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REFLECTOR ARRAY ANTENNA DESIGN AT MILLIMETRIC (MM) BAND FOR ON THE MOVE APPLICATIONS

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ABSTRACT

This paper presents a reflector array which is designed at mm band (79GHz) for the applications like, it is easy to achieve gigabit rates with the help of mill metric wave technologies and it includes video transmission from set-top-box (STB) to an HDTV. Here the reflector array is considered as receiving antenna and the transmitting antenna is taken as microstrip patch antenna, the circular patch antenna, patch antenna and patch antenna with a coaxial feed. The simulations were done by using An-soft HFSSv13. The simulated array antenna is designed by using Rogers ultralam 1300 with dielectric constant 3mm.

Keywords: reflector array, mm-band, beam steering, HFSSv13.

INTRODUCTION

The antenna is characterized as a metallic device for emanating (or) accepting radio waves [1]. The array is nothing but the systematic arrangement of comparable objects, often in lines and segments. The antenna array is an arrangement of at least two (or) more antennas. Numerous applications require radiation characteristics that may not be accomplished by a solitary component along these lines, so array antennas are utilized [1]. A reflector is a specific intelligent surface used to divert light towards a given object (or) scene. Reflector antennas give correspondence over substantial measurements [1]. A reflector array antenna is a kind of directive antenna in which different driven components mounted on a level surface used to mirror the radio waves in the desired direction. Reflectarrays have gotten substantially more interest since they joined the advantages of reflector antennas and phased arrays [2] [7]. The advantage of using reflectarray rather than that of a reflector is, it is easy to fabricate, less weight and the scanning ability is high [8] [9] [10]. Antenna reflectors can exist as an independent gadget for diverting radio frequency energy. The scope of mm band is from 30GHz to 300GHz. Because of the high frequency of millimeter waves and their spread qualities make them helpful for applications including a huge measure of PC information, cellular communications, and radar. The explanations behind utilizing mm band are since there are a few restrictions in the lower frequency bands. The confinements are, the data transmission will be less on account of s-band, needs a bigger satellite dish on account of a c-band, just a little portion (1.3GHz-1.7GHz) of L-band is designated to satellite communications and for the most part of military utilize very little business offerings in x-band. The applications for mm band are scientific research, broadcast communications, weapon framework, security screening, thickness gauging and drug.

Nowadays the parabolic reflector antennas are utilized because of high gain and its directivity. However, a portion of the power that gets reflected from the parabolic reflector is obstructed, because of the little measurement of the paraboloid. To overcome the above inconvenience, we are utilizing the square reflector and circular reflector.

DESIGN TOPOLOGY

This paper consists of a reflectarray antenna which is taken as a receiving antenna and the source antenna may be taken as microstrip patch antenna, the circular patch antenna, patch antenna and patch antenna with a coaxial feed. A reflector is designed by utilizing Ansoft HFSSv13. A reflectarray consists of six columns and each column consists of five patches and the feeding may be taken in a series manner. For reflectarray, the substrate is designed by using Rogers ultralam1300(tm) material with thickness 100µm and ε_r=3mm [3].

The length and width of the patch for the transmitting antenna are calculated by using the formulae shown below [4].

$$W = \frac{V_o}{2F_r}\sqrt{\frac{2}{\varepsilon_r + 1}}$$

Where v_0= velocity of light in free space.

$$L = \frac{C}{2F_r\sqrt{\varepsilon_{reff}}} - 2\Delta l$$

$$\Delta l = 0.412h\frac{(\varepsilon_{reff} + 0.03)(w + 0.26h)}{(\varepsilon_{reff} - 0.258)(w + 0.8h)}$$

Where Δl=Extension in length due to fringing effects

The effective dielectric constant is given by

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + \left[\frac{12h}{w}\right]\right]^{-1/2}$$

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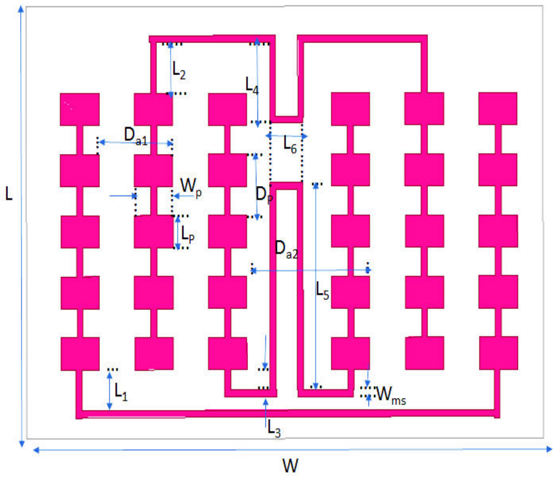

Figure-1. Layout of the square reflector array. Dimensions are L=13.78mm, W=18.56mm, L_P=1.12mm, W_p=1.56mm, D_p=2.12mm, D_{a1}=3mm, D_{a2}=5mm, W_{ms}=244µm, L_1=1.7mm, L_2=2mm, L_3=0.7mm, L_4=2.85mm, L_5=7.15mm and L_6=1.35mm

Similarly, the circular reflector has designed by using Ansoft HFSS and is as shown below.

