



US009531058B2

(12) **United States Patent**
Isöhätälä

(10) **Patent No.:** **US 9,531,058 B2**
(45) **Date of Patent:** **Dec. 27, 2016**

(54) **LOOSELY-COUPLED RADIO ANTENNA
APPARATUS AND METHODS**

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(75) Inventor: **Anne Isöhätälä**, Kello (FI)

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

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 793 days.

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(21) Appl. No.: **13/331,802**

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(22) Filed: **Dec. 20, 2011**

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

(65) **Prior Publication Data**

US 2013/0154886 A1 Jun. 20, 2013

(Continued)

Primary Examiner — Dameon E Levi

Assistant Examiner — Collin Dawkins

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

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 9/04 (2006.01)

H01Q 5/371 (2015.01)

H01Q 5/378 (2015.01)

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

CPC **H01Q 1/243** (2013.01); **H01Q 5/371**
(2015.01); **H01Q 5/378** (2015.01); **H01Q**
9/045 (2013.01); **H01Q 9/0421** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/38; H01Q 9/0421
USPC 343/702, 846, 848
See application file for complete search history.

(57) **ABSTRACT**

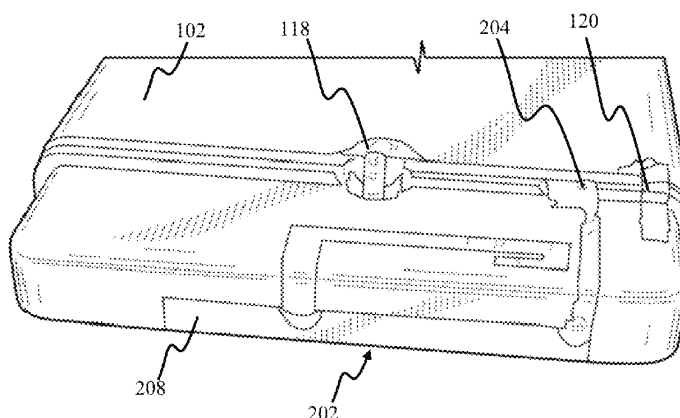
A multiband internal antenna apparatus and methods of tuning and utilizing the same. In one embodiment, the antenna configuration is used within a handheld mobile device (e.g., cellular telephone or smartphone). The device enclosure is fabricated from a conductive material and has two parts: the main portion, housing the device electronics and ground plane, and the antenna cap, which substantially envelops a directly fed radiator structure of the antenna. Electromagnetic coupling of the cap portion to the device feed effects formation of a parasitic antenna radiator in a lower frequency band. The cap portion is separated from the main portion by a narrow gap, extending along circumference of the device, and is grounded at a location selected to cause desired resonance and to widen antenna bandwidth. In one implementation, a second parasitic radiator is disposed proximate the directly feed radiator to further expand antenna frequency bands of operation.

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23 Claims, 5 Drawing Sheets





US009531059B2

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

(10) **Patent No.:** **US 9,531,059 B2**

(45) **Date of Patent:** **Dec. 27, 2016**

(54) **SIDE FACE ANTENNA FOR A COMPUTING DEVICE CASE**

(71) Applicant: **Microsoft Corporation**, Redmond, WA (US)

(72) Inventors: **Devis Iellici**, Cambridge (GB); **Marc Harper**, Issaquah, WA (US)

(73) Assignee: **Microsoft Technology Licensing, LLC**, Redmond, WA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 227 days.

(21) Appl. No.: **14/090,542**

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

(65) **Prior Publication Data**

US 2014/0347227 A1 Nov. 27, 2014

Related U.S. Application Data

(60) Provisional application No. 61/827,421, filed on May 24, 2013, provisional application No. 61/827,372, filed on May 24, 2013.

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/22 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/2266** (2013.01); **H01Q 5/378** (2015.01); **H01Q 5/40** (2015.01); **H01Q 9/42** (2013.01); **Y10T 29/49016** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 13/10; H01Q 1/2266; H01Q 5/371; H01Q 9/42
(Continued)

(56) **References Cited**

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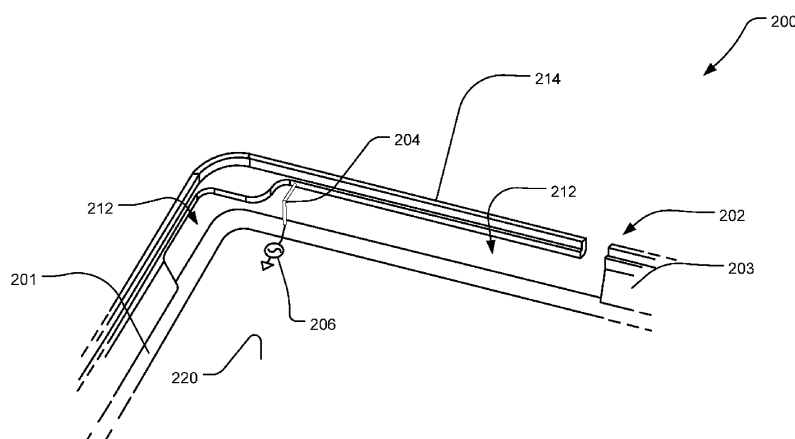
Primary Examiner — Tho G. Phan

(74) *Attorney, Agent, or Firm* — Brandon Roper; Judy Yee; Micky Minhas

(57) **ABSTRACT**

An antenna assembly includes a portion of the metal computing device case as a primary radiating structure. The metal computing device case includes a back face and four side faces bounding at least a portion of the back face. The metal computing device case further includes a radiating structure having an aperture formed in the back face from which a notch extends from the aperture cutting through the back face and through at least one side face of the metal computing device case. A conductive feed structure is connected to a radio. The conductive feed structure is connected to or positioned proximal to the radiating structure of the metal computing device case and is configured to excite the radiating structure at one or more resonance frequencies.

20 Claims, 14 Drawing Sheets





US009531061B2

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

(10) **Patent No.:** **US 9,531,061 B2**

(45) **Date of Patent:** **Dec. 27, 2016**

(54) **ELECTRONIC DEVICE ANTENNA WITH REDUCED LOSSY MODE**

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

(72) Inventors: **Liang Han**, Sunnyvale, CA (US);
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Yijun Zhou, Sunnyvale, CA (US);
Hongfei Hu, Santa Clara, CA (US);
Salih Yarga, Sunnyvale, CA (US);
Mattia Pascolini, San Francisco, CA (US);
Yuehui Ouyang, Sunnyvale, CA (US);
Erdinc Irci, Sunnyvale, CA (US);
Enrique Ayala Vazquez, Watsonville, 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 314 days.

(21) Appl. No.: **14/476,490**

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

(65) **Prior Publication Data**

US 2016/0064801 A1 Mar. 3, 2016

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 9/42 (2006.01)
H01Q 13/10 (2006.01)
H01Q 5/328 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 5/328** (2015.01); **H01Q 9/42** (2013.01); **H01Q 13/10** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 13/10; H01Q 5/328; H01Q 9/42; H01Q 1/243

USPC 343/700 MS, 702, 745
See application file for complete search history.

(56) **References Cited**

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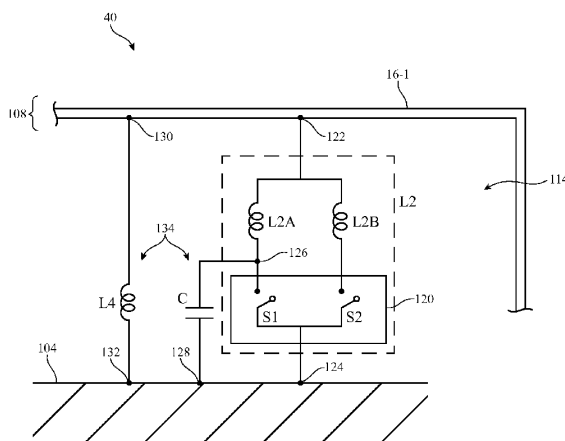
Primary Examiner — Khai M Nguyen

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

(57) **ABSTRACT**

An electronic device may be provided with an antenna. The antenna may have an antenna resonating element and an antenna ground. An adjustable inductor may be coupled between the antenna resonating element and the antenna ground. An antenna feed may have a positive feed terminal coupled to the antenna resonating element and a ground antenna feed coupled to the antenna ground. The adjustable inductor may have first and second inductors coupled to respective first and second ports of a switch. The switch may have a third port coupled to the antenna ground. A capacitor may have a first terminal coupled to ground and a second terminal coupled to the first inductor at the first port of the switch. An inductor may be coupled between the antenna resonating element and antenna ground at a location between the adjustable inductor and the antenna feed.

