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Compact Dual-Band Gap Coupled Monopole Antenna with DGP for WiMax & WLAN Applications

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***Abstract*---This paper introduces a compact dual-band gap coupled monopole MSA with DGP for covering the frequency range of WiMax and WLAN applications with 3.5 GHz and 5.8 GHz central frequencies respectively. The frequency band for WIMAX is 3.3 to 3.6 GHz and WLAN is 5.725 to 5.825 GHz. This antenna shows good flexibility on the selection of dual-band by varying the dimensions of patch and slots at the defected ground plane (DGP) and capacitive matching is achieved by gap coupling. This antenna has a compact size of 48mm x 44mm x 1.6736mm.**

***Keywords*--- DGP, Gap coupling, Impedance bandwidth, MFL, MSA, Return loss, WiMax/WLAN**

I. INTRODUCTION

Now a day in wireless communication reduction in the size of their components is a very important factor. Also, dual and multi-band operations are very popular presently [7]. Now we are using 4G/LTE technology for communication purposes but for better communication, we have to use more advanced technology or the next generation of technology i.e. 5G. In the 5G communication wireless networks, we need to improve their compatibility by using smaller antennas [7]. The Worldwide Interoperability for Microwave Access (Wimax) and Wireless Local Area Network (WLAN) band's frequency ranges are covered in the lower 5G range. The frequency range of the lower 5G band is 3GHz to 6GHz. Among different usage, dual-band microstrip antenna (MSA) is extremely appropriate for the present objective [7].

During measurement of any type of antenna two parameters are very important [7]. The first parameter is return loss at each port which is generally measured in dB [7]. The second important parameter is the impedance bandwidth [7]. These two parameters are primarily linked with elements of patch & feed [7]. At present, there are different kinds of feeding which are utilizing in MSA [7]. But generally, two kinds of it are mainly utilized in MSA- the first is microstrip line feeding (MFL) & the second is coaxial feed [7]. They both are simple to manufacture as compared to others [2-4, 7]. In place of utilizing a complementary single split-ring resonator (CSSRR), DGP has been utilized to create a structure of slotted ground [4, 6-7]. Defected ground plane (DGP) is that ground plane that does not has the same dimensions as substrate. But in this design, we use DGP with 3 different slots.

Coupling due to the gap is one of the most broadly employed matching techniques which has been referred to in the literature [5, 7].

In the present work, simulations are executed by using CST V.2018 software [7]. The antenna is designed at two resonant frequencies- one is 3.5GHz and another is 5.8GHz. The geometry of this antenna is described in section 2. Results and discussion of simulations are explained in section 3 [7]. In the end, the conclusion with future aspects is given in section 4 [7].

II. GEOMETRY OF ANTENNA DESIGN

The detailed Geometry of the proposed antenna design has been displayed in Fig. 1 and 2. Antenna is printed on FR-4 lossy substrate with dielectric constant=4.3 and loss tangent=0.025 and height (h) = 1.6mm [7]. The patch has a shape that has been described as an Octagonal Patch with Chopped Alternating Corners and O Shaped Slot (OPCAC/OSS) with an inner radius of 0.5mm at the center of the patch. The value of Micro-strip Feeding Line (MFL) width is such that impedance matching is achieved with impedance 50Ω. Here the value of microstrip feeding line width is 5mm and the dimension of the proposed patch is given in Table 1 and displayed in Fig. (2.x). Required dual-band frequencies are acquired by three slots (horizontal slot, vertical slot, circular ring slot) in DGP with dimensions as shown in Fig. (2.y) and given in Table 1. Also, a rectangular strip with a size 8mm x 1mm is in between the microstrip feeding line and proposed patch for better dual-band operation. The thickness of ground and patch is 0.0368mm and the gap between rectangular strip and micro-strip feeding line is 0.96mm and that is for rectangular strip and the proposed patch is 1.5mm.

