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Stub-Based Higher Order Harmonics Suppression for Upper W-LAN Band Microstrip Patch Antenna

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ABSTRACT

In this paper, the authors investigate the elimination of higher order harmonics in a microstrip patch antenna operating in higher bands for wireless local area networks (WLAN). The goal will be the subsequent suppression of harmonics without further complication of the design by either introducing additional structures or filters, while the stub is included in the design. The report presents the methodol- ogy employed, which involves designing and simulating a microstrip patch antenna with stubs strategically placed at specific locations. The outcomes show how successful the suggested technique in reducing the higher-order harmonics, leading to improved antenna performance. The findings highlight the importance of stub placement and dimensions in achieving desired harmonic suppression. Based on the results, recommendations are provided for optimizing stub configurations to further enhance the elimination of higher-order harmonics in microstrip patch antennas operating in W-LAN higher bands. This research advances the creation of compact and efficient antenna designs for modern wireless communication systems.

Keyword: *Microstrip patch antenna, Higher-order harmonics, Stub placement, Harmonic suppression, Wireless local area network (WLAN)*

1. INTRODUCTION

Microstrip patch antennas are widely used in wireless communication systems, such as WLAN, due to their small size, flat profile, and easy integration. However, they can pro- duce higher-order harmonics, which can lead to interference, signal deterioration, and non- compliance with regulations. These antennas are made up of a conductive patch on a di- electric substrate with a ground plane and are utilized in mobile phones, satellite communi- cation, Wi-Fi networks, and radar systems[8,9]. In WLAN systems that operate at higher frequencies, dealing with higher-order harmon- ics poses significant challenges. Conventional methods for suppressing harmonics involve in- tricate structures or additional components, which can increase the size and cost of the an-enna system [1, 3, 4].

This study explores the use of strategi- cally placed stubs within the antenna design to eliminate higher-order harmonics in microstrip patch antennas operating in the higher band of WLAN. The aim is to investigate the feasibility and effectiveness of using stubs for harmonic suppression-only. This is done through the design and simulation of microstrip patch antenna with stubs to ascertain the influences of the variation in stub placement and dimensions on harmonic suppression, with a view towards optimizing stub configurations. [2, 6, 7].

Higher-order harmonics, which are multi- ples of the fundamental frequency, can create interference with adjacent frequency bands when microstrip antennas operate at high power levels. Eliminating these harmonics is essential for achieving high spectral purity and enhanced efficiency. Previous studies have investigated various techniques for eliminating higher-order harmonics in microstrip antennas, contributing to the advancement of compact and efficient antenna designs for modern wire- less communication systems [5, 7]. This ensures better signal quality, reduced interference, and compliance with regulations

ANTENNA DESIGN

Initially designed with the operating frequency of 5.8 GHz as in Figure 1, the microstrip antenna has a stub suitably incorporated into the design to achieve the necessary elimination of higher order modes and corresponding frequencies. This is shown in a later figure.

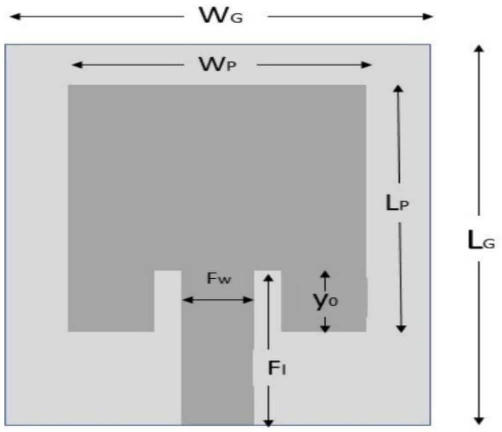

Fig. 1. The basic layout of a reference antenna at 5.75GHz frequency (top view).(Wg=30mm, Lg=40 mm, Wp=16.34 mm, Lp=22.9 mm, Fw=3.9 mm, Fl=12.5 mm,Yo=5.2 mm)

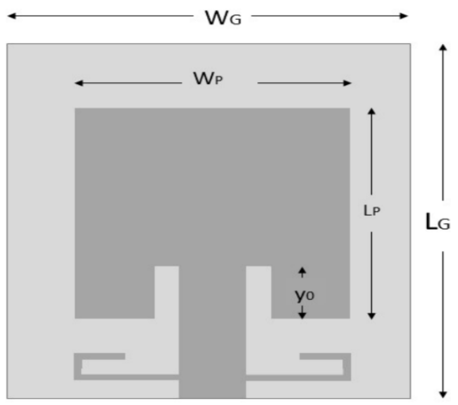

Fig.2: Proposed antenna from a top view along with two symmetrical stubs resonating at 5.75GHz fre- quency.

