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Gain and Bandwidth Enhancement of Array Antenna for S and C Band Application

Kanchan Wagh, S. S. Shriramwar

Abstract: *This letter presents a 4×4 hexagonal shaped microstrip antenna array with dual band characteristics at 2.4 GHz and 5.8 GHz. For the enhancement of gain and miniaturization of array antenna, a complimentary SRR (split ring resonator) is etched into ground plane. Corporate feed network is chosen for the equal amplitude distribution at the input of patch elements. The CSRR structure incorporated into the design. This design behaves like a metamaterial which has negative permeability and permittivity which results into negative reflective index. So transmitted wave could not pass into the structure and it gets reflected back from the structure. It also disturbs the current distribution at ground plane. This design work achieves efficiency up to 83%. For the miniaturization of an array, the CSRR etched on the back side of patch element. So that the frequency get shifted. Again for the desired frequency the dimensions of the patch get to reduce. So that the design get miniaturized*

Index Terms: Metamaterial , CSRR, Corporate feed

I. INTRODUCTION

Due to the various advantages of microstrip antennas, like light weight, low volume, these antennas are commonly preferred in radar applications, specifically for weather radar and Synthetic Aperture Radar as mentioned in [1]. Research has been carried out in the recent past to improve the performance & efficiency of these patch antennas. Rapid development in patch antennas started in 1970s & by the end of 1980s the idea of using microstrip array antenna in wireless communication was well established. In single element antenna the radiation pattern is usually very broad. So the directivity is effectively very low. By enlarging the size of the element the directivity can get increased. The alternative way is to assemble the antenna elements in a geometrical configuration. The individual which forms the array are usually identical and they can be of any form explained in [10]. Complimentary Split Ring Resonator exhibits band stop characteristics as it is the dual counterpart of split ring resonator at resonant if electromagnetic fields are aligned appropriately [1].To enhance the efficiency and gain, a novel engineered magnetic superstrate is designed in [7]. Defective Ground Structure use for the reduction of harmonics is explained in [8]. The modified split ring resonator unit cell is designed in such a way to get positive values for the effective permeability and permittivity at the center frequency of the antenna. Now a days ground plane is preferred by people for the inclusion of DGS. A miniaturized antenna array is designed with the help of DGS inclusion on the ground plane of antenna. They found the antenna size reduction upto 83% on the DGS properties with respect to miniaturization of antenna. DGS is an etched periodic or non periodic structure in the ground plane which disturbs the current distribution because of the defect in the ground plane. DGS can also be used for the reduction of cross polarization and mutual coupling. It can also be used for the reduction of cross polarization and mutual coupling explained in [9]. The plnar antenna array for Ku band at 13 GHz is presented in [10]. The inclusion of CSRR in the ground plane is very useful technique for antenna miniaturization and the multiband operation of an antenna [10].The DGS structure is also responsible for the suppression of cross polarization without affecting the dominant mode, input impedance and co polarized reduction pattern. Debatosh Guha presented a new concept in [11] for a particular DGS pattern employing a patch having circular shape as the radiator. The CSRR concept of duality has been demonstrated and presented in year 2004 by F. Falcon and the CSRR excited by the axial electric field could reveal negative permeability upon their resonance. In [10], a 4-element dual-polarized aperture-coupled microstrip patch antenna array have been designed for high isolation, wide bandwidth and low cross-polarization levels which will be applicable for a radar system. In array antenna mutual coupling and cross polarization must be reduced. Mutual coupling gives the amount of power coupled between two antenna elements. Formulas are explained in [10]. Array configuration and types of feeding are explain and array antenna for higher frequency with corporate feed is presented in [11].

In this work, the CSRR is etched on the ground plane for the enhancement of gain, efficiency and suppression of surface wave. The dual band 4×4 hexagonal antenna array is presented with and without CSRR and simulation results are also compared. The CSRR composed is of two concentric broken circular rings etched on the ground plane between the patch elements. Some model structure that have been proposed in [6] and also demonstrate how electrostatic energy can strongly concentrated in these structures.

II. Design of Proposed Antenna

In this letter a 4×4 hexagonal shaped dual band Microstrip antenna array has been designed and simulated at 2.4 GHz and 5.8 GHz. The patch is the dominant part of microstrip antenna. Patch and ground plane is on the other side of substrate.

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* Correspondence Author
Kanchan Wagh*, Ph.D. Scholar, Department of Electronics, Priyadarshini College of Engineering, R.T.M. Nagpur University, Nagpur.
Dr. S. S. Shriramwar, Department of Electronics, Priyadarshini College of Engineering, R.T.M. Nagpur University, Nagpur, India.

