US010411327B2

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

(10) **Patent No.: US 10,411,327 B2**
(45) **Date of Patent: Sep. 10, 2019**

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

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

(72) Inventors: **Ji-Won Kim**, Gyeonggi-do (KR); **Jinu Kim**, Seoul (KR); **Hui-Won Cho**, Gyeonggi-do (KR)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 518 days.

(21) Appl. No.: **15/056,638**

(22) Filed: **Feb. 29, 2016**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Feb. 27, 2015 (KR) 10-2015-0028340

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H01Q 1/24 (2006.01)
H01Q 1/38 (2006.01)

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

(58) **Field of Classification Search**
CPC H01Q 1/243
(Continued)

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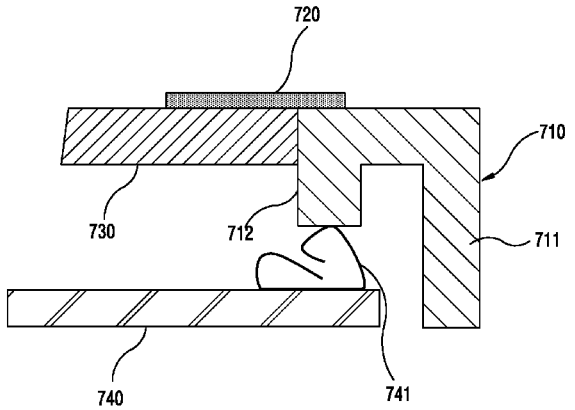
Primary Examiner — Daniel Munoz
(74) *Attorney, Agent, or Firm* — The Farrell Law Firm, P.C.

(57) **ABSTRACT**

An electronic device and an antenna device are provided herein. An electronic device includes a conductive sidewall; a conductive structure located within a space formed by the conductive sidewall and extending from the conductive sidewall, wherein the conductive structure includes a first surface directed toward a front of the portable electronic device and a second surface directed toward a back of the portable electronic device; a non-conductive structure located within the space formed by the conductive sidewall and contacting the conductive structure, wherein the non-conductive structure includes a first surface directed toward the front of the portable electronic device and a second surface directed toward the back of the portable electronic device; an antenna pattern electrically connected to the conductive structure; and a flexible conductive connector electrically connected to the conductive structure and the antenna pattern. The antenna pattern extends on a portion of the first surface of the conductive structure and on a portion of the first surface of the non-conductive structure, or extends on a portion of the second surface of the conductive structure and on a portion of the second surface of the non-conductive structure.

19 Claims, 39 Drawing Sheets



US010454154B2

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

(10) **Patent No.: US 10,454,154 B2**
(45) **Date of Patent: Oct. 22, 2019**

(54) **ANTENNA DEVICE AND ELECTRONIC DEVICE COMPRISING SAME**

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

(72) Inventors: **Jung-Hwan Yeom**, Gyeonggi-do (KR); **Bong-Soo Kang**, Gyeonggi-do (KR); **Dae-Hun Jung**, Gyeonggi-do (KR)

(73) Assignee: **Samsung Electronics Co., Ltd** (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.: **15/775,545**

(22) PCT Filed: **Nov. 11, 2016**

(86) PCT No.: **PCT/KR2016/013021**
§ 371 (c)(1),
(2) Date: **May 11, 2018**

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PCT Pub. Date: **May 18, 2017**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

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

(52) **U.S. Cl.**
CPC ***H01Q 1/24*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 9/42*** (2013.01); ***H01Q 21/28*** (2013.01); *H04B 1/16* (2013.01)

(58) **Field of Classification Search**
CPC .. H01Q 1/24; H01Q 1/38; H01Q 9/42; H01Q 21/28
(Continued)

(56) **References Cited**

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(Continued)

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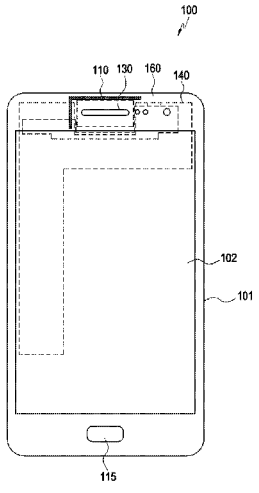
(Continued)

Primary Examiner — Andrea Lindgren Baltzell
(74) *Attorney, Agent, or Firm* — The Farrell Law Firm, P.C.

(57) **ABSTRACT**

An electronic device according to various embodiments is provided and includes a conductive inner module in which a plurality of layers are stacked; an electrical opening formed in at least a portion of the rim of the conductive inner module when stacking the plurality of layers; and an antenna module disposed at the periphery of the electrical opening, wherein the antenna module may include a feeding part formed on at least one of a plurality of layers forming the conductive inner module, and a conductive pattern which is connected to the feeding part and disposed circumferencing at least one of the electrical openings.

14 Claims, 17 Drawing Sheets



US010454155B2

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

(10) **Patent No.: US 10,454,155 B2**
(45) **Date of Patent: Oct. 22, 2019**

(54) **ANTENNA MODULE AND MOBILE TERMINAL USING SAME**

(71) Applicants: **Tan Yew Choon**, Singapore (SG); **Ng Guan Hong**, Singapore (SG); **Tay Yew Siow**, Singapore (SG)

(72) Inventors: **Tan Yew Choon**, Singapore (SG); **Ng Guan Hong**, Singapore (SG); **Tay Yew Siow**, Singapore (SG)

(73) Assignee: **AAC Technologies Pte. Ltd.**, Singapore (SG)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 54 days.

(21) Appl. No.: **15/283,539**

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

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Oct. 26, 2015 (CN) 2015 1 0700339

(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H01Q 9/04	(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 9/0457*** (2013.01); ***H01Q 13/103*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 9/0442; H01Q 9/42; H01Q 9/0457; H01Q 13/103; H01Q 13/10; H01Q 13/106; H01Q 5/371; H01Q 7/005; H01Q 5/328; H01Q 9/0407; H01Q 9/26; H01Q 3/247; H01Q 1/243

See application file for complete search history.

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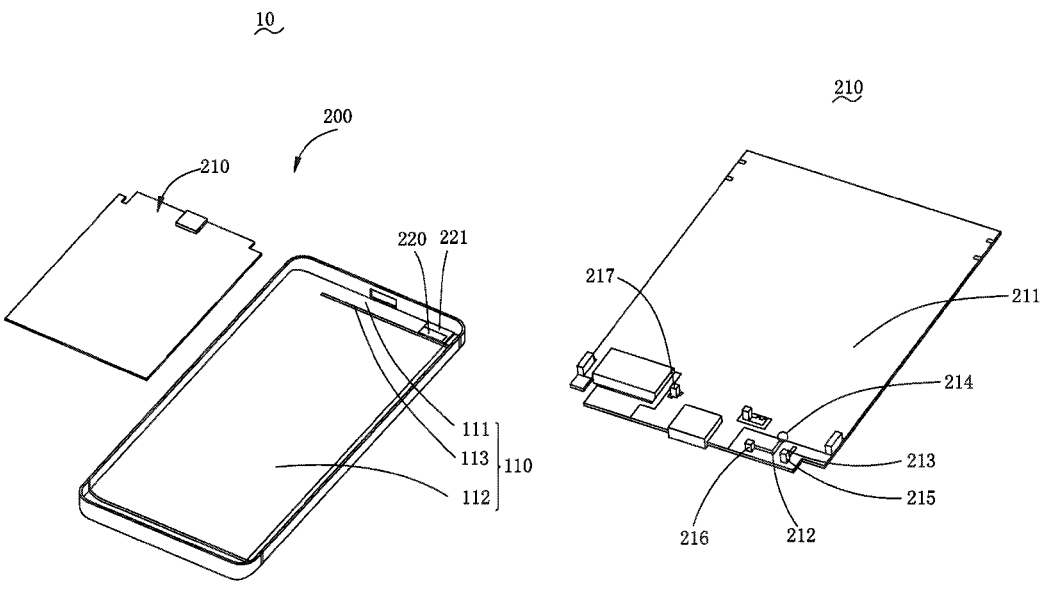
(Continued)

Primary Examiner — Ricardo I Magallanes
(74) *Attorney, Agent, or Firm* — IPro, PLLC; Na Xu

(57) **ABSTRACT**

An antenna module is disclosed. The antenna module includes a radiator. The radiator includes a first radiation part, a second radiation part connecting with the first radiation part partially and a coupling slot arranged between the first radiation part and the second radiation part. Further, the antenna module includes a circuit board which is arranged opposite to the radiator and includes a system base, a grounding line connecting with the system base electrically, a feeder line and a tuning switch controlling ON/OFF of the grounding line, and a capacitance feed sheet facing one side of the first radiation part which faces the circuit board and connecting with the first radiation part. The capacitance feed sheet is connected with the feeder line electrically; the grounding line is connected with the first radiation part electrically; and the system base is connected with the said second radiation part electrically.

