Gain Enhancement of An Antenna using Meta Materials

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***Abstract*— In this article PRS with high gain antenna using meta material ground plane is designed.A patch antenna act as a source which is surrounded by MMGP to reduce the in and out band's of Radar cross section for an antenna. The antenna directivity can be improved by placing a PRS above the MMGP. This patch antenna is designed such that it can get a wide bandwidth and improved gain and efficiency with low RCS compared with slot antenna. The operating frequencies of this proposed antenna is around 8-17 GHz.the in band RCS reduction is approximately 17dB and out band RCS reduction is approximately 13dB for both Transverse electric and transverse magnetic polarization.the gain of this antenna is around 18dB with respect to reference antenna.**

Keywords:-** **MMGP ,PRS, RCSreduction, GainEnhacement, Meta material Antenna

I. INTRODUCTION

In last decade there will be more improvement in Stealth technology,to reduce the radar cross section reduction byproper shaping and using passive materials and active cancellation technology is being employed,in proper reduction of radarcross section it will be coated with some radar absorbing materials such as perfect meta material absorber, EBG loaded with lumped resistance etc., there parameters will work only under narrow band.instead of absorbing the back scattering energy it can be dispersed by using another technology called redirecting scattering energy which combines prefect electric conductor with artificial magnetic conductor to disperse the energy.there will ba disadvantage by using PEC and AMC is that there will be in phase reflections it can be over come by using different artificial magnetic conductors with different shapes and sizes in order to control the phase cancellations .this methods are used for reducing radar cross section in boresight.

Frequency selective surface with meta material ground plane is used with FP cavity in order to explore the bandwidth of the patch antenna. A classic artificial Structure of planar antenna with partial reflective surface have been designed to improve the directivity of the patch antenna which is placed between the array and meta material ground plane.partial reflective surface is placed above the meta material ground plane spaced at a distance of one half wavelength to get good radiation and gain with low profile.the goal of this work is provide radar cross section reduction with proper utilization of partial reflecting surface and meta material ground plane.

II. DESIGN OF PARTIAL REFLECTING SURFACE ANTENNA

Partial reflecting surface design method to get high gain and low radar cross sction reduction.partial reflecting surface consisting of unit cells in both the directions such as in x and y directions.the cells are coated with absorptive materials at one side such as perfect material absorber one side i.e., at the upper side of partial reflecting surface and other side is coated with reflective surface materials such as a combination of PEC and AMC on down side of partial reflecting surface.

When a plane wave light up's towards the dirction of z-axis then the present structure would reduce the radar cross section of an antenna for both Transverse electric field and transverse magnetic field polarizations.this structure consists of partial reflecting surface which is placed on FP cavity in order to emphasize the gain of an antenna.FP cavity consists of two mirrors facing each other this is more suitable for plane wave analysis using CST microwave studio.the absorptivity and reflectivity can be evaluated in terms of omega in both TE and TM polarizations.

$$A(\omega) = 1 - \left|S_{11}(\omega)\right|^2 - \left|S_{21}(\omega)\right|^2$$

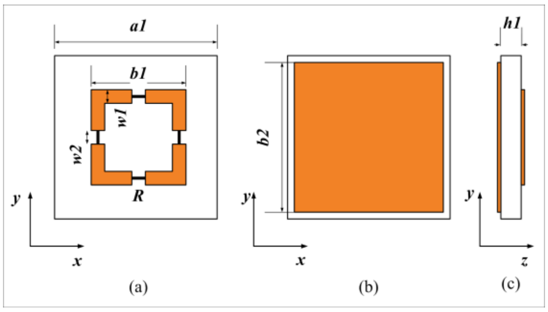
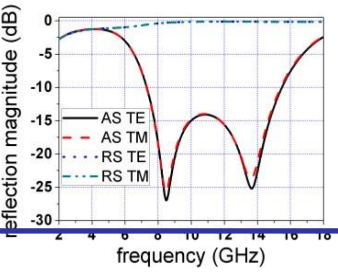


Fig 1. The unit cell of proposed PRS structure (a) the absorbing surface (b) the reflecting surface (c)the side view.



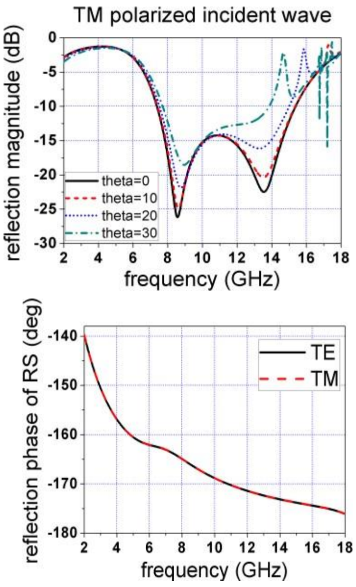


Fig 2. (a) the reflection magnitudes of AS and RS by plane wave (b) TE polarization of the incident wave (c) TM polarization of the incident wave (d)reflection phase of plane wave

This proposed antenna is designed to operate at a frequency of 10 GHz and resonant condition for this antenna is given in terms of

$$\Delta\emptyset = \emptyset + \varphi$$

Where N=0,1,2…

Maximum directivity can be achieved if the ground plane is perfect electric conductor when the cavity is equal to equal to -180^0 and the cavity thickness is around 90^0 hence the maximum directivity can be obtained by

D_{max}=1+R/1-R

The above equation expresses the maximum directivity of partial reflecting surface of antenna.

