Enhancing Patch Antennas Performance Using Back Rectangular holes in substrate for 5G Applications

Marai M. Abousetta
Libyan Academy for Postgraduate Studies
Studies, Tripoli, Libya
m.abousetta@academy.edu.ly

Jamal A. ELjurni
Higher Institute of Sciences and Technology
SoqAlkamis Msehel-Libya
jeljurni@gmail.com

Ali A. Ashour
Libyan Academy for Postgraduate Studies
Studies, Tripoli, Libya
alijurni04@gmail.com

ABSTRACT

This research presents patch antenna design that enhances its performance to work in 5G band with: sufficient bandwidth, acceptable insertion loss level and effective gain value. A selective procedure for finding suitable patch height has been undertaken. Parallel to this a technique of inserting appropriate Rectangular back holes in substrate has been also made. A simulation program using recent version of the well-known HFSS has been used for obtaining best of results. Sufficient bandwidth values in the range of (27 - 29.39)GHz with return loss range(-15dB - -33dB) have been obtained with acceptable gain value.

1. INTRODUCTION

Patch antennas are preferred for various applications due to their small size, low weight, and low manufacturing cost. Substantial research efforts have been carried out worldwide [1] making it a very well established field.

Ideally, a micro-strip antenna should have a substrate with low permittivity for good performance. On the other hand using high permittivity substrates like silicon and gallium arsenide are in demand due to the rapid growth of IC technology and requirement of small size antennas for wireless communications. With such substrates, it would be possible to integrate the antenna on a single chip with other circuit elements. As circuit design moves towards higher levels of system integration fabrication of micro-strip antennas on high permittivity substrates is desired. Such a design i.e. on high permittivity.

substrates leads to increased surface wave losses and reduced bandwidth. Surface waves, which propagate along the substrate, will also lead to increased coupling between adjacent elements. In highly compact circuits with large packing density surface waves will degrade

the system performance [2]. One of the methods used [3] Rectangular air holes in substrate Leading to the reduction in surface waves. Substrate is constructed by means of periodic Rectangular air columns drilled in the silicon substrate. These substrates show a complete bandgap periodicity is chosen such that the resonance of the patch falls in the stop band of the BRH substrate then no surface wave will exist in the substrate. Both of these method already investigated but no micro-strip antenna design reported that have utilized both of the technique on the same substrate. In this paper, we elaborate on a design with BRH configurations have been comparatively studied to establish the superiority of unifying these method

2. ANTENNA STRUCTURE

This design includes one techniques, where the Back Rectangular holes substrate, the capacity of generating band width good impedance matching conditions. This work is divided into tow parts; where the first part consists of convention rectangular micro-strip antenna with operation frequency at 28GHz,

2.1. Conventional Micro-strip Antenna Design

The micro-strip patch antenna design use rectangular patch shape with use silicon substrate having dielectric constant of εr = 11.9 feeding by micro-strip method with input impedance of 50**Ω**. The other parameters as shown in table [1**]**

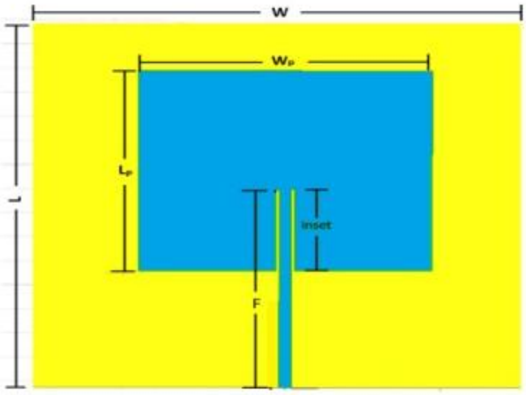

Fig.1: The structure of a normal conventional patch antenna

TABLE 1: Parameter of the proposed MSA

Parameter	Value
Frequency	**28GHz**
Substrate material	silicon
Height of the substrate	**0.5mm**
Material of the patch	Gold
Width of substrate (w)	**5.5**
Length of substrate (L)	**4.5**
Patch width (Wp)	**1.75**
Patch length (Lp)	**1.17**
Thickness of the ground	**0.01**