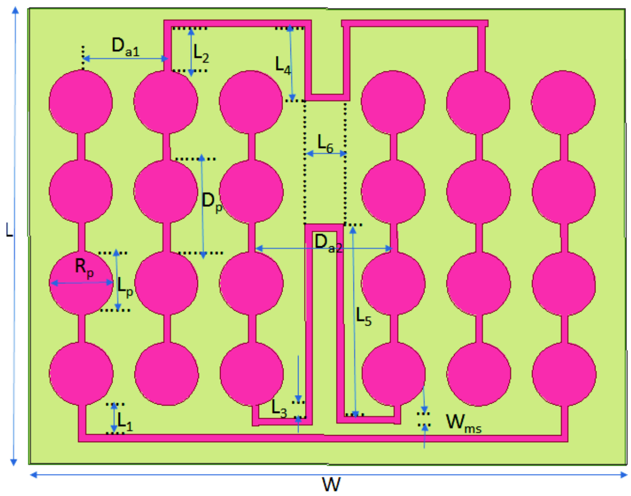

Figure-2. Layout of the circular reflector array. Dimensions are L=13.78mm, W=18.56mm, L_P=1.12mm, R_p=1.12mm, D_p=2.12mm, D_{a1}=3mm, D_{a2}=5mm, W_{ms}=244µm, L_1=1.7mm, L_2=2mm, L_3=0.7mm, L_4=2.85mm, L_5=7.15mm and L_6=1.35mm.

Now the microstrip patch antenna, patch antenna, circular patch antenna and patch antenna with a coaxial feed which is used as a transmitting antenna are shown below.

Microstrip patch antenna

Microstrip patch antenna is a printed kind of an antenna comprising a dielectric substrate sandwiched in the middle of a ground plane and a patch. Microstrip patch antenna is chosen because of the small gain and lower bandwidth. Microstrip patch antennas have many advantages when compared with other heavier type of antennas and they are light weight, low manufacture cost, low profile setup [4] [6].

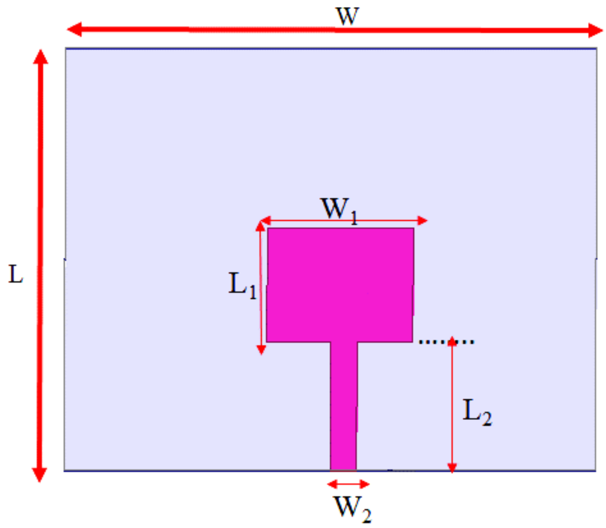

Figure-3. Micostrip patch antenna. Dimensions are L=6mm, W=7mm, L_1=1.081mm, W_1=1.377mm, L_2=1.2532mm and W_2=0.2513mm.

Circular patch antenna

Microstrip patch antennas are convenient to fabricate on a curved surface. Thus, the circular patch antenna is a kind of microstrip patch antenna. The advantages of using microstrip patch antenna are less cost, low size, and less weight. The disadvantages are low gain and lesser efficiency.

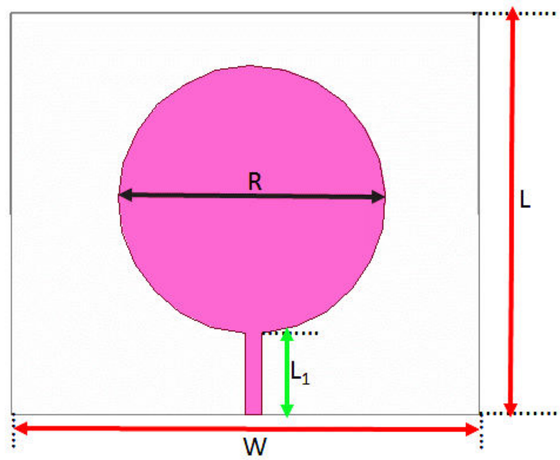

Figure-4. Circular patch antenna. Dimensions are L=6mm, W=7mm, L_1=1.2532mm and R=2mm.

Patch antenna with a co-axial feed

The patch antenna is provided with a co-axial feeding because the impedance matching is easily obtained by altering the feed position. Impedance matching is the

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most important factor to obtain the required bandwidth, otherwise, the efficiency will be lower [5].