20 Claims, 10 Drawing Sheets





US009531063B2

(12) **United States Patent**
Andrenko

(10) **Patent No.:** **US 9,531,063 B2**

(45) **Date of Patent:** **Dec. 27, 2016**

(54) **PLANAR INVERTED-F ANTENNA**

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333/161

(71) Applicant: **FUJITSU LIMITED**, Kawasaki-shi,
Kanagawa (JP)

6,542,126 B2 4/2003 Bahr et al.
7,375,686 B2 5/2008 Ku et al.
7,903,043 B2 3/2011 Rawat et al.
2006/0145927 A1 7/2006 Choi et al.

(72) Inventor: **Andrey S Andrenko**, Kawasaki (JP)

(Continued)

(73) Assignee: **FUJITSU LIMITED**, Kawasaki (JP)

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(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 271 days.

CN 1901278 A 1/2007
EP 1168495 A2 1/2002
(Continued)

(21) Appl. No.: **14/023,587**

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(22) Filed: **Sep. 11, 2013**

Extended European Search Report dated Jan. 7, 2014 for corre-
sponding European Application No. 13185731.0.

(65) **Prior Publication Data**

US 2014/0139383 A1 May 22, 2014

(Continued)

(30) **Foreign Application Priority Data**

Nov. 19, 2012 (JP) 2012-253565

Primary Examiner — Dameon E Levi

Assistant Examiner — Walter Davis

(74) *Attorney, Agent, or Firm* — Fujitsu Patent Center

(51) **Int. Cl.**

H01Q 1/27 (2006.01)

H01Q 1/40 (2006.01)

H01Q 9/04 (2006.01)

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

CPC **H01Q 1/273** (2013.01); **H01Q 1/40**
(2013.01); **H01Q 9/0421** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/273

USPC 343/718

See application file for complete search history.

(56) **References Cited**

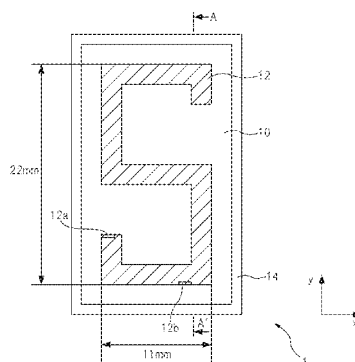
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6,343,208 B1 * 1/2002 Ying H01Q 1/243
343/702

(57) **ABSTRACT**

The planar inverted-F antenna includes a first substrate made of a dielectric material, a grounding electrode disposed on a first surface of the first substrate; an emitting electrode disposed to be opposite to the grounding electrode so as to sandwich the first substrate, wherein the emitting electrode has an S-shape, and has a short-circuiting point short-circuited to the grounding electrode at an edge portion thereof, and a feed point at which power is fed and which is located away from the short-circuiting point by a distance at which the characteristic impedance of the planar inverted-F antenna for electric waves with a certain design wavelength has a certain value; and a second substrate disposed to cover the entire emitting electrode together with the first substrate and made of a dielectric material.

3 Claims, 7 Drawing Sheets





US009531066B2

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

(10) **Patent No.:** **US 9,531,066 B2**

(45) **Date of Patent:** **Dec. 27, 2016**

(54) **ANTENNA PATTERN FRAME AND
ELECTRONIC DEVICE INCLUDING THE
SAME**

(58) **Field of Classification Search**

None

See application file for complete search history.

(71) Applicant: **SAMSUNG
ELECTRO-MECHANICS CO., LTD.,**
Suwon-Si, Gyeonggi-Do (KR)

(56) **References Cited**

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Primary Examiner — Robert Karacsony

(74) *Attorney, Agent, or Firm* — NSIP Law

(*) 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.: **14/717,940**

(22) Filed: **May 20, 2015**

(65) **Prior Publication Data**

US 2016/0079657 A1 Mar. 17, 2016

(30) **Foreign Application Priority Data**

Sep. 11, 2014 (KR) 10-2014-0120460

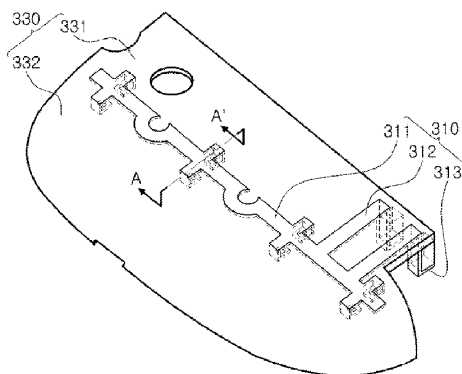
(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/12 (2006.01)
H01Q 1/40 (2006.01)
H01Q 9/42 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/40** (2013.01); **H01Q 1/1207**
(2013.01); **H01Q 1/243** (2013.01); **H01Q 9/42**
(2013.01)

(57) **ABSTRACT**

There is provided an antenna pattern frame including: a radiator including an antenna pattern part transmitting and receiving signals and a connection terminal part electrically connecting the antenna pattern part and a circuit board to each other; and a radiator frame provided by performing injection molding on the radiator while allowing the antenna pattern part to be exposed to one surface thereof and allowing the connection terminal part to be exposed to the other surface thereof, wherein the antenna pattern part is provided with a support part protruding outwardly from the antenna pattern part and bent in a direction toward the radiator frame to be disposed inwardly of the radiator frame.

9 Claims, 7 Drawing Sheets





US009531071B2

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

(10) **Patent No.:** **US 9,531,071 B2**

(45) **Date of Patent:** **Dec. 27, 2016**

(54) **ANTENNA STRUCTURES HAVING
RESONATING ELEMENTS AND PARASITIC
ELEMENTS WITHIN SLOTS IN
CONDUCTIVE ELEMENTS**

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

(72) Inventors: **Jerzy S. Guterman**, Mountain View,
CA (US); **Hao Xu**, Cupertino, CA (US);
Douglas Blake Kough, San Jose, CA
(US); **Eduardo Lopez Camacho**,
Watsonville, CA (US); **Mattia**
Pascolini, San Francisco, CA (US);
Robert W. Schlub, 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
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(21) Appl. No.: **14/992,213**

(22) Filed: **Jan. 11, 2016**

(65) **Prior Publication Data**

US 2016/0118718 A1 Apr. 28, 2016

Related U.S. Application Data

(63) Continuation of application No. 12/888,350, filed on
Sep. 22, 2010, now Pat. No. 9,236,648.

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

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 5/357** (2015.01); **H01Q 1/2266**
(2013.01); **H01Q 5/378** (2015.01)

(58) **Field of Classification Search**

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

(56) **References Cited**

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Primary Examiner — Hoang V Nguyen

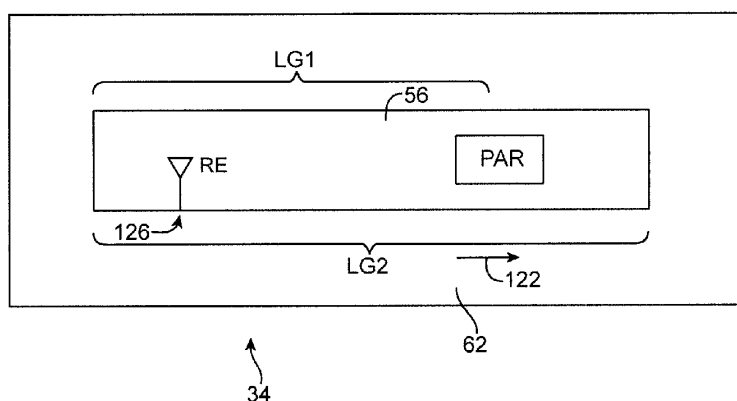
Assistant Examiner — Hai Tran

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

(57) **ABSTRACT**

Electronic devices may include radio-frequency transceiver circuitry and antenna structures. The antenna structures may include antenna resonating elements such as dual-band antenna resonating elements that resonate in first and second communications bands. The antenna structures may also contain parasitic antenna elements such as elements that are operative in only the first or second communications band and elements that are operative in both the first and second communications bands. The antenna resonating elements and parasitic elements may be mounted on a common dielectric carrier. The dielectric carrier may be mounted within a slot or other opening in a conductive element. The conductive element may be formed from conductive housing structures in an electronic device such as a portable computer. The portable computer may have a clutch barrel with a dielectric cover. The dielectric cover may overlap and cover the slot and the dielectric carrier.

