NEW PATCH ANTENNA FOR ISM BAND AT 2.45 GHz

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ABSTRACT

In this paper we present a new patch antenna as a hexagonal patch operating in the Industrial Scientific Medical (ISM) frequency band at 2.45 GHz, the proposed antenna is verifying using to different numerical techniques which are Finite Element Method FEM and Method of Moment MoM, the compression results give us good agreement. When human body is presented near the antenna the antenna performance such as S_{11} and bandwidth are affected, the result demonstrates that the new antenna has negligible effect compared with that of the rectangular patch antenna.

Keywords: patch antenna, ISM band, biomedical application.

INTRODUCTION

In [1] a compact dual-frequency hybrid resonator antenna suitable for wireless communication applications at 1.9 and 2.45 GHz. The proposed antenna utilizes a combination of a disk dielectric resonator (DR) and a microstrip fed rectangular slot, and a circular metal sheet partially covers the top of the DR.

The ability of a single layer strip fed printed monopole, which has a serial-slot and an end-stepped feed-strip, to operate at dual Industrial, scientific, and Medical-band (2.4 and 5.8 GHz bands) is demonstrated. This antenna combines omnidirectional and broad bandwidth in an easy to fabricate structure. Experimental results indicate that the VSWR 2:1 bandwidths achieved were 8.2% and 18.2% at 2.45 GHz and 5.5 GHz. Effects of varying the serial-slot dimensions and the ground-plane size on the antenna performance are also described [2].

A single-feed rectangular-ring textile antenna is proposed for wireless body area networks operating in the 2.45 GHz ISM band. The conductive parts of the planar antenna consist of FlecTron1, whereas fleece fabric is used as non-conductive antenna substrate. This results in a highly efficient, flexible and wearable antenna to be integrated in garments. The robustness of the antenna characteristics with respect to bending is proven [3].

In [4] design and fabrication of a dual-polarized microstrip antenna fed by two coplanar waveguides (CPWs) for operation at 2.45 GHz are presented. Obtained results show an impedance bandwidth of 44.3 MHz using a single layer of substrate. The simulated return loss for both polarizations is less than -35 dB, and the isolation between the ports of the antenna is better than 21 dB.

In this [5] a self-diplexed antenna is proposed for a RFID transponder application. The development cycle is divided into two stages: antenna design and filters design. The antenna is based on a square microstrip patch filled with metamaterial structures. The inclusion of these structures allows simultaneous operation over several frequencies, which can be arbitrarily chosen. The antenna working frequencies are chosen to be 2.45 GHz (receiver) and 1.45 GHz (transmitter). In addition, the antenna is fed through two orthogonal coupled microstrip lines, what provides higher isolation between both ports. Some filters based on metamaterial particles are coupled or connected to the antenna feeding microstrip lines to avoid undesired interferences. This approach avoids using of an external filter or diplexer, providing larger size reduction and a compact self-diplexed antenna.

The influance of artificial magnetic conductors (AMC), so-called Sievenpiper High Impedance Surfaces (HIS), on the MIMO and Diversity performance of a planar linear-polarized 2×2 dipole array in the ISM-band at 2.45GHz. The characteristic performance criteria such as envelope correlation coefficient, spectral efficiency, and Mean Effective Gain (MEG) and Diversity gain of a coupled 2×2 dipole array are investigated. By means of full-wave electromagnetic analysis as well as Monte-Carlo simulations applying statistical channel models the characteristic antenna pattern just as the MIMO and Diversity analysis is performed, respectively. The obtained results show that the application of Sievenpiper High Impedance Surfaces to planar antenna arrays enables good MIMO and Diversity performance compared to ideal configuration in free-space while offering the design of low profile antennas with simultaneously enhanced characteristics [6].

A novel single-layer passive RFID tag antenna for the resonant frequency 2.45/2.41 GHz using a square microstrip patch with a pair of U and T slots is proposed, which is suitable for attaching to metallic objects. The proposed antenna was fabricated with a thin copper layer printed on a thin lossy FR4 substrate for low-cost production. The dimensions of the proposed antenna are around 35x35 mm. The antenna shows near-linear phase characteristics, 250 MHz bandwidth under the condition of voltage standing-wave ratio less than 2 and it covers all RFID microwave bands. The gain of the proposed antenna is 2.0-2.2 dBi for worldwide RFID microwave bands [7].

