US012416949B2

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

(10) **Patent No.: US 12,416,949 B2**
(45) **Date of Patent: Sep. 16, 2025**

(54) **ELECTRONIC DEVICE INCLUDING BRACKET FORMED OF METAL MATERIAL**

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

(72) Inventors: **Jungsik Park**, Suwon-si (KR); **Wonjoon Choi**, Suwon-si (KR); **Woongeun Kwak**, 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 428 days.

(21) Appl. No.: **17/960,430**

(22) Filed: **Oct. 5, 2022**

(65) **Prior Publication Data**

US 2023/0161388 A1 May 25, 2023

Related U.S. Application Data

(63) Continuation of application No. PCT/KR2022/012344, filed on Aug. 18, 2022.

(30) **Foreign Application Priority Data**

Nov. 25, 2021 (KR) 10-2021-0164954

(51) **Int. Cl.**
G06F 1/16 (2006.01)
G06F 1/20 (2006.01)
H01Q 1/24 (2006.01)

(52) **U.S. Cl.**
CPC ***G06F 1/1681*** (2013.01); ***G06F 1/1616*** (2013.01); ***G06F 1/203*** (2013.01); ***H01Q 1/243*** (2013.01)

(58) **Field of Classification Search**
CPC G06F 1/1681; G06F 1/1616; G06F 1/203; G06F 1/1641; G06F 1/1652;
(Continued)

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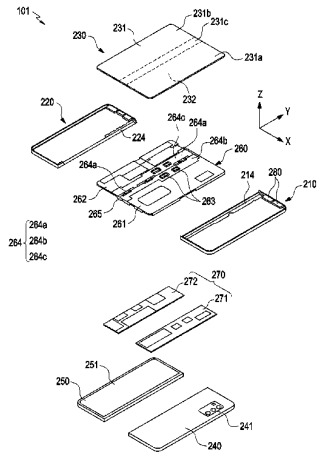
Primary Examiner — Kabir A Timory
(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

(57) **ABSTRACT**

An electronic device is provided. The electronic device includes a foldable housing including a hinge structure, a first housing connected to the hinge structure and including a first side wall structure and a first bracket located inside the first side wall structure, and a second housing connected to the hinge structure and including a second side wall structure and a second bracket located inside the second side wall structure, the second housing being folded with the first housing about the hinge structure, a display panel extending from the first housing to the second housing across the hinge structure and configured to output a screen, and a second antenna structure including a second ground and a second feeding portion disposed on the second side wall structure of the second housing, wherein the first side wall structure of the first housing and the second side wall structure of the second housing may include a first metal material, and the first bracket of the first housing includes the first metal material, and the second bracket of the second housing may include a second metal material.

18 Claims, 14 Drawing Sheets



US012418097B2

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

(10) **Patent No.: US 12,418,097 B2**
(45) **Date of Patent: Sep. 16, 2025**

(54) **MICROELECTRONIC DEVICE PACKAGE INCLUDING ANTENNA AND SEMICONDUCTOR DEVICE**

(71) Applicant: **Texas Instruments Incorporated**, Dallas, TX (US)

(72) Inventors: **Yiqi Tang**, Allen, TX (US); **Rajen Manicon Murugan**, Dallas, TX (US); **Juan Alejandro Herbsommer**, Allen, TX (US)

(73) Assignee: **TEXAS INSTRUMENTS INCORPORATED**, Dallas, TX (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.: **18/530,179**

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

(65) **Prior Publication Data**

US 2024/0113413 A1 Apr. 4, 2024

Related U.S. Application Data

(63) Continuation of application No. 17/539,110, filed on Nov. 30, 2021, now Pat. No. 11,837,775.

(60) Provisional application No. 63/177,913, filed on Apr. 21, 2021.

(51) **Int. Cl.**

H01Q 1/22	(2006.01)
H01L 23/31	(2006.01)
H01L 23/66	(2006.01)
H05K 1/02	(2006.01)

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

CPC ***H01Q 1/2283*** (2013.01); ***H01L 23/3114*** (2013.01); ***H01L 23/66*** (2013.01); ***H05K 1/0237*** (2013.01); *H01L 2223/6677* (2013.01)

(58) **Field of Classification Search**

CPC . H01Q 11/2283; H01L 23/3114; H01L 23/66; H01L 2223/6677; H05K 1/0237

USPC 343/878

See application file for complete search history.

(56) **References Cited**

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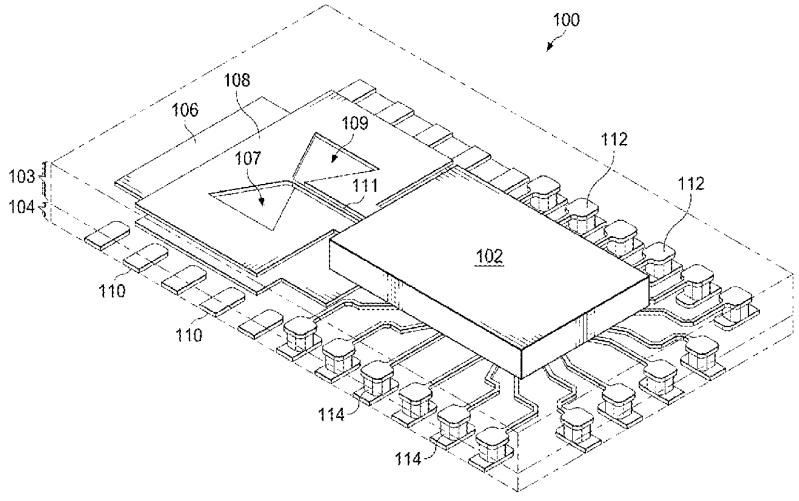
Primary Examiner — Peguy Jean Pierre

(74) *Attorney, Agent, or Firm* — Dawn Jos; Frank D. Cimino

(57) **ABSTRACT**

A described example includes an antenna formed in a first conductor layer on a device side surface of a multilayer package substrate, the multilayer package substrate including conductor layers spaced from one another by dielectric material and coupled to one another by conductive vertical connection layers, the multilayer package substrate having a board side surface opposite the device side surface; and a semiconductor die mounted to the device side surface of the multilayer package substrate spaced from and coupled to the antenna.

