



US008656579B2

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

(10) **Patent No.:** **US 8,656,579 B2**  
(45) **Date of Patent:** **Feb. 25, 2014**

(54) **METHOD OF FORMING A HOUSING WITH INTEGRAL ANTENNA**

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(73) Assignee: **Motorola Mobility LLC**, Libertyville, IL (US)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 836 days.

(21) Appl. No.: **12/534,957**

(22) Filed: **Aug. 4, 2009**

(65) **Prior Publication Data**  
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**Related U.S. Application Data**

(60) Provisional application No. 61/092,799, filed on Aug. 29, 2008.

(51) **Int. Cl.**  
**H01P 11/00** (2006.01)

(52) **U.S. Cl.**  
USPC ..... **29/600; 29/592.1; 343/700 MS; 343/702**

(58) **Field of Classification Search**  
USPC ..... 343/702, 700 MS, 846; 29/600, 592.1, 29/832  
See application file for complete search history.

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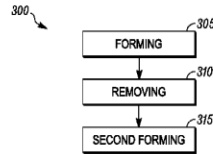
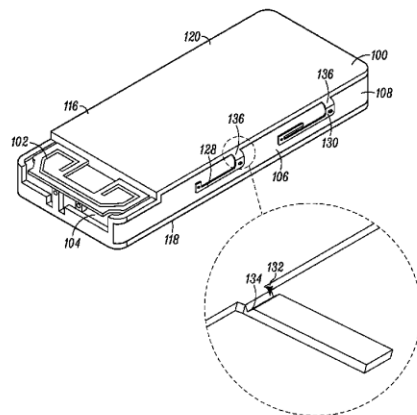
*Primary Examiner* — Minh Trinh

(74) *Attorney, Agent, or Firm* — Gary J. Cunningham

(57) **ABSTRACT**

A continuous housing (100) and integral antenna (102) and method (300) of forming a housing (100) and integral antenna (102), including: forming (305) an extrusion housing with a side opening defining a pocket configured to receive electrical components; removing (310) material of the extrusion housing in proximity to a wall portion of the extrusion housing; and forming (315) a desired antenna construction integral to the extrusion housing. Advantageously, the continuous housing (100) can form a wireless communication device, which is particularly adapted for mass production. This arrangement is adapted to allow a customer to design the look and feel of an electronic device.

**11 Claims, 7 Drawing Sheets**





US008659476B2

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

(10) **Patent No.:** **US 8,659,476 B2**  
(45) **Date of Patent:** **Feb. 25, 2014**

(54) **DEVICE AND METHOD FOR DETERMINING THE DISTANCE AND/OR ORIENTATION OF A MOVEABLE OBJECT**

(75) Inventors: **Andreas Eidloth**, Erlangen (DE); **Hans Adel, Stein** (DE); **Jörn Thielecke**, Erlangen (DE); **Alexander Popugaev**, Erlangen (DE)

(73) Assignees: **Fraunhofer-Gesellschaft zur Foerderung der angewandten Forschung e.V.**, Munich (DE); **Friedrich-Alexander-Universität Erlangen-Nürnberg**, Erlangen (DE)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 199 days.

(21) Appl. No.: **13/055,770**

(22) PCT Filed: **Jul. 27, 2009**

(86) PCT No.: **PCT/EP2009/005630**

§ 371 (c)(1),  
(2), (4) Date: **Jan. 25, 2011**

(87) PCT Pub. No.: **WO2010/009906**

PCT Pub. Date: **Jan. 28, 2010**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Jul. 25, 2008 (DE) ..... 10 2008 035 440

(51) **Int. Cl.**  
**G01S 1/00** (2006.01)  
**H01Q 21/24** (2006.01)  
**H04B 7/10** (2006.01)

(52) **U.S. Cl.**  
USPC ..... **342/385**; 342/361; 342/458; 342/463

(58) **Field of Classification Search**  
USPC ..... 342/458, 463-465, 361, 385, 386, 417, 342/423, 432  
See application file for complete search history.

(56) **References Cited**

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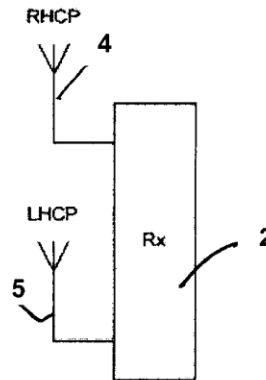
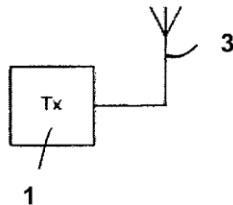
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*Primary Examiner* — Cassie Galt

(57) **ABSTRACT**

A device and method for determining a distance and/or orientation of a movable object includes a transmitter that is located on the object and a receiver. One of the transmitter and the receiver has an antenna having a known polarization plane. The other of the transmitter and the receiver has a counterclockwise circular polarized antenna and a clockwise circular polarized antenna.

**19 Claims, 5 Drawing Sheets**





US008659479B2

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

(10) **Patent No.:** **US 8,659,479 B2**  
(45) **Date of Patent:** **Feb. 25, 2014**

(54) **DUAL-BAND ANTENNA AND ANTENNA DEVICE HAVING THE SAME**

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2009/0021448 A1\* 1/2009 Tsai et al. .... 343/893

(75) Inventors: **Tiao-Hsing Tsai**, Yunghe (TW);  
**Chieh-Ping Chiu**, Yunlin County (TW);  
**Feng-Jen Weng**, Tao Yuan Shien (TW);  
**I-Ping Yen**, Yonghe (TW)

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(73) Assignee: **Quanta Computer, Inc.**, Tao Yuan Shien (TW)

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(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 879 days.

English translation of Search Report appended in an Office Action dated Dec. 4, 2012, issued to Chinese Counterpart Patent Application No. 200910205372.7, 2 pages.

(21) Appl. No.: **12/709,830**

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(22) Filed: **Feb. 22, 2010**

*Primary Examiner* — Dameon Levi  
*Assistant Examiner* — Collin Dawkins  
(74) *Attorney, Agent, or Firm* — Berenato & White, LLC

(65) **Prior Publication Data**

US 2011/0084882 A1 Apr. 14, 2011

(30) **Foreign Application Priority Data**

Oct. 8, 2009 (TW) ..... 98134111 A

(57) **ABSTRACT**

A dual-band antenna includes first and second connecting sections coupled to a ground unit, and first, second, and third radiator sections. The first connecting section extends in a direction from the ground unit toward an inner wall face of a housing of an electronic device. The first radiator section is connected to the first connecting section and is disposed to extend along the inner wall face. A feed-in section extends between the second connecting section and the inner wall face, and has a portion extending parallel to the first radiator section. The second radiator section is connected to the feed-in section and is disposed to extend along the inner wall face. The third radiator section is connected to the second radiator section, extends between the second radiator section and the feed-in section, and has a portion extending parallel to the second radiator section.

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

(52) **U.S. Cl.**  
USPC ..... **343/700 MS**; 343/702; 343/872

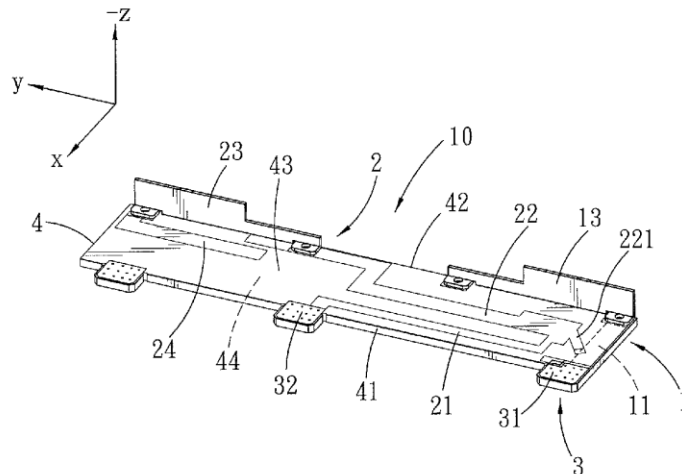
(58) **Field of Classification Search**  
USPC ..... 343/700 MS, 702, 872  
See application file for complete search history.

(56) **References Cited**

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**9 Claims, 8 Drawing Sheets**





US008659481B2

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

(10) **Patent No.:** **US 8,659,481 B2**  
(45) **Date of Patent:** **Feb. 25, 2014**

(54) **INTERNAL PRINTED ANTENNA**

(75) Inventors: **Wen-Shan Chen**, Tainan (TW); **Li-Yu Yeh**, Tainan (TW)

(73) Assignee: **Southern Taiwan University of Technology**, Tainan (TW)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 236 days.

(21) Appl. No.: **13/278,271**

(22) Filed: **Oct. 21, 2011**

(65) **Prior Publication Data**  
US 2013/0099978 A1 Apr. 25, 2013

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

(52) **U.S. Cl.**  
USPC ..... **343/700 MS**; 343/741; 343/742;  
343/743; 343/846; 343/895

(58) **Field of Classification Search**

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

(56) **References Cited**

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*Primary Examiner* — Jerome Jackson, Jr.

