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Study of Effects of Metallic Pin via in Metamaterial Structure

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Abstract: In this paper, we considered a rectangular patch antenna which operates at 3.3518 GHz frequency is considered for analysis purpose. Here to study the effect that having the metallic pin via for each periodic metallic plate in the metamaterial structure we consider a single layer structure and double layered metamaterial structure. In case (1) the single layered Metamaterial is considered and comparative analysis is given with and without metallic pin via connections. Similarly for the case (2) the two layered metamaterial structure comparative analysis is given for without having any metallic pins in either layers, metallic pins in upper layer, metallic pins in lower layer and metallic pins in both layers. The comparative analysis is presented based on return loss, radiation pattern and other antenna parameters.

Keywords: Metamaterial, single layered, double layered, rectangular patch antenna

I. INTRODUCTION

Metamaterial have been very useful in guiding EM waves in particular ways. These metamaterial structures are periodic structures which will suppress the surface wave propagations. From past few decades there have been different kinds of shapes and models implemented to suite different kind of needs. These metamaterial are key factors in Antenna, microwave, thermal cooling technology, cloaking implementation, filters etc. in general they are like artificial magnetic conductors which reflect or absorb the electromagnetic energy incident on it. This is one of the key properties that these structures possess. It is used to replace ground plane in patch antennas and sometimes as reflector plane [1,2]. These structures can be used to tune the antenna frequency by varying its designing dimensions and also steer the radiation energy in desired ways [3,4]. By varying electromagnetic parameters in metamaterial we can produce different types of electromagnetic materials [5-7]. These metamaterial structures are single layered and multi layered structures and these multilayered structures also have significant improvements over its single layered models. Double layered dielectric substrates are usually used to fill these structures. Some research outcomes that are proved over the years are how different dielectric materials can be used to effect the overall performance, gain improvement, tuning, radiation steering, coupling effect reduction, terahetz applications, plasmonics , cloacking, band width enhancement, multi band applications, low power small antennas, radiation enhancement and absorption etc[8-13].

II. DESIGN OF PROPOSED ANTENNA AND MET SURFACE

A Antenna Design

The proposed antenna design is shown in the following figure [1] the patch dimensions are 3.2cm in X direction and 2.8 cm in Y directions.. the dielectric substrate Rogers RT/duroid 5880(tm) having dielectric constant 2.2 and having lost tangents 0.0009 is considered and with dimensions of 9.1cm×9.1cm×62mil in XYZ directions respectively. The ground is 9.1cm×9.1cm in XY directions respectively and a thickness of 62mil in Z direction. The proposed antenna is excited by coaxial probe feed.

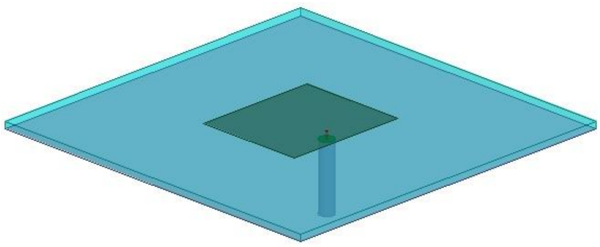

Fig 1. Proposed antenna

B Metamaterial structure

In general the metamaterial structures are periodic the most popular one is on a metallic base metallic pins are placed in a periodic manner and on top of the metallic pins the metallic patches were placed. Here the exact same structure is considered. In case (1) single layered structure is considered and in case (2) double layered metamaterial structure is considered. Here the metallic patch dimensions are 1.2cm×1.2cm×0.2cm in XYZ directions and the material used in stainless steel.

And the pin via is in cylindrical shape with 0.1cm radius and 62mil height with same material. The gap between the metallic pins and the patches is filled with FR4 material with relative permittivity 4.4 with same dimensions as the substrate. And the metal base is also of same dimensions with pec material is considered. Similar materials and dimensions were used for double layered structure. The proposed metamaterial structures and different considerations in case (1) and case (2) are shown in the following figures [2,3].

