US011936098B2

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

(10) **Patent No.: US 11,936,098 B2**
(45) **Date of Patent: Mar. 19, 2024**

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

(71) Applicant: **REALTEK SEMICONDUCTOR CORPORATION**, Hsinchu (TW)

(72) Inventors: **Ching-Wei Ling**, Hsinchu (TW); **Chih-Pao Lin**, Hsinchu (TW)

(73) Assignee: **REALTEK SEMICONDUCTOR 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 31 days.

(21) Appl. No.: **17/549,344**

(22) Filed: **Dec. 13, 2021**

(65) **Prior Publication Data**

US 2023/0058737 A1 Feb. 23, 2023

(30) **Foreign Application Priority Data**

Aug. 23, 2021 (TW) 110131145

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/52 (2006.01)
H01Q 9/04 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/521*** (2013.01); ***H01Q 9/0421*** (2013.01)

(58) **Field of Classification Search**
CPC .. H01Q 1/24; H01Q 1/52; H01Q 9/04; H01Q 1/243; H01Q 1/48; H01Q 1/521–523; H01Q 9/0421
See application file for complete search history.

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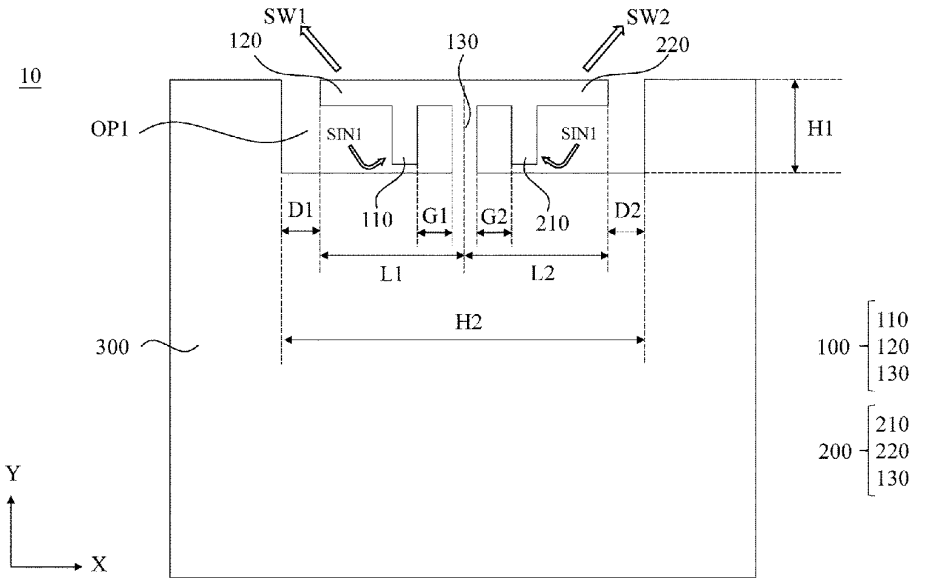
Primary Examiner — Hasan Islam
(74) *Attorney, Agent, or Firm* — WPAT, P.C.; Anthony King

(57) **ABSTRACT**

An antenna structure includes a first resonant unit and a second resonant unit. The first resonant unit is configured to transmit an input signal as a first wireless signal. The second resonant unit is configured to transmit the input signal as a second wireless signal. The first resonant unit and the second resonant unit have a substantially identical operating band, and the first resonant unit and the second resonant unit are a single continuous metal structure.

17 Claims, 9 Drawing Sheets



US011936099B2

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

(10) **Patent No.: US 11,936,099 B2**
(45) **Date of Patent: Mar. 19, 2024**

(54) **ELECTRONIC DEVICE INCLUDING ANTENNA**

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

(72) Inventors: **Ungryeol Lee**, Suwon-si (KR); **Heiseong Kwak**, Suwon-si (KR); **Myeonggeun Kim**, 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 119 days.

(21) Appl. No.: **17/587,842**

(22) Filed: **Jan. 28, 2022**

(65) **Prior Publication Data**

US 2022/0247070 A1 Aug. 4, 2022

Related U.S. Application Data

(63) Continuation of application No. PCT/KR2022/000746, filed on Jan. 14, 2022.

(30) **Foreign Application Priority Data**

Jan. 29, 2021 (KR) 10-2021-0013496

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

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/523*** (2013.01); ***H01Q 3/24*** (2013.01); ***H04B 1/0064*** (2013.01); ***H04M 1/0214*** (2013.01)

(58) **Field of Classification Search**
CPC .. H01Q 1/243; H01Q 1/521–523; H01Q 3/24; H04B 1/0064
See application file for complete search history.

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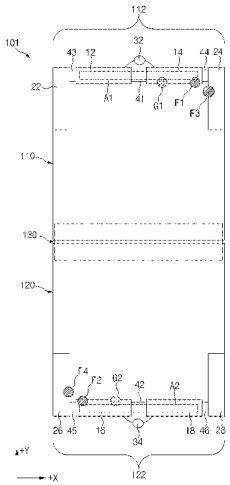
Primary Examiner — Hasan Islam

(57) **ABSTRACT**

An electronic device is provided. The electronic device may include a first housing including a first conductive part and a second conductive part spaced apart from the first conductive part, a second housing including a third conductive part and a fourth conductive part spaced apart from the third conductive part, a connection structure connected to the first housing and the second housing, respectively, a first switch to selectively and electrically connect the first conductive part to the second conductive part, a second switch to selectively and electrically connect the third conductive part to the fourth conductive part, a first connection to electrically connect the first conductive part to the third conductive part in the first state of the electronic device, a second connection to electrically connect the second conductive part to the fourth conductive part in the first state and a wireless communication circuit.

