



US009954270B2

(12) **United States Patent**
Nakayama

(10) **Patent No.:** **US 9,954,270 B2**
(45) **Date of Patent:** **Apr. 24, 2018**

(54) **MOBILE TERMINAL TO PREVENT
DEGRADATION OF ANTENNA
CHARACTERISTICS**

(71) Applicant: **SONY CORPORATION**, Tokyo (JP)

(72) Inventor: **Takashi Nakayama**, Chiba (JP)

(73) Assignee: **SONY 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 0 days.

(21) Appl. No.: **14/903,328**

(22) PCT Filed: **Jun. 12, 2014**

(86) PCT No.: **PCT/JP2014/003120**

§ 371 (c)(1),

(2) Date: **Jan. 7, 2016**

(87) PCT Pub. No.: **WO2015/033498**

PCT Pub. Date: **Mar. 12, 2015**

(65) **Prior Publication Data**

US 2016/0380334 A1 Dec. 29, 2016

(30) **Foreign Application Priority Data**

Sep. 3, 2013 (JP) 2013-181765

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H04M 1/02 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **G06F 1/1626**
(2013.01); **G06F 1/1698** (2013.01); **H01P 5/10**
(2013.01);

(Continued)

(58) **Field of Classification Search**

CPC **H01Q 1/241–1/243**
See application file for complete search history.

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343/700 MS
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343/700 MS

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Primary Examiner — Dameon E Levi

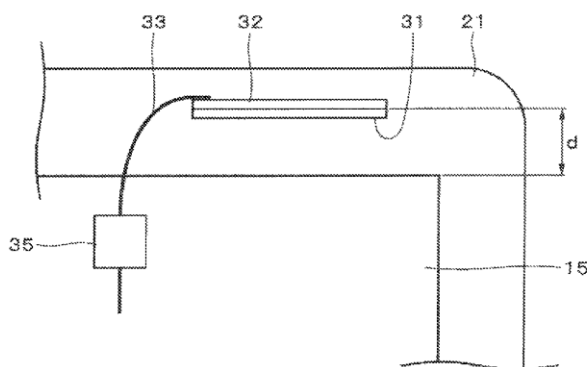
Assistant Examiner — Hasan Islam

(74) *Attorney, Agent, or Firm* — Chip Law Group

(57) **ABSTRACT**

A mobile terminal includes: a plurality of antenna inputs; a selecting unit configured to select one of the plurality of antenna inputs; a metal chassis used for holding a panel for display and maintaining mechanical strength of the panel; and a PIFA type antenna having a resonance pattern and a coaxial cable in which a coating removed portion is provided in a part in a manner that an external conductor is exposed, the PIFA type antenna being configured to fix the coating removed portion in a vicinity of an upper end of the metal chassis.

5 Claims, 8 Drawing Sheets





US009954275B2

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

(10) **Patent No.:** **US 9,954,275 B2**
(45) **Date of Patent:** **Apr. 24, 2018**

(54) **MULTIPLE-INPUT MULTIPLE-OUTPUT
ANTENNA, SYSTEM AND MOBILE
TERMINAL**

(58) **Field of Classification Search**
CPC H01Q 1/52; H01Q 7/00; H01Q 21/28
(Continued)

(71) Applicant: **ZTE Corporation**, Shenzhen,
Guangdong (CN)

(56) **References Cited**

U.S. PATENT DOCUMENTS

(72) Inventors: **Yu Zhang**, Shenzhen (CN); **Biao Li**,
Shenzhen (CN)

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343/700 MS

(73) Assignee: **ZTE CORPORATION**, Shenzhen
(CN)

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(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 22 days.

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(21) Appl. No.: **14/431,612**

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(22) PCT Filed: **Jun. 19, 2013**

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CN2013/077510, dated Sep. 26, 2013.

(86) PCT No.: **PCT/CN2013/077510**

(Continued)

§ 371 (c)(1),

(2) Date: **Mar. 26, 2015**

Primary Examiner — Huedung Mancuso

(87) PCT Pub. No.: **WO2013/170798**

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

PCT Pub. Date: **Nov. 21, 2013**

(65) **Prior Publication Data**

US 2015/0255864 A1 Sep. 10, 2015

(30) **Foreign Application Priority Data**

Sep. 27, 2012 (CN) 2012 1 0374387

(51) **Int. Cl.**

H01Q 1/52 (2006.01)

H01Q 7/00 (2006.01)

H01Q 21/28 (2006.01)

