Gain and Bandwidth Enhancement Technique in Square Microstrip Antenna for WLAN Applications

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Abstract - This paper presents the design and study of a stacked Identical dual square microstrip antenna to enhance its gain and bandwidth that is optimal for WLAN applications. The proposed antenna with an air-gap of 9 mm, resonates at 2.45 GHz with a gain of 8.05 dBi. The bandwidth achieved is 12.72% within 2:1VSWR.

Index Terms- Identical dual square microstrip antenna with an Air-gap (IDSMA), WLAN, stacked.

I. INTRODUCTION

Microstrip patch antennas are widely used in wireless communication due to their conformal and planar structure. Also their attributes such as compactness, low-profile, directive with high transmission efficiency , ease of manufacture and repeatability make them appropriate for Broadband wireless applications. However, the microstrip antennas inherently have a narrow bandwidth. The single layer square patch antenna has a bandwidth less than 2% which is not sufficient for wireless application. To overcome its inherent limitation of narrow impedance bandwidth, many techniques have been suggested. They are capacitive compensation [1],[2], thicker substrates[3] , reactive matching networks [4], and stacked patches[5]. This paper focuses on a novel probe fed Identical dual square microstrip antenna stacked on top of the other with an air-gap between them for enhancing the gain as well as bandwidth. For an optimum Air-gap height , the antenna is designed so that maximum gain and bandwidth are achieved. This proposed antenna IDSMA (Identical dual square microstrip antenna with an Air-gap) without increasing the lateral dimension, can be used as a WLAN(Wireless local area network) antenna resonating at 2.45 GHz (IEEE 802.11b) with a wide frequency range.

II. EFFECT OF PARASITIC PATCH AND AIR GAP

Presence of a parasitic patch (upper patch) immediately above the driven patch (lower patch) have two effects depending on the design[6]. Firstly, new resonant frequency appears in the S_{11} charecteristics due to the parasitic patch. Secondly, the bandwidth and gain increases in proportion to the induced currents coupling between the patches. Also, further increase in bandwidth can be obtained by introducing air-gap [7] between patches. Inserting an air-gap between the two identical patch reduces the average relative permittivity of the substrate and increases the total substrate thickness between the patches. As a consequence the bandwidth is increased. This technique has been adopted in IDSMA for gain and bandwidth enhancement. On simulation of IDSMA with IE3D, a maximum bandwidth of 12.21% is achieved for an air-gap of 9mm which is more desirable for WLAN. Variation in bandwidth and gain for different Air-gap height, is listed in Table 1.

TABLE 1
Effect of Air-gap on Antenna Bandwidth

Air-gap h_a (mm)	Bandwidth %	Gain (dBi)
1	2.33	6.41
2	2.63	6.56
3	2.91	6.77
4	3.38	6.96
5	4.13	7.14
6	6.12	7.44
7	7.07	7.73
8	11.7	7.9
9	12.21	8.05

Further increase in air-gap height resulted in decrease in bandwidth and shift in the resonant frequency. So, for IDSMA the air-gap height of 9mm is preferred for the design.

III. ANTENNA DESIGN

Fig. 1 shows the geometry of the proposed antenna IDSMA. The stacked configuration consists of two

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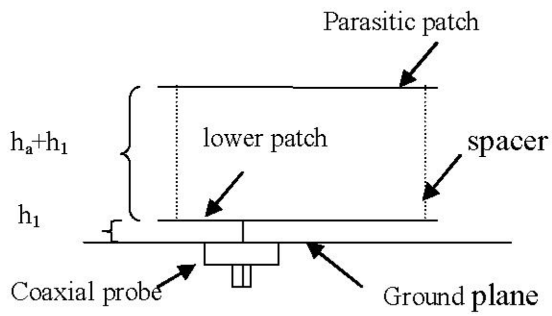
identical square patches stacked on top of the other. The lower patch is fed with a coaxial probe and the top parasitic patch is electromagnetically coupled to the lower one.



h_1- height of the substrate
h_a- height of an Air-gap

Fig. 1 Geometry of IDSMA

A substrate of 1.575mm thick RT/Duroid 5880 having 35 micron copper cladding is chosen. Calculation of patch dimensions are based on the transmission line model and empirical formulae from [8,9,10,11]. The dimension of a single layer square patch is 38.9mmX38.9mm on a RT/Duroid 5880. The design parameters for IDSMA are as follows: thickness of the RT/Duroid substrate 1.575mm, height of the Air-gap h_a 9mm, size of the lower and upper patch are 38.4mmX38.4mm and 38.9mmX38.9mm respectively.

