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Dolly shaped patch antenna with enhanced bandwidth implementing reactive impedance surface and L shaped slots on ground for UMTS (SATCOM) application

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Abstract

Background /Objective: In the recent past Reactive Impedance Surface is used to increase the bandwidth of the patch antenna by antenna designers. The aim is to design a compact antenna using RIS for UMTS spectra.
Methods/Statistical analysis: RIS are effectively used in the design of the proposed antenna (which is made Compact) to increase bandwidth.
Findings: The proposed antenna has superior radiating features due to slots in its ground plane. It resonates at 2.18 GHz having a gain of 4.6 dB.
Applications: This antenna finds application in UMTS (SATCOM).

Keywords: Microstrip Patch Antenna, Compactness, Miniaturization, Linear polarization, Wireless Application, Band width Enhancement, UMTS, SATCOM

1. Introduction

Microstrip patch antennas (MPA) are very popularly used in wireless domain due to its promising features like planar structure, Ease of Integration, Light weight, Cheaper in cost due to Photolithographic techniques of fabrication and much more [1,2]. The frequency spectrum of some of the wireless applications is seen in [3]. These planar antennas are often called printed antennas which finds abundant application in Space application, Defense, avionics, Radar, Consumer items like Mobiles, etc [4,5]. The main drawback or the feature that mainly needs the attention of designer is the Bandwidth which is always narrow in such antennas.

Several techniques are bombarded for achieving enhanced bandwidth and gain. One such attempt is RIS introduction [6,7,8]. Further certain shapes are etched on ground to improve its radiating feature by means of curtailing the presence of surface waves [9].

The MPA are versatile and they find application in many systems as discussed in prior passage but the phenomenal growth of satellite communication always places new demands to designers particularly antenna experts. The MPA designed in this paper is specially targeted for Universal Mobile Tele Communication system (UMTS- SATCOM).

The designed antenna is attractive in the sense that it is made compact through miniaturization by etching certain geometries on patch with increased bandwidth and effective surface wave suppression. The Model is presented with Conventional Patch details in Section I, Proposed Antenna with its detailed Analysis are discussed in Section II while Section III deals with Results and the discussions.

Section I

Conventional Patch Antenna is designed to resonate at 2.42 GHz by means of the most popular direct feeding mechanism i.e. Inset feeding. It is designed using Rogers 3003 substrate with ε_r of 3 and thickness of 120 mils. Microstrip line (same substrate) with 50Ω impedance is used to feed it. The model is designed using a commercial EM simulator.The patch antenna has a dimension of$0.3791\lambda_o \times 0.2742\lambda_o$. Figures 1, 2 shows the patch antenna model, and its reflection coefficient characteristics of -22.7 dB at its resonance of 2.42 GHz.The patch antenna is modeled using the design equations from [5].

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Figure 1. MPA

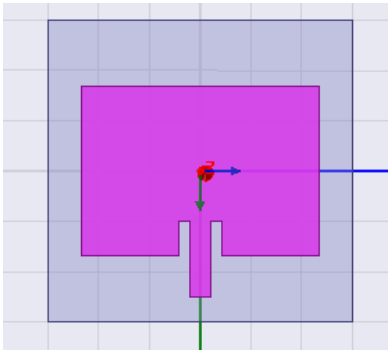
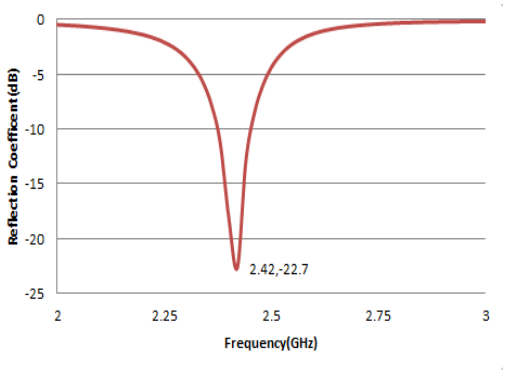


Figure 2. Reflection Coefficient of the MPA



All vital parameters of the antenna design are taken in to account during design. The Figures 3-8 give information about Gain, VSWR, Polar Plot, Radiation Pattern, Surface Current Distribution on patch, Directivity of the conventional patch.

