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New Broadband Optimal Directional Gain Microstrip Antenna for Pervasive Wireless Communication by Hybrid Modeling

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ABSTRACT

In this paper, hybrid modeling of Micro-strip antenna is presented. Broadband frequency of operation demonstrated by single geometry .for broadening the bandwidth and maximum directional gain (6.6dBi - 8dBi) gap-coupled multi-resonator loaded on parasitic and active patch. The geometry of a single probe fed rectangular Micro-strip antenna incorporating a slot and gap coupled with parasitic and active patch on left side of geometry is studied. After IE3D™ Simulation we achieved 67% -10dB Bandwidth and analyzed maximum directional gain (6.6dBi - 8dBi) between 8GHz - 14.5GHz. We investigated concept of strong signal coupling for higher and lower edge of frequency if S=.02λ, we investigated height between active and parasitic patch should be .0525λ and height between parasitic patch itself should be .0525λ. We investigated enhancement in maximum directional gain by using Radom effect concept and stack geometry with one active and two parasitic patches of different dimensions. We achieved 67%BW for VSWR<=2. This proposed antenna is used for satellite, and wireless communication at, X-Band and Ku Band.

Keywords

IE3D™ Simulator, slit loading, parasitic and active patch, VSWR, Maximum directional gain, Ku – Ka Band.

1. INTRODUCTION

An explosive growth of the wireless radio communication systems is currently observed in the microwave band. In the short range communications or contactless identification systems, antennas are key components, which must be small, low profile, and with minimal processing costs [1-4]. The main limitations of the Micro-strip antennas are low gain and narrow impedance bandwidth. The bandwidth of the Micro-strip antenna can be increased using various techniques such as by loading a patch, by using a thicker substrate, by reducing the dielectric constant, by using gap-coupled multi-resonator etc [3-5]. However, using a thicker substrate causes generation of spurious radiation and there are some practical problems in decreasing the dielectric constant. The spurious radiation degrades the antenna parameters. Among various antenna bandwidth enhancement configurations, the two gap-coupled Circular Micro-strip patch antenna is most elegant one. So, gap-coupling is the suitable method for enhancing the impedance bandwidth of the antennas [6, 7]. In the configuration of gap-coupled Micro-strip antennas method, two patches are placed close to each other. The gap-coupled Micro-strip antennas generate two resonant frequencies and the bandwidth of the Micro-strip antennas can be increased [6].There exist a wide range of basic Micro-strip antenna shapes such as rectangular, circular and triangular patch shapes which are commonly used patches. For these patches, operating at their Fundamental mode resonant frequency, are of the dimension of the patch is about half wavelength in dielectric. At lower frequencies the size of the Micro-strip antennas becomes large. Rectangular Micro-strip patch antenna with multiband frequency operation is designed by slits loaded on active and parasitic patch the results are investigated. High gain of operation achieved due to gap between itself parasitic patch, gap between parasitic patch, and active patch. We investigated hybrid modeling for proposed Micro-strip antenna. We investigated spacing between active and parasitic patch, spacing and height between parasitic patch by using iterative method on IE3D™ Simulator (MOM Simulator).we studied enhance the gain and reducing loss.

2. PROPOSED GEOMETRY DESIGN ANALYSIS

Proposed Rectangular Micro-strip antenna Included

- **a.** slot load on active and parasitic patch
- **b.** Δ=3mil Air gap between layer
- **c.** Whole geometry consist by thee layer glass epoxy PCB and air gap(FR-4 – air- FR-4)
- **d.** Total height of geometry is 121mil (from ground plan to top layer)
- **e.** Spacing between itself parasitic patch S_1=62mil.
- **f.** Spacing between active and parasitic patch in first case S= 23.62mil (.02λ)
- **g.** Top layer consists of patch dimension L x W= 411 x 446mil^2

Specification of Glass epoxy PCB is ε_r =4.3, h= 59mil and loss tangent tanδ =.019, we have substituted two parasitic patches on the top layer of dimensions L_1 x W_1 = 100 x 150mil^2. The spacing between patches are S=23.62mil (.02λ).We investigated height between active and parasitic patch should be .0525λ.and height between top and middle patch should be .0525λ.the proposed model shown in figure-2 and top view shown in figure-1

