



US008941548B2

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

(10) **Patent No.:** **US 8,941,548 B2**
(45) **Date of Patent:** **Jan. 27, 2015**

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

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

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

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

(21) Appl. No.: **13/460,350**

(22) Filed: **Apr. 30, 2012**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

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

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 5/0034** (2013.01); **H01Q 5/0058** (2013.01); **H01Q 9/42** (2013.01)
USPC **343/749**; 343/702

(58) **Field of Classification Search**
CPC H01Q 9/30; H01Q 5/0034; H01Q 9/32
USPC 343/749, 702
See application file for complete search history.

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Primary Examiner — Dameon E Levi

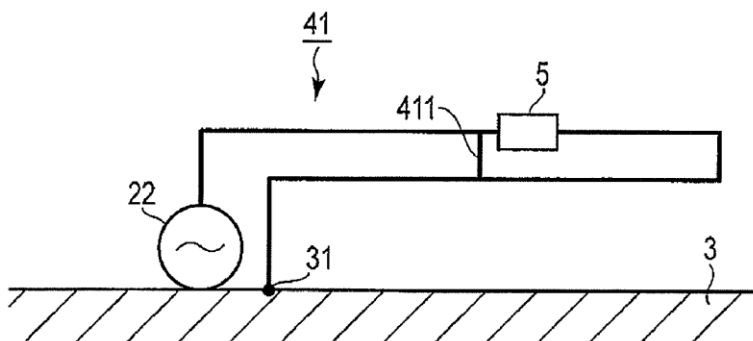
Assistant Examiner — Collin Dawkins

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

(57) **ABSTRACT**

According to one embodiment; an antenna device according to this embodiment includes the first antenna element formed from a folded monopole element and a capacitor element. The first antenna element has a first end connected to a feeding terminal, a second end connected to the first ground terminal, and a middle portion folded, with a stub being provided between the forward portion and backward portion formed by this folding. The capacitor element is inserted between the stub and the above feeding terminal of the forward portion of the first antenna element.

16 Claims, 17 Drawing Sheets





US008941550B2

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

(10) **Patent No.:** **US 8,941,550 B2**
(45) **Date of Patent:** **Jan. 27, 2015**

(54) **MOBILE WIRELESS COMMUNICATIONS DEVICE INCLUDING A SLOT ANTENNA AND RELATED METHODS**

(75) Inventors: **John Alfred Whitmore**, Heidelberg (CA); **Ying Tong Man**, Waterloo (CA)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 566 days.

(21) Appl. No.: **13/229,231**

(22) Filed: **Sep. 9, 2011**

(65) **Prior Publication Data**

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(51) **Int. Cl.**
H01Q 13/10 (2006.01)
H01Q 1/24 (2006.01)
H05K 1/02 (2006.01)

(52) **U.S. Cl.**
CPC **H05K 1/0243** (2013.01); **H01Q 1/242** (2013.01); **H01Q 13/10** (2013.01); **H05K 2201/10371** (2013.01)

USPC **343/767**; **343/702**; **343/850**

(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

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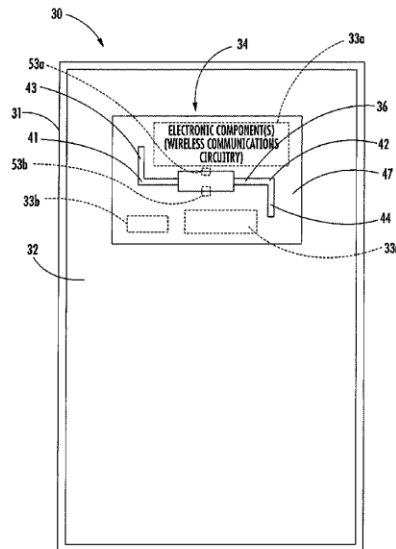
Primary Examiner — Trinh Dinh

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

(57) **ABSTRACT**

A mobile wireless communications device may include a portable housing and a printed circuit board (PCB) carried by the portable housing. The mobile wireless communications device may also include at least one electronic component carried by the PCB and an electrically conductive enclosure coupled to the PCB and having a top spaced above the PCB over the at least one electronic component. The top of the electrically conductive enclosure may have a slot therein defining a slot antenna.

17 Claims, 11 Drawing Sheets





US008942641B2

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

(10) **Patent No.:** **US 8,942,641 B2**
(45) **Date of Patent:** ***Jan. 27, 2015**

- (54) **ANTENNA APPARATUS AND COMMUNICATION APPARATUS**
- (71) Applicant: **Kabushiki Kaisha Toshiba**, Tokyo (JP)
- (72) Inventors: **Isao Ohba**, Hachioji (JP); **Hiroyuki Hotta**, Hamura (JP); **Koichi Sato**, Tachikawa (JP); **Masao Teshima**, Kunitachi (JP)
- (73) Assignee: **Kabushiki Kaisha Toshiba**, Tokyo (JP)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

USPC 455/425, 73, 77, 83, 550.1, 562.1, 455/575.7; 343/803, 871, 881, 915
See application file for complete search history.

- (21) Appl. No.: **14/171,254**
- (22) Filed: **Feb. 3, 2014**
- (65) **Prior Publication Data**

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Related U.S. Application Data

- (63) Continuation of application No. 13/082,246, filed on Apr. 7, 2011, now Pat. No. 8,699,964, which is a continuation of application No. PCT/JP2009/064994, filed on Aug. 27, 2009.

- (51) **Int. Cl.**
H04B 1/40 (2006.01)
H04M 1/00 (2006.01)
(Continued)

- (52) **U.S. Cl.**
CPC **H01Q 9/0442** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/0031** (2013.01); **H01Q 9/145** (2013.01); **H01Q 9/42** (2013.01); **H04B 1/40** (2013.01)
USPC **455/77**; 455/550.1; 455/575.7; 343/803; 343/881

- (58) **Field of Classification Search**
CPC H04B 1/16; H04B 1/40; H04B 2001/16; H04B 1/0028; H04B 1/163; H01Q 9/42; H03J 2200/06

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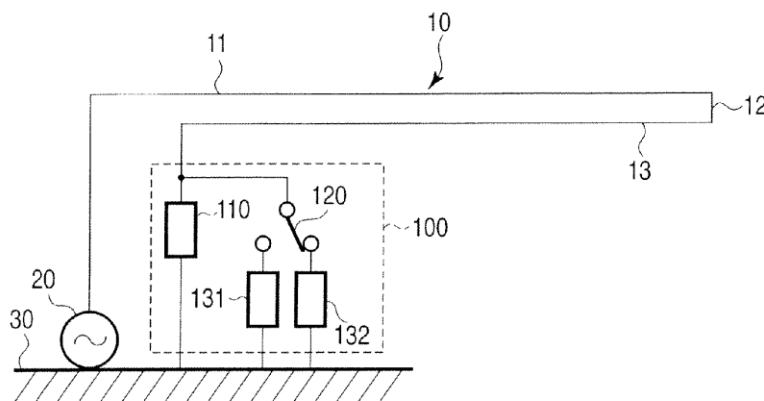
Primary Examiner — Andrew Wendell

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

(57) **ABSTRACT**

According to one embodiment, an antenna apparatus comprises an antenna element connected to a feeding point, a grounded first lumped constant element connected to the antenna element, and a grounded second and third lumped constant elements connected to the antenna element through a selector. The selector is configured to connect the grounded second lumped constant element to the antenna element in order to lower a resonant frequency of the antenna element, and to connect the grounded third lumped constant element to the antenna element in order to raise the resonant frequency of the antenna element.

23 Claims, 18 Drawing Sheets





US008947113B2

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

(10) **Patent No.:** **US 8,947,113 B2**
(45) **Date of Patent:** **Feb. 3, 2015**

(54) **METHODS FOR MODELING TUNABLE RADIO-FREQUENCY ELEMENTS**

(75) Inventors: **Liang Han**, Sunnyvale, CA (US);
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Robert W. Schlub, Cupertino, 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 299 days.

(21) Appl. No.: **13/466,017**

(22) Filed: **May 7, 2012**

(65) **Prior Publication Data**
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(51) **Int. Cl.**
G01R 31/00 (2006.01)

(52) **U.S. Cl.**
USPC **324/750.02**; 324/650

(58) **Field of Classification Search**
USPC 324/601, 750.01, 650
See application file for complete search history.

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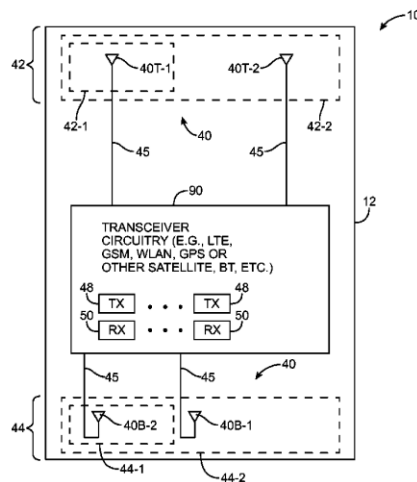
Primary Examiner — Vincent Q Nguyen

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

(57) **ABSTRACT**

A test system for characterizing an antenna tuning element is provided. The test system may include a test host, a radio-frequency tester, and a test fixture. The test system may calibrate the radio-frequency tester using known coaxial standards. The test system may then calibrate transmission line effects associated with the test fixture using a THRU-REFLECT-LINE calibration algorithm. The antenna tuning element may be mounted on a test socket that is part of the test fixture. While the antenna tuning element is mounted on the test socket, scattering parameter measurements may be obtained using the radio-frequency tester. An equivalent circuit model for the test socket can be obtained based on the measured scattering parameters and known characteristics of the antenna tuning element. Once the test socket has been characterized, an equivalent circuit model for the antenna tuning element can be obtained by extracting suitable modeling parameters from the measured scattering parameters.