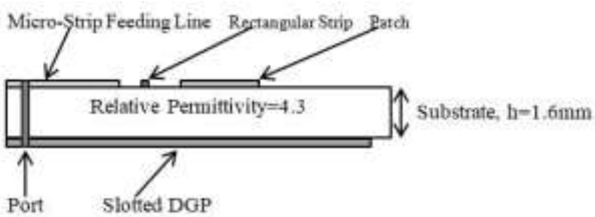
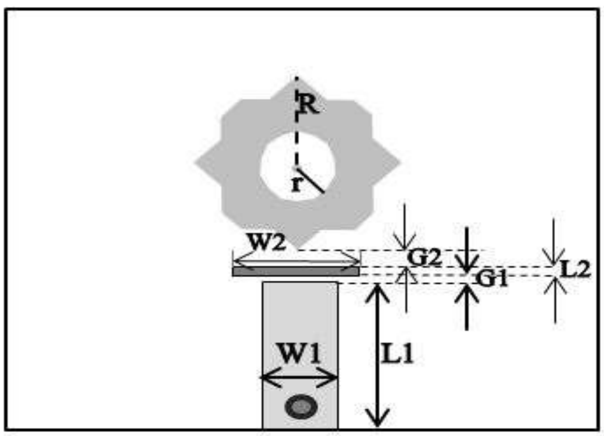
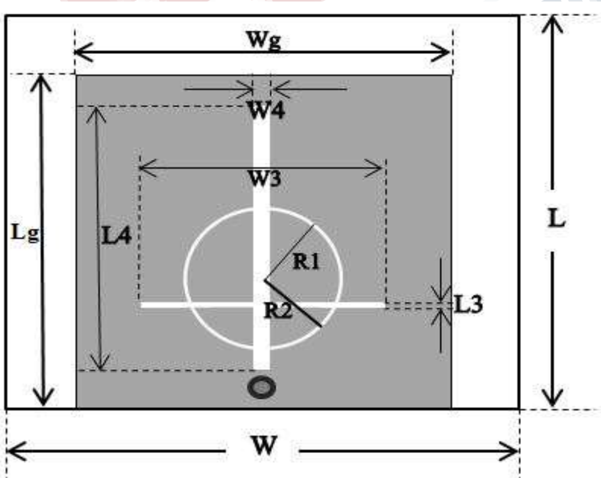


Fig. 1 Side view geometry of OPCAC/OSS antenna



(a)



(b)

Fig. 2 Configuration of OPCAC/OSS antenna (a) Front and (b) Back view

Table. I Optimized parameters of the OPCAC/OSS antenna

Parameter	Parameter meaning	Magnitude (mm)
L	Substrate length	44
W	Substrate width	48
Lg	Ground length	38
Wg	Ground width	34
L1	Micro-strip feeding line length	12.04
W1(or p)	Micro-strip feeding line width	5
L2	Length of rectangular strip	1
W2	Width of rectangular strip	8
L3	Length of the horizontal slot at DGP	0.6
W3	Width of the horizontal slot at DGP	21.6
L4	Length of the vertical slot at DGP	31
W4	Width of the vertical slot at DGP	1.4
R	The radius of the octagonal patch	7.5
r	The outer radius of O shaped slot	3
R1	The inner radius of circular ring slot at DGP	7.5
R2	The outer radius of the circular ring slot at DGP	8
G1	The gap between the rectangular strip and micro-strip feeding line	0.96
G2	The gap between the rectangular strip and proposed patch	1.5

III. RESULTS & DISSCUSSION

In this section, the simulated results of the proposed antenna are described [7]. Return loss in dB is displayed in Fig. 3. For wide impedance bandwidth calculations the value of S11 ≤ -10 dB [7]. However for simulations S11≤-20 dB is enough [7]. The two frequencies 3.5GHz and 5.8GHz are allotted for WiMax/WLAN applications by IEEE 802.11 standards [7]. The obtained impedance bandwidth is [7] shown in Fig. 3 and given in Table 2 for the required bands. The return loss is -27.617 dB & -29.762 dB at 3.5252 GHz & 5.7979 GHz respectively. From Fig.6 it will comprehend that; by changing the

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parameters of slots of DGP we can adjust the resonating frequencies [7]. This antenna design puts up to matching capacitance by coupling due to a gap in the middle of MFL & patch [7]. Ethically our frequencies necessity, the gap for capacitive matching, and magnitude of parameters of slots at DGP are chosen [5, 7]. A rectangular strip is also placed in between the patch and micro-strip feeding line for better operation of required dual-band frequencies.

