Proximity Coupled Rectangular Microstrip Antenna with X-slot for WLAN Application

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Received: 12 December 2013 Accepted: 4 January 2014 Published: 15 January 2014

Abstract
One of the major limitations of microstrip antenna is narrow bandwidth. Various techniques can be used to improve it’s BW. In this paper, Proximity coupling technique and X slot are employed to enhance the BW of Rectangular Microstrip antenna (RMSA). A RMSA with X slot has been designed at a frequency of 2.45GHz on FR4, one substrate and it is proximity coupled with microstrip feed, which is on the other substrate. Various parameters viz. Return loss, VSWR, input impedance, Gain, are obtained from HFSS simulation and Network analyzer test is performed to obtain VSWR. Percentage BW of VSWR from network analyzer is obtained as 7.14, which is more than that of a microstrip feed RMSA.

Index terms— rectangular microstrip antenna, proximity coupling, microstrip feed, X-slot, BW, return loss.

1 Introduction

The microstrip antenna in its simple form cannot satisfy the bandwidth requirements for most wireless communication systems. Antenna plays a vital component in wireless application systems. The microstrip antenna can be used for wireless applications as it has features such as light weight, easily mounted and it is easy to mass production. Although there are many features that suits well for microstrip antenna to be deployed for wireless applications, there is a very serious limitation where it has a very narrow bandwidth. The typical bandwidth of the microstrip antennas is between 1% to 3%. By overcoming this limitation the microstrip antenna can be used to its full potential. An alternative bandwidth enhancement technique is studied and then proposed in order to broaden the bandwidth of the microstrip antenna. The wireless application that is selected to be studied is the Wireless Local Area Network (WLAN) based on the IEEE 802.11b standard. This WLAN band spans from 2.4GHz to 2.48GHz. Inserting slot on ground plane and stacked patch supported by wall, the bandwidth can improve up to 25% without significant change in the frequency.

In this paper the bandwidth of RMSA is enhanced by using combination of two techniques, Proximity coupled feed line and adding X slot in the patch.

1.1 Proximity Coupled Feed

The microstrip antenna consists of a grounded substrate where a microstrip feed line is located. Above this material, there is another dielectric laminate with a rectangular microstrip patch etched on its top surface. There is no ground plane separating the two dielectric layers. The power from the feed network is coupled to the patch electromagnetically, as opposed to a direct contact. This form of microstrip patch is sometimes referred to as an electromagnetically coupled patch antenna.

A key attribute of the proximity-coupled patch is that its coupling mechanism is capacitive in nature. This is in contrast to the direct contact methods, which are predominantly inductive. The difference in coupling significantly affects the obtainable impedance bandwidth, because the inductive coupling of the edgeand probe-fed geometries limits the thickness of the material useable. Thus, bandwidth of a proximity-coupled patch is inherently greater than the direct contact feed patches.
2 b) Slots in The Patch

Recently, most applications need larger bandwidths, so in these application areas, microstrip antennas' biggest handicap is the narrow bandwidth. Because of this, there are lots of studies going on and various bandwidth enhancement techniques are reported [2]. These techniques to increase bandwidth include introducing multiple resonances into the structure [3]. This may take the form of stacked patches, coplanar parasitic patches, or patches that have novel shapes such as the U-shaped slot patch antenna. Using special feed networks or feeding techniques [4] to compensate for the natural impedance variation of the patch is another method. Etching a slot on the patch is a simple design. This design avoids the use of stacked or coplanar parasitic patches, either of which increases the thickness or the lateral size of the antenna. So, while changing the current distribution on the microstrip patch, by enhancing the impedance bandwidth sometimes more than one resonant frequency is obtained [5]. In this study, slots with various dimensions etched on present rectangular patch antennas in literature are tested and it is seen that their bandwidths can be enhanced by sacrificing a bit from the initial resonant frequencies. The simulation measurement without slots give near resonant frequencies to the experimental results; but all the bandwidths are under 5% and by using the slots with direct contact feeding techniques we can enhance the bandwidth up to 15%.

An analyzer test is performed to obtain VSWR. Percentage BW of VSWR from network analyzer is obtained as 7.14, which is more than that of a microstrip feed RMSA.

3 II.

4 Design of Proximity Coupled Fed Microstrip Antenna with X-Slot

This section describes the design of Rectangular Microstrip patch antenna (RMSA) to obtain the results at frequency of 2.45 GHz. The design of Proximity coupled RMSA with X-slot is simulated with HFSS simulator [7]. To get the satisfied simulation results, the design parameters are optimised. The optimised design parameters of proximity coupled RMSA with X-slot are shown in table 2.1.

