Comparison Of Radiation Patterns Of Monopole Antenna Under Different Reflecting Surfaces

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Abstract:

Mobile communication generally requires the highly directional antennas to direct the fields in one direction. Electrical conductor materials generally used as reflectors, Causes shorting and diffracting of waves. In present paper PMC, PEC and HIS are used as reflector for monopole antenna. The comparative analysis of three reflecting surfaces are presented, structure was designed and executed in Ansoft HFSS software.

Keywords: PMC, PEC, HIS, SW, Phase angle

Introduction:

Monopole antenna are very popular for wide band wireless communication applications they are very simple, easy to fabricate and of low cost. So far electrical conductor materials are popularly used as reflecting structures. the radiating element of antenna and reflecting surface are prepared with similar electrical conductors causes problems such as shorting out radiating element and diffracting waves from edges and corners of structure. To over come this problem an isolation is require between them. Present paper we considered PMC, PEC and HIS structures as reflecting surfaces. Electromagnetic waves incident on PMC produce 0 degree phase shift between incident and reflected waves, this is no doubted an advantage but pure PMC are not available. PEC surfaces reflect the waves with 180 degree phase shift, hence PEC is directly used as reflecting surfaces for monopole antenna, will cancel the radiations of antenna by out of phase reflected wave. To produce effective desired radiation the gap between antenna and reflecting surface must increase so that reflecting wave phase is close to incident wave. This approach increases the dimensions and also limits the band width of antenna. The PMC, PEC structures support surface waves because of its finite size. The surface wave propagate until they reach an edge or corner and from there itdiffract in to space. When these diffracted waves interfere with original antenna radiation will effect the radiation pattern. This interference can be reduced by introduction of HIS structure. In HIS the phase of the reflected field changes continuously from 180° to -180° versus frequency. High impedance reflecting

ISSN: 2278-0181
Vol. 2 Issue 4, April - 2013

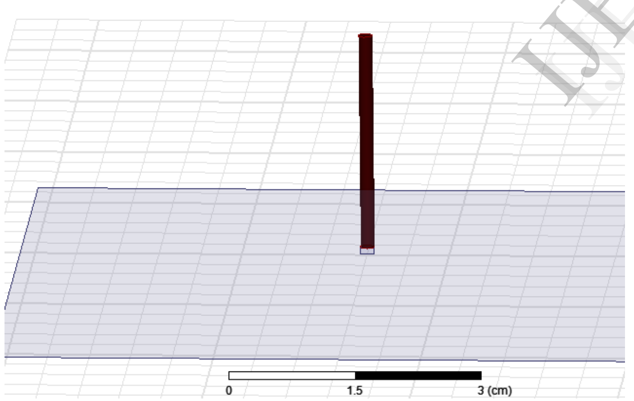
surfaces are two dimensional periodic structures called mushroom fields. HIS provide stop band for surface waves thus enhances the operational bandwidth and directivity and reduces coupling. Comparative analysis between PMC, PEC, HIS structures presented. Monopole antennas radiating element operates at 2.4GHz is considered in all cases.

Design Consideration:

Simple Monopole Antenna:

Here a monopole antenna of height 2.636cm and radius 0.084cm made up of Pec material is placed on infinite ground. And the radiation is occurred in Omni pattern. The general view of conventional antenna is shown in Figure 1.

Figure 1



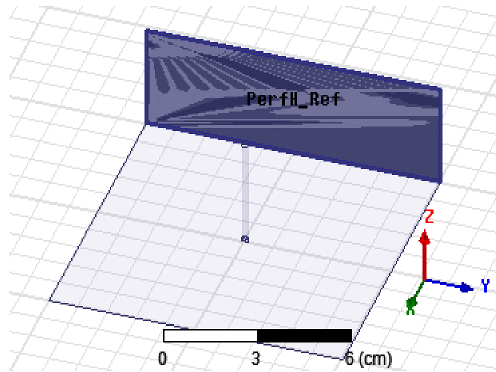
Parameter	Value
Operating Freq	2.4121GHz
Return Loss	-22.6392
Band Width	0.2909GHz

Table 1

PMC Reflector:

PMC structure when it used as reflector has very important advantage that they reflect field radiations with a phase shift of zero degree. The beam width of dipole antenna is increased, while the peak value of its far field is same as that of conventional antenna.