Fig 1 Top View for Proposed model

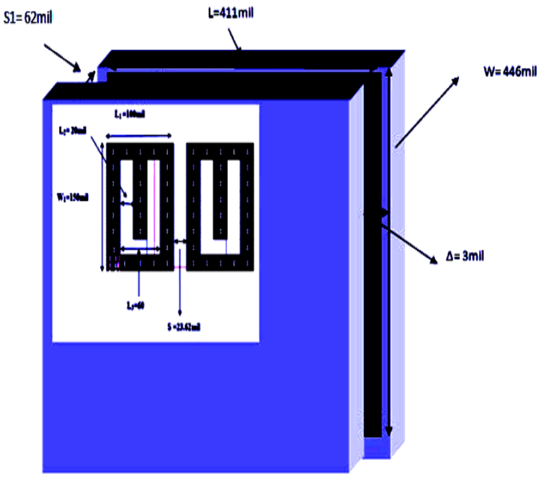
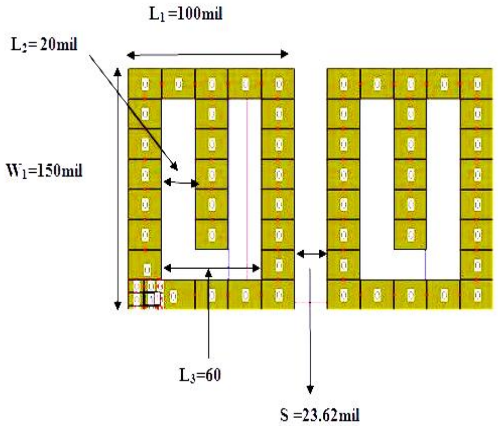


Fig 1 Proposed design model



3. RESULT AND DISCUSSION

The hybrid modeling used for improvement in overall performance of Micro-strip antenna. We focused on optimal gain and bandwidth. For achieving these outcomes we used iterative method on IE3D^{TM} Simulator. The impedance frequency bandwidth of a Micro-strip antenna depends primarily on both the thickness and the dielectric permittivity of the substrate. A thick substrate with a low dielectric permittivity can increase the bandwidth of the printed patch. Both these selections could be a solution of the problem of bandwidth enhancement if the thickness of substrate did not

a) Pose difficulties in integration of antenna with other microwave circuits

b) Cause some other problems such as the surface wave propagation and the large inductive image part of the input impedance of the antenna, which makes its resonance unfeasible. Thus, a reasonable thickness should be considered in the selection of substrate and the bandwidth would be enhanced using additional techniques. The most common and effective of them are:

i) The loading of the surface of the printed element with slots of appropriate shape
ii) The texturing of narrow or wide slits at the boundary of the Micro-strip patch.
iii) Stacked, shorted
iv) Extra Micro-strip resonators

The technique of stacked patches is based on the fact that bandwidth is in general proportional to the antenna volume measured in wavelengths but at the same time a relative large volume is a disadvantage for many applications. The utilization of additional parasitic patches of different patches of different size directly –or- gap coupled with main patch is an effective method. Superior to these methods is the techniques of slot loading or texturing the patches by slits because they ensure the small size and the low profile of the antennas. The wideband performance of the slit loaded patch is based similarly to the method of slot loading, on the excitation of more than one adjacent resonant mode. Moreover the presence of the slits in the vicinity of the feeding probe could add a capacitive load at the input impedance of the patch. This capacitive load could effectively contribute to the resonance of the patch because can counteract the inductive part of the probe's input impedance. It is noticed that this inductive part would inevitably be arge if a thick substrate is chosen for wideband operation so the insertion of slits enhances by two ways the width of the operation band, and it has been reported greater bandwidth. The width of the frequency band of the antenna can be controlled by slits' length and width and the slits' position. The slits divided the in more parts and each one corresponding an equivalent circuit of resonance. We studied and apply Radom effect concept and stack geometry with number of active and parasitic patches for enhancing the maximum directional gain and reduction in surface wave, cross polarization loss. We achieved good impedance matching due to all aspect of modeling.

3.1 Return Loss vs. frequency

We studied from first analysis when gap between active and parasitic patch is S=23.62mil. After IE3D^{TM} Simulation we investigated 67% -10dB Impendence Bandwidth of 8GHz - 15GHz(X-Band, Ku-Band). We studied when S=23.62mil (.2λ) more coupling between patches so that overall loss due to surface wave , cross polarization and poor impedance matching have been reduced. And we improved results towards higher frequency and lower frequency edge .We observed self and mutual impedance effect between active and parasitic patch, between top (121mil) and bottom (59mil) parasitic patch. These self impedance and mutual impedance provides good impedance matching over broad band. All result shown in figure-3 and Table-1. .

