FREQUENCY RECONFIGURABLEANTENNA FOR WIRELESS APPLICATIONS

A.Rajasekhar[1],SK.Sadhika yaseen[2],R.Kumar[3],U.Harikrishna[4],T.Devendra babu[5]

Assistant Professor[1],Students[2,3,4,5]

Electronics and Communication Engineering

N.B.K.R Institute of Science and Technology,Andhra Pradesh,India

ABSTRACT:ISM (Industrial, Scientific and Medical) band was being allocated to Industry, Science and Medical fields but later on various applications such as Wi-Fi, Bluetooth, cordless phone etc. It has been allowed to use ISM band frequencies. However, due to small size and weight microstrip patch antenna become dominant in this field from last few years. Reconfigurable antennas are able to dynamically modify its frequency and radiation properties. A low profile Frequency reconfigurable antenna for different ISM band applications is proposed. The proposed design consists of a microstrip patch antenna with a relatively small dimension of 40mm× 16mm. Two PIN diodes are used to achieve six different operating Frequency. The antenna design uses FR-4 substrate with a dielectric constant of 4.3. The antenna can operate between the frequency range of 1GHz to 5GHz. The design and simulation are done using CST software.

KEYWORDS: ISM,Reconfigurable,CST,FR4,Mcrostrip Patch

I.INTRODUCTION:

Reconfigurable antenna is an antenna which is capable of reconfiguring its characteristics such as frequency, radiation pattern and polarization to adapt the environment. Reconfigurable antenna is highly desirable antenna as it is useful for a wireless communication system which has different standards and multi-frequency applications. In the last 10-12 years, wireless communication technology and its application like Bluetooth, Wi-Fi, GPS, WLAN, and many others have demonstrated miraculous evolution. The reconfigurable antenna obtains wide bandwidth by using different ON and OFF switching conditions. Normally the switching condition can be achieved using PIN diode, RF MEMS switch, and varactor diode. Though varactor diode and RF MEMS switch have advantages like low insertion loss and Q-factor, the fabrication is difficult and expensive.

MICROSTRIP PATCH ANTENNA:

Heinrich Hertz demonstrated the microstrip antenna in 1886. Microstrip antennas are also named as “Printed Antennas.” In recent days, Microstrip antennas find application in different wireless standards. It has prominent features such as small figure, little weight, small volume, inexpensive, uniformity to planar and non-planar surfaces, rigorous and quickly integrated on printed circuit board. The microstrip antenna consists of three layers. The bottom layer is the ground plane, and the top layer is the patch with a dielectric substrate is placed between these layers. The range of dielectric constants of the substrate used in the design is 2.2 << 12. Copper is mostly used as a radiating material for patch and ground plane. The patch antenna has different form and size such as rectangular, square, dipole, circular, triangular, circular ring, elliptical. Excitation to antenna are provided using several types of feeding techniques. The most common are proximity coupled feeding, co-axial feeding, aperture coupled feeding and microstrip line feeding. Microstrip line feeding is the most commonly chosen feeding technique as it is easy to fabricate.

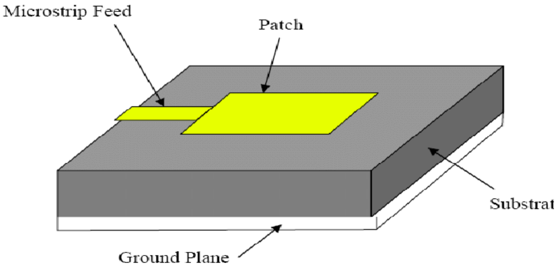


Figure 1: Microstrip Patch Antenna

RECONFIGURATION TYPES

The design of reconfigurable antennas is adopted using different methods based on the reconfiguration techniques as well as the properties of each reconfiguration. There are 4 main categories under which reconfigurable antenna are assorted on the basis their reconfigurability function

- **Frequency reconfigurable antenna**

Antennas under this group can change their frequency of operation based on the user's demand. They reconfigure their operation to function multiple frequency bands. Such antennas are widely useful in wireless communication applications that require a change in operating frequencies and to switch from one channel into another. Cognitive radio is an example application for this antenna group.

- **Radiation pattern reconfigurable antenna**

Antennas under this group can change their radiation pattern while maintaining a fixed frequency of operation. These antennas reshape their radiation patterns to block a signal or to allow radiation in a certain predetermined direction. Mobile antenna systems can be proposed as examples of such an antenna group.

