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 acts 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 17 dB and out band RCS reduction is approximately 13 dB for both Transverse electric and transverse magnetic polarization. The gain of this antenna is around 18 dB with respect to reference antenna.

Keywords:- MMGP, PRS, RCS reduction, Gain Enhancement, Meta material Antenna

I. INTRODUCTION

In last decade there will be more improvement in Stealth technology, to reduce the radar cross section reduction by proper shaping and using passive materials and active cancellation technology is being employed. In proper reduction of radar cross 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 perfect electric conductor with artificial magnetic conductor to disperse the energy. There will be disadvantage by using PEC and AMC is that there will be in phase reflections it can be overcome 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 to 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 section 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 direction 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.

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

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

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

\[ \Delta \phi = \varphi + \varphi. \]

Where \( N = 0, 1, 2, \ldots \)

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

\[ D_{\text{max}} = 1 + R/1 - R. \]

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.

IV. ANTENNA PERFORMANCE

- The structure of patch antenna is used as initial feeder which is designed on the same dielectric layer of metamaterial 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. Thickness of the substrate is around 1.6 mm and \( h = 4.6 \text{ mm} \) in order to get the desired gain of around 18 dB.
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 preferred. For better performance tilting is due to reflection phase of the partial reflected surface, which causes the frequency to vary along with incident angle and reflection phase which will lead to a re-distributed scattering energy along x, y and z directions.

**TABLE 1**

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

**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 surface. 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 impedance BW and 3 dB gain BW is relatively narrow low.

**REFERENCES**