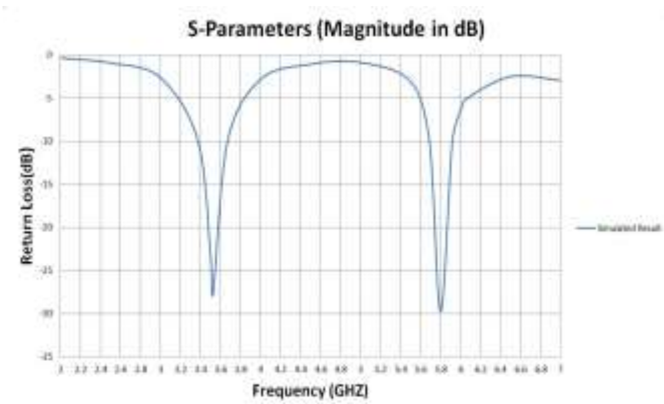


Fig. 3 Return loss(dB) of OPCAC/OSS dual-band antenna

Table. II Bandwidth with the lower and upper frequency of proposed OPCAC/OSS antenna

Band	Lower frequency (GHz)	Upper frequency (GHz)	Bandwidth (MHz)
WiMax	3.376	3.6702	294.2
WLAN	5.6875	5.9168	229.3

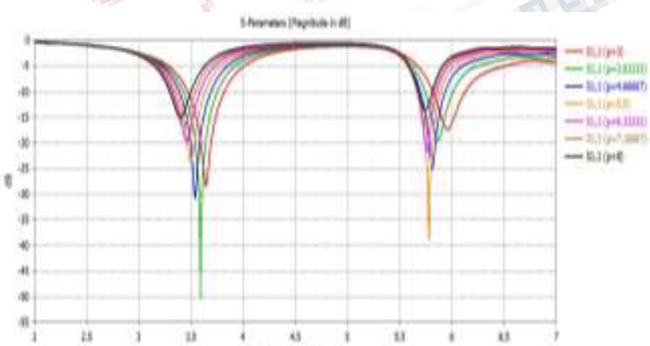


Fig. 4 Functioning of OPCAC/OSS dual-band antenna for distinct magnitudes of W1

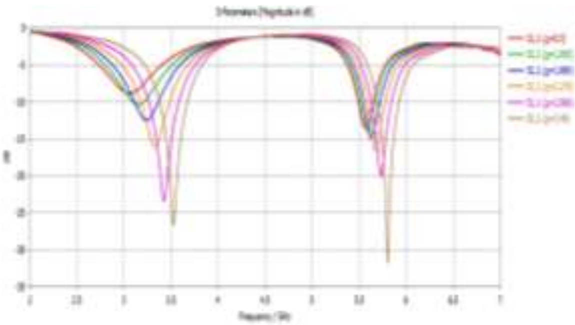


Fig. 5 Functioning of OPCAC/OSS dual-band antenna for distinct magnitudes of the gap between the patch and micro-strip feeding line

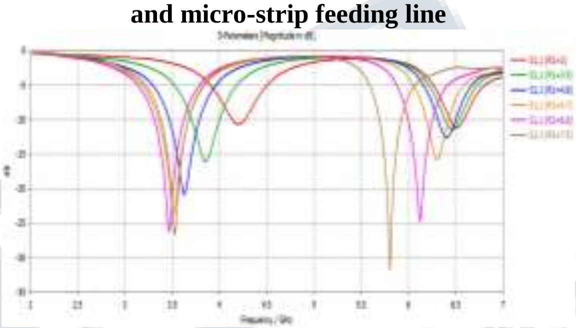
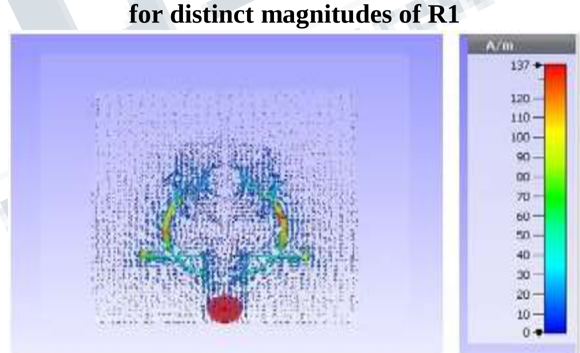
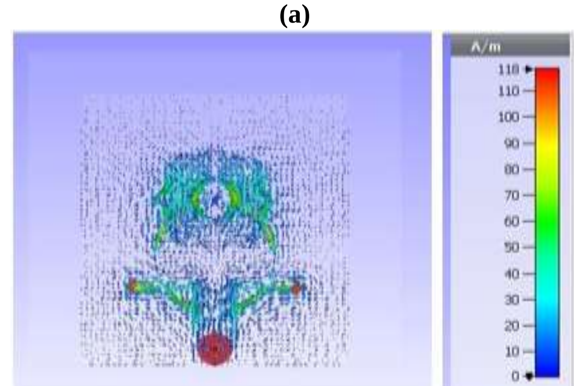


