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A 2x2 Patch Antenna Array for 1.8/2.4/3.6 GHz Applications

Alejandro Iturri-Hinojosa, Miguel Salazar-Ramirez and Diego Pacheco-Jardiners

Instituto Politécnico Nacional, ESIME Zacatenco, CDMX, México. C.P.07320

Abstract: A 2x2 patch antenna array for 1.8/2.4/3.5 GHz applications is proposed. The antenna array resonates at 1.8, 2.4 and 3.6 GHz frequencies, with bandwidths for baseband signals equal to 28.6 MHz, 61.36 MHz and 127 MHz, respectively. The 2x2 patch array is designed to operate in two technologies, Wireless Local Area Networks-WLAN and World Interoperability with Microwave Access-WiMAX. The designed dimension of the 2x2 antenna array is 12.5 x 12.5 cm^2, with printed patches in FR4 epoxy substrate with relative permittivity of 4.3, thickness of 1.6 mm, tangential loss of 0.02 and the ground plane at the bottom of the substrate. The antenna achieves a gain of -4 dB, 1.5 dB and 0.28 dB for the operation frequencies 1.8GHz, 2.4 GHz and 3.6 GHz respectively.

Key words: Antenna arrays · Rectangular patch antennas · WLAN · WiMAX

INTRODUCTION

Rectangular antenna arrays have multiple advantages and important properties, such as high gain, light weight, small dimensions compared to other antenna arrays, not to mention that it can achieve multi-band resonance enabling the user terminal to operate simultaneously in various communication technologies.

Currently there are interesting proposals for patch antenna arrays for use in short and long-range wireless communication systems, such as Wi-Fi and WiMax networks, respectively. [1] Presents a rectangular patch antenna containing an array of narrow L-slots for simultaneous operation in WiMAX and WLAN technologies, with resonance frequencies at 2.4 GHz and 3.6 GHz and gains of 3.65 dB and 1.01 dB, respectively. An interesting design is also presented in [2], a 2x2 patch array with rectangular slots with an estimated gain of 5.37 dBi, proposed for access points in the 5G C-band application. The design of a patch antenna for operation in GSM, WiMAX and WLAN technologies is presented by [3], with resonance frequencies at 1.8 GHz, 3.6 GHz and 5.5 GHz, respectively. The gains achieved in the mentioned frequencies are 6.45 dBi, 7.67 dBi and 7.55 dBi respectively.

Tri-Band Patchantenna Element: Figure 1 presents a top view and side view of the rectangular patch antenna geometry obtained from the design equations presented in [4, 5]. The dimensions are in millimeters. Figure 2 presents a patch antenna image already fabricated.

The dielectric substrate used is FR4 epoxy withthickness of 1.6 mm and 4.4 as relative permittivity.

Performance Results: The patch antennaof Figure 2 was consideredfor the array elements. It´s performance is measured using a vector network analyzer. Experimental and simulated results are shown in Figure 3. The return loss is in decibels, as a function of frequency, in GHz.

The experimental and simulatedreturn loss plots match satisfactorily at the three resonance frequencies statedbelow -10 dB. The first resonance frequency is at 2.45 GHz with a bandwidth of 80 MHz (from 2.40 GHz to 2.48 GHz), the second resonance frequency is at 3.65 GHz with a bandwidth of 83 MHz (from 3.584 GHz and 3.667 GHz) and the third resonance frequency is at 4.52 GHz with a bandwidth of 84 MHz (from 4.480 GHz and 4.564 GHz).The performance resultswere estimated using the High Frequency Structure Simulator (HFSS) electromagnetic simulation software.The estimated radiation patternsin E and H planesin polar coordinates (r, θ) are shown in Figures 4 and 5, respectively. The polar response in E plane shows the distribution of electric field intensity and theH plane shows the distribution of magnetic field intensity.

Corresponding Author: Alejandro Iturri-Hinojosa, Instituto Politécnico Nacional, ESIME Zacatenco, CDMX, México. C.P.07320.

