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# Performance Enhancement of a Microstrip Patch Antenna Using High Impedance Surfaces and Different Ground Plane Sizes

Alireza Foroozesh and Lotfollah Shafai
Department of Electrical Engineering, University of Manitoba, Winnipeg, Canada
alireza@ee.umanitoba.ca, shafai@ee.umanitoba.ca

## 1. Introduction

Impedance bandwidth of microstrip patch antennas can be enhanced using artificial ground planes [1-3]. This paper presents the microstrip patch antenna performance enhancement including both input impedance bandwidth and antenna gain. A high impedance surface (HIS) consisting of grounded dielectric slab loaded by metallic patches without vias is directly placed under the microstrip patch antenna and the conventional conducting ground plane is extended beyond that. It is shown that the antenna characteristics are remarkably improved. These enhancements are confirmed by measurement, demonstrating gains as high as 10.4 dBi and input impedance bandwidths of %28.

## 2. HIS Design, Characterization and Application

Although the first HIS designs were based on the grounded dielectric slabs loaded by periodic metallic patches with shorting pins [1], recent work revealed that HISs can be synthesized using periodic patches without shorting pins [3-4]. An HIS unit cell is shown in Fig. 1(a). Repeating this unit cell in the transverse directions, an HIS is produced which is used as the ground plane of microstrip patch antenna in this work. Side view and top view of such an antenna is shown in Fig. 1(b) and (c), respectively. Reflection coefficient phases of the HIS are shown in Fig. 2 for different polarizations. According to the definition in [1,4], HIS bandwidth is the frequency range in which reflection phase is between -90° and +90°. Therefore, the bandwidth of the HIS under study is 5.5-7 GHz.

## 3. Microstrip Patch Antenna on HIS with Extended Ground Plane

Top view of the microstrip patch antenna on the above-mentioned HIS consisting of 7×6 unit cells is shown in Fig. 1(c). Characteristics of these antennas with four different ground plane sizes along with the reference antennas with conventional ground planes are listed in Table 1. Simulated radiation patterns at the frequency of 6.4 GHz are shown for Antenna4 with conventional and artificial ground planes in Fig. 3(a) and 3(b), respectively. As shown in Fig. 3(a), a dip exists at boresight angle. This dip is removed when the antenna has artificial ground plane (Fig. 3(b)). Input impedances and gains of the antennas listed in Table I, are plotted vs. frequency in Fig. 4(a) and (b), respectively. Antenna aperture efficiencies are shown in Fig. 5. Obviously, antennas using proposed artificial ground planes are more efficient than the conventional antennas shown as

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references. One should not that the HIS consists of 7×6 unit cells in all cases listed in Table1. So, the HIS has the total dimensions of 57.4×49.2 mm$^2$

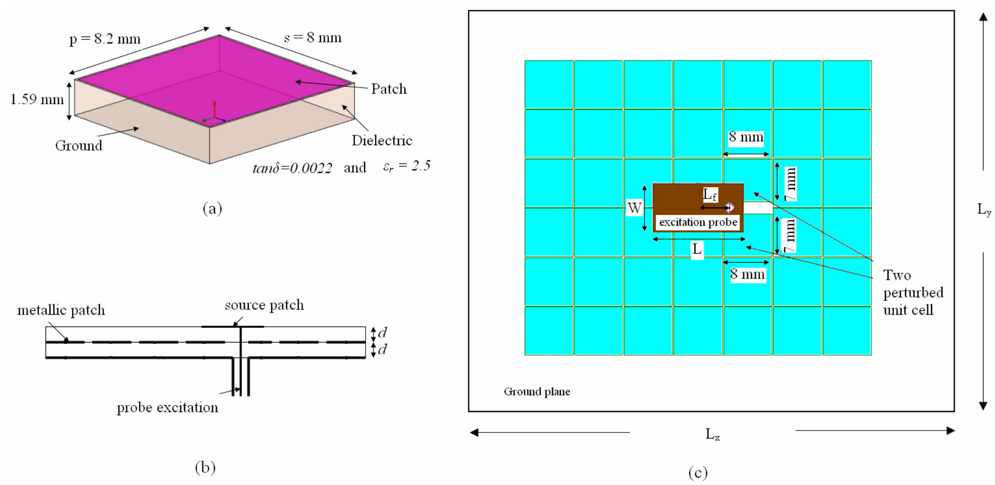


Fig. 1. (a) HIS unit cell. Antenna with HIS ground plane (b) side view and (c) top view.

