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ACS Feed Compact Multiband Antenna for Mobile Communication Applications

Onkar Musmade[1], A.S.Deshpande[2]
[1]*PG Student, Department of Electronics and Telecommunication, Imperial College of Engineering and Research, Pune University, Wagholi pune, Maharashtra, India*
[2]*Assistant Professor, Department of Electronics and Telecommunication, Imperial College of Engineering and Research, Pune University, Wagholi pune, Maharashtra, India*
onkarmusmade@gmail.com[1] panuradha2010@gmail.com[2]

Abstract- In this paper, design and examination of smaller asymmetric coplanar strip (ACS) fed antenna with opening resonators for tri-band operation for mobile communication applications is introduced. The proposed antenna has designed with a very compact size of 10 mm x 26 mm and operating from 2 GHz to 6 GHz band of frequencies. A rectangular-shaped-shortened structure is extended along with asymmetric ground plane to obtain proposed multiband operations including LTE-2.33 GHz, WiMAX-3.6 GHz and WLAN-5.45 GHz bands of mobile radio communications. The elliptical cut structures with semi-circle configurations are used in this design to achieve the expected triple band operations. Antenna design and optimizations has been carried out over the MOM based CADFEKO EM Simulation software. Proposed antenna is modeled and fabricated with FR-4 dielectric substrate having effective dielectric constant of 4.4 and loss tangent of 0.02. Reflection coefficient magnitudes of fabricated antenna shows <-14.5 dB at LTE band, <-16.15dB at WiMax band and <-17.45 dB at WLAN band with accurate impedance matching of 50Ω at excitation port

Index Terms- ACS fed, asymmetric ground plane, CADFEKO, triple band, opening resonators.

1. INTRODUCTION

In present days, communication frameworks consuming massive improvements in a wireless communication, there is an expanding interest for small geometries of communicating systems, multiband and wideband antennas for use in communication systems with low cost and higher reliabilities. Planar antennas are now a days are preferred due to variety of facts including ease of MMIC integration, low profile and weight, smaller geometries and has omnidirectional radiation mechanism targeted for the advanced communication applications with multi-band-multi-resonance applications [1].

Fast advancements in remote data access technologies request the combination of the different standards including DCS-1.8 GHz, WLAN-2.1 GHz, LTE-2.3/2.4/2.6 GHz, WiMAX-3.5 GHz, WLAN-5.5 GHZ on a common platform of radiation mechanism. Small sized, miniature antenna device must have characteristics to fulfill the requirements of these advancements in the technologies to achieve the higher range of communication through the available radio spectrum [2].

Size of the antenna is one of the common criterion to select the type of antenna for accomplishment of advanced wireless communication systems. Recently, monopole antennas being modelled by the uniplanar full-ground plane structures, destructed ground structures (DGS) of symmetric ground planes. Lately, coplanar waveguide (CPW) fed structures becoming more popular as it achieves variety of benefits including the dual sided geometrical operations, wider bandwidths and integrations of many on-board electrical circuitry. As geometrical considerations are always concerned in the advanced wireless communicating commercial and military equipment-pamphlets, pagers, USB dongles, smartphones, laptops, GPS-receivers, body wearable devices for point to point communication [3]-[6].

A reduced-geometrical asymmetric coplanar strip (ACS) fed antennas are developed to reduce the antenna size at half extends proving almost 50% of space saving capabilities offering small compact and conformal radiating structure. ACS fed antennas have best impedance matching capabilities, compactness with uniplanar feeding geometrical configurations along with simplicity in design [1], [7-9].

In this paper, a compact ACS feed MSA for Long Term Evolution (LTE) - 2.3 GHz, Worldwide Interoperability for Microwave Access (WiMax) – 3.5 GHz and Wireless Local Area Network (WLAN) – 5.5 GHz application with semi-circle geometrical configurations has been suggested. Designed antenna fulfills the return loss bellow to 10 dB at aforementioned operating bands with matched impedance characteristics. Design details and results discussion of simulated and fabricated antenna prototype is presented in next sections.

2. ANTENNA DESIGN SPECIFICATIONS

Antenna design parameters with detailed structure are shown in fig. 1. Antenna has been designed by using transmission line modeling theory [10]. Dielectric material FR-4 of dielectric constant of 4.4, loss tangent 0.02 and effective dielectric constant of 3.88 with substrate thickness of 1.6 mm is used to fabricate the simulated antenna. Antenna design parameters for triple band operations have been listed in table I.