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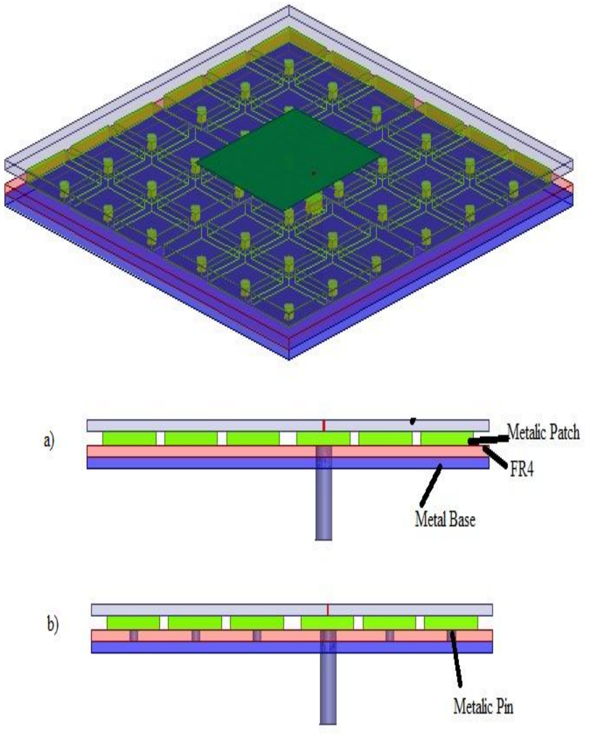

Fig 2 Antenna along with Proposed single layered metamaterial structure aand side views a) Without metalic pin b) With metalic pin

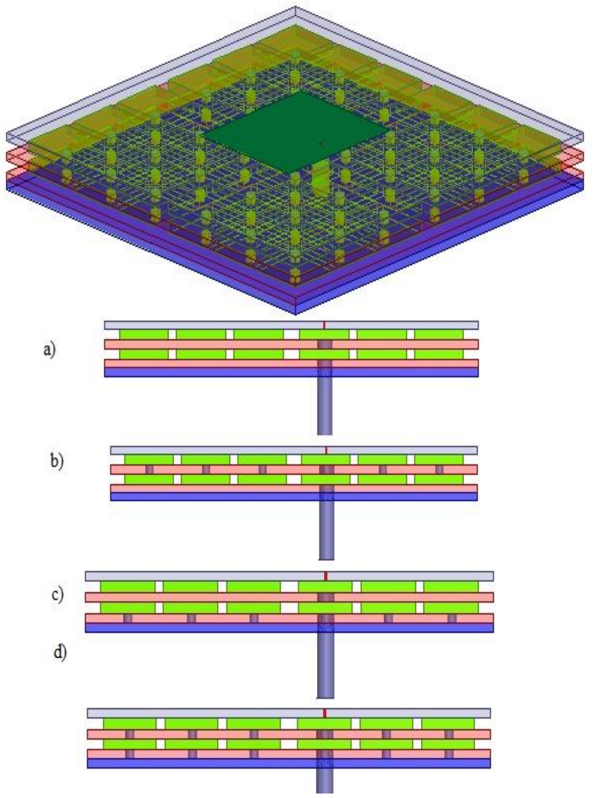

Fig 3 Antenna along with Proposed double layered metamaterial structure aand side views a) Without metalic pin b) With metalic pin in upper layer c) with metalic pin in lower layer and d) With metalic pin in bothe layers

III.SIMULATED RESULTS AND ANALYSIS

A Proposed antenna results

At first the proposed antennas is designed and simulated. And it operates at 3.3518GHz frequency.

Return Loss curve

The return loss curve for the proposed antenna is as shown in the following figure [4]

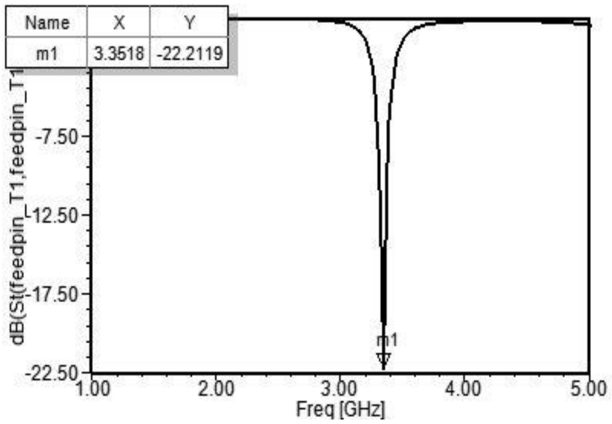

Fig 4 Return loss curve for proposed coaxial fed rectangular patch antenna

From the above figure [4] we can see that the proposed antenna works at 3.3518 GHz and the return loss is -22.2119 dB.

