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WIDE BAND CAVITY-BACKED PATCH ANTENNA FOR PCS/IMI2000/2.4 GHZ WLAN

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Abstract—A wideband cavity-backed patch antenna is presented for operating at PCS, IMT200, and 2.4 GHz WLAN bands. A parasitic patch and a probe with a capacitor patch is used to enhance the bandwidth. The cavity-backed and without cavity-backed antenna has been compared. It has been found that the cavity backed antenna has wide impedance bandwidth of 43% and high gain level. It can simultaneously serve most of the modern wireless communication applications that operate at 1.7 GHz–2.5 GHz.

1. INTRODUCTION

With the widely and rapidly development of modern wireless communication systems, multiband and wideband antennas are in highly demand. Antennas need to have multiband wideband characteristics in order to be flexible enough to cover multiple communication frequency bands. Many researchers investigated the design of multi-band and wideband antennas to cover multiple communication systems [1–5]. Microstrip patch antennas have been employed in many wireless communications systems. This is due to their various advantages including low profile, light weight, easy fabrication and conformability to mounting structure. However, it is well known that in many cases, one of the principle disadvantages of the conventional microstrip antenna is their narrow bandwidth. Different methods based on parasitic elements, appropriate impedance matching networks, or the utilization of matching networks, or the utilization of lossy materials have been developed to overcome this drawback [6].

For practical applications, patch antennas are used with a finite ground plane, which usually causes degradation (such as increased cross polarization and backward characteristics, thereby leading to decreased antenna gain. To overcome this problem, patch antennas with cavity ground structures have been demonstrated [7–9]. However, such patch antennas as presented in these studies have a narrow band width, which limits their practical applications.

In this paper, a wideband cavity-backed capacitive probe-fed patch antenna is presented. A parasitic patch is also used for bandwidth enhancement. The proposed antenna was simulated using numerical technology based on the FIT (finite integration technique) and the prototype of the antenna was constructed and tested. The suitable parameters are optimized, and thus the proposed antenna covers PCS, IMT2000 and 2.4 GHz WLAN bands.

2. ANTENNA DESIGN

The geometry of the capacitive probe fed patch antenna with a square cavity is described in Fig. 1. The central shorting pin keeps the antenna with mechanical stability and mode purity [10]. The antenna is capacitively feed from a coaxial feed probe with a capacitor patch in order to compensate the probe inductance [11, 12]. The feed probe is placed symmetrically with respect to the centerline of the square cavity.

The square cavity ground has a height H and side length L. A radiation patch with side length L_1 is centered inside the cavity ground with a height $b + c$, (that is, the proposed antenna has an air-layer substrate of thickness $b + c$). In order to enhance the wide bandwidth, one parasitic patch measuring $L_2 * L_2$ is used [13, 14]. The dimensions of the feed and parasitic patches, the air gap a between the two patches, and the feed-point location d are optimized for impedance bandwidth. The optimized dimensional parameters of the cavity-backed patch antenna are tabulated in Table 1.

Table 1. Parameters for the proposed patch antenna as shown in Fig. 1.

$L = 156\,\mathrm{mm}$	$L_1 = 30\,\mathrm{mm}$	$L_2 = 27\,\mathrm{mm}$
$a = 1.5\,\mathrm{mm}$	$b = 5.5\,\mathrm{mm}$	$c = 13\,\mathrm{mm}$
$H = 33\,\mathrm{mm}$	$r = 4.5\,\mathrm{mm}$	$d = 20\,\mathrm{mm}$

3. RESULT AND DISCUSSION

Using the design dimensions described in Section 2, the proposed antenna for covering the PCS, IMT200, 2.4 GHz WLAN bands was simulated, constructed and tested. A reference antenna (the proposed antenna geometry shown in Fig. 1 with $H = 0$) was also constructed for comparison. The measured results of the return loss for the proposed and reference antennas are shown in Fig. 2. Simulated results obtained using numerical technology based on FIT are also shown for comparison. Good agreement between the simulation and measurement is obtained, which verifies the performance of this antenna. The differences between the simulation and measurement results are mainly due to the effect of the SMA connector and cable. Largely due to the effects of the side walls of the cavity

