

BANDWIDTH ENHANCEMENT OF MICROSTRIP ANTENNA

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Abstract—A novel microstrip antenna with wide bandwidth is presented. Two different radiating elements connected together through a matched section and are embedded on a single layer structure. This new structure offers a dual-band microstrip antenna. By controlling the two resonance frequencies of the two elements, a wide frequency bandwidth of approximately 9% has been achieved. A more bandwidth enhancement, up to 12%, has been achieved by adding two parasitic elements to one element of the proposed antenna. Fabrication and measurement of S_{11} for the proposed antenna has been done. The measured results have been compared with the simulated results using commercial software HFSS version-8.0.

1. INTRODUCTION

Microstrip Patch Antennas (MPA) are extremely attractive candidates for use in many applications due to their interesting features such as low cost, light weight, thin profile and conformability. On the other side, the greatest disadvantage of MPA is its low bandwidth which can be as low as 1% [1]. The most straightforward way to improve the MPA bandwidth is to increase the patch-ground plane separation by using a thicker substrate [2]. Unfortunately, the thick substrate will support surface wave modes that will increase mutual coupling in antenna arrays [3]. Mutual coupling will result in serious degradations in impedance mismatch, large radiation loss, polarization distortion and scan blindness in phased array antennas [4, 5].

Another way to improve the bandwidth of an MPA is to create several resonant structures into one antenna by adding more layers, more patches or more extra components. Single layer double-band

antenna may be achieved by several techniques. Firstly the reactively loaded microstrip antenna [6] where two different coaxial stubs are used. Another one is the dual band microstrip antenna with monolithic reactive loading [7] or with modified circular disc by adding additional strips [8], or by patch trimming with a rectangular notch [9], or by adding shorting pins [10]. These concepts are ideal for closely spaced bands having frequency ratios up to 1.5:1. Another way of designing multi-band printed antennas based on the "window" concept having frequency band separation of 2:1 [11] or 4:1 [12] whereby windows were cut in a low frequency patch radiators to accommodate high frequency patch antennas.

The other technique for Multi-band antennas is the multiple layers which consist of two or more metallic patches supported by one or more dielectric layers. There are two techniques for multi-band MPA using multiple layers. Firstly the dichroic technique with frequency band separation of 10:1 [13]. Secondly the stacking technique which uses two or three substrates providing two or more metallic patches within the same aperture area with frequency bandwidth of 5.6% for the stacked circular disc [14] or up to 13% with four rectangular patches [15] or up to 33% with strip-slot-foam-inverted patch antenna [16]. Size, weight, feed fabrication, and high coupling between stacked patches are the main disadvantages of the stacked antennas [17].

The main goal of this paper is to present a new antenna configuration with dual-element offering dual-band frequency with a controllable frequency ratio of the two elements. Once the frequency response of the dual-element can be controlled, we can get a wide bandwidth antenna configuration by overlapping the two-element frequency response. Finally, the wide-band antenna performance has been improved by using parasitic elements with one of the two elements.

2. DUAL-BAND MPA DESIGN

In this section, a novel dual-band MPA is described where two different radiating elements connected together through a matched section and is embedded on a single layer structure as shown in Figure 1. The first element is a rectangular MPA with frequency f_1 controlled by patch dimensions L , and W and the second element is a printed dipole with frequency f_2 controlled by the dipole dimensions L_d , and W_d . The structure is fed by a coaxial probe through the dipole element which is directly coupled to the MPA by a quarter wave length matched section with width W_m , and length L_m [2]. The computer simulation is done using the commercial software HFSS version-8.0 with the fixed design

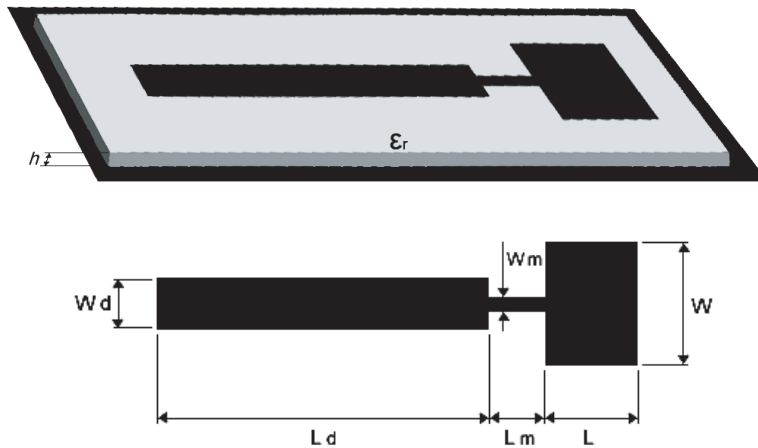


Figure 1. Configuration of the dual band MPA.

