



- (51) International Patent Classification:
H01Q 5/00 (2015.01) *H01Q 21/28* (2006.01)
H01Q 9/04 (2006.01)
- (21) International Application Number:
PCT/MY2014/000174
- (22) International Filing Date:
12 June 2014 (12.06.2014)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
PI 2013702401 10 December 2013 (10.12.2013) MY
- (71) Applicant: MIMOS BERHAD [MY/MY]; Technology Park Malaysia, 57000 Kuala Lumpur (MY).
- (72) Inventors: MOHAMAD @ DIN, Hafizal; c/o MIMOS Berhad, Technology Park Malaysia, 57000 Kuala Lumpur (MY). JAMALUDDIN, Mohd Haizal; c/o MIMOS Berhad, Technology Park Malaysia, 57000 Kuala Lumpur (MY). RAMLI, Nordin; c/o MIMOS Berhad, Technology Park Malaysia, 57000 Kuala Lumpur (MY).
- (74) Agent: TAY, Wee Chao; c/o Author IP, No. 2-3, Taman Arosa, Jalan Haji Jaib, 84000 Muar, Johor (MY).
- (81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.
- (84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ,

[Continued on next page]

(54) Title: A WIDEBAND ANTENNA

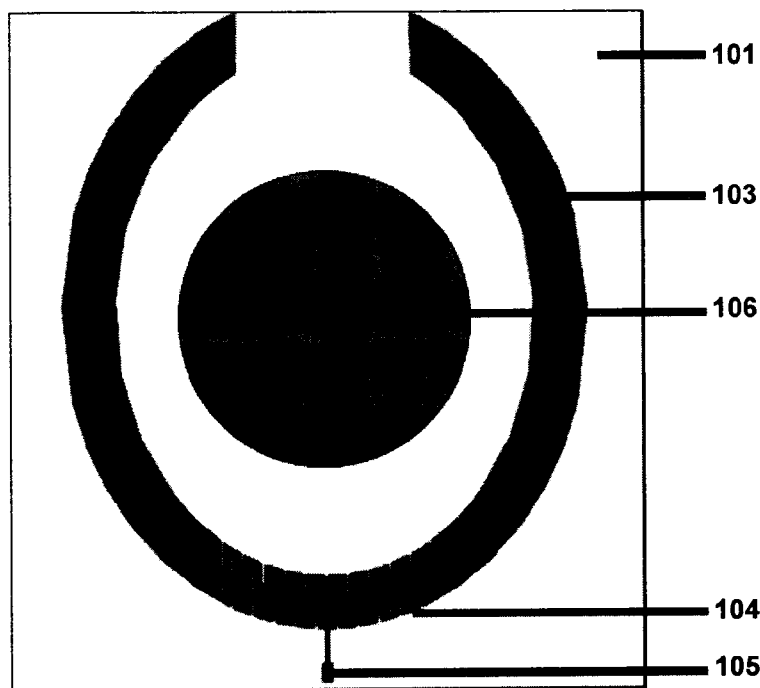


FIGURE 1

(57) Abstract: Disclosed herein is a wideband antenna with multiple functions that can be used in white space devices. Generally, the wideband antenna comprises a U-shaped patch (103) having a meander structure (104) to enable the wideband antenna to operate in high frequency covering the UHF Band IV and Band V, or any other frequencies with high impedance bandwidth; and a dielectric resonator (106) to enable the wideband antenna to support high data rate applications.



UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *of inventorship (Rule 4.17(iv))*

Published:

- *with international search report (Art. 21(3))*

Declarations under Rule 4.17:

- *as to the identity of the inventor (Rule 4.17(i))*

A WIDEBAND ANTENNA

TECHNICAL FIELD OF THE INVENTION

- 5 The present invention relates generally to a wideband antenna, and more particularly to a wideband antenna with multiple functions.

BACKGROUND OF THE INVENTION

- 10 Cognitive radio is useful for improving efficiency in spectrum utilization, whereby it can detect and allocate any unutilized spectrum, also known as white space, in an opportunistic manner while ensuring no interference. In 2008, the FCC has adopted rules to allow unlicensed use of television white space (TVWS). This is an important development to promote innovations within the UHF bands and to
15 provide long distance broadband access to hard-to-reach population in typical rural area.

- Recently, TVWS has generated much attention in cognitive radio applications due to worldwide digital transition of television broadcasting band. In other words,
20 there is now abundant of white space that is readily to and can be used, especially in the UHF region.

- White space device normally operates in UHF Band IV and Band V, i.e. high frequency range in between 470 MHz and 798 MHz. Therefore, the antenna
25 within the white space device is required to be small in size and at the same time supports high bandwidth. These requirements are difficult to be implemented due to the respective large wavelength of 400 mm to 640 mm, resulting in an antenna with very large dimension.

