

(10) **Patent No.:** US 12,510,789 B2
(45) **Date of Patent:** *Dec. 30, 2025

- (51) **Int. Cl.**
G02F 1/1362 (2006.01)
G02F 1/1333 (2006.01)
 (Continued)

- (52) **U.S. Cl.**
CPC .. **G02F 1/136286** (2013.01); **G02F 1/133357**
(2021.01); **G02F 1/13338** (2013.01);
(Continued)

- (58) **Field of Classification Search**
CPC G02F 1/136286; G02F 1/13338; G02F 1/13472
See application file for complete search history.

- (56)
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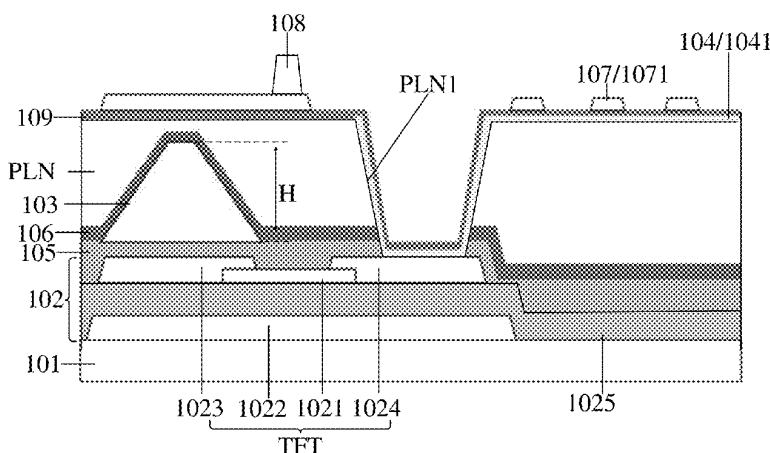
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- Primary Examiner* — Paisley L Wilson

- (74) *Attorney, Agent, or Firm* — Collard & Roe, P.C.

- (57) **ABSTRACT**

- A display substrate, a manufacturing method thereof and a display device. The display substrate includes a base substrate, a pixel driving circuit layer and an antenna layer, wherein the pixel driving circuit layer is arranged on the base substrate and includes a thin film transistor and a plurality of signal lines, and the antenna layer is arranged on a side of the pixel driving circuit layer far away from the
- (Continued)





US012510793B2

(12) **United States Patent**
Su

(10) **Patent No.:** **US 12,510,793 B2**
(45) **Date of Patent:** **Dec. 30, 2025**

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

(56) **References Cited**

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

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(72) Inventor: **Zipeng Su**, Dongguan (CN)

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

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 340 days.

International Search Report issued in corresponding International Application No. PCT/CN2022/079401, mailed May 31, 2022, 5 pages.

(21) Appl. No.: **18/244,218**

(Continued)

(22) Filed: **Sep. 9, 2023**

Primary Examiner — Richard H Kim

(65) **Prior Publication Data**

(74) *Attorney, Agent, or Firm* — IPX PLLC

US 2023/0418126 A1 Dec. 28, 2023

Related U.S. Application Data

(63) Continuation of application No. PCT/CN2022/079401, filed on Mar. 4, 2022.

Foreign Application Priority Data

Mar. 10, 2021 (CN) 202110260534.8

(57) **ABSTRACT**

An electronic device and a housing assembly are provided. The electronic device includes: a body; and a housing assembly, connected to the body, where the housing assembly includes a light-transmitting cover plate and an electrochromic assembly disposed on the light-transmitting cover plate, the electrochromic assembly includes a conductive layer and an electrochromic layer connected to the conductive layer, the conductive layer is connected to the light-transmitting cover plate, the conductive layer includes an antenna area and a conductive area, the antenna area and the conductive area are connected to each other through an isolation area, and the isolation area surrounds the antenna area. The antenna area is connected to a mainboard of the electronic device and serves as a communication antenna of the electronic device, and the electrochromic layer is connected to a power supply and changed in color in a case that the electrochromic layer is powered on.

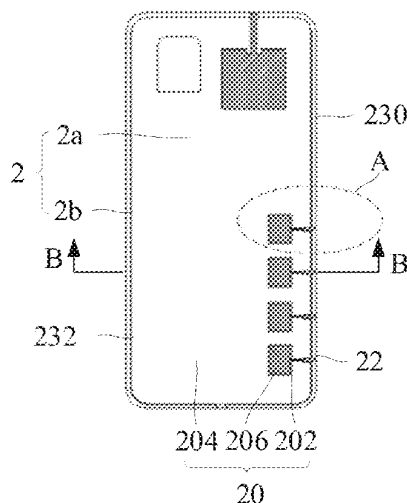
(51) **Int. Cl.**
G02F 1/153 (2006.01)
G02F 1/1333 (2006.01)
G02F 1/1345 (2006.01)
H01Q 1/22 (2006.01)

(52) **U.S. Cl.**
CPC **G02F 1/1533** (2013.01); **G02F 1/133317** (2021.01); **G02F 1/133331** (2021.01); **G02F 1/13452** (2013.01); **H01Q 1/22** (2013.01)

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

See application file for complete search history.

12 Claims, 7 Drawing Sheets





US012512590B2

(12) **United States Patent**
Lee

(10) **Patent No.:** **US 12,512,590 B2**
(45) **Date of Patent:** **Dec. 30, 2025**

(54) **WIDEBAND ANTENNA STRUCTURE**

(71) Applicant: **ASUSTeK COMPUTER INC.**, Taipei (TW)

(72) Inventor: **Cheng-Tse Lee**, Taipei (TW)

(73) Assignee: **ASUSTEK COMPUTER INC.**, Taipei (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 280 days.

(21) Appl. No.: **18/311,987**

(22) Filed: **May 4, 2023**

(65) **Prior Publication Data**

US 2024/0106117 A1 Mar. 28, 2024

(30) **Foreign Application Priority Data**

Sep. 28, 2022 (TW) 111136846

(51) **Int. Cl.**
H01Q 5/307 (2015.01)
H01Q 1/48 (2006.01)
H01Q 9/04 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 5/307** (2015.01); **H01Q 1/48** (2013.01); **H01Q 9/0421** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/307; H01Q 1/48; H01Q 9/0421; H01Q 13/106; H01Q 1/38; H01Q 9/0407; H01Q 9/065; H01Q 13/206; H01Q 15/142; H01Q 1/22; H01Q 1/24; H01Q 9/0414

See application file for complete search history.

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Primary Examiner — Dameon E Levi

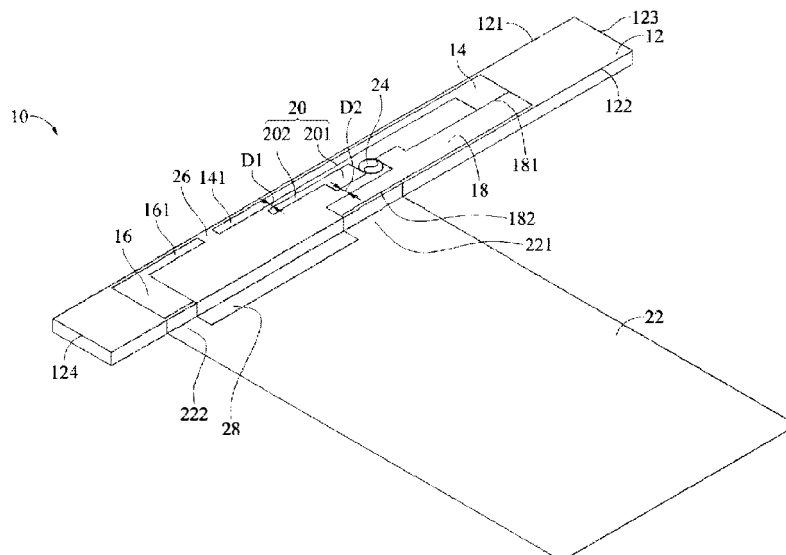
Assistant Examiner — David Andrew Kubera

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

(57) **ABSTRACT**

A wideband antenna structure includes: a first radiating portion on a dielectric substrate is close to a first short side and including a first bending section; a second radiating portion on the dielectric substrate is close to a second short side and including a second bending section; a grounding portion on the dielectric substrate is including a first side edge close to the first short side and a second side edge on the other end, where the first side edge is connected to the first radiating portion; a coupling portion is on the dielectric substrate and between the first radiating portion and the grounding portion; a third radiating portion, one side of which is with a first flange connected to the second side edge and a second flange connected to the second radiating portion; and a signal source, connected to the coupling portion and the grounding portion.

10 Claims, 14 Drawing Sheets





US012512592B2

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

(10) **Patent No.:** **US 12,512,592 B2**
(45) **Date of Patent:** **Dec. 30, 2025**

(54) **ANTENNA AND ANTENNA SYSTEM**

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

(72) Inventors: **Feng Wang**, Beijing (CN); **Jian Zhou**, Beijing (CN); **Yafei Zhang**, Beijing (CN); **Feng Qu**, Beijing (CN)

(73) Assignee: **Beijing BOE Technology Development 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 193 days.

(21) Appl. No.: **18/273,787**

(22) PCT Filed: **Jul. 1, 2022**

(86) PCT No.: **PCT/CN2022/103255**

§ 371 (c)(1),

(2) Date: **Jul. 24, 2023**

(87) PCT Pub. No.: **WO2023/000951**

PCT Pub. Date: **Jan. 26, 2023**

(65) **Prior Publication Data**

US 2024/0079783 A1 Mar. 7, 2024

(30) **Foreign Application Priority Data**

Jul. 20, 2021 (CN) 202110817204.4

(51) **Int. Cl.**

H01Q 9/04 (2006.01)

H04B 1/40 (2015.01)

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

CPC **H01Q 9/0407** (2013.01); **H04B 1/40** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 9/0407; H01Q 1/243; H01Q 1/38;
H01Q 1/36; H01Q 1/50; H01Q 9/04;
(Continued)

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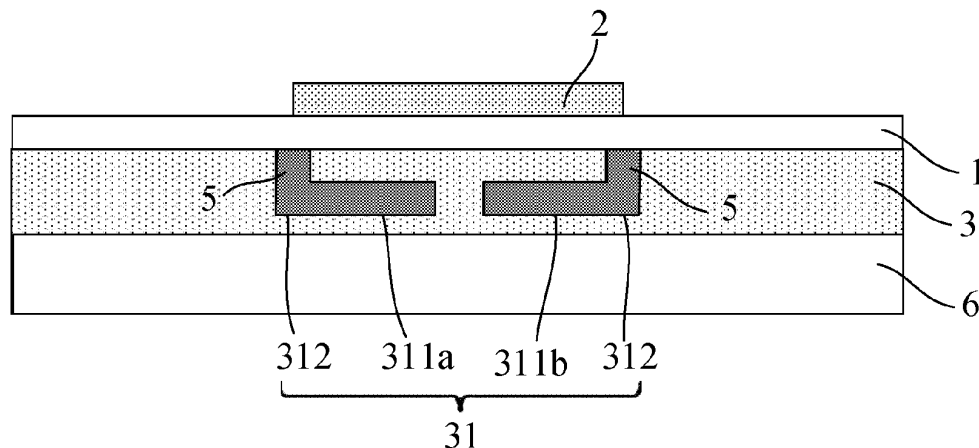
Primary Examiner — Lana N Le