20 Claims, 16 Drawing Sheets



US011942700B2

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

(10) **Patent No.: US 11,942,700 B2**
(45) **Date of Patent: Mar. 26, 2024**

(54) **ANTENNA APPARATUS AND WIRELESS COMMUNICATION APPARATUS**

(71) Applicant: **FCNT LIMITED**, Yamato (JP)

(72) Inventors: **Takahiro Shinojima**, Yamato (JP); **Yohei Koga**, Yamato (JP); **Satoshi Sakita**, Yamato (JP); **Tabito Tonooka**, Yamato (JP); **Yasumitsu Ban**, Yamato (JP); **Manabu Yoshikawa**, Yamato (JP)

(73) Assignee: **FCNT LIMITED**, Yamato (JP)

(*) 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.: **17/725,758**

(22) Filed: **Apr. 21, 2022**

(65) **Prior Publication Data**

US 2022/0247080 A1 Aug. 4, 2022

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2019/041491, filed on Oct. 23, 2019.

(51) **Int. Cl.**
H01Q 5/35 (2015.01)
H01Q 5/357 (2015.01)
H01Q 7/00 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 7/00*** (2013.01); ***H01Q 5/357*** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 7/00; H01Q 5/357
USPC 343/713
See application file for complete search history.

(56) **References Cited**

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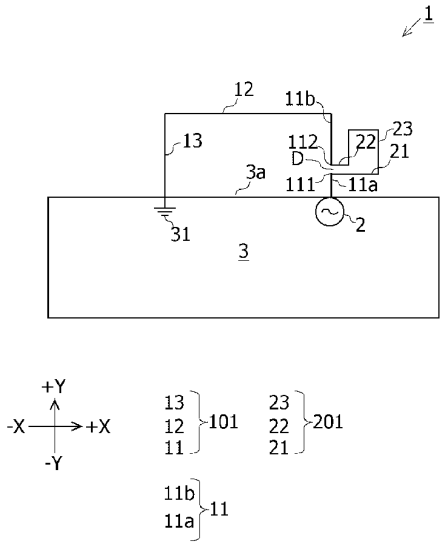
Primary Examiner — Peguy Jean Pierre
(74) *Attorney, Agent, or Firm* — WHDA, LLP

(57) **ABSTRACT**

An antenna apparatus includes a ground substrate, a feeding point provided on the ground substrate, a first loop antenna of which one end is electrically connected to the feeding point and of which another end is electrically connected to the ground substrate and moreover which operates at a first frequency, and a second loop antenna of which both ends are respectively connected to a first end point and a second end point of the first loop antenna and which operates at a second frequency. A space between the first end point and the second end point forms a gap with a range in which the first loop antenna is capable of resonating at the first frequency.

12 Claims, 16 Drawing Sheets



US011942704B2

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

(10) **Patent No.: US 11,942,704 B2**
(45) **Date of Patent: Mar. 26, 2024**

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

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

(72) Inventors: **Sumin Yun**, Suwon-si (KR); **Hosaeng Kim**, Suwon-si (KR); **Seongjin Park**, Suwon-si (KR); **Woomin Jang**, Suwon-si (KR); **Jehun Jong**, Suwon-si (KR); **Jaehoon Jo**, 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 234 days.

(21) Appl. No.: **17/584,981**

(22) Filed: **Jan. 26, 2022**

(65) **Prior Publication Data**

US 2022/0231420 A1 Jul. 21, 2022

Related U.S. Application Data

(63) Continuation of application No. PCT/KR2022/000638, filed on Jan. 13, 2022.

(30) **Foreign Application Priority Data**

Jan. 20, 2021 (KR) 10-2021-0007832

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/44 (2006.01)
H01Q 9/04 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 9/0421*** (2013.01); ***H01Q 1/44*** (2013.01); *H01Q 1/243* (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/0421; H01Q 1/528; H01Q 1/44; H01Q 1/243
(Continued)

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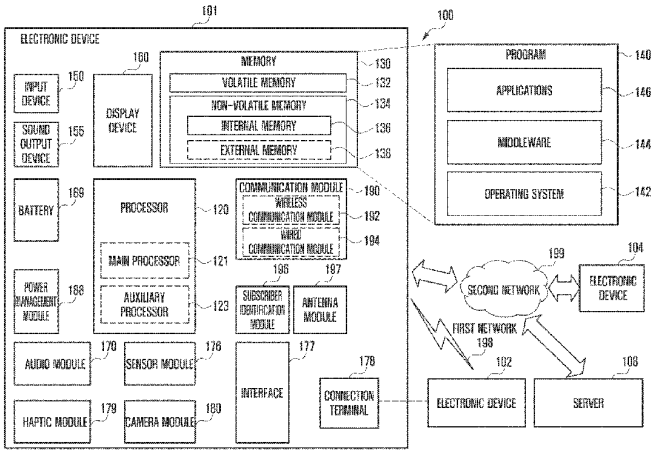
Primary Examiner — Peguy Jean Pierre
(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

(57) **ABSTRACT**

An electronic device is provided that includes a housing, an antenna structure, an electronic component, and a wireless communication circuit. The antenna structure includes a substrate, at least one conductive patch disposed at the substrate, at least one power feeder disposed at a position of the at least one conductive patch, and at least one electrical connection structure. The at least one electrical connection structure includes a first conductive via disposed to pass through the at least one conductive patch and a ground layer of the substrate, and a second conductive via passing through the at least one conductive patch and electrically connected to the ground layer. The electronic component is disposed to overlap at least in part with the at least one conductive patch when the substrate is viewed from above, and is electrically connected to a main board through the at least one electrical connection structure. The wireless communication circuit is electrically connected to the at least one power feeder, and is configured to form a beam pattern in a first direction through the at least one conductive patch.

20 Claims, 36 Drawing Sheets



US011949177B2

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

(10) **Patent No.: US 11,949,177 B2**
(45) **Date of Patent: Apr. 2, 2024**

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

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

(72) Inventors: **Yan Wang**, Shenzhen (CN); **Chien-Ming Lee**, Shenzhen (CN); **Jikang Wang**, Shanghai (CN); **Jiaqing You**, Shanghai (CN); **Hanyang Wang**, Reading (GB)

(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 305 days.