- 30 Further, TVWS applications require high data rate transmission, and therefore the white space device has to be equipped with more than one antenna. However, the problematic part is that most of the wireless terminal user equipment is small in size and has limited space for attachment of more than

one antenna. Even if there is enough space to accommodate more than one antenna, there is always insufficient space to make sure that there is an adequate separation between those antennas.

- 5 Therefore, it has become an objective of the present invention to overcome the above-identified disadvantages by introducing a multi-functional wideband antenna that operates in high frequency range with high impedance bandwidth, and supports high data rate applications, said wideband antenna is relatively compact and small in comparison with a conventional two monopole multiple-
10 input and multiple-output (MIMO) antenna.

SUMMARY OF THE INVENTION

- The core technical aspect of the present invention relates to a wideband antenna
15 with multiple functions that can be used in white space devices.

- According to an embodiment of the present invention, the wideband antenna comprises a planar substrate; a partial ground plane attached to a back surface of the planar substrate; a U-shaped patch having a meander structure printed on
20 a front surface of the planar substrate; at least one first feed line connected to the U-shaped patch; a dielectric resonator attached to the front surface of the planar substrate; and at least one second feed line connected to the dielectric resonator.

- 25 According to a preferred embodiment of the present invention, the meander structure is located at a bottom part of the U-shaped patch.

- According to another preferred embodiment of the present invention, the meander structure comprises a slot, wherein the slot has a width of 1 mm.

30

According to a further preferred embodiment of the present invention, the meander structure comprises at least one line resulting in two slots, wherein the line has a width of 1.5 mm, and each slot has a width of 1 mm.

According to still another preferred embodiment of the present invention the meander structure comprises twenty lines resulting in twenty one slots, wherein each line has a width of 1.5 mm, and each slot has a width of 1 mm.

5

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates the front view of the wideband antenna of the present invention;

10

Figure 2 illustrates the side view of the wideband antenna of the present invention;

Figure 3 illustrates the back view of the wideband antenna of the present invention;

15

Figure 4 illustrates the meander structure of the U-shaped patch having twenty lines resulting in twenty one slots, as the exemplary;

Figure 5 is a chart showing the reflection coefficient of the wideband antenna of the present invention, wherein the wideband antenna comprises a U-shaped patch having a meander structure with twenty lines resulting in twenty one slots;

20

Figure 6 is a chart showing the radiation pattern of the wideband antenna of the present invention measured at 500 MHz, wherein the wideband antenna comprises a U-shaped patch having a meander structure with twenty lines resulting in twenty one slots;

25

Figure 7 is a chart showing the reflection coefficient of the wideband antenna of the present invention, wherein the wideband antenna comprises a U-shaped patch having a meander structure with different numbers of slots;

30

Figure 8 is a chart showing the reflection coefficient of the wideband antenna of the present invention, wherein the wideband antenna comprises a U-shaped patch having a meander structure with different slot widths; and

- 5 Figure 9 is a chart showing the reflection coefficient of the wideband antenna of the present invention, wherein the wideband antenna comprises a U-shaped patch having a meander structure with different line widths.

10 **DETAILED DESCRIPTION OF THE INVENTION**

The above mentioned and other features and objects of this invention will become more apparent and better understood by reference to the following detailed description. It should be understood that the detailed description made known below is not intended to be exhaustive or limit the invention to the precise
15 disclosed form as the invention may assume various alternative forms. On the contrary, the detailed description covers all the relevant modifications and alterations made to the present invention, unless the claims expressly state otherwise.

20 The fundamental technical aspect of the present invention relates to a wideband antenna that can be utilized in white space devices. Ideally, an antenna for white space devices has to be multi-functional, i.e. operate in high frequency with high impedance bandwidth, and to support high data rate applications. In order to achieve these objectives, in general, the wideband antenna of the present
25 invention comprises a U-shaped patch (103) having a meander structure (104) to enable the wideband antenna to operate in high frequency covering the UHF Band IV and Band V (i.e. 470 MHz to 798 MHz), or any other frequencies with high impedance bandwidth; and a dielectric resonator (106) to enable the wideband antenna to support high data rate applications.

30

The size of the wideband antenna of the present invention is relatively small and compact. For example, when compared to a typical two monopole multiple-input

and multiple-output (MIMO) antenna with a $\lambda/2$ separation distance at 470 MHz, the wideband antenna of the present invention is 84% smaller.

Figure 1, Figure 2, Figure 3, and Figure 4 are now being referred.

5

Specifically, the wideband antenna comprises a planar substrate (101); a partial ground plane (102) attached to a back surface of the planar substrate (101); a U-shaped patch (103) having a meander structure (104) printed on a front surface of the planar substrate (101); at least one first feed line (105) connected to the U-shaped patch (104); a dielectric resonator (106) attached to the front surface of the planar substrate (101); and at least one second feed line (107) connected to the dielectric resonator (106).

An example of a planar substrate (101) that can be used in the present invention is a FR-4 board.