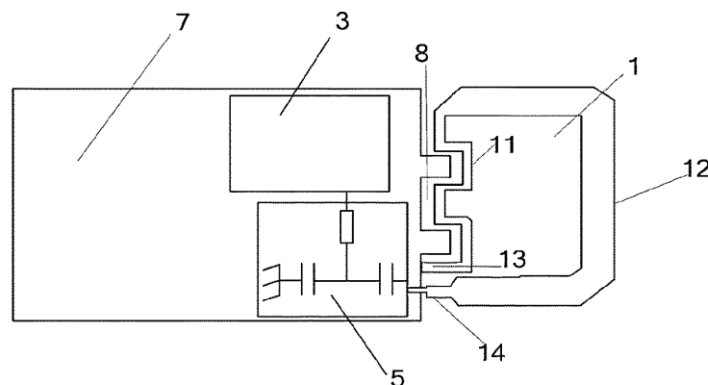
(52) **U.S. Cl.**

CPC **H01Q 1/521** (2013.01); **H01Q 1/52**
(2013.01); **H01Q 7/00** (2013.01); **H01Q 21/28**
(2013.01)

(57) **ABSTRACT**

A Multiple-Input Multiple-Output (MIMO) antenna is provided, which includes a Printed Circuit Board (PCB), an antenna connected with the PCB, a feed system, and a match circuit, wherein the antenna is connected with the feed system through the match circuit, the antenna connected with the PCB is the antenna having a Loop structure, and a gap having a fixed width is provided between a ground loop of the antenna connected with the PCB and the PCB. An MIMO antenna system and a mobile terminal are also provided. By adopting the MIMO antenna, system and mobile terminal, a coupling current between the MIMO antenna and the PCB can be relatively concentrated and current amplitude is small, thereby isolation between antennas is improved.

2 Claims, 1 Drawing Sheet





US009954285B2

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

(10) **Patent No.:** **US 9,954,285 B2**

(45) **Date of Patent:** **Apr. 24, 2018**

(54) **WIFI PATCH ANTENNA WITH DUAL U-SHAPED SLOTS**

(71) Applicant: **Taoglas Group Holdings Limited**,
Wexford (IE)

(72) Inventors: **Chen-yi Chuang**, Zhongli (TW);
Ronan Quinlan, Wexford (IE)

(73) Assignee: **TAOGLAS GROUP HOLDINGS LIMITED**, Wexford (IE)

(*) 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.: **14/853,996**

(22) Filed: **Sep. 14, 2015**

(65) **Prior Publication Data**

US 2016/0079676 A1 Mar. 17, 2016

Related U.S. Application Data

(60) Provisional application No. 62/049,873, filed on Sep. 12, 2014.

(51) **Int. Cl.**

H01Q 13/10 (2006.01)

H01Q 5/357 (2015.01)

H01Q 9/04 (2006.01)

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

CPC **H01Q 13/106** (2013.01); **H01Q 5/357**
(2015.01); **H01Q 9/0407** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 13/10; H01Q 21/064; H01Q 21/24;
H01Q 1/38

USPC 343/770, 768, 767, 746
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

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343/770

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343/700 MS

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Primary Examiner — Dameon E Levi

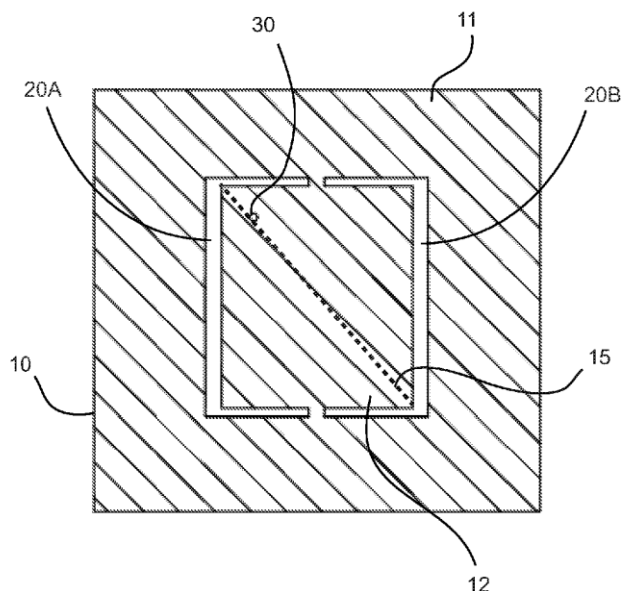
Assistant Examiner — Collin Dawkins

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

(57) **ABSTRACT**

The disclosure concerns a microstrip patch antenna configured for operation in the WiFi bands, including 2.4 GHz and 5.2/5.8 GHz. The microstrip patch antenna includes a pair of opposing u-shaped slots embedded in the patch conductor. The patch includes a patch width configured to provide a resonance at 2.4 GHz, and a slot width configured to provide a resonance at 5.2/5.8 GHz. Thus, the antenna provides a dual band WiFi patch antenna.