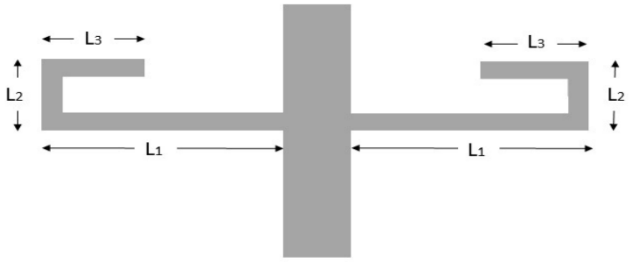

Fig.3.: Top view of proposed antenna with close to ‘C’ shape symmetrical open ended stubs.(L1= 6.17mm, L2= 2.33mm, L3=2.47mm)Width=0.75mm.

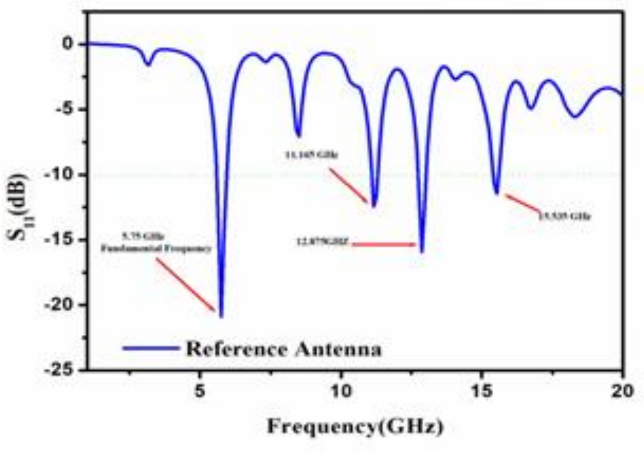

Fig.4: A simulated plot of S11 versus frequency, indicating a fundamental resonant frequency of 5.75 GHz and higher harmonics/modes

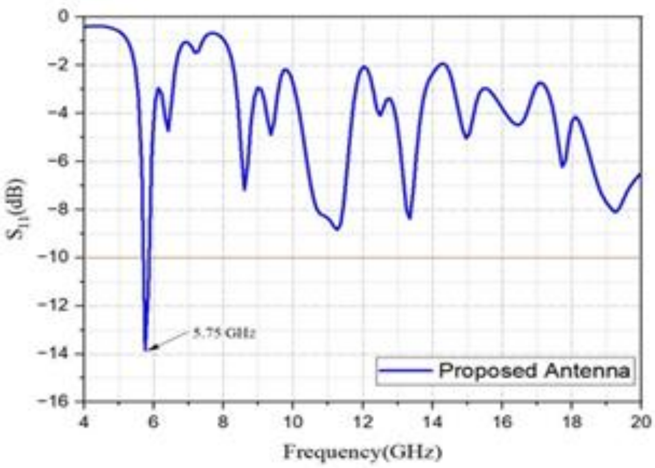

Fig. 5: A measured plot of S11 versus frequency for the manufactured antenna

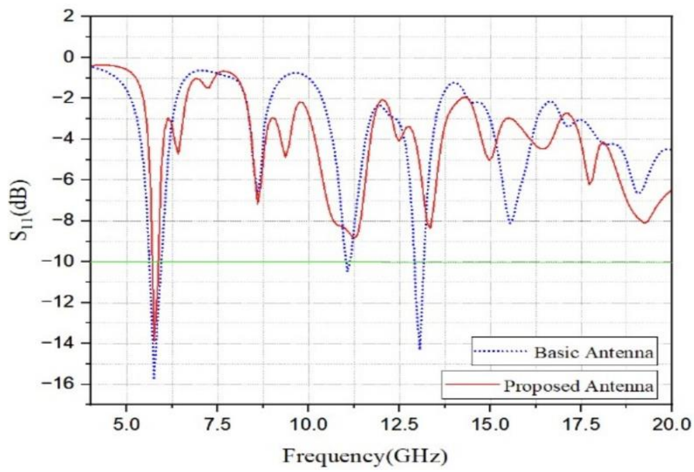

Fig. 6: The comparison of simulated graphs of S11 versus frequency for the basic and proposed structures of the antenna

