



US009246210B2

(12) **United States Patent**  
**Korva**

(10) **Patent No.:** **US 9,246,210 B2**  
(45) **Date of Patent:** **Jan. 26, 2016**

(54) **ANTENNA WITH COVER RADIATOR AND METHODS**

USPC ..... 343/702, 767, 872  
See application file for complete search history.

(75) Inventor: **Heikki Korva**, Tuusula (FI)

(56) **References Cited**

(73) Assignee: **PULSE FINLAND OY**, Kempele (FI)

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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 693 days.

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(21) Appl. No.: **13/579,559**

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(22) PCT Filed: **Feb. 7, 2011**

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(86) PCT No.: **PCT/FI2011/050102**

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§ 371 (c)(1),  
(2), (4) Date: **Jan. 11, 2013**

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"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.

PCT Pub. Date: **Aug. 25, 2011**

(Continued)

(65) **Prior Publication Data**

US 2013/0127674 A1 May 23, 2013

*Primary Examiner* — Dieu H Duong

(30) **Foreign Application Priority Data**

Feb. 18, 2010 (FI) ..... 20105158

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

(51) **Int. Cl.**  
**H01Q 1/24** (2006.01)  
**H01Q 1/42** (2006.01)  
**H01Q 9/04** (2006.01)  
**H01Q 9/42** (2006.01)

(Continued)

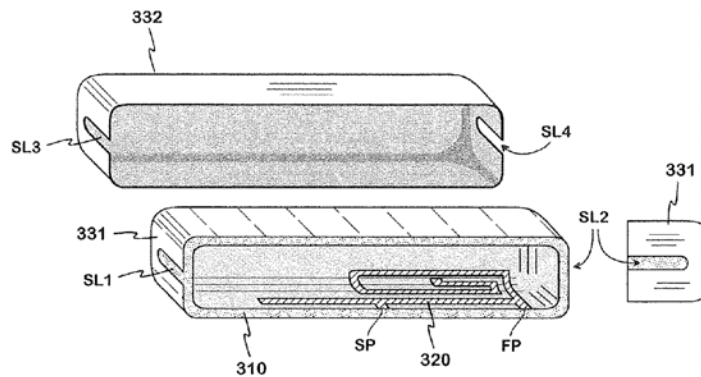
(57) **ABSTRACT**

A monopole antenna applicable especially to small mobile stations. In one embodiment, the radiator of the antenna is trough-like in shape so that it covers the head surface, front and rear surfaces and both side surfaces of the dielectric cover of the radio device at an end of the device. On the side of the side surfaces slots are formed in the radiator, starting from its edge, for increasing the electric size. The radiator is fed electromagnetically by a separate element which is shaped so that the antenna has at least two operating bands. The ground plane of the antenna is in one embodiment disposed apart from the radiator, thus not extending inside the 'trough'.

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/241** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/42** (2013.01); **H01Q 5/357** (2015.01); **H01Q 5/378** (2015.01); **H01Q 9/0421** (2013.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 1/24; H01Q 1/243

**21 Claims, 3 Drawing Sheets**





US009246212B2

(12) **United States Patent**  
**Varjonen**

(10) **Patent No.:** **US 9,246,212 B2**  
(45) **Date of Patent:** **Jan. 26, 2016**

(54) **APPARATUS COMPRISING AN ANTENNA ELEMENT AND A METAL PART**

(75) Inventor: **Eero Oskari Varjonen**, Turku (FI)  
(73) Assignee: **Nokia Technologies Oy**, Espoo (FI)  
(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 497 days.

(21) Appl. No.: **12/448,391**  
(22) PCT Filed: **Dec. 22, 2006**  
(86) PCT No.: **PCT/IB2006/004180**  
§ 371 (c)(1),  
(2), (4) Date: **Jun. 17, 2009**

(87) PCT Pub. No.: **WO2008/078144**  
PCT Pub. Date: **Jul. 3, 2008**

(65) **Prior Publication Data**  
US 2010/0007563 A1 Jan. 14, 2010

(51) **Int. Cl.**  
**H01Q 1/24** (2006.01)  
**H01Q 1/48** (2006.01)  
**H01Q 1/52** (2006.01)  
(52) **U.S. Cl.**  
CPC ..... **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 1/52** (2013.01); **Y10T 29/49018** (2015.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 1/243; H01Q 1/242  
USPC ..... 343/702, 700 MS, 725, 729, 841, 846  
See application file for complete search history.

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Primary Examiner — Dameon E Levi

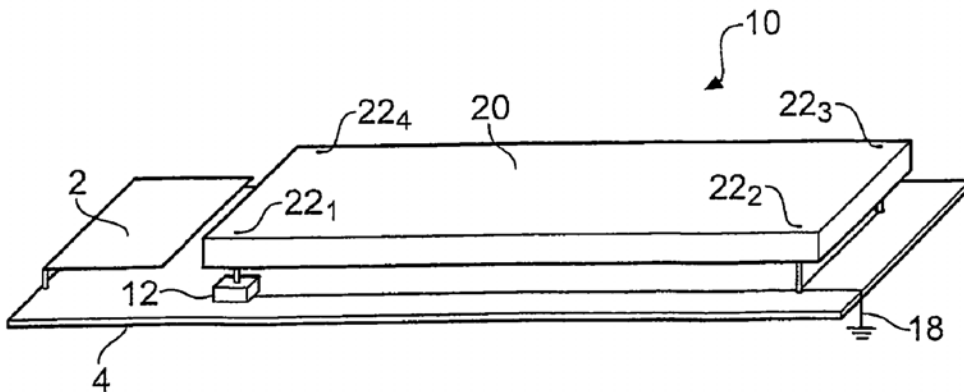
Assistant Examiner — Hasan Islam

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

(57) **ABSTRACT**

An apparatus including an antenna element; a metal part; a ground; and a filter connected between the metal part and the ground that has a frequency dependent impedance.

**20 Claims, 1 Drawing Sheet**





US009246215B1

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

(10) **Patent No.:** **US 9,246,215 B1**  
(45) **Date of Patent:** **Jan. 26, 2016**

- (54) **ANTENNA STRUCTURE WITH SPLIT-FEED ANTENNA ELEMENT AND COUPLED PARASITIC GROUNDING ELEMENT**
- (71) Applicant: **Amazon Technologies, Inc.**, Seattle, WA (US)
- (72) Inventor: **Tzung-I Lee**, San Jose, CA (US)
- (73) Assignee: **Amazon Technologies, Inc.**, Seattle, WA (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.: **14/511,066**
- (22) Filed: **Oct. 9, 2014**

**Related U.S. Application Data**

- (63) Continuation of application No. 13/626,403, filed on Sep. 25, 2012, now Pat. No. 8,890,753.
- (51) **Int. Cl.**  
*H01Q 1/24* (2006.01)  
*H01Q 1/48* (2006.01)  
*H01Q 5/00* (2015.01)  
*H01Q 9/04* (2006.01)
- (52) **U.S. Cl.**  
 CPC ..... *H01Q 1/48* (2013.01); *H01Q 5/0062* (2013.01); *H01Q 5/0093* (2013.01); *H01Q 9/045* (2013.01); *H01Q 9/0414* (2013.01)
- (58) **Field of Classification Search**  
 CPC ..... H01Q 1/243; H01Q 5/371; H01Q 5/392; H01Q 9/42; H01Q 21/30  
 USPC ..... 343/702, 848  
 See application file for complete search history.

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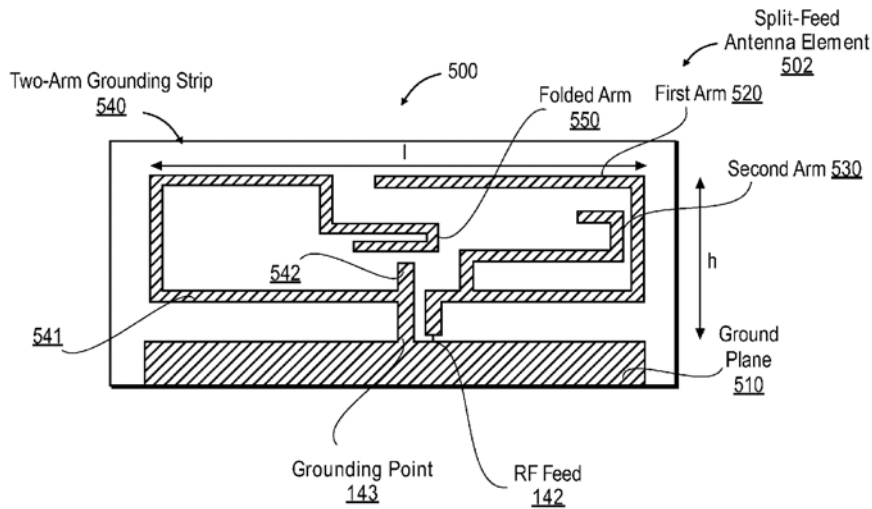
*Primary Examiner* — Hoang V Nguyen

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

(57) **ABSTRACT**

Antenna structures of electronic devices and methods of operating the electronic devices with the antenna structures are described. One apparatus includes a RF feed coupled to a split-feed antenna element of an antenna structure. The antenna structure also includes a parasitic grounding element coupled to a ground plane. The split-feed antenna element is configured to operate as a feeding structure to the parasitic grounding element that is not conductively connected to the RF feed. The antenna structure is disposed on at least two sides of an antenna carrier.

