US012259459B2

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

(10) **Patent No.: US 12,259,459 B2**
(45) **Date of Patent: Mar. 25, 2025**

(54) **HALF-WAVE BACK-FOLDING DIRECTIONAL MICROWAVE DETECTION ANTENNA**

(71) Applicant: **Shenzhen Merrytek Technology Co., Ltd.**, Shenzhen (CN)

(72) Inventors: **Gaodi Zou**, Shenzhen (CN); **Xin Zou**, Shenzhen (CN)

(73) Assignee: **Shenzhen Merrytek Technology 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 474 days.

(21) Appl. No.: **17/545,984**

(22) Filed: **Dec. 8, 2021**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

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Jul. 28, 2021 (CN) 202121726634.7
Jul. 28, 2021 (CN) 202121726640.2

(51) **Int. Cl.**
G01S 13/56 (2006.01)
H01Q 9/42 (2006.01)

(52) **U.S. Cl.**
CPC ***G01S 13/56*** (2013.01); ***H01Q 9/42*** (2013.01)

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

(56) **References Cited**

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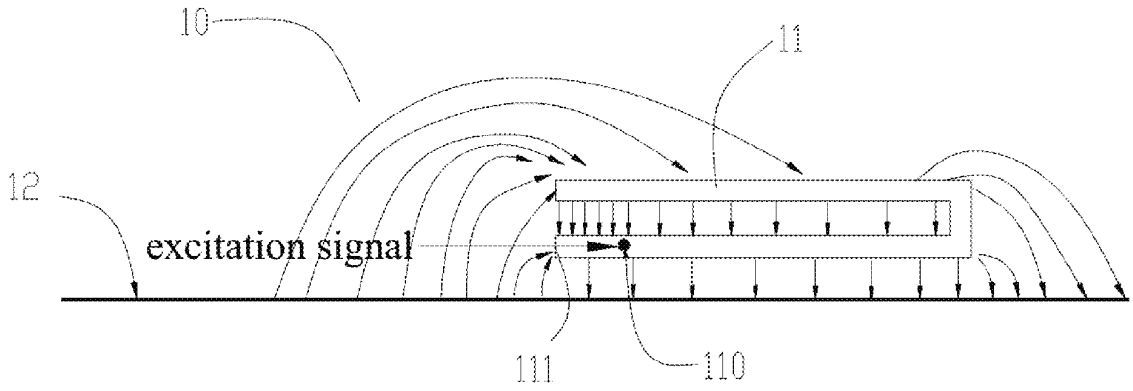
Primary Examiner — Whitney Moore
(74) *Attorney, Agent, or Firm* — David & Raymond Patent Firm; Raymond Y Chan

(57) **ABSTRACT**

A half-wave back-folding directional microwave detection antenna includes a half-wave oscillator and a reference ground. The half-wave oscillator has an electrical length greater than or equal to ½ wavelength and less than or equal to ¾ wavelength. The half-wave oscillator is folded back to form a feed point that a distance between two ends of the half-wave oscillator is greater than or equal to λ/128 and is lesser than or equal to λ/6. The two ends of the half-wave oscillator are spaced apart from the reference ground with a distance greater than or equal to λ/128. A distance between at least one end of the half-wave oscillator and the reference ground is lesser than or equal to λ/16. The two ends of the half-wave oscillator form a phase difference and are coupled to each other, wherein λ is wavelength parameter corresponding to frequency of the excitation signal.

26 Claims, 13 Drawing Sheets



US012260395B2

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

(10) **Patent No.: US 12,260,395 B2**
(45) **Date of Patent: Mar. 25, 2025**

(54) **CARD WITH FIELD STRENGTH VISUALIZATION DISPLAY**

(71) Applicant: **Capital One Services, LLC**, McLean, VA (US)

(72) Inventors: **Kevin Osborn**, Newton Highlands, MA (US); **David Kelly Wurmfeld**, Palm Bay, FL (US); **Bryant Yee**, Silver Spring, MD (US)

(73) Assignee: **Capital One Services, LLC**, McLean, VA (US)

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

(21) Appl. No.: **17/903,400**

(22) Filed: **Sep. 6, 2022**

(65) **Prior Publication Data**

US 2024/0078533 A1 Mar. 7, 2024

(51) **Int. Cl.**

G06K 19/07	(2006.01)
G06K 19/077	(2006.01)
G06Q 20/34	(2012.01)

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

CPC ***G06Q 20/357*** (2013.01); ***G06Q 20/352*** (2013.01)

(58) **Field of Classification Search**

CPC G06K 7/10722; G06K 7/10732; G06K 7/10693; G06K 7/1417; G06K 7/10861; G06K 7/10663; G06T 19/00; G06T 7/70;

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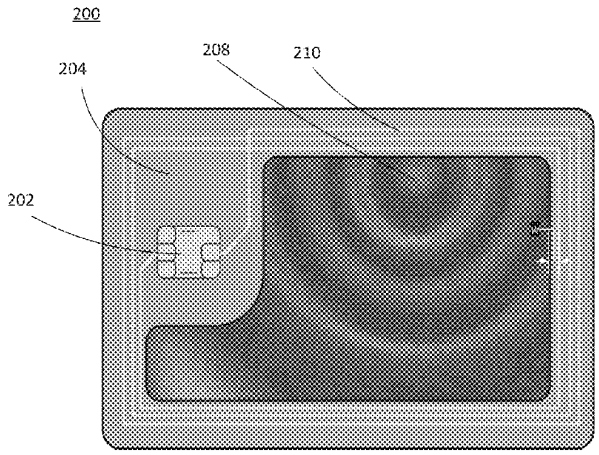
Zeng, "LLC Resonant Converter Topologies and Industrial Applications—A Review*" (Year: 2020).*

Primary Examiner — Thien T Mai
(74) *Attorney, Agent, or Firm* — Foley & Lardner LLP

(57) **ABSTRACT**

In some embodiments, a near-field communication card may be provided with an NFC-field-strength visualization display and a transparent window through which the NFC-field-strength visualization display is visible. In some embodiments, a token (e.g., the NFC card) may be constructed to include an electromagnetic field visualization display, a radiofrequency communication antenna, and a first transparent region having a transparent surface through which the electromagnetic field visualization display is visible. In some embodiments, a first layer of a token may be provided, where the first layer includes an electromagnetic field visualization display and a radiofrequency communication antenna. A second layer of the token may be provided, where the second layer includes a first transparent region. The first and second layers may be bonded such that the electromagnetic field visualization display of the first layer is visible through the first transparent region of the second layer.

20 Claims, 6 Drawing Sheets



US012261354B2

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

(10) **Patent No.: US 12,261,354 B2**
(45) **Date of Patent: Mar. 25, 2025**

(54) **ANTENNA STRUCTURE**

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

(72) Inventors: **Tzu-Min Wu**, Hsinchu (TW); **Kuang-Yuan Ku**, Hsinchu (TW); **Kuo-Jen Lai**, 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 200 days.

(21) Appl. No.: **18/328,938**

(22) Filed: **Jun. 5, 2023**

(65) **Prior Publication Data**

US 2023/0411837 A1 Dec. 21, 2023

(30) **Foreign Application Priority Data**

Jun. 16, 2022 (TW) 111122401
May 19, 2023 (TW) 112118693

(51) **Int. Cl.**
H01Q 5/328 (2015.01)
H01Q 1/36 (2006.01)
H01Q 1/48 (2006.01)
H01Q 5/371 (2015.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/36*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 5/328*** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 1/36; H01Q 1/48; H01Q 1/243; H01Q 9/30; H01Q 9/0414; H01Q 5/371; H01Q 5/328; H01Q 5/385
See application file for complete search history.

(56) **References Cited**

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2021/0050659 A1 * 2/2021 Yu H01Q 5/335

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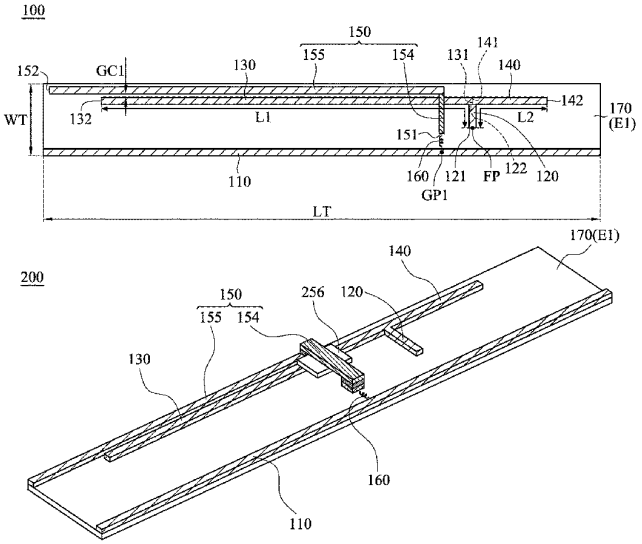
Primary Examiner — Thai Pham
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(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, an inductive element, 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 through the inductive element to a first grounding point on the ground element. The first coupling branch includes an elevated portion extending across the first radiation element. The ground element, the feeding radiation element, the first radiation element, the second radiation element, the inductive element, and the first coupling branch are disposed on the same surface of the dielectric substrate.

20 Claims, 10 Drawing Sheets



US012261363B2

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

(10) **Patent No.: US 12,261,363 B2**
(45) **Date of Patent: Mar. 25, 2025**

(54) **COMMUNICATION DEVICE**

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

(72) Inventors: **Jia-Hung Su**, Hsinchu (TW); **Kai Shih**, Hsinchu (TW); **Cheng-Geng Jan**, 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 202 days.

(21) Appl. No.: **18/167,148**

(22) Filed: **Feb. 10, 2023**

(65) **Prior Publication Data**

US 2023/0318193 A1 Oct. 5, 2023

(30) **Foreign Application Priority Data**

Mar. 31, 2022 (TW) 111112411

(51) **Int. Cl.**
H01Q 21/06 (2006.01)
H01Q 15/00 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 15/0086*** (2013.01); ***H01Q 21/065*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 17/00; H01Q 19/06; H01Q 15/0086; H01Q 21/065; H01Q 17/001
See application file for complete search history.