Figure 3. Gain pattern of the MPA

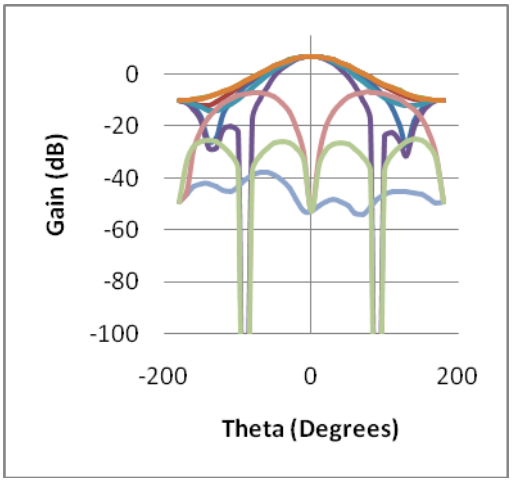


Figure 4. VSWR of the MPA

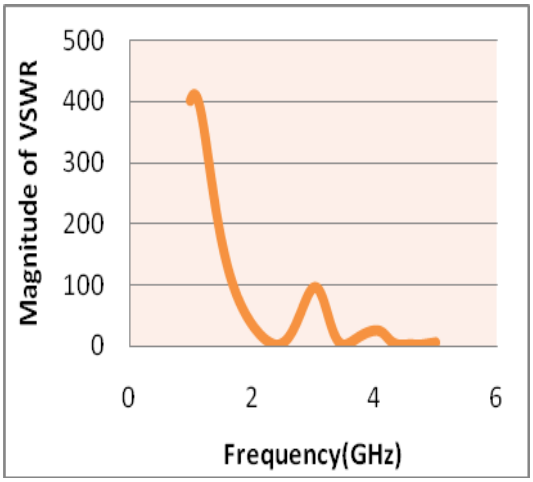


Figure 5. Polar plot of the MPA

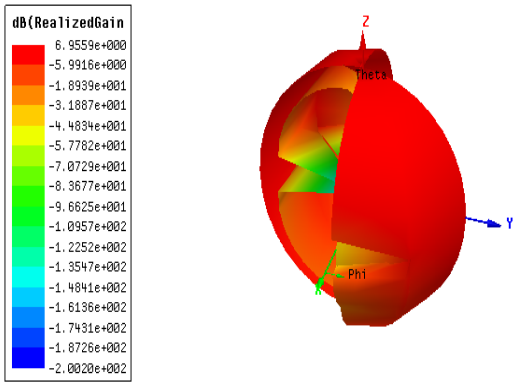


Figure 6. Radiation pattern of the MPA

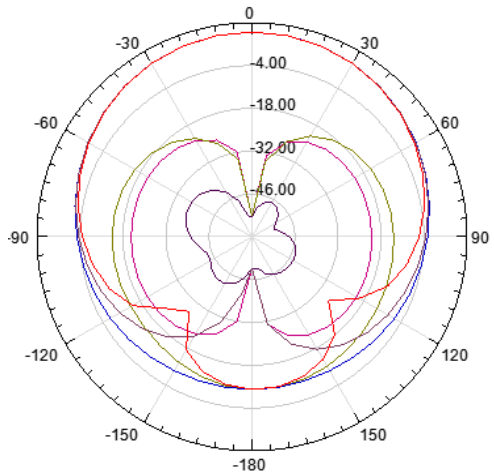


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Figure 7. Surface Current Density on the Patch

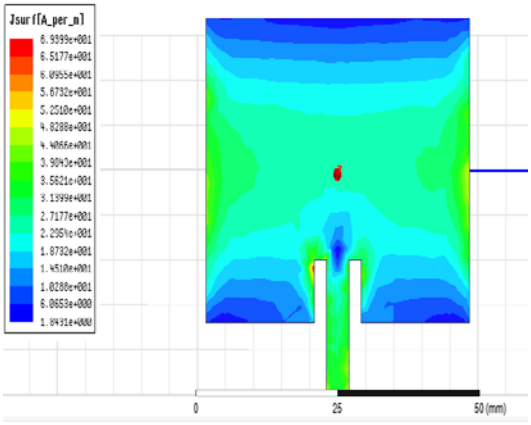
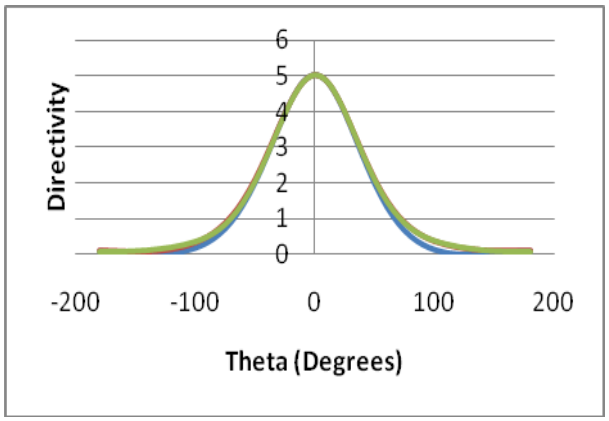


Figure 8. Directivity of the MPA



The VSWR Is always fixed to be less than 2. The directivity value of 5.0468 dB confirms uniform radiation and also it has a gain of 6.56dB. The efficiency is found to be 98.95% is shown in Table 1.