**17 Claims, 9 Drawing Sheets**





US009246220B2

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

(10) **Patent No.:** **US 9,246,220 B2**  
(45) **Date of Patent:** **Jan. 26, 2016**

(54) **FULL-BAND ANTENNA**

- (71) Applicant: **LUXSHARE-ICT CO., LTD.**, Taipei (TW)
- (72) Inventors: **Chien Yu Chiang**, New Taipei (TW); **Sheng Hsin Chang**, Kaohsiung (TW)
- (73) Assignee: **SHENZHEN LUXSHARE ACOUSTICS TECHNOLOGY LTD.**, Shenzhen, Guangdong Province (CN)
- (\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 188 days.

(21) Appl. No.: **14/159,717**

(22) Filed: **Jan. 21, 2014**

(65) **Prior Publication Data**  
US 2015/0207229 A1 Jul. 23, 2015

(51) **Int. Cl.**  
**H01Q 7/00** (2006.01)  
**H01Q 1/50** (2006.01)

(52) **U.S. Cl.**  
CPC ... **H01Q 7/00** (2013.01); **H01Q 1/50** (2013.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 7/00; H01Q 1/50  
USPC ..... 343/866, 867, 868, 870  
See application file for complete search history.

(56) **References Cited**

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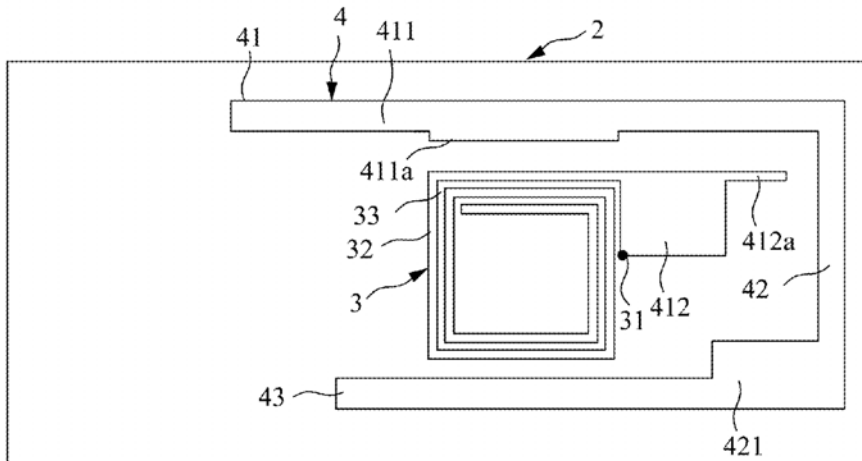
*Primary Examiner* — Huedung Mancuso

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

(57) **ABSTRACT**

A full-band antenna includes a dielectric layer, and a first and a second patterned conductive layer provided on the dielectric layer. The first patterned conductive layer includes a feed portion and a loop portion outwardly extended from the feed portion. The loop portion defines a plurality of radiation sections, between which a multi-coupling effect is created to form at least one variable frequency. The second patterned conductive layer includes a conductive portion and a short-circuit portion. The conductive portion forms at least one fixed frequency. The at least one variable frequency of the loop portion can be adjusted in its frequency distribution and frequency range by changing a width of the radiation sections and a spacing distance between the radiation sections.

**11 Claims, 8 Drawing Sheets**





US009246221B2

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

(10) **Patent No.:** **US 9,246,221 B2**  
(45) **Date of Patent:** **Jan. 26, 2016**

(54) **TUNABLE LOOP ANTENNAS**  
(75) Inventors: **Nanbo Jin**, Sunnyvale, CA (US); **Mattia Pascolini**, Campbell, CA (US); **Matt A. Mow**, Los Altos, CA (US); **Robert W. Schlub**, Cupertino, CA (US); **Ruben Caballero**, San Jose, CA (US)

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(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 927 days.

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(21) Appl. No.: **13/041,934**

Jarvis et al., U.S. Appl. No. 12/823,929, filed Jun. 25, 2010.

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

(Continued)

(65) **Prior Publication Data**  
US 2012/0231750 A1 Sep. 13, 2012

*Primary Examiner* — Michael C Wimer

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

(51) **Int. Cl.**  
**H01Q 1/24** (2006.01)  
**H01Q 7/00** (2006.01)

(57) **ABSTRACT**

(52) **U.S. Cl.**  
CPC ..... **H01Q 7/005** (2013.01); **H01Q 1/243** (2013.01)

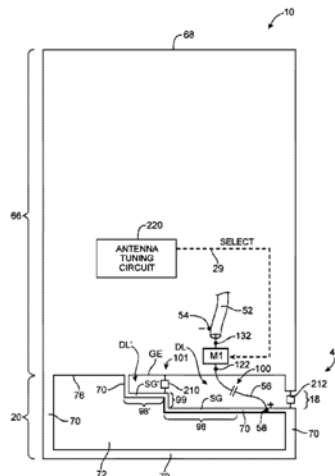
Electronic devices are provided that contain wireless communications circuitry. The wireless communications circuitry may include radio-frequency transceiver circuitry and antenna structures. A parallel-fed loop antenna may be formed from portions of a conductive bezel and a ground plane. The antenna may operate in multiple communications bands. The bezel may surround a peripheral portion of a display that is mounted to the front of an electronic device. The bezel may contain a gap. Antenna feed terminals for the antenna may be located on opposing sides of the gap. A variable capacitor may bridge the gap. An inductive element may bridge the gap and the antenna feed terminals. A switchable inductor may be coupled in parallel with the inductive element. Tunable matching circuitry may be coupled between one of the antenna feed terminals and a conductor in a coaxial cable connecting the transceiver circuitry to the antenna.

(58) **Field of Classification Search**  
CPC ..... H01Q 1/24; H01Q 1/241; H01Q 1/242; H01Q 1/243; H01Q 1/38; H01Q 5/00; H01Q 7/00; H01Q 7/005  
USPC ..... 343/702, 741–745, 748, 860, 861  
See application file for complete search history.

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**24 Claims, 17 Drawing Sheets**





US009246223B2

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

(10) **Patent No.:** **US 9,246,223 B2**  
(45) **Date of Patent:** **Jan. 26, 2016**

(54) **ANTENNA TUNING FOR MULTIBAND OPERATION**

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(75) Inventors: **Firass Mirza Badaruzzaman**, Forest Park, IL (US); **Randy Alan Wiessner**, Palatine, IL (US); **Marshall Joseph Katz**, Palatine, IL (US)

FOREIGN PATENT DOCUMENTS

(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 523 days.

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(21) Appl. No.: **13/551,248**

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(22) Filed: **Jul. 17, 2012**

(Continued)

(65) **Prior Publication Data**

US 2014/0022132 A1 Jan. 23, 2014

(51) **Int. Cl.**  
**H01Q 9/00** (2006.01)  
**H01Q 9/14** (2006.01)  
**H01Q 9/04** (2006.01)  
**H03H 7/40** (2006.01)  
**H01Q 5/371** (2015.01)

*Primary Examiner* — Sue A Purvis  
*Assistant Examiner* — Jae Kim

(74) *Attorney, Agent, or Firm* — Guntin & Gust, PLC; Ralph Trementozzi

(52) **U.S. Cl.**  
CPC ..... **H01Q 9/14** (2013.01); **H01Q 5/371** (2015.01); **H01Q 9/0421** (2013.01); **H03H 7/40** (2013.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 9/0421; H01Q 9/14; H01Q 5/0058; H03H 7/40  
USPC ..... 343/745, 700 MS  
See application file for complete search history.

(57) **ABSTRACT**

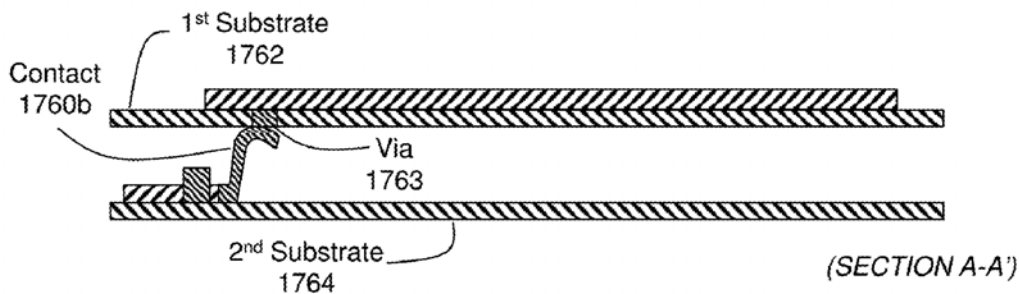
A system and process that includes a multiband antenna as may be used in mobile communications devices. The multiband antenna includes a feed port coupled to each of a first radiating portion and a second radiating portion. Each of the first and second radiating portions defines a respective resonant bandwidth. The multiband antenna also includes at least one adjustable tuning circuit disposed between separate and displaced radiating segments of a respective one of the first and second radiating portions. Adjustment of the tuning circuit alters a corresponding resonant bandwidth allowing the corresponding resonant bandwidth to be tuned independently of the other resonant bandwidth and without affecting performance of the other resonant bandwidth. Other embodiments are disclosed.