8 Claims, 6 Drawing Sheets





US009961173B2

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

(10) **Patent No.:** **US 9,961,173 B2**
(45) **Date of Patent:** **May 1, 2018**

(54) **ANTENNA AND MOBILE TERMINAL INCLUDING THE SAME**

(71) Applicant: **Beijing Xiaomi Mobile Software Co., Ltd.**, Haidian District, Beijing (CN)

(72) Inventors: **Zonglin Xue**, Beijing (CN); **Linchuan Wang**, Beijing (CN); **Xiaofeng Xiong**, Beijing (CN)

(73) Assignee: **Beijing Xiaomi Mobile Software Co., Ltd.**, Beijing (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.

(21) Appl. No.: **15/411,705**

(22) Filed: **Jan. 20, 2017**

(65) **Prior Publication Data**

US 2017/0272557 A1 Sep. 21, 2017

(30) **Foreign Application Priority Data**

Mar. 16, 2016 (CN) 2016 1 0151308

(51) **Int. Cl.**
H04M 1/02 (2006.01)
H04M 1/725 (2006.01)
H01Q 1/24 (2006.01)
H01Q 5/371 (2015.01)
H01Q 5/385 (2015.01)

(52) **U.S. Cl.**
CPC **H04M 1/026** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/371** (2015.01); **H01Q 5/385** (2015.01); **H04M 1/725** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 5/385
USPC 455/66.1, 550.1, 63.4, 575.5, 575.7
See application file for complete search history.

(56) **References Cited**

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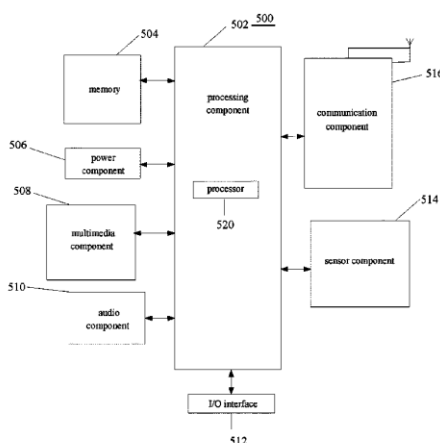
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Primary Examiner — John J Lee

(57) **ABSTRACT**

An antenna and a mobile terminal are provided. The antenna may include a radiation unit and at least one parasitic unit. The radiation unit includes a first radiation sub-unit and a second radiation sub-unit. A first terminal of the first radiation sub-unit is connected to a bottom edge of a rear cover of the mobile terminal. A second terminal of the first radiation sub-unit is provided with a feed point, a first terminal of the second radiation sub-unit is connected to the bottom edge. A second terminal of the second radiation sub-unit is provided with a ground point. A distance from the feed point to the ground point is greater than zero and less than a preset value. The at least one parasitic unit is coupleable with the radiation unit via the feed point.

10 Claims, 6 Drawing Sheets





US00996653B2

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

(10) **Patent No.:** **US 9,966,653 B2**
(45) **Date of Patent:** **May 8, 2018**

(54) **ANTENNAS FOR ELECTRONIC DEVICE
WITH HEAT SPREADER**

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

(72) Inventors: **Erin A. McAuliffe**, Campbell, CA
(US); **James W. Jervis**, Santa Clara,
CA (US); **Andrea Ruaro**, Copenhagen
(DK); **Mattia Pascolini**, San Francisco,
CA (US); **Jerzy S. Guterman**,
Mountain View, 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 175 days.

(21) Appl. No.: **14/839,619**

(22) Filed: **Aug. 28, 2015**

(65) **Prior Publication Data**

US 2017/0062906 A1 Mar. 2, 2017

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 9/42 (2006.01)
H01Q 5/371 (2015.01)
H01Q 1/06 (2006.01)
H01Q 1/38 (2006.01)
H01Q 9/04 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/24** (2013.01); **H01Q 1/06**
(2013.01); **H01Q 1/243** (2013.01); **H01Q 1/38**
(2013.01); **H01Q 5/371** (2015.01); **H01Q 9/04**
(2013.01); **H01Q 9/42** (2013.01)

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

(56) **References Cited**

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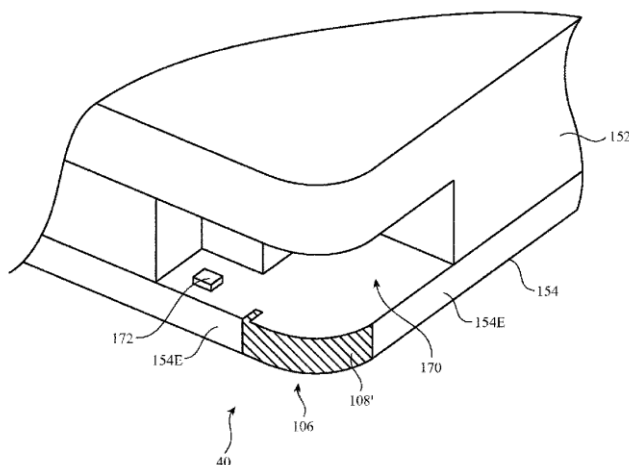
Primary Examiner — Trinh Dinh

(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.;
G. Victor Treyz; Tianyi He

(57) **ABSTRACT**

An electronic device may have wireless circuitry with antennas. The electronic device may have a dielectric housing. A printed circuit board with electrical components may be mounted in the dielectric housing. Heat spreader structures may be used to dissipate heat from the electrical components. The heat spreader structures be configured to form antenna cavities. The antennas in the electronic device may be formed from the antenna cavities and may have antenna resonating elements formed on the printed circuit. An electrical component such as a light-emitting diode may be mounted in one of the antenna cavities. Each antenna element may be an inverted-F antenna resonating element with short and long arms. The short arm of each antenna resonating element may be formed from edge plated metal traces on an edge of the printed circuit.