IV. RESULTS AND DISCUSSION

The simulation for the proposed antenna was carried out using IE3D software. The antenna was tested using Network Analyzer. Simulation characteristics of single layer patch without an air-gap results in more impedance variation within the operating frequency range and impedance bandwidth of 1.42 %. Whereas, as evidenced in Fig. 2 and Table 2, with the application of IDSMA the bandwidth enhancement achieved is 12.21 % with less impedance variation at resonant frequency which make them more appropriate for WLAN applications. In IDSMA the VSWR bandwidth achieved is 382 MHz (VSWR<2) which is optimal for WLAN when compared to that of single patch.(Fig.3 & Table 2& 3).

The performance parameters of the antennas on simulation and testing are listed in Table 1 and 2. The radiation efficiency of IDSMA is 92.79%. If lower efficiencies can be tolerated, thicker substrate may be used for even wider bandwidth.

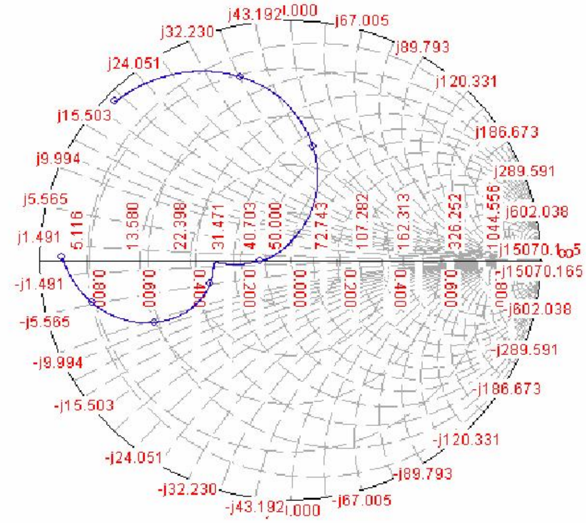


Fig. 2 Variation of impedance with frequency in IDSMA

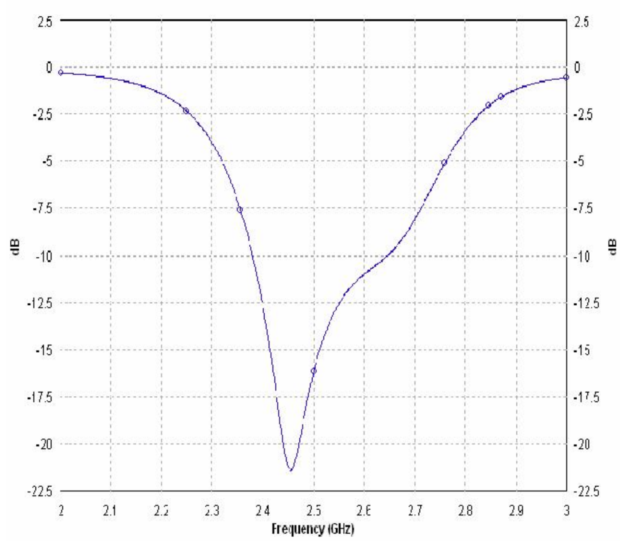


Fig. 3 Variation of Return Loss with frequency in IDSMA

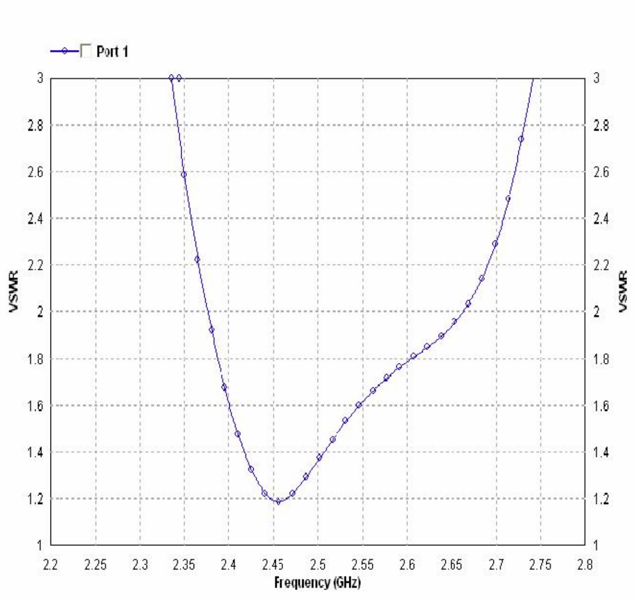


Fig. 3 Variation of VSWR with frequency in IDSMA