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**13 Claims, 14 Drawing Sheets**





US009246228B2

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

(10) **Patent No.:** **US 9,246,228 B2**  
(45) **Date of Patent:** **Jan. 26, 2016**

(54) **MULTIBAND COMPOSITE RIGHT AND LEFT HANDED (CRLH) SLOT ANTENNA**

(75) Inventors: **Cheng-Jung Lee**, San Diego, CA (US);  
**Ajay Gummalla**, San Diego, CA (US);  
**Maha Achour**, Encinitas, CA (US)

(73) Assignee: **Tyco Electronics Services GmbH** (CH)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 784 days.

(21) Appl. No.: **12/723,540**

(22) Filed: **Mar. 12, 2010**

(65) **Prior Publication Data**  
US 2010/0231470 A1 Sep. 16, 2010

**Related U.S. Application Data**

(60) Provisional application No. 61/159,694, filed on Mar. 12, 2009.

(51) **Int. Cl.**  
**H01Q 13/10** (2006.01)  
**H01Q 15/00** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **H01Q 13/10** (2013.01); **H01Q 15/0086** (2013.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 13/10; H01Q 13/085; H01Q 1/38  
USPC ..... 343/767, 770, 768  
See application file for complete search history.

(56) **References Cited**

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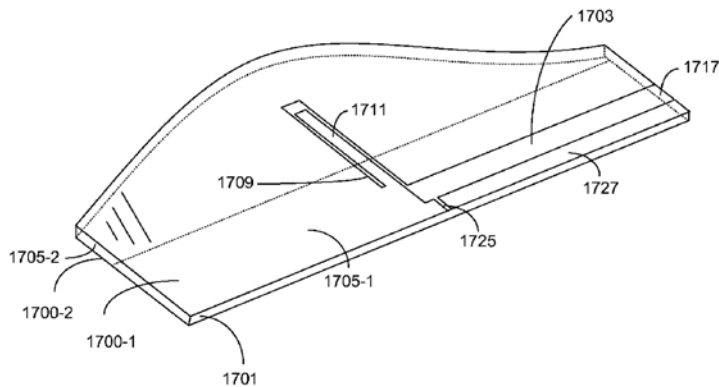
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*Primary Examiner* — Dameon E Levi  
*Assistant Examiner* — Collin Dawkins

(57) **ABSTRACT**

An antenna device includes a substrate having a first surface and a second surface. A first conductive layer is formed on the first surface of the substrate, the first conductive layer having a perimeter defined by one or more shapes having straight or curved edges. The first conductive layer defines a slot and a coupling gap, and also includes a top ground. The coupling gap separates the top ground from a metal plate region. A second conductive layer is formed on the second surface of the substrate, the second conductive layer including a bottom ground. The slot, coupling gap, first conductive layer, and substrate form a composite right and left handed (CRLH) structure.

**28 Claims, 36 Drawing Sheets**





US009246237B2

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

(10) **Patent No.:** **US 9,246,237 B2**  
(45) **Date of Patent:** **Jan. 26, 2016**

(54) **DUAL ANTENNA, SINGLE FEED SYSTEM**

(75) Inventors: **Ole Jagielski**, FredericksHAVN (DK);  
**Simon Svendsen**, Aalborg (DK)

(73) Assignee: **Molex, LLC**, Lisle, IL (US)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 76 days.

(21) Appl. No.: **13/878,647**

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

(86) PCT No.: **PCT/US2011/055979**

§ 371 (c)(1),  
(2), (4) Date: **Apr. 10, 2013**

(87) PCT Pub. No.: **WO2012/051311**

PCT Pub. Date: **Apr. 19, 2012**

(65) **Prior Publication Data**

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**Related U.S. Application Data**

(60) Provisional application No. 61/392,181, filed on Oct. 12, 2010.

(51) **Int. Cl.**

**H01Q 9/00** (2006.01)  
**H01Q 21/30** (2006.01)  
**H01Q 1/24** (2006.01)  
**H01Q 9/04** (2006.01)  
**H01Q 5/371** (2015.01)  
**H01Q 5/40** (2015.01)

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

CPC ..... **H01Q 21/30** (2013.01); **H01Q 1/243**  
(2013.01); **H01Q 5/371** (2015.01); **H01Q 5/40**  
(2015.01); **H01Q 9/0421** (2013.01); **H01Q**  
**9/0457** (2013.01)

(58) **Field of Classification Search**

CPC ..... H01Q 9/00  
USPC ..... 343/751, 770, 848  
See application file for complete search history.

(56) **References Cited**

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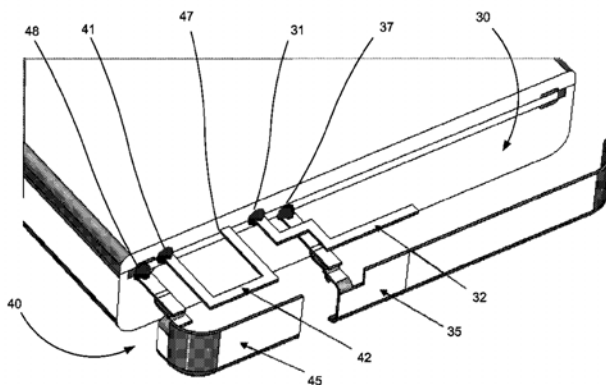
*Primary Examiner* — Huedung Mancuso

(74) *Attorney, Agent, or Firm* — Stephen L. Sheldon

(57) **ABSTRACT**

An antenna system includes a low-band antenna configured for low-band frequencies and a high-band antenna configured for high-band frequencies. The low-band antenna is configured so that high-band frequencies have a high impedance while the high-band antenna is configured so that low-band frequencies have a high impedance. A transmission line can be used to couple both antennas together and the transmission line can be used to add phase delay to the impedance of the low-band and high-band antennas so that the corresponding frequencies that the antennas are not configured for are shifted toward an infinite impedance point on a Smith chart.

**4 Claims, 8 Drawing Sheets**







US009252481B2

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

(10) **Patent No.:** **US 9,252,481 B2**  
(45) **Date of Patent:** **Feb. 2, 2016**

(54) **ADJUSTABLE ANTENNA STRUCTURES FOR ADJUSTING ANTENNA PERFORMANCE IN ELECTRONIC DEVICES**

(56) **References Cited**

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

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(72) Inventors: **Shayan Malek**, San Jose, CA (US);  
**John B. Ardisana, II**, San Francisco, CA (US); **Michael B. Wittenberg**, Sunnyvale, CA (US)

(73) Assignee: **Apple Inc.**, Cupertino, CA (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 369 days.

*Primary Examiner* — Hoanganh Le

(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.; G. Victor Treyz; Zachary D. Hadd

(21) Appl. No.: **13/706,758**

(57) **ABSTRACT**

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

Adjustable antenna structures may be used to compensate for manufacturing variations in electronic device antennas. An electronic device antenna may have an antenna feed and conductive structures such as portions of a peripheral conductive electronic device housing member and other conductive antenna structures. The adjustable antenna structures may have a movable dielectric support. Multiple conductive paths may be formed on the dielectric support. The movable dielectric support may be installed within an electronic device housing so that a selected one of the multiple conductive paths is coupled into use to convey antenna signals. Coupling the selected path into use adjusts the position of an antenna feed terminal for the antenna feed and compensates for manufacturing variations in the conductive antenna structures that could potentially lead to undesired variations in antenna performance.

(65) **Prior Publication Data**

US 2014/0159989 A1 Jun. 12, 2014

(51) **Int. Cl.**

**H01Q 1/24** (2006.01)

**H01Q 7/00** (2006.01)

**H01Q 9/04** (2006.01)

**H01Q 13/10** (2006.01)

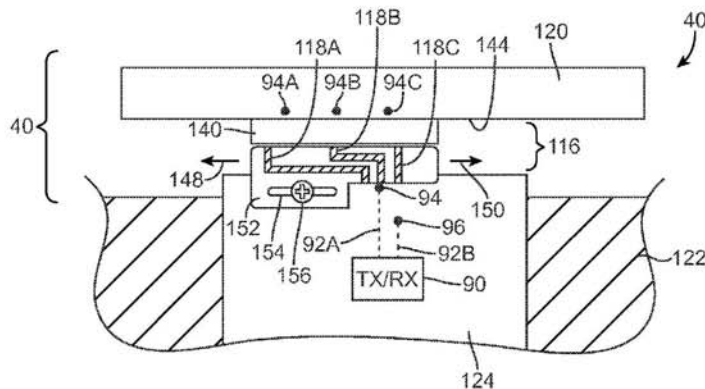
(52) **U.S. Cl.**

CPC ..... **H01Q 1/243** (2013.01); **H01Q 7/00** (2013.01); **H01Q 9/0421** (2013.01); **H01Q 9/0442** (2013.01); **H01Q 13/10** (2013.01); **Y10T 29/49018** (2015.01)

(58) **Field of Classification Search**

CPC ..... H01Q 1/243; H01Q 9/42; H01Q 9/14  
See application file for complete search history.