19 Claims, 24 Drawing Sheets





US009531072B2

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

(10) **Patent No.:** **US 9,531,072 B2**
(45) **Date of Patent:** **Dec. 27, 2016**

(54) **ANTENNA DEVICE, FEED ELEMENT, AND COMMUNICATION TERMINAL DEVICE**

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

(72) Inventors: **Shinichi Nakano**, Nagaokakyo (JP);
Kuniaki Yosui, Nagaokakyo (JP);
Noboru Kato, Nagaokakyo (JP)

(73) Assignee: **MURATA MANUFACTURING CO., LTD.**, Kyoto (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 152 days.

(21) Appl. No.: **14/221,437**

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

(65) **Prior Publication Data**

US 2014/0203992 A1 Jul. 24, 2014

Related U.S. Application Data

(63) Continuation of application No.
PCT/JP2013/067805, filed on Jun. 28, 2013.

(30) **Foreign Application Priority Data**

Jun. 28, 2012 (JP) 2012-144968
Sep. 14, 2012 (JP) 2012-202755
Oct. 12, 2012 (JP) 2012-226975

(51) **Int. Cl.**
H01Q 7/00 (2006.01)
G06K 7/10 (2006.01)
H01Q 7/06 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 7/00** (2013.01); **G06K 7/10009**
(2013.01); **H01Q 7/06** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 7/00

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Primary Examiner — Dameon E Levi

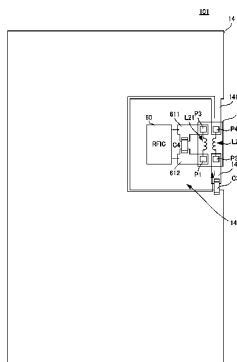
Assistant Examiner — Andrea Lindgren Baltzell

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

(57) **ABSTRACT**

An antenna device includes a conductor surface in which an opening having an open edge portion in communication with the outside is provided, a feed element including a first coil connected to the feed element and a second coil magnetically coupled to the first coil, a first mounting portion disposed in the open edge portion and connected to a first end of the second coil, and a second mounting portion disposed in the open edge portion in a state isolated from the first mounting portion and connected to a second end of the second coil. The first mounting portion and the conductor surface are directly or indirectly conducted to each other, and the second mounting portion and the conductor surface are directly or indirectly conducted to each other. A loop is defined around the opening through the first mounting portion, the second mounting portion, and the second coil.

18 Claims, 14 Drawing Sheets





US009531074B2

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

(10) **Patent No.:** **US 9,531,074 B2**

(45) **Date of Patent:** **Dec. 27, 2016**

(54) **PLANAR INVERTED F ANTENNA WITH
IMPROVED FEEDING LINE CONNECTION**

H01Q 1/273; H01Q 1/38; H01Q 1/40;
H01Q 5/364; H01Q 5/371

(Continued)

(75) Inventors: **Yoshiyuki Yonei**, Chiba (JP); **Masahiro Sobu**, Chiba (JP); **Akinori Matsui**, Fukaya (JP); **Misao Haneishi**, Saitama (JP)

(56)

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(73) Assignees: **SEIKO SOLUTIONS INC.** (JP);
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EDUCATIONAL FOUNDATION
(JP); **MISAO HANEISHI** (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 296 days.

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WO 2005020371 3/2005

(21) Appl. No.: **14/240,123**

(22) PCT Filed: **Aug. 10, 2012**

(86) PCT No.: **PCT/JP2012/070454**

§ 371 (c)(1),
(2), (4) Date: **Feb. 21, 2014**

(87) PCT Pub. No.: **WO2013/031517**

PCT Pub. Date: **Mar. 7, 2013**

(65) **Prior Publication Data**

US 2014/0197996 A1 Jul. 17, 2014

(30) **Foreign Application Priority Data**

Aug. 26, 2011 (JP) 2011-185316

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 9/04 (2006.01)
H01Q 5/364 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 9/0421** (2013.01); **H01Q 5/364**
(2015.01); **H01Q 9/045** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/0421; H01Q 9/0407; H01Q 9/045;
H01Q 9/0471; H01Q 9/42; H01Q 1/243;

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Primary Examiner — Lam T Mai

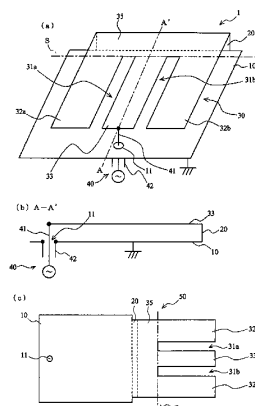
(74) *Attorney, Agent, or Firm* — Adams & Wilks

(57)

ABSTRACT

A planar inverted F antenna has a ground conductive plate and a main conductive plate that are short-circuited by a short circuit member. The main conductive plate connects to a feeding line for feeding power to the antenna and includes opposite side ends, a base extending from one side end to a prescribed position in the direction toward the other side end, and a slit extending from the other side end of the main conductive plate up to the prescribed position to form a microstrip line that is connected to the feeding line and at least one excitation conductive plate spaced apart from the microstrip line. The prescribed position includes a feeding point to which power is supplied from the feeding line via the microstrip line having a width such that an input impedance of the antenna at the feeding point and a characteristic impedance become Z.

20 Claims, 25 Drawing Sheets





US009531076B2

(12) **United States Patent**
Lahti

(10) **Patent No.:** **US 9,531,076 B2**

(45) **Date of Patent:** **Dec. 27, 2016**

(54) **ELECTRICALLY TUNABLE MINIATURE ANTENNA**

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

(72) Inventor: **Saku Lahti**, Tampere (FI)

(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 251 days.

(21) Appl. No.: **14/138,187**

(22) Filed: **Dec. 23, 2013**

(65) **Prior Publication Data**

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(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 9/06 (2006.01)
H01Q 9/28 (2006.01)
H01Q 5/335 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 9/065** (2013.01); **H01Q 5/335** (2015.01); **H01Q 9/285** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/065; H01Q 5/335; H01Q 9/285
See application file for complete search history.

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Primary Examiner — Hoang V Nguyen

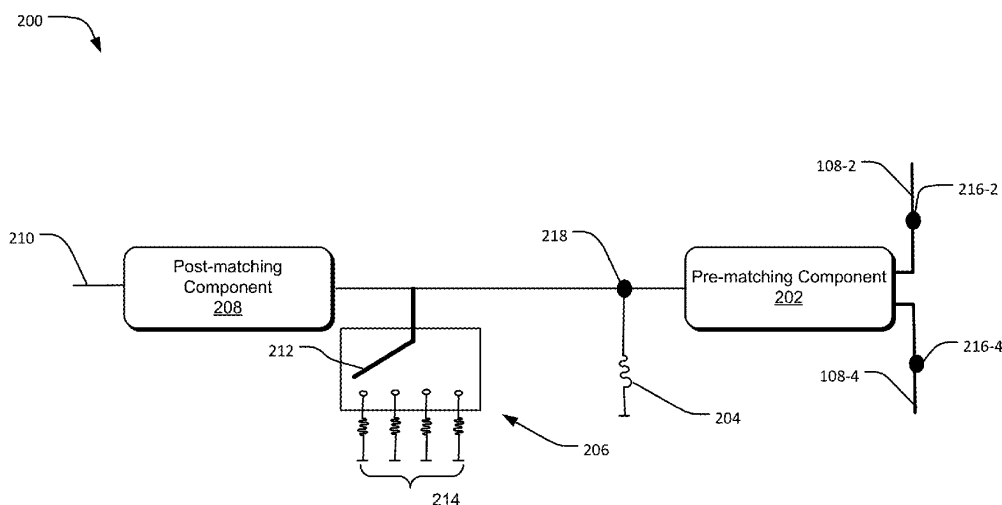
Assistant Examiner — Michael Bouizza

(74) *Attorney, Agent, or Firm* — Forefront IP Lawgroup, PLLC

(57) **ABSTRACT**

Described herein are architectures, platforms and methods for electrically tuning radiators in a portable device.