Initially a single patch is designed at 2.4 GHz and then a slot is inserted into the patch design to have the other resonating band at 5.8 GHz. But our aim is to design an array antenna for higher gain. So 16 elements microstrip antenna array have been designed and simulated. For the further improvement in the gain, a CSRR is etched into the ground plane for the enhancement of gain, efficiency and reduction of surface current and cross polarization. Corporate feed network is chosen for the equal amplitude distribution at the input of patch elements. It disturbs the current distribution. Also electrical length increases so it affects the antenna parameter. It is observed that cross polarization also get reduced after the inclusion of CSRR into the structure. The CSRR structure behaves like a metamaterial which has negative permeability and permittivity which results in negative reflective index. So transmitted wave could not pass into the structure. It gets reflected back from the structure.

III. Results & Discussions

The 4×4 antenna array is presented in fig. 1. Fig. 2 shows return loss of array at 2.4 GHz and 5.8 GHz. The array antenna has been resonating at other frequencies as shown in fig. 2. But for this design, the concentration is made on these two major frequencies. Fig. 3 shows the antenna array with CSRR into the ground plane. Fig. 4 shows the geometry of CSRR unit element. Fig.5 shows return loss of an antenna array with CSRR structure. A pair of CSRR is carved in the ground plane between the two patch elements. It is observed that after the inclusion of CSRR, antenna radiation pattern will get improved. These results are compared with the literature results. Gain versus frequency plot is presented in fig.7. And fig. 8 shows the 2 D radiation pattern.

After the analysis of proposed concept, a comparison between the proposed array antennas with other array in the literature is given in the table I. The proposed array achieves a high gain and efficiency as compared to the designs shown in Table I. This work shows the reduction of surface wave.

