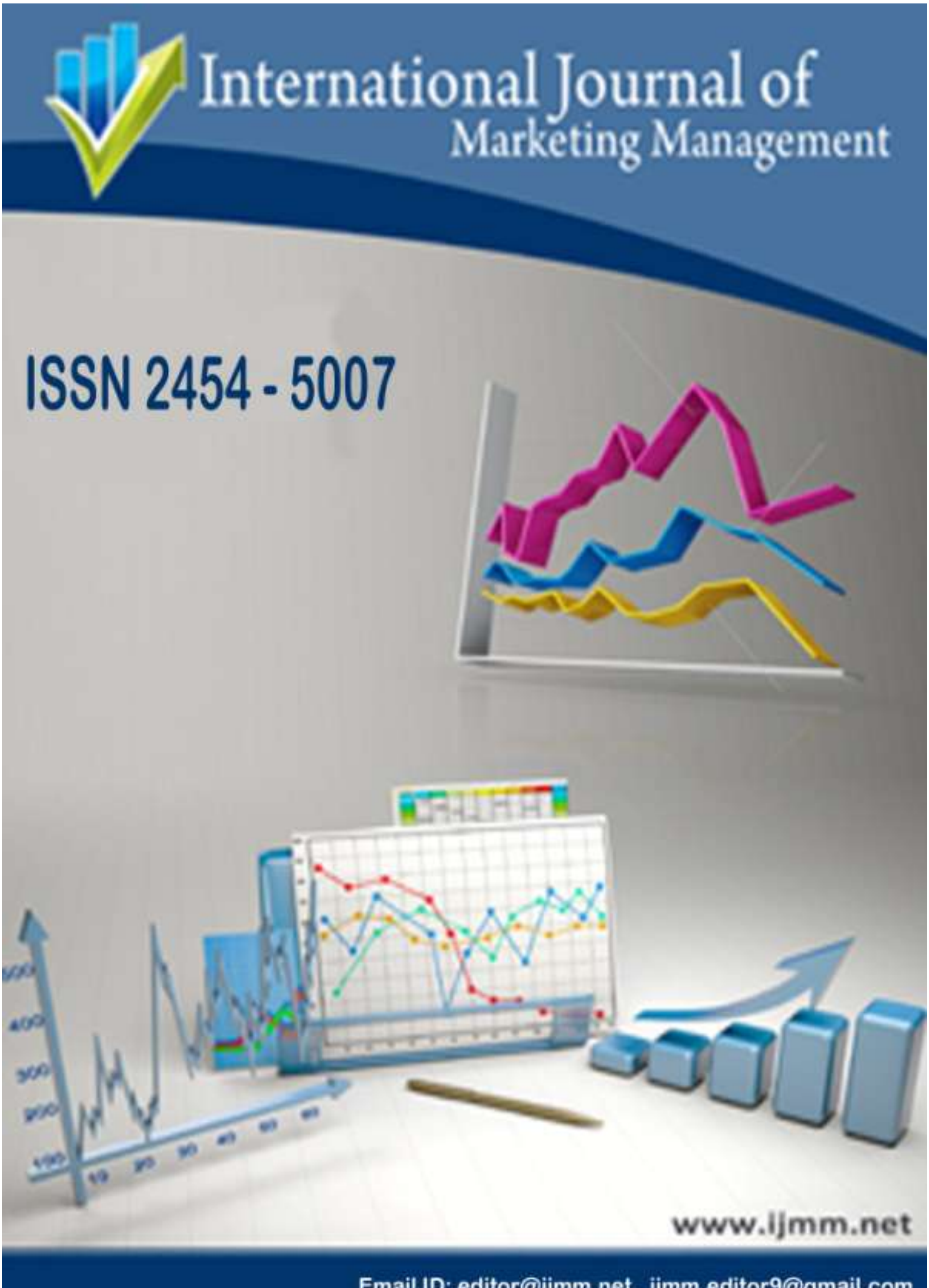


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# Design of 2 x2 Array Micro stri patch Antenna with High Gain and Directivity for RFID Reader Applications