**23 Claims, 18 Drawing Sheets**





US009252490B2

(12) **United States Patent**  
**Wei**

(10) **Patent No.:** **US 9,252,490 B2**  
(45) **Date of Patent:** **Feb. 2, 2016**

(54) **MULTI-BAND ANTENNA AND ELECTRONIC DEVICE PROVIDED WITH THE SAME**

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

(72) Inventor: **Shih-Chiang Wei**, 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 363 days.

(21) Appl. No.: **13/743,724**

(22) Filed: **Jan. 17, 2013**

(65) **Prior Publication Data**

US 2014/0009342 A1 Jan. 9, 2014

(30) **Foreign Application Priority Data**

Jul. 3, 2012 (TW) ..... 101123878 A

(51) **Int. Cl.**

**H01Q 9/04** (2006.01)

**H01Q 1/22** (2006.01)

**H01Q 9/42** (2006.01)

**H01Q 21/28** (2006.01)

**H01Q 5/371** (2015.01)

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

CPC ..... **H01Q 9/04** (2013.01); **H01Q 1/2266** (2013.01); **H01Q 5/371** (2015.01); **H01Q 9/42** (2013.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**

CPC ..... H01Q 9/04; H01Q 5/371; H01Q 21/28; H01Q 9/42; H01Q 1/2266

USPC ..... 343/702  
See application file for complete search history.

(56) **References Cited**

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| 2012/0293376 A1 * | 11/2012 | Hung et al.   | 343/702    |
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*Primary Examiner* — Hoang V Nguyen

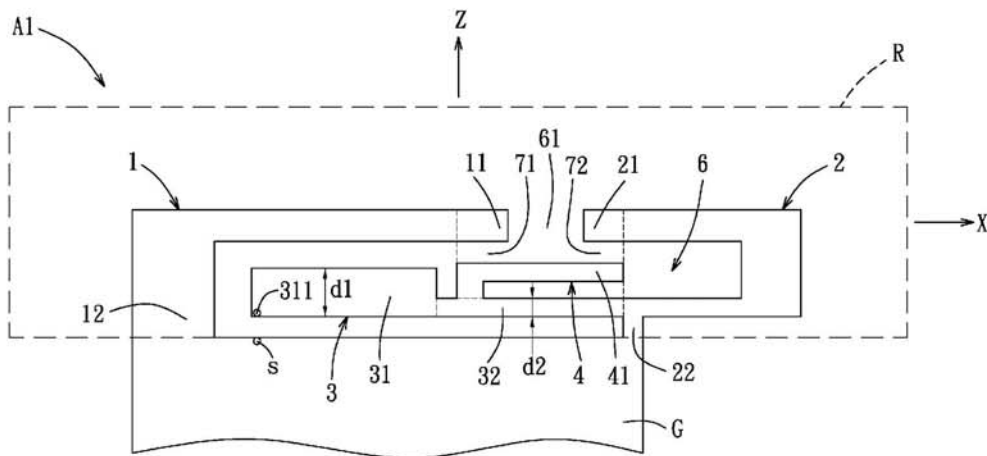
*Assistant Examiner* — Michael Bouizza

(74) *Attorney, Agent, or Firm* — SmithAmundsen LLC; Kelly J. Smith; Dennis S. Schell

(57) **ABSTRACT**

A multi-band antenna includes a ground plane, and a radiating unit including an L-shaped first radiating arm, a U-shaped second radiating arm, a feed-in arm and a coupling arm. The first and second radiating arms are connected to the ground plane, and have respective free end portions that are spaced apart from and overlap the ground plane, that face each other, and that define an opening in spatial communication with an inner space defined by the first and second radiating arms and the ground plane. The feed-in arm is disposed in the inner space between the first radiating arm and the ground plane, is connected to the ground plane, and overlaps the opening. The coupling arm is connected to the connecting segment, and overlaps the free end portions.

**14 Claims, 18 Drawing Sheets**





US009252494B2

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

(10) **Patent No.:** **US 9,252,494 B2**  
(45) **Date of Patent:** **Feb. 2, 2016**

(54) **FREQUENCY-VARIABLE ANTENNA CIRCUIT, ANTENNA DEVICE CONSTITUTING IT, AND WIRELESS COMMUNICATIONS APPARATUS COMPRISING IT**

(75) Inventors: **Kenji Hayashi**, Tottori (JP); **Hiroshi Okamoto**, Tottori (JP); **Hiroto Ideno**, Tottori (JP)

(73) Assignee: **HITACHI METALS, 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 17 days.

(21) Appl. No.: **13/391,954**

(22) PCT Filed: **Nov. 15, 2010**

(86) PCT No.: **PCT/JP2010/070302**

§ 371 (c)(1),  
(2), (4) Date: **Feb. 23, 2012**

(87) PCT Pub. No.: **WO2011/059088**

PCT Pub. Date: **May 19, 2011**

(65) **Prior Publication Data**

US 2012/0146865 A1 Jun. 14, 2012

(30) **Foreign Application Priority Data**

Nov. 13, 2009 (JP) ..... 2009-260127  
Aug. 6, 2010 (JP) ..... 2010-177561

(51) **Int. Cl.**  
**H01Q 9/00** (2006.01)  
**H01Q 9/42** (2006.01)  
**H01Q 5/392** (2015.01)

(52) **U.S. Cl.**  
CPC . **H01Q 9/42** (2013.01); **H01Q 5/392** (2015.01)

(58) **Field of Classification Search**  
USPC ..... 343/750, 702, 745, 700 MS  
See application file for complete search history.

(56) **References Cited**

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*Primary Examiner* — Hoang V Nguyen

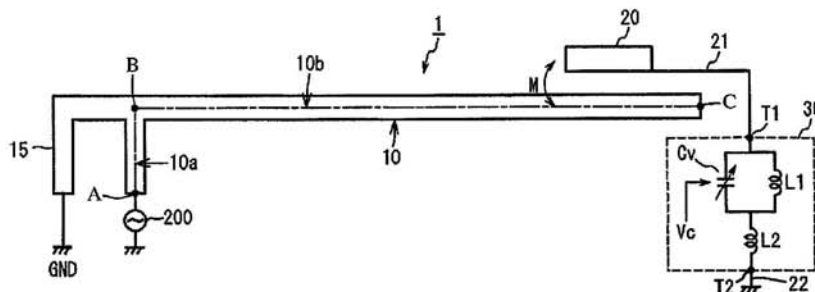
*Assistant Examiner* — Hai Tran

(74) *Attorney, Agent, or Firm* — Sughrue Mion, PLLC

(57) **ABSTRACT**

An antenna device comprising an antenna element disposed on a mounting board separate from a main circuit board, a coupling means disposed on the mounting board such that it is electromagnetically coupled to the antenna element, and a frequency-adjusting means disposed on the mounting board such that it is connected to the coupling means, the antenna element comprising first and second strip-shaped antenna elements integrally connected for sharing a feeding point, the second antenna element being shorter than the first antenna element; the coupling means being formed on a dielectric chip attached to the mounting board, and having a coupling electrode electromagnetically coupled to part of the first antenna element. The frequency-adjusting means comprises a parallel resonance circuit comprising a variable capacitance circuit and a first inductance element, and a second inductance element series-connected to the parallel resonance circuit.

**19 Claims, 19 Drawing Sheets**





US009252502B2

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

(10) **Patent No.:** **US 9,252,502 B2**  
(45) **Date of Patent:** **Feb. 2, 2016**

(54) **INVERTED F-ANTENNAS AT A WIRELESS COMMUNICATION NODE**

(71) Applicant: **Telefonaktiebolaget L M Ericsson**, Stockholm (SE)

(72) Inventors: **Anders Ek**, Hisings Backa (SE); **Ola Kaspersson**, Varberg (SE); **Hakan Karlsson**, Gothenburg (SE)

(73) Assignee: **Telefonaktiebolaget L M Ericsson (publ)**, Stockholm (SE)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 296 days.

(21) Appl. No.: **13/920,781**

(22) Filed: **Jun. 18, 2013**

(65) **Prior Publication Data**  
US 2014/0368405 A1 Dec. 18, 2014

**Related U.S. Application Data**

(63) Continuation of application No. PCT/EP2013/062567, filed on Jun. 18, 2013.

(51) **Int. Cl.**  
**H01Q 1/38** (2006.01)  
**H01Q 21/29** (2006.01)  
(Continued)

(52) **U.S. Cl.**  
CPC ..... **H01Q 21/29** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/521** (2013.01); **H01Q 5/371** (2015.01); **H01Q 9/0421** (2013.01); **H01Q 9/42** (2013.01); **H01Q 21/12** (2013.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 1/243; H01Q 21/12; H01Q 9/0421; H01Q 9/42  
USPC ..... 343/700 MS, 829, 846, 702  
See application file for complete search history.

