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A BROADBAND MICROSTRIP ANTENNA FOR IEEE802.11.A/WIMAX/HIPERLAN2 APPLICATIONS

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Abstract—A simple electromagnetically coupled broadband printed microstrip antenna suitable for multifunctional wireless communication bands is presented. V-slots and corner notches are employed in a rectangular patch to achieve broadband operation. The proposed antenna has a 2 : 1 VSWR bandwidth of 51% from 3.75 GHz to 6.33 GHz. The simulated and measured reflection characteristics of the antenna along with the radiation patterns and gain are presented and discussed.

1. INTRODUCTION

Printed microstrip antennas are attractive for compact multifunctional wireless communication systems due to low profile, light weight and low cost. Narrow bandwidth of about 2–3% limits their use in modern communication systems. Researchers have offered numerous methods like aperture coupling [1], use of shorting pins [2, 3], stacking [4–6], modifications in the feed [7] and use of coupled parasites [8] to enhance the bandwidth of microstrip antennas.

Diego et al. demonstrated a wide band E-shaped patch antenna on a low dielectric substrate of thickness $0.061\lambda_0$ (where λ_0 is the free-space wavelength at the central operating frequency) that enables an impedance bandwidth of about 29.8% by cutting a zigzag slot in the patch [9]. Gh. Z. Rafi et al. has experimentally shown that a probe fed diamond shaped V-slotted patch antenna on a foam substrate of height $0.083\lambda_0$ achieves approximately 50% impedance bandwidth [10]. All the above mentioned techniques increase either the overall volume or design complexity of the antenna.

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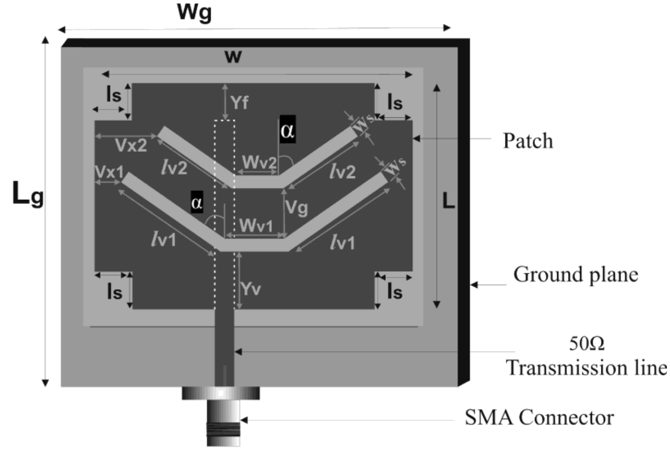
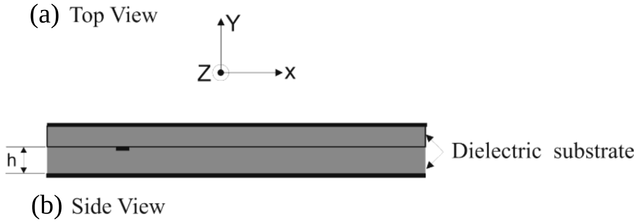
In this paper, a broadband proximity coupled microstrip patch antenna fabricated on a substrate of dielectric constant 4.4 and thickness $0.0267\lambda_0$, features an impedance bandwidth of 51% from 3.75 GHz to 6.33 GHz with sufficient gain and stable radiation characteristics. The proposed antenna is suitable for IEEE 802.11.a (5.15–5.35 GHz, 5.725–5.825 GHz), WiMAX (5.25–5.85 GHz), HiperLAN2 (5.47–5.725 GHz) and HiSWaNa (5.15–5.25 GHz) wireless application bands.

2. ANTENNA GEOMETRY

The geometry of the antenna fabricated on an FR-4 substrate of dielectric constant $\varepsilon_r = 4.4$ with loss tangent $(\tan\delta)$ of 0.02 and height $h = 1.6$ mm is shown in Fig. 1. Initially, four square regions



(a) Top View



(b) Side View

Figure 1. Geometry of the proposed antenna ($L = 35$, $W = 49$, $l_{v1} = 15$, $l_{v2} = 12$, $W_{v1} = 10.73$, $W_{v2} = 8.73$, $W_s = 2$, $V_g = 7$, $l_s = 5.89$, $h = 1.6$, $Y_f = 5.5$, $Y_v = 10$, $V_{x2} = 9.69$, $V_{x1} = 5.49$, $L_f = 31.5$, $W_{f=}3$, $L_g = 60$, and $W_g = 60$ (unit: mm) $\alpha = 55°$ and $\varepsilon_r = 4.4$).

($l_s \times l_s\,\mathrm{mm}^2$) are cut off from the corners of a rectangular patch ($L \times W\,\mathrm{mm}^2$), resulting in a cross patch. A V slot ($l_{v1} \times W_{v1} \times W_s\,\mathrm{mm}^3$) is etched on the above cross patch. The arms of the V slots are tilted by an angle $\alpha°$. The antenna is electromagnetically coupled with a $50\,\Omega$ transmission line $L_f \times W_f\,\mathrm{mm}^2$ fabricated using the same substrate. A second V-slot ($l_{v2} \times W_{v2} \times W_s\,\mathrm{mm}^3$) is added at a distance V_g from the top of the first V-slot. All the parameters have been optimized for best bandwidth performance. The height of the antenna is 2.67% of the free-space wavelength at the central operating frequency. The overall dimension of the antenna is $L_g \times W_g \times 2h\,\mathrm{mm}^3$.