1- Return Loss and Bandwidth

The figure (2) shows the S11 parameters (Return Loss =-14.7) for the proposed antenna . the designed antenna resonates at 28GHz more negative is the return loss The obtained bandwidth is at the resonant frequency BW=1.24 GHz

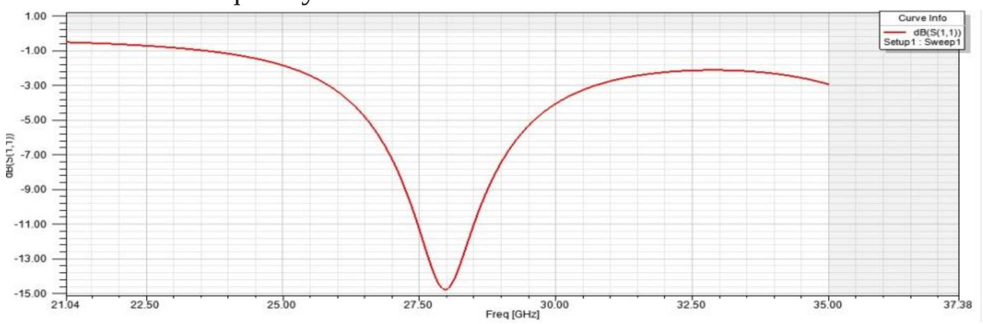

Fig. (4.2) Simulated return loess of convention micro-strip patch antenna at 28 GHz

2- Gain

Figure (3) show the gain of proposal antenna , the total gain plot gives =2.16 dB

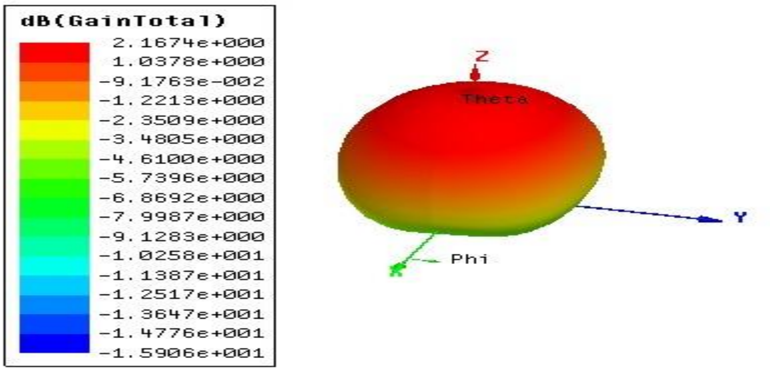

Fig.3: 3D Radiation pattern of designed normal conventional patch antenna at 28GHz

2.2. Proposed Design Structure

The proposed antenna shows in figure (1). Had the same configuration of substrate that design in figure (4) with addition of **Back Rectangular** on the substrate . where used silicon substrate having dielectric constant . $\varepsilon_r = 11.9$ feeding by micro-strip feeding line method with the input impedance of 50Ω the substrate thickness of 0.7mm , the rectangular patch having width of $W_p = 1.75mm$ and length of $L_p = 1.17mm$ with **Back Rectangular** in the center of the substrate . the antenna dimensions with **Back Rectangular** have summarized in the table (2) below.

