Bandwidth Enhancement of a Microstrip Line-Fed Patch Antenna by Using Printed Wide Slot with Parasitic Centre Patch

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Abstract- A printed wide slot antenna with centre parasitic patch for bandwidth enhancement is presented in this paper. Basically a comparison is done here between conventional design of microstrip patch antenna and a novel design of microstrip patch antenna which consists of a slotted ground plane with a triangular shaped patch at the centre on the top side of the substrate. A 50Ω microstrip line is located at the back side of the substrate which is used to excite the parasitic patch. The simulation result of the proposed antenna shows that 18.38% of the impedance bandwidth is between 5.157 to 6.196GHz for $20\log|S_{11}|<-10dB$ while for the conventional antenna it shows the impedance bandwidth 3.068% between 5.222 to 5.385GHz. The proposed antenna is designed to cover the Worldwide Interoperability for Microwave Access (WiMAX) applications based on the IEEE 802.16 standards for the frequency band 5.15 to 5.85 GHz and Wireless Local Area Network (WLAN) applications band that based on the IEEE 802.11 standard for the frequency band of 5.15 to 5.825GHz. Some important parameters of the designed structure are investigated using finite element method based electromagnetic solver, HFSS.

Keywords- Bandwidth enhancement, parasitic patch, WLAN, WiMAX.

INTRODUCTION

Rapid growth in wireless communication systems has resulted in great demand for small devices capable of providing wide bandwidth for multiple services, printed slot antenna is currently under consideration for use in wideband communication systems due to their attractive features, such as wide impedance bandwidth, compact size, simple structure, low cost and easy integration with monolithic microwave integrated circuits. To achieve wide bandwidth for wireless devices, there are many antenna design and techniques can be used. Some printed slot antenna designs with various shapes like square [1], triangle [2], rectangle [3], rhombus [4], fractal [5] and binomial-curve [6] have been reported for wideband applications. Coupling between the feeding structure and slot can be used to obtain an optimum impedance bandwidth [7]-[10]. A broad bandwidth can be obtained by a printed wide-slot antenna fed by a microstrip line with a fork-like tuning stub through the proper parameters of the fork-like tuning stub [7]. In [8], it can be seen that introducing an L-shaped slot with a W-shaped feed stub can improve bandwidth. However, these configurations of antenna design are more complicated. There are three operation bands in the IEEE 802.11 WLAN standards: 2.4 GHz (2400-2484 MHz), 5.2 GHz (5150-5350MHz) and 5.8 GHz (5725-5825 MHz). In the Asia Pacific region, frequencies available for WiMAX deployments are in the 2.3/3.3/3.5/5.5 GHz range. In this paper, a printed microstrip-line-fed slot antenna with a pair of parasitic patches is proposed based on the works of [11], [12]. A comparison is presented in this paper, between the results of a conventional antenna and proposed new design antenna.

![Fig.1 Structure of the proposed antenna](image-url)
substrate while the excitation to the antenna is given by the microstrip feedline from the bottom side of the substrate. Shape of the parasitic patch is triangle. By using proposed technique impedance bandwidth can be enhance from 3.068% to 18.38%. Fig. 1 shows the structure of the proposed new design antenna.

[2] ANTENNA DESIGN

Fig.1 shows the antenna configuration of the conventional design of microstrip antenna. The simulated antenna is fabricated on FR-4 substrate. Area of the substrate is 40×40mm² and height of the substrate is 1.6mm. Here the shape of the patch is an equilateral triangle and its dimension is obtained by a formula given by the Eq. 2.1. One side of the triangle calculated by the formula is \( a = 17.3358 \text{mm} \). The feedline of the antenna is also obtained by the formula given by the Eq. 2.2, which is \( L_2 = 6.5009 \text{mm} \). The length and width of the ground are \( L = 40 \text{mm} \) and \( W = 40 \text{mm} \) respectively.

Side of the triangular patch \( a = 2c/3f_r\sqrt{\varepsilon_r} \) (2.1)

Length of transmission line \( L_2 = \lambda/4 \) (2.2)

The configuration of the proposed printed wide slot antenna with parasitic centre patch is shown in Fig. 2. Dimension of substrate, ground and patch are similar to the conventional antenna. But there is a square slot in the ground, and the triangle shaped patch is located in the centre of the slot. The size of the square slot is 20×20mm². The length of the feedline of the proposed design is different from the conventional antenna because of the matching purpose, and it is \( L_2 = 16 \text{mm} \). The material used for the substrate of the proposed prototype is similar to the material used for conventional antenna i.e. FR-4 epoxy. The top view and bottom view of the proposed antenna is shown in Fig. 2(a) and Fig. 2(b) respectively. Table 1 shows the optimized design parameters of the conventional design and new proposed design.

<table>
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<th>Parameter</th>
<th>Value(mm)</th>
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<td>( L )</td>
<td>40</td>
<td>( W_2 )</td>
<td>2</td>
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<tr>
<td>( W )</td>
<td>40</td>
<td>( L_3 )</td>
<td>16</td>
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<td>( L_2 )</td>
<td>6.5009</td>
<td>( a )</td>
<td>17.3358</td>
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[3] RESULT AND DISCUSSION

It can be seen from the Fig. 3 that by using the proposed new design, bandwidth can be improved in the great extent. Bandwidths obtained from the conventional antenna and proposed antenna is 163MHz and 1039MHz respectively. The impedance bandwidth of conventional antenna is 3.068% with respect to the centre frequency at 5.3063GHz; however bandwidth of the new design antenna is 18.38% with respect to the centre frequency at 5.6533GHz. The return loss values for conventional and new design antenna are -13.4dB and -34.41dB respectively. The gain for the two antennas is 1.988dB and 1.058dB for conventional and new design antenna respectively.

Fig. 3 Comparison between simulated return loss of the conventional antenna and new design antenna

Now hereby a parametric study is carried out to understand the effects of size of ground slot and length of feedline. Fig. 4 shows the return loss of proposed antenna with different ground slot size. And from the figure we can easily conclude that optimum result is obtained at $L_1=20\text{mm}$ and $W_1=20\text{mm}$. The return loss of the proposed antenna at different length of feedline is shown in Fig. 5. In our proposed prototype, $L_3=16\text{mm}$ is taken because antenna is giving best result to this dimension.

Fig. 4 Simulated return loss of the proposed antenna with different $L_1\times W_1(\text{mm}^2)$.

Fig. 5 Simulated return loss of the proposed antenna with different $L_3$.

[4] CONCLUSION

A printed wide slot antenna with parasitic centre patch for bandwidth enhancement has been designed successfully. With the optimized geometry, the proposed antenna is provided a impedance bandwidth of 18.38% which is greater than bandwidth obtained from conventional antenna i.e. 3.068%. The values of reflection coefficient for the conventional antenna and proposed antenna are -13.4dB and -34.41dB respectively. However the values of gain for conventional and proposed antenna are 1.988dB and 1.058dB respectively. By properly tuning the dimension of slot, and feedline, the design with enhanced bandwidth is obtained. So, this antenna can be used for WLAN application and WiMAX application.
REFERENCE


