fig. 3 which consists of dual band operation. The lower band is resonated with 2.45 GHz and the upper band is 5.40 GHz. The bandwidth of lower and upper band are 2.14-2.77 GHz, 5.12-5.77 GHz with a good return loss are generated at both resonance conditions. The return loss of two resonance conditions are -21.00 dB and -35.00 dB. The return loss of lower band is very low due to the less coupling effect of rigid strip as compared to the T shaped strip.

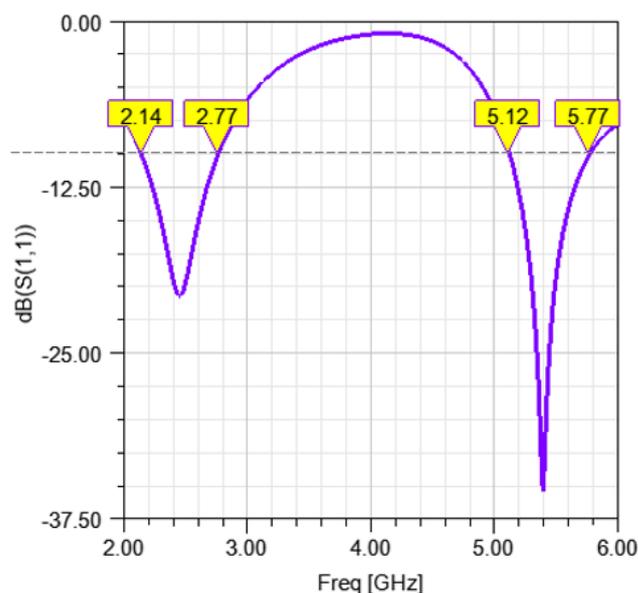


Fig.3 Return loss of antenna.

The current distribution plot of an antenna is crucial for understanding how current flows over the antenna surface when it is excited. It visually represents the intensity and pattern of current at different points, which directly affects the antenna's radiation characteristics. Analyzing current distribution helps in identifying active regions of radiation and areas that contribute less to performance. This insight allows engineers to optimize the antenna design for improved efficiency,

bandwidth, and gain. It also helps in identifying any unintended resonances or hotspots that can lead to poor radiation or unwanted losses. By studying the current pattern, designers can ensure proper impedance matching and minimize reflections. It is especially useful in complex or multi-band antennas to verify that each section operates as intended. The plot can reveal asymmetries or design flaws that are not obvious through other analysis methods. Accurate current distribution aids in the

validation of simulation models with experimental results. Overall, current distribution plots are essential for refining antenna designs and ensuring optimal real-world performance. The surface current distribution of antenna is shown in Fig. 4, which consists of two distribution plot. The first plot consists of surface current distribution at lower

resonance condition, where majority of the current being distributed along the T shaped patch. At this condition current distribution is very low in rigid strip as compared to longer strip. The rigid strip radiates at higher resonance frequency, which generates more current distribution in that resonance condition and detailed in Fig. 4.

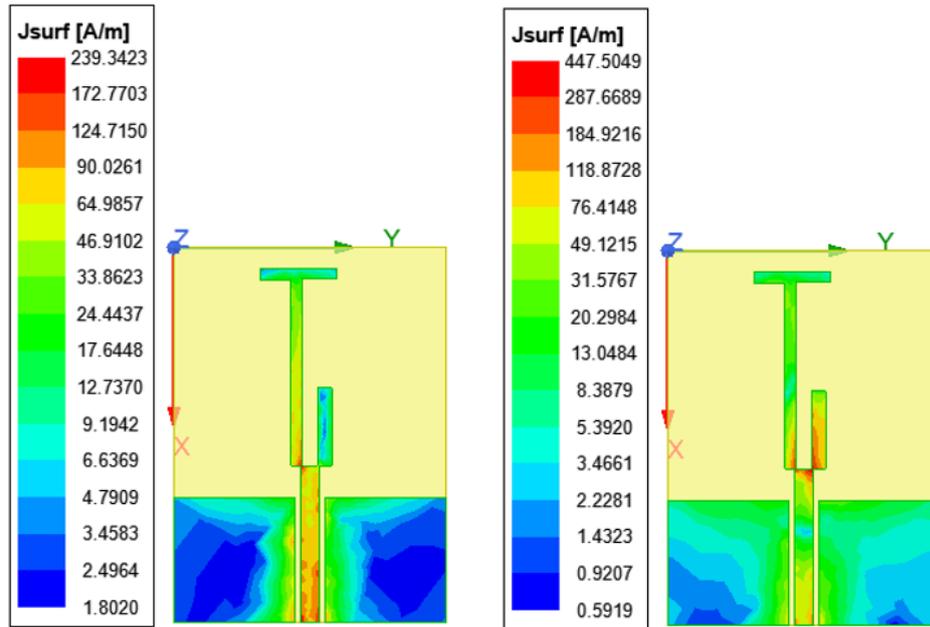


Fig.4 Surface current distribution of antenna at two resonance frequencies.