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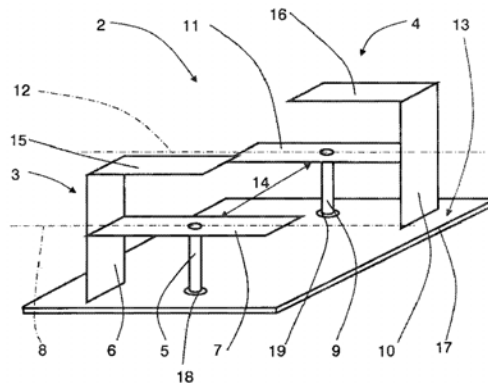
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*Primary Examiner* — Tho G Phan  
(74) *Attorney, Agent, or Firm* — Rothwell, Figg, Ernst & Manbeck, P.C.

(57) **ABSTRACT**

The disclosure relates to a node in a wireless communication arrangement, the node comprising an antenna arrangement that comprises a first and second inverted F antenna. The inverted F antennas comprise a corresponding first and second feed connection, first and second ground connection and a corresponding first and second radiating element mainly extending from the respective ground connection along a corresponding first and second longitudinal extension. The inverted F antennas are arranged on, or in, a plane. Furthermore, the first and second radiating elements are extending in opposite directions along their respective longitudinal extensions from the respective ground connections, the first longitudinal extension and the second longitudinal extension being mutually parallel. The closest distance between the first radiating element and the second radiating element exceeds  $0.4\lambda_0$ , where  $\lambda_0$  is the wavelength for the centre frequency of the frequency band for which the inverted F antennas are intended.

**7 Claims, 3 Drawing Sheets**





US009257738B2

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

(10) **Patent No.:** **US 9,257,738 B2**  
(45) **Date of Patent:** **Feb. 9, 2016**

(54) **MOBILE TERMINAL, AND METHOD FOR IMPROVING RADIATION PERFORMANCE AND SPECIFIC ABSORPTION RATE OF AN ANTENNA OF A MOBILE TERMINAL**

(2013.01); **H01Q 3/24** (2013.01); **H01Q 9/0421** (2013.01)

(75) Inventors: **Young Kon Lim**, Suwon-si (KR); **Joo Hwan Park**, Suwon-si (KR)

(58) **Field of Classification Search**  
CPC ..... H04B 1/3838  
USPC ..... 455/120, 121, 123, 125, 129, 575.5, 455/575.7  
See application file for complete search history.

(73) Assignee: **Samsung Electronics Co., Ltd.**, Suwon-si (KR)

(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 223 days.

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(21) Appl. No.: **13/399,447**

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(22) Filed: **Feb. 17, 2012**

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(65) **Prior Publication Data**  
US 2013/0090072 A1 Apr. 11, 2013

EP 1701406 A1 9/2006  
WO 03-026063 A1 3/2003

(30) **Foreign Application Priority Data**  
Oct. 10, 2011 (KR) ..... 10-2011-0102916

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*Primary Examiner* — Ping Hsieh

(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

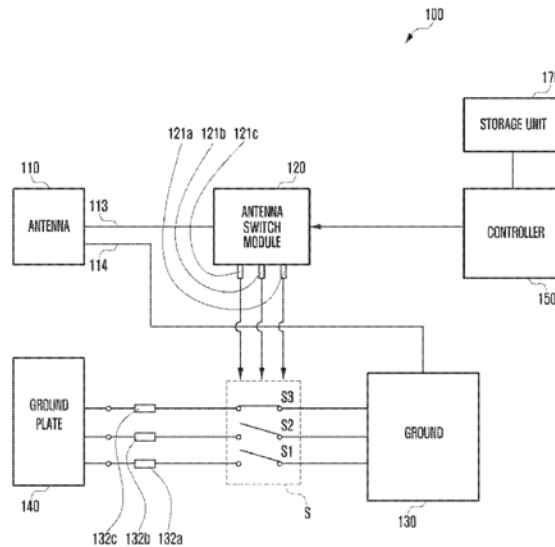
(51) **Int. Cl.**  
**H01Q 11/12** (2006.01)  
**H04B 1/04** (2006.01)  
**H01Q 1/24** (2006.01)  
**H01Q 1/38** (2006.01)  
**H01Q 1/48** (2006.01)  
**H01Q 9/04** (2006.01)  
**H01Q 3/24** (2006.01)

(57) **ABSTRACT**

A method and a mobile terminal of improving radiation performance and Specific Absorption Rate (SAR) of an antenna are provided. The mobile terminal includes a controller for generating a control signal for switching a ground according to a frequency band used by an antenna, and a switch unit for switching a contact point for each frequency band according to the control signal.

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/243** (2013.01); **H01Q 1/245** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/48**

**14 Claims, 16 Drawing Sheets**





US009257740B2

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

(10) **Patent No.:** **US 9,257,740 B2**  
(45) **Date of Patent:** **Feb. 9, 2016**

(54) **WATCH WITH BEZEL ANTENNA CONFIGURATION**

(71) Applicant: **Garmin Switzerland GmbH**, Schaffhausen (CH)

(72) Inventors: **Justin R. Lyons**, Olathe, KS (US); **Todd P. Register**, Olathe, KS (US); **Toby C. Wilcher**, Prairie Village, KS (US); **Jesse R. Simpson**, Overland Park, KS (US); **David L. Dorris**, Olathe, KS (US)

(73) Assignee: **Garmin Switzerland GmbH** (CH)

(\* ) 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.: **14/863,110**

(22) Filed: **Sep. 23, 2015**

(65) **Prior Publication Data**

US 2016/0013544 A1 Jan. 14, 2016

**Related U.S. Application Data**

(63) Continuation of application No. 14/174,330, filed on Feb. 6, 2014, now Pat. No. 9,172,148.

(60) Provisional application No. 61/762,662, filed on Feb. 8, 2013.

(51) **Int. Cl.**

**H01Q 1/24** (2006.01)  
**H01Q 1/27** (2006.01)  
**G01S 19/14** (2010.01)  
**G01S 19/24** (2010.01)  
**G04G 21/04** (2013.01)  
**G04G 17/02** (2006.01)  
**H01Q 21/28** (2006.01)  
**H01Q 9/30** (2006.01)  
**H01Q 7/08** (2006.01)

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

CPC ..... **H01Q 1/273** (2013.01); **G01S 19/14** (2013.01); **G01S 19/24** (2013.01); **G04G 17/02** (2013.01);

(Continued)

(58) **Field of Classification Search**

CPC ..... H01Q 1/243; H01Q 1/273; H01Q 7/08; H01Q 9/30  
USPC ..... 343/702, 718, 788, 900; 702/104; 455/344, 351, 100  
See application file for complete search history.

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*Primary Examiner* — Joseph Lauture

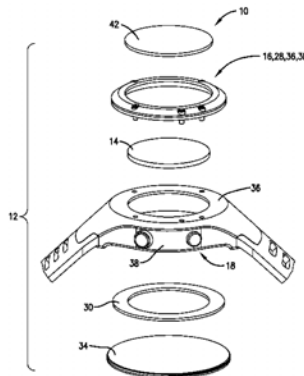
(74) *Attorney, Agent, or Firm* — Samuel M. Korte; Maxwell M. Ali

(57)

**ABSTRACT**

A wrist-worn electronic device comprises a housing, a display, a location determining element, a first antenna, and second antenna. The housing includes a lower surface configured to contact a wearer's wrist, an opposing upper surface, and an internal cavity. The display is visible from the upper surface of the housing. The location determining element is configured to process a location signal to determine a current geolocation of the electronic device. The first antenna is positioned on the upper surface of the housing adjacent a perimeter of the display and electrically connected with the second antenna positioned at least partially within the internal cavity. The first antenna and second antenna function in cooperation to receive the location signal from a satellite-based positioning system and communicate the location signal to the location determining element.

**20 Claims, 5 Drawing Sheets**





US009257749B2

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

(10) **Patent No.:** **US 9,257,749 B2**  
(45) **Date of Patent:** **Feb. 9, 2016**

(54) **ANTENNA ASSEMBLY**

(71) Applicant: **Chiun Mai Communication Systems, Inc.**, New Taipei (TW)

(72) Inventors: **Geng-Hong Liou**, New Taipei (TW);  
**Yen-Hui Lin**, New Taipei (TW)

(73) Assignee: **Chiun Mai 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 196 days.