(21) Appl. No.: **17/433,770**

(22) PCT Filed: **Feb. 10, 2020**

(86) PCT No.: **PCT/CN2020/074578**
§ 371 (c)(1),
(2) Date: **Aug. 25, 2021**

(87) PCT Pub. No.: **WO2020/173292**
PCT Pub. Date: **Sep. 3, 2020**

(65) **Prior Publication Data**

US 2022/0140486 A1 May 5, 2022

(30) **Foreign Application Priority Data**

Feb. 27, 2019 (CN) 201910146577.6
Jul. 8, 2019 (CN) 201910614002.2

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

(52) **U.S. Cl.**
CPC ***H01Q 9/42*** (2013.01); ***H01Q 5/371*** (2015.01); *H01Q 1/242* (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/42; H01Q 5/371; H01Q 5/378; H01Q 5/335; H01Q 1/22; H01Q 1/2266;
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(56) **References Cited**

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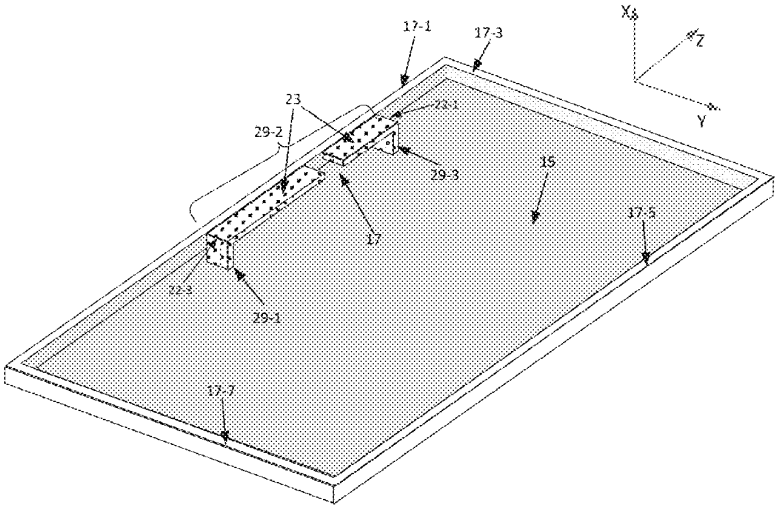
Primary Examiner — Hoang V Nguyen
(74) *Attorney, Agent, or Firm* — Conley Rose, P.C.

(57) **ABSTRACT**

An antenna has an exciting element disposed above a ground plane of an electronic device. Power fed to the exciting element excites the ground plane to generate radiation. In this way, radiation capability of the ground plane is not affected by clearance between a display screen and the ground plane, and the antenna is applicable to an electronic device with limited antenna space. In addition, the ground plane serves as a radiation aperture of the electronic device.

18 Claims, 38 Drawing Sheets



US011955695B2

(12) **United States Patent**
Cao

(10) **Patent No.: US 11,955,695 B2**
(45) **Date of Patent: Apr. 9, 2024**

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

(71) Applicant: **BEIJING XIAOMI MOBILE SOFTWARE CO., LTD.**, Beijing (CN)

(72) Inventor: **Heng Cao**, Beijing (CN)

(73) Assignee: **BEIJING XIAOMI MOBILE SOFTWARE CO., LTD.**, Beijing (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 190 days.

(21) Appl. No.: **17/383,411**

(22) Filed: **Jul. 22, 2021**

(65) **Prior Publication Data**

US 2022/0311124 A1 Sep. 29, 2022

(30) **Foreign Application Priority Data**

Mar. 23, 2021 (CN) 202110309263.0

(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H01Q 9/04	(2006.01)
H04B 1/00	(2006.01)
H04M 1/02	(2006.01)

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

CPC ***H01Q 1/243*** (2013.01); ***H01Q 9/0442*** (2013.01); ***H04B 1/006*** (2013.01); ***H04M 1/026*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 9/0442; H01Q 1/44; H01Q 5/371; H01Q 5/392; H01Q 9/42; H01Q 1/36; H01Q 5/28; H04B 1/006; H04M 1/026

See application file for complete search history.

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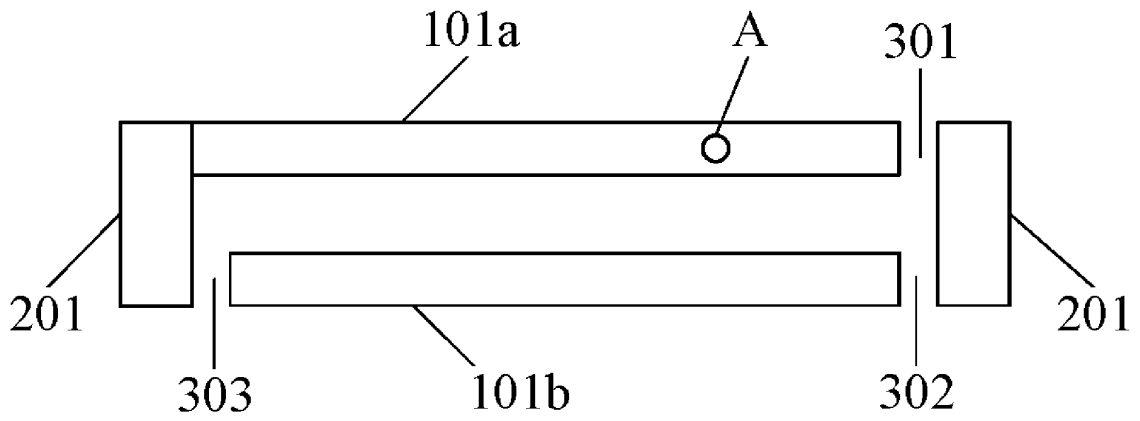
Primary Examiner — Hai V Tran
Assistant Examiner — Michael M Bouizza
(74) *Attorney, Agent, or Firm* — Syncoda LLC; Feng Ma

(57) **ABSTRACT**

An antenna module includes: a middle frame, wherein a bezel of the middle frame is provided with an opening for providing a functional module, the bezel is formed with a first conductive strip on one side of the opening, and the bezel is formed with a second conductive strip on the other side of the opening, wherein the first conductive strip and/or the second conductive strip is/are connected to a feed line, to be used as an antenna radiator for transmitting and receiving radio signals. The first conductive strip and the second conductive strip are formed by the bezel at the opening for providing the functional module, to transmit and receive the radio signals, such that the bezel at the opening can be multiplexed to transmit and receive the radio signals in a case that space is limited.

