



US012206175B2

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

(10) **Patent No.:** **US 12,206,175 B2**
(45) **Date of Patent:** **Jan. 21, 2025**

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

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

(72) Inventors: **Keumsu Song**, Suwon-si (KR);
Younghak Sin, Suwon-si (KR);
Byungchan Jang, 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 358 days.

(21) Appl. No.: **17/578,916**

(22) Filed: **Jan. 19, 2022**

(65) **Prior Publication Data**
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Related U.S. Application Data
(63) Continuation of application No.
PCT/KR2022/000039, filed on Jan. 4, 2022.

(30) **Foreign Application Priority Data**
Jan. 12, 2021 (KR) 10-2021-0003810

(51) **Int. Cl.**
H01Q 21/08 (2006.01)
H01Q 21/24 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 21/08** (2013.01); **H01Q 21/24**
(2013.01); **H01Q 21/30** (2013.01); **H01Q**
1/243 (2013.01)

(58) **Field of Classification Search**
CPC H01Q 21/08; H01Q 21/24; H01Q 21/30;
H01Q 1/243; H01Q 21/28; H01Q 23/00
See application file for complete search history.

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2022, issued in International Application No. PCT/KR2022/
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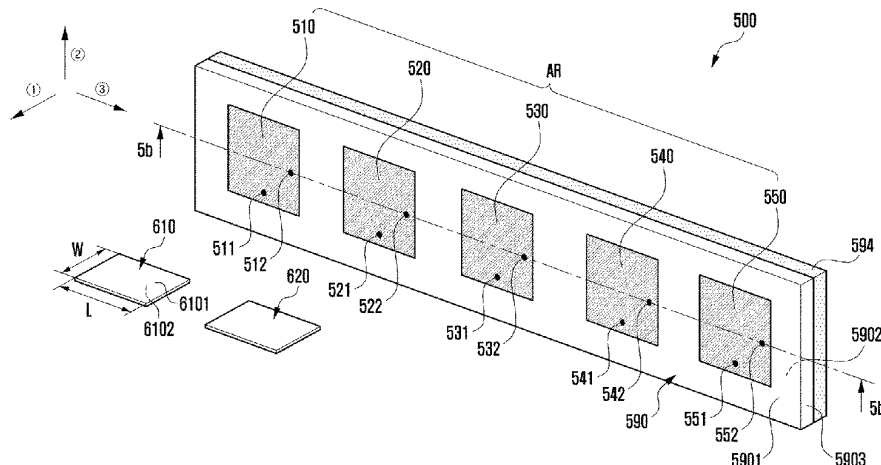
Primary Examiner — Hai V Tran

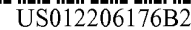
(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

(57) **ABSTRACT**

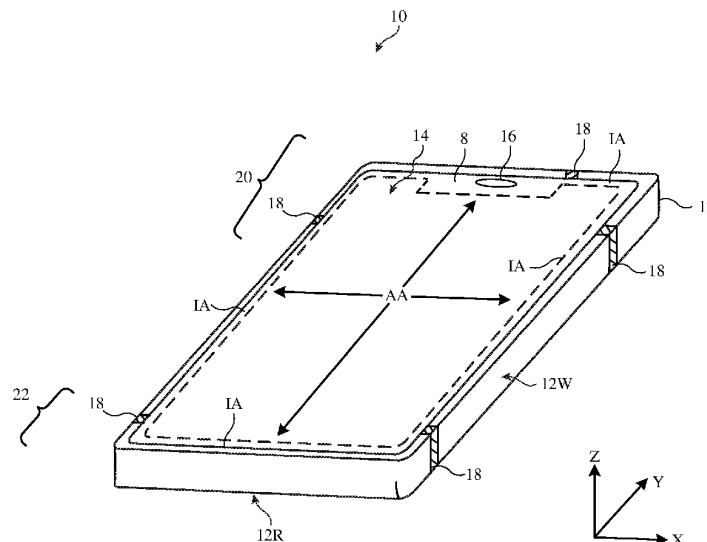
An electronic device is provided. The electronic device includes a housing including a conductive part coupled to a non-conductive, an antenna structure including a substrate disposed in an internal space of the housing and at least one antenna element disposed to form a beam pattern in a first direction in the substrate, at least one conductive dummy plate disposed between the at least one antenna element and the housing in the internal space, and a wireless communication circuit configured to transmit and/or receive a wireless signal in a specified frequency band through the at least one antenna element. The antenna structure is disposed at a position at least partially overlapped with the non-conductive part, and the at least one conductive dummy plate is disposed at a position at least partially overlapped with the at least one antenna element, when the housing is viewed from the outside of the electronic device.

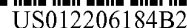
20 Claims, 27 Drawing Sheets





(10) **Patent No.:** US 12,206,176 B2
(45) **Date of Patent:** Jan. 21, 2025





(10) **Patent No.:** US 12,206,184 B2
(45) **Date of Patent:** Jan. 21, 2025

- (52) **U.S. Cl.**
CPC *H01Q 5/35* (2015.01); *H01Q 1/241*
(2013.01); *H01Q 9/0407* (2013.01)

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

- (56)
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343/846 |
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- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 139 days.

- (21) Appl. No.: 17/977,205

- (22) Filed: **Oct. 31, 2022**

- (65) **Prior Publication Data**
US 2023/0052259 A1 Feb. 16, 2023

- | Related U.S. Application Data | | | |
|-------------------------------|--|----------------|-----|
| (63) | Continuation | of application | No. |
| | PCT/KR2021/005422, filed on Apr. 29, 2021. | | |

- (30) **Foreign Application Priority Data**
 Apr. 29, 2020 (KR) 10-2020-0052083

- (51) **Int. Cl.**
H01Q 5/35 (2015.01)
H01Q 1/24 (2006.01)
H01Q 9/04 (2006.01)

- (Continued)

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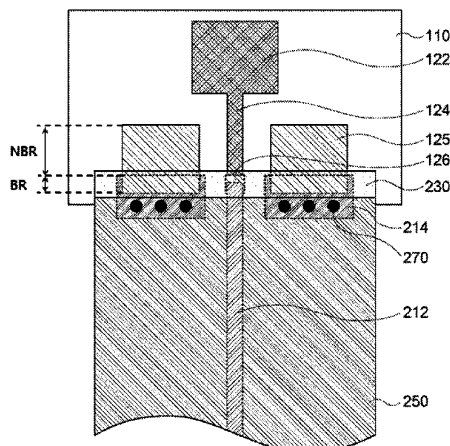
- Notice of Allowance issued on Mar. 20, 2024 from Korean Patent Office in a counterpart Korean Patent Application No. 10-2020-0052083 (all the cited references are listed in this IDS.) (English translation is also submitted herewith.).

- (Continued)

- Primary Examiner — Hoang V Nguyen
Assistant Examiner — Brandon Sean Woods
(74) Attorney, Agent, or Firm — The PL Law Group,
PLLC

- (57) **ABSTRACT**

- An antenna package according to an embodiment includes an antenna unit including a radiator, a transmission line extending from the radiator and an antenna ground pad disposed around the transmission line, and a circuit board electrically connected to the antenna unit. The circuit board includes a core layer, a circuit wiring layer disposed on one surface of the core layer, the circuit wiring layer including a signal transmission wiring electrically connected to the
- (Continued)





US012206188B2

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

(10) **Patent No.:** **US 12,206,188 B2**
(45) **Date of Patent:** **Jan. 21, 2025**

(54) **CIRCUIT INTEGRATED ANTENNA**

(56) **References Cited**

(71) Applicant: **Nippon Telegraph and Telephone Corporation, Tokyo (JP)**

U.S. PATENT DOCUMENTS

(72) Inventors: **Go Itami, Tokyo (JP); Hiroshi Hamada, Tokyo (JP); Hideyuki Nosaka, Tokyo (JP)**

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11,005,980 B1 * 5/2021 Lee H01Q 1/44
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(73) Assignee: **Nippon Telegraph and Telephone Corporation, Tokyo (JP)**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 283 days.

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(21) Appl. No.: **17/770,570**

Hau, G. et al., "High Efficiency, Wide Dynamic Range Variable Gain and Power Amplifier MMICs for Wide-Band CDMA Handsets," IEEE Microwave and Wireless Components Letters, vol. 1, No. 1, Jan. 2001, 3 pages.

(22) PCT Filed: **Oct. 31, 2019**

(Continued)

(86) PCT No.: **PCT/JP2019/042877**

§ 371 (c)(1),

(2) Date: **Apr. 20, 2022**

Primary Examiner — Thien M Le

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

(87) PCT Pub. No.: **WO2021/084705**

PCT Pub. Date: **May 6, 2021**

(57) **ABSTRACT**

(65) **Prior Publication Data**

US 2022/0393357 A1 Dec. 8, 2022

Arranged on a surface of a substrate are a patch conductor that radiates an electromagnetic field having been fed, a feed line that feeds the patch conductor with the electromagnetic field having been input, two slits parallel to the feed line on both sides of a connection part of the feed line toward an inner side of the patch conductor, and a ring conductor at a space from the patch conductor with an interposition of a gap to surround an outer periphery of the patch conductor. Accordingly, an electric capacitance can be formed between the patch conductor and the ring conductor, and when achieving impedance matching with the feed line, adjustment can be performed using the size of the ring conductor and the gap.

(51) **Int. Cl.**

H01Q 9/04 (2006.01)

H01Q 1/22 (2006.01)

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

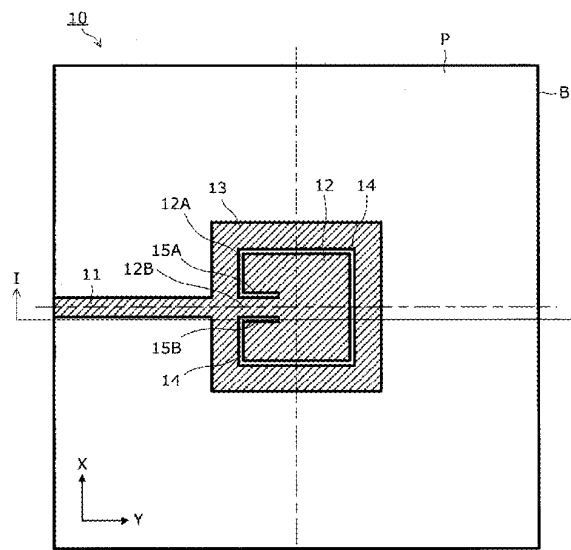
CPC **H01Q 9/0464** (2013.01); **H01Q 1/2283** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/2283; H01Q 9/0464; H01Q 21/0093; H01Q 5/364; H01Q 9/0457

See application file for complete search history.