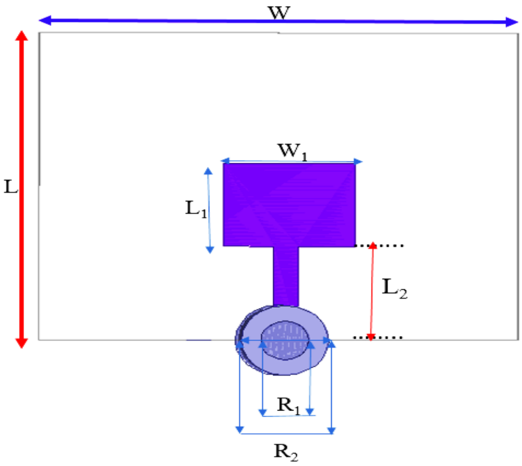

Figure-5. Patch antenna with a coaxial feed. Dimensions are L=6mm, W=7mm, L_1=1.081mmW_1=1.377mm, L_2=1.2532mm, R_1=0.2513mm and R_2=0.4562mm.

Patch antenna

A patch antenna is usually built on a dielectric substrate, generally by utilizing a similar kind of lithographic patterning used to manufacture on a PCB. The advantages are fabrication can be done very easily, less cost and feeding can be easily done. Disadvantages are less gain and efficiency will be low.

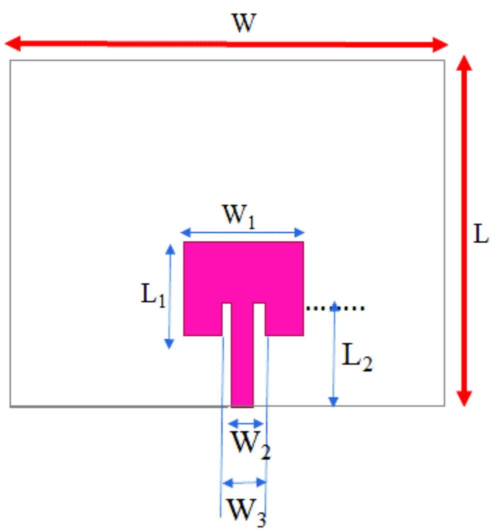

Figure-6. Patch antenna. Dimensions are L=6mm, W=7mm, L_1=1.081mm, W_1=1.377mm, L_2=1.2532mm, W_2=1.2532mm and W_3=0.5mm.

Microstrip patch antenna with slot

A slot of width x=0.1 and y=0.1 has been kept on the radiating patch for better performance of the return loss and gain. Similarly, a slot has been kept on the patch for above antennas.

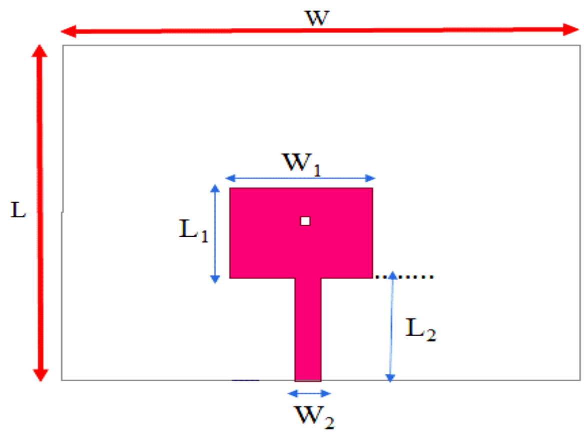

Figure-7. Microstrip patch antenna with a slot. Dimensions are L=6mm, W=7mm, L_1=1.081mm, W_1=1.377mm, L_2=1.2532mm and W_2=0.2513mm.

RESULTS AND DISCUSSIONS

Antenna performance is shown in terms of gain, directivity and radiation pattern and those parameters are shown for two reflectors which are considered as a receiving antenna and four antennas which are taken as a transmitting antenna.

Measured return loss

The return loss for the square reflector, circular reflector without slot and with slot by using microstrip patch antenna, a circular patch antenna, patch antenna and patch antenna with a coaxial feed is as shown below.

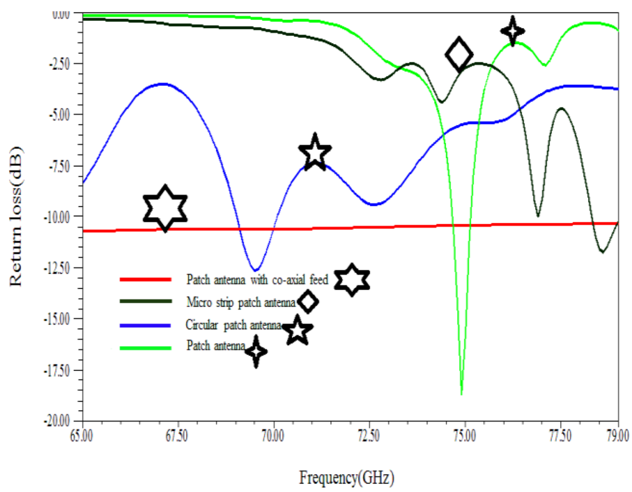

Figure-8. Return loss for square reflector without a slot.

