Broadband Microstrip Patch Antenna Fed by a Novel Coupling Device

Wenwen Chai¹,², Xiaojuan Zhang¹, and Jibang Liu¹,²

¹Institute of Electronics, Chinese Academy of Sciences, Beijing 100080, China
²Graduate School of Chinese Academy of Sciences, Beijing 100039, China

Abstract— Two broadband microstrip patch antennas are designed here. Both are fed by the CPW with an H-shape coupling slot which is modified by the conversion idea. The former has a bandwidth of 26.5% and a gain of more than 8 dBi in the operating frequency band, while the latter attain 40% impedance bandwidth and 20% gain bandwidth above 6 dBi. All result data prove the validity of designed models.

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1. INTRODUCTION

Microstrip antennas have been extensively used in the past because of their several advantages (low weight, low cost, conformability, and low profile) over conventional antennas. However, their small impedance bandwidth has always been a major constraint as it limits the frequency range over which the antenna can perform satisfactorily. For broadening the bandwidth, in this paper we propose two broadband antennas where a coplanar waveguide with H-shape coupling slot and a varactor diode is used as a novel feeding system. This type of antennas not only possesses the same technological advantages as conventional coplanar waveguide-fed microstrip antennas [1–3] such as low radiation loss, less dispersion and unipolar configuration, but has two extremely attractive advantages: First, various experiments are carried out to show that H-shaped aperture has a higher resonant impedance implying larger coupling than rectangular aperture and “bowtie”-shaped aperture of the same length. Therefore, it is possible to obtain maximum coupling for the smallest slot area to reduce back radiation; Secondly, the freedom in modifying the coupling simply by tuning the varactor diode helps to realize the optimum impedance characteristics in practice. And because this tuning process doesn’t involve any change of antenna structure, good antennas performance can be obtained very easily.

2. STACKED ANTENNAS A DESIGN AND RESULT

Dual-patch [4] antennas A fed by the conversion coupling device is designed here. The model is shown in Fig. 1. The fed patch is printed on one side of the substrate material with relative permittivity of 2.2 and thickness of 1.6 mm, while the coplanar waveguide with a H-shape slot is arranged on the opposite side of the substrate. Two pins of a varactor diode are connected to points A and B on the slot, respectively. The parasitic patch is separated by 4.6 mm from the fed patch. The middle dielectric layer is made of foam with relative permittivity approximately equal to 1 and thickness equal to the separation between the fed patch and parasitic patch.

Figure 1: Geometry of proposed broadband antenna A.
The return-loss characteristics of the antenna are shown in Fig. 2. Two minima are apparent, where the first resonance is almost completely due to interactions between the lower patch and the aperture, while the second one is due to a coupled resonance between the two patches. This postulation is supported by the fact that the second resonance is least affected by tuning the varactor diode, while the first resonance develops with the change in the capacitance value. Therefore, the frequency of operation can be switched over a wide range by modifying the coupling between the lower patch and the aperture using the varactor diode. As a result, a bandwidth ($VSWR\leq2$) of 26.5% in the frequency range of 3.6–4.7 GHz is achieved. It is shown that this feeding approach results in a large increasing in bandwidth over the typical stacked patch.

The gain characteristics of antennas A are shown in Fig. 3 as a function of frequency. The gain is more than 8 dB and varies less than 1 dB over the broadband frequency region of 25% as shown in the figure. Surface wave efficiency is about 80% over the entire band.

The radiation patterns on E- and H-plane of antenna A are shown in Fig. 4 at edge frequency points. The back-radiation levers are all suppressed to less than $-20$ dB.

![Figure 2: Return loss characteristics.](image1)

![Figure 3: Gain characteristics.](image2)

![Figure 4: Radiation patterns —E-plane —H-plane.](image3)

![Figure 5: Geometry of proposed broadband antenna B.](image4)
3. U-SLOT PATCH ANTENNAS B DESIGN AND RESULT

U-shaped patch [5] antennas B fed by the conversion coupling device is shown in Fig. 5(a). The patch is printed on one side of the substrate material with relative permittivity of 2.2 and thickness of 6.6 mm. The detailed dimensions of the patch and feed device are presented in Fig. 5(b). The size of the patch and feed slot and capacity value are tuned appropriately to optimize antennas performance.

The VSWR curve of fabricated wideband antenna B is shown in Fig. 6. The bandwidth (VSWR ≤ 2) is about 40% in the frequency range of 1.85–2.8 GHz. The measured gain versus frequency curve is shown in Fig. 7 with maximum gain of 6.8 dBi, and the bandwidth of gain above 6 dBi is about 20%. Fig. 8 shows the radiation patterns of antennas B in E-plane and H-plane. All these data verify the success of developing a wideband U-slot patch antenna.

![Figure 6: Return loss characteristics.](image1.png)

![Figure 7: Gain characteristics.](image2.png)

![Figure 8: Radiation patterns on E- and H-plane of antenna.](image3.png)

4. CONCLUSIONS

Two broadband microstrip antenna fed by coplanar waveguide with a H-shape slot and a varactor diode is designed. The experimental results indicate that the two microstrip antenna have extremely good broadband performance in return loss, gain characteristics and radiation patterns. Therefore, this novel type of broadband antenna which can be optimized conveniently, is considered to be applicable as a candidate in mobile communication systems.

REFERENCES