5 Table 2.1: Optimised design parameters

With the above design parameters, the RMSA has been fabricated and tested using network analyzer. From measurement VSWR characteristic is obtained which is shown in figure 3.1.

6 Simulation Results

The High Frequency Simulation Software Return loss is the difference between forward and reflected power, in dB, generally measured at the input to the coaxial cable connected to the antenna. If the power transmitted from the source is P T and the power reflected back to the source is P R, then the return loss is given by \( \frac{P_R}{P_T} \). For maximum power transfer, the return loss should be as small as possible. This means that the ratio should be as small as possible, or expressed in dB, the return loss should be as large a negative number as possible. For example a return loss of -40dB is better than one of -20dB.

The designed antenna resonates at 2.45GHz with return losses of -26 dB which is shown in figure 3.1 and percentage BW is calculated as 8.17%

7 Bandwidth Calculation

Where f 1 and f 2 lower and upper frequencies
b) Voltage Standing Wave Ratio (VSWR)

The most common case for measuring and examining VSWR is when installing and tuning transmitting antennas. When a transmitter is connected to an antenna by a feed line, the impedance of the antenna and feed line must match exactly for maximum energy transfer from the feed line to the antenna to be possible. When an antenna and feed line do not have matching impedances, some of the electrical energy cannot be transferred from the feed line to the antenna. Ideally, VSWR must lie in the range of 1-2 which is achieved in figure 4.4 for the frequency 2.45 GHz, near the operating frequency value.

8 c) Radiation Pattern

The radiation pattern is a graphical depiction of the relative field strength transmitted from or received by the antenna. Antenna radiation patterns are taken at one frequency, one polarization, and one plane cut. The patterns are usually presented in polar or rectilinear form with a dB strength scale.

Since a Microstrip patch antenna radiates normal to its patch surface, the elevation pattern for \( \theta = 0^\circ \) and \( \phi = 90^\circ \) would be important. Figure 7.10 below shows the gain of the antenna at 2.45GHz for \( \theta = 0^\circ \) and \( \phi = 90^\circ \).
9 d) Input Impedance

We expect pure real impedance at frequencies where the patch resonates, that is, where the patch is designed to radiate. As a result, the input impedance plot in Fig 3 shows that around the desired radiating frequency, sufficient reactance cancellation can only occur inside a narrow bandwidth. In addition, one needs to match the resonant resistance with the characteristic impedance of the feed line. A small antenna can be tuned to resonate with an appropriate addition of reactance, or it can be made to self-resonate so that the reactance cancellation at resonance happens naturally in the antenna structure. Since adding external reactance for this purpose increases the power loss and it also requires extra space, it is advisable to follow the second alternative. The fabricated Proximity coupled RMSA with Xslot is tested with HP Make network analyser. From this test, the VSWR characteristics are obtained. The percentage Bandwidth from VSWR plot is calculated as 7.14%,

10 Conclusion

Proximity coupling and X slot techniques are introduced for improving the BW of RMSA at 2.45GHz. The proposed design of RMSA has been simulated and practically tested with network analyzer. For proposed antenna design, BW of 8.17% is obtained from HFSS simulation, where as from network analyser test the BW of 7.14% is calculated. The bandwidth before adding the slot and the stacked patch was 2.5% whereas after adding the slot and the stacked patch the bandwidth increased. Thus the proposed design is useful for BW enhancement for RMSA, which is required for Wireless AN.

Figure 1: Figure 2

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Figure 2: Figure 2.2: Figure 2.3: Figure 2.4:

Figure 3:
f) BW Comparison

The percentage BWs of Proximity coupled RMSA with X-slot is compared, those values are calculated from HFSS simulation results and Network analyser test. Table 4.1 shows comparison of % BW between the simulation and practical results.
8. Ansoft HFSS12.1 Simulation software.

<table>
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<th>Results</th>
<th>Rectangular MSA (Without X-Slot)</th>
<th>Proximity coupled fed Rectangular MSA with X-slot</th>
</tr>
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<td>Simulation Results</td>
<td>5.68%</td>
<td>8.17%</td>
</tr>
<tr>
<td>Practical Results</td>
<td>2.4%</td>
<td>7.14%</td>
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</tbody>
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Figure 8:
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