6 Claims, 14 Drawing Sheets





US008947302B2

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

(10) **Patent No.:** **US 8,947,302 B2**
(45) **Date of Patent:** **Feb. 3, 2015**

(54) **ANTENNA SYSTEM WITH ANTENNA SWAPPING AND ANTENNA TUNING**

(75) Inventors: **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 531 days.

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(22) Filed: **Nov. 5, 2010**

(65) **Prior Publication Data**
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(51) **Int. Cl.**
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H01Q 21/00 (2006.01)
H01Q 9/04 (2006.01)
H01Q 9/42 (2006.01)
H01Q 21/28 (2006.01)
H04B 7/06 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 9/0421** (2013.01); **H01Q 9/42** (2013.01); **H01Q 21/28** (2013.01); **H04B 7/0602** (2013.01); **H04B 7/0689** (2013.01)
USPC **343/702**; 343/725

(58) **Field of Classification Search**
CPC H01Q 1/44; H01Q 21/28
USPC 343/702, 725
See application file for complete search history.

(56) **References Cited**
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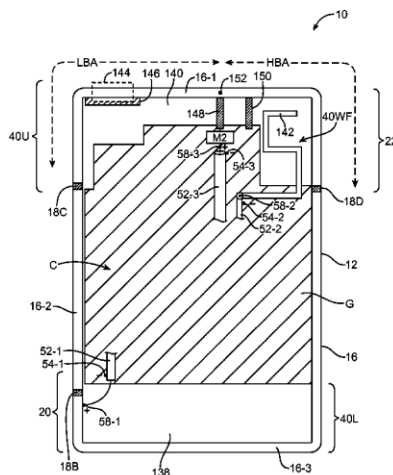
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Primary Examiner — Graham Smith
(74) *Attorney, Agent, or Firm* — Treyz Law Group; G. Victor Treyz; Michael H. Lyons

(57) **ABSTRACT**
Electronic devices may be provided that contain wireless communications circuitry. The wireless communications circuitry may include radio-frequency transceiver circuitry and first and second antennas. An electronic device may include a housing. The first antenna may be located at an upper end of the housing and the second antenna may be located at a lower end of the housing. A peripheral conductive member may run around the edges of the housing and may be used in forming the first and second antennas. The radio-frequency transceiver circuitry may have a transmit-receive port and a receive port. Switching circuitry may connect the first antenna to the transmit-receive port and the second antenna to the receiver port or may connect the first antenna to the receive port and the second antenna to the transmit-receive port.

15 Claims, 8 Drawing Sheets





US008947303B2

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

(10) **Patent No.:** **US 8,947,303 B2**
(45) **Date of Patent:** **Feb. 3, 2015**

(54) **PERIPHERAL ELECTRONIC DEVICE
HOUSING MEMBERS WITH GAPS AND
DIELECTRIC COATINGS**

(75) Inventors: **Albert J. Golko**, Saratoga, CA (US);
Daniel W. Jarvis, 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 1080 days.

(21) Appl. No.: **12/973,586**

(22) Filed: **Dec. 20, 2010**

(65) **Prior Publication Data**

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(51) **Int. Cl.**
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G06F 1/16 (2006.01)
H01Q 1/22 (2006.01)
H04M 1/02 (2006.01)
H01Q 9/04 (2006.01)
H01Q 13/10 (2006.01)
H01Q 21/28 (2006.01)
H04W 88/02 (2009.01)

(52) **U.S. Cl.**
CPC **G06F 1/1698** (2013.01); **H01Q 1/2266**
(2013.01); **H04M 1/026** (2013.01); **H01Q**
1/243 (2013.01); **H01Q 9/0407** (2013.01);
H01Q 13/10 (2013.01); **H01Q 21/28** (2013.01);
H04W 88/02 (2013.01)
USPC **343/702**

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

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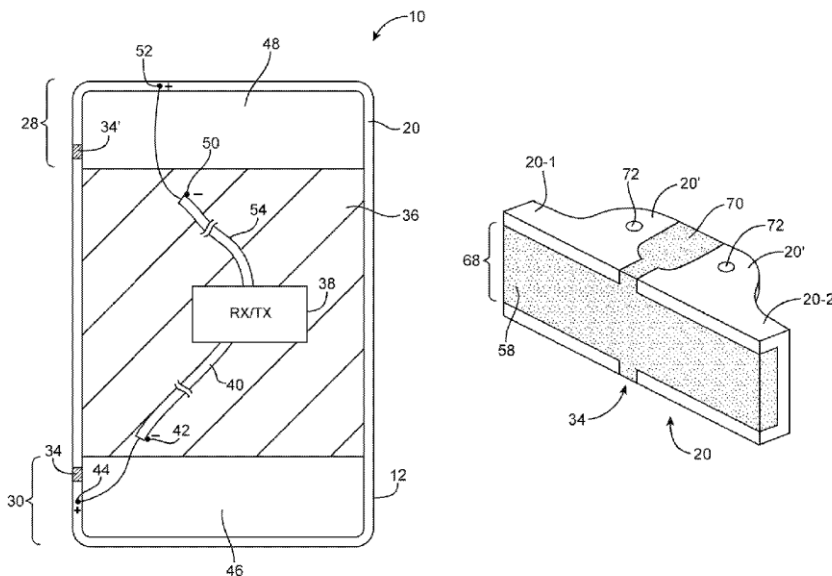
Primary Examiner — Graham Smith

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

(57) **ABSTRACT**

An electronic device such as a handheld device may have a rectangular housing with a rectangular periphery. A conductive peripheral housing member may run along the rectangular periphery and may surround the rectangular housing. Radio-frequency transceiver circuitry within the electronic device may be coupled to antenna structures for transmitting and receiving radio-frequency signals. The conductive peripheral housing member may form part of the antenna structures. A gap in the conductive peripheral housing member may be filled with dielectric. The conductive peripheral housing member may be configured to form a recess. The recess may have the shape of a rectangle, oval, diamond, or other shape that overlaps and is bisected by the gap. The recess may also have the shape of a groove that extends around the entire periphery of the housing. The dielectric in the recess may include one or more different materials such as clear and opaque polymers.

32 Claims, 19 Drawing Sheets





US008947305B2

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

(10) **Patent No.:** **US 8,947,305 B2**
(45) **Date of Patent:** **Feb. 3, 2015**

(54) **ELECTRONIC DEVICES WITH CAPACITIVE PROXIMITY SENSORS FOR PROXIMITY-BASED RADIO-FREQUENCY POWER CONTROL**

(71) Applicant: **Apple Inc.**, Cupertino, CA (US)
(72) Inventors: **David T. Amm**, Sunnyvale, CA (US); **Robert W. Schlub**, Cupertino, CA (US); **Omar S. Leung**, Palo Alto, CA (US); **Brian M. King**, Cupertino, CA (US); **Qingxiang Li**, Mountain View, CA (US); **Enrique Ayala Vazquez**, Watsonville, CA (US); **Rodney A. Gomez Angulo**, Sunnyvale, CA (US); **Yi Jiang**, Cupertino, 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 0 days.

(21) Appl. No.: **13/871,839**

(22) Filed: **Apr. 26, 2013**

(65) **Prior Publication Data**

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Related U.S. Application Data

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(60) Provisional application No. 61/226,683, filed on Jul. 17, 2009.

(51) **Int. Cl.**
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H01Q 1/44 (2006.01)
H03K 17/955 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/24** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/245** (2013.01); **H01Q 1/44** (2013.01); **H03K 17/955** (2013.01); **H03K 2217/960755** (2013.01)
USPC **343/702**

(58) **Field of Classification Search**
CPC H01Q 1/243; H04M 1/0202
USPC 343/702; 455/575.7
See application file for complete search history.