(56) **References Cited**

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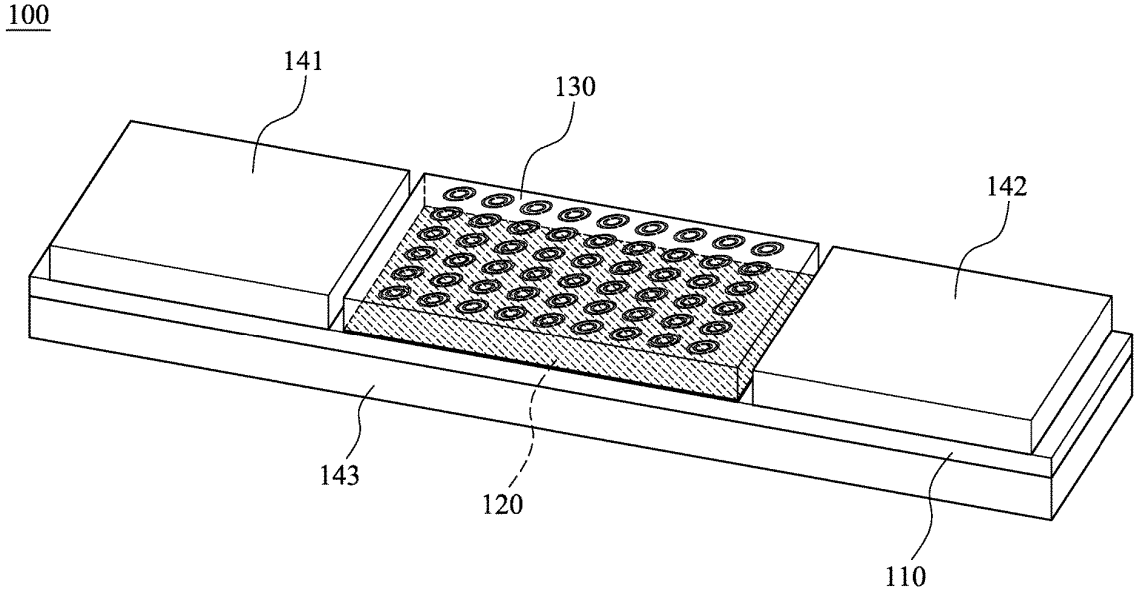
Primary Examiner — Graham P Smith
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

A communication device includes a dielectric substrate, an antenna layer, a metamaterial layer, a first absorber element, a second absorber element, and a third absorber element. The dielectric substrate has a first surface and a second surface which are opposite to each other. The antenna layer is disposed on the first surface of the dielectric substrate. The metamaterial layer is adjacent to the antenna layer. The antenna layer and the metamaterial layer are both positioned between the first absorber element and the second absorber element. The third absorber element is disposed on the second surface of the dielectric substrate.

16 Claims, 11 Drawing Sheets



US012261367B2

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

(10) **Patent No.: US 12,261,367 B2**
(45) **Date of Patent: Mar. 25, 2025**

(54) **ANTENNA UNIT AND WINDOW GLASS**

(71) Applicants: **AGC Inc.**, Tokyo (JP); **AGC GLASS EUROPE**, Louvain-la-neuve (BE); **AGC FLAT GLASS NORTH AMERICA, INC.**, Alpharetta, GA (US); **AGC Vidros do Brasil Ltda.**, Sao Paulo (BR)

(72) Inventors: **Ryuta Sonoda**, Tokyo (JP); **Masaki Horie**, Tokyo (JP)

(73) Assignees: **AGC Inc.**, Tokyo (JP); **AGC GLASS EUROPE**, Louvain-la-neuve (BE); **AGC FLAT GLASS NORTH AMERICA, INC.**, Alpharetta, GA (US); **AGC Vidros do Brasil Ltda.**, Sao Paulo (BR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 184 days.

(21) Appl. No.: **17/688,948**

(22) Filed: **Mar. 8, 2022**

(65) **Prior Publication Data**

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Related U.S. Application Data

(63) Continuation of application No. PCT/JP2020/033784, filed on Sep. 7, 2020.

(30) **Foreign Application Priority Data**

Sep. 18, 2019 (JP) 2019-169601

(51) **Int. Cl.**
H01Q 21/06 (2006.01)
H01Q 1/12 (2006.01)
H01Q 19/02 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 21/065*** (2013.01); ***H01Q 1/1271*** (2013.01); ***H01Q 19/021*** (2013.01)

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

(56) **References Cited**

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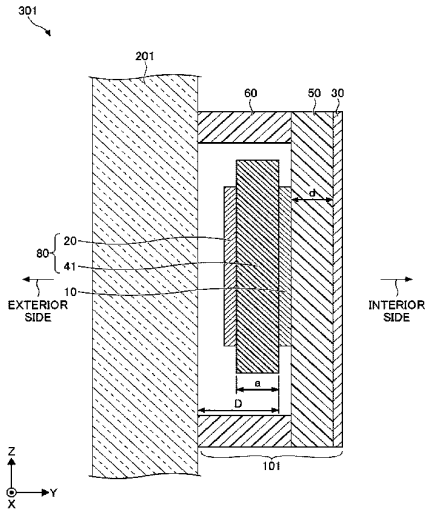
Primary Examiner — Dameon E Levi
Assistant Examiner — Ahn N Ho
(74) *Attorney, Agent, or Firm* — Oblon, McClelland, Maier & Neustadt, L.L.P.

(57) **ABSTRACT**

An antenna unit to be used by being installed so as to face window glass for a building includes a radiating element, a phase control member situated on an exterior-side with reference to the radiating element and configured to control a phase of an electromagnetic wave radiated from the radiating element, and a conductor situated on an interior-side with reference to the radiating element, wherein the phase control member is a member including a dielectric and a plurality of conductor portions.

12 Claims, 17 Drawing Sheets



US012261368B2

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

(10) **Patent No.: US 12,261,368 B2**
(45) **Date of Patent: Mar. 25, 2025**

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

(71) Applicant: **Murata Manufacturing Co., Ltd.**, Nagaokakyo (JP)

(72) Inventors: **Ryusuke Yamaguchi**, Nagaokakyo (JP); **Takaya Nemoto**, Nagaokakyo (JP)

(73) Assignee: **Murata Manufacturing Co., Ltd.**, Nagaokakyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 133 days.

(21) Appl. No.: **17/875,425**

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

(65) **Prior Publication Data**

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Related U.S. Application Data

(63) Continuation of application No. PCT/JP2021/002074, filed on Jan. 21, 2021.

(30) **Foreign Application Priority Data**

Jan. 30, 2020 (JP) 2020-014028

(51) **Int. Cl.**
H01Q 21/06 (2006.01)
H01Q 1/48 (2006.01)
H01Q 19/10 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 21/065*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 19/10*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 21/065; H01Q 1/48; H01Q 19/10; H01Q 1/243
See application file for complete search history.

(56) **References Cited**

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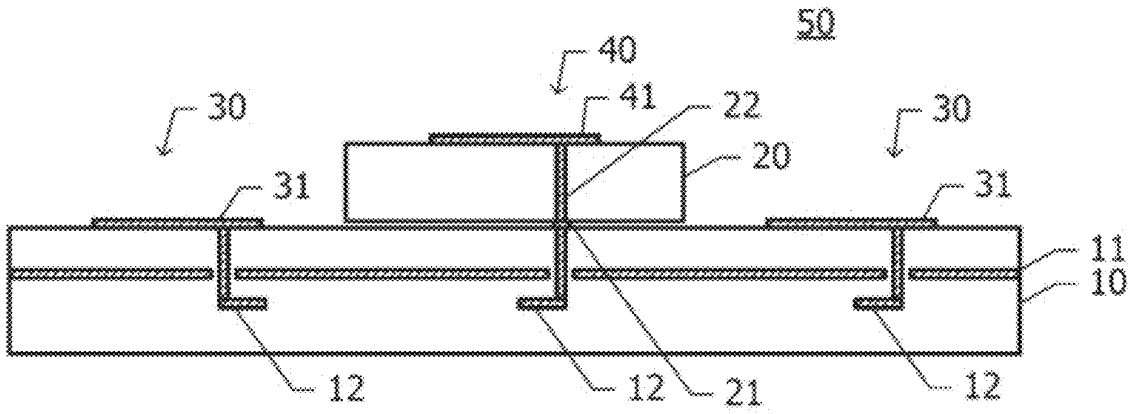
Primary Examiner — Dieu Hien T Duong
(74) *Attorney, Agent, or Firm* — XSENSUS LLP

(57) **ABSTRACT**

A ground plane is disposed on or in an inner layer of a dielectric substrate. Moreover, a feed line is disposed on or in the dielectric substrate. A first antenna element and a second antenna element are supported on the dielectric substrate. The first antenna element and the second antenna element include a first radiating element and a second radiating element connected to the feed line, respectively, and are disposed on a same side when seen from the ground plane. With a height of the ground plane being a reference, a top portion of the second antenna element is located higher than a top portion of the first antenna element. There is provided an antenna device of which the band can be expanded and of which the internal space of the casing can be effectively utilized.

20 Claims, 12 Drawing Sheets



US012261371B2

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

(10) **Patent No.: US 12,261,371 B2**
(45) **Date of Patent: Mar. 25, 2025**

(54) **ANTENNA MODULE AND COMMUNICATION DEVICE INCORPORATING THE SAME**

(71) Applicant: **Murata Manufacturing Co., Ltd.**, Nagaokakyo (JP)

(72) Inventors: **Kaoru Sudo**, Nagaokakyo (JP); **Kengo Onaka**, Nagaokakyo (JP); **Yoshiki Yamada**, Nagaokakyo (JP)

(73) Assignee: **MURATA MANUFACTURING CO., LTD.**, Nagaokakyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 123 days.

(21) Appl. No.: **18/090,519**

(22) Filed: **Dec. 29, 2022**

(65) **Prior Publication Data**

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Related U.S. Application Data

(63) Continuation of application No. PCT/JP2021/016805, filed on Apr. 27, 2021.