20 Claims, 8 Drawing Sheets



US011955699B2

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

(10) **Patent No.: US 11,955,699 B2**
(45) **Date of Patent: Apr. 9, 2024**

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

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

(72) Inventors: **Mincheol Seo**, Suwon-si (KR); **Donghun Shin**, Suwon-si (KR); **Minkyung Lee**, Suwon-si (KR); **Jiho Kim**, Suwon-si (KR); **Sunghyup Lee**, Suwon-si (KR); **Kyihyun Jang**, Suwon-si (KR); **Huiwon Cho**, 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 283 days.

(21) Appl. No.: **17/568,128**

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

(65) **Prior Publication Data**

US 2022/0216595 A1 Jul. 7, 2022

Related U.S. Application Data

(63) Continuation of application No. PCT/KR2021/019038, filed on Dec. 15, 2021.

(30) **Foreign Application Priority Data**

Jan. 4, 2021 (KR) 10-2021-0000462

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

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

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

(56) **References Cited**

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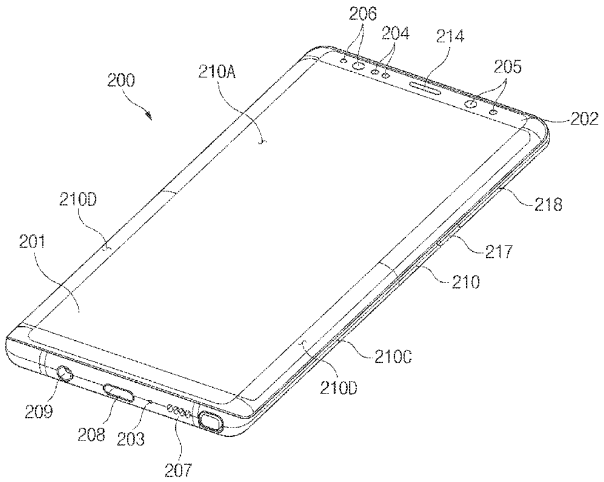
International Search Report dated Mar. 29, 2022, issued in International Application No. PCT/KR2021/019038.

Primary Examiner — April G Gonzales
(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

(57) **ABSTRACT**

An electronic device is provided. The electronic device includes a housing including a side member, a support member, a display, an antenna module including one or more patch antennas, a printed circuit board (PCB), a wireless communication circuit disposed on the PCB, a first conductive member, a first connector, a second connector, and a protrusion extending from the first end of the first conductive member toward an interior of the housing, and electrically connected to the first conductive member. The antenna module is disposed at locations corresponding to a first opening defined by the first conductive member, the support member, the first connector, and the second connector, and a second opening defined by the first conductive member, the support member, the first connector, and the protrusion, and the wireless communication circuit is electrically connected to the protrusion and the antenna module.

20 Claims, 14 Drawing Sheets



US011955704B2

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

(10) **Patent No.: US 11,955,704 B2**
(45) **Date of Patent: Apr. 9, 2024**

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

(71) Applicants: **DONGWOO FINE-CHEM CO., LTD.**, Jeollabuk-do (KR); **POSTECH RESEARCH AND BUSINESS DEVELOPMENT FOUNDATION**, Gyeongsangbuk-do (KR)

(72) Inventors: **Yoon Ho Huh**, Seoul (KR); **Jong Min Kim**, Gyeonggi-do (KR); **Han Sub Ryu**, Gyeongsangbuk-do (KR); **Won Bin Hong**, Seoul (KR)

(73) Assignees: **DONGWOO FINE-CHEM CO., LTD.**, Jeollabuk-do (KR); **POSTECH RESEARCH AND BUSINESS DEVELOPMENT FOUNDATION**, Gyeongsangbuk-do (KR)

(*) 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.: **17/492,903**

(22) Filed: **Oct. 4, 2021**

(65) **Prior Publication Data**

US 2022/0029280 A1 Jan. 27, 2022

Related U.S. Application Data

(63) Continuation of application No. PCT/KR2020/004487, filed on Apr. 2, 2020.

(30) **Foreign Application Priority Data**

Apr. 4, 2019 (KR) 10-2019-0039637

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 1/44 (2006.01)

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

(58) **Field of Classification Search**
CPC H01Q 1/38; H01Q 1/44; H01Q 1/364; H01Q 1/523; H01Q 19/005; H01Q 21/08; H01Q 1/22
See application file for complete search history.

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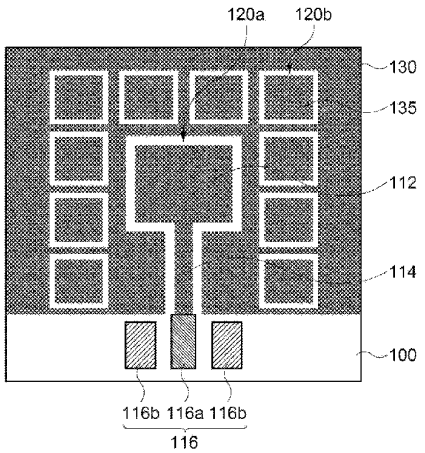
Primary Examiner — Daniel D Chang
(74) *Attorney, Agent, or Firm* — The PL Law Group, PLLC

(57) **ABSTRACT**

An antenna device according to an embodiment of the present invention includes a dielectric layer, an antenna unit disposed on a top surface of the dielectric layer, the antenna unit including a radiator and a transmission line connected to the radiator, a dummy electrode separated from the antenna unit on the top surface of the dielectric layer, the dummy electrode at least partially surrounding the antenna unit, and a blocking pattern arranged around the antenna unit
(Continued)



US011955707B2

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

(10) **Patent No.: US 11,955,707 B2**
(45) **Date of Patent: Apr. 9, 2024**

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

(71) Applicant: **PEGATRON CORPORATION**, Taipei (TW)

(72) Inventors: **Chao-Hsu Wu**, Taipei (TW); **Hau Yuen Tan**, Taipei (TW); **Chien-Yi Wu**, Taipei (TW); **Shih-Keng Huang**, Taipei (TW); **Cheng-Hsiung Wu**, Taipei (TW); **Ching-Hsiang Ko**, Taipei (TW)

(73) Assignee: **PEGATRON 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 102 days.