(74) *Attorney, Agent, or Firm* — Ling Wu; Stephen Yang;
Ling and Yang Intellectual Property

(57) **ABSTRACT**

An antenna and an antenna system. The antenna includes: a first dielectric layer (1) having a first surface and a second surface, which are arranged opposite each other in a thickness direction thereof; a radiation patch (2), which is arranged on the first surface of the first dielectric layer; and a first electrode layer (3), which is arranged on the second surface of the first dielectric layer, and at least partially overlaps with the orthographic projection of the radiation patch on the second surface, wherein the first electrode layer has inner recesses (31, 32), and openings of the inner recesses face the radiation patch. The orthographic projection of at least part of a radiation edge of the radiation patch

(Continued)





US012513820B2

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

(10) **Patent No.:** **US 12,513,820 B2**
(45) **Date of Patent:** **Dec. 30, 2025**

(54) **FLEXIBLE PRINTED CIRCUIT AND ANTENNA STRUCTURE**

(71) Applicant: **Wistron NeWeb Corporation**, Hsinchu (TW)

(72) Inventors: **Li-Kai Kuo**, Hsinchu (TW);
Ching-Wen Chen, 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 329 days.

(21) Appl. No.: **18/190,181**

(22) Filed: **Mar. 27, 2023**

(65) **Prior Publication Data**
US 2023/0363089 A1 Nov. 9, 2023

(30) **Foreign Application Priority Data**
May 9, 2022 (TW) 111117382

(51) **Int. Cl.**
H05K 1/03 (2006.01)
H05K 1/02 (2006.01)

(52) **U.S. Cl.**
CPC **H05K 1/032** (2013.01); **H05K 1/028** (2013.01); **H05K 2201/0355** (2013.01); **H05K 2201/10098** (2013.01)

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

(56) **References Cited**

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Primary Examiner — Timothy J Thompson

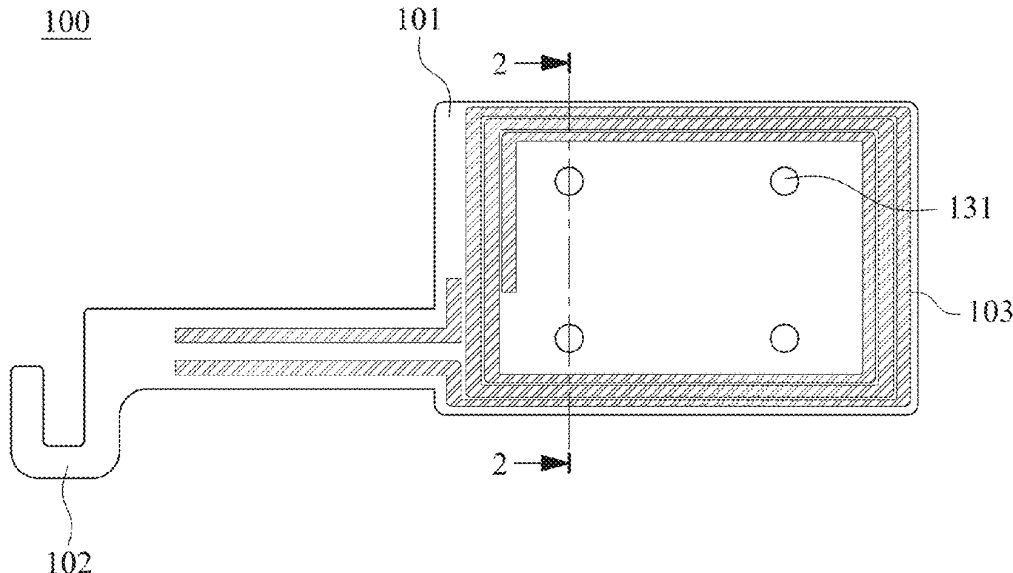
Assistant Examiner — John B Freal

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

(57) **ABSTRACT**

A flexible printed circuit and an antenna structure are provided. The flexible printed circuit has a main body part and a bending part and includes a substrate, two copper foil layers, and two coverlays. The substrate includes a first surface and a second surface, and one surface of each of the two copper foil layers is disposed on the first surface and the second surface of the substrate, respectively. Each of the two coverlays is disposed on another surface of each of the two copper foil layers. Each of the two coverlays includes at least two coverlay holes, and the at least two coverlay holes penetrate through the coverlay and are disposed on the main body part.

19 Claims, 6 Drawing Sheets





US012519204B2

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

(10) **Patent No.:** **US 12,519,204 B2**
(45) **Date of Patent:** **Jan. 6, 2026**

(54) **ELECTRONIC DEVICE**

(71) Applicant: **Lenovo (Beijing) Limited**, Beijing (CN)

(72) Inventors: **Yuling Xu**, Beijing (CN); **Dafei Mo**, Beijing (CN)

(73) Assignee: **LENOVO (BEIJING) LIMITED**, Beijing (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 106 days.

(21) Appl. No.: **18/524,830**

(22) Filed: **Nov. 30, 2023**

(65) **Prior Publication Data**
US 2024/0178546 A1 May 30, 2024

(30) **Foreign Application Priority Data**
Nov. 30, 2022 (CN) 202211524409.4

(51) **Int. Cl.**
H01Q 1/22 (2006.01)
H01Q 1/24 (2006.01)
H01Q 1/48 (2006.01)
H01Q 21/30 (2006.01)

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

CPC **H01Q 1/22** (2013.01); **H01Q 1/48** (2013.01); **H01Q 21/30** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/22; H01Q 1/2266; H01Q 1/24; H01Q 1/243; H01Q 1/36; H01Q 1/42; H01Q 1/48; H01Q 1/50; H01Q 21/28; H01Q 21/30

See application file for complete search history.

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Primary Examiner — Hoang V Nguyen

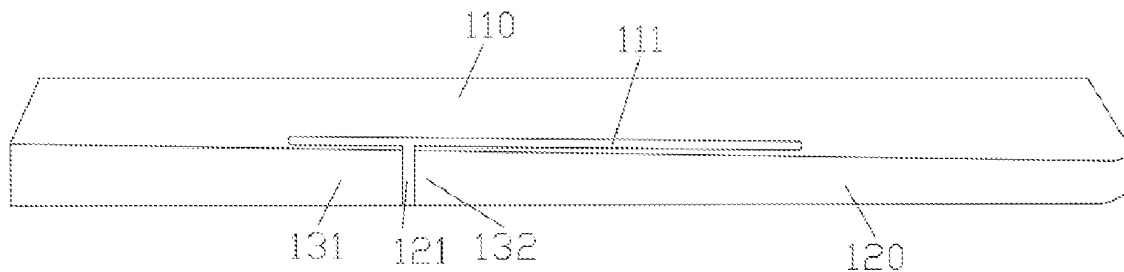
(74) *Attorney, Agent, or Firm* — ANOVA LAW GROUP, PLLC

(57)

ABSTRACT

An electronic device includes a shell forming an accommodation space. The shell includes a first wall including a first opening communicating with the accommodation space. At least a part of the first wall located at the first opening forms a first antenna radiator of the electronic device.

20 Claims, 7 Drawing Sheets





US012519206B2

(12) **United States Patent**
Li

(10) **Patent No.:** **US 12,519,206 B2**
(45) **Date of Patent:** **Jan. 6, 2026**

(54) **ELECTRONIC DEVICE**

(71) Applicant: **Honor Device Co., Ltd.**, Shenzhen
(CN)

(72) Inventor: **Yuanpeng Li**, Shenzhen (CN)

(73) Assignee: **Honor Device Co., Ltd.**, Shenzhen
(CN)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 368 days.

(21) Appl. No.: **18/029,489**

(22) PCT Filed: **Feb. 9, 2022**

(86) PCT No.: **PCT/CN2022/075717**

§ 371 (c)(1),

(2) Date: **Mar. 30, 2023**

(87) PCT Pub. No.: **WO2022/222580**

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

(65) **Prior Publication Data**

US 2024/0014541 A1 Jan. 11, 2024

(30) **Foreign Application Priority Data**

Apr. 19, 2021 (CN) 202110420862.X

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

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/2216** (2013.01); **H01Q 1/002**
(2013.01); **H01Q 1/273** (2013.01); **H01Q 1/38**
(2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/2216; H01Q 1/002; H01Q 1/273;
H01Q 1/38; H01Q 1/42; H01Q 7/00;
(Continued)

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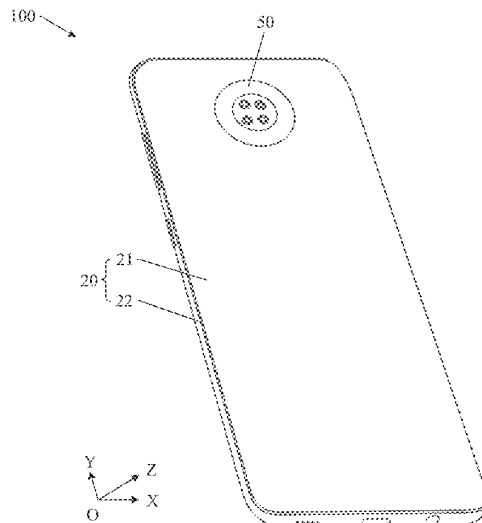
Primary Examiner — Fayyaz Alam

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

(57) **ABSTRACT**

An electronic device is provided. The electronic device
comprises an NFC antenna and a metal member. The NFC
antenna includes an NFC coil, and the metal member is
located on the side of a plane in which the NFC coil is
located. The NFC coil includes a first part and a second part
that are arranged along a circumferential direction of the
NFC coil, the first part is located outside an orthographic
projection that is of the metal member and that is on the
plane in which the NFC coil is located, and the second part
passes through the orthographic projection that is of the
metal member and that is on the plane in which the NFC coil
is located.

20 Claims, 21 Drawing Sheets





US012519212B2

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

(10) **Patent No.:** **US 12,519,212 B2**
(45) **Date of Patent:** **Jan. 6, 2026**

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

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

(72) Inventors: **Chanju Park**, Suwon-si (KR); **Junhwa
Oh**, Suwon-si (KR); **Sanghyuk Wi**,
Suwon-si (KR); **Jungi Jeong**, 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 244 days.