- **Polarization Reconfigurable Antenna**

Antennas under this group can change their polarization type while maintaining their fixed frequency and radiation pattern. These antennas reshape their radiation characteristics to exhibit multiple polarization schemes. Multiple input multiple-output (MIMO) channels are application examples of such antenna group.

- **Hybrid reconfiguration antenna**

Antennas under this group can simultaneously change multiple characteristics in their operation. These antennas can, for example, change their operating frequency as well as their polarization scheme for each frequency of interest. They can also reshape their radiation pattern while changing their operating frequencies or polarizations.

RECONFIGURATION TECHNIQUES

Several reconfiguration techniques are proposed ever since the conspicuous rise of reconfiguration antenna. Reconfiguration techniques are selected depending on the properties of reconfigurable antenna. Considering the constraints, a suitable reconfiguration technique is selected by the antenna designer. The four main reconfiguration techniques proposed are

a) Electrical reconfiguration technique

b) Optical reconfiguration technique

c) Mechanical reconfiguration technique

d) Material change reconfiguration technique

II.ANTENNA DESIGN EQUATIONS

The essential parameters for the design of a rectangular Microstrip Patch Antenna are:

1.Calculation of width (W)

$$Wp = \frac{C_0}{2f_r}\sqrt{\frac{2}{1+\varepsilon}}$$

W - Width of the patch

C_o - Speed of light (3×108m/s)

Ɛ - Value of the dielectric substrate

2. Calculation of effective Dielectric constant (ε_{ref})

$$\varepsilon_{\mathrm{ref}} = \frac{\varepsilon+1}{2} + \frac{\varepsilon-1}{2}\left[1 + 12\frac{h}{w}\right]^{-\frac{1}{2}}$$

Where,

W - Width of the patch

3. Calculation extension Length

It is used for calculating resonant frequency of Microstrip antenna.

$$\Delta L = 0.412\frac{(\varepsilon+0.3)\left(\frac{Wp}{h}-0.264\right)}{(\varepsilon-0.258)\left(\frac{Wp}{h}-0.8\right)}$$

Where,

W_p- Width of the patch

4. Calculation of Length (L)

Effective Length (Leff):

Actual Length (L):

$$L_{eff} = \frac{V_f}{2f*\sqrt{\varepsilon}}$$

$$L = L_{eff} - 2\Delta L$$

Where,

ε_{ref}- Effective dielectric constant

III.SIMULATION RESULTS:

1.RETURN LOSS VS FREQUENCY

The Figures in this section shows the corresponding return loss result against frequency. The simulated return loss for all the frequency bands are less than -10dB.