Table 1. Parameters of the MPA

Quantity	Value
Directivity(dB)	5.0468
Gain (dB)	6.56
Efficiency	98.95
VSWR	<2

The Surface current distribution over patch is presented for comparison with the proposed model.

Section II

The design of a miniaturized antenna with enhanced bandwidth is the key target (UMTS-SATCOM) and it began with rigorous hunt for commercial vendor specification of such antennas. The following modifications are done on the conventional patch model. The various views of modified patch are seen in Figures 9-11.

Figure 9. Top View of the proposed antenna

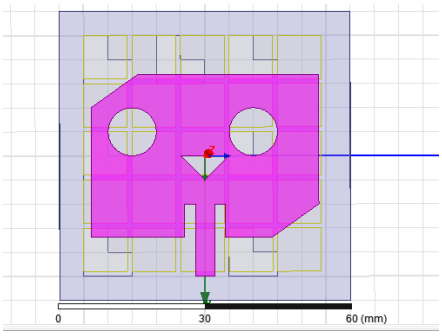


Figure 10. RIS Layer of the proposed antenna

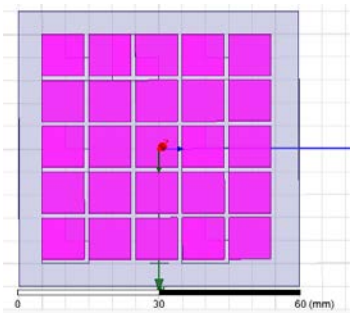
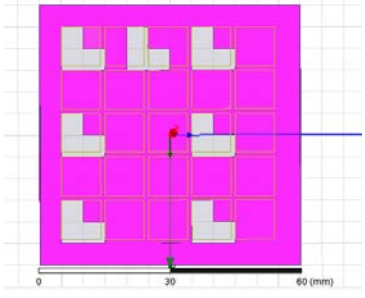


Figure 11 Ground layer of the proposed antenna



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The lowemost edge is chamfered at right side while top edge is chamfered at left side. Then to create a dolly antenna two circles and one triangular slot is cut on patch.
RIS Layer is created over first substrate layer as in [8,9,10].L shaped structures are etched on ground (seven such structures) to improve radiating features for effective suppression of surface waves. Reactive impedance surface is created over substrate 1 (with thickness of 60 mils) and Substrate layer two is also of same substrate and thickness. The optimized dimensions of this antenna is tabulated in Table 2.

Table 2. Dimension of the proposed antenna

Parameters	Size
Substrate	Two layer each of 60 mils
Ground	60 X60
Two circles on Patch of Radius	5 mm
One Triangle of sides	7,7,10 mm
RIS Each of size	9 X 9 mm
L shape Area on Ground	100 mm^2

Section III

The inset feed position is adjusted for required resonance and Return Loss characteristics. The antenna is found to resonate at 2.18 GHz with a return loss of -28 dB as in Figure 12. The key antenna parameters which includes Gain, Polar Plot, VSWR, Directivity are shown in Figures 13-16. The simulated surface current distribution at the resonant frequency is presented in Figure 17.

The consolidated antenna parameters got from the simulators are presented Table 3. In Table 4 gives the comparison of proposed antenna with a commercial vendor antenna to establish its validity. Further comparative information between conventional and proposed antenna is given in Table 5.

Table 3. Antenna parameters

Quantity	Value
Directivity	4.7021
Gain (dB)	4.6018
Efficiency	97.998
VSWR	< 2

Table 4. Validation of the proposal

Parameters	Proposed Antenna	Round Solutions [10]
Gain	4.6 dB	3.5 dBi
VSWR	< 2	3
Polarization	Linear	Linear
Efficiency	97.998	60%
Resonance	1	3
Ground Size	60 X 60 mm	106 X 45 mm

Table 5. Summary of Conventional & Proposed Antenna

Parameters	Conventional	Proposed
Resonance	2.42 GHz	2.18GHz
10 dB Bandwidth	60 MHz	80 MHz
Gain	6.5 dB	4.5 dB
VSWR	<2	<2
Directivity	5.04 dB	4.70 dB
Efficiency	98.95%	97.998%

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Figure 12. Reflection coefficient of the proposed antenna

