



US008988286B2

(12) **United States Patent**
Ahn et al.

(10) **Patent No.:** **US 8,988,286 B2**
(45) **Date of Patent:** **Mar. 24, 2015**

(54) **MULTI-BAND ANTENNA FOR PORTABLE TERMINAL WITH RADIATORS ON OPPOSITE SURFACES OF SUBSTRATE**

USPC **343/700 MS**; 343/713; 343/846;
343/895; 343/873

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(58) **Field of Classification Search**
USPC 343/702, 713, 700 MS, 846, 895, 873,
343/876
See application file for complete search history.

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(56) **References Cited**
U.S. PATENT DOCUMENTS

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 584 days.

2005/0007279 A1 * 1/2005 Chang 343/700 MS
2006/0145925 A1 * 7/2006 Mei 343/700 MS
2006/0170598 A1 * 8/2006 Kwan et al. 343/702
2009/0002244 A1 * 1/2009 Woo 343/702
2009/0251385 A1 * 10/2009 Xu et al. 343/911 R
2010/0053007 A1 * 3/2010 Ni et al. 343/745

* cited by examiner

(21) Appl. No.: **12/852,568**

Primary Examiner — Sue A Purvis

Assistant Examiner — Jae Kim

(22) Filed: **Aug. 9, 2010**

(74) *Attorney, Agent, or Firm* — Cha & Reiter, LLC

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Aug. 17, 2009 (KR) 10-2009-0075683

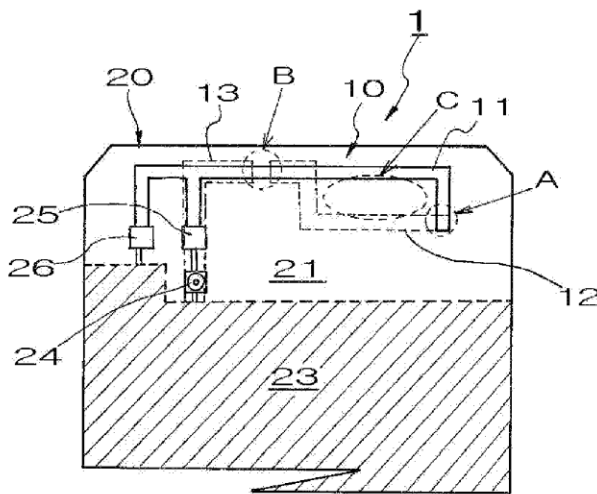
(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 9/42 (2006.01)
H01Q 5/00 (2006.01)

(57) **ABSTRACT**

A multi-band built-in antenna of a portable terminal is provided. The antenna includes a first antenna radiator on a front surface of a substrate (e.g., a main board), and a second antenna radiator on an opposite surface of the substrate. The substrate has ground surfaces on both sides separated from a non-ground area on which the radiators are disposed. The first radiator may be in the form of a Planar Inverted F Antenna (PIFA), with a first end branched off into two parts, one part used for power feeding and the other part electrically coupled to the ground surface. The first radiator has a portion that extends from the first end to an opposite end. The second radiator is continuous from the opposite end of the first radiator through a via (hole) in the main board.

(52) **U.S. Cl.**
CPC **H01Q 9/42** (2013.01); **H01Q 5/0051** (2013.01); **H01Q 5/0062** (2013.01)

15 Claims, 5 Drawing Sheets





US008988288B2

(12) **United States Patent**
Handro et al.

(10) **Patent No.:** **US 8,988,288 B2**
(45) **Date of Patent:** **Mar. 24, 2015**

(54) **TRI-BAND ANTENNA FOR NONCELLULAR WIRELESS APPLICATIONS**

(75) Inventors: **Andreas Handro**, Münster (DE);
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(73) Assignee: **BlackBerry Limited**, Waterloo (CA)

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(21) Appl. No.: **13/547,648**

(22) Filed: **Jul. 12, 2012**

(65) **Prior Publication Data**

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H01Q 5/00 (2006.01)
H01Q 9/04 (2006.01)
H01Q 1/24 (2006.01)
H01Q 9/42 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 5/0031** (2013.01); **H01Q 5/0058**
(2013.01); **H01Q 5/0062** (2013.01); **H01Q 9/42**
(2013.01)
USPC **343/700 MS**; **343/702**

(58) **Field of Classification Search**
CPC . H01Q 9/0457; H01Q 5/0072; H01Q 5/0068;
H01Q 21/28
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,559,811 B1 5/2003 Pulimi et al.
6,784,843 B2 * 8/2004 Onaka et al. 343/700 MS
6,795,021 B2 9/2004 Ngai et al.
6,975,278 B2 12/2005 Song et al.

7,180,467 B2 2/2007 Fabrega-Sanchez et al.
7,388,543 B2 6/2008 Vance
7,925,319 B2 4/2011 Kenoun et al.
8,294,618 B2 * 10/2012 Lee et al. 343/700 MS
2007/0279285 A1 * 12/2007 Hilgers 343/700 MS
2008/0246668 A1 * 10/2008 Qi et al. 343/702
2009/0273521 A1 11/2009 Wong et al.
2009/0289859 A1 11/2009 Pan

(Continued)

FOREIGN PATENT DOCUMENTS

EP 1703587 9/2006

OTHER PUBLICATIONS

Tang et al "A compact coupled-fed penta-band antenna for mobile phone application" Proceedings of Asia-Pacific Microwave Conference 2010; Dec. 7-10, 2010; pp. 2260-2263.*

(Continued)

Primary Examiner — Dameon E Levi

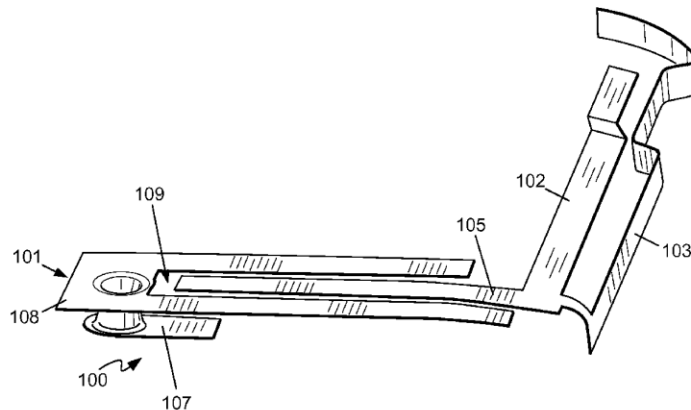
Assistant Examiner — Ricardo Magallanes

(74) *Attorney, Agent, or Firm* — Hanley, Flight & Zimmerman LLC

(57) **ABSTRACT**

A tri-band antenna for noncellular wireless applications is provided. The antenna comprises: a first radiating arm for generating a first resonance in a first frequency band, the first radiating arm further enabled for connection to an antenna tuning circuit; the first radiating arm comprising a capacitive coupling structure; a coupling arm separated by a gap from the first radiating arm; a second radiating arm for generating a second resonance in a second frequency band lower than the first frequency band, the second radiating arm connected to the coupling arm such that the second radiating arm is capacitively coupled to the first radiating arm; and a third radiating arm for generating a third resonance in a third frequency band lower than the second frequency band, the third radiating arm connected to the coupling arm such that the third radiating arm is capacitively coupled to the first radiating arm.

20 Claims, 12 Drawing Sheets





US008988290B2

(12) **United States Patent**
Ozden et al.

(10) **Patent No.:** **US 8,988,290 B2**
(45) **Date of Patent:** **Mar. 24, 2015**

(54) **APPARATUS AND METHOD OF PROVIDING AN APPARATUS**

(75) Inventors: **Sinasi Ozden**, Soborg (DK); **Mirsad Cviko**, Malmo (SE)

(73) Assignee: **Nokia Corporation**, Espoo (FI)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1455 days.

(21) Appl. No.: **12/617,775**

(22) Filed: **Nov. 13, 2009**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Nov. 15, 2008 (GB) 0820939.7

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/00 (2006.01)
H01Q 9/04 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 5/0048** (2013.01); **H01Q 9/0421** (2013.01)
USPC **343/702**

(58) **Field of Classification Search**
USPC 343/702, 872, 873, 906
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,434,579 A * 7/1995 Kagoshima et al. ... 343/700 MS
6,590,539 B2 7/2003 Shinichi 343/702
6,853,336 B2 2/2005 Asano et al. 343/702

6,937,196 B2	8/2005	Korva	343/702
6,963,308 B2	11/2005	Korva	343/700 MS
2004/0145527 A1	7/2004	Mikkola	343/700 MS
2004/0147297 A1	7/2004	Mikkola et al.	455/575.7
2006/0097918 A1	5/2006	Oshiyama et al.	343/700
2006/0135090 A1	6/2006	Annamaa	455/95
2006/0208951 A1	9/2006	Korva et al.	343/702
2006/0232475 A1	10/2006	Huang et al.	343/700 MS
2008/0018541 A1	1/2008	Pang et al.	343/702
2008/0143630 A1	6/2008	Kato et al.	
2009/0051604 A1 *	2/2009	Zhang et al.	343/702

FOREIGN PATENT DOCUMENTS

EP	1 387 435 A1	2/2004
EP	1 439 602 A1	7/2004

(Continued)

OTHER PUBLICATIONS

Huang, C-F et al., "Realization of a Printed-On-Display Antenna for Mobile Terminals", © 2001, IEEE, pp. 140-143.

(Continued)

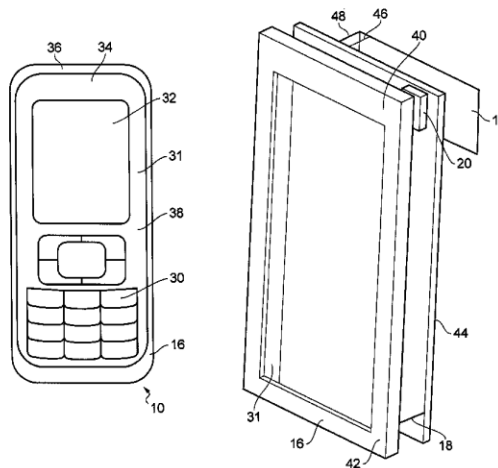
Primary Examiner — Robert Karacsony

(74) Attorney, Agent, or Firm — Harrington & Smith

(57) **ABSTRACT**

An apparatus and method of providing an apparatus, the apparatus including a conductive cover portion defining at least a portion of an external surface of the apparatus; a feed element configured to capacitively couple radio circuitry to the conductive cover portion at a feed point; a ground plane galvanically connected to the conductive cover portion at a ground point; wherein the feed point and the ground point are separated along a length of the conductive cover portion and configure the conductive cover portion to resonate at a first resonant frequency so as to be operable as an antenna in a first frequency band and wherein the first resonant frequency of the conductive cover portion is controlled by the separation between the feed point and the ground point.

17 Claims, 9 Drawing Sheets





US008988292B2

(12) **United States Patent**
Hotta et al.

(10) **Patent No.:** **US 8,988,292 B2**

(45) **Date of Patent:** **Mar. 24, 2015**

(54) **ANTENNA DEVICE AND ELECTRONIC DEVICE INCLUDING ANTENNA DEVICE**

(75) Inventors: **Hiroyuki Hotta**, Hamura (JP); **Koichi Sato**, Tachikawa (JP)

(73) Assignee: **Kabushiki Kaisha Toshiba**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 441 days.

(21) Appl. No.: **13/345,283**

(22) Filed: **Jan. 6, 2012**

(65) **Prior Publication Data**
US 2012/0249393 A1 Oct. 4, 2012

(30) **Foreign Application Priority Data**
Mar. 30, 2011 (JP) 2011-076288

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/38 (2006.01)
H01Q 5/00 (2006.01)
H01Q 7/00 (2006.01)
H01Q 9/42 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 5/0055** (2013.01); **H01Q 5/0062** (2013.01); **H01Q 7/00** (2013.01); **H01Q 9/42** (2013.01)
USPC **343/702**; 343/700 MS

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/38; H01Q 5/0055; H01Q 7/00; H01Q 9/42
USPC 343/700 MS, 702, 829, 843, 846
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,407,710 B2 * 6/2002 Keilen et al. 343/702
6,639,560 B1 * 10/2003 Sullivan et al. 343/700 MS
6,738,603 B1 5/2004 Saito
6,870,504 B2 3/2005 Ikegaya et al.

(Continued)

FOREIGN PATENT DOCUMENTS

JP 09-307344 11/1997
JP 1079622 3/1998

(Continued)

OTHER PUBLICATIONS

Japanese Patent Application No. 2011-076288, First Office Action, mailed Apr. 17, 2012, (with English Translation).