Figure 2

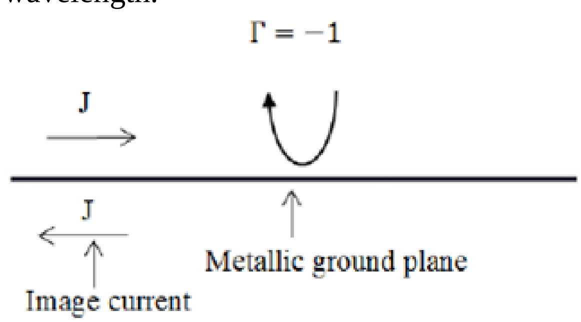


Parameter	Value
Operating Freq	2.4121GHz
Return Loss	-24.3666
Band Width	0.2667GHz

Table 2

PEC Reflector:

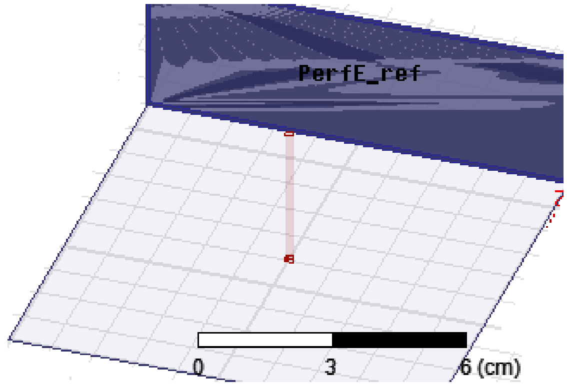
General consideration about PEC is that PEC is complimentary to PMC. This structure reflects fields of monopole antenna with 180 degree phase shift when radiating element place less than quarter the guide wavelength.



This degrades radiating efficiency to avoid this in our project we maintained gap between reflecting and radiating elements is exactly equal to quarter the guide wave length.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 2 Issue 4, April - 2013

Figure3 .

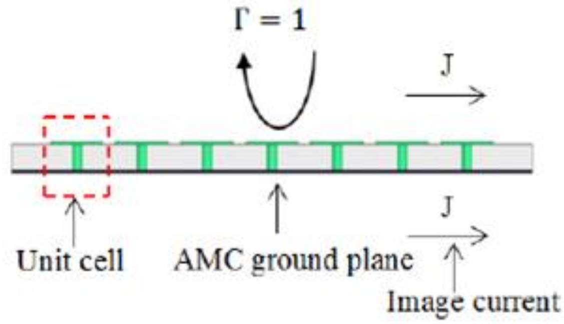


Parameter	Value
Operating Freq	2.2909GHz
Return Loss	-22.4694
Band Width	0.2182GHz

Table 3

HIS Reflector:

This structure consists of mainly four parts 1) square metal patches 2) Ground plane 3) Dielectric substrate 4) connecting via. This structure functions like two dimensional electric filter array. These surface have very high surface impedance with in a specific limited frequency range where the tangential magnetic field is small even with large electric field along the surface. Hence this surface has reflecting co-efficient of +1. (Reflecting phase is the phase of reflected electric field which is normalized to the phase of incident electric field at the reflecting surface)When the dimensions of the lattice are small compared to the wavelength of the illuminating energy, then the surface can analyzed with parallel LC circuit



The inductance L comes from current flowing through via. $L=\mu_o\mu_r h$. The capacitance C develops by the applied voltage parallel to the surface, results charges to built up on the ends of metal plate. This fringing electric fields between adjacent metal patches resembles capacitance effect.