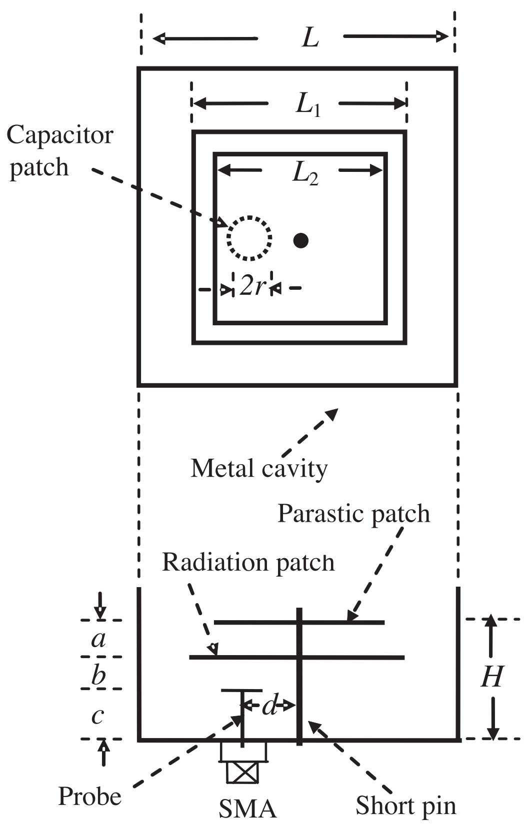

Figure 1. Geometry of the proposed cavity-backed patch antenna.

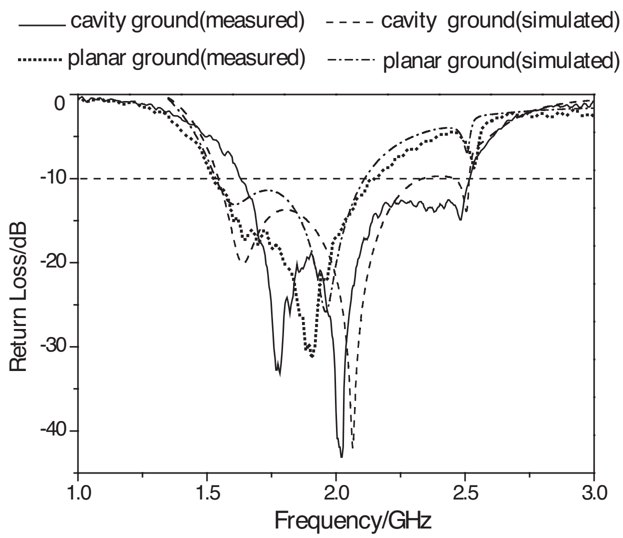

Figure 2. Measured and simulated return losses.

ground, the proposed antenna has a wider bandwidth than that of the reference antenna. The change which is more than 250 MHz is very significant for $S_{11} < -10$ dB. For the proposed antenna, the obtained -10 dB return loss impedance bandwidth reaches 885 MHz (spans from around 1630 MHz to 2515 MHz), with a very wide bandwidth of 43%, simultaneously covering the PCS, IMT-2000 and 2.4 GHz WLAN bands.

The impedance of the prototype is also represent in Smith Charts (Fig. 3, Fig. 4) so that information for both parts (real and imaginary) is appeared. As can be observed from Fig. 3 and Fig. 4, the cavity ground has little impact on the impedance of the low frequency band (1600–2200 MHz), but affects the impedance of the high frequency band obviously. The impedance (both real and imaginary parts) of reference antenna with planar ground is increased over 2200 MHz, there for the bandwidth comes to narrower. The cavity decreased the inductive reactance high resistance so that wide bandwidth is obtained for the cavity-backed patch antenna.

Fig. 5 shows the simulated and measured antenna gain for the proposed and reference antennas. Good agreement between the simulation and measurement is seen. For the operating bands, it is clearly seen that the gain level of the proposed antenna is higher than that of the reference antenna. Especially for the 2.4 GHz band, the gain level of the proposed antenna is about 10 dBi, which is about 2.5 dBi

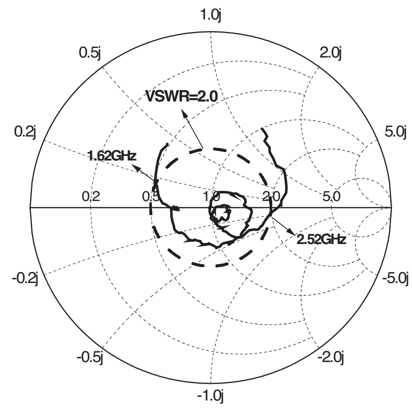

Figure 3. Measured input impedance in Smith Chart for the proposed antenna with cavity ground (using the parameter tabulated in Table 1).