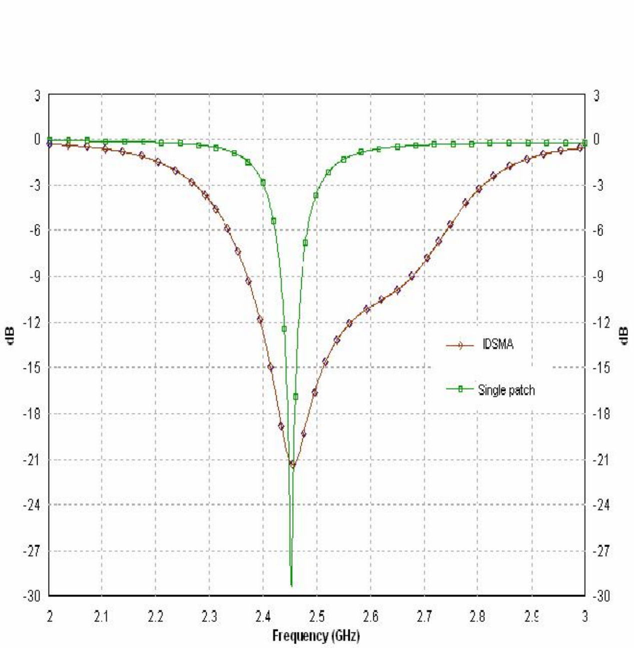


Fig. 4 Impedance bandwidth comparison of single square patch and IDSMA

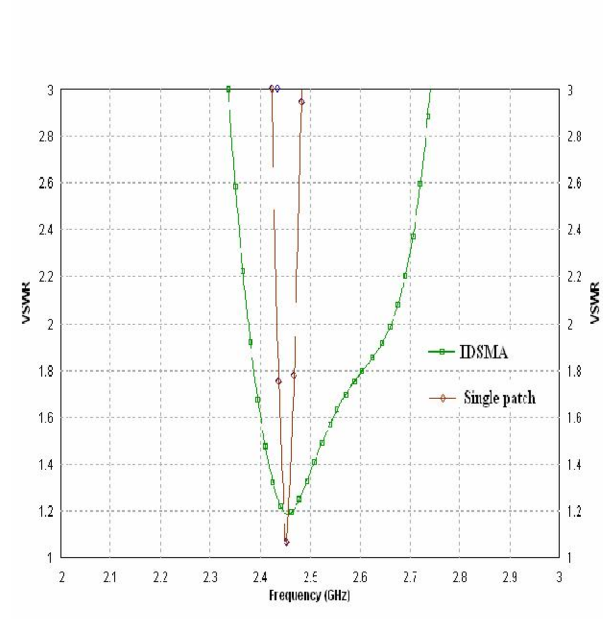


Fig. 5 Impedance bandwidth comparison of single square patch and IDSMA

TABLE 2
Performance parameters of antennas by Simulation

Parameters	Single patch	IDSMA
Resonant frequency	2.45 GHz	2.45 GHz
10 dB bandwidth % bandwidth	34.764 MHz 1.42 %	299.3 MHz 12.21 %
VSWR 1.5:1 VSWR < 2	21 MHz 38 MHz	113 MHz 328 MHz
Radiation η Antenna η	84.64 % 80.21 %	92.79 % 92.57 %
Gain	6.26 dBi	8.05 dBi
Directivity	7.32 dBi	8.59 dBi

TABLE 3
Performance parameters of antenna on Testing

Parameters	Single patch	IDSMA
Resonant frequency	2.489 GHz	2.435 GHz
Bandwidth	36.72 MHz 1.498 %	311.56 MHz 12.72 %

V. CONCLUSIONS

The characteristics of the proposed IDSMA for WLAN 802.11b communication standard at 2.4 GHz are compared with that of a single layer square patch antenna. With IDSMA an enhanced gain of 8.05 dBi at the resonant frequency and 12.72 % bandwidth has been achieved . Further enhancement in gain and bandwidth can be achieved integrating more identical patches in the stacked configuration.

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