



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

# IJRSET

International Journal of Innovative Research in  
**SCIENCE | ENGINEERING | TECHNOLOGY**

# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 12, Issue 4, April 2023

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

Impact Factor: 8.423

9940 572 462

6381 907 438

[ijirset@gmail.com](mailto:ijirset@gmail.com)

[www.ijirset.com](http://www.ijirset.com)

# Design and analysis of Multiple Input Multiple Output Antenna for UWB Applications

Kolla Dharaneeshwar <sup>1</sup>, Muvva Harsha Vardhan <sup>2</sup>, Myneedi Naren Rohan <sup>3</sup>, Kanneganti Lokesh <sup>4</sup>,  
Ramavath Tejaswini <sup>5</sup>

U.G. Student, Department of Electronics and Communication Engineering, Vasireddy Venkatadri Institute of  
Technology, Nambur, Guntur, Andhra Pradesh, India<sup>1,2,3,4</sup>

Assistant Professor, Department of Electronics and Communication Engineering, Vasireddy Venkatadri Institute of  
Technology, Nambur, Guntur, Andhra Pradesh, India<sup>5</sup>

**ABSTRACT:** This paper proposes a compact 1x2 MIMO antenna for Ultra-Wideband (UWB) applications. The proposed antenna operates at frequencies ranging from 3.3 to 10 GHz, making it suitable for various UWB applications. The dimension of the proposed MIMO antenna is 55x26.05 mm<sup>2</sup> and consists of two circular patches. It resonates at frequencies 4.56GHz and 6.17GHz. The isolation between the antenna elements is around 20 dB, which helps to mitigate the interference between the two antennas. The simulation results show that the proposed antenna has a wide bandwidth, good radiation characteristics, and excellent isolation between the antenna elements, indicating that it may be used in UWB applications and this antenna can also be used in various applications that require MIMO technology, such as wireless communication systems, radar systems, and medical imaging systems.

**KEYWORDS:** Envelope Correlation Coefficient, Multiple-Input-Multiple-Output antenna, Ultra-Wide Band applications.

## I. INTRODUCTION

Modern wireless communication improvements call for a system that can exchange a massive quantity of data at a high data rate, increased capacity, dependability, and security with little complexity. Ultra-wideband (UWB) technology can be used to meet these requirements. As UWB technology uses a low-cost infrastructure to deliver a high data rate, it is a possible contender for many wireless communication systems. Nevertheless, multipath propagation issues plague conventional UWB technology.

In recent years, multiple-input multiple-output (MIMO) technology has developed into a significant study topic for this reason. The results of the research demonstrate that the MIMO antenna system can meet the demands of the UWB systems. The challenge of designing such an antenna is fairly difficult since various antenna systems provide additional performance criteria. One of the crucial performance variables, mutual coupling (isolation) between the antenna elements, should be as low as feasible to prevent channel capacity loss.

Stubs between patch radiators, electromagnetic band gap (EBG) structures, frequency selective surfaces (FSS), neutralization lines between the radiator and the ground plane, defected ground structures (DGS), decoupling structures, slotted edge substrate, etc. have all been used to improve the coupling between the antenna elements. These methods have produced reasonable results in reducing coupling between the antenna parts, although it should be noted that the antenna designs have a narrow bandwidth, are huge in size, or have poor isolation (20 dB). Moreover, the designs described above either have complex structures or sophisticated decoupling mechanisms.

This study presents the design of a small 1 x 2 modified circular MIMO antenna array for UWB applications. Broad impedance bandwidth is accomplished through ground plane and radiating patch optimization. From the setup that is being shown, it can be seen that the proposed array operates between 3.3 and 10 GHz and offers around 20 dB of isolation between array components.

II. ANTENNA DESIGN

**A. Antenna Configuration:**

A small modified MIMO antenna with circular shaped patches is constructed. This antenna's total dimensions are 55 X 26.05 mm<sup>2</sup>. It features two modified patch parts that are identical. Two rectangular-shaped ground stubs are employed to ensure adequate matching and isolation. The CST simulation tool is used to simulate the proposed antenna. This antenna is constructed on a FR4 substrate (height = 1.6 mm, dielectric constant = 4.4, and loss tangent = 0.02), and a prototype snapshot is provided.