(Continued)

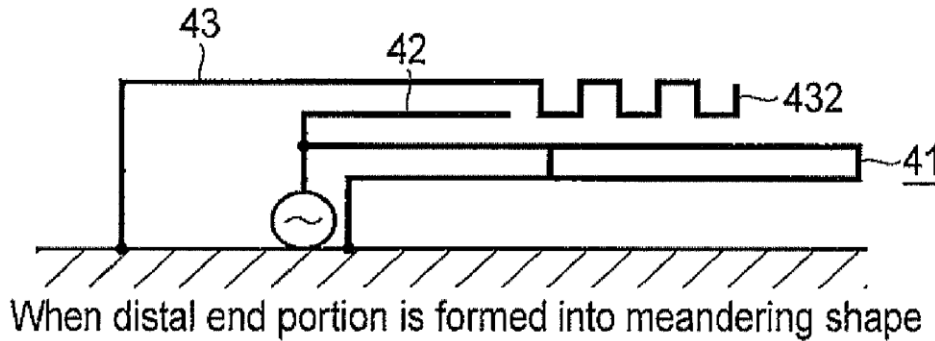
Primary Examiner — Tho G Phan

(74) *Attorney, Agent, or Firm* — Blakely, Sokoloff, Taylor & Zafman LLP

(57) **ABSTRACT**

According to one embodiment, a first antenna element is formed from a folded monopole element having one end connected to a feeding terminal, and the other end connected to a first ground terminal, with a stub being provided between a forward portion and a backward portion formed by folding a middle portion. A second antenna element is formed from a monopole element having one end connected to the feeding terminal directly or indirectly through part of the first antenna element. A third antenna element is formed from a parasitic element having one end connected to a second ground terminal provided at a position opposite to the first ground terminal through the feeding terminal, and the other end open, with at least part of the parasitic element being placed parallel to the second antenna element so as to be configured to be capacitively coupled to the second antenna element.

22 Claims, 24 Drawing Sheets





US008988296B2

(12) **United States Patent**
Koskiniemi et al.

(10) **Patent No.:** **US 8,988,296 B2**
(45) **Date of Patent:** **Mar. 24, 2015**

(54) **COMPACT POLARIZED ANTENNA AND METHODS**

(75) Inventors: **Kimmo Koskiniemi**, Oulu (FI); **Pertti Nissinen**, Kempele (FI)

(73) Assignee: **Pulse Finland Oy**, Kempele (FI)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 242 days.

(21) Appl. No.: **13/439,576**

(22) Filed: **Apr. 4, 2012**

(65) **Prior Publication Data**

US 2013/0265199 A1 Oct. 10, 2013

(51) **Int. Cl.**
H01Q 1/12 (2006.01)
H01Q 1/24 (2006.01)
G01S 19/14 (2010.01)
H01Q 1/27 (2006.01)
H01Q 9/42 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/273** (2013.01); **G01S 19/14** (2013.01); **H01Q 9/42** (2013.01); **Y10T 29/49016** (2013.01)

(58) **Field of Classification Search**
USPC **343/718**; **343/702**
USPC **343/718**, **702**
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,745,102 A 5/1956 Norgorden
3,938,161 A 2/1976 Sanford
4,004,228 A 1/1977 Mullett
4,028,652 A 6/1977 Wakino et al.
4,031,468 A 6/1977 Ziebell et al.

4,054,874 A 10/1977 Oltman
4,069,483 A 1/1978 Kaloi
4,123,756 A 10/1978 Nagata et al.
4,123,758 A 10/1978 Shibano et al.
4,131,893 A 12/1978 Munson et al.
4,201,960 A 5/1980 Skutta et al.
4,255,729 A 3/1981 Fukasawa et al.
4,313,121 A 1/1982 Campbell et al.
4,356,492 A 10/1982 Kaloi

(Continued)

FOREIGN PATENT DOCUMENTS

CN 1316797 10/2007
DE 10104862 8/2002

(Continued)

OTHER PUBLICATIONS

"An Adaptive Microstrip Patch Antenna for Use in Portable Transceivers", Rostbakken et al., Vehicular Technology Conference, 1996, Mobile Technology for the Human Race, pp. 339-343.

(Continued)

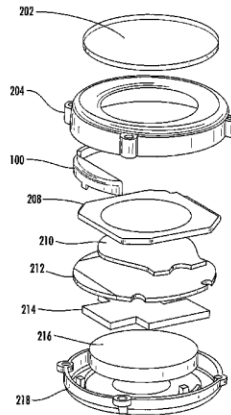
Primary Examiner — Hoang V Nguyen

(74) *Attorney, Agent, or Firm* — Gazdzinski & Associates, PC

(57) **ABSTRACT**

A right-hand circular polarized antenna and associated methods. In one embodiment, a quarter-wave antenna configuration is used within a small form factor portable device (e.g. wristwatch). The antenna comprises a radiator element which operates in as a linear polarized antenna while the device is operating in free space. However, when the device is attached to a user (e.g. at a user's wrist), the antenna utilizes the loading of the user's body tissue in order to suppress unwanted signals (e.g. left hand polarized signals) to permit operation in circular polarized mode (e.g. right hand polarized mode), thereby allowing for increased sensitivity to received circularly polarized signals such as those emanated from global positioning satellites.

26 Claims, 17 Drawing Sheets





US008988306B2

(12) **United States Patent**
Kuo et al.

(10) **Patent No.:** **US 8,988,306 B2**
(45) **Date of Patent:** **Mar. 24, 2015**

(54) **MULTI-FEED ANTENNA**
(75) Inventors: **Yen-Liang Kuo**, Taoyuan County (TW);
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(73) Assignee: **HTC Corporation**, Taoyuan District,
Taoyuan (TW)

2005/0181847 A1* 8/2005 Boyle 455/575.7
2006/0192720 A1* 8/2006 Shtrom 343/795
2008/0258993 A1* 10/2008 Gummalla et al. 343/876
2009/0115674 A1 5/2009 Fujieda
2011/0043415 A1 2/2011 Chang
2011/0102290 A1 5/2011 Milosavljevic
2011/0241962 A1 10/2011 Chen

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 257 days.

FOREIGN PATENT DOCUMENTS

CN	101662070	A	3/2010
CN	201498592	U	6/2010
CN	101997160	A	3/2011
DE	112009001935	T5	2/2012
EP	0892459	A1	1/1999
EP	1608035	A1	12/2005
EP	2005516	B1	6/2011

(21) Appl. No.: **13/294,187**

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(65) **Prior Publication Data**
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(Continued)

OTHER PUBLICATIONS

Office action mailed on Mar. 18, 2013 for the DE application No. 102012220366.4, p. 1-6.

(Continued)

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H01Q 3/22 (2006.01)
H01Q 9/42 (2006.01)
H01Q 3/24 (2006.01)

(52) **U.S. Cl.**
CPC ... **H01Q 9/42** (2013.01); **H01Q 3/24** (2013.01)
USPC **343/876**

(58) **Field of Classification Search**
CPC H01Q 3/22
USPC 343/876
See application file for complete search history.

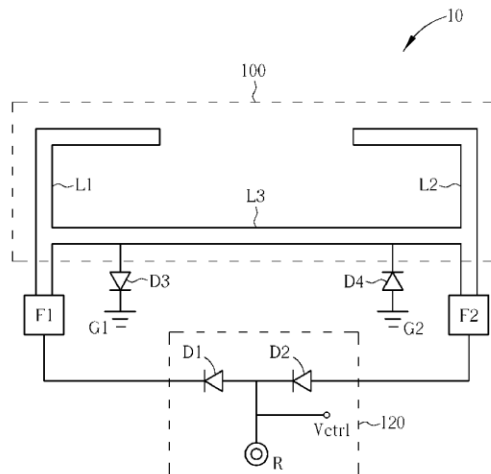
Primary Examiner — Dameon E. Levi
Assistant Examiner — Andrea Lindgren Baltzel
(74) *Attorney, Agent, or Firm* — Winston Hsu; Scott Margo

(56) **References Cited**
U.S. PATENT DOCUMENTS

6,639,555	B1	10/2003	Kane	
6,753,815	B2	6/2004	Okubora	
6,759,897	B2*	7/2004	Ciemniak	327/553
7,375,689	B2	5/2008	Chen	
7,760,150	B2	7/2010	Sato	
8,094,076	B2	1/2012	Zhang	

(57) **ABSTRACT**
A multi-feed antenna is disclosed. The multi-feed antenna includes a first feed terminal, a second feed terminal, a first ground terminal, a second ground terminal, a radiator and a control circuit. The radiator is coupled to the first feed terminal, the second feed terminal, the first ground terminal and the second ground terminal. The control circuit is coupled to the first feed terminal and the second feed terminal and used for switching a radio frequency (RF) signal between the first feed terminal to the first ground terminal and the second feed terminal to the second ground terminal.

11 Claims, 7 Drawing Sheets





US00898894B2

(12) **United States Patent**
Lin

(10) **Patent No.:** **US 8,988,894 B2**
(45) **Date of Patent:** **Mar. 24, 2015**

(54) **ELECTRONIC DEVICE**
(75) Inventor: **Ching-Chi Lin**, New Taipei (TW)
(73) Assignee: **Acer Incorporated**, New Taipei (TW)
(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 223 days.

2006/0023872	A1 *	2/2006	Chang	379/440
2009/0160717	A1 *	6/2009	Tsutsumi et al.	343/726
2009/0256763	A1	10/2009	Chi et al.	
2010/0283694	A1 *	11/2010	Kato	343/730
2011/0128206	A1 *	6/2011	Wakabayashi	343/860
2012/0218723	A1 *	8/2012	Kwak et al.	361/748

FOREIGN PATENT DOCUMENTS

CN	101466214	6/2009
EP	2006995	12/2008
EP	2157665	2/2010

OTHER PUBLICATIONS

Lee et al., "Design of Small-Size Wide-Bandwidth Microstrip-Patch Antennas," *IEEE Antennas and Propagation Magazine*, Feb. 1, 2003, pp. 75-83, vol. 45, No. 1.
Wong et al., "Broadband Triangular Microstrip Antenna with U-shaped slot," *Electronics Letters*, Dec. 4, 1997, pp. 2085-2087, vol. 33, No. 25.

* cited by examiner

Primary Examiner — Forrest M Phillips
(74) *Attorney, Agent, or Firm* — Jianq Chyun IP Office

(57) **ABSTRACT**

An electronic device is provided. The electronic device includes a metal housing, a first opening, a first metal line, a first grounding point and a first current zero point. The first opening passes through the metal housing. The first metal line is disposed inside the first opening, wherein a first end of the first metal line is electrically connected to a side of the first opening, and a second end of the first metal line has a first feeding point. The first grounding point and the first current zero point are located on the side of the first opening. The metal housing forms a first loop antenna to transmit or receive a first radio frequency signal by a first excitation path from the first feeding point to the first grounding point.

10 Claims, 3 Drawing Sheets

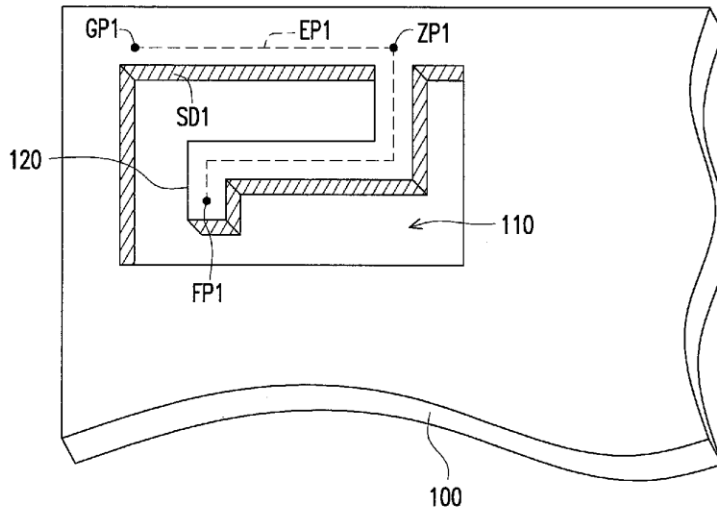
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H05K 7/14 (2006.01)
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H01Q 13/10 (2006.01)

(52) **U.S. Cl.**
CPC . **H01Q 7/00** (2013.01); **H01Q 13/10** (2013.01)
USPC **361/799**; 361/679.01

(58) **Field of Classification Search**
USPC 361/799, 679.01
See application file for complete search history.

(56) **References Cited**
U.S. PATENT DOCUMENTS
5,754,143 A * 5/1998 Warnagiris et al. 343/767
6,011,698 A * 1/2000 Buehler 361/799
7,453,404 B2 * 11/2008 Ying 343/702
2004/0104851 A1 6/2004 Kadambi et al.
2005/0088342 A1 4/2005 Parsche





US008994595B2

(12) **United States Patent**
Huang et al.

