



US009876270B2

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

(10) **Patent No.:** **US 9,876,270 B2**
(45) **Date of Patent:** **Jan. 23, 2018**

(54) **ANTENNA STRUCTURE, ELECTRONIC DEVICE USING SAME, AND METHOD FOR MAKING SAME**

(71) Applicants: **SHENZHEN FUTAIHONG PRECISION INDUSTRY CO., LTD.**, Shenzhen (CN); **FIH (HONG KONG) LIMITED**, Kowloon (HK)

(72) Inventors: **Xu Liu**, Shenzhen (CN); **Yi Yang**, Shenzhen (CN)

(73) Assignees: **SHENZHEN FUTAIHONG PRECISION INDUSTRY CO., LTD.**, Shenzhen (CN); **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 121 days.

(21) Appl. No.: **14/570,600**

(22) Filed: **Dec. 15, 2014**

(65) **Prior Publication Data**

US 2015/0236402 A1 Aug. 20, 2015

(30) **Foreign Application Priority Data**

Feb. 17, 2014 (CN) 2014 1 0052060

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
C23C 28/02 (2006.01)
H01Q 1/38 (2006.01)
C25D 5/12 (2006.01)
C25D 7/00 (2006.01)
B29L 31/34 (2006.01)
B29K 101/00 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **C23C 28/023** (2013.01); **C25D 5/12** (2013.01); **C25D 7/00** (2013.01); **H01Q 1/38** (2013.01); **B29K 2101/00** (2013.01); **B29L 2031/3456** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/38
See application file for complete search history.

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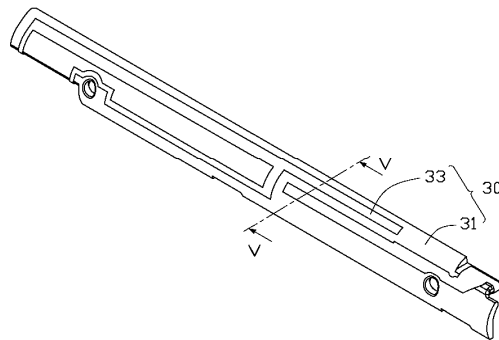
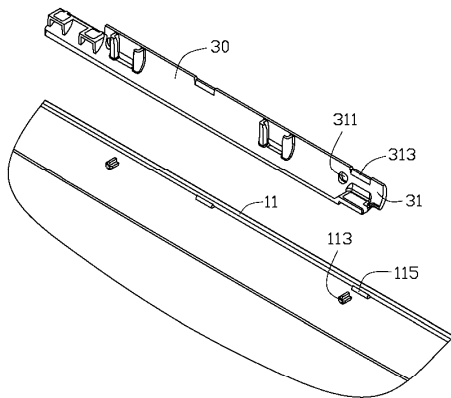
Primary Examiner — Dieu H Duong

(74) *Attorney, Agent, or Firm* — ScienBiziP, P.C.

(57) **ABSTRACT**

An antenna structure includes a carrier and an antenna coupled to the carrier. The carrier has at least one end, at least one fixing hole formed on the end of the carrier, and at least one groove formed in the middle of the carrier. A manufacture method of the antenna structure and an electronic device using the antenna structure are also provided.

9 Claims, 6 Drawing Sheets





US009876272B2

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

(10) **Patent No.:** **US 9,876,272 B2**
(45) **Date of Patent:** **Jan. 23, 2018**

(54) **ELECTRONIC DEVICE ANTENNA WITH EMBEDDED PARASITIC ARM**

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

(72) Inventors: **Hongfei Hu**, Santa Clara, CA (US); **Benjamin Shane Bustle**, Cupertino, CA (US); **Enrique Ayala Vazquez**, Watsonville, CA (US); **Nanbo Jin**, Milpitas, CA (US); **Miguel Christophy**, San Francisco, CA (US); **Erdinc Irci**, Santa Clara, CA (US); **Salih Yarga**, Sunnyvale, CA (US); **Erica Tong**, Pacifica, CA (US); **Anand Lakshmanan**, San Jose, CA (US); **Mattia Pascolini**, San Francisco, CA (US); **Tyler Cater**, Cupertino, CA (US); **Christopher T. Cheng**, 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 139 days.

(21) Appl. No.: **14/829,008**

(22) Filed: **Aug. 18, 2015**

(65) **Prior Publication Data**

US 2017/0054196 A1 Feb. 23, 2017

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 13/10 (2006.01)
H01Q 5/357 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 5/357** (2015.01); **H01Q 13/103** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 13/103; H01Q 5/357; H01Q 1/38; H01Q 19/10
USPC 343/700 MS, 702, 767, 817, 818, 834
See application file for complete search history.

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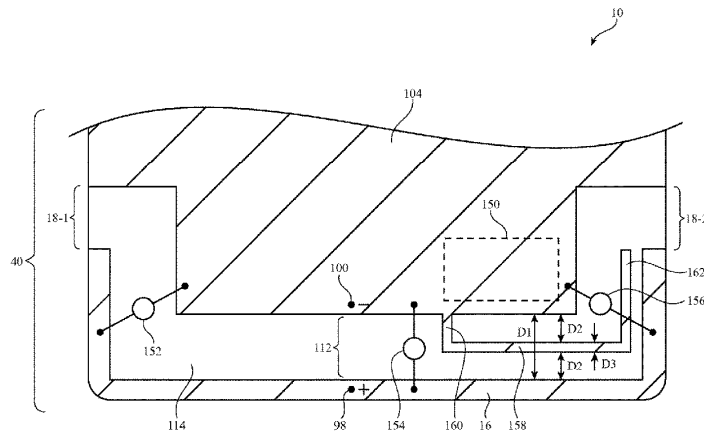
Primary Examiner — Tho G Phan

(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 peripheral conductive structures running along the edges of a device housing. The peripheral conductive structures may form housing sidewalls. A slot may be machined into a metal housing that separates the housing sidewalls from a planar rear housing portion that forms a ground for an antenna. The slot may be filled with plastic filler. A parasitic antenna resonating element arm that supports an antenna resonance at high band frequencies may be embedded within the plastic filler. The parasitic antenna resonating element may be formed from a portion of the planar rear housing portion.