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**Abstract**- Design and analysis of a "2x2 array microstrip patch antenna with high gain and directivity for RFID reader applications" is the primary goal of this research. In today's wireless communication systems, such as RFID (Radio Frequency identification), Mobile Communication, and healthcare, microstrip antennas play a huge role. Simple microstrip antenna arrays at 2.5GHz frequency are built with one RT/duroid-5880 (r1=2.2) and another C foam material as multilayered substrates to address the issue of poor gain. Dielectric constant (r2) = 1.03 for C-foam material, which has a dielectric constant comparable to air. Coaxial probe feeding is used to match the array antenna to the parallel feed network, which has a symmetric construction and is fed by a T-type power distributer. To evaluate the proposed antenna's performance, HFSS software measures the return loss, voltage-to-signal ratio (VSWR), gain, and directivity. The proposed antenna has a maximum gain of 14.34dB, a bandwidth of 290MHz, and a relative bandwidth of 11.6 percent based on the simulation results.

**Keywords**-MicrostripPatchantenna,airsubstrate,RFID,HighGain

## I.**INTRODUCTION**

Radio frequency identification (RFID) is a form of automatic identification that does not require the reader to come into direct contact with the electronic tag being read. Electronic tags are automatically identified and exchanged via radio frequency signals. Low Frequency (LF) 120 to 150 kHz, High Frequency (HF) up to 13.56 MHz, Ultra High Frequency (UHF) 433MHz, ISM band 865-868 MHz (Europe) 902-928 MHz (North America), Microwave (2.45-2.80 GHz) and Ultra Wide band 3.1-10GHz are the four main frequency bands used by RFID devices. An RFID device can be used in a wide range of applications ranging from electronic toll collection to access control and animal tracking [1–2].A reader or interrogator is a device that reads data from an RFID tag or transponder. The reader emits a radio signal through the antenna in RFID system functioning. This electromagnetic energy powers and transmits the data stored in any passive transponders or electronic tags travelling through it [1,2]. As depicted in figure 1, the RFID tag and reader communicate via a predeterminedprotocol.


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**Figure1showstheRFID systemcomponentsandoperation[4].**

The reader antenna is a critical component of an RFID system that has an impact on its overall performance. In constructing RFID systems, microstrip patch antennas are frequently utilized due of their low profile, tiny size, light weight, and ease of fabrication. When installed on solid surfaces, these antennae can be mounted on planar or non-planar surfaces with excellent strength and flexibility. To address the telecommunications needs of the aviation, aerospace, and military industries, several research have been conducted to optimize microstrip antennas. Low gain, polarization purity, narrow bandwidth, and dielectric material losses limit the use of microstrip antennas. The typical gain of a microstrip antenna is 6-8 dB.

This study uses a 2.5GHz microstrip patch antenna with a 2x2 array to boost the antenna's gain and directivity. As substrate, this work uses a multilayer structure with an air layer that has a dielectric constant (r) of just 1.03 and a coaxial probe feeding technique that uses a thick substrate with a low dielectric constant value. A simple antenna with good performance and a gain of 14.34 dB is developed in this study.

**LITERATUREREVIEW**

A simple 2x2 array antenna working at 2.45GHz was developed by Du Yongxing [6]. For feeder, the antenna uses coaxial wire with a simple impedance network of T-shape form. The highest possible gain is 13.9 decibels.To operate at 2.45GHz, O. Ouazzani[5] developed a 4x1 array antenna with a quarter-wave impedance matching approach and a 50-ohm microstrip feed. The resulting gain is 8.36 dB. In spite of the great size of the antenna, the obtained gain is extremely poor.Using MEMS technology, Yang Liufeng [8] has created a

