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A NOVEL (Q-SLOT) MULTI BAND ANTENNA FOR WIRELESS COMMUNICATIONS

Amer Tawfeeq Abed Sahab

Assist Lect., Communication Engineering Department, Al-Mammon University, Iraq.

Abstract: In this research the proposed antenna is a novel design made out of (Q- slot) that fed by step impedance micro strip line open mouth ended. The proposed antenna is intended to work at four bandwidth frequency groups meet the specifications of DO,1xRTT-3G(1xRTT is a data transmission system used on CDMA networks that allows for connection speeds of up to a theoretical limit of 144kbps),Wi-Fi-IEEE802.11e (local area wireless computer networking technology) andWiMAX-IEEE802.16m(Worldwide Interoperability for Microwave Access) communications. The surface current distribution at resonant frequencies and the effect of varying the dimensions of parameters had been studied carefully in this research to enhanced the performance of resonant frequency. Also the radiation patterns in (E-plane) and (H-plane) for the antenna had been studiedThis document is a livetemplate. The various components of your paper [title, text, heads, etc.] are already defined on the style sheet, as illustrated by the portions given in this document. It should not exceed 200 words. It should brieflyindicate the general scope and also state the main results obtained, methods used, the value of the work and the conclusions drawn. No figure numbers, table numbers, references or displayed mathematical expressions should be included.

Keywords: *Slot antenna, Single later and Radiation properties.*

طريقة مستحدثة لتصميم هوائي شقي متعدد الحزمة الترددية لاغراض الاتصالات اللاسلكية

الخلاصة:في هذا البحث تم تصميم هوائي شقي بطريقة مستحدثة بحيث يتم تغذيته بشريط دقيق ذات ممانعة متزايدة تدريجيا ينتهي بشكل فم مفتوح .لقد تم تصميم الهوائي ليوافق الخواص الراديوية لحزمة الاتصالات اللاسلكية المستخدمة في البروتكولات (DO,1xRTT-3G), كذلك دراسة كثافة توزيع التيار السطحي وتاثير تغيير ابعاد (Wi- Fi-IEEE802.11e),(Wi-MAX-IEEE802.16m) اجزاء الهوائي على المواصفات الراديوية للهوائي للوصول الى افضل تصميم يؤمن التوافق التام مع الغاية من استخدام الهوائي باربعة حزم ترددية مختلفة . كما تم دراسة نماذج الاشعاع الهوائي لكافة الحزم الترددية الاربعة ومقارنة نماذج الاشعاع للهوائي مع المعادلة الرياضية القياسية الخاصة بالهوائيات ذات التصميم الشقي البيضوي .

1. Introduction

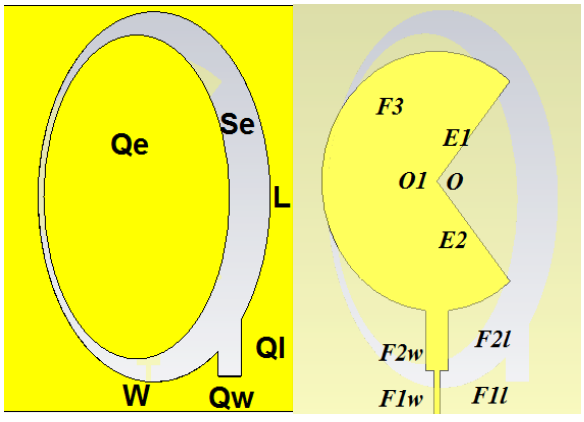
In recent years multi band antennas had been received attention in modern applications of communication system such as Wi-MAX and Wi-Fi .Different types of single-layer

designs using square and circular patches with several slits has been represented as multi bands slot antenna with different shapes of slot (circular, elliptical) in many research papers [1-9].

The proposed antenna had resonant frequencies 2.1GHz,2.5GHz, 3.6GHz, and 5.57GHz. The first resonant frequency 2.1GHz with bandwidth 10% had reflection coefficient less than -10dB and minimum value -28.4dB at resonant frequency 2.1GHz can be utilized for DO,1xRTT-3G and UMTS-FDD. The second bandwidth 2.48GHz ~ 2.56GHz can be utilized to meet the specification of UMTS-TDD 2.5GHz and Wi-Fi. 802.11b, g, & n. 2.5GHz applications with reflection coefficient less than (-10dB) and minimum value -24.2dB at center frequency 2.53GHz. Less than -10dB as a return losses for the third bandwidth 3.43GHz ~ 3.78GHz and -21 dB reflection coefficient at resonant frequency 3.6GHz can be utilized to meet the specification of Wi-Max 802.16e .The last band4.7GHz t~ 6.8 GHz is broad band with return losses less than(-10dB) and minimum value of (S - parameter) -33.6dB at center frequency 5.57GHz, this band can be used for Wi-MAX-802.16 e,m and Wi-Fi802.11-, 4.9GHz, 5.0GHz, 5.2GHz, 5.6GHz, 5.8GHz and 5.9GHz applications.

