



US009142876B2

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

(10) **Patent No.:** **US 9,142,876 B2**
(45) **Date of Patent:** **Sep. 22, 2015**

(54) **PLANAR ANTENNA AND HANDHELD DEVICE**

(75) Inventors: **Min-Che Chen**, Taoyuan County (TW);
Chia-I Lin, Taoyuan County (TW);
Chih-Wei Hsu, Taoyuan County (TW)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 838 days.

(21) Appl. No.: **13/041,435**

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

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Mar. 30, 2010 (TW) 99109633 A

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/52 (2006.01)
H01Q 9/42 (2006.01)
H01Q 21/28 (2006.01)
H01Q 5/10 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/521** (2013.01); **H01Q 5/10** (2015.01); **H01Q 9/42** (2013.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/521; H01Q 21/28
See application file for complete search history.

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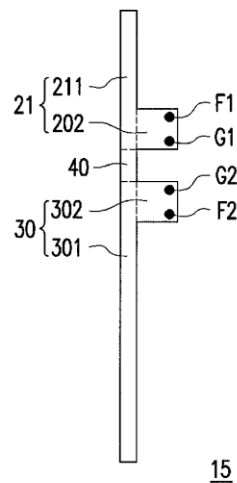
Primary Examiner — Robert Karacsony

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

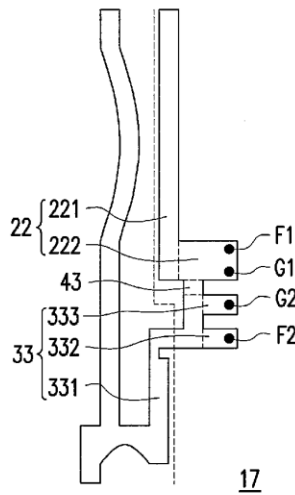
(57) **ABSTRACT**

A planar antenna and a handheld device are provided. The handheld device includes the planar antenna and a system ground plane. The planar antenna has a first feed point, a first ground point, a second feed point, and a second ground point. The first ground point and the second ground point are located between the first feed point and the second feed point. The system ground plane is electrically connected to the first feed point, the first ground point, the second feed point, and the second ground point. Thereby, the performance in radio signal transceiving is improved.

6 Claims, 8 Drawing Sheets



15



17



US009142878B2

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

(10) **Patent No.:** **US 9,142,878 B2**
(45) **Date of Patent:** **Sep. 22, 2015**

- (54) **ANTENNA AND PORTABLE WIRELESS TERMINAL**
- (75) Inventors: **Nozomu Hikino**, Osaka (JP); **Hiroyuki Takebe**, Osaka (JP); **Mikio Kuramoto**, Osaka (JP); **Hiroyasu Suetake**, Osaka (JP); **Toshinori Kondo**, Osaka (JP)
- (73) Assignee: **SHARP KABUSHIKI KAISHA**, Osaka (JP)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 474 days.

- (21) Appl. No.: **13/580,484**
- (22) PCT Filed: **Feb. 22, 2011**
- (86) PCT No.: **PCT/JP2011/053865**
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- (87) PCT Pub. No.: **WO2011/105380**
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- (65) **Prior Publication Data**
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- (30) **Foreign Application Priority Data**
Feb. 24, 2010 (JP) 2010-039288

- (51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 1/24 (2006.01)
H01Q 9/42 (2006.01)
H01Q 5/40 (2015.01)
- (52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 5/40** (2015.01); **H01Q 9/42** (2013.01)

- (58) **Field of Classification Search**
CPC H01Q 9/04
USPC 343/700 MS
See application file for complete search history.

- (56) **References Cited**
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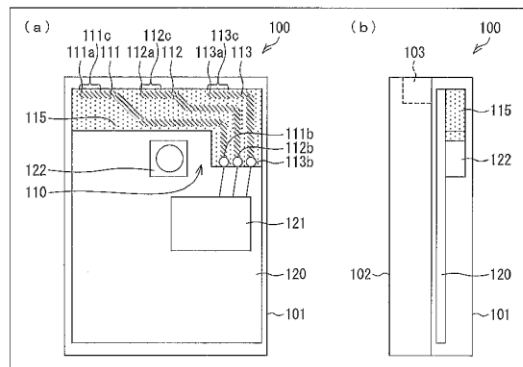
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Primary Examiner — Dameon E Levi
Assistant Examiner — Andrea Lindgren Baltzell
(74) *Attorney, Agent, or Firm* — Birch, Stewart, Kolasch & Birch, LLP

- (57) **ABSTRACT**
An antenna includes a first antenna element, a second antenna element, and a third antenna element. The second antenna element is placed between the first antenna element and the third antenna element. A first connecting end, a second connecting end, and a third connecting end are each placed in a position that is closer to a third apical end than to a first apical end. Thus, even in the case of an antenna including three antenna element that are used for an identical system, the antenna can be provided with a suppressed difference in radiation efficiency among frequency bands to which the antenna elements respectively correspond.

15 Claims, 7 Drawing Sheets





US009142879B2

(12) **United States Patent**
Galeev

(10) **Patent No.:** **US 9,142,879 B2**
(45) **Date of Patent:** **Sep. 22, 2015**

(54) **WIRELESS ELECTRONIC DEVICES WITH A METAL PERIMETER INCLUDING A PLURALITY OF ANTENNAS**

(58) **Field of Classification Search**
USPC 343/702, 866, 867
See application file for complete search history.

(71) Applicant: **Sony Mobile Communications AB**,
Lund (SE)

(56) **References Cited**

(72) Inventor: **Roustem Galeev**, Lund (SE)

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(73) Assignees: **Sony Corporation**, Tokyo (JP); **Sony Mobile Communications AB**, Lund (SE)

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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 338 days.

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(22) Filed: **Nov. 13, 2012**

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US 2014/0132457 A1 May 15, 2014

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Chinese Office Action Corresponding to Chinese Application No. 201310472716.7, Mailing Date: Jul. 1, 2015; Foreign Text, 7 Pages, English Translation Thereof, 10 pages.

(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H01Q 1/48 (2006.01)
H01Q 9/04 (2006.01)
H01Q 9/42 (2006.01)
H01Q 13/10 (2006.01)
H01Q 21/30 (2006.01)
H01Q 5/35 (2015.01)
H01Q 1/52 (2006.01)

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Primary Examiner — Tan Ho

(74) *Attorney, Agent, or Firm* — Myers Bigel Sibley & Sajovec, PA

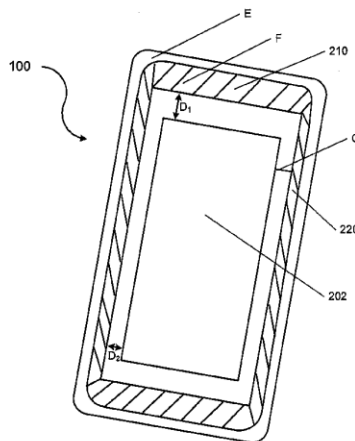
(52) **U.S. Cl.**

CPC **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/35** (2015.01); **H01Q 9/0442** (2013.01); **H01Q 9/42** (2013.01); **H01Q 13/103** (2013.01); **H01Q 21/30** (2013.01); **H01Q 1/521** (2013.01)

ABSTRACT

Wireless electronic devices may include a ground plane and a metal perimeter around the ground plane. The metal perimeter may include a plurality of antennas and may provide a front surface and/or edge surfaces of the wireless electronic devices.

17 Claims, 8 Drawing Sheets





US009142884B2

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

(10) **Patent No.:** **US 9,142,884 B2**
(45) **Date of Patent:** **Sep. 22, 2015**

(54) **ANTENNA DEVICE**
(75) Inventors: **Shinsuke Yukimoto**, Saitama (JP); **Ryo Saito**, Saitama (JP)
(73) Assignee: **MITSUBISHI MATERIALS CORPORATION**, Tokyo (JP)
(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 183 days.

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(21) Appl. No.: **13/989,734**
(22) PCT Filed: **Nov. 21, 2011**
(86) PCT No.: **PCT/JP2011/006467**
§ 371 (c)(1),
(2), (4) Date: **May 24, 2013**

Primary Examiner — Huedung Mancuso
(74) *Attorney, Agent, or Firm* — Locke Lord LLP; Jeffrey D. Hsi

(87) PCT Pub. No.: **WO2012/073450**
PCT Pub. Date: **Jun. 7, 2012**

(57) **ABSTRACT**

(65) **Prior Publication Data**
US 2013/0249742 A1 Sep. 26, 2013
(30) **Foreign Application Priority Data**
Nov. 30, 2010 (JP) 2010-267804

Provided is an antenna device that is capable of ensuring sufficient antenna performance by maximally utilizing a limited antenna occupied area. The antenna device is provided with a substrate main body (2); a ground plane (GND) that is formed on the substrate main body; an antenna-occupied area (AOA) that is provided in contact with one side (2a) of the substrate main body; a slit section (S) that is bored in the ground plane so as to extend from this area in the direction opposite to the one side (2a) of the substrate main body; a power feeding pattern (3) that is formed so as to extend into the slit section, provided with a power feeding point at the base end side, and connected with a first passive element (P1) halfway while the tip end side extends into the antenna-occupied area toward the one side of the substrate main body; an antenna element (AT) of a dielectric antenna that is connected to the tip end of the power feeding pattern and positioned along the one side of the substrate main body; a second passive element (P2) that is connected between the antenna element (AT) and the adjoining ground plane; and a ground connection pattern (5) for connecting the tip end of the power feeding pattern with the ground plane.