In [8], the on-body performance of a range of wearable antennas was investigated by measuring [S_{21}] path gain between two devices mounted on tissue-equivalent numerical and experimental phantoms, representative of human muscle tissue at 2.45 GHz. In particular, the study focused on the performance of a compact higher mode microstrip patch antenna (HMMPA) with a profile as low as $\lambda/20$ and 10-mm-high HMMPA prototypes had an impedance bandwidth of 6.7% and 8.6%, respectively, sufficient for the operating requirements of the 2.45-GHz industrial, scientific, and medical (ISM) band and both antennas offered 11-dB higher path gain compared to a fundamental-mode microstrip patch antenna. Notably, on-body HMMPA performance was comparable to a quarter wave monopole antenna on the same size of ground plane, mounted normal to the tissue surface, indicating that the low-profile and physically more robust antenna is a promising solution for body worn antenna applications.

A new frequency-reconfigurable quasi-Yagi dipole antenna is presented. It consists of a driven dipole element with two varactors in two arms, a director with an additional varactor, a truncated ground plane reflector, a microstrip-to-coplanar-stripline (CPS) transition, and a novel biasing circuit. The effective electrical length of the director element and that of the driven arms are adjusted together by changing the biasing voltages. A 35% continuously frequency-tuning bandwidth, from 1.80 to 2.45 GHz, is achieved. This covers a number of wireless communication systems, including 3G UMTS, US WCS, and WLAN. The length-adjustable director allows the end-fire pattern with relatively high gain to be maintained over the entire tuning bandwidth [9].

A novel miniature planar inverted-F antenna (PIFA) design without empty space is presented for 2.4 GHz ISM band applications. The antenna fabricated on an FR4 substrate has an overall size of only 10 (L) x 3 (W) x 3.5 (H) mm3 to be embedded inside the portable devices. By properly adding a shorting pin and etching a bent slot, the operating frequency of the antenna can be lowered more flexibly. Moreover, owing to no additional empty space, the circuit routing on the PCB is permitted underneath and around the antenna. The impedance bandwidth of the antenna is about 160 MHz from 2.39 to 2.55 GHz. Good omnidirectional radiation pattern with appreciable gain across the band can be obtained so that the proposed antenna is suitable for Bluetooth and WLAN applications [10].

A wideband circularly-polarized printed antenna is proposed, which employs an asymmetrical dipole and a slit in the ground plane which are fed by an L-shaped microstrip feedline using a via. The proposed antenna geometry is arranged so that the orthogonal surface currents, which are generated in the dipole, feed line and ground plane, have the appropriate phase to provide circular polarization. A parametric study of the key parameters is made and the mechanism for circular polarization is described. The measured results show that the impedance bandwidth is approximately 1.34 GHz (2.45 GHz to 3.79 GHz) and the 3 dB axial ratio bandwidth is approximately 770MHz (2.88GHz to 3.65GHz) which represent fractional bandwidths of approximately 41%and 23%, respectively, with respect to a center frequency of 3.3 GHz [11].

In [12] design of the first wearable active receiving textile antenna in the 2.45 GHz ISM band is addressed for use in personal area networks. The integrated low-noise amplifier is realized on a hybrid textile substrate and positioned directly underneath a wearable patch antenna. The antenna and low-noise amplifier are designed by means of circuit/full-wave co-optimization techniques within a novel multi-platform simulation setup to account for all the losses induced by using textile materials. The effect of the human body on the active antenna performance is investigated by means of on-body measurements.

A novel high-gain dual-band antenna for radio frequency identification (RFID) reader applications covering free ISM bands of 2.45 and 5.8 GHz is presented in this letter. The antenna is composed of a U-shaped copper strip with unequal arm, a printed rectangular ring, and the ground plane. A good impedance bandwidth of 120 MHz has been achieved for 2.37 to 2.49 GHz, while 420 MHz (from 5.55 to 5.97 GHz). The U-shaped feeding strip excites the rectangular ring effectively by providing a good impedance matching with over 85% of total antenna efficiency in both the frequency bands and also 9.56 and 10.17 dBi gain in the lower and higher frequency band, respectively [13].