**Fig:2:TopandBottomviewofthedesignedantenna**

10GHz 2x2 array antenna with low resistivity silicon sandwiched between high resistivity silicon to make a double-layered silicon substrate. The overall increase is 10.9 dB.FR-4 material with a dielectric constant of 4.9 was used by Norfishah Ab Wahab [10] to create a 4x1 array antenna with quarter wave impendence matching and feed that operates at 2.5GHz. Microstrip line with a 50 ohm impedance. Because of the antenna's size, the gain is only 5.732 dB.With the help of the network feed, Chen Jianjun [7] built a four-unit microstrip array antenna with two identical angles of cut, using two substrate layers of air and an air/RT/duroid-5880 power divider. Using this design, a 14.2 dB gain is attained, and the antenna construction is somewhat intricate.When operating at 2.55GHz, the antenna is fed with a coaxial probe to achieve maximum gain of 14.34 dB and minimum return loss of 34.10%. This antenna is developed using multi-layered substrate and coaxial probe feeding technology..

## II. ANTENNADESIGNSTRUCTURE

A dielectric substance with permittivity values ranging from 2.2r 12 separates the radiating patch on one side from the ground plane on the other, forming a Microstrip patch antenna. The low profile, light weight, and conformability to planar and non-planar surfaces of Microstrip patch antennas are the primary reasons for its use in RFID technology. Microstrip patch antennas rely heavily on dielectric materials for their construction. Gold or copper-based patches can be found in a variety of forms and sizes depending on the design. [3] A photo etched dielectric substrate is used to create the radiating patch.].

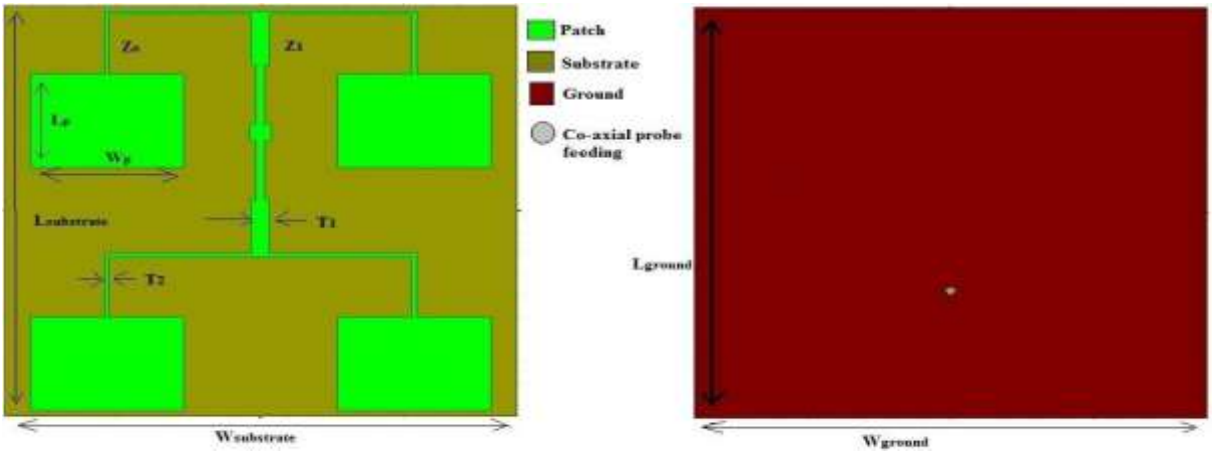


Figure 2 depicts the two-by-two arrangement of the antenna's rectangular patch elements, which makes up the antenna's overall shape. Using a dielectric substrate, a patch is produced and ground on one side of the substrate.

As illustrated in figure 3, the dielectric substrate has a thickness of h = 6.6mm and is composed of two materials stacked on top of each other. An RT/duroid-5880 substrate of (r1) = 2.22, loss tangent tan- = 9.10-4, and thickness h1 = 2.22 millimeters is present below the patch. Second, a low-density C-foam [12] substrate is used to support it. dielectricconstant(εr2)=1.03andthicknessh2=4.4mm.C-foammaterialisselectedbecauseofit dielectric constant valueclose toair.Sothis dielectricmaterial actsasair