20 Claims, 18 Drawing Sheets





US009876274B2

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

(10) **Patent No.:** **US 9,876,274 B2**
(45) **Date of Patent:** **Jan. 23, 2018**

(54) **ANTENNA RADIATOR HAVING HETEROGENEOUS ANTENNAS CROSS-LINKED WITH EACH OTHER AND MANUFACTURING METHOD THEREFOR**

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/36; H01Q 1/38; H01Q 1/50
(Continued)

(71) Applicant: **Jae Beom Kim**, Seoul (KR)

(56) **References Cited**

(72) Inventors: **Jae Beom Kim**, Seoul (KR); **Sung Woo Bang**, Seoul (KR)

U.S. PATENT DOCUMENTS

(73) Assignee: **Jae Beom Kim**, Seoul (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 0 days.

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(21) Appl. No.: **15/123,249**

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(22) PCT Filed: **Mar. 28, 2014**

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(86) PCT No.: **PCT/KR2014/002694**

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(2) Date: **Sep. 2, 2016**

International Search Report in International Application No. PCT/KR2014/002694, dated Nov. 21, 2014.

Primary Examiner — Graham Smith

(87) PCT Pub. No.: **WO2015/133675**

(74) *Attorney, Agent, or Firm* — Park, Kim & Suh, LLC

PCT Pub. Date: **Sep. 11, 2015**

(57) **ABSTRACT**

(65) **Prior Publication Data**

US 2017/0062907 A1 Mar. 2, 2017

The present invention relates to an antenna radiator having heterogeneous antennas cross-linked with each other, and a manufacturing method therefor. More specifically, the present invention provides an antenna radiator having heterogeneous antennas cross-linked with each other, wherein the antenna radiator has an antenna pattern constituted with an in-mold antenna provided on an end of a frame, and a printed or plated antenna provided on an adjacent area to the in-mold antenna, the in-mold antenna having a protrusion on at least one area thereof, and the printed or plated antenna provided to overlap the protrusion such that the in-mold antenna and the printed or plated antenna are cross-linked with each other; and a manufacturing method for the antenna radiator.

(30) **Foreign Application Priority Data**

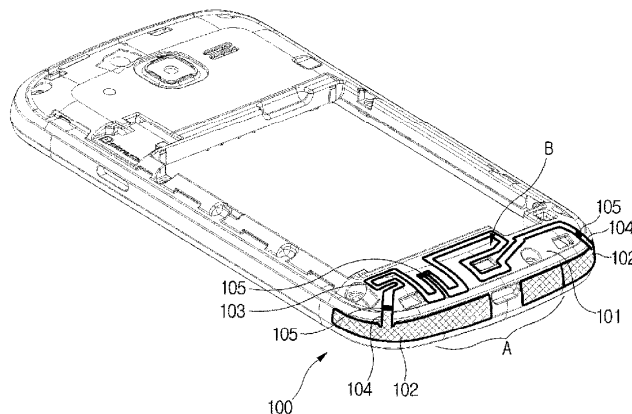
Mar. 4, 2014 (KR) 10-2014-0025698

7 Claims, 5 Drawing Sheets

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

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/40** (2013.01); **H01Q 1/50** (2013.01)





US009876275B2

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

(10) **Patent No.:** **US 9,876,275 B2**
(45) **Date of Patent:** **Jan. 23, 2018**

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

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 13/10; H01Q 1/50;
H01Q 1/36; H01Q 7/04
See application file for complete search history.

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

(56) **References Cited**

(72) Inventors: **Shinichi Nakano**, Nagaokakyo (JP);
Masahiro Ozawa, Nagaokakyo (JP);
Nobuhito Tsubaki, 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.: **15/257,982**

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(22) Filed: **Sep. 7, 2016**

Nakano, et al. "Antenna Device and Electronic Apparatus Including Antenna Device", U.S. Appl. No. 14/278,080, filed May 15, 2014.
(Continued)

(65) **Prior Publication Data**
US 2016/0380338 A1 Dec. 29, 2016

Related U.S. Application Data

(63) Continuation of application No. 14/278,080, filed on May 15, 2014, now Pat. No. 9,466,871, which is a (Continued)

Primary Examiner — Hoang Nguyen
(74) *Attorney, Agent, or Firm* — Keating & Bennett, LLP

(30) **Foreign Application Priority Data**

(57) **ABSTRACT**

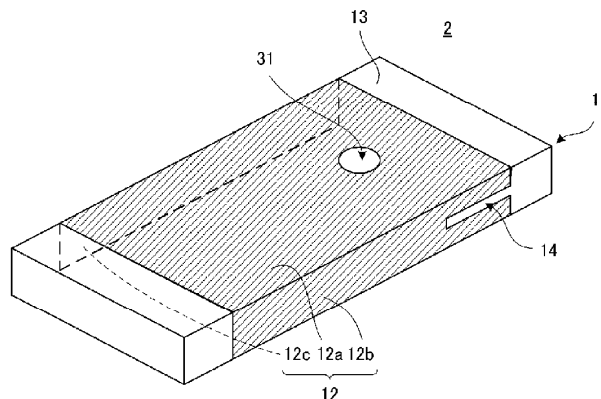
Sep. 26, 2012 (JP) 2012-211709
Jul. 5, 2013 (JP) 2013-141969

An antenna device includes a casing including a metal casing portion and a feed coil. The metal casing portion includes a main surface, a side surface connected to the main surfaces, and a notch portion located in the side surface. The feed coil is disposed inside the casing to be coupled with the metal casing portion by a magnetic field, and includes a winding central portion forming a coil opening portion. The feed coil is disposed near the notch portion, with the coil opening portion directed to a region including the notch portion.

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

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/241** (2013.01); **H01Q 1/36** (2013.01); **H01Q 1/50** (2013.01);
(Continued)

4 Claims, 16 Drawing Sheets





US009876276B2

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

(10) **Patent No.:** **US 9,876,276 B2**
(45) **Date of Patent:** **Jan. 23, 2018**

(54) **DEVICE WITH RADIO AND BODY-COUPLED-COMMUNICATION CONNECTIVITY**

- (71) Applicant: **Sony Mobile Communications, Inc.**, Tokyo (JP)
- (72) Inventors: **Erik Bengtsson**, Eslöv (SE); **Ying Zhinong**, Lund (SE)
- (73) Assignee: **Sony Mobile Communications, Inc.**, Tokyo (JP)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 311 days.