(21) Appl. No.: **14/038,977**

(22) Filed: **Sep. 27, 2013**

(65) **Prior Publication Data**

US 2014/0300524 A1 Oct. 9, 2014

(30) **Foreign Application Priority Data**

Apr. 9, 2013 (TW) ..... 102112525 A

(51) **Int. Cl.**  
**H01Q 5/15** (2015.01)  
**H01Q 1/24** (2006.01)  
**H01Q 5/378** (2015.01)

(52) **U.S. Cl.**  
CPC ..... **H01Q 5/15** (2015.01); **H01Q 1/243** (2013.01); **H01Q 5/378** (2015.01)

(58) **Field of Classification Search**

CPC ..... H01Q 5/15; H01Q 5/20; H01Q 5/30;  
H01Q 5/378; H01Q 1/243  
USPC ..... 343/702, 700 MS  
See application file for complete search history.

(56) **References Cited**

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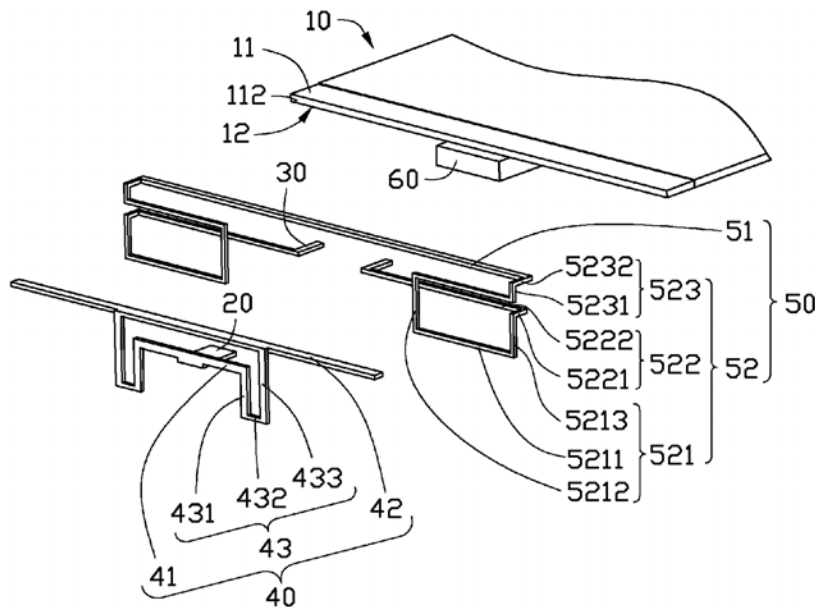
*Primary Examiner* — Hoang V Nguyen

(74) *Attorney, Agent, or Firm* — Novak Druce Connolly Bove + Quigg LLP

(57) **ABSTRACT**

An antenna assembly includes a feed end, a pair of ground ends, a first antenna, and a second antenna connected to the ground ends. The first antenna is connected to the feed end. The first antenna activates a high frequency band resonance mode. The second antenna is connected to the ground ends, and coupled with the first antenna to activate a low frequency band resonance mode. The feed end and the pair of ground ends are parallel to each other. The feed end and the pair of ground ends are coplanar to form a coplanar-waveguide feed structure.

**18 Claims, 4 Drawing Sheets**





US009257750B2

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

(10) **Patent No.:** **US 9,257,750 B2**  
(45) **Date of Patent:** **Feb. 9, 2016**

(54) **ELECTRONIC DEVICE WITH MULTIBAND ANTENNA**

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

(72) Inventors: **Enrique Ayala Vazquez**, Watsonville, CA (US); **Miroslav Samardzija**, Mountain View, CA (US); **Salih Yarga**, Sunnyvale, CA (US); **Robert W. Schlub**, Cupertino, 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 262 days.

(21) Appl. No.: **13/895,194**

(22) Filed: **May 15, 2013**

(65) **Prior Publication Data**

US 2014/0340265 A1 Nov. 20, 2014

(51) **Int. Cl.**  
**H01Q 1/38** (2006.01)  
**H01Q 5/371** (2015.01)  
**H01Q 9/42** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **H01Q 5/371** (2015.01); **H01Q 9/42** (2013.01); **H01Q 1/38** (2013.01)

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

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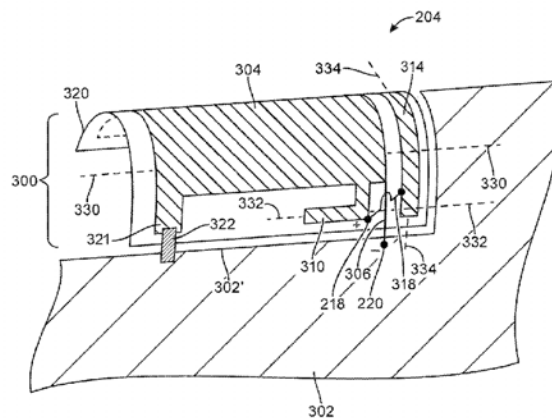
*Primary Examiner* — Tan Ho

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

(57) **ABSTRACT**

An electronic device may have an antenna for providing coverage in wireless communications bands of interest. The wireless communications bands may include first, second, third, and fourth communications bands. The antenna may have an antenna resonating element with first, second, and third arms and may have an antenna ground. The antenna ground may be formed from metal housing structures and other conductive structures in the electronic device. The first arm may be configured to exhibit an antenna resonance in the first and third communications bands. The second arm may be configured to exhibit an antenna resonance in the second communications band. The third arm may be configured to exhibit an antenna resonance in the fourth communications band. The third arm may be located between the first arm and the ground. A diagonal crossover path may pass over a return path and may couple the second and third arms.

**20 Claims, 11 Drawing Sheets**







US009257755B2

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

(10) **Patent No.:** **US 9,257,755 B2**  
(45) **Date of Patent:** **Feb. 9, 2016**

(54) **APPARATUS FOR CONTROLLING ELECTRIC FIELD DISTRIBUTION BY UTILIZING SHORT TRACE STRUCTURES**

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(75) Inventors: **Shih-Wei Hsieh**, Taipei (TW);  
**Han-Chang Lin**, Kaohsiung (TW);  
**Cho-Yi Lin**, New Taipei (TW)

(Continued)

(73) Assignee: **Shenzhen China Star Optoelectronics Technology Co., Ltd.**, Guangming District of Shenzhen, Shenzhen, Guangdong (CN)

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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 551 days.

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(Continued)

(21) Appl. No.: **13/555,208**

(22) Filed: **Jul. 23, 2012**

(65) **Prior Publication Data**  
US 2013/0249739 A1 Sep. 26, 2013

Primary Examiner — Trinh Dinh

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

(30) **Foreign Application Priority Data**  
Mar. 20, 2012 (TW) ..... 101109458 A

(57) **ABSTRACT**

An apparatus for controlling electric field distribution is provided, where the apparatus includes at least one portion of a portable electronic device, the portable electronic device includes a plurality of wireless communication functions respectively corresponding to different communication standards, and the plurality of wireless communication functions includes a mobile phone function and at least one other wireless communication function. The apparatus includes: a main antenna, connected to a first side of a PCB of the portable electronic device, for performing the mobile phone function; and a plurality of short trace structures, positioned at the first side of the PCB and connected to the PCB, wherein at least one of the plurality of short trace structures is selectively utilized as at least one short trace or utilized as at least one secondary antenna corresponding to the at least one other wireless communication function.

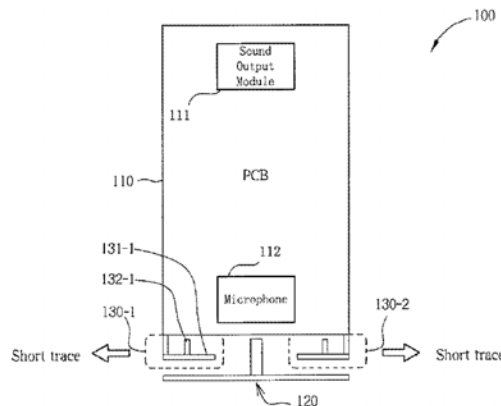
(51) **Int. Cl.**  
**H01Q 1/24** (2006.01)  
**H01Q 21/28** (2006.01)  
**H01Q 3/24** (2006.01)  
(52) **U.S. Cl.**  
CPC ..... **H01Q 21/28** (2013.01); **H01Q 1/243** (2013.01); **H01Q 3/24** (2013.01)

(58) **Field of Classification Search**  
None  
See application file for complete search history.

(56) **References Cited**  
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**12 Claims, 7 Drawing Sheets**





US009258025B2

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

(10) **Patent No.:** **US 9,258,025 B2**  
(45) **Date of Patent:** **Feb. 9, 2016**

(54) **ANTENNA STRUCTURE AND WIRELESS COMMUNICATION DEVICE USING THE SAME**

H04B 1/3833; H04L 29/06217; H04L 29/06442; H01Q 1/243; H01Q 1/242; H01Q 1/244; H01Q 1/084; H01Q 1/38; H01Q 9/0407; H01Q 9/0421

(71) Applicant: **Chiun Mai Communication Systems, Inc.**, New Taipei (TW)

USPC ..... 455/78, 79, 82, 90.2, 550.1, 575.5, 455/575.7; 343/700 MS  
See application file for complete search history.

(72) Inventors: **Chih-Hung Lai**, New Taipei (TW); **Yen-Hui Lin**, New Taipei (TW)

(56) **References Cited**

(73) Assignee: **Chiun Mai Communication Systems, Inc.**, New Taipei (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 55 days.