19 Claims, 9 Drawing Sheets





US009966655B2

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

(10) **Patent No.:** **US 9,966,655 B2**

(45) **Date of Patent:** **May 8, 2018**

(54) **ANTENNA STRUCTURE AND MOBILE
TERMINAL DEVICE**

(71) Applicant: **Huawei Device Co., Ltd.**, Shenzhen
(CN)

(72) Inventors: **Yuanpeng Li**, Beijing (CN); **Yafang
Yu**, Beijing (CN); **Meng Hou**, Shanghai
(CN)

(73) Assignee: **Huawei Device (Dongguan) Co., Ltd.**,
Dongguan (CN)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 62 days.

(21) Appl. No.: **15/173,086**

(22) Filed: **Jun. 3, 2016**

(65) **Prior Publication Data**
US 2016/0285153 A1 Sep. 29, 2016

Related U.S. Application Data

(63) Continuation of application No.
PCT/CN2014/092945, filed on Dec. 3, 2014.

(30) **Foreign Application Priority Data**
Dec. 6, 2013 (CN) 2013 1 0656510

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

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/50**
(2013.01); **H01Q 5/385** (2015.01); **H01Q 7/00**
(2013.01); **H01Q 9/0421** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 5/385; H01Q 1/50;
H01Q 7/00; H01Q 9/0421

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(56) **References Cited**

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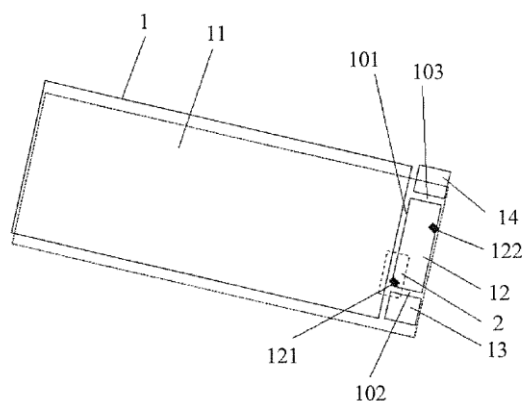
Rohith K. Raj et al., "A New Compact Microstrip-Fed Dual-Band
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Antennas and Propagation, vol. 54, No. 12, Dec. 2006, p. 3755-
3762.

Primary Examiner — Andrea Lindgren Baltzell

(57) **ABSTRACT**

The present invention discloses an antenna structure and ensures an all-metal housing feature of the mobile terminal device. The antenna structure includes a housing and a feed plate, where the housing includes a main housing, a first floating object, a second floating object, and an antenna radiator; and the first floating object, the second floating object, and the antenna radiator are separated from the main housing by a first slot; there is a second slot between the first floating object and one side of the antenna radiator, and a third slot between the second floating object and the other side of the antenna radiator; the main housing, the first floating object, the second floating object, and the antenna radiator are connected as a whole by an insulator; and the feed plate is disposed opposite to the main housing, the first floating object, and the antenna radiator at an interval.

13 Claims, 3 Drawing Sheets





US00996663B1

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

(10) **Patent No.:** **US 9,966,663 B1**
(45) **Date of Patent:** **May 8, 2018**

(54) **DUAL-BAND ANTENNA MODULE**

(71) Applicant: **UNIVERSAL SCIENTIFIC INDUSTRIAL (SHANGHAI) CO., LTD.**, Shanghai (CN)

(72) Inventors: **Hsin-Hong Chen**, Shanghai (CN);
Jui-Kun Shih, Shanghai (CN);
Chun-Huan Lee, Shanghai (CN);
Jui-Chih Chien, Shanghai (CN);
Chih-Sen Hsieh, Shanghai (CN)

(73) Assignee: **UNIVERSAL SCIENTIFIC INDUSTRIAL (SHANGHAI) CO., LTD.**, Shanghai (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 22 days.

(21) Appl. No.: **15/386,598**

(22) Filed: **Dec. 21, 2016**

(30) **Foreign Application Priority Data**

Oct. 21, 2016 (CN) 2016 1 0919775

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/307 (2015.01)
H01Q 1/22 (2006.01)
H01Q 1/48 (2006.01)
H01Q 1/38 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 5/307** (2015.01); **H01Q 1/2291** (2013.01); **H01Q 1/36** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/35** (2015.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/24; H01Q 1/241; H01Q 1/243;
H01Q 5/307; H01Q 5/35; H01Q 1/2291;
H01Q 21/28
See application file for complete search history.