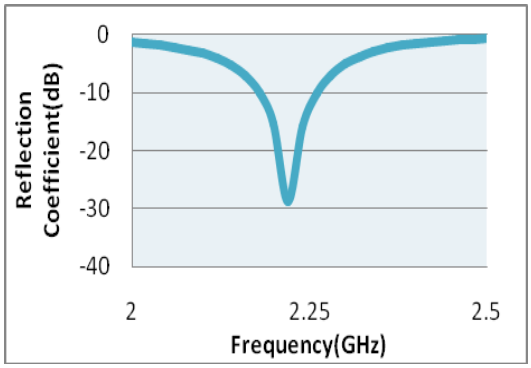


Figure 13. Radiation pattern of the proposed antenna

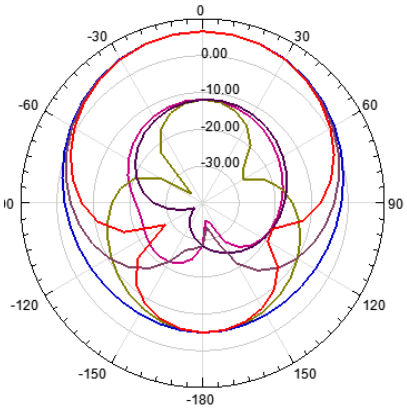


Figure 14. Polar Plot (Gain) of the proposed antenna

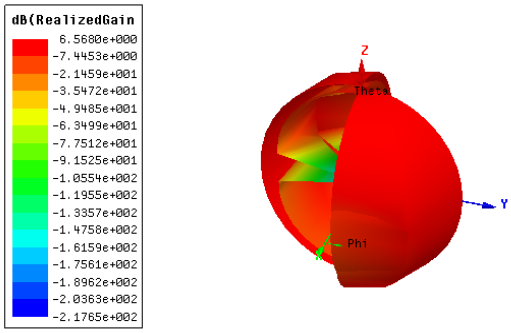


Figure 15. VSWR Characteristics of the proposed antenna

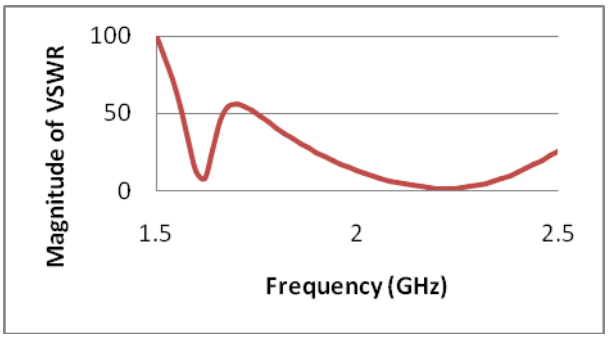


Figure 16. Directivity of the proposed antenna

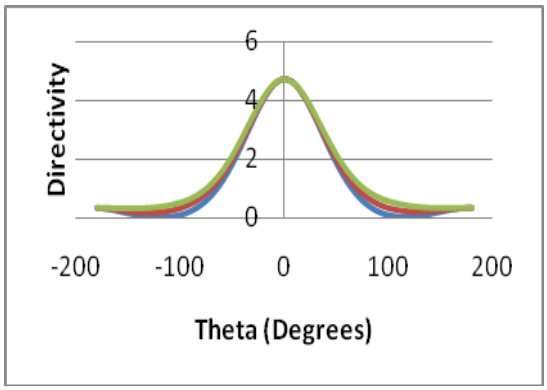
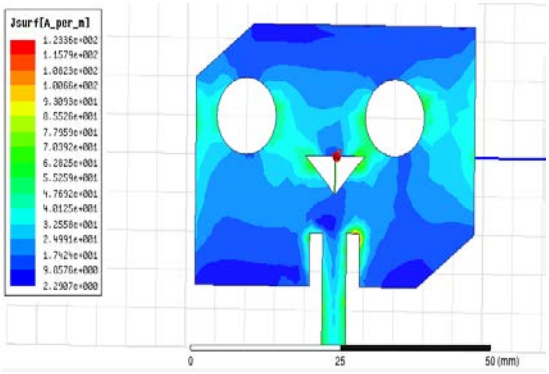


Figure 17. Surface current distributions on patch of the proposed antenna



2. Conclusion

A Novel miniaturized (Compact) Antenna with improved bandwidth is proposed in this paper. The suggested antenna is effective because of its features like compactness, use of cheaper substrate. The bandwidth is found to be 86 MHz with RIS introduction while the spectrum covered for UMTS is from to 2.14- 2.26GHz. The proposed antenna has atleast -12 dB difference between co and cross polarization levels in gain pattern. Circular Polarization may be the further aspects of improvement of the proposed antenna.

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