**B. Substrate:**

A great deal of work has been done on many substrates. The permittivity of substrates used in micro strip patch antennas range from 2.2 to 12. The size of the antenna increases as the permittivity of the dielectric material decreases, but the efficiency and bandwidth are improved. Performance suffers when a substrate with a higher dielectric constant is utilized. Here, FR4 lossy material with dimensions of 55 by 26.05 mm<sup>2</sup> is employed as the substrate.

**C. Ground:**

The most often used methods, particularly when it comes to reducing mutual interaction between broadband and ultra-wideband MIMO antenna components are deficient ground structures. There are several review studies on DGSs in the literature that demonstrate their significance when designing MIMO antennas. Basically, DGS is a ground plane defect that severely disrupts the distribution of surface current. The transmission line's impedance will alter as a result. By reducing the current on the ground plane, it functions as a band stop filter and suppresses the coupled fields between the nearby antenna components of the MIMO antenna. The ground for designed antenna is shown below and dimensions are given in Table 1.

**D. Patch:**

The patch design of presented antenna is shown in Fig.2. It is combination of two identical elements on the substrate where each element consisting of a circular patch connecting to the feedline. PEC (Perfect Electric Conductor) material is used for patch design. The distance between two identical patch elements is 33.50mm. The radius of the circular patch and the parameters of feedline is given in the below table.

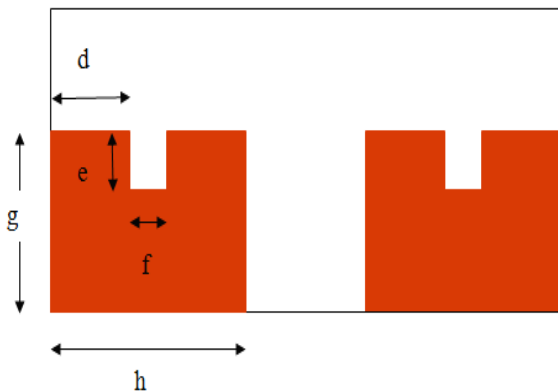


Fig 1: Ground Design

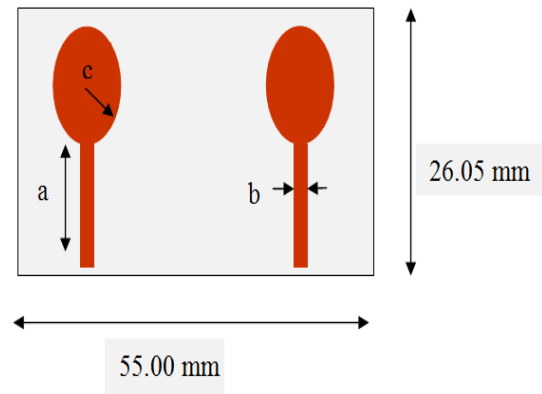


Fig 2: Patch Design

Parameter	a	b	c	d	e	f	g	h
Value(mm)	12.62	2.5	6.5	7.5	2	4	11.5	19

Table 1: Patch Design Dimensions (in mm)

E. **Finalized Design:** The finalized design of our proposed antenna is shown in Fig 3.

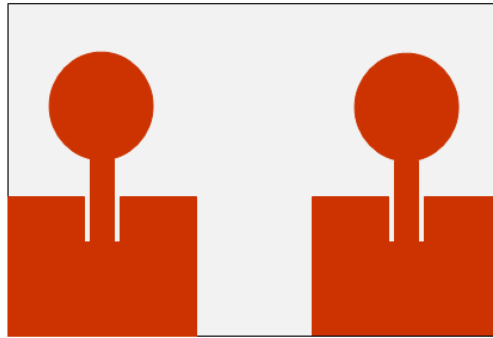


Fig 3: Finalized Design

**F: Antenna Design Equations:**

Step-1: Evaluate width 'W' of the patch using the formula.

$$W = \frac{V_0}{2f_r} \sqrt{\frac{2}{\epsilon_r + 1}}$$

Step-2: Calculate the effective dielectric constant  $\epsilon_{\text{reff}}$  of the patch using formula below.

$$\epsilon_{\text{reff}} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[ 1 + 12 \frac{h}{W} \right]^{-1/2}$$

Step-3: Calculate  $\Delta L$  using formula below.