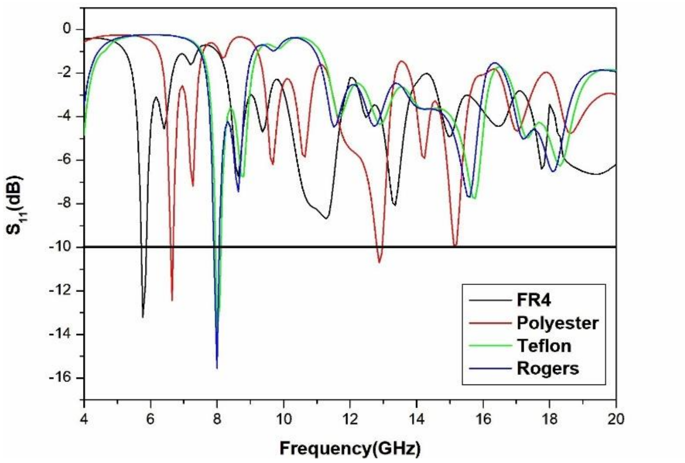

Fig. 7: Comparison of S11 frequency of different substrate.

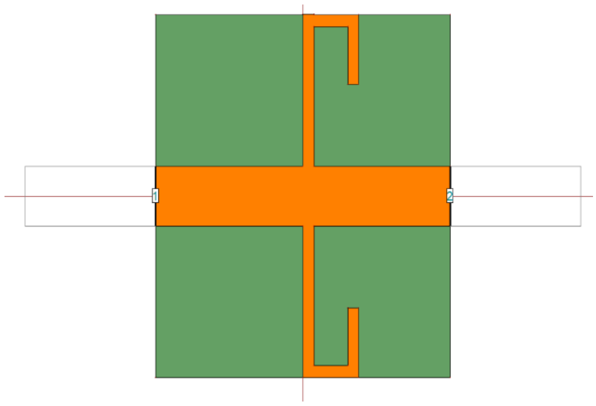

Fig. 8: Basic geometry of Reference Transmission line and Stubs in ZeLand.

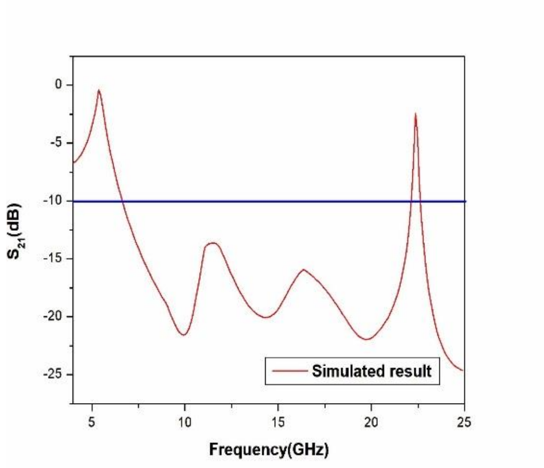

Fig. 9: Simulated Stopband Characteristics with Stub

EXPERIMENT AND RESULTS

Such filters can be integrated within a narrow band of stop band with high selectivity as defined by 50 transmission line. To measure its operation, an antenna simulation test is performed on an FR-4 substrate of ϵ r = 4.4, h =1.578 mm. The results of the simulation show that all high-order modes up to second harmonics of the primary frequency have been effectively suppressed and emitting radiation through these frequencies is drastically reduced.

The following studies are then to investigate the fields radiated by the fundamental modes and anyone other modes that show such effects due to the incorporation of the stubs. The presence of stubs does not make a significant difference to the mother mode radiation traits. Their endeavors also extend to include the characteristics of the first harmonic radiation at the second harmonic.