20 Claims, 17 Drawing Sheets





US012212044B2

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

(10) **Patent No.:** **US 12,212,044 B2**
(45) **Date of Patent:** **Jan. 28, 2025**

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

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

(72) Inventors: **Seungmin Woo**, Seoul (KR); **Yusuhk Suh**, Seoul (KR); **Dongik Lee**, 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 147 days.

(21) Appl. No.: **18/002,957**

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

(86) PCT No.: **PCT/KR2020/009638**

§ 371 (c)(1),

(2) Date: **Dec. 22, 2022**

(87) PCT Pub. No.: **WO2022/019351**

PCT Pub. Date: **Jan. 27, 2022**

(65) **Prior Publication Data**

US 2023/0246326 A1 Aug. 3, 2023

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

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 3/36** (2013.01); **H01Q 9/0407** (2013.01); **H01Q 9/28** (2013.01)

(58) **Field of Classification Search**

CPC **H01Q 1/24**; **H01Q 1/243**; **H01Q 1/38**;
H01Q 1/48; **H01Q 1/52**; **H01Q 1/523**;
(Continued)

(56) **References Cited**

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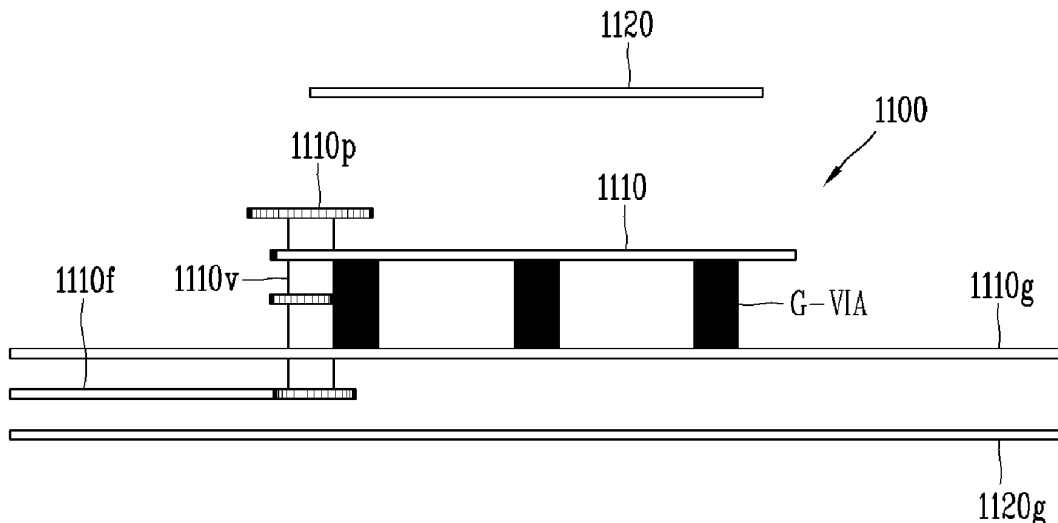
Primary Examiner — Tho G Phan

(74) Attorney, Agent, or Firm — LEE, HONG, DEGERMAN, KANG & WAIMEY

(57) **ABSTRACT**

Provided is an electronic device having a multilayer substrate according to an embodiment. The electronic device may include a multilayer substrate on which an antenna is disposed and which includes a front layer, a back layer, a plurality of middle layers, and a plurality of ground layers. The antenna may include a lower patch that is disposed on a layer different from an upper ground among the plurality of ground layers and is electrically connected to the upper ground at a plurality of offset points; and an upper patch disposed spaced apart from the lower patch by a predetermined distance.

26 Claims, 25 Drawing Sheets





US012212052B2

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

(10) **Patent No.:** **US 12,212,052 B2**
(45) **Date of Patent:** **Jan. 28, 2025**

(54) **ANTENNA AND ELECTRONIC DEVICE**

(71) Applicant: **Huawei Technologies Co., Ltd.**,
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(72) Inventors: **Jiaming Wang**, Shanghai (CN); **Liang Xue**, Shanghai (CN); **Jiahui Chu**,
Shanghai (CN); **Jiaqing You**, Shanghai
(CN); **Lijun Ying**, Shanghai (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 217 days.

(21) Appl. No.: **17/637,370**

(22) PCT Filed: **Aug. 7, 2020**

(86) PCT No.: **PCT/CN2020/107867**

§ 371 (c)(1),

(2) Date: **Feb. 22, 2022**

(87) PCT Pub. No.: **WO2021/036753**

PCT Pub. Date: **Mar. 4, 2021**

(65) **Prior Publication Data**

US 2022/0278446 A1 Sep. 1, 2022

(30) **Foreign Application Priority Data**

Aug. 23, 2019 (CN) 201910794483.X

(51) **Int. Cl.**

H01Q 1/38 (2006.01)

H01Q 1/24 (2006.01)

H01Q 5/10 (2015.01)

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

CPC **H01Q 1/38** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 5/10** (2015.01)

(58) **Field of Classification Search**

USPC 343/893
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Hoang V Nguyen

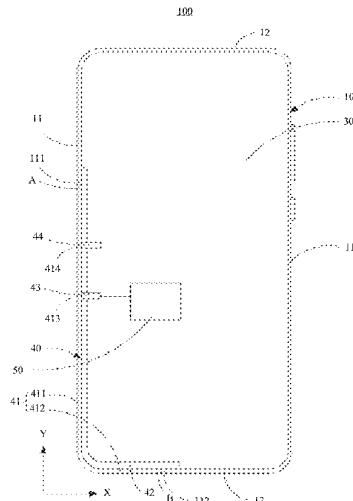
Assistant Examiner — Brandon Sean Woods

(74) *Attorney, Agent, or Firm* — Leydig, Voit & Mayer,
Ltd.

(57) **ABSTRACT**

This application provides an antenna having an L-shaped
antenna body. The antenna body comprises a first end, a
second end, and a feed point, a physical length between the
feed point and the first end is greater than a physical length
between the feed point and the second end, the antenna body
generates resonance of a first wavelength between the feed
point and the first end, and the antenna body generates
resonance of a second wavelength between the first end and
the second end, wherein the first wavelength is greater than
the second wavelength. The antenna can have relatively
good radiation performance regardless of whether the elec-
tronic device is in free space (FS) or in a handheld state.

28 Claims, 16 Drawing Sheets





US012212055B2

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

(10) **Patent No.:** **US 12,212,055 B2**
(45) **Date of Patent:** **Jan. 28, 2025**

(54) **ANTENNA DECOUPLING STRUCTURE, MIMO ANTENNA, AND TERMINAL**

(71) Applicant: **HONOR DEVICE CO., LTD.**,
SHENZHEN (CN)

(72) Inventors: **Yiwu Hu**, Shenzhen (CN); **Kunpeng Wei**, Shenzhen (CN)

(73) Assignee: **HONOR DEVICE 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 53 days.

(21) Appl. No.: **18/013,338**

(22) PCT Filed: **Apr. 25, 2022**

(86) PCT No.: **PCT/CN2022/089005**

§ 371 (c)(1),
(2) Date: **Dec. 28, 2022**

(87) PCT Pub. No.: **WO2022/233248**

PCT Pub. Date: **Nov. 10, 2022**

(65) **Prior Publication Data**

US 2023/0261370 A1 Aug. 17, 2023

(30) **Foreign Application Priority Data**

May 6, 2021 (CN) 202110490769.6

(51) **Int. Cl.**
H01Q 1/52 (2006.01)
H01Q 1/22 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/521** (2013.01); **H01Q 1/2291**
(2013.01); **H01Q 1/48** (2013.01); **H01Q**
9/0421 (2013.01); **H01Q 9/0457** (2013.01);
H01Q 21/00 (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/2291; H01Q 1/48; H01Q 1/52;
H01Q 1/521; H01Q 1/523; H01Q 1/525;
H01Q 9/0421; H01Q 9/0457; H01Q 5/40
See application file for complete search history.

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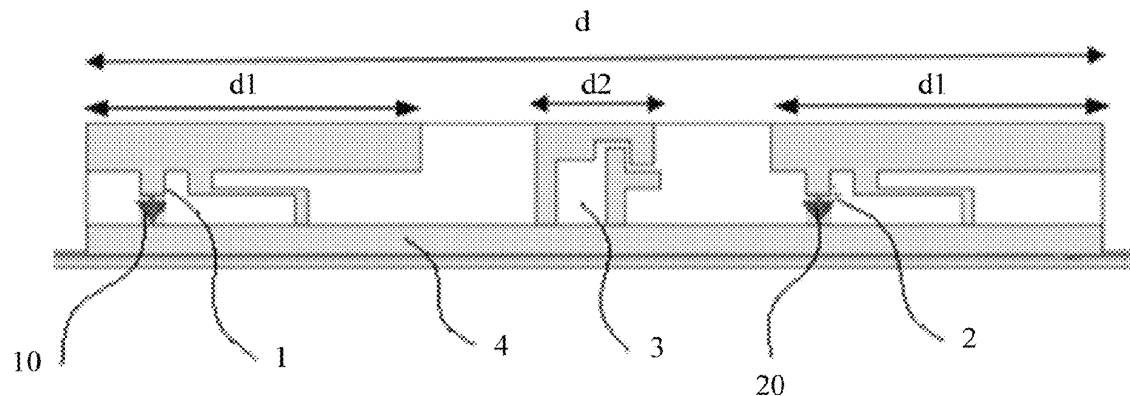
Primary Examiner — Jason M Crawford

(74) *Attorney, Agent, or Firm* — WOMBLE BOND
DICKINSON (US) LLP

(57) **ABSTRACT**

This application provides an antenna decoupling structure, a MIMO antenna, and a terminal. The antenna decoupling structure includes a grounding stub and a capacitor structure, where a first end of the grounding stub is connected to an antenna floor, to form an equivalent inductor; and a first end of the capacitor structure is connected to the antenna floor, and a second end of the capacitor structure is connected to a second end of the grounding stub, so that the equivalent inductor and the capacitor structure form an LC resonant structure, where a parameter corresponding to the LC resonant structure meets a decoupling requirement for at least one target decoupling frequency band. Because the resonant frequency depends on the inductance and the capacitance that correspond to the LC resonant structure, antenna miniaturization can be realized by reducing a size of each portion of the decoupling structure.