$$\frac{\Delta L}{h} = 0.412 \frac{(\epsilon_{\text{reff}} + 0.3) \left( \frac{W}{h} + 0.264 \right)}{(\epsilon_{\text{reff}} - 0.258) \left( \frac{W}{h} + 0.8 \right)}$$

Step-4: Calculate length of the patch using formula below.  $V_0$  is speed of light in free space.

$$L = \frac{V_0}{2f_r \sqrt{\epsilon_{\text{reff}}}} - 2\Delta L$$

**III. RESULTS AND DISCUSSION**

The proposed antenna can be used for a variety of UWB applications because it operates at frequencies between 3.3 and 10 GHz. At the frequencies of 4.56GHz and 6.17GHz, it resonates. The isolation obtained is around 20 dB, which reduces interference between the two antennas. The simulation results demonstrate the suggested antenna's wide bandwidth, good radiation properties, and superior element isolation. The VSWR at 6.17GHz is 1.02. Moreover, it is 74% effective at resonate frequencies..

**A. S-Parameters:**

S-parameters can be used to characterize the performance of the antenna at each resonant frequency, which can be useful in designing and optimizing the antenna for specific applications. The proposed antenna achieved a wide

impedance bandwidth ( $S_{11} < -10$  dB) of 6.7 GHz from 3.3 to 10 GHz. The proposed antenna resonates at frequencies 4.56 and 6.17 GHz respectively. The reflection coefficient of the antenna at 4.56 GHz is -39.91dB and at 6.17 GHz is -38.19dB used in 5G communications. From the graphs of S-parameters it can be observed that the antenna system exhibits a minimum isolation of around 20dB.

For a two-port network, S-parameters are

$S_{11}$ : Input port voltage reflection coefficient

$S_{12}$ : Reverse voltage gain

$S_{21}$ : Forward voltage gain

$S_{22}$ : Output port voltage reflection coefficient

$S_{11}$  and  $S_{22}$ :

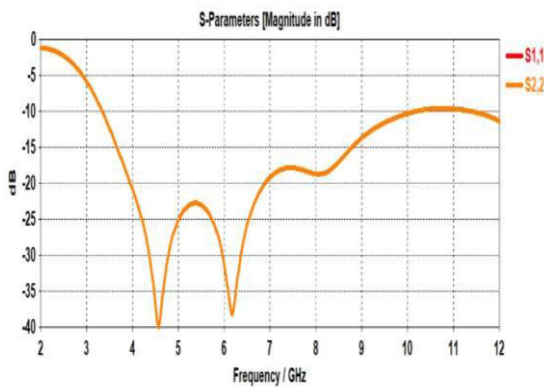


Fig 4:  $S_{11}$  and  $S_{22}$

$S_{12}$  and  $S_{21}$ :

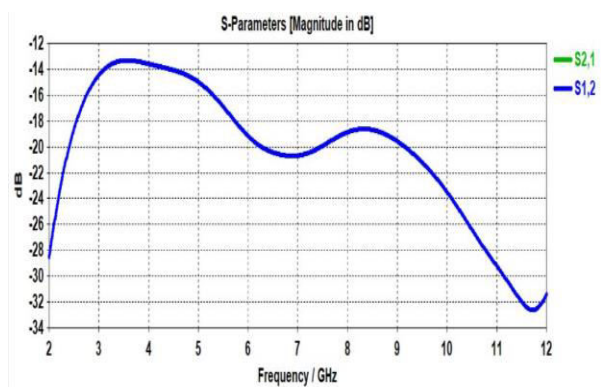


Fig 5:  $S_{12}$  and  $S_{21}$

**B. VSWR:**

VSWR stands for Voltage Standing Wave Ratio, and is also referred to as Standing Wave Ratio (SWR). The reflection coefficient ( $\Gamma$ ), which specifies the power reflected from the antenna, is a function of VSWR. The VSWR is described by the following formula if the reflection coefficient is provided.

$$VSWR = \frac{1 + |\Gamma|}{1 - |\Gamma|}$$

The VSWR is always a real and positive quantity for antennas. The ideal value of VSWR is 1. However, the proposed antenna has a VSWR of 1.02 at resonating frequency of 4.56GHz and 6.17GHz shown in Fig 6.