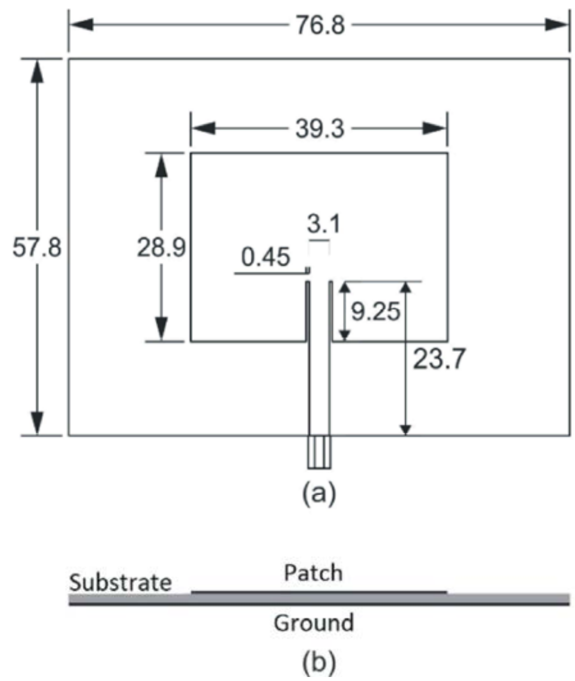

Fig. 1: Patch antenna's geometry (a) Top view and(b) Side view, with dimensions in millimeters

