ISSN 2454-8065

International Journal of Applied Theoretical Science and Technology
Volume 03, Issue 08, pp613-617, 30th 0ctober2016

Modified Minkowski Shaped Patch Antenna with Rectangular Parasitic Patch Elements

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Abstract: **The Minkowski shaped antenna with the rectangular parasitic patch elements is for parametric study. Generally, patch antenna has four parts. Those are patch, feed line, ground plane and parasitic elements. A patch antenna is basically a metal patch suspended over a ground plane. In Minkowski shaped patch, the rectangular parasitic elements are placed at the bottom. Different patch sizes involved in parametric design study i.e., (Design 2*A*, Design 2*B*, Design 2*C*, Design 2*D* and Design 2*E*). The parameters of patch antenna are return loss, radiation pattern, directivity, efficiency, bandwidth and gain. For Worldwide Interoperability for Microwave Access (WiMAX) application the frequency of this antenna is 5.8 GHz (i.e. upper frequency). It gives the bandwidth of 254 MHz (5.676 GHz to 5.930 GHz), return loss of –24.477 dB and a gain of 2.351 Db**

***Keywords*: Minkowski, patch antenna, return loss, *bandwidth* and gain.**

I. INTRODUCTION

Nowadays, in the developing world, technological progress is rapidly growing. Third-generation (3G) wireless communication has made great strides forward to fourth-generation (4G) communications. The path is small in size freedom in convenience and lifestyle support the fast data transfer, and mobility devices. The characteristics of the antenna depends on the radiation pattern, efficiency, quality factor, directivity, gain and the bandwidth result.

Worldwide Interoperability for Microwave Access (WiMAX) is a wireless communication standard. It is established by the IEEE 802.16 (fixed WiMAX) and IEEE 802.16e (Mobile WiMAX). WiMAX is classified into three categories depends upon its frequency bands. i.e. 2.300 GHz to 2.690 GHz for low frequency band, 3.200 GHz to 3.800 GHz for the middle frequency band, and finally upper frequency band with 5.200 GHz to 5.800 GHz. The operated frequency used in Mobile WiMAX applications are 2.300 GHz (frequency range of 2.300 GHz to 2.400 GHz) [1]. WiMAX is possible to change the global system for mobile (GSM) communication in the present cellular technologies.

The micro strip patch antenna is very popular selection for the researcher because it is a low profile, smaller in size, low cost material, lightweight easy to fabricate and production is easy. Many investigators had been enhanced antenna's performance of gain, radiation pattern, resonant frequency, return loss, efficiency, directivity, bandwidth and also gain. Several shapes of antennas are used in the development process. The special structure is added to the patch antenna, placed the RF components and integrated circuit (IC) also added to the patch antenna. Electromagnetic band gap (EBG), defected ground structure (DGS), split ring resonator (SRR), parasitic elements and fractal geometry shapes are the examples of structures.

Fractals geometry shape is composed by applying multiple copies of the similarity structure with different size and scale. Minkowski, Sierpinski gasket, Tee fractal, Hilbert curve fractal, box meander-line, meander-line planer, Giuseppe Peano fractal and Koch fractal, are some Fractal geometry shapes. and other fractal elements theoretically to decrease antenna and increase the bandwidth of the patch antenna. The hybrid design of the Minkowski shaped fractal is Minkowski island and Minkowski-like pre-fractal (MLPF).

Figure 1 shows the primary stage of Minkowski shaped patch antenna. This Minkowski shaped patch antenna is designed by using FR -4 substrates with permittivity, $\varepsilon r = 4.3$. After optimization work for the modified Minkowski patch antenna the final measurements are 34.0 mm width and 45.0 mm length. The thickness of the substrate is 1.6 mm. The copper thickness for both patch and ground layer is 0.035 mm.

