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Design of Compact Common Radiator MIMO Antenna for X Band Applications

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Abstract

A compact common radiator multi input multi output diversity antenna for X band wireless services is proposed in this paper. The antenna is printed over a low cost material in a space of 24.1x24.1 mm^2 employing defected ground isolation which helps in size reduction as well. The antenna also employs polarisation diversity by feeding the common radiator in orthogonal fashion. The antenna is resonant over the entire X band showing stable performance in terms of matching, reflection coefficient, gain, directivity, ECC and radiation efficiency. The simulations are carried out in Advanced Design System simulator and performance evaluated.

Keywords: *Common radiator, MIMO antenna, Defected ground, ECC, Radar applications.*

INTRODUCTION

Due to the latest trends in communication technology, there is a vast spread use of wireless devices demanding for an increase in speed and data rate, as well as reliability in transmission. Multiple-input multiple-output (MIMO) systems seem to be the most promising technology to cater to the tremendous increase in traffic exploiting multipath propagation, spatial diversity and spatial multiplexing. By increasing the number of antenna elements, it is possible to linearly increase the throughput of the channel. Thus MIMO is gaining importance due to low multipath fading, high data rate, increase in capacity, and low interference and compact terminals.

The main challenge lies in suppressing the mutual coupling thereby isolating the antenna elements, within a very constrained space of wireless terminals. Varied decoupling methods exist in practice to get rid of mutual interference between the antenna elements and to preserve the radiation characteristics of the antenna. Antenna elements of varied types[9]could be employed but they suffer due to impedance matching problems. Parasitic structures[7]achieve high isolation over a wide bandwidth. Antennas fed in dual polarisation[10] also helps combat coupling. A more compact design of shared radiators[10] are discussed with protruded ground branch[5,10] for bandwidth and isolation enhancement. Metamaterials[4] and EBG structures[8]are also used to suppress

surface waves and enhance isolation between the elements. A special decoupling network[12]inserted between the elements helps mitigating mutual coupling. Defected ground [2] suppresses the surface propagation and Neutralisation line[13] prevents surface current from flowing to the adjacent element.

It is observed that varied antennas catering to various applications are proposed, developed and implemented. But a compact planar antenna to suit radar application with the convenience of MIMO providing extended target space-sample providing spatial ability and resolution is the greatest challenge.

In this communication, a new simple and compact circular slotted antenna with common radiator is presented for MIMO-Radar application. The antenna is very compact and fits easily into any mobile equipment. The antenna exhibits fairly good isolation and required radiation performance with directional pattern.

The article is organized as follows. Section 2 deals about the motivation on the development of compact MIMO antennas for radar applications. Section 3 gives the development of the proposed dual polarized slotted circular microstrip patch antenna. Section 4 carry out performance analysis of the proposed antenna. The communication is concluded in Section 5.

BAND RADAR

X band refers to the band of frequencies in the electromagnetic spectrum specified by IEEE as 8 to 12GHz.It is widely used in radars including continuous wave, pulsed, phased, synthetic aperture radars, etc. Subbands are used for air traffic control, vehicle speed control, weather monitoring and maritime control. Recently radars are also employed for high resolution imaging purposes.ITU has recommended portions of X band for deep space exploration. The main advantage of X band is that it is less affected by adverse weather. It is also easy for the detectors to pick up at large distances with rare false alarms. MIMO concept is well applicable for radars in de-correlating target RCS fluctuations, viewing different aspect of the target[1].MIMO-radar is an emerging technology where multiple signals from the transmitter elements of a phased array could be coherently combined on reception to form multiple beams. MIMO radar capitalize on target scintillations[3] to improve on the performance. It is noted from the survey that extension of MIMO to radars improves on the detection efficiency.

CIRCULAR SLOTTED PATCH ANTENNA

The proposed common circular slotted radiator based antenna consists of a circular metallic plate which is slotted in concentric fashion by removing the metal as a circular ring. The common radiator is fed in dual polarisation using balanced 50 ohm microstrip line. The antenna is developed over a low cost FR4 material with a dielectric constant of 4.4 and loss tangent 0.02.The antenna occupies a compact volume of $24.1x24.1x1.6mm^3$.The evolution of the antenna is shown in Fig.1(a-d).The optimised design of common radiator based antenna with dimensions is shown in Figure.2. The common radiator based antenna provides isolation by virtue of defected ground incorporated in the design.