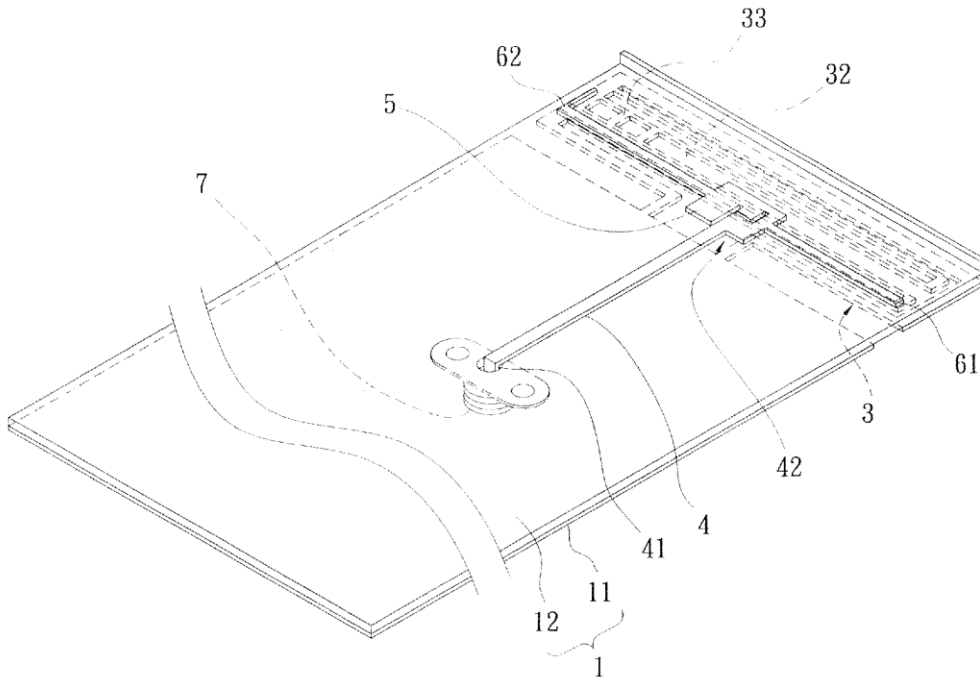
*Assistant Examiner* — Hai Tran

(74) *Attorney, Agent, or Firm* — Rosenberg, Klein & Lee

(57) **ABSTRACT**

An internal printed antenna is revealed. The internal printed antenna includes a dielectric substrate, a ground plane, a metal loop radiating portion, and a microstrip feed line. The metal loop radiating portion includes a plurality of bends and a gap area is formed between adjacent bends. Two short circuit parts are arranged at the gap area.

**10 Claims, 12 Drawing Sheets**





US008659482B2

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

(10) **Patent No.:** **US 8,659,482 B2**  
(45) **Date of Patent:** **Feb. 25, 2014**

(54) **MIMO ANTENNA HAVING PLURALITY OF ISOLATION ADJUSTMENT PORTIONS**

(75) Inventors: **Chan-Ho Kim**, Incheon (KR);  
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**Jae-Ho Lee**, Gumi (KR); **Heung-Ju Ahn**, Suwon (KR)

(73) Assignee: **Mobitech Corp.**, Seoul (KR)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 171 days.

(21) Appl. No.: **13/300,413**

(22) Filed: **Nov. 18, 2011**

(65) **Prior Publication Data**  
US 2012/0127038 A1 May 24, 2012

(30) **Foreign Application Priority Data**  
Nov. 23, 2010 (KR) ..... 10-2010-0116730

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

(52) **U.S. Cl.**  
USPC ..... **343/700 MS**

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

(56) **References Cited**

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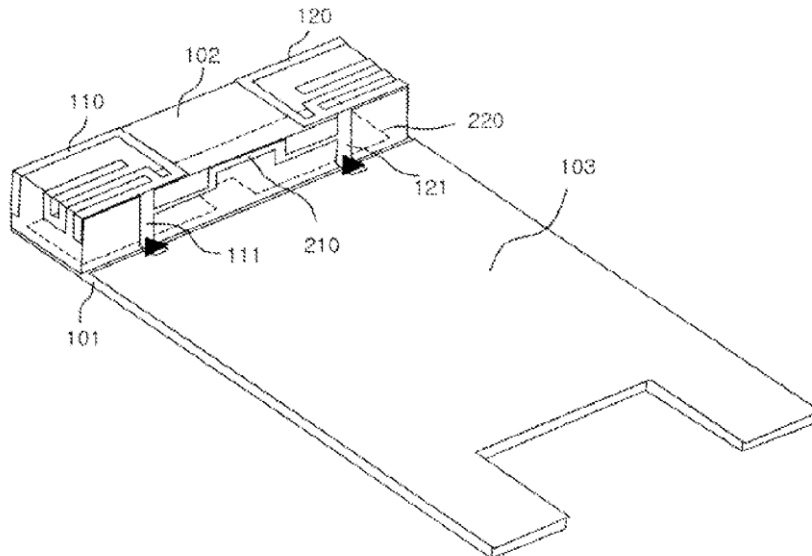
*Primary Examiner* — Dieu H Duong

(74) *Attorney, Agent, or Firm* — LRK Patent Law Firm

(57) **ABSTRACT**

A Multiple-Input and Multiple-Output (MIMO) antenna having a plurality of isolation adjustment portions is provided. The MIMO antenna includes a plurality of radiation elements and a plurality of isolation adjustment portions. The plurality of radiation elements is symmetrically formed on the surfaces of the left and right sides of a dielectric element having a predetermined shape, is spaced apart from each other by a predetermined distance, operates in multiple frequency bands, and includes feeding portions, respectively. The plurality of isolation adjustment portions is coupled to the plurality of radiation elements so that they have electromagnetic characteristics different from those of the plurality of radiation elements, thereby improving isolation in each of the frequency bands in which the plurality of radiation elements operate.

**11 Claims, 8 Drawing Sheets**





US008659484B2

(12) **United States Patent  
Cheng**

(10) **Patent No.:** US 8,659,484 B2  
(45) **Date of Patent:** Feb. 25, 2014

(54) **PRINTED ANTENNA**

(56) **References Cited**

(75) Inventor: **Shih-Chieh Cheng**, Tainan (TW)

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

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(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 170 days.

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(21) Appl. No.: **13/434,126**

*Primary Examiner* — Hoang V Nguyen

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

(22) Filed: **Mar. 29, 2012**

(57) **ABSTRACT**

(65) **Prior Publication Data**

US 2013/0009843 A1 Jan. 10, 2013

A printed antenna comprising a substrate, a first ground plane, a low frequency radiation, a high frequency radiation, a first matching portion, a second matching portion is provided. The first ground plane, the low frequency radiation portion, the high frequency radiation portion and the first matching portion are located on an upper surface of the substrate. The low frequency radiation portion is connected to the high frequency radiation portion, and the first matching portion is extended from the first ground plane and towards the high frequency radiation portion. The second matching portion is adjacent to the first matching portion but does not overlap the first matching portion.

(30) **Foreign Application Priority Data**

Jul. 4, 2011 (TW) ..... 100123559 A

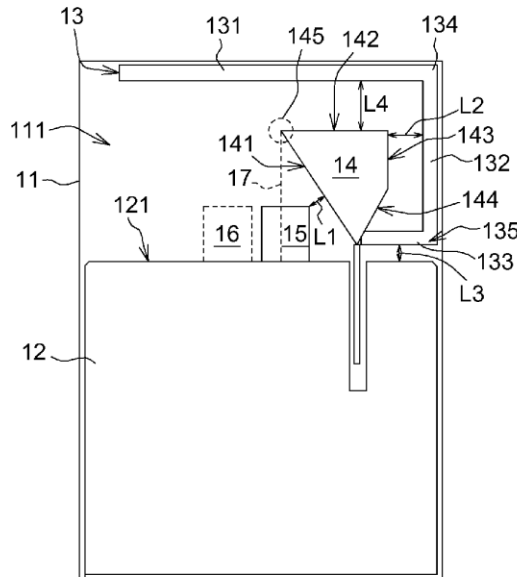
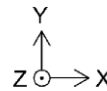
(51) **Int. Cl.**  
*H01Q 1/38* (2006.01)  
*H01Q 1/24* (2006.01)

(52) **U.S. Cl.**  
USPC ..... **343/700 MS; 343/702**

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

**13 Claims, 8 Drawing Sheets**

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US008659485B2

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

(10) **Patent No.:** **US 8,659,485 B2**  
(45) **Date of Patent:** **\*Feb. 25, 2014**

(54) **ANTENNA DESIGNING METHOD AND DATA CARD SINGLE BOARD OF WIRELESS TERMINAL**

(75) Inventors: **Yao Lan**, Shenzhen (CN); **Shuhui Sun**, Shenzhen (CN); **Ping Lei**, Shenzhen (CN); **Yi Fan**, Shenzhen (CN); **Zhitai Zheng**, Beijing (CN); **Yanping Xie**, Shenzhen (CN); **Yongling Ban**, 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 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **13/590,807**

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

(65) **Prior Publication Data**

US 2012/0314381 A1 Dec. 13, 2012

**Related U.S. Application Data**

(63) Continuation of application No. 13/290,695, filed on Nov. 7, 2011, which is a continuation of application No. PCT/CN2010/070407, filed on Jan. 29, 2010.

(30) **Foreign Application Priority Data**

May 8, 2009 (CN) ..... 2009 1 0136609

(51) **Int. Cl.**  
**H01Q 1/38** (2006.01)  
**H01Q 19/00** (2006.01)  
**H05K 1/11** (2006.01)

(52) **U.S. Cl.**  
USPC ..... **343/700 MS**; 361/748; 29/601; 343/833;  
343/857

(58) **Field of Classification Search**

USPC ..... 343/700 MS, 833, 857  
See application file for complete search history.