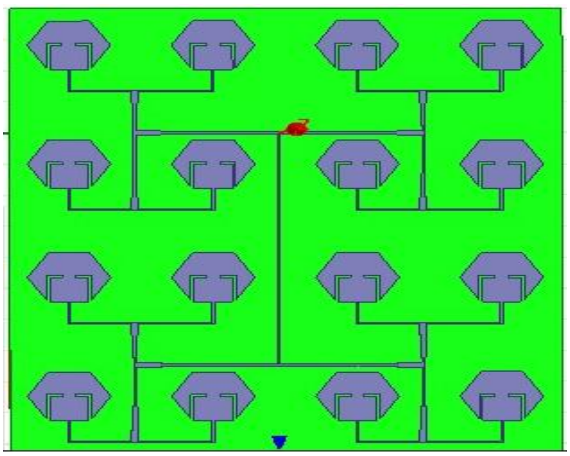

Fig. 1. 4 × 4 Antenna Array

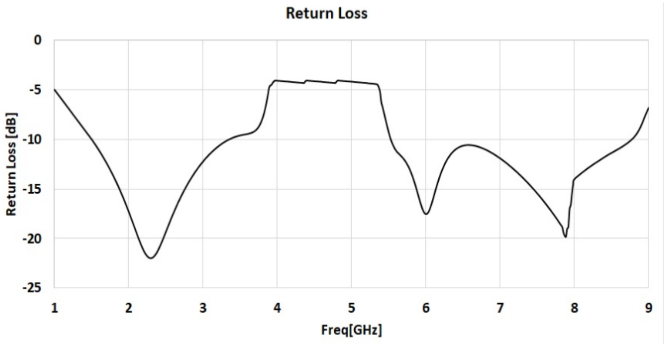

Fig. 2. Return Loss

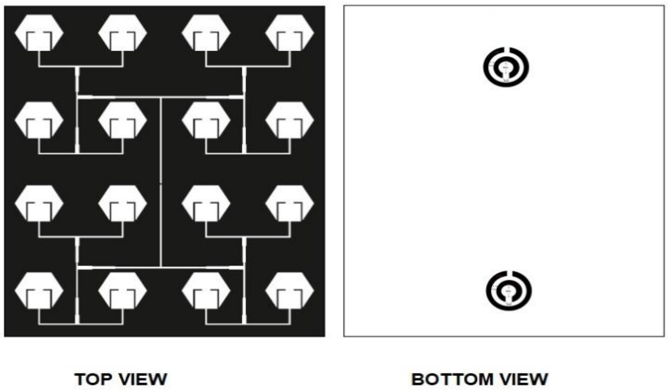

Fig. 3. 4×4 Antenna Array with CSRR

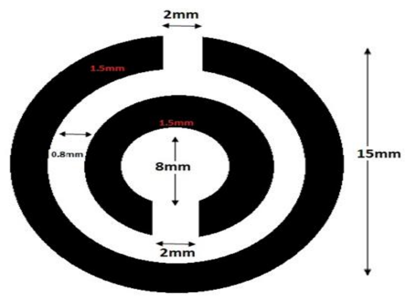

Fig.4. CSRR Dimensions

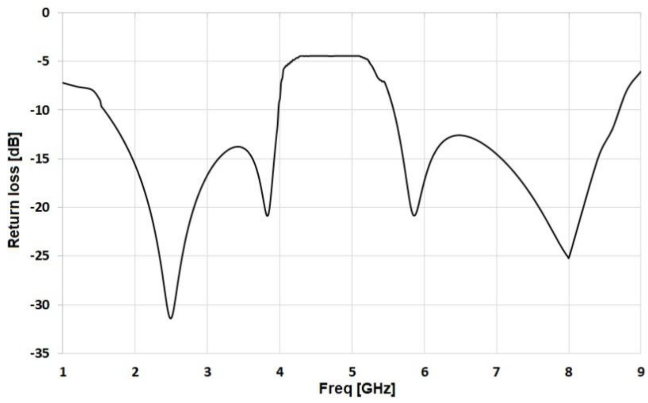

Fig. 5. Return Loss with CSRR

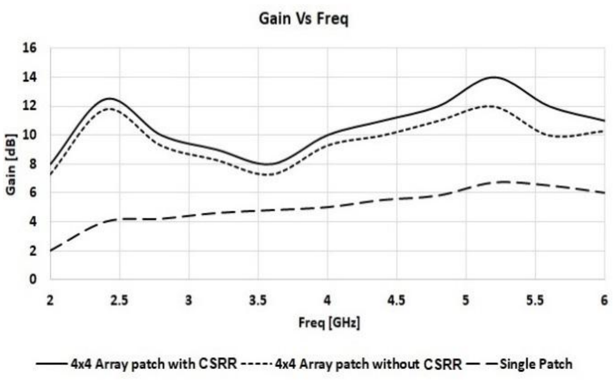

Fig. 7. Gain versus frequency plot

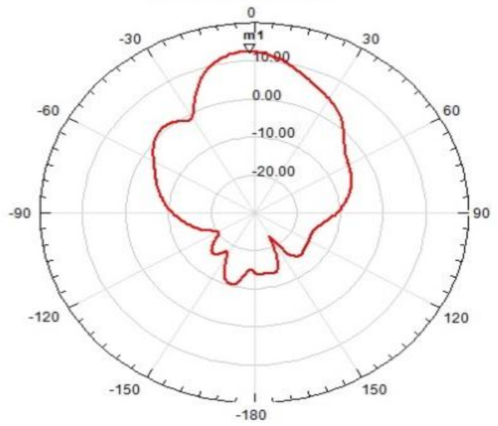

Fig.8. 2 D radiation pattern

TABLE I : Comparison between reference papers

Sr.No.	Shape of MSA	Freq (GHz)	Return Loss(dB)	VSWR	Bandwidth (MHZ)	Dir (dB)	Gain (dB)
1.	Single hexagonal	2.43	-24.83	1.12	40	4.6	4.0
		5.81	-20.99	1.11	110		
2.	2x2 Hexagonal Array without CSRR	2.43	-16.59	1.34	62	8.0	7.4
		5.87	-19.46	1.23	300		
3.	2x2 Hexagonal Array with CSRR	2.47	-13.65	1.52	50	9.7	8.1
		5.84	-15.80	1.38	270		
4.	4x4 Hexagonal Array without CSRR	2.42	-21.16	1.21	1100	12.4	11.8
		5.87	-16.60	1.34	2400		
5.	4x4 Hexagonal Array with CSRR	2.41	-28.67	1.05	2400	13.2	12.4
		5.88	-20.57	1.20	2550		

IV. CONCLUSION

A dual band 16 element antenna array having corporate fed network with and without CSRR has been developed for the improvement of gain, efficiency and also for the reduction of surface wave. To improve the gain and efficiency of an antenna array, reduction of mutual coupling and surface wave between the patch elements, a new method is presented. Such types of array antennas can be used for dual band radar system like weather radar and synthetic aperture radar.

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AUTHORS PROFILE

Prof. Kanchan Wagh Prof. Kanchan H. Wagh completed her bachelor's degree in Electronic Engineering from Y.C.C.E., Nagpur , India, in 2006. She completed her Masters in Electronics Engineering from the same Institute in 2008. She is doing her Ph.D. from Rashtrasanta Tukadoji Maharaj Nagpur University, India. Having an experience of 10 years. She is currently associated in Ele ctronics & Telecommunication department at St. Vincent Pallotti College of Engineering & Technology, Nagpur, India. She has 08 International Journal papers, 05 International Conference, 02 National Conference papers on accord. During her graduation she was the meritorious student of RTM Nagpur University. She is the third merit during her M.Tech. of batch 2007-08. She is the third merit during her M.Tech. of batch 2007-08. She is the member of professional body ISTE.

Dr. S.S. Shriramwar Dr. S.S. Shriramwar completed his degree in Elctronics Engineering in 1994 from B.D.C.O.E, Wardha and M.Tech degree in Electronics Engineering in 2005 from Y.C.C.E., Nagpur Ph.D. degree in Electronics from RTM Nagpur University in 2013. Having total experience of 21 years. He is currently working as a Professor in Electronics department t at Priyadarshini College of Engineering , Nagpur, India. He has published around 18 papers in International Journal, 13 papers in International Conferences, and 3 in National Conferences. Has worked as reviewer for many National and International conferences. He is a member of Board of studies for Electronics Engineering RTM Nagpur University for last 03 years. He is member of professional societies like IEEE and ISTE.