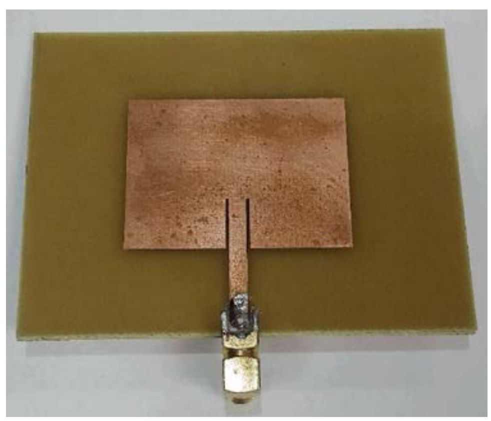

Fig. 2: Fabricated Tri-band patch antenna

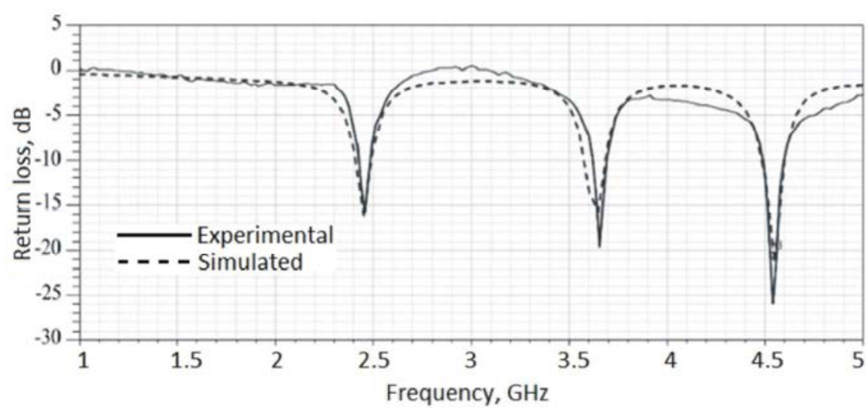

Fig. 3: Tri-band patch antenna's return loss

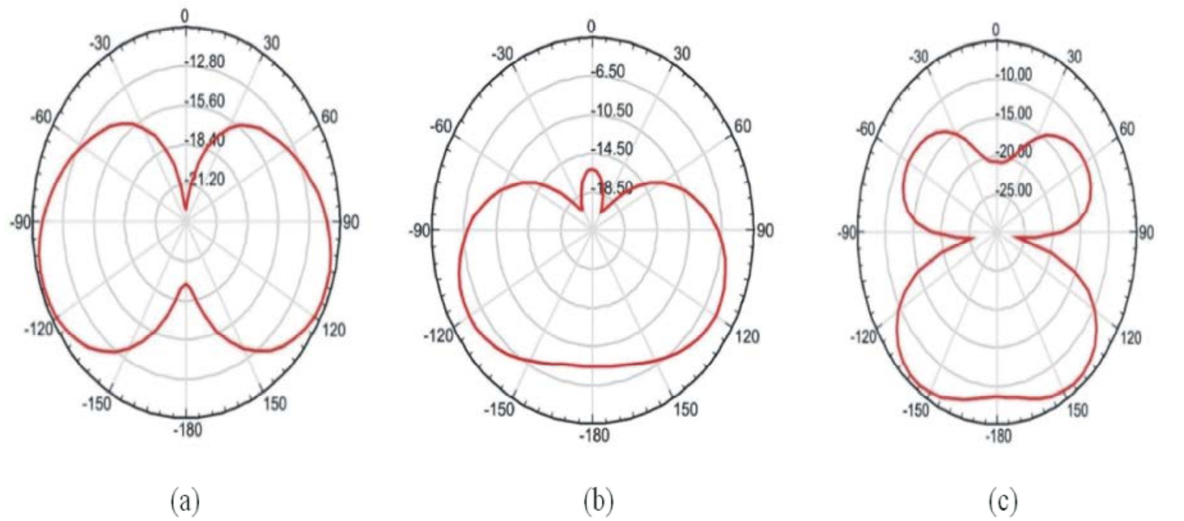

Fig. 4: Estimated Radiation patterns in E plane of the triband antenna for the frequencies (a) 2.4 GHz, (b) 3.6 GHz y (c) 4.5 GHz

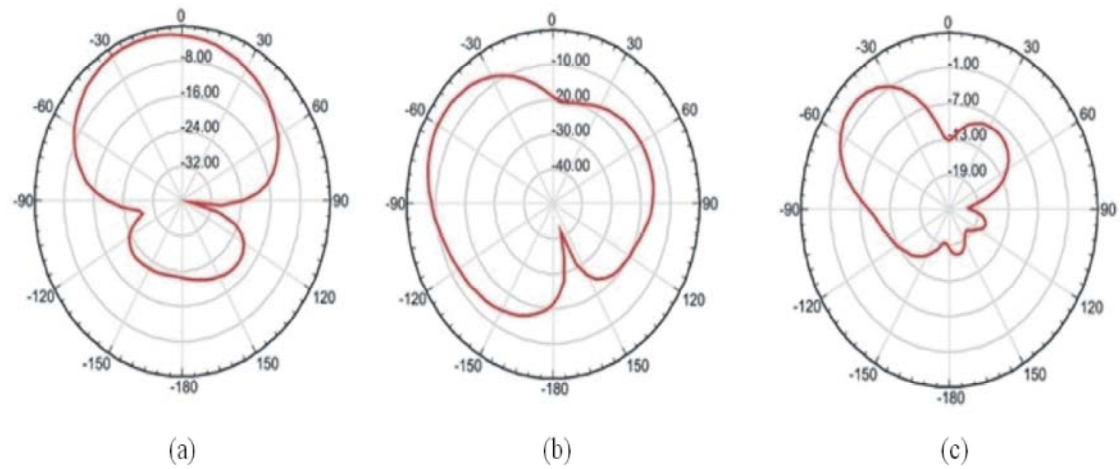

Fig. 5: Estimatedradiation patterns in H plane of the triband antenna for the frequencies (a) 2.4 GHz, (b) 3.6 GHz y (c) 4.5 GHz

Figure 6 presents the patch antenna's radiation patterns. The patch antenna reaches the gains of 2.3 dB, 1.2 dB and 4.6 dB at the frequencies 2.4 GHz, 3.6 GHz and 4.5 GHz, respectively.