(10) **Patent No.:** **US 8,994,595 B2**
(45) **Date of Patent:** **Mar. 31, 2015**

(54) **MULTI-FREQUENCY ANTENNA**

(56) **References Cited**

(75) Inventors: **Chih-Yung Huang**, Taichung (TW);
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Sy-Ben Wang, Hsinchu County (TW)

U.S. PATENT DOCUMENTS

2007/0296636	A1*	12/2007	Lee	343/702
2010/0164830	A1*	7/2010	Huang et al.	343/846
2011/0122042	A1*	5/2011	Huang et al.	343/860
2011/0205138	A1*	8/2011	Yanagi et al.	343/845
2012/0146865	A1*	6/2012	Hayashi et al.	343/750

(73) Assignee: **Arcadyan Technology Corp.**, Hsinchu (TW)

FOREIGN PATENT DOCUMENTS

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 158 days.

CN	102110887	A	6/2011
EP	2204880	A1	7/2010

OTHER PUBLICATIONS

(21) Appl. No.: **13/530,666**

Office action from Chinese Patent Office in a counterpart Chinese Patent Application No. 100037, Dated Feb. 21, 2014.

(22) Filed: **Jun. 22, 2012**

* cited by examiner

(65) **Prior Publication Data**

US 2013/0009845 A1 Jan. 10, 2013

Primary Examiner — Sue A Purvis

Assistant Examiner — Daniel J Munoz

(30) **Foreign Application Priority Data**

Jul. 6, 2011 (TW) 100123960 A

(74) *Attorney, Agent, or Firm* — The PL Law Group, PLLC

(57) **ABSTRACT**

(51) **Int. Cl.**

H01Q 9/42 (2006.01)

H01Q 1/12 (2006.01)

H01Q 1/24 (2006.01)

An antenna for receiving and transmitting a signal is provided. The antenna includes a connection portion receiving and transmitting the signal, a first radiation portion and a second radiation portion. The connection portion includes a first end, a second end and a third end, wherein the first end is configured at a first distance from a ground. The first radiation portion is connected to the second end, and includes at least one folding area forming thereon at least one folding segment, wherein the folding segment and the connection portion have therebetween a shortest distance being a second distance. The second radiation portion is connected to the third end.

(52) **U.S. Cl.**

CPC . **H01Q 9/42** (2013.01); **H01Q 1/243** (2013.01)

USPC **343/702**; **343/700 MS**

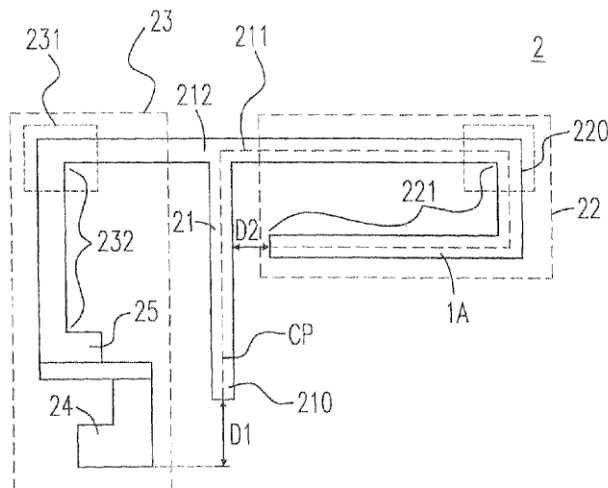
(58) **Field of Classification Search**

CPC H01Q 1/38; H01Q 1/243

USPC **343/700 MS**, **702**, **749**, **860**

See application file for complete search history.

20 Claims, 8 Drawing Sheets





US008994596B2

(12) **United States Patent**
Du et al.

(10) **Patent No.:** **US 8,994,596 B2**
(45) **Date of Patent:** **Mar. 31, 2015**

(54) **MULTI-BAND ANTENNA**

(75) Inventors: **Jian-Jhih Du**, Taipei (TW); **Kuo-Chang Lo**, Miaoli County (TW); **Chih-Yung Huang**, Taichung (TW)

(73) Assignee: **Arcadyan Technology Corporation**, Hsinchu (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 225 days.

(21) Appl. No.: **13/557,397**

(22) Filed: **Jul. 25, 2012**

(65) **Prior Publication Data**
US 2013/0033413 A1 Feb. 7, 2013

(30) **Foreign Application Priority Data**
Aug. 4, 2011 (TW) 100127804 A

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/00 (2006.01)
H01Q 9/42 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 5/0058** (2013.01); **H01Q 5/0062** (2013.01); **H01Q 5/0072** (2013.01); **H01Q 9/42** (2013.01)
USPC **343/702**; 343/700 MS

(58) **Field of Classification Search**
CPC ... H01Q 1/243; H01Q 5/0058; H01Q 5/0062; H01Q 5/0072; H01Q 9/42
USPC 343/700 MS, 702, 846
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,050,010	B2 *	5/2006	Wang et al.	343/702
7,768,460	B2	8/2010	Yang et al.	
7,830,326	B2	11/2010	Hung et al.	
7,868,831	B2	1/2011	Hung et al.	
7,928,912	B2	4/2011	Chen et al.	
7,928,916	B2	4/2011	Hung et al.	
7,990,321	B2	8/2011	Shih	
8,223,075	B2 *	7/2012	Pan	343/700 MS
2007/0176835	A1	8/2007	Qi et al.	
2008/0180333	A1 *	7/2008	Martiskainen et al.	343/722

(Continued)

FOREIGN PATENT DOCUMENTS

CN	1753248	A	3/2006
CN	101783435	A	7/2010

(Continued)

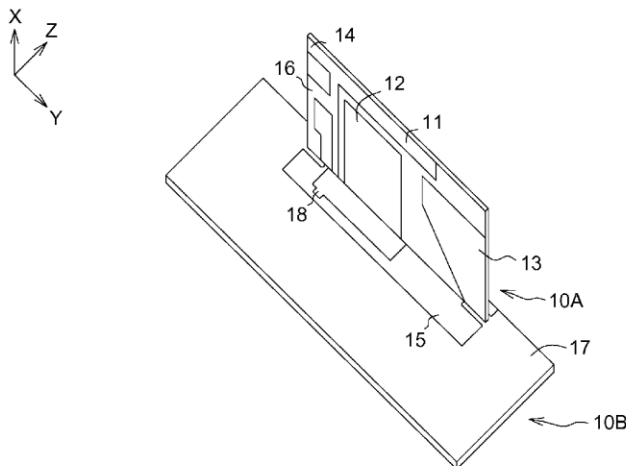
Primary Examiner — Hoanganh Le

(74) Attorney, Agent, or Firm — Rabin & Berdo, P.C.

(57) **ABSTRACT**

A multi-band inverted-F antenna including a ground plane, a signal feeding circuit, first, second and third main radiation parts is provided. The signal feeding circuit is electrically isolated from the ground plane and receives/transmits wireless signals. The first and the second main radiation part are both physically and electrically connected to the signal feeding circuit, and generate first and second frequency band operation modes for the inverted-F antenna, respectively. The third main radiation part is electrically isolated from the signal feeding circuit, the first and the second main radiation parts, and generates a third frequency band operation mode for the inverted-F antenna via to signal coupling between the first and the third main radiation parts and/or signal coupling between the second and the third main radiation parts.

13 Claims, 12 Drawing Sheets





US008994597B2

(12) **United States Patent**
Hill et al.

(10) **Patent No.:** **US 8,994,597 B2**
(45) **Date of Patent:** **Mar. 31, 2015**

(54) **HYBRID ANTENNAS FOR ELECTRONIC DEVICES**

(71) Applicant: **Apple Inc.**, Cupertino, CA (US)

(72) Inventors: **Robert J. Hill**, Salinas, CA (US); **Scott A. Myers**, San Francisco, CA (US); **Robert W. Schlub**, Cupertino, CA (US); **Dean F. Darnell**, San Jose, CA (US); **Zhijun Zhang**, Beijing (CN)

(73) Assignee: **Apple Inc.**, Cupertino, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **13/848,454**

(22) Filed: **Mar. 21, 2013**

(65) **Prior Publication Data**

US 2013/0222195 A1 Aug. 29, 2013

Related U.S. Application Data

(62) Division of application No. 13/343,420, filed on Jan. 4, 2012, now Pat. No. 8,410,986, which is a division of application No. 12/120,012, filed on May 13, 2008, now Pat. No. 8,106,836.

(60) Provisional application No. 61/044,448, filed on Apr. 11, 2008.

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 13/10 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 13/103** (2013.01); **H01Q 1/243** (2013.01); **H01Q 9/0421** (2013.01); **H01Q 9/42** (2013.01);

(Continued)

(58) **Field of Classification Search**
USPC 343/702, 767
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,947,987 A 8/1960 Dodington
4,641,366 A 2/1987 Yokoyama et al.

(Continued)

FOREIGN PATENT DOCUMENTS

CN 2733831 10/2005
CN 1692565 11/2005

(Continued)

OTHER PUBLICATIONS

Schlub et al. U.S. Appl. No. 13/092,875, filed Apr. 22, 2011.

(Continued)

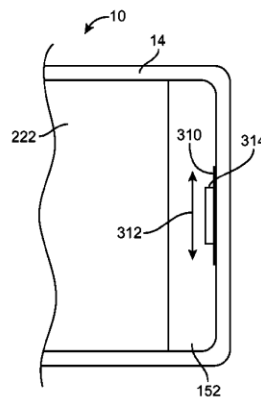
Primary Examiner — Dieu H Duong

(74) *Attorney, Agent, or Firm* — Treyz Law Group; G. Victor Treyz; Michael H. Lyons

(57) **ABSTRACT**

A portable electronic device is provided that has a hybrid antenna. The hybrid antenna may include a slot antenna structure and an inverted-F antenna structure. The slot antenna portion of the hybrid antenna may be used to provide antenna coverage in a first communications band and the inverted-F antenna portion of the hybrid antenna may be used to provide antenna coverage in a second communications band. The second communications band need not be harmonically related to the first communications band. The electronic device may be formed from two portions. One portion may contain conductive structures that define the shape of the antenna slot. One or more dielectric-filled gaps in the slot may be bridged using conductive structures on another portion of the electronic device. A conductive trim member may be inserted into an antenna slot to trim the resonant frequency of the slot antenna portion of the hybrid antenna.

4 Claims, 22 Drawing Sheets





US008994604B2

(12) **United States Patent**
Puente Baliarda et al.

(10) **Patent No.:** **US 8,994,604 B2**
(45) **Date of Patent:** ***Mar. 31, 2015**

(54) **COUPLED MULTIBAND ANTENNAS**

(75) Inventors: **Carles Puente Baliarda**, San Cugat del Valles (ES); **Jaume Anguera Pros**, Vinaros (ES); **Jordi Soler Castany**, Mataro (ES); **Antonio Condes Martinez**, Esplugues de Llobregat (ES)

(73) Assignee: **Fractus, S.A.**, Barcelona (ES)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 543 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **11/950,835**

(22) Filed: **Dec. 5, 2007**

(65) **Prior Publication Data**

US 2008/0129630 A1 Jun. 5, 2008

Related U.S. Application Data

(63) Continuation of application No. 11/075,980, filed as application No. PCT/EP02/11355 on Sep. 10, 2002, now Pat. No. 7,315,289.

(51) **Int. Cl.**
H01Q 9/26 (2006.01)
H01Q 9/42 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC . **H01Q 9/42** (2013.01); **H01Q 1/36** (2013.01);
H01Q 1/362 (2013.01); **H01Q 1/40** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 5/0062
USPC 343/793, 803, 893
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,628,322 A 12/1986 Marko et al.
4,751,513 A 6/1988 Daryoush et al.

(Continued)

FOREIGN PATENT DOCUMENTS

EP 0655797 5/1995
EP 0 942 488 9/1999

(Continued)

OTHER PUBLICATIONS

Hisamatsu Nakano et al., "Realization of Dual-Frequency and Wide-Band VSWR Performances Using Normal-Mode Helical and Inverted-F Antennas", IEEE Transactions on Antennas and Propagation, vol. 46, No. 6, Jun. 1998, pp. 788-793.

