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A Compact Microstrip-Fed Patch Antenna with Enhanced Bandwidth for Wi-Fi/Wi-Max Applications using Metamaterial

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Abstract: **- A microstrip fed patch antenna with features of bandwidth enhancement is proposed. For this purpose a pair of λ/4 resonators was introduced with insert fed technique to a rectangular patch. The wide bandwidth property can be obtained by using the radiating patch and non- radiating λ/4 resonators. Substrate used for this purpose is FR-4 EPOXY with an operating frequency of 4.8 GHz which reduces the cost of the designed antenna and hence results in the increased bandwidth. The bandwidth thus obtained is twice the bandwidth of the traditional microstrip patch thus resulting in higher range for Wi-Fi/Wi-Max applications.**

Keywords**: - Enhanced bandwidth, λ/4resonators, microstrip patch, Wi-Fi/Wi-Max.**

I. INTRODUCTION

IN MODERN communication system, the antenna and the front-end are closely placed together. In these systems, the microstrip patch antenna is much popular since it can be easily integrated with many other active and passive circuits such as filters, amplifiers, oscillators, and mixers. Despite these attractive features, the microstrip antenna usually suffers from several inherent drawbacks. One is the narrow bandwidth because of its resonant property with a high Q; the other is the high level of harmonic radiation, which will decrease the efficiency of the system and even cause harmful interferences with other systems. We can enhance the bandwidth of the microstrip fed patch by using the aperture coupling feed, proximity coupling feed, or stacked patch configurations. But, these techniques require multilayer substrates, resulting in difficulty and high cost in fabrication. It is preferred to enhance the bandwidth of patch antennas using a single-layer insert-fed method. It is well known that the patch antenna can be treated as a resonator with radiation loss. If another resonance is introduced to be incorporated with this resonating patch, the bandwidth is expected to increase significantly [1]. A typical fed method is to adopt the modified probe with L-, T-, and hook-shaped configurations [2]–[5]. Another method is to load the radiating patch with different slots, e.g., U-, E-, and -shaped slots [6]–[10]. Recently, single-layer coplanar capacitive-fed patch antennas are reported in [11]–[14], which are relatively simple to fabricate and assemble.

Comparing with the probe-fed method, the microstrip-fed approach is much useful in the implementation of an array antenna with a number of radiating elements. By using the printing technology the microstrip feeding network and patch radiating elements can be integrated on a single layer substrate and the array is fabricated. In [15] and [16], a half wavelength (λ/2) resonator and a composite right-/left-handed resonator are employed, respectively, to achieve the wideband performance. Since the sizes of the feeding networks are significantly enlarged, these approaches can hardly be applied in the design of an array. A size-miniaturization method is reported in [17], but the patch configuration is destroyed by an extra T-shaped resonator. Moreover, the harmonic radiation cannot be suppressed because this T-shaped resonator operates as a λ/2 resonator.

The advantages of this method are as follows.

1) Operating bandwidth of a patch antenna is enhanced for an electrically thin substrate which can be further controlled by adjusting the space between the patch and λ/4 resonators.
2) Overall size of the Patch antenna is maintained by keeping the feeding line section small in size for its array applications.
3) The geometric symmetry of the antenna helps in achieving a low cross – polarization level

II. GEOMETRY AND WORKING PRINCIPLE

A. Geometry

The proposed microstrip-fed patch antenna with enhanced bandwidth is depicted in Fig. 1. The antenna comprises of a rectangular patch and two λ/4 resonators in the feeding line section. A shorting pin with a radius of r is shared among the

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two λ/4 resonators. The dimensions of the patch are Lp× Wp, and of λ/4 resonator are Lr× Wr. Apart from the traditional insert fed method, the radiating patch and feed line impedance is matched through the λ/4 resonators which are located at a distance d from the patch. This can be fabricated on a single- layer substrate with a thickness of h and a relative permittivity of εr.

B. Working Principle

A resonator-type patch antenna requires an electrically thin substrate, having a narrow bandwidth. Bandwidth enhancement can be achieved by using dual resonance structure. For this purpose, an extra non-radiating resonator is usually introduced in proximity to the radiating patch. For example, by making use of the

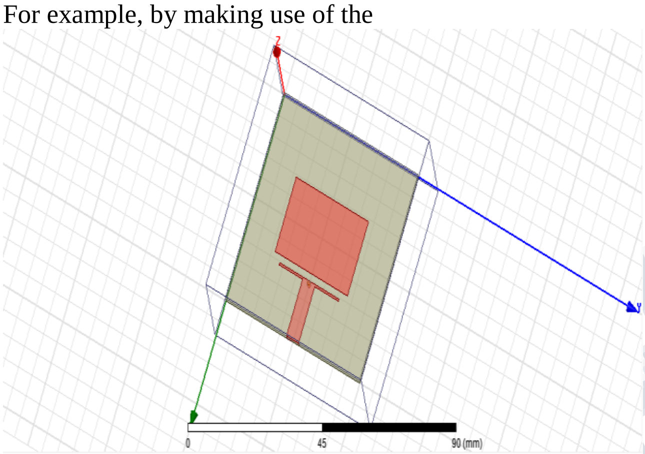

Fig. 1. Geometry of the proposed microstip-fed patch antenna.