10 Claims, 6 Drawing Sheets



US010454156B1

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

(10) **Patent No.: US 10,454,156 B1**
(45) **Date of Patent: Oct. 22, 2019**

(54) **ANTENNA STRUCTURE**

(71) Applicant: **Wistron NeWeb Corp.**, Hsinchu (TW)

(72) Inventors: **Cheng-Da Yang**, Hsinchu (TW); **Yan-Ting Wu**, Hsinchu (TW); **Irving Tseng**, Hsinchu (TW)

(73) Assignee: **WISTRON NEWEB CORP.**, Hsinchu (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.: **16/101,755**

(22) Filed: **Aug. 13, 2018**

(30) **Foreign Application Priority Data**

Jun. 7, 2018 (TW) ..... 107119672 A

(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H01Q 5/335	(2015.01)
H01Q 13/10	(2006.01)
H01Q 5/378	(2015.01)
H01Q 9/04	(2006.01)
H01Q 9/16	(2006.01)
H01Q 1/48	(2006.01)
H04M 1/02	(2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 5/335*** (2015.01); ***H01Q 5/378*** (2015.01); ***H01Q 9/0421*** (2013.01); ***H01Q 9/16*** (2013.01); ***H01Q 13/10*** (2013.01); *H04M 1/0202* (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/48; H01Q 9/16; H01Q 9/0421; H01Q 13/10; H01Q 5/33
USPC ..... 343/700 R
See application file for complete search history.

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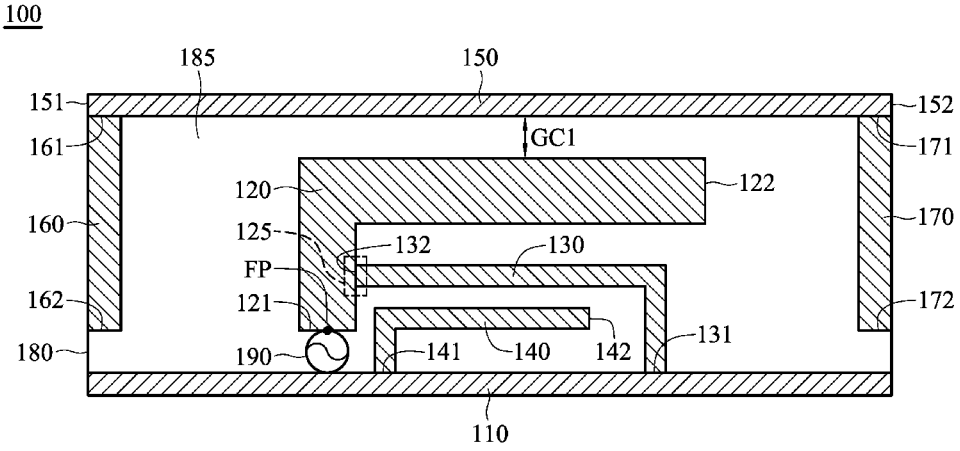
Primary Examiner — Brian K Young
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

An antenna structure includes a first ground element, a feeding element, a shorting element, a parasitic tuning element, a second ground element, a first parasitic element, a second parasitic element, and a dielectric substrate. The feeding element is coupled through the shorting element to the first ground element. The parasitic tuning element is coupled to the first ground element. The parasitic tuning element is at least partially surrounded by the feeding element, the shorting element, and the first ground element. The second ground element is adjacent to the feeding element. The first parasitic element and the second parasitic element are coupled to the second ground element. The feeding element, the shorting element, the parasitic tuning element, the first parasitic element, the second parasitic element, and at least one of the first ground element and the second ground element are disposed on the dielectric substrate.

20 Claims, 6 Drawing Sheets



US010454173B2

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

(10) **Patent No.: US 10,454,173 B2**
(45) **Date of Patent: Oct. 22, 2019**

(54) **FREQUENCY-TUNABLE AND SLOT-FED PLANAR ANTENNA, AND SATELLITE-BASED POSITIONING RECEIVER COMPRISING SUCH AN ANTENNA**

(71) Applicants: **Universite De Rennes 1**, Rennes (FR); **CNRS—Centre National de la Recherche Scientifique**, Paris (FR)

(72) Inventors: **Yaakoub Taachouche**, Rennes (FR); **Mohamed Himdi**, Rennes (FR)

(73) Assignees: **UNIVERSITE DE RENNES 1**, Rennes (FR); **CNRS—CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE**, Paris (FR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 27 days.

(21) Appl. No.: **15/127,579**

(22) PCT Filed: **Mar. 17, 2015**

(86) PCT No.: **PCT/EP2015/055484**
§ 371 (c)(1),
(2) Date: **Sep. 20, 2016**

(87) PCT Pub. No.: **WO2015/140127**
PCT Pub. Date: **Sep. 24, 2015**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Mar. 20, 2014 (FR) 14 52301

(51) **Int. Cl.**

H01Q 9/04	(2006.01)
H01Q 9/14	(2006.01)
H01Q 5/50	(2015.01)
H01Q 1/38	(2006.01)

(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 9/0407*** (2013.01); ***H01Q 1/288*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 1/48*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 9/0407–0457
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Jessica Han
Assistant Examiner — Amal Patel
(74) *Attorney, Agent, or Firm* — David D. Brush; Westman, Champlin & Koehler, P.A.

(57) **ABSTRACT**

A Frequency-tunable and slot-fed planar antenna is proposed. The antenna includes resonant patch, a first dielectric layer, a ground plane having a first slot for each linear polarization, a second dielectric layer and a transmission line having, for each first slot, an end strand extending beneath the first slot. The antenna is frequency tunable for each linear polarization through at least one variable capacitance element. The matching of the antenna varies, for each linear polarization, as a function of a bias voltage applied to the

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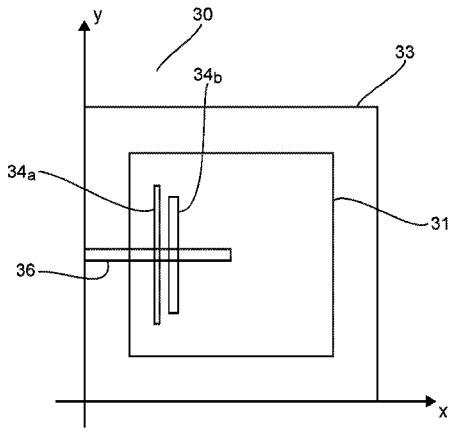

US010454176B2

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

(10) **Patent No.: US 10,454,176 B2**
(45) **Date of Patent: Oct. 22, 2019**

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

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

(72) Inventors: **Yohei Koga**, Kawasaki (JP); **Takashi Yamagajo**, Yokosuka (JP); **Manabu Kai**, Yokohama (JP); **Mitsuharu Hoshino**, Kawasaki (JP); **Masatomo Mori**, Kawasaki (JP)

(73) Assignee: **FUJITSU LIMITED**, Kawasaki (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.: **15/832,096**

(22) Filed: **Dec. 5, 2017**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**

H01Q 9/40	(2006.01)
H01Q 9/38	(2006.01)
H01Q 21/00	(2006.01)
H01Q 1/48	(2006.01)
H01Q 1/24	(2006.01)
H01Q 9/42	(2006.01)
H01Q 21/28	(2006.01)

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

CPC ***H01Q 9/38*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 5/35*** (2015.01); ***H01Q 9/42*** (2013.01); ***H01Q 21/0006*** (2013.01); ***H01Q 21/28*** (2013.01); *H01Q 1/52* (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/48; H01Q 1/52; H01Q 9/40–9/42

USPC ..... 343/700 MS, 702, 846–848

See application file for complete search history.