In this paper a new patch antenna is design and simulates is used in the Industrial, Scientific and Medical ISM band operating at the frequency 2.45 GHz as a hexagonal patch microstrip antenna with microstripline feed. The effect of the human tissue is studied on the resonance frequency and gain.

ANTENNA GEOMETRY

Figure-1 shows the geometry of the proposed antenna, the substrate of antenna is RO3730 of the dielectric constant 3 and height 1.534, the antenna side is 21.8 mm

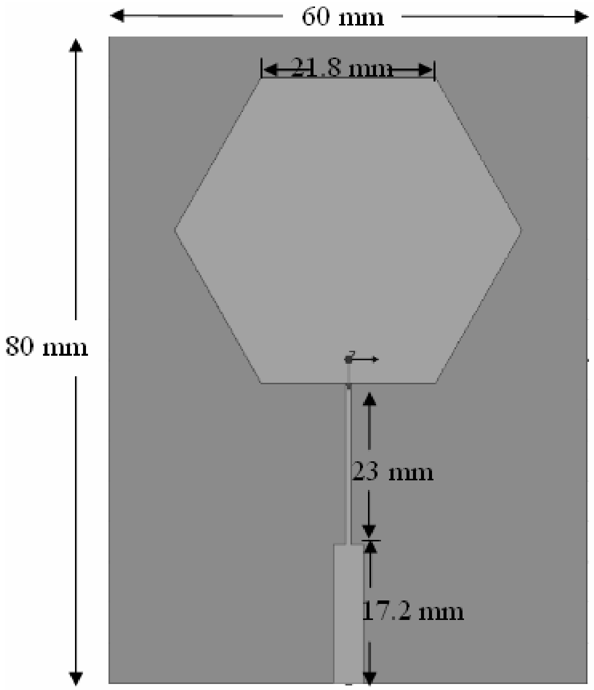


Figure-1. Antenna geometry.

The antenna used to compare the results of the proposed antenna is a rectangular patch microstrip antenna of 39 mm × 34.5 mm mounted on the dielectric substrate of 80 mm × 50 mm × 1.534 mm. In order to simulate the effect of the human body presence on the antenna performances a human tissue model is modeled as the multi-layers as shown in Figure-2, its layers dimensions are 120 mm × 130 mm with 1mm height for the Skin of the constitutive parameters of (ε_r = 38.0066 and σ =1.464 S/m), 2 mm for fat of the constitutive parameters of (ε_r = 5.280 and σ =.104 S/m), and 30 mm for muscle of the constitutive parameters of (ε_r =54.417 and σ =1.882 S/m). The antenna mounted above the model to show the effect of the human body antenna performances.

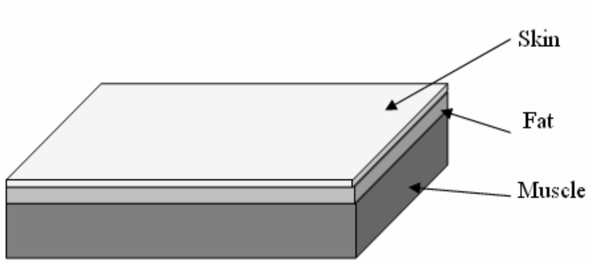


Figure-2. Human tissue model.

SIMULATING RESULTS

In order to validate our design of the proposed antenna of Figure-1 High frequency structure simulation HFSS based on the Finite Element Method FEM and HFSS integral equation IE solver based on the method of moments MoM are used, Figure-3 shows the return loss, S_{11}, of the proposed antenna compared with the rectangular patch antenna operated in the same ISM band at frequency of 2.45 GHz.

To study the effect of the human body tissues on the antenna performance, the antenna but on the tissue model, Figure-4 shows the simulated results for the S_{11} parameter and, while Figure-5 for the radiation pattern parameters for tow antennas under study.

In the Figures 6 and 7 the return losses and the radiation pattern of the rectangular microstrip patch antenna.

The antenna performances are listed in the Table-1. As shown from previous Figures and the Table-1, the proposed antenna performances are enhanced in bandwidth and maximum total gain with no change in the resonant frequency. Figure-8 shows the three dimension radiation pattern of rectangular patch and the proposed antenna in air and on the human body model.