$$C= \frac{W\varepsilon_o(1+\varepsilon_r) \cosh^{-1}(2W/g)}{\pi}$$

The resonant frequency is $f= \frac{1}{2\pi\sqrt{LC}}$

The surface impedance equal to impedance of parallel resonant circuit

$$Z= JwL/(1-w^2LC)$$

The band width of band gap is determined by surface capacitance and inductance

$$BW=Z_0/ή$$

Where intrinsic impedance of free space is 120π

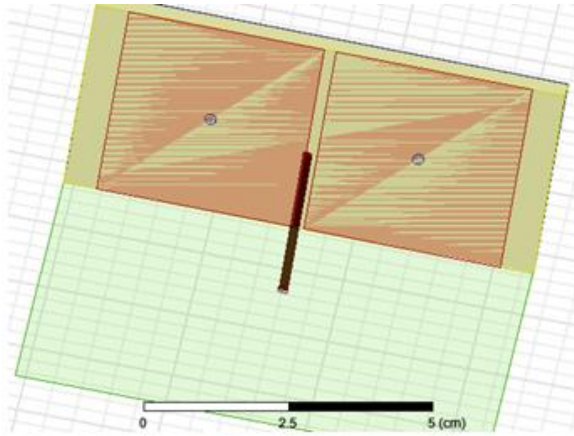
Design Calculations

Parameter	Value
Patch width	3.5cm
Band Gap	0.2cm
Sub Height	0.5cm
Reflecting Freq	2.4GHz
Surface Impedance	2.513Ω
Inductance	6.28×10^{-5}H
Capacitance	7×10^{-11} F

Table 4

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 2 Issue 4, April - 2013

Figure 4



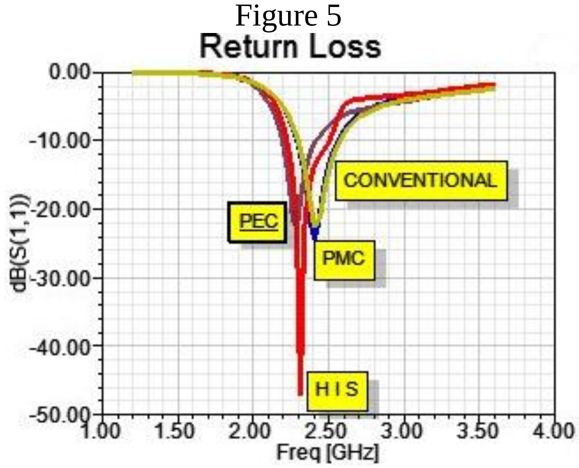
Parameter	Value
Operating Freq	2.3152GHz
Return Loss	-47.0278
Band Width	0.2909GHz

Table 5

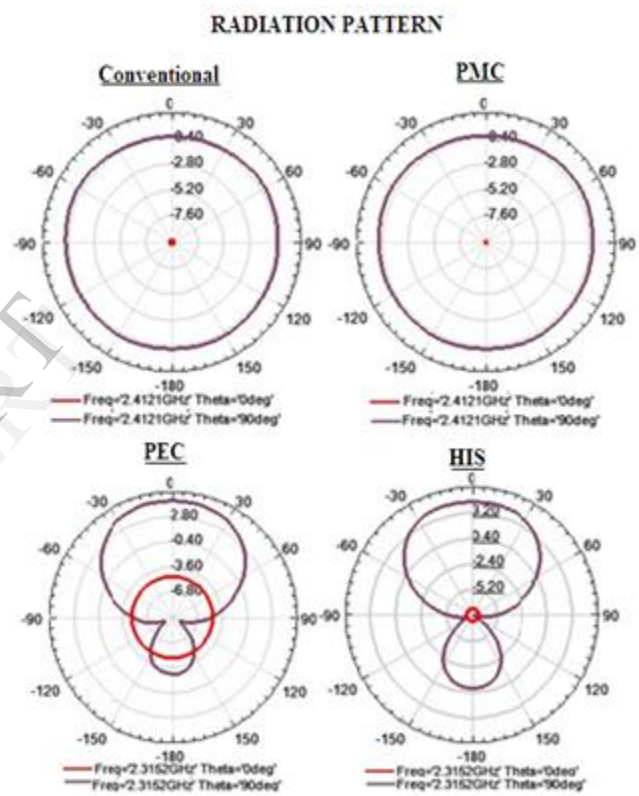
Results and discussions:

Return Loss: This parameter is explaining how effectively the incident power from the port is coupled this is obtained by solving S11. The return loss of three structures were shown in tables1, 2,3,and 5. HIS structure is showing better lower value out of remaining three structures

Figure 5



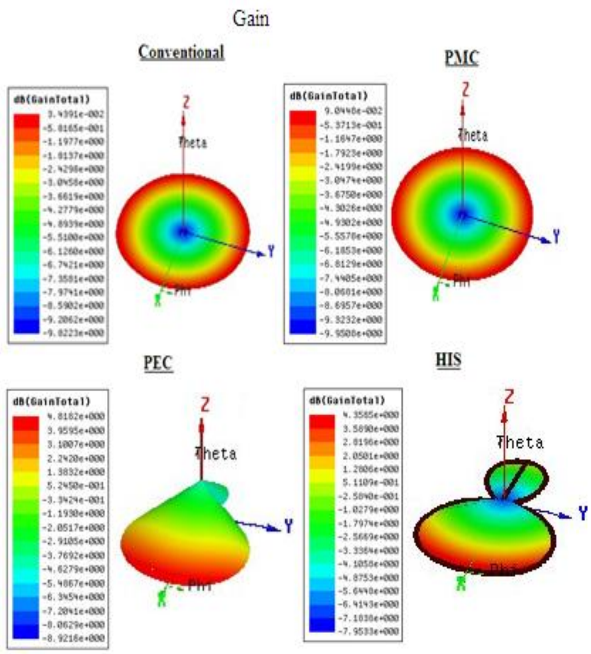
Radiation Pattern: Radiation pattern of an antenna is an graphical representation of its radiation properties as the function of the space co-ordinates. This assumes a three dimensional pattern. The analysis is done to realize the radiation pattern which showing the enhancement in radiation in one direction for clear visibility and easy understanding the radiation pattern is presented in Phi direction.



3D Gain:

Gain explains figure of merit of antenna which combines antennas directivity and electrical efficiency. Bellow figure shows 3D view of total gain curves.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 2 Issue 4, April - 2013



Antenna Parameters:

General parameters of antenna were presented in table 6. Which showing clearly the enhancement in all the parameters of monopole antenna by HIS reflector

Table 6

Quantity	Conventional	PMC	PEC	HIS
Max U	0.139(W/sr)	0.137(W/sr)	0.454(W/sr)	0.446(W/sr)
Peak Directivity	1.736	1.727	5.755	5.584
Peak Gain	1.7581	1.7395	5.795	5.6066
Peak Realized Gain	1.7485	1.7331	5.712	5.6065
Radiated Power	1.0071(W)	1.0031 (W)	0.9925 (W)	1.0040 (W)
Accepted Power	0.9945(W)	0.996 (W)	0.985 (W)	0.9999 (W)
Incident Power	1(W)	1(W)	1(W)	1(W)
Radiation Efficiency	1.01267	1.0068	1.0069	1.0040

Conclusion:

Present paper comparative analysis of PMC,PFC and HIS structures were designed in Ansoft HFSS software and obtained results were presented in comparative manner, out of all structures how HIS structure is keeping the band width of monopole antenna is equal to conventional design. How HIS is enhancing the parameters of antenna also presented.

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