(56) **References Cited**

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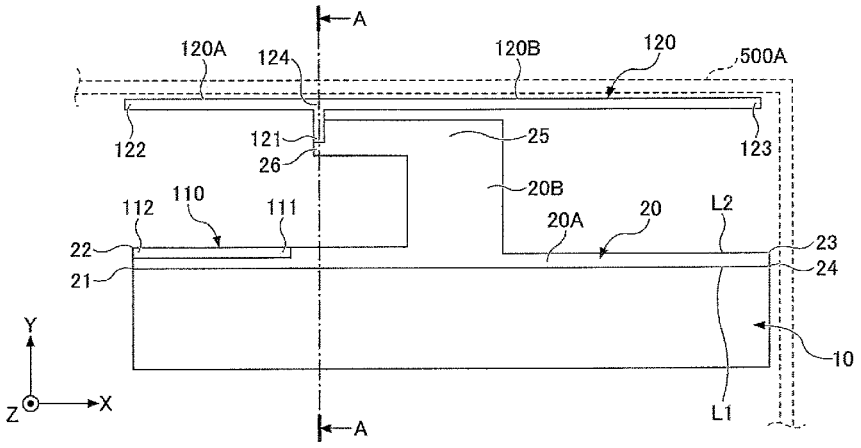
Primary Examiner — Dameon E Levi
Assistant Examiner — Hasan Z Islam
(74) *Attorney, Agent, or Firm* — Arent Fox LLP

(57) **ABSTRACT**

An antenna apparatus includes a ground plane having an edge; a monopole type first antenna element having a first feed point and configured to communicate at a first frequency; and a monopole type second antenna element having a second feed point and configured to communicate at a second frequency, the second antenna element extending from the second feed point in a direction away from the edge. An end portion of the first antenna element is arranged closer to the ground plane than an end portion of the second antenna element is. A length of an interval between the first feed point and the second feed point is in a range of from 0.25-fold to 0.7-fold of an electrical length of a first wavelength at the first frequency. A length of the second antenna element is a length in a range of from 0.15-fold to 0.55-fold of the electrical length.

5 Claims, 12 Drawing Sheets



US010461424B2

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

(10) **Patent No.: US 10,461,424 B2**
(45) **Date of Patent: *Oct. 29, 2019**

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

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

(72) Inventors: **Cheng-Han Lee**, New Taipei (TW); **Yi-Wen Hsu**, New Taipei (TW); **Wei-Xuan Ye**, 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 76 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **15/626,159**

(22) Filed: **Jun. 18, 2017**

(65) **Prior Publication Data**

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Related U.S. Application Data

(60) Provisional application No. 62/364,303, filed on Jul. 19, 2016.

(30) **Foreign Application Priority Data**

Aug. 6, 2016 (CN) 2016 1 0636898

(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H01Q 1/42	(2006.01)
H01Q 5/371	(2015.01)
H01Q 5/50	(2015.01)
H01Q 5/378	(2015.01)

(Continued)

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

CPC ***H01Q 5/371*** (2015.01); ***H01Q 1/243*** (2013.01); ***H01Q 5/378*** (2015.01); ***H01Q 5/50*** (2015.01); ***H01Q 9/42*** (2013.01); ***H01Q 21/28*** (2013.01); *H01Q 21/0006* (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/42; H01Q 9/065; H01Q 13/18; H01Q 1/24; H01Q 1/243; H01Q 1/38; H01Q 21/28; H01Q 5/314; H01Q 5/328; H01Q 5/371; H01Q 5/378; H01Q 5/50; H01Q 9/14; H01Q 9/42; H01Q 21/0006

See application file for complete search history.

(56) **References Cited**

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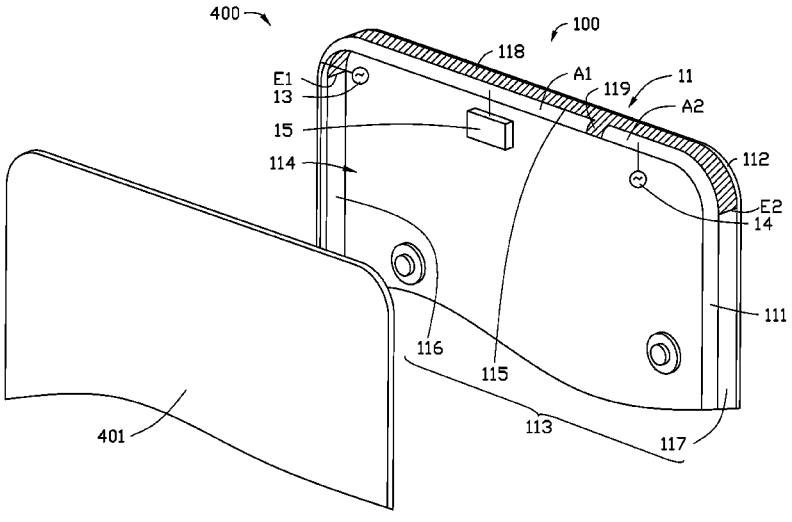
Primary Examiner — Tho G Phan

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

(57) **ABSTRACT**

An antenna structure includes a metallic member and a first feed source. The metallic member includes a front frame, a backboard, and a side frame. The side frame is positioned between the front frame and the backboard. The first feed source is electrically connected to the front frame. The side frame includes at least a top portion, a first side portion, and a second side portion. The first side portion and the second side portion are respectively connected to two ends of the top portion. The side frame defines a slot and the slot is defined on the top portion. The front frame defines a gap. The gap communicates with the slot and extends across the front frame.

33 Claims, 26 Drawing Sheets



US010461425B2

(12) **United States Patent**
Liou

(10) **Patent No.: US 10,461,425 B2**
(45) **Date of Patent: Oct. 29, 2019**

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

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

(72) Inventor: **Geng-Hong Liou**, New Taipei (TW)

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

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(22) Filed: **Oct. 18, 2017**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**

H01Q 13/10	(2006.01)
H01Q 5/50	(2015.01)
H01Q 5/371	(2015.01)
H01Q 5/378	(2015.01)
H01Q 9/30	(2006.01)
H01Q 1/24	(2006.01)
H01Q 9/42	(2006.01)
H01Q 21/28	(2006.01)
H01Q 5/35	(2015.01)
H01Q 1/36	(2006.01)

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

CPC ***H01Q 5/50*** (2015.01); ***H01Q 1/243*** (2013.01); ***H01Q 5/35*** (2015.01); ***H01Q 5/371*** (2015.01); ***H01Q 5/378*** (2015.01); ***H01Q 9/30*** (2013.01); ***H01Q 9/42*** (2013.01); ***H01Q 13/106*** (2013.01); ***H01Q 21/28*** (2013.01); *H01Q 1/36* (2013.01)

(58) **Field of Classification Search**

CPC H01Q 13/18; H01Q 9/0407; H01Q 1/286; H01Q 1/243; H01Q 1/38; H01Q 9/0421

USPC 343/746, 702, 872, 878

See application file for complete search history.

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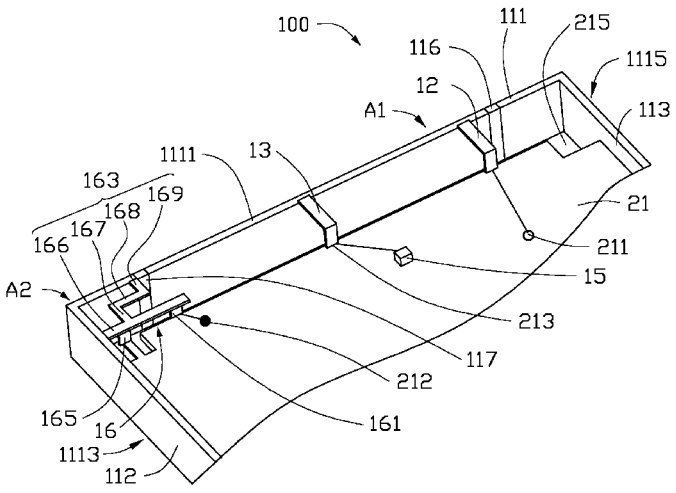
CN 105958201 A 9/2016

Primary Examiner — Hai V Tran
Assistant Examiner — Collin Dawkins
(74) *Attorney, Agent, or Firm* — ScienBiziP, P.C.