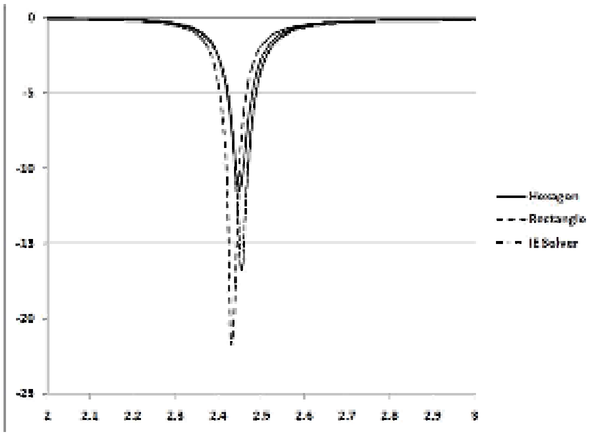
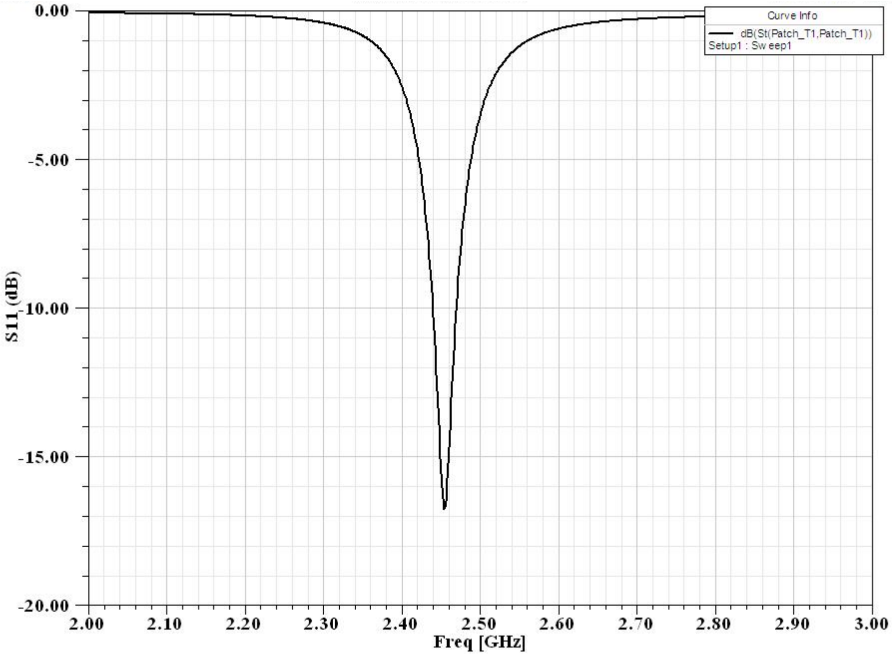
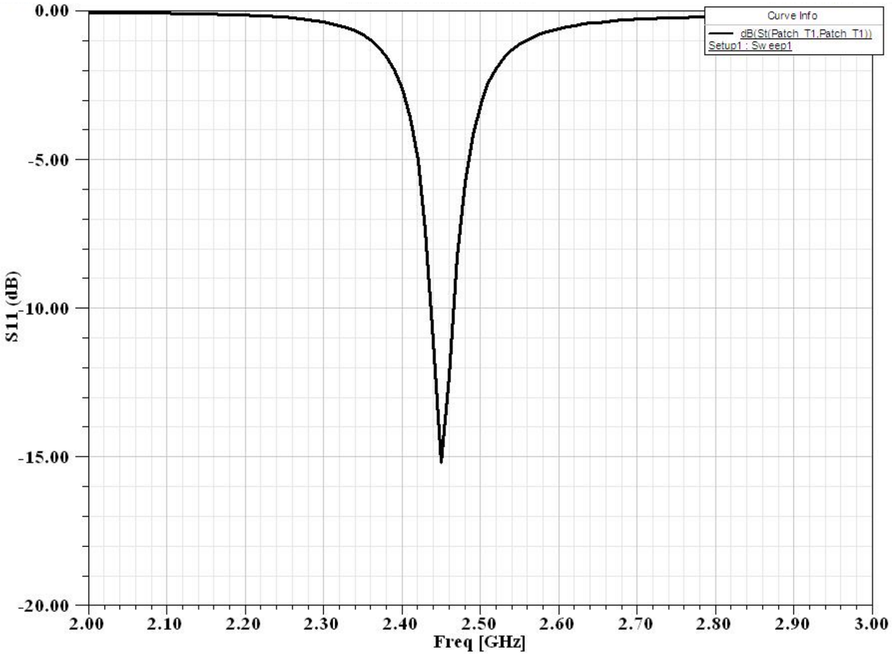


Figure-3. Return losses of the proposed antenna in two different numerical methods compared with rectangular patch antenna.