The above figure represents the return loss comparison of microstrip patch antenna, a circular patch

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antenna, a patch antenna and patch antenna with a coaxial feed by using a square reflector without a slot. The return loss for patch antenna with coaxial feed is -10.3dB at 77GHz, for microstrip patch antenna is -11.75dB at 78.6GHz, for circular patch antenna, is -12.6dB at 69.5GHz and for patch antenna is -18.7dB at 74.9GHz.

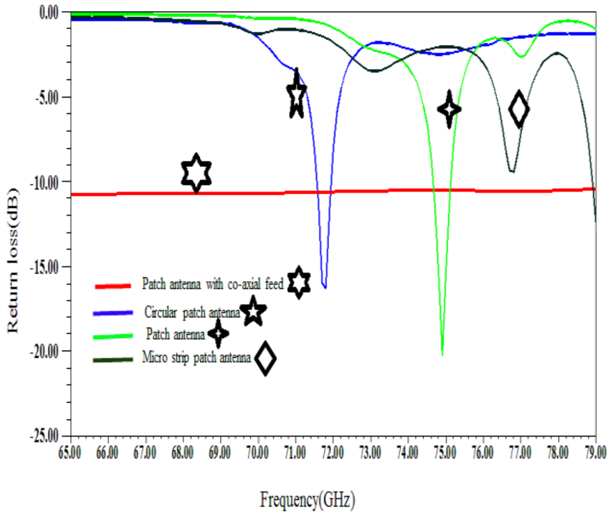

Figure-9. Return loss for square reflector with a slot.

The above figure represents the return loss comparison of microstrip patch antenna, a circular patch antenna, a patch antenna and patch antenna with a coaxial feed by using a square reflector with a slot. The return loss for patch antenna with coaxial feed is -10.53dB at 76GHz, for microstrip patch antenna, is -23.4324dB at 79.2GHz, for circular patch antenna is about -16.2592dB at 71.8GHz and for patch antenna is -20.25dB at 74.9GHz.

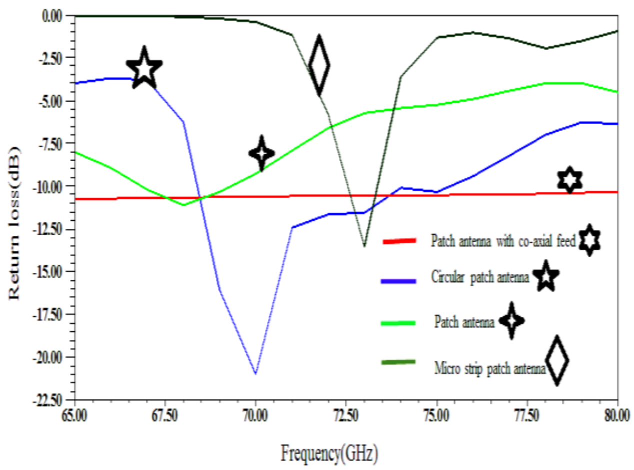

Figure-10. Return loss for circular reflector without a slot.

The above figure represents the return loss comparison of microstrip patch antenna, a circular patch antenna, a patch antenna and patch antenna with a coaxial feed by using a circular reflector without a slot. The return loss for patch antenna with coaxial feed is -10.4dB at 79GHz, for microstrip patch antenna is -13.5dB at 73GHz, for circular patch antenna is about -20.95dB at 70GHz and for patch antenna is -11.1dB at 68GHz.

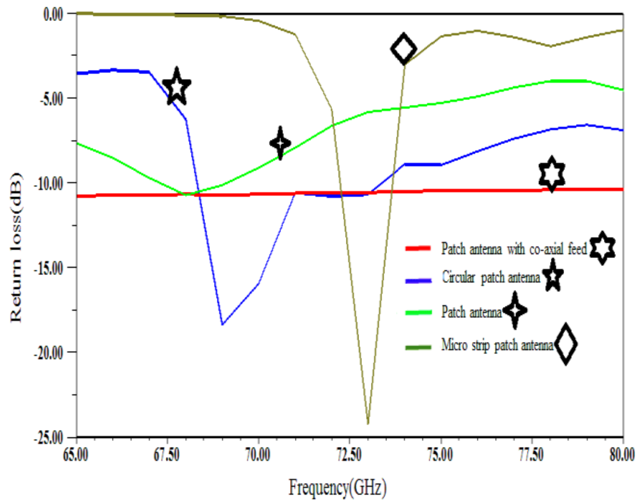

Figure-11. Return loss for circular reflector with a slot.

The above figure represents the return loss comparison of microstrip patch antenna, a circular patch antenna, a patch antenna and patch antenna with a coaxial feed by using a circular reflector with a slot. The return loss for patch antenna with coaxial feed is -10.7dB at 69GHz, for microstrip patch antenna is -24.2dB at 73GHz, for circular patch antenna is about -18.35dB at 69GHz and for patch antenna is -10.7358dB at 68GHz.