(57) **ABSTRACT**

An antenna structure includes a metallic member, a feed portion, a ground portion, and a radiator. The metallic member defines at least one slot and is divided into a first combining portion and a second combining portion by the at least one slot. The feed portion feeds current to the first combining portion. The ground portion grounds the first combining portion. The radiator feeds current to the second combining portion. The first combining portion, the feed portion, and the ground portion cooperatively form a first antenna to activate a first mode for generating radiation signals in a first frequency band. The second combining portion and the radiator cooperatively form a second antenna to activate a second mode for generating radiation signals in a second frequency band.

19 Claims, 12 Drawing Sheets



US010461427B2

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

(10) **Patent No.: US 10,461,427 B2**
(45) **Date of Patent: Oct. 29, 2019**

(54) **ANTENNA AND ELECTRONIC DEVICES COMPRISING THE SAME**

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

(72) Inventors: **Soon Ho Hwang**, Seoul (KR); **Sung Koo Park**, Suwon-si (KR); **Joon Ho Byun**, Yongin-si (KR); **Chan Kyu An**, Incheon (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 125 days.

(21) Appl. No.: **14/681,521**

(22) Filed: **Apr. 8, 2015**

(65) **Prior Publication Data**

US 2016/0301138 A1 Oct. 13, 2016

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 1/24 (2006.01)
H01Q 9/42 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 9/0407*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 9/42*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/0407; H01Q 9/42; H01Q 1/243
See application file for complete search history.

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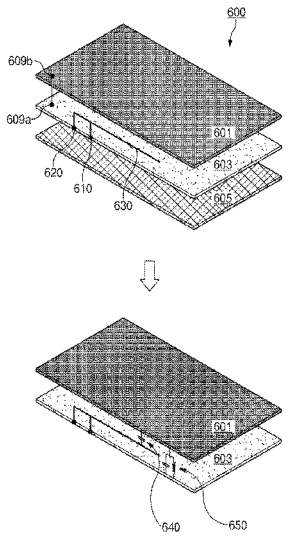
Primary Examiner — Jessica Han
Assistant Examiner — Michael Bouizza
(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

(57) **ABSTRACT**

An electronic device having an antenna is provided. The electronic device includes a substrate including a grounding area, a non-grounding area and at least one feeding unit for feeding an antenna radiator, and a non-segmented metal cover forming an outer frame of the electronic device and operating as a part of the antenna.

8 Claims, 12 Drawing Sheets



US010461794B2

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

(10) **Patent No.: US 10,461,794 B2**
(45) **Date of Patent: Oct. 29, 2019**

(54) **MOBILE TERMINAL**

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

(72) Inventors: **Yeomin Youn**, Seoul (KR); **Jaehyun Choi**, Seoul (KR); **Jungsun Ahn**, Seoul (KR); **Changil Kim**, Seoul (KR); **Kangjae Jung**, 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.: **16/122,600**

(22) Filed: **Sep. 5, 2018**

(65) **Prior Publication Data**

US 2019/0007085 A1 Jan. 3, 2019

Related U.S. Application Data

(63) Continuation of application No. 15/961,227, filed on Apr. 24, 2018, now Pat. No. 10,122,401, which is a (Continued)

(30) **Foreign Application Priority Data**

Dec. 3, 2013 (KR) 10-2013-0149413

(51) **Int. Cl.**
H04B 1/3888 (2015.01)
H01Q 1/24 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H04B 1/3888*** (2013.01); ***G06F 1/1626*** (2013.01); ***G06F 1/1656*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H04B 1/3888; H04B 2001/3894; H04M 1/0202; H04M 1/0249; H04M 1/18
(Continued)

(56) **References Cited**

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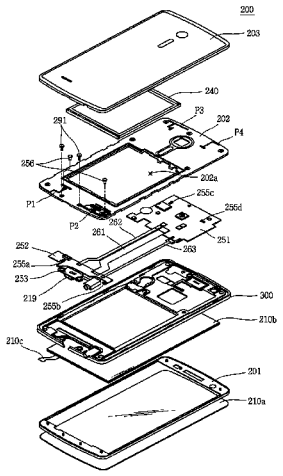
(Continued)

Primary Examiner — April G Gonzales
(74) *Attorney, Agent, or Firm* — Lee, Hong, Degerman, Kang & Waimey PC

(57) **ABSTRACT**

A mobile terminal includes a metal frame including a base portion and an edge portion formed along the outer edge of the base portion, first and second cases bonded to the front and back sides of the metal frame so as to expose the edge portion to the outside, first and second waterproof layers formed between the cases and the metal frame, conductive members that operate a radiator for antennas, together with the edge portion, and are formed on one side of the second case, and feeding portions for feeding the conductive members, the feeding portions being disposed in an enclosed space formed by the waterproof layers.

14 Claims, 15 Drawing Sheets



US010468746B2

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

(10) **Patent No.: US 10,468,746 B2**
(45) **Date of Patent: Nov. 5, 2019**

(54) **ELECTRONIC DEVICE HAVING LOOP ANTENNA**

(71) Applicant: **SAMSUNG ELECTRONICS CO., LTD.**, Suwon-si, Gyeonggi-do (KR)

(72) Inventors: **Woosup Lee**, Suwon-si (KR); **Jungsik Park**, Suwon-si (KR)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 211 days.

(21) Appl. No.: **15/718,327**

(22) Filed: **Sep. 28, 2017**

(65) **Prior Publication Data**

US 2018/0097275 A1 Apr. 5, 2018

(30) **Foreign Application Priority Data**

Oct. 5, 2006 (KR) 10-2016-0128402

(51) **Int. Cl.**
H01Q 1/22 (2006.01)
H01Q 7/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 1/2266*** (2013.01); ***G06F 1/1635*** (2013.01); ***G06F 1/1637*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC ... G06F 1/1635; G06F 1/1637; H04B 5/0087; H01Q 7/00; H01Q 1/2266; G06K 19/07779
See application file for complete search history.

(56) **References Cited**

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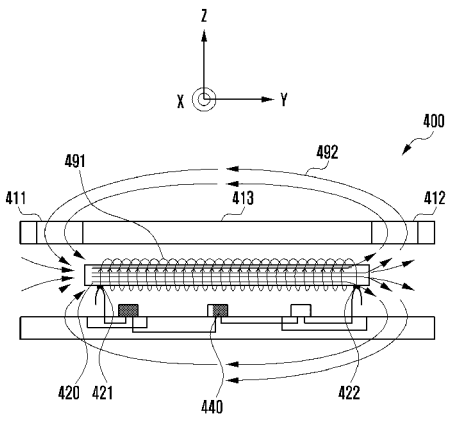
Primary Examiner — Hoang V Nguyen
Assistant Examiner — Jae K Kim
(74) *Attorney, Agent, or Firm* — Nixon & Vanderhye, P.C.

(57) **ABSTRACT**

An electronic device includes a housing including a first surface facing in a first direction, a second surface facing in a second direction to the first direction, and a side member enclosing at least a portion of a space between the first surface and the second surface; a first metal plate positioned between the first surface and the second surface; a conductive coil positioned within the housing, having a shaft substantially perpendicular to the first direction or the second direction, and that winds around the first metal plate; a first communication circuit positioned within the housing and electrically connected to the conductive coil; a second communication circuit positioned within the housing and electrically connected to the first metal plate; a display exposed through at least a portion of the first surface; and a processor positioned within the housing and electrically connected to the first communication circuit, the second communication circuit, and the display. The second surface may include a first portion made of a conductive material and including a first opening and a second portion made of a non-conductive material and that fills the first opening. The
(Continued)



US010468749B2

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

(10) **Patent No.: US 10,468,749 B2**
(45) **Date of Patent: Nov. 5, 2019**

(54) **MOBILE DISPLAY TERMINAL**

(71) Applicant: **BOE TECHNOLOGY GROUP CO., LTD.**, Beijing (CN)

(72) Inventors: **Yongchun Lu**, Beijing (CN); **Jian Xu**, Beijing (CN); **Xinyin Wu**, Beijing (CN); **Yong Qiao**, Beijing (CN); **Jianbo Xian**, Beijing (CN)

(73) Assignee: **BOE TECHNOLOGY GROUP 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 5 days.