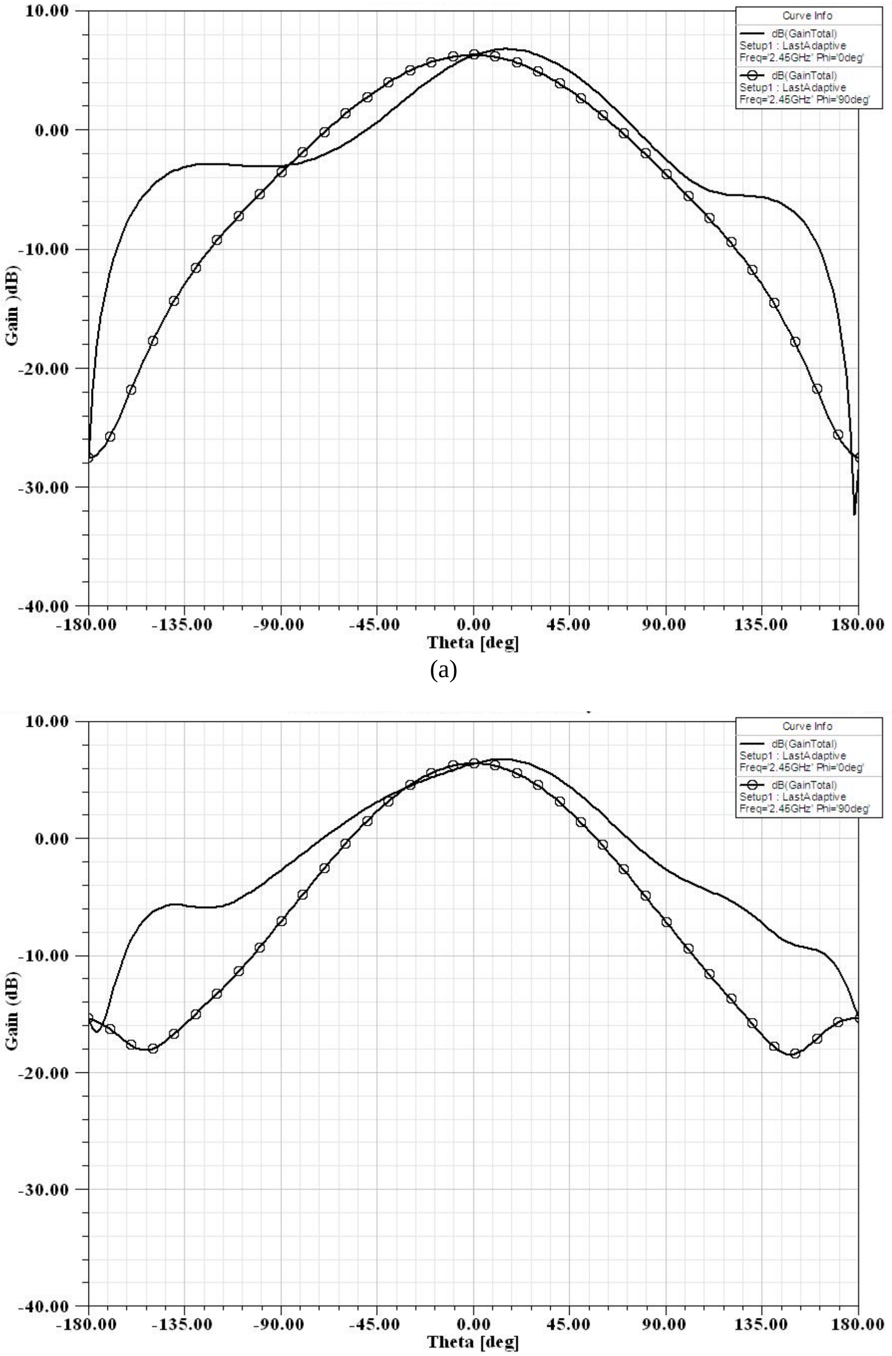


(a)