(21) Appl. No.: **18/272,917**

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

(86) PCT No.: **PCT/KR2022/001376**

§ 371 (c)(1),

(2) Date: **Jul. 18, 2023**

(87) PCT Pub. No.: **WO2022/169182**

PCT Pub. Date: **Aug. 11, 2022**

(65) **Prior Publication Data**

US 2024/0120642 A1 Apr. 11, 2024

(30) **Foreign Application Priority Data**

Feb. 2, 2021 (KR) 10-2021-0014879

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

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

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 21/24; H01Q 1/24;
H01Q 21/0025; H01Q 21/0075;
(Continued)

(56) **References Cited**

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European Patent Application No. 22749933.2.

Primary Examiner — Hoang V Nguyen

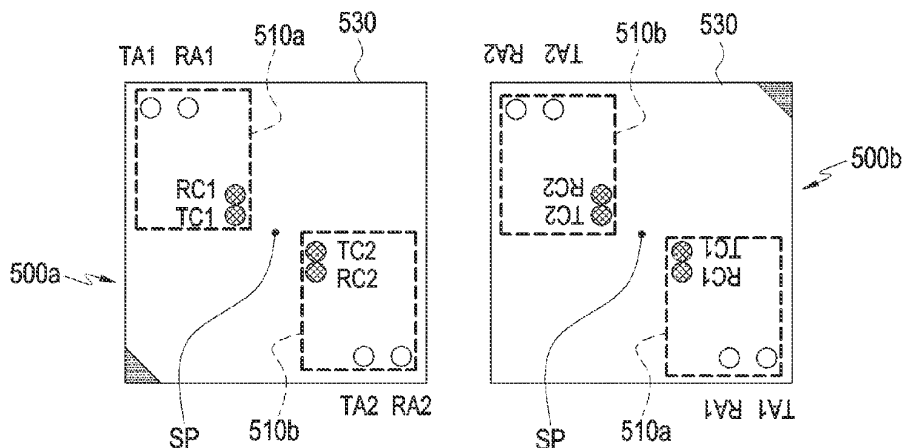
Assistant Examiner — Anna N Hamadyk

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

(57) **ABSTRACT**

An antenna is provided. The antenna includes a communi-
cation circuit part; an antenna part stacked-up on or above
the communication circuit part and comprising multiple
antenna elements; and a network part disposed between the
communication circuit part and the antenna part; at least one
first subarray formed of a combination of some of the
antenna elements; and at least one second subarray formed
of a combination another of the antenna elements, and
disposed to be point symmetric to the first subarray; a first
transmission port corresponding to a transmission input
terminal of the first subarray; a first reception port cor-
responding to a reception input terminal of the first subarray;
a second transmission port corresponding to a transmission

(Continued)





US012519221B2

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

(10) **Patent No.:** **US 12,519,221 B2**
(45) **Date of Patent:** **Jan. 6, 2026**

(54) **COMMUNICATION MODULE**

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

(72) Inventors: **Doojung Kim**, Seoul (KR); **Seungmin Woo**, Seoul (KR); **Dongwan Roh**, 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 334 days.

(21) Appl. No.: **18/255,288**

(22) PCT Filed: **Dec. 6, 2021**

(86) PCT No.: **PCT/KR2021/018394**

§ 371 (c)(1).

(2) Date: **May 31, 2023**

(87) PCT Pub. No.: **WO2022/124743**

PCT Pub. Date: **Jun. 16, 2022**

(65) **Prior Publication Data**

US 2024/0006758 A1 Jan. 4, 2024

(30) **Foreign Application Priority Data**

Dec. 11, 2020 (KR) 10-2020-0173587

(51) **Int. Cl.**

H01Q 1/52 (2006.01)

H01Q 9/04 (2006.01)

(Continued)

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

CPC **H01Q 1/526** (2013.01); **H01Q 9/0421** (2013.01); **H04B 1/0064** (2013.01); **H04B 1/40** (2013.01); **H01Q 1/2291** (2013.01)

(58) **Field of Classification Search**

CPC **H01Q 1/526**; **H01Q 1/2291**; **H01Q 9/0421**;
H04B 1/0064; **H04B 1/40**

See application file for complete search history.

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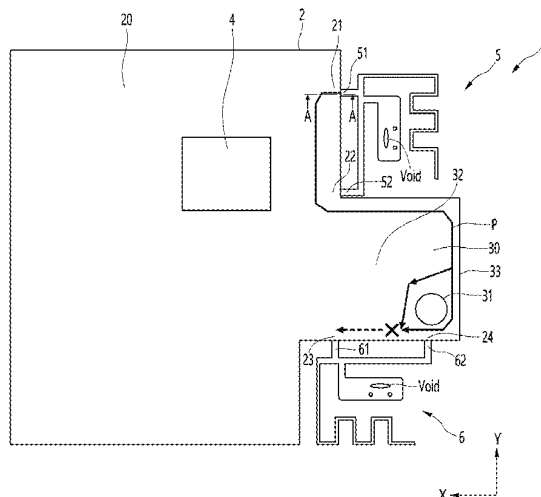
Primary Examiner — Junpeng Chen

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

(57) **ABSTRACT**

A communication module according to the present embodiment comprises: a substrate in which a ground shield protrudes from a main body; at least one communication chip provided in the main body; a first antenna having a first feeding unit and a first ground that are connected to the main body; and a second antenna which has a second feeding unit and a second ground that are connected to the main body, and which is spaced from the first antenna, wherein the ground shield protrudes between the first antenna and the second antenna, and at least one hole can be formed in the ground shield.

10 Claims, 9 Drawing Sheets





US012519231B2

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

(10) **Patent No.:** **US 12,519,231 B2**
(45) **Date of Patent:** **Jan. 6, 2026**

(54) **ELECTRONIC DEVICE HAVING ANTENNA
TUNERS AROUND CONNECTOR**

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

(72) Inventors: **Enrique Ayala Vazquez**, Watsonville, CA (US); **Ming-Ju Tsai**, Sunnyvale, CA (US); **Yiren Wang**, Cupertino, CA (US); **Yuan Tao**, Santa Clara, CA (US); **Hao Xu**, Cupertino, CA (US); **Sidharath Jain**, Redwood City, CA (US); **Haozhan Tian**, San Jose, CA (US); **Yuancheng Xu**, San Jose, CA (US); **Eric W Bates**, San Jose, CA (US); **Peter A Dvorak**, Menlo Park, CA (US); **Harlan S Dannenberg**, San Francisco, CA (US); **Rees S Parker**, San Francisco, CA (US); **Obinna O Onyemepu**, Campbell, CA (US); **Victor C Lee**, Santa Clara, CA (US); **Han Wang**, Campbell, CA (US); **Hongfei Hu**, Cupertino, CA (US)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 34 days.

(21) Appl. No.: **18/458,720**

(22) Filed: **Aug. 30, 2023**

(65) **Prior Publication Data**

US 2024/0079778 A1 Mar. 7, 2024

Related U.S. Application Data

(60) Provisional application No. 63/404,095, filed on Sep. 6, 2022.

(51) **Int. Cl.**
H01Q 5/328 (2015.01)
H01Q 9/04 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 5/328** (2015.01); **H01Q 9/0442** (2013.01); **H01Q 9/045** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/328; H01Q 9/0442; H01Q 9/045
See application file for complete search history.

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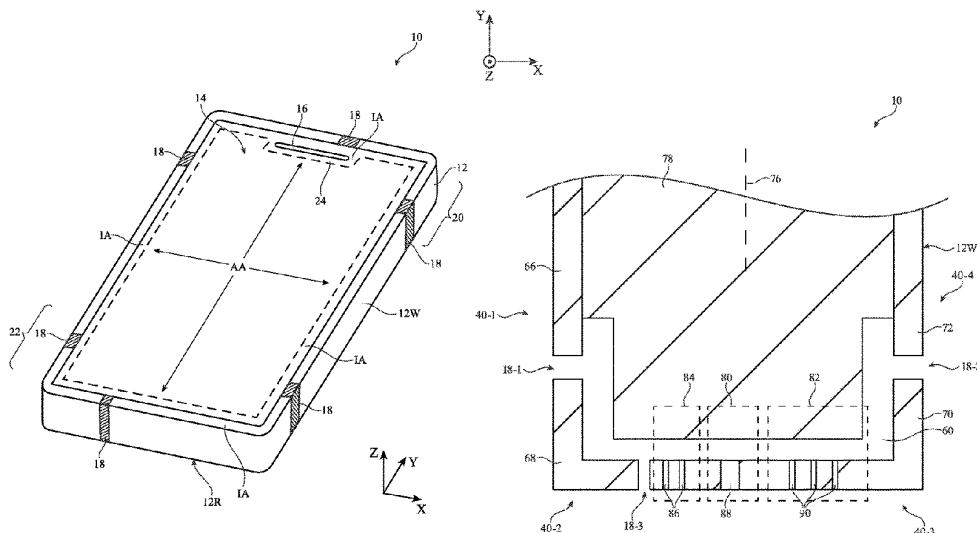
Primary Examiner — Henry Luong

(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.;
Michael H. Lyons

(57) **ABSTRACT**

An electronic device may be provided with an antenna having a resonating element formed from a segment of peripheral conductive housing structures. A speaker may be aligned with first openings in the segment. A vent may be aligned with second openings in the segment. A connector may protrude through the segment. A trace combiner for the antenna may be patterned onto the speaker and may be coupled to the segment. Tuners for the antenna may be disposed on first and second flexible printed circuits that extend along opposing sides of the connector. The tuners may be controlled through the speaker. The second flexible printed circuit may extend along the vent. The vent may have a vent cowling with a cut-out region next to the tuner on the second flexible printed circuit.

20 Claims, 10 Drawing Sheets





US012519234B2

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

(10) **Patent No.:** **US 12,519,234 B2**
(45) **Date of Patent:** **Jan. 6, 2026**

(54) **ULTRA-WIDEBAND ANTENNA ASSEMBLY**

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

(72) Inventors: **Alden T Rush**, San Diego, CA (US);
Han Wang, Campbell, CA (US); **Jingni**
Zhong, Santa Clara, CA (US); **Ming**
Chen, Cupertino, CA (US); **Yiren**
Wang, Cupertino, CA (US); **Yuan Tao**,
Santa Clara, CA (US); **Hao Xu**,
Cupertino, CA (US); **Hongfei Hu**,
Cupertino, CA (US); **Mattia Pascolini**,
San Francisco, CA (US)

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

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 167 days.