2.Antenna Structure

In current study the proposed antenna is a single layer with rectangular patch and asymmetrical elliptical slot. The antenna is excited by a strip line with different lengths (*F1l* ,*F2l*)and widths (*F1w* ,*F2w*) ends by elliptical strip(f3) that gives open mouth shape (E1and E2) etched on the substrate (flame retardant FR-4) (glass-reinforced epoxy) with permittivity = 4.3 , tan tangent =0.0027 and thickness =0.8mm, the slots and the feeding line are printed on different sides of the dielectric substrates, the slot had asymmetrical width taken the shape of capital letter (Q) to create different resonant frequencies as shown in Fig.1 .



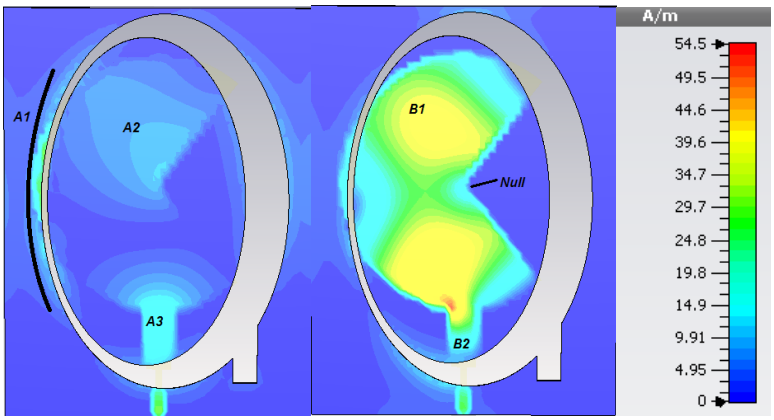
a b

Fig.1. Geometry of proposed antenna:
(a)-Ground face
(b)-Feed face.

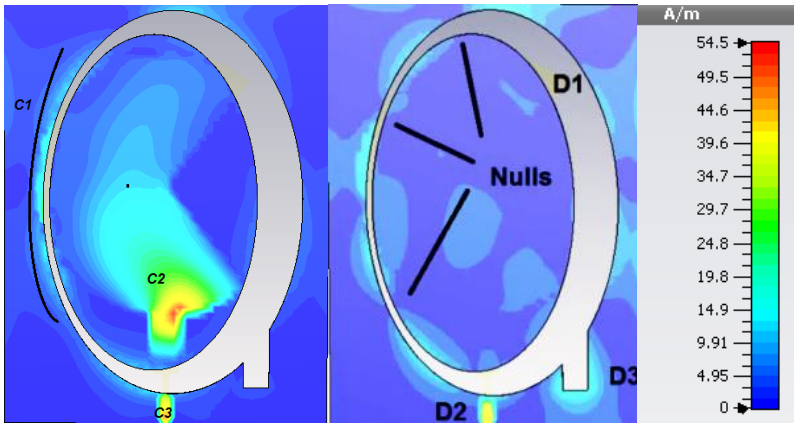
TABLE.1 Parameters Dimension

Parameter	*W*	*L*	*F1l*	*F2l*	*F1w*
Dimensions (mm)	50	70	10	12	1
Parameter	*F2w*	*E1*	*E2*	*Ql*	*Qw*
Dimensions (mm)	4	15	15	10	4
Elliptic	Center	Small radius (mm)		Large radius (mm)	
Se	(-1,-3)	20		32	
Qe	(2,-3)	16		28	

The center(O_1)of the elliptical feed strip(F3) had been chosen to match the original point (O) , the normal cuts (E1 and E2) create phase shift (90) degree at the end of strip line .Resonant frequencies can be controlled by selecting the dimensions of the slot and feed strip, that had been illustrated by table (1). The current distribution for all resonant frequencies simulated by (CST)software had been illustrated by Fig.2. The curve of return losses is shown in Fig.3 had concave shape at frequencies 2.1 GHz,2.5GHz, 3.6GHz and 5.57GHz.



(a) (b)



(c) (d)

Fig .2 Surface current for Sequentially resonant frequencies 2.18,2.5, 3.6 and 5.57GHz.