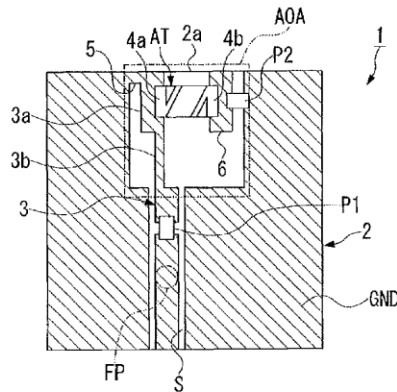
(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 1/38 (2006.01)
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(52) **U.S. Cl.**
CPC **H01Q 1/38** (2013.01); **H01Q 1/2283** (2013.01); **H01Q 9/36** (2013.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/04; H01Q 21/30; H01Q 1/38; H01Q 1/24
USPC 343/749, 702, 700 MS, 767
See application file for complete search history.

(56) **References Cited**
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2 Claims, 11 Drawing Sheets





US009142885B2

(12) **United States Patent**
Chen

(10) **Patent No.:** **US 9,142,885 B2**
(45) **Date of Patent:** **Sep. 22, 2015**

(54) **WIRELESS COMMUNICATION MODULES WITH REDUCED IMPEDANCE MISMATCH**

- (71) Applicant: **Quanta Computer Inc.**, Kuei Shan Hsiang, Tao Yuan Shien (TW)
- (72) Inventor: **Shuenn-Shyan Chen**, Tao Yuan Shien (TW)
- (73) Assignee: **QUANTA COMPUTER INC.**, Guishan Dist., Taoyuan (TW)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 102 days.

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(22) Filed: **Feb. 20, 2014**

(65) **Prior Publication Data**
US 2015/0155620 A1 Jun. 4, 2015

(30) **Foreign Application Priority Data**
Dec. 2, 2013 (TW) 102143984 A

(51) **Int. Cl.**
H01Q 1/50 (2006.01)
H01Q 1/38 (2006.01)
H01Q 1/42 (2006.01)

(52) **U.S. Cl.**
 CPC . *H01Q 1/38* (2013.01); *H01Q 1/42* (2013.01);
H01Q 1/50 (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/50; H01Q 1/42; H01Q 1/38; H01Q 21/28
USPC 343/872, 725, 900, 906
See application file for complete search history.

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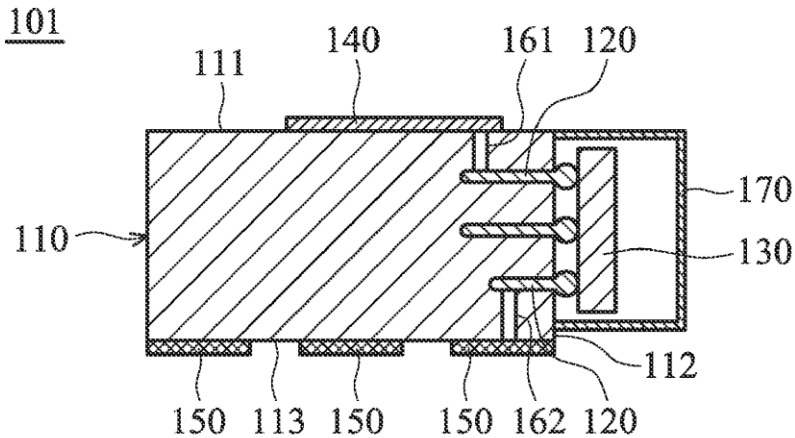
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Primary Examiner — Lam T Mai
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**
A wireless communication module is disclosed. A circuit board includes a first sidewall, a second sidewall, and a third sidewall. The second sidewall is perpendicular to and connected between the first and third sidewalls. Multiple interlayer traces are formed in the circuit board. An antenna integrated circuit is disposed on the second sidewall of the circuit board and is connected to the interlayer traces. An antenna is formed on the first sidewall of the circuit board. One of the interlayer traces is connected between the antenna integrated circuit and the antenna. At least one external solder pad is formed on the third sidewall of the circuit board. Another one of the interlayer traces is connected between the antenna integrated circuit and the external solder pad.

10 Claims, 3 Drawing Sheets





US009142888B2

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

(10) **Patent No.:** **US 9,142,888 B2**
(45) **Date of Patent:** **Sep. 22, 2015**

(54) **ANTENNA-DEVICE SUBSTRATE AND ANTENNA DEVICE**

USPC 343/749, 702, 700 MS, 767
See application file for complete search history.

(75) Inventors: **Shinsuke Yukimoto**, Saitama (JP); **Ryo Saito**, Saitama (JP)

(56) **References Cited**

(73) Assignee: **MITSUBISHI MATERIALS CORPORATION**, Tokyo (JP)

U.S. PATENT DOCUMENTS

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 213 days.

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(21) Appl. No.: **13/878,690**

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WO WO-2008117558 A1 10/2008

(22) PCT Filed: **Oct. 13, 2011**

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(86) PCT No.: **PCT/JP2011/005723**

International Search Report of PCT/JP2011/005723.

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

Primary Examiner — Huedung Mancuso

(87) PCT Pub. No.: **WO2012/049847**

(74) *Attorney, Agent, or Firm* — Locke Lord LLP; Jeffrey D. Hsi

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

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Oct. 15, 2010 (JP) 2010-233129

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

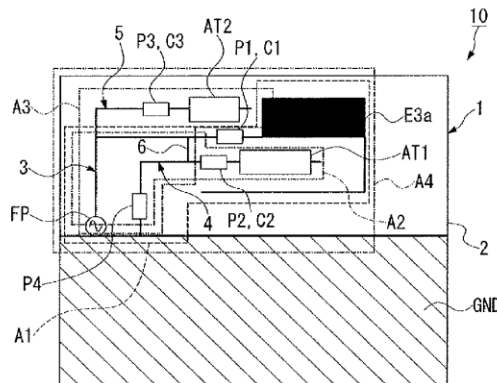
(57) **ABSTRACT**

Provided is an antenna-device substrate which is capable of flexibly adjusting multiple resonance frequencies, and also provided is an antenna device. The antenna-device substrate is provided with a substrate main body (2), a ground plane (GND) on the surface of the substrate main body (2), first to third elements (1 to 3), and a short part (6) connecting the first element (3) and the second element (4). The first element is provided with a feed point (FP) at the base end and extends comprising a first connector (C1) of a first passive element (P1). The second element is connected to the ground plane and is provided with a first antenna element (AT1) at the tip end, and extends comprising a second connector (C2) of a second passive element (P2) and comprising a fourth passive element (P4). The third element extends comprising a third connector (C3) of a third passive element (P3). The first element extends with a gap provided between the first element and each of the second element, the third element, and the ground plane such that a floating capacitance can be generated therebetween.

(52) **U.S. Cl.**
CPC **H01Q 9/04** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 5/321** (2015.01); **H01Q 5/371** (2015.01); **H01Q 5/392** (2015.01); **H01Q 9/42** (2013.01); **H01Q 21/30** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/04; H01Q 21/30; H01Q 1/38; H01Q 1/24

9 Claims, 6 Drawing Sheets





US009142890B2

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

(10) **Patent No.:** **US 9,142,890 B2**
(45) **Date of Patent:** **Sep. 22, 2015**

- (54) **ANTENNA ASSEMBLY**
- (71) Applicant: **FIH (Hong Kong) Limited**, Kowloon (HK)
- (72) Inventors: **Cheng-Hung Ko**, Shindian (TW); **Hao-Ying Chang**, Shindian (TW); **Chih-Yang Tsai**, Shindian (TW)
- (73) Assignee: **FIH (Hong Kong) Limited**, Kowloon (HK)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 169 days.
- (21) Appl. No.: **13/730,869**
- (22) Filed: **Dec. 29, 2012**
- (65) **Prior Publication Data**
US 2013/0241786 A1 Sep. 19, 2013
- (30) **Foreign Application Priority Data**
Mar. 15, 2012 (TW) 101108905 A
- (51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 13/10 (2006.01)
H01Q 1/24 (2006.01)
H01Q 1/48 (2006.01)
H01Q 9/04 (2006.01)

- (52) **U.S. Cl.**
CPC **H01Q 13/106** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/48** (2013.01); **H01Q 9/0421** (2013.01)
- (58) **Field of Classification Search**
USPC 343/700 MS, 702, 767, 846
See application file for complete search history.
- (56) **References Cited**
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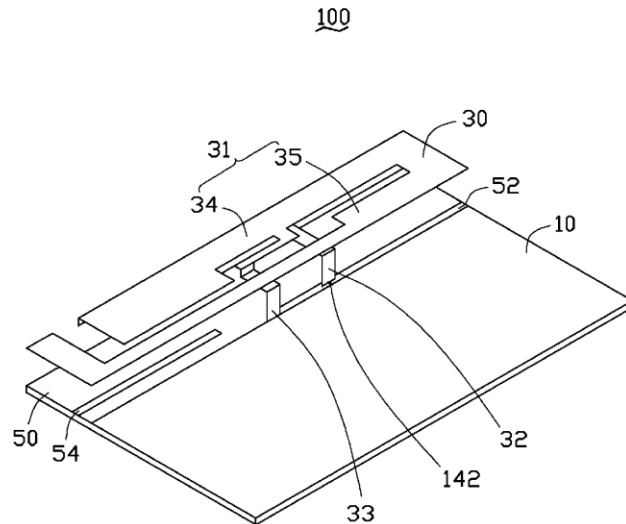
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Primary Examiner — Graham Smith
(74) *Attorney, Agent, or Firm* — Novak Druce Connolly Bove + Quigg LLP

(57) **ABSTRACT**
An antenna assembly includes a carrier, a metal sheet, and an antenna. The metal sheet is attached to the carrier and defining at least one notch. The antenna is connected to the metal sheet and includes a radio body for receiving and transmitting wireless signals. The radio body is positioned above the metal sheet. The length of current path in a peripheral wall of the at least one notch is in a predetermined proportion to the wavelength of the wireless signals, enabling the metal sheet to resonate with the radio body to increase the bandwidth of the antenna.