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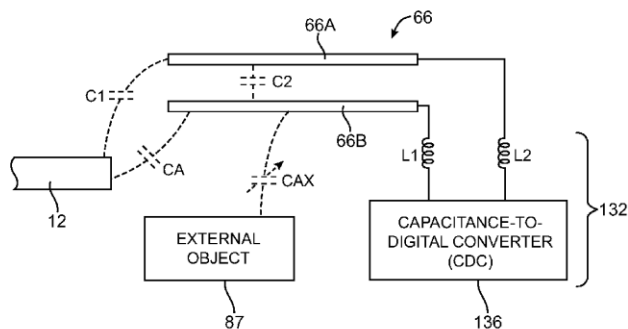
Primary Examiner — Dieu H Duong

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

(57) **ABSTRACT**

An electronic device may have a housing in which an antenna is mounted. An antenna window may be mounted in the housing to allow radio-frequency signals to be transmitted from the antenna and to allow the antenna to receive radio-frequency signals. Near-field radiation limits may be satisfied by reducing transmit power when an external object is detected in the vicinity of the dielectric antenna window and the antenna. A capacitive proximity sensor may be used in detecting external objects in the vicinity of the antenna. The proximity sensor may have conductive layers separated by a dielectric. A capacitance-to-digital converter may be coupled to the proximity sensor by inductors. The capacitive proximity sensor may be interposed between an antenna resonating element and the antenna window. The capacitive proximity sensor may serve as a parasitic antenna resonating element and may be coupled to the housing by a capacitor.

14 Claims, 12 Drawing Sheets





US008947308B2

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

(10) **Patent No.:** **US 8,947,308 B2**
(45) **Date of Patent:** **Feb. 3, 2015**

(54) **METHOD AND APPARATUS FOR CONTROLLING AN ANTENNA**

USPC 343/700 MS, 702, 725, 729, 876
See application file for complete search history.

(71) Applicant: **Skycross, Inc.**, Fremont, CA (US)

(56) **References Cited**

(72) Inventors: **Li Chen**, Melbourne, FL (US); **Frank M. Caimi**, Vero Beach, FL (US); **Mark T. Montgomery**, Melbourne Beach, FL (US); **Paul A. Tornatta, Jr.**, Melbourne, FL (US)

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(73) Assignee: **Skycross, Inc.**, San Jose, 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 168 days.

Primary Examiner — Tho G Phan

(21) Appl. No.: **13/768,834**

(74) Attorney, Agent, or Firm — Guntin & Gust, PLC; Jay H. Anderson

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

(65) **Prior Publication Data**

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Related U.S. Application Data

(60) Provisional application No. 61/600,240, filed on Feb. 17, 2012.

(57) **ABSTRACT**

A system that incorporates the subject disclosure may include, for example, a method for coupling a primary antenna to an auxiliary antenna portion with a current-controlled switch. The method further includes generating a unidirectional direct current or a first bias voltage having a first polarity to cause the current-controlled switch to substantially form a conduction channel between the primary antenna and the auxiliary antenna portion. While the conduction channel is present, a first resonance frequency range of the primary antenna is frequency shifted to a second resonance frequency range. The method can also include removing the unidirectional direct current or generating a second bias voltage having a second polarity to cause the current-controlled switch to form an open circuit between the primary antenna and the auxiliary antenna portion. While the open circuit is present, the first resonance frequency range of the primary antenna is restored. Other embodiments are disclosed.

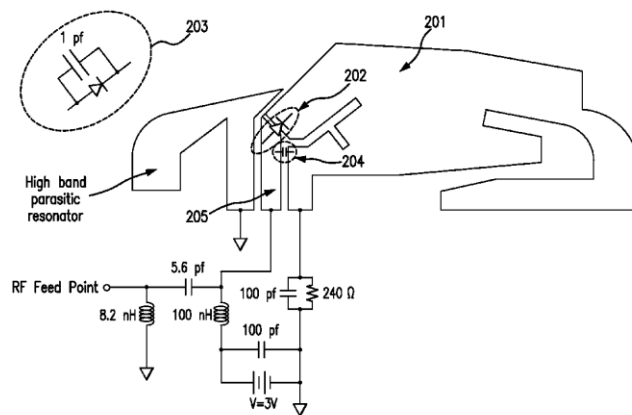
(51) **Int. Cl.**
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H01Q 23/00 (2006.01)
H01Q 1/24 (2006.01)

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(52) **U.S. Cl.**
CPC **H01Q 23/00** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/0034** (2013.01); **H01Q 5/0062** (2013.01); **H01Q 9/0421** (2013.01)
USPC **343/725**; 343/700 MS; 343/702; 343/729; 343/876

(58) **Field of Classification Search**
CPC H01Q 5/34; H01Q 5/62; H01Q 9/421

20 Claims, 13 Drawing Sheets





US008947309B2

(12) **United States Patent**
Hamabe

(10) **Patent No.:** **US 8,947,309 B2**
(45) **Date of Patent:** **Feb. 3, 2015**

(54) **ANTENNA DEVICE AND DISPLAY DEVICE**

USPC 343/702, 725, 726, 727, 803, 805, 795,
343/806

(75) Inventor: **Taichi Hamabe**, Hyogo (JP)

See application file for complete search history.

(73) Assignee: **Panasonic Intellectual Property Management Co., Ltd.**, Osaka (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 327 days.

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(21) Appl. No.: **13/537,881**

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

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(65) **Prior Publication Data**

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Related U.S. Application Data

(63) Continuation of application No. PCT/JP2011/003268, filed on Jun. 9, 2011.

Primary Examiner — Tho G Phan

(30) **Foreign Application Priority Data**

Jun. 10, 2010 (JP) 2010-132684

(74) *Attorney, Agent, or Firm* — McDermott Will & Emery LLP

(51) **Int. Cl.**
H01Q 21/30 (2006.01)
H01Q 19/24 (2006.01)
H01Q 1/24 (2006.01)

(Continued)

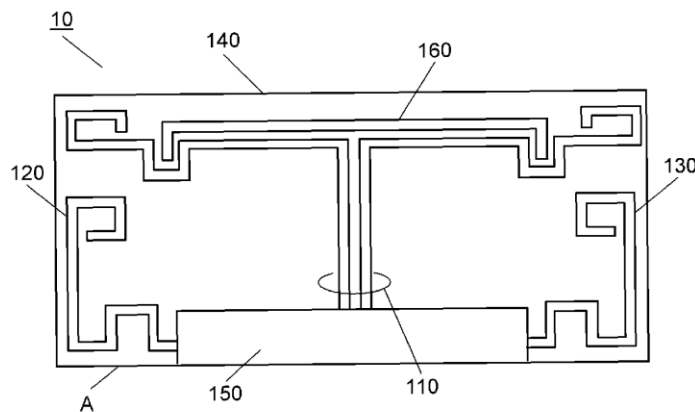
(57) **ABSTRACT**

An antenna device, in which a dipole antenna (110), a first monopole antenna, and a second monopole antenna are disposed on an insulating board (140), wherein the dipole antenna (110) includes left and right elements connected to a power feeding section (150), and the left and right elements have: first portions extended from the power feeding section in a state of facing each other; and second portions extended from the first portions separately to left and right sides, and the first monopole antenna (120) connects to the power feeding section and extends toward the second portion of the left element in the dipole antenna (110), and the second monopole antenna (130) connects to the power feeding section (150) and extended toward the second portion of the right element of the dipole antenna (110).

(52) **U.S. Cl.**
CPC **H01Q 19/24** (2013.01); **H01Q 1/241** (2013.01); **H01Q 9/26** (2013.01); **H01Q 9/42** (2013.01); **H01Q 21/28** (2013.01); **H01Q 25/00** (2013.01)
USPC **343/727**; 343/795; 343/803; 343/806

(58) **Field of Classification Search**
CPC H01Q 19/24; H01Q 1/241; H01Q 21/28;
H01Q 9/26; H01Q 9/42

8 Claims, 6 Drawing Sheets





US008947310B2

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

(10) **Patent No.:** **US 8,947,310 B2**
(45) **Date of Patent:** **Feb. 3, 2015**

- (54) **DUAL-BAND ANTENNA**
- (71) Applicant: **Wistron NeWeb Corporation**, Hsinchu (TW)
- (72) Inventors: **Kai-Yang Cheng**, Hsinchu (TW);
Ming-Feng Chang, Hsinchu (TW);
Chih-Ming 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 166 days.

- (21) Appl. No.: **13/745,857**
- (22) Filed: **Jan. 20, 2013**
- (65) **Prior Publication Data**
US 2014/0071009 A1 Mar. 13, 2014
- (30) **Foreign Application Priority Data**
Sep. 7, 2012 (TW) 101132787 A

- (51) **Int. Cl.**
H01Q 13/10 (2006.01)
H01Q 5/00 (2006.01)
H01Q 13/16 (2006.01)
- (52) **U.S. Cl.**
CPC **H01Q 13/10** (2013.01); **H01Q 5/0058** (2013.01); **H01Q 5/0062** (2013.01); **H01Q 13/16** (2013.01)
USPC **343/770**

- (58) **Field of Classification Search**
USPC 343/702, 767, 770
See application file for complete search history.