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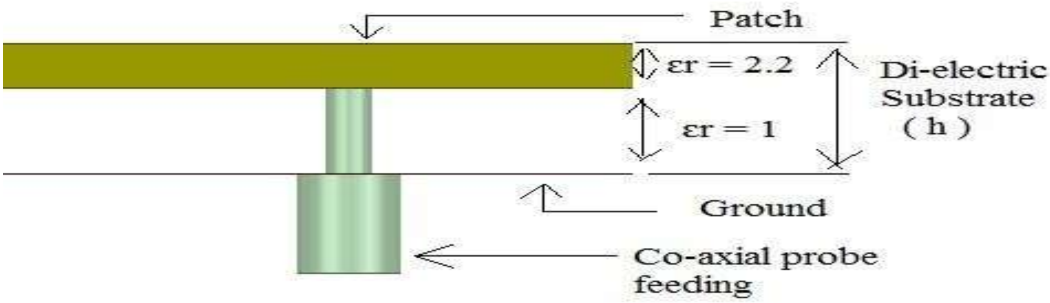
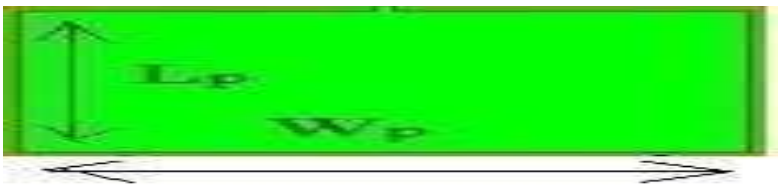



Fig:3:Sideviewofthedesignedantenna

The designed antenna dimensions are calculated using the standard formulae [3]. Single patchdimensions width ($w$) andlength ($L$) ofthe patch arecalculated usingequations(1)and (5).




$w$=$c$ +($gr$−1)⁄(√1+12$h$)

2$f$

2 (2)

√

$gr$+1 $reff$ 2 2 $w$

(1)

$\epsilon$ =$gr$+1 $Leff$

= $c$
$2f\sqrt{\epsilon_{reff}}$

(3)

ΔL=0.412$h$(

$\epsilon_r$+0.3 ($h$+0.264)

(4)

($\epsilon_r$−0.258)

$w$
($h$+0.8)

$L=L_{eff}-2\Delta L$ (5)
$L_{substrate}=6h+L$ (6)
$w_{substrate}=6h+w$ (7)

$L_f$

$Z$

= $L$
$2\sqrt{\epsilon_{reff}}$

= 60

(8)

ln[8$h$+$w_f$] (9)

$o$ $\sqrt{\epsilon_{reff}}$

$w_f$ 4$h$

Where $w$ = Width of thepatch
$L$ = Lengthofthepatch

$\epsilon_r$
h =
= Dielectricconstantvalue ofthesubstrate
ThicknessorHeightoftheSubstrate
$\epsilon_{reff}$ = EffectiveDielectricconstantvalue
$\Delta L$ = ExtensioninLengthduetofringingeffect
$L_{eff}$ = EffectiveLength
$L_{substrate}$ = LengthoftheSubstrate
$w_{substrate}$ = Widthof theSubstrate
$L_f$ = Lengthofthefeed line
$Z_o$ = Impendence
$f$ = ResonantFrequency
$c$ = SpeedofLight

**Thecalculatedpatch andsubstrate dimensions areasshowninTable1.**
**Table1:dimensionsof thedesignedantenna**

| Variables | Values(inmm) |
|---|---|
| Lp | 47 |
| Wp | 36 |
| $L_{substrate}$ | 190 |
| $W_{substrate}$ | 180 |
| $T_1$ | 6.5 |
| $T_2$ | 1.5 |
| $L_{ground}$ | 190 |

| | |
|---|---|
| Wground | 180 |
| H | 6.6 |
| h1 (εr1 =2.2) | 2.2 |
| h2 (εr2 =2.2) | 4.4 |

Each of the four patch elements in the planned antenna is spaced appropriately apart from the next. As depicted in figure 2, the parallel feed network is achieved using a T-type power distributor with Zo = 100 ohm and Z1 = 50 ohm, respectively. Using HFSS (High Frequency Structure Simulator) software, a co-axial probe feeding technique is employed to simulate and analyze the antenna performance.