(21) Appl. No.: **18/458,916**

(22) Filed: **Aug. 30, 2023**

(65) **Prior Publication Data**

US 2024/0079782 A1 Mar. 7, 2024

Related U.S. Application Data

(60) Provisional application No. 63/403,613, filed on Sep.
2, 2022.

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

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 7/00** (2013.01); **H01Q 1/38**
(2013.01); **H01Q 1/48** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/38; H01Q 1/48;
H01Q 9/0485; H01Q 9/42; H01Q 1/273;
H01Q 21/28; H01Q 1/2258; H01Q
9/0407; H01Q 1/422; H01Q 1/50; H01Q
5/371; H01Q 1/241

See application file for complete search history.

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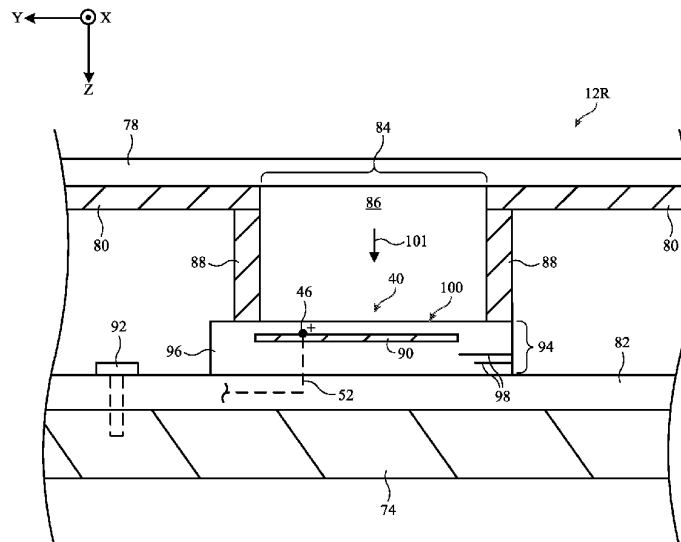
Primary Examiner — Wei (Victor) Y Chan

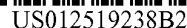
(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.;
Michael H. Lyons

(57) **ABSTRACT**

An electronic device may be provided with a housing and an antenna. The antenna may be on a first substrate mounted to a second substrate. The housing may include a dielectric cover, a conductive plate on the dielectric cover, and a mid-chassis. The second substrate may be mounted to the mid-chassis. The antenna may include a conductive patch extending from a segment of a conductive ring on the first substrate. The conductive plate may have an opening aligned with the conductive patch. The first substrate may be separated from the dielectric cover by an air gap. A conductive gasket may couple the conductive ring to the conductive plate and may laterally surround the air gap and the opening. The antenna may convey ultra-wideband (UWB) signals through the air gap, the opening, and the dielectric cover layer.

20 Claims, 10 Drawing Sheets





(10) **Patent No.:** US 12,519,238 B2
(45) **Date of Patent:** Jan. 6, 2026

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- Primary Examiner* — Dameon E Levi

- Assistant Examiner — Anh N Ho
(74) Attorney, Agent, or Firm — McClure, Qualey & Rodack, LLP

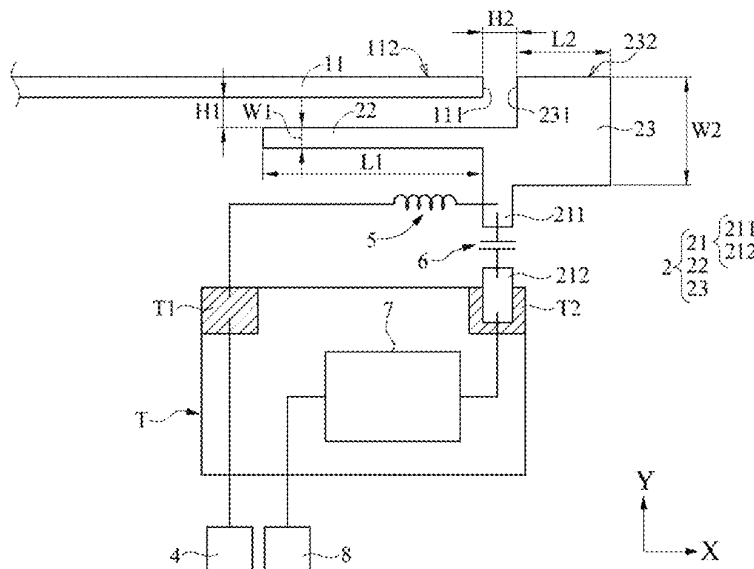
- (57) **ABSTRACT**

- An antenna module and an electronic device are provided. The antenna module is disposed in a housing of the electronic device. The antenna module includes a first radiating element, a second radiating element, and a feeding element. The first radiating element includes a first radiating portion, a second radiating portion, and a feeding portion. The feeding portion is connected between the first radiating portion and the second radiating portion. A length of the first radiating portion is greater than a length of the second radiating portion. The second radiating element includes a connecting portion, a third radiating portion, and a fourth radiating portion. The connecting portion is connected between the third radiating portion and the fourth radiating portion. A length of the third radiating portion and a length of the fourth radiating portion are not equal to each other.

- 16 Claims, 10 Drawing Sheets**

- (52) **U.S. Cl.**
CPC **H01Q 9/0421** (2013.01); **H01Q 1/2291**
(2013.01); **H01Q 9/30** (2013.01)

- See application file for complete search history.





US012519248B2

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

(10) **Patent No.:** **US 12,519,248 B2**
(45) **Date of Patent:** **Jan. 6, 2026**

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

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

(72) Inventors: **Seungho Choi**, Suwon-si (KR); **Yoongeon Kim**, Suwon-si (KR); **Seungtae Ko**, Suwon-si (KR); **Junsig Kum**, Suwon-si (KR); **Jungmin Park**, Suwon-si (KR); **Bumhee Lee**, Suwon-si (KR); **Youngju Lee**, Suwon-si (KR); **Jongmin 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 96 days.

(21) Appl. No.: **18/122,964**

(22) Filed: **Mar. 17, 2023**

(65) **Prior Publication Data**

US 2023/0231321 A1 Jul. 20, 2023

Related U.S. Application Data

(63) Continuation of application No. PCT/KR2021/012824, filed on Sep. 17, 2021.

(30) **Foreign Application Priority Data**

Sep. 18, 2020 (KR) 10-2020-0120969

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

(52) **U.S. Cl.**
CPC **H01Q 21/065** (2013.01); **H01Q 1/246** (2013.01); **H01Q 1/48** (2013.01); **H04B 7/0413** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 21/06; H01Q 21/061; H01Q 21/065; H01Q 1/246; H01Q 5/378; H01Q 9/0407; H01Q 9/0414; H01Q 9/0457
See application file for complete search history.

(56) **References Cited**

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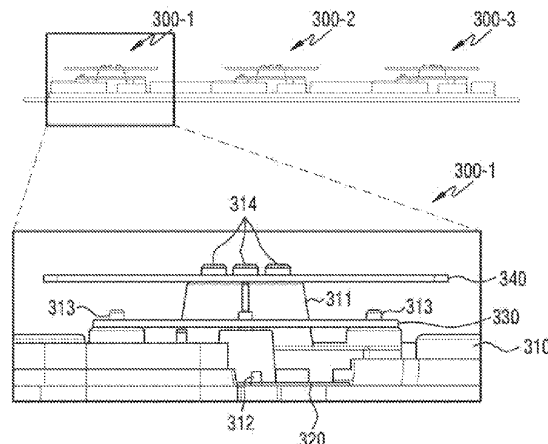
Primary Examiner — Jason M Crawford

(74) *Attorney, Agent, or Firm* — Sughrue Mion, PLLC

(57) **ABSTRACT**

The present disclosure relates to a 5th generation (5G) or pre-5G communication system for supporting higher data transmission rates than 4th generation (4G) communication systems such as Long-Term Evolution (LTE). According to one or more embodiments, an antenna includes: a first metal patch; a second metal patch; a feeding circuit; and a substrate. The first metal patch and the second metal patch are arranged on the substrate. The feeding circuit is coupled to the substrate and is spaced apart from the first metal patch.

10 Claims, 18 Drawing Sheets





US012519253B2

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

(10) **Patent No.:** **US 12,519,253 B2**
(45) **Date of Patent:** **Jan. 6, 2026**

(54) **ANTENNA SYSTEM, METHOD, AND WIRELESS COMMUNICATION DEVICE**

(71) Applicant: **Honor Device Co., Ltd.**, Shenzhen (CN)

(72) Inventors: **Yi Wang**, Shenzhen (CN); **Yuan Xu**, Shenzhen (CN); **Ziyan Zhang**, Shenzhen (CN); **Kunpeng Wei**, Shenzhen (CN)

(73) Assignee: **Honor Device Co., Ltd.**, Shenzhen (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 355 days.

(21) Appl. No.: **18/032,053**

(22) PCT Filed: **Dec. 21, 2022**

(86) PCT No.: **PCT/CN2022/140644**

§ 371 (c)(1),

(2) Date: **Apr. 14, 2023**

(87) PCT Pub. No.: **WO2023/169044**

PCT Pub. Date: **Sep. 14, 2023**

(65) **Prior Publication Data**

US 2024/0372273 A1 Nov. 7, 2024

(30) **Foreign Application Priority Data**

Mar. 10, 2022 (CN) 202210240268.7

(51) **Int. Cl.**

H01Q 21/30 (2006.01)

H01Q 9/42 (2006.01)

H04B 1/401 (2015.01)

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

CPC **H01Q 21/30** (2013.01); **H01Q 9/42** (2013.01); **H04B 1/401** (2013.01)

(58) **Field of Classification Search**

CPC H04B 1/0064; H04B 1/0458; H04B 1/72; H01Q 21/30; H01Q 15/002; H01Q 15/006

See application file for complete search history.

(56) **References Cited**

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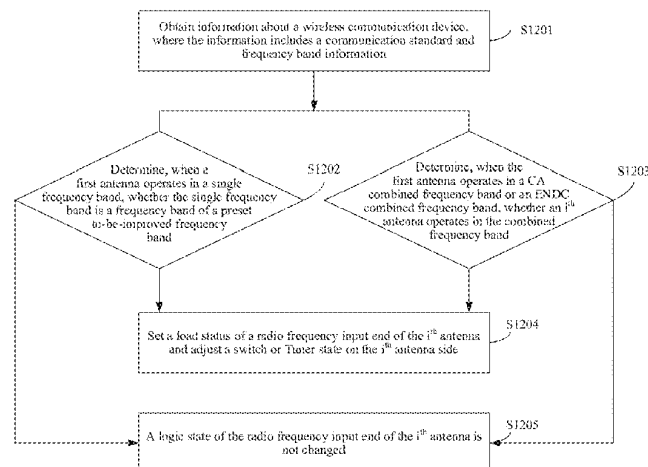
Primary Examiner — Wen W Huang

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

(57) **ABSTRACT**

This application provides an antenna system related to the field of terminal technologies. The system includes: a radio frequency chip, a controller, and a plurality of antennas, where the radio frequency chip is connected to the plurality of antennas: a first antenna, a second antenna, . . . , and an Nth antenna by a power amplifier and switches, where the first antenna is a to-be-improved antenna, an ith antenna is an auxiliary antenna; and the controller determines that a frequency band in which an antenna of the wireless communication device operates belongs to a preset to-be-improved frequency band of the first antenna; determines whether the ith antenna operates; and sets a load status of a radio frequency input end of the ith antenna and adjusts a switch or Tuner state on the ith antenna side when the ith antenna does not operate.