20 Claims, 11 Drawing Sheets



US012418099B2

(12) **United States Patent**
Wu

(10) **Patent No.: US 12,418,099 B2**
(45) **Date of Patent: Sep. 16, 2025**

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

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

(72) Inventor: **Xiaopu Wu**, Dongguan (CN)

(73) Assignee: **GUANGDONG OPPO MOBILE TELECOMMUNICATIONS CORP., 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 86 days.

(21) Appl. No.: **18/385,051**

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

(65) **Prior Publication Data**

US 2024/0063527 A1 Feb. 22, 2024

Related U.S. Application Data

(63) Continuation of application No. PCT/CN2022/080623, filed on Mar. 14, 2022.

(30) **Foreign Application Priority Data**

Apr. 30, 2021 (CN) 202110484710.6

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/48 (2006.01)
H01Q 5/35 (2015.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 5/35*** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/48; H01Q 5/35; H01Q 3/24; H01Q 21/28; H01Q 9/42; H01Q 1/242; H01Q 1/36; H01Q 5/307; H01Q 21/00
See application file for complete search history.

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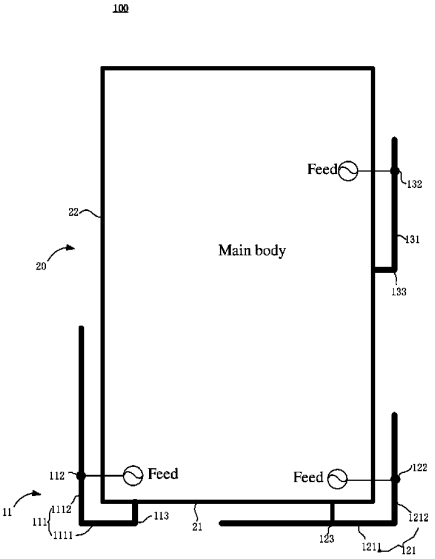
(Continued)

Primary Examiner — Seung H Lee
(74) *Attorney, Agent, or Firm* — Sheppard, Mullin, Richter &Hampton LLP

(57) **ABSTRACT**

Provided is an antenna device. The antenna device includes a first antenna. The first antenna includes a first radiator. The first radiator includes a first branch and a second branch that are connected to each other. The second branch bends and extends from an end of the first branch. The first antenna supports both a first operation mode and a second operation mode. The first antenna covers a bandwidth greater than 190 MHz by using the first operation mode and the second operation mode together. In addition, a mobile terminal is provided.

18 Claims, 10 Drawing Sheets



US012418100B2

(12) **United States Patent**
Wu

(10) **Patent No.: US 12,418,100 B2**
(45) **Date of Patent: Sep. 16, 2025**

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

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

(72) Inventor: **Xiaopu Wu**, Guangdong (CN)

(73) Assignee: **GUANGDONG OPPO MOBILE TELECOMMUNICATIONS CORP., LTD.**, Guangdong (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 127 days.

(21) Appl. No.: **18/503,330**

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

(65) **Prior Publication Data**

US 2024/0072418 A1 Feb. 29, 2024

Related U.S. Application Data

(63) Continuation of application No. PCT/CN2022/086365, filed on Apr. 12, 2022.

(30) **Foreign Application Priority Data**

May 26, 2021 (CN) 202110582433.2

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/335 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 5/335*** (2015.01); ***H03H 7/38*** (2013.01); ***H04B 1/0064*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 5/335; H01Q 5/35; H03H 7/38; H04B 1/0064
See application file for complete search history.

(56) **References Cited**

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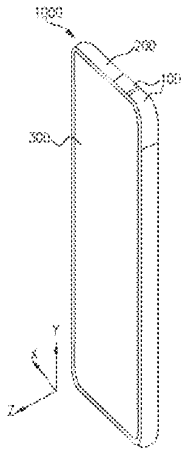
Primary Examiner — Thien M Le
(74) *Attorney, Agent, or Firm* — Hodgson Russ LLP

(57) **ABSTRACT**

Provided are an antenna assembly and an electronic device. The antenna assembly includes a first radiator, a second radiator, a first matching module, a first feeding module, a second matching module, and a second feeding module. The first radiator has a first ground end, a first coupling end, and a first feeding point. The second radiator has a second coupling end, a second ground end, and a second feed point. A first coupling gap is defined between the second coupling end and the first coupling end. The first matching module is electrically connected between the first feeding point and the first feeding module. The second matching module is electrically connected between the second feeding point and the second feeding module. The first radiator and the second radiator support multiple resonant modes, where at least one resonant mode is a ⅛ to ¼ wavelength mode.