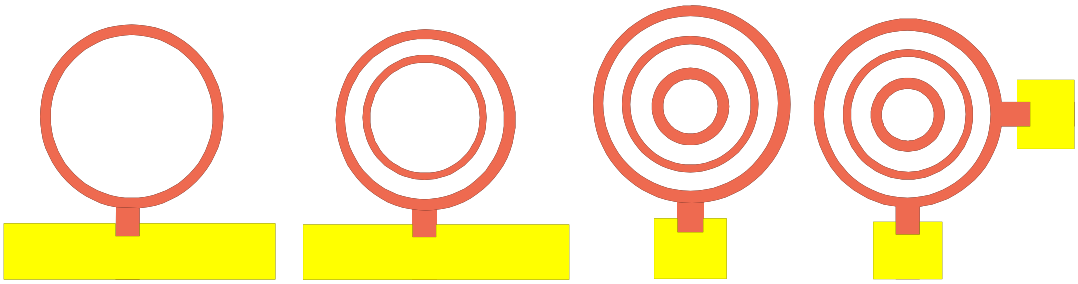


Fig 1. *Evolution of the proposed antenna*

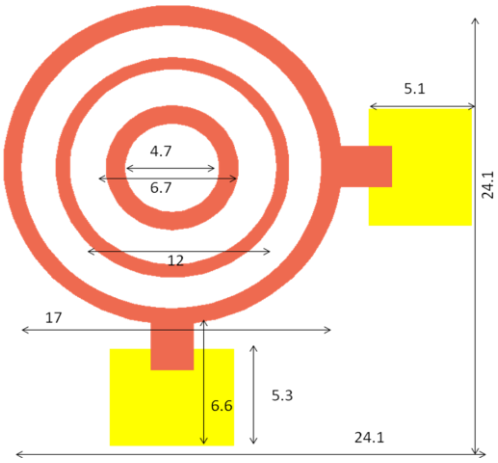
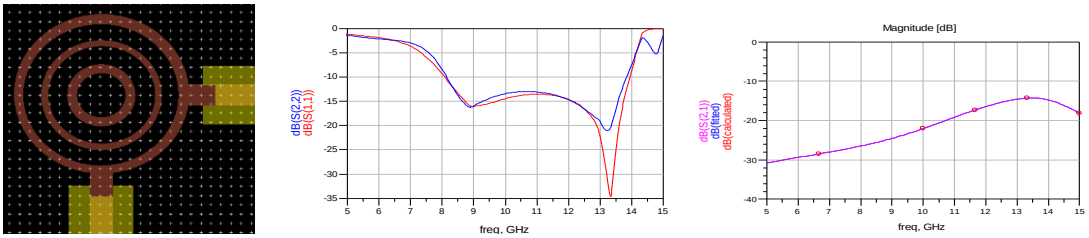


Fig 2. *Geometry of the circular slotted antenna.*

RESULTS AND DISCUSSION

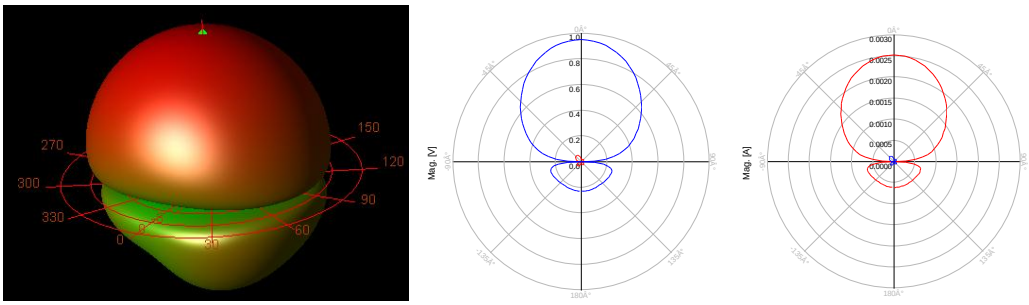
The slot antenna consists of a flat metal surface with slots cut out which when driven as an antenna, radiates energy. The driving frequency along with the size and shape of the slot, guides the electromagnetic energy and determines the pattern. Slot antennas often give greater control of power distribution providing directivity and gain. Upon investigating the effect of ground plane size on antenna behaviour, it is observed that the edge diffracted waves cause tilting of the beam in the direction of lower elevation and decrease the gain[6].Finite ground plane gives edge diffraction of electromagnetic waves resulting change in antenna radiation characteristics. The current distribution of the proposed antenna occurs along the circumference of the circular disc. The current characteristics will not be affected if the complete circular disc antenna is slotted in the middle portion since current density is always low in the core. The effective path of the surface current becomes longer and the size of the antenna gets reduced[11].Slots on the radiator prevents the surface currents from propagating to the other port helping in reduction of mutual coupling. The electrical performance is enhanced by cutting a small groove near the feed. The designed layout of the antenna is shown in Figure 3.