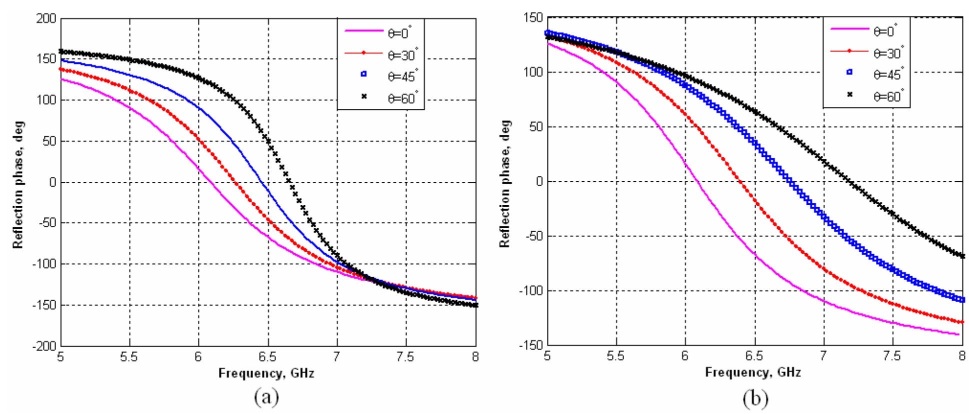


Fig. 2. Reflection phases of the HIS under study. (a) TE and (b) TM polarizations.

## 4. Measurement results and Conclusions

Two fabricated prototypes of Antenna4 with artificial ground plane, listed in Table 1, are shown in Fig. 6(a). Measured radiation patterns of one prototype are shown in Fig. 6(b) at 6.1 GHz. Input impedance and gains vs. frequency are shown in Fig. 7(a) and (b), respectively. There is slight frequency shift (less than %5) between simulation results in Fig. 4(a) and measured results for the first resonant frequency. As can be seen, input impedance bandwidths of about %28 and antenna gains of 10.4 dBi are obtained. This performance enhancement is very significant, in comparison to the conventional microstrip antennas.

## .References

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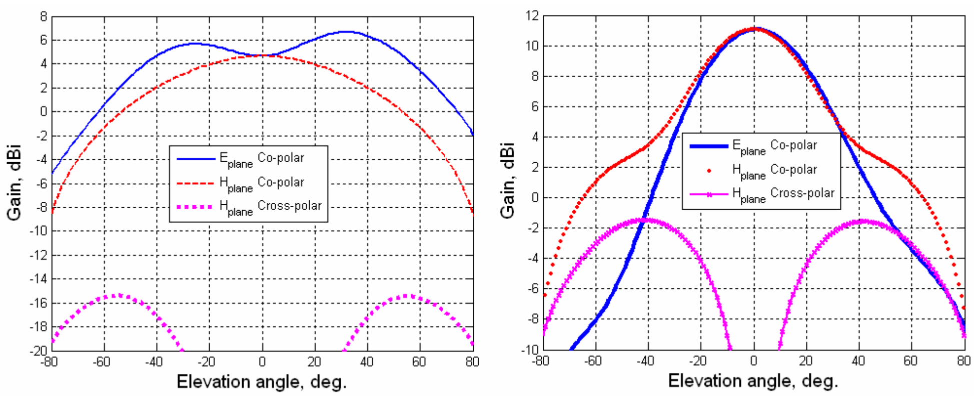
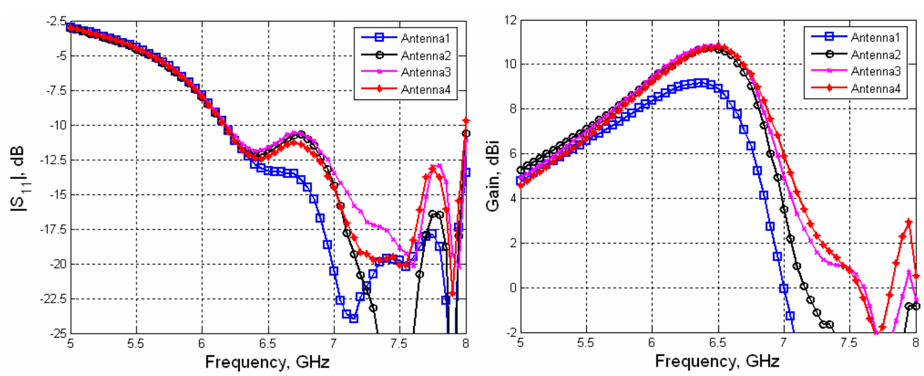
Table I. Input impedance bandwidth of antennas with different ground plane sizes.

| | Ground plane size (Lx ×Ly) | Input impedance bandwidth of reference antennas | Input impedance bandwidth of antennas with artificial ground planes antennas |
|---|---|---|---|
| Antenna1 | 57.4×49.2 ($mm^2$) | %2.4 | %27.78 |
| Antenna2 | 60×60 ($mm^2$) | %2.4 | %25.35 |
| Antenna3 | 70×70 ($mm^2$) | %3.1 | %25.35 |
| Antenna4 | 80×80 ($mm^2$) | %3.1 | %25.35 |