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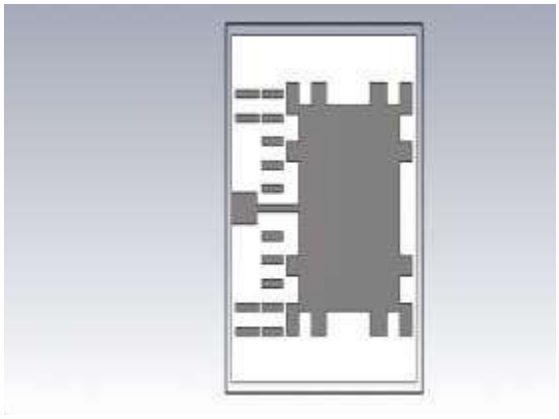

Fig. 1. Schematic diagram of Minkowski shaped patch antenna design

Figure 2 shows the s-parameters of Minkowski shaped patch antenna for 2.400 GHz applications. The resonant frequency of this antenna is at 2.404 GHz with a return loss of – 47.990 dB. The return loss at 2.400 GHz is – 33.140 dB, lower that the result in resonant frequency point. The gain at the resonant frequency of 2.404 GHz is 2.445 dB while the gain at 2.400 GHz is 2.448 dB. Figure 3 shows the Voltage Standing Wave Ratio(VSWR) of Minkowski shaped patch antenna.

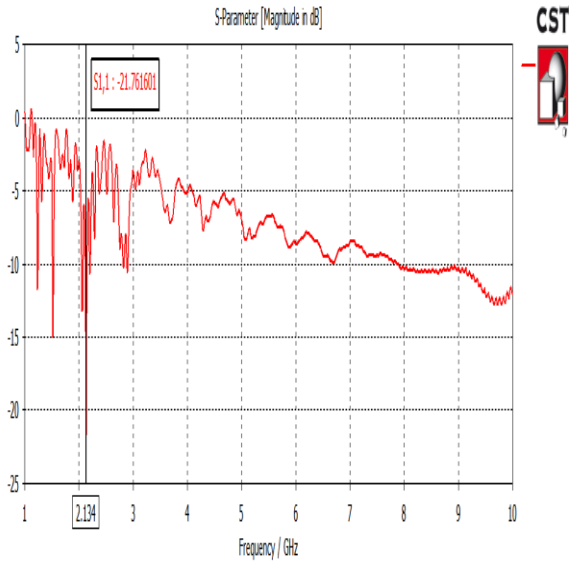

Fig.2 s-parameters of Minkowski shaped patch antenna

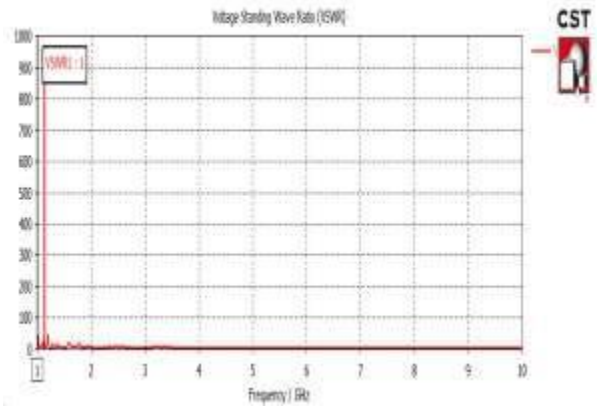

Fig.3 VSWR of MINKOWSKI shaped patch antenna

The aim of this design is to study the result of the parasitic patch elements to the Minkowski and Minkowski MMO shaped patch antenna design. The target frequency of this antenna is 5.800 GHz with a return loss must be better than – 10 dB.