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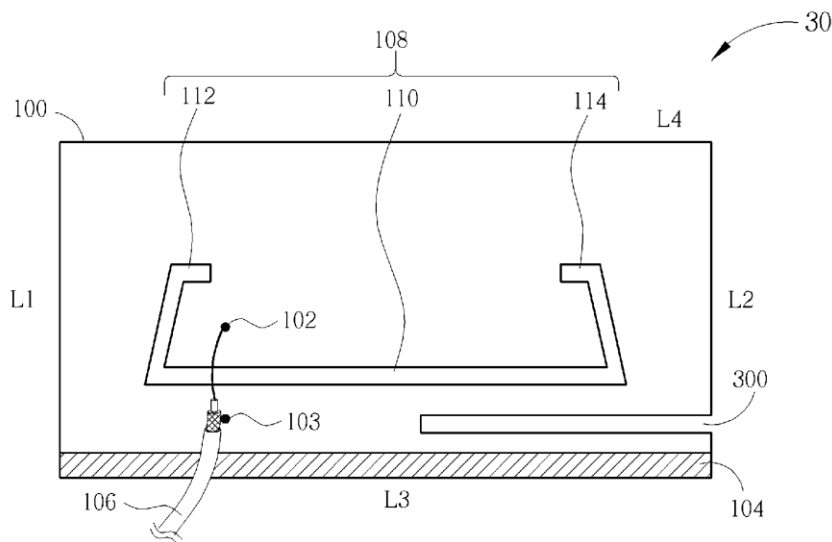
Primary Examiner — Tan Ho

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

(57) **ABSTRACT**

A dual-band antenna utilized in a wireless communication device for receiving or transmitting wireless signals of a first frequency band and a second frequency band includes a rectangular metal plane formed with a slot structure substantially extending from a first side to a second side of the rectangular metal plane, a feeding terminal formed on the rectangular metal plane, and a grounding element, disposed on a third side or a fourth side of the rectangular metal plane, for electrically connecting the rectangular metal plane and a system ground of the wireless communication device, wherein the first side is substantially parallel to the second side, the third side is substantially parallel to the fourth side, and the first side is substantially perpendicular to the third side or the fourth side.

11 Claims, 15 Drawing Sheets





US008947314B2

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

(10) **Patent No.:** **US 8,947,314 B2**
(45) **Date of Patent:** **Feb. 3, 2015**

(54) **MOBILE COMMUNICATION DEVICE AND BUILT-IN ANTENNA INTEGRATED WITH A GROUND PORTION THEREOF**

(75) Inventors: **Kin-Lu Wong**, Tapei Hsien (TW);
Fang-Hsien Chu, Tapei Hsien (TW)

(73) Assignee: **Acer Inc.**, Taipei Hsien (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 479 days.

(21) Appl. No.: **12/849,066**

(22) Filed: **Aug. 3, 2010**

(65) **Prior Publication Data**
US 2011/0227806 A1 Sep. 22, 2011

(30) **Foreign Application Priority Data**
Mar. 22, 2010 (TW) 99108373 A

(51) **Int. Cl.**
H01Q 1/48 (2006.01)
H01Q 5/00 (2006.01)
H01Q 1/24 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 5/0068** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01)
USPC **343/848**; 343/700 MS; 343/906

(58) **Field of Classification Search**
USPC 343/848, 700 MS, 906
IPC H01Q 5/0068, 1/243, 1/48
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Sue A Purvis

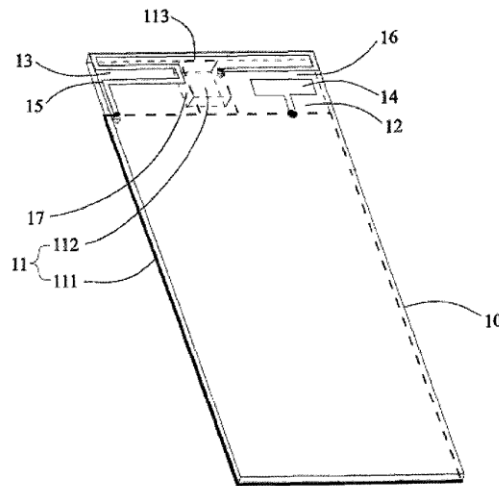
Assistant Examiner — Jae Kim

(74) *Attorney, Agent, or Firm* — Alan D. Kamrath; Kamrath IP Lawfirm, P.A.

(57) **ABSTRACT**

A mobile communication device includes an antenna structure having a dielectric substrate and an antenna. The dielectric substrate includes a ground portion, a first non-ground portion, and a second non-ground portion. The ground portion further includes a main ground and a protruded ground electrically connected to the main ground and extending between the first non-ground portion and the second non-ground portion. The first non-ground portion and the second non-ground portion are separated by the protruded ground. One edge of the protruded ground aligns with one edge of the dielectric substrate. The antenna includes a feeding portion located in the first non-ground portion and a radiating portion extending over the protruded ground and having a first end located in the first non-ground portion and electrically connected to the main ground and a second end of the radiating portion is located in the second non-ground portion and electrically connected to the main ground. There is a coupling gap between the radiating portion and the feeding portion in the first non-ground portion, and the radiating portion is excited by the capacitive coupling effect from the feeding portion.

14 Claims, 4 Drawing Sheets





US008947315B2

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

(10) **Patent No.:** **US 8,947,315 B2**
(45) **Date of Patent:** **Feb. 3, 2015**

(54) **MULTIBAND ANTENNA AND MOUNTING STRUCTURE FOR MULTIBAND ANTENNA**

(75) Inventors: **Kengo Onaka**, Yokohama (JP);
Tsuyoshi Mukai, Nagaokakyo (JP);
Munehisa Watanabe, Yasu (JP)

(73) Assignee: **Murata Manufacturing Co., Ltd.**,
Kyoto-fu (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 812 days.

(21) Appl. No.: **12/958,049**

(22) Filed: **Dec. 1, 2010**

(65) **Prior Publication Data**

US 2011/0134009 A1 Jun. 9, 2011

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2009/055104, filed on Mar. 17, 2009.

(30) **Foreign Application Priority Data**

Jun. 6, 2008 (JP) 2008-149651

(51) **Int. Cl.**
H01Q 21/00 (2006.01)
H01Q 5/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 5/0068** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 5/0041** (2013.01); **H01Q 9/42** (2013.01)
USPC **343/853**; 343/700 MS; 343/833; 343/895; 343/786; 343/756

(58) **Field of Classification Search**
USPC 343/700 MS, 702, 895, 786, 756, 767, 343/833

See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Sue A Purvis

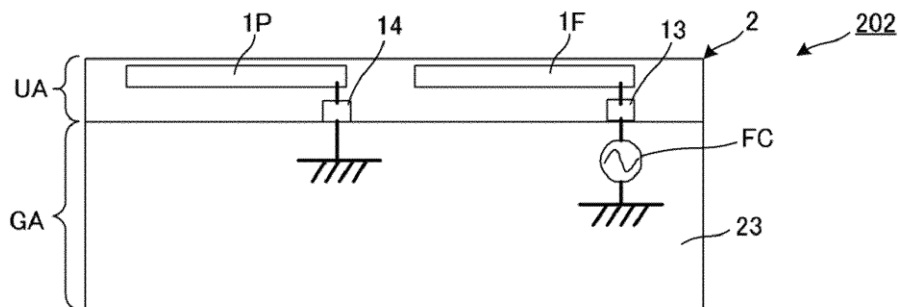
Assistant Examiner — Jae Kim

(74) *Attorney, Agent, or Firm* — Studebaker & Brackett PC

(57) **ABSTRACT**

An antenna that resonates at each of at least operating two frequency bands includes a first LC parallel circuit having a first impedance between a feeding element and a feeding circuit, and a second LC parallel circuit having a second impedance between a parasitic element and ground. The feeding element and the parasitic element are configured such that multiple resonant frequencies are positioned between the two operating frequency bands in a case where the impedances of the first and second LC parallel circuits are set to 0, and the LC parallel circuits having the first and second impedances cause the multiple resonance frequencies to shift to an operating frequency band on the lower frequency side and to the higher frequency side, of the two operating frequency bands.

20 Claims, 6 Drawing Sheets





US008947318B2

(12) **United States Patent**
Bungo

(10) **Patent No.:** **US 8,947,318 B2**
(45) **Date of Patent:** **Feb. 3, 2015**

- (54) **ANTENNA APPARATUS**
- (75) Inventor: **Akihiro Bungo**, Tokyo (JP)
- (73) Assignee: **Sony Mobile Communications Inc.**, Tokyo (JP)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 273 days.
- (21) Appl. No.: **13/358,059**
- (22) Filed: **Jan. 25, 2012**

(65) **Prior Publication Data**
US 2012/0268345 A1 Oct. 25, 2012

Related U.S. Application Data
(60) Provisional application No. 61/478,288, filed on Apr. 22, 2011.

(51) **Int. Cl.**
H01Q 21/00 (2006.01)
H01Q 1/52 (2006.01)
H01Q 1/24 (2006.01)
H01Q 21/28 (2006.01)
H01Q 9/42 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/521** (2013.01); **H01Q 1/243** (2013.01); **H01Q 21/28** (2013.01); **H01Q 9/42** (2013.01)
USPC **343/893**; 343/853; 343/810; 343/834

(58) **Field of Classification Search**
CPC H01Q 1/38; H01Q 21/08; H01Q 21/24; H01Q 1/243; H01Q 21/28; H01Q 1/521; H01Q 9/42

See application file for complete search history.