20 Claims, 25 Drawing Sheets



US012418111B2

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

(10) **Patent No.: US 12,418,111 B2**
(45) **Date of Patent: Sep. 16, 2025**

(54) **ANTENNA STRUCTURE**

(71) Applicant: **Quanta Computer Inc.**, Taoyuan (TW)

(72) Inventors: **Chun-I Lin**, Taoyuan (TW); **Bo-Wei Lin**, Taoyuan (TW)

(73) Assignee: **QUANTA COMPUTER INC.**, Taoyuan (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 153 days.

(21) Appl. No.: **18/500,384**

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

(65) **Prior Publication Data**

US 2025/0112363 A1 Apr. 3, 2025

(30) **Foreign Application Priority Data**

Sep. 28, 2023 (TW) 112137402

(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 1/48; H01Q 5/307; H01Q 5/371; H01Q 5/378; H01Q 9/0421; H01Q 9/42
See application file for complete search history.

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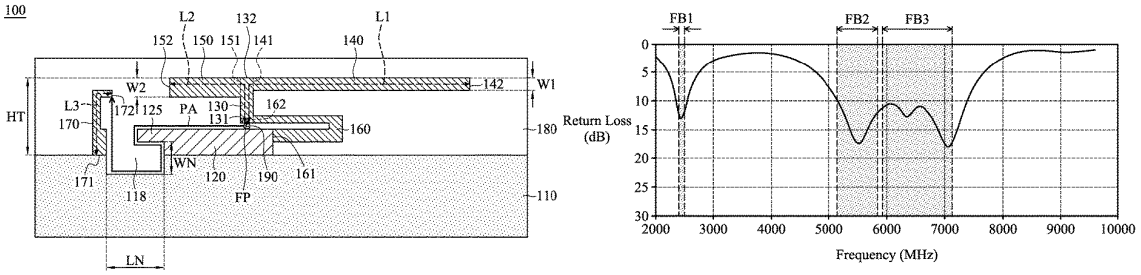
Primary Examiner — Sean Kayes

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

(57) **ABSTRACT**

An antenna structure includes a main ground element, an extension ground element, a feeding radiation element, a first radiation element, a second radiation element, a shorting radiation element, a third radiation element, and a dielectric substrate. The extension ground element is coupled to the main ground element. A notch region is defined by the main ground element and the extension ground element. 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 feeding radiation element is also coupled through the shorting radiation element to the extension ground element. The third radiation element is coupled to the main ground element.

9 Claims, 4 Drawing Sheets



US012418605B2

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

(10) **Patent No.: US 12,418,605 B2**
(45) **Date of Patent: Sep. 16, 2025**

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

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

(72) Inventors: **Hangyu Hwang**, Suwon-si (KR); **Changsu Kim**, Suwon-si (KR); **Pranveer Singh Rathore**, Suwon-si (KR); **Yongseok Lee**, Suwon-si (KR); **Sangsik Na**, Suwon-si (KR); **Hyunjung Jung**, Suwon-si (KR); **Jinho Lim**, Suwon-si (KR); **Minwoo Yoo**, 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 399 days.

(21) Appl. No.: **17/831,963**

(22) Filed: **Jun. 3, 2022**

(65) **Prior Publication Data**

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Related U.S. Application Data

(63) Continuation of application No. PCT/KR2022/007212, filed on May 20, 2022.

(30) **Foreign Application Priority Data**

Jun. 14, 2021 (KR) 10-2021-0076961

(51) **Int. Cl.**
H04M 1/18 (2006.01)
H01Q 1/24 (2006.01)

(52) **U.S. Cl.**
CPC ***H04M 1/18*** (2013.01); ***H01Q 1/243*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 13/28; H04M 1/0249; H04M 1/185
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Imani N Hayman
Assistant Examiner — Theron S Milliser
(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

(57) **ABSTRACT**

A portable electronic device is provided. The portable electronic device includes a metal housing, an antenna module positioned in the metal housing, a first injection-molded member positioned in a radiation direction of the antenna module and having a first dielectric constant, a second injection-molded member at least partially in contact with the first injection-molded member, positioned in the radiation direction of the antenna module, and having a second dielectric constant different from the first dielectric constant, and a first organic film disposed along an inner surface of the metal housing to bond with at least a portion of the first injection-molded member, wherein the second injection-molded member forms, together with the metal housing, an exterior of the portable electronic device, and wherein the

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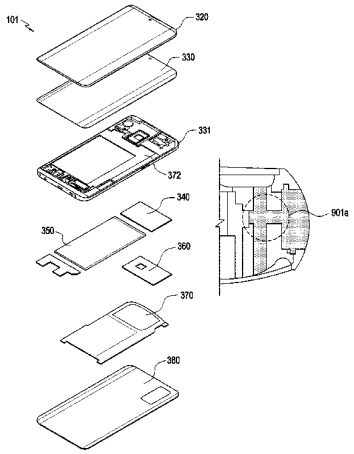

US012424725B2

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

(10) **Patent No.: US 12,424,725 B2**
(45) **Date of Patent: Sep. 23, 2025**

(54) **ELECTRONIC DEVICE INCLUDING ANTENNA**

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

(72) Inventors: **Sooyoung Jang**, Suwon-si (KR); **Yoonjung Kim**, Suwon-si (KR); **Gyubok Park**, Suwon-si (KR); **Dongryul Shin**, Suwon-si (KR); **Donghun Shin**, Suwon-si (KR); **Hoonsang Yoo**, Suwon-si (KR); **Minkyung Lee**, Suwon-si (KR); **Huiwon Cho**, Suwon-si (KR)

(73) Assignee: **SAMSUNG ELECTRONICS CO., LTD.**, Suwon-si (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 252 days.