Fig. 6 Functioning of OPCAC/OSS dual-band antenna for distinct magnitudes of R1



(a)



(b)

Fig. 7 Current of the surface of proposed OPCAC/OSS antenna at (x) 3.5GHz & (y) 5.8GHz

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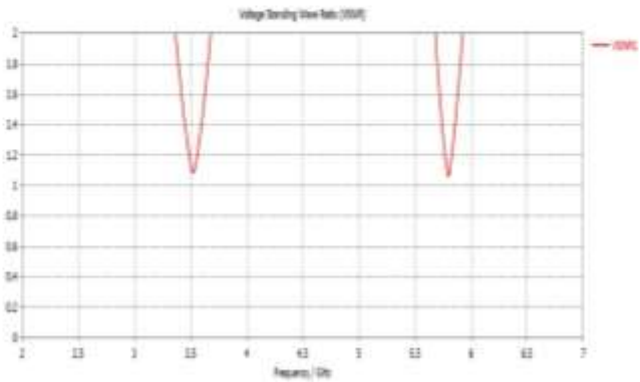


Fig. 8 VSWR of the OPCAC/OSS antenna

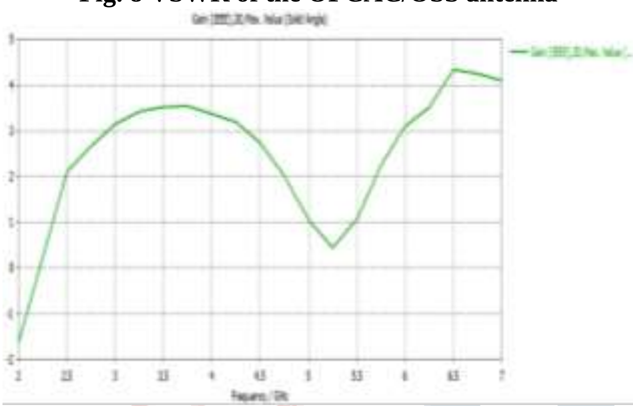
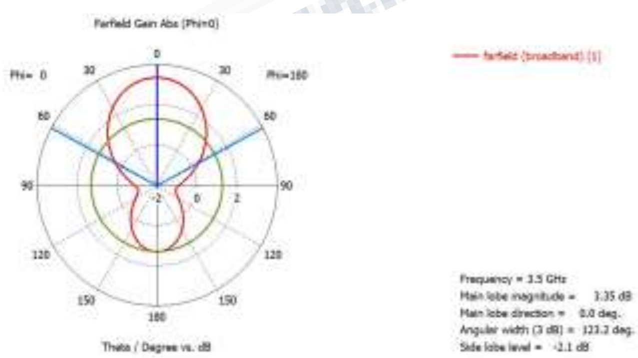


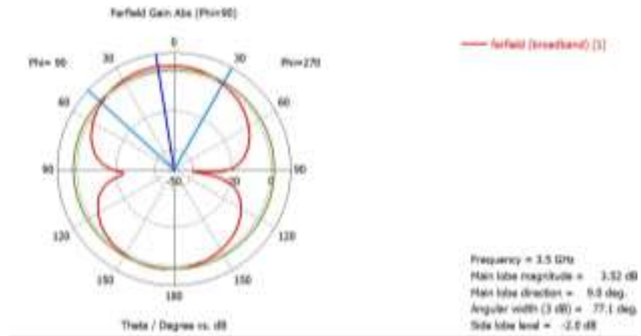
Fig. 9 The gain of the OPCAC/OSSantenna

Table. III VSWR and Gain value at central frequencies of two different bands of proposed OPCAC/OSS antenna

Band	Central frequency (GHz)	VSWR	Gain (dB)
WiMax	3.5	1.1464	3.5189
WLAN	5.8	1.0672	2.4158