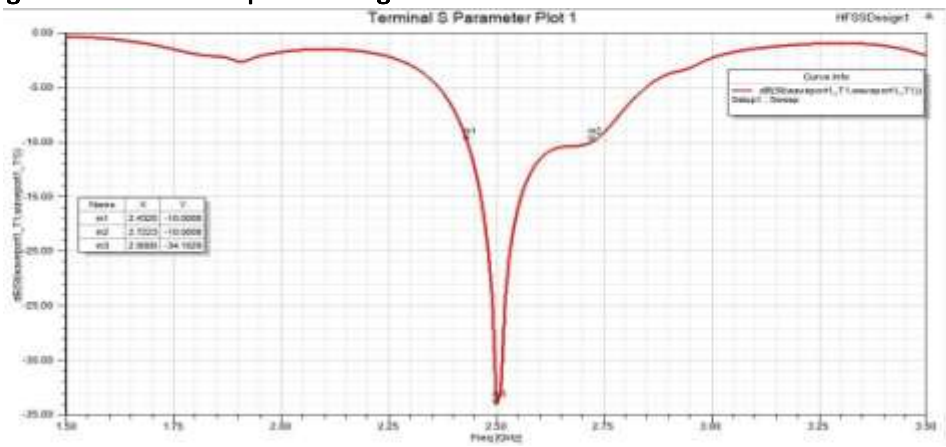
III.**SIMULATIONRESULTS**

A 2.5GHz microstrip patch antenna with a 2x2 array has been built and simulated in this section. With the help of HFSS software, we investigate Return Loss, VSWR, Gain, and Directivity results.

\S11: a. Return Loss

Optical fiber or transmission line discontinuity can cause a signal to lose power owing to return loss. To avoid signal degradation, return loss should be minimized. Figure 5 shows that the antenna's return loss is -34.1029 dB. Proof that the antenna's return loss is minimal.

**Fig5Return LossorS11plotof designedantenna**




To determine the antenna's bandwidth, we used (10) at -10dB, as shown in Figure 5. This antenna has a 290 MHz bandwidth.

-10dB Bandwidth (BW) = f(max)-f(min) (10)

Standing Wave Ratio (VSWR) of a voltage source

Both input impendence and VSWR Value are used to measure an antenna's ability to adapt to its environment. In order to use this antenna, you must have a VSWR less than 2. Figure 6 shows the VSWR graph. At 2.5GHz, the final value is 0.3426. In this way, we can conclude that the antenna array and coaxial probe input are well-matched.

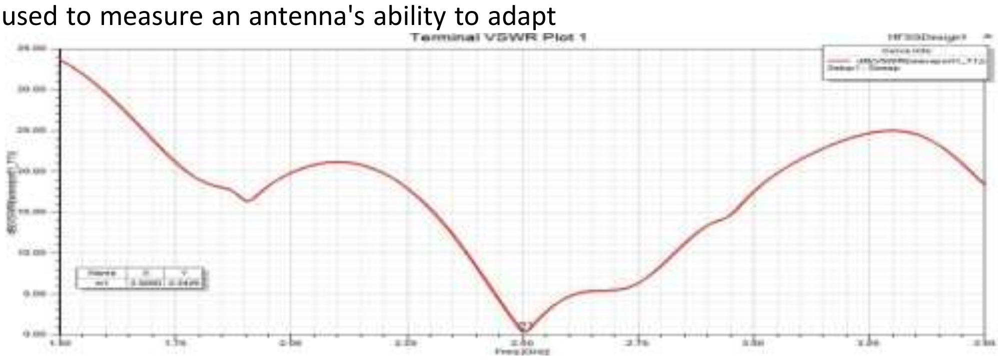



**Fig6VSWR plot**

**a. GainandDirectivity:**

In radio, gain is a measure of antenna directionality. For example, while an isotropic antenna can transmit energy in all directions, a practical antenna can transmit only one direction. Figure 7 shows the gain plot in 2D and 3D formats. The antenna's gain is 14.3450 dB, or 14.3450 percent.