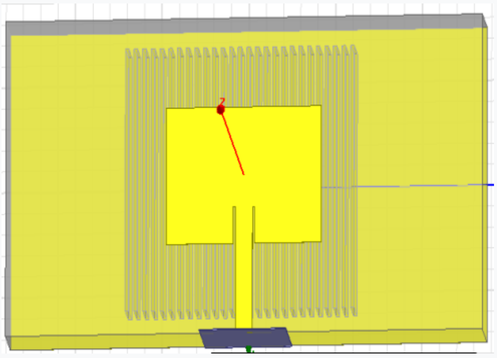

Fig. (4) Geometry the proposed top view Back Rectangular in substrate

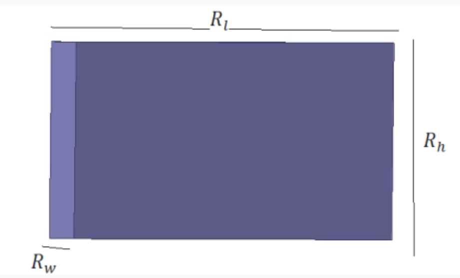

Fig. (5) Dimensions of the Back Rectangular

The table (2) Dimensions of the Back Rectangular in substrate

Parameter	Value(mm)
R_l	2.5mm
R_w	0.04mm
R_h	0.1mm
R_t	0.45mm
R_s	0.1mm
n	27

2.2.1.1. Simulation and Results

1- Return loss and Antenna Bandwidth.

Figure (6) shows the result of return loss and bandwidth for the Back Rectangular with resonant frequency, the return loss for 28GHz is -32.8dB and having bandwidth of BW=2.39GHz

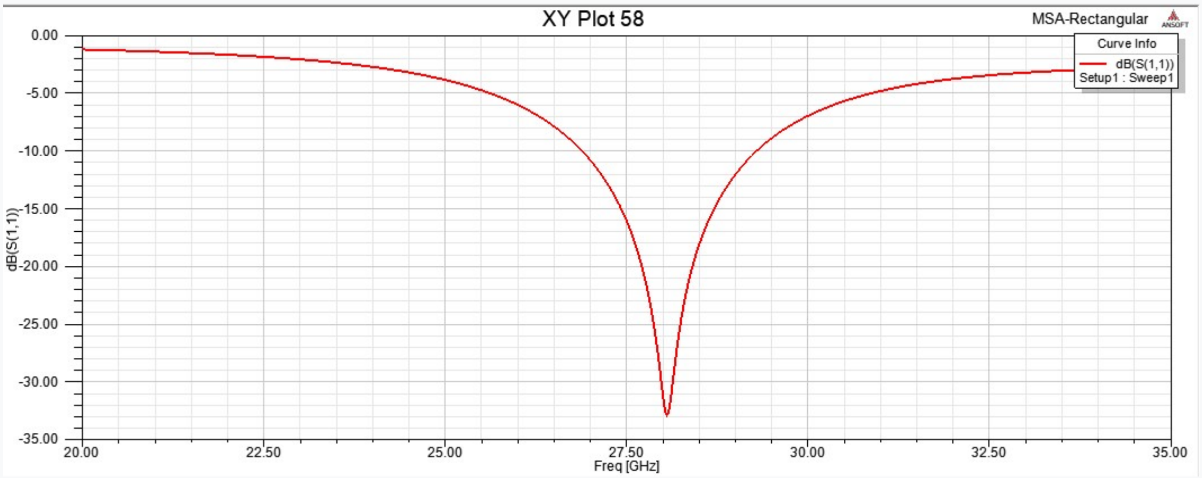

Fig. (6) Simulated return loess of convention micro-strip patch antenna at 28 GHz

2- Gain

Figure (7) in bellow shown the total gain for proposed Back Rectangular with the resonant frequency , the gain of the normal inset fed patch antenna is 2.14dB at the center frequency , and the radiation pattern is also shown in this figure