15

An example of a partial ground plane (102) that can be used in the present invention is a partial metal ground plane. Basically, it is used for the purpose of grounding mechanism.

20

The specific design of the U-shaped patch (103) allows the wideband antenna to operate in high frequency covering the UHF Band IV and Band V, or any other frequencies with high impedance bandwidth. Additionally, the U-shaped patch has a special characteristic that enhances this particular feature even more, which is the meander structure (104). It is also due to the meander structure that the drastic size reduction of the wideband antenna is made possible. Preferably, the meander structure (104) is located at a bottom part of the U-shaped patch (103), although it is possible to have the meander structure (104) to be located at any part of the U-shaped patch (103).

25

30

The U-shaped patch (103) is fabricated firstly by printing an elliptical shaped patch onto the planar substrate (101). Thereafter, an inner part of the elliptical

shaped patch is removed to form a O-shaped patch. Subsequently, a top part of the O-shaped patch is removed to form the U-shaped patch (103).

Referring specifically to Figure 4, it can be seen that the meander structure (104) comprises a number of lines (104a) and a number of slots (104b).

The number of slots (104b) of the meander structure (104) plays an important role in determining how well the wideband antenna can operate in terms of impedance bandwidth. Therefore, a specific investigation has been carried out to examine the relationship between number of slots (104b) and impedance bandwidth, and the results are shown in Table 1, and Figure 7.

Number of Slots	Frequency Range (MHz)	Impedance Bandwidth (MHz) ($S_{11} < -10$ dB)
0	494 – 629	136
1	494 – 629	136
3	498 – 665	167
5	496 – 670	174
7	486 – 718	232
9	485 – 730	245
11	480 – 750	270
13	477 – 760	287
15	470 – 778	308
17	465 – 786	321
19	461 – 798 (covering UHF band IV & V)	337
21	459 – 808 (covering UHF Band IV & V)	349
23	457 – 820 (Notch: 530 – 593)	363
25	451 – 821 (Notch: 498 – 629)	370

Table 1: The relationship between number of slots and impedance bandwidth.

Referring now to Table 1 and Figure 7, they show that a small impedance bandwidth of 136 MHz is achieved for U-shaped patch (103) without any slot

(104b), i.e. without the meander structure (104). However, when the number of slots (104b) is increased, the value of impedance bandwidth starts to increase as well. The slots (104b) act as a mechanism for matching purposes and at the same time they can enhance the impedance bandwidth of the wideband antenna.

5 It is found that the optimum number of slots (104b) to enable the wideband antenna of the present invention to cover the UHF Band IV and Band V MHz band is twenty one slots (104b). It is further observed that the meander structure (104) with more than twenty three slots (104b) will cause the wideband antenna to operate in high impedance bandwidth with an additional notch. Conclusion is

10 made in that the optimum number of slots (104b) is twenty one slots (104b).

The impedance bandwidth of the wideband antenna is further influenced by the slot (104b) width. A parametric study has been carried out to investigate this particular influence, and the results are shown in Figure 8. The study is carried

15 out with the line (104a) width fixed at 2 mm. From the figure, it can be observed that when the slot (104b) width is increased, the resonant frequency of the wideband antenna is shifted to higher frequency. At the same time, a large impedance bandwidth is obtained for each of the experiments with slot (104b) width of 1 mm and 1.5 mm. Further increase in the slot (104b) width will reduce

20 the impedance bandwidth. Conclusion is made in that the optimum slot (104b) width is 1 mm.

The impedance bandwidth of the wideband antenna is even further influenced by the line (104a) width. Another parametric study has been carried out to

25 investigate this particular influence, and the results are shown in Figure 9. The study is carried out with the slot (104b) width fixed at 1 mm. From the figure, it can be observed that there is not much change on the reflection coefficient for each of the experiments with line (104a) width of 0.5 mm and 1 mm. However, a large impedance bandwidth is achieved for each of the experiments with line

30 (104a) width of 1.5 mm and 2.0 mm. Conclusion is made in that the optimum line (104a) width is 1.5 mm.

In view of the above, the following three embodiments can be made:

A first embodiment where the meander structure (104) may comprise a slot (104b), wherein the slot has a width of 1 mm.

- 5 A second embodiment where the meander structure (104) may comprise at least one line (104a) resulting in two slots (104b), wherein the line has a width of 1.5 mm, and each slot has a width of 1 mm.

10 A third embodiment where the meander structure (104) may comprise twenty lines (104a) resulting in twenty one slots (104b), wherein each line has a width of 1.5 mm, and each slot has a width of 1 mm. It is determined that this particular embodiment causes the wideband antenna to operate at a frequency range of 459 MHz to 808 MHz with the highest impedance bandwidth of 349 MHz.