(30) **Foreign Application Priority Data**

Jul. 1, 2020 (JP) 2020-114111

(51) **Int. Cl.**
H01Q 21/30 (2006.01)
H01Q 1/24 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 21/30*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 9/045*** (2013.01); ***H01Q 21/06*** (2013.01)

(58) **Field of Classification Search**
CPC .. H01Q 21/0006; H01Q 21/06; H01Q 21/065; H01Q 21/08; H01Q 21/24;
(Continued)

(56) **References Cited**

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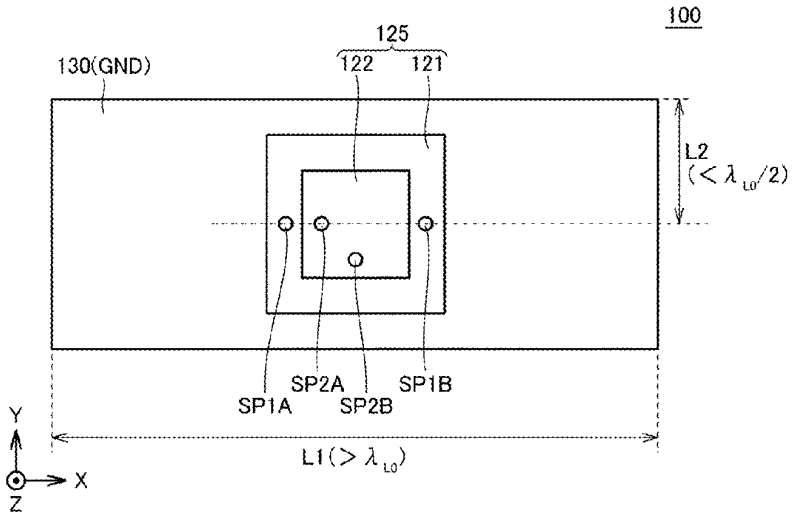
Primary Examiner — Jason M Crawford
(74) *Attorney, Agent, or Firm* — XSENSUS LLP

(57) **ABSTRACT**

An antenna module includes feed elements each having a flat plate shape and a ground electrode arranged opposite the feed elements. The feed element radiates a radio wave of a first frequency band. The feed element radiates a radio wave of a second frequency band that is higher than the first frequency band. In a plan view of the feed element, the distance from the center of the feed element to an end portion of the ground electrode in a first direction is shorter than or equal to ½ of a free space wavelength of a radio wave radiated from the feed element. A feed point of the feed element is arranged at a location shifted in a second direction from the center of the feed element, and the second direction is different from the first direction.

19 Claims, 7 Drawing Sheets



US012261374B2

(12) **United States Patent**
Wang

(10) **Patent No.: US 12,261,374 B2**
(45) **Date of Patent: Mar. 25, 2025**

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

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

(72) Inventor: **Shen Wang**, Dongguan (CN)

(73) Assignee: **VIVO MOBILE COMMUNICATION CO., LTD.**, Dongguan (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 219 days.

(21) Appl. No.: **18/118,117**

(22) Filed: **Mar. 6, 2023**

(65) **Prior Publication Data**

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Related U.S. Application Data

(63) Continuation of application No. PCT/CN2021/115320, filed on Aug. 30, 2021.

(30) **Foreign Application Priority Data**

Sep. 4, 2020 (CN) 202010923239.1

(51) **Int. Cl.**
H01Q 3/26 (2006.01)
H01Q 5/35 (2015.01)

(52) **U.S. Cl.**
CPC ***H01Q 3/2694*** (2013.01); ***H01Q 5/35*** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 3/2694; H01Q 5/35; H01Q 1/24
See application file for complete search history.

(56) **References Cited**

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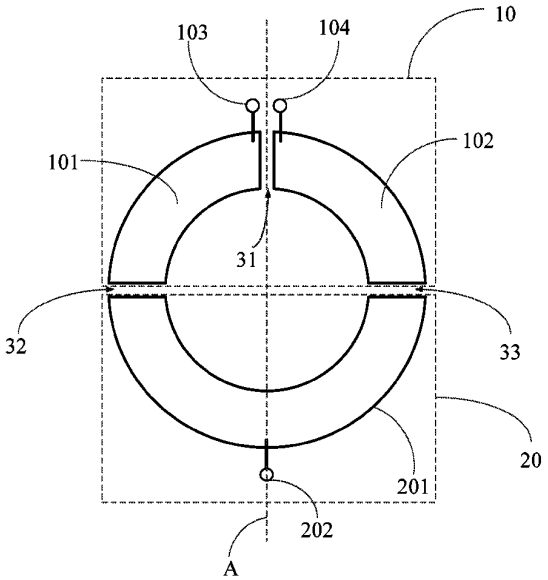
(Continued)

Primary Examiner — Dieu Hien T Duong
(74) *Attorney, Agent, or Firm* — IPX PLLC

(57) **ABSTRACT**

An antenna structure and an electronic device, are provided. The antenna structure includes a first antenna and a second antenna, the first antenna includes a first radiator, a second radiator, a first port, and a second port, and the second antenna includes a third radiator and a third port. The first radiator, the second radiator, and the third radiator jointly constitute a ring structure, and there is a first gap between the first radiator and the second radiator, a second gap between the first radiator and the third radiator, and a third gap between the second radiator and the third radiator.

8 Claims, 12 Drawing Sheets



US012261379B2

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

(10) **Patent No.: US 12,261,379 B2**
(45) **Date of Patent: Mar. 25, 2025**

(54) **ANTENNA DEVICE**

(71) Applicant: **DENSO CORPORATION**, Kariya (JP)

(72) Inventors: **Yuuji Kakuya**, Nisshin (JP); **Masakazu Ikeda**, Nisshin (JP); **Kenichirou Sanji**, Kariya (JP); **Tomokazu Miyashita**, Kariya (JP); **Ryozou Fujii**, Kariya (JP)

(73) Assignee: **DENSO CORPORATION**, Kariya (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 135 days.

(21) Appl. No.: **18/070,277**

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

(65) **Prior Publication Data**

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Related U.S. Application Data

(63) Continuation of application No. PCT/JP2021/023456, filed on Jun. 21, 2021.

(30) **Foreign Application Priority Data**

Jun. 26, 2020 (JP) 2020-110670

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 1/32 (2006.01)
H01Q 1/48 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 9/0421*** (2013.01); ***H01Q 1/3291*** (2013.01); ***H01Q 1/48*** (2013.01)

(58) **Field of Classification Search**
USPC 343/848
See application file for complete search history.

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2022/0006195	A1	1/2022	Ikeda et al.	

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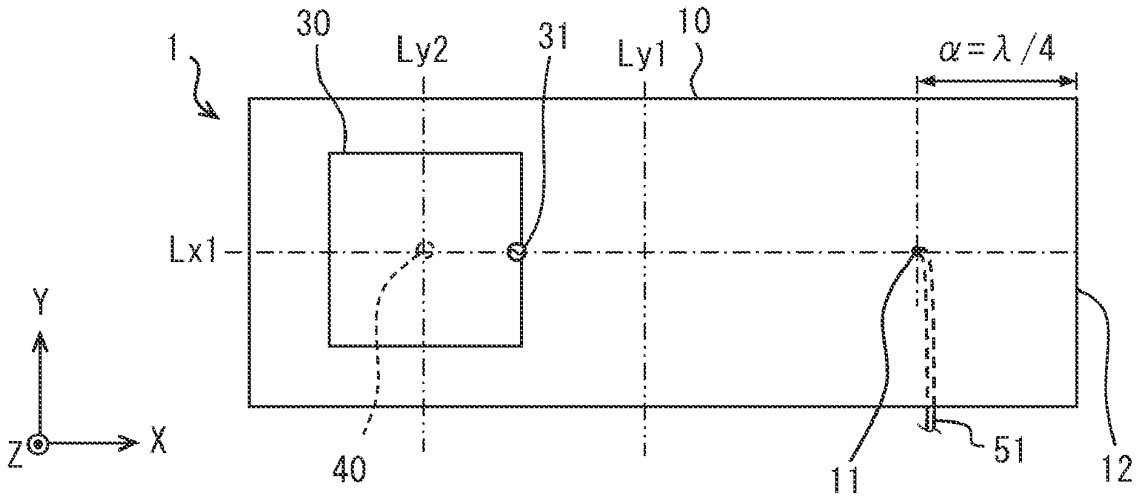
Primary Examiner — Hoang V Nguyen
Assistant Examiner — Brandon Sean Woods
(74) *Attorney, Agent, or Firm* — Harness, Dickey & Pierce, P.L.C.

(57) **ABSTRACT**

An antenna device includes a ground plate and an antenna element. The ground plate is a conductor member with a flat rectangular shape. The antenna element is a conductor member having a feed point electrically connected to a feeder line. A length of the ground plate in a predetermined direction is shorter than a target wavelength that is a wavelength of a radio wave to be transmitted or received. The ground plate is connected to a grounding cable at a connection position on the ground plate. The connection position is shifted from an edge of the ground plate by an odd multiple of ¼ of the target wavelength.

10 Claims, 6 Drawing Sheets



US012266848B2

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

(10) **Patent No.: US 12,266,848 B2**
(45) **Date of Patent: Apr. 1, 2025**

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

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

(72) Inventors: **Pengfei Wu**, Shanghai (CN); **Hanyang Wang**, Reading (GB); **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 383 days.