2x2 Rectangular Patch Array: A 2x2 array antenna was designed with the patch element described in the previous section. Each element of the array antenna is oriented ±45° with respect to the central transmission line. The rectangular patches are spaced 62.5 millimeters in "x" and "y" directions, which is equal to half a wavelength with respect to the 2.4 GHz frequency. The array antenna uses the RSA-3271 type connector of RF Industries LTD, with 50 Ω input impedance.In order to improve the bandwidths at the three resonance frequencies, the position of the feed point of the array was tuned. With the new location of the feed point, a better performance response was achieved with an additional resonance frequency at 1.8 GHz and greater bandwidth at each frequency. Figure 7 shows the geometry of the 2x2 patch antenna array.

Figure 8 shows the fabricated patch antenna array with the tuned feeding point in the central transmission line.

Figure 9 shows the experimental test of the 2x2 patch antenna arrayusing the vectorial network analyzer (VNA).

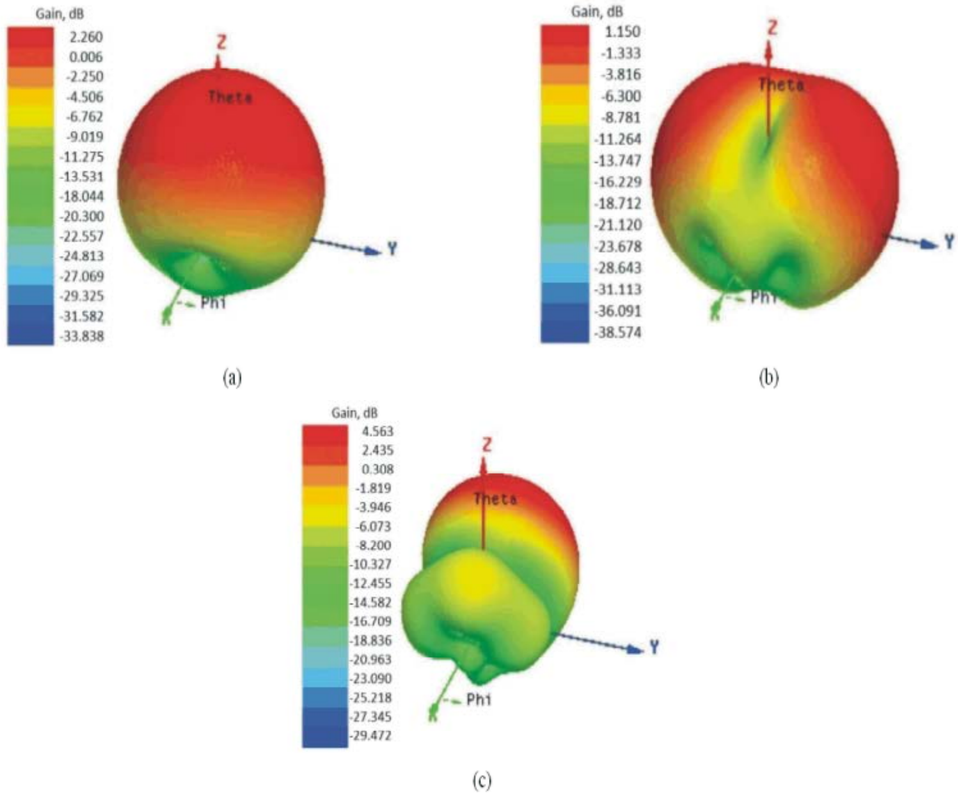

Fig. 6: Radiation pattern in 3 dimensions of the patch antenna for the frequencies (a) 2.4 GHz, (b) 3.6 GHz y (c) 4.5 GHz