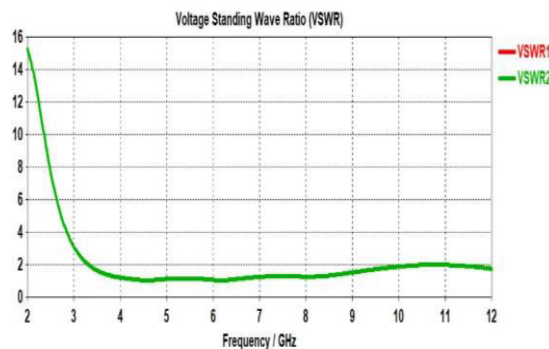


Fig 6: VSWR

Frequently antennas must fulfil a bandwidth requirement that is specified in terms of VSWR. For instance, an antenna might state that it can operate with  $VSWR < 3$  between 100 and 200 MHz. This signifies that the VSWR is less than 3.0 for the selected frequency range. The reflection coefficient over the specified frequency range is also implied by this VSWR specification to be less than 0.5 (i.e., reflection coefficient  $< 0.5$ ).

**C. Reference Impedance:**

Scattering parameters are specified using reference impedance, which is a numerical value. The reference impedance is required if you have S-Parameters and need information about voltages and currents (or vice versa). The reference impedance, however, can generally be complicated or frequency-dependent. The reference impedance obtained at resonating frequencies 4.56GHz and 6.17GHz is  $54.8\Omega$  shown in Fig 7.

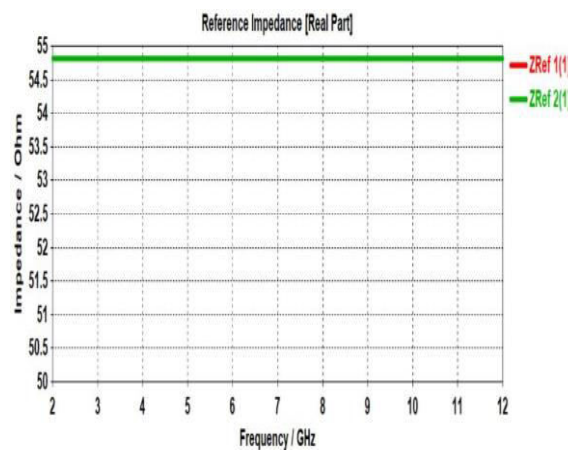


Fig 7: Reference Impedance

**D. Efficiency:**

Antenna Efficiency is the ratio of power radiated by the antenna to the power supplied to the antenna. A perfect antenna has 100% antenna efficiency i.e., it transmits all the power provided to it. A good antenna, however, only radiates between 50 and 60 percent of the power applied to it in reality. The efficiency obtained at resonating frequencies 4.56GHz and 6.17 GHz is 74% and 76% respectively as shown in Fig 8

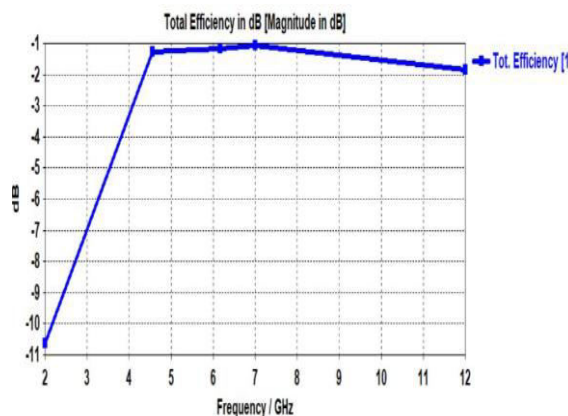


Fig 8: Efficiency

**E. Far-Fields:** Far-field refers to a field that is away from the antenna. As the radiation impact is strong here, it is also known as a radiation field. Several antenna properties, including antenna directivity and radiation pattern, are only taken into account in this area.

Field pattern refers to the field distribution that may be quantified in terms of field intensity. In other words, the plotted radiated power from the antenna is expressed as an electric field,  $E$  (v/m). It is called a "field pattern" as a result. Power pattern is the phrase used when anything is measured in terms of power (W). Reactive near field or non-radiative field, which is located extremely close to the antenna, is one in which radiation is not dominating. Due to the radiation's dominance and the distribution of the angular field, the area adjacent to it might be referred to as a Fresnel field or radiating near field. Radiating far-field region is the area next to it. The field distribution in this area is unaffected by antenna distance. In this area, the effective radiation pattern is shown.