(21) Appl. No.: **14/248,656**

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

(65) **Prior Publication Data**
US 2015/0295304 A1 Oct. 15, 2015

(51) **Int. Cl.**
H01Q 1/12 (2006.01)
H01Q 1/27 (2006.01)
H01Q 9/04 (2006.01)
H04W 4/00 (2009.01)
H04B 13/00 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/273** (2013.01); **H01Q 9/0407** (2013.01); **H04B 13/005** (2013.01); **H04W 4/008** (2013.01)

(58) **Field of Classification Search**
USPC 343/718, 702, 700 MS, 866
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Jessica Han

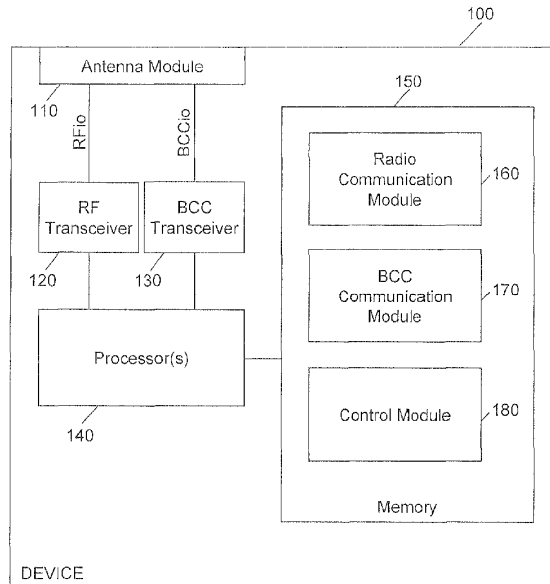
Assistant Examiner — Hai Tran

(74) *Attorney, Agent, or Firm* — Wolf, Greenfield & Sacks, P.C.

(57) **ABSTRACT**

A device is equipped with one or more communication modules supporting communication on the basis of radio signals and communication on the basis of body-coupled communication signals. Further, the device is equipped with an antenna for transmission of the radio signals. The antenna is further operable to transfer the body-coupled communication signals between the device and a body of a user of the device.

24 Claims, 7 Drawing Sheets





US009881882B2

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

(10) **Patent No.:** **US 9,881,882 B2**
(45) **Date of Patent:** **Jan. 30, 2018**

(54) **SEMICONDUCTOR PACKAGE WITH THREE-DIMENSIONAL ANTENNA**

(71) Applicant: **MEDIATEK INC.**, Hsin-Chu (TW)

(72) Inventors: **Chih-Chun Hsu**, New Taipei (TW);
Sheng-Mou Lin, Hsinchu (TW)

(73) Assignee: **MEDIATEK INC.**, Hsin-Chu (TW)

(*) 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.: **15/335,226**

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

(65) **Prior Publication Data**

US 2017/0194271 A1 Jul. 6, 2017

Related U.S. Application Data

(60) Provisional application No. 62/275,280, filed on Jan. 6, 2016.

(51) **Int. Cl.**
H01L 23/66 (2006.01)
H01L 23/31 (2006.01)
H01L 23/552 (2006.01)
H01L 23/00 (2006.01)

(52) **U.S. Cl.**
CPC **H01L 23/66** (2013.01); **H01L 23/3128** (2013.01); **H01L 23/552** (2013.01); **H01L 24/13** (2013.01); **H01L 24/16** (2013.01); **H01L 2223/6677** (2013.01); **H01L 2224/131** (2013.01); **H01L 2224/13147** (2013.01); **H01L 2224/16227** (2013.01); **H01L 2924/1421** (2013.01); **H01L 2924/15311** (2013.01); **H01L 2924/3025** (2013.01)

(58) **Field of Classification Search**
CPC ... H01L 23/66; H01L 23/552; H01L 23/3128; H01L 2223/6677; H01L 2924/3025
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Roy Potter

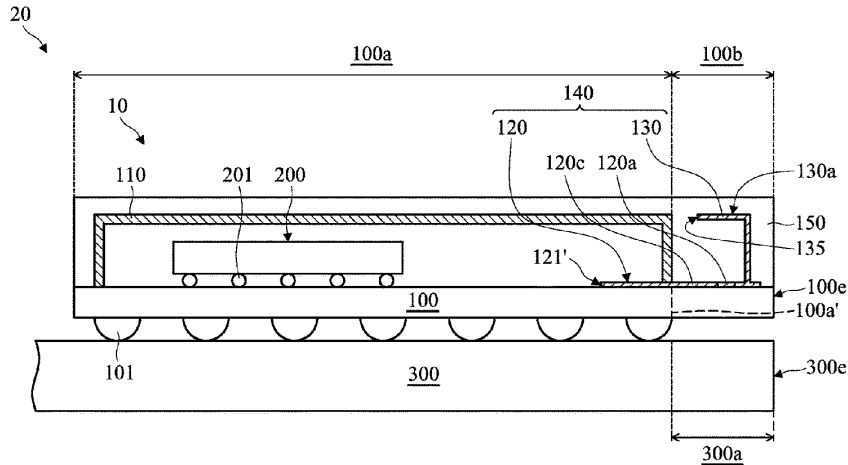
Assistant Examiner — Paul Patton

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

(57) **ABSTRACT**

A semiconductor package is provided. The semiconductor package includes a package substrate having a first region and a second region defined between an edge of the package substrate and an edge of the first region. A semiconductor die is disposed on the package substrate in the first region. A three-dimensional (3D) antenna is disposed on the package substrate in the second region. The 3D antenna includes a planar structure portion and a bridge or wall structure portion. A molding compound encapsulates the semiconductor die and at least a portion of the 3D antenna. A conductive shielding element is inside the molding compound or partially covers the molding compound. A semiconductor package assembly having the semiconductor package is also provided.

26 Claims, 8 Drawing Sheets





US009882264B2

(12) **United States Patent**
Gummalla

(10) **Patent No.:** **US 9,882,264 B2**
(45) **Date of Patent:** **Jan. 30, 2018**

(54) **ANTENNAS FOR COMPUTERS WITH CONDUCTIVE CHASSIS**

- (71) Applicant: **GOOGLE INC.**, Mountain View, CA (US)
- (72) Inventor: **Ajay Chandra Venkata Gummalla**, Sunnyvale, CA (US)
- (73) Assignee: **GOOGLE LLC**, Mountain View, CA (US)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 210 days.