16 Claims, 4 Drawing Sheets





US009147932B2

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

(10) **Patent No.:** **US 9,147,932 B2**
(45) **Date of Patent:** **Sep. 29, 2015**

(54) **TUNABLE MULTIBAND ANTENNA WITH DIELECTRIC CARRIER**

(71) Applicant: **Apple Inc.**, Cupertino, CA (US)
(72) Inventors: **Salih Yarga**, Sunnyvale, CA (US);
Qingxiang Li, Mountain View, CA (US);
Matthew A. Mow, Los Altos, 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 304 days.

(21) Appl. No.: **13/647,106**

(22) Filed: **Oct. 8, 2012**

(65) **Prior Publication Data**

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(51) **Int. Cl.**
H04M 1/00 (2006.01)
H01Q 1/38 (2006.01)
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(52) **U.S. Cl.**
CPC **H01Q 1/38** (2013.01); **H01Q 1/243** (2013.01); **H01Q 9/06** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/244; H01Q 1/245; H01Q 1/42; H01Q 1/422; H01Q 1/38; H01Q 9/06; H04W 88/02
USPC 455/575.8, 575.1, 121, 562.1, 575.7, 455/575.5, 575.6, 90.3, 104, 106, 107, 111; 343/700, 745, 736, 702, 720, 866, 848, 343/741, 850, 893; 174/126.1

See application file for complete search history.

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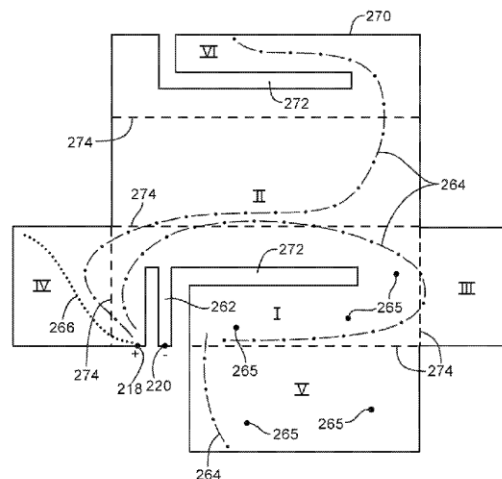
Primary Examiner — Tan Trinh

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

(57) **ABSTRACT**

Antenna structures for an antenna may be formed from a dielectric carrier with metal structures. The metal structures may be patterned to cover all sides of the dielectric carrier. The dielectric carrier may have a shape with six sides or other shape that creates a three-dimensional layout for the antenna structures. The antenna structures may have a tunable circuit that allows the antenna to be tuned. The tunable circuit may have first and second terminals coupled to one of the sides of the carrier. The metal structures may be configured to form an inverted-F antenna resonating element. Portions of the metal structures may form a first arm for an inverted-F antenna and portions of the metal structures may form a second arm for the inverted-F antenna. The antenna may operate in multiple communications bands. The tunable circuit may tune one band without significantly tuning other bands.

20 Claims, 13 Drawing Sheets





US009147938B2

(12) **United States Patent**
Hallivuori

(10) **Patent No.:** **US 9,147,938 B2**
(45) **Date of Patent:** **Sep. 29, 2015**

(54) **LOW FREQUENCY DIFFERENTIAL MOBILE ANTENNA**

(75) Inventor: **Juha Samuel Hallivuori**, Tampere (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 413 days.

(21) Appl. No.: **13/554,058**

(22) Filed: **Jul. 20, 2012**

(65) **Prior Publication Data**

US 2014/0022136 A1 Jan. 23, 2014

(51) **Int. Cl.**
H01Q 9/26 (2006.01)
H01Q 7/00 (2006.01)
H01Q 1/48 (2006.01)
H01Q 9/42 (2006.01)

(52) **U.S. Cl.**
CPC . **H01Q 7/00** (2013.01); **H01Q 1/48** (2013.01);
H01Q 9/26 (2013.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/48; H01Q 9/26; H01Q 7/00;
H01Q 9/42
See application file for complete search history.

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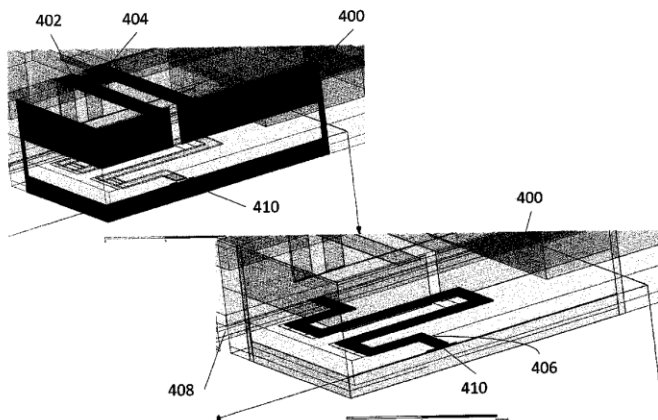
Primary Examiner — Trinh Dinh

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

(57) **ABSTRACT**

An antenna which is advantageous for low frequency communications and suitable for use in a portable electronic device comprises an antenna resonator element and a grounding line. The resonator element is configured to resonate at a frequency f, and comprises a first port and a second port that are configured to be differentially fed. The grounding line couples a virtual node of the resonator element to ground, where the virtual node defines a negligible current when the resonator element is resonant at the frequency f. In the specific examples the antenna could be a folded monopole, a folded dipole, a loop, or other type of differential antennas. Radiation efficiency is quantified for a long folded monopole implementation which shows a marked improvement over an identical antenna without such a grounding line, particularly when used with a radio receiver.

20 Claims, 12 Drawing Sheets





US009148180B2

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

(10) **Patent No.:** **US 9,148,180 B2**
(45) **Date of Patent:** **Sep. 29, 2015**

(54) **COMMUNICATION DEVICE AND ANTENNA ELEMENT THEREIN**

USPC 455/188.1
See application file for complete search history.

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

(56) **References Cited**

(72) Inventors: **Kin-Lu Wong**, New Taipei (TW);
Ya-Jyun Li, New Taipei (TW)

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(73) Assignee: **ACER INCORPORATED**, 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 26 days.

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(21) Appl. No.: **14/215,451**

Primary Examiner — Ajibola Akinyemi
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(22) Filed: **Mar. 17, 2014**

(65) **Prior Publication Data**

(57) **ABSTRACT**

US 2015/0188581 A1 Jul. 2, 2015

A communication device including a ground element and an antenna element is provided. The antenna element includes a metal element and a circuit element assembly. The metal element is adjacent to an edge of the ground element and does not overlap with the ground element. The circuit element assembly includes a first circuit and a second circuit, and is substantially surrounded by the metal element and the edge of the ground element. The first circuit includes a switch element, and the second circuit is a reactance circuit. The metal element is coupled through the first circuit to a first signal source. The metal element is further coupled through the second circuit to a second signal source.

(30) **Foreign Application Priority Data**

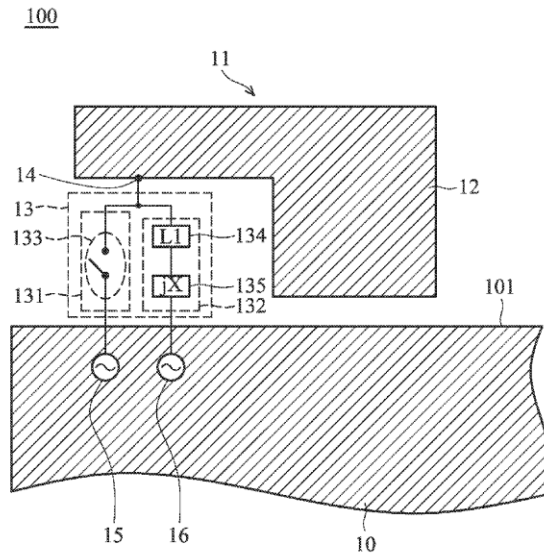
Dec. 26, 2013 (TW) 102148374 A

(51) **Int. Cl.**
H04B 1/18 (2006.01)
H04B 1/00 (2006.01)

(52) **U.S. Cl.**
CPC **H04B 1/006** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/04; H01Q 1/22; H01Q 1/24;
H01Q 1/36; H01Q 23/00; H01Q 9/38; H01Q
1/2275

18 Claims, 5 Drawing Sheets





US009153856B2

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

(10) **Patent No.:** **US 9,153,856 B2**
(45) **Date of Patent:** **Oct. 6, 2015**

(54) **EMBEDDED ANTENNA STRUCTURES**

(75) Inventors: **Benjamin M. Rappoport**, Los Gatos, CA (US); **Bruce E. Berg**, Santa Clara, CA (US); **John Raff**, Menlo Park, CA (US); **Stephen R. McClure**, San Francisco, 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 494 days.

(21) Appl. No.: **13/243,549**

(22) Filed: **Sep. 23, 2011**

(65) **Prior Publication Data**

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H01Q 9/42 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 9/42** (2013.01); **Y10T 29/49016** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/40; H01Q 1/405
USPC 343/702, 872, 873; 29/600
See application file for complete search history.

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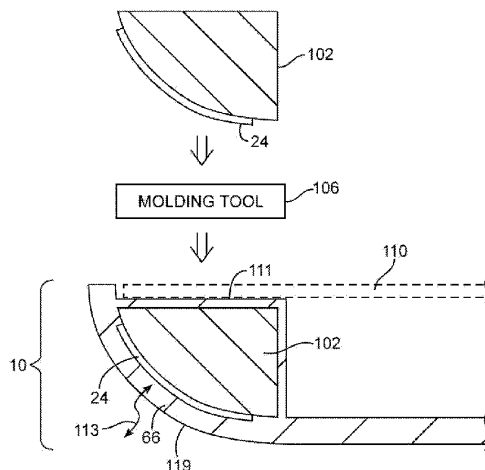
Primary Examiner — Dieu H Duong

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

(57) **ABSTRACT**

An electronic device may be provided with antenna structures that are embedded in a dielectric such as plastic. The plastic may be molded over the antenna structures using molding equipment. Antenna structures may be embedded in molded plastic structures such as plastic electronic device housing structures. The plastic electronic device housing structures may form housing structures such as housing wall structures. The antenna structures may be embedded within the housing wall structures in the vicinity of an exterior surface of the housing wall structures. Embedded antenna structures may also be mounted under other dielectric structures such portions of a display cover layer.

