APPLYING ELECTRIC-MAGNETIC-ELECTRIC (EME) COMPOSITE METAL STRIPS TO REDUCE THE SIZE OF PATCH ANTENNAS

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This paper presents a novel technology to reduce the size of microstrip patch antennas. Utilizing this recently developed periodic structure (EME metal strips), we can increase the slow-wave factor of microstrip lines. This benefit can help us to reduce the size of patch antennas. According to our experimental results, the resonant length and area of the EME patch can be reduced to be 76 % and 57% when compared with the conventional one.

1 Introduction

Microstrip antennas have many advantages such as low cost, low profile, lightweight, and easy fabrication. Mobile phones, satellite communications systems, portable computers are typical applications. However, the microstrip size becomes larger for applications at low frequency. The size reduction of the radiating elements becomes decisive to the system design and integration. Recently, several techniques have been proposed to minimize the microstrip patch antennas. Using shorting or resistive posts to reduce the patch size is very popular [1-2]. Although these methods can achieve considerable size reduction of patch antennas, the performances of gain and bandwidth will decrease. Another method to reduce the size is using high dielectric constant material [3]. However, this way usually results in narrow bandwidth and degradation of gain. Also, the limited availability of low lost, low cost, high dielectric constant material is another problem with this technique.

Previously, photonic band-gap (PBG) materials have been proposed to improve the performances of microwave circuits and antennas. [4]. The photonic band-gap structure is successfully employed to enhance gain and bandwidth of patch antennas [5]. Here we propose a novel technique for size reduction of microstrip patches incorporating Electric-Magnetic-Electric (EME) composite metal strips [6]. This newly developed periodic structure results in the increase of slow-wave factor (λ_0/λ_g), higher characteristic impedance, and the same Q-factor with a microstrip line. The theoretical results show the increases of the SWF (slow-wave factor) and the characteristic impedance at 2~3 GHz [6]. Therefore we can reduce the patch dimension by incorporating the EME metal strips at design frequency range.

2 Statement of the EME Microstrip Patch Antenna

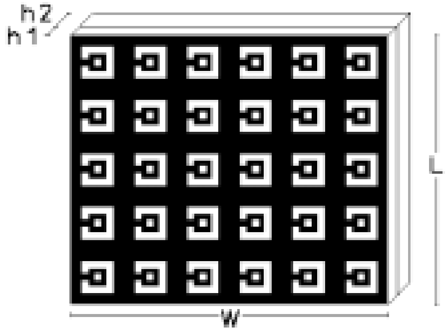
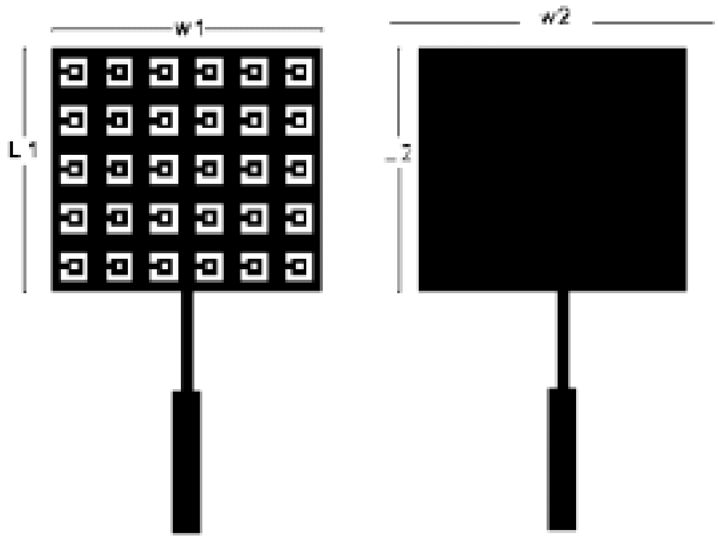


Fig. 1 Geometry of the EME patch with ε_r = 3.38, h1 = 8mil, h2= 20mil.

The geometry of the proposed structure with EME metal strips is illustrated in Fig. 1. It displays an array of coupled inductors with via holes. The EME microstrip is metallized on a RO4003 ^{TM} dielectric slab with thickness of 8 mil (h1) and relative permittivity (ε_r) of 3.38. Then we glue it on a grounded RO4003 ^{TM} substrate of thickness 20mil (h2) and ε_r equal to 3.38 as shown in Fig. 1. The metal strips then replaced by electric-magnetic-electric (EME) composite metal strips (cell dimension is 60 by 60 mil^2, 8 mil gap). The resonant length of the rectangular microstrip antenna is about one half wavelength. We directly feed the patch by using a quarter-wave transformer as shown in Fig. 2. Fig.2 (a) and Fig.2 (b) show the layout of the EME patch antenna and conventional one, respectively. The total resonant length and area of the EME patch are 1010 mil and (1010x1344) mil^2. On the other hand, the conventional patch is made from the same RO4003^{TM} substrate (thickness = 28 mil and ε_r = 3.38). The resonant length and area of the conventional one are 1330 mil and (1330x1796) mil^2. It achieves to be 76% and 57% reduction in the resonant length and area in comparison with the conventional one.



(a) EME patch. (b) Conventional patch.

Fig.2 Microstrip edge feed with quarter-wave transformer

3 Measurement Results

We illustrate the measured return loss versus frequency for the two patch antennas as Fig. 3. The conventional patch has the minimum return loss of –22.98 dB at 2.57 GHz and bandwidth of 1%. However, the EME patch antenna measured a peak return loss of –26.15 dB at 2.56 GHz and bandwidth of 1%. Both two antennas have the return losses lower than -20 dB. The experimental results exhibit that we can reduce the patch size by employing the EME metal strips without decreasing the bandwidth of microstrip antennas.