The gain of an antenna is a fundamental parameter that measures how effectively it directs or concentrates radiated power in a specific direction. It combines the antenna's efficiency and directivity into a single value, usually expressed in dBi or dBd. A higher antenna gain indicates stronger signal transmission and reception in the intended direction. This is crucial for improving communication range and signal quality, especially in long-distance or directional systems. Antennas with high gain can focus energy more effectively, reducing power waste in undesired directions. Gain plays a vital role in applications like satellite communication, radar, and wireless networks. It also helps overcome signal losses due to distance or environmental interference. Properly selecting

antenna gain ensures better link performance and reduces the need for higher transmission power. Engineers must balance gain with coverage needs, as higher gain often comes with narrower beam width. Therefore, antenna gain is key to achieving efficient, focused, and reliable wireless communication. The gain of antenna is shown in Fig. 5 that consists of -1.20 dB at lower resonance condition, 1.25 dB at upper resonance frequency. These simulated value shows that antenna produce good radiation in the upper band as compared to lower band. This high radiation of upper band is due to low value of return loss in the upper band as compared to lower band. The radiation characteristics of lower band can be improved by reducing the coupling effect.

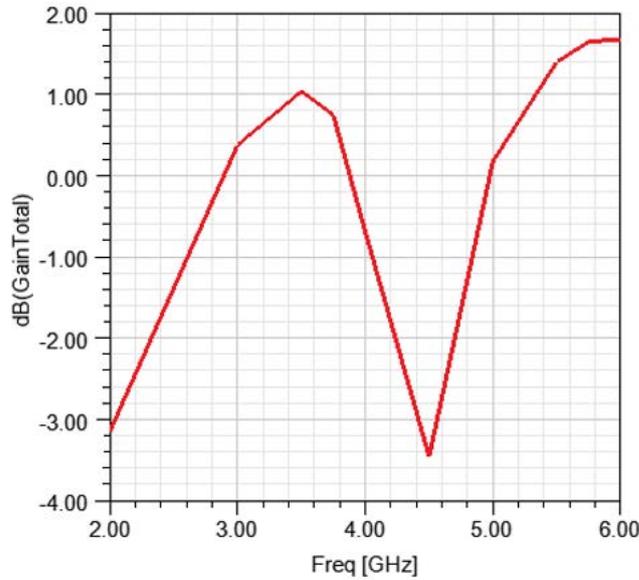


Fig. 5 Gain of proposed antenna.

The radiation efficiency of proposed radiator is shown in Fig. 6 and consists of good radiation efficiency in both lower and upper band. At 2.45 GHz resonance condition the

radiation efficiency is 94.00 % and in the upper resonance condition it become 92.00 %. These simulated results shows that antenna is a good radiator in both lower and upper band

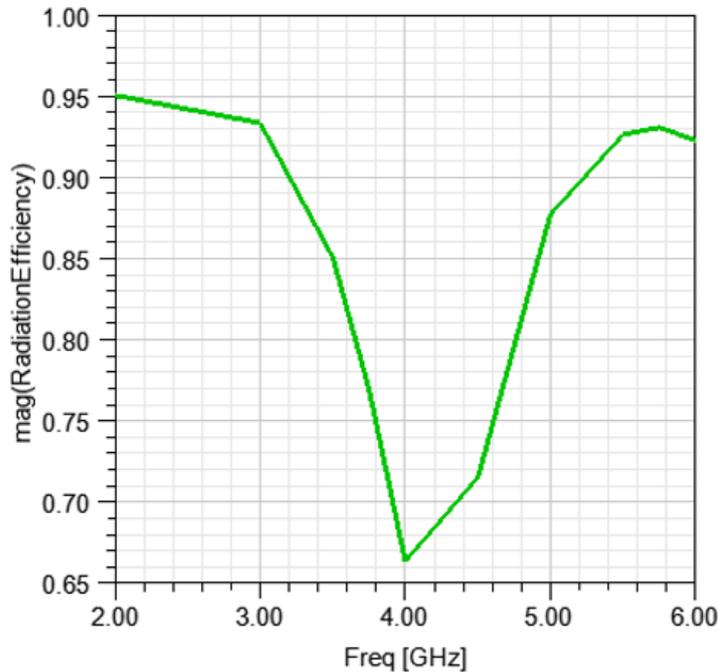


Fig. 6 Radiation efficiency of proposed antenna.