18 Claims, 10 Drawing Sheets





US009153865B2

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

(10) **Patent No.:** **US 9,153,865 B2**
(45) **Date of Patent:** **Oct. 6, 2015**

(54) **ANTENNA DEVICE AND COMMUNICATION
TERMINAL APPARATUS**

USPC 343/749
See application file for complete search history.

(71) Applicant: **Murata Manufacturing Co., Ltd.**,
Nagaokakyo-shi, Kyoto-fu (JP)

(56) **References Cited**

(72) Inventors: **Kenichi Ishizuka**, Nagaokakyo (JP);
Hiroshi Nishida, Nagaokakyo (JP)

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(73) Assignee: **Murata Manufacturing Co., Ltd.**,
Kyoto (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 0 days.

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(21) Appl. No.: **14/247,271**

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(22) Filed: **Apr. 8, 2014**

Official Communication issued in International Patent Application
No. PCT/JP2013/072673, mailed on Oct. 22, 2013.

(65) **Prior Publication Data**

(Continued)

US 2014/0218246 A1 Aug. 7, 2014

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2013/072673,
filed on Aug. 26, 2013.

Primary Examiner — Dameon E Levi

Assistant Examiner — Andrea Lindgren Baltzell

(74) *Attorney, Agent, or Firm* — Keating & Bennett, LLP

(30) **Foreign Application Priority Data**

(57) **ABSTRACT**

Aug. 28, 2012 (JP) 2012-187238

A multiband-capable antenna device includes a loop-shaped
radiation element including a power feed end and a ground
end, and a matching circuit including a first inductance
element loaded at the power feed end and a second inductance
element loaded at the ground end and magnetic-field coupled
to the first inductance element. The loop-shaped radiation
element is configured to resonate in a plurality of resonance
modes including an even mode and an odd mode. The first
inductance element and the second inductance element are
wound and connected such that magnetic fields are mutually
strengthened for one of the even mode and the odd mode, and
such that the magnetic fields are mutually weakened for the
other of the even mode and the odd mode.

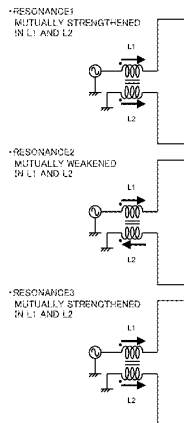
(51) **Int. Cl.**
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H01Q 7/00 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/50** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 5/335** (2015.01); **H01Q 5/357**
(2015.01); **H01Q 7/00** (2013.01); **H01Q 9/26**
(2013.01)

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

14 Claims, 8 Drawing Sheets





US009153867B2

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

(10) **Patent No.:** **US 9,153,867 B2**
(45) **Date of Patent:** **Oct. 6, 2015**

(54) **RECONFIGURABLE MULTIBAND ANTENNA**

(56) **References Cited**

(71) Applicant: **Futurewei Technologies, Inc.**, Plano, TX (US)

U.S. PATENT DOCUMENTS

(72) Inventors: **Daejong Kim**, San Diego, CA (US);
Shing Lung Steven Yang, San Diego, CA (US);
Wee Kian Toh, San Diego, CA (US)

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(73) Assignee: **Futurewei Technologies, Inc.**, Plano, TX (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 242 days.

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(21) Appl. No.: **13/720,017**

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(22) Filed: **Dec. 19, 2012**

(65) **Prior Publication Data**

(Continued)

US 2014/0168030 A1 Jun. 19, 2014

(51) **Int. Cl.**
H01Q 3/24 (2006.01)
H01Q 9/14 (2006.01)
H04B 1/04 (2006.01)
H04B 1/18 (2006.01)
H01Q 5/364 (2015.01)

Primary Examiner — Hoang V Nguyen

(74) *Attorney, Agent, or Firm* — Conley Rose, P.C.; Grant Rodolph

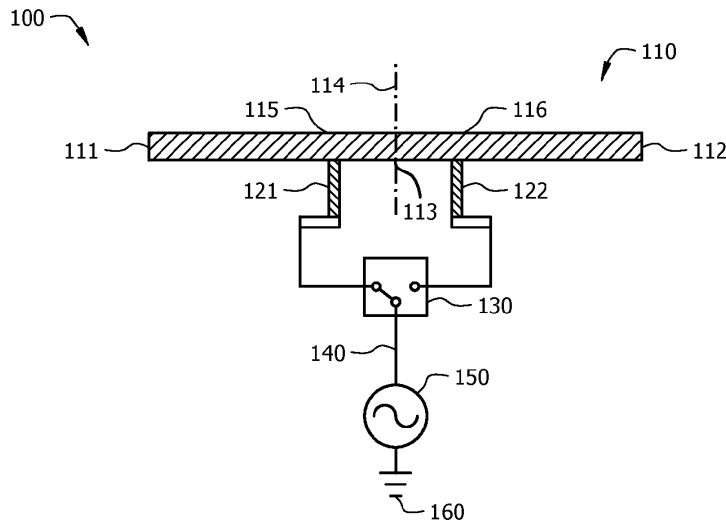
(52) **U.S. Cl.**
CPC **H01Q 3/247** (2013.01); **H01Q 5/364** (2013.01); **H01Q 9/145** (2013.01); **H04B 1/0458** (2013.01); **H04B 1/18** (2013.01)

(57) **ABSTRACT**

A mobile node (MN) comprising an antenna comprising a proximate end, a distal end, and a midpoint, a first feed coupled to the antenna between the proximate end and the midpoint, a second feed coupled to the antenna between the distal end and the midpoint, a first switch configured to toggle between coupling the first feed to a main feed and coupling the second feed to the main feed, and a controller configured to control the toggling of the first switch.

(58) **Field of Classification Search**
CPC H01Q 3/247; H01Q 5/0055; H01Q 9/145
USPC 343/876, 700 MS
See application file for complete search history.

24 Claims, 4 Drawing Sheets





US009153869B1

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

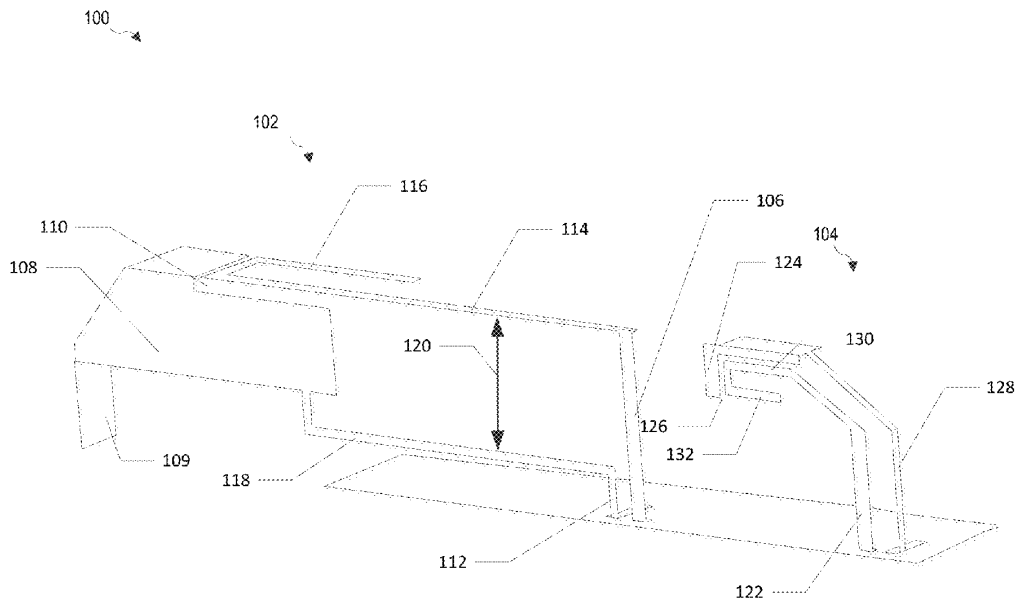
(10) **Patent No.:** **US 9,153,869 B1**
(45) **Date of Patent:** **Oct. 6, 2015**

- (54) **HARMONIC SUPPRESSED DUAL FEED ANTENNA**
- (71) Applicant: **Amazon Technologies, Inc.**, Reno, NV (US)
- (72) Inventors: **Tzung-I Lee**, San Jose, CA (US); **In Chul Hyun**, San Jose, CA (US); **Cheol Su Kim**, 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 357 days.
- (21) Appl. No.: **13/718,628**
- (22) Filed: **Dec. 18, 2012**
- (51) **Int. Cl.**
H01Q 21/00 (2006.01)
H01Q 9/04 (2006.01)
H01Q 21/30 (2006.01)
- (52) **U.S. Cl.**
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- (58) **Field of Classification Search**
CPC H01Q 21/00
USPC 343/893, 841, 700 MS, 702
See application file for complete search history.

- (56) **References Cited**
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- * cited by examiner
- Primary Examiner* — Huedung Mancuso
- (74) *Attorney, Agent, or Firm* — Seyfarth Shaw LLP; Ilan N. Barzilay

(57) **ABSTRACT**
A wideband antenna apparatus including a harmonically suppressed low band antenna is provided. The low band antenna is configured as a folded monopole antenna with patch coupling for resonance in a first frequency band. A patch portion of the low band antenna is widely separated from a folded feed portion of the low band antenna to avoid slot resonances above the first frequency band. The patch portion is relatively large to avoid folding of the patch portion that could introduce resonances above the first frequency band. The wideband antenna apparatus may also include a high band antenna proximate with the low band antenna. The high band antenna may be a folded monopole patch coupled antenna configured for resonating in a second frequency band. The high band antenna may optionally be configured like the low band antenna to suppress resonances of the high band antenna above the second frequency band.