(21) Appl. No.: **17/724,398**

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

(65) **Prior Publication Data**

US 2022/0352625 A1 Nov. 3, 2022

(51) **Int. Cl.**
H01Q 1/48 (2006.01)
H01Q 1/02 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/48*** (2013.01); ***H01Q 1/02*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/38; H01Q 1/48; H01Q 1/243; H01Q 1/2266; H01Q 1/2291; H01Q 5/328; H01Q 5/335; H01Q 5/371; H01Q 5/378
See application file for complete search history.

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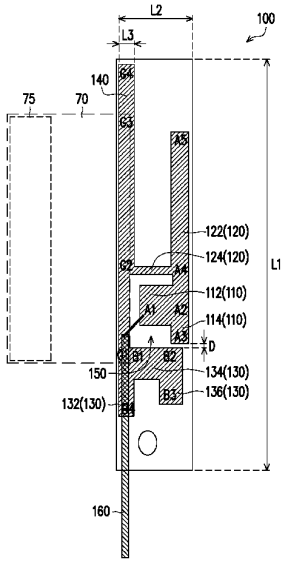
Primary Examiner — Tung X Le
(74) *Attorney, Agent, or Firm* — J.C. PATENTS

(57) **ABSTRACT**

An antenna module includes first to third radiators and a ground radiator. The first radiator includes first and second sections and excites at a first frequency band. An extension direction of the first section, including a feeding end, is not parallel to an extension direction of the second section. The second radiator includes third and fourth sections. The third section extends from an intersection of the first and second sections. The third section excites at a second frequency band. The third radiator is disposed beside the first radiator and away from the second radiator. The ground radiator is disposed on one side of the first, second, and third radiators, and includes a ground end. The fourth section of the second radiator is connected to the third section and the ground radiator. The third radiator is connected to the ground end.

10 Claims, 5 Drawing Sheets



US011955736B2

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

(10) **Patent No.: US 11,955,736 B2**
(45) **Date of Patent: Apr. 9, 2024**

(54) **ANTENNA, WIRELESS COMMUNICATION MODULE, AND WIRELESS COMMUNICATION DEVICE**

(71) Applicant: **KYOCERA CORPORATION**, Kyoto (JP)

(72) Inventors: **Hiromichi Yoshikawa**, Yokohama (JP); **Nobuki Hiramatsu**, Yokohama (JP); **Masamichi Yonehara**, Yokohama (JP)

(73) Assignee: **KYOCERA CORPORATION**, Kyoto (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 297 days.

(21) Appl. No.: **17/621,238**

(22) PCT Filed: **Jun. 23, 2020**

(86) PCT No.: **PCT/JP2020/024626**
§ 371 (c)(1),
(2) Date: **Dec. 21, 2021**

(87) PCT Pub. No.: **WO2020/262384**
PCT Pub. Date: **Dec. 30, 2020**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Jun. 25, 2019 (JP) 2019-117743

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

(52) **U.S. Cl.**
CPC ***H01Q 9/0471*** (2013.01); ***H01Q 1/24*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/36*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 9/0471; H01Q 9/04; H01Q 1/243; H01Q 1/24; H01Q 1/38; H01Q 1/36; H01Q 1/42; H01Q 15/006
(Continued)

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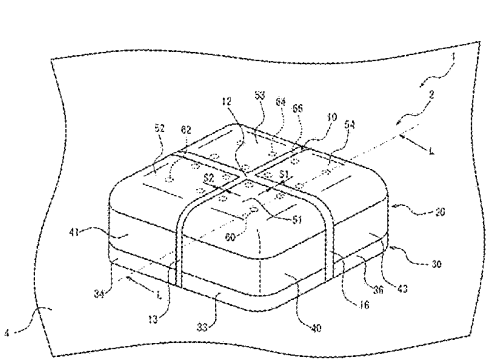
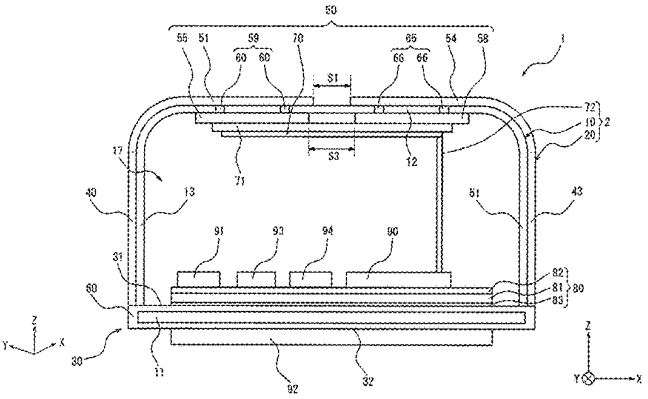
Primary Examiner — Hai V Tran
(74) *Attorney, Agent, or Firm* — HAUPTMAN HAM, LLP

(57) **ABSTRACT**

An antenna includes a housing, a first conductor group, and a power supply line. The housing includes a first surface including at least three first corner portions, a second surface including at least three second corner portions and facing the first surface, and a side surface connecting the first and second surfaces. A housing portion is surrounded by the first, second and side surfaces. The first conductor group includes a first conductor extending along the first surface, at least three second conductors separated from one another, and a second conductor group. The second conductors extend along the side surface from the first corner portions to the second corner portions and are electrically connected to the first conductor. The second conductor group extends along the second surface and capacitively couples the at least three
(Continued)





US011955738B2

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

(10) **Patent No.: US 11,955,738 B2**
(45) **Date of Patent: Apr. 9, 2024**

(54) **ANTENNA**

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

(72) Inventors: **Jinjin Shao**, Wuhan (CN); **Zhongyang Yu**, Shenzhen (CN)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 553 days.