(21) Appl. No.: **17/780,857**

(22) PCT Filed: **Nov. 27, 2020**

(86) PCT No.: **PCT/CN2020/132206**

§ 371 (c)(1),
(2) Date: **May 27, 2022**

(87) PCT Pub. No.: **WO2021/104447**

PCT Pub. Date: **Jun. 3, 2021**

(65) **Prior Publication Data**

US 2023/0006333 A1 Jan. 5, 2023

(30) **Foreign Application Priority Data**

Nov. 28, 2019 (CN) 201911192854.3
Jan. 22, 2020 (CN) 202010075891.2

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/36 (2006.01)
H01Q 1/48 (2006.01)
H01Q 1/50 (2006.01)
H01Q 5/20 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/36*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 1/50*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/36; H01Q 1/48; H01Q 1/50; H01Q 5/20; H01Q 5/335;
(Continued)

(56) **References Cited**

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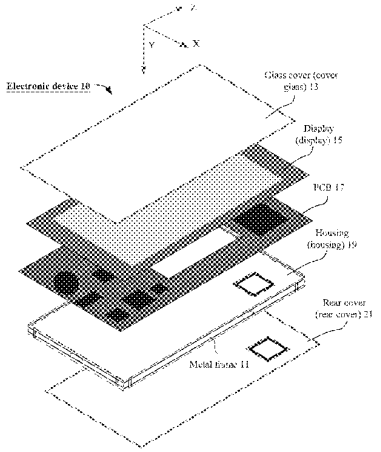
Primary Examiner — Seung H Lee
(74) *Attorney, Agent, or Firm* — Conley Rose, P.C.

(57) **ABSTRACT**

In an antenna design, a metal frame of an electronic device and a printed circuit board (PCB) form a slot antenna radiator, where two common mode (CM) slot antenna modes of the slot antenna radiator are excited through anti-symmetrical feeding, so that when dual resonances and wide-band coverage are implemented, specific absorption ratio (SAR) values in the two CM slot antenna modes are close.

19 Claims, 33 Drawing Sheets



US012266855B2

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

(10) **Patent No.: US 12,266,855 B2**
(45) **Date of Patent: Apr. 1, 2025**

(54) **ANTENNA SYSTEM**

(71) Applicant: **SHANGHAI CHUANGGONG TELECOM TECHNOLOGY CO., LTD.**, Shanghai (CN)

(72) Inventors: **Zhongjie Qin**, Shanghai (CN); **Zhichao Zhang**, Shanghai (CN)

(73) Assignee: **SHANGHAI CHUANGGONG TELECOM TECHNOLOGY CO., LTD.**, Shanghai (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.: **17/785,365**

(22) PCT Filed: **Dec. 31, 2020**

(86) PCT No.: **PCT/CN2020/142399**
§ 371 (c)(1),
(2) Date: **Jun. 14, 2022**

(87) PCT Pub. No.: **WO2021/244026**
PCT Pub. Date: **Dec. 9, 2021**

(65) **Prior Publication Data**

US 2023/0035028 A1 Feb. 2, 2023

(30) **Foreign Application Priority Data**

Jun. 5, 2020 (CN) 202010507913.8

(51) **Int. Cl.**
H01Q 13/18 (2006.01)
H01P 1/207 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 13/18*** (2013.01); ***H01P 1/207*** (2013.01); ***H01Q 1/242*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 1/52*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/38; H01Q 1/48; H01Q 13/10; H01Q 9/0407; H01Q 9/42; H01Q 15/14; H01Q 21/28; H01Q 9/0421
See application file for complete search history.

(56) **References Cited**

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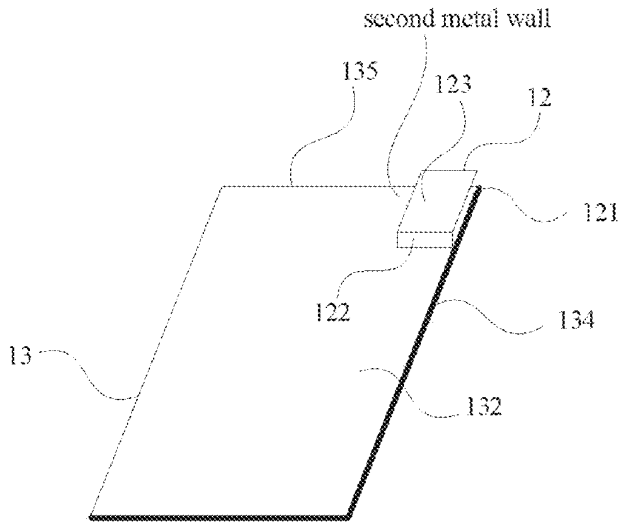
International Search Report for PCT/CN2020/142399 mailed on Mar. 19, 2021.

Primary Examiner — Wei (Victor) Y Chan
(74) *Attorney, Agent, or Firm* — The PL Law Group, PLLC

(57) **ABSTRACT**

An antenna system according to an embodiment of the present disclosure includes an antenna unit and a metal cavity corresponding to the antenna unit. The metal cavity is grounded and provided with an opening connected with the outside. By introducing the metal cavity, an embodiment of the present invention solves the problem of multi-band mutual coupling caused by a common ground current by using the cavity filter structure with a small size.

11 Claims, 8 Drawing Sheets



US012266871B2

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

(10) **Patent No.: US 12,266,871 B2**
(45) **Date of Patent: Apr. 1, 2025**

(54) **COMPACT ANTENNA DESIGN**

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

(72) Inventors: **Wei-Yu Mu**, Taipei (TW); **Prince Wang**, Taipei (TW); **N. F. Casazzone**, Dix Hills, NY (US)

(73) Assignee: **Zebra Technologies Corporation**, 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 310 days.

(21) Appl. No.: **17/992,426**

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

(65) **Prior Publication Data**

US 2024/0170848 A1 May 23, 2024

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 5/25 (2015.01)
H01Q 21/24 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 9/0421*** (2013.01); ***H01Q 5/25*** (2015.01); ***H01Q 9/0442*** (2013.01); ***H01Q 21/24*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/25; H01Q 9/0421; H01Q 9/0442; H01Q 21/24
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

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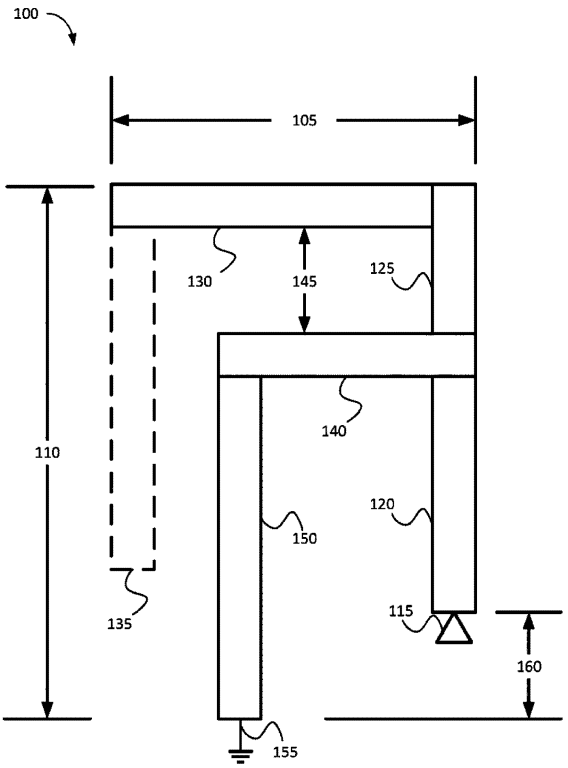
* cited by examiner

Primary Examiner — Jimmy T Vu

(57) **ABSTRACT**

A compact antenna design is provide with a carrier arm having a first end and a second end; a resonating arm, connected at the second end of the carrier arm and extending perpendicularly from the carrier arm in a first direction; a capacitive tuning arm, having a third end and a fourth end, connected at the third end to a portion of the carrier arm between to the first end and the second end, and extending perpendicularly from the carrier arm in the first direction; and a shorting arm, connected at the fourth end of the capacitive tuning arm and extending perpendicularly from the capacitive tuning arm in a second direction, away from the resonating arm.

20 Claims, 6 Drawing Sheets



US012272863B2

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

(10) **Patent No.: US 12,272,863 B2**
(45) **Date of Patent: Apr. 8, 2025**

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

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

(72) Inventors: **Yonghee An**, Suwon-si (KR); **Pilwon Seo**, Suwon-si (KR); **Bitna Kim**, Suwon-si (KR); **Haewon Sung**, Suwon-si (KR); **Yongwon Cho**, Suwon-si (KR); **Junhee Han**, Suwon-si (KR); **Jeongseob Kim**, Suwon-si (KR); **Hyunsuk 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 166 days.

(21) Appl. No.: **18/109,006**

(22) Filed: **Feb. 13, 2023**

(65) **Prior Publication Data**

US 2023/0253698 A1 Aug. 10, 2023

Related U.S. Application Data

(63) Continuation of application No. PCT/KR2023/000566, filed on Jan. 12, 2023.

(30) **Foreign Application Priority Data**

Feb. 8, 2022 (KR) 10-2022-0016479

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/307 (2015.01)
H01Q 9/04 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/24*** (2013.01); ***H01Q 5/307*** (2015.01); ***H01Q 9/0407*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/24; H01Q 5/307; H01Q 9/0407; H01Q 1/1207; H01Q 1/22; H01Q 1/38;
(Continued)

(56) **References Cited**

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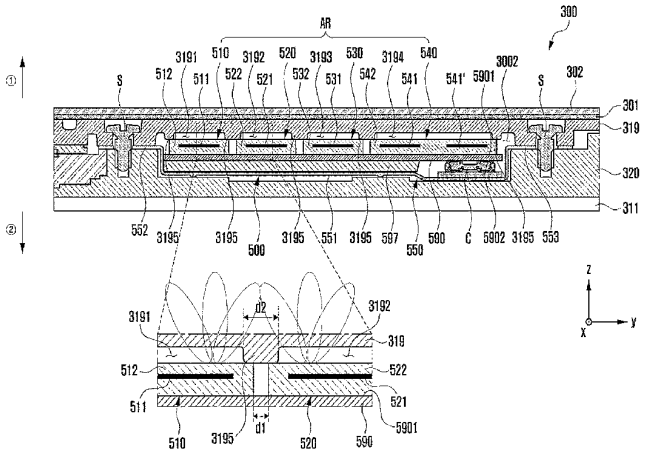
Primary Examiner — Dimary S Lopez Cruz
Assistant Examiner — Michael M Bouizza
(74) *Attorney, Agent, or Firm* — Sughrue Mion, PLLC

(57) **ABSTRACT**

An electronic device includes a housing, an antenna structure disposed in an inner space of the housing, a wireless communication circuit disposed in the inner space, and a first bracket. The antenna structure includes a substrate having a first substrate surface facing in a first direction and a second substrate surface facing in a second direction opposite to the first substrate surface, and a plurality of chip antennas sequentially arranged on the first substrate surface in a third direction perpendicular to the first direction. Each of the plurality of chip antennas includes an antenna element and is separated in the third direction from remaining chip antennas by separation spaces. The first bracket includes first and second protrusions that protrude in the second direction
(Continued)



US012272865B2

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

(10) **Patent No.: US 12,272,865 B2**
(45) **Date of Patent: Apr. 8, 2025**

(54) **ELECTRONIC DEVICE COMPRISING FLEXIBLE DISPLAY AND ANTENNA**

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

(72) Inventors: **Kookjoo Lee**, Suwon-si (KR); **Sungkoo Park**, Suwon-si (KR); **Hyeonuk Kang**, Suwon-si (KR); **Dongyeon Kim**, Suwon-si (KR); **Yongyoun Kim**, Suwon-si (KR); **Gun Lim**, Suwon-si (KR); **Hyunju Hong**, 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 108 days.