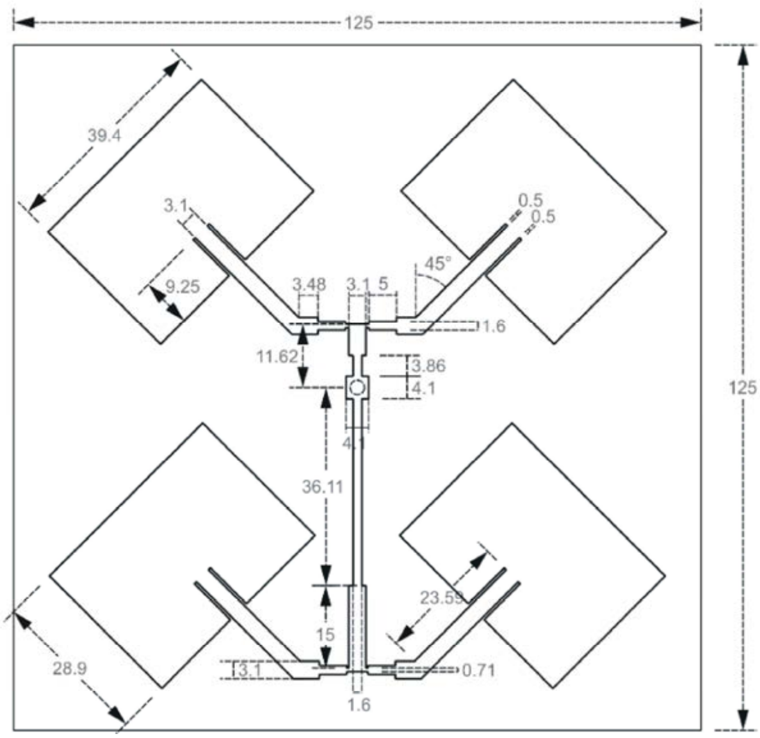

Fig. 7: 2x2 planarantenna array geometry with dimensions in millimeters

(a) (b)