(21) Appl. No.: **17/155,761**

(22) Filed: **Jan. 22, 2021**

(65) **Prior Publication Data**

US 2021/0143552 A1 May 13, 2021

Related U.S. Application Data

(63) Continuation of application No. PCT/CN2018/099115, filed on Aug. 7, 2018.

(51) **Int. Cl.**
H01Q 9/42 (2006.01)
H01Q 5/371 (2015.01)
H01Q 11/14 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 9/42*** (2013.01); ***H01Q 5/371*** (2015.01); ***H01Q 11/14*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/285; H01Q 3/44; H01Q 5/49; H01Q 19/30; H01Q 1/523; H01Q 9/16; H01Q 21/065
See application file for complete search history.

(56) **References Cited**

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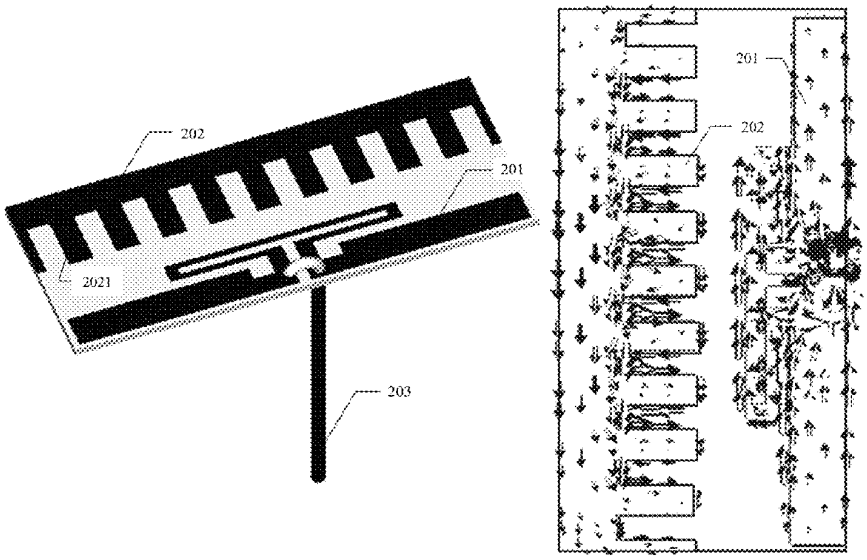
Primary Examiner — Ricardo I Magallanes
(74) *Attorney, Agent, or Firm* — Fish & Richardson P.C.

(57) **ABSTRACT**

The present disclosure relates to antenna. One example antenna includes a radiating element, a reflecting element, and a radio frequency coaxial cable. The radiating element and the reflecting element are located on a same plane, and the radiating element is connected to the radio frequency coaxial cable. The reflecting element is of a comb structure, the comb structure includes at least two comb teeth, sizes of all the comb teeth are the same, intervals between every two adjacent comb teeth are the same, and a comb-like opening face of the reflecting element is opposite to the radiating element.

20 Claims, 10 Drawing Sheets



US011962068B2

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

(10) **Patent No.: US 11,962,068 B2**
(45) **Date of Patent: Apr. 16, 2024**

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

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

(72) Inventors: **Dongjun Oh**, Suwon-si (KR); **Taeik Kim**, Suwon-si (KR); **Haeyeon Kim**, Suwon-si (KR); **Sehyun Park**, Suwon-si (KR); **Shinho Yoon**, Suwon-si (KR); **Jonghyuck Lee**, 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 226 days.

(21) Appl. No.: **17/431,861**

(22) PCT Filed: **Feb. 19, 2020**

(86) PCT No.: **PCT/KR2020/002374**
§ 371 (c)(1),
(2) Date: **Aug. 18, 2021**

(87) PCT Pub. No.: **WO2020/171580**
PCT Pub. Date: **Aug. 27, 2020**

(65) **Prior Publication Data**

US 2022/0115768 A1 Apr. 14, 2022

(30) **Foreign Application Priority Data**

Feb. 19, 2019 (KR) 10-2019-0019038

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/328 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 5/328*** (2015.01); ***H01Q 5/385*** (2015.01); ***H01Q 21/28*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 5/385; H01Q 5/328; H01Q 1/243; H01Q 9/42; H01Q 21/28; H04B 1/40; H04M 1/0268; H04M 1/0216
See application file for complete search history.

(56) **References Cited**

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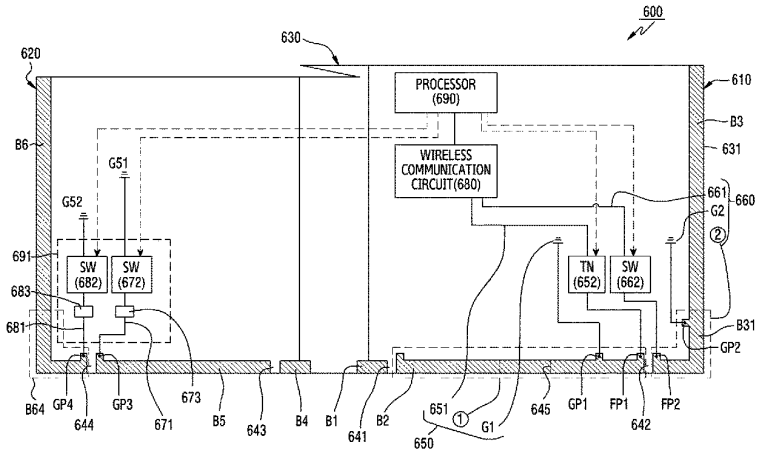
Primary Examiner — Hoang V Nguyen
(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