19 Claims, 24 Drawing Sheets





US012212057B2

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

(10) **Patent No.:** **US 12,212,057 B2**
(45) **Date of Patent:** **Jan. 28, 2025**

(54) **EXTERIOR ACCESSORY CLEAT WITH INTEGRATED ANTENNA**

(71) Applicant: **ZEBRA TECHNOLOGIES CORPORATION**, Lincolnshire, IL (US)

(72) Inventors: **Nicolas F Casazzone**, Dix Hills, NY (US); **Sripathi Yarasi**, Fort Lauderdale, FL (US); **Michele B. Feinstein**, Oceanside, NY (US)

(73) Assignee: **Zebra Technologies Corporaiton**, Lincolnshire, IL (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 386 days.

(21) Appl. No.: **17/675,863**

(22) Filed: **Feb. 18, 2022**

(65) **Prior Publication Data**
US 2023/0268645 A1 Aug. 24, 2023

(51) **Int. Cl.**
H01Q 1/52 (2006.01)
H01Q 13/10 (2006.01)
H04M 1/02 (2006.01)
H01Q 1/24 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/528** (2013.01); **H01Q 13/10** (2013.01); **H04M 1/0266** (2013.01); **H01Q 1/243** (2013.01)

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

(56) **References Cited**

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455/562.1
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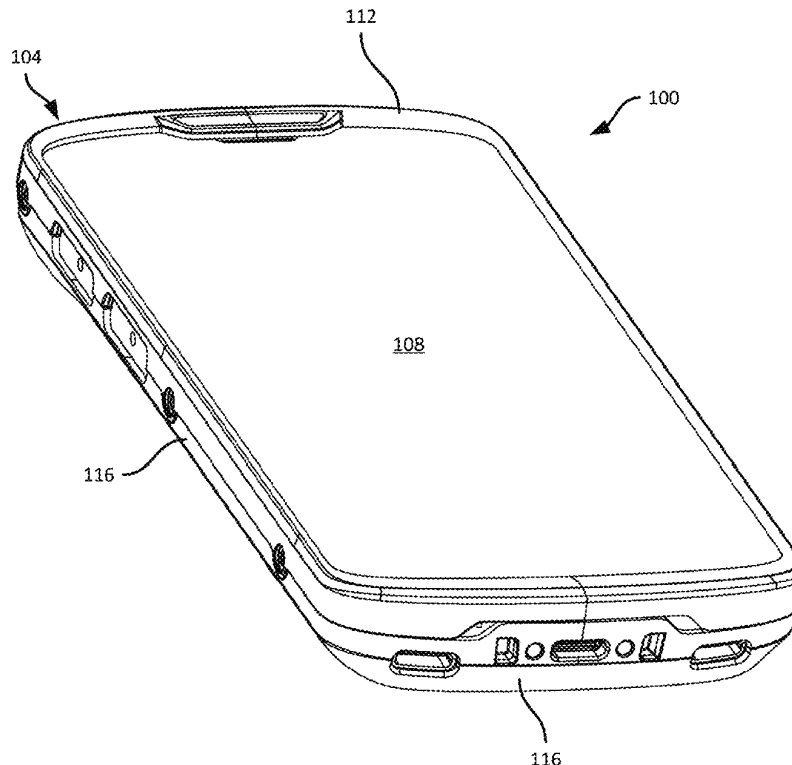
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Primary Examiner — Frantz Bataille

(57) **ABSTRACT**

A mobile computing device includes: a display; a device housing supporting the display and having a wall defining an exterior surface; a communications controller supported within a device interior enclosed between the display and the device housing; a cleat affixed to the exterior surface of the wall and configured to couple an accessory to the device housing, the cleat including a conductive antenna element; and a feed connector having an exterior end electrically coupled with the conductive antenna element of the cleat, an interior end electrically coupled with the communications controller, and a body traversing the wall to join the exterior and interior ends.

20 Claims, 11 Drawing Sheets





US012212059B2

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

(10) **Patent No.:** **US 12,212,059 B2**
(45) **Date of Patent:** **Jan. 28, 2025**

(54) **SYSTEM AND METHOD FOR OPERATING A PARTITIONED ANTENNA AT A VENT FORMED IN A BOTTOM METAL CHASSIS**

(71) Applicant: **Dell Products, LP**, Round Rock, TX (US)

(72) Inventors: **Suresh K. Ramasamy**, Cedar Park, TX (US); **Sumana Pallampati**, Austin, TX (US); **Changsoo Kim**, Cedar Park, TX (US)

(73) Assignee: **DELL PRODUCTS LP**, Round Rock, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 226 days.

(21) Appl. No.: **17/236,361**

(22) Filed: **Apr. 21, 2021**

(65) **Prior Publication Data**

US 2022/0344825 A1 Oct. 27, 2022

(51) **Int. Cl.**
H01Q 13/10 (2006.01)
H01Q 1/22 (2006.01)
H01Q 1/48 (2006.01)
H04R 1/02 (2006.01)
H04R 1/34 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 13/10** (2013.01); **H01Q 1/2258** (2013.01); **H01Q 1/48** (2013.01); **H04R 1/028** (2013.01); **H04R 1/345** (2013.01); **H04R 2499/15** (2013.01)

(58) **Field of Classification Search**
CPC H04R 1/028; H04R 1/345; H04R 1/2826; H01Q 1/2258–2266; H01Q 13/10
See application file for complete search history.

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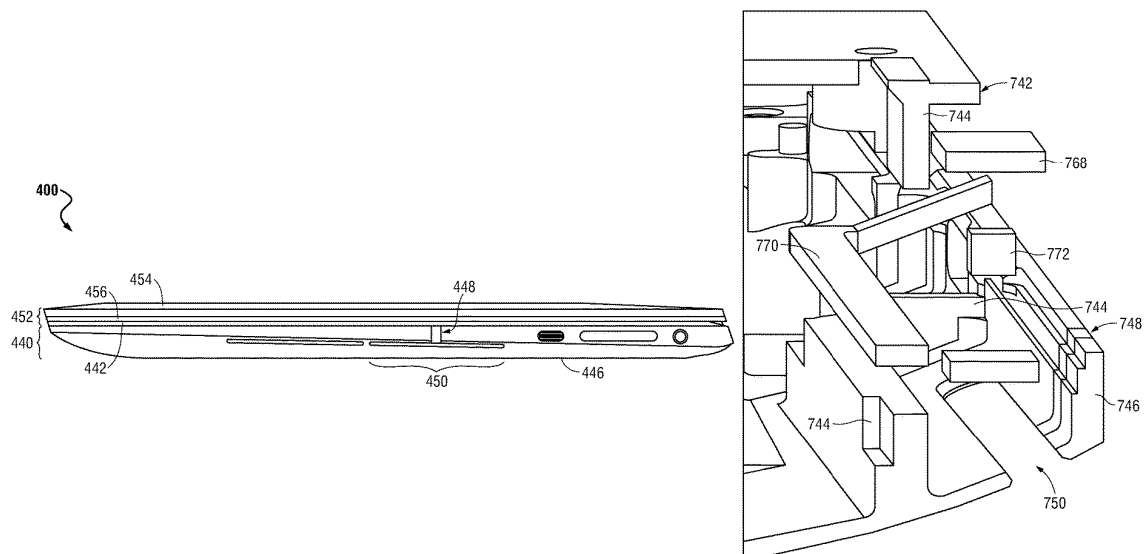
Primary Examiner — Ricardo I Magallanes

(74) *Attorney, Agent, or Firm* — Prol Intellectual Property Law, PLLC; H. Kenneth Prol

(57) **ABSTRACT**

An information handling system to wirelessly transmit and receive data at an antenna may include a processor; a memory; a power management unit; a bottom metal chassis of a base housing containing components of the information handling system; a vent formed into the bottom metal chassis; a slot formed between the vent and a terminal edge of the bottom metal chassis; and an antenna located within the bottom metal chassis and behind the vent to, upon execution of the processor, create radiating radio frequency (RF) bands along an edge of the vent.

20 Claims, 12 Drawing Sheets





US012212060B2

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

(10) **Patent No.:** **US 12,212,060 B2**
(45) **Date of Patent:** **Jan. 28, 2025**

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

(71) Applicant: **WISTRON NEWEB
CORPORATION**, Hsinchu (TW)

(72) Inventors: **Hsuan-Jui Chang**, Hsinchu (TW);
Hsieh-Chih Lin, Hsinchu (TW);
Guan-Ren Su, Hsinchu (TW)

(73) Assignee: **WISTRON NEWEB
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 300 days.

(21) Appl. No.: **17/817,406**

(22) Filed: **Aug. 4, 2022**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Oct. 15, 2021 (TW) 110138286

(51) **Int. Cl.**
H01Q 1/22 (2006.01)
H01Q 5/378 (2015.01)
H01Q 13/16 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 13/16** (2013.01); **H01Q 1/2266**
(2013.01); **H01Q 5/378** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 13/16; H01Q 1/2266; H01Q 5/378
See application file for complete search history.

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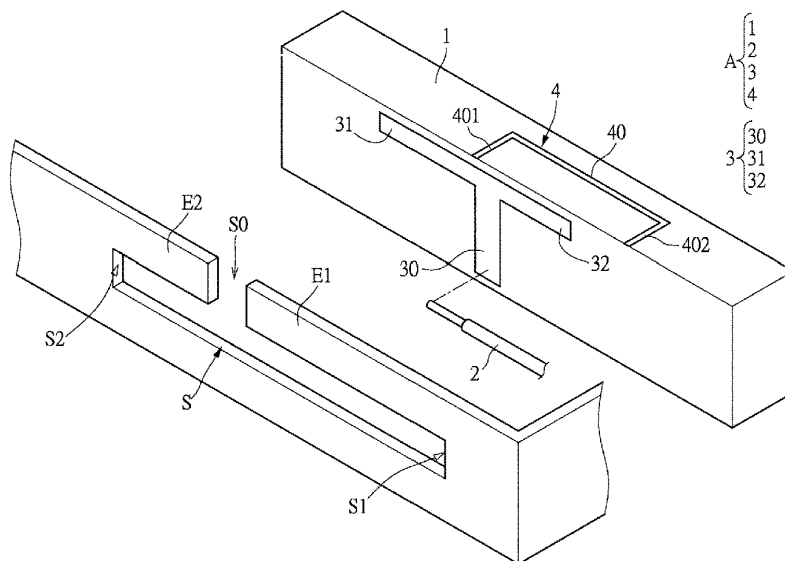
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Primary Examiner — Seokjin Kim
(74) Attorney, Agent, or Firm — McClure, Qualey &
Rodack, LLP

(57) **ABSTRACT**

An electronic device and an antenna module are provided. The electronic device includes a metal housing with a slot having an open end and a first upper edge portion located at an upper edge of the slot. The antenna module is arranged in the metal housing and includes a carrier board, a feeding element, a radiating element with a feeding portion connected to the feeding element, and a first parasitic radiating element arranged on the carrier board and connected or coupled to the first upper edge portion. A vertical projection of the radiating element on the metal housing at least partially overlaps the slot. One side of the first parasitic radiating element is near an edge of the open end. The radiating element is fed with a signal through the feeding element to generate a resonant mode and is coupled to the slot to excite another resonant mode.