(21) Appl. No.: **18/115,232**

(22) Filed: **Feb. 28, 2023**

(65) **Prior Publication Data**

US 2023/0208013 A1 Jun. 29, 2023

Related U.S. Application Data

(63) Continuation of application No. PCT/KR2021/011939, filed on Sep. 3, 2021.

(30) **Foreign Application Priority Data**

Sep. 3, 2020 (KR) 10-2020-0112607

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

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 9/0407*** (2013.01); ***H01Q 9/285*** (2013.01); ***H01Q 21/28*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 9/0407; H01Q 9/285; H01Q 21/28; G06F 1/1652
See application file for complete search history.

(56) **References Cited**

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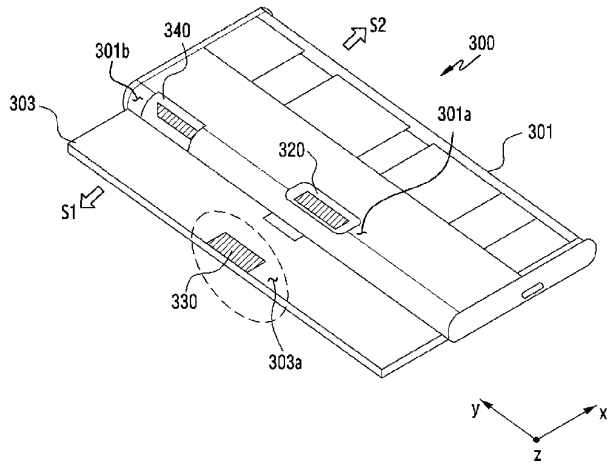
(Continued)

Primary Examiner — Dameon E Levi
Assistant Examiner — Leah Rosenberg
(74) *Attorney, Agent, or Firm* — Nixon & Vanderhye P.C.

(57) **ABSTRACT**

An electronic device may include: a first housing, a second housing configured to slide from the first housing, a flexible display disposed to the first housing and the second housing and having a screen configured to be reduced/extended according to the sliding of the second housing, a first antenna module including at least one antenna disposed to the first housing and configured to radiate a millimeter wave, and a second antenna module including at least one antenna disposed to the second housing and configured to radiate a millimeter wave. The second antenna module may be located adjacent to one side face of the second housing and may be configured to form a beam in a same direction as the first antenna module.

16 Claims, 25 Drawing Sheets



US012272877B2

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

(10) **Patent No.: US 12,272,877 B2**
(45) **Date of Patent: Apr. 8, 2025**

(54) **ELECTRONIC DEVICE INCLUDING ANTENNA**

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

(72) Inventors: **Bongsuk Choi**, Suwon-si (KR); **Minchang Shim**, Suwon-si (KR); **Soli Jung**, Suwon-si (KR)

(73) Assignee: **SAMSUNG ELECTRONICS CO., LTD.**, Gyeonggi-Do (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 161 days.

(21) Appl. No.: **17/956,725**

(22) Filed: **Sep. 29, 2022**

(65) **Prior Publication Data**

US 2023/0055640 A1 Feb. 23, 2023

Related U.S. Application Data

(63) Continuation of application No. PCT/KR2022/012206, filed on Aug. 16, 2022.

(30) **Foreign Application Priority Data**

Aug. 18, 2021 (KR) 10-2021-0108598

(51) **Int. Cl.**
H01Q 21/06 (2006.01)
H01Q 1/24 (2006.01)
H01Q 9/04 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 21/065*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 9/0414*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/142; H01Q 1/44; H01Q 1/243; H01Q 1/2266; H05K 5/006; H05K 7/12
See application file for complete search history.

(56) **References Cited**

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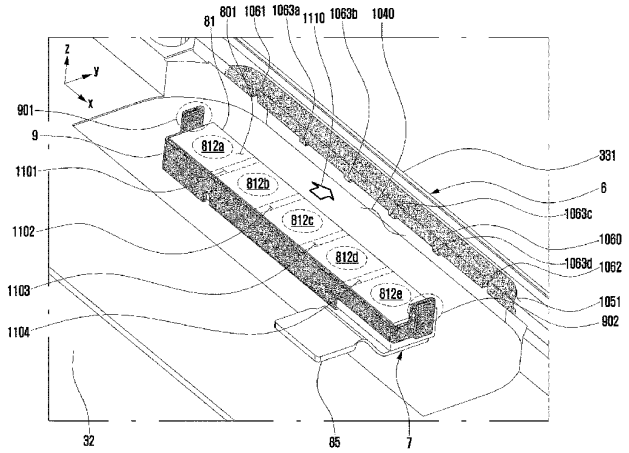
International Search Report and Written Opinion for International Application No. PCT/KR2022/012206; International Filing Date Aug. 16, 2022; Date of Mailing Nov. 18, 2022; 75 Pages.
(Continued)

Primary Examiner — Dimary S Lopez Cruz
Assistant Examiner — Austin M Back
(74) *Attorney, Agent, or Firm* — CANTOR COLBURN LLP

(57) **ABSTRACT**

An electronic device includes a housing, an antenna structure, and a support member. The housing provides a front surface, a rear surface, and a side surface of the electronic device. The antenna structure may be located in an inner space of the housing. The antenna structure may include a printed circuit board having a first surface facing the front surface and a second surface facing in a direction opposite to the first surface, and can include at least one antenna element. The support member may be combined with the housing. The antenna structure may be disposed on the support member. The support member on which the antenna structure is disposed may be inserted into a recess provided in a sidewall of the housing providing the side surface. The sidewall may include a connection portion, which may be combined with a front plate of the housing providing the front surface.

19 Claims, 17 Drawing Sheets



US012272882B2

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

(10) **Patent No.: US 12,272,882 B2**
(45) **Date of Patent: Apr. 8, 2025**

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

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

(72) Inventors: **Min Yu**, Chengdu (CN); **Xin Luo**, Chengdu (CN); **Yuping Shu**, Shenzhen (CN); **Yi Chen**, Chengdu (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 340 days.

(21) Appl. No.: **17/701,802**

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

(65) **Prior Publication Data**

US 2022/0216606 A1 Jul. 7, 2022

Related U.S. Application Data

(63) Continuation of application No. PCT/CN2020/116346, filed on Sep. 19, 2020.

(30) **Foreign Application Priority Data**

Sep. 27, 2019 (CN) 201910927624.0

(51) **Int. Cl.**
H01Q 3/44 (2006.01)
H01Q 1/38 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 3/44*** (2013.01); ***H01Q 5/314*** (2015.01); ***H01Q 15/14*** (2013.01); ***H01Q 19/10*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC .. H01Q 1/38; H01Q 1/48; H01Q 3/36; H01Q 3/44; H01Q 5/314; H01Q 15/14; H01Q 19/10
See application file for complete search history.

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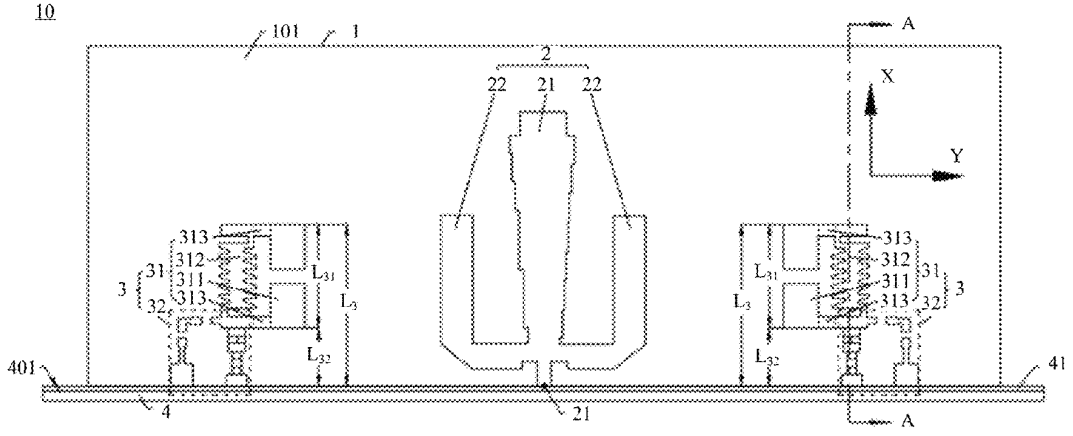
Primary Examiner — Hoang V Nguyen
Assistant Examiner — Amal Patel
(74) *Attorney, Agent, or Firm* — Rimon PC

(57) **ABSTRACT**

A directional antenna and a communication device are provided in this disclosure. The directional antenna includes a first element, a second element and a first reflector. An operating frequency band of the first element is a first frequency band, and an operating frequency band of the second element is a second frequency band. An equivalent electrical length of the first reflector is equal to or slightly greater than one half of the wavelength of the first frequency band. The first reflector includes a first resonant circuit, the first resonant circuit includes a first capacitive part and a first inductive part that are connected in parallel. A resonance frequency of the first resonant circuit is within the second frequency band, and an equivalent electrical length of any part other than the first resonant circuit in the first reflector is less than one half of the wavelength of the second frequency band.