(57) **ABSTRACT**

An electronic device is provided. The electronic device includes a first housing structure, a second housing structure, and a foldable housing structure for connecting the first housing structure and the second housing structure. The first housing structure and the second housing structure may include a front plate for interconnecting front surfaces with a flexible display, a rear plate which is an opposite surface to the front plate, a side member which surrounds a space between the front plate and the rear plate, and includes at
(Continued)



US011962070B2

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

(10) **Patent No.: US 11,962,070 B2**
(45) **Date of Patent: Apr. 16, 2024**

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

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

(72) Inventors: **Linping Xie**, Beijing (CN); **Fang Guo**, Beijing (CN); **Wei Wang**, Beijing (CN); **Jie Zhang**, Beijing (CN)

(73) Assignee: **BEIJING XIAOMI MOBILE SOFTWARE CO., LTD.**, Beijing (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 142 days.

(21) Appl. No.: **17/681,095**

(22) Filed: **Feb. 25, 2022**

(65) **Prior Publication Data**

US 2023/0061494 A1 Mar. 2, 2023

(30) **Foreign Application Priority Data**

Aug. 31, 2021 (CN) 202111012025.X

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H04B 1/40 (2015.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H04B 1/40*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/24; H01Q 1/243; H01Q 1/52; H01Q 21/28; H01Q 1/241; H01Q 1/244; H01Q 5/10; H01Q 5/328; H01Q 5/357; H04B 1/40
See application file for complete search history.

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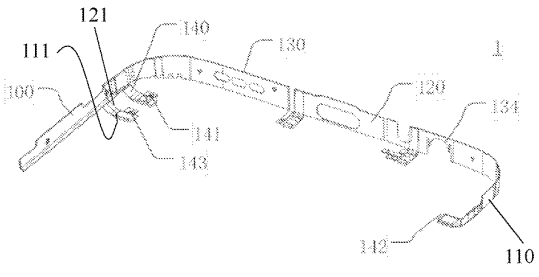
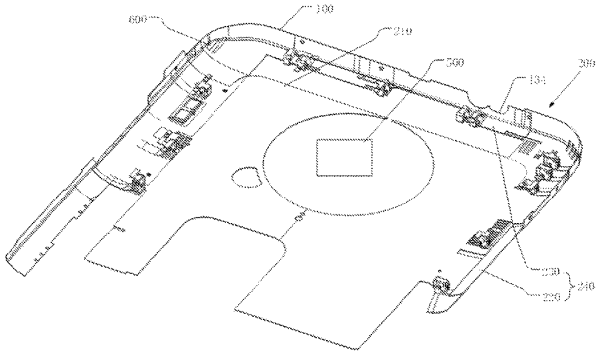
Primary Examiner — Thai Pham
(74) *Attorney, Agent, or Firm* — Volpe Koenig

(57) **ABSTRACT**

An antenna structure is arranged at an edge region of a shell of a mobile terminal. The antenna structure includes at least one segment of antenna body and includes a first surface and a second surface opposite to each other, in which a first surface of the antenna body includes an attachment region attached to the edge region in a conformal manner. The antenna structure further includes a connecting portion connected to the antenna body, at least one of a first surface of the connecting portion and a second surface of the connecting portion being used for electrical connection with a feed unit of the mobile terminal or grounding.

20 Claims, 5 Drawing Sheets





US011962071B2

(12) **United States Patent**
Woo

(10) **Patent No.: US 11,962,071 B2**
(45) **Date of Patent: Apr. 16, 2024**

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

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

(72) Inventor: **Seungmin Woo**, 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 78 days.

(21) Appl. No.: **17/797,314**

(22) PCT Filed: **Feb. 4, 2020**

(86) PCT No.: **PCT/KR2020/001610**
§ 371 (c)(1),
(2) Date: **Aug. 3, 2022**

(87) PCT Pub. No.: **WO2021/157752**
PCT Pub. Date: **Aug. 12, 2021**

(65) **Prior Publication Data**

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(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/36 (2006.01)
H01Q 1/48 (2006.01)
H01Q 21/24 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/36*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 21/24*** (2013.01)

(58) **Field of Classification Search**
CPC .. H01Q 1/243; H01Q 1/38–48; H01Q 21/065; H01Q 21/24; H01Q 5/30–35
See application file for complete search history.

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WO 2019165193 8/2019

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PCT International Application No. PCT/KR2020/001610, International Search Report dated Oct. 26, 2020, 5 pages.

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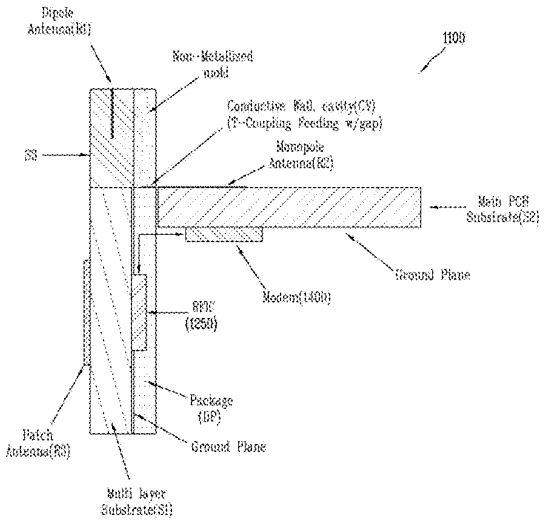
Primary Examiner — Hasan Islam
(74) *Attorney, Agent, or Firm* — LEE, HONG, DEGERMAN, KANG & WAIMEY

(57) **ABSTRACT**

An electronic device provided with an antenna is provided according to one embodiment. The electronic device comprises: a first radiator disposed inside a first substrate, and radiating a first signal, having a first polarization, in the direction of the side surface of the first substrate; a second radiator disposed on a second substrate which is disposed perpendicular to the first substrate, and radiating a second signal, having a second polarization perpendicular to the first polarization, in the direction of the side surface of the first substrate; and a transceiver circuit disposed on the rear of the first substrate, and transmitting or receiving at least one of the first signal and the second signal through at least one of the first radiator and the second radiator.