Gain 3D plot

The Gain in 3D is shown in figure 5 for the proposed antenna at 3.3518GHz frequency.

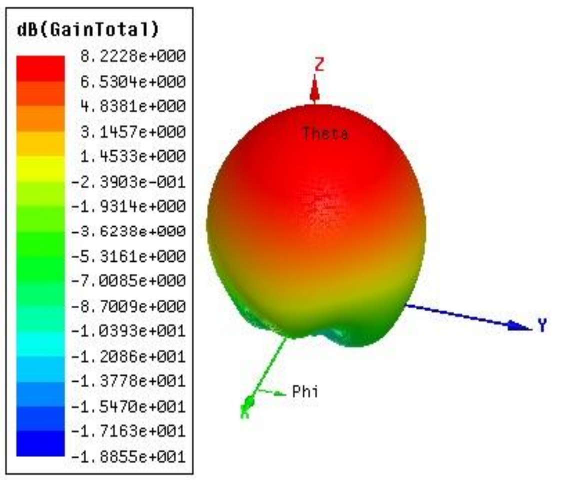

Fig 5 Gain in 3D plot for proposed coaxial fed rectangular patch antenna at 3.3518GHz

In the above figure 5 the antenna gives very good radiation up to 8.2228dB max in the plot data which will be varied the patch antenna is analyzed by using proposing case (1) and case (2) either the maximum value raises are reduces accordingly.

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Case (1) Antenna with Single layered metamaterial structure

Now for this analysis the ground plane is replaced with the single layered metamaterial structure and the comparative analysis is presented in the following figures 6&7.

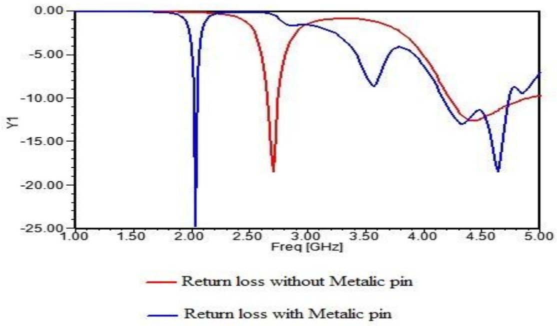

Fig 6 Return loss curve comparison for proposed coaxial fed rectangular patch antenna with single layered Metamaterial

From figure 6 we can see that without any metallic pins the patch antenna is operated at single frequency at 2.7085GHz with return loss -18.5145dB and when metallic pins are placed it operates at dual frequencies 2.0452GHz and 4.6382GHz with return loss -24.7144dB and -18.4721dB respectively. Total gain in 3D plot for corresponding frequencies is illustrated in the following figures [7-9] respectively.

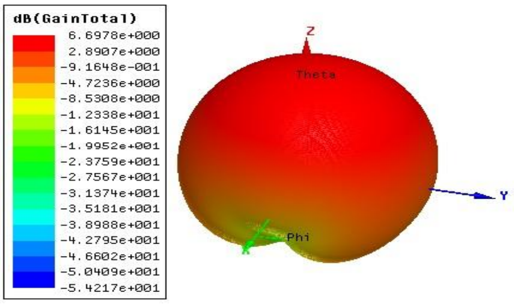

Fig 7 Gain in 3D plot for proposed coaxial fed rectangular patch antenna with single layered metamaterial structure without pin at 2.7085 GHz

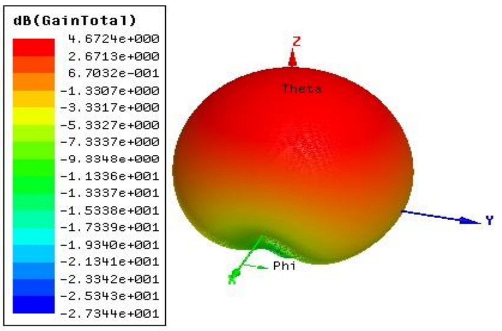

Fig 8 Gain in 3D plot for proposed coaxial fed rectangular patch antenna with metamaterial structure with pin at 2.0452 GHz