structure parameters given in Table 1 for a resonant frequency f_1 of the rectangular MPA at 10 GHz [1]. The simulated results are given in Table 2 which shows that as the dipole length L_d increases, its resonant frequency f_2 get closer to the MPA resonant frequency f_1 with slightly decrease in the later resonant frequency. The simulated results of S_{11} for the antenna shown in Figure 1 are given in Figure 2 for only three values of L_d (20, 24, and 28 mm).

3. OPTIMIZING THE DUAL-BAND ANTENNA FOR A WIDE BANDWIDTH

It is clear from Table 1 that we can get a wide bandwidth antenna by controlling the length L_d of the dipole element to get the resonant frequency f_2 close to f_1 (or $f_2/f_1 \cong 1$). The simulated dual-MPA with $L_d = 32$ mm, and the other parameters which are given in Table 1, has been fabricated on a Duriod substrate with permittivity $\epsilon_r = 2.22$, and thickness $h = 1.5875$ mm with copper cladding of thickness = 0.017 mm. The measured and simulated results of S_{11} are given in

Table 1. Designed structure parameters.

Rectangular MPA		Matching section		Dipole element	
L (mm)	W(mm)	L _m (mm)	W _m (mm)	L _d (mm)	W _d (mm)
11.859	8.871	5.3405	1.4232	22 - 32	4.8618

Table 2. Simulated results.

L_d (mm)	f_1 of MPA (GHz)	f_2 of dipole (GHz)	$f_2 - f_1$ (GHz)	f_2/f_1
20	10.02	13.80	3.78	1.38:1
22	10.27	13.60	3.33	1.32:1
24	10.13	12.85	2.72	1.27:1
26	9.92	11.88	1.96	1.20:1
28	9.64	10.74	1.10	1.10:1
30	9.40	10.31	0.85	1.09:1
32	9.38	10.13	0.75	1.08:1

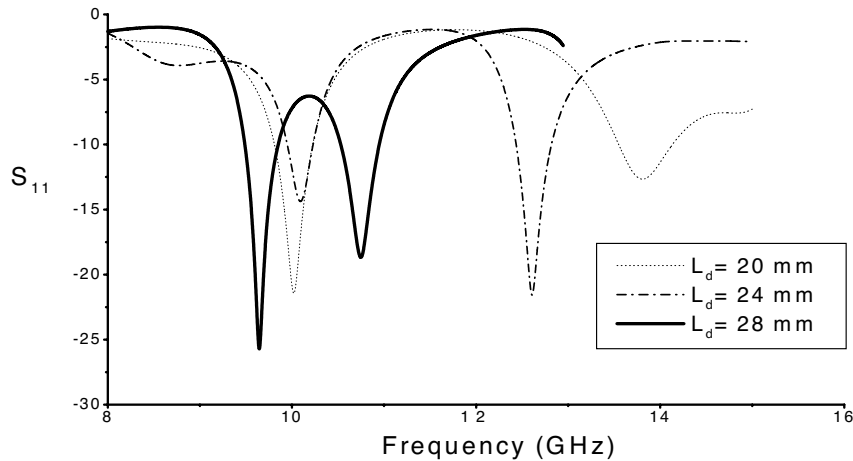
**Figure 2.** Simulated S_{11} for the antenna shown in Fig. 1 with different dipole lengths L_d .

Figure 3 which shows an impedance bandwidth of approximately 9% at -10 dB.

4. IMPROVED BANDWIDTH FOR THE OPTIMIZED DUAL-BAND MPA

One way to improve the antenna bandwidth is to add parasitic elements with the same patch layer [16]. The other approach is to add the parasitic elements at the second layer with electromagnetic coupled with the master patch embedded at the first layer [15]. In our design, a two parasitic strip lines with length L_p and width W_p are embedded