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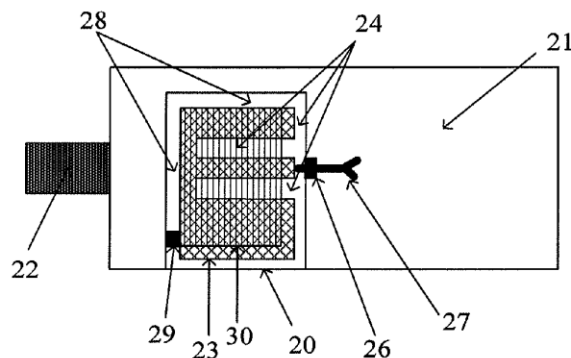
*Primary Examiner* — Jacob Y Choi

*Assistant Examiner* — Amal Patel

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

(57) **ABSTRACT**

An antenna designing method and a data card single board of a wireless terminal are provided. The antenna designing method provided by an embodiment of the present invention includes: dividing a semi-closed area without other metal wirings on a data card single board of the wireless terminal; and arranging an antenna wiring in the semi-closed area, where a gap exists between the antenna wiring and the data card single board, and the antenna wiring is coupled with the data card single board via the gap. The embodiments of the present invention also disclose a data card single board of the wireless terminal. According to the embodiments of the present invention, a Specific Absorption Rate (SAR) value of the antenna is reduced, and meanwhile, a working bandwidth of a broadband is realized.





US008659487B2

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

(10) **Patent No.:** **US 8,659,487 B2**  
(45) **Date of Patent:** **Feb. 25, 2014**

(54) **ANTENNA MODULE AND METHOD FOR MAKING THE SAME**

(75) Inventors: **Yong-Fa Fan**, Shenzhen (CN); **Yong Yan**, Shenzhen (CN); **Qi-Yuan Li**, Shenzhen (CN); **Xue-Li Zhang**, Shenzhen (CN); **Zhao-Yi Wu**, Shenzhen (CN); **Li Liu**, Shenzhen (CN)

(73) Assignees: **Shenzhen Futaihong Precision Industry Co., Ltd.**, Shenzhen (CN); **FIH (Hong Kong) Limited**, Kowloon (HK)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 129 days.

(21) Appl. No.: **13/309,693**

(22) Filed: **Dec. 2, 2011**

(65) **Prior Publication Data**  
US 2012/0319905 A1 Dec. 20, 2012

(30) **Foreign Application Priority Data**  
Jun. 16, 2011 (CN) ..... 2011 1 10162057

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

(52) **U.S. Cl.**  
USPC ..... **343/702; 343/700 MS**

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

(56) **References Cited**

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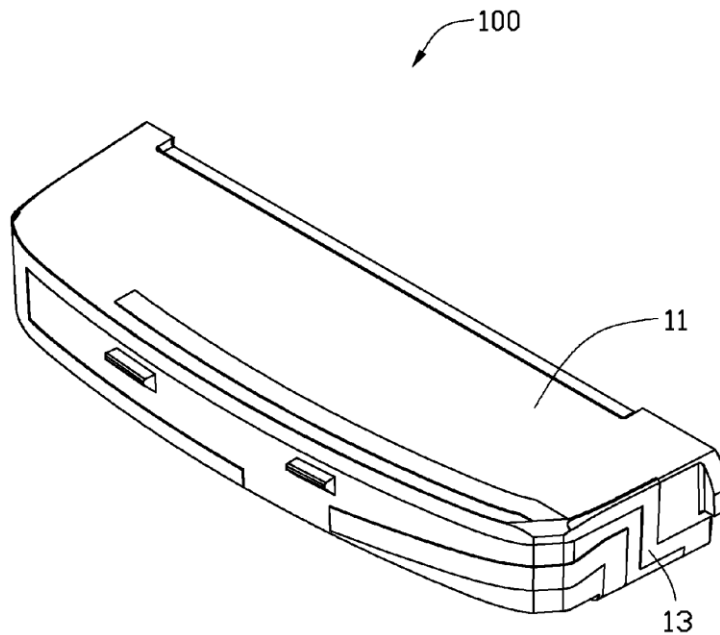
*Primary Examiner* — Hoang V Nguyen

(74) *Attorney, Agent, or Firm* — Altis Law Group, Inc.

(57) **ABSTRACT**

An antenna module includes a main body and an antenna radiator located on the main body. The antenna radiator is made of a liquid conductive material mixed by metal powders and diluting agent and is directly formed on the main body. A method for making the antenna module is also described.

**13 Claims, 3 Drawing Sheets**







US008659488B2

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

(10) **Patent No.:** **US 8,659,488 B2**  
(45) **Date of Patent:** **Feb. 25, 2014**

(54) **ANTENNA ASSEMBLY TO REDUCE SPECIFIC ABSORPTION RATE**

(75) Inventors: **Tiao-Hsing Tsai**, New Taipei (TW); **Chi-Yin Fang**, Pingtung (TW); **I-Ping Yen**, New Taipei (TW); **Chao-Hsu Wu**, Luzhu Township, Taoyuan County (TW); **Chun-Yuan Wang**, Tainan (TW)

(73) Assignee: **Quanta Computer Inc.**, Tao Yuan Shien (TW)

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 182 days.

(21) Appl. No.: **13/421,890**

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

(65) **Prior Publication Data**  
US 2013/0033411 A1 Feb. 7, 2013

(30) **Foreign Application Priority Data**  
Aug. 2, 2011 (TW) ..... 100127391 A

(51) **Int. Cl.**  
**H01Q 1/24** (2006.01)  
**H01Q 9/38** (2006.01)

(52) **U.S. Cl.**  
USPC ..... **343/702; 343/830**

(58) **Field of Classification Search**  
USPC ..... 343/702, 830, 700 MS, 846  
See application file for complete search history.

(56) **References Cited**

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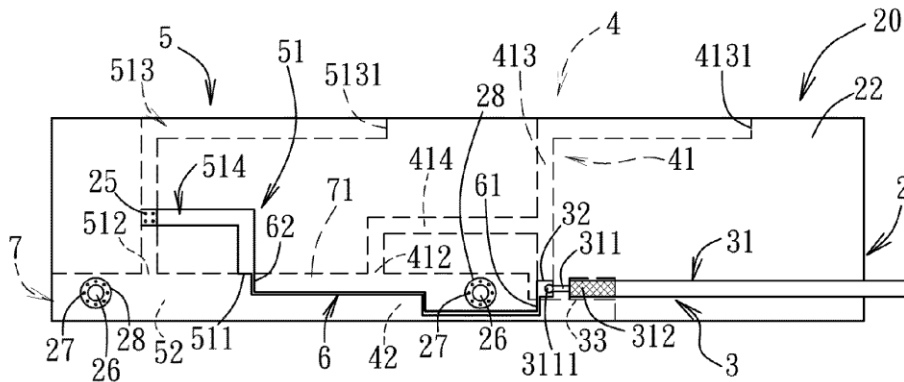
*Primary Examiner* — Hoang V Nguyen

(74) *Attorney, Agent, or Firm* — Nixon & Vanderhye P.C.

(57) **ABSTRACT**

An antenna assembly includes first and second antennas each generating a resonant mode to cover an operating bandwidth, and a transmission line. The first includes a first radiation unit with a feed-in portion coupled to a first feed portion in contact with a core wire of a coaxial cable and a first grounding portion. The second antenna includes a second radiation unit with a second feed-in portion coupled to a second feed portion in contact with a conductive shielding layer of the coaxial cable and a second grounding portion. The transmission line includes first and second connecting portions coupled respectively to the second feed portion of the second feed-in portion. When a signal within the operating bandwidth is transmitted through the coaxial cable, the energy of the signal is distributed among the first and second antennas.

**11 Claims, 7 Drawing Sheets**





US008659492B2

(12) **United States Patent**  
**Lee**

(10) **Patent No.:** **US 8,659,492 B2**  
(45) **Date of Patent:** **Feb. 25, 2014**

- (54) **MULTIBAND ANTENNA**
- (75) Inventor: **Yi-Chieh Lee, Tu-Cheng (TW)**
- (73) Assignee: **Chi Mei Communication Systems, Inc., 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 459 days.
- (21) Appl. No.: **13/052,208**
- (22) Filed: **Mar. 21, 2011**
- (65) **Prior Publication Data**  
US 2012/0162038 A1 Jun. 28, 2012
- (30) **Foreign Application Priority Data**  
Dec. 28, 2010 (TW) ..... 99146342 A
- (51) **Int. Cl.**  
**H01Q 9/00** (2006.01)
- (52) **U.S. Cl.**  
USPC ..... **343/749**
- (58) **Field of Classification Search**  
USPC ..... 343/700  
See application file for complete search history.

- (56) **References Cited**  
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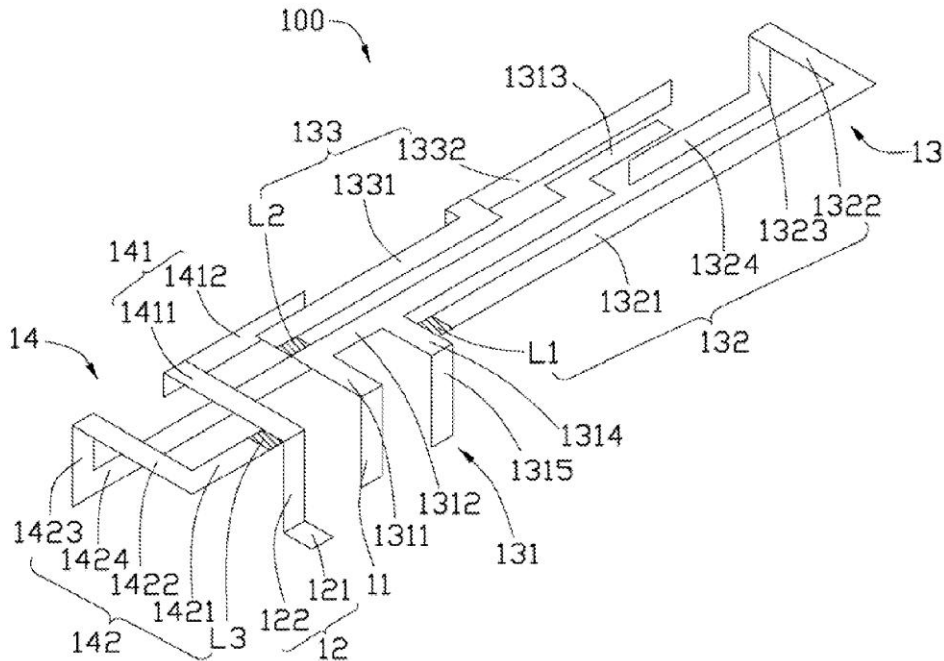
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*Primary Examiner* — Daniel Hess  
*Assistant Examiner* — Steven J Malone  
(74) *Attorney, Agent, or Firm* — Altis Law Group, Inc.