Layout *Reflection coefficient* *Isolation characteristics*

Fig 3. *Layout design of the circular slotted MIMO-Radar antenna and its performance.*

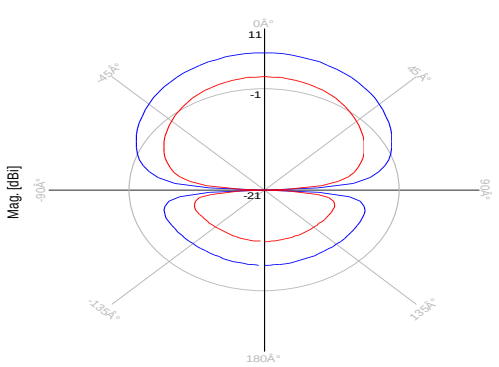
From the reflection coefficient curve it is seen that the antenna resonates for the entire X band. The return loss values are around -35dB and -20dB for input and output respectively. The isolation characteristics as observed from the S_{12} and S_{21} values, are worked out as 23.5dB. The bandwidth is around 7GHz. The antenna shows good directional radiation as observed from the radiation pattern throughout the band. The three dimensional and two dimensional patterns are shown in Figure 4.



E theta E phi ***H theta H phi***

Fig 4. *Antenna Radiation characteristics*

It could be seen that the back lobe is much reduced that gives an enhanced performance. The gain and the directivity values are observed as 4.8dBi and 7.2dBi as shown in the Figure 5. The efficiency of the antenna approaches 99%.A good impedance matching behaviour is also noted from the VSWR graphs, Figure 6. showing a value 1.4.



Directivity ***Gain***

Fig 5. *Gain and Directivity characteristics*

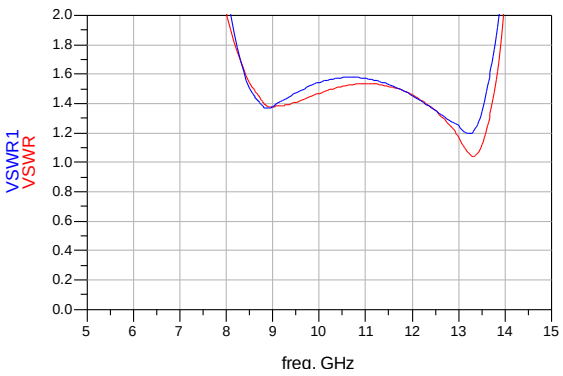


Fig 6. *VSWR characteristics*

It is always essential to test the antenna for MIMO performance by evaluating certain specific parameters.

Envelope correlation coefficient is a measure of the correlation between the antenna elements which is required to be as low as possible. It is directly related to the capacity of the system. The value of ECC is found to be <0.1 as shown in Figure.7(a),which means the system exhibits good diversity.

$$\rho = \frac{|S11 * S12 + S21 * S22|^2}{(1-|S11|^2-|S21|^2)(1-|S22|^2-|S12|^2)} \quad (1)$$

Diversity Gain refers to the factor by which the signal to noise ratio could be enhanced employing diversity scheme.

$$\text{Div Gain} = 10\,(1-\rho)^{0.5} \quad (2)$$

The diversity gain values vary around 9.8 as observed from the Figure.7(b)

