US011205831B2

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

(10) **Patent No.: US 11,205,831 B2**
(45) **Date of Patent: Dec. 21, 2021**

(54) **ANTENNA ELEMENT AND MANUFACTURING METHOD FOR SAME**

(71) Applicant: **AAC Technologies Pte. Ltd.**, Singapore (SG)

(72) Inventors: **Jianpeng Zhu**, Shenzhen (CN); **Hua Jiang**, Shenzhen (CN); **Lulong Li**, Shenzhen (CN)

(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 0 days.

(21) Appl. No.: **16/996,877**

(22) Filed: **Aug. 18, 2020**

(65) **Prior Publication Data**

US 2021/0036399 A1 Feb. 4, 2021

Related U.S. Application Data

(63) Continuation of application No. PCT/CN2019/094040, filed on Jun. 30, 2019.

(51) **Int. Cl.**
H01Q 1/12 (2006.01)
H01Q 1/50 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/12*** (2013.01); ***H01Q 1/50*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/12; H01Q 1/1207; H01Q 1/1242; H01Q 1/20; H01Q 1/38; H01Q 1/50; H01Q 9/04; H01Q 9/0407; H01Q 9/0414; H01Q 9/045; H01Q 15/14; H01Q 15/141; H01Q 15/142
See application file for complete search history.

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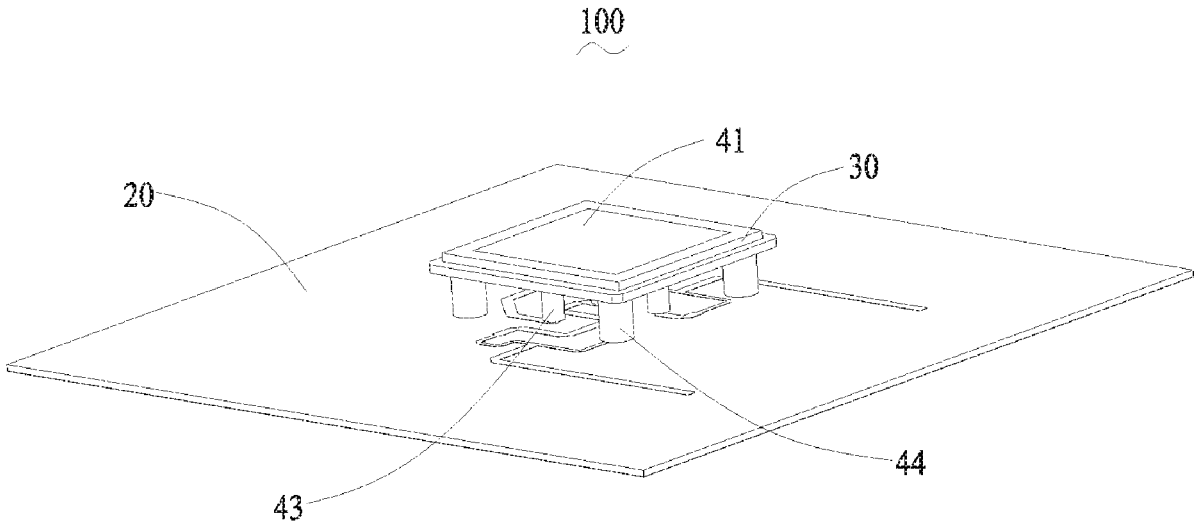
(Continued)

Primary Examiner — Jason Crawford
(74) *Attorney, Agent, or Firm* — W&G Law Group

(57) **ABSTRACT**

The invention provides an antenna element and a manufacturing method of the antenna element. The antenna element includes a main body and a feeding board. The main body has an insulation bracket and a conductive layer by way of electroplating or lasering. The insulation bracket includes a base, first support legs and second support legs. The conductive layer includes a radiation layer covering the top surface, a coupling layer covering the bottom surface and coupled to the radiation layer, a feeding column layer covering the outer surface of each first support leg and a branch layer covering the outer surface of each second support leg. By virtue of the configuration, it is unnecessary to assemble the main body additionally, so that the consistency of the antenna element is improved.

20 Claims, 3 Drawing Sheets



US011205833B2

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

(10) **Patent No.: US 11,205,833 B2**
(45) **Date of Patent: Dec. 21, 2021**

(54) **ELECTRONIC DEVICE AND ANTENNA**

(71) Applicant: **Lenovo (Beijing) Co., Ltd.**, Beijing (CN)

(72) Inventors: **Wenlei Wang**, Beijing (CN); **Chang Su**, Beijing (CN); **Weimin Bao**, Beijing (CN)

(73) Assignee: **LENOVO (BEIJING) 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 46 days.

(21) Appl. No.: **16/729,373**

(22) Filed: **Dec. 28, 2019**

(65) **Prior Publication Data**

US 2020/0212535 A1 Jul. 2, 2020

(30) **Foreign Application Priority Data**

Dec. 29, 2018 (CN) 201811646097.8

(51) **Int. Cl.**

H01Q 1/36	(2006.01)
H01Q 1/22	(2006.01)
H01Q 5/314	(2015.01)
H01Q 9/30	(2006.01)
H01Q 21/30	(2006.01)
H01Q 13/10	(2006.01)

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

CPC ***H01Q 1/2258*** (2013.01); ***H01Q 1/36*** (2013.01); ***H01Q 5/314*** (2015.01); ***H01Q 9/30*** (2013.01); ***H01Q 13/10*** (2013.01); ***H01Q 21/30*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/2258; H01Q 9/30
USPC 342/702
See application file for complete search history.

(56) **References Cited**

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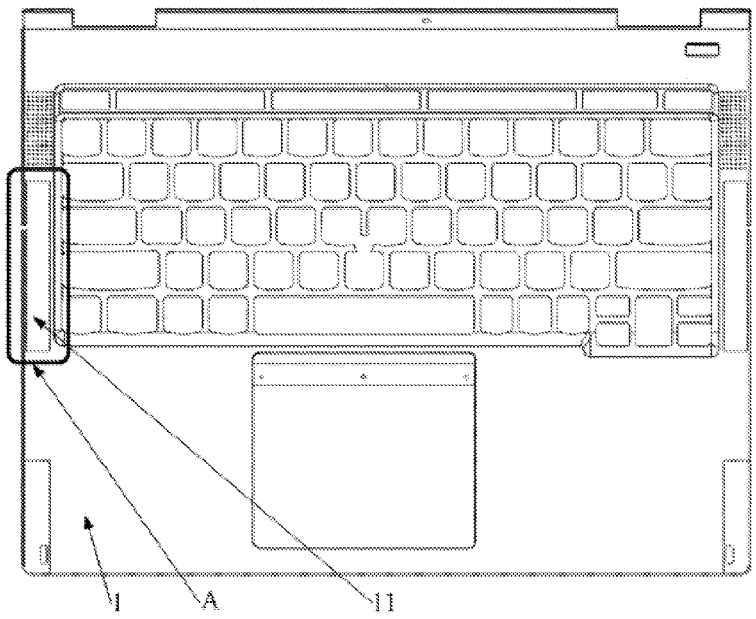
Primary Examiner — Peguy Jean Pierre
(74) *Attorney, Agent, or Firm* — Anova Law Group, PLLC

(57) **ABSTRACT**

Embodiments of the present disclosure provide an electronic device and an antenna. The antenna for includes a first component configured for high frequency feed; a second component configured for low frequency feed; a third component configured for high frequency signal transmission; and a fourth component configured for low frequency signal transmission. The first component is coupling a high frequency signal to the third component, and the second component is coupling a low frequency signal to the fourth component.

17 Claims, 4 Drawing Sheets



US011205834B2

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

(10) **Patent No.: US 11,205,834 B2**
(45) **Date of Patent: Dec. 21, 2021**

(54) **ELECTRONIC DEVICE ANTENNAS HAVING SWITCHABLE FEED TERMINALS**

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

(72) Inventors: **Enrique Ayala Vazquez**, Watsonville, CA (US); **Hongfei Hu**, Cupertino, CA (US); **Mattia Pascolini**, San Francisco, CA (US); **Nanbo Jin**, San Jose, CA (US); **Kevin M. Froese**, San Francisco, CA (US); **Erica J. Tong**, Pacifica, CA (US); **Xu Han**, 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 300 days.

(21) Appl. No.: **16/019,322**

(22) Filed: **Jun. 26, 2018**

(65) **Prior Publication Data**

US 2019/0393586 A1 Dec. 26, 2019

(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H01Q 1/48	(2006.01)
H01Q 13/10	(2006.01)
H01Q 5/328	(2015.01)

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

CPC ***H01Q 1/242*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 5/328*** (2015.01); ***H01Q 13/103*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 21/28; H01Q 1/48; H01Q 9/42; H01Q 5/328; H01Q 1/243; H01Q 13/103; H01Q 1/242

See application file for complete search history.