Total gain

The total gain for a square reflector, circular reflector without slot and with slot by using microstrip patch antenna, a circular patch antenna, a patch antenna and patch antenna with a coaxial feed is as shown below.

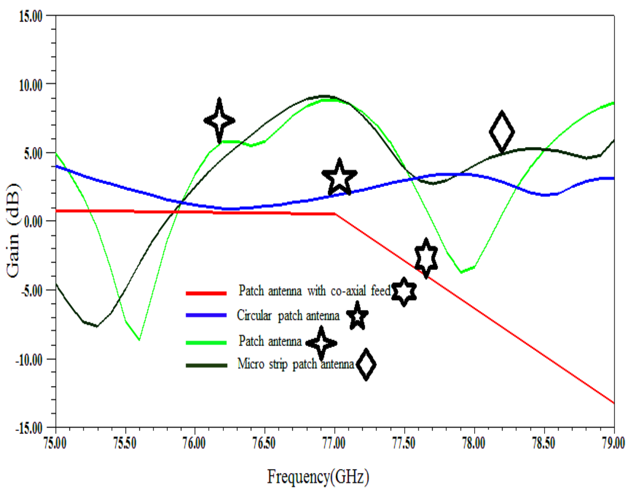

Figure-12. Gain plot for square reflector without a slot.

The above figure represents the gain comparison of microstrip patch antenna, a circular patch antenna, a

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patch antenna and patch antenna with a coaxial feed by using a square reflector without a slot. The gain for patch antenna with coaxial feed is 8.9dB at 77GHz, for microstrip patch antenna is 7.6dB at 78.6GHz, for circular patch antenna is 7.9dB at 69.5GHz and for patch antenna is 7.6dB at 74.9GHz.

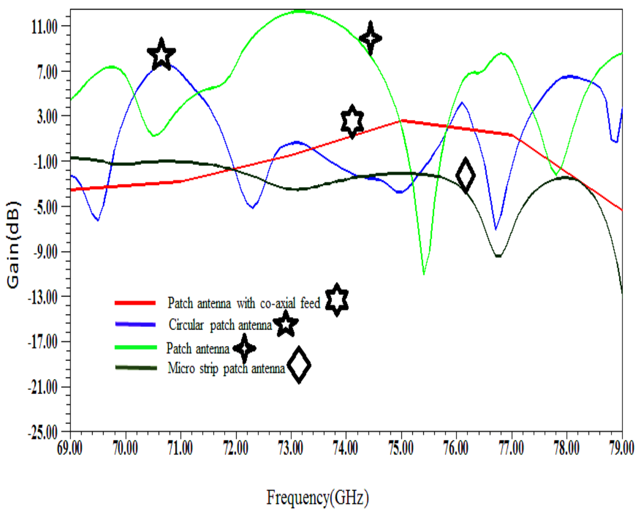

Figure-13. Gain plot for square reflector with a slot.

The above figure represents the gain comparison of microstrip patch antenna, a circular patch antenna, a patch antenna and patch antenna with a coaxial feed by using a square reflector with a slot. The gain for patch antenna with coaxial feed is 9.1dB at 77GHz, for microstrip patch antenna is 9dB at 78.6GHz, for circular patch antenna is 6.36dB at 69.5GHz and for patch antenna is 9dB at 74.9GHz

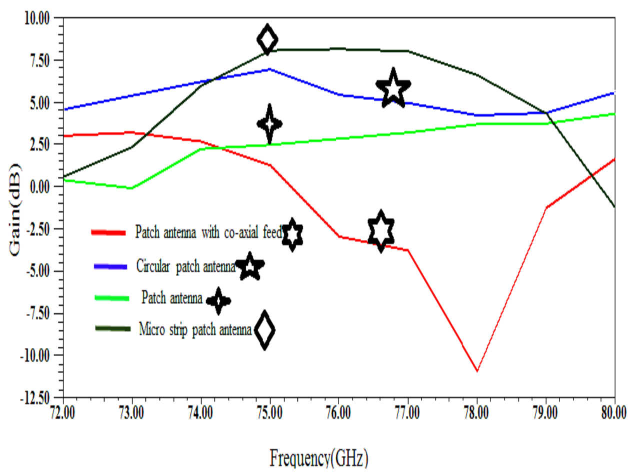

Figure-14. Gain plot for circular reflector without a slot.

The above figure represents the gain comparison of microstrip patch antenna, a circular patch antenna, a patch antenna and patch antenna with a coaxial feed by using a circular reflector without a slot. The gain for patch antenna with coaxial feed is 9.95dB at 77GHz, for microstrip patch antenna is 5.8dB at 78.6GHz, for circular patch antenna is 9.6dB at 69.5GHz and for patch antenna is 9.9dB at 74.9GHz.