17 Claims, 5 Drawing Sheets





US012212061B2

(12) **United States Patent**
Tsuchiya

(10) **Patent No.:** **US 12,212,061 B2**
(45) **Date of Patent:** **Jan. 28, 2025**

(54) **ANTENNA APPARATUS**

(56) **References Cited**

(71) Applicant: **NEC Platforms, Ltd.**, Kawasaki (JP)

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(72) Inventor: **Masato Tsuchiya**, Kanagawa (JP)

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(73) Assignee: **NEC Platforms, Ltd.**, Kanagawa (JP)

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 143 days.

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(21) Appl. No.: **17/893,582**

(22) Filed: **Aug. 23, 2022**

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(65) **Prior Publication Data**

US 2023/0076815 A1 Mar. 9, 2023

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JP Official Communication for JP Application No. 2021-144679, mailed on Jul. 23, 2024 with English Translation.

(30) **Foreign Application Priority Data**

Sep. 6, 2021 (JP) 2021-144679

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Primary Examiner — Graham P Smith

(51) **Int. Cl.**

H01Q 13/16 (2006.01)

H01Q 21/20 (2006.01)

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

CPC **H01Q 13/16** (2013.01); **H01Q 21/205** (2013.01)

(58) **Field of Classification Search**

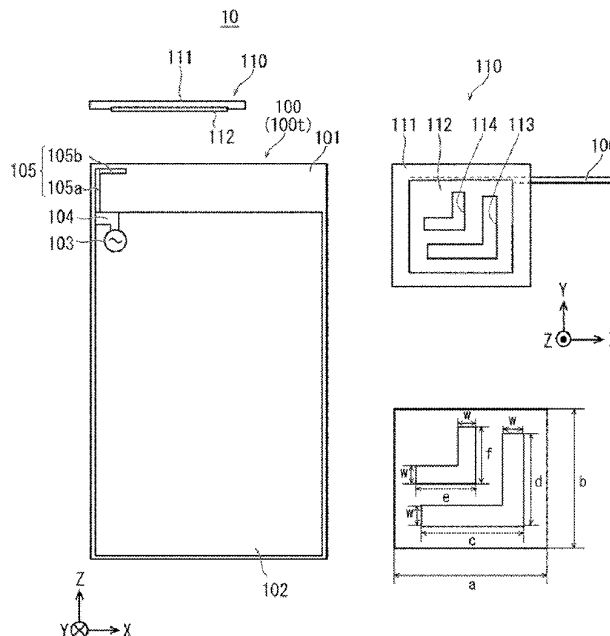
CPC H01Q 13/16; H01Q 21/205

See application file for complete search history.

(57) **ABSTRACT**

An antenna apparatus including an antenna capable of having both a wide-band characteristic and an omni-directional characteristic is provided. An antenna apparatus according to the present disclosure includes a feeding antenna, and a passive element part disposed in a Z-direction of the feeding antenna, in which the passive element part is disposed in parallel to an XY-plane orthogonal to the Z-direction, is made of a conductor, and includes a passive element with a plurality of slots formed therein.

6 Claims, 13 Drawing Sheets





US012212068B2

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

(10) **Patent No.:** **US 12,212,068 B2**
(45) **Date of Patent:** **Jan. 28, 2025**

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

(58) **Field of Classification Search**
None

See application file for complete search history.

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

(56) **References Cited**

(72) Inventors: **Daehee Park**, Gyeonggi-do (KR);
Jungmin Park, Gyeonggi-do (KR);
Janghoon Han, Gyeonggi-do (KR)

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(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 97 days.

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(21) Appl. No.: **17/892,826**

(22) Filed: **Aug. 22, 2022**

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(65) **Prior Publication Data**

US 2023/0047210 A1 Feb. 16, 2023

PCT/ISA/210 Search Report issued on PCT/KR2021/018255, Mar. 30, 2022, pp. 5.

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Related U.S. Application Data

(63) Continuation of application No.
PCT/KR2021/018255, filed on Dec. 3, 2021.

Primary Examiner — Jany Richardson

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

(30) **Foreign Application Priority Data**

Dec. 3, 2020 (KR) 10-2020-0167764

(57)

ABSTRACT

(51) **Int. Cl.**

H01Q 21/08 (2006.01)

H01Q 1/24 (2006.01)

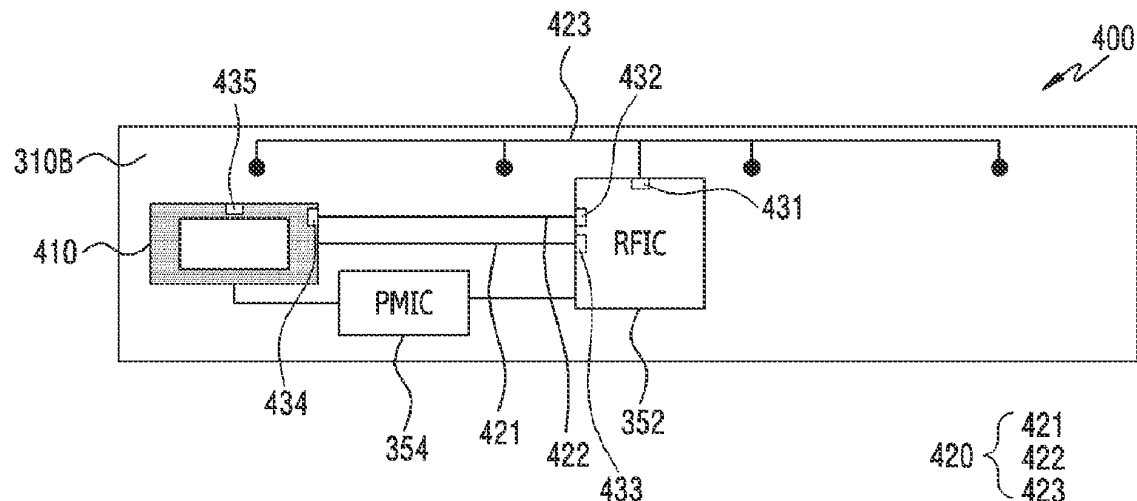
H01Q 9/04 (2006.01)

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

CPC **H01Q 21/08** (2013.01); **H01Q 1/243** (2013.01); **H01Q 9/045** (2013.01)

Disclosed is an electronic device including an antenna module comprising a first array antenna disposed on a first surface, a radio frequency integrated circuit (RFIC) disposed on a second surface which is parallel to the first surface, and a connector, a wireless communication circuit electrically connected with the antenna module through the connector, and a flexible printed circuit board (FPCB) electrically

(Continued)





US012216498B2

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

(10) **Patent No.:** **US 12,216,498 B2**
(45) **Date of Patent:** **Feb. 4, 2025**

(54) **ELECTRONIC DEVICE INCLUDING
ANTENNA AND CABLE STRUCTURE**

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

(72) Inventors: **Yeonghun Gu**, Suwon-si (KR);
Keunpyo Park, Suwon-si (KR);
Youngho Park, Suwon-si (KR); **Jiwoo
Lee**, Suwon-si (KR); **Kio Jung**,
Suwon-si (KR); **Ko Choi**, Suwon-si
(KR); **Woojin Choi**, 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 66 days.

(21) Appl. No.: **17/989,316**

(22) Filed: **Nov. 17, 2022**

(65) **Prior Publication Data**
US 2023/0100675 A1 Mar. 30, 2023

Related U.S. Application Data

(63) Continuation of application No.
PCT/KR2022/014629, filed on Sep. 29, 2022.

(30) Foreign Application Priority Data

Sep. 30, 2021 (KR) 10-2021-0129704
Dec. 2, 2021 (KR) 10-2021-0171224

(51) **Int. Cl.**
G06F 1/16 (2006.01)
H05K 7/14 (2006.01)

(52) **U.S. Cl.**
CPC **G06F 1/1641** (2013.01); **G06F 1/1681**
(2013.01); **G06F 1/1698** (2013.01); **H05K**
7/1427 (2013.01)

(58) **Field of Classification Search**
CPC G06F 1/1641; G06F 1/1681; G06F 1/1698;
H05K 7/1427; H01Q 1/2266; H01Q 1/48;
H01Q 9/0414
See application file for complete search history.

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cation No. PCT/KR2022/014629.

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Primary Examiner — Daniel C Puentes

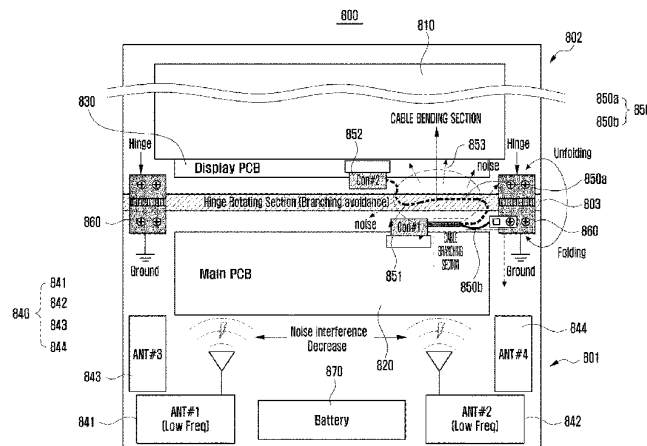
Assistant Examiner — Peter Krim

(74) *Attorney, Agent, or Firm* — Nixon & Vanderhye,
P.C.