15 Claims, 14 Drawing Sheets





US012519878B2

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

(10) **Patent No.:** **US 12,519,878 B2**
(45) **Date of Patent:** **Jan. 6, 2026**

(54) **ELECTRONIC DEVICE COMPRISING ANTENNA**

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

(72) Inventors: **Cheolhong Son**, Suwon-si (KR);
Gyusub Kim, Suwon-si (KR);
Jongwon Kim, Suwon-si (KR);
Kyungmoon Seol, Suwon-si (KR);
Jungkyl Lee, Suwon-si (KR); **Bumjin**
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 510 days.

(21) Appl. No.: **18/167,497**

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

(65) **Prior Publication Data**
US 2023/0224395 A1 Jul. 13, 2023

Related U.S. Application Data

(63) Continuation of application No.
PCT/KR2023/000687, filed on Jan. 13, 2023.

(30) **Foreign Application Priority Data**

Jan. 13, 2022 (KR) 10-2022-0005314
Mar. 21, 2022 (KR) 10-2022-0034767

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

(52) **U.S. Cl.**
CPC **H04M 1/0277** (2013.01); **H01Q 1/243**
(2013.01); **H04M 1/0216** (2013.01); **H04M**
1/0268 (2013.01); **H04M 2201/08** (2013.01)

(58) **Field of Classification Search**

CPC H04M 1/0277; H04M 1/0216; H04M
1/0268; H04M 2201/08; H01Q 1/243
See application file for complete search history.

(56) **References Cited**

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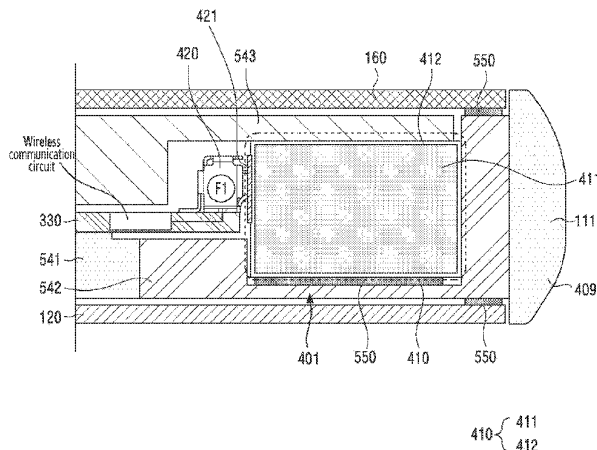
Primary Examiner — Lewis G West

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

(57) **ABSTRACT**

An electronic device is provided. The electronic device includes a housing including a first housing and a second housing connected to the first housing by a hinge structure to be rotatable around a first axis, a magnet structure disposed inside the housing, the magnet structure including a magnet and a conductive coating member for enclosing a surface of the magnet, and a wireless communication circuit electrically connected to the conductive coating member, wherein the magnet is disposed to maintain a folding state in which the first housing and the second housing are folded, and the wireless communication circuit is configured to feed a portion of the conductive coating member of the magnet structure to transmit and/or receive a signal in a designated

(Continued)





US012519879B2

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

(10) **Patent No.:** **US 12,519,879 B2**
(45) **Date of Patent:** **Jan. 6, 2026**

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

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

(72) Inventors: **Hyungjoo Lee**, Suwon-si (KR);
Gyusub Kim, Suwon-si (KR); **Hosaeng 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 272 days.

(21) Appl. No.: **18/189,772**

(22) Filed: **Mar. 24, 2023**

(65) **Prior Publication Data**
US 2023/0239385 A1 Jul. 27, 2023

Related U.S. Application Data
(63) Continuation of application No. PCT/KR2021/013001, filed on Sep. 24, 2021.

(30) **Foreign Application Priority Data**
Oct. 7, 2020 (KR) 10-2020-0129571

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

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

(58) **Field of Classification Search**
CPC H04M 1/0277; H01Q 1/243
(Continued)

(56) **References Cited**

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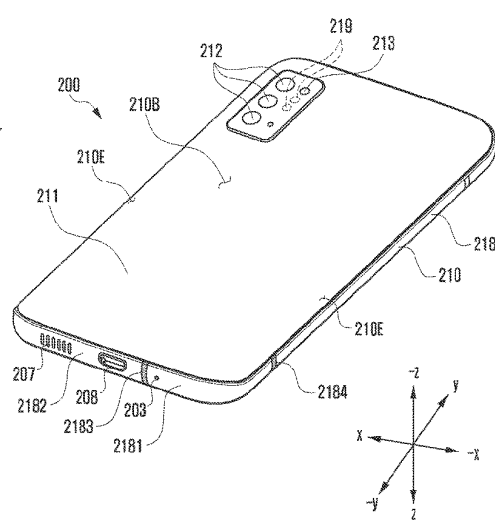
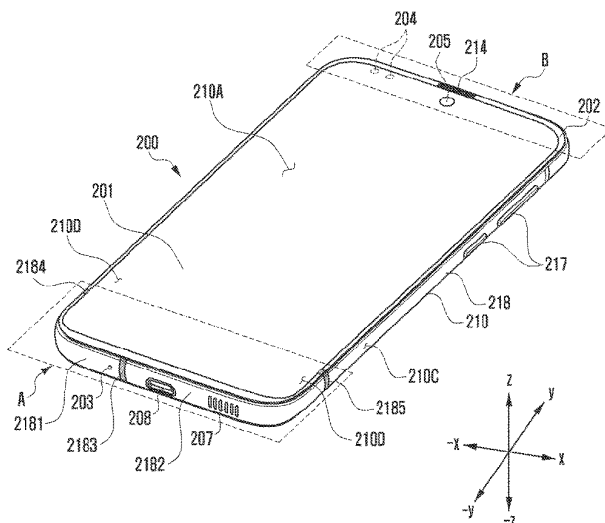
Primary Examiner — Michael R Neff

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

(57) **ABSTRACT**

An electronic apparatus is provided. The electronic device includes a lateral member including a first conductive part disposed between a first non-conductive part formed on a first lateral surface and a second non-conductive part formed on a second lateral surface, a second conductive part disposed between the first non-conductive part and a third non-conductive part formed on a third lateral surface, and a third conductive part disposed on the second lateral surface and facing the first conductive part, a wireless communication circuit electrically connected to a first point of the first conductive part, a first switching circuit for electrically connecting the wireless communication circuit to a second point of the second conductive part, a second switching circuit for connecting the first conductive part to the third conductive part, and at least one processor for controlling the first switching circuit and the second switching circuit.

20 Claims, 17 Drawing Sheets





US012525718B2

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

(10) **Patent No.:** **US 12,525,718 B2**
(45) **Date of Patent:** **Jan. 13, 2026**

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

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

(72) Inventors: **Yali Wang**, Beijing (CN); **Xichao Fan**, Beijing (CN)

(73) Assignees: **BEIJING BOE TECHNOLOGY DEVELOPMENT CO., LTD.**, Beijing (CN); **BOE TECHNOLOGY GROUP CO., LTD.**, Beijing (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 99 days.

(21) Appl. No.: **18/636,551**

(22) Filed: **Apr. 16, 2024**

(65) **Prior Publication Data**

US 2024/0347914 A1 Oct. 17, 2024

Related U.S. Application Data

(63) Continuation of application No. PCT/CN2023/088484, filed on Apr. 14, 2023.

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 1/22 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 9/0457** (2013.01); **H01Q 1/2283** (2013.01)

(58) **Field of Classification Search**
CPC .. H01Q 9/0414; H01Q 9/0457; H01Q 1/2283; H01Q 13/08
See application file for complete search history.

(56) **References Cited**

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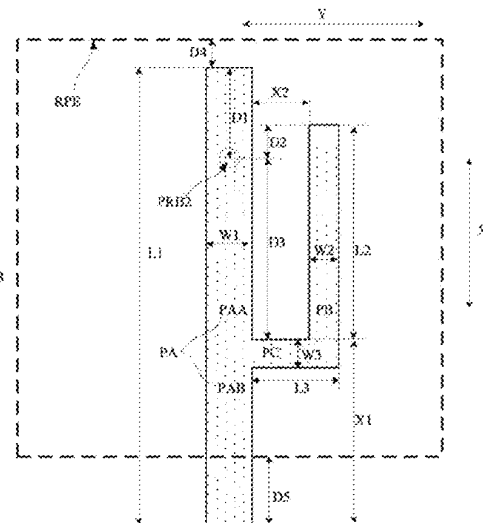
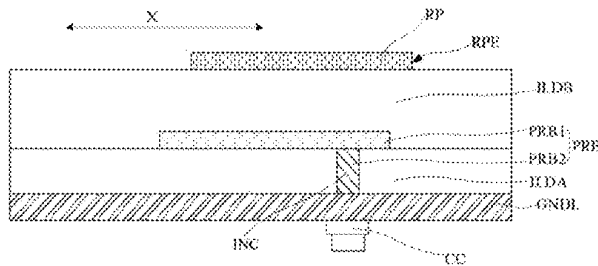
Primary Examiner — Daniel Munoz

(74) *Attorney, Agent, or Firm* — XSENSUS LLP

(57) **ABSTRACT**

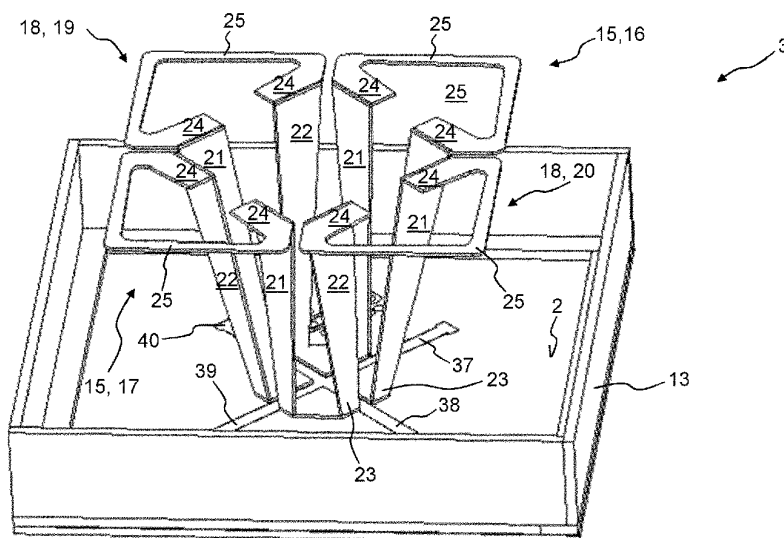
The present disclosure provides a filtering antenna. The filtering antenna includes: a ground layer, a first dielectric layer, a second dielectric layer and a radiating patch and a coupling probe. The coupling probe includes a microstrip line sandwiched between the first and second dielectric layers, and includes a feeder that penetrates the first dielectric layer. The microstrip line includes a trunk line and an open-circuit branch line connected to the trunk line. A distance between a feed center of the microstrip line and a first end of the trunk line is D1, and a distance between an orthographic projection of the first end of the trunk line on the second dielectric layer and an orthographic projection of an edge of the radiating patch on the second dielectric layer is D4, where $2.5 \leq D1/D4 \leq 3.0$.