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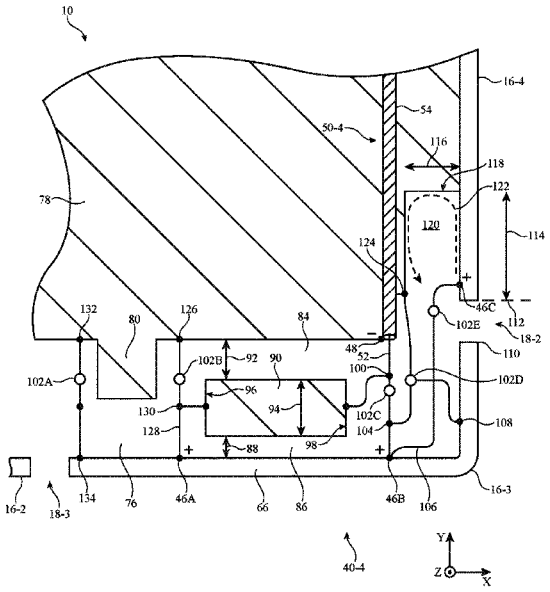
Primary Examiner — Graham P Smith
Assistant Examiner — Jae K Kim
(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.; Michael H. Lyons; Tianyi He

(57) **ABSTRACT**

An electronic device may include a conductive housing and an antenna. The antenna may include an arm formed from a first segment of the housing. A gap may separate the first segment from a second segment. The antenna may include a feed coupled to a transmission line having a signal conductor. The feed may include first and second positive terminals on the first segment and a third positive terminal on the second segment. An adjustable component may be coupled between the first and third terminals. The signal conductor may be coupled to the first terminal. A wide conductive trace may be coupled between the signal conductor and the second terminal. A switch may be interposed on the signal conductor. The second terminal may cover a cellular low band when the switch is open. The first terminal may cover the cellular low band and higher bands when the switch is closed.

20 Claims, 11 Drawing Sheets



US011205835B2

(12) **United States Patent**
Kim

(10) **Patent No.: US 11,205,835 B2**
(45) **Date of Patent: Dec. 21, 2021**

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

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

(72) Inventor: **Yeonwoo Kim**, Gyeonggi-do (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 0 days.

(21) Appl. No.: **16/932,945**

(22) Filed: **Jul. 20, 2020**

(65) **Prior Publication Data**

US 2021/0066788 A1 Mar. 4, 2021

(30) **Foreign Application Priority Data**

Aug. 30, 2019 (KR) 10-2019-0106955

(51) **Int. Cl.**
H01Q 3/34 (2006.01)
H01Q 1/24 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 3/34*** (2013.01)

(58) **Field of Classification Search**
CPC H01G 1/243; H01G 3/34
See application file for complete search history.

(56) **References Cited**

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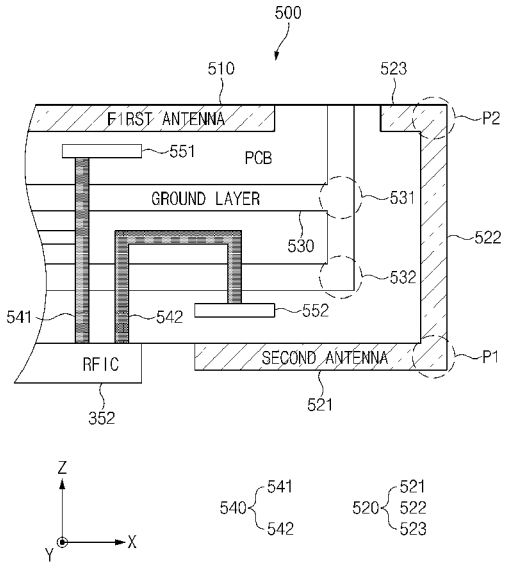
Primary Examiner — Graham P Smith
(74) *Attorney, Agent, or Firm* — Cha & Reiter, LLC

(57) **ABSTRACT**

Disclosed in one embodiment is an antenna module which includes a printed circuit board (PCB) that includes a first surface, a second surface, and a third surface, a first antenna that is disposed on the first surface, a second antenna that includes a first portion disposed on the second surface, a second portion extended from the first portion so as to be adjacent to the third surface, and a third portion extended from the second portion so as to face the first antenna, at least one ground layer that is interposed between the first antenna and the second antenna, and at least one wire that feeds the first antenna and the second antenna. The first antenna and at least a portion of the first portion overlap each other when viewed in the second direction, and the first antenna and the second portion are disposed to be spaced from each other.

20 Claims, 26 Drawing Sheets



US011205850B2

(12) **United States Patent**
Jia

(10) **Patent No.: US 11,205,850 B2**
(45) **Date of Patent: Dec. 21, 2021**

(54) **HOUSING ASSEMBLY, ANTENNA ASSEMBLY, AND ELECTRONIC DEVICE**

(71) Applicant: **GUANGDONG OPPO MOBILE TELECOMMUNICATIONS CORP., LTD.**, Guangdong (CN)

(72) Inventor: **Yuhu Jia**, Guangdong (CN)

(73) Assignee: **SHENZHEN HEYTAP TECHNOLOGY CORP., 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.: **16/891,964**

(22) Filed: **Jun. 3, 2020**

(65) **Prior Publication Data**

US 2020/0411993 A1 Dec. 31, 2020

(30) **Foreign Application Priority Data**

Jun. 30, 2019 (CN) 201910588901.X

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 1/42 (2006.01)
H01Q 15/00 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 9/0414*** (2013.01); ***H01Q 1/422*** (2013.01); ***H01Q 15/0026*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/422; H01Q 1/42; H01Q 1/22; H01Q 1/243; H01Q 1/38; H01Q 1/50; H01Q 1/523
See application file for complete search history.

(56) **References Cited**

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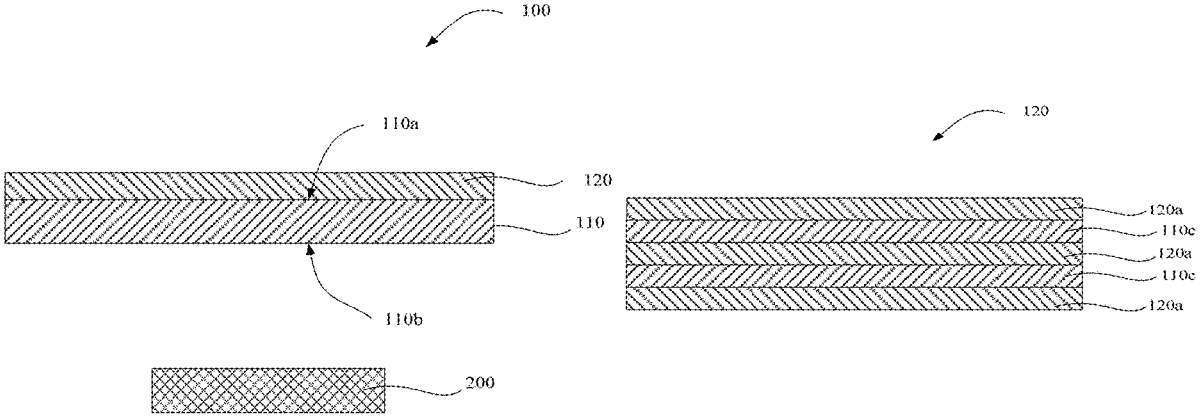
Primary Examiner — Lam T Mai
(74) *Attorney, Agent, or Firm* — Young Basile Hanlon & MacFarlane, P.C.

(57) **ABSTRACT**

A housing assembly, an antenna assembly, and an electronic device are provided according to the present disclosure. The housing assembly includes a dielectric substrate and a radio-wave transparent structure. The dielectric substrate has a first transmittance for a radio frequency signal in a preset frequency band. The radio-wave transparent structure includes a first radio-wave transparent layer and a second radio-wave transparent layer coupled with the first radio-wave transparent layer. The first radio-wave transparent layer and the second radio-wave transparent layer are indirectly stacked together, and the radio-wave transparent structure at least partially covers the dielectric substrate. A region of the housing assembly corresponding to the radio-wave transparent structure has a second transmittance for the radio frequency signal in the preset frequency band, and the second transmittance is larger than the first transmittance.

20 Claims, 31 Drawing Sheets



US011205859B2

(12) **United States Patent**
Segador Alvarez et al.

(10) **Patent No.: US 11,205,859 B2**
(45) **Date of Patent: Dec. 21, 2021**

(54) **DUAL-POLARIZED RADIATING ELEMENT AND ANTENNA**

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

(72) Inventors: **Juan Segador Alvarez**, Munich (DE); **Tao Tang**, Dongguan (CN); **Bruno Biscontini**, Munich (DE)

(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.: **16/673,430**

(22) Filed: **Nov. 4, 2019**

(65) **Prior Publication Data**

US 2020/0067205 A1 Feb. 27, 2020

Related U.S. Application Data

(63) Continuation of application No. PCT/EP2017/060689, filed on May 4, 2017.

(51) **Int. Cl.**
H01Q 21/26 (2006.01)
H01Q 5/307 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 21/26*** (2013.01); ***H01Q 5/307*** (2015.01); ***H01Q 9/26*** (2013.01); ***H01Q 21/0006*** (2013.01); *H01Q 1/243* (2013.01); *H01Q 1/246* (2013.01); *H01Q 19/08* (2013.01); *H01Q 21/062* (2013.01); *H01Q 21/30* (2013.01)

(58) **Field of Classification Search**
CPC H01Q 21/26; H01Q 21/30; H01Q 21/062; H01Q 19/108; H01Q 1/243; H01Q 21/065
See application file for complete search history.