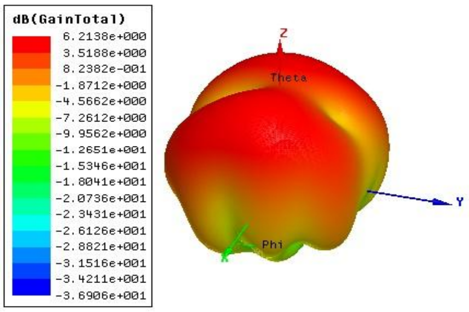

Fig 9 Gain in 3D plot for proposed coaxial fed rectangular patch antenna with single layered metamaterial structure with pin at 4.6382 GHz

In the above figures 7-9 the maximum total gain from plot data is around 6dB for lower frequencies 2.7085, 2.0452GHz and it is 8.23dB at 4.6382GHz. The change is due the placement and absence of the metallic pins. In general when the backward energy incident on the metamaterial structures they will be guided in an unexpected ways. If they are reflected with zero phase shift then they will be added and enhanced that will lead to the improvement of the gain but some time the phase will be reflected in a way that it will cancel the other resulting poor performance. And this can be varies by changing the pin dimensions and the metallic patch dimensions of the metamaterial structures because the current will exist in the pin when it is exposed to the antenna radiation and it will act as the inductor L and also due the existence of the fringing fields in between these periodically placed metallic patches there exists the capacitance C together this LC combination is usually very handy in tuning the antenna operating frequencies sometimes it will significantly affect the radiation from the radiating element.

Case (2) Antenna with Multi layered metamaterial structure

Similarly the single layered metamaterial structure will be replaced by the multi layered metamaterial structures and the comparison between the two layers without any pins in upper layer, lower layer, and in both layers in presented below.

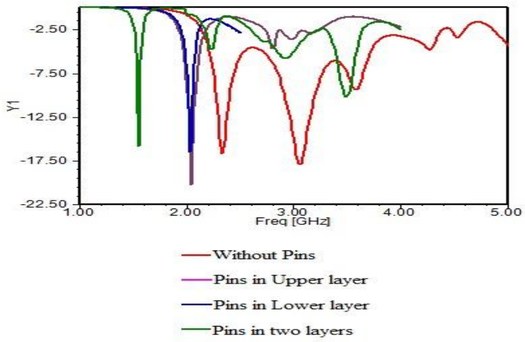

Fig 10 Return loss curve comparison for proposed coaxial fed rectangular patch antenna with Multi layered Metamaterial

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In the above figure 10 when there are no pins placed in either of the two layers then it operates at dual frequencies at 2.3266, 3.0704GHz with return loss -16.6596, -17.9381dB, when pins are placed in upper layer it operates at single frequency 2.0402 GHz with return loss -20.1792dB. For pin in lower layer at 2.0327GHZ with return loss -16.4773dB and when pins placed in both layers 1.5578GHz with return loss -15.8444dB respectively. Here some time the operating frequency can be either shifted to lower frequencies are to higher frequencies and also some time these metamaterial structures can be used to make the antenna operate at multi band for multi band applications and also for wideband applications. This will help in reducing the number of radiating elements needed to be integrated for multi-tasking applications it will help in reducing the antenna size. And the same antenna can be tuned to different frequencies by mechanical variations are electronically tuning of these metamaterial structures.

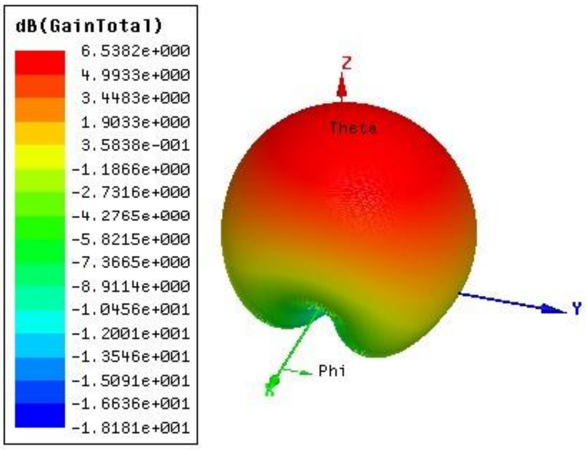

Fig 11 Gain in 3D plot for proposed coaxial fed rectangular patch antenna with double layered metamaterial structure without pin in either layers at 2.3266 GHz