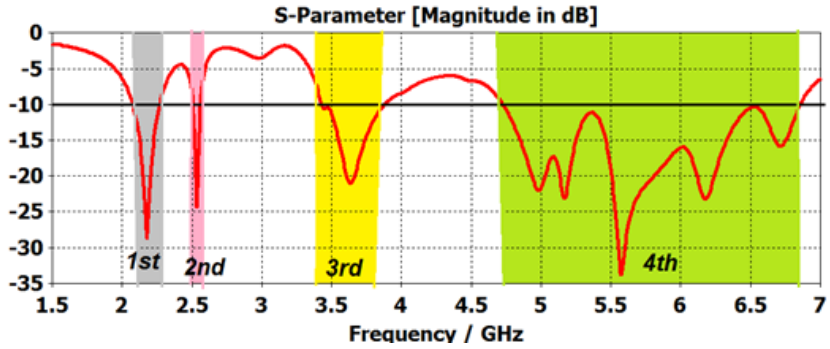


Fig.3. Simulated return losses for proposed antenna.

The maximum current distribution illustrated by Fig.2(a) concentrated in regions(A1 , A2 and A3) , A1 is the narrow edge of the slot and A2 is the upper part of feed strip (F3) while (A3) is the feed strip (F1 and F2), the summation of lengths (A1,A2 and A3) is equal to 69mm which is matched with the half wave length of resonant frequency 2.18 GHz. Fig.2(b) illustrated maximum current distribution concentrated in regions (B1) and (B2) ,the summation of these lengths is equal to60 mm which is about one guided wavelength of resonant frequency2.5GHz. Fig.2(c) represented the maximum current distribution stationed on regions (C1 ,C2 and C3) and the total length of the lengths is 39.7mm which is matched with half wave length of the 3rd resonant frequency3.6 GHz. The summation of lengths (D1),(D2)and(D3)which represent the maximum surface current in Fig.2 (d) is equal to 50mm matched with the wave length of the 4th resonant frequency 5.57GHz. The dimensions of parameters (*Ql and Qw*) are the effective parameters on this frequency band which denoted by (D3) in Fig.2 (d)

3. Antenna Structure

The step impedance open mouth ended strip feed had been utilized to enhance the parameter improvement flexibility to match all four frequency bands

3.1. The effect of the point (O_1)

($O1$) point is the center of open mouth elliptical strip feed (F3) as shown in Fig.1 (b), when the point($O1$) matched with the original point(O) the dynamic impedance will change causing resonant frequencies at 2.1 GHz,2.5GHz, 3.6GHz,and 5.57GHz and VSWR < 2 will be achieved at that four bands as shown in Fig.4(the black curve).As the point (O_1) shifted to (-3,0) the impedance of proposed antenna will be changed because the feed strip became closed the wide side of the slot so a new resonant frequencies will be created and the 1st resonant frequency 2.1GHz will be changed to 1.95 GHz as shown in figure(4) (the green curve). The brown curve in Fig.4 illustrates the values of (VSWR) when the point (O_1)shifted to (-5,0) it's clear that the upper resonant frequencies 5.4GHs to 7 GHz would have (VSWR>2) because the feed strip became closer to wide side of the slot, dynamic impedance will be changed and new lower resonant frequency would be observed at 1.75GHz.

3.2. The effect of parameter (Q_w)

The parameter(Q_w)is the width of (Q-slot) as shown in Fig.1(a). Fig.4 represents the effect of varying the dimension of the parameter (Q_w)on the impedance of the proposed antenna and its clear that the 4th band 4.7GHz to 6.8 GHz was sensitive to that variation . The red curve in Fig.4 illustrates (VSWR) when (Q_w)became equal to 2mm the 4th band separates into two sub bands around 5GHz , as the width of the parameter (Q_w)increased to 6mm the 4th band will be separated into two narrow bands around 6.5GHz as in Fig.4(blue curve) .The dimension of parameter (Q_w) has been chosen to be 4mm to optimize the specifications of the proposed antenna as shown in black curve Fig.4. The 1st, 2nd and 3rd resonant frequencies are not affected by the parameter (Q_w).