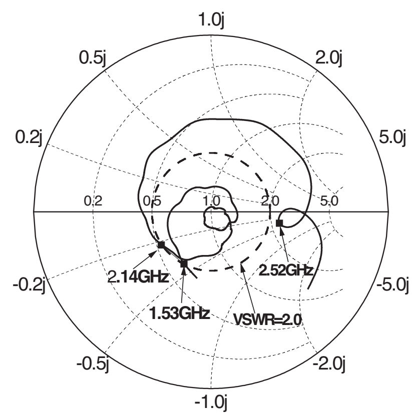

Figure 4. Measured input impedance in Smith Chart for the reference antenna with planar ground ($H = 0$, other parameters are the same as in Table 1).

larger than that of the reference antenna. The radiation patterns for the proposed antenna are computed at 1.9 GHz and 2.4 GHz. Fig. 6 plots the 2D radiation patterns in the E and H-planes. Note that all the patterns are normalized with respect to the maximum radiation intensity of the proposed antenna. The 3 dB beamwidth in the E plane is 52°, and 51° at 1.9 and 2.4 GHz, respectively, while in H plane, it is 69°, and 72° respectively.

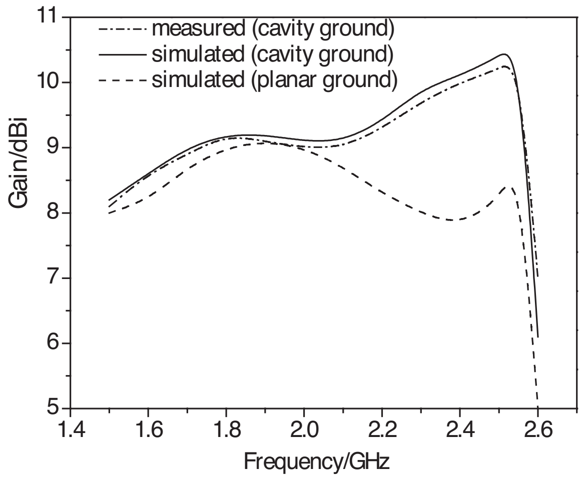

Figure 5. Measured and simulated gain.

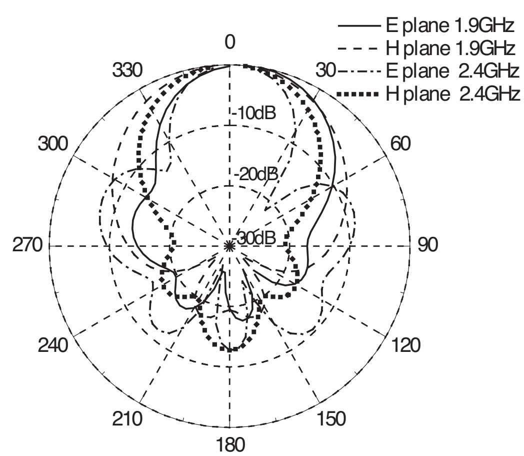

Figure 6. Simulated radiation patterns for the proposed antenna.

The aforementioned results show that the antenna is a very good candidate for the modern wireless communication applications that require wideband characteristics. Using this antenna gives these systems the ability to serve simultaneously the frequency bands of the GSM 1800 and GSM 1900, IMT2000, and both industrial, scientific and medical ISM band around 2.4 GHz, in addition to 2.4 GHz WLAN.

4. CONCLUSION

A wideband capacitively probe fed cavity-backed patch antenna with a parasitic patch has been proposed, and a constructed prototype suitable for operating at PCS, IMT200, and 2.4 GHz WLAN bands has been demonstrated. The proposed prototype showed wide impedance bandwidth of 43% and high gain of about 10 dB at 2.4 GHz WLAN band. This antenna is a good candidate for wideband wireless applications.

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