(21) Appl. No.: **17/976,449**

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

(65) **Prior Publication Data**

US 2023/0112380 A1 Apr. 13, 2023

Related U.S. Application Data

(63) Continuation of application No. PCT/KR2022/014627, filed on Sep. 29, 2022.

(30) **Foreign Application Priority Data**

Oct. 13, 2021 (KR) 10-2021-0135690

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

(52) **U.S. Cl.**
CPC ***H01Q 1/02*** (2013.01); ***H01Q 1/241*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/02; H01Q 1/241; H01Q 1/24; H01Q 1/243
See application file for complete search history.

(56) **References Cited**

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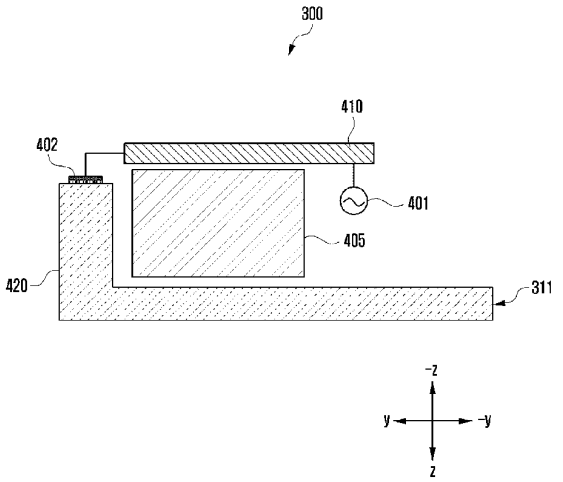
(Continued)

Primary Examiner — Dieu Hien T Duong
(74) *Attorney, Agent, or Firm* — Nixon & Vanderhye, P.C.

(57) **ABSTRACT**

An example electronic device including an antenna includes a housing including a first conductive portion, a first support member disposed inside the housing, a printed circuit board disposed on one surface of the first support member and including a wireless communication module, an electronic component electrically connected to the printed circuit board, and a conductive plate supporting the electronic component. The conductive plate is constituted such that a first portion is electrically connected to the wireless communication module and a second portion is electrically connected to the first conductive portion, and thereby broadband radiation characteristics can be provided.

18 Claims, 17 Drawing Sheets



US012424729B2

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

(10) **Patent No.: US 12,424,729 B2**
(45) **Date of Patent: Sep. 23, 2025**

(54) **ELECTRONIC DEVICE**

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

(72) Inventors: **Min Young Yoon**, Osan-si (KR); **Young Ki Lee**, Suwon-si (KR); **Kyeol Kwon**, Hwaseong-si (KR); **Dong Kwon Choi**, Suwon-si (KR); **Doo Seok Choi**, Suwon-si (KR); **Joon Hoi Hur**, 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 275 days.

(21) Appl. No.: **18/152,422**

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

(65) **Prior Publication Data**

US 2023/0231295 A1 Jul. 20, 2023

(30) **Foreign Application Priority Data**

Jan. 19, 2022 (KR) 10-2022-0007888
Apr. 19, 2022 (KR) 10-2022-0048261

(51) **Int. Cl.**
H01Q 1/22 (2006.01)
H01Q 21/00 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/2283*** (2013.01); ***H01Q 21/0025*** (2013.01)

(58) **Field of Classification Search**
USPC ..... 343/700 R
See application file for complete search history.

(56) **References Cited**

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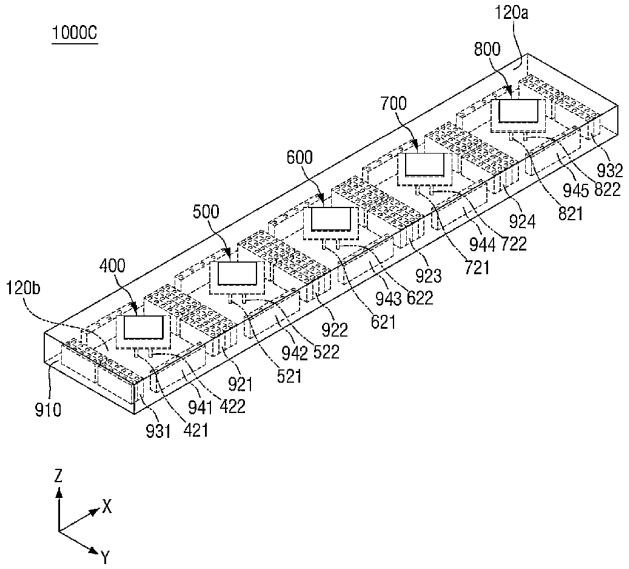
Primary Examiner — Dimary S Lopez Cruz
Assistant Examiner — Brandon Sean Woods
(74) *Attorney, Agent, or Firm* — Harness, Dickey & Pierce, P.L.C.

(57) **ABSTRACT**

An electronic device is provided. An electronic device includes a radio frequency integrated circuit (RFIC) chip, and an antenna array electrically connected to the RFIC chip, the antenna array including a first face and a second face facing each other in a first direction, and a third face and a fourth face connecting the first and second faces to each other and facing each other in a second direction intersecting the first direction, the antenna array including a plurality of substrates sequentially stacked in a third direction intersecting a plane defined by the first and second directions, first and second antenna modules on the plurality of substrates and sequentially arranged along the first direction, a first metal partition-wall including at least one metal via extending through the plurality of substrates in the third direction, and a second metal partition-wall surrounding the first to fourth faces.