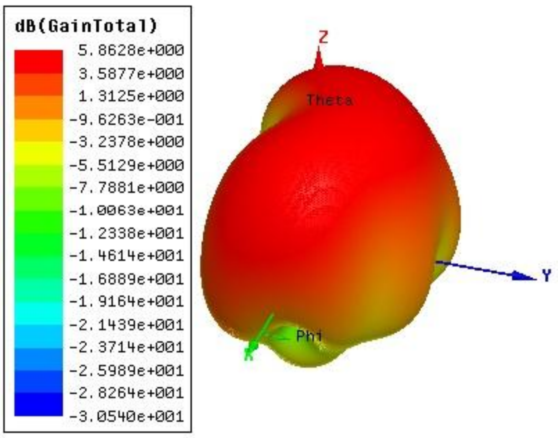

Fig 12 Gain in 3D plot for proposed coaxial fed rectangular patch antenna with double layered metamaterial structure without pin in either layers at 3.0704 GHz

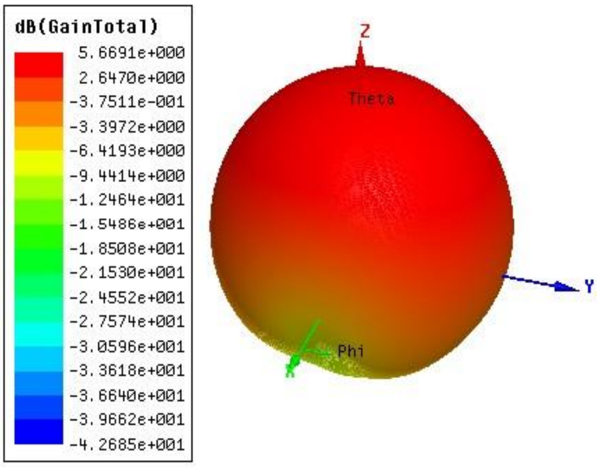

Fig 13 Gain in 3D plot for proposed coaxial fed rectangular patch antenna with double layered metamaterial structure with pin in upper layers at 2.0402 GHz

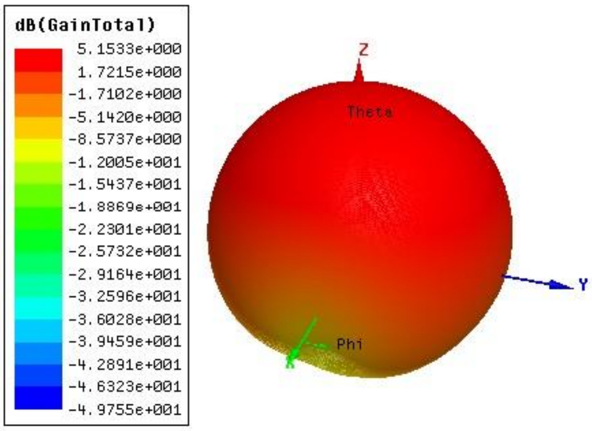

Fig 14 Gain in 3D plot for proposed coaxial fed rectangular patch antenna with double layered metamaterial structure with pin in lower layers at 2.0327 GHz

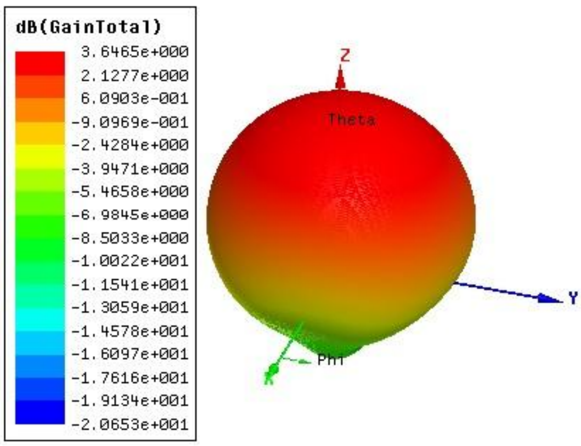

Fig 15 Gain in 3D plot for proposed coaxial fed rectangular patch antenna with double layered metamaterial structure with pin in both layers at 1.5578 GHz

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For all the operating frequencies the gain in 3D plot is presented in the above figures [11-15] where we can observe the significant rise and fall in the maximum value of gain in the data plot.