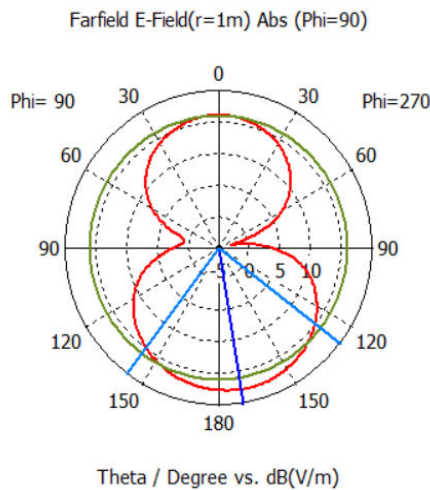


Fig 9: E-Field at 4.56 GHz

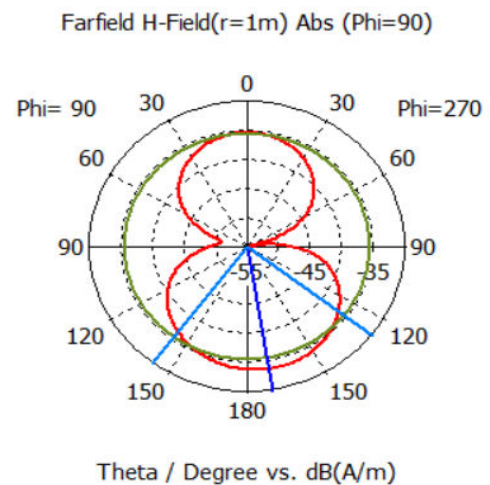


Fig 10: H-Field at 4.56 GHz

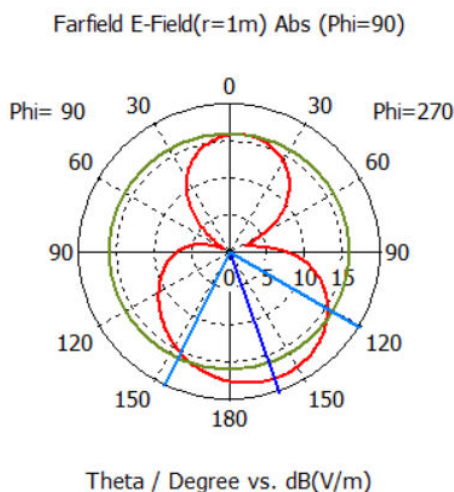


Fig 11: E-Field at 6.17 GHz

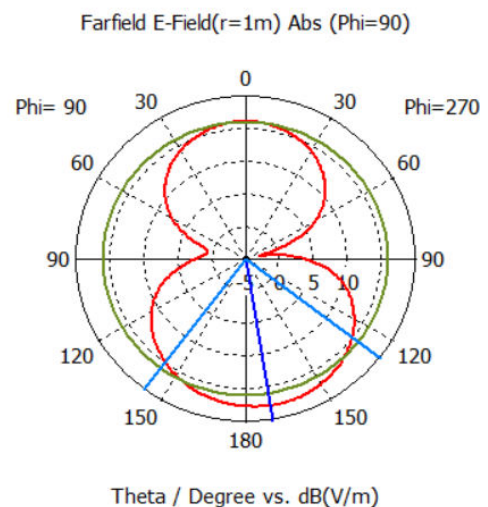


Fig 12 H-Field at 6.17 GHz

#### IV. CONCLUSION

The design of a two port MIMO antenna with dimensions of 55 X 26.05 mm<sup>2</sup> on a FR-4 substrate has been performed on CST Microwave Studio. The design of this antenna, which accommodates UWB operations, utilizes two circular patch elements. The suggested antenna is appropriate for a variety of UWB applications since it works between 3.3 and 10 GHz. Both 4.56GHz and 6.17GHz are resonance frequencies for it. The designed antenna has an isolation of around 20dB between the antenna elements. This antenna may also be employed in a variety of MIMO-required applications, including wireless communication systems, radar systems, and medical imaging systems.