(56) **References Cited**

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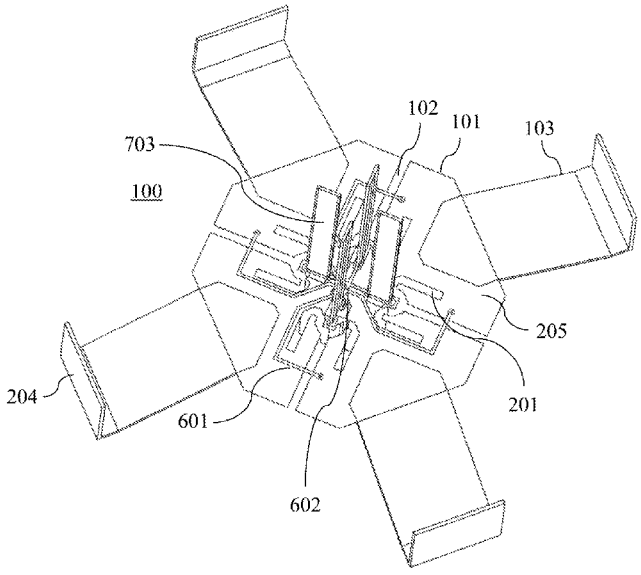
Primary Examiner — Joseph J Lauture
(74) *Attorney, Agent, or Firm* — Leydig, Voit & Mayer, Ltd.

(57) **ABSTRACT**

The present disclosure provides a dual-polarized radiating element comprising a feeding arrangement and four dipole arms. The feeding arrangement comprises four slots, which extend from a periphery towards a center of the feeding arrangement and are arranged at regular angular intervals forming a first angular arrangement. The four dipole arms extend outwards from the feeding arrangement and are arranged at regular angular intervals forming a second angular arrangement. The second angular arrangement of the four dipole arms is rotated with respect to the first angular arrangement of the four slots.

19 Claims, 15 Drawing Sheets



US011217873B2

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

(10) **Patent No.: US 11,217,873 B2**
(45) **Date of Patent: Jan. 4, 2022**

(54) **ANTENNA MODULE**

(71) Applicants: **Chao-Lin Wu**, Taipei (TW); **Shih-Chia Liu**, Taipei (TW); **Yen-Hao Yu**, Taipei (TW); **Li-Chun Lee**, Taipei (TW); **Jhin-Ciang Chen**, Taipei (TW); **Jui-Hung Lai**, Taipei (TW)

(72) Inventors: **Chao-Lin Wu**, Taipei (TW); **Shih-Chia Liu**, Taipei (TW); **Yen-Hao Yu**, Taipei (TW); **Li-Chun Lee**, Taipei (TW); **Jhin-Ciang Chen**, Taipei (TW); **Jui-Hung Lai**, Taipei (TW)

(73) Assignee: **COMPAL ELECTRONICS, INC.**, Taipei (TW)

(*) 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.: **16/253,170**

(22) Filed: **Jan. 21, 2019**

(65) **Prior Publication Data**

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Related U.S. Application Data

(60) Provisional application No. 62/621,561, filed on Jan. 24, 2018.

(51) **Int. Cl.**
H01Q 1/22 (2006.01)
H04B 1/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 1/22*** (2013.01); ***H01Q 13/10*** (2013.01); ***H04B 1/0053*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/22; H01Q 13/10; H01Q 1/243; H01Q 5/335; H01Q 9/42; H01Q 5/371;
(Continued)

(56) **References Cited**

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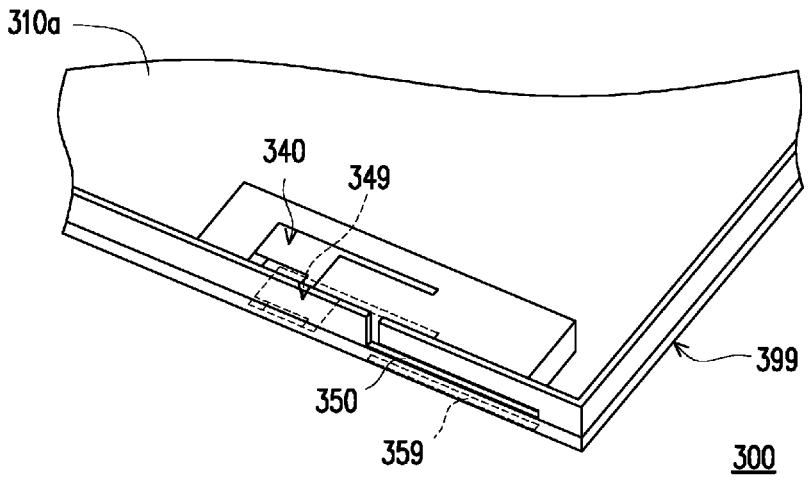
Primary Examiner — Alexander H Taningco
Assistant Examiner — Amy X Yang
(74) *Attorney, Agent, or Firm* — JCIPRNET

(57) **ABSTRACT**

The disclosure provides an antenna module adapted for an electronic device having a metal casing. The antenna module includes an antenna structure and a slot structure. The antenna structure includes a radiation portion, a feeding portion, a ground portion and an extension portion, wherein the feeding portion, the ground portion and the extension portion are connected to the radiation portion. The slot structure has an open end and a closed end, wherein the open end of the slot structure is adjacent to the extension portion of the antenna structure. The antenna structure is excited and resonates to generate a first antenna resonant mode, and the slot structure is coupled to the antenna structure and resonates to generate a second antenna resonant mode.

14 Claims, 8 Drawing Sheets



US011217875B2

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

(10) **Patent No.: US 11,217,875 B2**
(45) **Date of Patent: Jan. 4, 2022**

(54) **ELECTRONIC DEVICE COMPRISING ANTENNA**

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

(72) Inventors: **Dong Yeon Kim**, Gyeonggi-do (KR); **Jun Hwa Oh**, Seoul (KR); **Hyung Joo Lee**, Gyeonggi-do (KR); **Soon Ho Hwang**, Seoul (KR); **Sung Hyup Lee**, Gyeonggi-do (KR); **Yoon Jae Lee**, Gyeonggi-do (KR)

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

(*) 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.: **15/935,504**

(22) Filed: **Mar. 26, 2018**

(65) **Prior Publication Data**

US 2018/0277934 A1 Sep. 27, 2018

(30) **Foreign Application Priority Data**

Mar. 24, 2017 (KR) 10-2017-0037523

(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H01Q 1/38	(2006.01)
H01Q 9/42	(2006.01)
H04M 1/02	(2006.01)

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

CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 9/42*** (2013.01); ***H04M 1/026*** (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

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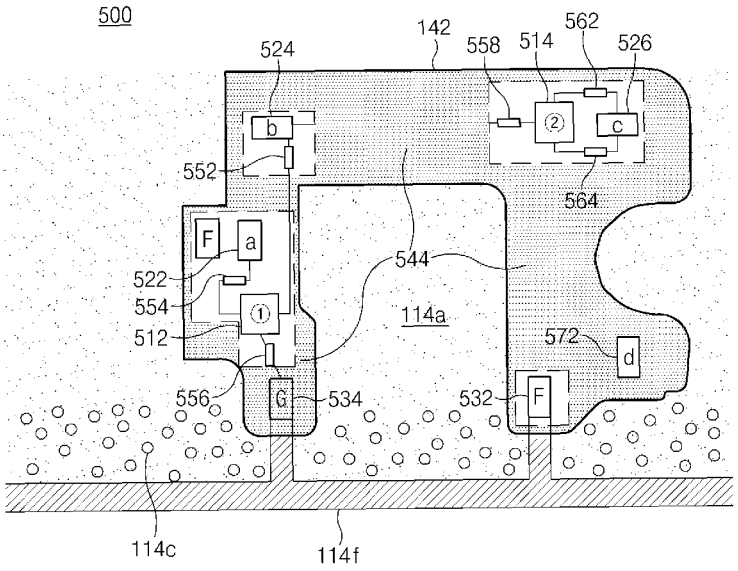
Primary Examiner — Gennadiy Tsvey

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

(57) **ABSTRACT**

An electronic device includes a cover glass, a display exposed through the cover glass, a housing for mounting the display, a first printed circuit board (PCB) and a second PCB that are disposed inside the housing, a back cover coupled to the housing, a first antenna element electrically connected to a ground area through the first PCB, and a communication circuit feeding the first antenna element and transmitting or receiving a signal through the first antenna element. A spaced distance between the first PCB and the display is longer than a spaced distance between the second PCB and the display.

13 Claims, 20 Drawing Sheets



US011217878B2

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

(10) **Patent No.: US 11,217,878 B2**
(45) **Date of Patent: Jan. 4, 2022**

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

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

(72) Inventors: **Myunghun Jeong**, Suwon-si (KR); **Jaehoon Jo**, Suwon-si (KR); **Dongyeon Kim**, Suwon-si (KR); **Hosaeng Kim**, Suwon-si (KR); **Seongjin Park**, Suwon-si (KR); **Sumin Yun**, Suwon-si (KR); **Woomin Jang**, Suwon-si (KR); **Jehun Jong**, Suwon-si (KR); **Jaebong Chun**, 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 0 days.

(21) Appl. No.: **16/788,822**

(22) Filed: **Feb. 12, 2020**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Feb. 15, 2019 (KR) 10-2019-0017915

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

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/2283*** (2013.01); ***H01Q 9/0407*** (2013.01); ***H04M 1/0266*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/1221; H01Q 1/2283; H01Q 1/405; H01Q 9/0407; H01Q 9/045; H01Q 21/08; H01Q 21/24
See application file for complete search history.