III.THE DESIGN OF METAMATERIAL GROUND PLANE

- Corresponding to the above equation 2 the metamaterial ground plane is sensitive to the incident wave.then the waveforms obtained for transverse electric field and transverse magnetic fields are different.for TE polarization
- satisfies the polarization of waves in the same direction of an antenna where as in TM polarization the wave is diffracted. In order to reduce radar cross section the metamaterial ground plane is designed in such a way that it consists of split ring resonators. Metamaterial ground plane is extended in both the directions along the x-axis and y-axis.

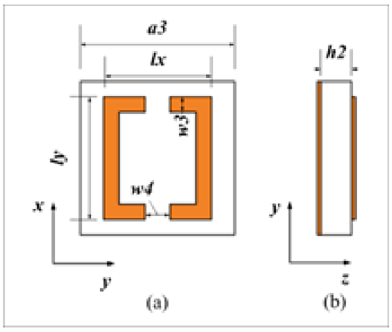


Fig 3 shows the unit cell of proposed metamaterial ground plane(a)The top view (b)the side view

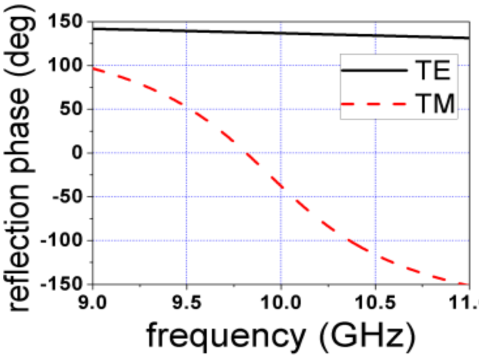
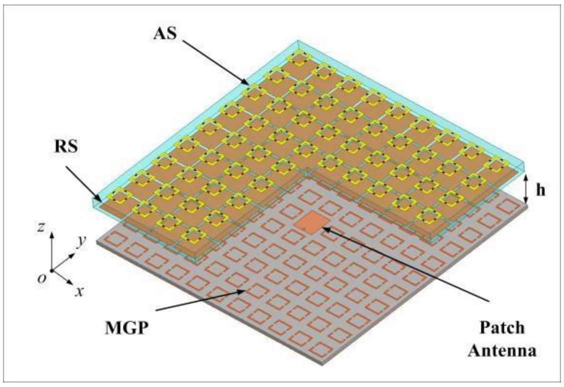


Fig 4 the graph of reflection phase of metamaterial ground plane illuminated by a plane wave propagating along z-axis.

IV. ANTENNA PERFORMANCE

- The structure of patch antenna is used as intaial feeder which is designed on the same die electric layer of meta material ground plane.the patch antenna is surrounded in the middle of metamaterial ground plane.the partial reflecting surface is placed at a space of one half of the wavelength.thichness of the substrate is around 1.6mm and h=4.6mm in order to get the desired gain of around 18dB.



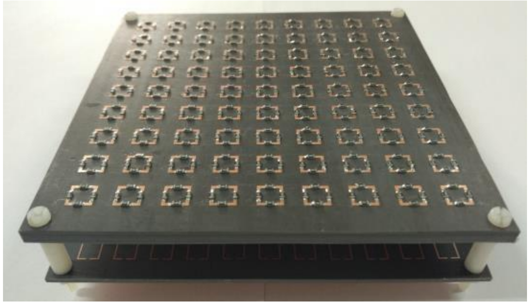


Fig 5 (a)the geometrical structure of an antenna (b)the photocopy of the designed antenna.

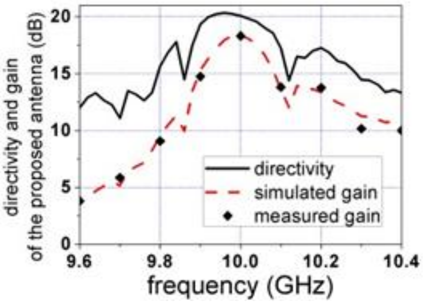


Fig 6 frequency response of the directivity and gain of the antenna.

While more loss tangent leads to low radiation as well as less efficiency of an antenna.the optimum gain is achieved with proper selection of the dielectric substrate and lower loss tangent is preffered.For better performance tilting is due to reflection phase of the partial reflected surface,which causes the frequency is varing along with incident angle and reflection phase which will leads to a re-distributed scattering energy along x,y and z directions.

TABLE 1
COMPARISION OF ANTENNA PERFORMANCE

S.No	Parameters	Gain	Aperture effieciency	In-band radar cross section reduction	Average Gain	Out of band radar cross section reduction
1	Proposed Antenna	18.4dB	40.2%	17dB(TM)	13 dB	8-17 GHz
2	Reference[8]	10.5 dB	20.2%	Not designed	10 dB	4-18 GHz
3	Reference[9]	Around 7dB	39.9%	13 dB(TM)	17 dB	3-10 GHz
4	Reference[17]	13.2 dB	22.8%	Around 5dB	10 dB	6-14 z

V.CONCLUSION AND DISCUSSION

In this Article a patch Antenna with improved gain with sufficient in band and out band Radar cross section reduction is discussed.A reflecting surface of an Antenna is used to enhance the antenna directivity over a wide range is obtained by using reflecting suface.A metamaterial ground plane is used to reduce the in band radar cross section reduction.the maximum gain obtained by using proposed antenna is around 18 dB.comparing with reference [8],[9],[17] this antenna gives higher gain,the impedence BW and 3 dB gain BW is relativelynarrow low.

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