23 Claims, 3 Drawing Sheets





US009531852B2

(12) **United States Patent**
Kim

(10) **Patent No.:** **US 9,531,852 B2**
(45) **Date of Patent:** **Dec. 27, 2016**

(54) **WIRELESS COMMUNICATION TERMINAL**

(71) Applicant: **LG ELECTRONICS INC.**, Seoul
(KR)

(72) Inventor: **Junhong Kim**, Seoul (KR)

(73) Assignee: **LG ELECTRONICS INC.**, Seoul
(KR)

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

(21) Appl. No.: **15/032,094**

(22) PCT Filed: **Sep. 3, 2014**

(86) PCT No.: **PCT/KR2014/008259**

§ 371 (c)(1),

(2) Date: **Apr. 26, 2016**

(87) PCT Pub. No.: **WO2015/076486**

PCT Pub. Date: **May 28, 2015**

(65) **Prior Publication Data**

US 2016/0248893 A1 Aug. 25, 2016

(30) **Foreign Application Priority Data**

Nov. 25, 2013 (KR) 10-2013-0143870

(51) **Int. Cl.**

H04M 1/00 (2006.01)

H04M 1/02 (2006.01)

(Continued)

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

CPC **H04M 1/026** (2013.01); **H01Q 1/2266**
(2013.01); **H04B 1/036** (2013.01)

(58) **Field of Classification Search**

CPC H04M 1/0202; H04M 1/026; H04M 1/035;

H04R 1/1058; H01Q 1/243; H01Q 13/18

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(56) **References Cited**

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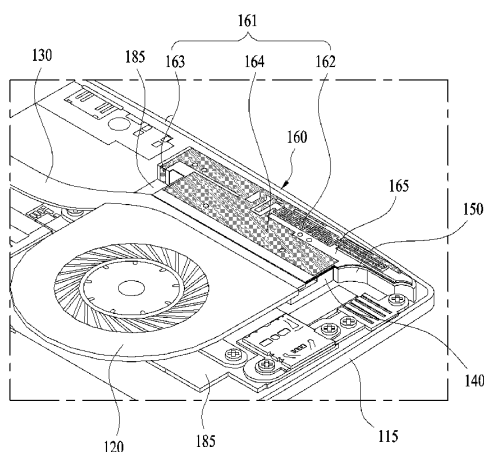
Primary Examiner — Keith Ferguson

(74) *Attorney, Agent, or Firm* — KED & Associates, LLP

(57) **ABSTRACT**

To achieve the above objectives, a wireless communication terminal of the present invention comprises: a case having a bent hole formed in one side thereof; an antenna carrier disposed in the case such that a side thereof faces the bent hole, and including a duct passing through one side and the other side thereof; a fan disposed on the other side of the antenna carrier; and an antenna disposed on the antenna carrier and the top surface of the fan and having an antenna pattern for transmitting and receiving wireless signals, wherein the wireless communication terminal has the antenna and a heat dissipating structure disposed in proximity such that one member performs two or more functions, so as to provide a wireless communication terminal making good use of internal space.

9 Claims, 4 Drawing Sheets





US009537218B2

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

(10) **Patent No.:** **US 9,537,218 B2**
(45) **Date of Patent:** **Jan. 3, 2017**

(54) **BROADBAND ANTENNA AND WIRELESS COMMUNICATION DEVICE EMPLOYING SAME**

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

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

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 267 days.

(21) Appl. No.: **14/306,481**

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

(65) **Prior Publication Data**

US 2014/0375507 A1 Dec. 25, 2014

(30) **Foreign Application Priority Data**

Jun. 19, 2013 (TW) 102121645 A

(51) **Int. Cl.**

H01Q 5/00 (2015.01)

H01Q 5/378 (2015.01)

H01Q 1/36 (2006.01)

H01Q 21/28 (2006.01)

H01Q 5/371 (2015.01)

H01Q 1/24 (2006.01)

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

CPC **H01Q 5/378** (2015.01); **H01Q 1/36** (2013.01); **H01Q 5/371** (2015.01); **H01Q 21/28** (2013.01); **H01Q 1/241** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/36; H01Q 5/371; H01Q 5/378
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Sue A Purvis

Assistant Examiner — Amal Patel

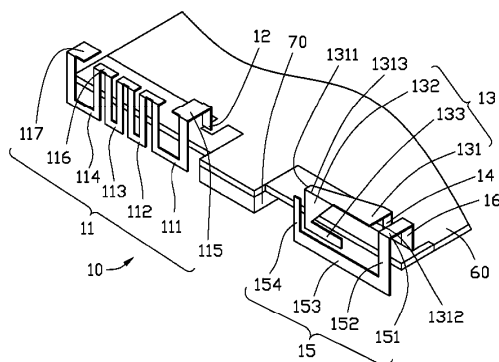
(74) *Attorney, Agent, or Firm* — Zhigang Ma

(57) **ABSTRACT**

A broadband antenna for a wireless communication device includes a first feeding portion, a second feeding portion, a grounding portion, a low band radiating unit, a high band radiating unit, and a resonating unit. The low band radiating unit is connected to the first feeding portion and establishing a first current path to generate a low band frequency. The high band radiating unit is connected to the second feeding portion and establishing a second current path to generate a first high band frequency. The resonating unit is connected to the grounding portion and establishing a third current path to generate a second high band frequency. The resonating unit resonates with the high band radiating unit to generate a third high band frequency.

16 Claims, 6 Drawing Sheets

100





US009537219B2

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

(10) **Patent No.:** **US 9,537,219 B2**
(45) **Date of Patent:** **Jan. 3, 2017**

(54) **ELECTRONIC DEVICE WITH PASSIVE
ANTENNA RETUNING CIRCUITRY**

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

(72) Inventors: **Enrique Ayala Vazquez**, Watsonville,
CA (US); **Mattia Pascolini**, San
Francisco, CA (US); **Hongfei Hu**, Santa
Clara, CA (US); **Erdinc Irci**, Santa
Clara, CA (US); **Yuehui Ouyang**,
Sunnyvale, CA (US); **Jennifer M.**
Edwards, San Francisco, CA (US);
Jayesh Nath, Milpitas, CA (US); **Salih**
Yarga, Sunnyvale, CA (US); **Yijun**
Zhou, Sunnyvale, CA (US); **Hao Xu**,
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 122 days.

(21) Appl. No.: **14/500,819**

(22) Filed: **Sep. 29, 2014**

(65) **Prior Publication Data**

US 2016/0093955 A1 Mar. 31, 2016

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 1/24 (2006.01)
H01Q 9/42 (2006.01)
H01Q 5/328 (2015.01)
H01Q 5/335 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 9/0442** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 5/328** (2015.01); **H01Q**
5/335 (2015.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 9/0442; H01Q 5/328; H01Q 5/335;
H01Q 1/243; H01Q 9/42

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

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Primary Examiner — Dameon E Levi

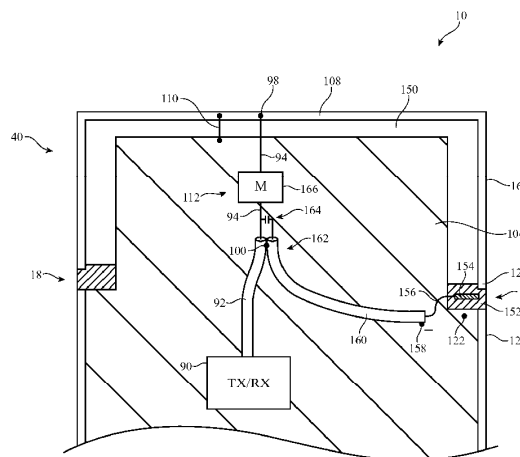
Assistant Examiner — David Lotter

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

(57) **ABSTRACT**

An electronic device may have wireless circuitry with
antennas. An antenna may have an inverted-F antenna
resonating element, an antenna ground, and other resonating
element structures. A tip of the antenna resonating element
and the antenna ground may be separated by a peripheral
housing gap filled with plastic. The antenna may be sensitive
to capacitance changes induced by the presence of a user's
hand overlapping the gap or other portions of the antenna. A
hand capacitance sensing electrode may be mounted in the
plastic of the gap or elsewhere in the vicinity of the antenna.
A transmission line may couple the hand capacitance sens-
ing electrode to the antenna to retune the antenna in the
event that the user's hand overlaps the antenna.

22 Claims, 7 Drawing Sheets





US009537220B2

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

(10) **Patent No.:** **US 9,537,220 B2**
(45) **Date of Patent:** **Jan. 3, 2017**

(54) **ANTENNA ASSEMBLY AND WIRELESS COMMUNICATION DEVICE EMPLOYING SAME**

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

(72) Inventors: **Tze-Hsuan Chang**, New Taipei (TW);
Cho-Kang Hsu, New Taipei (TW)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 480 days.