3. RESULTS AND DISCUSSIONS

The proposed antenna is designed and optimized using a frequency domain three-dimensional full wave electromagnetic field solver (Ansoft HFSS). The characteristics of the fabricated antenna have been measured using HP8510C vector network analyzer. The simulated and measured reflection characteristics of the antenna with and without V-slot is given in Fig. 2. It is observed that, without the slot, there exist two poorly matched resonances around 3.97 GHz and 4.2 GHz. These two resonances are lowered by the introduction of the V-slots into the patch as seen in Fig. 2 and improve the input impedance by effectively suppressing the excess reactance at these resonances as shown in Fig. 3. Corresponding to the two merged resonances around 3.82 GHz and 4.2 GHz, a full-wave variation is noted on the top and bottom edges of the patch along the X-direction. The resonances around 5.29 GHz and 6.13 GHz are due to the three and four half-wave variations respectively along the sides of the patch and the edges of the slot. At the optimum design, these resonances are merged together to achieve the maximum bandwidth with dual V-slot loaded patch as shown in Fig. 2. The small discrepancies between simulated and measured return loss characteristics of the antenna are due to the tolerance errors in antenna fabrication. From both results, the proposed antenna offers a 2 : 1 VSWR bandwidth of 51% from 3.75 GHz to 6.33 GHz.

Figure 4 shows the effect of V-slot gap on return loss characteristics of the antenna. There is only a slight variation in the bandwidth with V_g while the reflection coefficient in the mid- band region is more dependent on V_g. Therefore, $V_g = 7\,\mathrm{mm}$ is a good selection which provides minimum reflection at the center portion of resonant band. It is also worth noting that the last resonant frequency is more affected by the V-slot gap than other resonances.

The influence of the corner notches on the reflection characteristics of the optimized prototype is illustrated in Fig. 5. It is observed that

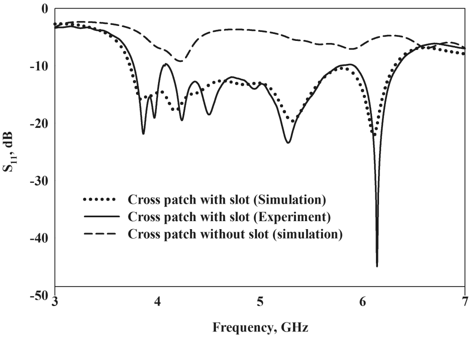
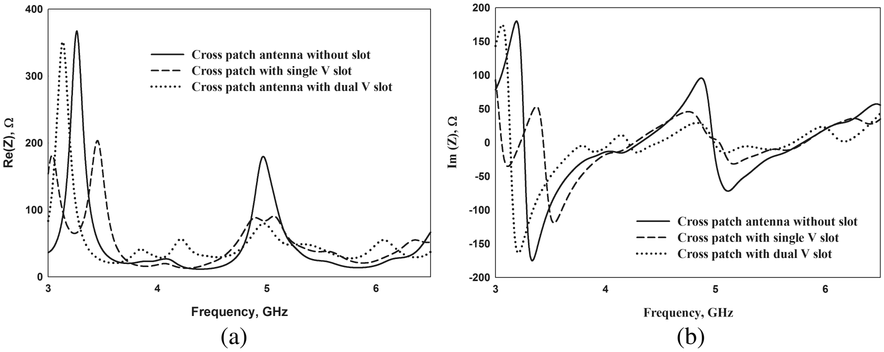


Figure 2. Measured and simulated reflection characteristics of the antenna.



(a) (b)

Figure 3. Input impedance of the antenna with and without slot, (a) real part and (b) imaginary part.

all the resonances are shifted towards the higher frequency region with the increase in l_s. Also impedance matching becomes poor in low frequency region when l_s is lowered. Similarly increase in l_s degrades the impedance matching in the high frequency region. Therefore, $l_s = 5.89\,\text{mm}$ is a compromise between impedance matching and bandwidth.

Figure 6 shows the normalized YZ and XZ plane radiation patterns at 3.75 GHz, 5 GHz and 6.33 GHz respectively. The main beams of the radiation pattern are tilted similar to other wideband U or V-slotted patch antennas which also increase with frequency due to the excitation of higher order modes. The measured gain of the antenna is given in Fig. 7. The designed antenna has a maximum gain of 7 dBi in the mid-band region and has an average gain of 5 dBi within

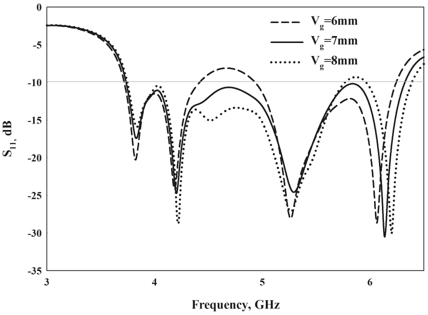


Figure 4. Effect of V-slot gap V_g on the reflection characteristics of the antenna ($L = 35$, $W = 49$, $l_{v1} = 15$, $l_{v2} = 12$, $W_{v1} = 10.73$, $W_{v2} = 8.73$, $W_s = 2$ and $l_s = 5.89$ (unit: mm)).