- (21) Appl. No.: **14/290,535**
- (22) Filed: **May 29, 2014**

(65) **Prior Publication Data**
US 2014/0266928 A1 Sep. 18, 2014

Related U.S. Application Data
(63) Continuation of application No. 13/269,572, filed on Oct. 8, 2011, now Pat. No. 8,779,999.
(Continued)

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

(52) **U.S. Cl.**
CPC **H01Q 1/2258** (2013.01); **G06F 1/1656** (2013.01); **G06F 1/1698** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 13/10; H01Q 13/106; H01Q 13/16; H01Q 1/24; H01Q 1/241; H01Q 1/242
(Continued)

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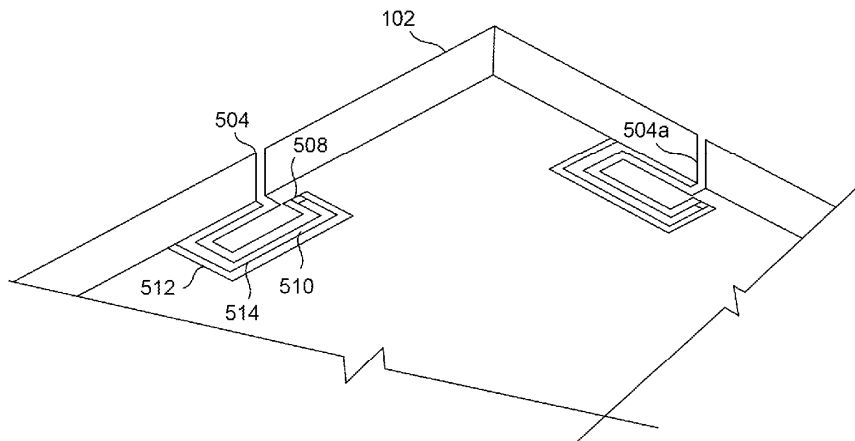
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Primary Examiner — Dameon E Levi
Assistant Examiner — Jennifer F Hu
(74) *Attorney, Agent, or Firm* — Brake Hughes Bellermann LLP

(57) **ABSTRACT**

According to one general aspect, a computing device may include a conductive frame and a slot antenna formed, at least in part, by the conductive frame. The slot antenna defines a cavity that extends into the conductive frame from an opening on the conductive frame to a closed end defined by an internal portion of the conductive frame. The slot antenna includes a feed point disposed at a position along the slot antenna such that the slot antenna forms an open-circuited portion and a short-circuited portion, and the feed point is disposed between the open-circuited portion and the short-circuited portion. The computing device may also include a coupling element configured to be excited by an electrical signal via the feed point.

9 Claims, 6 Drawing Sheets





US009882265B2

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

(10) **Patent No.:** **US 9,882,265 B2**
(45) **Date of Patent:** **Jan. 30, 2018**

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

(75) Inventors: **Bum-Jin Cho**, Hwaseong-si (KR);
Gyu-Sub Kim, Suwon-si (KR);
Joon-Ho Byun, Seongnam-si (KR)

(73) Assignee: **SAMSUNG ELECTRONICS CO., LTD.**, Suwon-si (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1137 days.

(21) Appl. No.: **13/619,965**
(22) Filed: **Sep. 14, 2012**

(65) **Prior Publication Data**
US 2013/0321226 A1 Dec. 5, 2013

(30) **Foreign Application Priority Data**
May 29, 2012 (KR) 10-2012-0056451

(51) **Int. Cl.**
H01Q 9/42 (2006.01)
H01Q 1/24 (2006.01)
H01Q 1/48 (2006.01)
H01Q 1/52 (2006.01)
H01Q 13/10 (2006.01)
H01Q 5/364 (2015.01)
H01Q 5/392 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 1/528** (2013.01); **H01Q 9/42** (2013.01); **H01Q 13/10** (2013.01); **H01Q 5/364** (2015.01); **H01Q 5/392** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 13/10; H01Q 1/243; H01Q 9/42
USPC 343/767-770, 702, 700 MS, 846
See application file for complete search history.

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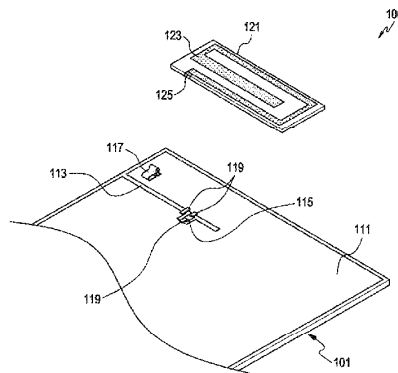
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Primary Examiner — Dameon E Levi
Assistant Examiner — Hasan Islam

(57) **ABSTRACT**

A portable terminal includes an antenna device having a circuit board on a surface of which a conductive layer is formed, a slit that removes a portion of the conductive layer and extends in a direction, an auxiliary board positioned on the slit to face a surface of the circuit board, and a radiation pattern formed on the auxiliary board, in which the radiation pattern is disposed to partially enclose the slit. Even when the radiation pattern is disposed on the conductive layer, induced current generated around the slit can be controlled in the same direction as signal power, thereby preventing radiation performance from being degraded by an inverse current phenomenon in spite of disposition of the radiation pattern on the conductive layer.

10 Claims, 7 Drawing Sheets





US009882266B2

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

(10) **Patent No.:** **US 9,882,266 B2**
(45) **Date of Patent:** **Jan. 30, 2018**

(54) **MOBILE DEVICE HAVING AN INTERIOR MULTIBAND ANTENNA AND A PARTIALLY METAL BACK**

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

(72) Inventors: **Dong Wang**, Waterloo (CA); **Shirook M. Ali**, Milton (CA)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 253 days.

(21) Appl. No.: **14/486,724**

(22) Filed: **Sep. 15, 2014**

(65) **Prior Publication Data**

US 2016/0079654 A1 Mar. 17, 2016

(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H01Q 9/42 (2006.01)
H01Q 21/28 (2006.01)
H01Q 5/371 (2015.01)
H01Q 5/378 (2015.01)
H01Q 1/50 (2006.01)
H04M 1/02 (2006.01)

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

CPC **H01Q 1/243** (2013.01); **H01Q 1/50** (2013.01); **H01Q 5/371** (2015.01); **H01Q 5/378** (2015.01); **H01Q 9/42** (2013.01); **H01Q 21/28** (2013.01); **H04M 1/0202** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/50; H01Q 9/42; H01Q 5/371; H01Q 5/378; H01Q 21/28
USPC 343/702
See application file for complete search history.