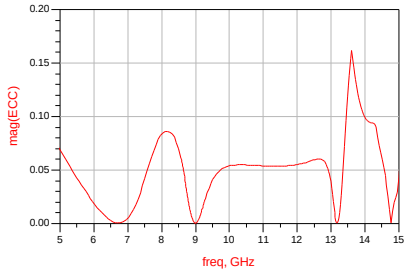


Fig 7(a). *Envelope Correlation coefficient*

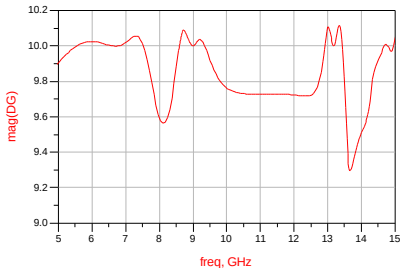


Fig 7(b). *Diversity Gain*

CONCLUSION

In this article, common circular slotted radiator based MIMO antenna for X band applications is proposed. The proposed antenna is developed over a compact dimension of 24.1x24x1.6mm^3 over a readily available FR4 substrate. The proposed antenna exhibits good impedance match throughout the designed frequency band. The reflection coefficient, isolation, gain, directivity, ECC and diversity gain as obtained through simulation studies shows antenna exhibits good radiation behavior rendering it suitable for radar and satellite applications.

REFERENCE

1. V.S. Chernyak 2010," On the Concept of MIMO Radar", Moscow Aviation Institute, IEEE National Radar Conference - Proceedings · June 2010.
2. Deng, J. Y., L. X. Guo, and X. L. Liu 2016, "An ultrawideband MIMO antenna with a high isolation," IEEE Antennas Wireless Propag. Lett., Vol. 15, 182–185, 2016.
3. B J Donnet and I D Longstaff 2016," MIMO Radar, Techniques and Opportunities", Proceedings of the 3rd European Radar Conference Proceedings of the 3rd European Radar Conference, 2009.
4. Ghosh, Jeet, et al. "Mutual Coupling Reduction Between Closely Placed Microstrip Patch Antenna Using Meander Line Resonator." Progress In Electromagnetics Research Letters 59 (2016): 115-122.
5. Hui Li, Jinhai Liu, Ziyang Wang,Ying-Zeng Yin 2017,"Compact 1 × 2 and 2 × 2 MIMO Antennas with Enhanced Isolation for Ultrawideband Application", Progress In Electromagnetics Research C, Vol. 71, 41–49, 2017.
6. Josaphat Tetuko, Sri Sumantyo, Koichi Ito, David Delaune, Toshimitsu Tanaka, Teruo Onishi and Hiroyuki Yoshimura 2005, "Numerical analysis of ground plane size effects on patch array antenna characteristics for mobile satellite communications", International Journal Of Numerical Modelling: Electronic Networks, Devices And Fields,2005;18:95–106.
7. Khan, M. S., A. D. Capobianco, A. I. Najam, I. Shoaib, E. Autizi, and M. F. Shafique, "Compact ultra-wideband

diversity antenna with a floating parasitic digitated decoupling structure," IET Microw. Antennas Propag., Vol. 8, 747–753, 2014.
8. Li.Q, A. P. Feresidis, M. Mavridou, et al. 2015,"Miniaturized double-layer EBG structures for broadband mutual coupling reduction between UWB monopoles", IEEE Transactions on Antennas and Propagation, Vol. 63, No. 3,1168–1171, 2015.
9. Malik, J., A. Patnaik, and M. V. Kartikeyan 2015, "Novel printed MIMO antenna with pattern and polarization diversity, IEEE Antennas Wireless Propag. Lett., Vol. 14, 739–742, 2015.
10. Mao, C. X. and Q. X. Chu 2014, "Compact coradiator UWB-MIMO antenna with dual polarization, IEEE Transactions on Antennas and Propagation, Vol. 62, 4474–4480, 2014.
11. Shuainan Gu, Ke Li, Xiukun Ren, and Na-e Zheng 2016,"Antenna Array Design in MIMO Radar Using NSK Polynomial Factorization Algorithm", Research article, International Journal of Antennas and Propagation Volume 2016, Article ID 4580479, 10 pages http://dx.doi.org/10.1155/2016/4580479.
12. Ziyang Wang, Luyu Zhao, Aobo Chen, and Yingzeng Yin 2017,"A Second Order Decoupling Design Using a Resonator and an Interdigital Capacitor for a MIMO Antenna Pair", Progress In Electromagnetics Research Letters, Vol. 67, 19–24, 2017.
13. Zhang, S. and G. F. Pedersen 2016, "Mutual coupling reduction for UWB MIMO antennas with a wideband neutralization line," IEEE Antennas Wireless Propag. Lett., Vol. 15, 166–169, 2016.