(b)

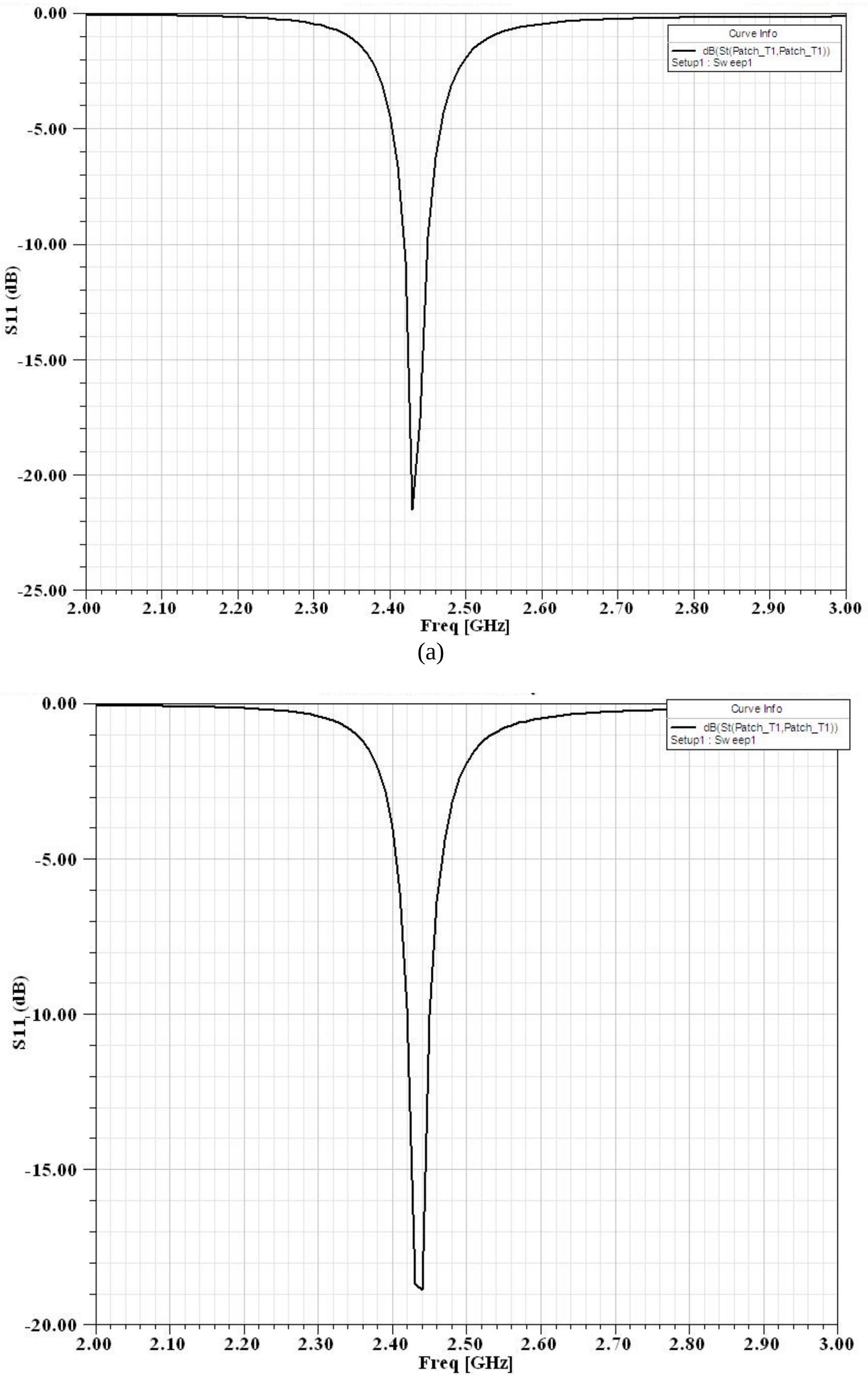
Figure-4. Return losses of the proposed antenna in (a) in air, and (b) on the human body.