Fig. 8: Fabricated 2x2 patch antenna array (a) top view and (b) bottom view

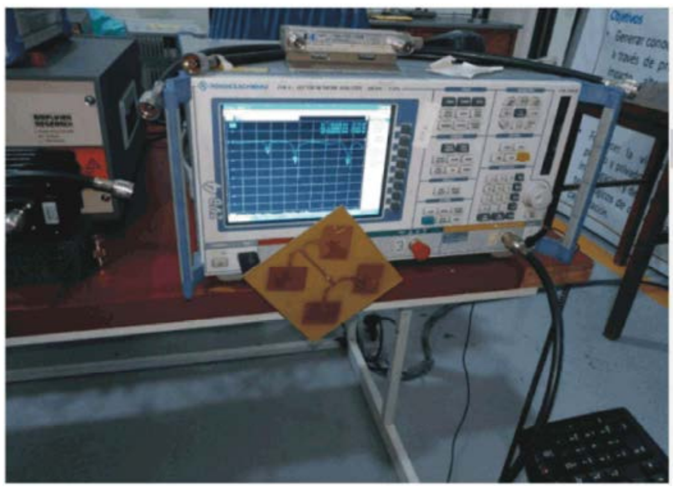

Fig. 9: Performance measurement using vector network analyzer

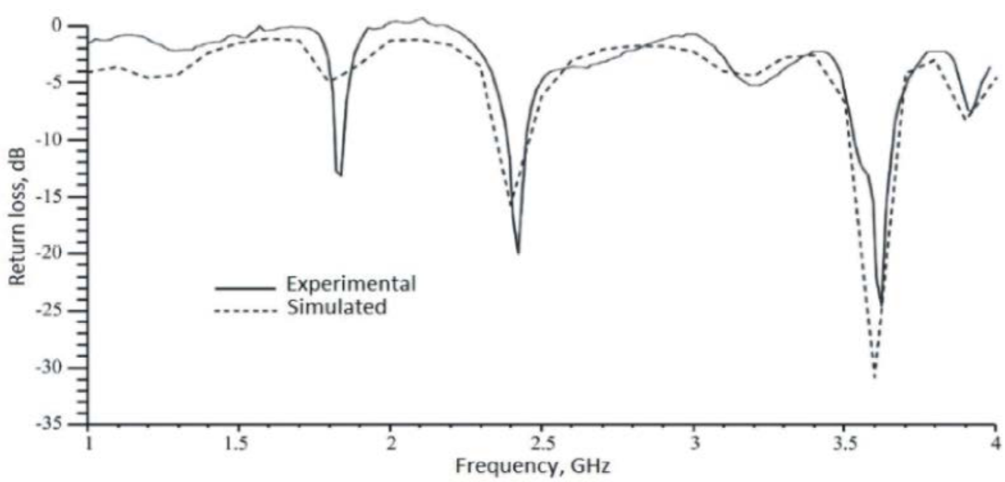

Fig. 10: Estimated and experimental return loss of the planar antenna array

Figure 10 shows the experimental and simulated results of the return loss parameter of the 2x2 patch antenna array.

Three resonance frequencies are shownin the experimental return loss result, at 1.85 GHz, 2.24 GHz and 3.62 GHz, with bandwidths of 28.6 MHz, 61.36 MHz and 127 MHz, respectively.

The radiation patterns in the E and H planes estimated using Ansys HFSS software for the three resonance frequencies are presented in Figure 11.

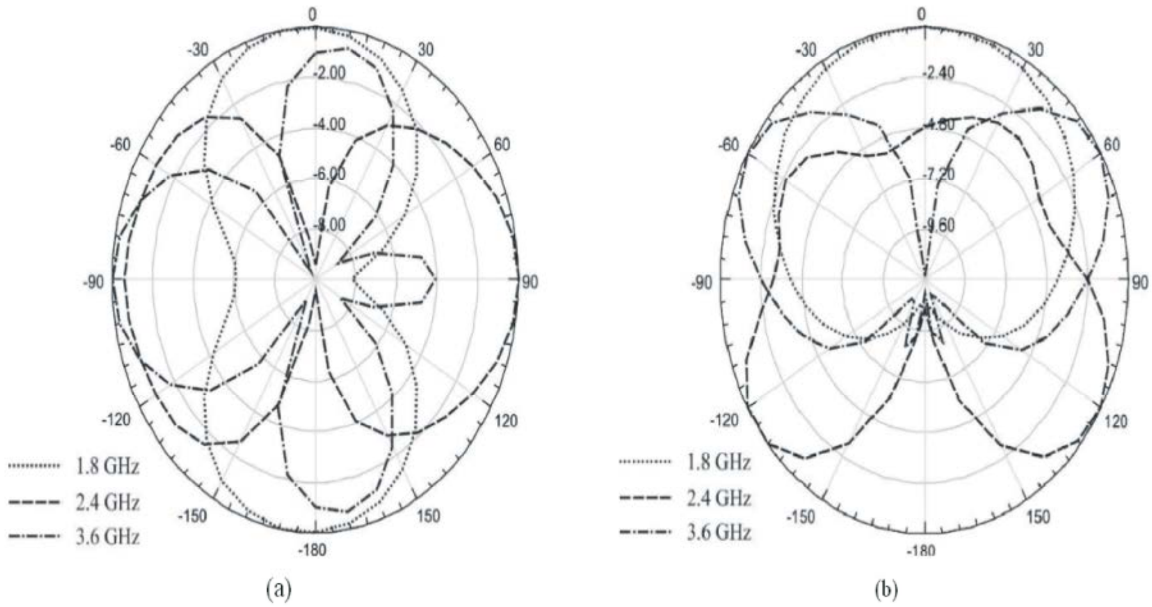

Fig. 11: Estimated radiation patterns in the (a) E and (b) H –planes of the 2x2 planar antenna 3D radiation patterns for the circular antenna array are presented in Figure 12, with the reached gain in dB