20 Claims, 25 Drawing Sheets





(45) **Date of Patent:** Jan. 13, 2026





US012506247B2

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

(10) **Patent No.:** **US 12,506,247 B2**
(45) **Date of Patent:** **Dec. 23, 2025**

(54) **ELECTRONIC DEVICE COMPRISING
CONDUCTIVE HOUSING AND ANTENNA**

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

(72) Inventors: **Sooyoung Jang**, Gyeonggi-do (KR);
Seho Kim, Gyeonggi-do (KR); **Ilseub
Kim**, Gyeonggi-do (KR); **Gyubok
Park**, Gyeonggi-do (KR); **Dongryul
Shin**, Gyeonggi-do (KR); **Yonghee An**,
Gyeonggi-do (KR); **Bomi Lee**,
Gyeonggi-do (KR); **Injin Hwang**,
Gyeonggi-do (KR)

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

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 272 days.

(21) Appl. No.: **18/096,111**

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

(65) **Prior Publication Data**
US 2023/0146643 A1 May 11, 2023

Related U.S. Application Data
(63) Continuation of application No.
PCT/KR2021/010103, filed on Aug. 3, 2021.

(30) **Foreign Application Priority Data**
Aug. 4, 2020 (KR) 10-2020-0097660

(51) **Int. Cl.**
H01Q 1/22 (2006.01)
H01Q 1/48 (2006.01)
H01Q 9/04 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/22** (2013.01); **H01Q 1/48**
(2013.01); **H01Q 9/045** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/22; H01Q 1/48; H01Q 9/045;
H01Q 1/243

See application file for complete search history.

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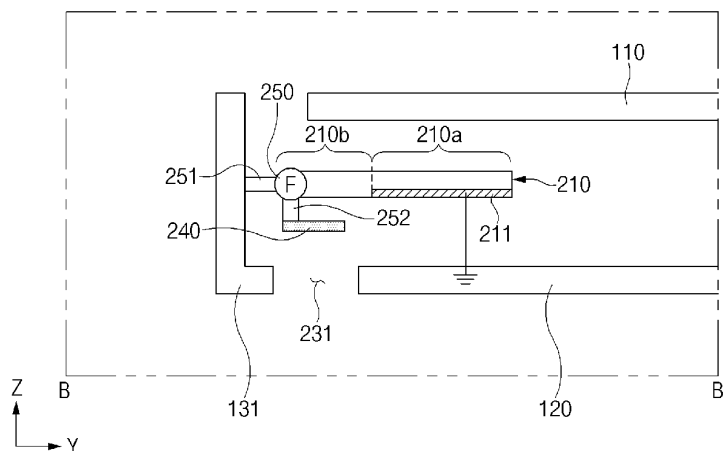
Primary Examiner — Dieu Hien T Duong

(74) *Attorney, Agent, or Firm* — Cha & Reiter, LLC

(57) **ABSTRACT**

Disclosed is an electronic device including a display; a rear plate including a conductive material; a side member including a conductive material and disposed to surround a space between the display and the rear plate; a printed circuit board disposed between the display and the rear plate; an antenna pattern at least partially disposed between the printed circuit board and the rear plate and at a position corresponding to a slit between the rear plate and the side member; and a communication module which generates a communication signal transmitted to a power feeding unit. A portion of the antenna pattern may be electrically connected to the power feeding unit. Another portion of the antenna pattern may be electrically connected to a ground region of the printed circuit board. The power feeding unit may be connected to a portion of the side member. Various other embodiments are possible.

13 Claims, 13 Drawing Sheets





US012506258B2

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

(10) **Patent No.:** **US 12,506,258 B2**
(45) **Date of Patent:** **Dec. 23, 2025**

(54) **ANTENNA DEVICE**

(71) Applicants: **KABUSHIKI KAISHA TOKAI RIKAI**
DENKI SEISAKUSHO, Aichi (JP);
TAIWAN INPAQ ELECTRONIC
CO., LTD., Miaoli County (TW);
TOYOTA JIDOSHA KABUSHIKI
KAISHA, Aichi-ken (JP)

(72) Inventors: **Masateru Furuta**, Aichi (JP); **Tadashi**
Fukagai, Aichi (JP); **Yuki Kono**, Aichi
(JP); **Yutaka Kubo**, Aichi (JP); **Taiichi**
Yamaguchi, Kanagawa (JP); **Ta-Fu**
Cheng, Miaoli County (TW);
Chih-Ming Su, Miaoli County (TW);
Tetsuya Kobayashi, Aichi-ken (JP);
Junzou Ohe, Aichi-ken (JP)

(73) Assignees: **KABUSHIKI KAISHA TOKAI RIKAI**
DENKI SEISAKUSHO, Aichi (JP);
TAIWAN INPAQ ELECTRONIC
CO., LTD., Miaoli County (TW);
TOYOTA JIDOSHA KABUSHIKI
KAISHA, Aichi-Ken (JP)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 182 days.

(21) Appl. No.: **18/214,698**

(22) Filed: **Jun. 27, 2023**

(65) **Prior Publication Data**
US 2024/0006751 A1 Jan. 4, 2024

(30) **Foreign Application Priority Data**
Jul. 4, 2022 (JP) 2022-107597

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 11/12 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/38** (2013.01); **H01Q 11/12**
(2013.01)

(58) **Field of Classification Search**
CPC . H01Q 1/38; H01Q 11/12; H01Q 9/04; H01Q
5/25
See application file for complete search history.

(56) **References Cited**

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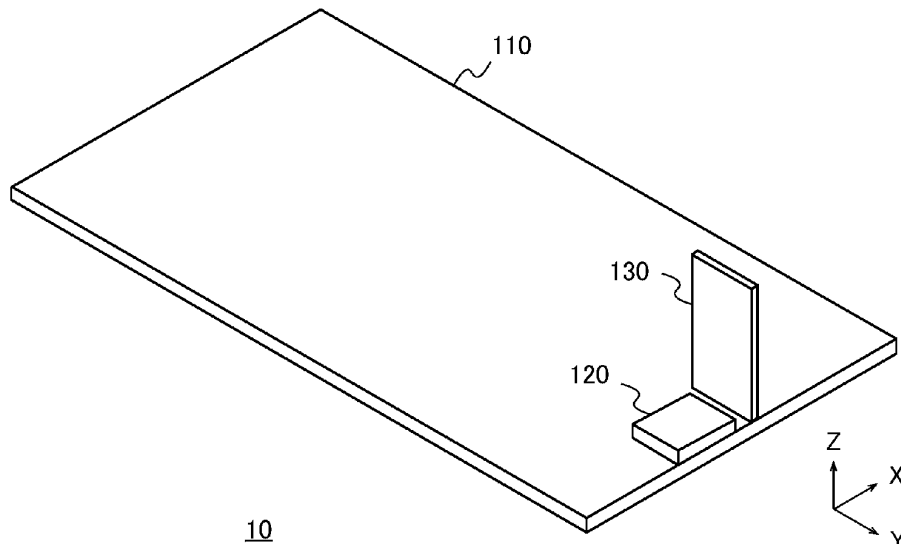
Primary Examiner — Seung H Lee

(74) *Attorney, Agent, or Firm* — Greenblum & Bernstein,
P.L.C.

(57) **ABSTRACT**

There is provided an antenna device comprising: a chip
antenna arranged on a substrate; and a metal element
arranged on the same substrate as the chip antenna, wherein
the metal element is arranged such that a longitudinal
direction of the metal element is vertical with respect to the
substrate in a direction in which a current flows in the chip
antenna.

12 Claims, 6 Drawing Sheets





US012506263B2

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

(10) **Patent No.:** **US 12,506,263 B2**
(45) **Date of Patent:** **Dec. 23, 2025**

(54) **ANTENNA STRUCTURE**

(56)

References Cited

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

U.S. PATENT DOCUMENTS

(72) Inventors: **Li-Kai Kuo**, Hsinchu (TW);
Cheng-Wei Chiang, Hsinchu (TW);
Wen-Pin Ho, Hsinchu (TW)

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(73) Assignee: **WISTRON NEWEB CORP.**, Hsinchu (TW)

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 100 days.