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Primary Examiner — Dameon E Levi

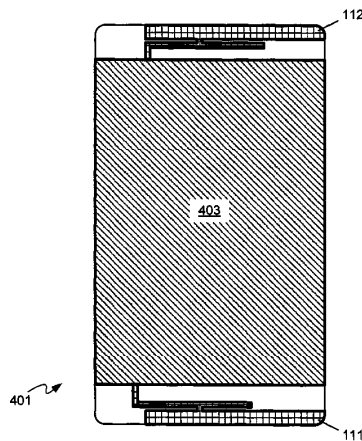
Assistant Examiner — Ab Salam Alkassim, Jr.

(74) *Attorney, Agent, or Firm* — Perry + Currier Inc.

(57) **ABSTRACT**

A mobile device having an interior multiband antenna and a partially metal back is provided. The device comprises: a back side comprising: a conducting central portion; non-conducting portions comprising respective widths from respective end edges of the back side to the conducting central portion, the conducting central portion separating the non-conducting portions; an interior chassis covered by the back side; antennas located on the interior chassis behind each of the non-conducting portions, each of the antennas comprising at least two respective radiating arms configured to resonate in at least three frequency ranges; one or more antenna feeds connected to each of the antennas; and, a switch configured to select one or more of the antennas for operation.

15 Claims, 14 Drawing Sheets





US009882268B2

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

(10) **Patent No.:** **US 9,882,268 B2**
(45) **Date of Patent:** **Jan. 30, 2018**

(54) **RADIATOR FRAME HAVING ANTENNA PATTERN EMBEDDED THEREIN AND METHOD OF MANUFACTURING THE SAME**

(71) Applicant: **Samsung Electro-Mechanics Co., Ltd.**, Suwon-si (KR)

(72) Inventors: **Jun Seung Yi**, Suwon-si (KR); **Ye Ji Park**, Suwon-si (KR); **Sun Hee Lee**, Suwon-si (KR); **Hyeon Gil Nam**, Suwon-si (KR); **Nam Ki Kim**, Suwon-si (KR); **Su Hyun Kim**, Suwon-si (KR); **Ha Ryong Hong**, Suwon-si (KR); **Sung Eun Cho**, Suwon-si (KR); **Dae Seong Jeon**, Suwon-si (KR); **Ho Jin Lee**, Suwon-si (KR)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 150 days.

(21) Appl. No.: **14/830,192**

(22) Filed: **Aug. 19, 2015**

(65) **Prior Publication Data**
US 2016/0056529 A1 Feb. 25, 2016

(30) **Foreign Application Priority Data**
Aug. 21, 2014 (KR) 10-2014-0109104
Jan. 21, 2015 (KR) 10-2015-0009849

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

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 5/371** (2015.01); **H01Q 9/42** (2013.01); **B29C 45/14639** (2013.01); **B29L 2031/3481** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/38; H01Q 5/371; H01Q 9/42; H01Q 1/12
(Continued)

(56) **References Cited**

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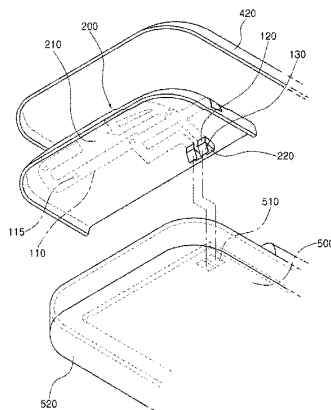
Chinese Office Action dated Nov. 17, in the corresponding Chinese Patent Application No. 201510520282.2. (26 pages in English and 12 pages in Chinese).

Primary Examiner — Tho G Phan

(57) **ABSTRACT**

A radiator frame having an antenna radiator formed on a surface thereof and a method of manufacturing the same are provided. The radiator frame includes: a radiator including an antenna pattern portion configured to transmit or receive a signal, and a connection terminal portion configured to electrically connect the antenna pattern portion and a circuit board; and a molding frame connected to the radiator such that the antenna pattern portion is exposed at one surface of the molding frame and the connection terminal portion is exposed at another surface of the molding frame opposing

(Continued)





US009882269B2

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

(10) **Patent No.:** **US 9,882,269 B2**
(45) **Date of Patent:** **Jan. 30, 2018**

(54) **ANTENNAS FOR HANDHELD ELECTRONIC DEVICES**

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

(72) Inventors: **Robert J. Hill**, Salinas, 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 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **15/141,693**

(22) Filed: **Apr. 28, 2016**

(65) **Prior Publication Data**

US 2016/0248148 A1 Aug. 25, 2016

Related U.S. Application Data

(60) Continuation of application No. 14/064,589, filed on Oct. 28, 2013, now Pat. No. 9,356,355, which is a (Continued)

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

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 1/52** (2013.01); **H01Q 1/521** (2013.01);
(Continued)

(58) **Field of Classification Search**
USPC 343/700 MS, 702, 767, 829, 846
See application file for complete search history.

(56) **References Cited**

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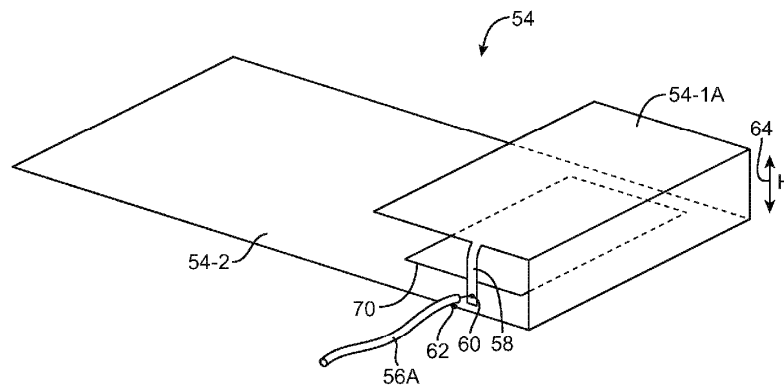
Primary Examiner — Tho G Phan

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

(57) **ABSTRACT**

A handheld electronic device may be provided that contains wireless communications circuitry. The handheld electronic device may have a housing and a display. The display may be attached to the housing using a conductive bezel. The handheld electronic device may have one or more antennas for supporting wireless communications. A ground plane in the handheld electronic device may serve as ground for one or more of the antennas. The ground plane and bezel may define an opening. A rectangular slot antenna or other suitable slot antenna may be formed from or within the opening. One or more antenna resonating elements may be formed above the slot. An electrical switch that bridges the slot may be used to modify the perimeter of the slot so as to tune the communications bands of the handheld electronic device.