(21) Appl. No.: **14/081,052**

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

(65) **Prior Publication Data**

US 2014/0218244 A1 Aug. 7, 2014

(30) **Foreign Application Priority Data**

Feb. 1, 2013 (TW) 102104102 A

(51) **Int. Cl.**
H01Q 5/30 (2015.01)
H01Q 21/28 (2006.01)
H01Q 13/10 (2006.01)
H01Q 1/24 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 13/10** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/30** (2015.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 13/10; H01Q 1/243; H01Q 1/3827; H01Q 5/35; H01Q 5/371
USPC 343/770
See application file for complete search history.

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Primary Examiner — Dameon E Levi

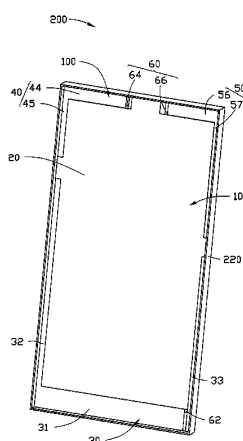
Assistant Examiner — Jennifer F Hu

(74) *Attorney, Agent, or Firm* — Zhigang Ma

(57) **ABSTRACT**

An antenna assembly includes a base, a ground surface, a first radiating portion, a second radiating portion, a third radiating portion, and a feed portion. The ground surface is arranged on a surface of the base. The feed portion includes a plurality of feed points mounted on the radiating portions. The first radiating portion and one feed point transmit and receive wireless signals at a first frequency band and a second frequency band; the second radiating portion and the third radiating portion couple with the feed points to transmit and receive wireless signals at a third frequency band and a fourth frequency. The first radiating portion, the second radiating portion, and the third radiating portion form several slot antennas. A wireless communication device employing the antenna assembly is also described.

12 Claims, 9 Drawing Sheets





US009537223B2

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

(10) **Patent No.:** **US 9,537,223 B2**
(45) **Date of Patent:** **Jan. 3, 2017**

(54) **MULTI-OUTPUT ANTENNA**

(75) Inventors: **Peter Hall**, Birmingham (GB);
Zhenhua Hu, Solihull (GB)

(73) Assignee: **Smart Antenna Technologies Ltd.**,
Birmingham (GB)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 270 days.

(21) Appl. No.: **14/234,951**

(22) PCT Filed: **Jul. 26, 2012**

(86) PCT No.: **PCT/GB2012/051799**

§ 371 (c)(1),
(2), (4) Date: **Jan. 24, 2014**

(87) PCT Pub. No.: **WO2013/014458**

PCT Pub. Date: **Jan. 31, 2013**

(65) **Prior Publication Data**

US 2014/0159971 A1 Jun. 12, 2014

(30) **Foreign Application Priority Data**

Jul. 26, 2011 (GB) 1112839.4

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

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 21/0006** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 5/335** (2015.01); **H01Q**
21/28 (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/145; H01Q 9/30; H01Q 9/14;
H01Q 23/00; H01Q 1/243
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(56) **References Cited**

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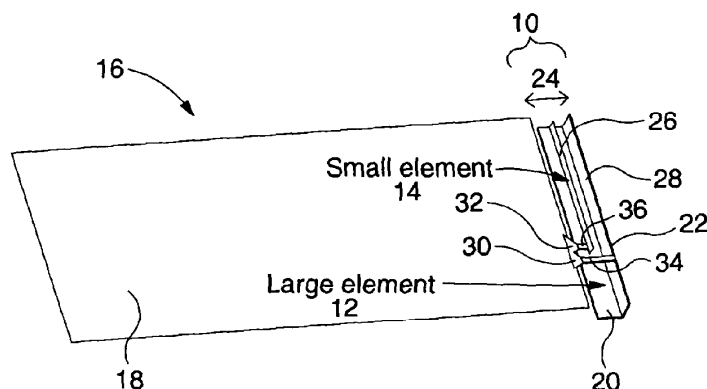
Primary Examiner — Huedung Mancuso

(74) *Attorney, Agent, or Firm* — Shumaker & Sieffert,
P.A.

(57) **ABSTRACT**

A reconfigurable multi-output antenna (16) is disclosed comprising: one or more radiating elements (12, 14), at least two matching circuits (42, 44, 50, 52) coupled to the or each radiating element (12, 14) via e.g. a splitter (30, 32) or a duplexer; and wherein each matching circuit (42, 44, 50, 52) is associated with a separate port (38, 40, 46, 48) arranged to drive a separate resonant frequency so that the or each radiating element (12, 14) is operable to provide multiple outputs simultaneously. The resonant frequency of each output is independently controllable by each matching circuit, with good isolation with each other port, thereby offering very wide operating frequency range with simultaneous multi-independent output operations. Also described is a multi-output antenna control module for coupling to one or more radiating elements, an antenna structure and an antenna interface module. A reconfigurable multi-output antenna is disclosed comprising: one or more radiating.

20 Claims, 16 Drawing Sheets





US009543639B2

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

(10) **Patent No.:** **US 9,543,639 B2**
(45) **Date of Patent:** **Jan. 10, 2017**

(54) **BACK FACE ANTENNA IN A COMPUTING DEVICE CASE**

(71) Applicant: **Microsoft Corporation**, Redmond, WA (US)

(72) Inventors: **Devis Iellici**, Cambridge (GB); **Marc Harper**, Issaquah, WA (US)

(73) Assignee: **Microsoft Technology Licensing, LLC**, Redmond, WA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 270 days.

(21) Appl. No.: **14/090,465**

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

(65) **Prior Publication Data**

US 2014/0347226 A1 Nov. 27, 2014

Related U.S. Application Data

(60) Provisional application No. 61/827,372, filed on May 24, 2013, provisional application No. 61/827,421, filed on May 24, 2013.

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/22 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/2266** (2013.01); **H01Q 5/371** (2015.01); **H01Q 5/378** (2015.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 13/10; H01Q 1/2266; H01Q 5/371; H01Q 9/42
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(56) **References Cited**

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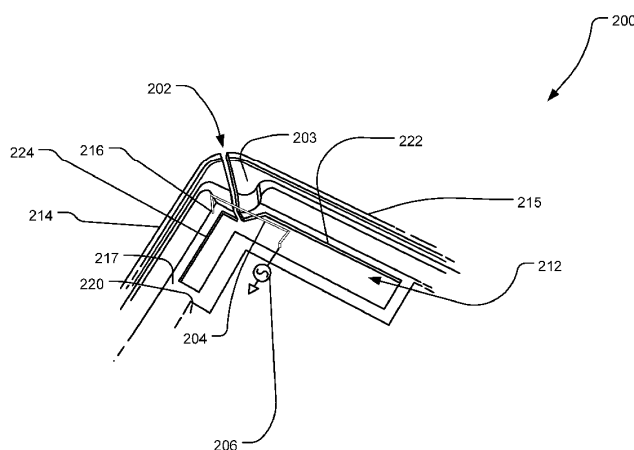
Primary Examiner — Tho G Phan

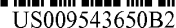
(74) *Attorney, Agent, or Firm* — Brandon Roper; Judy Yee; Micky Minhas

(57) **ABSTRACT**

An antenna assembly includes a portion of the metal computing device case as a primary radiating structure. The metal computing device case includes a back face and one or more side faces bounding the back face. The metal computing device case further includes a radiating structure having an aperture formed in the back face from which a notch extends from the aperture cutting through the back face and through at least one side face of the metal computing device case. A conductive feed structure is connected to a radio. The conductive feed structure is positioned proximal to the radiating structure of the metal computing device case and is configured to excite the radiating structure at one or more resonance frequencies.