20 Claims, 24 Drawing Sheets



US012272883B2

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

(10) **Patent No.: US 12,272,883 B2**
(45) **Date of Patent: Apr. 8, 2025**

(54) **ELECTRONIC DEVICE PROVIDED WITH 5G ANTENNA**

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

(72) Inventors: **Songyi Lee**, Seoul (KR); **Moonsoo Song**, Seoul (KR); **Chisang You**, Seoul (KR); **Sungjoon Hong**, Seoul (KR); **Youngtaek Hong**, 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 378 days.

(21) Appl. No.: **17/755,059**

(22) PCT Filed: **Oct. 30, 2019**

(86) PCT No.: **PCT/KR2019/014419**
§ 371 (c)(1),
(2) Date: **Apr. 20, 2022**

(87) PCT Pub. No.: **WO2021/085667**
PCT Pub. Date: **May 6, 2021**

(65) **Prior Publication Data**

US 2022/0393349 A1 Dec. 8, 2022

(51) **Int. Cl.**
H01Q 5/307 (2015.01)
H01Q 1/24 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 5/307*** (2015.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 9/045*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 5/307; H01Q 1/243; H01Q 1/48; H01Q 9/045; H01Q 21/06; H04B 1/40; H04B 7/0413
See application file for complete search history.

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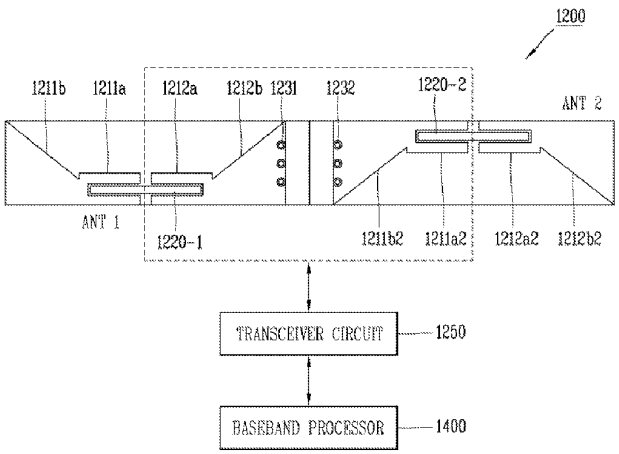
Abu Saada et al., "Design of Efficient Microstrip Linear Antenna Array for 5G Communications Systems," 2017 International Conference on Promising Electronic Technologies (ICPET), Oct. 2017, 7 pages.

Primary Examiner — Justin Y Lee
(74) *Attorney, Agent, or Firm* — LEE, HONG, DEGERMAN, KANG & WAIMEY

(57) **ABSTRACT**

Provided is an electronic device provided with a 5G antenna according to the present invention. The electronic device is provided with a first antenna including: a metal pattern in which metal having a predetermined length and a predetermined width is printed and disposed on the entire surface of a substrate, and which is configured to radiate a first signal; and a feeding pattern which is disposed inside a region in which the metal pattern is separated and spaced, and configured to couple-feed the first signal to the metal pattern. Further, the electronic device further comprises a second antenna that includes a metal pattern and a second feeding pattern arranged to be symmetric to the first antenna on the
(Continued)



US012272888B2

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

(10) **Patent No.: US 12,272,888 B2**
(45) **Date of Patent: Apr. 8, 2025**

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

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

(72) Inventors: **Hsuan-Jui Chang**, Hsinchu (TW); **Yun-Tsan Lee**, Hsinchu (TW); **Chia-Hao Chang**, 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 720 days.

(21) Appl. No.: **17/403,938**

(22) Filed: **Aug. 17, 2021**

(65) **Prior Publication Data**

US 2022/0320740 A1 Oct. 6, 2022

(30) **Foreign Application Priority Data**

Mar. 31, 2021 (TW) 110111907

(51) **Int. Cl.**
H01Q 9/42 (2006.01)
H01Q 13/10 (2006.01)
H01Q 1/22 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 9/42*** (2013.01); ***H01Q 13/10*** (2013.01); *H01Q 1/2266* (2013.01)

(58) **Field of Classification Search**
CPC H01Q 13/10; H01Q 1/2266; H01Q 1/243
See application file for complete search history.

(56) **References Cited**

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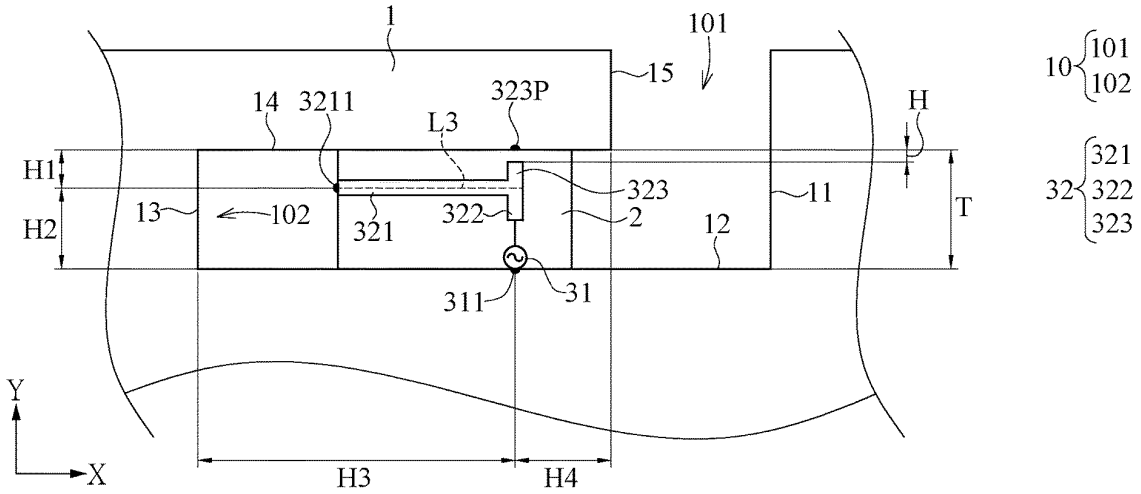
Primary Examiner — Graham P Smith
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

An electronic device and an antenna feeding module are provided. The electronic device includes a metal housing and an antenna feeding module. The metal housing is provided with a slot with an opening end and a closed end. The antenna feeding module includes a carrier board and a feeding circuit. The feeding circuit includes a feeding element and a radiating element. The radiating element includes a coupling portion, a radiating branch and a feeding portion. There is a coupling gap between the coupling portion and the metal housing, and the coupling gap is less than 0.5 times the width of the slot. The feeding circuit is used to excite the metal housing, so that the metal housing and the radiating element generate a first resonance path with a first resonance mode and a second resonance path with a second resonance mode.

8 Claims, 10 Drawing Sheets



US012278426B2

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

(10) **Patent No.: US 12,278,426 B2**
(45) **Date of Patent: Apr. 15, 2025**

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

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

(72) Inventors: **Kexin Liu**, Shanghai (CN); **Dong Yu**, Shanghai (CN); **Pengfei Wu**, 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 216 days.

(21) Appl. No.: **18/007,899**

(22) PCT Filed: **Mar. 30, 2021**

(86) PCT No.: **PCT/CN2021/084156**
§ 371 (c)(1),
(2) Date: **Dec. 2, 2022**

(87) PCT Pub. No.: **WO2021/244115**
PCT Pub. Date: **Sep. 12, 2021**

(65) **Prior Publication Data**

US 2023/0318172 A1 Oct. 5, 2023

(30) **Foreign Application Priority Data**

Jun. 3, 2020 (CN) 202010495093.5

(51) **Int. Cl.**
H01Q 5/28 (2015.01)
H01Q 1/52 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 1/521*** (2013.01); ***H01Q 5/28*** (2015.01); ***H01Q 5/328*** (2015.01); ***H01Q 5/335*** (2015.01);
(Continued)

(58) **Field of Classification Search**
USPC 343/725
See application file for complete search history.

(56) **References Cited**

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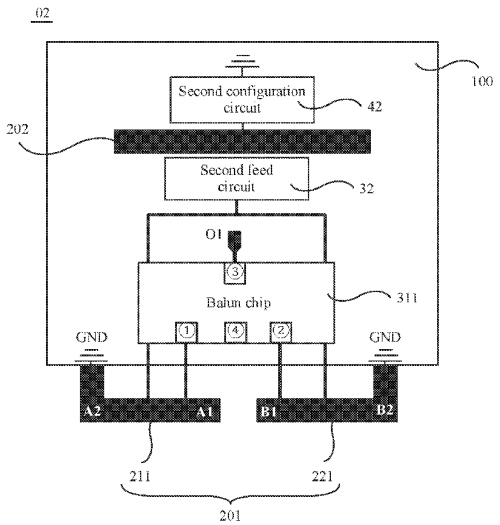
Primary Examiner — Hoang V Nguyen
Assistant Examiner — Brandon Sean Woods
(74) *Attorney, Agent, or Firm* — Conley Rose, P.C.

(57) **ABSTRACT**

An antenna apparatus includes a circuit board and an antenna body. The antenna body includes a first radiator and a second radiator that are indirectly coupled. The first radiator comprises a first stub and a second stub that are opposite to, but do not touch each other to form a first gap, the first stub and the second stub are located on a first side edge of the circuit board, a second gap is configured between the first stub and the first side edge, and also between the second stub and the first side edge. The second radiator is located on the circuit board to form a third gap in-between. A vertical projection of the second radiator is located on the first surface. The first stub and the second stub are electrically connected to reference ground of the circuit board separately.

20 Claims, 24 Drawing Sheets



US012278431B2

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

(10) **Patent No.: US 12,278,431 B2**
(45) **Date of Patent: Apr. 15, 2025**

(54) **ANTENNA ASSEMBLY AND COMMUNICATION TERMINAL**

(71) Applicant: **Lanto Electronic Limited**, Kunshan (CN)

(72) Inventors: **Bo Sun**, Kunshan (CN); **Rong Fu**, Kunshan (CN); **Xiange Yang**, Kunshan (CN); **Tonghui Xiao**, Kunshan (CN)

(73) Assignee: **LANTO ELECTRONIC LIMITED**, Kunshan (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 203 days.