20 Claims, 22 Drawing Sheets



US012424732B2

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

(10) **Patent No.: US 12,424,732 B2**
(45) **Date of Patent: Sep. 23, 2025**

(54) **ELECTRONIC DEVICE COMPRISING ANTENNA**

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

(72) Inventors: **Seongjin Park**, Suwon-si (KR); **Hosaeng Kim**, Suwon-si (KR); **Sumin Yun**, Suwon-si (KR); **Chaejun Lee**, Suwon-si (KR); **Woomin Jang**, Suwon-si (KR); **Myunghun Jeong**, Suwon-si (KR); **Jehun Jong**, Suwon-si (KR); **Jaehoon Jo**, Suwon-si (KR)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 470 days.

(21) Appl. No.: **18/074,952**

(22) Filed: **Dec. 5, 2022**

(65) **Prior Publication Data**

US 2023/0094039 A1 Mar. 30, 2023

Related U.S. Application Data

(63) Continuation of application No. PCT/KR2021/007020, filed on Jun. 4, 2021.

(30) **Foreign Application Priority Data**

Jun. 5, 2020 (KR) 10-2020-0068649

(51) **Int. Cl.**
H01Q 1/46 (2006.01)
H01Q 1/24 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 9/045*** (2013.01); ***H01Q 21/062*** (2013.01); ***H01Q 21/065*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/48; H01Q 9/045; H01Q 21/062; H01Q 21/065; H01Q 1/523;
(Continued)

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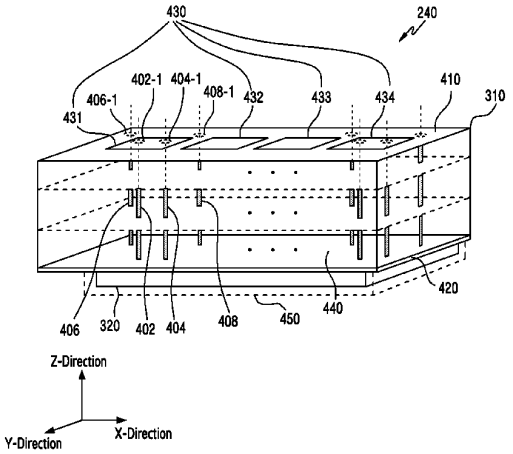
Primary Examiner — Dimary S Lopez Cruz
Assistant Examiner — Bamidele A Immanuel
(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

(57) **ABSTRACT**

An electronic device is provided. The electronic device includes a printed circuit board (PCB) including a plurality of layers, a communication circuit electrically coupled to the PCB, and at least one processor electrically coupled to the communication circuit. The PCB may include a first layer in which a plurality of patch antennas disposed, a first feeding path which feeds a first point of a first patch antenna so that the first patch antenna disposed to the first layer transmits and/or receives a first polarized signal, a second feeding path which feeds a second point of the first patch antenna so that the first patch antenna disposed to the first layer transmits
(Continued)



US012424733B2

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

(10) **Patent No.: US 12,424,733 B2**
(45) **Date of Patent: Sep. 23, 2025**

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

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

(72) Inventors: **Kookjoo Lee**, Suwon-si (KR); **Sumin Yun**, 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 220 days.

(21) Appl. No.: **18/171,897**

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

(65) **Prior Publication Data**

US 2023/0198131 A1 Jun. 22, 2023

Related U.S. Application Data

(63) Continuation of application No. PCT/KR2021/010538, filed on Aug. 10, 2021.

(30) **Foreign Application Priority Data**

Aug. 25, 2020 (KR) 10-2020-0107192

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
G06F 1/16 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***G06F 1/1616*** (2013.01); ***G06F 1/1652*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/38; H01Q 3/30; H01Q 3/2605; H01Q 21/08; G06F 1/1616;
(Continued)

(56) **References Cited**

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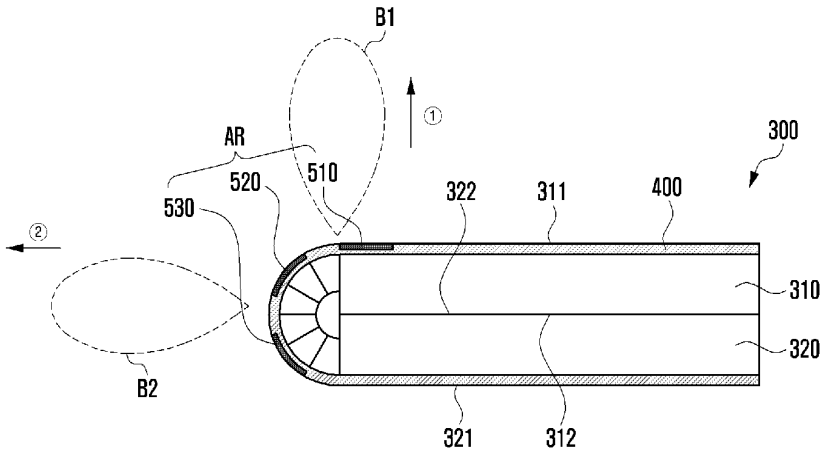
Primary Examiner — Dameon E Levi
Assistant Examiner — Jordan E. DeWitt
(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