(a)

(b)

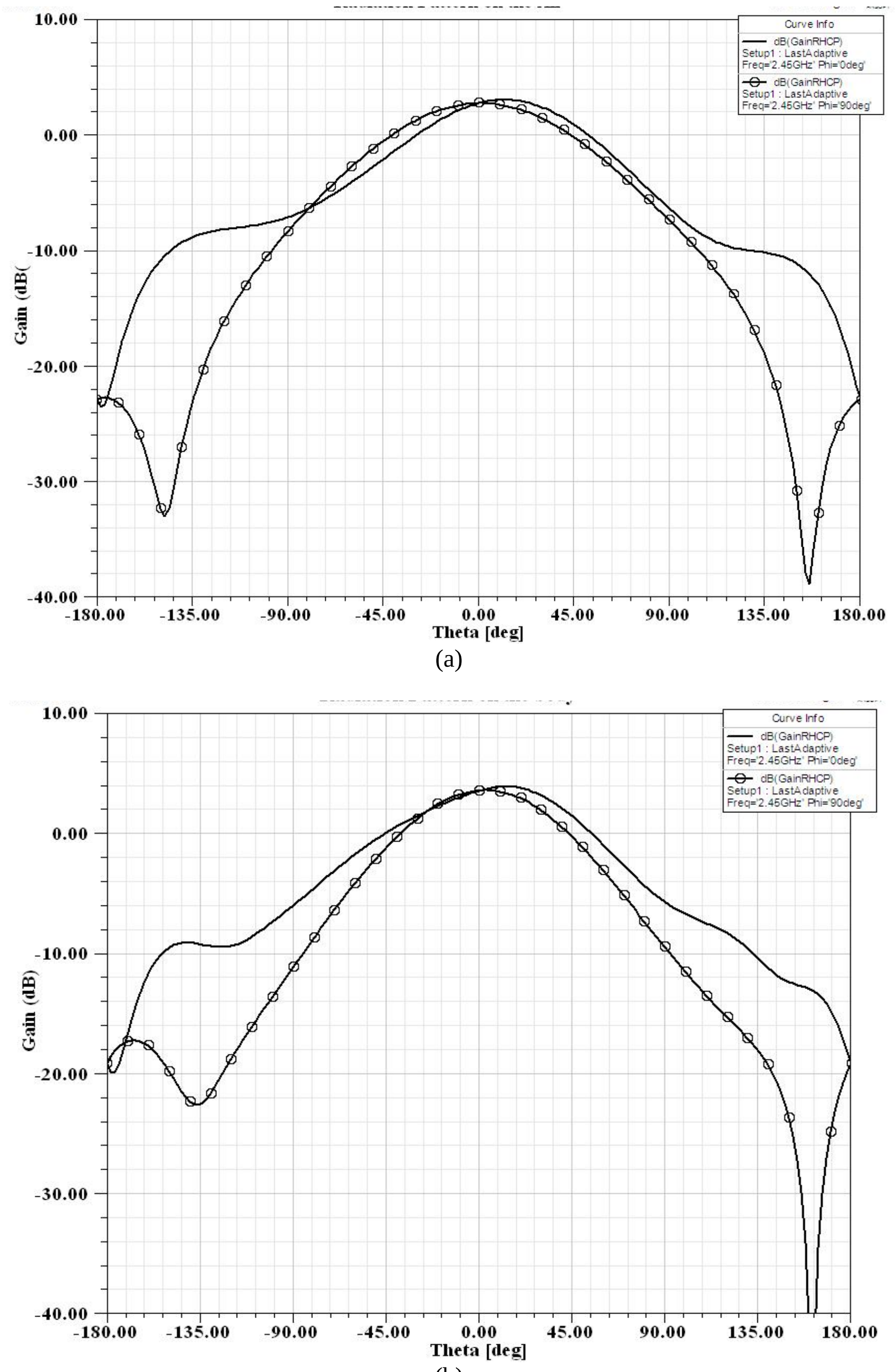
Figure-5. Radiation pattern of the proposed antenna in (a) in air, and (b) on the human body.



(a)

(b)

Figure-6. Return losses of the rectangular patch antenna in (a) in air, and (b) on the human body.