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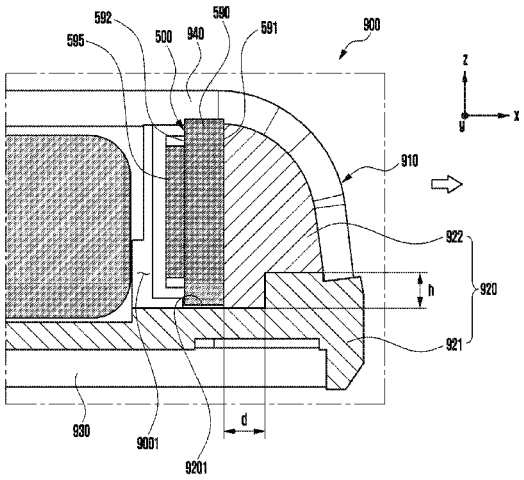
Primary Examiner — Hoang V Nguyen
(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

(57) **ABSTRACT**

An electronic device is provided. The electronic device includes a housing and an antenna structure. The housing includes a front plate, a rear plate, and a lateral member surrounding a space between the front and rear plates. The antenna structure is disposed in the space includes a printed circuit board (PCB) disposed in the space and includes a ground layer at least in part. The antenna structure further includes at least one conductive patch disposed on the PCB in a second direction and configured to transmit and/or receive first and second signals having a frequency between about 3 GHz and about 100 GHz. The conductive patch includes a first feeder and a second feeder. The first feeder is disposed on a first virtual line passing through a center of the conductive patch and forming a first angle with respect to a virtual axis passing through the center and perpendicular to the second direction, and configured to transmit and/or
(Continued)



US011217879B2

(12) **United States Patent**
Liu

(10) **Patent No.: US 11,217,879 B2**
(45) **Date of Patent: Jan. 4, 2022**

(54) **ANTENNA ASSEMBLY AND ELECTRONIC DEVICE USING SAME**

(71) Applicant: **AAC Technologies Pte. Ltd.**, Singapore (SG)

(72) Inventor: **Feng Liu**, Shenzhen (CN)

(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 0 days.

(21) Appl. No.: **16/936,412**

(22) Filed: **Jul. 22, 2020**

(65) **Prior Publication Data**

US 2020/0411955 A1 Dec. 31, 2020

Related U.S. Application Data

(63) Continuation of application No. PCT/CN2019/093346, filed on Jun. 27, 2019.

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

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H04M 1/026*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H04M 1/0266
See application file for complete search history.

(56) **References Cited**

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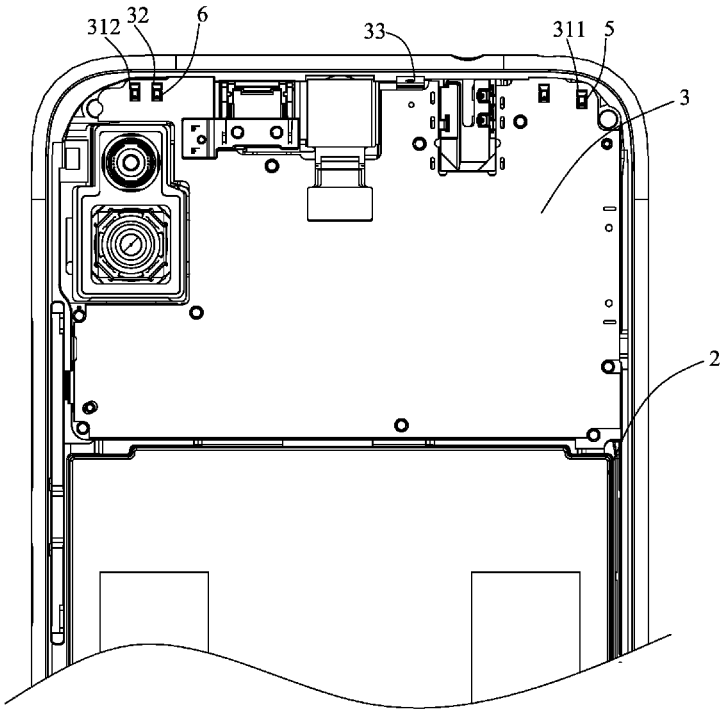
Primary Examiner — Lewis G West
(74) *Attorney, Agent, or Firm* — W&G Law Group

(57) **ABSTRACT**

The present application provides an antenna assembly and an electronic device. The antenna assembly includes a plastic housing, a frame body and a circuit board arranged in the frame body, wherein the frame body includes a middle frame and an outer metal frame surrounding the edge of the middle frame and connected with the middle frame. The plastic housing covers the outer side of the outer metal frame. A number of gaps are arranged on the outer metal frame. The present application can randomly set the positions of the gaps as described in requirements of an antenna structure, then the performance of the antennas can be ensured, and the attractiveness is not affected.

4 Claims, 6 Drawing Sheets



US011217887B2

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

(10) **Patent No.: US 11,217,887 B2**
(45) **Date of Patent: Jan. 4, 2022**

(54) **ANTENNA MODULE**

(71) Applicants: **Inventec (Pudong) Technology Corporation**, Shanghai (CN); **INVENTEC CORPORATION**, Taipei (TW)

(72) Inventors: **Chih-Cheng Li**, Taipei (TW); **Ssu-Han Ting**, Taipei (TW)

(73) Assignees: **Inventec (Pudong) Technology Corporation**, Shanghai (CN); **INVENTEC CORPORATION**, Taipei (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.: **16/902,283**

(22) Filed: **Jun. 16, 2020**

(65) **Prior Publication Data**

US 2021/0376459 A1 Dec. 2, 2021

(30) **Foreign Application Priority Data**

Jun. 2, 2020 (CN) 202010490475.9

(51) **Int. Cl.**
H01Q 1/48 (2006.01)
H01Q 9/04 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/48*** (2013.01); ***H01Q 9/0457*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/24–1/48; H01Q 9/0407; H01Q 9/0457; H01Q 1/243
See application file for complete search history.

(56) **References Cited**

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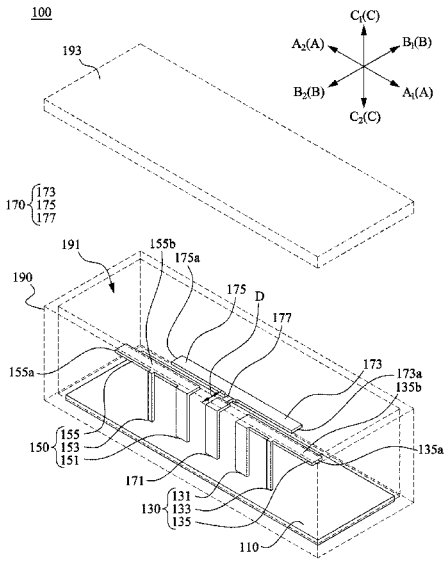
Primary Examiner — Hasan Islam
(74) *Attorney, Agent, or Firm* — CKC & Partners Co., LLC

(57) **ABSTRACT**

An antenna module includes a grounding plane, a first high-frequency radiator, a second high-frequency radiator, and a low-frequency grounding component. The first high-frequency radiator includes a first feeding portion, a first grounding portion, and a first radiating portion. The first grounding portion is coupled to the grounding plane. The second high-frequency radiator includes a second feeding portion, a second grounding portion, and a second radiating portion. The second grounding portion is coupled to the grounding plane. The low-frequency grounding component located between the first and second high-frequency radiators. The low-frequency grounding component includes a third grounding portion which is coupled to the grounding plane, a first coupling portion, and a second coupling portion. The low-frequency grounding component extends from the third grounding portion and extends in a first direction and a second direction of a first axis respectively to form the first and second coupling portions.

8 Claims, 5 Drawing Sheets



US011217892B2

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

(10) **Patent No.: US 11,217,892 B2**
(45) **Date of Patent: Jan. 4, 2022**

(54) **ANTENNA STRUCTURE**

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

(72) Inventors: **Cheng-Han Lee**, New Taipei (TW); **Te-Chang Lin**, New Taipei (TW); **Huo-Ying Chang**, New Taipei (TW); **Min-Hui Ho**, 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 500 days.

(21) Appl. No.: **16/217,066**

(22) Filed: **Dec. 12, 2018**

(65) **Prior Publication Data**

US 2019/0181554 A1 Jun. 13, 2019

Related U.S. Application Data

(60) Provisional application No. 62/614,364, filed on Jan. 6, 2018, provisional application No. 62/597,442, filed on Dec. 12, 2017.

(51) **Int. Cl.**

H01Q 5/35	(2015.01)
H01Q 9/28	(2006.01)
H01Q 3/24	(2006.01)
H01Q 9/42	(2006.01)
H01Q 5/335	(2015.01)
H01Q 21/28	(2006.01)
H01Q 1/24	(2006.01)
H01Q 13/10	(2006.01)
H01Q 9/30	(2006.01)

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

CPC ***H01Q 5/35*** (2015.01); ***H01Q 1/243*** (2013.01); ***H01Q 3/247*** (2013.01); ***H01Q 5/335*** (2015.01); ***H01Q 9/285*** (2013.01); ***H01Q 9/30*** (2013.01); ***H01Q 9/42*** (2013.01); ***H01Q 13/10*** (2013.01); ***H01Q 21/28*** (2013.01)

(58) **Field of Classification Search**

USPC 343/702

See application file for complete search history.