#### REFERENCES

- [1] Tang, Z.; Wu, X.; Zhan, J.; Hu, S.; Xi, Z.; Liu, Y. Compact UWB- MIMO antenna with high isolation and triple band-notched characteristics. *IEEE Access* 2019, 7, 19856–19865.
- [2] Tiwari, R.N.; Singh, P.; Kanaujia, B.K. A compact UWB MIMO antenna with neutralization line for WLAN/ISM/mobile applications. *Int. J. RF Microw. Comput.-Aided Eng.* 2019, 29, e21907.
- [3] Ramanujam, P.; Venkatesan, P.R.; Arumugam, C.; Ponnusamy, M. Design of miniaturized super wideband printed monopole antenna operating from 0.7 to 18.5 GHz. *AEU-Int. J. Electron. Commun.* 2020, 123, 153273. [CrossRef]
- [4] Dey, A.B.; Pattanayak, S.S.; Mitra, D.; Arif, W. Investigation and design of enhanced decoupled UWB MIMO antenna for wearable applications. *Microw. Opt. Technol. Lett.* 2020, 63, 845–861.
- [5] Kumar, N.; Kiran, K.U. Meander-line electromagnetic bandgap structure for UWB MIMO antenna mutual coupling reduction in E- plane. *AEU-Int. J. Electron. Commun.* 2020, 127, 153423.
- [6] Rafique, U.; Din, S.U.; Khalil, H. Compact CPW-fed Super Wideband Planar Elliptical Antenna. *Int. J. Microw. Wirel. Technol.* 2021, 13, 407–414.
- [7] Khan, A.A.; Naqvi, S.A.; Khan, M.S.; Ijaz, B. Quad port miniaturized MIMO antenna for UWB 11 GHz and 13 GHz frequency bands. *AEU-Int. J. Electron. Commun.* 2021, 131, 153618.
- [8] Modak, S.; Khan, T. A slotted UWB-MIMO antenna with quadruple band-notch characteristics using mushroom EBG structure. *AEU- Int. J. Electron. Commun.* 2021, 134, 153673.
- [9] Rekha, V.S.D.; Pardhasaradhi, P.; Madhav, B.T.P.; Devi, Y.U. Dual Band Notched Orthogonal 4-Element MIMO Antenna with Isolation for UWB Applications. *IEEE Access* 2020, 8, 145871–145880.
- [10] Wang, E.; Wang, W.; Tan, X.; Wu, Y.; Gao, J.; Liu, Y. A UWB MIMO slot antenna using defected ground structures for high isolation. *Int.J. RF Microw. Comput.-Aided Eng.* 2020, 30, e22155.
- [11] Sohi, A.K.; Kaur, A. A complementary Sierpinski gasket fractal antenna array integrated with a complementary Archimedean defected ground structure for portable 4G/5G UWB MIMO communication devices. *Microw. Opt. Technol. Lett.* 2020, 62, 2595–2605.
- [12] Shobit Agarwal, Umair Rafique, Rizwan Ullah, Shakir Ullah, Salahuddin Khan and Massimo Donelli, Double Overt-Leaf Shaped CPW-Fed Four Port UWB MIMO Antenna.
- [13] oohestani, M.; Moreira, A.A.; Skrivervik, A.K. A novel compact CPW-fed polarization diversity ultrawideband antenna. *IEEE*.
- [14] *Antennas Wirel. Propag. Lett.* 2014, 13, 563–566.
- [15] Balanis, C.A. *Antenna Theory: Analysis and Design*; John Wiley & Sons: Hoboken, NJ, USA, 2015.
- [16] Sharawi, M.S. Printed multi-band MIMO antenna systems and their performance metrics [wireless corner]. *IEEE Antennas Propag. Mag.* 2013, 55, 218–232.
- [17] Li, Y.; Zou, H.; Wang, M.; Peng, M.; Yang, G. Eight-element MIMO antenna array for 5G/Sub-6GHz indoor micro wireless access points. In *Proceedings of the 2018 International Workshop on Antenna Technology (iWAT)*, Nanjing, China, 5–7 March 2018.





**INNO SPACE**  
SJIF Scientific Journal Impact Factor  
**Impact Factor: 8.423**



**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA



# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

9940 572 462 6381 907 438 [ijirset@gmail.com](mailto:ijirset@gmail.com)



[www.ijirset.com](http://www.ijirset.com)

Scan to save the contact details