(Continued)

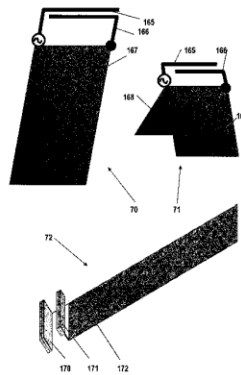
Primary Examiner — Robert Karacsony

(74) *Attorney, Agent, or Firm* — Edell, Shapiro & Finnan LLC

(57) **ABSTRACT**

The present invention consists of an antenna comprising at least two radiating structures, said radiating structures taking the form of two arms, said arms being made of or limited by a conductor, superconductor or semiconductor material, said two arms being coupled to each other through a region on first and second superconducting arms such that the combined structure of the coupled two-arms forms a small antenna with a broadband behavior, a multiband behavior or a combination of both effects. According to the present invention, the coupling between the two radiating arms is obtained by means of the shape and spatial arrangement of said two arms, in which at least one portion on each arm is placed in close proximity to each other (for instance, at a distance smaller than a tenth of the longest free-space operating wavelength) to allow electromagnetic fields in one arm being transferred to the other through said specific close proximity regions. Said proximity regions are located at a distance from the feeding port of the antenna (for instance a distance larger than 1/40 of the free-space longest operating wavelength) and specifically exclude said feeding port of the antenna.

36 Claims, 17 Drawing Sheets





US008996080B2

(12) **United States Patent**
You et al.

(10) **Patent No.:** **US 8,996,080 B2**
(45) **Date of Patent:** ***Mar. 31, 2015**

(54) **RADIO-FREQUENCY DEVICE AND WIRELESS COMMUNICATION DEVICE**

USPC **455/575.5**; 343/850; 343/852; 343/845; 343/846; 307/104; 307/98; 307/109; 455/121; 455/193.1; 455/197.2; 455/197.3

(71) Applicant: **Wistron NeWeb Corporation**, Hsinchu (TW)

(58) **Field of Classification Search**
CPC H01B 1/3838; H01Q 9/42; H01Q 1/245
USPC 455/121, 193.1, 197.2, 197.3; 343/850, 343/852, 845, 846; 307/104, 98, 109
See application file for complete search history.

(72) Inventors: **Shang-Sian You**, Hsinchu (TW);
Kuan-Hsueh Tseng, Hsinchu (TW)

(73) Assignee: **Wistron NeWeb Corporation**, Hsinchu Science Park, Hsinchu (TW)

(56) **References Cited**

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 37 days.
This patent is subject to a terminal disclaimer.

U.S. PATENT DOCUMENTS

2006/0281423 A1* 12/2006 Caimi et al. 455/129
2013/0120200 A1* 5/2013 Desclos et al. 343/745
2013/0154894 A1* 6/2013 Caimi et al. 343/858

* cited by examiner

(21) Appl. No.: **13/964,115**

Primary Examiner — Khalid Shaheed

(22) Filed: **Aug. 12, 2013**

(74) *Attorney, Agent, or Firm* — Winston Hsu; Scott Margo

(65) **Prior Publication Data**

US 2014/0315606 A1 Oct. 23, 2014

(30) **Foreign Application Priority Data**

Apr. 19, 2013 (TW) 102113979 A

(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H01Q 7/00 (2006.01)
H01Q 9/16 (2006.01)
H01Q 9/26 (2006.01)
H01Q 9/42 (2006.01)

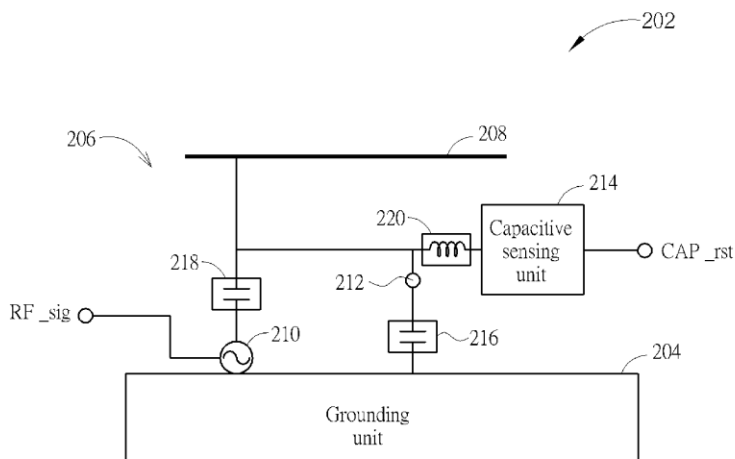
(52) **U.S. Cl.**

CPC **H04B 1/3838** (2013.01); **H01Q 1/245** (2013.01); **H01Q 7/00** (2013.01); **H01Q 9/16** (2013.01); **H01Q 9/26** (2013.01); **H01Q 9/42** (2013.01)

(57) **ABSTRACT**

A radio-frequency (RF) device for a wireless communication device includes a grounding element, an antenna, a first DC blocking element for cutting off a direct-current (dc) signal route between a grounding terminal of the antenna and the grounding element, a capacitive sensing unit capable of using a radiating element of the antenna to sense an environment capacitance within a specific range, a second DC blocking element electrically connected between the radiating element and the feed-in element for blocking a dc signal path from the radiating element to the feed-in element, and a high-frequency blocking element electrically connected between the radiating element and the capacitive sensing unit for blocking a high-frequency signal path from the radiating element to the capacitive sensing unit.

18 Claims, 19 Drawing Sheets





US009000984B2

(12) **United States Patent**
Rao et al.

(10) **Patent No.:** **US 9,000,984 B2**
(45) **Date of Patent:** **Apr. 7, 2015**

(54) **MULTIPLE INPUT, MULTIPLE OUTPUT ANTENNA FOR HANDHELD COMMUNICATION DEVICES**

6,448,933 B1 9/2002 Hill et al.
6,515,627 B2 2/2003 Lopez et al.
6,593,887 B2 7/2003 Luk et al.
6,614,401 B2 9/2003 Onaka et al.

(75) Inventors: **Qinjiang Rao**, Waterloo (CA); **Dong Wang**, Waterloo (CA)

(Continued)

(73) Assignee: **BlackBerry Limited**, Waterloo (CA)

FOREIGN PATENT DOCUMENTS

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 410 days.

EP 1077505 A2 2/2001
EP 116288 A1 12/2001

(Continued)

(21) Appl. No.: **13/447,418**

OTHER PUBLICATIONS

(22) Filed: **Apr. 16, 2012**

Antonio Forenza et al., Benefit of Pattern Diversity via Two-Element Array of Circular Patch Antennas in Indoor Clustered MIMO Channels, IEEE Transactions on Communications, vol. 54, No. 5, pp. 943-954, May 2006.

(65) **Prior Publication Data**

US 2012/0200462 A1 Aug. 9, 2012

(Continued)

Related U.S. Application Data

(63) Continuation of application No. 12/364,932, filed on Feb. 3, 2009, now Pat. No. 8,179,324.

Primary Examiner — Huedung Mancuso

(74) *Attorney, Agent, or Firm* — Moffat & Co.

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 9/04 (2006.01)
H01Q 21/28 (2006.01)

(57) **ABSTRACT**

(52) **U.S. Cl.**
CPC **H01Q 9/045** (2013.01); **H01Q 1/38** (2013.01); **H01Q 9/0421** (2013.01); **H01Q 21/28** (2013.01)

An antenna assembly for a mobile wireless communication device has a support with a first surface and a second surface between which a third surface and a fourth surface extend. A conductive ground plane is formed on the second surface. An antenna includes an electrically conductive patch located on the first surface, and first and second electrically conductive legs and an electrically conductive stripe all abutting the patch. In one version the first and second legs and the strip are all on the third surface. In another version the first and second legs are on the third surface and the strip is on the fourth surface that is orthogonal to the third surface. A first signal port is adapted to apply a first signal to the first leg and a second signal port is adapted to apply a second signal to the third leg.

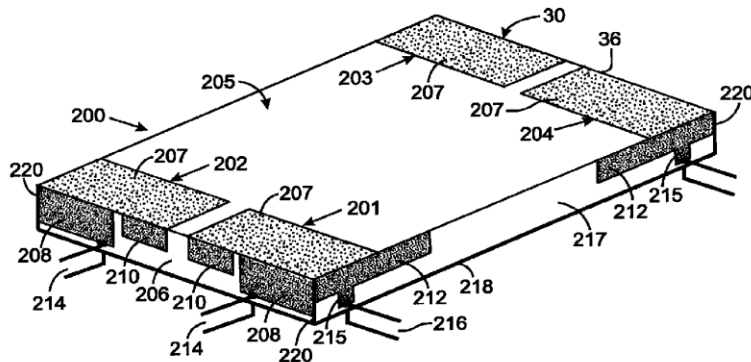
(58) **Field of Classification Search**
CPC H01Q 1/38; H01Q 9/0407; H01Q 9/0421; H01Q 1/243; H01Q 5/0003
USPC 343/700 MS, 702, 745, 846, 767
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,547,100 A 8/1996 Johnson
5,633,646 A 5/1997 Strickland

12 Claims, 4 Drawing Sheets





US009000993B2

(12) **United States Patent**
Jeon et al.

(10) **Patent No.:** **US 9,000,993 B2**
(45) **Date of Patent:** **Apr. 7, 2015**

(54) **ANTENNA FEEDING STRUCTURE AND ANTENNA**

(71) Applicant: **Radina Co., Ltd**, Seoul (KR)

(72) Inventors: **Sin-Hyung Jeon**, Seoul (KR);
Hyeng-Cheul Choi, Seoul (KR);
Jae-Seok Lee, Seoul (KR); **Oul Cho**,
Suwon-si (KR)

(73) Assignee: **Radina Co., Ltd**, Seoul (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 197 days.

(21) Appl. No.: **13/645,530**

(22) Filed: **Oct. 5, 2012**

(65) **Prior Publication Data**
US 2013/0027260 A1 Jan. 31, 2013

Related U.S. Application Data
(63) Continuation of application No. PCT/KR2011/002420, filed on Apr. 6, 2011.

(30) **Foreign Application Priority Data**
Apr. 6, 2010 (KR) 10-2010-0031243
May 7, 2010 (KR) 10-2010-0042963
Apr. 6, 2011 (KR) 10-2011-0031505

(51) **Int. Cl.**
H01Q 9/00 (2006.01)
H01Q 5/00 (2006.01)
H01Q 7/00 (2006.01)
H01Q 9/04 (2006.01)
(52) **U.S. Cl.**
CPC **H01Q 5/0058** (2013.01); **H01Q 7/005**
(2013.01); **H01Q 9/0421** (2013.01)

(58) **Field of Classification Search**
CPC . H01Q 5/0024; H01Q 5/0051; H01Q 5/0058;
H01Q 9/0407; H01Q 9/0421; H01Q 1/243;
H01Q 7/005
USPC 343/749, 702, 745
See application file for complete search history.

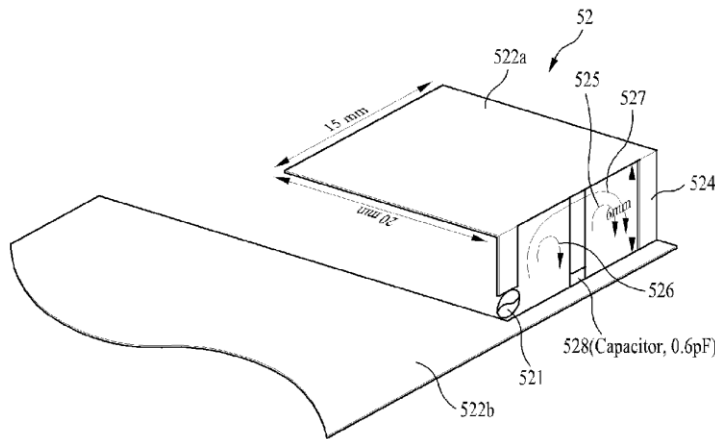
(56) **References Cited**
U.S. PATENT DOCUMENTS
6,903,688 B2 * 6/2005 Edvardsson 343/700 MS
2004/0087341 A1 5/2004 Edvardsson
(Continued)

FOREIGN PATENT DOCUMENTS
CN 1484876 A 3/2004
JP 2005-210568 A 8/2005
KR 10-2003-0066779 A 8/2003
(Continued)

OTHER PUBLICATIONS
Korean Intellectual Property Office, International Search Report for PCT/KR2011/002420, mailed Aug. 29, 2011.
Primary Examiner — Hoang V Nguyen
(74) *Attorney, Agent, or Firm* — Park, Kim & Suh, LLC

(57) **ABSTRACT**
The disclosure provides an antenna feeding structure having a low frequency loop, an intermediate frequency loop, and a high frequency loop, and generates resonance between the inductance of the intermediate frequency loop itself and a capacitive element in the intermediate frequency loop, wherein the antenna feeding structure is configured to be able to adjust the resonance frequency using the area of the loop and the value of the capacitive element, thereby allowing the antenna to have a broadband characteristic, and further, making it possible to easily design an antenna having a desired band.

10 Claims, 9 Drawing Sheets





US09001000B2

(12) **United States Patent**
Satou et al.