(57) **ABSTRACT**  
A multiband antenna includes a feed unit, a transceiving unit, and a resonance unit positioned adjacent to but separate from the feed unit and the transceiving unit. When feed signals are input to the feed unit, the feed signals are transmitted to the transceiving unit to form current paths of different lengths, and the resonance unit is driven to resonate and generates additional current paths of different lengths. In this way, the transceiving unit and the resonance unit are enabled to respectively receive and send wireless signals of different frequencies, and thus the multiband antenna is capable of receiving and sending wireless signals in more than two frequency bands.

**11 Claims, 3 Drawing Sheets**





US008659498B2

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

(10) **Patent No.:** **US 8,659,498 B2**  
(45) **Date of Patent:** **Feb. 25, 2014**

(54) **VARIABLE FREQUENCY PATCH ANTENNA**

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2003/0214438 A1 11/2003 Hatch et al.  
2009/0096582 A1 4/2009 Choi et al.

(75) Inventors: **Edward J. Rothwell**, Williamston, MI (US); **Lynn Greetis**, East Lansing, MI (US)

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(73) Assignee: **Board of Trustees Operating Michigan State University**, East Lansing, MI (US)

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(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 476 days.

(21) Appl. No.: **12/761,064**

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(22) Filed: **Apr. 15, 2010**

"Self-Structuring Antennas," Coleman et al., IEEE Antenna's and Propagation Magazine, vol. 44, No. 3, Jun. 2002.\*

(65) **Prior Publication Data**

"Microstrip Antennas with Frequency Agility and Polarization Diversity," Schaubert et al., IEEE Transactions on Antennas and Propagation, vol. AP-29, No. 1, Jan. 1981.\*

US 2010/0194663 A1 Aug. 5, 2010

**Related U.S. Application Data**

(Continued)

(63) Continuation-in-part of application No. PCT/US2008/080076, filed on Oct. 16, 2008.

(60) Provisional application No. 60/999,852, filed on Oct. 19, 2007.

*Primary Examiner* — Dameon Levi

*Assistant Examiner* — Graham Smith

(51) **Int. Cl.**  
**H01Q 3/24** (2006.01)  
**H01Q 1/38** (2006.01)

(74) *Attorney, Agent, or Firm* — Harness, Dickey & Pierce, P.L.C.

(52) **U.S. Cl.**  
USPC ..... **343/876; 343/700 MS**

(57) **ABSTRACT**

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

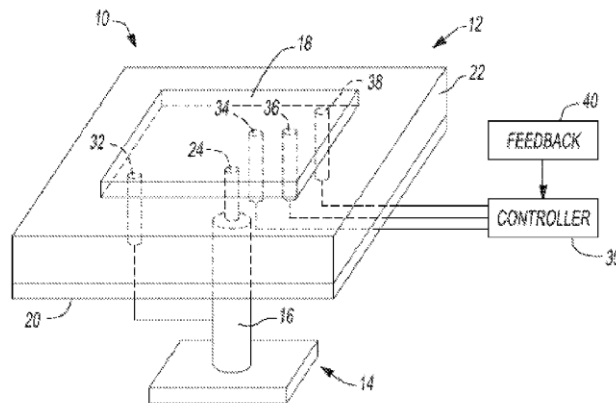
A patch antenna system comprises a patch antenna having a patch spatially separated from a ground plane; a plurality of pins interposed between the patch and the ground plane selectively connecting the patch to the ground plane; and a control module operably coupled to the plurality of pins and operable to set an operating frequency characteristic of the patch antenna by selectively connecting the patch to the ground plane with one or more of the plurality of pins.

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**18 Claims, 5 Drawing Sheets**





US008659500B2

(12) **United States Patent**  
**Wu**

(10) **Patent No.:** **US 8,659,500 B2**  
(45) **Date of Patent:** **Feb. 25, 2014**

- (54) **MULTI-ANTENNA FOR A MULTI-INPUT MULTI-OUTPUT WIRELESS COMMUNICATION SYSTEM**
- (75) Inventor: **Min-Chung Wu**, Taoyuan County (TW)
- (73) Assignee: **Ralink Technology Corp.**, Jhubei, 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 443 days.

- (21) Appl. No.: **12/632,820**
- (22) Filed: **Dec. 8, 2009**
- (65) **Prior Publication Data**  
US 2010/0315313 A1 Dec. 16, 2010

- (30) **Foreign Application Priority Data**  
Jun. 11, 2009 (TW) ..... 98119522 A

- (51) **Int. Cl.**  
**H01Q 21/00** (2006.01)
- (52) **U.S. Cl.**  
USPC ..... **343/893**; 343/700 MS; 343/793;  
343/725; 343/727; 343/729; 343/730

- (58) **Field of Classification Search**  
USPC ..... 343/893, 700 MS, 702, 793, 725, 727,  
343/729, 730  
See application file for complete search history.

- (56) **References Cited**  
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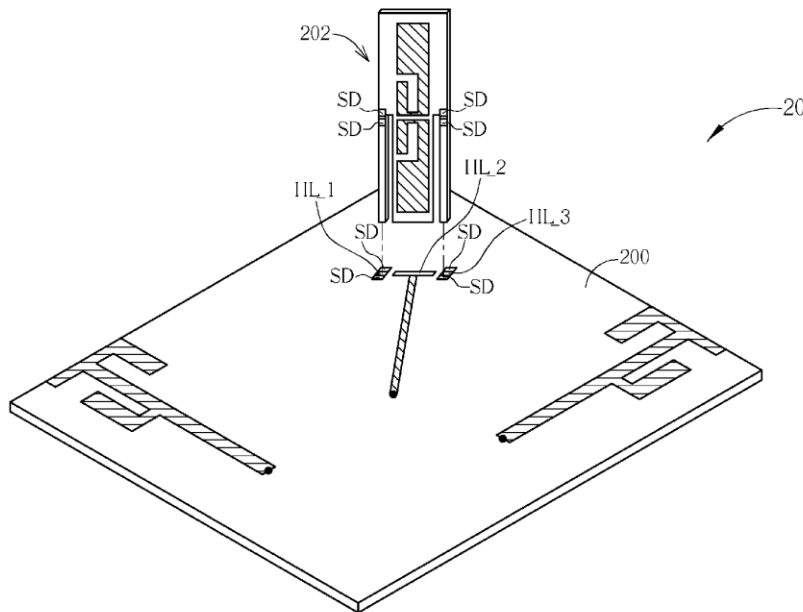
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*Primary Examiner* — Dieu H Duong  
(74) *Attorney, Agent, or Firm* — Winston Hsu; Scott Margo

- (57) **ABSTRACT**  
A multi-antenna for a multi-input multi-output wireless communication system includes a substrate, a first planar antenna formed on the substrate along a first direction, a second planar antenna formed on the substrate along a second direction, and a vertical antenna including a conductor formed on the substrate and between the first planar antenna and the second planar antenna, and a radiator perpendicular to the substrate and coupled to the conductor.

**20 Claims, 7 Drawing Sheets**





US008660620B2

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

(10) **Patent No.:** **US 8,660,620 B2**  
(45) **Date of Patent:** **Feb. 25, 2014**

(54) **ANTENNA BUILT IN MOBILE TERMINAL**

(75) Inventors: **Tsukasa Gouro**, Kato (JP); **Kazunori Katou**, Kawasaki (JP)

(73) Assignee: **Fujitsu Limited**, Kawasaki (JP)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1142 days.

(21) Appl. No.: **12/615,765**

(22) Filed: **Nov. 10, 2009**

(65) **Prior Publication Data**

US 2010/0056235 A1 Mar. 4, 2010

**Related U.S. Application Data**

(63) Continuation of application No. PCT/JP2007/000714, filed on Jun. 28, 2007.

(51) **Int. Cl.**

**H04M 1/00** (2006.01)  
**H01Q 1/24** (2006.01)  
**H04B 1/38** (2006.01)

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

CPC ..... **H01Q 1/243** (2013.01); **H01Q 1/242** (2013.01); **H04B 1/3833** (2013.01)  
USPC ..... **455/575.1**; 343/702; 343/721; 343/895

(58) **Field of Classification Search**

USPC ..... 455/436, 575.7; 343/702, 721, 895  
See application file for complete search history.

(56) **References Cited**

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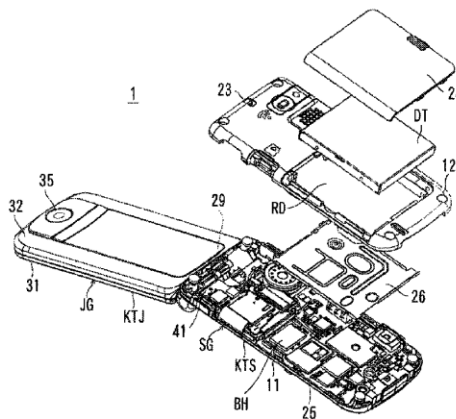
*Primary Examiner* — William D Cumming

(74) *Attorney, Agent, or Firm* — Westerman, Hattori, Daniels & Adrian, LLP

(57) **ABSTRACT**

An antenna built in a mobile phone that includes a front case having, on its surface, an operation portion and a rear case arranged on the rear of the front case is provided. The antenna includes a bar-shaped support member that is made of a synthetic resin and is located in the rear case along an upper side of the inside surface thereof, an antenna element integrally formed with the support member, and a concave portion provided in the support member to avoid interfering with a strap retaining portion that projects into the rear case at the center of the upper side of the rear case. The antenna element is formed in such a manner that the antenna element straddles a gap between edge portions of both side walls of the concave portion to avoid interfering with the strap retaining portion.