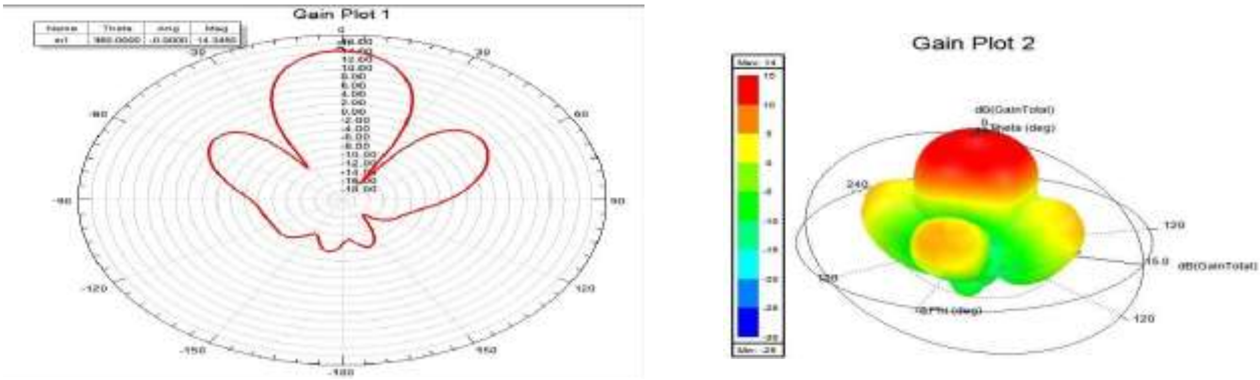



Fig7Gainplotin2Dand3Drepresentationfordesignedantenna

Directivity is the ratio of Radiation intensity in a specific direction from the antenna to the average Radiation intensity in all the directions.. The 2D representation of an antenna's gain is derived from a slice of its 3D directivity, which is a representation of its radiation in three dimensions. It is displayed in Figure 8 and the maximum value achieved is 14dB in directivity.

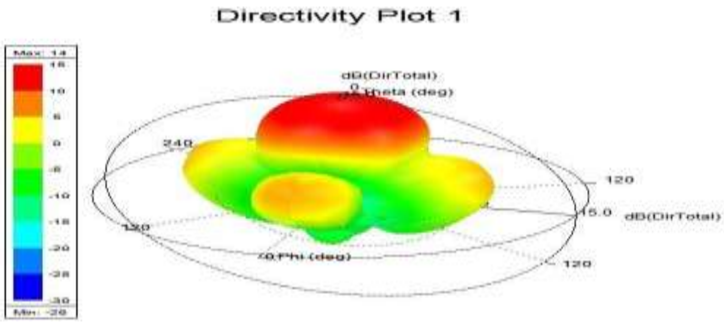



Fig8Directivityplot ofarrayantenna

It's clear from the array antenna's gain and directivity numbers that it has a significant advantage over the other designs in table 2. It can be observed that the antenna's structure is simple, but it has a high gain and excellent adaptation.

Table2:comparisonwithotherworks

| **Parameters/article** | DuYongxing[6] | InthisProposedarticle |
|---|---|---|
| Design | 2x2arrayantenna | 2x2arrayantenna |
| Returnloss | -23.7dB | -34.1029dB |
| VSWR | VSWR<2.0: 1 | VSWR =0.3426 |
| Gain | 13.9 dB | 14.3450 dB |

IV. **CONCLUSION**

Microstrip patch antennas operating at 2.5 GHz with a basic structure were the focus of this investigation. A T-type power distributor and a coaxial probe feed the simple construction. HFSS software is used to evaluate the antenna's return loss, VSWR, gain, and directivity. The antenna's modeling results reveal a maximum gain of 14.34dB, a bandwidth of 290MHz, and a relative bandwidth of 11.6 percent. Because of its simple structure, large gain, and good adaption capabilities, the suggested antenna can be used in RFID systems to improve their performance.

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There is a lot of information about the ANSYS+HFSS software at http://ansys.com
C-foam-pf-2 and pf-4.html [12].