(10) **Patent No.:** **US 9,001,000 B2**
(45) **Date of Patent:** **Apr. 7, 2015**

(54) **ANTENNA**

(75) Inventors: **Hiroshi Satou**, Kanagawa (JP); **Yoshio Koyanagi**, Kanagawa (JP); **Takanori Hirobe**, Ishikawa (JP); **Hiroyuki Uejima**, Ishikawa (JP)

(73) Assignee: **Panasonic Intellectual Property Management Co., Ltd.**, Osaka (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 246 days.

(21) Appl. No.: **13/821,368**

(22) PCT Filed: **May 16, 2012**

(86) PCT No.: **PCT/JP2012/003213**

§ 371 (c)(1),
(2), (4) Date: **Mar. 7, 2013**

(87) PCT Pub. No.: **WO2012/157274**

PCT Pub. Date: **Nov. 22, 2012**

(65) **Prior Publication Data**

US 2013/0162497 A1 Jun. 27, 2013

(30) **Foreign Application Priority Data**

May 19, 2011 (JP) 2011-112274

(51) **Int. Cl.**

H01Q 21/00 (2006.01)

H01Q 5/00 (2006.01)

(Continued)

(52) **U.S. Cl.**

CPC **H01Q 5/0058** (2013.01); **H01Q 21/28** (2013.01); **H01Q 21/0006** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/0048** (2013.01); **H01Q 9/30** (2013.01); **H01Q 1/521** (2013.01)

(58) **Field of Classification Search**

CPC ... H01Q 1/243; H01Q 5/0048; H01Q 5/0058; H01Q 1/521; H01Q 21/28; H01Q 21/0006; H01Q 9/30
USPC 343/702, 850, 852, 853
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,508,420 B2* 8/2013 Fujieda et al. 343/745
2008/0278405 A1* 11/2008 Montgomery et al. 343/893

(Continued)

FOREIGN PATENT DOCUMENTS

WO 2011/102143 A1 8/2011
WO 2011/142135 A1 11/2011

OTHER PUBLICATIONS

Chen et al., "A Decoupling Technique for Increasing the Port Isolation Between Two Strongly Coupled Antennas," IEEE Transactions on Antennas and Propagation, 56(12):3650-3568, Dec. 2008.

(Continued)

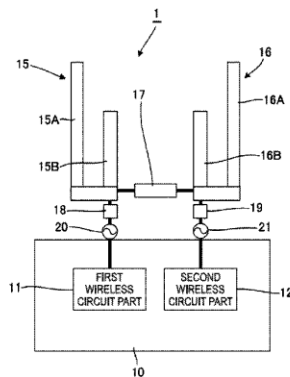
Primary Examiner — Hoanganh Le

(74) *Attorney, Agent, or Firm* — Seed IP Law Group PLLC

(57) **ABSTRACT**

A first antenna element is embodied in a blancheted structure, and a second antenna element is embodied in a blancheted structure. A low coupling circuit for increasing susceptance with an increase in frequency is interposed between the first antenna element and the second antenna element. The first antenna element and the second antenna element exhibit resonance of a Y12 component of an admittance matrix between first and second frequencies and between second and third frequencies. The first branch element and the third branch element assume a value of nearly a quarter of a resonant electrical length of the Y12 component of the admittance matrix between the first and second frequencies. The second branch element and the fourth branch element assume a value of nearly a quarter of the resonant electrical length of the Y12 component of the admittance matrix between the second and third frequencies.

6 Claims, 24 Drawing Sheets





US009001003B2

(12) **United States Patent**
Chen et al.

(10) **Patent No.:** **US 9,001,003 B2**
(45) **Date of Patent:** **Apr. 7, 2015**

(54) **HANDHELD DEVICE**

FOREIGN PATENT DOCUMENTS

(75) Inventors: **Chien-Chih Chen**, Taoyuan (TW);
Chun-Wei Tseng, Taoyuan (TW);
Yen-Liang Kuo, Taoyuan (TW);
Wan-Ming Chen, Taoyuan (TW)

JP 8-321716 12/1996
JP 2006-165834 6/2006
JP 2007-288360 11/2007

OTHER PUBLICATIONS

(73) Assignee: **HTC Corporation**, Taoyuan (TW)
(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 868 days.

Office Action from corresponding Japanese Appln. No. 2011-116319 dated Sep. 10, 2013. English summary translation attached.
Office Action from corresponding Korean Appln. No. 10-2011-0134190 dated Sep. 24, 2013. English summary translation attached.
Office Action from corresponding Japanese Appln. No. 2011-116319 dated Mar. 5, 2013. English summary translation attached.
Office Action from corresponding Korean Appln. No. 10-2011-0134190 dated Mar. 19, 2013. English translation attached.

(21) Appl. No.: **13/041,858**

(22) Filed: **Mar. 7, 2011**

* cited by examiner

(65) **Prior Publication Data**
US 2012/0229346 A1 Sep. 13, 2012

Primary Examiner — Robert Karacsony
(74) *Attorney, Agent, or Firm* — Grossman, Tucker, Perreault & Pfleger, PLLC

(51) **Int. Cl.**
H01Q 3/24 (2006.01)
H01Q 1/24 (2006.01)
H01Q 5/00 (2006.01)
H01Q 9/42 (2006.01)
H04B 1/00 (2006.01)
H04W 88/02 (2009.01)

(57) **ABSTRACT**

A handheld device is provided, wherein the handheld device comprises a housing, a circuit board, a planar antenna and a switch. The housing comprising an outer surface is configured to define a receiving space. The circuit board is disposed in the receiving space. The planar antenna comprises a metal layer, wherein the metal layer comprising a first connecting point and a second connecting point is patterned on the outer surface. The switch comprising a first electrode and a second electrode is configured to control the electrical connection between the first connecting point and the second connecting point, wherein the first electrode and the second electrode are electrically connected between the first connecting point and the second connecting point. The planar antenna operates at a first central band when the switch is turned on, and operates at a second central band when the switch is turned off.

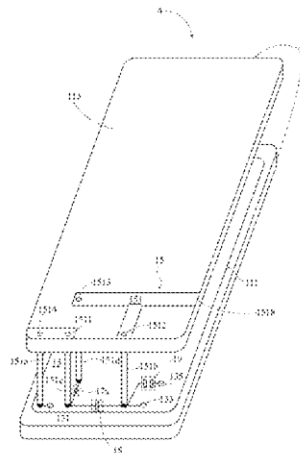
(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 5/0055** (2013.01); **H01Q 9/42** (2013.01); **H04B 1/006** (2013.01); **H04W 88/02** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/0055; H01Q 9/42; H01Q 9/0421
USPC 343/702, 876
See application file for complete search history.

(56) **References Cited**
U.S. PATENT DOCUMENTS

8,098,204 B2 1/2012 Tsujimura et al.
2009/0058735 A1* 3/2009 Hill et al. 343/702
2010/0033397 A1* 2/2010 Narasimhan et al. 343/860

2 Claims, 7 Drawing Sheets





US009002262B1

(12) **United States Patent**
Kuo

(10) **Patent No.:** **US 9,002,262 B1**
(45) **Date of Patent:** **Apr. 7, 2015**

(54) **MULTI-MODE WIDEBAND ANTENNA**

(71) Applicant: **Amazon Technologies, Inc.**, Reno, NV (US)

(72) Inventor: **Jerry W. Kuo**, San Jose, CA (US)

(73) Assignee: **Amazon Technologies, Inc.**, Reno, NV (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 153 days.

(21) Appl. No.: **13/685,582**

(22) Filed: **Nov. 26, 2012**

(51) **Int. Cl.**
H04B 7/24 (2006.01)
H01Q 1/50 (2006.01)
H04B 1/04 (2006.01)

(52) **U.S. Cl.**
CPC ... **H01Q 1/50** (2013.01); **H04B 1/04** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 9/42
USPC 455/39, 73, 562.1, 575.7; 343/702, 815, 343/833, 848, 860
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,136,019 B2* 11/2006 Mikkola et al. 343/702
2010/0141536 A1* 6/2010 Zhang et al. 343/702

* cited by examiner

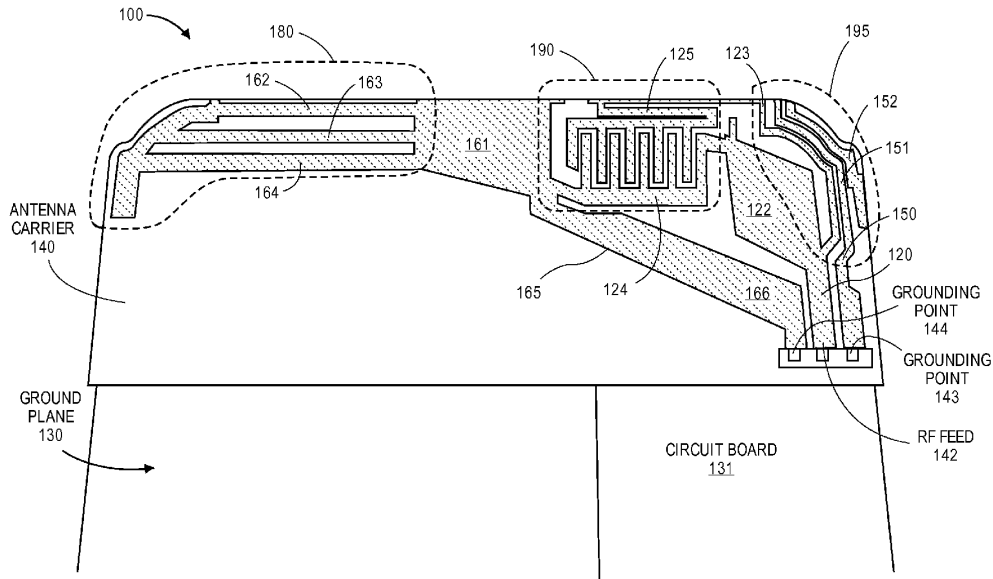
Primary Examiner — Tuan H Nguyen

(74) *Attorney, Agent, or Firm* — Lowenstein Sandler LLP

(57) **ABSTRACT**

Methods and systems for extending a bandwidth of a multi-mode wideband antenna of a user device are described. A multi-mode wideband antenna includes a single radio frequency (RF) feed coupled to a first element, and a second element coupled to the first element and a ground plane. The first element is to operate as a feeding structure to a parasitic grounding element that is coupled to the ground plane, but is not conductively connected to the RF feed. The multi-mode wideband antenna is configured to provide multiple resonant modes.

24 Claims, 9 Drawing Sheets





US009002297B2

(12) **United States Patent**
Chen et al.

(10) **Patent No.:** **US 9,002,297 B2**
(45) **Date of Patent:** **Apr. 7, 2015**

(54) **MOBILE DEVICE AND TUNABLE ANTENNA THEREIN**

(56) **References Cited**

(71) Applicant: **HTC Corporation**, Taoyuan, Taoyuan County (TW)

(72) Inventors: **Ju-Hung Chen**, Taoyuan (TW);
Chien-Pin Chiu, Taoyuan (TW);
Chang-Yen Cheng, Taoyuan (TW);
Chi-Hsien Chiu, Taoyuan (TW)

(73) Assignee: **HTC Corporation**, Taoyuan (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 289 days.

(21) Appl. No.: **13/670,068**

(22) Filed: **Nov. 6, 2012**

(65) **Prior Publication Data**

US 2014/0128007 A1 May 8, 2014

(51) **Int. Cl.**
H04B 1/44 (2006.01)
H01Q 11/12 (2006.01)
H04B 1/04 (2006.01)
H04B 1/18 (2006.01)

(52) **U.S. Cl.**
CPC **H04B 1/18** (2013.01)

(58) **Field of Classification Search**
USPC 455/117, 161.1, 161.2, 161.3, 217, 82, 455/83

See application file for complete search history.

U.S. PATENT DOCUMENTS

7,671,804	B2	3/2010	Zhang et al.	
8,787,215	B1 *	7/2014	Khlal et al.	370/280
2004/0152426	A1 *	8/2004	Suzuki et al.	455/83
2006/0055606	A1	3/2006	Boyle	
2008/0280570	A1	11/2008	Blin	
2008/0291591	A1 *	11/2008	Huang et al.	361/56
2010/0149057	A9 *	6/2010	Milosavljevic et al.	343/722
2012/0038525	A1 *	2/2012	Monsalve Carcelen et al.	343/705
2012/0112852	A1	5/2012	Manssen et al.	