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|                |         |        |       | 343/700 MS  |

(21) Appl. No.: **14/287,713**

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

*Primary Examiner* — Nhan Le

(65) **Prior Publication Data**

(74) *Attorney, Agent, or Firm* — Novak Druce Connolly Bove + Quigg LLP

US 2014/0357203 A1 Dec. 4, 2014

(30) **Foreign Application Priority Data**

(57) **ABSTRACT**

Jun. 3, 2013 (TW) ..... 102119562 A

Antenna structure includes a feed section, a first radiator, and a second radiator. The first radiator includes a first radiation portion, a ground end, a second radiation portion, the first radiation portion is spaced from the feed end, the ground end is connected between the first radiation portion and the second radiation portion. The second radiator is located below the second radiation portion, and includes a first extending strip, a ground portion, a second extending strip, and a third extending strip. The first extending strip is spaced from the feed end, the second extending strip is connected to the first extending strip and extends along the first extending strip, and the ground portion is connected to a junction of the first extending strip, the second extending strip, and the third extending strip.

(51) **Int. Cl.**

**H04B 1/38** (2015.01)  
**H04B 1/3827** (2015.01)  
**H01Q 1/24** (2006.01)  
**H01Q 5/371** (2015.01)  
**H01Q 5/40** (2015.01)

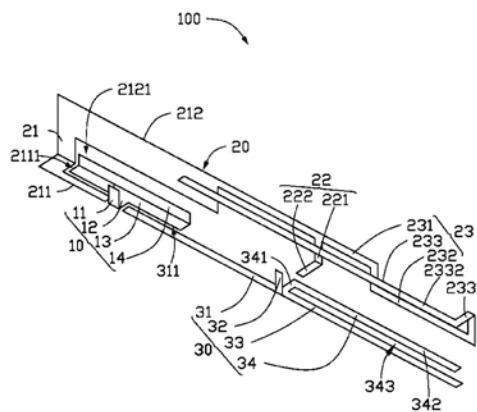
(52) **U.S. Cl.**

CPC ..... **H04B 1/3827** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/371** (2015.01); **H01Q 5/40** (2015.01)

(58) **Field of Classification Search**

CPC ..... H04W 76/005; H04W 4/10; H04B 1/38;

**15 Claims, 4 Drawing Sheets**





US009263788B2

(12) **United States Patent**  
**Ayatollahi**

(10) **Patent No.:** **US 9,263,788 B2**  
(45) **Date of Patent:** **Feb. 16, 2016**

(54) **MOBILE DEVICE HAVING RECONFIGURABLE ANTENNA AND ASSOCIATED METHODS**

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(75) Inventor: **Mina Ayatollahi**, Waterloo (CA)

(73) Assignee: **BLACKBERRY LIMITED**, Ontario (CA)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1011 days.

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(21) Appl. No.: **13/227,968**

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(65) **Prior Publication Data**

US 2013/0065543 A1 Mar. 14, 2013

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(51) **Int. Cl.**  
**H04B 1/44** (2006.01)  
**H01Q 1/24** (2006.01)  
**H01Q 7/00** (2006.01)  
**H01Q 9/14** (2006.01)

Primary Examiner — Hsin-Chun Liao

(74) *Attorney, Agent, or Firm* — Guntin & Gust, PLC; Ralph Trementozzi

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/243** (2013.01); **H01Q 7/00** (2013.01); **H01Q 9/145** (2013.01)

(57) **ABSTRACT**

A mobile wireless communications device includes a wireless transceiver, and a reconfigurable antenna coupled to the wireless transceiver. The reconfigurable antenna has a dielectric substrate, with a plurality of electrical conductors on the dielectric substrate laterally adjacent the ground plane and arranged in a series of spaced apart antenna loops with each successive outer antenna loop surrounding an adjacent inner loop, each antenna loop having a pair of endpoints. A plurality of switches are associated with respective endpoints of the antenna loops. A processor is adapted to reconfigure the reconfigurable antenna and couple the wireless transceiver thereto via the plurality of switches.

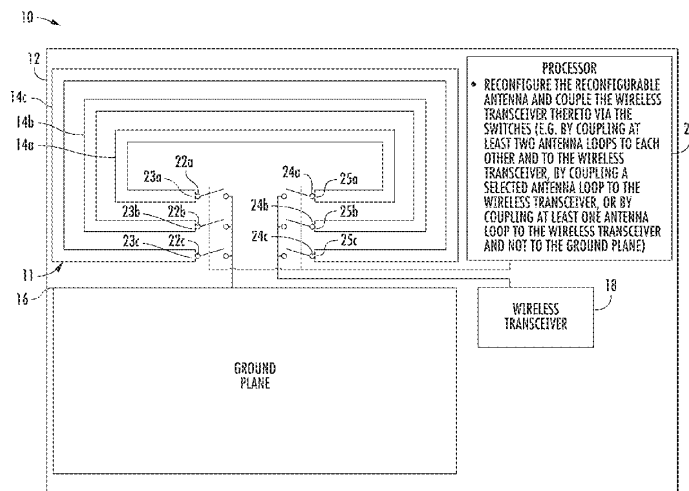
(58) **Field of Classification Search**  
USPC ..... 455/78, 90.2, 90.3, 418; 343/876  
See application file for complete search history.

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**23 Claims, 14 Drawing Sheets**





US009263789B2

(12) **United States Patent**  
**Breiter**

(10) **Patent No.:** **US 9,263,789 B2**  
(45) **Date of Patent:** **Feb. 16, 2016**

- (54) **ANTENNA APPARATUS AND METHODS**
- (75) Inventor: **Richard Breiter**, Fredriksberg (DK)
- (73) Assignee: **Nokia Technologies Oy**, Espoo (FI)
- (\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 178 days.
- (21) Appl. No.: **13/989,249**
- (22) PCT Filed: **Nov. 25, 2010**
- (86) PCT No.: **PCT/IB2010/055433**  
§ 371 (c)(1),  
(2), (4) Date: **May 23, 2013**
- (87) PCT Pub. No.: **WO2012/069884**  
PCT Pub. Date: **May 31, 2012**
- (65) **Prior Publication Data**  
US 2013/0241781 A1 Sep. 19, 2013
- (51) **Int. Cl.**  
**H01Q 1/24** (2006.01)  
**H01Q 5/35** (2015.01)  
**H01Q 5/364** (2015.01)  
**H01Q 5/40** (2015.01)
- (52) **U.S. Cl.**  
CPC ..... **H01Q 1/243** (2013.01); **H01Q 5/35** (2015.01); **H01Q 5/364** (2015.01); **H01Q 5/40** (2015.01); **Y10T 29/49016** (2015.01)
- (58) **Field of Classification Search**  
CPC ..... H01Q 5/35; H01Q 5/364; H01Q 1/243; H01Q 5/40  
USPC ..... 343/702, 700 MS, 872, 873, 741, 866  
See application file for complete search history.

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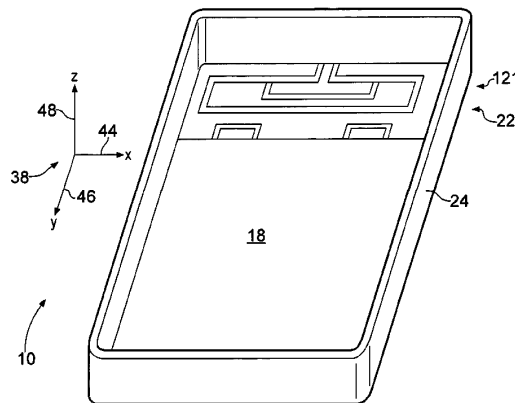
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*Primary Examiner* — Hoanganh Le  
(74) *Attorney, Agent, or Firm* — Nokia Technologies Oy

(57) **ABSTRACT**  
An apparatus comprising: a cover portion defining an exterior surface of the apparatus and including a conductive cover part; a first conductive loop connected to the conductive cover part; and a first coupling member, connectable to radio circuitry and configured to electromagnetically couple with at least one of the first conductive loop and the conductive cover part, wherein at least the conductive cover part and the first conductive loop have a first electrical length and are configured to operate in a first frequency band.

**20 Claims, 9 Drawing Sheets**





US009263790B2

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

(10) **Patent No.:** **US 9,263,790 B2**  
(45) **Date of Patent:** **Feb. 16, 2016**

(54) **STRUCTURES FOR SHIELDING AND MOUNTING COMPONENTS IN ELECTRONIC DEVICES**

(2013.01); **H01Q 1/42** (2013.01); **H01Q 1/526** (2013.01); **Y10T 29/49016** (2015.01)

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

(58) **Field of Classification Search**  
CPC ..... H01Q 1/243; H01Q 1/38; H01Q 1/42  
USPC ..... 343/702, 878; 361/683, 686, 679.01  
See application file for complete search history.