(56) **References Cited**

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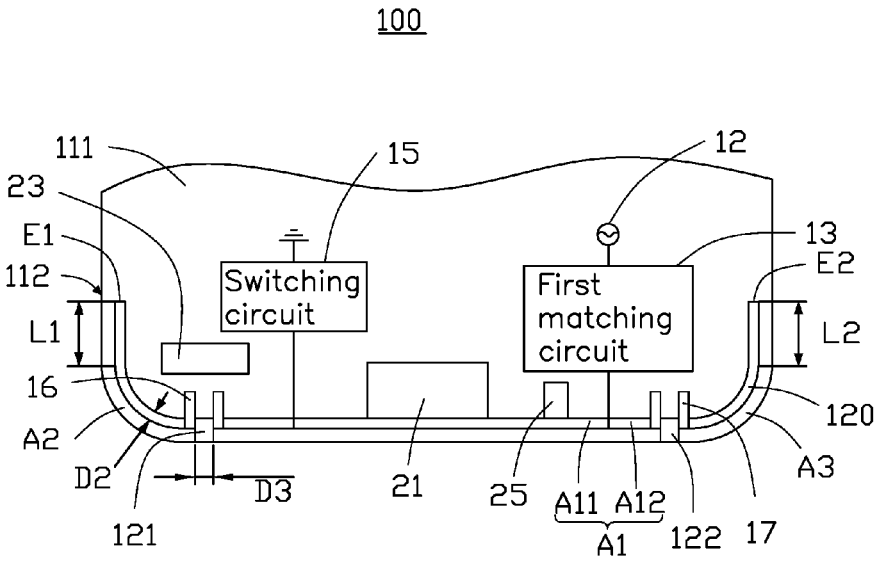
Primary Examiner — Trinh V Dinh

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

(57) **ABSTRACT**

An antenna structure includes a housing, a first feed source, and a second feed source. The first feed source is electrically coupled to a first radiating portion of the housing and adapted to provide an electric current to the first radiating portion. The second feed source is electrically coupled to one of a second radiating portion or a third radiating portion of the housing. The other one of the second radiating portion or the third radiating portion is electrically coupled to the first radiating portion.

20 Claims, 32 Drawing Sheets



US011217903B2

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

(10) **Patent No.: US 11,217,903 B2**
(45) **Date of Patent: Jan. 4, 2022**

(54) **ANTENNA SYSTEM FOR A WIRELESS COMMUNICATION DEVICE**

(71) Applicant: **HUAWEI TECHNOLOGIES CO., LTD.**, Guangdong (CN)

(72) Inventors: **Alexander Khripkov**, Helsinki (FI); **Linsheng Li**, Kista (SE)

(73) Assignee: **HUAWEI TECHNOLOGIES CO., LTD.**, Guangdong (CN)

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

(21) Appl. No.: **16/757,821**

(22) PCT Filed: **Nov. 15, 2017**

(86) PCT No.: **PCT/EP2017/079321**
§ 371 (c)(1),
(2) Date: **Apr. 21, 2020**

(87) PCT Pub. No.: **WO2019/096376**
PCT Pub. Date: **May 23, 2019**

(65) **Prior Publication Data**

US 2021/0194153 A1 Jun. 24, 2021

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 21/06 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 21/064*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 13/085*** (2013.01); ***H01Q 13/10*** (2013.01); ***H04W 16/28*** (2013.01)

(58) **Field of Classification Search**
CPC H01G 21/064; H01G 1/243; H01G 13/085; H01G 13/10
See application file for complete search history.

(56) **References Cited**

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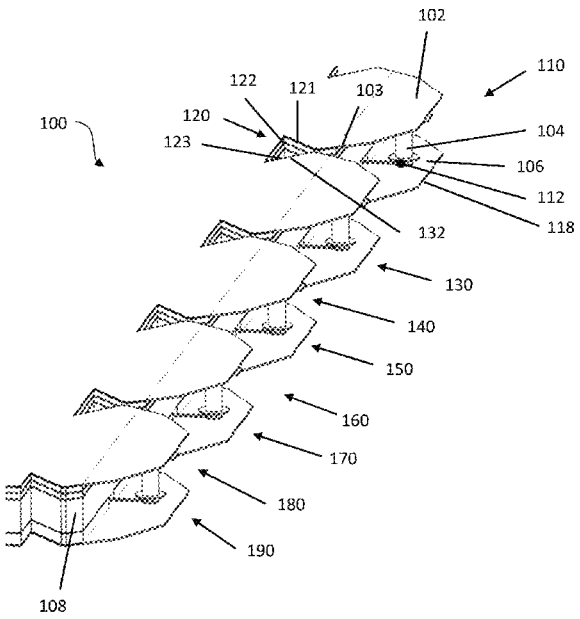
Primary Examiner — Graham P Smith
(74) *Attorney, Agent, or Firm* — Westerman, Hattori, Daniels & Adrian, LLP

(57) **ABSTRACT**

An antenna system for a mobile device includes a first trough antenna element formed by a first planar conductive member, a second conductive member spaced apart from the first planar conductive member; and a back wall member disposed between the first planar conductive member and the second conductive member. A first slot antenna is formed in the first planar conductive member and the second conductive member adjacent to the first trough antenna element.

14 Claims, 16 Drawing Sheets



US011218583B2

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

(10) **Patent No.: US 11,218,583 B2**
(45) **Date of Patent: Jan. 4, 2022**

(54) **MOBILE TERMINAL**

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

(72) Inventors: **Jaewon Lee**, Seoul (KR); **Seungwoo Ryu**, Seoul (KR); **Joohee Lee**, Seoul (KR); **Junyoung Jung**, Seoul (KR); **Jaewan Kim**, Seoul (KR); **Sangjo Park**, 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.: **16/590,287**

(22) Filed: **Oct. 1, 2019**

(65) **Prior Publication Data**

US 2020/0036824 A1 Jan. 30, 2020

Related U.S. Application Data

(63) Continuation of application No. 16/034,215, filed on Jul. 12, 2018, now Pat. No. 10,455,065.
(Continued)

(30) **Foreign Application Priority Data**

May 2, 2018 (KR) 10-2018-0050813

(51) **Int. Cl.**
H04M 1/02 (2006.01)
H01Q 9/04 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H04M 1/0277*** (2013.01); ***H01Q 1/2283*** (2013.01); ***H01Q 1/243*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H04M 1/0277; H04M 1/0274; H01Q 21/065; H01Q 1/243; H01Q 9/0435;
(Continued)

(56) **References Cited**

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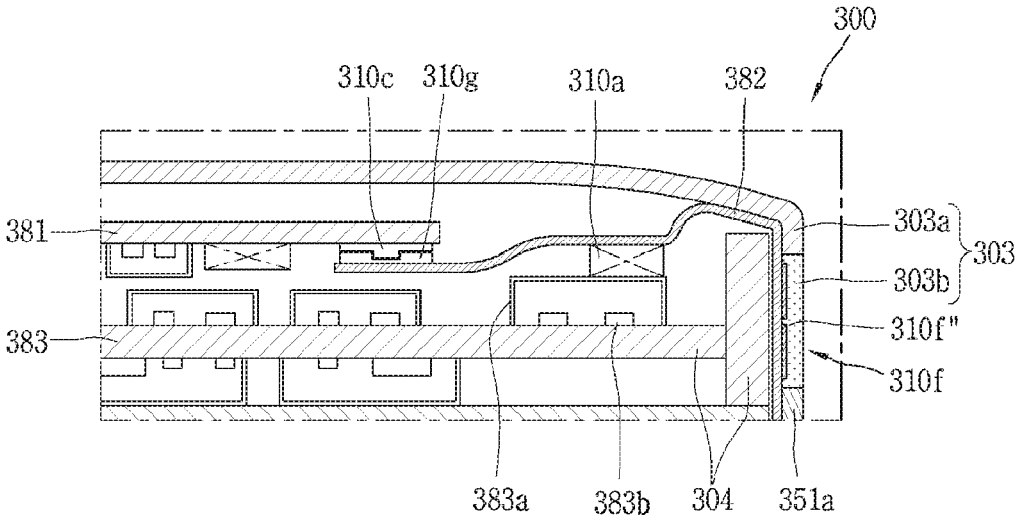
Primary Examiner — Marcos L Torres
(74) *Attorney, Agent, or Firm* — Lee, Hong, Degerman, Kang & Waimey PC

(57) **ABSTRACT**

The present disclosure discloses a mobile terminal, including a case forming a portion of an appearance; a circuit board disposed inside the case; a flexible printed circuit board electrically connected to the circuit board; a first connector mounted on the circuit board; a second connector mounted on the flexible printed circuit board and fastened to the first connector; and a first antenna having array elements mounted on the flexible printed circuit board, wherein the first antenna is disposed to face a side surface of the case to radiate beam-formed wireless signals through the side surface adjacent to one side of the circuit board.

18 Claims, 10 Drawing Sheets



US011223102B2

(12) **United States Patent**
Jeon

(10) **Patent No.: US 11,223,102 B2**
(45) **Date of Patent: Jan. 11, 2022**

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

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

(72) Inventor: **Seung Gil Jeon**, 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 143 days.

(21) Appl. No.: **16/614,710**

(22) PCT Filed: **May 17, 2018**

(86) PCT No.: **PCT/KR2018/005660**
§ 371 (c)(1),
(2) Date: **Nov. 18, 2019**

(87) PCT Pub. No.: **WO2018/221879**
PCT Pub. Date: **Dec. 6, 2018**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

May 30, 2017 (KR) 10-2017-0066626

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 21/00 (2006.01)
H01Q 21/06 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/24*** (2013.01); ***H01Q 21/0006*** (2013.01); ***H01Q 21/06*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/24; H01Q 21/0006; H01Q 21/06; H01Q 1/38; H01Q 1/243; H01Q 9/04
See application file for complete search history.