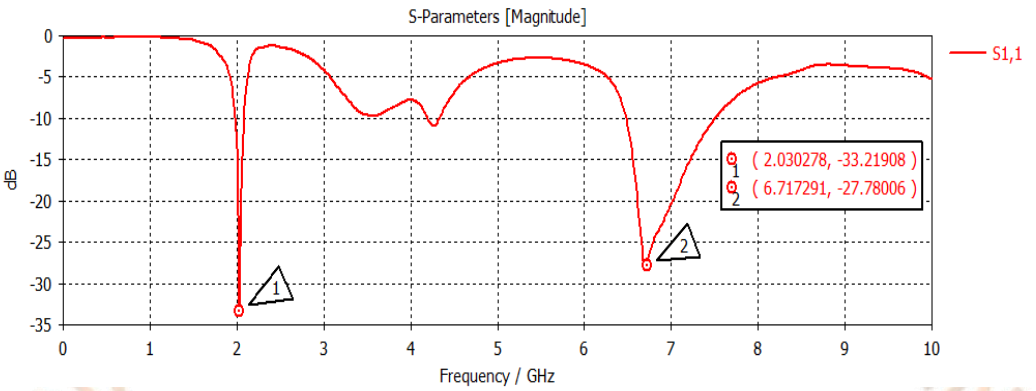


Fig. 1: Return loss VS Frequency at Case-1=> D1=off D2=off

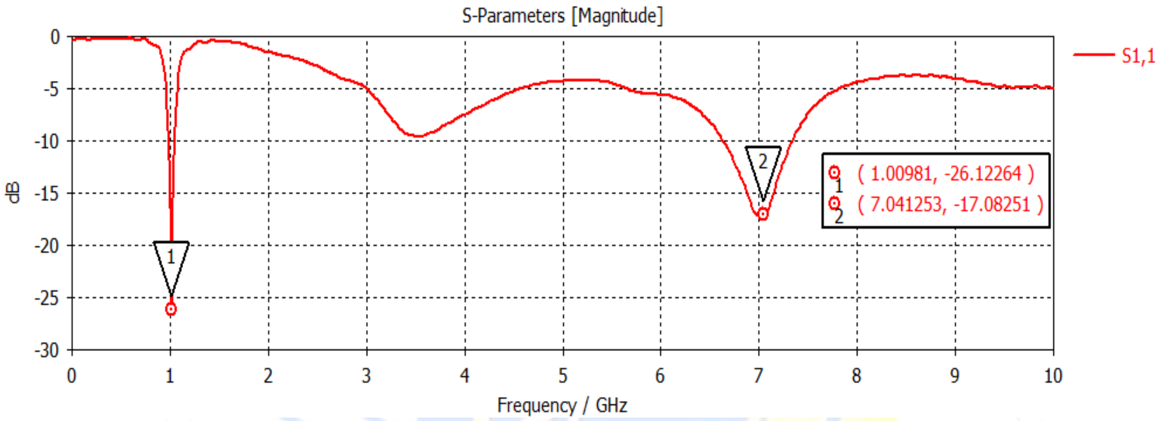


Fig. 2: Return loss VS Frequency at Case-1=> D1=off D2=on

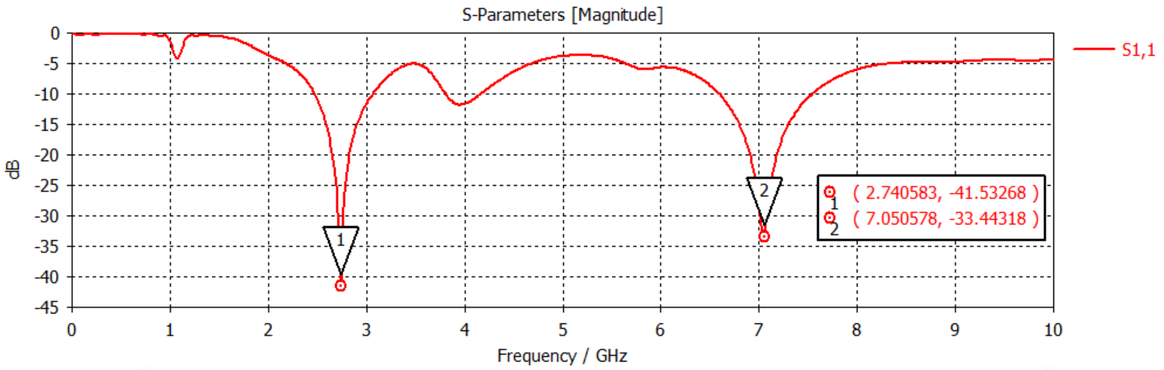


Fig. 3: Return loss VS Frequency at Case-1=> D1=on D2=off

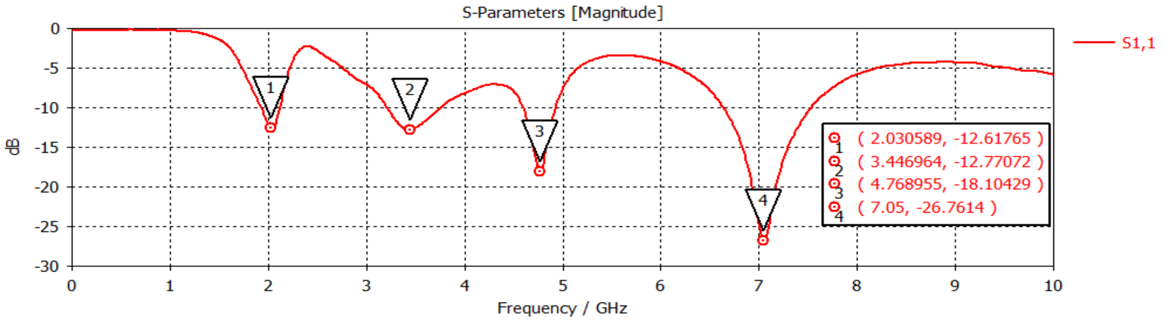


Fig. 4: Return loss VS Frequency at Case-1=> D1=on D2=on

Six different frequencies are achieved using this antenna based on ON and OFF state of the two diodes. The details of switching configuration are given in the table below:

Frequency	D1	D2
F1= 2 GHz F2= 6.7 GHz	OFF	OFF
F3= 1GHz F4=7 GHz	OFF	ON
F5= 2.7 GHz F4= 7 GHz	ON	OFF
F6= 4.7 GHz F4= 7 GHz	ON	ON

Table 1: Details of switching configuration

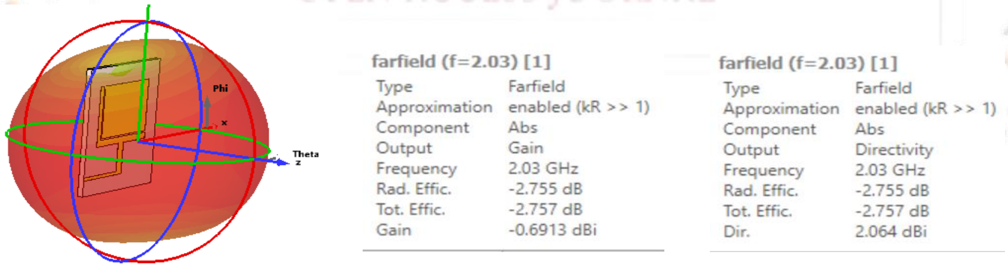
The below table summarizes Operating Frequency, Return loss and Directivity of the designed antenna.

Frequency Configuration	Simulated Frequency (GHz)	Return loss (dB)	Gain (dBi)	Directivity (dBi)
F1	2	-33.21	-0.69	2.06
F2	6.7	-27.7	2.46	5.46
F3	1	-26.12	-8.3	1.59
F4	7	-17.08	1.89	4.46
F5	2.7	-41.53	1.56	2.76
F6	4.7	-18.10	2.64	6.22

Table 2: Operating Frequency, Return loss and Directivity of proposed antenna

RADIATION PATTERN:

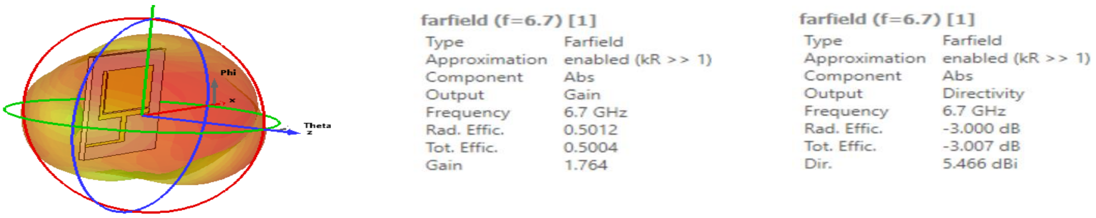
The following Figures shows simulated radiation pattern results for eight different frequencies.



```
farfield (f=2.03) [1]
Type            Farfield
Approximation   enabled (kR >> 1)
Component       Abs
Output          Gain
Frequency       2.03 GHz
Rad. Effic.     -2.755 dB
Tot. Effic.     -2.757 dB
Gain            -0.6913 dBi
```

```
farfield (f=2.03) [1]
Type            Farfield
Approximation   enabled (kR >> 1)
Component       Abs
Output          Directivity
Frequency       2.03 GHz
Rad. Effic.     -2.755 dB
Tot. Effic.     -2.757 dB
Dir.            2.064 dBi
```

Fig. 1: Simulated 3D Radiation pattern, Gain & Directivity at F=2.03 GHz & Case-1=> D1=off D2=off



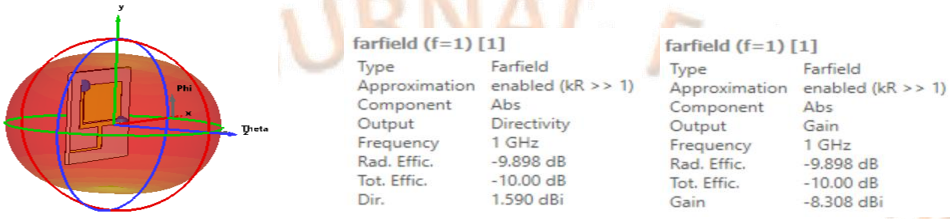
farfield (f=6.7) [1]