20 Claims, 20 Drawing Sheets





(10) **Patent No.:** US 9,543,650 B2
(45) **Date of Patent:** Jan. 10, 2017

- (58) **Field of Classification Search**
CPC G01Q 7/00; G01Q 7/005
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- (56) **References Cited**
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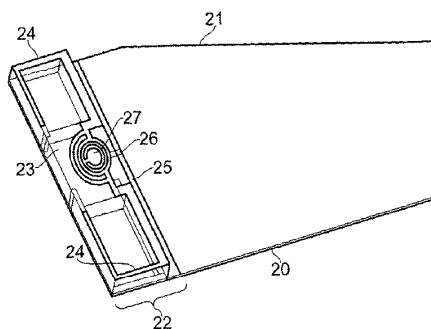
Primary Examiner — Huedung Mancuso
(74) *Attorney, Agent, or Firm* — Brandon Roper; Judy Yee; Micky Minhas

(57) **ABSTRACT**

- There is disclosed an antenna system for mobile handsets and other devices. The antenna system comprises a dielectric substrate having first and second opposed surfaces, a conductive track on the substrate, and a separate, directly driven antenna to drive the parasitic loop antenna formed by the conductive track. Two grounding points are provided adjacent to each other on the first surface of the substrate, with the arms of the conductive track extending in generally opposite directions from the grounding points. The conductive tracks then extend towards an edge of the dielectric substrate, before passing to the second surface of the dielectric substrate and then passing across the second surface of the dielectric substrate following a path generally following the path taken on the first surface of the dielectric substrate. The conductive tracks then connect to respective sides of a
- (Continued)

(Continued)

- (52) **U.S. Cl.**
CPC ***H01Q 5/378*** (2015.01); ***H01Q 1/243***
(2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 5/321***
(2015.01);
- (Continued)





US009543660B2

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

(10) **Patent No.:** **US 9,543,660 B2**
(45) **Date of Patent:** **Jan. 10, 2017**

(54) **ELECTRONIC DEVICE CAVITY ANTENNAS WITH SLOTS AND MONOPOLES**

(56) **References Cited**

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

U.S. PATENT DOCUMENTS

(72) Inventors: **Harish Rajagopalan**, San Jose, CA (US); **Huan-Chu Huang**, Taoyuan County (TW); **Ke Sun**, Beijing (CN); **Qingxiang Li**, Mountain View, CA (US); **Robert W. Schlub**, Cupertino, CA (US); **Rodney A. Gomez Angulo**, Sunnyvale, CA (US); **Umar Azad**, San Jose, CA (US)

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

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 152 days.

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(21) Appl. No.: **14/510,724**

Primary Examiner — Hoang V Nguyen

(22) Filed: **Oct. 9, 2014**

Assistant Examiner — Hai Tran

(65) **Prior Publication Data**

US 2016/0104944 A1 Apr. 14, 2016

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

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 21/00 (2006.01)
H01Q 9/04 (2006.01)
H01Q 13/18 (2006.01)
H01Q 9/42 (2006.01)

(57) **ABSTRACT**

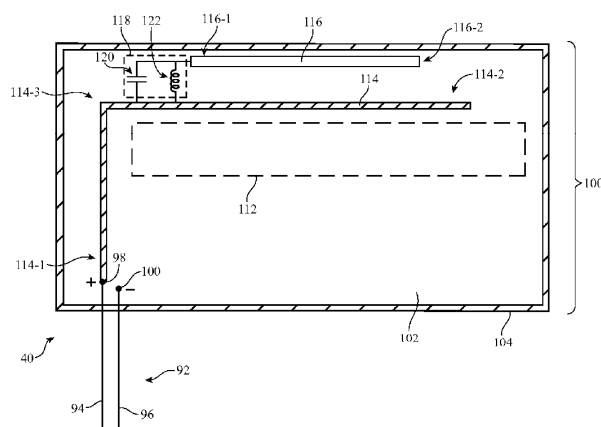
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An electronic device may be provided with wireless circuitry. The wireless circuitry may include cavity antennas. A cavity antenna may be formed from a metal antenna cavity and resonating element structures. The metal antenna cavity may be formed from metal traces on a dielectric carrier. The resonating element structures may include directly fed and indirectly fed slot antenna resonating elements and monopole antenna resonating elements. The metal antenna cavity may exhibit a resonance that is tuned using a transmission line tuning stub. Filters and duplexer circuits may be used in routing signals at different frequency bands among the antenna resonating elements.

(52) **U.S. Cl.**
CPC **H01Q 21/005** (2013.01); **H01Q 5/378** (2015.01); **H01Q 9/045** (2013.01); **H01Q 9/42** (2013.01); **H01Q 13/18** (2013.01); **H01Q 21/30** (2013.01); **H01Q 1/243** (2013.01); **H01Q 9/36** (2013.01)

(58) **Field of Classification Search**
USPC 343/702, 700 MS, 767, 725, 826
See application file for complete search history.

20 Claims, 8 Drawing Sheets





US009543661B2

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

(10) **Patent No.:** **US 9,543,661 B2**
(45) **Date of Patent:** **Jan. 10, 2017**

(54) **RF MODULE AND ANTENNA SYSTEMS**

(75) Inventors: **Cheng Jung Lee**, Santa Clara, CA (US); **Nhan Duc Nguyen**, Oceanside, CA (US); **Ajay Gummalla**, Sunnyvale, CA (US)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1238 days.

(21) Appl. No.: **12/942,932**

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

(65) **Prior Publication Data**

US 2011/0175789 A1 Jul. 21, 2011

Related U.S. Application Data

(60) Provisional application No. 61/297,274, filed on Jan. 21, 2010, provisional application No. 61/259,589, filed on Nov. 9, 2009.

(51) **Int. Cl.**

H01Q 21/00 (2006.01)

H01Q 21/06 (2006.01)

H01Q 1/24 (2006.01)

H01Q 1/36 (2006.01)

H01Q 21/30 (2006.01)

H01Q 5/20 (2015.01)

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

CPC **H01Q 21/065** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/36** (2013.01); **H01Q 5/20** (2015.01); **H01Q 21/30** (2013.01)

(58) **Field of Classification Search**

USPC 343/853
See application file for complete search history.

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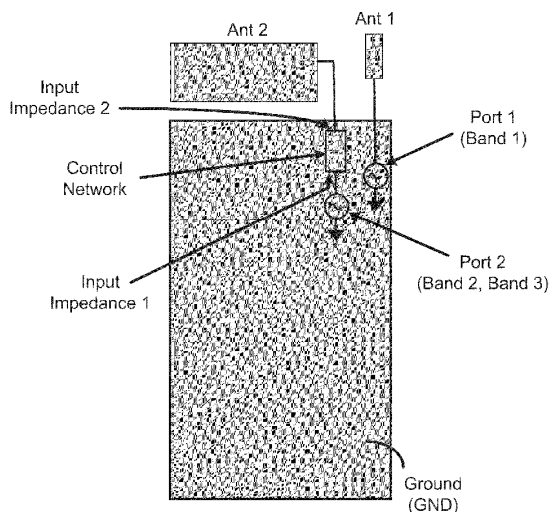
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Primary Examiner — Graham Smith

(57) **ABSTRACT**

Architectures and implementations of a transceiver system for wireless communications are presented, the system including one or more antennas supporting a single frequency band or multiple frequency bands, a transmit circuit, a receive circuit, and an isolation circuit that is coupled to the one or more antennas and the transmit and receive circuits and provides adequate isolation between the transmit circuit and the receive circuit.

11 Claims, 64 Drawing Sheets





US009544405B1

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

(10) **Patent No.:** **US 9,544,405 B1**

(45) **Date of Patent:** **Jan. 10, 2017**

(54) **METHOD AND APPARATUS FOR WIRED AND WIRELESS COMMUNICATION**

27/0255;H01L 27/0688; H01L 2924/3011;

H01L 31/02021; H02M 1/44

See application file for complete search history.

(71) Applicant: **SONY MOBILE COMMUNICATIONS INC.**, Tokyo (JP)

(56) **References Cited**

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(72) Inventors: **Kenichiro Kodama**, Tokyo (JP);
Tomoo Kobayashi, Tokyo (JP);
Tomokazu Fujiwara, Tokyo (JP)

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439/607.25

(73) Assignees: **Sony Corporation**, Tokyo (JP); **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 0 days.

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Primary Examiner — Quan M Hua

(21) Appl. No.: **14/841,279**

(22) Filed: **Aug. 31, 2015**

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

(51) **Int. Cl.**
H04B 3/56 (2006.01)
H04M 3/18 (2006.01)
H04M 1/02 (2006.01)
H01R 24/60 (2011.01)
H01R 24/58 (2011.01)
H01R 107/00 (2006.01)

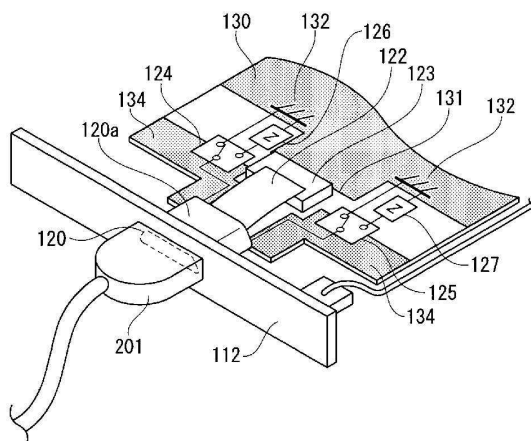
(57) **ABSTRACT**

Aspects of the disclosure provide a terminal device that includes an antenna element and an interface component. The antenna element is mounted on a casing of the terminal device to transmit/receive electromagnetic waves. The interface component is configured to couple an external device with the terminal device for a wired transmission. The interface component includes a metal shell configured to have a fixed potential state to shield the wired transmission from noise when the interface component is active for the wired transmission, and to have a floating state to avoid affecting the antenna element for transmitting/receiving electromagnetic waves when the interface component is idle.