- (56) **References Cited**
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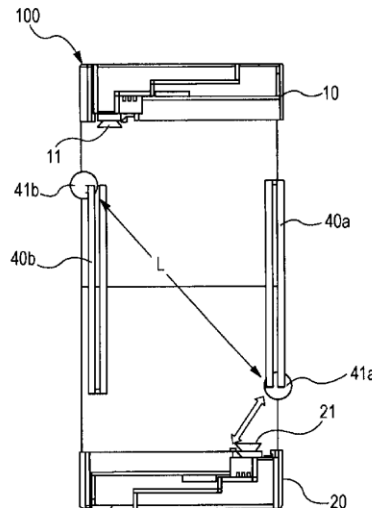
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Primary Examiner — Trinh Dinh
(74) *Attorney, Agent, or Firm* — Oblon, Spivak, McClelland, Maier & Neustadt, L.L.P.

(57) **ABSTRACT**
An antenna apparatus that includes a first antenna having a first feed point, a second antenna having a second feed point, and a first non-feed element grounded at a first ground point disposed at a first predetermined distance from the first feed point and the second feed point.

16 Claims, 29 Drawing Sheets





US008948827B2

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

(10) **Patent No.:** **US 8,948,827 B2**
(45) **Date of Patent:** **Feb. 3, 2015**

(54) **MOBILE COMMUNICATION DEVICE**

(71) Applicant: **Acer Incorporated**, New Taipei (TW)

(72) Inventors: **Wan-Chu Wei**, New Taipei (TW);
Pei-Yuan Chiu, New Taipei (TW);
Chih-Hua Chang, New Taipei (TW)

(73) Assignee: **Acer Incorporated**, New Taipei (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 85 days.

(21) Appl. No.: **13/887,374**

(22) Filed: **May 6, 2013**

(65) **Prior Publication Data**

US 2014/0113693 A1 Apr. 24, 2014

(30) **Foreign Application Priority Data**

Oct. 19, 2012 (TW) 101138734 A

(51) **Int. Cl.**

H04M 1/00 (2006.01)

H04B 1/38 (2006.01)

H01Q 5/00 (2006.01)

H01Q 1/24 (2006.01)

H01Q 9/42 (2006.01)

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

CPC **H04B 1/3833** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/0062** (2013.01); **H01Q 9/42** (2013.01); **H04B 1/3888** (2013.01)

USPC **455/575.7**; **455/90.3**; **455/552.1**; **343/700 MS**; **343/866**

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 21/30; H01Q 5/0062;
H01Q 1/38; H01Q 9/30; H04B 1/0064;
H04B 1/3833

USPC 455/90.3, 550.1, 552.1, 553.1, 575.1,
455/575.7; 343/700 MS, 748, 767, 866, 870
See application file for complete search history.

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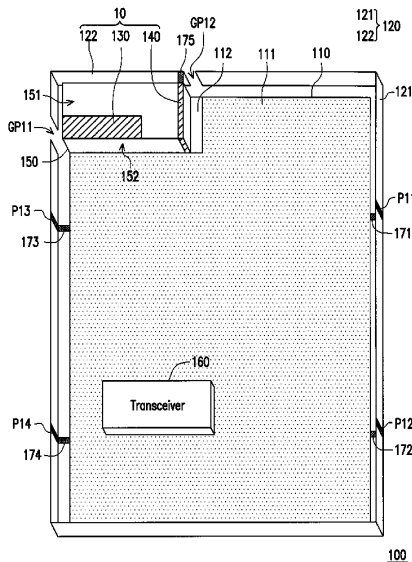
Primary Examiner — Quochien B Vuong

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

(57) **ABSTRACT**

A mobile communication device includes a substrate, a metal frame, a feeding portion, and a parasitic portion. The substrate includes a ground plane and a non-ground area. The metal frame surrounds the substrate and includes a plurality of gaps to form a first frame element and a second frame element separated from each other. The first frame element is electrically connected to the ground plane. The feeding portion and the parasitic portion are located in the non-ground area. A first end of the feeding portion is configured to receive a feeding signal, and a second end of the feeding portion is an open end. The parasitic portion is electrically connected to the second frame element and the ground plane. The feeding portion, the second frame element, and the parasitic portion of the mobile communication device constitute a loop antenna.

10 Claims, 3 Drawing Sheets





US008952850B2

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

(10) **Patent No.:** **US 8,952,850 B2**
(45) **Date of Patent:** **Feb. 10, 2015**

(54) **MIMO ANTENNA APPARATUS**
(75) Inventors: **Sung Won Park**, Suwon-si (KR); **Yeon Joo Lee**, Yongin-si (KR)
(73) Assignee: **Samsung Electronics Co., Ltd.**, Suwon-Si (KR)
(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 429 days.

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

(56) **References Cited**
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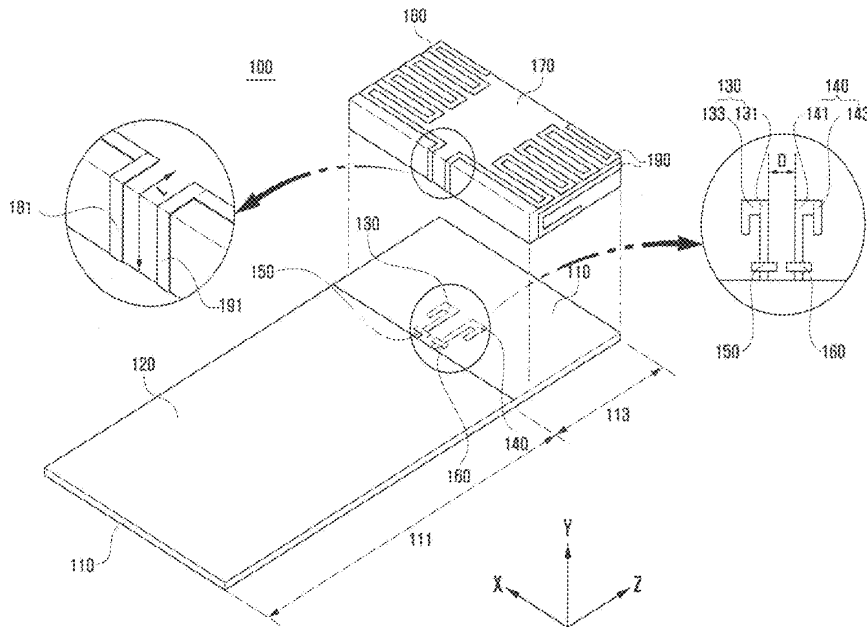
(21) Appl. No.: **13/373,564**
(22) Filed: **Nov. 18, 2011**
(65) **Prior Publication Data**
US 2012/0127056 A1 May 24, 2012
(30) **Foreign Application Priority Data**
Nov. 24, 2010 (KR) 10-2010-0117467

Primary Examiner — Dieu H Duong

(57) **ABSTRACT**
A MIMO antenna apparatus is provided. The MIMO antenna apparatus includes a plurality of antenna devices each having an operation line extending parallel by a predetermined extension length from one end portion and configured to operate in a resonant frequency band when power is supplied. The apparatus also includes a main board divided into a device area and a ground area. The apparatus further includes a plurality of ground pads each extending from the ground plate to the device area in the main board and configured to connect the one end portion of each of the antenna devices to the ground plate. The apparatus also includes a plurality of feeding pads mounted adjacent to the ground pad in the device area and configured to connect each of the antenna devices to the main board and to provide power to each of the antenna devices.

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 1/52 (2006.01)
H01Q 9/42 (2006.01)
H01Q 21/28 (2006.01)
(52) **U.S. Cl.**
CPC **H01Q 1/521** (2013.01); **H01Q 9/42** (2013.01); **H01Q 21/28** (2013.01)
USPC **343/700 MS**; 343/702; 343/893; 343/853

20 Claims, 16 Drawing Sheets





US008952851B1

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

(10) **Patent No.:** **US 8,952,851 B1**
(45) **Date of Patent:** **Feb. 10, 2015**

(54) **DIRECT FEED PATCH ANTENNA**

(56) **References Cited**

(75) Inventors: **Morris Hsu**, Santa Clara, CA (US);
Anuj Dron, San Jose, CA (US); **Tzung-I Lee**, San Jose, CA (US)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 208 days.