- 15 It should be noted that the above-mentioned studies are simulated, and the above-mentioned frequency ranges and impedance bandwidths are experimental/simulated values. To ascertain the real values, the wideband antenna in accordance with the aforementioned third embodiment is built and tested, and the results are shown in Figure 5 and Figure 6. From Figure 5, the reflection coefficient curve has several resonance frequencies that are combined together to perform high impedance bandwidth. It can be observed that, at $S_{11} < -10$ dB, the wideband antenna operates in a frequency range of 325 MHz to 815 MHz with an impedance bandwidth of 490 MHz. We refer now to Figure 6. In order to observe the radiation pattern of the wideband antenna of the present invention, two planes, namely E-plane and H-plane, are selected. It can be observed that the antenna gain is 2.2 dBi with a nearly omnidirectional pattern in H-plane, which remains constant at a specific frequency, in this case 500 MHz. It is proven that the wideband antenna radiates over the interested frequency, which is suitable for TVWS applications. The radiation patterns in co-polar of E-plane and H-plane indicate that a good pattern stability has been obtained. Overall, the testing results confirm that the wideband antenna of the third embodiment outperforms the simulated results.
- 20
- 25
- 30

Referring back to Figure 1, Figure 2, Figure 3, and Figure 4, the first feed line (105) allows the U-shaped patch (103) to be connected to a radio transmitter or receiver. Preferably, the first feed line (105) is located at a bottom part of the U-shaped patch (103), although it is possible to have the first feed line (105) to be
5 located at any part of the U-shaped patch (103).

As mentioned previously, the dielectric resonator (106) of the present invention is attached to the front surface of the planar substrate (101), preferably to the center of the front surface of the planar substrate (101). It is also possible to
10 have the dielectric resonator (106) to be attached to any unutilized space of the planar substrate (101). The dielectric resonator (106) has a cylindrical shape, although it is possible to have the dielectric resonator (106) in various kind of shape.

15 The second feed line (107) allows the dielectric resonator (106) to be connected to a radio transmitter or receiver. Preferably, the second feed line (107) is located at the back surface of the planar substrate (101), and connected to the dielectric resonator (106) through the planar substrate (101). It is possible to supply the dielectric resonator (106) with more than one second feed line (107)
20 to perform multi antenna capability by exploiting dielectric permittivity.

CLAIMS

- 1) A wideband antenna with multiple functions that operates in high frequency with high impedance bandwidth, and supports high data rate applications, the wideband antenna comprises:
- 5
- a) a planar substrate (101);
 - b) a partial ground plane (102) attached to a back surface of the planar substrate (101);
 - c) a U-shaped patch (103) having a meander structure (104) printed on a front surface of the planar substrate (101);
 - 10
 - d) at least one first feed line (105) connected to the U-shaped patch (104);
 - e) a dielectric resonator (106) attached to the front surface of the planar substrate (101); and
 - 15
 - f) at least one second feed line (107) connected to the dielectric resonator (106).
- 2) A wideband antenna in accordance with claim 1, wherein the meander structure (104) is located at a bottom part of the U-shaped patch (103).
- 20
- 3) A wideband antenna in accordance with claim 1, wherein the meander structure (104) comprises a slot (104b).
- 4) A wideband antenna in accordance with claim 3, wherein the slot (104b) has a width of 1 mm.
- 25
- 5) A wideband antenna in accordance with claim 1, wherein the meander structure (104) comprises at least one line (104a) resulting in two slots (104b).
- 30
- 6) A wideband antenna in accordance with claim 5, wherein the line (104a) has a width of 1.5 mm, and each slot (104b) has a width of 1 mm.

- 7) A wideband antenna in accordance with claim 1, wherein the meander structure (104) comprises twenty lines (104a) resulting in twenty one slots (104b).
- 5 8) A wideband antenna in accordance with claim 7, wherein each line (104a) has a width of 1.5 mm, and each slot (104b) has a width of 1 mm.
- 9) A wideband antenna in accordance with claim 1 is used in white spaces devices.
- 10 10) A wideband antenna in accordance with claim 1 operates in a frequency range of 325 MHz to 815 MHz with impedance bandwidth of 490 MHz.