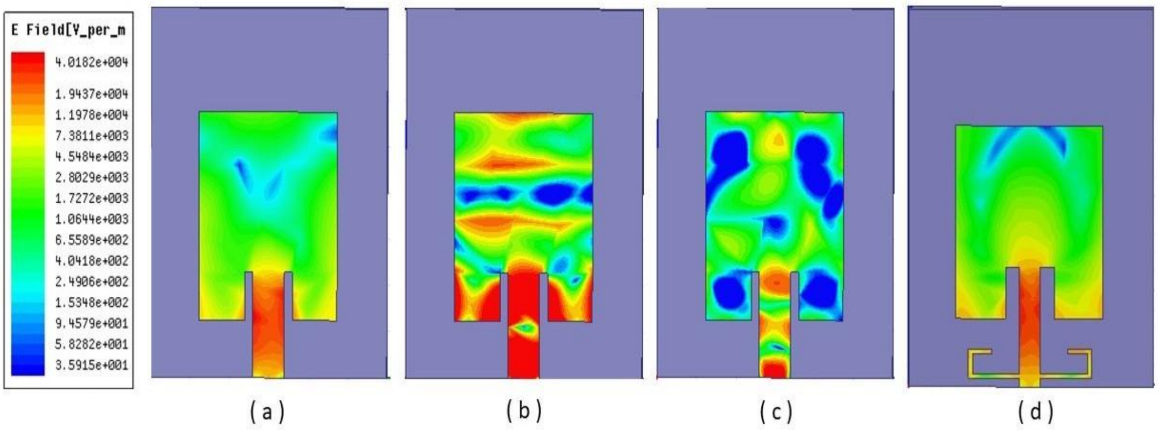

Figure : Current distribution for (a) fundamental frequency (5.75 GHz), (b) 1st Harmonic frequency (11.165 GHz), (c) 2nd Harmonic frequency (15.535 GHz) of Reference antenna and (d) proposed antenna (5.75 GHz).

Table 1: The number of harmonics suppressed from different methods and an overview of that value.

Year & Reference	No. of harmonic suppressed	Fundamental Frequency(GHz)	DGS/Stub used
2005 [5]	1	1.79	DGS
2015 [9]	1	5.2	Stub
2018 [8]	2	3.475	DGS & Stub
Present	2	5.75	Stub

2. DISCUSSION

The proposed stub-based method for harmonic suppression in microstrip patch antennas demonstrates a significant advancement in achieving spectral purity for WLAN applications without complicating the antenna structure. Through strategic placement and sizing of open-ended stubs, higher-order harmonics up to the second harmonic have been effectively suppressed, as validated by both simulation and experimental results.

Therefore, the design of the structure is compact and simple compared to earlier techniques with the use of Defected Ground Structures (DGS) or combining DGS with stubs, with the advantage of avoiding complex fabrication processes. The findings show that the addition of stubs has minimal impact on the fundamental mode's radiation pattern, thereby preserving the antenna's performance at the operating frequency (5.75 GHz).

The comparative analysis (Table 1) highlights that the proposed design suppresses two harmonics, improving upon previous works that managed either one or two harmonics but often required additional structures. Moreover, the study confirms that substrate material also plays a crucial role, as evident from the comparison of S11 characteristics across different substrates.

Radiation performance analysis reveals that the stubs predominantly affect the higher-order modes without deteriorating the fundamental mode's radiation characteristics. This selective suppression ensures that the antenna can operate efficiently in its intended frequency band while minimizing unwanted emissions that could cause interference with adjacent channels.

Furthermore, the successful demonstration of stopband characteristics using stubs emphasizes their effectiveness as an alternative to conventional harmonic suppression methods. This research suggests that fine-tuning the length and width of the stubs could further optimize suppression performance, opening possibilities for future work on multiband or reconfigurable antenna designs using similar techniques.

3. CONCLUSION

The stub-based LPF is very much successful in suppressing higher-order modes to the second harmonic in a rectangular patch. The use of stubs in the antenna configuration enhances performance without compromising compactness. By minimizing back side radiation and preserving the flexibility of the structure, the radiating patch remains undisturbed. This method exhibits potential for a range of prac- tical uses in microwave integrated circuits.

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