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Primary Examiner — Tho G Phan

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

(21) Appl. No.: **13/523,508**

(57) **ABSTRACT**

(22) Filed: **Jun. 14, 2012**

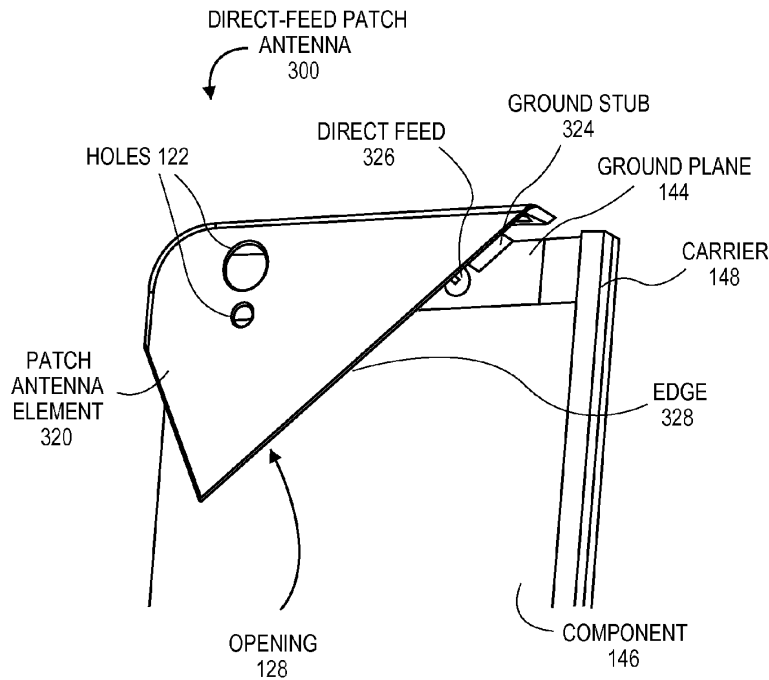
Methods and systems for radiating electromagnetic energy with a direct-feed patch antenna are described. The direct-feed patch antenna may be formed of a metal member of the user device and is grounded to the ground plane at a ground point disposed in relation to a feed location of the direct-feed patch antenna, the feed location to be directly coupled to receive a radio frequency (RF) signal. The direct-feed patch antenna is configured to radiate electromagnetic energy in response to the RF signal.

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

(52) **U.S. Cl.**
USPC **343/700 MS; 343/846**

(58) **Field of Classification Search**
USPC **343/700 MS, 829, 846**
See application file for complete search history.

28 Claims, 15 Drawing Sheets





US008952852B2

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

(10) **Patent No.:** **US 8,952,852 B2**
(45) **Date of Patent:** **Feb. 10, 2015**

(54) **MOBILE WIRELESS COMMUNICATIONS DEVICE INCLUDING ANTENNA ASSEMBLY HAVING SHORTED FEED POINTS AND INDUCTOR-CAPACITOR CIRCUIT AND RELATED METHODS**

(56) **References Cited**

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Primary Examiner — Robert Karacsony

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

(75) Inventors: **Firass Mirza Badaruzzaman**, Oak Park, IL (US); **Shing Lung Steven Yang**, Rolling Meadows, IL (US); **Brian Francisco Rojas**, Chicago, IL (US)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 954 days.

(21) Appl. No.: **13/045,104**

(22) Filed: **Mar. 10, 2011**

(65) **Prior Publication Data**

US 2012/0229349 A1 Sep. 13, 2012

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 9/00 (2006.01)
H01Q 5/00 (2006.01)
H01Q 9/42 (2006.01)
H01Q 9/14 (2006.01)

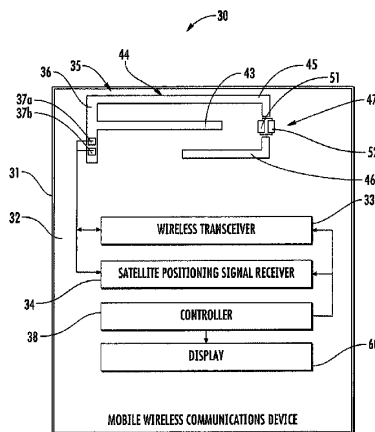
(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 5/0058** (2013.01); **H01Q 9/42** (2013.01); **H01Q 9/14** (2013.01)
USPC **343/702**; 343/749

(58) **Field of Classification Search**
CPC ... H01Q 5/0058; H01Q 1/243; H01Q 5/0031; H01Q 9/14; H01Q 9/42
USPC 343/749, 702
See application file for complete search history.

(57) **ABSTRACT**

A mobile wireless communications device may include a portable housing, at least one wireless transceiver carried by the portable housing, and at least one satellite positioning signal receiver carried by the portable housing. The device may also include an antenna assembly carried by the portable housing. The antenna assembly may include a base conductor having a pair of shorted antenna feed points defined therein and coupled to the at least one wireless transceiver and the at least one satellite positioning receiver, and a first conductor arm extending outwardly from the base conductor. The antenna assembly may also include a second conductor arm also extending outwardly from the base conductor. The second conductor arm may include a proximal conductor portion adjacent the base conductor, a distal conductor portion, and an inductor-capacitor circuit coupling the proximal and distal conductor portions.

24 Claims, 6 Drawing Sheets





US008952853B2

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

(10) **Patent No.:** **US 8,952,853 B2**
(45) **Date of Patent:** ***Feb. 10, 2015**

(54) **WIRELESS HANDHELD ELECTRONIC DEVICE**

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

(72) Inventors: **Phillip M. Hobson**, Menlo Park, CA (US); **Stephen P. Zadesky**, Portola Valley, CA (US); **Erik L. Wang**, Cupertino, CA (US); **Tang Yew Tan**, Palo Alto, CA (US); **Richard H. Dinh**, San Jose, CA (US); **Adam D. Mittleman**, San Francisco, CA (US); **Kenneth A. Jenks**, Capitola, CA (US); **Robert J. Hill**, Salinas, 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 57 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **13/773,010**

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

(65) **Prior Publication Data**
US 2013/0162485 A1 Jun. 27, 2013

Related U.S. Application Data

(63) Continuation of application No. 13/008,586, filed on Jan. 18, 2011, now Pat. No. 8,395,555, which is a continuation of application No. 12/142,552, filed on Jun. 19, 2008, now Pat. No. 7,876,274.

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

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/24** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/48** (2013.01);
(Continued)

(58) **Field of Classification Search**
USPC 343/700 MS, 702, 718, 741, 767, 846, 343/905, 906; 455/575.7
See application file for complete search history.

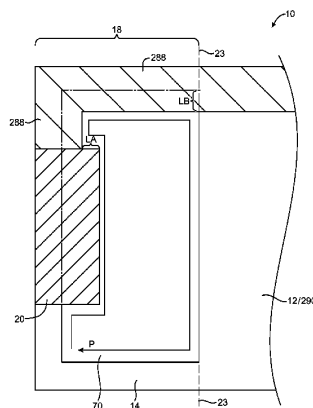
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(Continued)

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

(57) **ABSTRACT**
A handheld electronic device may be provided that contains a conductive housing and other conductive elements. The conductive elements may form an antenna ground plane. One or more antennas for the handheld electronic device may be formed from the ground plane and one or more associated antenna resonating elements. Transceiver circuitry may be connected to the resonating elements by transmission lines such as coaxial cables. Ferrules may be crimped to the coaxial cables. A bracket with extending members may be crimped over the ferrules to ground the coaxial cables to the housing and other conductive elements in the ground plane. The ground plane may contain an antenna slot. A dock connector and flex circuit may overlap the slot in a way that does not affect the resonant frequency of the slot. Electrical components may be isolated from the antenna using isolation elements such as inductors and resistors.

20 Claims, 38 Drawing Sheets





US008952861B2

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

(10) **Patent No.:** **US 8,952,861 B2**
(45) **Date of Patent:** **Feb. 10, 2015**

- (54) **MULTI-BAND MIMO ANTENNA**
- (71) Applicants: **Laurent Desclos**, San Diego, CA (US); **Sebastian Rowson**, San Diego, CA (US); **Jeffrey Shamblin**, San Marcos, CA (US); **Young Cha**, San Diego, CA (US)
- (72) Inventors: **Laurent Desclos**, San Diego, CA (US); **Sebastian Rowson**, San Diego, CA (US); **Jeffrey Shamblin**, San Marcos, CA (US); **Young Cha**, San Diego, CA (US)
- (73) Assignee: **Ethertronics, Inc.**, San Diego, CA (US)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.
- (21) Appl. No.: **13/966,074**
- (22) Filed: **Aug. 13, 2013**
- (65) **Prior Publication Data**
US 2013/0335290 A1 Dec. 19, 2013

Related U.S. Application Data

- (60) Division of application No. 13/548,221, filed on Jul. 13, 2012, now Pat. No. 8,542,158, which is a continuation-in-part of application No. 13/548,211, filed on Jul. 13, 2012, now Pat. No. 8,648,756, which is a continuation-in-part of application No. 13/289,901, filed on Nov. 4, 2011, now Pat. No. 8,717,241, which is a continuation of application No. 12/894,052, filed on Sep. 29, 2010, now Pat. No. 8,077,116, which is a continuation of application No. 11/841,207, filed on Aug. 20, 2007, now Pat. No. 7,830,320.

- (51) **Int. Cl.**
H01Q 21/28 (2006.01)
H01Q 9/04 (2006.01)
- (52) **U.S. Cl.**
CPC **H01Q 21/28** (2013.01); **H01Q 9/0442** (2013.01)
USPC **343/853**; 343/858
- (58) **Field of Classification Search**
CPC H01Q 21/28; H01Q 9/0442; H01Q 1/521; H01Q 21/0006
USPC 343/702, 893, 853, 858
See application file for complete search history.