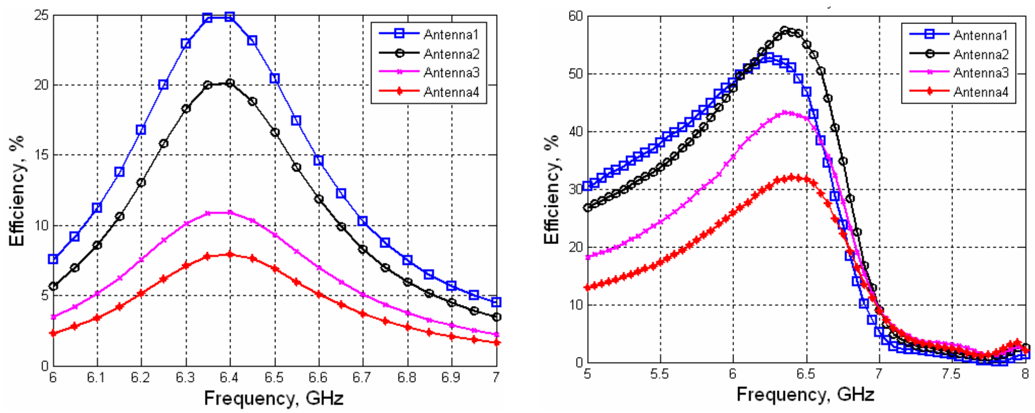

(a) (b)

Fig. 3. Radiation patterns. (a) Reference Antenna4 and (b) Antenna4 having HIS ground plane.



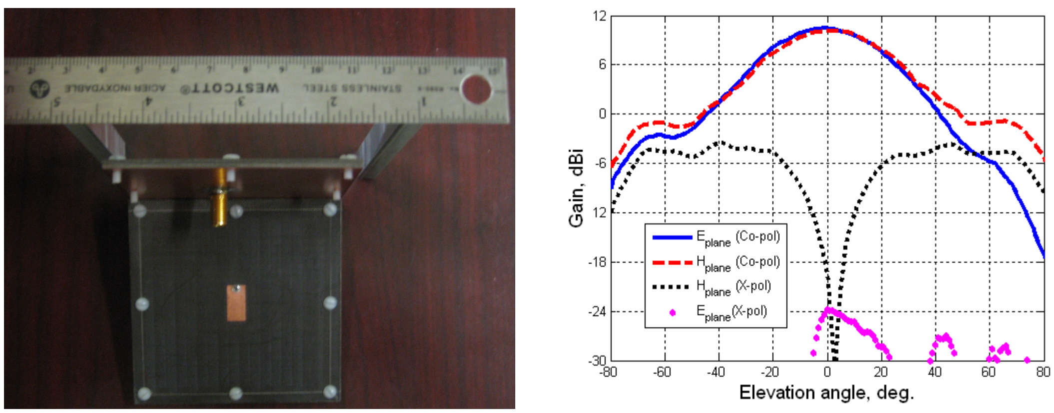

(a) (b)

Fig. 4. (a) Return loss and (b) Gain of the antennas having HIS ground plane as listed in Table I (Simulations results obtained by Ansoft Designer).



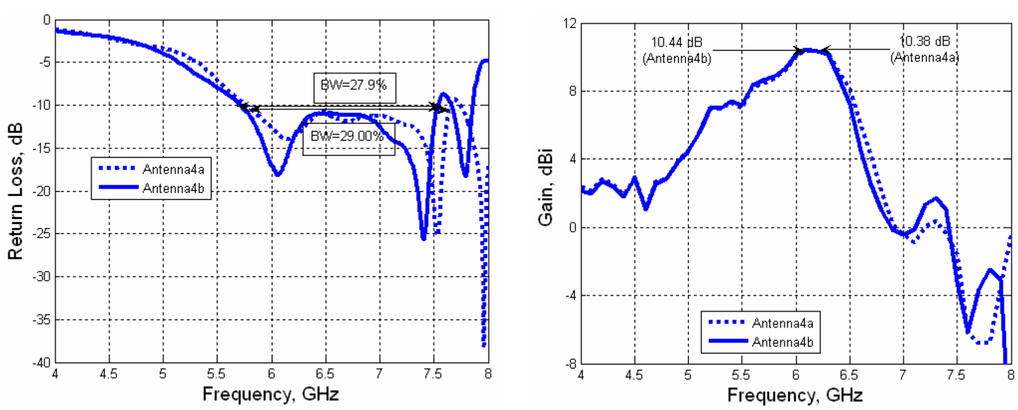

(a) (b)

Fig. 5. Antenna aperture efficiencies. (a) Reference Antennas and (b) antennas having HIS ground plane.




(a) (b)

Fig. 6. (a) Two fabricated prototypes of Antenna4 on HIS ground planes. (b) Measured radiation patterns.




(a) (b)

Fig. 7. (a) Measured return loss and (b) measured gain of the two fabricated prototypes vs. frequency.