**8 Claims, 18 Drawing Sheets**





US008665157B2

(12) **United States Patent**  
**Chiang**

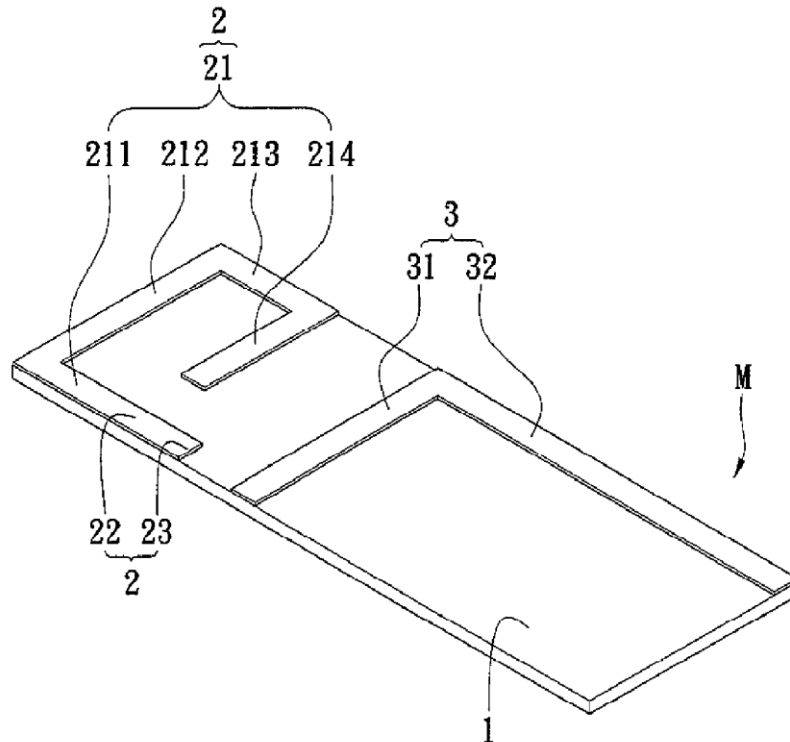
(10) **Patent No.:** **US 8,665,157 B2**  
(45) **Date of Patent:** **Mar. 4, 2014**

- (54) **ANTENNA STRUCTURE**
- (75) Inventor: **Chi-Ming Chiang**, Taoyuan County (TW)
- (73) Assignee: **Auden Techno Corp.**, Taoyuan County (TW)
- (\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 349 days.
- (21) Appl. No.: **13/071,593**
- (22) Filed: **Mar. 25, 2011**
- (65) **Prior Publication Data**  
US 2012/0242545 A1 Sep. 27, 2012
- (51) **Int. Cl.**  
**H01Q 1/38** (2006.01)
- (52) **U.S. Cl.**  
USPC ..... **343/700 MS; 343/906**
- (58) **Field of Classification Search**  
USPC ..... **343/700 MS, 906**  
See application file for complete search history.

- (56) **References Cited**  
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\* cited by examiner  
*Primary Examiner* — Allyson Trail  
(74) *Attorney, Agent, or Firm* — Li & Cai Intellectual Property (USA) Office

(57) **ABSTRACT**  
An antenna structure includes a microwave substrate, a main-antenna unit, an extension grounding unit. The main antenna unit is arranged on the surface of the microwave substrate. The main antenna unit includes a main-radiation portion, a main-feeding portion, a main-grounding portion. The extension grounding unit is arranged on the surface of the microwave substrate. The extension grounding unit includes a first extension grounding portion and a second extension grounding portion. The antenna structure can adjust the radiation pattern and improve the antenna directivity. The main-antenna unit and the sub-antenna unit share the extension grounding unit in common. So, the antenna structure can reduce the antenna occupied volume and save the mass production cost.

**8 Claims, 5 Drawing Sheets**





US008665158B2

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

(10) **Patent No.:** **US 8,665,158 B2**  
(45) **Date of Patent:** **Mar. 4, 2014**

(54) **PRINTED FILTERING ANTENNA**

(75) Inventors: **Shyh-Jong Chung**, Hsinchu County (TW); **Chao-Tang Chuang**, Hualien County (TW)

(73) Assignee: **National Chiao Tung University**, Hsinchu, Taiwan (TW)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 240 days.

(21) Appl. No.: **13/342,116**

(22) Filed: **Jan. 2, 2012**

(65) **Prior Publication Data**

US 2013/0049900 A1 Feb. 28, 2013

(30) **Foreign Application Priority Data**

Aug. 29, 2011 (TW) ..... 100130932 A

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

(52) **U.S. Cl.**  
USPC ..... **343/700 MS**; 343/722; 343/909;  
333/134; 333/204

(58) **Field of Classification Search**  
USPC ..... 343/700 MS, 756, 909; 333/134, 202,  
333/204

See application file for complete search history.

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Integration of filters and microstrip antennas.  
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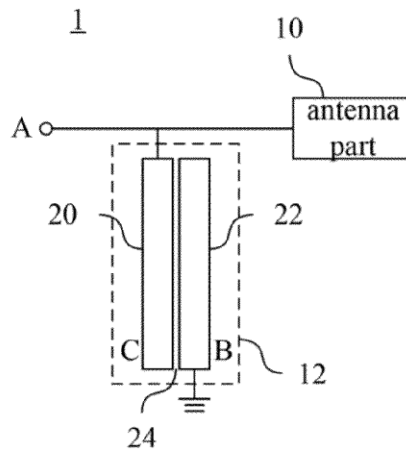
*Primary Examiner* — Tho G Phan

(74) *Attorney, Agent, or Firm* — CKC & Partners Co., Ltd.

(57) **ABSTRACT**

A printed filtering antenna is provided. This filtering antenna comprises an antenna part and a coupled line resonator. The antenna part is directly connected to a coupled line resonator and occupies an antenna area. The coupled line resonator provides a filtering mechanism together with the antenna part. The coupled line resonator comprises a short-circuited stub and an open-circuited stub. The short-circuited stub comprises an open-circuited end and a short-circuited end connected to ground. The open-circuited stub is parallel to the short-circuited stub. The open-circuited stub comprises a first end and a second end. The first end is connected to the feed point and is corresponding to the open-circuited end of the short-circuited stub such that the open-circuited stub is coupled to the short-circuited stub.

**13 Claims, 11 Drawing Sheets**





US008665159B2

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

(10) **Patent No.:** **US 8,665,159 B2**  
(45) **Date of Patent:** **Mar. 4, 2014**

(54) **HANDHELD DEVICE AND DISPOSITION METHOD OF PLANAR ANTENNA**

(75) Inventors: **Yen-Liang Kuo**, Taoyuan County (TW);  
**Wan-Ming Chen**, Taoyuan County (TW)

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

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 324 days.

(21) Appl. No.: **12/768,736**

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

(65) **Prior Publication Data**

US 2011/0084884 A1 Apr. 14, 2011

(30) **Foreign Application Priority Data**

Oct. 9, 2009 (TW) ..... 98134312 A

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

(52) **U.S. Cl.**  
USPC ..... **343/702; 343/873**

(58) **Field of Classification Search**  
USPC ..... 343/702, 872, 873, 700 MS  
See application file for complete search history.

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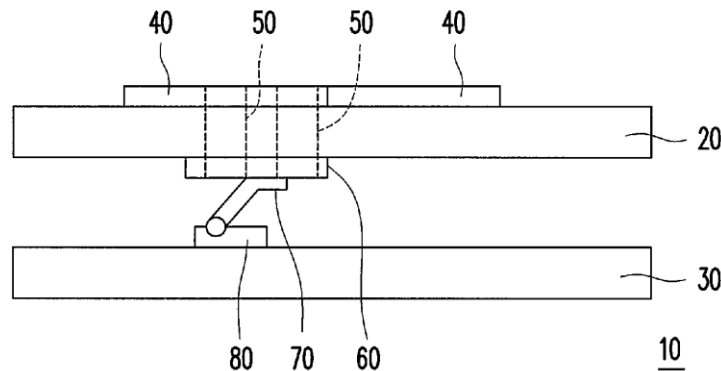
Primary Examiner — Hoang V Nguyen

(74) Attorney, Agent, or Firm — Jianq Chyun IP Office

(57) **ABSTRACT**

A handheld device and a disposition method of a planar antenna are provided. The handheld device includes an appearance, a system ground plane, and the planar antenna. The appearance includes a via. The system ground plane is disposed inside the appearance. The planar antenna is disposed on the appearance and extended to an inner surface of the appearance through the via so as to be coupled to the system ground plane. Thereby, the performance of the planar antenna is improved.

15 Claims, 6 Drawing Sheets







US008665160B2

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

(10) **Patent No.:** **US 8,665,160 B2**  
(45) **Date of Patent:** **Mar. 4, 2014**

(54) **ANTENNA, SHIELDING AND GROUNDING**

(75) Inventors: **Erik A. Uttermann**, Cupertino, CA (US); **Jeremy C. Franklin**, San Francisco, CA (US); **Stephen R. McClure**, San Francisco, CA (US); **Sean S. Corbin**, San Jose, CA (US); **Qingxiang Li**, Mountain View, CA (US); **Rodney A. Gomez Angulo**, Sunnyvale, CA (US)

(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 472 days.

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(21) Appl. No.: **13/018,184**

(22) Filed: **Jan. 31, 2011**

(65) **Prior Publication Data**  
US 2012/0194393 A1 Aug. 2, 2012

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

(52) **U.S. Cl.**  
USPC ..... **343/702**; 343/841

(58) **Field of Classification Search**  
USPC ..... 343/702, 700 MS, 841, 718, 846, 848  
See application file for complete search history.