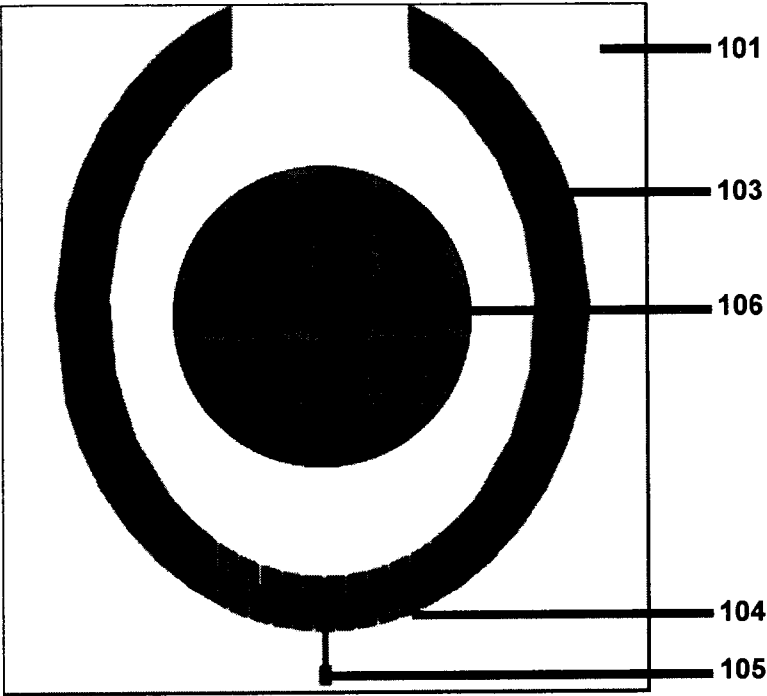


FIGURE 1

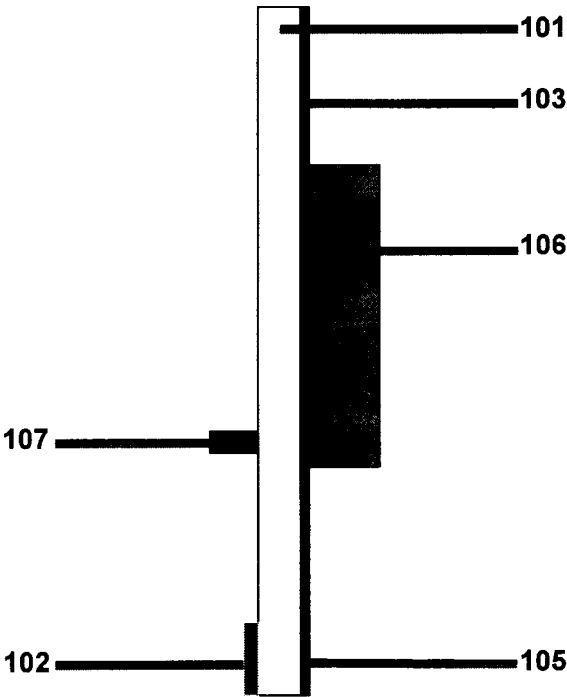


FIGURE 2

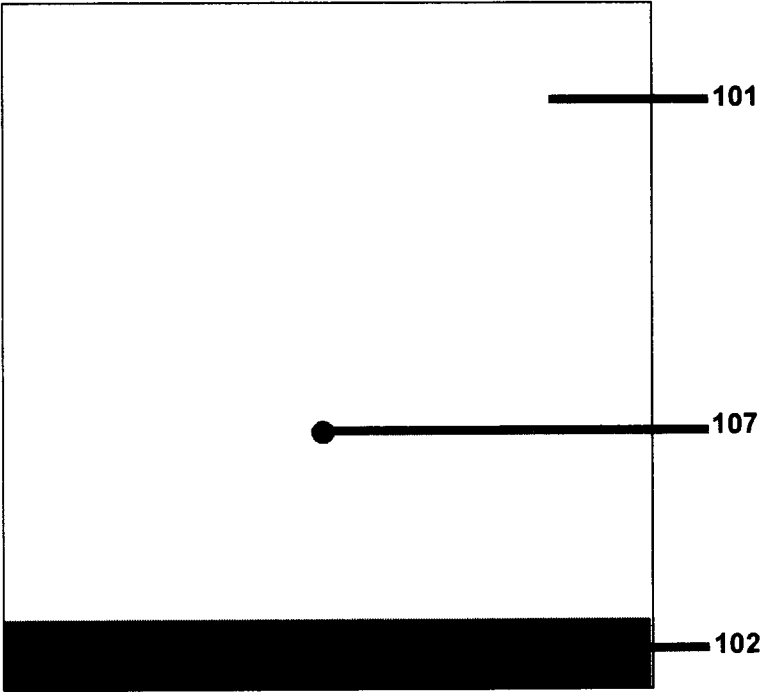


FIGURE 3

4/7

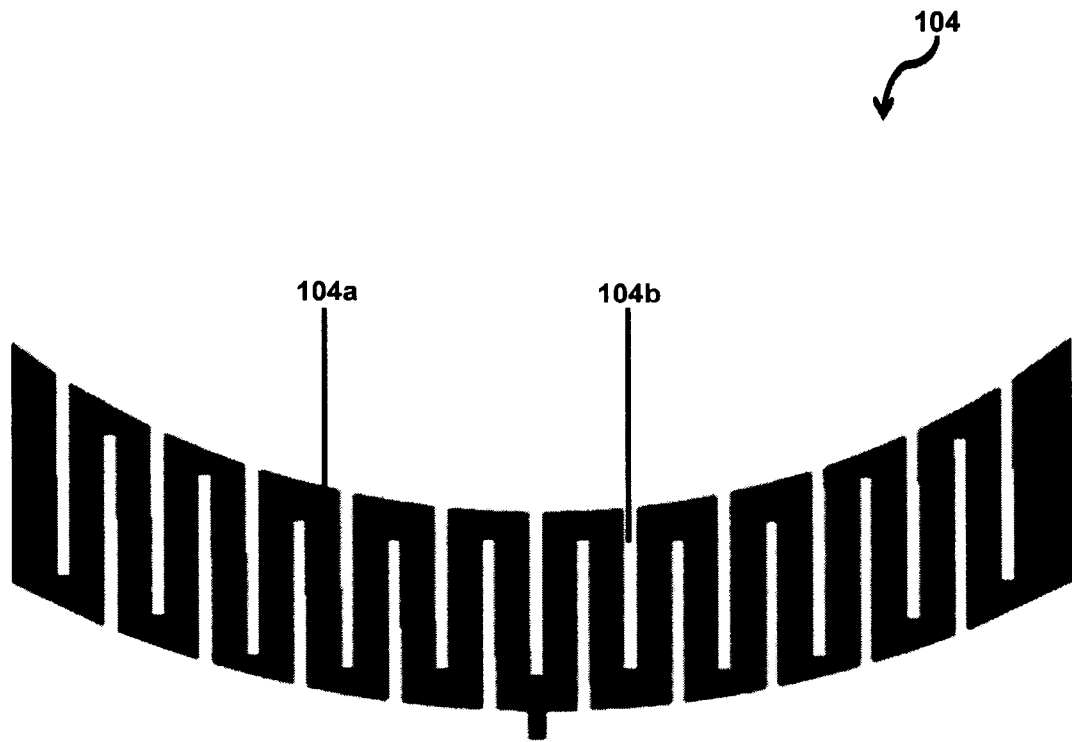


FIGURE 4

5/7

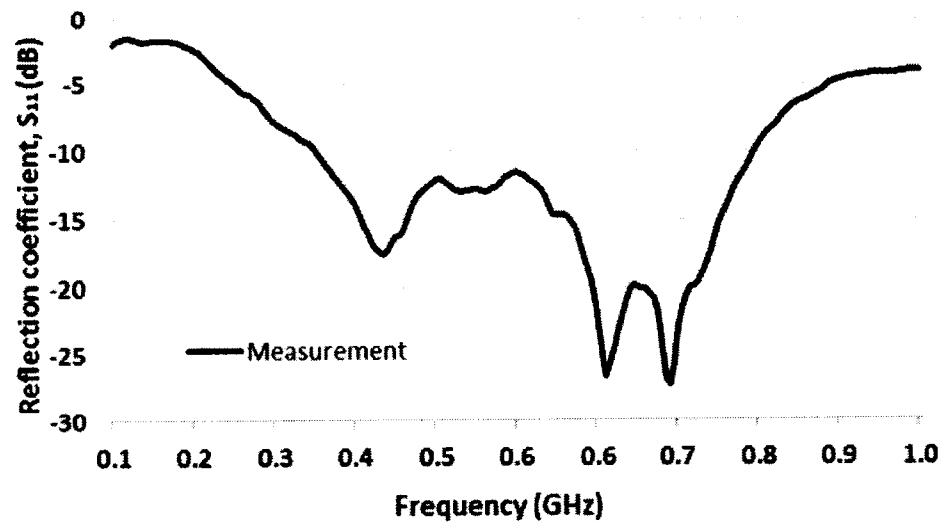


FIGURE 5

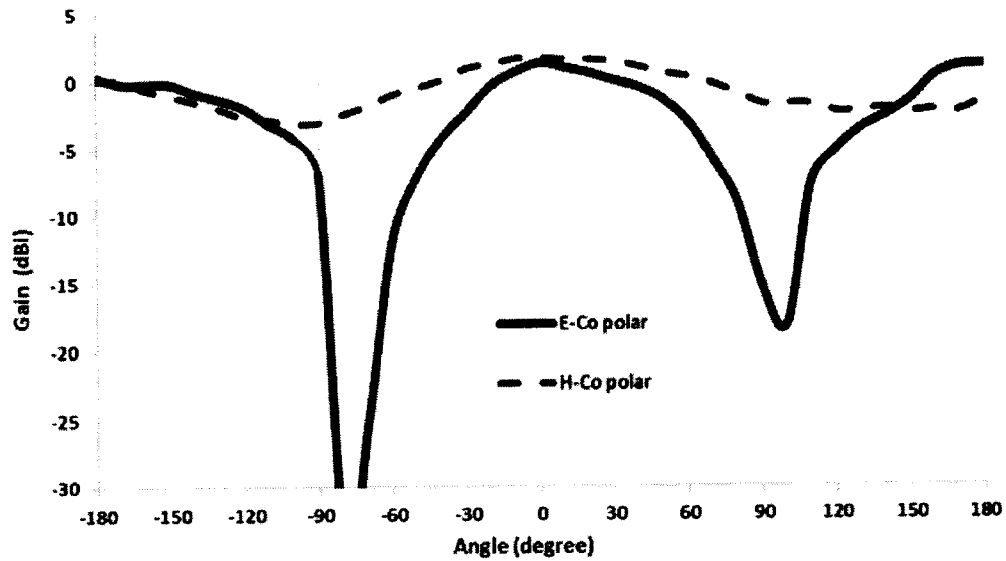


FIGURE 6

6/7

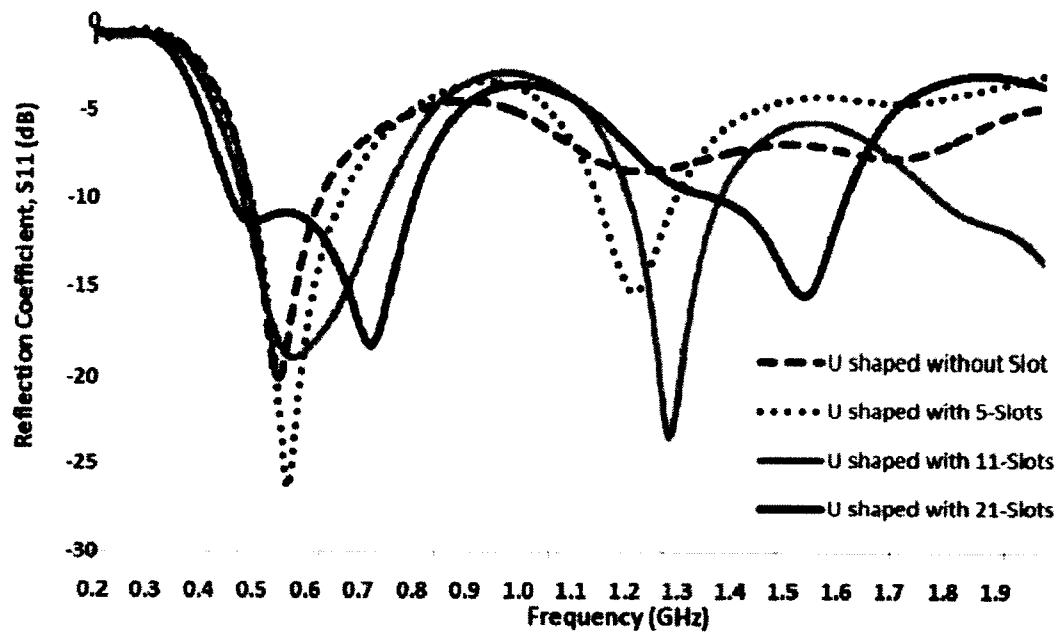


FIGURE 7

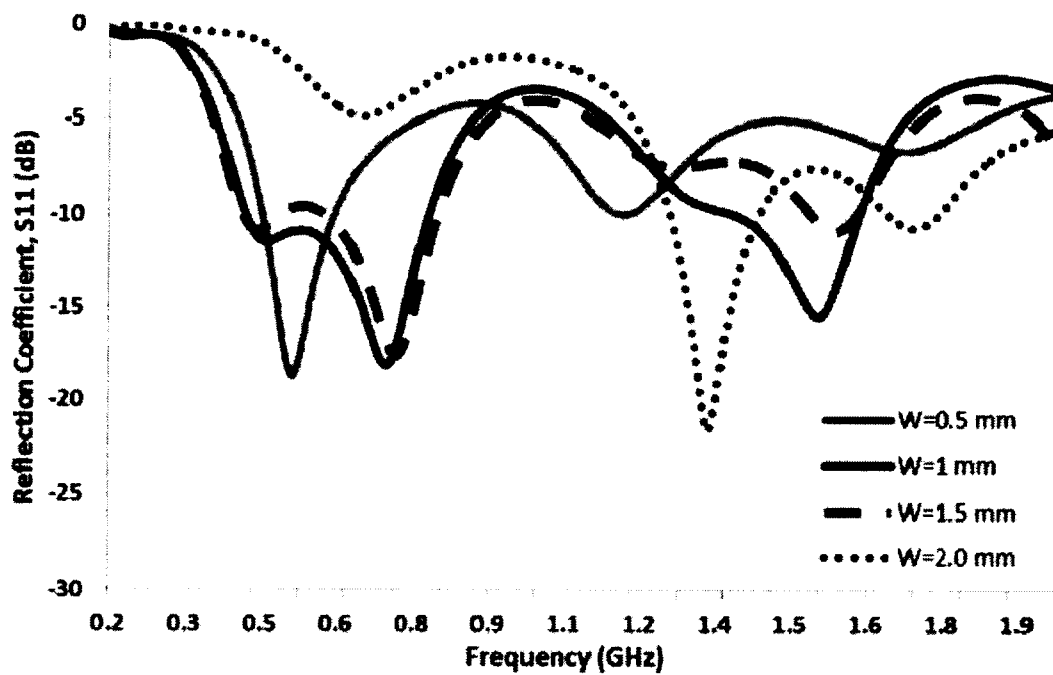


FIGURE 8

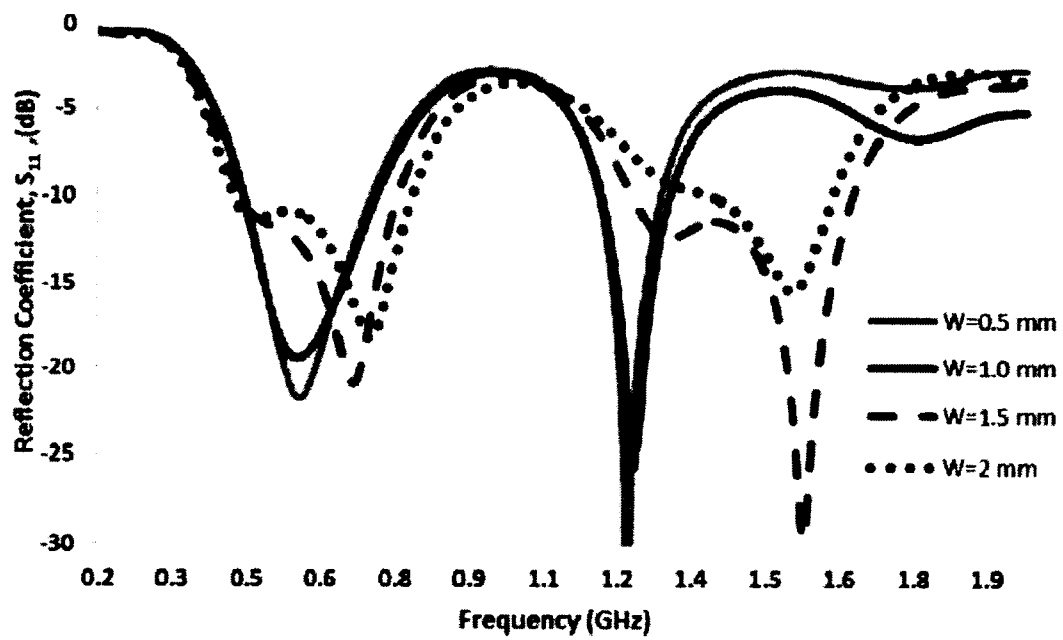


FIGURE 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/MY2014/000174