(57) ABSTRACT

An electronic device according to various embodiments of the disclosure may include a first housing on which a first printed circuit board including a processor is disposed, a second housing on which a second printed circuit board including a display driver for a display is disposed, a hinge structure configured to physically connect the first housing and the second housing such that the first housing and the second housing are foldable/unfoldable, and a cable structure configured to electrically connect the first printed circuit board and the second printed circuit board via the hinge structure. The cable structure may include a first cable configured to transfer display signals and a second cable

(Continued)





US012218409B2

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

(10) **Patent No.:** **US 12,218,409 B2**
(45) **Date of Patent:** **Feb. 4, 2025**

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

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

(72) Inventors: **Taegyu Kim**, Suwon-si (KR); **Jesun Moon**, Suwon-si (KR); **Kyungbae Ko**, Suwon-si (KR); **Hanbin Lee**, Suwon-si (KR); **Donghwan Kim**, Suwon-si (KR); **Jinwoo Jung**, 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 155 days.

(21) Appl. No.: **17/752,170**

(22) Filed: **May 24, 2022**

(65) **Prior Publication Data**
US 2022/0336944 A1 Oct. 20, 2022

Related U.S. Application Data
(63) Continuation of application No. PCT/KR2022/005421, filed on Apr. 14, 2022.

(30) **Foreign Application Priority Data**
Apr. 14, 2021 (KR) 10-2021-0048817
Sep. 14, 2021 (KR) 10-2021-0122728

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

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/02** (2013.01); **H01Q 1/48** (2013.01); **H01Q 1/526** (2013.01); **H01Q 5/307** (2015.01); **H01Q 7/00** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/02; H01Q 1/243; H05K 9/0081; H05K 9/0075; H05K 9/0088;
(Continued)

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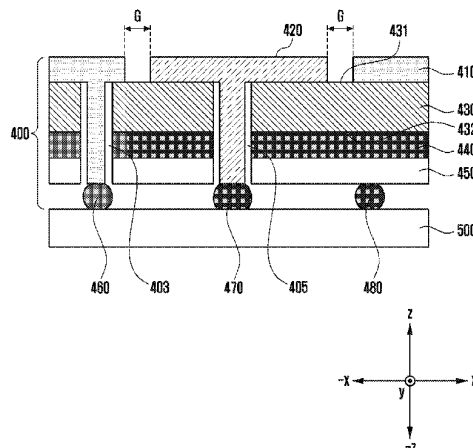
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Primary Examiner — Ricardo I Magallanes
Assistant Examiner — Aladdin Abdalbaki
(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

(57) **ABSTRACT**

An electronic device is provided. The electronic device includes a housing having a front surface and a rear surface, a first antenna, a second antenna, a printed circuit board, and an electromagnetic interference (EMI) shielding sheet. The first antenna may be disposed inside the housing. The second antenna may be disposed in an area surrounded by a radiator of the first antenna when viewed from above the rear surface. The printed circuit board may include a wireless communication module for operating the first antenna and the second antenna, and may be electrically connected to the first antenna and the second antenna. The first antenna may be positioned between the rear surface and the EMI shielding sheet.

19 Claims, 17 Drawing Sheets





US012218419B2

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

(10) **Patent No.:** **US 12,218,419 B2**
(45) **Date of Patent:** **Feb. 4, 2025**

(54) **ANTENNA MODULE AND ANTENNA SYSTEM APPLYING THE ANTENNA MODULE**

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

(72) Inventors: **Chia-Yen Wei**, Hsinchu (TW);
Jen-Chun Wen, Hsinchu (TW)

(73) Assignee: **MEDIATEK INC.**, Hsinchu (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 162 days.

(21) Appl. No.: **18/085,508**

(22) Filed: **Dec. 20, 2022**

(65) **Prior Publication Data**

US 2023/0216186 A1 Jul. 6, 2023

Related U.S. Application Data

(60) Provisional application No. 63/296,034, filed on Jan. 3, 2022.

(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H01Q 1/22 (2006.01)
H01Q 1/38 (2006.01)
H01Q 1/42 (2006.01)
H01Q 3/12 (2006.01)
H05K 1/02 (2006.01)
H05K 1/14 (2006.01)

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

CPC **H01Q 1/427** (2013.01); **H01Q 1/2283** (2013.01); **H01Q 3/12** (2013.01); **H05K 1/0243** (2013.01); **H05K 1/147** (2013.01); **H05K 2201/10098** (2013.01); **H05K 2201/10128** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/22; H01Q 1/2283; H01Q 1/24; H01Q 1/38; H01Q 1/42; H01Q 1/427; H01Q 21/28; H01Q 3/01; H01Q 3/12; H05K 1/02; H05K 1/0243; H05K 1/14; H05K 1/147; H05K 2201/10098; H05K 2201/10128

See application file for complete search history.

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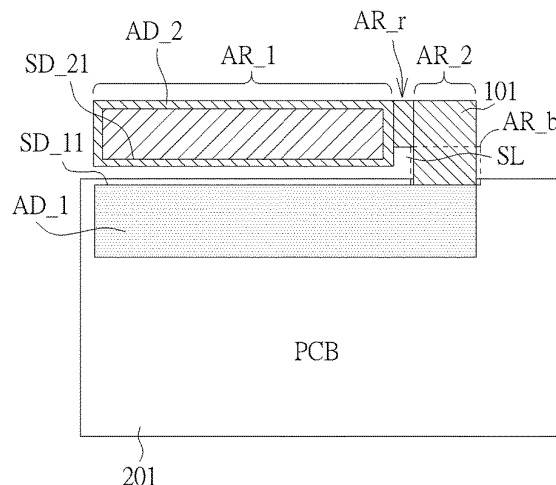
Primary Examiner — Tho G Phan

(74) *Attorney, Agent, or Firm* — Winston Hsu

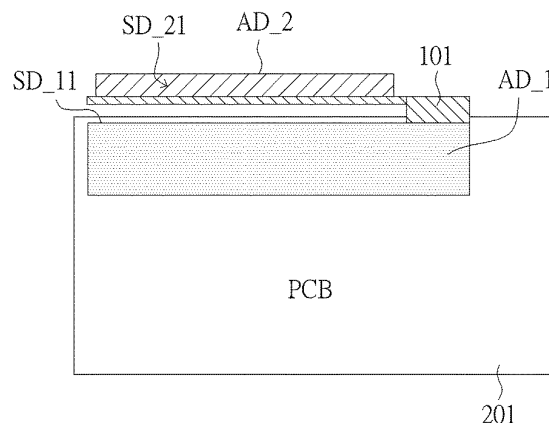
(57) **ABSTRACT**

An antenna module, comprising: a first antenna device, which is an AiM (Antenna in Module) and comprises at least one first antenna; a first FPC (flexible printed circuit), coupled to an outer surface of the first antenna device via a conductive structure; and at least one second antenna device, coupled to the first FPC, comprising at least one second antenna. By this way, an antenna module which can change directions of antennas via simplified structures is provided. Further, an antenna system applying the antenna module is also provided.

17 Claims, 10 Drawing Sheets



Mode 1



Mode 2-1



US012218420B2

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

(10) **Patent No.:** **US 12,218,420 B2**
(45) **Date of Patent:** **Feb. 4, 2025**

(54) **ELECTRONIC DEVICE INCLUDING ANTENNA**

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

(72) Inventors: **Byungjoon Kim**, Suwon-si (KR);
Kyunghoon Moon, Suwon-si (KR);
Heejin Park, Suwon-si (KR);
Yongyoun Kim, Suwon-si (KR);
Youngmi Jang, Suwon-si (KR);
Eunseong Choi, 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 85 days.

(21) Appl. No.: **17/987,343**

(22) Filed: **Nov. 15, 2022**

(65) **Prior Publication Data**
US 2023/0136210 A1 May 4, 2023

Related U.S. Application Data
(63) Continuation of application No. PCT/KR2022/015834, filed on Oct. 18, 2022.

(30) **Foreign Application Priority Data**
Nov. 1, 2021 (KR) 10-2021-0148240

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

(52) **U.S. Cl.**
CPC **H01Q 1/521** (2013.01); **H01Q 1/243** (2013.01); **H01Q 9/0407** (2013.01); **H01Q 21/24** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/521; H01Q 1/243; H01Q 9/0407;
H01Q 21/24; H01Q 1/24; H01Q 1/32;
(Continued)

(56) **References Cited**
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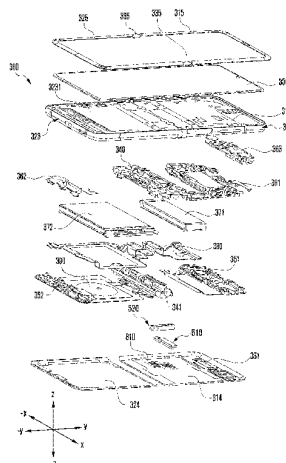
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Primary Examiner — Wei (Victor) Y Chan
(74) *Attorney, Agent, or Firm* — Sughrue Mion, PLLC

(57) **ABSTRACT**
An electronic device is provided. The electronic device includes: a first housing comprising a first support member facing in a first direction, a first rear cover facing in a second direction opposite the first direction, and a first side member surrounding a first space between the first support member and the first rear cover; a second housing; a hinge structure connected to the first housing and the second housing and configured to be folded about a folding axis; a first antenna structure disposed in the first space and configured to form a first electric field in the second direction; a second antenna structure disposed near the first antenna structure in the first space; and a conductive member disposed between the first antenna structure and the second antenna structure.

20 Claims, 19 Drawing Sheets





US012218439B2

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

(10) **Patent No.:** **US 12,218,439 B2**
(45) **Date of Patent:** **Feb. 4, 2025**

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

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

(72) Inventors: **Jiho Kim**, Suwon-si (KR); **Moohyun Roh**, Suwon-si (KR); **Gyubok Park**, Suwon-si (KR); **Kyungmoon Seol**, Suwon-si (KR); **Seongyong An**, Suwon-si (KR); **Kyihyun Jang**, Suwon-si (KR); **Jaewon Choe**, 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 39 days.

(21) Appl. No.: **17/863,996**

(22) Filed: **Jul. 13, 2022**

(65) **Prior Publication Data**
US 2022/0352632 A1 Nov. 3, 2022

Related U.S. Application Data

(63) Continuation of application No.
PCT/KR2021/000672, filed on Jan. 18, 2021.