(56) **References Cited**

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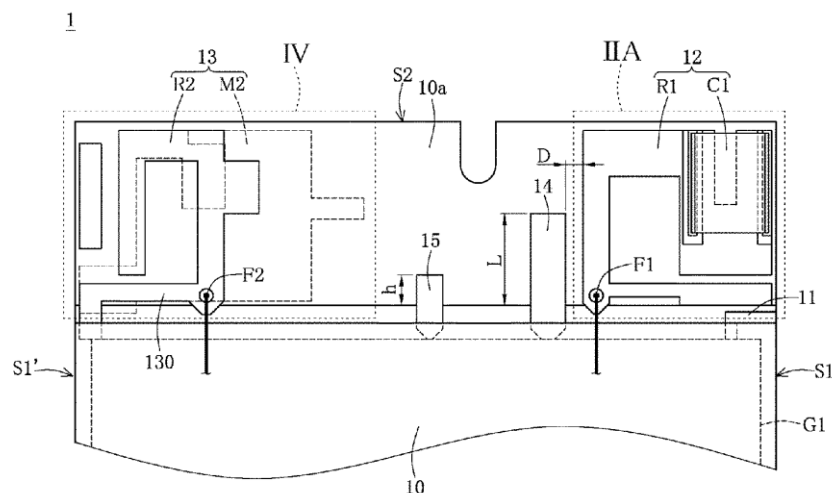
Primary Examiner — Hoang Nguyen

(74) *Attorney, Agent, or Firm* — Li & Cai Intellectual Property (USA) Office

(57) **ABSTRACT**

A dual-band antenna module is provided. The dual-band antenna module includes a circuit board, a ground coupling portion electrically connected to a reference ground plane of the circuit board, a first antenna, and a second antenna spaced from the first antenna. The first antenna and the ground coupling portion are disposed on the circuit board and configured to couple each other. The first antenna includes a first radiation unit, a U-shaped conductive frame, and a first feeding portion. The U-shaped conductive frame is disposed on the first radiation unit and opens toward the circuit board. The second antenna includes a second radiation unit, a high-frequency impedance portion, and a second feeding portion. The second radiation unit and the high-frequency impedance portion are respectively disposed on two opposite surfaces of the circuit board to resonate to each other. The second radiation unit includes a ground extension portion electrically grounded.

11 Claims, 6 Drawing Sheets





US00996666B2

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

(10) **Patent No.:** **US 9,966,666 B2**

(45) **Date of Patent:** **May 8, 2018**

(54) **ANTENNA DEVICE AND ELECTRONIC APPARATUS HAVING THE SAME**

(56) **References Cited**

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(71) Applicant: **Samsung Electronics Co., Ltd.**,
Suwon-si, Gyeonggi-do (KR)

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333/134

(72) Inventors: **Hyun-Jin Kim**, Seoul (KR); **Goudelev Alexander**, Suwon-si (KR); **Anton S. Lukyanov**, Suwon-si (KR); **Won-Bin Hong**, Seoul (KR); **Byung-Chul Kim**, Hwaseong-si (KR); **Young-Ju Lee**, Seoul (KR)

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343/700 MS

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

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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 166 days.

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(21) Appl. No.: **14/341,194**

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(22) Filed: **Jul. 25, 2014**

(65) **Prior Publication Data**

US 2015/0035715 A1 Feb. 5, 2015

(30) **Foreign Application Priority Data**

Aug. 1, 2013 (KR) 10-2013-0091551

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

(52) **U.S. Cl.**
CPC **H01Q 9/0421** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/0421
USPC 343/787
See application file for complete search history.

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Primary Examiner — Dieu H Duong

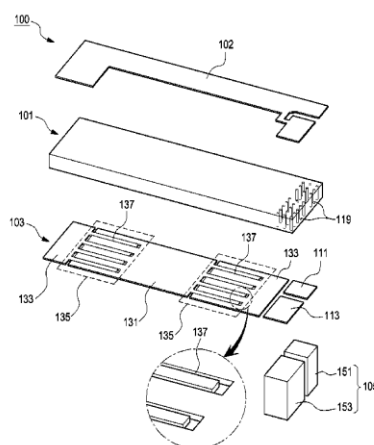
Assistant Examiner — Bamidele A Jegede

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

(57) **ABSTRACT**

An antenna device is provided. The antenna device may include a conductive radiator pattern formed on one surface of a dielectric substrate, an artificial magnetic conductor layer including at least one unit cell formed on the other surface of the dielectric substrate, and a shorting pin connected to the unit cell. The artificial magnetic conductor layer may be configured to form an induction current of the same phase with regard to a signal current flowing through the conductive radiator pattern.