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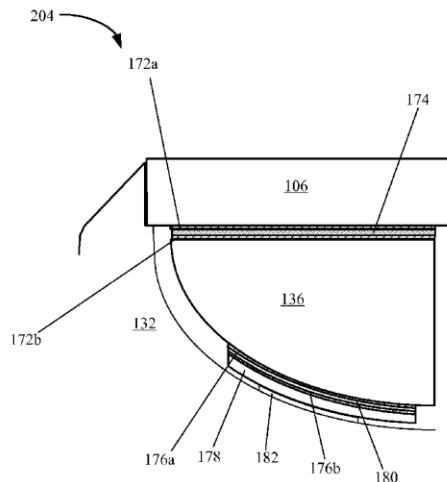
WO 2009/126480 10/2009

*Primary Examiner* — Hoanganh Le  
(74) *Attorney, Agent, or Firm* — Brownstein Hyatt Farber Schreck, LLP

(57) **ABSTRACT**

A portable computing device is disclosed. The portable computing device can take many forms such as a laptop computer, a tablet computer, and so on. The portable computing device can include a single piece housing formed from a radio opaque material with a cover formed from a radio transparent material. To implement a wireless interface, an antenna stack-up can be provided that allows an antenna to be mounted to a bottom of the cover. Methods and apparatus are provided for improving wireless performance. For instance, in one embodiment, a metal housing can be thinned to improve antenna performance. As another example, a faraday cage can be formed around speaker drivers to improve antenna performance.

**20 Claims, 16 Drawing Sheets**





US008665162B2

(12) **United States Patent**  
**Koga**

(10) **Patent No.:** **US 8,665,162 B2**  
(45) **Date of Patent:** **Mar. 4, 2014**

(54) **ANTENNA WITH LOOP FORM RADIATOR FOR MOBILE TERMINALS**

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2009/0251383 A1 10/2009 Tani et al.

(75) Inventor: **Yohei Koga**, Kawasaki (JP)

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(73) Assignee: **Fujitsu Limited**, Kawasaki (JP)

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(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 181 days.

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(21) Appl. No.: **13/234,607**

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(22) Filed: **Sep. 16, 2011**

Patent Abstracts of Japan, Publication No. 2001-326514, Published Nov. 22, 2001.

(65) **Prior Publication Data**

US 2012/0146864 A1 Jun. 14, 2012

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(30) **Foreign Application Priority Data**

Dec. 13, 2010 (JP) ..... 2010-276736

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

*Primary Examiner* — Hoanganh Le

(52) **U.S. Cl.**  
USPC ..... **343/702; 343/741**

(74) *Attorney, Agent, or Firm* — Staas & Halsey LLP

(58) **Field of Classification Search**  
USPC ..... 343/702, 700 MS, 846, 741, 748  
See application file for complete search history.

(57) **ABSTRACT**

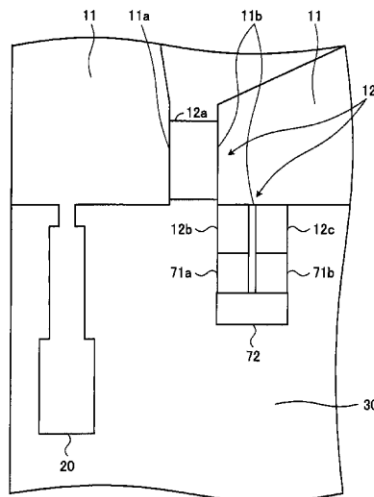
A radiation section of an antenna includes a first connection portion and a second connection portion, and is in a loop form having a plate shape. A switch unit couples the second connection portion to the first connection portion e.g. according to a signal input from the outside. Further, the switch unit couples the second connection portion e.g. to ground formed on a reverse side of a substrate according to a signal input from the outside.

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**14 Claims, 22 Drawing Sheets**





US008665164B2

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

(10) **Patent No.:** **US 8,665,164 B2**  
(45) **Date of Patent:** **Mar. 4, 2014**

(54) **MULTIBAND HANDHELD ELECTRONIC DEVICE SLOT ANTENNA**

(75) Inventors: **Robert J. Hill**, Salinas, CA (US);  
**Robert W. Schlub**, Campbell, CA (US);  
**Ruben Caballero**, San Jose, CA (US)

(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 826 days.

(21) Appl. No.: **12/274,311**

(22) Filed: **Nov. 19, 2008**

(65) **Prior Publication Data**

US 2010/0123632 A1 May 20, 2010

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

(52) **U.S. Cl.**  
USPC ..... **343/767; 343/769; 343/702**

(58) **Field of Classification Search**  
USPC ..... **343/782, 767, 702, 795**  
See application file for complete search history.

(56) **References Cited**

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*Primary Examiner* — Jacob Y Choi

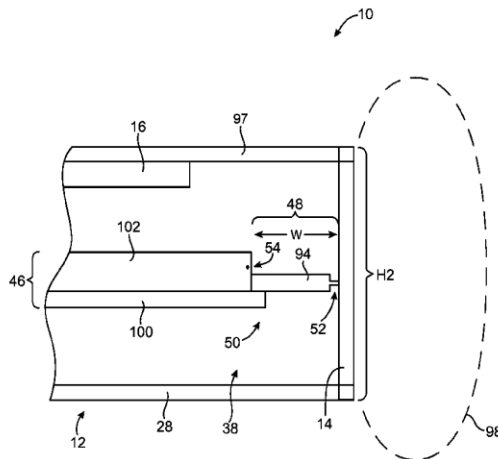
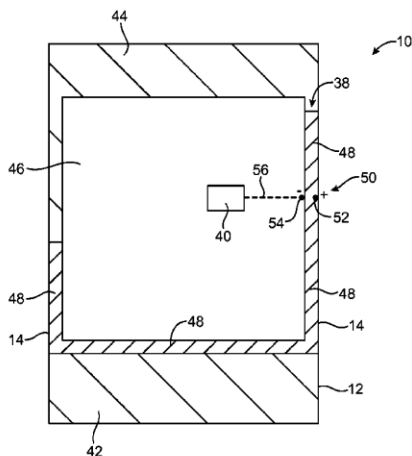
*Assistant Examiner* — Amal Patel

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

(57) **ABSTRACT**

An electronic device such as a portable electronic device may have an antenna and associated wireless communications circuitry. The antenna may be a slot antenna having a dielectric slot opening. The slot opening may have a shape such as a U shape or an L shape in which elongated regions of the slot run parallel to the edges of the portable electronic device. The portable electronic device may have a housing with conductive sidewalls. The conductive sidewalls may help define the shape of the slot. Antenna feed arrangements may be used to feed the slot antenna in a way that excites harmonic frequencies and that supports multiband operation while being shielded from proximity effects.

**20 Claims, 22 Drawing Sheets**





US008666462B2

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

(10) **Patent No.:** **US 8,666,462 B2**

(45) **Date of Patent:** **\*Mar. 4, 2014**

(54) **MOBILE WIRELESS COMMUNICATIONS DEVICE HAVING FREQUENCY SELECTIVE GROUNDING AND RELATED METHOD**

(58) **Field of Classification Search**  
USPC ..... 455/575; 361/752, 753  
See application file for complete search history.

(71) Applicant: **Research In Motion Limited**, Waterloo (CA)

(56) **References Cited**

(72) Inventors: **Joshua Kwan Ho Wong**, Waterloo (CA); **Adrian Matthew Cooke**, Kitchener (CA)

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

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

This patent is subject to a terminal disclaimer.

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WO	2008078144	7/2008

*Primary Examiner* — Dwayne Bost  
*Assistant Examiner* — Gerald Johnson

(21) Appl. No.: **13/799,322**

(74) *Attorney, Agent, or Firm* — Allen, Dyer, Doppelt, Milbrath & Gilchrist, P.A.

(22) Filed: **Mar. 13, 2013**

(65) **Prior Publication Data**

US 2013/0196722 A1 Aug. 1, 2013

**Related U.S. Application Data**

(63) Continuation of application No. 13/442,968, filed on Apr. 10, 2012, now Pat. No. 8,417,300, which is a continuation of application No. 12/868,763, filed on Aug. 26, 2010, now Pat. No. 8,180,412.

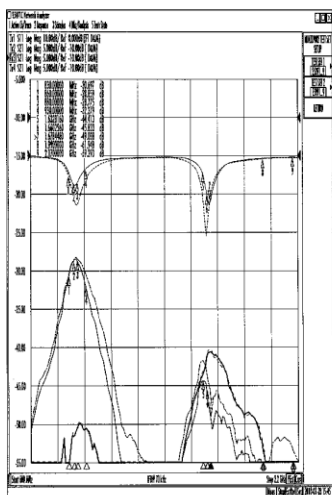
(57) **ABSTRACT**

A mobile wireless communications device includes a portable housing having a metallic front housing forming a peripheral sidewall as a metallic ring. A circuit board is carried by the portable housing and forms a chassis ground plane. A wireless communications circuit is carried by a circuit board. An antenna circuit is carried by a circuit board and connected to the wireless communications circuit. A frequency selective grounding circuit is positioned at a selected grounding location at the chassis ground plane and metallic front housing and forms a harmonic trap that responds to a specific range of frequencies.

(51) **Int. Cl.**  
**H04M 1/00** (2006.01)

(52) **U.S. Cl.**  
USPC ..... **455/575.2; 343/700 R; 333/189; 455/575.1; 455/114.1; 455/550**

**24 Claims, 13 Drawing Sheets**





US008669914B2

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

(10) **Patent No.:** **US 8,669,914 B2**

(45) **Date of Patent:** **Mar. 11, 2014**

(54) **DUAL-BAND ANTENNA AND RELATED WIRELESS COMMUNICATION APPARATUS**

(56) **References Cited**

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(75) Inventors: **Bo Pan**, Irvine, CA (US); **Ching-Wei Ling**, Tainan County (TW)

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(73) Assignee: **Realtek Semiconductor Corp.**, Hsinchu (TW)

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(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 386 days.