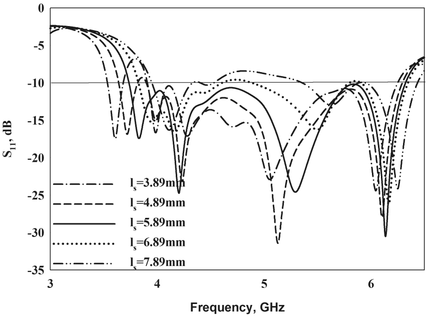
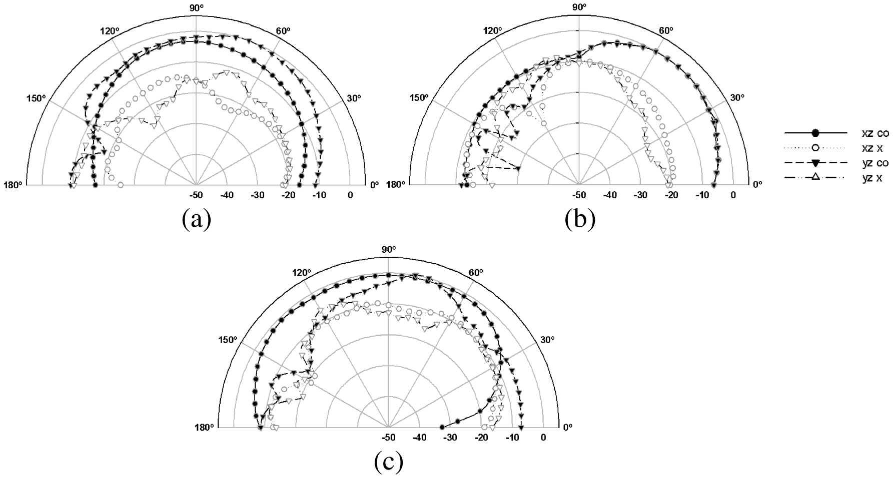


Figure 5. Variation of reflection characteristics with corner notch dimension l_s of the antenna ($L = 35$, $W = 49$, $l_{v1} = 15$, $l_{v2} = 12$, $W_{v1} = 10.73$, $W_{v2} = 8.73$, $W_s = 2$ and $V_g = 7$ (unit: mm)).



(a) (b) (c)

Figure 6. Measured radiation patterns, (a) at 3.75 GHz, (b) at 5 GHz, (c) at 6.33 GHz.

the operating band. It can be seen that the opposing currents on either sides of the slot cause field cancelation along the on axis at the far field giving a reduced gain at the higher frequency. The polarization of the antenna is also verified. The antenna is linearly polarized along the X-axis.

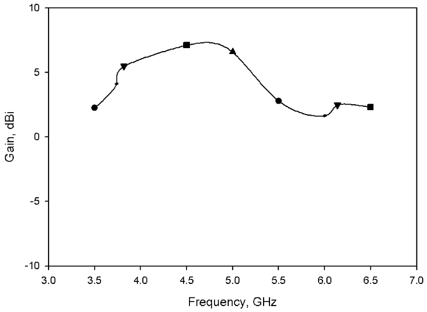


Figure 7. Measured gain of the antenna.

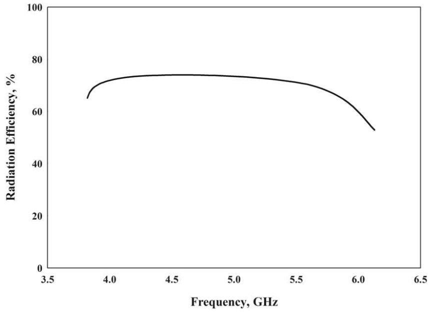


Figure 8. Simulated radiation efficiency of the antenna.

The simulated radiation efficiency of the antenna is shown in Fig. 8. Maximum efficiency is found to be 73.8% at 4.93 GHz with an average efficiency of 65.3%. Small antenna design is always a compromise between size, bandwidth, and efficiency. This configuration delivers broader bandwidth and acceptable gain although the efficiency of the total system will suffer due to dielectric losses.

4. CONCLUSION

A broadband electromagnetically coupled dual V-slotted cross shaped microstrip antenna suitable for wireless communications has been developed and studied. The proposed antenna is compact, occupies small volume and has simple structure compared to other antenna designs. The antenna offers a 2 : 1 VSWR bandwidth of 51% from 3.75 GHz to 6.33 GHz exhibiting good radiation characteristics and gain.

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