13 Claims, 20 Drawing Sheets



US011962086B2

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

(10) **Patent No.: US 11,962,086 B2**
(45) **Date of Patent: Apr. 16, 2024**

(54) **SLOT ANTENNA AND ELECTRONIC DEVICE COMPRISING SAID SLOT ANTENNA**

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

(72) Inventors: **Antti Karilainen**, Kista (SE); **Konstantin Sokolov**, Helsinki (FI); **Dong Liu**, Shenzhen (CN); **Zlatoljub Milosavljevic**, Helsinki (FI); **Joonas Krogerus**, Helsinki (FI); **Jouni Pennanen**, Kista (SE)

(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 309 days.

(21) Appl. No.: **17/424,357**

(22) PCT Filed: **Jan. 29, 2019**

(86) PCT No.: **PCT/EP2019/052078**
§ 371 (c)(1),
(2) Date: **Jul. 20, 2021**

(87) PCT Pub. No.: **WO2020/151839**
PCT Pub. Date: **Jul. 30, 2020**

(65) **Prior Publication Data**

US 2022/0115789 A1 Apr. 14, 2022

(30) **Foreign Application Priority Data**

Jan. 22, 2019 (WO) PCT/EP2019/051419

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

(52) **U.S. Cl.**
CPC ***H01Q 13/10*** (2013.01); ***H01Q 1/24*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 13/10; H01Q 1/24; H01Q 1/243
See application file for complete search history.

(56) **References Cited**

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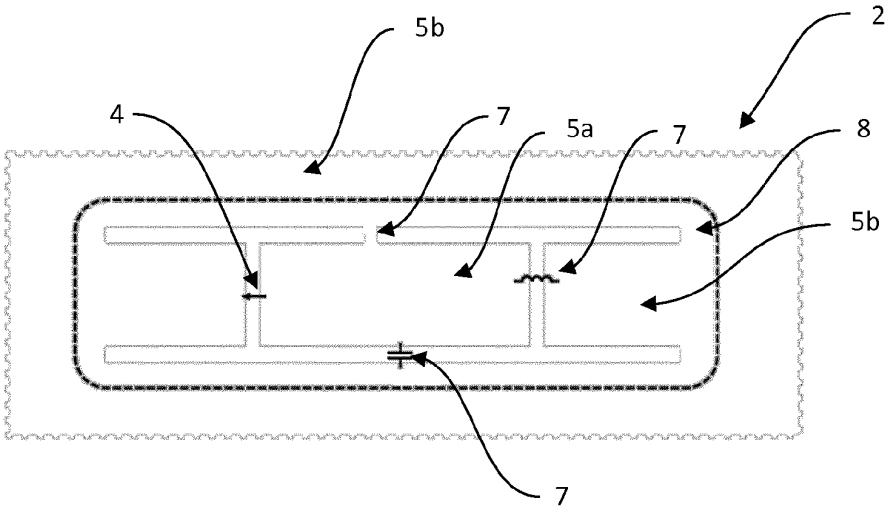
Primary Examiner — Daniel D Chang
(74) *Attorney, Agent, or Firm* — Conley Rose, P.C.

(57) **ABSTRACT**

A slot antenna comprising a first conductive structure, a second conductive structure, and an antenna feed coupled to the first conductive structure. The first conductive structure is wholly or partially enclosed by the second conductive structure and comprises a conductive surface and a non-conductive pattern. The non-conductive pattern comprises a longitudinal slot and a lateral slot extending at an angle from the longitudinal slot.

26 Claims, 6 Drawing Sheets



US011967753B2

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

(10) **Patent No.: US 11,967,753 B2**
(45) **Date of Patent: Apr. 23, 2024**

(54) **ELECTRONIC DEVICE INCLUDING ANTENNA**

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

(72) Inventors: **Dongjin Kim**, Seoul (KR); **Sungwon Kim**, Seoul (KR); **Jihun Ha**, Seoul (KR); **Youngbae Kwon**, Seoul (KR); **Byungwoon Jung**, Seoul (KR)

(73) Assignee: **LG ELECTRONICS INC.**, Seoul (KR)

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

(21) Appl. No.: **18/555,964**

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

(86) PCT No.: **PCT/KR2021/005092**
§ 371 (c)(1),
(2) Date: **Oct. 18, 2023**

(87) PCT Pub. No.: **WO2022/225083**
PCT Pub. Date: **Oct. 27, 2022**

(65) **Prior Publication Data**

US 2024/0097315 A1 Mar. 21, 2024

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

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/24*** (2013.01); ***H01Q 1/52*** (2013.01); *H04M 1/0268* (2013.01); *H04M 1/0277* (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/52; H01Q 1/24; H04M 1/0277; H04M 1/0268
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Primary Examiner — Hai V Tran
(74) *Attorney, Agent, or Firm* — LEE, HONG, DEGERMAN, KANG & WAIMEY

(57) **ABSTRACT**

A mobile terminal including an antenna according to an embodiment is provided. The mobile terminal includes a slide metal part and a front metal part, and a contact member configured to contact the slide metal part and the front metal part is provided on a side of the front metal part. In a first state in which a display area of the mobile terminal is contracted, the contact member may remove parasitic resonance caused by a slot area, as the slide metal part and the front metal part contact are contacted by the contact member at a first position which is a lower end of the slot area, and in a second state in which the display area is expanded, the contact member may remove parasitic resonance caused by the slot area, as the slide metal part and the front metal part are contacted by the contact member at a second position which is an upper end of the slot area.

20 Claims, 36 Drawing Sheets