Type	Farfield
Approximation	enabled (kR >> 1)
Component	Abs
Output	Gain
Frequency	6.7 GHz
Rad. Effic.	0.5012
Tot. Effic.	0.5004
Gain	1.764

farfield (f=6.7) [1]

Type	Farfield
Approximation	enabled (kR >> 1)
Component	Abs
Output	Directivity
Frequency	6.7 GHz
Rad. Effic.	-3.000 dB
Tot. Effic.	-3.007 dB
Dir.	5.466 dBi

Fig. 2: Simulated 3D Radiation pattern, Gain & Directivity at F=6.7 GHz & Case-1=> D1=off D2=off



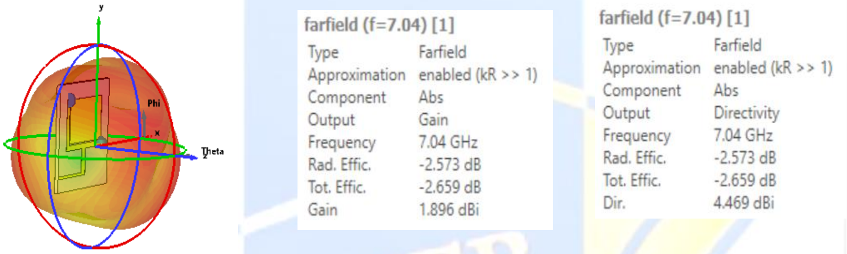
farfield (f=1) [1]

Type	Farfield
Approximation	enabled (kR >> 1)
Component	Abs
Output	Directivity
Frequency	1 GHz
Rad. Effic.	-9.898 dB
Tot. Effic.	-10.00 dB
Dir.	1.590 dBi

farfield (f=1) [1]

Type	Farfield
Approximation	enabled (kR >> 1)
Component	Abs
Output	Gain
Frequency	1 GHz
Rad. Effic.	-9.898 dB
Tot. Effic.	-10.00 dB
Gain	-8.308 dBi

Fig. 3: Simulated 3D Radiation pattern, Gain & Directivity at F=1 GHz & Case-1=> D1=off D2=on



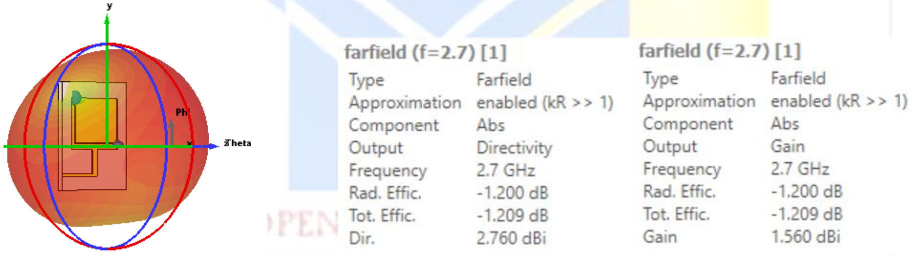
farfield (f=7.04) [1]

Type	Farfield
Approximation	enabled (kR >> 1)
Component	Abs
Output	Gain
Frequency	7.04 GHz
Rad. Effic.	-2.573 dB
Tot. Effic.	-2.659 dB
Gain	1.896 dBi

farfield (f=7.04) [1]

Type	Farfield
Approximation	enabled (kR >> 1)
Component	Abs
Output	Directivity
Frequency	7.04 GHz
Rad. Effic.	-2.573 dB
Tot. Effic.	-2.659 dB
Dir.	4.469 dBi

Fig.4 : Simulated 3D Radiation pattern, Gain & Directivity at F=7.04 GHz & Case-1=> D1=off D2=on