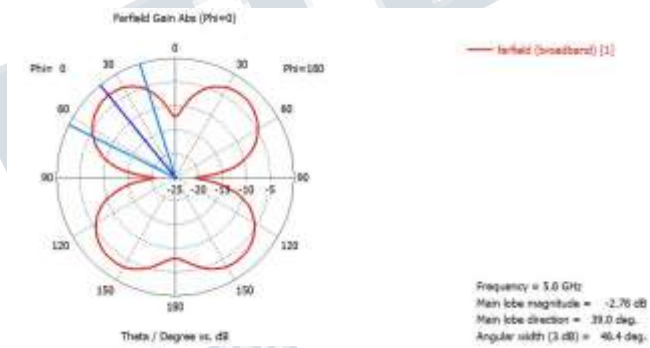


H-Plane



E-Plane

Fig. 10(a) Farfield Gain radiation pattern of proposed OPCAC/OSS antenna at 3.5GHz



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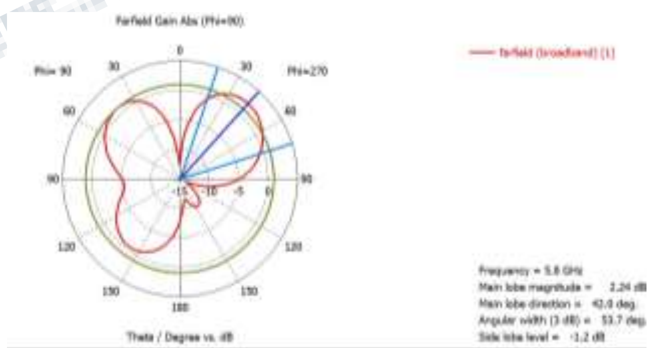

E-Plane

Fig. 10(a) Farfield Gain radiation pattern of proposed OPCAC/OSS antenna at 5.8GHz

Table. IV Details of the field at central frequencies of two different bands of proposed OPCAC/OSS antenna

Band	Resonant frequency (fr)/GHz	Gain of E-plane (dB)	Gain of H-plane (dB)	Radiation efficiency (dB)
WiMax	3.5	3.519	3.519	-0.8370
WLAN	5.8	2.224	2.224	-2.602

The simulated results of the execution of the antenna with VSWR & gain have been given in Table [7] 3 & with radiation efficiency and gain has been shown in Table 4 where fr is the resonant or central frequency in GHz. Surface current results are shown in Fig [8]. 7. Fig. 8 shows the Voltage Standing Wave Ratio (i.e. VSWR) of present work which is absolute to the ideal magnitude of VSWR [9] at resonating frequency ($VSWR_{ideal}$ = 1 [9]). The practical value of VSWR is less than and equal to 1.5 but if it is less than 2 that will be acceptable. Fig. 9 shows the gain of the present dual-band antenna, which has a maximum value of 4.34 at 6.5 GHz. Fig. 10(x) and 10(y) show the radiation pattern of the proposed dual antenna in both E-plane and H-plane for both bands at 3.5GHz & 5.8GHz respectively [7]. It is an almost bidirectional antenna at both frequency bands. Fig. 4 shows the functioning of the antenna with a change in [7] the width of micro-strip feeding line (W1 or p) which is equal to 5mm for impedance (Z) matching with Z=50Ω. Fig. 5 displays the result of the variation of the gap between path and micro-strip feeding line (g= G1+L2+G2). Hence the gap coupling offers the power's matching from port to the patch along MFL [8]. Fig. 6 shows the functioning of the antenna with distinct magnitudes of R1 [4] of a circular slot at DGP, this functioning and patch center through ground supplies capacitive matching of the antenna [6, 7].

IV. CONCLUSION

In the present work, we design a compact dual-band gap coupled monopole MSA antenna [11] with the defected ground plane (DGP) and capacitive matching for WiMax and WLAN applications [8]. The shape of the patch is octagonal with chopped alternating corners and O shaped slot (OPCAC/OSS) with an inner radius of 0.5mm at the center of the patch and that is for micro-strip feeding is rectangular. The value of [12] MFL's width is 5mm for [12] impedance matching with 50Ω. Three different slots have been used in DGP to get the required dual-bands [7]. The proposed antenna is successfully designed [7] and simulated to get dual-bands for WiMax (fr=3.5GHz) and WLAN (fr=5.8GHz) applications [7]. By adding an extra rectangular strip between MFL and patch & by analyzing the proposed antenna [10], get improvised results in comparison to previous work [7]. The future work is to improve the radiation efficiency in both bands. Fabrication and experimental result measurement is the next task to validate [8] this work.

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