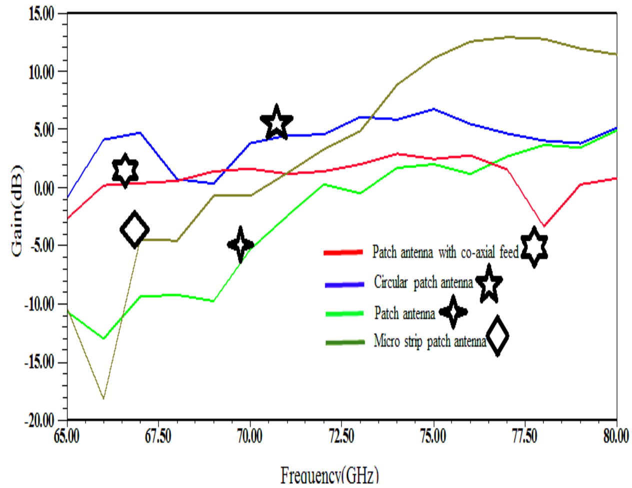

Figure-15. Gain plot for circular reflector with a slot.

The above figure represents the gain comparison of microstrip patch antenna, a circular patch antenna, a patch antenna and patch antenna with a coaxial feed by using a circular reflector with a slot. The gain for patch antenna with coaxial feed is 8dB at 77GHz, for microstrip patch antenna is 6.8dB at 78.6GHz, for circular patch antenna is 9.7dB at 69.5GHz and for patch antenna is 9.9dB at 74.9GHz.

Radiation pattern

The radiation pattern for a square reflector, circular reflector without slot and with slot by using microstrip patch antenna, a circular patch antenna, a patch antenna and patch antenna with a coaxial feed is as shown below.

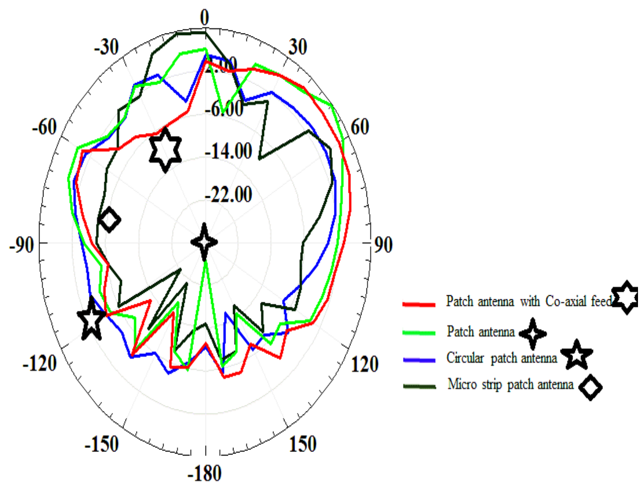

Figure-16. Radiation pattern for square reflector without a slot.

The above figure represents the radiation pattern comparison of microstrip patch antenna, a circular patch

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antenna, a patch antenna and patch antenna with a coaxial feed by using a square reflector without a slot. From the figure, it represents that it is having the omnidirectional radiation pattern which is suitable for RADAR applications.

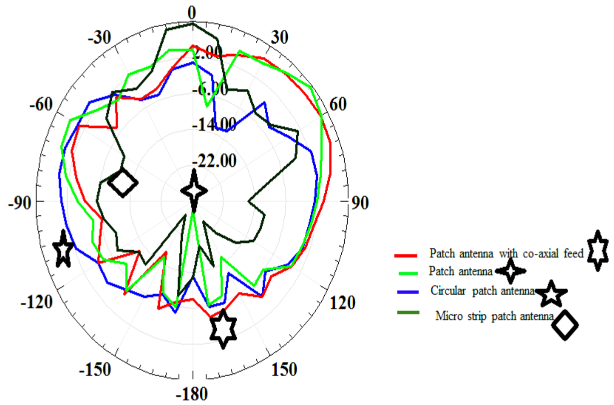

Figure-17. Radiation pattern for square reflector with a slot.

The above figure represents the radiation pattern comparison of microstrip patch antenna, a circular patch antenna, a patch antenna and patch antenna with a coaxial feed by using a square reflector with a slot. From the figure, it represents that it is having the omnidirectional radiation pattern which is suitable for RADAR applications.

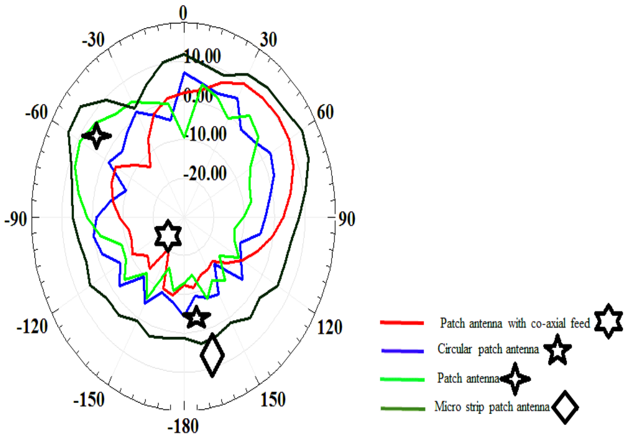

Figure-18. Radiation pattern for circular reflector without a slot.