(56) **References Cited**

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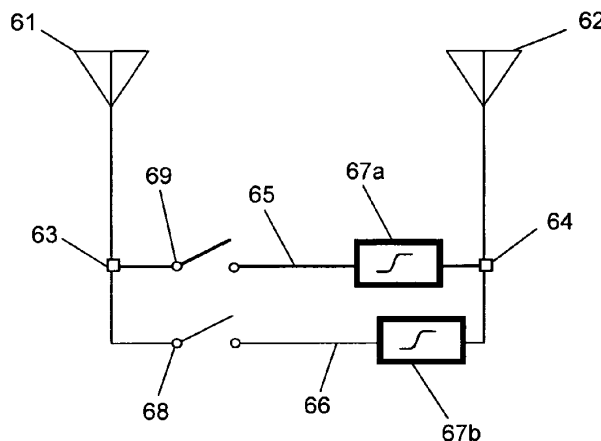
Primary Examiner — Hoanganh Le

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

(57) **ABSTRACT**

A multi-band antenna system for MIMO applications is adapted to provide high isolation between antennas across a wide range of frequencies. Multiple Isolated Magnetic Dipole (IMD) antennas are co-located and connected with a feed network that can include switches that adjust phase length for transmission lines connecting the antennas. Filtering is integrated into the feed network to improve rejection of unwanted frequencies. Filtering can also be implemented on the antenna structure. Either one or multi-port antennas can be used.

9 Claims, 9 Drawing Sheets





US008954122B2

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

(10) **Patent No.:** **US 8,954,122 B2**
(45) **Date of Patent:** **Feb. 10, 2015**

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

USPC 455/83, 575.7, 575.1; 340/572.5, 572.1, 340/572.7; 342/375, 368, 372; 343/895, 343/720, 718, 702
See application file for complete search history.

(71) Applicant: **BluFlux RF Technologies, LLC**,
Louisville, CO (US)

(56) **References Cited**

(72) Inventors: **Benjamin R. Wilmhoff**, Boulder, CO (US); **Andrew D. Rowser**, Boulder, CO (US)

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(73) Assignee: **BluFlux RF Technologies, LLC**,
Louisville, CO (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.

(21) Appl. No.: **14/322,027**

(22) Filed: **Jul. 2, 2014**

(65) **Prior Publication Data**

US 2015/0011273 A1 Jan. 8, 2015

Related U.S. Application Data

(60) Provisional application No. 61/842,735, filed on Jul. 3, 2013, provisional application No. 62/007,002, filed on Jun. 3, 2014.

(51) **Int. Cl.**
H04M 1/00 (2006.01)
H01Q 1/24 (2006.01)
H04W 4/02 (2009.01)

(52) **U.S. Cl.**
CPC **H01Q 1/245** (2013.01); **H01Q 1/243** (2013.01); **H04W 4/02** (2013.01)
USPC **455/575.7**; 455/575.1; 343/895; 343/720; 343/718; 342/375

(58) **Field of Classification Search**
CPC H04W 4/02; H04Q 1/245; H04Q 1/243; H04M 1/00

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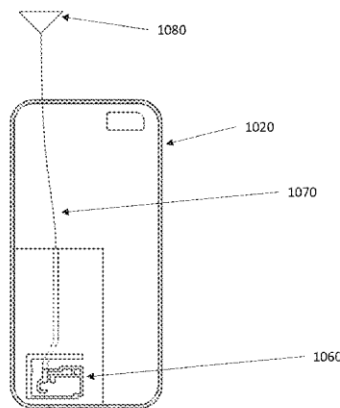
Primary Examiner — Mahendra Patel

(74) *Attorney, Agent, or Firm* — Kelly Frazier

(57) **ABSTRACT**

A case for a mobile electronic device is provided. The case includes a shell, a case antenna, a transmission line, and a near-field coupling device. The shell encases at least a portion of the mobile electronic device. The case antenna is attached to the shell. The transmission line is also attached to the shell and electrically interconnects to the case antenna. The near-field coupling device has a feed port electrically interconnected to the transmission line and is configured to near-field couple to a native antenna of the mobile electronic device to capture an electromagnetic signal generated by the native antenna of the mobile electronic device. The near-field coupling device is also configured to conduct the captured electromagnetic signal from the feed port of the near-field coupling device to the case antenna through the transmission line.

19 Claims, 16 Drawing Sheets





US008957813B2

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

(10) **Patent No.:** **US 8,957,813 B2**
(45) **Date of Patent:** **Feb. 17, 2015**

(54) **EXTERNAL CASE FOR REDISTRIBUTION OF RF RADIATION AWAY FROM WIRELESS COMMUNICATION DEVICE USER AND WIRELESS COMMUNICATION DEVICE INCORPORATING RF RADIATION REDISTRIBUTION ELEMENTS**

(75) Inventors: **Ryan G McCaughey**, Sherman Oaks, CA (US); **Karl Richard Shields**, North Hills, CA (US); **Nikhil Nilakantan**, West Hills, CA (US)

(73) Assignee: **Pong Research Corporation**, Encinitas, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 508 days.

(21) Appl. No.: **13/287,680**

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

(65) **Prior Publication Data**
US 2012/0044115 A1 Feb. 23, 2012

Related U.S. Application Data

(63) Continuation-in-part of application No. 12/724,290, filed on Mar. 15, 2010, now Pat. No. 8,214,003, and a continuation-in-part of application No. 12/614,132, filed on Nov. 6, 2009, now Pat. No. 8,208,980.

(60) Provisional application No. 61/160,282, filed on Mar. 13, 2009.

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

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

(2013.01); **H01Q 7/00** (2013.01); **H01Q 19/005** (2013.01); **H01Q 19/28** (2013.01)

USPC **343/702**; 343/834

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/52; H01Q 19/005
USPC 343/700 MS, 702, 866, 834
See application file for complete search history.

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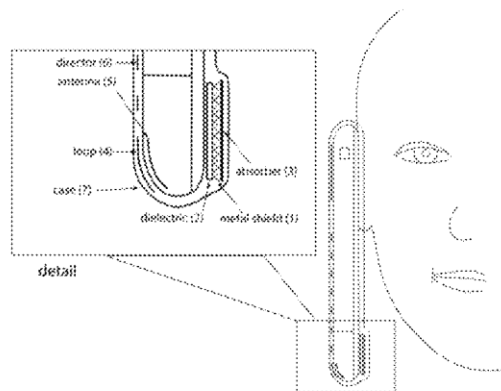
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Primary Examiner — Tan Ho

(57) **ABSTRACT**

A case for a wireless tablet computer device includes a number of RF resonant loop elements and elongated RF director coupling strip elements mounted in the case and configured such that RF radiation is coupled from an internal antenna of the wireless device out of the device to the RF resonant and coupling elements. The case incorporates a cut-out section in a location leaving exposed a strip that covers an area proximate the internal antenna. The RF resonant loops and director coupling strip elements alternatively may be incorporated with the wireless tablet computer device itself.

17 Claims, 14 Drawing Sheets





US008957814B2

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

(10) **Patent No.:** **US 8,957,814 B2**
(45) **Date of Patent:** **Feb. 17, 2015**

(54) **ANTENNA DEVICE FOR A PORTABLE TERMINAL**

(2013.01); **H01Q 5/0062** (2013.01); **H01Q 5/0072** (2013.01); **H01Q 9/42** (2013.01); **H01Q 13/16** (2013.01)

(75) Inventors: **Sang-Jin Eom**, Gyeonggi-do (KR); **Hoon Park**, Seoul (KR); **Ho-Saeng Kim**, Gyeonggi-do (KR); **Austin Kim**, Gyeonggi-do (KR); **Yong-Jin Kim**, Seoul (KR); **Chi-Hyung Ahn**, Gyeonggi-do (KR)

USPC **343/702**; 343/767
(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 5/0062; H01Q 9/42
USPC 343/702, 767
See application file for complete search history.

(73) Assignee: **Samsung Electronics Co., Ltd.**, Samsung-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do (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 230 days.

U.S. PATENT DOCUMENTS

(21) Appl. No.: **13/435,269**

(22) Filed: **Mar. 30, 2012**

(65) **Prior Publication Data**

US 2012/0313834 A1 Dec. 13, 2012

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Primary Examiner — Hoang V Nguyen

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

(30) **Foreign Application Priority Data**

Jun. 10, 2011 (KR) 10-2011-0056410

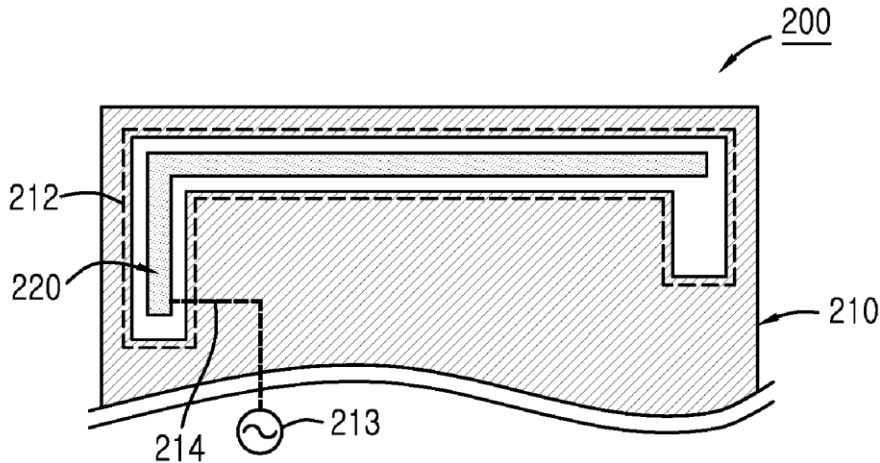
(57) **ABSTRACT**

An antenna device attains good antenna performance using at least one or more metal members installed in a portable terminal. The antenna device includes a main board equipped with a power supply part for supplying power, a slot part which is positioned in at least one or more metal members or is formed by a combination of the metal members, and a power supply antenna member for receiving power from the power supply part and which is electromagnetically coupled with the slot part.