(21) Appl. No.: **18/127,753**

(22) Filed: **Mar. 29, 2023**

(65) **Prior Publication Data**

US 2024/0145917 A1 May 2, 2024

(30) **Foreign Application Priority Data**

Oct. 26, 2022 (CN) 202211319689.5

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/378 (2015.01)
H01Q 13/10 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 5/378*** (2015.01); ***H01Q 13/10*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/24; H01Q 1/242; H01Q 1/22; H01Q 1/136; H01Q 1/48; H01Q 1/50; H01Q 5/28; H01Q 5/307; H01Q 5/371; H01Q 5/378; H01Q 13/10
See application file for complete search history.

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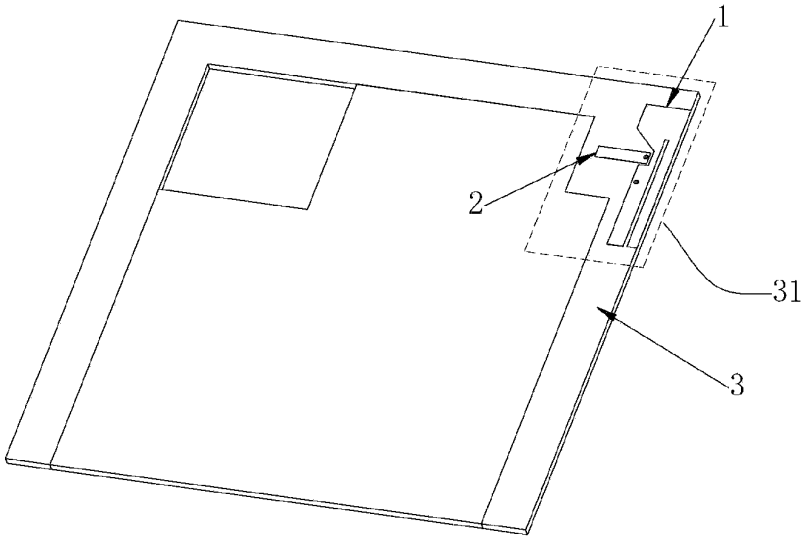
Primary Examiner — Hoang V Nguyen
(74) *Attorney, Agent, or Firm* — Birch, Stewart, Kolasch & Birch, LLP

(57) **ABSTRACT**

Disclosed in the embodiments of the present disclosure are an antenna assembly and a communication terminal, where a layout region is arranged at an edge position on a base frame, and a radiation pattern and a parasitic branch are arranged together on the layout region. Thus, in an aspect, when the communication terminal is assembled, it is convenient to observe the connection between a feed point and a ground point of the antenna assembly, thereby improving the assembly efficiency of the communication terminal. In another aspect, a parasitic branch is arranged near a second branch, so that the antenna has a larger bandwidth in a high frequency band. In yet another aspect, configuring a shape of a first slot, a second slot, and the parasitic branch enables direct adjustment to a resonance frequency of the antenna, which improves the adaptability of the antenna to different applications.

20 Claims, 8 Drawing Sheets



US012283743B2

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

(10) **Patent No.: US 12,283,743 B2**
(45) **Date of Patent: Apr. 22, 2025**

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

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

(72) Inventors: **Hanyang Wang**, Reading (GB); **Yuanpeng Li**, Shenzhen (CN); **Dawei Zhou**, Shenzhen (CN); **Le Chang**, Shenzhen (CN); **Hai Zhou**, 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 211 days.

(21) Appl. No.: **17/773,381**

(22) PCT Filed: **Oct. 30, 2020**

(86) PCT No.: **PCT/CN2020/125466**
§ 371 (c)(1),
(2) Date: **Apr. 29, 2022**

(87) PCT Pub. No.: **WO2021/083362**
PCT Pub. Date: **May 6, 2021**

(65) **Prior Publication Data**

US 2022/0407217 A1 Dec. 22, 2022

(30) **Foreign Application Priority Data**

Oct. 31, 2019 (CN) 201911054822.7

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/371 (2015.01)
H01Q 9/04 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 5/371*** (2015.01); ***H01Q 9/0421*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 5/371; H01Q 9/0421
See application file for complete search history.

(56) **References Cited**

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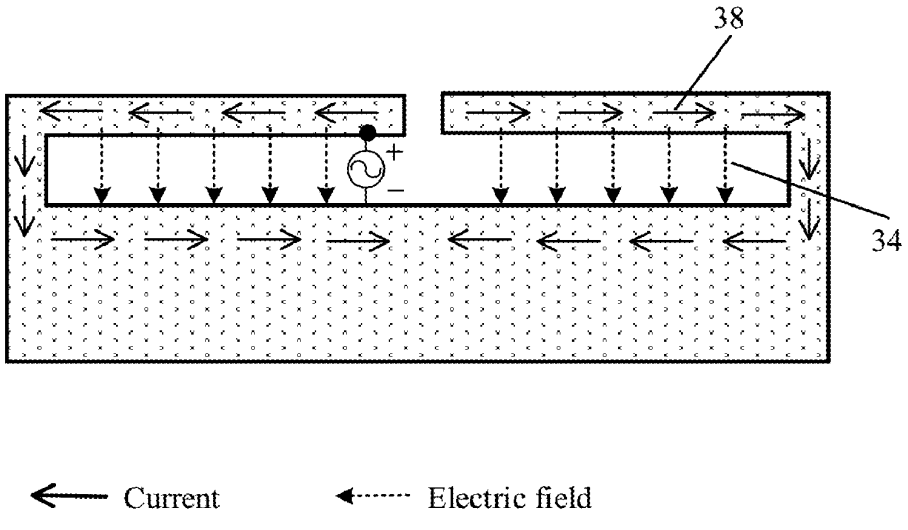
Primary Examiner — Hoang V Nguyen
Assistant Examiner — Aladdin Abdulbaki
(74) *Attorney, Agent, or Firm* — Rimon PC

(57) **ABSTRACT**

A single feed antenna design is conducted on a radiator of a specific shape (for example, a strip radiator or a slot radiator) to excite a plurality of antenna modes. For example, performing a feed design on a strip radiator may excite a CM wire antenna mode and a DM wire antenna mode. For another example, performing a feed design on a slot radiator may feed a CM slot antenna mode and a DM slot antenna mode. The antenna design may be used to cover a plurality of frequency bands when an antenna is miniaturized.

10 Claims, 57 Drawing Sheets



US012283744B2

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

(10) **Patent No.: US 12,283,744 B2**
(45) **Date of Patent: Apr. 22, 2025**

(54) **METHOD AND DEVICE FOR SHARING DC-TO-DC CONVERTER BETWEEN ANTENNA MODULES**

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

(72) Inventors: **Jihee Kang**, Suwon-si (KR); **Junghwan Son**, Suwon-si (KR); **Namjun Cho**, Suwon-si (KR); **Hyoseok Na**, 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 65 days.

(21) Appl. No.: **18/311,599**

(22) Filed: **May 3, 2023**

(65) **Prior Publication Data**

US 2023/0275339 A1 Aug. 31, 2023

Related U.S. Application Data

(63) Continuation of application No. PCT/KR2021/015385, filed on Oct. 29, 2021.

(30) **Foreign Application Priority Data**

Nov. 4, 2020 (KR) 10-2020-0146104

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 1/24 (2006.01)
H04B 1/40 (2015.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/38*** (2013.01); ***H04B 1/40*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/38; H04B 1/40
USPC 343/904, 905, 906
See application file for complete search history.

(56) **References Cited**

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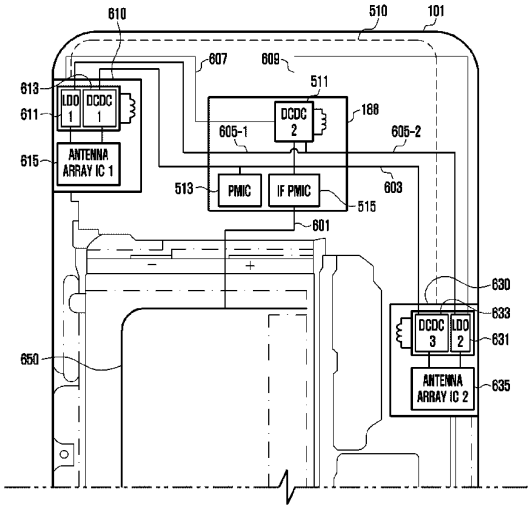
(Continued)

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

(57) **ABSTRACT**

An electronic device may include a low drop output regulator (LDO); a first DC-to-DC converter; an antenna module including an antenna array IC and an antenna array; a second DC-to-DC converter disposed outside the antenna module and supplying power to the low drop output regulator; a power generation circuit for supplying power to the first DC-to-DC converter and the second DC-to-DC converter; and a processor operatively coupled to the antenna module, the second DC-to-DC converter, and the power generation circuit.

20 Claims, 12 Drawing Sheets



US012283747B2

(12) **United States Patent**
Chiang

(10) **Patent No.: US 12,283,747 B2**
(45) **Date of Patent: Apr. 22, 2025**

(54) **DUAL-FREQUENCY ANTENNA STRUCTURE**

(71) Applicant: **AUDEN TECHNO CORP.**, Taoyuan (TW)

(72) Inventor: **Chi-Ming Chiang**, Taoyuan (TW)

(73) Assignee: **AUDEN TECHNO CORP**, Taoyuan (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 257 days.

(21) Appl. No.: **18/137,496**

(22) Filed: **Apr. 21, 2023**

(65) **Prior Publication Data**

US 2024/0356222 A1 Oct. 24, 2024

(51) **Int. Cl.**
H01Q 1/50 (2006.01)
H01Q 5/35 (2015.01)
H01Q 9/04 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/50*** (2013.01); ***H01Q 5/35*** (2015.01); ***H01Q 9/0435*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/50; H01Q 5/30; H01Q 5/307; H01Q 5/314; H01Q 5/321; H01Q 5/328; H01Q 5/335; H01Q 5/342; H01Q 5/35; H01Q 5/50; H01Q 9/0428; H01Q 9/0435; H01Q 9/0442; H01Q 9/045; H01Q 9/0457
See application file for complete search history.