(21) Appl. No.: **14/915,613**

(22) PCT Filed: **Sep. 29, 2015**

(86) PCT No.: **PCT/CN2015/091078**
§ 371 (c)(1),
(2) Date: **Feb. 29, 2016**

(87) PCT Pub. No.: **WO2016/155275**
PCT Pub. Date: **Oct. 6, 2016**

(65) **Prior Publication Data**

US 2017/0040669 A1 Feb. 9, 2017

(30) **Foreign Application Priority Data**

Apr. 3, 2015 (CN) ..... 2015 2 0200997 U

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/38 (2006.01)
H01Q 21/28 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 21/28*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/38; H01Q 1/50; H01Q 21/28
See application file for complete search history.

(56) **References Cited**

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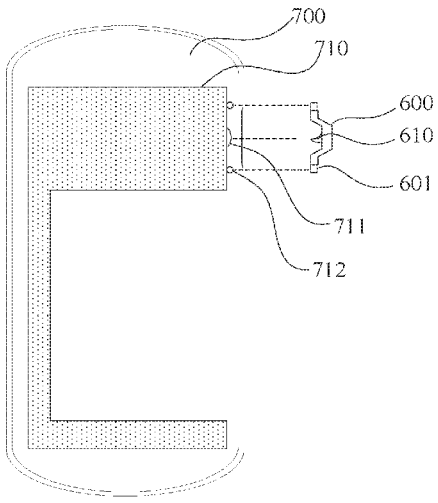
Primary Examiner — Robert Karacsony
(74) *Attorney, Agent, or Firm* — Brooks Kushman P.C.

(57) **ABSTRACT**

The present disclosure provides a mobile display terminal, including a case, a main board and an antenna. The main board is arranged inside the case, a circuit board is arranged on the main board, and the antenna is arranged on the case. The mobile display terminal further includes a connector configured to electrically connect the antenna to the circuit board.

9 Claims, 6 Drawing Sheets



US010468750B2

(12) **United States Patent**
Park

(10) **Patent No.: US 10,468,750 B2**
(45) **Date of Patent: Nov. 5, 2019**

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

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

(72) Inventor: **Joo-Hwan Park**, Gyeonggi-do (KR)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 93 days.

(21) Appl. No.: **14/946,267**

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

(65) **Prior Publication Data**

US 2016/0149291 A1 May 26, 2016

(30) **Foreign Application Priority Data**

Nov. 21, 2014 (KR) 10-2014-0163756

(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H01Q 5/328	(2015.01)
H01Q 5/378	(2015.01)
H01Q 1/48	(2006.01)

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

CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 5/328*** (2015.01); ***H01Q 5/378*** (2015.01)

(58) **Field of Classification Search**

CPC .. H01Q 1/241–244; H01Q 1/48; H01Q 5/328; H01Q 5/371; H01Q 5/378; H01Q 5/385; H01Q 19/005; H01Q 19/32; H01Q 3/446; H01Q 1/243

See application file for complete search history.

(56) **References Cited**

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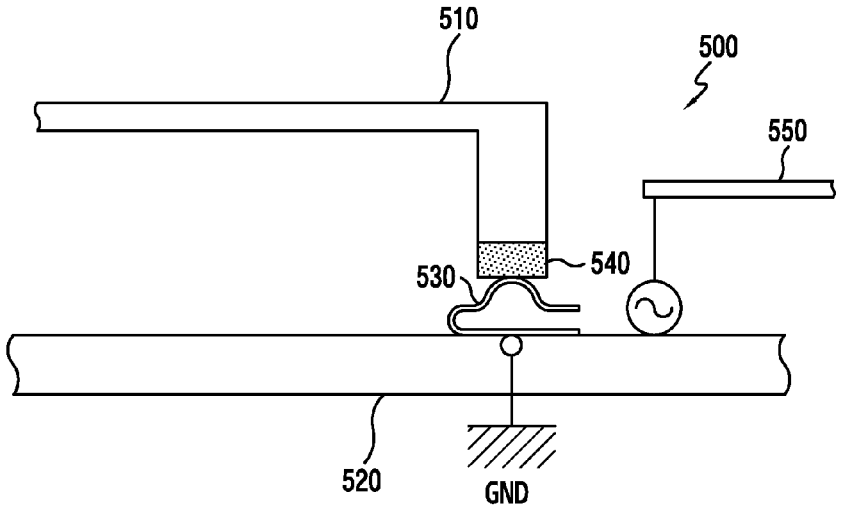
(Continued)

Primary Examiner — Hoang V Nguyen
Assistant Examiner — Awat M Salih
(74) *Attorney, Agent, or Firm* — The Farrell Law Firm, P.C.

(57) **ABSTRACT**

Provided are an antenna and an electronic device including the same. The antenna includes a substrate, an antenna radiator fed from the substrate, at least one metallic member disposed near the antenna radiator, a connector member electrically connected to the substrate, and a capacitor formed by a dielectric interposed between the connector member and the at least one metallic member.

13 Claims, 17 Drawing Sheets



US010468754B2

(12) **United States Patent**
Vanjani

(10) **Patent No.: US 10,468,754 B2**
(45) **Date of Patent: Nov. 5, 2019**

(54) **BIFURCATED MULTI-MODE RING ANTENNA FOR A WIRELESS COMMUNICATION DEVICE**

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

(72) Inventor: **Kiran Vanjani**, 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 1 day.

(21) Appl. No.: **15/835,150**

(22) Filed: **Dec. 7, 2017**

(65) **Prior Publication Data**

US 2019/0181537 A1 Jun. 13, 2019

(51) **Int. Cl.**

H01Q 7/00	(2006.01)
H01Q 1/24	(2006.01)
H01Q 5/30	(2015.01)
H01Q 13/10	(2006.01)

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

CPC ***H01Q 1/243*** (2013.01); ***H01Q 5/30*** (2015.01); ***H01Q 7/00*** (2013.01); ***H01Q 13/10*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 7/00; H01Q 5/30; H01Q 13/10

USPC ..... 343/700 MS, 725

See application file for complete search history.

(56) **References Cited**

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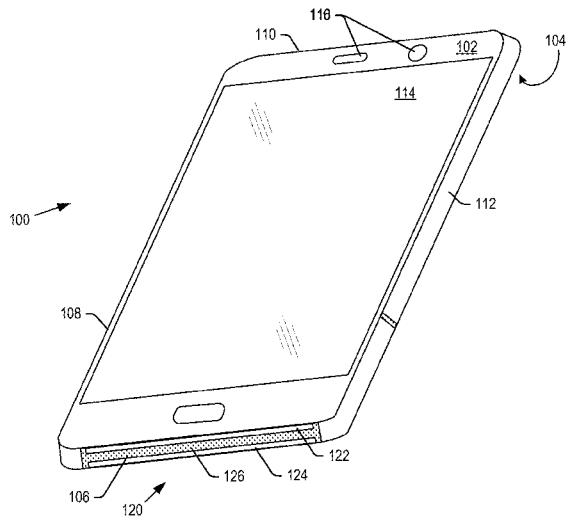
* cited by examiner

Primary Examiner — Jean B Jeanglaude
(74) *Attorney, Agent, or Firm* — Vierra Magen Marcus LLP

(57) **ABSTRACT**

The present technology relates to a multiband antenna for wireless mobile communication devices such as cellular telephones. The antenna may include a bifurcated ring structure along one, two, three or all four edges of the device. The ring structure may include bifurcated metal conductors, or bars, extending along the length of the one or more edges.