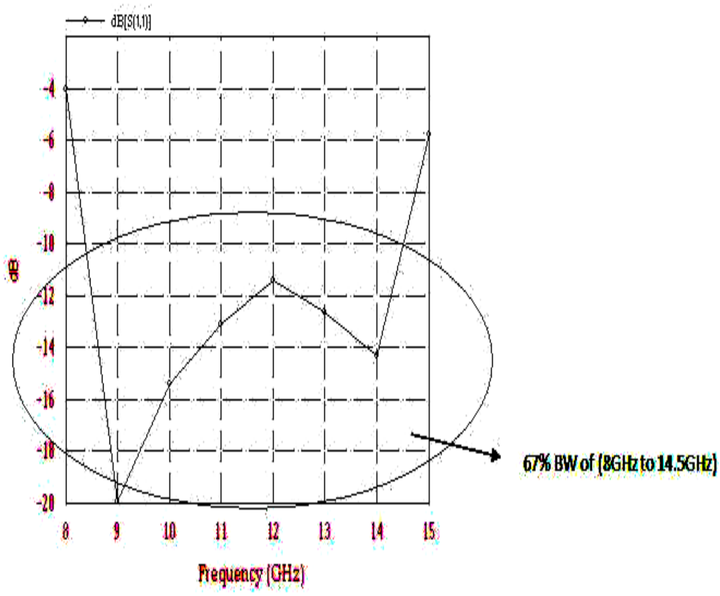


Figure 3 Return Loss vs. frequency

3.2 VSWR vs. Frequency

We studied VSWR S=23.62mil(S=.02λ), all results shown below in figure-4, and Result Table. We analyzed 67% VSWR<=2 over broadband. We investigated as per as result discussion that S=.02λ proposed design effectively used at lower and higher edge of frequency.

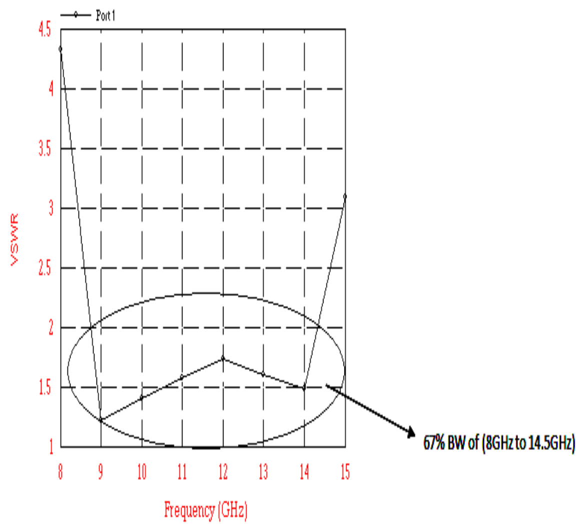


Figure 4 VSWR Vs Frequency at S=23.62mil(S=.02λ)

3.3 Maximum Directional Gain analysis

We studied maximum directional gain analysis at S=.02λ. We studied optimal gain 6.6dBi to 8dBi over 8– 15GHz frequency spectrum as shown in above figure5

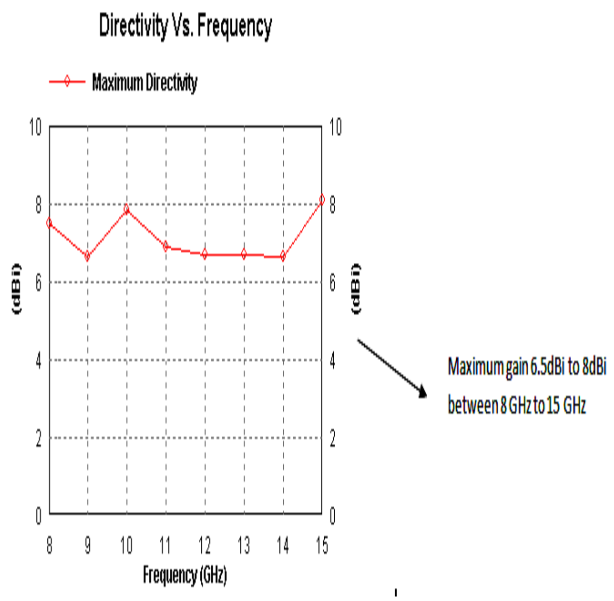


Figure 5 Directivity vs. frequency

3.4 Simulation Result Table

The results of proposed hybrid modeling Micro-strip antenna. Simulated on IE3DTM Simulator, Investigated results of VSWR, Directional Gain and return loss shown in Result Table Result Table:-