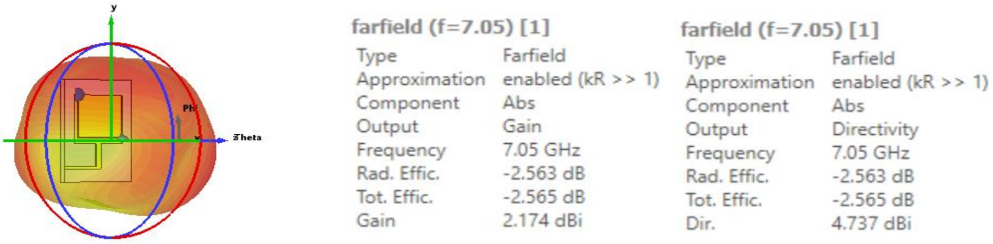
farfield (f=2.7) [1]

Type	Farfield
Approximation	enabled (kR >> 1)
Component	Abs
Output	Directivity
Frequency	2.7 GHz
Rad. Effic.	-1.200 dB
Tot. Effic.	-1.209 dB
Dir.	2.760 dBi

farfield (f=2.7) [1]

Type	Farfield
Approximation	enabled (kR >> 1)
Component	Abs
Output	Gain
Frequency	2.7 GHz
Rad. Effic.	-1.200 dB
Tot. Effic.	-1.209 dB
Gain	1.560 dBi

Fig.5: Simulated 3D Radiation pattern, Gain & Directivity at F=2.7 GHz & Case-1=> D1=on D2=off



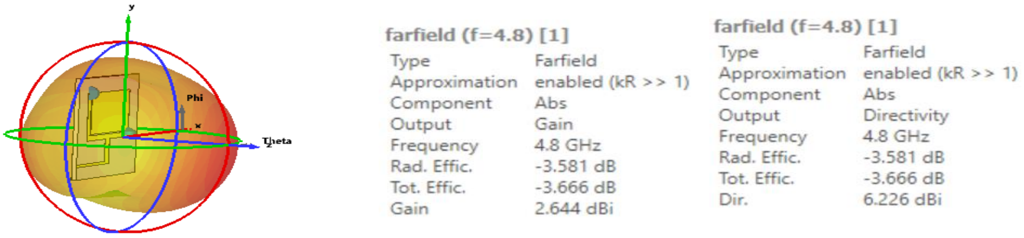
farfield (f=7.05) [1]

Type	Farfield
Approximation	enabled (kR >> 1)
Component	Abs
Output	Gain
Frequency	7.05 GHz
Rad. Effic.	-2.563 dB
Tot. Effic.	-2.565 dB
Gain	2.174 dBi

farfield (f=7.05) [1]

Type	Farfield
Approximation	enabled (kR >> 1)
Component	Abs
Output	Directivity
Frequency	7.05 GHz
Rad. Effic.	-2.563 dB
Tot. Effic.	-2.565 dB
Dir.	4.737 dBi

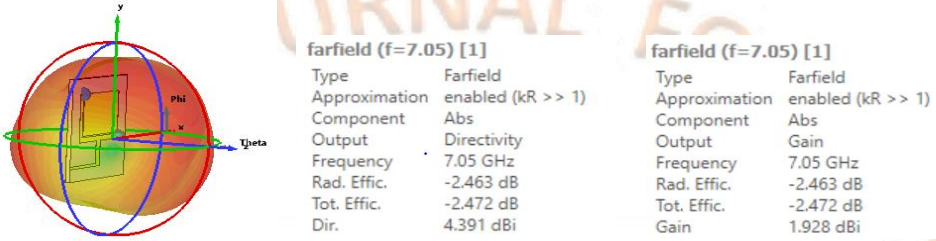
Fig. 6: Simulated 3D Radiation pattern, Gain & Directivity at F=7 GHz & Case-1=> D1=on D2=off



```
farfield (f=4.8) [1]
Type            Farfield
Approximation   enabled (kR >> 1)
Component       Abs
Output          Gain
Frequency       4.8 GHz
Rad. Effic.     -3.581 dB
Tot. Effic.     -3.666 dB
Gain            2.644 dBi
```

```
farfield (f=4.8) [1]
Type            Farfield
Approximation   enabled (kR >> 1)
Component       Abs
Output          Directivity
Frequency       4.8 GHz
Rad. Effic.     -3.581 dB
Tot. Effic.     -3.666 dB
Dir.            6.226 dBi
```