The co-polarization and cross-polarization plots of an antenna are essential for evaluating its polarization performance and signal purity. Co-polarization refers to the desired polarization component that aligns with the antenna's intended polarization, while cross-polarization represents the unwanted orthogonal

component. High co-polarization levels ensure that the transmitted or received signal maintains its intended orientation, maximizing communication efficiency. Low cross-polarization is crucial to minimize signal interference, crosstalk, and degradation in multi-antenna or polarization-sensitive systems.

These plots help assess how well the antenna suppresses unwanted polarization components. Analyzing both plots allows designers to optimize the antenna structure for better polarization purity and isolation. In applications such as satellite communication, radar, and MIMO systems, precise polarization control is critical for reliable performance. Cross-polarization levels can indicate asymmetries or design flaws in the antenna. Proper polarization

behavior enhances overall antenna gain, efficiency, and reduces signal fading. Therefore, co- and cross-polarization plots are vital tools in designing and validating high-performance antenna systems. The spherical plot of polarization of antenna at 2.45 GHz is shown in Fig. 7. This proposed antenna produce a high value of co-pol and very low value of cross polarization is produced in the two operating frequencies.

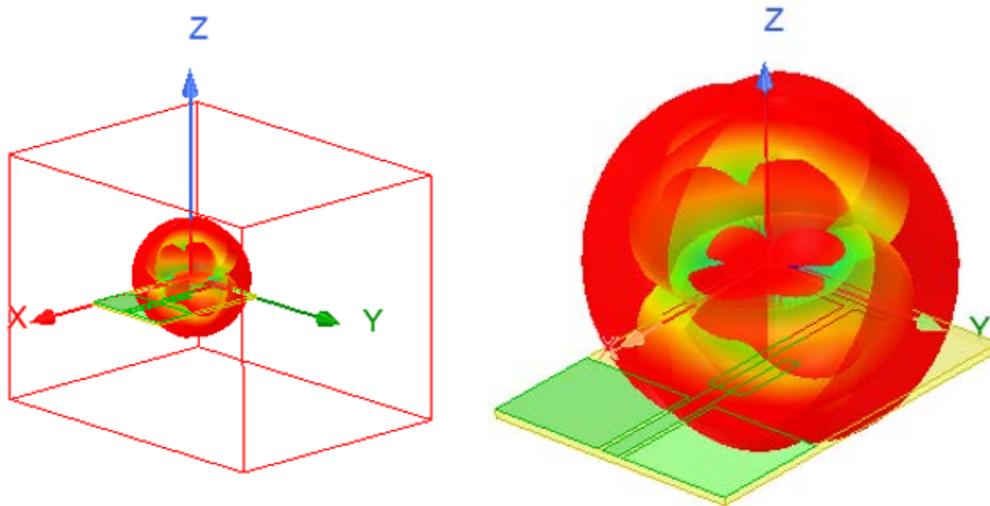


Fig. 7 Spherical plot of polarization of antenna at 2.45 GHz.

4. Conclusion

The proposed compact dual-band radiator, utilizing a combination of a T-shaped patch and a rigid radiating element with CPW feeding, demonstrates efficient performance across multiple wireless communication bands. The strategic decoupling of the two radiating elements effectively reduces cross-polarization without compromising antenna gain or radiation efficiency. With broad impedance bandwidths of 2.14–2.77 GHz and 5.12–5.77 GHz, and radiation efficiency consistently above 90%, the antenna is well-suited for a wide range of applications, including WLAN (2.4 GHz, 5.15–5.35 GHz), WiMAX (2.5–2.69 GHz, 5.25–5.85 GHz), ISM (2.4–2.5 GHz), and 5 GHz Wi-Fi. This makes the design an excellent candidate for compact, high-performance wireless systems.

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