The proposed antenna has designed with size of 10 mm x 26 mm and has an operating from 2 GHz to 6 GHz band using CADFEKO simulation tool [11]. A rectangular-shaped-truncated structure is extended along with asymmetric ground plane to obtain proposed-multiband operations. The ellipse shape structure with semi-circle is used in this design. Asymmetrical coplanar strip (ACS) feed multiband antennas provide easy integration solutions with RF-MMIC circuits. The radius of semi-circular transmitting bend, *Rib*, is computed utilizing equation (1), and length of the slot *Le* given by (4) [10]:

$$Cib = \pi Rib \quad (1)$$

$$Cib = C0/4fib\varepsilon reff \quad (2)$$

$$\varepsilon reff = (\varepsilon reff + 1)/2 \quad (3)$$

$$Le = Co/4fr\sqrt{\varepsilon ref} \quad (4)$$

Table 1. Antenna Design Parameters

Parameters	Calculated Values
Resonance frequency (Fr)	2 GHz to 6 GHz
Lower Edge frequency (f)	2.3 GHz
Relative permittivity of substrate (εr)	4.4
Loss tangent (tanδ)	0.02
Substrate height (h)	1.6 mm
Effective dielectric constant (εreff)	3.33
Substrate length (Ls) and width (Ws)	26mm x 10mm
Patch radius (Rib) in	7.5mm
Patch strip width (Wib) in	2mm
Strip length (Le)	12mm
Strip width (wl)	1mm
Feed line length (Lf)	8.5mm
Feed line width (Wf)	2 mm

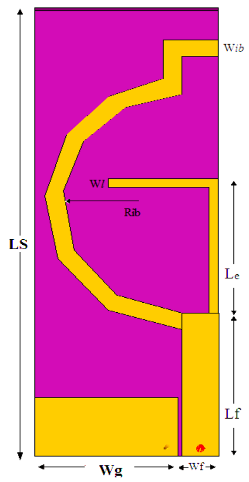


Fig. 1.Simulated antenna geometry.

3. RESULTS AND DISCUSSIONS

VSWR plot of simulated antenna is shown in fig. 3. Antenna occupies best matching characteristics as VSWR tending 1 to 2 for obtained reflection coefficient. The VSWR values of 1.75, 1.5, and 1.5 are reflected in the simulated operating bands.

Complete impedance characteristics are shown in fig.4.For resonating frequency bands with center frequencies at 2.3 GHz, 3.6 GHz, 5.4 GHz, proposed antenna offers approximately 50.3 Ω impedance at respective application band.

Fig.5. shows efficiency plot of proposed ACS fed antenna. Proposed antenna shows efficient operation at simulation frequencies with maximum efficiency of 89 % at 2 GHz to 6 GHz of operating frequencies.

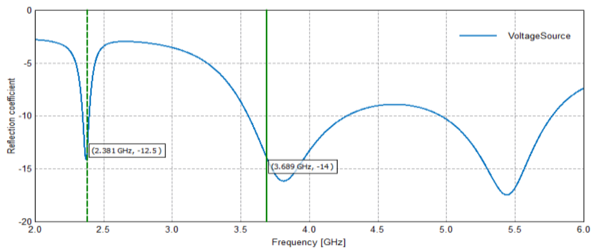


Fig. 2.Reflection coefficient magnitude of proposed antenna

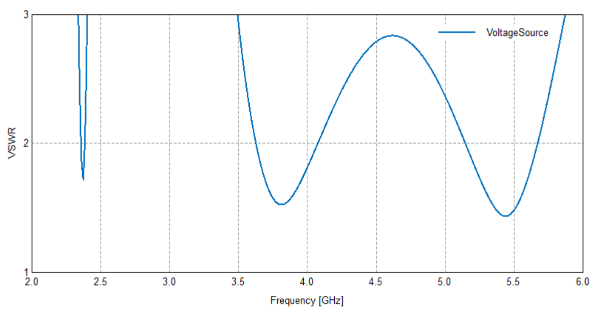


Fig. 3.VSWR magnitude of proposed antenna.

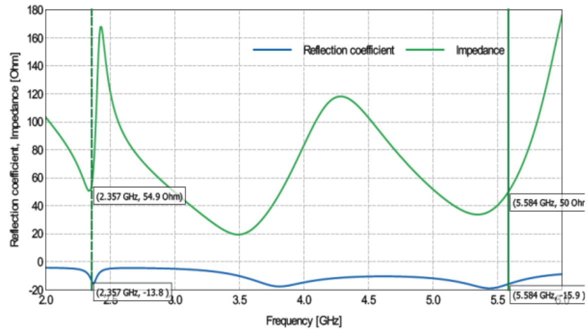


Fig. 4.Impedance magnitude of proposed antenna.