(30) **Foreign Application Priority Data**

Jan. 21, 2020 (KR) 10-2020-0007885

(51) **Int. Cl.**
H01Q 5/328 (2015.01)
H01Q 5/335 (2015.01)
H01Q 5/50 (2015.01)

(52) **U.S. Cl.**
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(58) **Field of Classification Search**
CPC H01Q 5/50; H01Q 5/328; H01Q 5/335;
H01Q 1/48; H01Q 9/42; H01Q 9/44;
(Continued)

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Primary Examiner — Hai V Tran

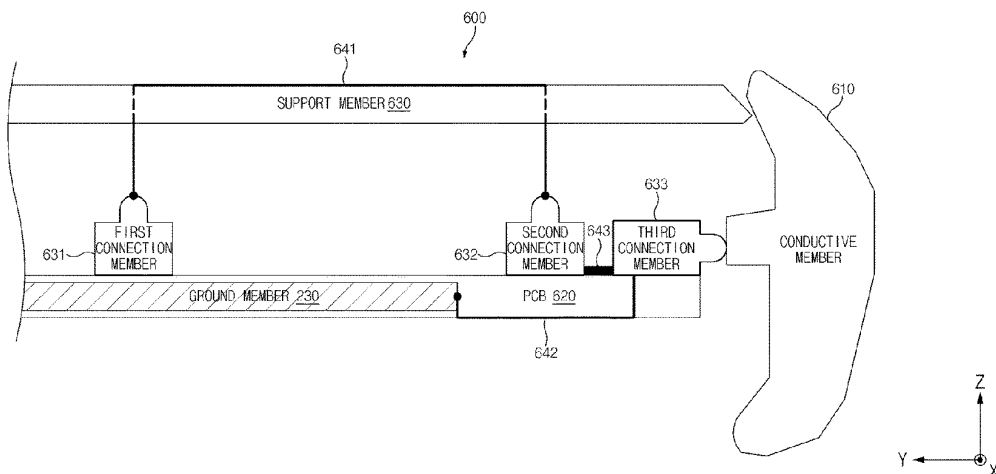
Assistant Examiner — Michael M Bouizza

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

(57) **ABSTRACT**

An electronic device is provided. The electronic device includes a housing including a conductive member on which at least one power supply point and ground point are positioned, at least one ground member arranged inside the housing, a first ground path connecting the ground point to the ground member, a second ground path connecting the ground point to the ground member, a printed circuit board (PCB) arranged inside the housing and a processor arranged on the PCB. The processor is configured to supply power to the at least one power supply point so that the conductive member transmits and/or receives a signal of a first frequency band.

15 Claims, 12 Drawing Sheets





US012218440B2

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

(10) **Patent No.:** **US 12,218,440 B2**
(45) **Date of Patent:** **Feb. 4, 2025**

(54) **ANTENNA STRUCTURE**

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

(72) Inventors: **Tzu-Min Wu**, Hsinchu (TW); **Kuo-Jen Lai**, Hsinchu (TW); **Kuang-Yuan Ku**, Hsinchu (TW); **Hung-Ying Lin**, Hsinchu (TW); **Wen-Tai 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 162 days.

(21) Appl. No.: **18/317,147**

(22) Filed: **May 15, 2023**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Jun. 16, 2022 (TW) 111122401

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

(52) **U.S. Cl.**
CPC **H01Q 9/0414** (2013.01); **H01Q 9/0421** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 9/0414; H01Q 9/0421; H01Q 1/48; H01Q 5/385

See application file for complete search history.

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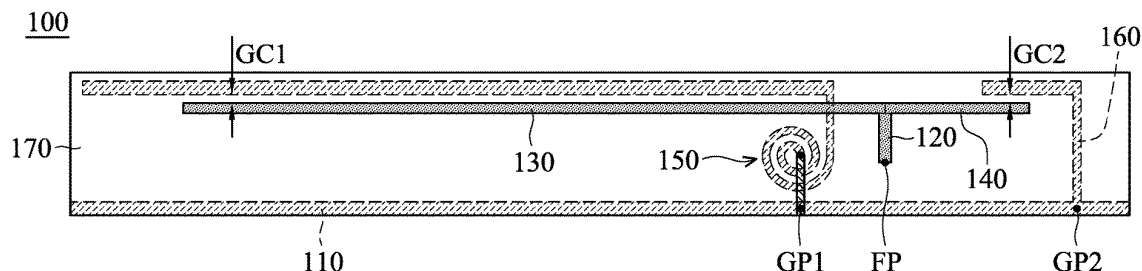
Primary Examiner — Dieu Hien T Duong

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

(57) **ABSTRACT**

An antenna structure includes a ground element, a feeding radiation element, a first radiation element, a second radiation element, a first coupling branch, and a dielectric substrate. The feeding radiation element has a feeding point. The first radiation element is coupled to the feeding radiation element. The second radiation element is coupled to the feeding radiation element. The second radiation element and the first radiation element substantially extend in opposite directions. The first coupling branch is coupled to a first grounding point on the ground element. The first coupling branch extends across the first radiation element. The first coupling branch includes a first coil portion and a first connection portion.

20 Claims, 6 Drawing Sheets





US012224483B2

(12) **United States Patent**
Li

(10) **Patent No.:** **US 12,224,483 B2**
(45) **Date of Patent:** **Feb. 11, 2025**

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

(71) Applicant: **VIVO MOBILE COMMUNICATION CO., LTD.**, Guangdong (CN)

(72) Inventor: **Pengpeng Li**, Guangdong (CN)

(73) Assignee: **VIVO MOBILE COMMUNICATION 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 185 days.

(21) Appl. No.: **17/844,125**

(22) Filed: **Jun. 20, 2022**

(65) **Prior Publication Data**

US 2022/0320714 A1 Oct. 6, 2022

Related U.S. Application Data

(63) Continuation of application No. PCT/CN2020/139592, filed on Dec. 25, 2020.

(30) **Foreign Application Priority Data**

Dec. 27, 2019 (CN) 201911374802.8

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/36 (2006.01)
H01Q 1/50 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/24** (2013.01); **H01Q 1/36** (2013.01); **H01Q 1/50** (2013.01)

(58) **Field of Classification Search**
CPC .. H01Q 1/24; H01Q 1/36; H01Q 1/50; H01Q 5/328; H01Q 5/35; H01Q 9/42; H01Q 1/243

See application file for complete search history.

(56) **References Cited**

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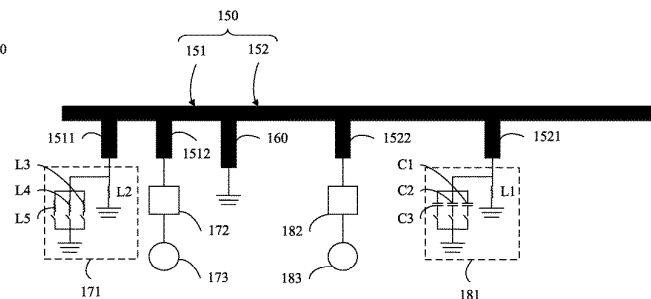
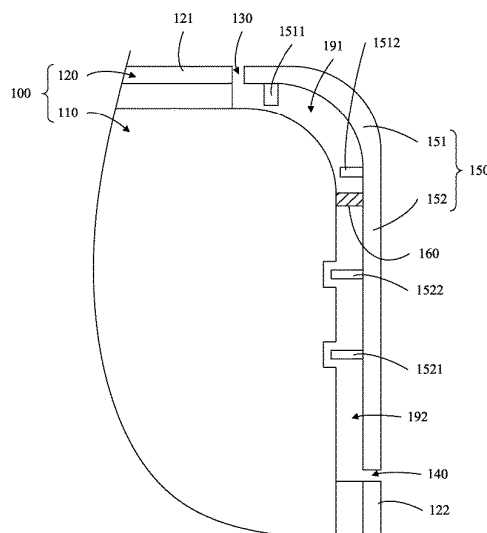
Primary Examiner — Raymond R Chai

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

(57) **ABSTRACT**

An antenna assembly and an electronic device are provided. The antenna assembly includes a rectangular metal frame, where the metal frame includes an inner frame and an outer frame, a first frame of the outer frame is provided with a first gap, a second frame of the outer frame is provided with a second gap, a metal antenna is formed at a part of the outer frame separated between the first gap and the second gap, the metal antenna is connected to the inner frame via a metal connector, a first radiation branch is formed at a part of the metal antenna between the metal connector and the first gap, a second radiation branch is formed at a part of the metal antenna between the metal connector and the second gap.

13 Claims, 2 Drawing Sheets





US012224485B2

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

(10) **Patent No.:** **US 12,224,485 B2**
(45) **Date of Patent:** **Feb. 11, 2025**

(54) **MICROMINIATURIZED ANTENNA FEED
MODULE AND ELECTRONIC DEVICE
USING THE SAME**

(71) Applicant: **FIH CO., LTD.**, New Taipei (TW)

(72) Inventors: **Cho-Kang Hsu**, New Taipei (TW);
Min-Hui Ho, New Taipei (TW);
Wei-Cheng Su, New Taipei (TW);
Yen-Hui Lin, New Taipei (TW)

(73) Assignee: **FIH CO., LTD.**, 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 351 days.

(21) Appl. No.: **17/828,328**

(22) Filed: **May 31, 2022**

(65) **Prior Publication Data**
US 2023/0361450 A1 Nov. 9, 2023

(30) **Foreign Application Priority Data**
May 7, 2022 (CN) 202210490827.X

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

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H04B 1/006**
(2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H04B 1/006
See application file for complete search history.