And for clear understanding for all changes the comparison with the operating frequencies and their return loss values, peak gain and efficiency are illustrated in the following Table [1].

Table [1] Frequency, return loss, gain, and efficiency comparison for all changes

Type	Freq(GHz)	Return loss(dB)	Peak Gain dB	Efficiency
Proposed antenna	3.3518	-22.2119	6.6417	98.256
Single layered Metamaterial				
Without pins	2.7085	-18.5145	4.675	88.361
With pins	2.0452	-24.7144	2.9325	64.355
	4.6382	-18.4721	4.182	73.912
Multi layered Metamaterial				
Without pins in either layers	2.3266	-16.6596	4.5063	89.394
	3.0704	-17.9381	3.8573	86.269
Pins in Upper layer	2.0402	-20.1792	3.689	81.48
Pins in Lower Layer	2.0327	-16.4773	3.2749	74.995
Pins in Both layers	1.5578	-15.8444	2.3155	58.455

IV. CONCLUSION

The performance of proposed antenna is analysed and compared for both single and multi-layered metamaterial structures with and without placing the metric pins. The placement of metallic pins effect the antenna performance sometimes it improves the return loss and BW but sometime result in poor efficiency and it can be adjusted by placing pins and metal patch dimensions to yield the better performance

REFERENCES

[1] Sievenpiper, D., "High-impedance electromagnetic surfaces," Ph.D. Thesis, University of California, Los Angeles, 1999.

[2] J. Doondi kumar , "Analysis of Monopole Antenna by Placing High Impedance Absorber Surface at one Side" /Volume-2Number-1PP-317-321

[3] Filippo costa, An active High impedance surface for low profile Tunable and steerable Antennas, IEEE ANTENNAS AND WIRELESS PROPAGATION LETTER, VOL 7, 2008.

[4] Yang, F. and Y. Rahmat-Samii, "Reflection phase characterizations of the EBG ground plane for low profile wire antenna applications," IEEE Trans. Antennas Propag., Vol. 51, No. 10, 2691– 2703, 2003.

[5] H. T. Jiang, H. H. Chen, Q. Li, Phys. Rev. Lett. 69, 066607 (2004).

[6] A. Andrea, Microwave Theor. Tech. 52, 199 (2004).

[7] D. R. Smith, J. J. Mock, A. F. Starr, D. Schurig, Phys.Rev. E 71, 036609 (2005).

[8] Bergman D J and Stockman M I 2003 Surface plasmon amplification by stimulated emission of radiation: quantum generation of coherent surface plasmons in nanosystemsPhys. Rev. Lett. 90 027402

[9] Al-Naib I A I, Jansen C, Born N and Koch M 2011 Polarization and angle independent terahertz metamaterialswith high Q-factors Appl. Phys. Lett. 98 091107

[10] Ziolkowski, R.W., and Kipple, A.: 'Application of double negative metamaterials to increase the power radiated by electrically small antennas', IEEE Trans. Antennas Propag., 2003, 51, pp. 2626–2640

[11] Ziolkowski, R.W., and Erentok, A.: 'Metamaterial-based efficient electrically small antennas', IEEE Trans. Antennas Propag., 2006, 54, pp. 2113–2130

[12] Auzanneau, F., and Ziolkowski, R.W.: 'Microwave signal rectification using artificial composite materials composed of diode loaded, electrically small dipole antennas', IEEE Trans. Microw. Theory Tech., 1998, 46, (11), pp. 1628–1637

[13] Wittwer, D.C., and Ziolkowski, R.W.: 'Two time-derivative Lorentz material (2TDLM) formulation of a Maxwellian absorbing layer matched to a lossy media', IEEE Trans. Antennas Propag., 2000, 48, (2), pp. 192–199