FOREIGN PATENT DOCUMENTS

CN	1650469	A	8/2005
TW	200814427	A	3/2008
WO	WO 2008/010149	A1	1/2008

* cited by examiner

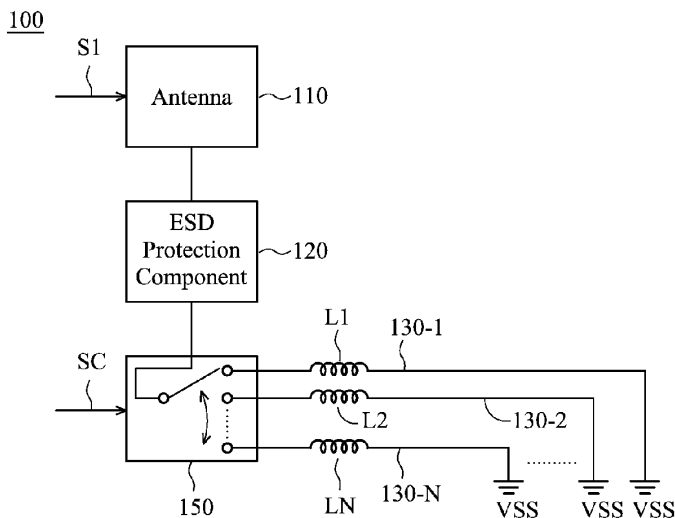
Primary Examiner — Nguyen Vo

(74) Attorney, Agent, or Firm — Birch, Stewart, Kolasch & Birch, LLP

(57) **ABSTRACT**

A mobile device includes an antenna, an ESD (Electrostatic Discharge) protection component, a plurality of branches, and a switch. The antenna is configured to transmit and receive an RF (Radio Frequency) signal. The branches provide different inductances or different capacitances, and are respectively coupled to a ground voltage terminal. The switch is coupled through the ESD protection component to the antenna, and switches between the branches according to a control signal such that the antenna is capable of operating in a plurality of frequency intervals. The ESD protection component is configured to protect the switch from being damaged.

20 Claims, 7 Drawing Sheets





US009002422B2

(12) **United States Patent**
Merz et al.

(10) **Patent No.:** **US 9,002,422 B2**
(45) **Date of Patent:** ***Apr. 7, 2015**

(54) **ENGAGEMENT FEATURES AND ADJUSTMENT STRUCTURES FOR ELECTRONIC DEVICES WITH INTEGRAL ANTENNAS**

(58) **Field of Classification Search**
USPC 455/550.1, 575.1, 575.5, 575.6, 575.7, 455/90.1, 90.3, 351; 343/700 MS, 702
See application file for complete search history.

(71) Applicant: **Apple Inc.**, Cupertino, CA (US)

(56) **References Cited**

(72) Inventors: **Nicholas G. L. Merz**, San Francisco, CA (US); **Dean F. Darnell**, San Jose, CA (US)

U.S. PATENT DOCUMENTS

6,675,461 B1 1/2004 Rowson et al.
6,853,338 B2 2/2005 McConnell

(Continued)

(73) Assignee: **Apple Inc.**, Cupertino, CA (US)

FOREIGN PATENT DOCUMENTS

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

EP 1632424 8/2006
EP 2109185 10/2009

OTHER PUBLICATIONS

This patent is subject to a terminal disclaimer.

Strasser F et al., "Stanzteile zum Einbetten in Kunststoffteile", Kunststoffe International, Carl Hanser Verlag, Munchen, Feb. 1, 1988, vol. 78, No. 2, pp. 151-153.

Primary Examiner — Thanh Le

(74) Attorney, Agent, or Firm — Treyz Law Group; G. Victor Treyz

(21) Appl. No.: **14/287,747**

(22) Filed: **May 27, 2014**

(65) **Prior Publication Data**

US 2014/0266926 A1 Sep. 18, 2014

(57) **ABSTRACT**

Electronic devices may be provided that contain wireless communications circuitry. The wireless communications circuitry may include antenna structures that are formed from an internal ground plane and a peripheral conductive housing member. The internal ground plane and peripheral conductive housing member may be separated by a gap. The internal ground plane may be formed from sheet metal structures having engagement features such as tabs bent upwards at an angle. Plastic structures may be insert molded over the engagement features. When the internal ground plane is mounted in the electronic device, the plastic structures may bridge the gap between the internal ground plane and the peripheral conductive housing member. An adjustable structure such as a washer with a selectable thickness may be mounted to the peripheral conductive housing member opposing conductive structures across the gap. The thickness may be adjusted to adjust antenna performance.

Related U.S. Application Data

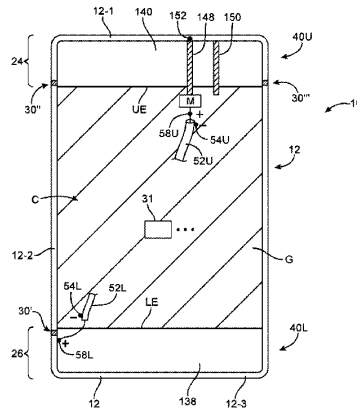
(63) Continuation of application No. 13/018,263, filed on Jan. 31, 2011, now Pat. No. 8,750,949.

(60) Provisional application No. 61/431,523, filed on Jan. 11, 2011.

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H04B 1/38 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H04B 1/38** (2013.01); **H01Q 9/0421** (2013.01); **H01Q 13/10** (2013.01)

20 Claims, 9 Drawing Sheets





US009007266B2

(12) **United States Patent**
Hsu et al.

(10) **Patent No.:** **US 9,007,266 B2**
(45) **Date of Patent:** ***Apr. 14, 2015**

(54) **RECEIVING DEVICE FOR GLOBAL POSITIONING SYSTEM AND ANTENNA STRUCTURE THEREOF**

(58) **Field of Classification Search**
USPC 343/702, 825, 828, 846, 700 MS
See application file for complete search history.

(75) Inventors: **Hsi-Hsing Hsu**, Taoyuan (TW); **Kai-Ta Wang**, Taoyuan (TW); **Chin-Lin Chang**, Taoyuan (TW); **Chuan-Ku Liu**, Taoyuan (TW); **Kuei-Chiang Huang**, Taoyuan (TW); **Kuo-Cheng Chen**, Taoyuan (TW)

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,892,483 A 4/1999 Hayes et al.
5,986,607 A 11/1999 Rudisill

(Continued)

FOREIGN PATENT DOCUMENTS

TW M279993 11/2005

OTHER PUBLICATIONS

Taiwanese language office action dated Sep. 26, 2012.
(Continued)

(73) Assignee: **HTC Corporation**, Taoyuan District, Taoyuan

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 55 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **13/603,363**

(22) Filed: **Sep. 4, 2012**

(65) **Prior Publication Data**

US 2012/0326932 A1 Dec. 27, 2012

Related U.S. Application Data

(63) Continuation of application No. 12/176,483, filed on Jul. 21, 2008, now Pat. No. 8,289,215.

(30) **Foreign Application Priority Data**

Jul. 31, 2007 (TW) 96127852 A

(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H01Q 9/04 (2006.01)
G01S 19/36 (2010.01)

(52) **U.S. Cl.**

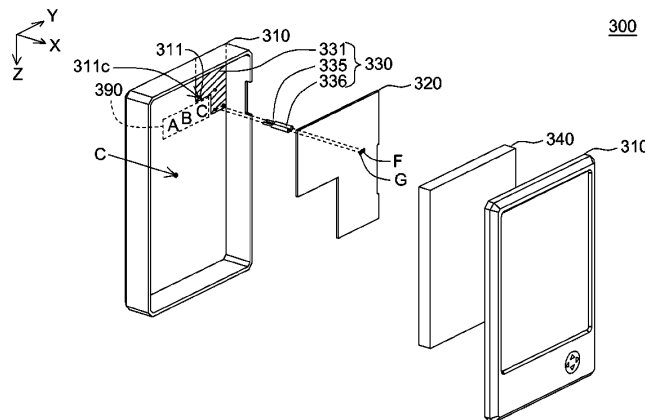
CPC **G01S 19/36** (2013.01); **H01Q 1/243** (2013.01); **H01Q 9/0421** (2013.01)

Primary Examiner — Michael C Wimer
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

A receiving device for a global positioning system and an antenna structure thereof. The receiving device includes a housing, a circuit board and the antenna structure. The circuit board is disposed inside the housing and has a ground portion and a signal feeding portion. The antenna structure is disposed inside the housing and includes a metal plate, a first electric conducting element and a second electric conducting element. The metal plate is used for receiving a GPS signal. The first electric conducting element has one end coupled to the metal plate, and the other end coupled to the ground portion of the circuit board. The second electric conducting element for feeding the GPS signal to the circuit board has one end coupled to the metal plate, and the other end coupled to the signal feeding portion of the circuit board.

25 Claims, 11 Drawing Sheets





US009007274B2

(12) **United States Patent**
Ban et al.

(10) **Patent No.:** **US 9,007,274 B2**
(45) **Date of Patent:** **Apr. 14, 2015**

(54) **RECONFIGURABLE MOBILE PHONE
BUILT-IN ANTENNA AND
IMPLEMENTATION METHOD THEREOF**

(75) Inventors: **Yongling Ban**, Shenzhen (CN); **Peihua Shua**, Shenzhen (CN); **Ping Lei**, Shenzhen (CN); **Hengyi Duan**, Shenzhen (CN)

(73) Assignee: **Huawei Device Co., Ltd.**, Shenzhen (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 412 days.

(21) Appl. No.: **13/529,422**

(22) Filed: **Jun. 21, 2012**

(65) **Prior Publication Data**

US 2012/0256804 A1 Oct. 11, 2012

Related U.S. Application Data

(60) Provisional application No. PCT/CN2010/079820, filed on Dec. 15, 2010.

(30) **Foreign Application Priority Data**

Dec. 24, 2009 (CN) 2009 1 0215550

(51) **Int. Cl.**
H01Q 1/48 (2006.01)
H01Q 1/38 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC . **H01Q 9/14** (2013.01); **H01Q 1/48** (2013.01);
H01Q 9/0421 (2013.01); **H01Q 1/243**
(2013.01); **H01Q 1/245** (2013.01); **H01Q 5/364**
(2013.01)

(58) **Field of Classification Search**
USPC 343/700 MS, 702, 846, 848
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,306,976 B1 10/2001 Matsuda et al.
7,714,786 B2* 5/2010 Chen et al. 343/700 MS

(Continued)

FOREIGN PATENT DOCUMENTS

CN 1391416 A 1/2003
CN 1190101 C 2/2005

(Continued)

OTHER PUBLICATIONS

Written Opinion of the International Searching Authority issued in corresponding PCT Patent Application No. PCT/CN2010/079820, mailed Mar. 24, 2011.

(Continued)

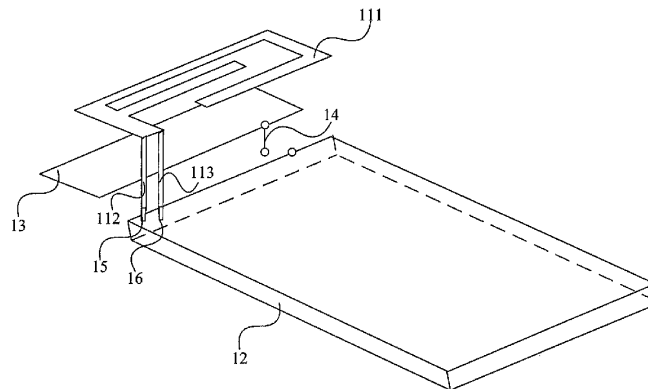
Primary Examiner — Tan Ho

(74) *Attorney, Agent, or Firm* — Brinks Gilson & Lione

(57) **ABSTRACT**

A reconfigurable mobile phone built-in antenna and its implementation method are disclosed. The antenna comprises an antenna main structure, an additional ground area, a ground area printed on one surface of a printed board, an electronic switch and an antenna feeding point and a grounding point printed on the other surface of the printed board, the antenna main structure comprises a wiring structure of the antenna, a feeding spring piece in contact with the antenna feeding point and a grounding spring piece in contact with the grounding point, and the additional ground area is positioned under the wiring structure; the electronic switch is used for disconnecting the additional ground area with the ground area on one surface of the printed board when the antenna works at low-frequency frequency band and connecting the additional ground area with the ground area on when the antenna works at high-frequency frequency band.

7 Claims, 5 Drawing Sheets





US009007275B2

(12) **United States Patent**
Pros et al.

(10) **Patent No.:** **US 9,007,275 B2**
(45) **Date of Patent:** **Apr. 14, 2015**

- (54) **DISTRIBUTED ANTENNA SYSTEM ROBUST TO HUMAN BODY LOADING EFFECTS**
- (75) Inventors: **Jaume Anguera Pros**, Vinaros (ES); **Carles Puente Baliarda**, Barcelona (ES)
- (73) Assignee: **Fractus, S.A.**, Barcelona (ES)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1250 days.