16 Claims, 8 Drawing Sheets





US009153870B2

(12) **United States Patent**
An

(10) **Patent No.:** **US 9,153,870 B2**
(45) **Date of Patent:** **Oct. 6, 2015**

(54) **BROADBAND MOBILE PHONE ANTENNA WITH PARASITIC ANTENNA AND MOBILE PHONE**
(71) Applicant: **Huizhou TCL Mobile Communication CO., LTD.**, Hui Zhou (CN)
(72) Inventor: **Xinrong An**, Ningbo (CN)
(73) Assignee: **HUIZHOU TCL MOBILE COMMUNICATION CO., LTD.**, Guangdong (CN)
(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(2015.01); **H01Q 9/14** (2013.01); **H01Q 19/005** (2013.01); **H04B 1/40** (2013.01); **H04M 1/026** (2013.01)
(58) **Field of Classification Search**
CPC ... H01Q 9/0442; H01Q 19/005; H01Q 5/378; H01Q 5/392; H01Q 9/14; H01Q 1/243; H04B 1/40; H04M 1/026
See application file for complete search history.

(21) Appl. No.: **14/401,507**
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(86) PCT No.: **PCT/CN2013/080604**
§ 371 (c)(1),
(2) Date: **Nov. 14, 2014**
(87) PCT Pub. No.: **WO2014/086163**
PCT Pub. Date: **Jun. 12, 2014**

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(65) **Prior Publication Data**
US 2015/0148110 A1 May 28, 2015
(30) **Foreign Application Priority Data**
Dec. 7, 2012 (CN) 2012 1 0522150

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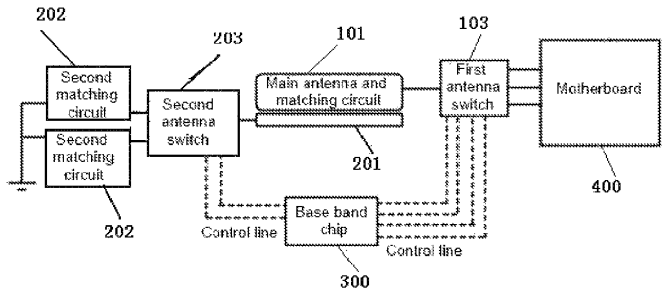
(51) **Int. Cl.**
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H01Q 9/14 (2006.01)
H01Q 5/378 (2015.01)
H01Q 5/392 (2015.01)
H01Q 19/00 (2006.01)
H04B 1/40 (2015.01)
H04M 1/02 (2006.01)

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Primary Examiner — Dinh P Nguyen
(74) *Attorney, Agent, or Firm* — Shimokaji IP

(52) **U.S. Cl.**
CPC **H01Q 9/0442** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/378** (2015.01); **H01Q 5/392**

(57) **ABSTRACT**
A broadband mobile phone antenna with a parasitic antenna and a mobile phone thereof are disclosed. The mobile phone antenna includes a main antenna and a matching circuit thereof, a first antenna switch connected with the main antenna and the matching circuit thereof. The first antenna switch is used to perform frequency band switching of the main antenna. The mobile phone antenna also includes a parasitic antenna, at least two second matching circuits, and a second antenna switch connected with the parasitic antenna and the second matching circuits. The parasitic antenna is set on one side of the main antenna. The second antenna switch is controlled by a mobile phone base band chip and is used to make the parasitic antenna switch between the second matching circuits.

20 Claims, 2 Drawing Sheets





US009153874B2

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

(10) **Patent No.:** **US 9,153,874 B2**
(45) **Date of Patent:** **Oct. 6, 2015**

(54) **ELECTRONIC DEVICE HAVING MULTIPORT ANTENNA STRUCTURES WITH RESONATING SLOT**

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

(72) Inventors: **Yuehui Ouyang**, Sunnyvale, CA (US); **Nanbo Jin**, Sunnyvale, CA (US); **Yijun Zhou**, Sunnyvale, CA (US); **Enrique Ayala Vazquez**, Watsonville, CA (US); **Anand Lakshmanan**, San Jose, CA (US); **Robert W. Schlub**, Cupertino, CA (US); **Mattia Pascolini**, Campbell, CA (US); **Matthew A. Mow**, Los Altos, 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 388 days.

(21) Appl. No.: **13/846,459**

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

(65) **Prior Publication Data**
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(51) **Int. Cl.**
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H01Q 1/38 (2006.01)
H01Q 21/28 (2006.01)
H01Q 1/48 (2006.01)
H01Q 9/04 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 21/28** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/321** (2015.01); **H01Q 5/328** (2015.01); **H01Q 5/335** (2015.01); **H01Q 5/378** (2015.01); **H01Q 9/0421** (2013.01); **H01Q 13/106** (2013.01)

(58) **Field of Classification Search**
USPC 343/702, 729, 745, 700 MS, 766
See application file for complete search history.

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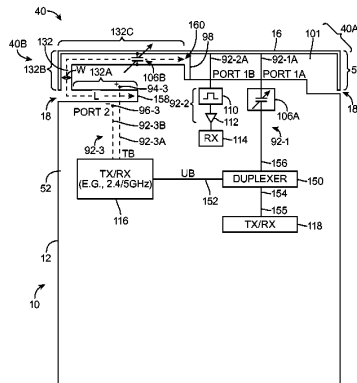
Primary Examiner — Tan Ho

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

(57) **ABSTRACT**

Electronic devices may include radio-frequency transceiver circuitry and antenna structures. The antenna structures may include an inverted-F antenna resonating element and an antenna ground that form an inverted-F antenna having first and second antenna ports. The antenna structures may include a slot antenna resonating element. The slot antenna resonating element may serve as a parasitic antenna resonating element for the inverted-F antenna at frequencies in a first communications band and may serve as a slot antenna at frequencies in a second communications band. The slot antenna may be directly fed using a third antenna port. An adjustable capacitor may be coupled to the first port to tune the inverted-F antenna. The inverted-F antenna may also be tuned using an adjustable capacitor bridging the slot antenna resonating element.

30 Claims, 6 Drawing Sheets





US009154972B2

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

(10) **Patent No.:** **US 9,154,972 B2**
(45) **Date of Patent:** **Oct. 6, 2015**

(54) **METHODS AND APPARATUS FOR TESTING ELECTRONIC DEVICES WITH ANTENNA ARRAYS**

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

(72) Inventors: **Jerzy Guterman**, Mountain View, CA (US); **Joshua G. Nickel**, San Jose, CA (US); **Boon W. Shiu**, San Jose, CA (US); **Mattia Pascolini**, Campbell, 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 297 days.

(21) Appl. No.: **13/916,090**

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

(65) **Prior Publication Data**
US 2014/0370821 A1 Dec. 18, 2014

(51) **Int. Cl.**
H04W 24/00 (2009.01)

(52) **U.S. Cl.**
CPC **H04W 24/00** (2013.01)

(58) **Field of Classification Search**
CPC H04B 17/0085; H04B 17/002; H04B 17/0025; H04B 17/29; H04W 24/00
USPC 455/67.14, 67.11, 67.12, 115.1, 115.2, 455/226.1; 324/750.16, 756.04, 750.19
See application file for complete search history.

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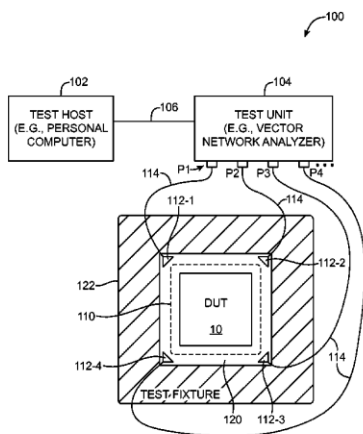
Primary Examiner — Minh D Dao

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

(57) **ABSTRACT**

A wireless electronic device may be provided with antenna structures. The antenna structures may be formed from an antenna ground and an array of antenna resonating elements formed along its periphery. The antenna resonating elements may be formed from metal traces on a dielectric support structure that surrounds the antenna ground. The electronic device may be tested using a test system for detecting the presence of manufacturing/assembly defects. The test system may include an RF tester and a test fixture. The device under test (DUT) may be attached to the test fixture during testing. Multiple test probes arranged along the periphery of the DUT may be used to transmit and receive RF test signals for gathering scattering parameter measurements on the device under test. The scattering parameter measurements may then be compared to predetermined threshold values to determine whether the DUT contains any defects.

20 Claims, 12 Drawing Sheets





US009160057B2

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

(10) **Patent No.:** **US 9,160,057 B2**
(45) **Date of Patent:** **Oct. 13, 2015**

- (54) **UNSYMMETRICAL DIPOLE ANTENNA**
- (75) Inventors: **I-Shan Chen**, Hsinchu (TW); **Jia-Fong Wu**, Hsinchu (TW); **Chia-Hong Lin**, Hsinchu (TW); **Cheng-Hsiung Hsu**, Hsinchu (TW); **Chao-Chun Lin**, 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 286 days.