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(21) Appl. No.: **18/405,206**

Primary Examiner — David E Lotter

(22) Filed: **Jan. 5, 2024**

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

(65) **Prior Publication Data**

US 2024/0266735 A1 Aug. 8, 2024

(30) **Foreign Application Priority Data**

Feb. 8, 2023 (TW) 112104352

(51) **Int. Cl.**
H01Q 5/40 (2015.01)
H01Q 1/38 (2006.01)

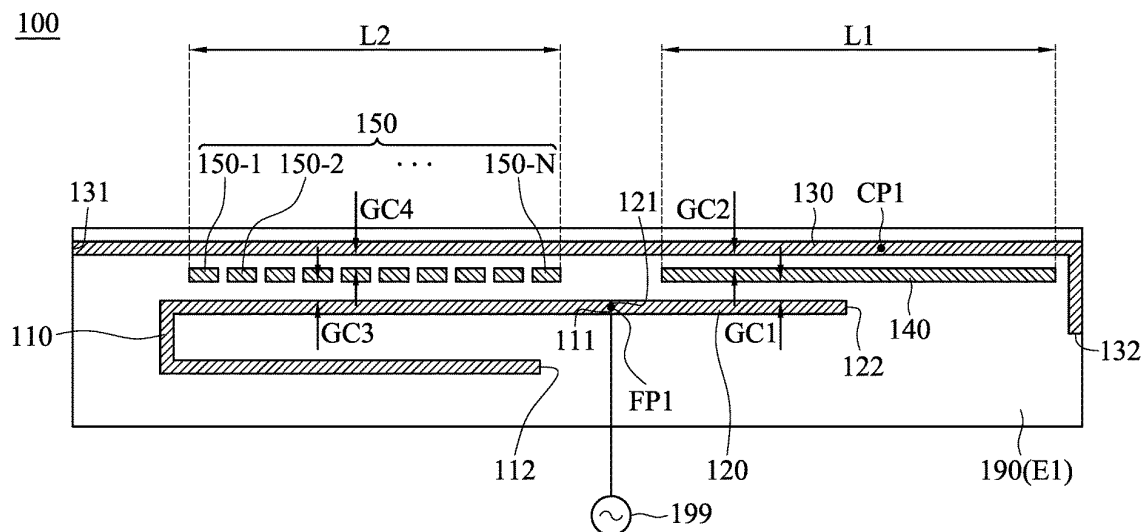
(52) **U.S. Cl.**
CPC **H01Q 5/40** (2015.01); **H01Q 1/38** (2013.01)

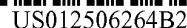
(58) **Field of Classification Search**
CPC H01Q 5/40; H01Q 1/38; H01Q 1/243;
H01Q 5/378; H01Q 9/42
See application file for complete search history.

(57) **ABSTRACT**

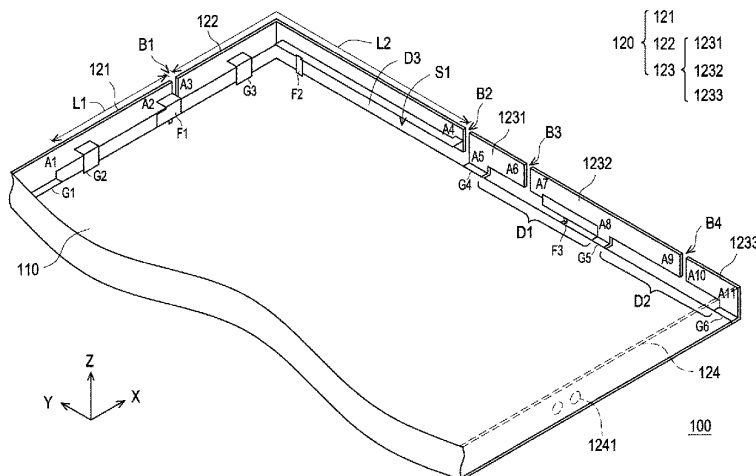
An antenna structure includes a first radiation element, a second radiation element, a third radiation element, a first floating metal element, a second floating metal element, a tuning circuit, and a nonconductive support element. The first radiation element has a feeding point. The second radiation element is coupled to the feeding point. The third radiation element is coupled through the tuning circuit to a ground voltage. The first floating metal element is disposed between the second radiation element and the third radiation element. The second floating metal element is disposed between the first radiation element and the third radiation element. The first radiation element, the second radiation element, the third radiation element, and the tuning circuit are disposed on the nonconductive support element.

20 Claims, 6 Drawing Sheets





(45) **Date of Patent:** **Dec. 23, 2025**





US012506266B2

(12) **United States Patent**
Tang

(10) **Patent No.:** **US 12,506,266 B2**
(45) **Date of Patent:** **Dec. 23, 2025**

(54) **PRINTED DIPOLE ANTENNA**

(56)

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(71) Applicant: **PCI Private Limited**, Singapore (SG)

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(72) Inventor: **Wee Hua Tang**, Singapore (SG)

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 387 days.

(21) Appl. No.: **18/039,698**

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

(86) PCT No.: **PCT/SG2020/095001**

§ 371 (c)(1),

(2) Date: **May 31, 2023**

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(87) PCT Pub. No.: **WO2022/124977**

PCT Pub. Date: **Jun. 16, 2022**

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(65) **Prior Publication Data**

US 2024/0021992 A1 Jan. 18, 2024

International Search Report in International Application No. PCT/SG2020/095001, mailed Jul. 22, 2021; 4 pp.

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(51) **Int. Cl.**

H01Q 9/28 (2006.01)

H01Q 1/48 (2006.01)

H01Q 5/364 (2015.01)

H01Q 9/04 (2006.01)

Primary Examiner — Hasan Islam

(74) *Attorney, Agent, or Firm* — Nixon Peabody LLP

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

CPC **H01Q 9/0407** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/364** (2015.01)

(57)

ABSTRACT

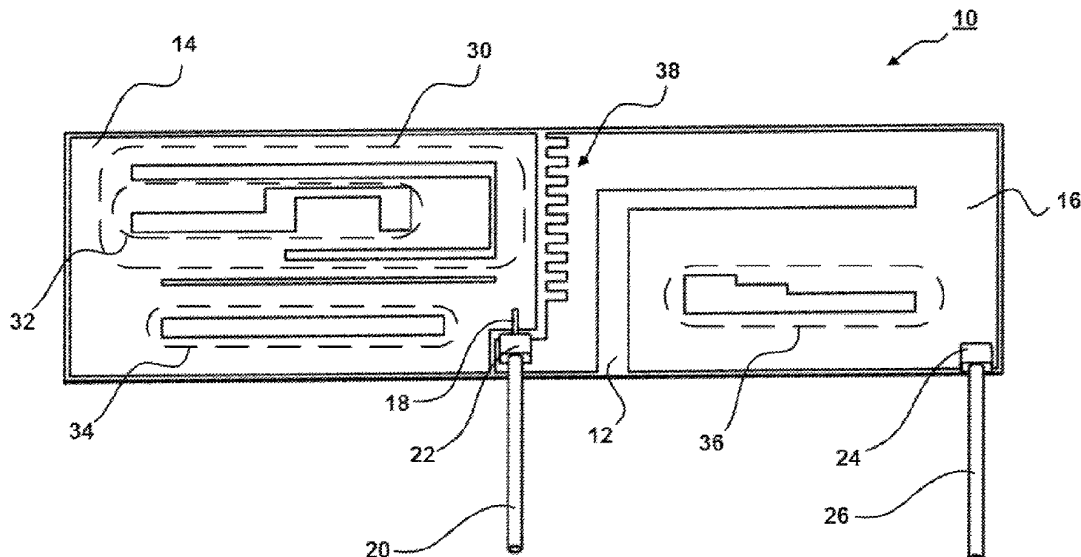
A printed dipole antenna (10) is provided. The printed dipole antenna (10) includes a plurality of antenna elements (14) and a reference ground (16) on a dielectric substrate (12). Each of the antenna elements (14) is configured to generate resonant modes for a frequency band in a radio-frequency spectrum.

(58) **Field of Classification Search**

CPC H01Q 1/38; H01Q 1/48; H01Q 5/30–40; H01Q 9/0407; H01Q 9/285

See application file for complete search history.

9 Claims, 6 Drawing Sheets





US012506270B2

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

(10) **Patent No.:** **US 12,506,270 B2**
(45) **Date of Patent:** ***Dec. 23, 2025**

(54) **BROADBAND DECOUPLED MIDBAND
DIPOLE FOR A DENSE MULTIBAND
ANTENNA**

(71) Applicant: **John Mezzalingua Associates, LLC,**
Liverpool, NY (US)

(72) Inventors: **Jiaqiang Zhu,** Baldwinsville, NY (US);
Niranjan Sundararajan, Clay, NY
(US); **Wengang Chen,** Liverpool, NY
(US)

(73) Assignee: **John Mezzalingua Associates, LLC,**
Liverpool, NY (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.

This patent is subject to a terminal dis-
claimer.

(21) Appl. No.: **18/628,100**

(22) Filed: **Apr. 5, 2024**

(65) **Prior Publication Data**

US 2024/0339757 A1 Oct. 10, 2024

Related U.S. Application Data

(63) Continuation of application No. 18/118,187, filed on
Mar. 7, 2023, now Pat. No. 11,973,282, which is a
continuation of application No. 17/689,278, filed on
Mar. 8, 2022, now Pat. No. 11,605,893.

(60) Provisional application No. 63/158,028, filed on Mar.
8, 2021.

(51) **Int. Cl.**
H01Q 9/26 (2006.01)
H01Q 5/20 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 9/26** (2013.01); **H01Q 5/20**
(2015.01)

(58) **Field of Classification Search**

CPC H01Q 9/26; H01Q 9/285; H01Q 9/065;
H01Q 9/265; H01Q 5/20; H01Q 5/364;
H01Q 5/42; H01Q 5/48; H01Q 1/246;
H01Q 1/521; H01Q 21/26

See application file for complete search history.

(56) **References Cited**

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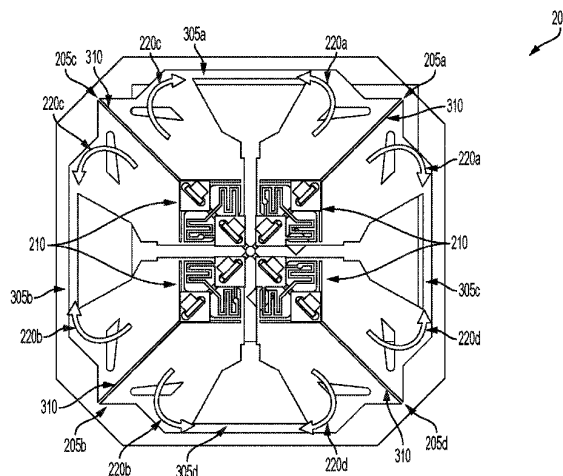
Primary Examiner — Awat M Salih

(74) *Attorney, Agent, or Firm* — Meunier Carlin &
Curfman LLC

(57) **ABSTRACT**

Disclosed is a midband dipole for use in a multiband
antenna. The midband dipole has four folded dipoles, each
of which is coupled to a decoupling circuit that has two
capacitance points. The disclosed decoupling circuit con-
figuration mitigates common mode resonance with nearby
lowband dipoles, further preventing cross polarization in the
midband.

8 Claims, 11 Drawing Sheets





US012506271B2

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

(10) **Patent No.:** **US 12,506,271 B2**
(45) **Date of Patent:** **Dec. 23, 2025**

(54) **HORIZONTALLY POLARIZED
OMNIDIRECTIONAL MULTI-BAND
ANTENNA STRUCTURE**

(71) Applicant: **Alpha Networks Inc.**, Hsinchu (TW)

(72) Inventors: **Guan-Ting Chen**, Hsinchu (TW);
Kuang-Wei Lin, Hsinchu (TW)

(73) Assignee: **Alpha Networks Inc.**, Hsinchu (TW)

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

(21) Appl. No.: **18/666,775**

(22) Filed: **May 16, 2024**

(65) **Prior Publication Data**
US 2025/0239779 A1 Jul. 24, 2025

(30) **Foreign Application Priority Data**
Jan. 24, 2024 (TW) 113102799

(51) **Int. Cl.**
H01Q 13/08 (2006.01)
H01Q 5/50 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 13/08** (2013.01); **H01Q 5/50**
(2015.01)

(58) **Field of Classification Search**
CPC H01Q 13/08; H01Q 5/50; H01Q 5/364;
H01Q 1/2291; H01Q 21/205; H01Q 9/42
See application file for complete search history.