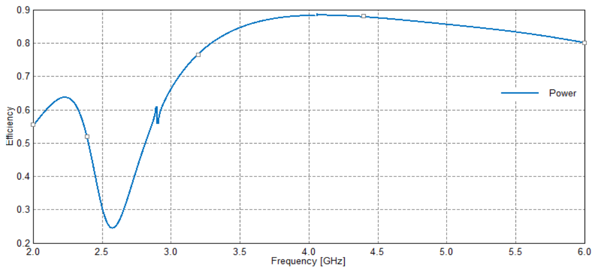


Fig. 5.Simulated efficiency of proposed antenna.

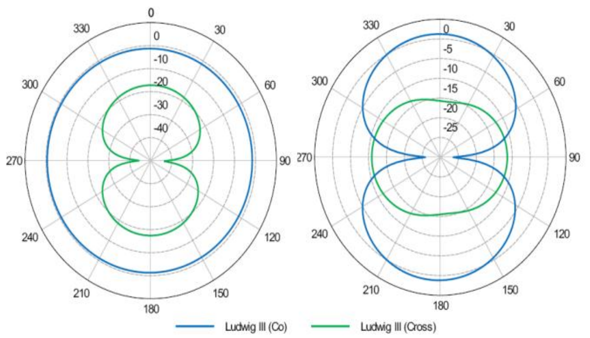
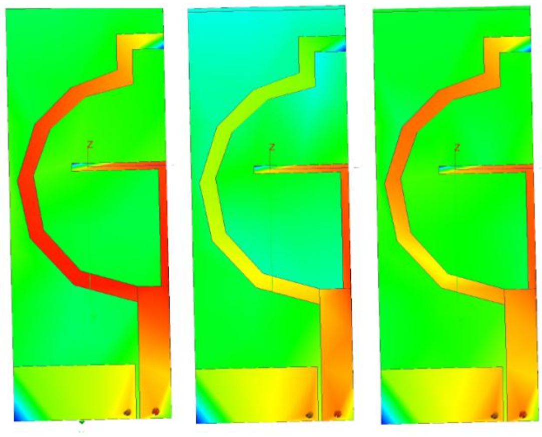


Fig. 6. Radiation Patterns of proposed antenna.

The far-field radiation characteristics of the proposed antenna are shown by fig.6. Radiation patterns of designed antenna are obtained at simulation frequency of 2.35 GHz. It is observed that, designed antenna offers almost directional patterns shaped as integer letter eight (8) along E-plane, where omnidirectional patterns are observed along H-plane. Cross polarization heights of proposed antenna is obtained lower than -29dB at resonating frequency of 2.35 GHz, showing that designed antenna is good candidate for faded wireless environment.

Furthermore, simulated current distributions have been investigated at sampling frequencies of 2.3 GHz, 3.6 GHz and 5.5 GHz. The current distribution is nearly constant along the feed line while increases along the radiating patch as the frequency goes on increasing. The simulated surface current distribution on the ACS feed antenna is shown in fig.7



(a) (b) (c)

Fig.7. Simulated surface current distribution at :(a) 2300 MHz (4G Band), (b) 3500 MHz (WIMAX Band), (c) 5500 MHz (WLAN Band).

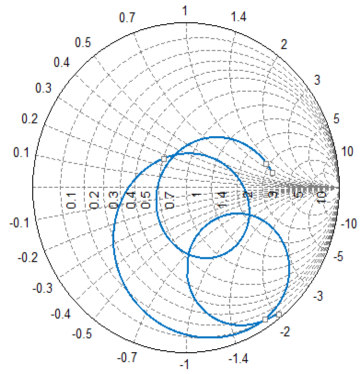


Fig.8. Simulate antenna Schmitt chart pattern at respective voltage source.

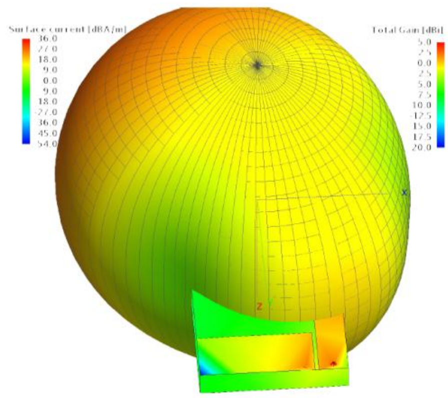


Fig. 9.3D gain of proposed antenna

Proposed ACS antenna gives best impedance matching at 2300 MHz (4G Band), 3500 MHz (WIMAX Band) and 5500 MHz (WLAN Band). Simulated Schmitt chart of proposed antenna is shown in fig.8.