A. CLASSIFICATION OF SUBJECT MATTER INV. H01Q5/00 H01Q9/04 H01Q21/28 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) H01Q		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	SUKUR M I A ET AL: "Compact hybrid dielectric resonator with patch antenna operating at Ultra-High Frequency band", 2013 PROCEEDINGS OF THE INTERNATIONAL SYMPOSIUM ON ANTENNAS & PROPAGATION, ANTENNA SOCIETY OF THE CHINESE INSTITUTE OF ELECTRONICS, vol. 1, 23 October 2013 (2013-10-23), pages 123-126, XP032554566, ISBN: 978-7-5641-4279-7 [retrieved on 2014-01-20] the whole document	1-10
Y	US 2012/169553 A1 (NOMURA MASATO [JP] ET AL) 5 July 2012 (2012-07-05) paragraph [0118]; figure 18 ----- -/--	1-10
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 5 December 2014		Date of mailing of the international search report 15/12/2014
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Pastor Jiménez, J

INTERNATIONAL SEARCH REPORT

International application No

PCT/MY2014/000174

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2002/196190 A1 (LIM BENG-TECK [US]) 26 December 2002 (2002-12-26) paragraph [0009] paragraph [0029] - paragraph [0032] paragraph [0045]; figure 2A paragraph [0071] - paragraph [0072]; figures 4,5 paragraph [0077] - paragraph [0078] -----	1-10
A	US 2004/051675 A1 (INOUE JINICHI [JP]) 18 March 2004 (2004-03-18) paragraph [0074] - paragraph [0077]; figures 1-7 -----	1-10

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/MY2014/000174

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2012169553 A1	05-07-2012	CN 102576939 A	11-07-2012
		JP 5522177 B2	18-06-2014
		US 2012169553 A1	05-07-2012
		WO 2011045970 A1	21-04-2011
US 2002196190 A1	26-12-2002	US 6292141 B1	18-09-2001
		US 6700539 B2	02-03-2004
		US 2002196190 A1	26-12-2002
US 2004051675 A1	18-03-2004	DE 60221697 T2	06-12-2007
		EP 1445831 A1	11-08-2004
		JP 3420232 B2	23-06-2003
		JP 2003152445 A	23-05-2003
		KR 20040058099 A	03-07-2004
		US 2004051675 A1	18-03-2004
		WO 03043130 A1	22-05-2003