(56) **References Cited**

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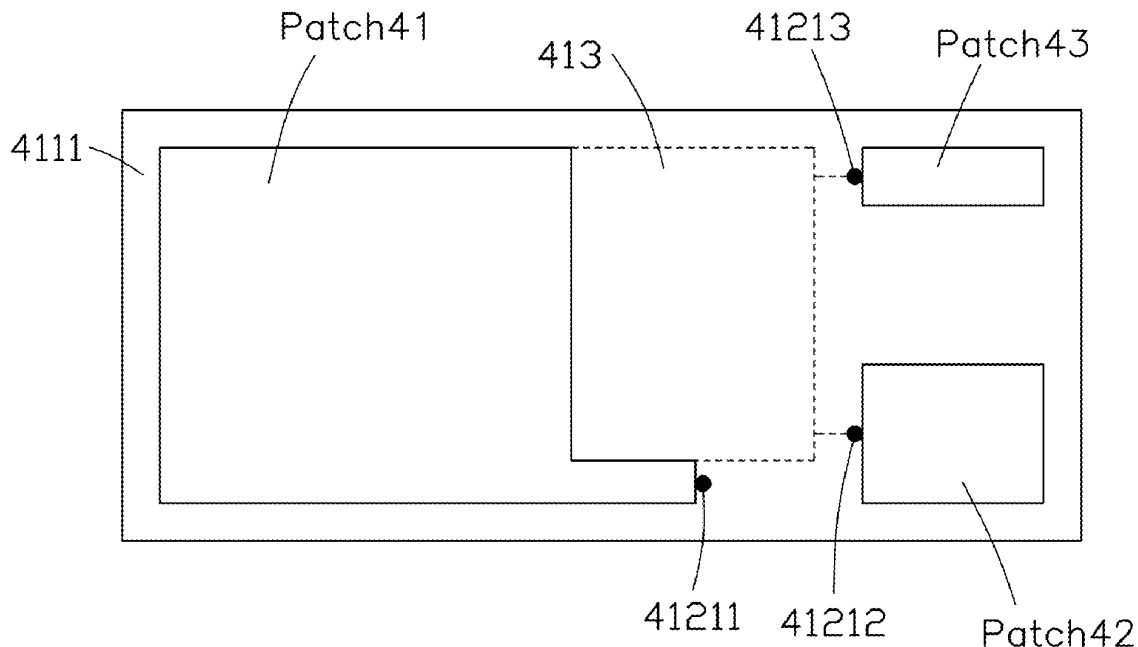
Primary Examiner — Henry Luong

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

(57) **ABSTRACT**

A microminiaturized antenna feed module includes a substrate, a plurality of coupled feed portions, and an active circuit. The substrate defines a plurality of visa penetrating the substrate. The coupled feed portions, made of conductive material and have different coupling areas, are electrically connected to the active circuit through the holes, to feed in electrical signals, the coupled feed portions couple the electrical signals to the metal frame to radiate wireless signals; the active circuit controls the switching of radiation modes of the metal frame. The application also provides an electronic device with the microminiaturized antenna feed module.

18 Claims, 12 Drawing Sheets





US012224504B2

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

(10) **Patent No.:** **US 12,224,504 B2**
(45) **Date of Patent:** **Feb. 11, 2025**

(54) **ANTENNA ARRANGEMENT AND
COMMUNICATION DEVICE**

(56) **References Cited**

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

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343/702

(72) Inventors: **Janne Iivonen**, Helsinki (FI);
Jari-Matti Hannula, Espoo (FI); **Riku
Kormilainen**, Espoo (FI); **Anu
Lehtovuori**, Espoo (FI); **Rasmus
Luomaniemi**, Espoo (FI); **Ville Viikari**,
Espoo (FI); **Alexander Khripkov**,
Helsinki (FI); **Joonas Krogerus**,
Helsinki (FI)

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(73) Assignee: **Huawei Technologies Co., Ltd.**,
Shenzhen (CN)

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No. 3, doi: 10.1109/TAP.2013.2293788, Total 8 pages, Institute of
Electrical and Electronics Engineers, New York, New York (Mar.
2014).

(21) Appl. No.: **17/975,253**

(Continued)

(22) Filed: **Oct. 27, 2022**

Primary Examiner — Hai V Tran

Assistant Examiner — Bamidele A Immanuel

(65) **Prior Publication Data**

US 2023/0118728 A1 Apr. 20, 2023

(74) *Attorney, Agent, or Firm* — Leydig, Voit & Mayer,
Ltd.

Related U.S. Application Data

(63) Continuation of application No.
PCT/EP2020/061638, filed on Apr. 27, 2020.

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

(52) **U.S. Cl.**
CPC **H01Q 9/0414** (2013.01); **H01Q 9/0421**
(2013.01)

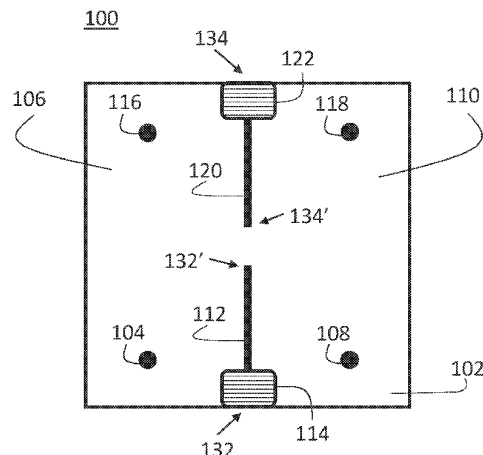
(58) **Field of Classification Search**
CPC H01Q 9/0414; H01Q 9/0421; H01Q 1/243;
H01Q 9/045; H01Q 9/0442; H01Q
9/0407; H01Q 3/36

See application file for complete search history.

(57) **ABSTRACT**

An antenna arrangement for a communication device com-
prises a top conductive patch comprising at least a first
coupling point and a second coupling point coupled to one
or more feed circuits carrying a radio frequency (RF) signal
to or from the top conductive patch. The RF signal has a first
phase in the first coupling point and a second phase in the
second coupling point. A first slot extends in the conductive
patch between the first coupling point and the second
coupling point. The antenna arrangement according enables
a desired current distribution to be realized in the antenna in
a controlled and systematic manner. A communication
device includes such an antenna arrangement.

19 Claims, 8 Drawing Sheets





US012224506B2

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

(10) **Patent No.:** **US 12,224,506 B2**
(45) **Date of Patent:** **Feb. 11, 2025**

(54) **ANTENNA FOR FOLDABLE ELECTRONIC
DEVICE AND FOLDABLE ELECTRONIC
DEVICE**

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

(72) Inventors: **Yuan Zhou**, Shanghai (CN); **Xiaopeng
Liu**, Shenzhen (CN); **Meng Hou**,
Shanghai (CN); **Dong Yu**, Shanghai
(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 90 days.

(21) Appl. No.: **18/044,303**

(22) PCT Filed: **Aug. 5, 2021**

(86) PCT No.: **PCT/CN2021/110863**

§ 371 (c)(1),

(2) Date: **Mar. 7, 2023**

(87) PCT Pub. No.: **WO2022/052690**

PCT Pub. Date: **Mar. 17, 2022**

(65) **Prior Publication Data**

US 2024/0030607 A1 Jan. 25, 2024

(30) **Foreign Application Priority Data**

Sep. 10, 2020 (CN) 202010945216.0

(51) **Int. Cl.**

H01Q 9/04 (2006.01)

G06F 1/16 (2006.01)

(Continued)

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

CPC **H01Q 9/0421** (2013.01); **G06F 1/1616**
(2013.01); **G06F 1/1698** (2013.01);
(Continued)

(58) **Field of Classification Search**

CPC H01Q 9/0421; H01Q 1/2266; H01Q 1/48;
H01Q 1/50; H01Q 13/10; H01Q 15/14;
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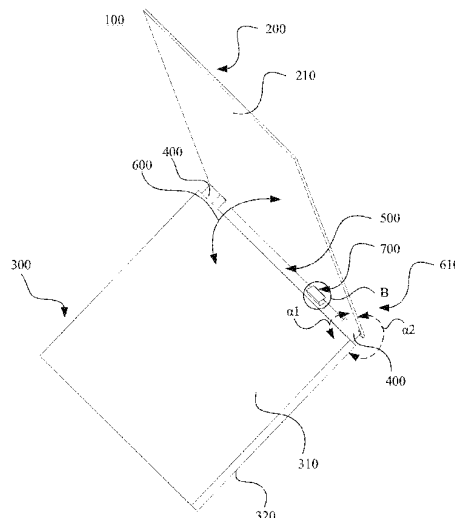
Primary Examiner — Daniel D Chang

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

(57) **ABSTRACT**

A foldable electronic device includes a first housing and a second housing that are rotationally connected to each other by means of rotating shafts located on two sides, and an antenna. The first housing can switch between an unfolded state and a folded state relative to the second housing, and the antenna is disposed in a closed slot. The antenna includes a first antenna segment and a second antenna segment that are sequentially connected and disposed in a length direction of the antenna. One end of the first antenna segment is connected to a ground plate of the first housing. The first antenna segment extends from one end toward a direction in which an opening/closing region of the first housing and the second housing in the unfolded state is away from the first housing.

20 Claims, 31 Drawing Sheets





US012224507B2

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

(10) **Patent No.:** **US 12,224,507 B2**
(45) **Date of Patent:** **Feb. 11, 2025**

(54) **ANTENNA AND DISPLAY APPARATUS**

(56) **References Cited**

(71) Applicants: **Beijing BOE Technology Development Co., Ltd.**, Beijing (CN); **BOE Technology Group Co., Ltd.**, Beijing (CN)

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343/700 MS

(72) Inventors: **Yali Wang**, Beijing (CN); **Feng Qu**, Beijing (CN)

(73) Assignees: **Beijing BOE Technology Development Co., Ltd.**, Beijing (CN); **BOE Technology Group Co., Ltd.**, Beijing (CN)

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

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(21) Appl. No.: **17/760,258**

(22) PCT Filed: **Nov. 17, 2021**

(86) PCT No.: **PCT/CN2021/131071**

§ 371 (c)(1),

(2) Date: **Aug. 5, 2022**

Primary Examiner — Hai V Tran

(74) *Attorney, Agent, or Firm* — Intellectual Valley Law, P.C.

(87) PCT Pub. No.: **WO2023/087162**

PCT Pub. Date: **May 25, 2023**

(65) **Prior Publication Data**

US 2024/0186703 A1 Jun. 6, 2024

(51) **Int. Cl.**

H01Q 9/04 (2006.01)

H01Q 1/22 (2006.01)

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

CPC **H01Q 9/0428** (2013.01); **H01Q 1/22** (2013.01); **H01Q 9/04** (2013.01)

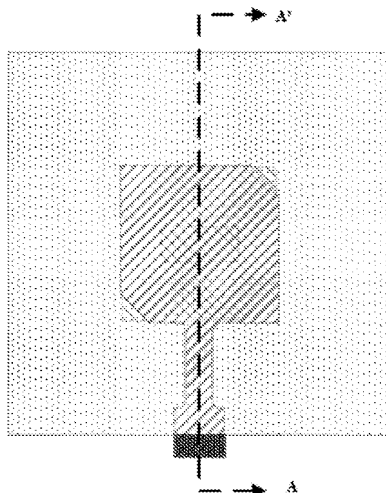
(58) **Field of Classification Search**

CPC H01Q 9/0428; H01Q 1/22; H01Q 9/04
See application file for complete search history.