(57) **ABSTRACT**

An electronic device is provided. The electronic device includes a flexible display comprising a display panel which includes a first portion, a second portion, and a third portion, and is disposed to be at least partially visible in a folded state, an array antenna which is formed on a dielectric sheet disposed on the display panel and includes a first mesh pattern portion disposed at a position corresponding to the first portion, a second mesh pattern portion disposed at a position corresponding to the third portion, and at least one third mesh pattern portion formed at a position spaced apart from the first mesh pattern portion, at a position corresponding to the first portion, a wireless communication circuit
(Continued)



US012424748B2

(12) **United States Patent**
Celik

(10) **Patent No.: US 12,424,748 B2**
(45) **Date of Patent: Sep. 23, 2025**

(54) **FILTERED DUAL-BAND PATCH ANTENNA**

(71) Applicant: **Trimble Inc.**, Sunnyvale, CA (US)

(72) Inventor: **Nuri Celik**, Milpitas, CA (US)

(73) Assignee: **Trimble Inc.**, Westminster, CO (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 328 days.

(21) Appl. No.: **17/109,043**

(22) Filed: **Dec. 1, 2020**

(65) **Prior Publication Data**

US 2022/0173512 A1 Jun. 2, 2022

(51) **Int. Cl.**

H01Q 5/321	(2015.01)
H01Q 1/48	(2006.01)
H01Q 5/314	(2015.01)
H01Q 5/378	(2015.01)
H01Q 9/04	(2006.01)
H01Q 19/00	(2006.01)

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

CPC ***H01Q 5/321*** (2015.01); ***H01Q 1/48*** (2013.01); ***H01Q 5/314*** (2015.01); ***H01Q 5/378*** (2015.01); ***H01Q 9/045*** (2013.01); ***H01Q 9/0464*** (2013.01); ***H01Q 19/005*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 5/321; H01Q 1/48; H01Q 5/314; H01Q 5/378; H01Q 9/045; H01Q 9/0464; H01Q 19/005

See application file for complete search history.

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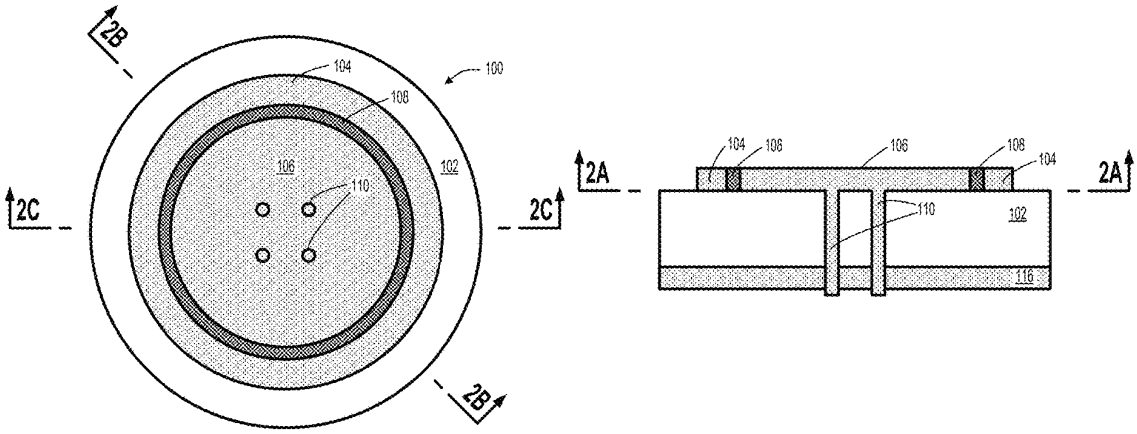
Primary Examiner — Dameon E Levi
Assistant Examiner — Yonchan J Kim
(74) *Attorney, Agent, or Firm* — Kilpatrick Townsend & Stockton LLP

(57) **ABSTRACT**

A dual-band patch antenna is described. The antenna includes a ground plane. The antenna also includes an inner conductor disposed above the ground plane. The inner conductor forms a high-frequency patch for receiving radio waves at an upper frequency band. The antenna further includes an outer conductor surrounding the inner conductor. The outer conductor and the inner conductor collectively form a low-frequency patch for receiving radio waves at a lower frequency band. The antenna further includes a filter disposed between the inner conductor and the outer conductor. The filter is configured to at least partially block electrical signals at the upper GNSS frequency band and to let pass electrical signals at the lower GNSS frequency band.

20 Claims, 16 Drawing Sheets



US012424753B2

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

(10) **Patent No.: US 12,424,753 B2**
(45) **Date of Patent: Sep. 23, 2025**

(54) **ANTENNA AND ELECTRONIC DEVICE**

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

(72) Inventors: **Zhe Chen**, Beijing (CN); **Yunnan Jin**, Beijing (CN); **Zhifeng Zhang**, Beijing (CN); **Guohui Nan**, Beijing (CN); **Chunnan Feng**, Beijing (CN); **Sihui Bao**, Beijing (CN); **Shuo Yang**, Beijing (CN)

(73) Assignees: **Beijing BOE Sensor Technology 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 0 days.