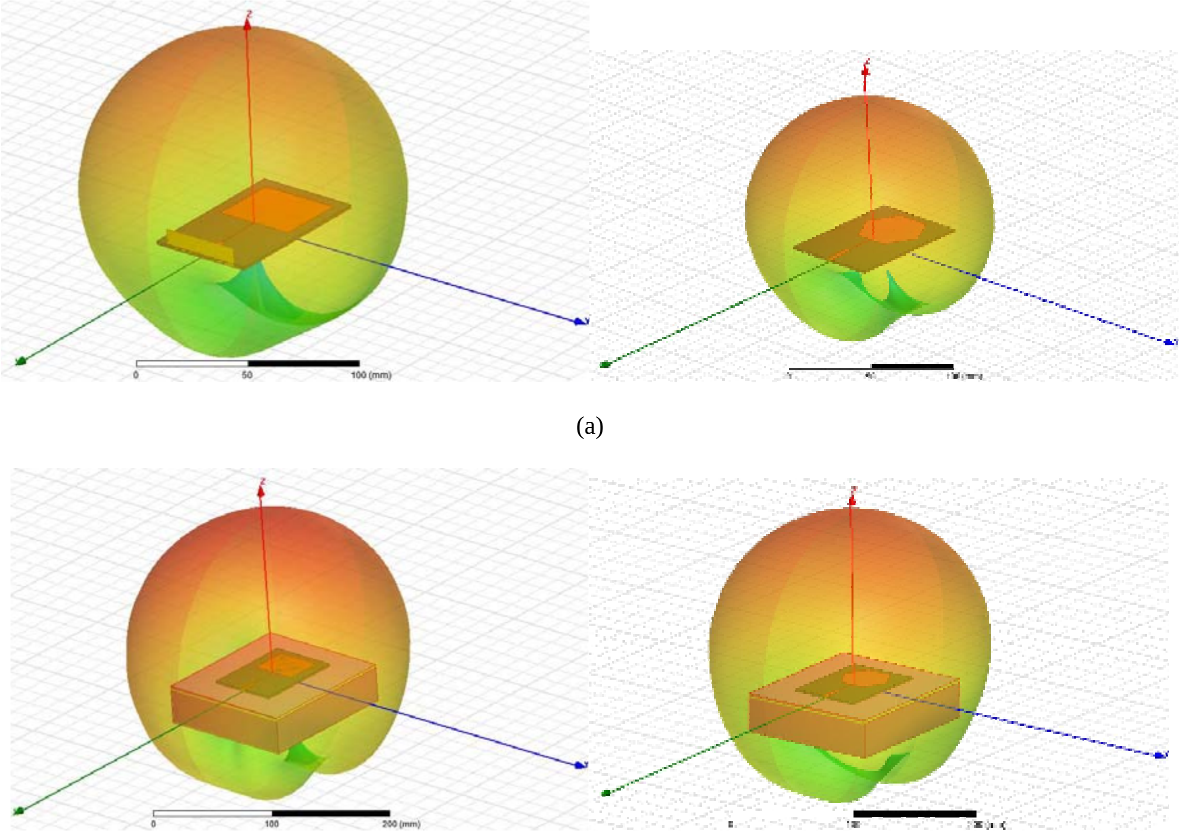
(a)

(b)

Figure-7. Radiation pattern of the rectangular antenna in (a) in air, and (b) on the human body.

Table-1. Antennas performances.

Antenna type	**On the air**				**On the human body**			
	Bandwidth (MHz)	**Max gain** (dB)		f_c (GHz)	**Bandwidth** (MHz)	**Max gain** (dB)		f_c (GHz)
		$\varphi=0^o$	$\varphi=90^o$			$\varphi=0^o$	$\varphi=90^o$	
Rectangular	34	5.74	5.26	2.43	28.7	3.88	3.56	2.44
Hexagonal	29.8	5.75	5.47	2.45	29.6	6.71	6.37	2.45



(a)

(b)

Figure-8. Radiation pattern of the rectangular and proposed antenna in (a) in air, and (b) on the human body.

CONCLUSIONS

A new antenna has been design and simulates to use in the ISM band at the center frequency of 2.45 GHz. New antenna has no significant effects in its performances when the human body is present compared with the rectangular patch microstrip antenna.

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