35 Claims, 7 Drawing Sheets



US010468757B2

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

(10) **Patent No.: US 10,468,757 B2**
(45) **Date of Patent: Nov. 5, 2019**

(54) **WEARABLE DEVICE AND ANTENNA THEREOF**

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

(72) Inventors: **Wen Wang**, Shenzhen (CN); **Shuhui Sun**, Shenzhen (CN); **Qing Liu**, Shenzhen (CN); **Lina Chen**, Shenzhen (CN)

(73) Assignee: **HUAWEI TECHNOLOGIES CO., LTD.**, Shenzhen (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.: **15/779,407**

(22) PCT Filed: **Nov. 27, 2015**

(86) PCT No.: **PCT/CN2015/095745**
§ 371 (c)(1),
(2) Date: **May 25, 2018**

(87) PCT Pub. No.: **WO2017/088164**
PCT Pub. Date: **Jun. 1, 2017**

(65) **Prior Publication Data**

US 2018/0309194 A1 Oct. 25, 2018

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/27 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 1/273*** (2013.01); ***H01Q 1/50*** (2013.01); ***H01Q 9/0414*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/24; H01Q 1/50; H01Q 13/10; H01Q 1/385
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(56) **References Cited**

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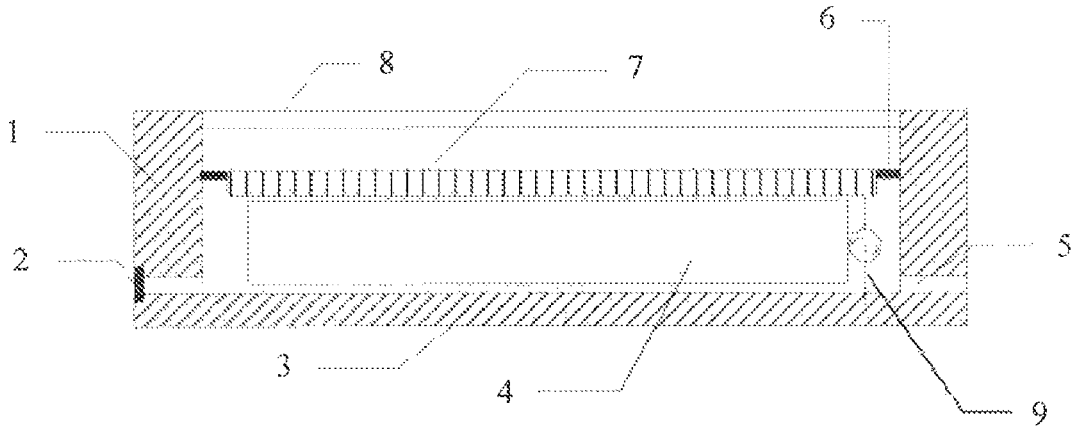
Primary Examiner — Huedung X Mancuso
(74) *Attorney, Agent, or Firm* — Conley Rose, P.C.

(57) **ABSTRACT**

An antenna of a wearable device includes a metal bottom housing of the wearable device, a printed circuit board, a metal middle housing that encircles the printed circuit board, and a communications circuit set on the printed circuit board. A slot exists between the metal middle housing and the metal bottom housing. The metal middle housing is connected to the metal bottom housing using a second connecting wire. The metal middle housing and the printed circuit board jointly serve as a ground plate. An antenna feed line is used to connect the metal bottom housing and the communications circuit module. The metal bottom housing serves as an antenna radiation body.

11 Claims, 1 Drawing Sheet



US010468775B2

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

(10) **Patent No.: US 10,468,775 B2**
(45) **Date of Patent: Nov. 5, 2019**

(54) **ANTENNA ASSEMBLY, WIRELESS COMMUNICATIONS ELECTRONIC DEVICE AND REMOTE CONTROL HAVING THE SAME**

(71) Applicant: **AUTEL ROBOTICS CO., LTD.**, Shenzhen, Guangdong (CN)

(72) Inventors: **Shengzhao Xiang**, Guangdong (CN); **Yiye Sun**, Guangdong (CN); **Zhuanpeng Cheng**, Guangdong (CN)

(73) Assignee: **AUTEL ROBOTICS CO., LTD.**, Shenzhen, Guangdong (CN)

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

(21) Appl. No.: **15/883,673**

(22) Filed: **Jan. 30, 2018**

(65) **Prior Publication Data**

US 2018/0331430 A1 Nov. 15, 2018

Related U.S. Application Data

(63) Continuation of application No. PCT/CN2017/107379, filed on Oct. 23, 2017.

(30) **Foreign Application Priority Data**

May 12, 2017 (CN) 2017 1 0335550

(51) **Int. Cl.**
H01Q 13/10 (2006.01)
H01Q 1/38 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 13/106*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 9/0407*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/38; H01Q 1/085; H01Q 13/106; H01Q 13/08; H01Q 9/0407; H01Q 21/08
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(56) **References Cited**

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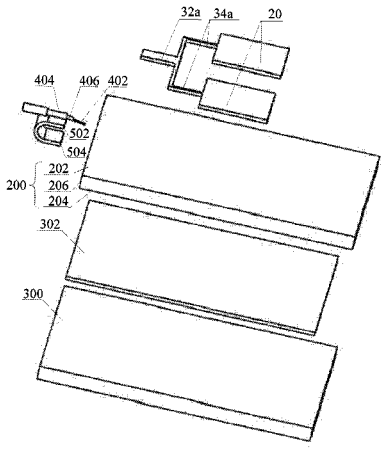
Primary Examiner — Lam T Mai

(57) **ABSTRACT**

The present application relates to the field of communications, and provides an antenna assembly which is disposed in a wireless communications electronic device. The wireless communications electronic device is provided with a substrate. The antenna assembly includes: a radiation element, disposed at a first surface of the radiation element; a feeder, electrically connected to the radiation element; and a reference ground, disposed at a second surface of the substrate. The antenna assembly in the embodiments of the present application uses the substrate of the wireless communications electronic device as a medium to bear the radiation element, reducing space and costs of the antenna assembly; and because the substrate is relatively thick, a bandwidth of the antenna assembly is also increased. The
(Continued)



US010474282B2

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

(10) **Patent No.: US 10,474,282 B2**
(45) **Date of Patent: Nov. 12, 2019**

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

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

(72) Inventors: **Jung-Sik Park**, Suwon-si (KR); **Jae-Young Shin**, Yongin-si (KR); **Seunggil Jeon**, Suwon-si (KR); **Chongyoon Chung**, Seoul (KR); **Dohyung Ha**, Seoul (KR); **Byoung-Uk Yoon**, Hwaseong-si (KR); **Hyun-Ju Hong**, Osan-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 2 days.

(21) Appl. No.: **15/458,565**

(22) Filed: **Mar. 14, 2017**

(65) **Prior Publication Data**

US 2017/0285844 A1 Oct. 5, 2017

(30) **Foreign Application Priority Data**

Mar. 31, 2016 (KR) 10-2016-0039590

(51) **Int. Cl.**
G06F 3/041 (2006.01)
G06F 1/16 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***G06F 3/0416*** (2013.01); ***G06F 1/1643*** (2013.01); ***G06F 1/1647*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC G06F 3/041–047; G06F 2203/041–04113; G06F 3/0416;
(Continued)

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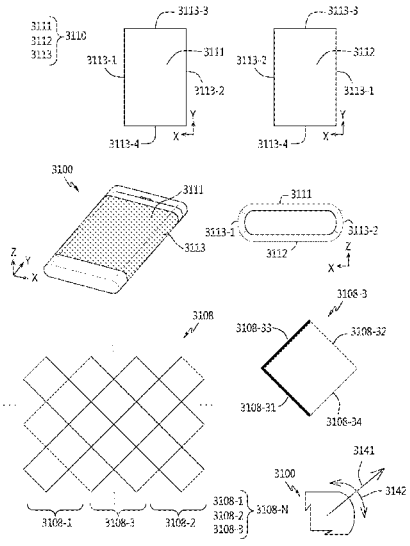
Primary Examiner — Roberto W Flores
(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

(57) **ABSTRACT**

An electronic device is provided. The electronic device includes a housing having a first face, a second face that faces a direction opposite to the first face, and a side face that encloses at least a portion of a space between the first face and the second face, a touch sensing circuit disposed within the housing, a communication circuit disposed within the housing, a transparent substrate that forms at least a portion of the first face, the second face, and the side face of the housing, at least one display disposed within the housing along at least a portion of the transparent substrate, a first conductive pattern disposed between the transparent substrate and the at least one display or inside the at least one display, and electrically connected with the touch sensing circuit, and a second conductive pattern disposed between the transparent substrate and the first conductive pattern, and electrically connected with the wireless communication circuit.