(21) Appl. No.: **13/304,698**

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

(65) **Prior Publication Data**
US 2013/0027266 A1 Jan. 31, 2013

(30) **Foreign Application Priority Data**
Jul. 29, 2011 (TW) 100126987 A

(51) **Int. Cl.**
H01Q 9/16 (2006.01)
H01Q 1/24 (2006.01)
H01Q 9/26 (2006.01)
H01Q 5/357 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 5/357** (2015.01); **H01Q 9/26** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/16
USPC 343/793
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Dameon E Levi

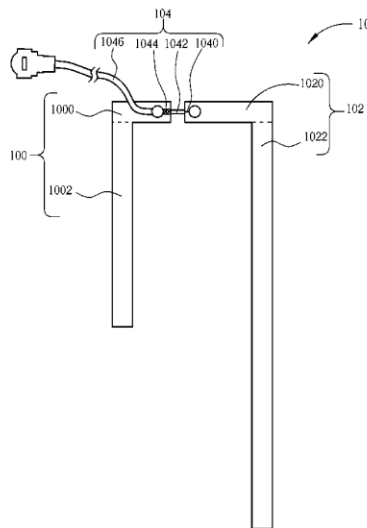
Assistant Examiner — Andrea Lindgren Baltzell

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

(57) **ABSTRACT**

An unsymmetrical dipole antenna includes a grounding element, a radiating element, and a feed-in wire. The grounding element includes a first short side metal plane and a first long side metal plane. The radiating element includes a second short side metal plane and a second long side metal plane. The feed-in wire includes a metal wire, coupled to the second short side metal plane for transmitting a feed-in signal; an insulation layer, covering the metal wire; a metal weave, covering the insulation layer, having one terminal coupled to the first short side metal plane of the grounding element, and another terminal coupled to a system ground of the wireless communication device; and a protective layer, covering the metal weave. A size of the grounding element and a size of the radiating element are irrelative.

9 Claims, 9 Drawing Sheets





US009160058B2

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

(10) **Patent No.:** **US 9,160,058 B2**
(45) **Date of Patent:** **Oct. 13, 2015**

(54) **PORTABLE COMMUNICATION DEVICE**

(75) Inventors: **Tun-Yuan Tsou**, Taoyuan (TW); **Pei-Ling Teng**, Taoyuan (TW); **Yi-Chun Chen**, Taoyuan (TW); **Hong-Lung Chen**, Taoyuan (TW); **Kuo-Cheng Chen**, Taoyuan (TW)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 279 days.

(21) Appl. No.: **13/304,726**

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

(65) **Prior Publication Data**
US 2013/0135157 A1 May 30, 2013

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 21/00 (2006.01)
H01Q 1/22 (2006.01)
H01Q 1/52 (2006.01)
H01Q 3/24 (2006.01)
H01Q 9/04 (2006.01)
H01Q 9/14 (2006.01)
H01Q 9/42 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/2266** (2013.01); **H01Q 1/52** (2013.01); **H01Q 3/24** (2013.01); **H01Q 9/0421** (2013.01); **H01Q 9/145** (2013.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 23/00
USPC 343/702
See application file for complete search history.

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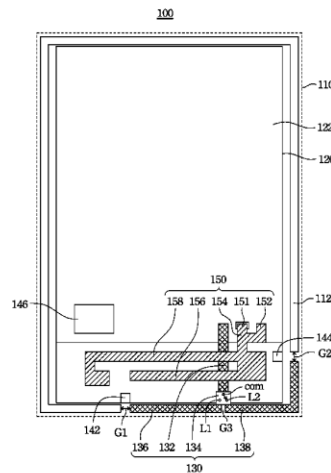
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Primary Examiner — Dameon E Levi
Assistant Examiner — Andrea Lindgren Baltzell
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**
A portable communication device includes an appearance, a substrate and a switchable resonant antenna. The substrate is disposed in the appearance, and the substrate has a ground plane. The switchable resonant antenna comprises a first connection portion, a switching unit, a first metal element and a second metal element, where the first connection portion is electrically coupled between the ground plane and the switching unit, the switching unit is configured to electrically couple the first connection portion to the first metal element or the second metal element according to a control signal generated corresponding to a detecting result, in order to generate a first resonant mode.

18 Claims, 6 Drawing Sheets





US009160061B2

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

(10) **Patent No.:** **US 9,160,061 B2**
(45) **Date of Patent:** **Oct. 13, 2015**

(54) **MOBILE DEVICE COVER INCLUDING AT LEAST ONE ANTENNA**

(71) Applicant: **Intel Corporation**, Santa Clara, CA (US)

(72) Inventors: **Anand Konanur**, San Jose, CA (US);
Ulun Karacaoglu, San Diego, CA (US);
Songnan Yang, San Jose, CA (US);
Shawn McEuen, Portland, OR (US)

(73) Assignee: **INTEL CORPORATION**, Santa Clara, CA (US)

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

(21) Appl. No.: **14/280,796**

(22) Filed: **May 19, 2014**

(65) **Prior Publication Data**

US 2014/0333489 A1 Nov. 13, 2014

Related U.S. Application Data

(63) Continuation of application No. 13/076,990, filed on Mar. 31, 2011, now Pat. No. 8,760,349.

(60) Provisional application No. 61/417,292, filed on Nov. 26, 2010.

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/22 (2006.01)
H01Q 1/40 (2006.01)
H01Q 21/28 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/2266** (2013.01); **H01Q 1/40** (2013.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**
USPC 235/702, 700, 745, 873; 343/702, 742, 343/700, 745, 873
See application file for complete search history.

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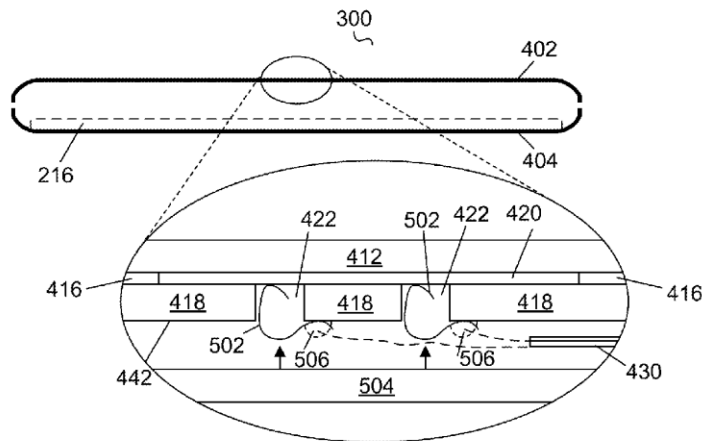
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Primary Examiner — Allyson Trail
(74) *Attorney, Agent, or Firm* — Shichrur & Co.

(57) **ABSTRACT**

Embodiments of systems and methods for providing in-mold laminate antennas are generally described herein. Other embodiments may be described and claimed.

16 Claims, 5 Drawing Sheets





US009160068B2

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

(10) **Patent No.:** **US 9,160,068 B2**
(45) **Date of Patent:** **Oct. 13, 2015**

(54) **SYSTEMS AND METHODS FOR ANTENNA ARRANGEMENTS IN AN ELECTRONIC DEVICE**

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(71) Applicant: **Google Technology Holdings LLC**,
Mountain View, CA (US)

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(72) Inventors: **Lynn M Greetis**, Mundelein, IL (US);
Soo Won Hong, Vernon Hills, IL (US);
Benjamin O. White, Crystal Lake, IL (US)

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(73) Assignee: **Google Technology Holdings LLC**,
Mountain View, 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 229 days.

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(21) Appl. No.: **13/890,425**

Primary Examiner — Tan Ho

(22) Filed: **May 9, 2013**

(65) **Prior Publication Data**

US 2014/0333486 A1 Nov. 13, 2014

(57) **ABSTRACT**

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

Systems and methods are provided for arranging antennas in an electronic device (200). According to one aspect, the electronic device includes a housing (202) and an antenna arrangement. The antenna arrangement includes a first volume (206) positioned adjacent to an edge (212) of the housing, the first volume enclosing a first antenna structure (230) shaped substantially according to a geometry of the edge; a second volume (208) positioned adjacent to a first corner (216) of an opposing edge (214) of the housing, the second volume including a second antenna structure (232) shaped substantially according to a geometry of the first corner; and a third volume (210) adjacent to a second corner (218) of the opposing edge, the third volume including a third antenna structure (234) shaped substantially according to a geometry of the second corner, wherein the first, second, and third volumes do not overlap and are discontinuous.

(52) **U.S. Cl.**
CPC **H01Q 1/52** (2013.01); **H01Q 1/243** (2013.01); **H01Q 21/28** (2013.01); **Y10T 29/49018** (2015.01)

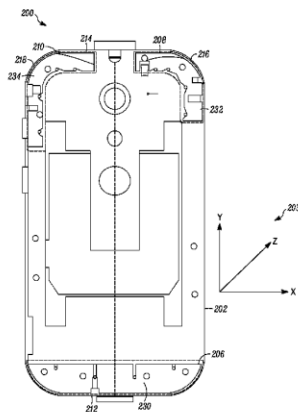
(58) **Field of Classification Search**
USPC 343/700 MS, 702
See application file for complete search history.

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23 Claims, 9 Drawing Sheets





US009160074B2

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

(10) **Patent No.:** **US 9,160,074 B2**
(45) **Date of Patent:** **Oct. 13, 2015**

(54) **MODAL ANTENNA WITH CORRELATION MANAGEMENT FOR DIVERSITY APPLICATIONS**

(71) Applicant: **Ethertronics, Inc.**, San Diego, CA (US)

(72) Inventors: **Laurent Desclos**, San Diego, CA (US); **Barry Matsumori**, La Jolla, CA (US); **Sebastian Rowson**, San Diego, CA (US); **Jeffrey Shamblin**, San Marcos, 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 316 days.

(21) Appl. No.: **13/674,137**

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

(65) **Prior Publication Data**

US 2013/0147672 A1 Jun. 13, 2013

Related U.S. Application Data

(63) Continuation-in-part of application No. 13/029,564, filed on Feb. 17, 2011, now Pat. No. 8,362,962, which is a continuation of application No. 12/043,090, filed on Mar. 5, 2008, now Pat. No. 7,911,402, and a continuation-in-part of application No. 13/227,361, filed on Sep. 7, 2011, now abandoned.

(51) **Int. Cl.**
H01Q 9/00 (2006.01)
H01Q 9/06 (2006.01)
H01Q 1/24 (2006.01)
H01Q 3/00 (2006.01)
H01Q 9/04 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 9/06** (2013.01); **H01Q 1/243** (2013.01); **H01Q 3/00** (2013.01); **H01Q 9/0421** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 3/00; H01Q 5/0072; H01Q 9/06
USPC 343/700 MS, 745, 815, 817, 834
See application file for complete search history.