17 Claims, 6 Drawing Sheets





US00996667B2

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

(10) **Patent No.:** **US 9,966,667 B2**
(45) **Date of Patent:** **May 8, 2018**

(54) **ELECTRONIC DEVICE ANTENNA WITH SWITCHABLE RETURN PATHS**

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

(72) Inventors: **Enrique Ayala Vazquez**, Watsonville, CA (US); **Hongfei Hu**, Cupertino, CA (US); **Nanbo Jin**, San Jose, CA (US); **Matthew A. Mow**, Los Altos, CA (US); **Liang Han**, Sunnyvale, CA (US); **Ming-Ju Tsai**, Sunnyvale, CA (US); **Erica J. Tong**, Pacifica, CA (US); **Erdinc Irci**, Sunnyvale, CA (US); **Salih Yarga**, Sunnyvale, CA (US); **Mattia Pascolini**, San Francisco, CA (US); **Benjamin Shane Bustle**, Cupertino, CA (US); **Ruben Caballero**, San Jose, CA (US)

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

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

(21) Appl. No.: **15/806,986**

(22) Filed: **Nov. 8, 2017**

(65) **Prior Publication Data**

US 2018/0069317 A1 Mar. 8, 2018

Related U.S. Application Data

(63) Continuation of application No. 14/811,714, filed on Jul. 28, 2015.

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

(52) **U.S. Cl.**
CPC **H01Q 13/103** (2013.01); **H01Q 1/245** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 13/103; H01Q 1/245

USPC 343/702

See application file for complete search history.

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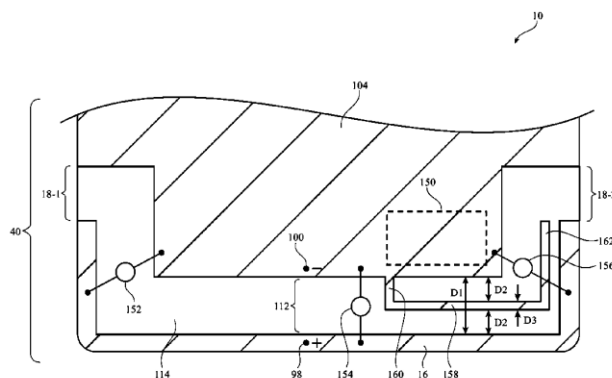
Primary Examiner — Andrea Lindgren Baltzel

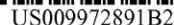
(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.; G. Victor Treyz; Michael H. Lyons

(57) **ABSTRACT**

An electronic device may have wireless circuitry with antennas. An antenna resonating element arm for an antenna may be formed from conductive housing structures running along the edges of a device. The antenna may have a pair of switchable return paths that bridge a slot between the antenna resonating element and an antenna ground. An adjustable component and a feed may be coupled in parallel across the slot. The adjustable component may switch a capacitor into use or out of use and the return paths may be selectively opened and closed to compensate for antenna loading due to the presence of external objects near the electronic device.

20 Claims, 10 Drawing Sheets





(10) **Patent No.:** US 9,972,891 B2
(45) **Date of Patent:** May 15, 2018

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

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- Primary Examiner — Hoang Nguyen

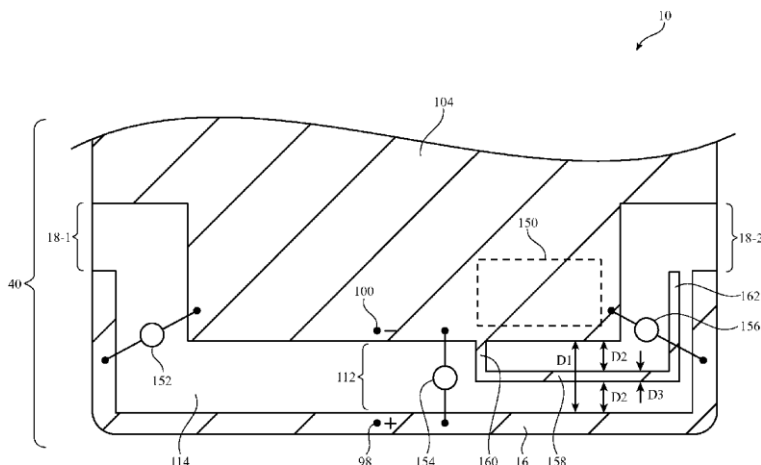
- (74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.;
G. Victor Treyz; Michael H. Lyons

- (57) **ABSTRACT**

- US 2017/0040668 A1 Feb. 9, 2017

- (52) **U.S. Cl.**
CPC *H01Q 1/243* (2013.01); *H01Q 5/328*
(2015.01); *H01Q 5/335* (2015.01); *H01Q*
5/378 (2015.01); *H01Q 9/42* (2013.01); *H01Q*
13/106 (2013.01)