(56) **References Cited**

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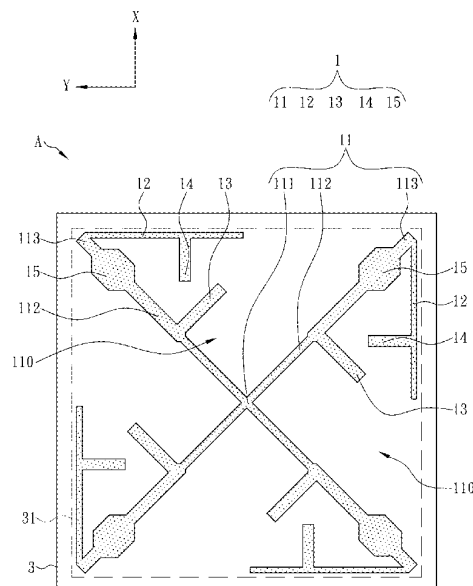
Primary Examiner — Seokjin Kim

(74) *Attorney, Agent, or Firm* — CIPO IP Group

(57) **ABSTRACT**

A horizontally polarized omnidirectional multi-band antenna structure includes a substrate and two structurally-symmetric radiators, each being provided on a layout area on one of the two opposite sides of the substrate, and including a X-shaped primary microstrip line, four secondary microstrip lines, four primary stubs, four secondary stubs and four resonators. The primary microstrip line has four end points arranged with the secondary microstrip lines along different extending directions. The primary stubs extend along different directions from four sections of the primary microstrip line. Each secondary microstrip line is provided with one of the secondary stubs. Resonators are provided between four end points of the primary microstrip line and the primary stubs. The antenna structure supports WiFi 6E/WiFi 7 frequency bands including the 2 GHz, 5 GHz and 6 GHz bands, has characteristics of horizontal polarization and omnidirectionality, and effectively satisfies the needs for miniaturized multi-band and wide band antennas.

8 Claims, 6 Drawing Sheets





US012506279B2

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

(10) **Patent No.:** **US 12,506,279 B2**
(45) **Date of Patent:** **Dec. 23, 2025**

(54) **ELECTRONIC APPARATUS COMPRISING ANTENNA**

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

(72) Inventors: **Kookjoo Lee**, Suwon-si (KR); **Sumin Yun**, Suwon-si (KR); **Minwoo Lee**, Suwon-si (KR); **Juseok Lee**, Suwon-si (KR); **Wonhee Choe**, Suwon-si (KR); **Chaejun Lee**, Suwon-si (KR); **Jinwoo Jung**, Suwon-si (KR); **Jaebong Chun**, Suwon-si (KR); **Hochul Hwang**, 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 96 days.

(21) Appl. No.: **18/118,905**

(22) Filed: **Mar. 8, 2023**

(65) **Prior Publication Data**
US 2023/0223708 A1 Jul. 13, 2023

Related U.S. Application Data
(63) Continuation of application No. PCT/KR2021/012055, filed on Sep. 6, 2021.

(30) **Foreign Application Priority Data**
Sep. 8, 2020 (KR) 10-2020-0114821

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

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

(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

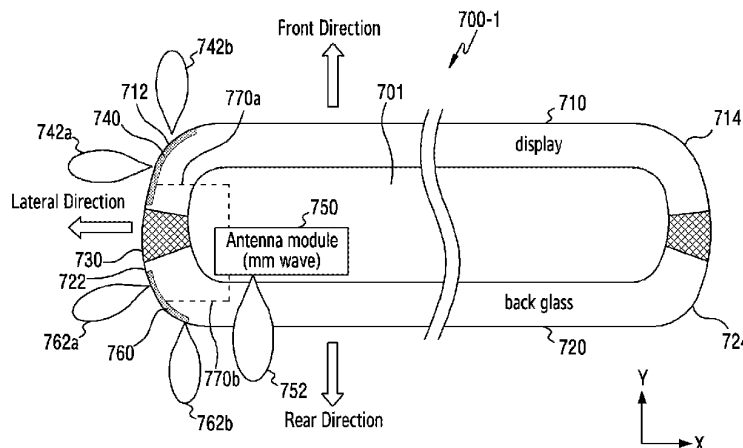
Assistant Examiner — Anh N Ho

(74) *Attorney, Agent, or Firm* — NIXON & VANDERHYE P.C.

(57) **ABSTRACT**

An electronic device may comprise: a display; an antenna module including at least one antenna; a conductive connection member comprising a conductive material; and at least one antenna structure. The display may be arranged in the inner space of a housing to be visible from the outside and may include a curved side surface portion. The antenna module may be arranged in the inner space of the housing. The conductive connection member may be electrically connected to the antenna module. The at least one antenna structure may be arranged on a side surface portion of the display. The conductive connection member may electrically connect the antenna structure to the antenna module. The antenna structure may include at least one first-type

(Continued)





US012506280B2

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

(10) **Patent No.:** **US 12,506,280 B2**
(45) **Date of Patent:** **Dec. 23, 2025**

(54) **DUAL-POLARIZATION ANTENNA
ELEMENT FOR GENERATION OF
MILLIMETER-WAVE FREQUENCY
RADIATION**

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

(72) Inventors: **Alexander Khripkov**, Helsinki (FI);
Janne Ilvonen, Helsinki (FI)

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

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 87 days.

(21) Appl. No.: **18/580,447**

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

(86) PCT No.: **PCT/EP2021/070477**

§ 371 (c)(1),

(2) Date: **Jan. 18, 2024**

(87) PCT Pub. No.: **WO2023/001375**

PCT Pub. Date: **Jan. 26, 2023**

(65) **Prior Publication Data**

US 2024/0347932 A1 Oct. 17, 2024

(51) **Int. Cl.**
H01Q 21/24 (2006.01)
H01Q 5/28 (2015.01)

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 21/24** (2013.01); **H01Q 5/28**
(2015.01); **H01Q 5/385** (2015.01); **H01Q**
13/085 (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 5/28; H01Q 5/385;
H01Q 13/085; H01Q 21/24; H01Q 21/28

See application file for complete search history.

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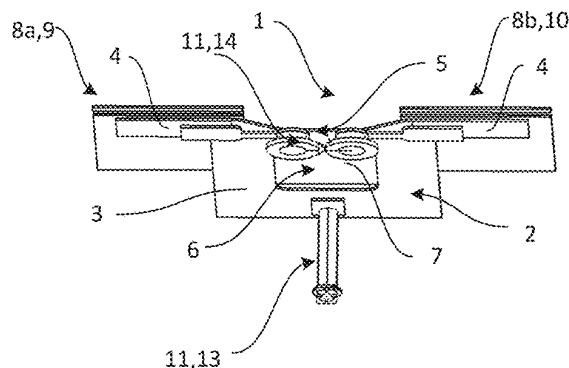
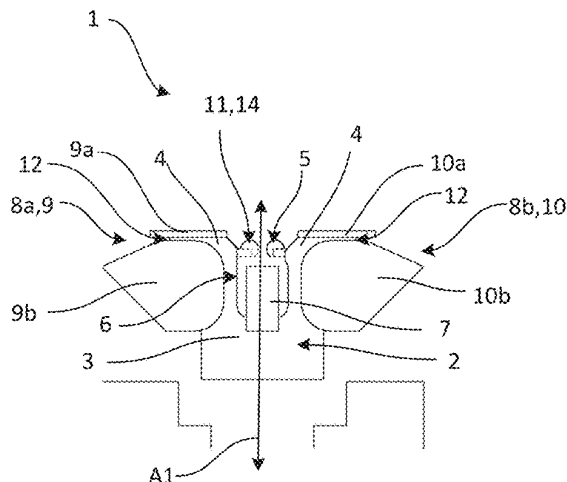
Primary Examiner — Daniel Munoz

(74) *Attorney, Agent, or Firm* — Fish & Richardson P.C.

(57) **ABSTRACT**

An example dual-polarization antenna element comprises a
radiator layer and a resonator layer. The radiator layer
comprises a planar antenna radiator, the planar antenna
radiator comprising a split ring, enclosing a dielectric area
and having ends separated by a first dielectric gap, and two
second radiator sections extending from said ends. The
resonator layer comprises a center resonator superimposed
with said dielectric area and two offset resonator arrange-
ments. Each offset resonator arrangement is at least partially
superimposed with one of said second radiator sections, and
each offset resonator arrangement comprises at least one
sub-resonator. A feed arrangement is at least partially
arranged in said radiator layer or in an additional feed layer.

20 Claims, 4 Drawing Sheets





US012506282B2

(12) **United States Patent**
Taki

(10) **Patent No.:** **US 12,506,282 B2**
(45) **Date of Patent:** **Dec. 23, 2025**

(54) **ANTENNA DEVICE**

(56) **References Cited**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 214 days.

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(21) Appl. No.: **18/500,455**

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

(65) **Prior Publication Data**

US 2024/0178578 A1 May 30, 2024

(30) **Foreign Application Priority Data**

Nov. 24, 2022 (JP) 2022-187718
Apr. 18, 2023 (JP) 2023-067854

(51) **Int. Cl.**
H01Q 21/28 (2006.01)
H01Q 9/04 (2006.01)
H01Q 9/06 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 21/28** (2013.01); **H01Q 9/0414**
(2013.01); **H01Q 9/065** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 21/28; H01Q 9/0414; H01Q 9/065;
H01Q 1/243; H01Q 5/321; H01Q 9/42
See application file for complete search history.

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(57) **ABSTRACT**

An antenna board of an antenna device includes a connection portion, and first and second conductor elements. The connection portion includes an inner side portion electrode and an outer side portion electrode connected to a coaxial cable. The first conductor element includes first conductor portion connected to the inner side portion electrode at first end, and second conductor portion disposed such that first mounting region is present between second and third ends. The second conductor is disposed such that second and third mounting regions are respectively present between fifth end and the inner side portion electrode and between the fifth end and the outer side portion electrode. An electrical length between the first and second ends of the first conductor portion is equal to an electrical length between the fifth and sixth ends of the second conductor element.

5 Claims, 24 Drawing Sheets