Simulated gain of proposed triple band antenna is shown in fig. 9. Proposed antenna attains 3.9 dBi of total gain at its operating frequencies.

The fabricated structure of the proposed antenna is shown in fig.10. The proposed antennas is fabricated on a single-sided low profile FR-4 substrate having thickness of 1.6mm and has substrate dimensions of 10 mm x 26 mm.

Fig.10.Top view of the proposed fabricated antenna.

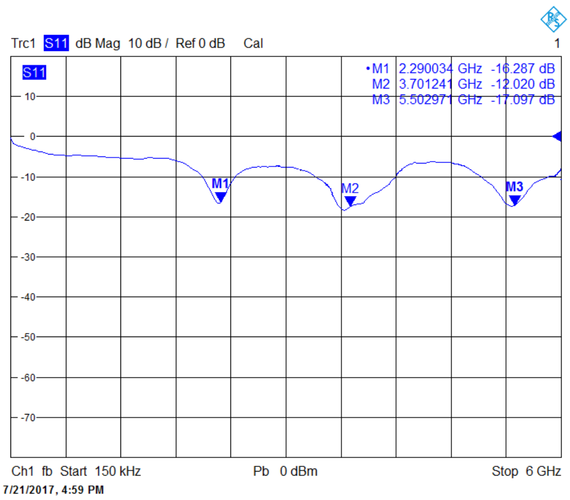


Fig.11. Measured reflection coefficient parameter of fabricated antenna

The antenna is tested using the ROHDE&SCHWARZ ZVA8 vector network analyzer for reflection coefficient and VSWR parameters [12].Measured reflection coefficient parameter of fabricated antenna is shown in fig.11.

Measured VSWR parameters of fabricated antenna are shown in fig.12. It is resolved that the value of VSWR for each center frequency lies between 1 and 2.The acquired values from graph for VSWR are 1.08, 1.48,and 1.47 for triple band resonance frequencies.

Table II shows the comparison between simulated and measured antenna results. It is observed that the measured antenna and simulated antenna approximately matches their performance parameters.

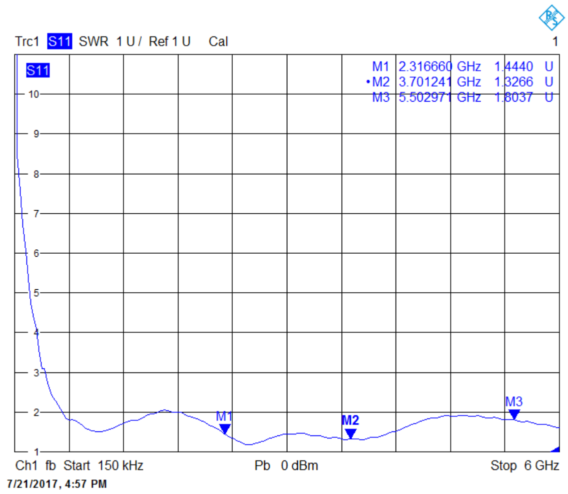


Fig.12. Measured VSWR magnitude of fabricated antenna.

Table 2. Comparison between Simulated and Tested Antenna Results

Parameters	LTE		WiMAX		WLAN	
	Simulation	Tested	Simulation	Tested	Simulation	Tested
Frequency	2.33GHz	2.29GHz	3.6GHz	3.70GHz	5.45GHz	5.50GHz
Return loss	-14.5dB	-16.287 dB	-16.15dB	-12.02dB	-17.45dB	-17.09dB
VSWR	1.7	1.4	1.35	1.32	1.23	1.8

CONCLUSION

Design of compact ACS fed microstrip antenna for triple band applications including LTE-4G, WiMax and WLAN wireless communication application has been exhibited. The exploratory outcomes discovers the proposed antenna is equipped for working over the recurrence ranges including 2.3 – 2.62 GHz, 3.3– 3.7 GHz and 5.15 – 5.85GHz of LTE, WiMax and WLAN applications with center frequencies of 2.3 GHz, 3.5 GHz and 5.5 GHz. Because of compact size of proposed antenna, making it an appropriate possibility for portable correspondence applications, data dongles, etc. Simulated radiation effectiveness of the proposed antenna is around 90% over all frequencies. Fabricated and simulated antenna performance parameters concludes the approximate design constrains at operating frequencies. Designed antenna depicts moral contribution in the world of advanced wireless communication with higher incitements.

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