19 Claims, 20 Drawing Sheets





US009882275B2

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

(10) **Patent No.:** **US 9,882,275 B2**
(45) **Date of Patent:** **Jan. 30, 2018**

- (54) **ANTENNAS FOR HANDHELD DEVICES**
- (71) Applicant: **Essential Products, Inc.**, Palo Alto, CA (US)
- (72) Inventors: **Andrew E. Rubin**, Los Altos, CA (US); **Matthew Hershenson**, Los Altos, CA (US); **David John Evans, V**, Palo Alto, CA (US); **Xiaoyu Miao**, Palo Alto, CA (US); **Xinrui Jiang**, San Jose, CA (US); **Joseph Anthony Tate**, San Jose, CA (US); **Jason Sean Gagne-Keats**, Cupertino, CA (US)
- (73) Assignee: **ESSENTIAL PRODUCTS, INC.**, Palo Alto, 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.: **15/336,686**

(22) Filed: **Oct. 27, 2016**

(65) **Prior Publication Data**
US 2017/0125897 A1 May 4, 2017

Related U.S. Application Data
(60) Provisional application No. 62/317,466, filed on Apr. 1, 2016, provisional application No. 62/300,631, filed (Continued)

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

(52) **U.S. Cl.**
CPC **H01Q 1/50** (2013.01); **C23C 4/12** (2013.01); **C23C 24/04** (2013.01); **H01Q 1/243** (2013.01);
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(58) **Field of Classification Search**
None
See application file for complete search history.

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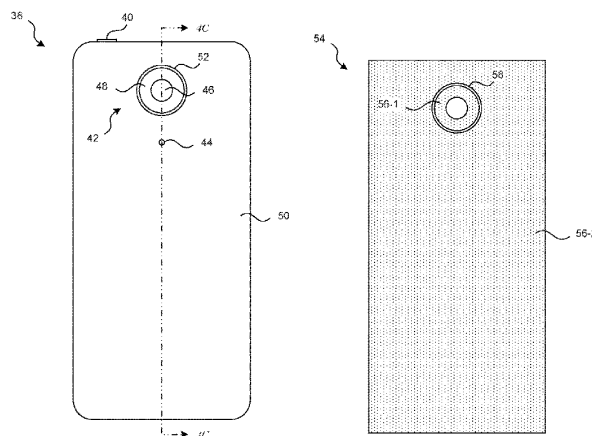
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Primary Examiner — Trinh Dinh
(74) *Attorney, Agent, or Firm* — Perkins Coie LLP

(57) **ABSTRACT**
A handheld device can include an encasing, one or more appurtenances associated with the encasing, communications circuitry contained within the encasing, and antenna elements. The antenna elements can be electrically coupled to the communications circuitry and integrated with the encasing and the one or more appurtenances. The appurtenances can include any of a touch-sensitive display screen, a button, a joystick, a click wheel, a scrolling wheel, a touchpad, a keypad, a keyboard, a microphone, a speaker, a camera, a sensor, a light-emitting diode, a data port, or a power port.

12 Claims, 15 Drawing Sheets





US009882278B2

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

(10) **Patent No.:** **US 9,882,278 B2**
(45) **Date of Patent:** **Jan. 30, 2018**

(54) **ANTENNA SWITCHING SYSTEM AND WIRELESS COMMUNICATION DEVICE USING THE ANTENNA SWITCHING SYSTEM**

(58) **Field of Classification Search**
CPC H01Q 3/24; H01Q 1/245
USPC 455/277.1
See application file for complete search history.

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

(56) **References Cited**

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

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

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 603 days.

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Primary Examiner — Sanh Phu

(21) Appl. No.: **14/522,286**

(74) Attorney, Agent, or Firm — ScienBiziP, P.C.

(22) Filed: **Oct. 23, 2014**

(57) **ABSTRACT**

(65) **Prior Publication Data**

US 2015/0188220 A1 Jul. 2, 2015

An antenna switching system includes a first antenna, a second antenna, a first sensing unit, a second sensing unit, a controlling unit, and a switching unit. The first sensing unit detects a distance between an object and the first antenna. The second sensing unit detects a distance between the object and the second antenna. The controlling unit is electronically connected to the first sensing unit and the second sensing unit. The switching unit is electronically connected to the controlling unit, the first antenna, and the second antenna. The controlling unit is configured to activate and deactivate the first antenna and the second antenna via the switching unit based on detections of the first sensing unit and the second sensing unit.

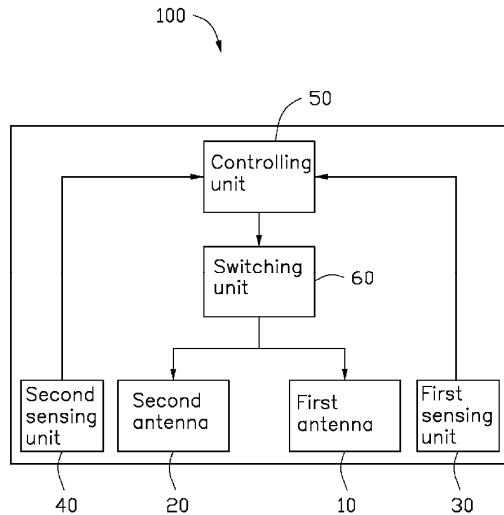
(30) **Foreign Application Priority Data**

Dec. 31, 2013 (CN) 2013 1 0749264

(51) **Int. Cl.**
H04B 7/00 (2006.01)
H01Q 3/24 (2006.01)
H01Q 1/24 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 3/24** (2013.01); **H01Q 1/245** (2013.01)