- (21) Appl. No.: **12/227,963**
- (22) PCT Filed: **May 31, 2007**
- (86) PCT No.: **PCT/EP2007/055329**
§ 371 (c)(1),
(2), (4) Date: **Mar. 31, 2009**
- (87) PCT Pub. No.: **WO2007/141187**
PCT Pub. Date: **Dec. 13, 2007**

- (65) **Prior Publication Data**
US 2009/0318094 A1 Dec. 24, 2009

- Related U.S. Application Data**
- (60) Provisional application No. 60/812,548, filed on Jun. 9, 2006.

- (30) **Foreign Application Priority Data**
Jun. 8, 2006 (EP) 06115119

- (51) **Int. Cl.**
H01Q 21/00 (2006.01)
H01Q 1/24 (2006.01)
(Continued)

- (52) **U.S. Cl.**
CPC **H01Q 3/36** (2013.01); **H01Q 1/245** (2013.01); **H01Q 21/29** (2013.01)

- (58) **Field of Classification Search**
CPC H01Q 1/38; H01Q 9/0421; H01Q 13/085; H01Q 1/243; H01Q 1/36
USPC 343/702, 844, 846, 850, 860, 853, 864; 455/757.7, 276.1, 269, 575.7
See application file for complete search history.

- (56) **References Cited**
U.S. PATENT DOCUMENTS
4,316,194 A * 2/1982 De Santis et al. 343/700 MS
4,633,258 A * 12/1986 Mok et al. 342/373
(Continued)

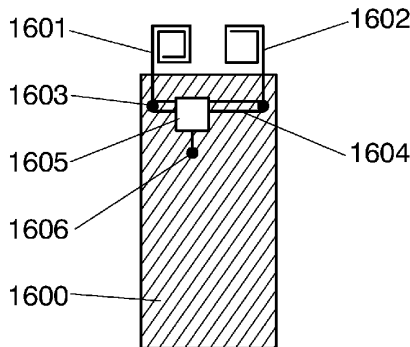
- FOREIGN PATENT DOCUMENTS
EP 0571124 11/1993
EP 1280230 A1 1/2003
(Continued)

- OTHER PUBLICATIONS
Morishita, H.; Kim, Y.; Fujimoto, K. Analysis of handset antennas in the vicinity of the human body by the electromagnetic simulator IEICE Trans. Electron. Jul. 2001.
(Continued)

Primary Examiner — Dameon E Levi
Assistant Examiner — Hasan Islam
(74) *Attorney, Agent, or Firm* — Edell Shapiro & Finnan LLC

- (57) **ABSTRACT**
The invention relates to an antenna system comprising a ground-plane (1100) and at least two antenna elements (1101) connected to a common input/output port (1106) for said antenna system. Each of said antenna elements (1101) comprise one driven point (1102). The antenna system further comprises means (1103) for transmitting the signal from the antenna elements (1101) towards said common input/output port (1106), and a combining means (1105) to interconnect the signals to said common input/output port (1106). Further, the system comprises at least one phase shifting element (1104) placed between at least one of said driven points (1102) and said combining means (1105) and arranged to provide a phase shift that minimizes the sum of the reflection coefficients of said at least two antenna elements (1101) measured at said common input/output port (1106).

8 Claims, 15 Drawing Sheets





US009008728B2

(12) **United States Patent**
Abdul-Gaffoor et al.

(10) **Patent No.:** **US 9,008,728 B2**
(45) **Date of Patent:** **Apr. 14, 2015**

(54) **ANTENNA ARRANGEMENT FOR 3G/4G SVLTE AND MIMO TO ENABLE THIN NARROW BORDERED DISPLAY PHONES**

7,292,195 B2 11/2007 Phillips et al.
7,750,866 B2 7/2010 Rambeau et al.
8,725,102 B2 * 5/2014 Winters et al. 455/277.2
8,744,504 B2 * 6/2014 Faccin et al. 455/507
2006/0109191 A1 5/2006 Shtrom et al.

(71) Applicant: **Motorola Mobility LLC**, Libertyville, IL (US)

(Continued)

(72) Inventors: **Mohammed R. Abdul-Gaffoor**, Palatine, IL (US); **Md Faisal Abedin**, Lindenhurst, IL (US); **Minh H. Duong**, Lake Bluff, IL (US)

FOREIGN PATENT DOCUMENTS

WO 2012008946 A1 1/2012

(73) Assignee: **Google Technology Holdings LLC**, Mountain View, CA (US)

OTHER PUBLICATIONS

Qinjiang Rao et al.: Compact low coupling dual-antennas for MIMO applications in handheld devices, Antennas and Propagation Society International Symposium, 2009, APSURSI '09, IEEE, IEEE, Piscataway, NJ, USA, Jun. 1, 2009, pp. 1-4.

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 192 days.

(Continued)

(21) Appl. No.: **13/682,765**

Primary Examiner — Sonny Trinh

(22) Filed: **Nov. 21, 2012**

(74) *Attorney, Agent, or Firm* — Faegre Baker Daniels LLP

(65) **Prior Publication Data**

(57) **ABSTRACT**

US 2014/0141731 A1 May 22, 2014

(51) **Int. Cl.**
H04M 1/00 (2006.01)
H04B 7/04 (2006.01)
H04B 1/44 (2006.01)
H01Q 1/24 (2006.01)

A method and system provides a multiple input multiple output (MIMO) antenna arrangement in a wireless communication device. A first antenna element and a second antenna element co-located within a same antenna volume are respectively coupled to first and second antenna feeds proximate to a base perimeter segment of a device chassis. The first antenna feed is at a pre-calculated distance from the second antenna feed. The second antenna element, a first MIMO antenna, is coupled to an antenna ground positioned proximate to the first antenna feed and at a pre-determined distance from the second antenna feed. A third antenna element operating as a second MIMO antenna is placed proximate to a top perimeter segment of the device chassis. The antenna arrangement achieves (a) low correlation between the MIMO antennas and (b) an acceptable or pre-determined level of antenna isolation between the first antenna element and the second antenna element.

(52) **U.S. Cl.**
CPC **H04B 7/0413** (2013.01); **H04B 1/44** (2013.01); **H01Q 1/243** (2013.01)

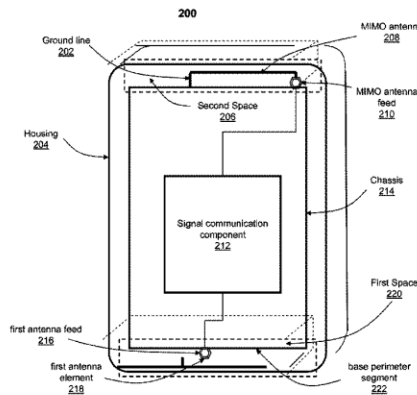
(58) **Field of Classification Search**
USPC 343/562.1, 82, 83, 121, 129; 455/700 MS, 846, 876, 702, 854, 853
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,154,177 A 11/2000 Saito et al.
6,909,401 B2 6/2005 Rutfors et al.

20 Claims, 10 Drawing Sheets





US009008737B2

(12) **United States Patent**
Na et al.

(10) **Patent No.:** **US 9,008,737 B2**
(45) **Date of Patent:** **Apr. 14, 2015**

(54) **MOBILE TERMINAL AND AN ANTENNA FOR THE MOBILE TERMINAL**

(71) Applicant: **LG Electronics Inc.**, Seoul (KR)
(72) Inventors: **Youngsoo Na**, Gyeonggi-Do (KR);
Joungsub Shin, Gyeonggi-Do (KR)
(73) Assignee: **LG Electronics Inc.**, Seoul (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 153 days.

(21) Appl. No.: **13/666,785**

(22) Filed: **Nov. 1, 2012**

(65) **Prior Publication Data**

US 2013/0109329 A1 May 2, 2013

(30) **Foreign Application Priority Data**

Nov. 2, 2011 (KR) 10-2011-0113548

(51) **Int. Cl.**
H04M 1/00 (2006.01)
H01Q 1/24 (2006.01)
H01Q 9/04 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 9/0442** (2013.01)

(58) **Field of Classification Search**
CPC H04B 1/3838
USPC 455/575.5, 575.7, 90.2, 90.3
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,554,494	B2 *	6/2009	Kim et al.	343/702
2006/0089184	A1 *	4/2006	Kim et al.	455/575.5
2009/0239595	A1 *	9/2009	Sung et al.	455/575.7
2010/0316246	A1 *	12/2010	Cho et al.	381/386
2011/0193752	A1 *	8/2011	Wang et al.	343/702

FOREIGN PATENT DOCUMENTS

CN	201374380	12/2009
CN	101682119	3/2010

OTHER PUBLICATIONS

European Patent Office Application Serial No. 12006478.7, Search Report dated Mar. 7, 2013, 5 pages.

The State Intellectual Property Office of the People's Republic of China Application Serial No. 201210380676.9, Office Action dated Oct. 21, 2014, 7 pages.

* cited by examiner

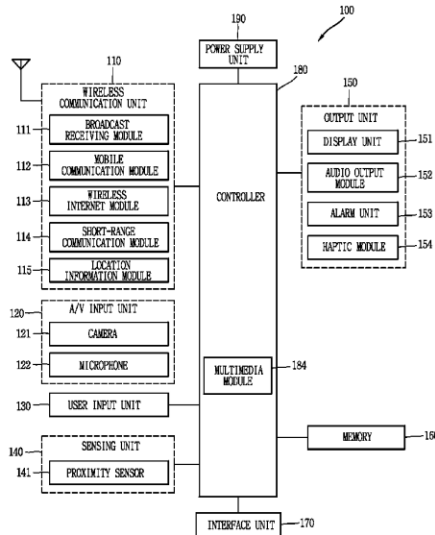
Primary Examiner — April G Gonzales

(74) *Attorney, Agent, or Firm* — Lee, Hong, Degerman, Kang & Waimey

(57) **ABSTRACT**

A mobile terminal includes a terminal body, an antenna module coupled to the terminal body and including a radiator for transmitting and receiving radio signals, a circuit board electrically coupled to the antenna module for processing the transmitted and received radio signals, and at least one coupling member positioned proximate to and spaced from the radiator a particular distance for coupling the antenna module to the terminal body. The at least one coupling member is coupled to the radiator.

18 Claims, 6 Drawing Sheets





US009013354B2

(12) **United States Patent**
Huang et al.

(10) **Patent No.:** **US 9,013,354 B2**
(45) **Date of Patent:** **Apr. 21, 2015**

(54) **MULTI-BAND ANTENNA**

(56) **References Cited**

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(72) Inventors: **Yi-Feng Huang**, New Taipei (TW); **Jia-Hung Su**, New Taipei (TW); **Kai Shih**, New Taipei (TW)
(73) Assignee: **Cheng Uei Precision Industry Co., Ltd.**, New Taipei (TW)

U.S. PATENT DOCUMENTS

2004/0140941 A1* 7/2004 Joy et al. 343/795
2004/0222926 A1* 11/2004 Kontogeorgakis et al. ... 343/702
2008/0246668 A1* 10/2008 Qi et al. 343/702
2008/0266202 A1* 10/2008 Lin et al. 343/893
2009/0027275 A1* 1/2009 Su et al. 343/700 MS
2010/0060528 A1* 3/2010 Chiu et al. 343/700 MS

* cited by examiner

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 283 days.

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Assistant Examiner — Daniel J Munoz

(74) *Attorney, Agent, or Firm* — Cheng-Ju Chiang

(21) Appl. No.: **13/653,403**

(57) **ABSTRACT**

(22) Filed: **Oct. 16, 2012**

A multi-band antenna includes a substrate and a conductive layer. The conductive layer covered on a top surface of the substrate includes a ground element, a first radiating element and a second radiating element. The ground element is connected with a bottom side edge of the substrate. The first radiating element is connected with one end of a lower top edge of the ground element. The first radiating element includes a connection portion, a first coupling portion, a first radiating portion and a first inductance portion. The second radiating element is connected with the other end of the lower top edge of the ground element. The second radiating element includes a second inductance portion, a second coupling portion, a second radiating portion and a third radiating portion.

(65) **Prior Publication Data**

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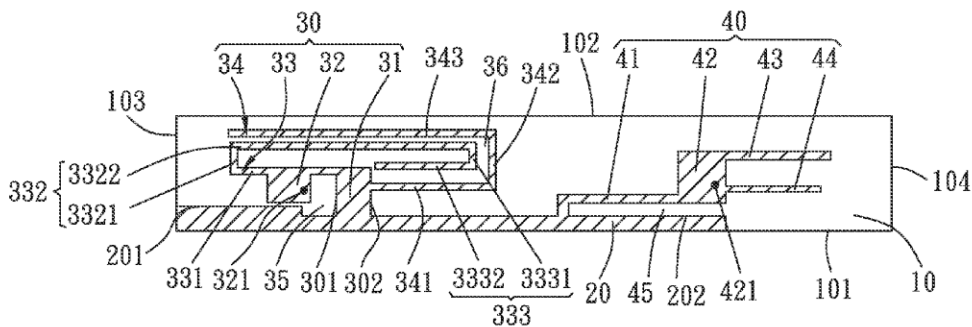
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H01Q 21/28 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 9/42** (2013.01); **H01Q 21/28** (2013.01); **H01Q 5/371** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 1/38; H01Q 1/48; H01Q 9/0407
USPC 343/700 MS, 702, 725, 893
See application file for complete search history.