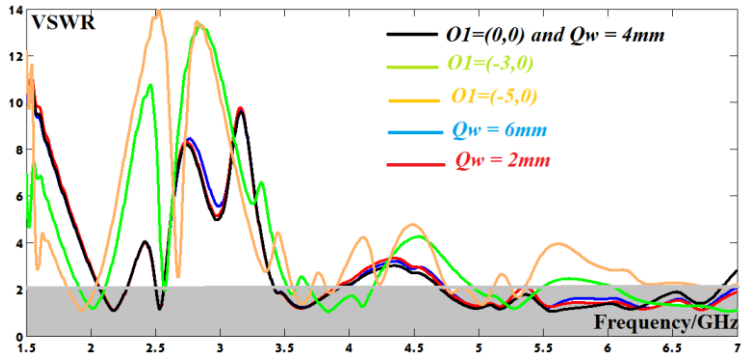


Fig.4. Simulated VSWR with variance (Q_w)and variance position of point (O_1).

4.Radiation Properties

The complementary antenna for an elliptical slot is the elliptical loop antenna [10]. The pattern depends on both the size and shape(circular ,square and elliptical) of the antenna and in general the pattern is non-uniform if the antenna has elliptical shape as shown in equation (1) [10] .

$$f_h = J_1(\delta)((\sin 2(\delta) + (\frac{b}{a})^2 \cos 2(\delta))^{0.5} \qquad (1)$$

Where

$$\delta = Ka \sin(\theta) \sqrt{\cos(\varphi)^2 + (\frac{a}{b})^2 \sin(\varphi)^2}$$

a= small radius of elliptical loop antenna
b= large radius of elliptical loop antenna.

For a small slot , it will be demonstrated that the radiation pattern is independent of shape and is almost circular[10]. Consequently its clear that the radiation pattern of a small elliptical slot in the H- plane is independent of the angle(Ø)and is therefore circular[10]. But Fig.5 represents non circular radiation pattern in H-plan for all resonant frequencies due to asymmetrical slot used in proposed antenna (narrow slot on left side and wide slot on right side as shown in Fig.1 (a) which causes asymmetrical current distribution. The measured gain values at the four bands of the proposed antenna are 4.5 dBi at 2.1, 4.77dBi at 2.5GHz , 5.2 dBi at 3.6 GHz and 7.76dBi at 5.58 GHz, respectively**.**

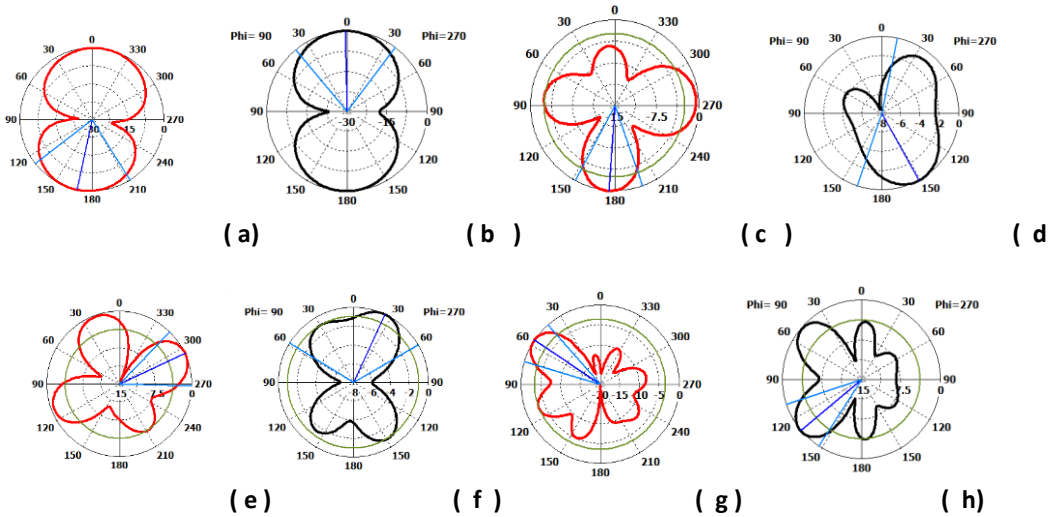


Fig.5. Simulated radiation pattern: (a) E- plane at 2.1GHz, (b) H- plane at 2.1 GHz, (c) E- plane at 2.5 GHz, (d) H- plane at 2.5 GHz, (e) E- plane at 3.6 GHz, (f) H- plane at 3.6 GHz, (g) E-plane at5.58Ghz ,(h) H-plane at 5.58 GHz.

5.Conclusion

Four bands Q-slot antenna fed by strip line had different lengths and widths ended by elliptical strip with open mouth shape had been desired and optimized to give good radiation properties suitable for Wi-Max and Wi-Fi applications. Its new simple single-feed design for micro strip slot antenna suitable for wireless communications .

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