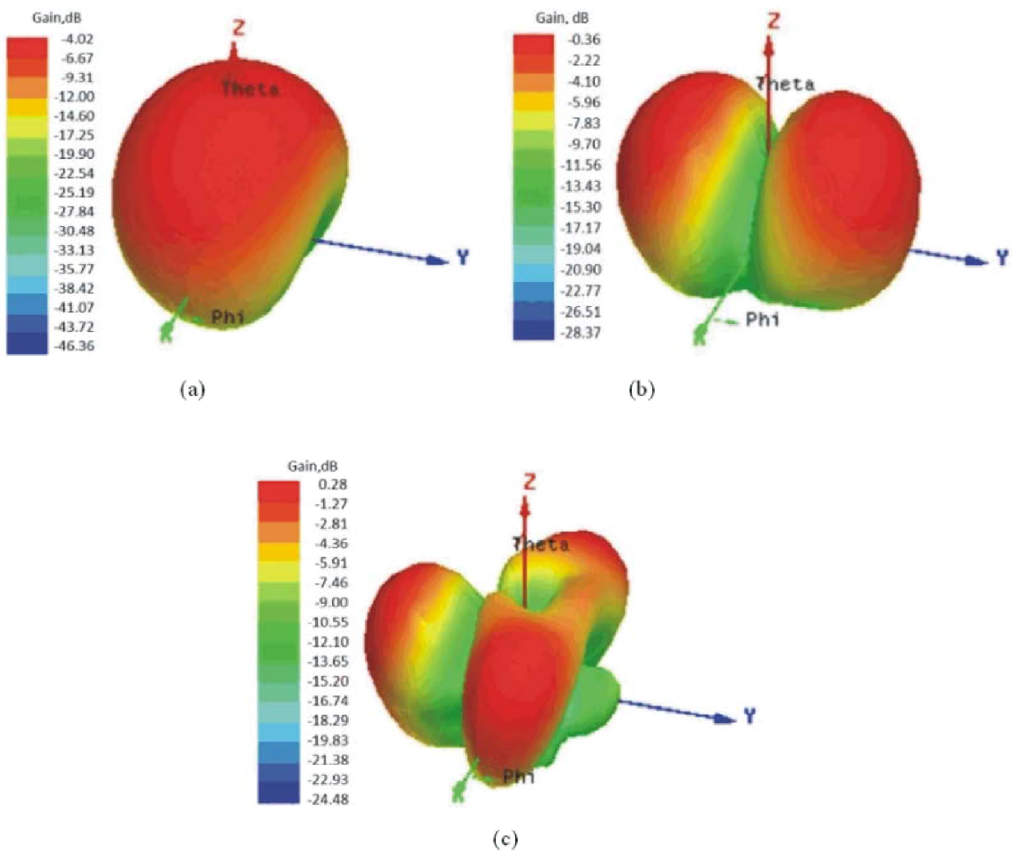

Fig. 12: Radiation patterns in 3 dimensions of the patch antenna array for (a) 1.8 GHz, (b) 2.4 GHz and (b) 3.6 GHz frequencies

CONCLUSIONS

A 2x2 antenna array for GSM, WiLAN and WiMAX technologies is proposed. The rectangular patchelement and the array antenna were manufactured and tested experimentally. Also, the performance results are presented. The patch element presentsresonance frequencies at 2.45 GHz, 3.65 GHz and 4.52 GHz, each with a return losses of -15 dB, -20 dB and -25 dB and frequency bandwidths of80 MHz, 83 MHz and 84 MHz, respectively. The gain reached by the patch antenna is equal to 1.98 dB at the frequency 2.4 GHz, 1.2 dB at 3.6 GHz and 4.6 dB at 4.5 GHz. The radiation patterns in the E and H planes arealso presented. The 2x2 array antenna was designedusing 4 of the rectangular patch antennas. The 2x2 planar antenna array was designed for the GSM technology and for a simultaneous application in WLAN and WiMAX technologies. The return loss response of the 2x2 antenna array has three resonance frequencies, at 1.85 GHz, 2.24 GHz and 3.62 GHz, with bandwidths of 28.6 MHz, 61.36 MHz and 127 MHz and gain values of -4.02 dB, 1.5 dB and 0.27 dB, respectively.

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