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/00 (2006.01)
H01Q 9/42 (2006.01)
H01Q 13/16 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 5/0017**

19 Claims, 13 Drawing Sheets





US008957825B2

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

(10) **Patent No.:** **US 8,957,825 B2**
(45) **Date of Patent:** **Feb. 17, 2015**

- (54) **DECOUPLING CIRCUIT AND ANTENNA DEVICE**
- (71) Applicant: **Wistron NeWeb Corporation**, Hsinchu (TW)
- (72) Inventors: **I-Shan Chen**, Hsinchu (TW);
Chao-Chun Lin, Hsinchu (TW);
Yi-Chieh Wang, Hsinchu (TW);
Cheng-Hsiung Hsu, Hsinchu (TW)
- (73) Assignee: **Wistron NeWeb Corporation**, Hsinchu (TW)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 201 days.
- (21) Appl. No.: **13/789,613**
- (22) Filed: **Mar. 7, 2013**
- (65) **Prior Publication Data**
US 2014/0125543 A1 May 8, 2014
- (30) **Foreign Application Priority Data**
Nov. 6, 2012 (TW) 101141134 A
- (51) **Int. Cl.**
H01Q 21/28 (2006.01)
H01Q 1/32 (2006.01)
H01Q 1/42 (2006.01)
H01Q 1/52 (2006.01)
H01Q 9/42 (2006.01)
- (52) **U.S. Cl.**
CPC **H01Q 21/28** (2013.01); **H01Q 1/3275** (2013.01); **H01Q 1/42** (2013.01); **H01Q 1/521** (2013.01); **H01Q 9/42** (2013.01)

USPC **343/841**; 343/700 MS

(58) **Field of Classification Search**
CPC H01Q 1/3275; H01Q 1/42; H01Q 21/28; H01Q 9/42; H01Q 1/521
USPC 343/841, 702, 700 MS
See application file for complete search history.

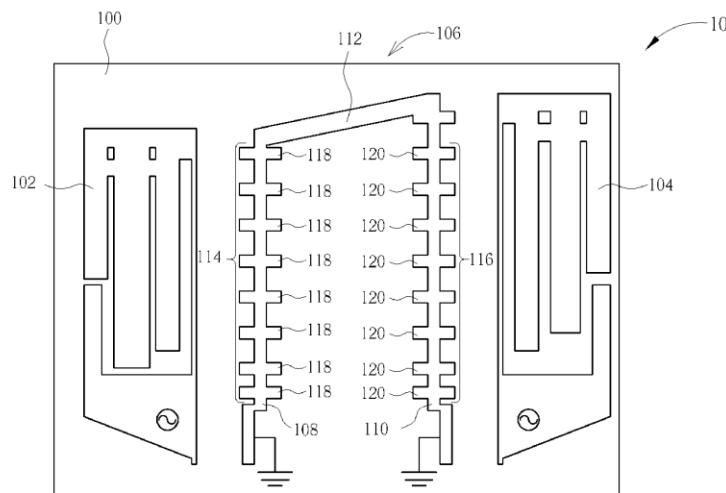
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Primary Examiner — Hoanganh Le
(74) *Attorney, Agent, or Firm* — Winston Hsu; Scott Margo

(57) **ABSTRACT**

A decoupling circuit for enhancing isolation of two antennas is disclosed. The two antennas are substantially symmetrically disposed on a substrate. The decoupling circuit includes a first and second metal strips parallel disposed between the two antennas and electrically connected to a ground, a connection strip electrically connected between terminals of the first and second metal strips, to substantially form a door-frame structure, a first comb structure comprising a plurality of metal segments parallel to each other, disposed on the substrate, electrically connected to and perpendicular to the first metal strip, and a second comb structure comprising a plurality of metal segments parallel to each other, disposed on the substrate, electrically connected to and perpendicular to the second metal strip.

20 Claims, 13 Drawing Sheets





US008957826B2

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

(10) **Patent No.:** **US 8,957,826 B2**
(45) **Date of Patent:** ***Feb. 17, 2015**

(54) **ANTENNA DEVICE**

(71) Applicant: **Fujitsu Component Limited**, Tokyo (JP)
(72) Inventors: **Shigemi Kurashima**, Tokyo (JP); **Masahiro Yanagi**, Tokyo (JP); **Hideaki Yoda**, Tokyo (JP)
(73) Assignee: **Fujitsu Component Limited**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 238 days.
This patent is subject to a terminal disclaimer.

(21) Appl. No.: **13/645,752**
(22) Filed: **Oct. 5, 2012**

(65) **Prior Publication Data**
US 2013/0093642 A1 Apr. 18, 2013

(30) **Foreign Application Priority Data**
Oct. 18, 2011 (JP) 2011-229216

(51) **Int. Cl.**
H01Q 1/48 (2006.01)
H01Q 1/38 (2006.01)
H01Q 1/42 (2006.01)
G06K 19/00 (2006.01)
H01Q 9/04 (2006.01)
H01Q 1/22 (2006.01)

(52) **U.S. Cl.**
CPC . **H01Q 1/38** (2013.01); **H01Q 1/42** (2013.01);
H01Q 1/48 (2013.01); **G06K 19/00** (2013.01);
H01Q 9/0421 (2013.01); **H01Q 1/22** (2013.01)
USPC **343/848**; **343/702**

(58) **Field of Classification Search**
CPC H01Q 1/38; H01Q 1/42; H01Q 1/48; H01Q 1/22
USPC 343/702, 700 MS, 846, 848
See application file for complete search history.

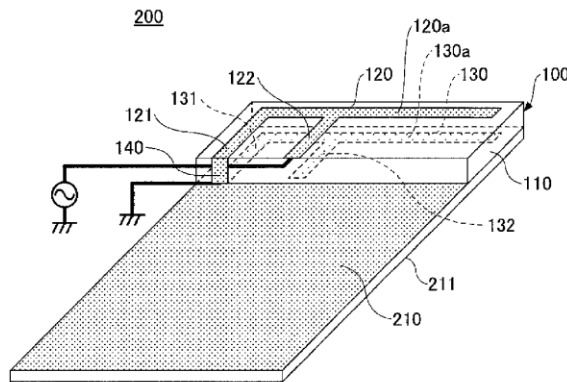
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Primary Examiner — Hoanganh Le
(74) *Attorney, Agent, or Firm* — IPUSA PLLC

(57) **ABSTRACT**
An antenna device to be inserted in a memory card slot of an electronic device, includes an insulating layer, an antenna element formed on one surface of the insulating layer, and a ground element formed on the other surface of the insulating layer, the antenna element and the ground element being formed such that at least a part of the antenna element and at least a part of the ground element protrude from the memory card slot of the electronic device when the antenna device is inserted in the memory card slot, respectively; and a ground pattern extending in parallel relationship with the antenna element to be electrically connected to at least the ground element.

11 Claims, 26 Drawing Sheets





US008957827B1

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

(10) **Patent No.:** **US 8,957,827 B1**
(45) **Date of Patent:** **Feb. 17, 2015**

(54) **ANTENNA STRUCTURE WITH MULTIPLE MATCHING CIRCUITS**

(71) Applicants: **Tzung-I Lee**, San Jose, CA (US); **In Chul Hyun**, San Jose, CA (US)

(72) Inventors: **Tzung-I Lee**, San Jose, CA (US); **In Chul Hyun**, San Jose, CA (US)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 241 days.

(21) Appl. No.: **13/627,628**

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

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

(52) **U.S. Cl.**
USPC **343/852**; 343/700 MS; 343/702

(58) **Field of Classification Search**
USPC 343/702, 700 MS, 848, 850, 860, 852
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

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(57) **ABSTRACT**

Off-feed matching circuits for antenna structures of user devices and methods of operating the user devices with the off-feed matching circuits are described. Off-feed matching circuits are matching circuits that are positioned on the radiating elements and not on the feed line. One apparatus includes a RF feed coupled to an excitation antenna element of an antenna structure. The antenna structure also includes two radiating antenna elements and two matching circuits, one for each of the radiating antenna elements. The two radiating antenna elements may be conductively coupled to the excitation antenna element or parasitically coupled to the excitation element.

22 Claims, 7 Drawing Sheets