The above figure represents the radiation pattern comparison of microstrip patch antenna, a circular patch antenna, a patch antenna and patch antenna with a coaxial feed by using a circular reflector without a slot. From the figure, it represents that it is having the omnidirectional radiation pattern which is suitable for RADAR applications.

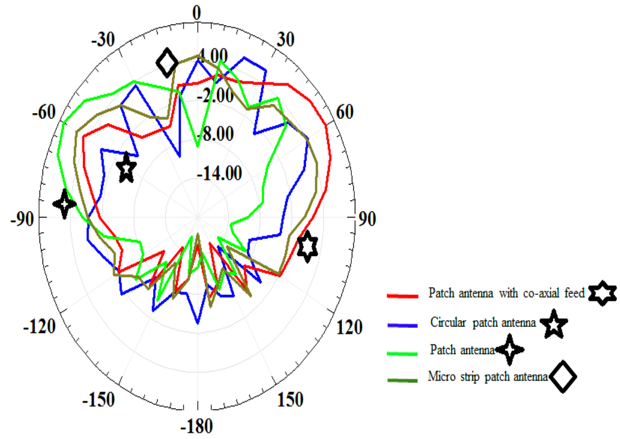

Figure-19. Radiation pattern for circular reflector without a slot.

The above figure represents the radiation pattern comparison of microstrip patch antenna, a circular patch antenna, a patch antenna and patch antenna with a coaxial feed by using a circular reflector with a slot. From the figure, it represents that it is having the omnidirectional radiation pattern which is suitable for RADAR applications.

E-Field

The E-field for a square reflector, circular reflector without slot and with slot by using circular patch antenna is as shown below.

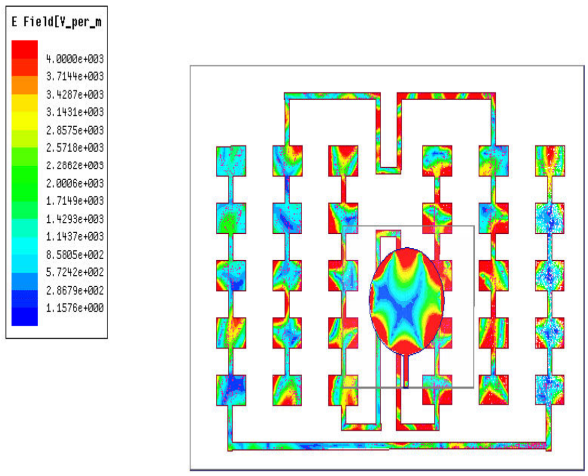

Figure-20. E-field of circular patch antenna using square reflector without a slot.

The above figure represents the E-field of circular patch antenna by using a square reflector without a slot.

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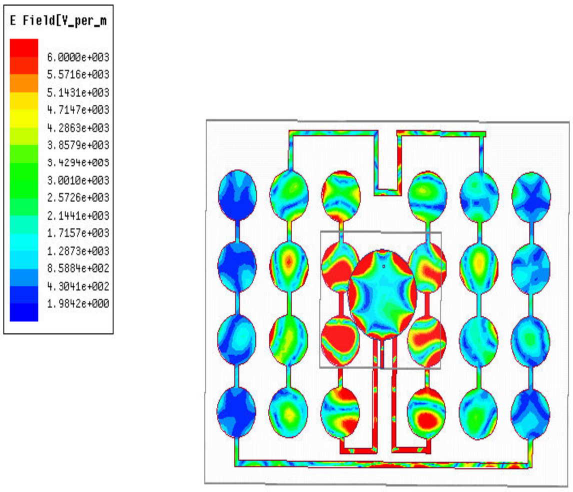

Figure-21. E-field of circular patch antenna using a square reflector with a slot.

The above figure represents the E-field of circular patch antenna by using a square reflector with a slot.

H-Field

The H-field for the square reflector, circular reflector without slot and with slot by using circular patch antenna is as shown below.

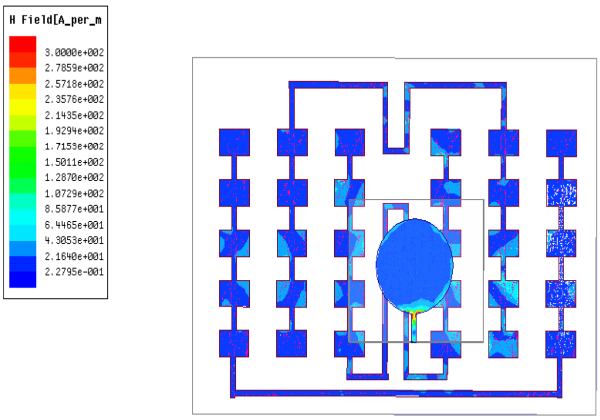

Figure-22. E-field of circular patch antenna using circular reflector without a slot.

The above figure represents the E-field of circular patch antenna by using a square reflector without a slot.