Frequency (GHz)	VSWR	RETURN LOSS (dBi)	MAXIMUM DIRECTIONAL GAIN(dBi)	3dB Beam Width degrees
8	4.323	-4.093	7.5	55.524, 97.3629
9	1.223	-19.97	6.8	60.7748
10	1.406	-15.46	6.7	63.58
11	1.567	-13.11	6.858	64.88
12	1.735	-11.41	6.7	17,108
13	1.605	-12.68	6.7	49.29,82
14	1.475	-14.33	6.7	67,149
15	3.088	-5.855	8.059	65,78

3.5 Radiation Pattern

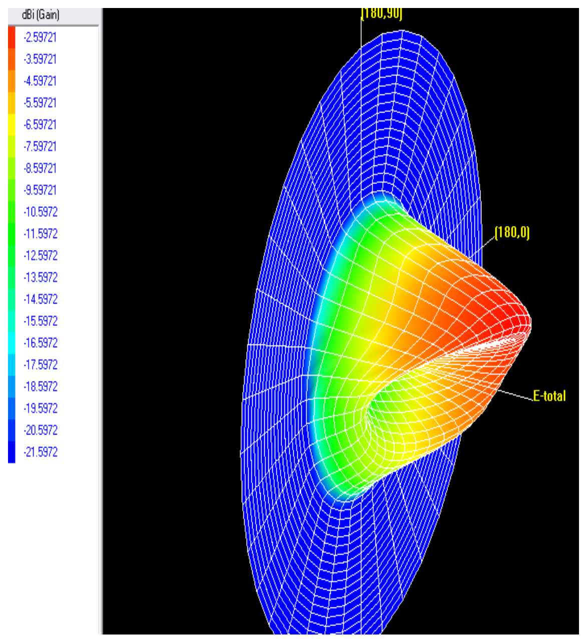


Figure 6 3D radiation patterns

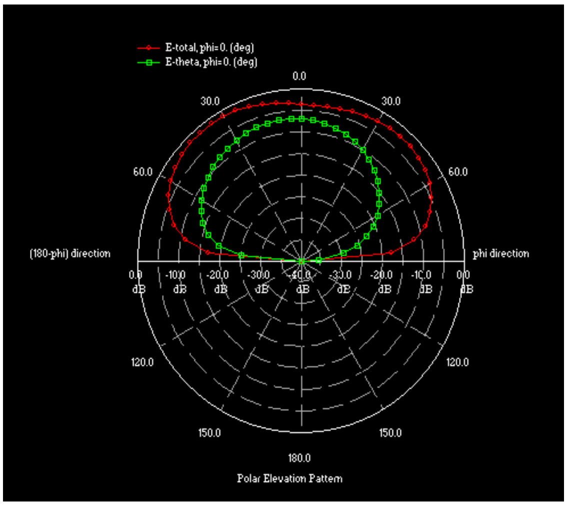


Figure 7 Elevation Pattern at 9GHz

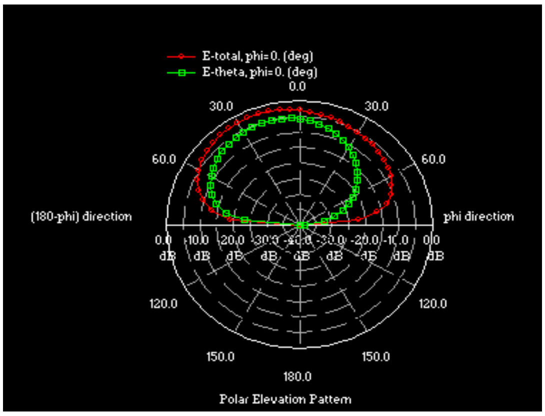


Figure 8 elevation pattern at 10GHz

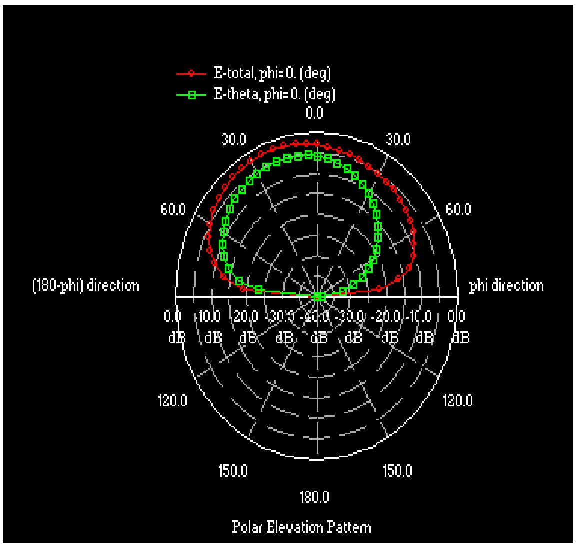


Figure 9 Elevation Pattern at 14GHz

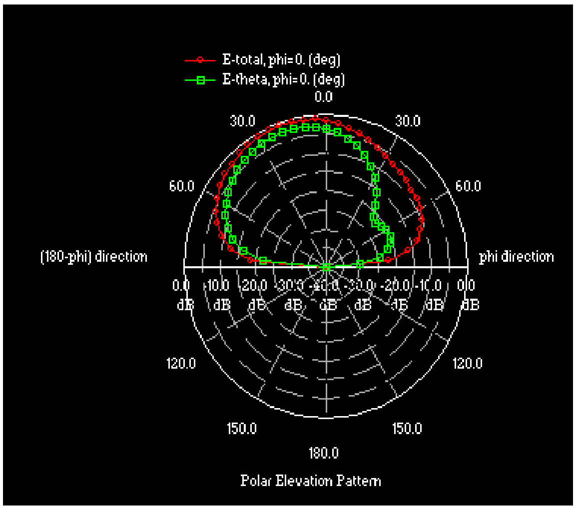


Figure 10 Elevation pattern at 11GHz

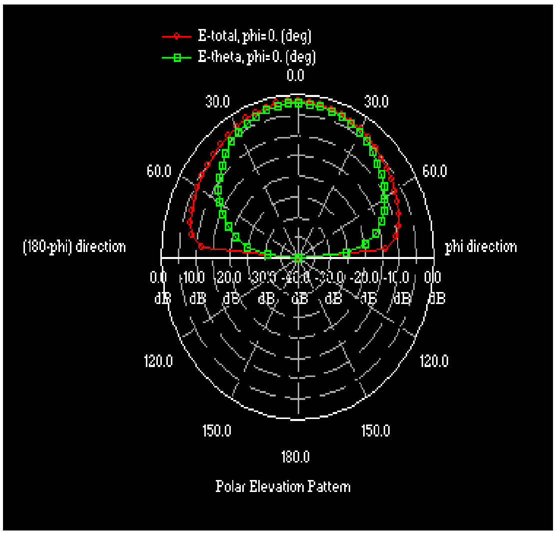


Figure 11 Elevation Pattern at 13GHz

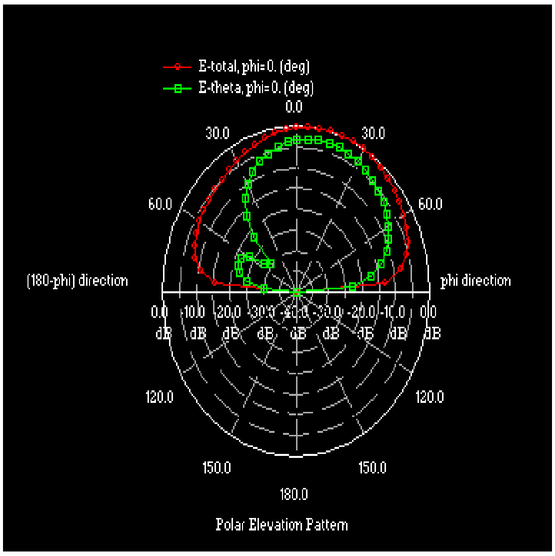


Figure 12 Elevation Pattern at 15GHz

We studied radiation pattern at different frequency shown in above figure

4. CONCLUSIONS

In this paper, hybrid modeling of Micro-strip antenna is presented. We studied broadband frequency of operation demonstrated by single geometry. We achieved 67% bandwidth and maximum directional gain (6.6dBi - 8dBi) by using gap-coupled multi-resonator loaded on parasitic and active patch; different configurations for the presented antenna are suggested. The simulated results are presented and discussed for different geometry on IE3D^{TM} SIMULATOR by iterative method. The geometry of a single probe fed rectangular Micro-strip antenna incorporating a slot loaded and gap coupled with parasitic and active patch is studied. After loading a slot multi resonator broadband operation achieved. We achieved 67% -10dB Bandwidth and 67% VSWR<=2 over 8GHz-14.5GHz(X Band Ku Band).We investigated enhancement in maximum directional gain by using concept of stack geometry with one active and two parasitic patch of different dimensions. This proposed antenna is used for satellite, Radar, and wireless communication at, Ku-Band and X Band.

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