20 Claims, 5 Drawing Sheets





US009882282B2

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

(10) **Patent No.:** **US 9,882,282 B2**
(45) **Date of Patent:** **Jan. 30, 2018**

(54) **WIRELESS CHARGING AND COMMUNICATIONS SYSTEMS WITH DUAL-FREQUENCY PATCH ANTENNAS**

(56) **References Cited**

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

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343/700 MS

(72) Inventors: **Basim H. Noori**, San Jose, CA (US);
Khan M. Salam, Dublin, CA (US);
Liang Han, Sunnyvale, CA (US);
Matthew A. Mow, Los Altos, CA (US);
Mattia Pascolini, San Francisco, CA (US);
Ruben Caballero, San Jose, CA (US);
Thomas E. Biedka, San Jose, CA (US);
Yi Jiang, Sunnyvale, CA (US);
Yuehui Ouyang, Sunnyvale, CA (US)

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

(57) **ABSTRACT**

An electronic device may be provided with wireless circuitry. The wireless circuitry may include one or more dual-frequency dual-polarization patch antennas. Each patch antenna may have a patch antenna resonating element that lies in a plane and a ground that lies in a different parallel plane. The patch antenna resonating element may have a first feed located along a first central axis and a second feed located along a second central axis that is perpendicular to the first central axis. The patch antenna resonating element may be rectangular, may be oval, or may have other shapes. A shorting pin may be located at an intersecting point between the first and second axes. The patch antennas may be used in beam steering arrays. The patch antennas may be used for wireless power transfer at microwave frequencies or other frequencies and may be used to support millimeter wave communications.

(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 59 days.

(21) Appl. No.: **14/921,895**

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

(65) **Prior Publication Data**
US 2017/0117754 A1 Apr. 27, 2017

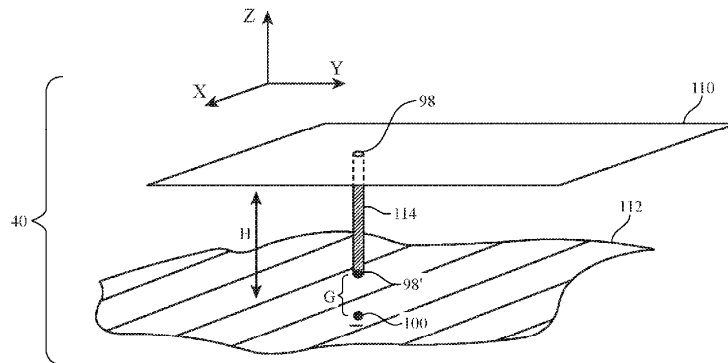
(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H04W 4/00 (2009.01)

(52) **U.S. Cl.**
CPC **H01Q 9/0407** (2013.01); **H04W 4/008** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/0407

(Continued)

13 Claims, 9 Drawing Sheets





US009882283B2

(12) **United States Patent**
Kawata

(10) **Patent No.:** **US 9,882,283 B2**
(45) **Date of Patent:** **Jan. 30, 2018**

(54) **PLANE-SHAPED ANTENNA WITH WIDE BAND AND HIGH RADIATION EFFICIENCY**

(58) **Field of Classification Search**
CPC .. H01Q 9/26; H01Q 1/24; H01Q 1/38; H01Q 7/00

(71) Applicant: **Yamaha Corporation**, Hamamatsu-shi, Shizuoka (JP)

(Continued)

(72) Inventor: **Akihiro Kawata**, Aichi (JP)

(56) **References Cited**

(73) Assignee: **Yamaha Corporation**, Hamamatsu-shi (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 12 days.

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(21) Appl. No.: **14/407,315**

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(22) PCT Filed: **Jun. 14, 2013**

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(86) PCT No.: **PCT/JP2013/066499**

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§ 371 (c)(1),

(2) Date: **Dec. 11, 2014**

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PCT Pub. Date: **Dec. 19, 2013**

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(65) **Prior Publication Data**

US 2015/0162664 A1 Jun. 11, 2015

Primary Examiner — Jessica Han

Assistant Examiner — Jae Kim

(74) *Attorney, Agent, or Firm* — Crowell & Moring LLP

(30) **Foreign Application Priority Data**

Jun. 14, 2012 (JP) 2012-134795
Feb. 12, 2013 (JP) 2013-024551

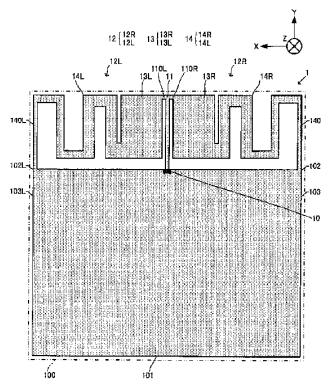
(57) **ABSTRACT**

An antenna has the following formed on a plane thereof: a vertical element formed in a vertical direction; a left horizontal element formed on a left side of the vertical element; a right horizontal element formed on a right side of the vertical element; a left short stub that connects the left horizontal element and a left upper corner of a ground pattern; and a right short stub that connects the right horizontal element and a right upper corner of the ground pattern. The right and left horizontal elements have a flat plate shape and a capacity hat.

(51) **Int. Cl.**
H01Q 9/26 (2006.01)
H01Q 1/38 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 9/26** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 7/00** (2013.01); **H01Q 9/065** (2013.01); **H01Q 9/42** (2013.01)

6 Claims, 12 Drawing Sheets





US009882284B2

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

(10) **Patent No.:** **US 9,882,284 B2**
(45) **Date of Patent:** **Jan. 30, 2018**

(54) **ANTENNA DEVICE OF MOBILE TERMINAL**

(56) **References Cited**

(71) Applicant: **Samsung Electronics Co. Ltd.**,
Suwon-si, Gyeonggi-do (KR)
(72) Inventors: **Sangjin Eom**, Suwon-si (KR); **Jaehche Kim**,
Suwon-si (KR); **Sukho Kim**, Seongnam-si (KR); **Haeyeon Kim**,
Suwon-si (KR); **Jinkyu Bang**, Suwon-si (KR); **Joonho Byun**,
Seongnam-si (KR); **Kyungmoon Seol**, Suwon-si (KR)
(73) Assignee: **Samsung Electronics Co., Ltd.**,
Suwon-si (KR)
(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 855 days.