*Primary Examiner* — Ahshik Kim

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

(21) Appl. No.: **13/096,436**

(57) **ABSTRACT**

(22) Filed: **Apr. 28, 2011**

A dual-band antenna is disclosed including: a first antenna comprising: a first radiating portion including a plurality of separated radiating strips positioned on a first plane of a circuit board; a second radiating portion including a plurality of separated radiating strips positioned on a second plane of the circuit board; and a plurality of vias for coupling the plurality of radiating strips on the first plane with the plurality of radiating strips on the second plane to form a spiral radiating body; a second antenna having a radiating plane coupled with the first radiating portion or the second radiating portion; a shorting element coupled with the radiating plane and shared by the first and second antennas; and a feeding element coupled with the radiating plane and shared by the first and second antennas; wherein the width of part of the radiating plane gradually increases along a direction.

(65) **Prior Publication Data**

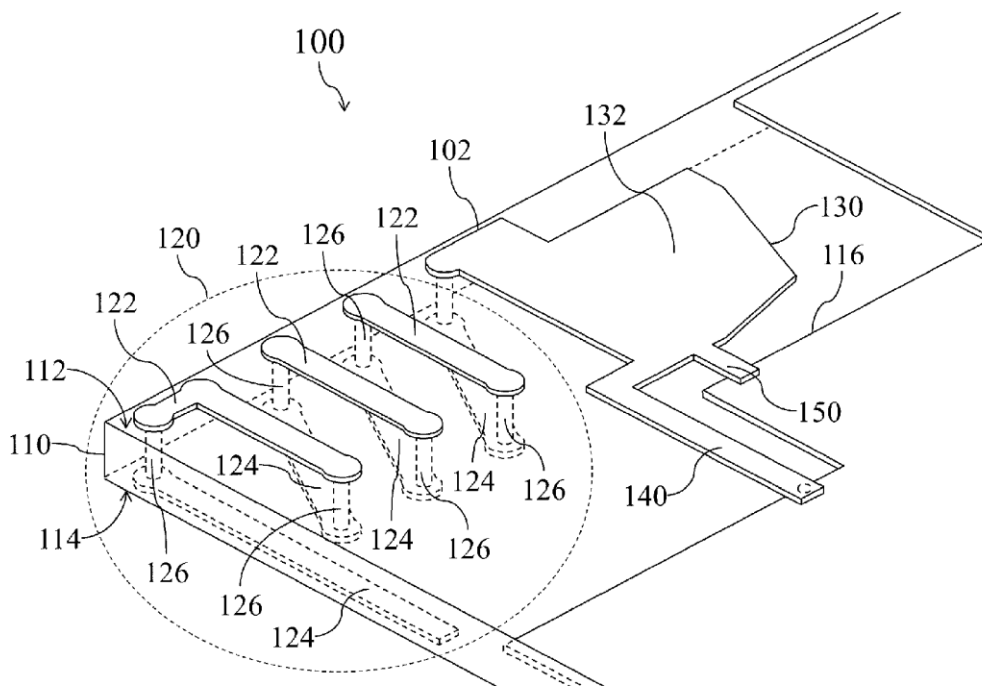
US 2012/0274534 A1 Nov. 1, 2012

(51) **Int. Cl.**  
**H01Q 11/00** (2006.01)

(52) **U.S. Cl.**  
USPC ..... **343/843; 343/770**

(58) **Field of Classification Search**  
USPC ..... 343/843, 770, 796  
See application file for complete search history.

**24 Claims, 6 Drawing Sheets**





US008674881B2

(12) **United States Patent**  
**Suzuki**

(10) **Patent No.:** **US 8,674,881 B2**  
(45) **Date of Patent:** **Mar. 18, 2014**

(54) **ANTENNA APPARATUS**

(75) Inventor: **Tomotaka Suzuki**, Miyagi-Ken (JP)

(73) Assignee: **ALPS Electric Co., Ltd.**, Tokyo (JP)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 771 days.

(21) Appl. No.: **12/961,106**

(22) Filed: **Dec. 6, 2010**

(65) **Prior Publication Data**

US 2011/0133992 A1 Jun. 9, 2011

(30) **Foreign Application Priority Data**

Dec. 7, 2009 (JP) ..... 2009-277773

(51) **Int. Cl.**

**H01Q 1/38** (2006.01)

**H01Q 1/24** (2006.01)

**H01Q 21/24** (2006.01)

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

USPC ..... 343/700 MS; 343/702; 343/853

(58) **Field of Classification Search**

USPC ..... 343/700 MS, 702, 795, 846, 853

See application file for complete search history.

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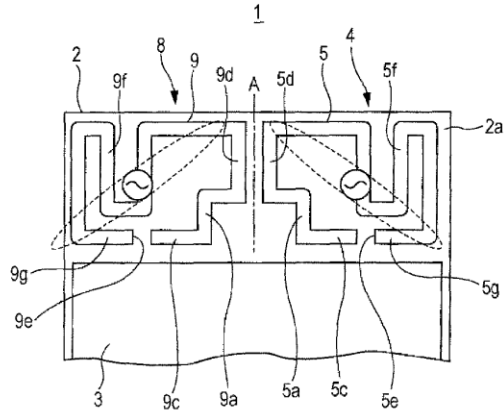
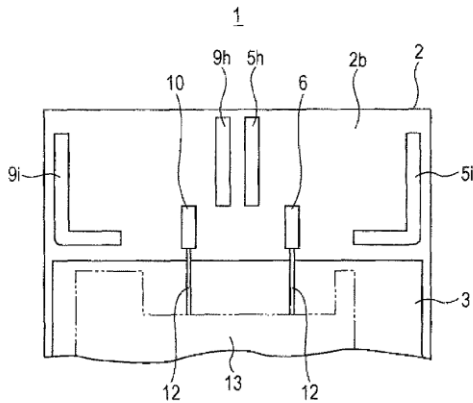
*Primary Examiner* — Michael C Wimer

(74) *Attorney, Agent, or Firm* — Hunton & Williams LLP

(57) **ABSTRACT**

In an antenna apparatus, two pattern antennas are arranged side by side in an area close to a ground conductor layer on a surface of a dielectric substrate, in such a manner as to be formed substantially line-symmetrical with each other. Each of the pattern antennas includes a radiation element having a feed coupler, a mutual coupler, and a feed element fed by a high frequency circuit unit. An open end of the radiation element is located near the ground conductor layer. The feed element and the feed coupler are capacitively coupled with each other, whereby the radiation element is excited. At the excitation, the mutual couplers that extend substantially in parallel with and close to each other are capacitively coupled with each other, and hence, polarization planes of the electric fields radiated from the radiation elements can be made orthogonal to each other.

**4 Claims, 5 Drawing Sheets**





US008674884B2

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

(10) **Patent No.:** **US 8,674,884 B2**  
(45) **Date of Patent:** **Mar. 18, 2014**

(54) **DUAL-BAND CIRCULARLY POLARIZED ANTENNA**

(75) Inventors: **Chia-Hong Lin**, Hsinchu (TW); **I-Shan Chen**, Hsinchu (TW); **Chang-Hsiu Huang**, Hsinchu (TW); **Chin-Yu Wang**, Hsinchu (TW)

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

(\* ) 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.: **13/271,237**

(22) Filed: **Oct. 12, 2011**

(65) **Prior Publication Data**  
US 2013/0027253 A1 Jan. 31, 2013

(30) **Foreign Application Priority Data**  
Jul. 28, 2011 (TW) ..... 100126770 A

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

(52) **U.S. Cl.**  
USPC ..... **343/700 MS; 343/713; 340/10.4**

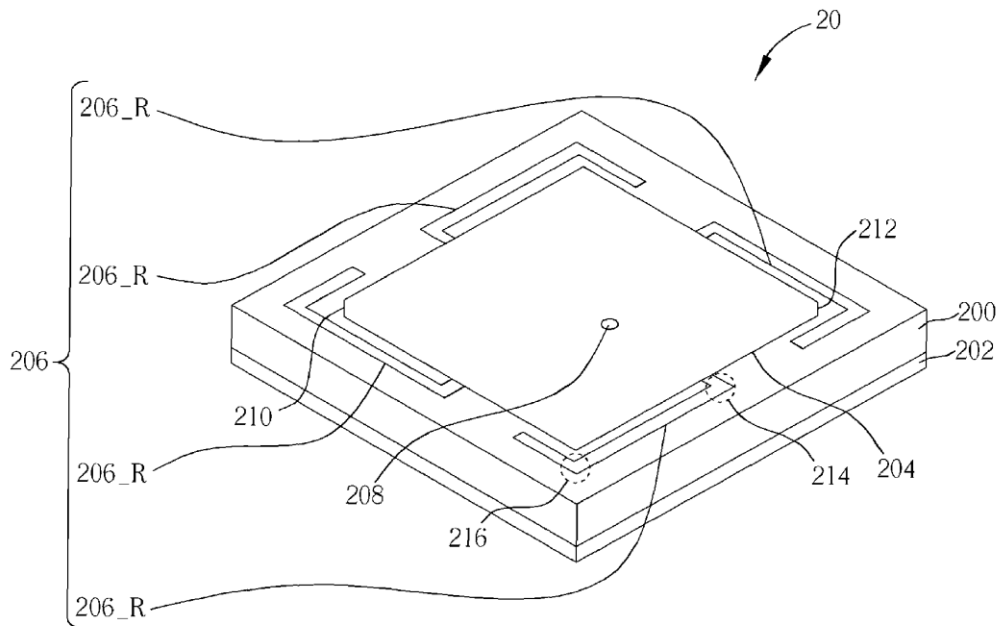
(58) **Field of Classification Search**  
USPC ..... 343/700 MS  
See application file for complete search history.