L-probe [2] or coplanar capacitive-coupled probe-fed structure [11], the reactance introduced by the probe and the capacitance introduced by the other capacitive part can make up an extra lumped resonating circuit. The dual resonances introduced by the patch and the extra resonating circuit could be adjusted close to each other; thus, a wideband performance could be achieved. But, the methods in [2] and [11] are only valid for a thick substrate. For a thin substrate used mostly in microstrip patch antennas, the reactance of the probe is too small to excite the extra resonance[1].

To form a coplanar distributed resonator a lumped resonator in a thick substrate and a pair λ/4 resonators is used, which in proximity to the main patch of depicted in Fig. 1. The coupling gap helps in achieving a wideband performance.Moreoever; its width affects the dual resonant frequencies significantly. Therefore, the gap width is optimized by making the two resonant frequencies close to each other, thus combining two narrower bands into a single wide band. Since, the second resonance only relates to the λ/4 resonator and the coupling gap, this proposed method is valid for varied substrate thicknesses.

On one hand, the patch antenna is capacitively fed through a pair of λ/4 resonators. In this case, the energy can only be transmitted to the patch in discrete frequencies where both the patch and λ/4 resonators are resonating, which is completely different from the traditional insert-fed patch antenna [18]. On the other hand, all the even-order resonant modes could not be excited in the λ/4 resonators because of the shorting pin introduced in the central plane. As discussed in [19] and [20], the second order mode is the most harmful mode, but it can be naturally suppressed because of its even symmetrical property in the transverse plane.

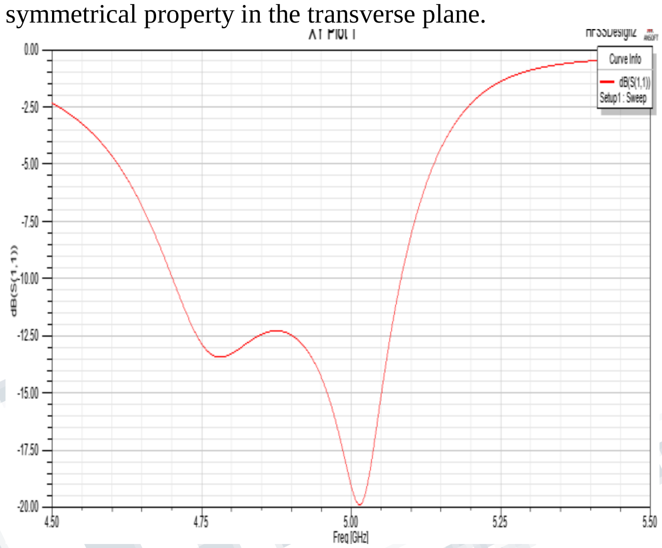

Fig. 2. Stimulated result of the proposed patch antenna.

III .EXPERIMENTAL VERIFICATION

To examine the effectiveness of this technique, a patch antenna prototype using the proposed technique is designed in this section, and its performance will be investigated against the traditional insert-fed antenna. Both of them operate at 4.8 GHz and are fabricated on the FR-4 EPOXY substrates with a relative permittivity of εr= 4.4 and a thickness of h = 1.6 mm. The design and fabricated patch prototypes with a few main parameters are denoted. The simulated electric-field distributions of the patch at a central frequency 4.8 GHz are depicted. We can see that the radiation is produced at both the upper and lower edges, that these two patch antennas are both operating at TM10 mode. However, the field distribution on the proposed patch is more symmetrical since it is not disturbed by the feed line because of capacitive or non contacting insert feeding scheme.

A. Bandwidth Enhancement

In measurement, the reflection coefficients, |S11|, of the two fabricated patch antennas are measured by an Agilent N5230A vector network analyser. The simulated and measured results in the operating band around 4.8 GHz are given in Fig. 2. The simulated and measured results are found in good agreement with each other, thus confirming the predicted performances of these two antennas. The measured frequency range of the proposed patch antenna with |S11| lower than −10dB is 4.69–5.10 GHz (8.4%), while that of the traditional patch is 4.82–4.97 GHz (3.1%). It means that the bandwidth of our proposed antenna has been enhanced by 2.7 times.

B. Gains

The gains of these two patch antennas were measured by using the SATIMO near-field antenna measurement system, and the relevant results are shown in Fig. 10. For the traditional patch antenna in Fig. 10(a), there is a peak of 7.8 dBi in the gain response. For the proposed one in Fig. 10(b), there is a flat range around the central frequency and its maximum value is about 7.3 dBi. In addition, the gain response of our proposed antenna is more symmetric with respect to the central frequency. The 3-dB gain bandwidths of the traditional and proposed patches are 430 and 570 MHz, respectively.

IV. CONCLUSION

This paper presents a compact-fed patch antenna. The bandwidth is enlarged significantly and the harmonic radiations are effectively suppressed by using a pair of λ/4 resonators .While the cost of the antenna is reduced by using FR4 epoxy substrate .The compactness of the antenna is very good because of the modified patch and ground plane. According to our investigation the bandwidth of the patch can be widened by simply adjusting the gap between the patch and the λ/4 resonators. A prototype antenna operating at 4.8 GHz is designed and fabricated to validate the design method. This proposed antenna is suitable for the modern wireless communication such as Wi-fi and Wi-Max application.

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