(52) **U.S. Cl.**
CPC **H04M 1/02** (2013.01); **H01R 24/58** (2013.01); **H01R 24/60** (2013.01); **H01R 2107/00** (2013.01)

(58) **Field of Classification Search**
CPC H01L 2224/16245; H01L 2224/73257; H01L 23/3121; H01L 23/49562; H01L 23/49575; H01L 23/60; H01L 24/16; H01L 24/48; H01L 24/49; H01L

14 Claims, 5 Drawing Sheets





US009548525B2

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

(10) **Patent No.:** **US 9,548,525 B2**
(45) **Date of Patent:** **Jan. 17, 2017**

(54) **MULTI-BAND ANTENNA ON THE SURFACE OF WIRELESS COMMUNICATION DEVICES**

- (71) Applicant: **Futurewei Technologies, Inc.**, Plano, TX (US)
- (72) Inventors: **Wee Kian Toh**, San Diego, CA (US);
Hongwei Liu, San Diego, CA (US);
Ping Shi, San Diego, CA (US)
- (73) Assignee: **Futurewei Technologies, Inc.**, Plano, TX (US)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 183 days.

- (21) Appl. No.: **14/596,002**
- (22) Filed: **Jan. 13, 2015**

(65) **Prior Publication Data**
US 2016/0204499 A1 Jul. 14, 2016

- (51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 9/04 (2006.01)
H01Q 1/38 (2006.01)
H01Q 5/10 (2015.01)
H01Q 1/42 (2006.01)
H01Q 1/52 (2006.01)
- (52) **U.S. Cl.**
CPC **H01Q 1/24** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/42** (2013.01); **H01Q 1/521** (2013.01); **H01Q 5/10** (2015.01); **H01Q 9/0407** (2013.01)
- (58) **Field of Classification Search**
CPC H01Q 1/24; H01Q 1/38; H01Q 1/42; H01Q 1/521; H01Q 5/10; H01Q 9/0407
See application file for complete search history.

(56) **References Cited**

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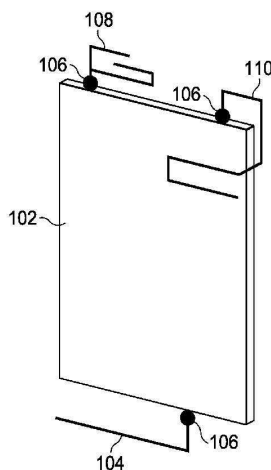
Primary Examiner — Tho G Phan

(74) Attorney, Agent, or Firm — Slater Matsil, LLP

(57) **ABSTRACT**

An embodiment wireless communication device includes a circuit board and a cover having a back surface covering a portion of a first surface of the circuit board and an opening in the back surface. A top antenna is disposed within the cover and is electrically connected to the circuit board at a first feed point on a first edge of the circuit board. A secondary antenna disposed within the cover has a first antenna portion connected to the circuit board at a second feed point, and a second antenna portion of the second antenna extends laterally from a second edge of the circuit board over the first surface of the circuit board and between the back surface of the cover and the first surface of the circuit board such that at least a portion of the second antenna portion is exposed through the opening in the back surface.

20 Claims, 3 Drawing Sheets





US009548532B2

(12) **United States Patent**
Chiang

(10) **Patent No.:** **US 9,548,532 B2**

(45) **Date of Patent:** **Jan. 17, 2017**

(54) **ANTENNA APPARATUS HAVING SENSING COMPONENT COUPLED TO FIRST ANTENNA COMPONENT TO ADDITIONALLY ACT AS SECOND ANTENNA COMPONENT AND RELATED SIGNAL PROCESSING DEVICE**

(75) Inventor: **Hung-Chung Chiang**, Taipei (TW)

(73) Assignee: **JIENG TAI INTERNATIONAL ELECTRIC CORP.**, 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 384 days.

(21) Appl. No.: **13/563,757**

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

(65) **Prior Publication Data**

US 2013/0033400 A1 Feb. 7, 2013

(30) **Foreign Application Priority Data**

Aug. 2, 2011 (TW) 100127394 A
Jul. 31, 2012 (TW) 101127593 A

(51) **Int. Cl.**
H01Q 21/30 (2006.01)
H01Q 9/04 (2006.01)
H01Q 1/44 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/44** (2013.01); **H01Q 21/30** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 21/30; H01Q 1/44; H01Q 9/04;
H03K 17/955; H03K 2017/945
See application file for complete search history.

(56) **References Cited**

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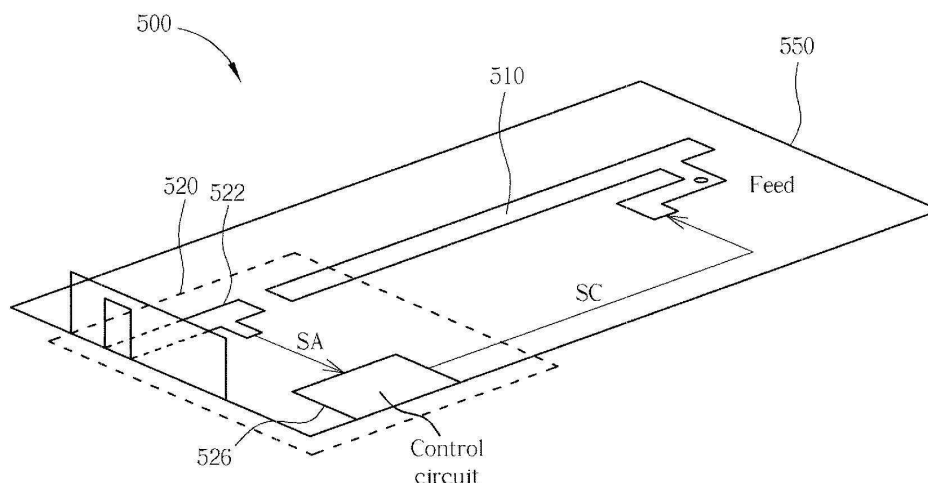
Primary Examiner — Hoang V Nguyen

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

(57) **ABSTRACT**

An antenna apparatus includes a first antenna component and a first sensing component. The first antenna component has at least one first mode. The sensing component is a front-end component of a sensing device, wherein the sensing component is further coupled to the first antenna component to act as a second antenna component having a second mode.

9 Claims, 5 Drawing Sheets





US009548535B1

(12) **United States Patent**
Kuo

(10) **Patent No.:** **US 9,548,535 B1**

(45) **Date of Patent:** **Jan. 17, 2017**

(54) **PHASE-CONTROLLED ANTENNA WITH
INDEPENDENT TUNING CAPABILITY**

(71) Applicant: **AMAZON TECHNOLOGIES, INC.**,
Reno, NV (US)

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

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

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 334 days.

(21) Appl. No.: **13/787,631**

(22) Filed: **Mar. 6, 2013**

(51) **Int. Cl.**
H01Q 3/34 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 3/34** (2013.01)

(58) **Field of Classification Search**
USPC 343/833, 834
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Sue A Purvis

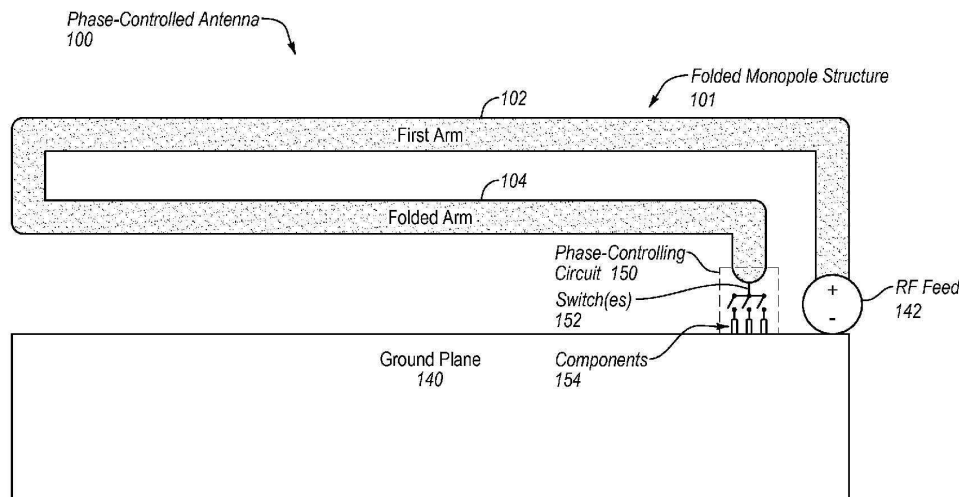
Assistant Examiner — Noel Maldonado

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

(57) **ABSTRACT**

Antenna structures and methods of operating the same of a phase-controlled antenna of an electronic device are described. A phase-controlled antenna includes a radio frequency (RF) feed, an antenna structured coupled to the RF feed and including a ground path coupled to a ground node, and a phase-controlling circuit coupled between the ground path and the ground node. The antenna structure is configured to operate at a resonant frequency in a first state, and the phase-controlling circuit is configured to introduce a phase shift in the antenna structure to change the resonant frequency of the antenna structure to a second resonant frequency in a second state.