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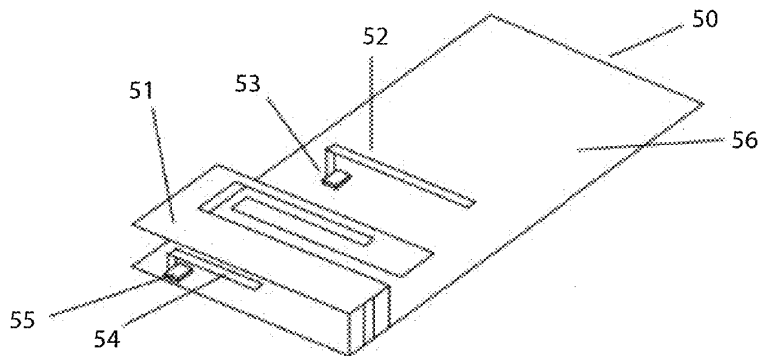
Primary Examiner — Tho G Phan

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

(57) **ABSTRACT**

Antenna systems comprising modal antennas for use in diversity and similar schemes include a modal antenna capable of multiple antenna modes wherein a distinct radiation pattern exists for each antenna mode, and a control signal for directing variation of the antenna modes. Methods for designing modal diversity antennas are further disclosed.

15 Claims, 14 Drawing Sheets





US009160075B2

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

(10) **Patent No.:** **US 9,160,075 B2**
(45) **Date of Patent:** **Oct. 13, 2015**

(54) **MULTI-BAND ANTENNA FOR PORTABLE COMMUNICATION DEVICE**

2003/0210193 A1* 11/2003 Rossman et al. 343/725
2008/0007460 A1* 1/2008 Ke et al. 343/700 MS
2008/0316115 A1 12/2008 Hill et al.

(75) Inventors: **Tiao-Hsing Tsai**, Taoyuan (TW);
Chi-Yin Fang, Taoyuan (TW);
Chao-Hsu Wu, Taoyuan (TW);
Tsung-Ming Kuo, Taoyuan (TW);
Chun-Yuan Wang, Taoyuan (TW);
Chien-Pin Chiu, Taoyuan (TW)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 571 days.

(21) Appl. No.: **13/304,722**

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

(65) **Prior Publication Data**

US 2013/0135156 A1 May 30, 2013

Primary Examiner — Dameon E Levi

Assistant Examiner — Andrea Lindgren Baltzell

(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(51) **Int. Cl.**

H01Q 5/01 (2006.01)
H01Q 9/42 (2006.01)
H01Q 5/371 (2015.01)
H01Q 1/24 (2006.01)
H01Q 1/48 (2006.01)
H01Q 13/18 (2006.01)

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

CPC **H01Q 9/42** (2013.01); **H01Q 5/371** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 13/18** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 5/01
USPC 343/702
See application file for complete search history.

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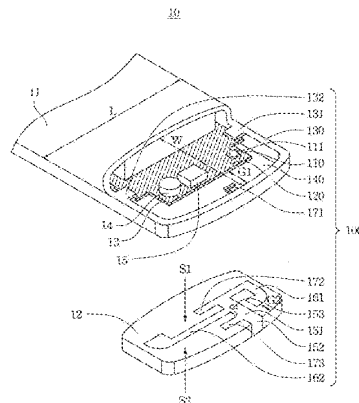
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7,629,940 B2 12/2009 Ke et al.

(57) **ABSTRACT**

A multi-band antenna for a portable communication device is disclosed, in which the communication device includes a first housing, a second housing and a substrate. The multi-band antenna includes a feeding portion, a system ground plane, a metal ring, a resonant cavity, a first and a second radiating portion. The system ground plane is disposed on the substrate. The metal ring is connected to the first housing, and forms a space with the first housing to accommodate the substrate, in which the metal ring is electrically coupled to the system ground plane through a plurality of ground ends. The resonant cavity is formed between the system ground plane and the metal ring to generate a first resonant mode. The first and the second radiating portion are disposed on the second housing, for generating a second and a third resonant mode, respectively.

12 Claims, 5 Drawing Sheets





US009166279B2

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

(10) **Patent No.:** **US 9,166,279 B2**
(45) **Date of Patent:** **Oct. 20, 2015**

(54) **TUNABLE ANTENNA SYSTEM WITH RECEIVER DIVERSITY**

(75) Inventors: **Nanbo Jin**, Sunnyvale, CA (US); **Mattia Pascolini**, San Mateo, 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 1190 days.

(21) Appl. No.: **13/041,905**

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

(65) **Prior Publication Data**
US 2012/0229347 A1 Sep. 13, 2012

Primary Examiner — Jinsong Hu
Assistant Examiner — Jean Chang
(74) *Attorney, Agent, or Firm* — Treyz Law Group; G. Victor Treyz; Michael H. Lyons

(57) **ABSTRACT**

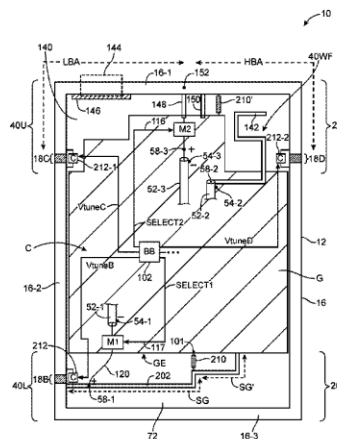
A wireless electronic device may include antenna structures and antenna tuning circuitry. The device may include a display mounted within a housing. A peripheral conductive member may run around the edges of the display and housing. Dielectric-filled gaps may divide the peripheral conductive member into individual segments. A ground plane may be formed within the housing. The ground plane and the segments of the peripheral conductive member may form antennas in upper and lower portions of the housing. The antenna tuning circuitry may include switchable inductor circuits and variable capacitor circuits for the upper and lower antennas. The switchable inductor circuits associated with the upper antenna may be tuned to provide coverage in at least two high-band frequency ranges of interest, whereas the variable capacitor circuits associated with the upper antenna may be tuned to provide coverage in at least two low-band frequency ranges of interest.

(51) **Int. Cl.**
H04M 1/00 (2006.01)
H01Q 5/01 (2006.01)
H01Q 1/24 (2006.01)
H01Q 7/00 (2006.01)
H01Q 9/14 (2006.01)
H01Q 9/42 (2006.01)
H01Q 21/28 (2006.01)
H01Q 1/44 (2006.01)
H01Q 5/307 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/44** (2013.01); **H01Q 5/307** (2015.01); **H01Q 7/00** (2013.01); **H01Q 9/14** (2013.01); **H01Q 9/42** (2013.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**
USPC 455/575.7; 343/702, 745
See application file for complete search history.

22 Claims, 9 Drawing Sheets





US009166292B2

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

(10) **Patent No.:** **US 9,166,292 B2**
(45) **Date of Patent:** **Oct. 20, 2015**

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

(71) Applicant: **FIH (Hong Kong) Limited**, Kowloon (HK)

(72) Inventors: **Chao-Wei Ho**, New Taipei (TW); **Hao-Ying Chang**, Shindian (TW)

(73) Assignee: **FIH (Hong Kong) Limited**, Kowloon (HK)

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

(21) Appl. No.: **14/204,008**

(22) Filed: **Mar. 11, 2014**

(65) **Prior Publication Data**
US 2014/0368402 A1 Dec. 18, 2014

(30) **Foreign Application Priority Data**
Jun. 17, 2013 (TW) 102121437 A

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 9/04 (2006.01)
H01Q 5/00 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 9/0414** (2013.01); **H01Q 5/0058** (2013.01); **H01Q 9/0457** (2013.01); **H01Q 9/0471** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/30; H01Q 5/371; H01Q 5/364; H01Q 9/0414; H01Q 9/0471
USPC 343/702, 860, 700 MS
See application file for complete search history.

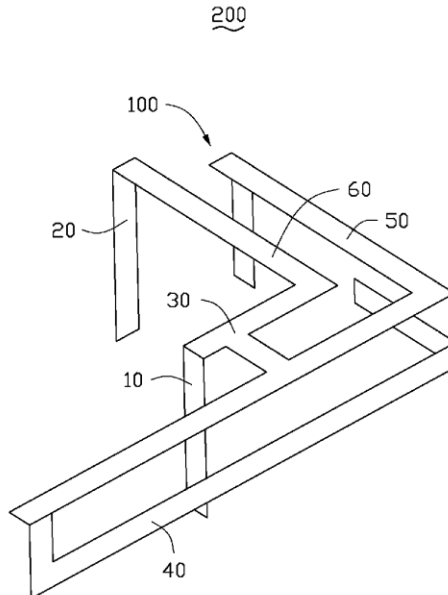
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Primary Examiner — Dameon E Levi
Assistant Examiner — Collin Dawkins
(74) *Attorney, Agent, or Firm* — Novak Druce Connolly Bove + Quigg LLP

(57) **ABSTRACT**
An antenna structure includes a feed section, a ground section, a common section, a first radiator, a second radiator, and a third radiator. The common section is electrically connected to the feed section, and the third radiator is electrically connected to the ground section. The first radiator, the second radiator, and the third radiator are all connected to the common section. The second radiator is spaced from the third radiator to allow current to be coupled from the second radiator to the third radiator.

16 Claims, 3 Drawing Sheets





US009166293B2

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

(10) **Patent No.:** **US 9,166,293 B2**
(45) **Date of Patent:** **Oct. 20, 2015**

(54) **ANTENNA AND THE METHOD FOR ADJUSTING THE OPERATION BANDWIDTH THEREOF**

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

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 423 days.