(56) **References Cited**

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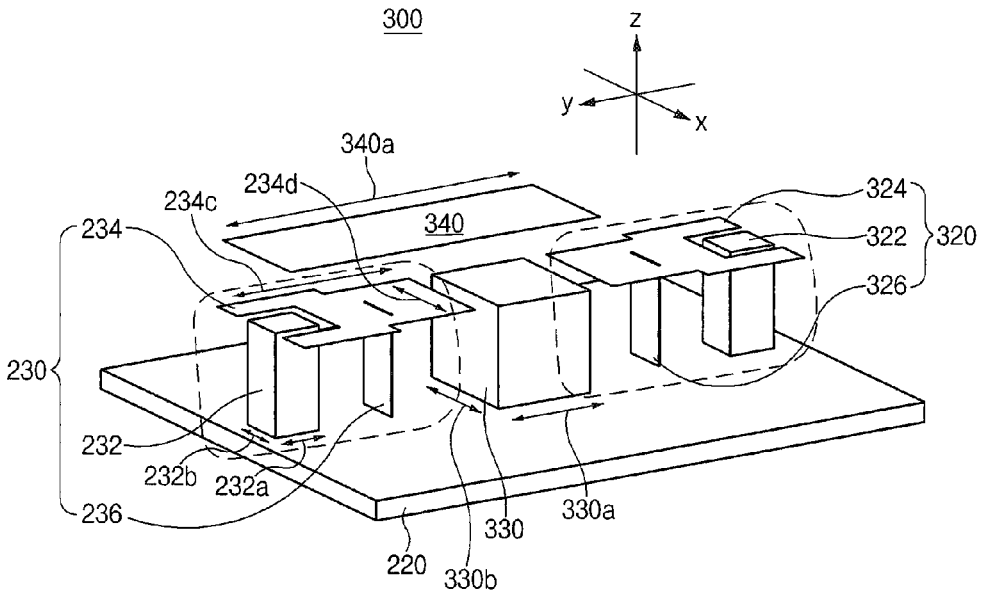
Primary Examiner — David E Lotter
(74) *Attorney, Agent, or Firm* — The Farrell Law Firm, P.C.

(57) **ABSTRACT**

An electronic device according to an embodiment of the disclosure may include housing including a rear cover and a cover glass facing away from the rear cover, an antenna array interposed between the rear cover and the cover glass and including at least one or more antenna units, a printed circuit board (PCB) interposed between the antenna array and the cover glass, and a communication circuit disposed on the PCB and feeding the antenna array. Other various embodiments as understood from the specification are also possible.

13 Claims, 25 Drawing Sheets



US011223103B2

(12) **United States Patent**
Gu

(10) **Patent No.: US 11,223,103 B2**
(45) **Date of Patent: Jan. 11, 2022**

(54) **ANTENNA DEVICE AND MIMO ANTENNA ARRAYS FOR ELECTRONIC DEVICE**

(71) Applicant: **Huanhuan Gu**, Waterloo (CA)

(72) Inventor: **Huanhuan Gu**, Waterloo (CA)

(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 574 days.

(21) Appl. No.: **15/881,343**

(22) Filed: **Jan. 26, 2018**

(65) **Prior Publication Data**

US 2019/0237851 A1 Aug. 1, 2019

(51) **Int. Cl.**

H01Q 9/04	(2006.01)
H01Q 1/24	(2006.01)
H01Q 5/10	(2015.01)
H01Q 5/35	(2015.01)

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

CPC ***H01Q 1/243*** (2013.01); ***H01Q 5/10*** (2015.01); ***H01Q 5/35*** (2015.01); ***H01Q 9/0435*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 5/10; H01Q 5/35; H01Q 9/0435; H01Q 21/28

See application file for complete search history.

(56) **References Cited**

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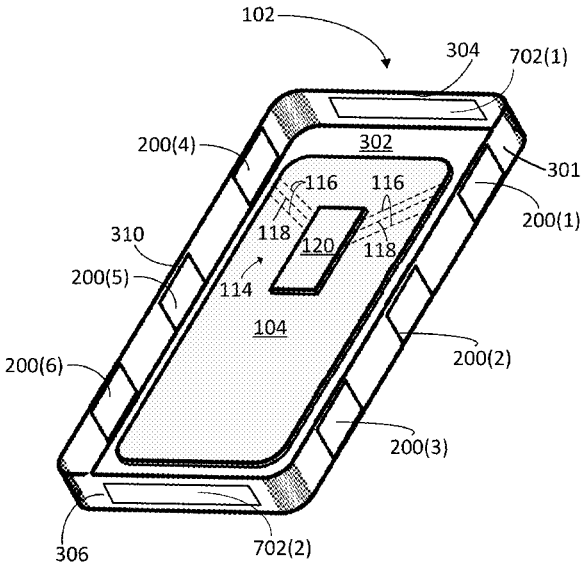
Primary Examiner — David E Lotter

(57) **ABSTRACT**

Radio Frequency (RF) signal antenna devices and MIMO antenna portion arrays including the RF signal antenna devices are described. An antenna device includes a radiator that functions both as a first antenna and as a second antenna, a ground terminal directly connected to the radiator between a first end and a second end of the radiator, a first feed terminal for the first antenna, directly connected to the radiator at a first feed point between the first end of the radiator and the ground terminal; and a second feed terminal for the second antenna, directly connected to the radiator at a second feed point between the second end of the radiator and the ground terminal.

18 Claims, 12 Drawing Sheets



US011223104B2

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

(10) **Patent No.: US 11,223,104 B2**
(45) **Date of Patent: *Jan. 11, 2022**

(54) **ELECTRONIC DEVICE WITH ANTENNA DEVICE**

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

(72) Inventors: **Young-Ju Lee**, Seoul (KR); **Seung-Tae Ko**, Bucheon-si (KR); **Hyun-Jin Kim**, Seoul (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 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **16/417,081**

(22) Filed: **May 20, 2019**

(65) **Prior Publication Data**

US 2019/0273308 A1 Sep. 5, 2019

Related U.S. Application Data

(63) Continuation of application No. 15/401,022, filed on Jan. 7, 2017, now Pat. No. 10,297,900.

(30) **Foreign Application Priority Data**

Jan. 7, 2016 (KR) 10-2016-0002003

(51) **Int. Cl.**
H01Q 15/02 (2006.01)
H01Q 1/24 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 1/44*** (2013.01); ***H01Q 15/02*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/38; H01Q 15/02; H01Q 15/08; H01Q 1/2291
See application file for complete search history.

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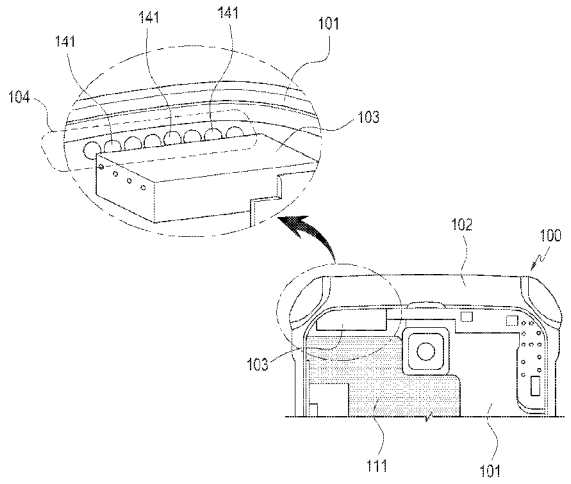
(Continued)

Primary Examiner — David E Lotter

(57) **ABSTRACT**

According to various embodiments of the present disclosure, an electronic device may include: an array antenna including a plurality of first radiating conductors that transmit or receive a wireless signal in a first frequency band and are arranged on a circuit board; and a lens unit including at least one lens disposed on a housing of the electronic device to correspond to the first radiating conductors. The lens unit may refract or reflect a wireless signal transmitted/received through each of the first radiating conductors. The electronic device as described above may be variously implemented according to embodiments. For example, a portion of the lens unit may transmit/receive a wireless signal in a frequency band that is different from the frequency band of the wireless signal transmitted/received by the first radiating conductors.

15 Claims, 18 Drawing Sheets



US011223106B2

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

(10) **Patent No.: US 11,223,106 B2**
(45) **Date of Patent: Jan. 11, 2022**

(54) **ANTENNA SYSTEM FOR A WIRELESS COMMUNICATION DEVICE**

(71) Applicants: **Huawei Technologies Co., Ltd.**, Shenzhen (CN); **Alexander Khripkov**, Helsinki (FI)

(72) Inventors: **Alexander Khripkov**, Helsinki (FI); **Joonas Krogerus**, Helsinki (FI); **Arun Sowpati**, Helsinki (FI); **Zlatoljub Milosavljevic**, Helsinki (FI)

(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 28 days.