(72) Inventors: **Emery A. Sanford**, San Francisco, CA (US); **Qingxiang Li**, Mountain View, CA (US); **Lijun Zhang**, San Jose, CA (US); **Anthony S. Montevirgen**, San Francisco, CA (US); **Teodor Dabov**, San Francisco, CA (US); **Erik G. de Jong**, San Francisco, CA (US); **Wey-Jiun Lin**, Los Altos Hills, CA (US)

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343/700 MS  
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(73) Assignee: **Apple Inc.**, Cupertino, CA (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 0 days.

*Primary Examiner* — Tho G Phan

(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.; G. Victor Treyz; Joseph F. Guihan

(21) Appl. No.: **14/736,992**

(57) **ABSTRACT**

(22) Filed: **Jun. 11, 2015**

An electronic device may be provided with a conductive housing. An antenna window structure may be formed in an opening in the housing. The antenna window structure may have an antenna support structure that is attached to the conductive housing and that supports antenna structures. An antenna window cap may be mounted in the opening and attached to the antenna support structure with liquid adhesive. Alignment structures may be provided in the antenna support structure. An antenna support plate with mating alignment structures may be used in attaching the antenna structures to the antenna support structures. Metal shielding structures may be used to provide electromagnetic shielding. A shielding wall may be formed from a sheet metal structure supported by a plastic support structure. A flexible metal shielding foil layer may be welded to the shielding wall using a sacrificial plate.

(65) **Prior Publication Data**

US 2015/0280313 A1 Oct. 1, 2015

**Related U.S. Application Data**

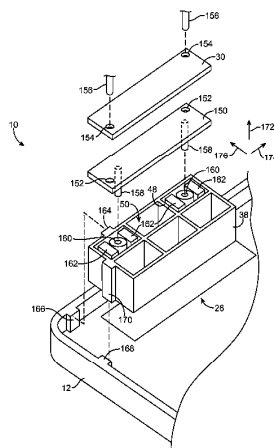
(62) Division of application No. 13/524,997, filed on Jun. 15, 2012, now Pat. No. 9,059,514.

(60) Provisional application No. 61/652,796, filed on May 29, 2012.

(51) **Int. Cl.**  
**H01Q 1/24** (2006.01)  
**H01Q 1/38** (2006.01)  
**H01Q 1/42** (2006.01)  
**H01Q 1/52** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/243** (2013.01); **H01Q 1/38**

**19 Claims, 14 Drawing Sheets**





US009263793B2

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

(10) **Patent No.:** **US 9,263,793 B2**  
(45) **Date of Patent:** **Feb. 16, 2016**

(54) **MULTI-BAND COMMUNICATION SYSTEM WITH ISOLATION AND IMPEDANCE MATCHING PROVISION**

USPC ..... 343/851-852, 860, 861  
See application file for complete search history.

(71) Applicants: **Alexandre Dupuy**, San Diego, CA (US);  
**Laurent Desclos**, San Diego, CA (US)

(56) **References Cited**

(72) Inventors: **Alexandre Dupuy**, San Diego, CA (US);  
**Laurent Desclos**, San Diego, CA (US)

U.S. PATENT DOCUMENTS

(73) Assignee: **ETHERTRONICS, INC.**, San Diego, CA (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 300 days.

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(Continued)

(22) Filed: **Dec. 17, 2012**

(65) **Prior Publication Data**

*Primary Examiner* — Huedung Mancuso

US 2013/0278477 A1 Oct. 24, 2013

(74) *Attorney, Agent, or Firm* — Coastal Patent Law Group, P.C.

**Related U.S. Application Data**

(60) Provisional application No. 61/636,558, filed on Apr. 20, 2012, provisional application No. 61/649,369, filed on May 21, 2012.

(51) **Int. Cl.**  
**H01Q 1/50** (2006.01)  
**H01Q 21/30** (2006.01)  
**H01Q 5/335** (2015.01)  
**H01Q 5/35** (2015.01)

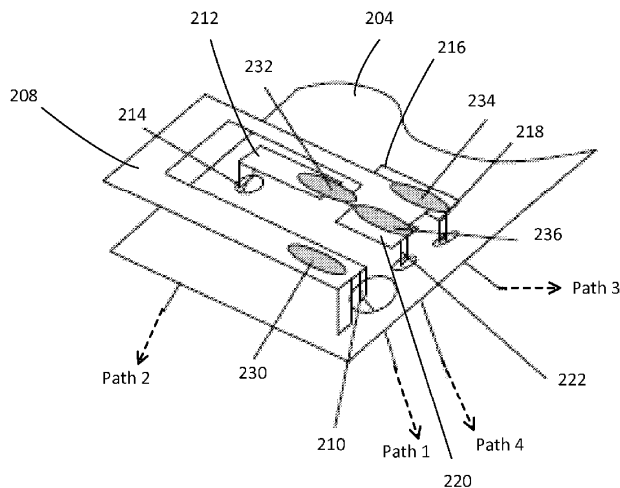
(57) **ABSTRACT**

A communication system is provided, including an antenna coupled to multiple RF paths, one or more matching networks, multiple switches, a controller configured to control the one or more matching networks and the multiple switches, and a look-up table coupled to the controller, the look-up table including characterization data according to frequency bands and conditions. The multiple switches are controlled to engage the signal path corresponding to the frequency band selected. The one or more matching networks are controlled by the controller to provide optimum impedance for the frequency band selected and a condition detected during a time interval with reference to the look-up table. Additional switches may be included to improve isolation.

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/50** (2013.01); **H01Q 5/335** (2015.01); **H01Q 5/35** (2015.01); **H01Q 21/30** (2013.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 1/50

**20 Claims, 18 Drawing Sheets**





US009263795B2

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

(10) **Patent No.:** **US 9,263,795 B2**  
(45) **Date of Patent:** **Feb. 16, 2016**

(54) **MOBILE WIRELESS COMMUNICATIONS DEVICE HAVING DUAL ANTENNA SYSTEM FOR CELLULAR AND WIFI**

(71) Applicant: **BLACKBERRY LIMITED**, Waterloo (CA)

(72) Inventors: **Ying Tong Man**, Waterloo (CA); **Yihong Qi**, Waterloo (CA)

(73) Assignee: **BLACKBERRY LIMITED**, Ontario (CA)

(\* ) 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.: **14/471,521**

(22) Filed: **Aug. 28, 2014**

(65) **Prior Publication Data**  
US 2014/0368390 A1 Dec. 18, 2014

**Related U.S. Application Data**

(63) Continuation of application No. 14/034,592, filed on Sep. 24, 2013, now Pat. No. 8,847,829, which is a continuation of application No. 13/103,144, filed on May 9, 2011, now Pat. No. 8,564,487, which is a continuation of application No. 12/392,321, filed on Feb. 25, 2009, now Pat. No. 7,940,222, which is a continuation of application No. 12/100,613, filed on Apr. 10, 2008, now Pat. No. 7,511,673, which is a continuation of application No. 11/468,803, filed on Aug. 31, 2006, now Pat. No. 7,369,091.

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(58) **Field of Classification Search**  
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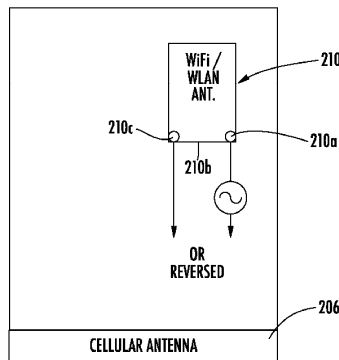
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(57) **ABSTRACT**

A mobile wireless communications device includes a housing and circuit board carried by the housing. Radio Frequency (RF) circuitry is mounted on the circuit board. A first antenna is supported by the circuit board within the housing and operatively connected to the RF circuitry and configured for cellular phone communications. A second antenna is supported by the circuit board within the housing and operatively connected to the RF circuitry and configured for WiFi communications. The second antenna comprises an inverted-F or monopole antenna having an opening gap that is pointed away from the first antenna.

**28 Claims, 5 Drawing Sheets**





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(54) **ANTENNA DEVICE AND ELECTRONIC DEVICE WITH THE SAME**

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- (52) **U.S. Cl.**  
CPC ..... *H01Q 7/00* (2013.01); *H01Q 1/2208* (2013.01); *H01Q 1/243* (2013.01); *H01Q 1/44* (2013.01); *H02J 7/025* (2013.01)
- (58) **Field of Classification Search**  
USPC ..... 343/702, 720, 866, 895  
See application file for complete search history.

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

(57) **ABSTRACT**

An electronic device includes a sheet shaped antenna which is particularly useful for near field communication. The antenna includes a loop type antenna radiator formed on a carrier, the radiator having spiraling loops along an outer region of the carrier. A first feed terminal is provided at one end of the antenna radiator and disposed inside the loops. A second feed terminal is provided at an opposite end of the antenna radiator and disposed outside the loops. The carrier has a cut-out in proximity to the first feed terminal, which enables the first feed terminal to be bent in the same direction as the second feed terminal without bending an outer segment of the antenna radiator adjacent to the cut-out. In this manner, the feed terminals may be defined on a single layer, allowing for a simplified assembly process.

**20 Claims, 4 Drawing Sheets**