(56) **References Cited**

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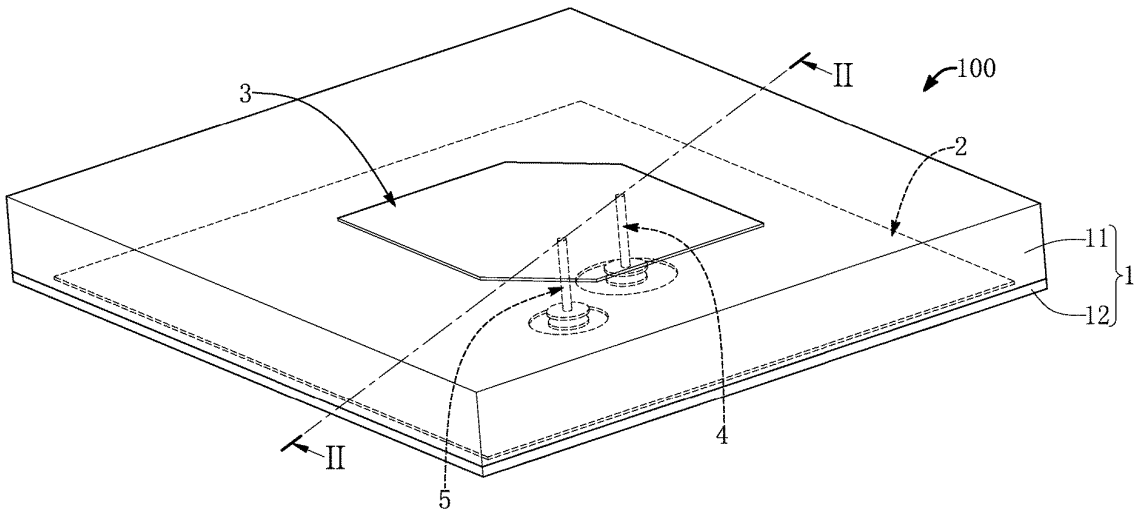
Primary Examiner — Robert Karacsony
(74) *Attorney, Agent, or Firm* — Li & Cai Intellectual Property (USA) Office

(57) **ABSTRACT**

A dual-frequency antenna structure includes a substrate, and a grounding element, a conductive sheet, a transmitting antenna, and a receiving antenna that are disposed on the substrate. The transmitting antenna includes a first coupling conductive pad, a first conductive column that is electrically coupled to the first coupling conductive pad and the conductive sheet, and a first feeding conductive pad. The first feeding conductive pad can produce a capacitive effect with each of the first coupling conductive pad and the grounding element. The receiving antenna includes a second coupling conductive pad, a second conductive column that is electrically coupled to the second coupling conductive pad and the conductive sheet, and a second feeding conductive pad. The second feeding conductive pad can produce a capacitive effect with each of the second coupling conductive pad and the grounding element.

9 Claims, 5 Drawing Sheets



US012283753B2

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

(10) **Patent No.: US 12,283,753 B2**
(45) **Date of Patent: Apr. 22, 2025**

(54) **DUAL POLARIZED FOLDED DIPOLE ELEMENT AND ANTENNA**

(71) Applicant: **DKK Co., Ltd.**, Tokyo (JP)

(72) Inventors: **Sadayuki Makiyama**, Tokyo (JP); **Hirotaka Ogura**, Tokyo (JP)

(73) Assignee: **DKK Co., Ltd.** (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 169 days.

(21) Appl. No.: **18/153,444**

(22) Filed: **Jan. 12, 2023**

(65) **Prior Publication Data**

US 2023/0238714 A1 Jul. 27, 2023

(30) **Foreign Application Priority Data**

Jan. 21, 2022 (JP) 2022-007806

(51) **Int. Cl.**
H01Q 9/26 (2006.01)
H01Q 5/48 (2015.01)
H01Q 21/24 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 21/24*** (2013.01); ***H01Q 5/48*** (2015.01); ***H01Q 9/26*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/48; H01Q 9/26; H01Q 21/24; H01Q 21/245; H01Q 21/26
See application file for complete search history.

(56) **References Cited**

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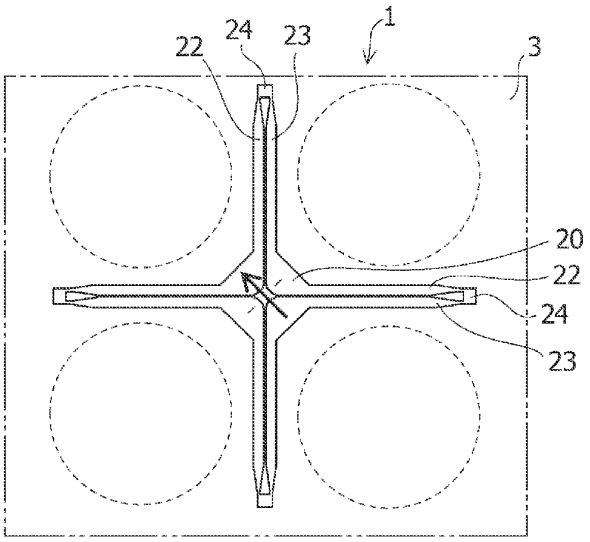
Primary Examiner — Daniel Munoz
(74) *Attorney, Agent, or Firm* — Lerner David LLP

(57) **ABSTRACT**

Provided is a dual polarized folded dipole element **1** including: four center portions **20** arranged adjacent to each other; and an element portion including two parallel wire portions **22**, **23** extending in parallel to each other from different adjacent two of the center portions **20** and a short circuit portion **24** that short-circuits each two parallel wire portions **22**, **23** at a distal end, in which: adjacent two of the center portions are physically connected to each other by the element portion; and the element portion extends in substantially the same plane in four directions from the center portions **20** with an angle of 90° therebetween. Also provided are antennae **10** and **10'** including the dual polarized folded dipole element **1**.

9 Claims, 16 Drawing Sheets



US012283756B2

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

(10) **Patent No.: US 12,283,756 B2**
(45) **Date of Patent: Apr. 22, 2025**

(54) **ANTENNA ARRAY ELEMENT WITH DUAL POLARIZATION, ANTENNA ARRAY INCLUDING ANTENNA ARRAY ELEMENT AND ELECTRONIC DEVICE INCLUDING ANTENNA ARRAY**

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

(72) Inventors: **Artem Rudolfovitch Vilenskiy**, Moscow (RU); **Elena Aleksandrovna Shepeleva**, Moscow (RU); **Gennadiy Aleksandrovich Evtyushkin**, Moscow (RU); **Anton Sergeevich Lukyanov**, Moscow (RU)

(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 68 days.

(21) Appl. No.: **18/177,503**

(22) Filed: **Mar. 2, 2023**

(65) **Prior Publication Data**

US 2024/0195085 A1 Jun. 13, 2024

Related U.S. Application Data

(63) Continuation of application No. PCT/KR2023/002579, filed on Feb. 23, 2023.

(30) **Foreign Application Priority Data**

Dec. 7, 2022 (RU) RU2022131923

(51) **Int. Cl.**
H01Q 25/00 (2006.01)
H01Q 21/06 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 25/001*** (2013.01); ***H01Q 21/065*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 25/001; H01Q 21/065
See application file for complete search history.

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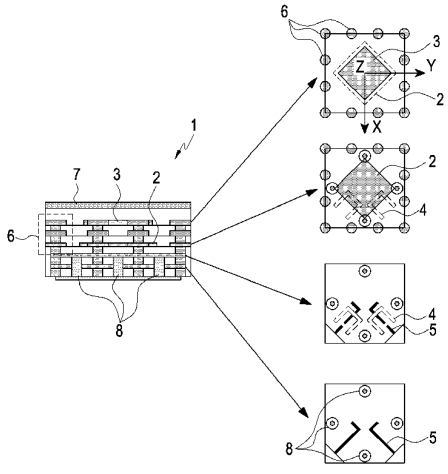
(57) **ABSTRACT**

An antenna array element with dual polarization is provided. The antenna array element includes a multilayer printed circuit board (PCB), a first patch placed on an inner layer of the multilayer PCB, a second patch placed on an upper layer of the multilayer PCB and coupled by electromagnetic field with the first patch, two U slots placed orthogonally on the multilayer PCB layer under the first patch, feedlines placed on one PCB layer under the U slots orthogonally to each other and configured to excite the U slots, ad a plurality of electromagnetic band gap (EBG) elements located in a boundary area of the antenna array element.

18 Claims, 4 Drawing Sheets



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Tanbo et al.

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(54) **ANTENNA MODULE AND COMMUNICATION DEVICE INCORPORATING THE SAME**

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(22) Filed: **Mar. 15, 2023**

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Related U.S. Application Data

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**
H01Q 5/314 (2015.01)
H01Q 1/24 (2006.01)
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CPC ***H01Q 5/314*** (2015.01); ***H01Q 1/24*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 1/521*** (2013.01); ***H01Q 13/106*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 13/10; H01Q 1/48; H01Q 5/307; H01Q 5/321; H01Q 1/523; H01Q 5/371; H01Q 21/28
See application file for complete search history.

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(57) **ABSTRACT**

An antenna module (**10**) includes a ground electrode (**30**) in which a slit (**33**) is formed in such a manner as to form an opening along a perimeter of the ground electrode, a first antenna (**110**) and a second antenna (**110**A) arranged in or on the ground electrode (**30**), and a coupling reducing electrode (**200**) connected to the ground electrode (**30**) within the slit (**33**). The slit (**33**) is formed on a path leading from the first antenna (**110**) to the second antenna (**110**A) along the perimeter of the ground electrode. The coupling reducing electrode (**200**) includes a first conductor (**220**) having a length corresponding to a first frequency and a second conductor (**230**) having a length corresponding to a second frequency, which is higher than the first frequency.

20 Claims, 17 Drawing Sheets