- CPC H01Q 1/243; H01Q 7/00; H01Q 9/14;
H01Q 21/28; H01Q 9/42; H01Q 1/44;
H01Q 5/328; H01Q 5/335; H01Q 5/378





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

- (54) ELECTRONIC DEVICE WITH MILLIMETER WAVE ANTENNAS ON STACKED PRINTED CIRCUITS

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

(72) Inventors: **Basim H. Noori**, San Jose, CA (US); **Boon W. Shiu**, San Jose, CA (US); **Kevin M. Marks**, San Francisco, CA (US); **Matthew A. Mow**, Los Altos, CA (US); **Mattia Pascolini**, San Francisco, CA (US); **Ming-Ju Tsai**, Cupertino, CA (US); **Ruben Caballero**, San Jose, CA (US); **Yuehui Ouyang**, Sunnyvale, CA (US); **Khan Salam**, Dublin, 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 112 days.

(21) Appl. No.: 15/138,689

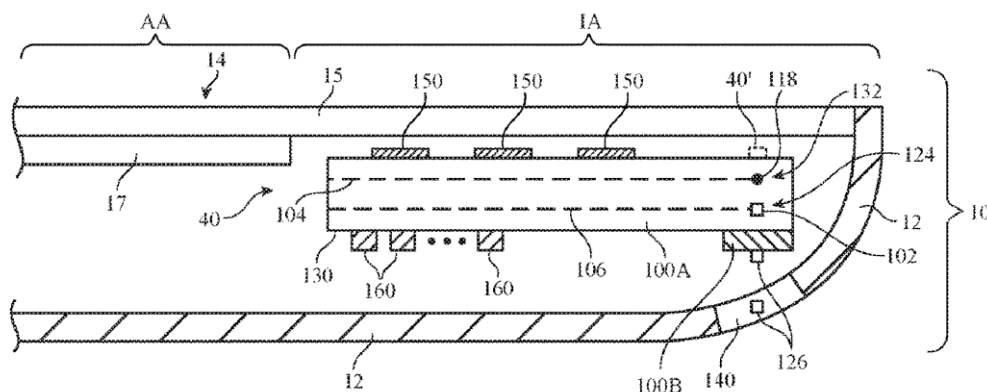
(22) Filed: **Apr. 26, 2016**

(65) **Prior Publication Data**

US 2017/0309992 A1 Oct. 26, 2017

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 21/06 (2006.01)
H01Q 19/10 (2006.01)
H01Q 1/22 (2006.01)
H01Q 19/30 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/2258***
(2013.01); ***H01Q 1/2266*** (2013.01); ***H01Q***
1/24 (2013.01); ***H01Q 1/241*** (2013.01); ***H01Q***





US009972908B2

(12) **United States Patent**
Sanchez

(10) **Patent No.:** **US 9,972,908 B2**

(45) **Date of Patent:** **May 15, 2018**

(54) **CAPACITIVELY COUPLED LOOP
INVERTED F RECONFIGURABLE ANTENNA**

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

(72) Inventor: **Jorge Fabrega Sanchez**, 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 294 days.

(21) Appl. No.: **13/939,631**

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

(65) **Prior Publication Data**

US 2015/0015445 A1 Jan. 15, 2015

(51) **Int. Cl.**

H01Q 5/00 (2015.01)

H01Q 7/00 (2006.01)

H01Q 5/364 (2015.01)

H01Q 5/328 (2015.01)

H01Q 9/04 (2006.01)

H01Q 5/321 (2015.01)

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

CPC **H01Q 5/364** (2015.01); **H01Q 5/321**
(2015.01); **H01Q 5/328** (2015.01); **H01Q 7/00**
(2013.01); **H01Q 9/0421** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 5/328; H01Q 5/364
See application file for complete search history.

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Primary Examiner — Jessica Han

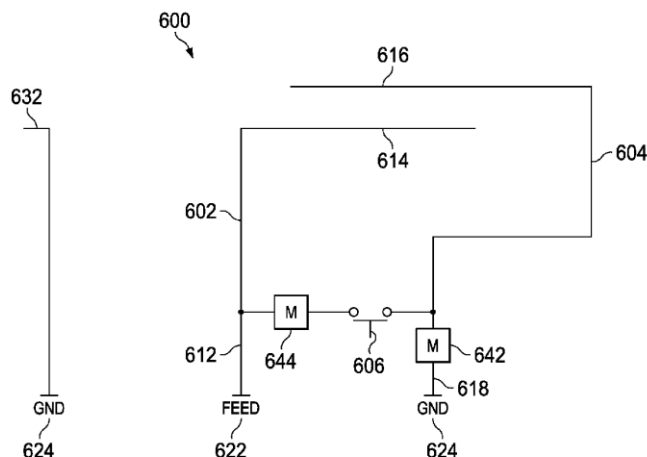
Assistant Examiner — Amal Patel

(74) Attorney, Agent, or Firm — Futurewei Technologies,
Inc.