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*Primary Examiner* — Jerome Jackson, Jr.  
*Assistant Examiner* — Hai Tran  
(74) *Attorney, Agent, or Firm* — Winston Hsu; Scott Margo

(57) **ABSTRACT**  
A dual-band circularly polarized antenna is disclosed, which includes a ground metal plate, a dielectric substrate, a first microstrip radiation portion and a second microstrip radiation portion. The dielectric substrate is formed on the ground metal plate. The first microstrip radiation portion is formed on the dielectric substrate and has at least one pair of symmetric truncated corners. The second microstrip radiation portion is formed on the dielectric substrate and includes a plurality of radiation units. Each of the plurality of radiation units is extended from the first microstrip radiation portion along a first direction.

**11 Claims, 11 Drawing Sheets**





US008674886B2

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

(10) **Patent No.:** **US 8,674,886 B2**  
(45) **Date of Patent:** **Mar. 18, 2014**

(54) **MOBILE TERMINAL**

(75) Inventors: **Junichi Ohno**, Saitama (JP); **Aiko Yoshida**, Kanagawa (JP)

(73) Assignees: **Sony Corporation**, Tokyo (JP); **Sony Mobile Communications Inc.**, Tokyo (JP)

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(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 313 days.

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(21) Appl. No.: **13/213,219**

(22) Filed: **Aug. 19, 2011**

(65) **Prior Publication Data**

US 2012/0162025 A1 Jun. 28, 2012

**Related U.S. Application Data**

(60) Provisional application No. 61/426,711, filed on Dec. 23, 2010.

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

(52) **U.S. Cl.**  
USPC ..... **343/702**

(58) **Field of Classification Search**  
USPC ..... 343/702, 700 MS, 876, 756; 455/575.3  
See application file for complete search history.

(56) **References Cited**

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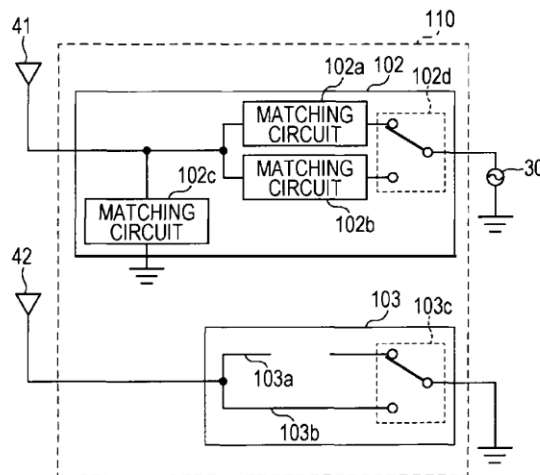
*Primary Examiner* — Huedung Mancuso

(74) *Attorney, Agent, or Firm* — Oblon, Spivak, McClelland, Maier & Neustadt, L.L.P.

(57) **ABSTRACT**

A mobile terminal including an antenna device including an antenna element and a first non-feeding element, a radio-frequency unit that receives a signal from the antenna element, first and second matching circuits connected to the antenna element, a first switch that selectively connects one of the first and second matching circuits to the radio-frequency unit, a second switch that selectively grounds the first non-feeding element, an attitude-detection unit that detects an attitude of the mobile terminal, and a control unit that controls the first and second switches based on an output of the attitude-detection unit.

**20 Claims, 20 Drawing Sheets**







US008674887B2

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

(10) **Patent No.:** **US 8,674,887 B2**  
(45) **Date of Patent:** **\*Mar. 18, 2014**

(54) **MULTI-BAND MONOPOLE ANTENNA FOR A MOBILE COMMUNICATIONS DEVICE**

(75) Inventors: **Alfonso Sanz**, Barcelona (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 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **13/556,626**

(22) Filed: **Jul. 24, 2012**

(65) **Prior Publication Data**

US 2012/0287001 A1 Nov. 15, 2012

**Related U.S. Application Data**

(63) Continuation of application No. 13/029,382, filed on Feb. 17, 2011, now Pat. No. 8,259,016, which is a continuation of application No. 12/652,974, filed on Jan. 6, 2010, now Pat. No. 8,253,633, which is a continuation of application No. 12/055,748, filed on Mar. 26, 2008, now Pat. No. 7,675,470, which is a continuation of application No. 11/713,324, filed on Mar. 2, 2007, now Pat. No. 7,403,164, which is a continuation of application No. 11/124,768, filed on May 9, 2005, now Pat. No. 7,411,556, which is a continuation of application No. PCT/EP02/14706, filed on Dec. 22, 2002.

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

(52) **U.S. Cl.**  
USPC ..... **343/702; 343/700 MS**

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

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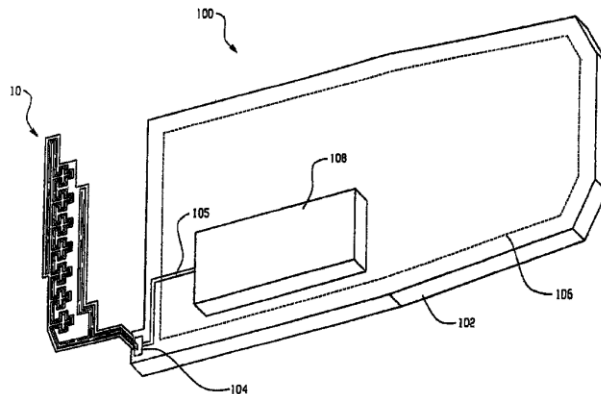
*Primary Examiner* — Tan Ho

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

(57) **ABSTRACT**

A multi-band monopole antenna for a mobile communications device includes a common conductor coupled to both a first radiating arm and a second radiating arm. The common conductor includes a feeding port for coupling the antenna to communications circuitry in a mobile communications device. In one embodiment, the first radiating arm includes a space-filling curve. In another embodiment, the first radiating arm includes a meandering section extending from the common conductor in a first direction and a contiguous extended section extending from the meandering section in a second direction.

**20 Claims, 7 Drawing Sheets**





US008674889B2

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

(10) **Patent No.:** **US 8,674,889 B2**  
(45) **Date of Patent:** **Mar. 18, 2014**

- (54) **TUNABLE ANTENNA ARRANGEMENT**
- (75) Inventors: **Erik Bengtsson**, Eslov (SE); **Richard Breiter**, Fredriksberg (DE)
- (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 478 days.

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- (21) Appl. No.: **12/999,454**
- (22) PCT Filed: **Jun. 23, 2008**
- (86) PCT No.: **PCT/EP2008/057977**  
§ 371 (c)(1),  
(2), (4) Date: **Feb. 1, 2011**

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- (65) **Prior Publication Data**  
US 2011/0148723 A1 Jun. 23, 2011

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- (51) **Int. Cl.**  
**H01Q 11/04** (2006.01)
- (52) **U.S. Cl.**  
USPC ..... **343/745**; 343/702; 343/876
- (58) **Field of Classification Search**  
USPC ..... 343/700, 702, 745, 860, 861, 876  
See application file for complete search history.

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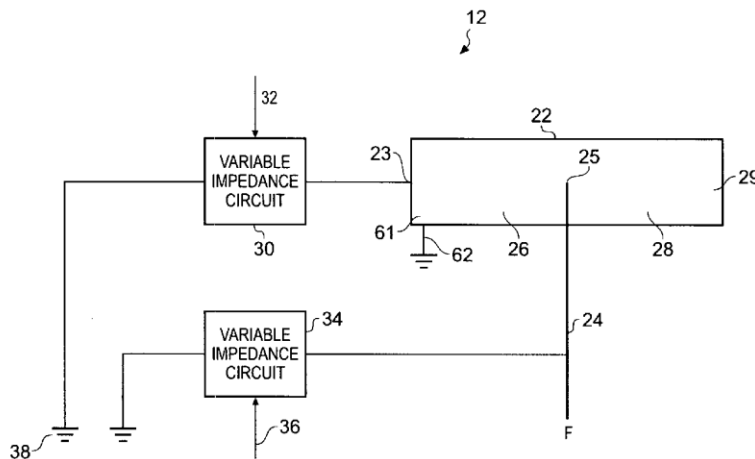
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(57) **ABSTRACT**

An antenna arrangement including an antenna; a first variable impedance circuit connected between ground and a first point of the antenna; and a second variable impedance circuit connected between ground and a second point of the antenna and a connection from a third point of the antenna to ground wherein; the first point of the antenna and the second point of the antenna are separated along the length of the antenna and the impedance of the first variable impedance circuit and the second variable impedance circuit control the resonant frequency of the antenna arrangement.

**20 Claims, 5 Drawing Sheets**





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(54) **TUNABLE METAMATERIAL ANTENNA STRUCTURES**

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(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 933 days.

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(65) **Prior Publication Data**

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**H01Q 19/06** (2006.01)  
**H01Q 15/02** (2006.01)  
**H01Q 1/38** (2006.01)

*Primary Examiner* — Robert Karacsony

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USPC ..... **343/753**; 343/909; 343/700 MS

(57) **ABSTRACT**

(58) **Field of Classification Search**  
USPC ..... 343/722, 753, 909, 911  
See application file for complete search history.

Apparatus and techniques that provide tuning elements in antenna devices to tune frequencies of the antenna devices, including composite right and left handed (CRLH) metamaterial (MTM) antenna devices. Examples of the tuning elements for CRLH MTM antenna devices include feed line tuning elements, cell patch tuning elements, meandered stub tuning elements, via line tuning elements, and via pad tuning elements that formed near corresponding antenna elements such as the feed line, cell patch, meandered stub, via line and via pad, respectively.

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**23 Claims, 34 Drawing Sheets**