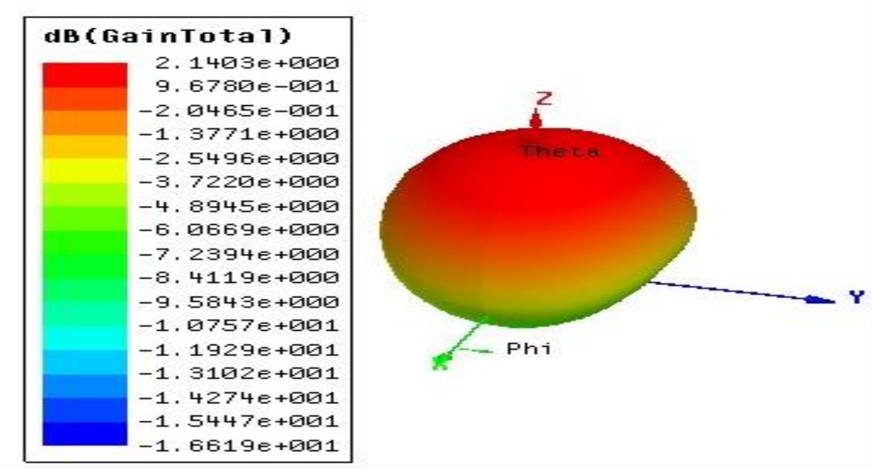

Fig. (7). 3D Radiation pattern at 28GHz

The table (3) Comparison results

Type of the antenna	RL (-dB)	BW (GHz)	Gain (dB)
MSA- Calculated	-14.7	1.24	2.16
MSA-Back Rectangular holes	-32.8	2.39	2.14

3. CONCLUSION

In this paper, the Back Rectangular holes (BRH) technique was used on silicon material with a permittivity of 11.9 and a height of 0.7, results are very encouraging; where value of bandwidth = 2.39GHz, gain=2.14dB) and return loss =32.8dB have been which encourages its application in 5g and wireless communication.

4. REFERENCES

[1] Constantine A. Balanis, "Antenna Theory: Analysis and Design", 3ed Edition; John Wiley & Sons, 2016.

[2] Thomas A. Milligan, "Modern Antenna Design Modern Antenna Design", 2nd Edition; John Wiley & Sons, 2005.

[3] Richard C. Johnson, "Antenna Engineering Handbook", 2nd Edition; McGraw-Hill,1984.

[4] N. Mittal, R. Khanna, J. Kaur, "Performance Improvement of U-Slot Microstrip Patch Antenna for RF Portable Devices using Electromagnetic Band Gap and Defected Ground Structure," International Journal of Wireless and Microwave Technologies (IJWMT), vol. 3, May 2016, pp. 20-28.

[5] Girish Kumar, K. P. Ray, "Broadband Microstrip Antennas", 4th Edition, Artech House, 2001.

[6] S. Murugan, E. Sathish Kumar, and V. Rajamani, "Design and Analysis of Double U Slot Loaded Dual-Frequency Microstrip Antenna", Progress in Electromagnetic Research C, Vol. 45, 101-112, 2013.

[7] K.Pengthaisong, P.Kracchhodnok, and R.wongsan, "Design of a Dual-band Antenna using a Patch and Frequency Selective Surface for WLAN and WiMAX". Conference: Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology (ECTI-CON), 2013.

[8] Meenal Kate and Anjana Goen, "A Survey Paper on Various Techniques of Microstrip Antenna", IJEECS, Vol.5, May 2016.

[10] Sana Arif, Syeda Areeba Nasir, Muhammad Mustaqim and Bilal A. Khawaja, "Dual U-Slot Triple Band Microstrip Patch Antenna for Next Generation Wireless Networks", Electronic and Power Engineering Department, PN-Engineering College (PNEC), National University of Sciences and Technology (NÜST), Karachi, Pakistan.

[11] K. F. Lee, S. L. Steven Yang, A. A. Kishk, "Dual and Multiband u-slot patch deg. antennas" IEEE Antenna Wireless tech. sys. comm., 2008

[12] Kumari, Pinki, and Abhishek Vaish, "Brainwave's energy feature extraction using wavelet transform" Electrical, Electronics and Computer Science (SCEECS), 2014 IEEE Students' Conference on. IEEE, 2014.