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343/787

(21) Appl. No.: **13/846,011**
(22) Filed: **Mar. 18, 2013**

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(65) **Prior Publication Data**
US 2013/0257662 A1 Oct. 3, 2013

Primary Examiner — Dameon E Levi
Assistant Examiner — Walter Davis
(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

(30) **Foreign Application Priority Data**
Mar. 29, 2012 (KR) 10-2012-0032181

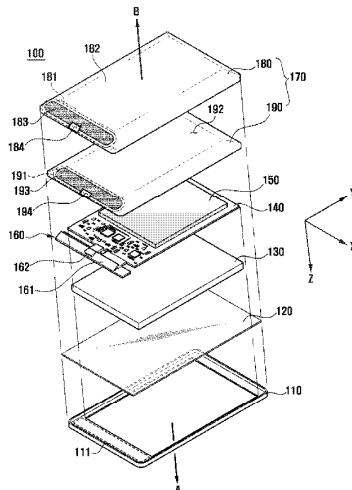
(57) **ABSTRACT**

(51) **Int. Cl.**
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)

An antenna device of a mobile terminal for securing a performance of an antenna of the mobile terminal having a case of a metal material is provided. The antenna device of the mobile terminal includes an antenna module for radiating electric waves, and a case for forming an external form of the mobile terminal, made of a metal material, having a slot in a portion of the metal material, and electrically connected to each of the antenna module and a ground of the mobile terminal, and for operating as a radiator through the slot.

(58) **Field of Classification Search**
CPC H01Q 13/10
USPC 343/702
See application file for complete search history.

14 Claims, 14 Drawing Sheets





US009887451B2

(12) **United States Patent**
Lin

(10) **Patent No.:** **US 9,887,451 B2**
(45) **Date of Patent:** **Feb. 6, 2018**

- (54) **ANTENNA STRUCTURE AND WIRELESS COMMUNICATION DEVICE USING SAME**
- (71) Applicant: **Chiun Mai Communication Systems, Inc.**, New Taipei (TW)
- (72) Inventor: **Yen-Hui Lin**, New Taipei (TW)
- (73) Assignee: **Chiun Mai Communication Systems, Inc.**, New Taipei (TW)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 475 days.
- (21) Appl. No.: **14/481,292**
- (22) Filed: **Sep. 9, 2014**
- (65) **Prior Publication Data**
US 2015/0109171 A1 Apr. 23, 2015
- (30) **Foreign Application Priority Data**
Oct. 18, 2013 (CN) 2013 1 04879973
- (51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 7/00 (2006.01)
H01Q 9/26 (2006.01)
H01Q 5/371 (2015.01)
- (52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 5/371** (2015.01); **H01Q 7/00** (2013.01); **H01Q 9/26** (2013.01)
- (58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 5/371; H01Q 7/00; H01Q 9/26
USPC 343/702
See application file for complete search history.

- (56) **References Cited**
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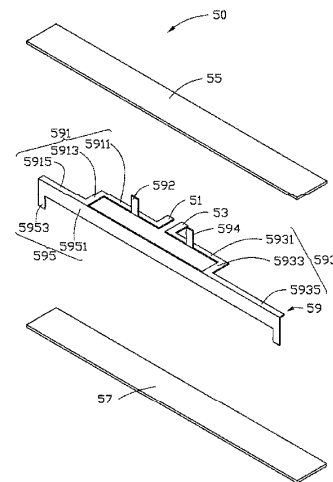
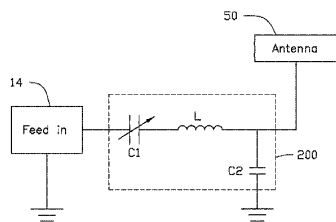
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Primary Examiner — Jessica Han
Assistant Examiner — Bamidele A Jegede
(74) *Attorney, Agent, or Firm* — ScienBiziP, P.C.

(57) **ABSTRACT**

An antenna structure includes a radiator, a first metallic sheet, and a second metallic sheet. The first metallic sheet and the second metallic are positioned at two opposite sides of the radiator. The radiator includes a first radiator portion, a second radiator portion, a third radiator portion. The second radiator portion and the third radiator portion are symmetrically connected to the first radiator portion. The first radiator portion is coupled to the second metallic sheet, both the second radiator portion and the third radiator portion are coupled to the first metallic sheet. The first metallic sheet, the second metallic sheet, and the radiator jointly form a loop structure.

19 Claims, 6 Drawing Sheets





US009887461B2

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

(10) **Patent No.:** **US 9,887,461 B2**
(45) **Date of Patent:** ***Feb. 6, 2018**

(54) **RE-CONFIGURABLE BUILT-IN ANTENNA FOR PORTABLE TERMINAL**

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/245; H01Q 5/364; H01Q 9/0442; H01Q 9/0421;
(Continued)

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

(72) Inventors: **Jin-U Kim**, Seoul (KR); **Austin Kim**,
Seongnam-Si (KR); **Dong-Hwan Kim**,
Hwaseong-si (KR); **Jae-Ho Lee**,
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(73) Assignee: **Samsung Electronics Co., Ltd.**,
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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 115 days.

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This patent is subject to a terminal disclaimer.

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(65) **Prior Publication Data**

US 2015/0109175 A1 Apr. 23, 2015

Related U.S. Application Data

(63) Continuation of application No. 13/100,445, filed on May 4, 2011, now Pat. No. 8,923,914.

Primary Examiner — Andrew Wendell

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

(30) **Foreign Application Priority Data**

May 10, 2010 (KR) 10-2010-0043519

(57) **ABSTRACT**

A re-configurable built-in antenna of a portable terminal is provided. The antenna includes an antenna radiator having a feeding pad electrically connected to a feeding portion of a main board of the terminal and at least one ground pad disposed in a position different from that of the feeding pad for selectively establishing an electrical connection to a ground portion of the terminal, and a switching element, commonly connected to the at least one ground pad of the antenna radiator, for selectively establishing an electrical connection to the ground portion by a switching operation. The antenna radiator changes a shape of the antenna radiator

(51) **Int. Cl.**
H04M 1/00 (2006.01)
H01Q 11/12 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 5/364** (2015.01); **H01Q 1/243** (2013.01); **H01Q 9/0421** (2013.01); **H01Q 9/0442** (2013.01)

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