20 Claims, 90 Drawing Sheets



US010476131B2

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

(10) **Patent No.: US 10,476,131 B2**
(45) **Date of Patent: Nov. 12, 2019**

(54) **ELECTRONIC DEVICE HAVING ANTENNA**

(71) Applicant: **HONGBO WIRELESS COMMUNICATION TECHNOLOGY CO., LTD.**, Taipei (TW)

(72) Inventors: **Yao-Yuan Chang**, Taipei (TW); **Chih-Chia Huang**, Taipei (TW); **Tsung-Wen Chiu**, Taipei (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 454 days.

(21) Appl. No.: **15/334,073**

(22) Filed: **Oct. 25, 2016**

(65) **Prior Publication Data**

US 2018/0026331 A1 Jan. 25, 2018

(30) **Foreign Application Priority Data**

Jul. 22, 2016 (TW) ..... 105123412 A

(51) **Int. Cl.**

H01Q 1/22	(2006.01)
H01Q 13/10	(2006.01)
H01Q 1/50	(2006.01)
H01Q 9/06	(2006.01)
H01Q 1/48	(2006.01)

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

CPC ***H01Q 1/2266*** (2013.01); ***H01Q 1/22*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 1/50*** (2013.01); ***H01Q 9/065*** (2013.01); ***H01Q 13/10*** (2013.01); ***H01Q 13/106*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/50; H01Q 1/2266; H01Q 13/106; H01Q 1/48; H01Q 9/065; H01Q 1/22; H01Q 13/10

USPC 343/702

See application file for complete search history.

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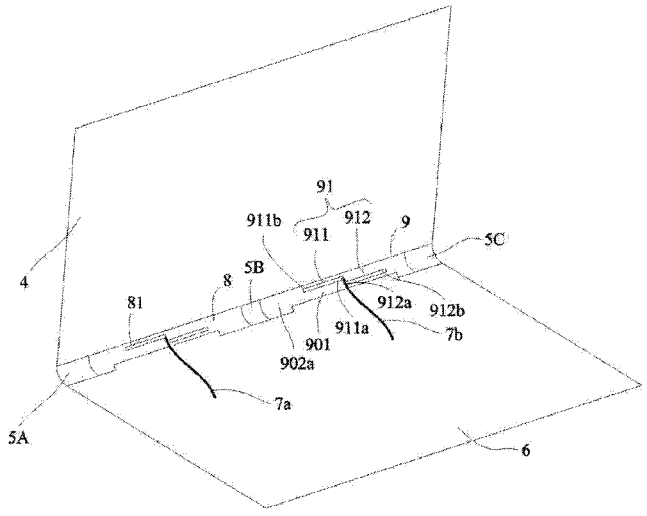
Primary Examiner — Hai V Tran

(74) *Attorney, Agent, or Firm* — Opes IP Consulting Co., Ltd.

(57) **ABSTRACT**

An electronic device having an antenna comprises a first metal casing, a second metal casing, a first hinge, a second hinge, and a first dipole antenna. A first slot antenna structure having a first half-wavelength resonant mode is constituted by the first hinge, the first metal casing, the second hinge and the second metal casing. The width of a first middle portion of the first slot antenna structure is narrower than the widths of the two end portion. The first dipole antenna unit located in the middle portion of the first slot antenna structure has a second half-wavelength resonant mode. The first dipole antenna is for exciting the first half-wavelength resonant mode. Accordingly, the antenna can be integrated with the hinges of the electronic device.

9 Claims, 5 Drawing Sheets



US010476137B1

(12) **United States Patent**
Su

(10) **Patent No.: US 10,476,137 B1**
(45) **Date of Patent: Nov. 12, 2019**

(54) **TERMINAL HOUSING AND TERMINAL**

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

(72) Inventor: **Jinhuai Su**, 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.: **16/384,924**

(22) Filed: **Apr. 16, 2019**

(30) **Foreign Application Priority Data**

May 28, 2018 (CN) 2018 1 0525028

(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H01Q 1/38	(2006.01)
H01Q 1/48	(2006.01)
H04M 1/02	(2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 1/48*** (2013.01); ***H04M 1/0249*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/242; H01Q 1/243; H01Q 1/38; H01Q 1/48; H01Q 1/50; H01Q 1/52; H01Q 1/521; H01Q 1/523; H04M 1/0249
See application file for complete search history.

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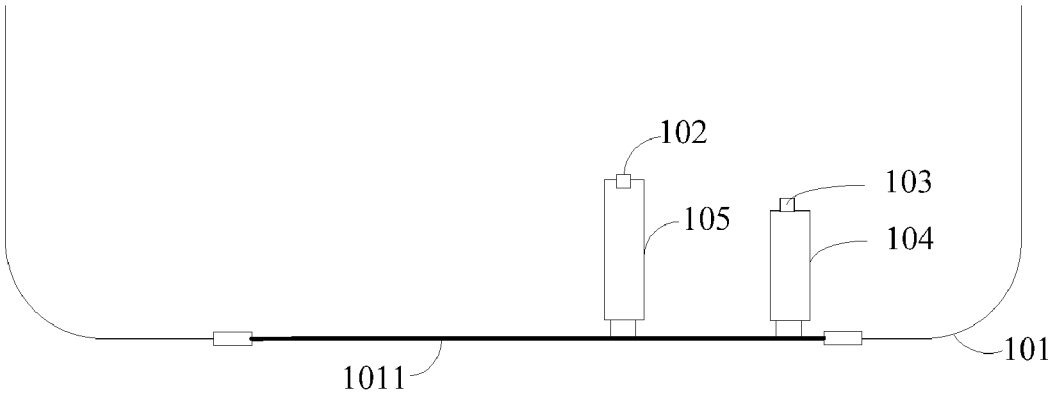
Primary Examiner — Dinh Nguyen
(74) *Attorney, Agent, or Firm* — Arch & Lake LLP

(57) **ABSTRACT**

The present disclosure provides a terminal housing and a terminal. The main board unit in the terminal housing includes a power supply module, a switching module, a first grounding area, a second grounding area and a third grounding area; the antenna unit includes a horizontal bezel, a first branch, a second branch, a third branch and a fourth branch; the power supply module is connected to the horizontal bezel through the first branch; the first end of the switching module is connected to the contact area of the second branch, the third branch, and the fourth branch, the second end of the switching module is connected to the third grounding area, and the switching module is configured to control the first end to be connected to or disconnected from the second end.

20 Claims, 4 Drawing Sheets



US010476151B2

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

(10) **Patent No.: US 10,476,151 B2**
(45) **Date of Patent: Nov. 12, 2019**

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

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

(72) Inventors: **Jaemin Seo**, Suwon-si (KR); **Suyang Park**, Hwaseong-si (KR); **Jaesun Park**, 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 1007 days.

(21) Appl. No.: **14/282,551**

(22) Filed: **May 20, 2014**

(65) **Prior Publication Data**

US 2014/0347242 A1 Nov. 27, 2014

(30) **Foreign Application Priority Data**

May 27, 2013 (KR) 10-2013-0059565

(51) **Int. Cl.**
H01Q 1/48 (2006.01)
H01Q 1/24 (2006.01)
H01Q 1/52 (2006.01)

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

(58) **Field of Classification Search**
CPC .. H01Q 1/48; H01Q 9/40; H01Q 1/12; H01Q 1/243
USPC 343/848, 702, 878
See application file for complete search history.