(57) **ABSTRACT**

An antenna is provided. The antenna includes a ground plate, and a slot extending through the ground plate; a first dielectric layer on the ground plate and the slot; a microstrip feed line and a first radiating patch on a side of the first dielectric layer away from the ground plate, the first radiating patch being coupled to the microstrip feed line and configured to receive a signal from the microstrip feed line; a second dielectric layer on a side of the ground plate and the slot away from the first dielectric layer, the first radiating patch, and the microstrip feed line; and a second radiating patch on a side of the second dielectric layer away from the ground plate, the second radiating patch being configured to receive a signal by aperture coupling through the slot.

19 Claims, 37 Drawing Sheets





US012224508B2

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

(10) **Patent No.:** **US 12,224,508 B2**
(45) **Date of Patent:** **Feb. 11, 2025**

(54) **ZERO-CLEARANCE FIFTH-GENERATION (5G) ULTRA-WIDEBAND (UWB) MULTIPLE-INPUT MULTIPLE-OUTPUT (MIMO) ANTENNA**

(71) Applicant: **Anhui University**, Hefei (CN)

(72) Inventors: **Lixia Yang**, Hefei (CN); **Zhanhao Zhang**, Hefei (CN); **Aidi Ren**, Hefei (CN); **Haoran Yu**, Hefei (CN)

(73) Assignee: **Anhui University**, Hefei (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 141 days.

(21) Appl. No.: **17/970,559**

(22) Filed: **Oct. 20, 2022**

(65) **Prior Publication Data**

US 2023/0130277 A1 Apr. 27, 2023

(30) **Foreign Application Priority Data**

Oct. 21, 2021 (CN) 202111229025.5

(51) **Int. Cl.**
H01Q 9/06 (2006.01)
H01Q 13/10 (2006.01)
H01Q 21/00 (2006.01)
H04B 7/0413 (2017.01)

(52) **U.S. Cl.**
CPC **H01Q 9/065** (2013.01); **H01Q 13/106** (2013.01); **H01Q 21/0006** (2013.01); **H04B 7/0413** (2013.01)

(58) **Field of Classification Search**
CPC .. H01Q 9/065; H01Q 13/106; H01Q 21/0006; H04B 7/0413

See application file for complete search history.

(56) **References Cited**

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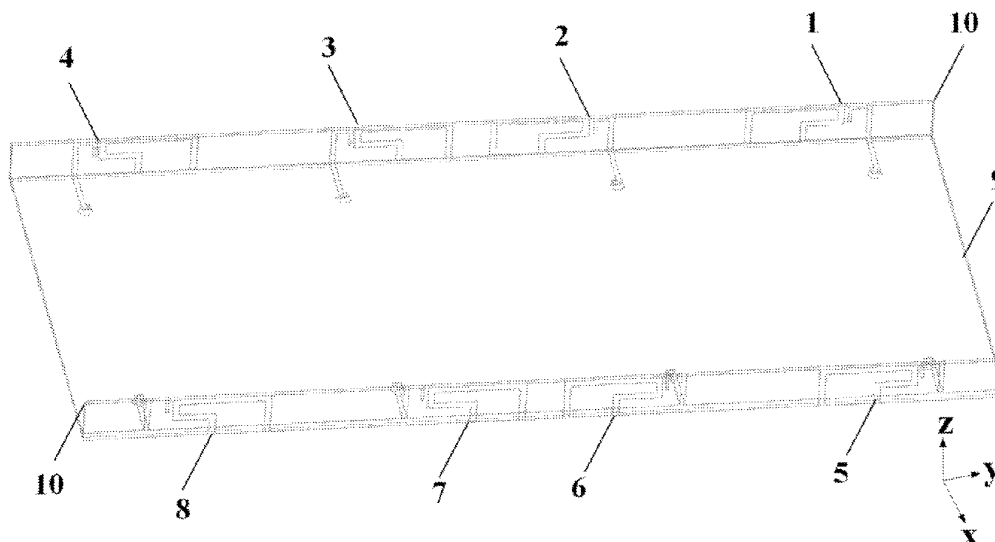
Primary Examiner — Jimmy T Vu

(74) *Attorney, Agent, or Firm* — NOD Law PC

(57) **ABSTRACT**

Provided is a zero-clearance fifth-generation (5G) ultra-wideband (UWB) Multiple-Input Multiple-Output (MIMO) antenna, including a main dielectric substrate, lateral dielectric substrates, and multiple antenna elements, where the lateral dielectric substrates are arranged at two sides of the main dielectric substrate; the multiple antenna elements are arranged on the lateral dielectric substrates; the antenna elements each include a feeding element and a grounding radiator element; the feeding element is provided at an inner side of each of the lateral dielectric substrates; and the grounding radiator element is provided at an outer side of the lateral dielectric substrate. Under a combined action of the feeding element and the grounding radiator element, the present disclosure forms a dual-resonant antenna structure to effectively cover N77, N78, N79 and 5G wireless local area network bands in 5G mobile communication, and achieves the desirable antenna efficiency as well as desirable isolation and ECC between the antenna elements.

6 Claims, 7 Drawing Sheets





US012225663B2

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

(10) **Patent No.:** **US 12,225,663 B2**
(45) **Date of Patent:** **Feb. 11, 2025**

(54) **ANTENNA STRUCTURE AND DISPLAY
DEVICE INCLUDING THE SAME**

(71) Applicant: **DONGWOO FINE-CHEM CO.,
LTD.**, Jeollabuk-do (KR)

(72) Inventors: **Na Yeon Kim**, Seoul (KR); **Dae Kyu
Kim**, Gyeonggi-do (KR); **Han Sub
Ryu**, Gyeongsangbuk-do (KR)

(73) Assignee: **DONGWOO FINE-CHEM CO.,
LTD.**, Jeollabuk-Do (KR)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 187 days.

(21) Appl. No.: **18/131,984**

(22) Filed: **Apr. 7, 2023**

(65) **Prior Publication Data**
US 2023/0328887 A1 Oct. 12, 2023

(30) **Foreign Application Priority Data**
Apr. 8, 2022 (KR) 10-2022-0043925

(51) **Int. Cl.**
H05K 1/11 (2006.01)
H01Q 1/38 (2006.01)
H01Q 1/24 (2006.01)

(52) **U.S. Cl.**
CPC **H05K 1/119** (2013.01); **H01Q 1/38**
(2013.01); **H01Q 1/243** (2013.01); **H05K**
2201/10098 (2013.01)

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

(56) **References Cited**

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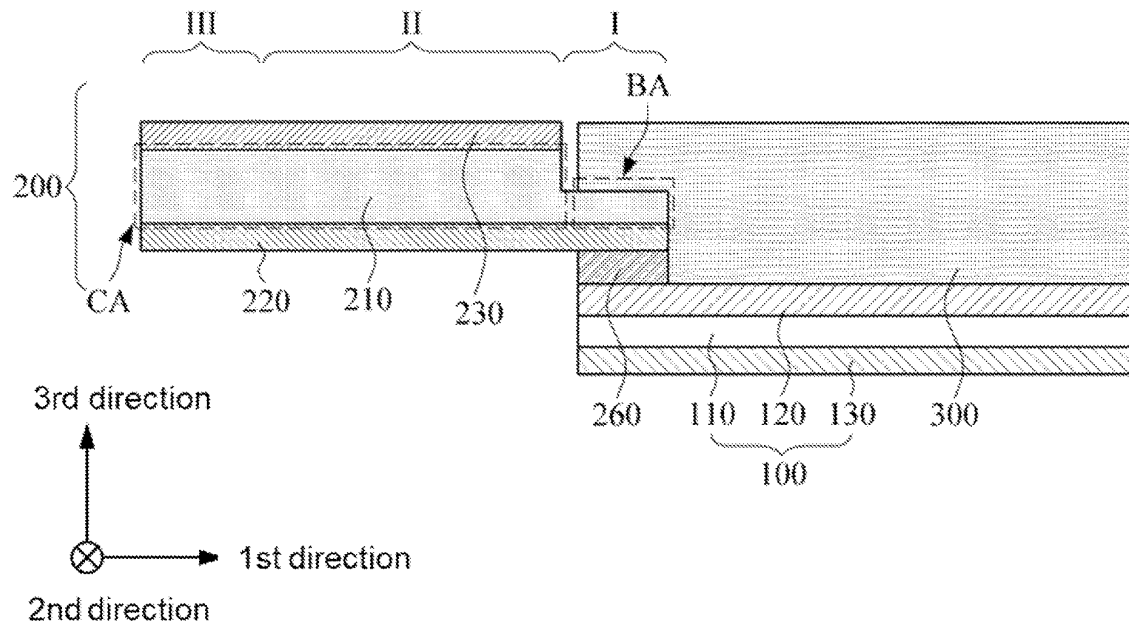
Primary Examiner — Wilson Lee

(74) *Attorney, Agent, or Firm* — The PL Law Group,
PLLC

(57) **ABSTRACT**

An antenna structure according to an embodiment includes an antenna device, a circuit board connected to the antenna device and including an inner insulation layer, and an outer insulation layer formed on the antenna device to cover the antenna unit and a portion of the circuit board. A portion of the inner insulation layer covered by the outer insulation layer may have a smaller thickness than a thickness of a portion of the inner insulation layer not covered by the outer insulation layer.

15 Claims, 5 Drawing Sheets





US012230896B2

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

(10) **Patent No.:** **US 12,230,896 B2**
(45) **Date of Patent:** **Feb. 18, 2025**

(54) **ANTENNA STRUCTURE AND ELECTRONIC
DEVICE USING THE SAME**

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

(72) Inventors: **Cho-Kang Hsu, 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 296 days.

(21) Appl. No.: **17/839,709**

(22) Filed: **Jun. 14, 2022**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Jun. 21, 2021 (CN) 202110688067.9

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/35 (2015.01)
H01Q 9/42 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 5/35** (2015.01); **H01Q 1/243**
(2013.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 5/20; H01Q 5/35;
H01Q 5/50; H01Q 9/42
See application file for complete search history.

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Primary Examiner — Daniel Munoz

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

(57) **ABSTRACT**

An antenna structure includes at least one radiation portion, first, second, and third feed sources, and first and second grounding portions. The at least one radiation portion is formed by a partial portion of the metal frame of the electronic device, the portion being defined by gaps. The first to third feed sources are arranged at intervals and are electrically connected to the at least one radiation portion in such a way as to make the radiation portion form a plurality of antennas. The first end of the first grounding portion is electrically connected to the radiation portion, the second end of the first grounding portion is grounded, the first end of the second grounding portion is electrically connected to the radiation portion, and the second end of the second grounding portion is grounded. The present disclosure also provides an electronic device with the antenna structure.

16 Claims, 11 Drawing Sheets