(21) Appl. No.: **18/021,914**

(22) PCT Filed: **Apr. 29, 2022**

(86) PCT No.: **PCT/CN2022/090118**
§ 371 (c)(1),
(2) Date: **Feb. 17, 2023**

(87) PCT Pub. No.: **WO2023/206314**
PCT Pub. Date: **Nov. 2, 2023**

(65) **Prior Publication Data**

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(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 13/10 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 9/0414*** (2013.01); ***H01Q 13/106*** (2013.01); ***H01Q 21/08*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC .. H01Q 21/064; H01Q 13/106; H01Q 9/0428; H01Q 9/0435; H01Q 1/521;
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(56) **References Cited**

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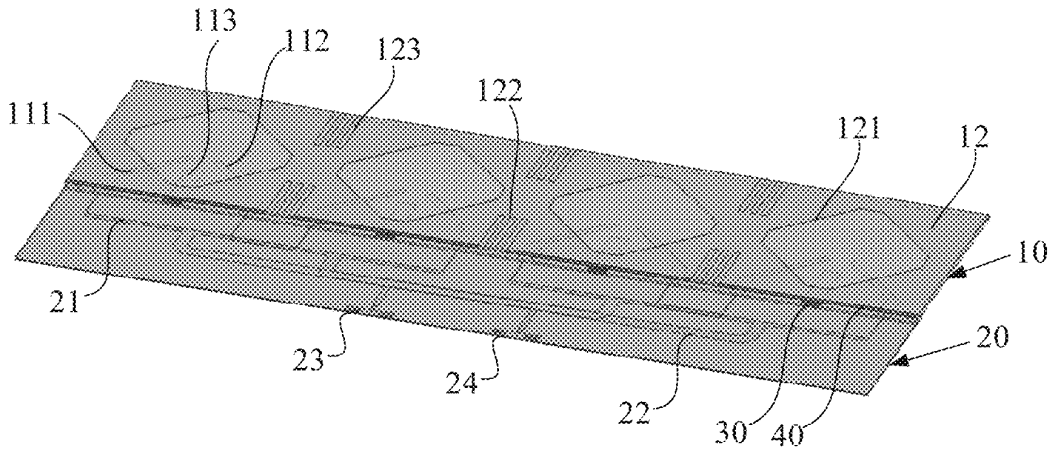
Primary Examiner — Dimary S Lopez Cruz
Assistant Examiner — Anna N Hamadyk
(74) *Attorney, Agent, or Firm* — Nath, Goldberg & Meyer; Joshua B. Goldberg

(57) **ABSTRACT**

An antenna and an electronic device are provided and belong to communication technology. The antenna includes an antenna substrate and a flexible circuit board. The antenna substrate includes: a first dielectric substrate, a first conductive layer on the first dielectric substrate and including at least one first feed line and at least one second feed line; a second conductive layer on a side of the first dielectric substrate away from the first conductive layer and including at least one first opening. The flexible circuit board includes: a second dielectric substrate and a third dielectric substrate opposite to each other; a third conductive layer between the second dielectric substrate and the third dielectric substrate; a first feed structure on a side of the second dielectric
(Continued)



US012424756B2

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

(10) **Patent No.: US 12,424,756 B2**
(45) **Date of Patent: Sep. 23, 2025**

(54) **ANTENNA AND ELECTRONIC DEVICE**

(71) Applicants: **Beijing BOE Sensor Technology Co., Ltd.**, Beijing (CN); **BOE TECHNOLOGY GROUP CO., LTD.**, Beijing (CN)

(72) Inventors: **Yunnan Jin**, Beijing (CN); **Chunnan Feng**, Beijing (CN); **Zhifeng Zhang**, Beijing (CN)

(73) Assignees: **Beijing BOE Sensor Technology 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 0 days.

(21) Appl. No.: **18/027,700**

(22) PCT Filed: **Mar. 28, 2022**

(86) PCT No.: **PCT/CN2022/083381**
§ 371 (c)(1),
(2) Date: **Mar. 22, 2023**

(87) PCT Pub. No.: **WO2023/184087**
PCT Pub. Date: **Oct. 5, 2023**

(65) **Prior Publication Data**

US 2024/0297440 A1 Sep. 5, 2024

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 1/36 (2006.01)
H01Q 21/08 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 9/0485*** (2013.01); ***H01Q 1/36*** (2013.01); ***H01Q 21/08*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/0485; H01Q 1/36; H01Q 21/08; H01Q 1/38; H01Q 1/50; H01Q 21/065;
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(56) **References Cited**

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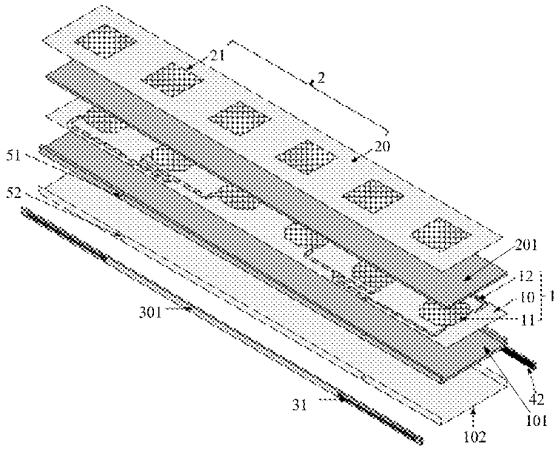
Primary Examiner — Dimary S Lopez Cruz
Assistant Examiner — Anna N Hamadyk
(74) *Attorney, Agent, or Firm* — HOUTTEMAN LAW LLC

(57) **ABSTRACT**

An antenna and an electronic device are provided, and belong to the field of communication technology. The antenna includes a first substrate and a second substrate opposite to each other. The first substrate includes a first dielectric substrate; a first radiation layer is on the first dielectric substrate and includes at least one first radiation portion and at least one feed structure. The first radiation portion is at least electrically connected to one feed structure; and a first reference electrode layer is on a side of the first dielectric substrate away from the first radiation layer. The second substrate includes a second dielectric substrate on a side of the first radiation layer away from the first dielectric substrate with a first distance therebetween; a second radiation layer is on the second dielectric substrate and includes at least one second radiation portion.