(21) Appl. No.: **16/753,513**

(22) PCT Filed: **Oct. 5, 2017**

(86) PCT No.: **PCT/EP2017/075385**
§ 371 (c)(1),
(2) Date: **Apr. 3, 2020**

(87) PCT Pub. No.: **WO2019/068331**
PCT Pub. Date: **Apr. 11, 2019**

(65) **Prior Publication Data**

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(51) **Int. Cl.**
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H01Q 1/48 (2006.01)
H01Q 5/35 (2015.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 5/35*** (2015.01)

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

(56) **References Cited**

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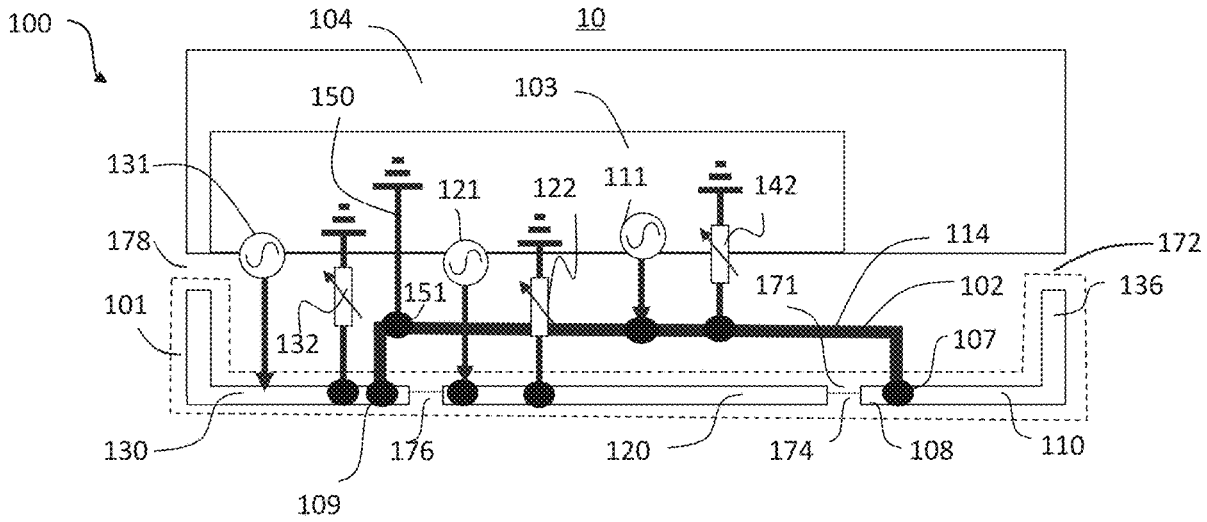
Primary Examiner — Tuan A Tran
(74) *Attorney, Agent, or Firm* — Slater Matsil, LLP

(57) **ABSTRACT**

An antenna system for a mobile device includes a first electrically conductive member having a plurality of segments including at least a first corner segment and a central segment that is disposed adjacent to the first corner segment. A dielectric material is disposed in a gap between the first corner segment and the central segment. A second electrically conductive member is disposed within the mobile device. A first end of the second electrically conductive member is connected to the first corner segment. A portion of the second electrically conductive member away from the first end is electrically connected to a first feeding portion. The central segment is connected to a second feeding portion.

20 Claims, 18 Drawing Sheets



US011223115B2

(12) **United States Patent**
Hashiguchi

(10) **Patent No.: US 11,223,115 B2**
(45) **Date of Patent: Jan. 11, 2022**

(54) **ANTENNA**

(71) Applicant: **JAPAN AVIATION ELECTRONICS INDUSTRY, LIMITED**, Tokyo (JP)

(72) Inventor: **Osamu Hashiguchi**, Tokyo (JP)

(73) Assignee: **JAPAN AVIATION ELECTRONICS INDUSTRY, LIMITED**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 85 days.

(21) Appl. No.: **16/736,909**

(22) Filed: **Jan. 8, 2020**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Mar. 5, 2019 (JP) JP2019-039447

(51) **Int. Cl.**
H01Q 1/36 (2006.01)
H01Q 1/50 (2006.01)

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

(58) **Field of Classification Search**
USPC 343/906
See application file for complete search history.

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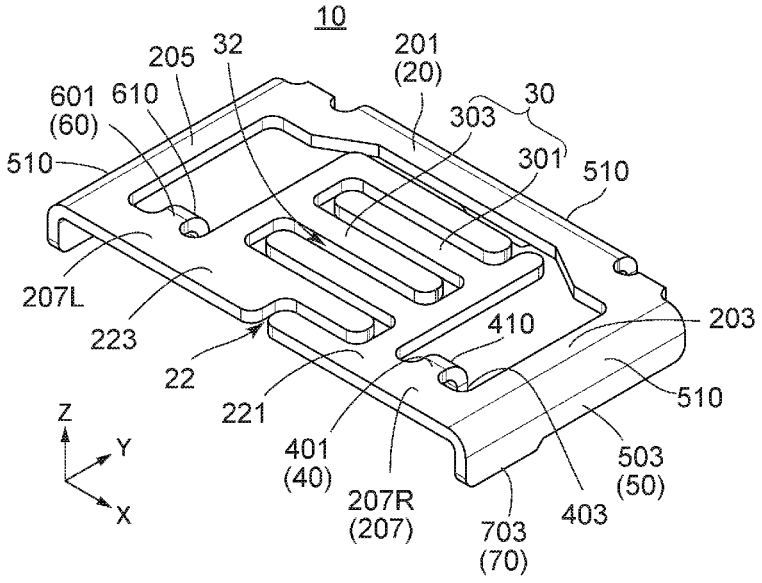
Primary Examiner — Peguy Jean Pierre
(74) *Attorney, Agent, or Firm* — Holtz, Holtz & Volek PC

(57) **ABSTRACT**

A main portion of an antenna has a ring-shape with a split and has a first end portion and a second end portion which form the split. A facing portion has a first facing portion provided on the first end portion and a second facing portion provided on the second end portion. The first facing portion and the second facing portion are arranged apart from each other and face each other. A first feeding terminal, a second feeding terminal and an additional terminal are provided on the main portion and used to be fixed to an object when the antenna is mounted on the object. On the main portion, the first feeding terminal is situated nearer to the first end portion than the second feeding terminal is situated, and the additional terminal is situated nearer to the second end portion than the second feeding terminal is situated.

8 Claims, 8 Drawing Sheets



US011223141B2

(12) **United States Patent**
Liu

(10) **Patent No.: US 11,223,141 B2**
(45) **Date of Patent: Jan. 11, 2022**

(54) **PLANAR ANTENNA MODULE**

(71) Applicant: **ACCTON TECHNOLOGY CORPORATION**, Hsinchu (TW)

(72) Inventor: **Chang-Cheng Liu**, Hsinchu (TW)

(73) Assignee: **ACCTON TECHNOLOGY CORPORATION**, Hsinchu (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 149 days.

(21) Appl. No.: **16/505,033**

(22) Filed: **Jul. 8, 2019**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Sep. 7, 2018 (CN) 201821468159.6

(51) **Int. Cl.**
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H01Q 1/38 (2006.01)
H01Q 9/04 (2006.01)
H01Q 15/24 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 21/061*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 9/0421*** (2013.01); ***H01Q 9/0435*** (2013.01); ***H01Q 15/24*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 21/061; H01Q 1/38; H01Q 9/0435; H01Q 15/24; H01Q 9/0421; H01Q 21/065; H01Q 9/045; H01Q 21/24; H01Q 21/006; H01Q 21/0075; H01P 3/08; H01P 3/081
See application file for complete search history.

(56) **References Cited**

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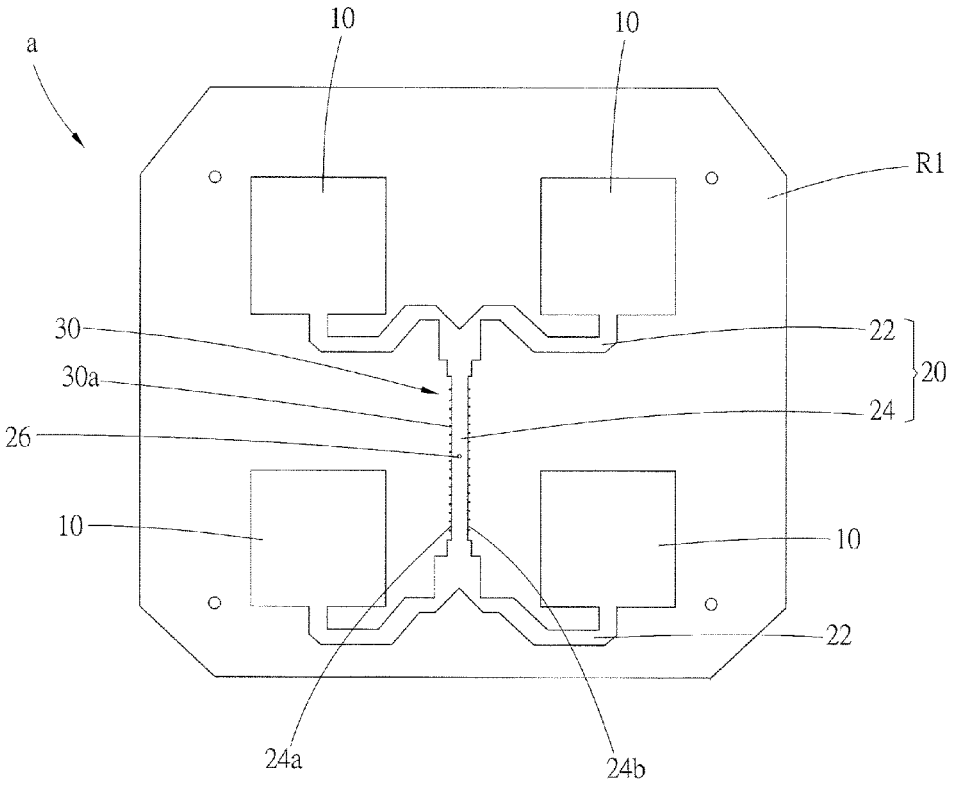
Primary Examiner — David E Lotter
(74) *Attorney, Agent, or Firm* — Birch, Stewart, Kolasch & Birch, LLP

(57) **ABSTRACT**

A planar antenna module includes a plurality of planar antennas, a first transmission line electrically connected to the planar antennas, and at least one gain enhancement structure formed on the first transmission line. Each gain enhancement structure has a plurality of toothed portions spaced apart. With the design of the gain enhancement structure, the gain of the planar antenna module could be enhanced.