(57) **ABSTRACT**

System and method embodiments are provided for capaci-
tively coupled loop inverted F reconfigurable multiband
antenna. The embodiments enable tuning and adjustment of
the low frequency response of the antenna without appre-
ciably effecting the high frequency response of the antenna.
In an embodiment, a reconfigurable multiband antenna
includes a first antenna section comprising a first end and a
second end, wherein the second end is coupled to an antenna
feed, a second antenna section comprising a third end and a
fourth end, wherein the third end is coupled to ground, and
a switch coupling the second end to the third end, wherein
the first end and the fourth end are capacitively coupled.

18 Claims, 7 Drawing Sheets





US009972911B1

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

(10) **Patent No.:** **US 9,972,911 B1**
(45) **Date of Patent:** **May 15, 2018**

(54) **WIDE BAND FREQUENCY AGILE MIMO ANTENNA**

(71) Applicant: **KING FAHD UNIVERSITY OF PETROLEUM AND MINERALS**, Dhahran (SA)

(72) Inventors: **Rifaqat Hussain**, Dhahran (SA); **Mohammad S. Sharawi**, Dhahran (SA)

(73) Assignee: **KING FAHD UNIVERSITY OF PETROLEUM AND MINERALS**, Dhahran (SA)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 29 days.

(21) Appl. No.: **15/333,157**

(22) Filed: **Oct. 24, 2016**

(51) **Int. Cl.**
H01Q 21/06 (2006.01)
H01Q 13/10 (2006.01)
H01Q 21/00 (2006.01)
H01Q 1/38 (2006.01)
H01Q 1/48 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 13/106** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/48** (2013.01); **H01Q 21/00** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/38; H01Q 1/48; H01Q 21/00
USPC 343/700 MS, 702, 749-751, 846, 850
See application file for complete search history.

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Primary Examiner — Dameon E Levi

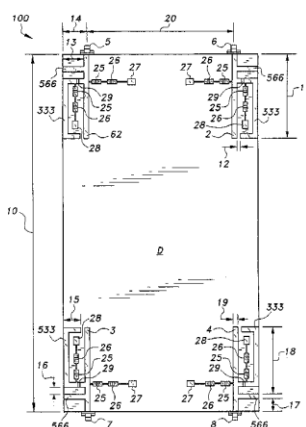
Assistant Examiner — Hasan Islam

(74) *Attorney, Agent, or Firm* — Richard C. Litman

(57) **ABSTRACT**

The wide band frequency agile MIMO antenna is a 4-element, reconfigurable multi-input multi-output (MIMO) antenna system. Frequency agility in the design is achieved using varactor diodes tuned for various capacitance loadings. The MIMO antennas operate over a wide band, covering several well-known wireless standards between 1610-2710 MHz. The present design is simple in structure with low profile antenna elements. The design is prototyped on commercial plastic material with board dimensions 60×100×0.8 mm³ and is highly suitable to be used in frequency reconfigurable and cognitive radio based wireless handheld devices.

5 Claims, 6 Drawing Sheets





US009973232B1

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

(10) **Patent No.:** **US 9,973,232 B1**
(45) **Date of Patent:** **May 15, 2018**

- (54) **LOW SPECIFIC ABSORPTION RATE (SAR) DUAL-BAND ANTENNA STRUCTURE**
- (71) Applicant: **AMAZON TECHNOLOGIES, INC.**,
Reno, NV (US)
- (72) Inventors: **Jerry Weiming Kuo**, San Jose, CA
(US); **Ming Zheng**, Cupertino, 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 287 days.
- (21) Appl. No.: **14/298,470**
- (22) Filed: **Jun. 6, 2014**
- (51) **Int. Cl.**
H04B 1/50 (2006.01)
- (52) **U.S. Cl.**
CPC **H04B 1/50** (2013.01)
- (58) **Field of Classification Search**
CPC H01Q 7/00; H01Q 9/42; H01Q 21/30;
H01Q 9/30; H01Q 21/24
USPC 343/728
See application file for complete search history.

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Primary Examiner — Jessica Han

Assistant Examiner — Bamidele A Jegede

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

(57) **ABSTRACT**

Dual-band antenna structures and methods of operating the
same of an electronic device are described. One apparatus
includes a radio frequency (RF) feed and a dual-band
antenna structure coupled to the RF feed at a feeding point
and coupled to a ground plane at a grounding point. The
structure includes a first loop antenna and a second loop
antenna, both coupled to the feeding point and the grounding
point. The first loop antenna radiates electromagnetic energy
in a first resonant mode in a first frequency band and the
second loop antenna radiates electromagnetic energy in a
second resonant mode in a second frequency band and
radiates electromagnetic energy in a third resonant mode in
the first frequency band. Surface currents create three or
more hot spots of magnetic field.

23 Claims, 10 Drawing Sheets