17 Claims, 11 Drawing Sheets





US009548538B2

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

(10) **Patent No.:** **US 9,548,538 B2**

(45) **Date of Patent:** **Jan. 17, 2017**

(54) **ANTENNA ARRANGEMENT AND DEVICE**

(71) Applicant: **Sony Corporation**, Tokyo (JP)

(72) Inventors: **Erik Lennart Bengtsson**, Eslöv (SE);
Ying Zhinong, Lund (SE)

(73) Assignees: **Sony Corporation**, Tokyo (JP); **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 51 days.

(21) Appl. No.: **14/360,091**

(22) PCT Filed: **Jun. 20, 2013**

(86) PCT No.: **PCT/IB2013/001290**

§ 371 (c)(1),

(2) Date: **May 22, 2014**

(87) PCT Pub. No.: **WO2014/203018**

PCT Pub. Date: **Dec. 24, 2014**

(65) **Prior Publication Data**

US 2015/0155634 A1 Jun. 4, 2015

(51) **Int. Cl.**

H01Q 9/00 (2006.01)

H01Q 9/04 (2006.01)

H01Q 19/00 (2006.01)

H01Q 5/378 (2015.01)

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

CPC **H01Q 9/0442** (2013.01); **H01Q 9/0421** (2013.01); **H01Q 19/005** (2013.01); **H01Q 5/378** (2015.01)

(58) **Field of Classification Search**

CPC H01Q 9/0442; H01Q 19/005

USPC 343/702, 745
See application file for complete search history.

(56) **References Cited**

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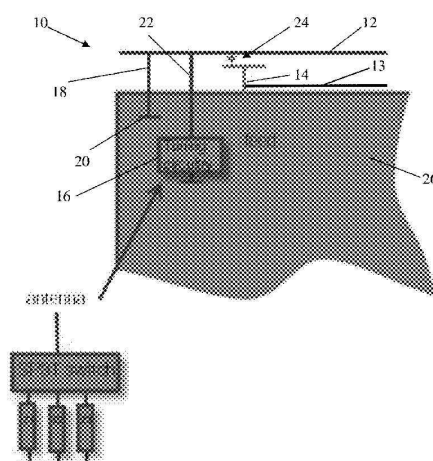
Primary Examiner — Dieu H Duong

(74) *Attorney, Agent, or Firm* — Tucker Ellis LLP

(57) **ABSTRACT**

Antenna arrangement (10) comprising at least one parasitic element (12), a feed element (14), and at least one-tuning circuitry (16). The at least one-parasitic element (12) comprises a first connection (18) connected to ground (20), and a second connection (22) connected to said at least one-tuning circuitry (16), and is galvanically separated from said feed element (14) and electromagnetically coupled to said feed element (14).

12 Claims, 2 Drawing Sheets





US009548540B2

(12) **United States Patent**
Hsu

(10) **Patent No.:** **US 9,548,540 B2**

(45) **Date of Patent:** **Jan. 17, 2017**

(54) **SLOT ANTENNA**

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

(72) Inventor: **Cho-Kang Hsu**, New Taipei (TW)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 71 days.

(21) Appl. No.: **14/585,375**

(22) Filed: **Dec. 30, 2014**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Oct. 13, 2014 (CN) 2014 1 0537600

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

(52) **U.S. Cl.**
CPC **H01Q 13/106** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 13/10; H01Q 13/106
USPC 343/767, 770
See application file for complete search history.

(56) **References Cited**

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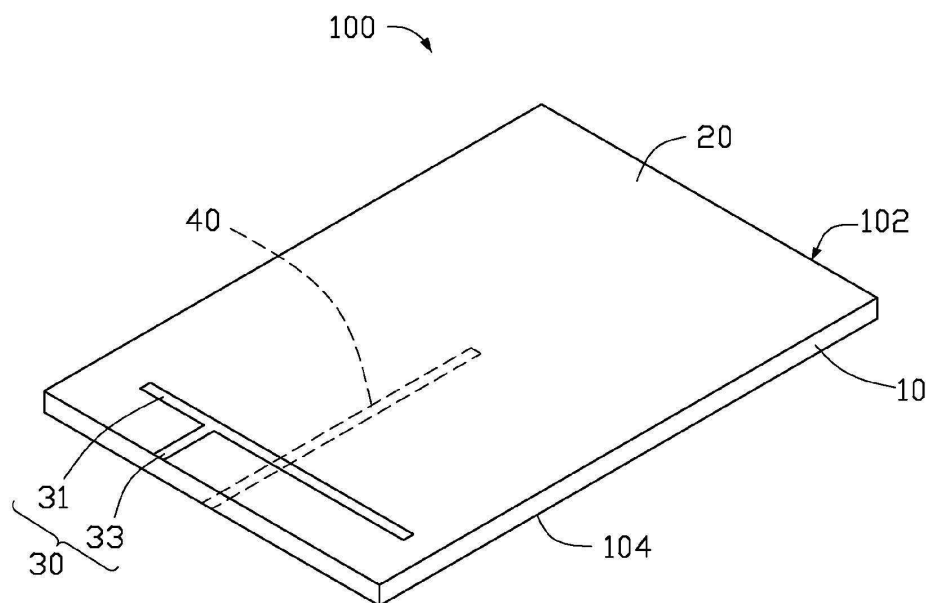
Primary Examiner — Hoang V Nguyen

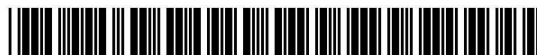
(74) *Attorney, Agent, or Firm* — Zhigang Ma

(57) **ABSTRACT**

A slot antenna includes a dielectric substrate, a conductive layer, a slot and a feeding strip. The dielectric substrate includes a first surface and a second surface opposite the first surface. The conductive layer is positioned on the first surface of the dielectric substrate, and is configured to electronically couple to ground. The slot is defined in the conductive layer and terminates on an edge of the conductive layer. The feeding strip is positioned on the second surface of the dielectric substrate and extends across the slot. The feeding strip is configured to feed current signal and resonate with the conductive layer.

12 Claims, 9 Drawing Sheets





US009548787B1

(12) **United States Patent**
Lee

(10) **Patent No.:** **US 9,548,787 B1**

(45) **Date of Patent:** **Jan. 17, 2017**

(54) **INTEGRATED BUTTON ANTENNA STRUCTURE**

(71) Applicant: **AMAZON TECHNOLOGIES, INC.**,
Seattle, WA (US)

(72) Inventor: **Cheng-Jung Lee**, San Jose, CA (US)

(73) Assignee: **Amazon Technologies, Inc.**, Seattle,
WA (US)

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

(21) Appl. No.: **14/563,876**

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

(51) **Int. Cl.**
H04B 1/48 (2006.01)

(52) **U.S. Cl.**
CPC **H04B 1/48** (2013.01)

(58) **Field of Classification Search**
CPC H04B 5/00; H01Q 9/0407; H01Q 1/088;
H04M 1/0277

See application file for complete search history.

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Primary Examiner — Cindy Trandai

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

(57) **ABSTRACT**

Antenna structures and methods of operating the same of an electronic device with an integrated power button-antenna structure are described. One apparatus includes a substrate, a first conductive trace disposed on the substrate, a second conductive trace disposed on the substrate and a switch mechanism including a non-conductive portion and a conductive portion. The switch mechanism electrically connects the first conductive trace and the second conductive trace to produce a first signal when the switch mechanism is activated. The second conductive trace forms an antenna element to radiate or receive electromagnetic energy.

19 Claims, 7 Drawing Sheets

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