15 Claims, 12 Drawing Sheets



US011228099B2

(12) **United States Patent**
Shen

(10) **Patent No.: US 11,228,099 B2**
(45) **Date of Patent: Jan. 18, 2022**

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

(71) Applicant: **AAC Technologies Pte. Ltd.**, Singapore (SG)

(72) Inventor: **Yachuan Shen**, Shenzhen (CN)

(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 16 days.

(21) Appl. No.: **16/702,487**

(22) Filed: **Dec. 3, 2019**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**
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H01Q 9/40 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/38*** (2013.01); ***H01Q 9/40*** (2013.01)

(58) **Field of Classification Search**
CPC .. H01Q 1/38; H01Q 9/40; H01Q 1/40; H01Q 1/42; H01Q 5/378; H01Q 1/2291
See application file for complete search history.

(56) **References Cited**

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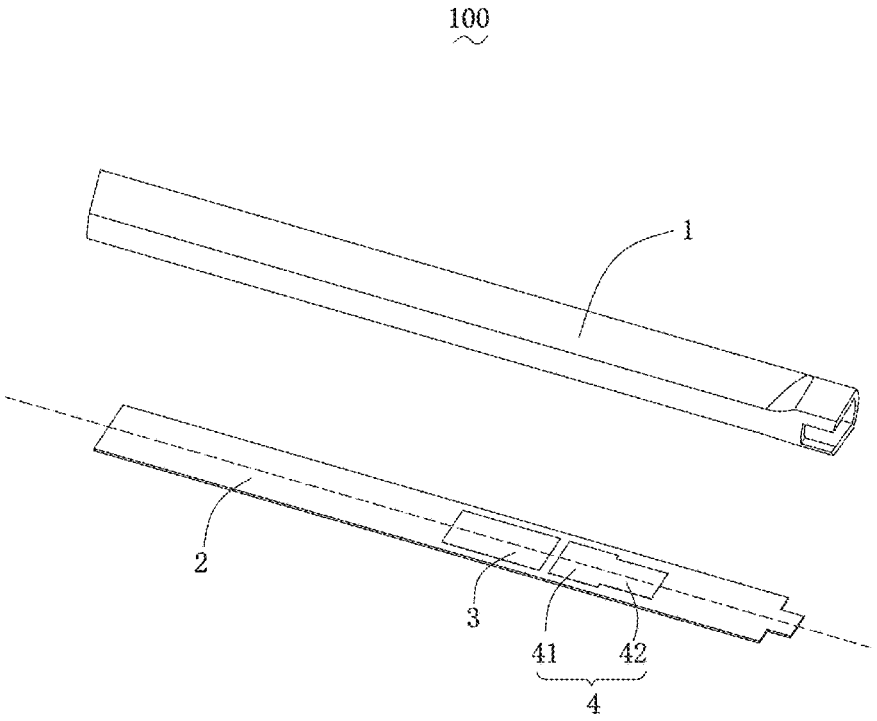
Primary Examiner — David E Lotter
(74) *Attorney, Agent, or Firm* — W&G Law Group

(57) **ABSTRACT**

The present invention provides an omnidirectional antenna and an electronic device. The omnidirectional antenna includes a dielectric substrate, a first metal sheet and a second metal sheet that are printed on a surface of the dielectric substrate, wherein the first metal sheet is rectangular, the second metal sheet is in a strip shape with one wide end and one narrow end, the first metal sheet and the second metal sheet are arranged in a coaxial manner and spaced one another, and the wide end of the second metal sheet is close to the first metal sheet.

14 Claims, 5 Drawing Sheets



US011228105B2

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

(10) **Patent No.: US 11,228,105 B2**
(45) **Date of Patent: Jan. 18, 2022**

(54) **ELECTRONIC DEVICE COMPRISING ANTENNA**

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

(72) Inventors: **Su Min Yun**, Gyeonggi-do (KR); **Myung Hun Jeong**, Gyeonggi-do (KR); **Je Hun Jong**, Gyeonggi-do (KR); **Jae Hoon Jo**, Gyeonggi-do (KR); **Se Hyun Park**, Gyeonggi-do (KR); **Jae Bong Chun**, Gyeonggi-do (KR)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 163 days.

(21) Appl. No.: **16/202,773**

(22) Filed: **Nov. 28, 2018**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Nov. 28, 2017 (KR) 10-2017-0160536

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/50 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 5/50*** (2015.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/42*** (2013.01); ***H01Q 1/44*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 5/50; H01Q 21/062; H01Q 1/42; H01Q 21/065; H01Q 1/44; H01Q 21/0025; H01Q 21/28; H01Q 1/243; H01Q 9/0407
See application file for complete search history.

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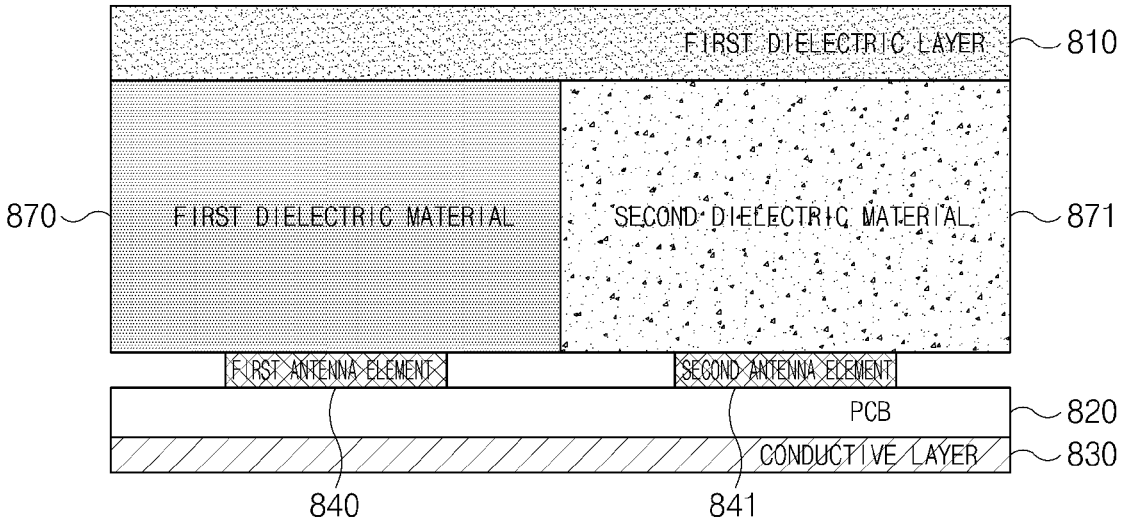
Primary Examiner — Dieu Hien T Duong
(74) *Attorney, Agent, or Firm* — The Farrell Law Firm, P.C.

(57) **ABSTRACT**

An electronic device is provided. The electronic device includes a housing including a first plate, a second plate facing the first plate and spaced from the first plate, and a side member surrounding a space between the first plate and the second plate, wherein the second plate includes a non-conductive material, at least one antenna element positioned within the space and positioned on a substrate parallel to the second plate, wherein the at least one antenna element is spaced from the second plate by a gap h, and a wireless communication circuit electrically connected to the antenna element and configured to transmit and/or receive a signal
(Continued)



US011228111B2

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

(10) **Patent No.: US 11,228,111 B2**
(45) **Date of Patent: Jan. 18, 2022**

(54) **COMPACT DIPOLE ANTENNA DESIGN**

(71) Applicant: **International Business Machines Corporation**, Armonk, NY (US)

(72) Inventors: **Duixian Liu**, Scarsdale, NY (US); **Arun Paidimarri**, White Plains, NY (US); **Bodhisatwa Sadhu**, Peekskill, NY (US); **Alberto Valdes Garcia**, Chappaqua, NY (US)

(73) Assignee: **International Business Machines Corporation**, Armonk, NY (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 19 days.

(21) Appl. No.: **16/381,528**

(22) Filed: **Apr. 11, 2019**

(65) **Prior Publication Data**

US 2020/0328522 A1 Oct. 15, 2020

(51) **Int. Cl.**

H01Q 9/28	(2006.01)
H01Q 1/36	(2006.01)
H01Q 9/40	(2006.01)
H01Q 9/04	(2006.01)

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

CPC ***H01Q 9/285*** (2013.01); ***H01Q 1/36*** (2013.01); ***H01Q 9/0407*** (2013.01); ***H01Q 9/40*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 9/285; H01Q 1/36; H01Q 9/0407; H01Q 9/40

USPC 343/703, 745, 843

See application file for complete search history.

(56) **References Cited**

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(Continued)

Primary Examiner — Wei (Victor) Y Chan

(74) *Attorney, Agent, or Firm* — Scully, Scott, Murphy & Presser, P.C.; Daniel P. Morris

(57) **ABSTRACT**

An antenna that can be embedded in a computer system or device is described. In an example, the antenna includes a feed operable to transmit and receive power. The antenna includes a first arm being extended from the feed towards a first direction to form a first partial loop. The antenna further includes a second arm being extended from the feed towards a second direction to form a second partial loop. The second direction is different from the first direction.

6 Claims, 6 Drawing Sheets