(21) Appl. No.: **13/184,826**

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

(65) **Prior Publication Data**

US 2012/0249377 A1 Oct. 4, 2012

(30) **Foreign Application Priority Data**

Apr. 1, 2011 (TW) 100111698 A

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01P 11/00 (2006.01)
H01Q 9/04 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 9/0421** (2013.01); **Y10T 29/49016** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 9/0421; H01Q 9/0414; H01Q 13/10
USPC 343/702, 700 MS
See application file for complete search history.

(56) **References Cited**

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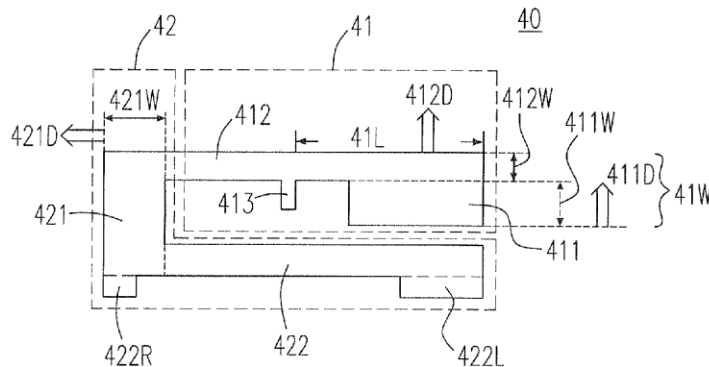
Corresponding Taiwan Patent Application Office Action, Taiwan Patent Office, Oct. 7, 2014.

Primary Examiner — Sue A Purvis
Assistant Examiner — Michael Bouizza
(74) *Attorney, Agent, or Firm* — Gottlieb, Rackman & Reisman P.C.

(57) **ABSTRACT**

A method for adjusting an operation bandwidth of an antenna is provided. The antenna includes a radiation element, and the radiation element includes a first adjusting portion having a first width and a second adjusting portion having a second width. The method includes steps of seeking an operation frequency of the antenna; and adjusting the operation bandwidth of the antenna by adjusting the second width based on the operation frequency.

19 Claims, 7 Drawing Sheets





US009166294B2

(12) **United States Patent**
Wilson

(10) **Patent No.:** **US 9,166,294 B2**
(45) **Date of Patent:** **Oct. 20, 2015**

(54) **QUAD-BAND PCB ANTENNA**
(75) Inventor: **David Wilson**, Toronto (CA)
(73) Assignee: **TYCO SAFETY PRODUCTS CANADA LTD.**, Concord, Ontario (CA)
(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 600 days.
(21) Appl. No.: **12/748,804**

USPC 343/767, 700 MS, 702
See application file for complete search history.

(56) **References Cited**

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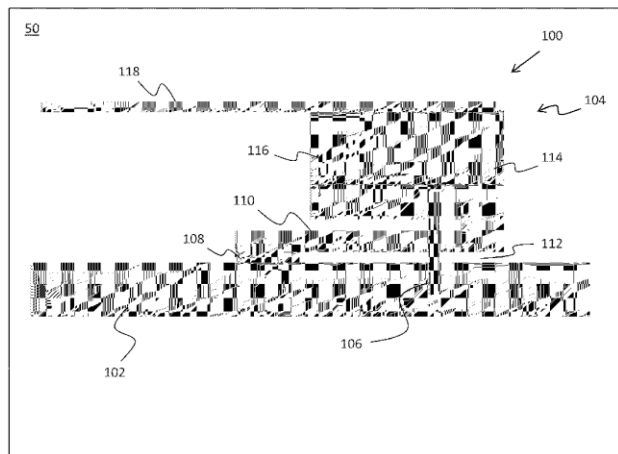
Primary Examiner — Hoang V Nguyen
Assistant Examiner — Michael Bouizza
(74) *Attorney, Agent, or Firm* — Kacvinsky Daisak Bluni PLLC

(57) **ABSTRACT**

A surface mount antenna includes a ground plane, a feed line, and a radiating element. The ground plane extends in a first direction on a first side of a substrate. The feed line extends in a second direction on a second side of the substrate. The radiating element includes a plurality of segments disposed on the first side of the substrate and is configured to resonate in a plurality of frequency modes.

18 Claims, 5 Drawing Sheets

(22) Filed: **Mar. 29, 2010**
(65) **Prior Publication Data**
US 2010/0245198 A1 Sep. 30, 2010
Related U.S. Application Data
(60) Provisional application No. 61/165,070, filed on Mar. 31, 2009.
(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 1/48 (2006.01)
H01Q 13/10 (2006.01)
H01Q 9/06 (2006.01)
H01Q 9/04 (2006.01)
H01Q 1/24 (2006.01)
H01Q 9/42 (2006.01)
H01Q 5/20 (2015.01)
H01Q 5/357 (2015.01)
(52) **U.S. Cl.**
CPC **H01Q 9/0442** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 5/20** (2015.01); **H01Q 5/357** (2015.01); **H01Q 9/42** (2013.01); **H01Q 13/10** (2013.01)
(58) **Field of Classification Search**
CPC ... H01Q 9/0442; H01Q 13/10; H01Q 5/0051; H01Q 9/42; H01Q 5/001; H01Q 1/243; H01Q 1/38; H01Q 5/0024





US009166296B2

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

(10) **Patent No.:** **US 9,166,296 B2**
(45) **Date of Patent:** **Oct. 20, 2015**

- (54) **LOOP-TYPE ANTENNA**
- (75) Inventors: **Chih-Yung Huang**, Taichung County (TW); **Kuo-Chang Lo**, Miaoli County (TW)
- (73) Assignee: **Arcadyan Technology Corporation**, Hsinchu (TW)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 479 days.

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- (21) Appl. No.: **13/185,633**
- (22) Filed: **Jul. 19, 2011**
- (65) **Prior Publication Data**
US 2012/0081261 A1 Apr. 5, 2012

- (30) **Foreign Application Priority Data**
Sep. 30, 2010 (TW) 99133365 A

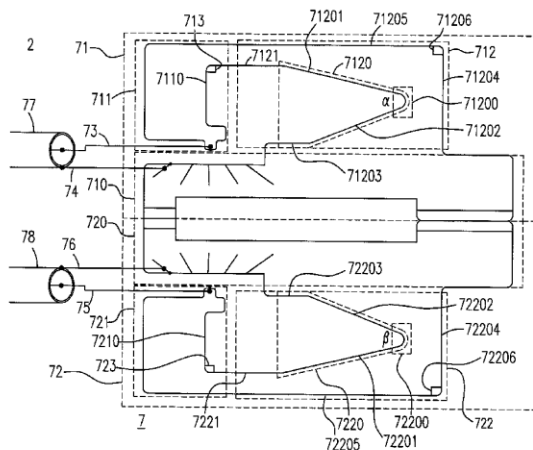
Primary Examiner — Hoang V Nguyen
Assistant Examiner — Michael Bouizza
(74) *Attorney, Agent, or Firm* — Gottlieb, Rackman & Reisman P.C.

- (51) **Int. Cl.**
H01Q 7/00 (2006.01)
H01Q 9/42 (2006.01)
H01Q 21/28 (2006.01)
- (52) **U.S. Cl.**
CPC . **H01Q 9/42** (2013.01); **H01Q 7/00** (2013.01); **H01Q 21/28** (2013.01)
- (58) **Field of Classification Search**
CPC H01Q 7/00; H01Q 9/42; H01Q 11/20
USPC 343/866
See application file for complete search history.

(57) **ABSTRACT**
An antenna interacting with a signal having a frequency is provided. The antenna includes a radiation element having a hollow portion having an angle corner related to the frequency, and including a first inner edge; a second inner edge, wherein the angle corner is formed by the first inner edge and the second inner edge; a third inner edge connected to the second inner edge; a first outer edge; and a second outer edge, wherein the first outer edge and the second outer edge form a first included angle.

- (56) **References Cited**
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17 Claims, 14 Drawing Sheets





US009166300B2

(12) **United States Patent**
Taura

(10) **Patent No.:** **US 9,166,300 B2**
(45) **Date of Patent:** **Oct. 20, 2015**

- (54) **SLOT ANTENNA**
- (75) Inventor: **Toru Taura**, Tokyo (JP)
- (73) Assignee: **NEC Corporation**, Tokyo (JP)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 219 days.

- (21) Appl. No.: **13/995,929**
- (22) PCT Filed: **Oct. 27, 2011**
- (86) PCT No.: **PCT/JP2011/006008**
§ 371 (c)(1),
(2), (4) Date: **Jun. 19, 2013**

- (87) PCT Pub. No.: **WO2012/107976**
PCT Pub. Date: **Aug. 16, 2012**

- (65) **Prior Publication Data**
US 2013/0271333 A1 Oct. 17, 2013

- (30) **Foreign Application Priority Data**
Feb. 9, 2011 (JP) 2011-026066

- (51) **Int. Cl.**
H01Q 13/10 (2006.01)
H01Q 5/357 (2015.01)
- (52) **U.S. Cl.**
CPC **H01Q 13/106** (2013.01); **H01Q 5/357**
(2015.01); **H01Q 13/10** (2013.01)
- (58) **Field of Classification Search**
CPC H01Q 13/10; H01Q 13/106
USPC 343/767
See application file for complete search history.

- (56) **References Cited**
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Primary Examiner — Dameon E Levi
Assistant Examiner — Collin Dawkins
(74) *Attorney, Agent, or Firm* — McGinn IP Law Group, PLLC

- (57) **ABSTRACT**
A slot antenna includes a dielectric substrate, a conductor surface provided on one of surfaces of the dielectric substrate, a slot formed by making a cut in the conductor surface, one end of the cut forming an opened end on an edge of the conductor surface, and a stub formed inside the slot, the stub being connected to one of opposing sides of the slot by using a connection part, in which the stub is formed in such a manner that a length of the connection part becomes longer than a distance between a side opposing to the side connected to the connection part and the stub.

15 Claims, 11 Drawing Sheets