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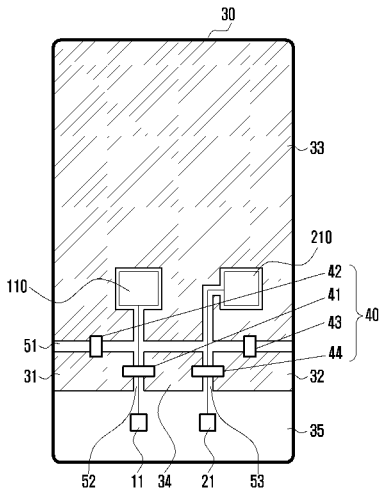
Primary Examiner — Dameon E Levi
Assistant Examiner — Collin Dawkins
(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

(57) **ABSTRACT**

An antenna apparatus that is able to improve isolation between antennas that are arranged adjacent to each other and an electronic device having the same are provided. The antenna apparatus includes a plurality of antennas, and a printed circuit board connected to the plurality of antennas, wherein the printed circuit board comprises a plurality of feeding units respectively connected to the plurality of antennas and a plurality of ground units respectively connected to the plurality of antennas, and each of the ground units is separated from the other ground units by means of at least one slot.

21 Claims, 6 Drawing Sheets



US010476161B2

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

(10) **Patent No.: US 10,476,161 B2**
(45) **Date of Patent: Nov. 12, 2019**

(54) **LOOP ANTENNA AND ELECTRONIC APPARATUS**

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

(72) Inventors: **Takashi Yamagajo**, Yokosuka (JP); **Manabu Kai**, Yokohama (JP)

(73) Assignee: **FUJITSU LIMITED**, Kawasaki (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.: **15/993,676**

(22) Filed: **May 31, 2018**

(65) **Prior Publication Data**

US 2018/0366827 A1 Dec. 20, 2018

(30) **Foreign Application Priority Data**

Jun. 15, 2017 (JP) 2017-117720

(51) **Int. Cl.**
H01Q 7/00 (2006.01)
H01Q 1/38 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 7/00*** (2013.01); ***H01Q 1/38*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 7/00; H01Q 1/38
See application file for complete search history.

(56) **References Cited**

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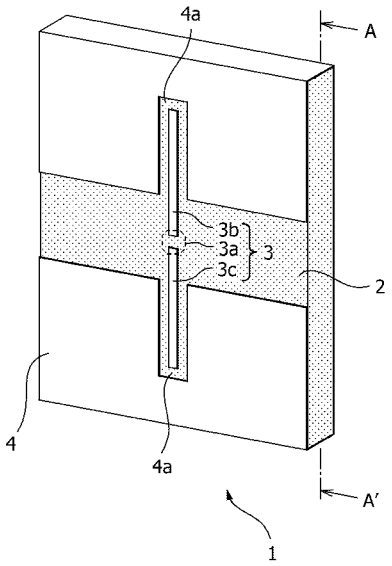
Primary Examiner — Hoang V Nguyen
(74) *Attorney, Agent, or Firm* — Fujitsu Patent Center

(57) **ABSTRACT**

A loop antenna includes: a substrate; a feeding element including a first portion and a second portion which are provided on a first surface of the substrate, have electrical conductivity, are fed with electric power from a feeding point, the first portion extending from the feeding point in a first direction, the second portion extending from the feeding point in a second direction; and an emitting element which has electrical conductivity, is formed in a loop shape in such a manner that the emitting element surrounds the substrate along a surface perpendicular to the first surface, and includes a first end provided so as to electromagnetically couple to the first portion on the first surface and a second end provided so as to electromagnetically couple to the second portion on the first surface, a gap being disposed between the first end and the second end.

11 Claims, 14 Drawing Sheets



US010476167B2

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

(10) **Patent No.: US 10,476,167 B2**
(45) **Date of Patent: Nov. 12, 2019**

(54) **ADJUSTABLE MULTIPLE-INPUT AND MULTIPLE-OUTPUT ANTENNA STRUCTURES**

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

(72) Inventors: **Enrique Ayala Vazquez**, Watsonville, CA (US); **Nanbo Jin**, Milpitas, CA (US); **Hongfei Hu**, Santa Clara, CA (US); **Han Wang**, Cupertino, CA (US); **Erdinc Irci**, Sunnyvale, CA (US); **Erica J. Tong**, Pacifica, CA (US); **Matthew A. Mow**, Los Altos, CA (US); **Ming-Ju Tsai**, Sunnyvale, CA (US); **Liang Han**, Sunnyvale, CA (US); **Georgios Atmatzakis**, Cupertino, CA (US); **Mattia Pascolini**, San Francisco, CA (US)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 239 days.

(21) Appl. No.: **15/655,660**

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

(65) **Prior Publication Data**

US 2019/0027833 A1 Jan. 24, 2019

(51) **Int. Cl.**
H01Q 21/00 (2006.01)
H01Q 5/35 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 21/0006*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/48*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 5/35; H01Q 1/243; H01Q 21/0006; H01Q 5/342; H01Q 9/145; H01Q 9/42; H01Q 21/28; H01Q 1/48
See application file for complete search history.

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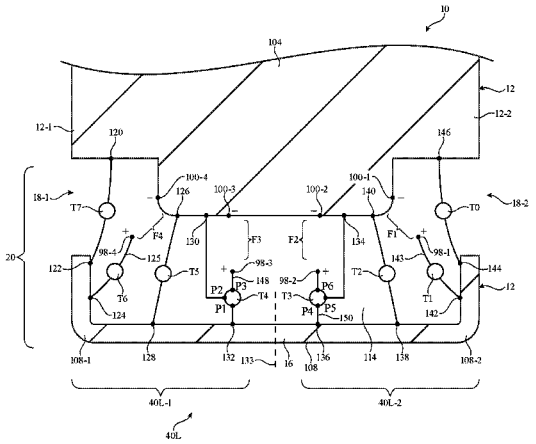
(Continued)

Primary Examiner — Graham P Smith
Assistant Examiner — Jae K Kim
(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.; Michael H. Lyons

(57) **ABSTRACT**

An electronic device may include antennas, a ground, and a housing. First and second gaps in the housing may define a segment that forms a resonating element for a first antenna. First, second, third, and fourth antenna feeds may be coupled between the segment and ground. Control circuitry may control adjustable components to place the device in first, second, third, or fourth modes. In the first and second modes, the first and fourth feeds convey signals at the same frequency using a multiple-input and multiple-output scheme while the second and third feeds are inactive. In the third mode, the second feed is active and the first, third, and fourth feeds are inactive. In the fourth mode, the third feed is active and the first, second, and fourth antenna feeds are inactive. Isolating return paths may be coupled between the segment and ground in the first and second modes.

20 Claims, 13 Drawing Sheets



US010477713B2

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

(10) **Patent No.: US 10,477,713 B2**
(45) **Date of Patent: Nov. 12, 2019**

(54) **SINGLE-PIECE METAL HOUSING WITH INTEGRAL ANTENNAS**

(71) Applicant: **Motorola Mobility LLC**, Chicago, IL (US)

(72) Inventors: **Joseph L Allore**, Mundelein, IL (US); **Mohammed R Abdul-Gaffoor**, Palatine, IL (US); **Michael J Lombardi**, Lake Zurich, IL (US)

(73) Assignee: **Motorola Mobility LLC**, Chicago, IL (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1054 days.

(21) Appl. No.: **14/613,406**

(22) Filed: **Feb. 4, 2015**

(65) **Prior Publication Data**

US 2016/0226130 A1 Aug. 4, 2016

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H05K 5/02 (2006.01)

(52) **U.S. Cl.**
CPC ***H05K 5/0247*** (2013.01); ***H01Q 1/243*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/38; H01Q 9/0421; H01Q 1/42; H01Q 1/12
USPC 343/702, 872, 878, 866, 879
See application file for complete search history.

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Primary Examiner — Dameon E Levi
Assistant Examiner — Collin Dawkins
(74) *Attorney, Agent, or Firm* — McKinney Phillips LLC; Phillip Pippenger

(57) **ABSTRACT**

An enhanced portable communication device includes a one-piece metal back plate, configured to reduce device thickness by eliminating the plastic-to-metal joints normally needed to isolate the device antennas and provide rigidity. The one-piece metal back plate includes four integral antennas in an embodiment, forming an antenna pair at each end of the device. An opening and gap used to form each antenna pair may be filled with a nonconductive material such as plastic. In an embodiment, an I/O port is exposed through the nonconductive material in the gap.

9 Claims, 8 Drawing Sheets