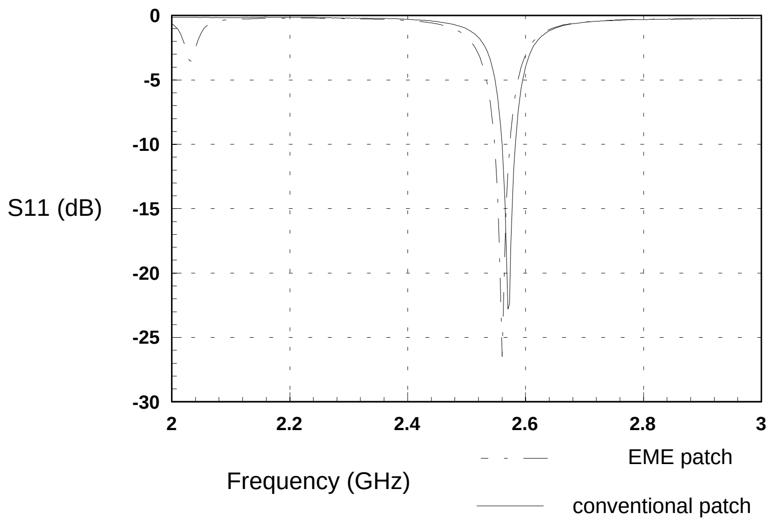


Fig.3 Measured return loss of the conventional and EME patch antennas.

Fig. 4 shows the measured H-plane and E-plane far field radiation patterns of both EME and conventional patch antennas. The measured gains of the EME and conventional patches are 4 dBi and 5.98 dBi, respectively. The antenna gain decrease due to EME cells is 1.98 dBi, which is a payment for size reduction. The co- and cross-polarization patterns on the H-plane and E-plane are both plotted in Fig4. (a), Fig4. (b). A broadside radiation is demonstrated and the cross-polarization are also observed. The EME patch's cross-polarization is slightly higher as compared to the conventional one. However, the –19.71 dBi (H-plane) and –17.62 dBi (E-plane) cross polarization levels of the EME patch are still low.

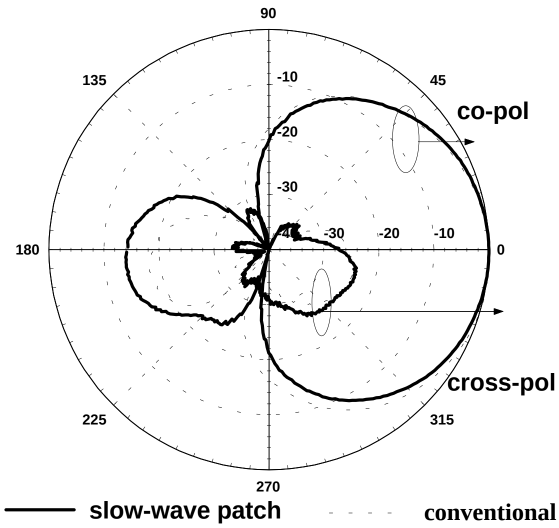


Fig4. (a)

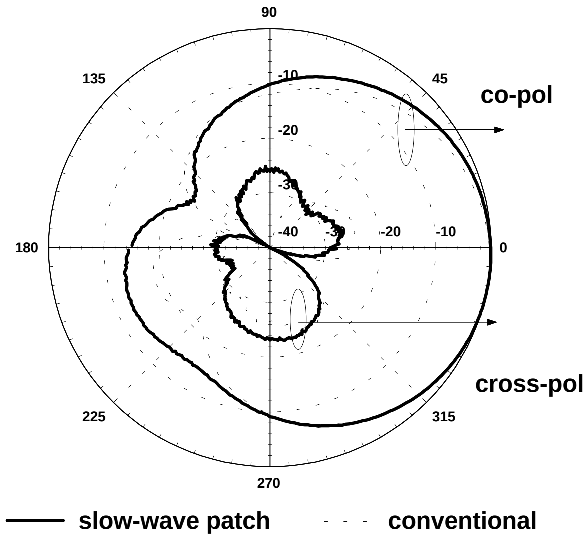


Fig4. (b)

Fig4. Measured radiation patterns for the EME and conference patch antennas: (a) H-Plane and (b) E-Plane.

The 3-dB beamwidth, measured at our frequency, are: EME antenna (E-plane = 94^o, H-plane = 72^o), conventional antenna (E-plane = 88^o, H-plane =72^o). The measured radiation patterns of both two patches are similar except the antenna gains. Measured resonance frequency, size, gain and 3-dB beamwidth of the two antennas are summarized in Table. 1.

	EME patch (60mil)	Conventional patch
Frequency (GHz)	2.56	2.57
Area (mil^2)	1010(L1) by 1344(W1)	1330(L2) by 1796(W2)
Peak Gain	4	5.98
3dB Beamwidth (H-plane)	72^o	72^o
3dB Beamwidth (E-plane)	94^o	88^o

Table. 1: Summary of two patch antennas.

4 Conclusion

We propose a novel technique to minimize the microstrip patch antenna. This technique incorporates the concept of Electric-Magnetic-Electric (EME) composite metal strips, which can increase the slow-wave factor and characteristic impedance and maintain the Q-factor at 2~3 GHz. As a result, the EME patch antenna dimension can be reduced to be 76 % in comparison with the conventional one.

Acknowledgements

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