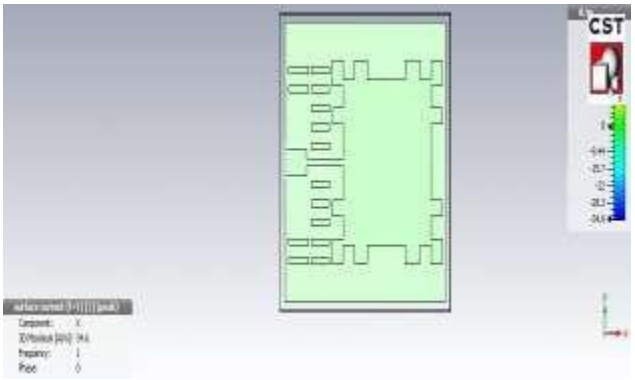

Fig.4 surface current of Minkowski shaped patch antenna

Figure 4 shows the 3D radiation pattern for the Minkowski shaped patch antenna (Design *2C*) that resonate at 5.800 GHz with gain performance of 2.351 dB

II. ANTENNA DESIGN

Figure 5 shows the schematic diagram of the Minkowski MIMO shaped patch antenna with rectangular parasitic patch elements. Table I show the dimension of the modified Minkowski patch antenna. The dimension of the FR-4 substrate is 19.20 mm width x 25.80 mm length x 1.60 mm thickness. Compared with the previous design, this antenna had been reduced 67.62 % of the FR-4 substrate size

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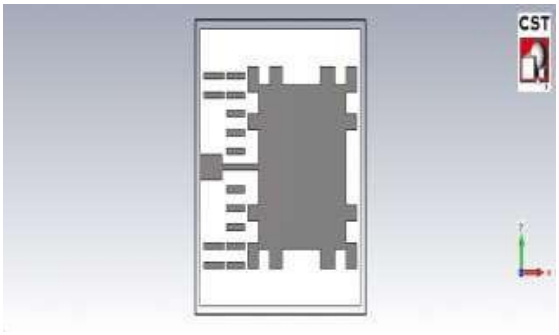

Fig. 5. Schematic diagram of Minkowski shaped patch antenna with parasitic patch elements

TABLE I. DIMENSION OF THE MINKOWSKI SHAPED PATCH ANTENNA WITH PARASITIC PATCH ELEMENTS

Part	Symbol	Dimension (mm)	
		Antenna 1	Antenna 2
Substrate width	W_S	440	880
Substrate length	L_S	440	880
Patch width	W_p	320	640
Patch length	L_p	300	600
Feed width	W_f	40	80
Feed length	L_f	80	160
Combined parasitic width	W_c	10	20
combined parasitic length	L_c	55	110
Slot1 parasitic length	L_x	30	60
Slot1 Parasitic width	Wx	30	60
Parasitic length	L_i	30	60
Parasitic gap	G_i	105	210

Parasitic patch elements are improving the patch antenna performance, to attach the antenna to use the another technique. The parasitic elements are designed to expand the bandwidth of the patch antennas. L-band parasitic element, spiral parasitic element, Inverted-L parasitic element and circular parasitic element are examples of patch antenna using parasitic elements.

The Minkowski shaped patch antenna containing four parts. Those are: patch, feed line, ground plane and rectangular parasitic elements. Patch antenna can be feed in different ways. In the feeding structure the patch antenna having the 50 ohm microstrip line. The feed line is placed between the rectangular parasitic patch elements and the bottom part of the patch antenna. This patch antenna is copied on the FR-4 substrate with dielectric constant, ε_r = 4.3. The thickness of the substrates is 1.60 mm while the thickness of the copper is 0.035 mm, same as the previous design. The ground plane contains the copper with same dimension of the patch antenna.

The square patch part dimension is 11.13 mm width x 11.13 mm length (85.13 % of the Minkowski shaped patch antenna size). The top of the substrate, the patch portion is placed. And it is connected to the feed line. The feed line is 10.50 mm in length and also 2.870 mm width. In below than Minkowski patch antenna element the parasitic elements are placed. In this, eight same size dimensions of a rectangular patch in the first row with 0.1 mm gap between each other. A single unit of the rectangular parasitic patch element dimension is 0.5 mm width x 2.975 mm long.