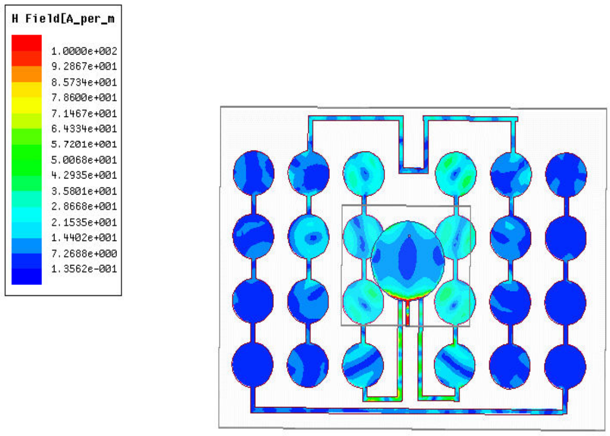

Figure-23. H-field of circular patch antenna using a circular reflector with a slot.

The above figure represents the H-field of circular patch antenna by using a square reflector with a slot.

CONCLUSIONS

The reflector array antenna which is considered as a receiving antenna and the transmitting antenna is taken as a microstrip patch antenna, circular patch antenna, patch antenna and patch antenna with a coaxial feed is designed, simulated and compared. After comparison of all these antennas, microstrip patch antenna shows the better performance in terms of return loss, gain and radiation pattern at a frequency of 79GHz.

FUTURE SCOPE

The elements in the square and circular reflector has been designed with equal sizes and in future, the sizes and shapes of those elements may be varied which can be used for different applications.

REFERENCES

[1] Constantine A. Balanis. Antenna theory analysis and design. pp. 1, 5, 6.

[2] Qi Luo. 2015. Design and analysis of a reflectarray using slot antenna elements for ka band sitcom. IEEE transactions on antennas and propagation. pp. 1-10.

[3] Paul Hallbjorner and Shi-Cheng. 2013. Improvement in 77-GHz radar cross section of road work jacket and side screen by use of planar flexible retro-directive reflectors. IEEE antennas and wireless propagation letters. 12: 1085-1088.

[4] Patil Sarang M and Bombale U.L. 2013. Design of beam steering rectangular microstrip antenna array for

2.45GHz. International journal of electrical and electronics engineering research. 3: 83-92.

[5] Keshav Gupta, Kiran Jain, Pratibha Singh. Analysis and design of circular microstrip patch antenna at 5.8 GHz. International journal of computer science and information technologies. 5: 3895-3898.

[6] E. Sarva Rameswarudu, Dr. P.V. Sridevi. 2016. Bandwidth enhancement Defected Ground Structure Microstrip patch antenna for K and Ka band applications. International Conference on Advances in Electrical, Electronics, Information, Communication and Bio-Informatics.

[7] M. Abdollahy, J.A. Encinar, K. Forooraghi, Z. Atlaasbaf, M. Barba. 2016. Single-Layer Dual Frequency Reflectarray for Ka Band Antennas. European conference on Antennas and Propagation.

[8] Muhammad M. Tahseen and Ahmed A. Kishk. 2016. Multi-Feed Beam Scanning Circularly Polarized Ka-Band Reflectarray. IEEE transactions on antennas and propagation, 2016.

[9] Muhammad M. Tahseen, and Ahmed A. Kishk. 2016. Bandwidth Enhancement in Ka-Band Circularly Polarized Reflectarray Using Stacked Cross-Bowtie Elements. IEEE transactions on antennas and propagation.

[10] Muhammad M. Tahseen and Ahmed A. Kishk. 2016. Comprehensive analysis on cross bow tie element for designing wide band CP Ka-band reflectarray. IEEE transactions on antennas and propagation.

[11] M. Venkata Narayana, Govardhani. Immadi, Dr. Habibulla Khan, N. Suryateja, D. Manasa, "Reduction Of Mutual Coupling In Antenna Arrays By Sparse Antenna", International Journal of Pure and Applied Mathematics, Volume 115 No. 7 2017, 465-469, ISSN: 1311-8080 (printed version); ISSN: 1314-3395 (on-line version).

[12] M. Venkata Narayana, Govardhani. Immadi, Dr. Habibulla Khan, Y. Suraj, B. Hema Brahmani, P.S.V.S. Naveen Chowdary, M. Emmanuel Raju, "Enhancement Of Bandwidth Of Electrically Small Antenna Using Spiral Resonator And Loop Feed", International Journal of Pure and Applied Mathematics, Volume 115 No. 7 2017, 471-476, ISSN: 1311-8080 (printed version); ISSN: 1314-3395 (on-line version).

[13] M. Venkata Narayana, Govardhani. Immadi, Dr. Habibulla Khan, Ch. Moulya Satya, N.D.S.Sri Harsha, N.Namrath Reddy, D. Kulakarni Sai Pavan" A Novel Design Of Meander Line Antenna For Ku-Band Applications", International Journal of Pure and Applied Mathematics, Volume 115 No. 7 2017, 483-487, ISSN: 1311-8080 (printed version); ISSN: 1314-3395 (on-line version.