Fig. 7: Simulated 3D Radiation pattern, Gain & Directivity at F=4.8 GHz & Case-1=> D1=on D2=on



```
farfield (f=7.05) [1]
Type            Farfield
Approximation   enabled (kR >> 1)
Component       Abs
Output          Directivity
Frequency       7.05 GHz
Rad. Effic.     -2.463 dB
Tot. Effic.     -2.472 dB
Dir.            4.391 dBi
```

```
farfield (f=7.05) [1]
Type            Farfield
Approximation   enabled (kR >> 1)
Component       Abs
Output          Gain
Frequency       7.05 GHz
Rad. Effic.     -2.463 dB
Tot. Effic.     -2.472 dB
Gain            1.928 dBi
```

Fig. 8: Simulated 3D Radiation pattern, Gain & Directivity at F=7 GHz & Case-1=> D1=on D2=on

IV:CONCLUSION:

A Frequency reconfigurable antenna with two PIN diodes which can be used for different ISM band applications is presented. Frequency reconfigurable antenna can change their frequency of operation based on the user’s demand. They reconfigure their operation to function in multiple frequency bands. Such antennas are widely useful in ISM band applications that require a change in operating frequencies and to switch from one channel into another. The presented antenna is compact and can operate at siX different frequencies. The parameters such as frequency, return loss, directivity and gain are also analysed. The antenna is designed and simulated using CST software. The proposed antenna finds application in wireless microphones, baby monitors, garage door openers, wireless doorbells, keyless entry systems for vehicles, radio control channels for UAVs (drones), wireless surveillance systems, RFID systems for merchandise, and wild animal tracking systems.

REFERENCES:

[1] ZhenghangNie, HuiqingZhai, Longhua Liu, Jiaxu Li, DiweiHu, Junhao Shi, ***“A Dual-Polarized Frequency-Reconfigurable Low-Profile Antenna With Harmonic Suppression for 5G Application”***, IEEE Antennas and Wireless Propagation Letters (Volume: 18, Issue: 6, June 2019)

[2] Guiping Jin, Chuhong Deng, Yechun Xu, Ju Yang; Shaowei Liao, ***“Differential Frequency-Reconfigurable Antenna Based on Dipoles for Sub-6 GHz 5G and WLAN Applications”***, IEEE Antennas and Wireless Propagation Letters (Volume: 19, Issue: 3, March 2020)

[3] Tauseef Siddiqui, Prabhat Khanal, Jari Holopainen,Ville Viikari, ***“Broadband Transponder Based on Frequency-Reconfigurable Cluster Antenna and Phased Modulators”***, IEEE Antennas and Wireless Propagation Letters (Volume: 19, Issue: 2, Feb. 2020)

[4] Laurens A. Bronckers, Anne Roc’h, Adrianus B. Smolders,***“A New Design Method for Frequency-Reconfigurable Antennas Using Multiple Tuning Components”***, IEEE Transactions on Antennas and Propagation (Volume: 67, Issue: 12, Dec. 2019)

[5] Muhammad Ikram, Emad Al Abbas, Nghia Nguyen-Trong, Khalil H. Sayidmarie; Amin Abbosh,**"*Integrated Frequency-Reconfigurable Slot Antenna and Connected Slot Antenna Array for 4G and 5G Mobile Handsets*",** IEEE Transactions on Antennas and Propagation (Volume: 67, Issue: 12, Dec. 2019)

[6] RajeshKumarSingh, AnanjanBasu, ShibanKishenKoul, **"*Reconfigurable Microstrip Patch Antenna With Polarization Switching in Three Switchable Frequency Bands*"**, IEEE Access (Volume 8) Date of Publication: 29 June 2020

[7]NiamatHussain,WahajAbbasAwan,SyedaIffatNaqvi, AdnanGhaffar, AbirZaidi, SyedAftabNaqvi, **"*Compact Flexible Frequency Reconfigurable Antenna for Heterogeneous Applications*"**, IEEE Access (Volume: 8) Date of Publication: 18 September 2020

[8]Sowmya Devi A, Phalguni Mathur, Anupam R Chandran,Nick Timmons, Jim Morrison, Sujith Raman **"*2.45 GHz Pattern Reconfigurable Antenna for Wireless Sensor Network applications*"** URSI AP-RASC 2019, New Delhi, India, 09 - 15 March 2019.

[9] P. Kalpana Devi,M Sujatha, **"*Design of Reconfigurable Integrated patch antenna in ISM band for IoT applications*",** J.Arun Prasath,2020 7th International Conference on Smart Structures and Systems (ICSSS), 23-24 July 2020.