13 Claims, 5 Drawing Sheets

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US009013355B1

(12) **United States Patent**
Yang et al.

(10) **Patent No.:** **US 9,013,355 B1**
(45) **Date of Patent:** **Apr. 21, 2015**

(54) **L-SHAPED FEED FOR A MATCHING NETWORK FOR A MICROSTRIP ANTENNA**

(71) Applicant: **Airgain, Incorporated**, San Diego, CA (US)

(72) Inventors: **Simon Yang**, Carlsbad, CA (US);
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(73) Assignee: **Airgain, Inc.**, San Diego, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/505,591**

(22) Filed: **Oct. 3, 2014**

Related U.S. Application Data

(62) Division of application No. 13/455,085, filed on Apr. 24, 2012, now Pat. No. 8,854,265.

(60) Provisional application No. 61/480,182, filed on Apr. 28, 2011.

(51) **Int. Cl.**
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H01Q 9/04 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 9/045** (2013.01)

(58) **Field of Classification Search**

USPC 343/700 MS, 846, 850, 702, 862
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,994,985 B2 * 8/2011 Luk et al. 343/700 MS
2009/0146883 A1 * 6/2009 Chin et al. 343/700 MS
2010/0194643 A1 * 8/2010 Petros 343/700 MS
2012/0146869 A1 * 6/2012 Holland et al. 343/795

* cited by examiner

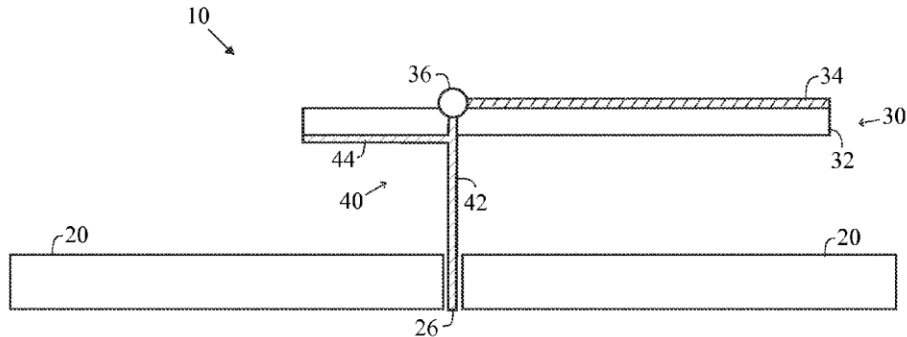
Primary Examiner — Huedung Mancuso

(74) *Attorney, Agent, or Firm* — Clause Eight IPS; Michael Catania

(57) **ABSTRACT**

A microstrip patch antenna including a ground plane base, an L-shaped feed structure and a laminate structure is disclosed herein. A matching network is formed by a clearance member of the laminate structure around a pin and a stub of the L-shaped feed structure on the bottom surface in which the clearance member around the pin effectively decreases shunt inductance and reduces a series capacitance at a feed point to enable a 50 ohm wideband operation.

9 Claims, 9 Drawing Sheets





US009013356B2

(12) **United States Patent**
Wang et al.

(10) **Patent No.:** **US 9,013,356 B2**
(45) **Date of Patent:** **Apr. 21, 2015**

(54) **HANDHELD DEVICE**
(75) Inventors: **Ching-Sung Wang**, Taoyuan County (TW); **Huang-Jen Chen**, Taoyuan County (TW); **Bing-Hsiao Wang**, Taoyuan County (TW)

2003/0146878	A1*	8/2003	Mikkola et al.	343/702
2005/0017909	A1*	1/2005	Carpenter et al.	343/702
2006/0017622	A1*	1/2006	Zinanti et al.	343/700 MS
2006/0111075	A1*	5/2006	Seol	455/343.6
2007/0109204	A1*	5/2007	Phillips et al.	343/702
2009/0195468	A1*	8/2009	Croman	343/767
2009/0213030	A1*	8/2009	Hynes et al.	343/906
2011/0012712	A1*	1/2011	Khozyainov	340/10.1

(73) Assignee: **HTC Corporation**, Taoyuan (TW)

FOREIGN PATENT DOCUMENTS

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 839 days.

CN	1416222	5/2003
CN	1114239	7/2003
CN	101083477	12/2007
DE	102008038251	3/2009
EP	0833455	4/1998

(Continued)

(21) Appl. No.: **12/769,628**

(22) Filed: **Apr. 28, 2010**

OTHER PUBLICATIONS

(65) **Prior Publication Data**
US 2011/0193752 A1 Aug. 11, 2011

"Extended Search Report of Europe Counterpart Application," Issued on Jul. 20, 2010, p. 1-p. 4.

(Continued)

(30) **Foreign Application Priority Data**
Feb. 10, 2010 (TW) 99104158 A

Primary Examiner — Graham Smith
(74) Attorney, Agent, or Firm — Jianq Chyun IP Office

(51) **Int. Cl.**
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(52) **U.S. Cl.**
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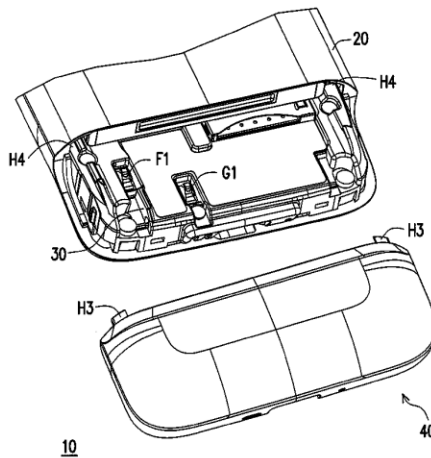
(57) **ABSTRACT**

A handheld device is disclosed, which includes an appearance part, a system ground plane and a detachable element. The detachable element includes a carrier and a planar antenna. The system ground plane is disposed in the appearance part and has a feed point. The planar antenna is disposed on the carrier and has a connection point. The carrier is detachably connected to the appearance part. When the carrier is connected to the appearance part, the above-mentioned connection point is electrically connected to the feed point. In this way, the radiation performance of the antenna can be improved and the frequency band of the antenna of the handheld device can be changed by replacing the detachable element.

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 9/0421
USPC 343/702, 872, 873
See application file for complete search history.

(56) **References Cited**
U.S. PATENT DOCUMENTS
5,918,189 A * 6/1999 Kivela 455/575.1
6,028,555 A * 2/2000 Harano 343/702

18 Claims, 6 Drawing Sheets





US009013357B2

(12) **United States Patent**
He et al.

(10) **Patent No.:** **US 9,013,357 B2**
(45) **Date of Patent:** **Apr. 21, 2015**

- (54) **MOBILE BROADBAND DEVICE**
- (75) Inventors: **Jinjun He**, Shenzhen (CN); **Bin Zhang**, Shenzhen (CN); **Yaming Jiang**, Wuhan (CN)
- (73) Assignee: **Huawei Device Co., Ltd.**, Shenzhen (CN)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 430 days.
- (21) Appl. No.: **13/455,262**
- (22) Filed: **Apr. 25, 2012**

(65) **Prior Publication Data**
US 2012/0212377 A1 Aug. 23, 2012

Related U.S. Application Data
(63) Continuation of application No. PCT/CN2010/078100, filed on Oct. 26, 2010.

(30) **Foreign Application Priority Data**
Oct. 26, 2009 (CN) 2009 2 0246276 U

(51) **Int. Cl.**
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H01Q 1/22 (2006.01)
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(52) **U.S. Cl.**
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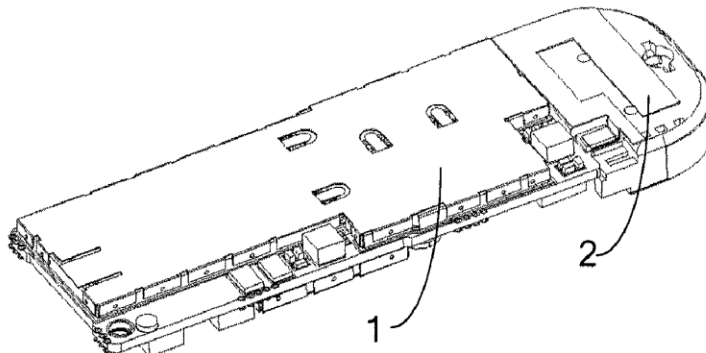
(58) **Field of Classification Search**
CPC H01Q 1/24; H01Q 1/38; H01Q 9/0421; H01Q 1/244; H01Q 1/242
USPC 343/702, 906; 455/89, 90
See application file for complete search history.

- (56) **References Cited**
- U.S. PATENT DOCUMENTS
- 6,437,745 B1 * 8/2002 Vaisanen et al. 343/702
- 6,518,927 B2 * 2/2003 Schremmer et al. 343/702
- (Continued)
- FOREIGN PATENT DOCUMENTS
- CN 2544422 4/2003
- CN 2554877 6/2003
- (Continued)
- OTHER PUBLICATIONS
- Extended European Search Report mailed Nov. 7, 2013 in corresponding European Application No. 10826070.4.
- (Continued)

Primary Examiner — Huedung Mancuso
(74) *Attorney, Agent, or Firm* — Staas & Halsey LLP

(57) **ABSTRACT**
The present invention provides a mobile broadband device, and relates to the field of communications technologies. The mobile broadband device includes a casing, a Printed Circuit Board Assembly (PCBA), and an antenna. The antenna and the PCBA are both set in the casing, and the PCBA can be slidably pulled out or retracted back along the casing. The antenna is fixedly set on an inner side of the casing and forms a hollow space for accommodating the retracted PCBA, there is a contact point set on the antenna, and the contact point is electrically connected to a feed point of the PCBA. With the mobile broadband device, the antenna does not individually occupy part of space in the casing without affecting the performance of the antenna; therefore, the volume and length of the mobile broadband device are effectively reduced, and the portability of the mobile broadband device is effectively improved.

14 Claims, 3 Drawing Sheets





US009013358B2

(12) **United States Patent**
Hsu

(10) **Patent No.:** **US 9,013,358 B2**
(45) **Date of Patent:** **Apr. 21, 2015**

(54) **ANTENNA ASSEMBLY AND WIRELESS COMMUNICATION DEVICE PROVIDED WITH THE SAME**

(71) Applicant: **Wistron NeWeb Corp.**, Hsinchu County (TW)

(72) Inventor: **Mao-Kai Hsu**, Hsinchu County (TW)

(73) Assignee: **Wistron NeWeb Corp.**, Hsinchu County (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 265 days.

(21) Appl. No.: **13/832,640**

(22) Filed: **Mar. 15, 2013**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Oct. 29, 2012 (TW) 101139932 A

(51) **Int. Cl.**

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H01Q 1/38 (2006.01)
H01Q 21/28 (2006.01)
H01Q 1/48 (2006.01)
H01Q 1/52 (2006.01)
H01Q 9/42 (2006.01)

(52) **U.S. Cl.**

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(58) **Field of Classification Search**

CPC H01Q 1/521; H01Q 1/243; H01Q 1/2266; H01Q 21/28

USPC 343/702, 700 MS, 841
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,624,789 B1 * 9/2003 Kangasvieri et al. 343/702
8,552,913 B2 * 10/2013 Ayatollahi et al. 343/702
8,816,921 B2 * 8/2014 Ayatollahi 343/745
8,922,448 B2 * 12/2014 Wong et al. 343/841
2012/0127038 A1 * 5/2012 Kim et al. 343/700 MS
2013/0120201 A1 * 5/2013 Park et al. 343/749

* cited by examiner

Primary Examiner — Hoang V Nguyen

(74) *Attorney, Agent, or Firm* — LeClairRyan

(57) **ABSTRACT**

An antenna assembly includes a pair of antennas and an interconnecting portion. Each antenna includes a ground portion, a feed-in portion spaced apart from the ground portion and having a feed-in end that is configured to be fed with a RF signal, a short-circuit portion electrically connected to the ground portion and the feed-in portion, and a radiating portion electrically connected to the feed-in portion and spaced apart from the ground portion. The interconnecting portion is electrically connected between the short-circuit portions and between the ground portions of the pair of antennas, and is formed with a U-shaped main groove that has a pair of opposite ends adjacent to the pair of antennas, respectively.

20 Claims, 6 Drawing Sheets