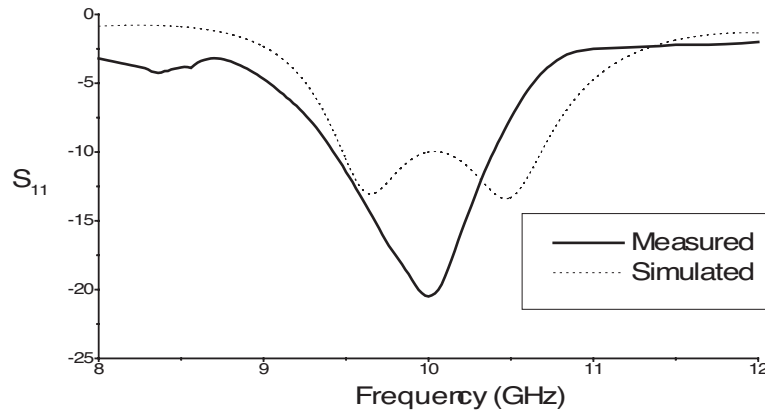


Figure 3. S_{11} for the antenna shown in Figure 1 with $L_d = 32$ mm.

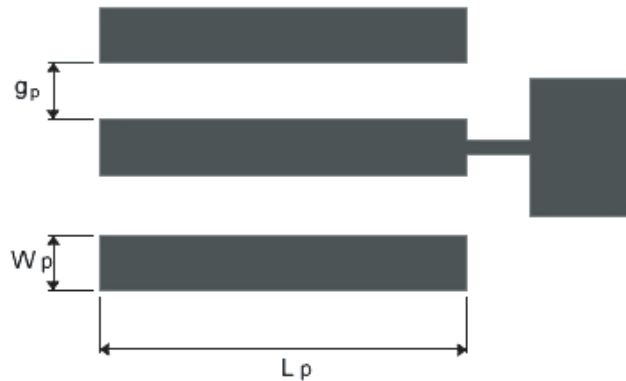


Figure 4. Configuration of the wide band MPA with parasitic elements.

in the same layer of the proposed design and parallel to the dipole element with a gap spacing equal to g_p as shown in Figure 4. A computer simulation has been run using HFSS program with the same parameters of the optimize dual-band MPA in Section 3 and $L_p = L_d = 32$ mm, $W_p = W_d = 4.86$ mm, and the parasitic gap g_b has been changed from 2 mm up to 6 mm. Simulated results of S_{11} for impedance bandwidth (at -10 dB) are best with parasitic gap $g_b = 3$ mm where a good coupling between the parasitic elements and the dipole element is exist. The measured results of S_{11} for the wide bandwidth dual-band MPA with the parasites elements with parasitic

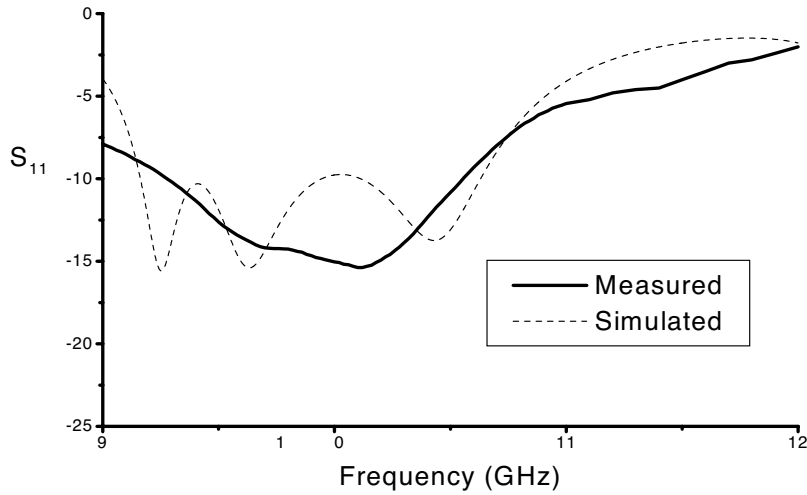


Figure 5. S_{11} for the antenna shown in Figure 4.

gab $g_b = 3$ mm are shown in Figure 5 simultaneously with the simulated results of the final proposed new antenna. Results show an impedance bandwidth of approximately 12% at -10 dB.

5. CONCLUSION

Simulations and measurements on the new proposed antenna configuration have provided a useful design for a wide bandwidth MPA of 9%, or with a controllable frequency separation of the two frequencies of the dual-element with $f_2/f_1 = 1.38 : 1$ for the given construction. A 12% bandwidth enhancement has been achieved with the two parasitic elements. With the simplicity of feeding and fabrication, the investigated wide bandwidth antenna is a good candidate for many wireless communications.

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