III. RESULT

The resonant frequency, return loss, realized gain, and bandwidth performance of the Minkowski patch antenna with rectangular parasitic patch elements are determined in this section. The s- parameters of Minkowski MIMO patch antenna (without any patch dimension changes) is shown in Figure 4.

The resonant frequency of this design is 5.800 GHz with - 24.472 dB of return loss. The - 10 dB bandwidth of this design is 0.254 GHz at the frequency between 5.676 GHz and 5.930 GHz.

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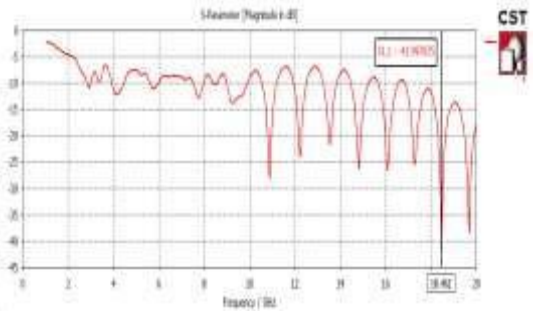

Fig:6 s-parameters of Minkowski MIMO patch antenna

The VSWR of Minkowski patch antenna with different size of patch part shows the Figure 5. From the graph, we can observe the additional of patch antenna dimension will decrease frequency resonant in the lower range while the reducing the size can effect higher range of resonant frequency.

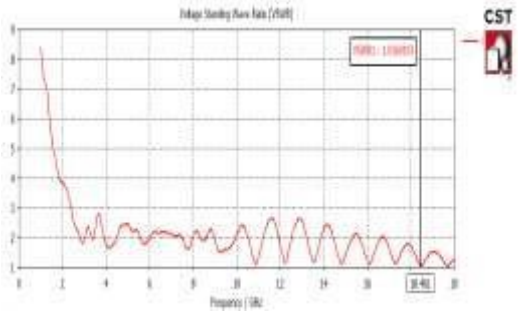

Fig:7 VSWR of Minkowski MIMO patch antenna

The frequency is shifted from 5.80 GHz to 5.26 GHz. The decrement 1.12 mm width x 1.12 mm length of the patch size, the frequency is shifted from 5.80 GHz to 6.42 GHz.

The bandwidth for this design is 267 MHz The normal design with only 254 MHz of bandwidth. The 3D radiation pattern of the Minkowski shaped patch antenna with parasitic rectangular patch antenna is shown in Figure 6. In This figure the signal is radiated front side from the patch antenna.

By adding the split ring resonator structure into the patch design the antenna is improved its gain performance. It decreases the size of the patch antenna

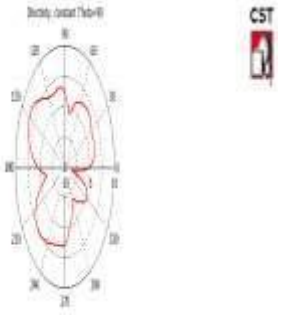

Fig. 6. 3D radiation pattern of Minkowski MIMO shaped patch antenna with parasitic rectangular patch antenna

It shows that the current flow is focusing at the patch antenna, feed line and the parasitic elements. At the outer border of the patch antenna part the strong current flow is placed.

IV. FUTURE WORKS

The proposed Minkowski shaped antenna design will be integrated with RF transmitter [21] and RF receiver [22] to form a complete RF front-end transceiver system. In the transceiver system the antenna will be integrated with the other subcomponents such as filters [23], amplifiers [24], switch [25], mixer [26] and oscillator [27].

V. CONCLUSION

By using the frequency range of WiMAX applications, the Minkowski shaped patch antenna is successfully operated. By using CST Microwave Studio simulation software, different dimension of patch effect the return loss, bandwidth, resonant frequency and realized gain of the Minkowski patch antenna with the rectangular parasitic elements are determined in simulation.

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