18 Claims, 12 Drawing Sheets



US012424760B2

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

(10) **Patent No.: US 12,424,760 B2**
(45) **Date of Patent: Sep. 23, 2025**

(54) **ANTENNA**

(71) Applicant: **MEDIATEK INC.**, Hsinchu (TW)

(72) Inventors: **Hsuan-Jui Chang**, Hsinchu (TW); **Nai-Chen Liu**, Hsinchu (TW); **Shih-Huang Yeh**, Hsinchu (TW); **Chung-Hsin Chiang**, Hsinchu (TW); **Wun-Jian Lin**, Hsinchu (TW)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 302 days.

(21) Appl. No.: **18/344,113**

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

(65) **Prior Publication Data**

US 2024/0039165 A1 Feb. 1, 2024

Related U.S. Application Data

(60) Provisional application No. 63/369,772, filed on Jul. 29, 2022.

(51) **Int. Cl.**
H01Q 5/364 (2015.01)
H01Q 1/42 (2006.01)
H01Q 13/16 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 13/16*** (2013.01); ***H01Q 1/42*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 13/16; H01Q 1/42; H01Q 1/241; H01Q 1/242; H01Q 1/243; H01Q 5/364; H01Q 19/108
See application file for complete search history.

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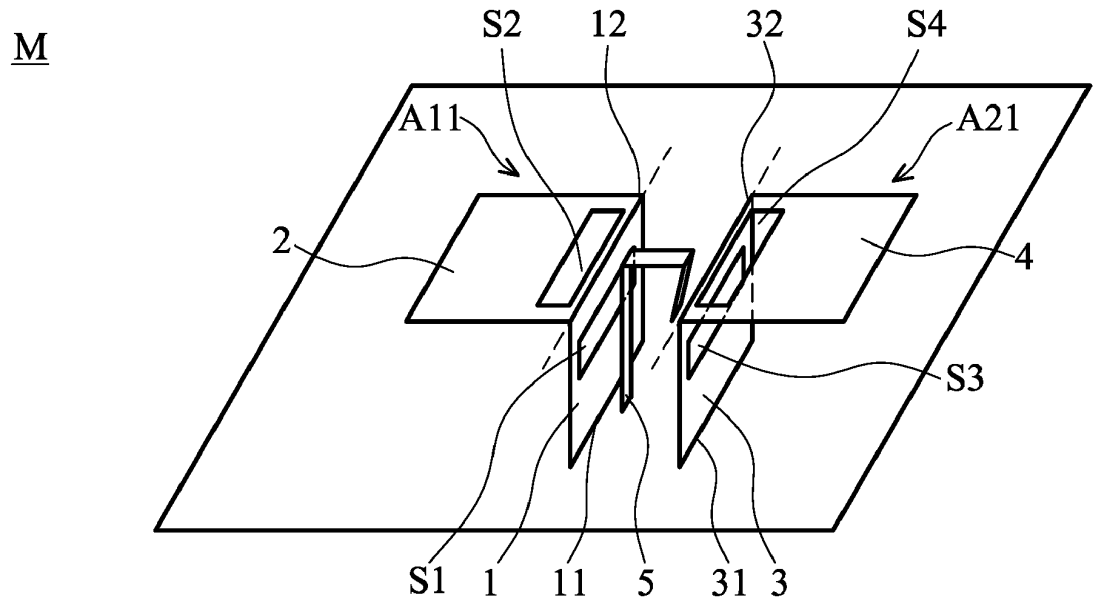
Primary Examiner — Awat M Salih

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

(57) **ABSTRACT**

An antenna is provided. The antenna includes a first radiator and a second radiator. The first radiator includes a first section and a second section. The first section includes a first grounding edge and a first bending edge. The second section is connected to the first bending edge. The first grounding edge is grounded. The first section is not parallel to the second section. A first slot is formed on the first section. The second radiator includes a third section and a fourth section. The third section includes a second grounding edge and a second bending edge. The fourth section is connected to the second bending edge. The second grounding edge is grounded. The third section is not parallel to the fourth section. The first section is parallel to the third section.

20 Claims, 14 Drawing Sheets



US012424761B2

(12) **United States Patent**
Lin

(10) **Patent No.: US 12,424,761 B2**
(45) **Date of Patent: *Sep. 23, 2025**

(54) **ANTENNA APPARATUS**

(71) Applicant: **RichWave Technology Corp.**, Taipei (TW)

(72) Inventor: **Shih-Kai Lin**, Taipei (TW)

(73) Assignee: **RichWave Technology Corp.**, Taipei (TW)

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

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **18/353,125**

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

(65) **Prior Publication Data**

US 2023/0369772 A1 Nov. 16, 2023

Related U.S. Application Data

(63) Continuation-in-part of application No. 17/565,457, filed on Dec. 30, 2021, now Pat. No. 11,764,477.

(30) **Foreign Application Priority Data**

Dec. 24, 2021 (TW) 110148774
May 22, 2023 (TW) 112118884

(51) **Int. Cl.**
H01Q 13/18 (2006.01)
H01Q 9/04 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 13/18*** (2013.01); ***H01Q 9/0457*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/045; H01Q 9/0457
See application file for complete search history.

(56) **References Cited**

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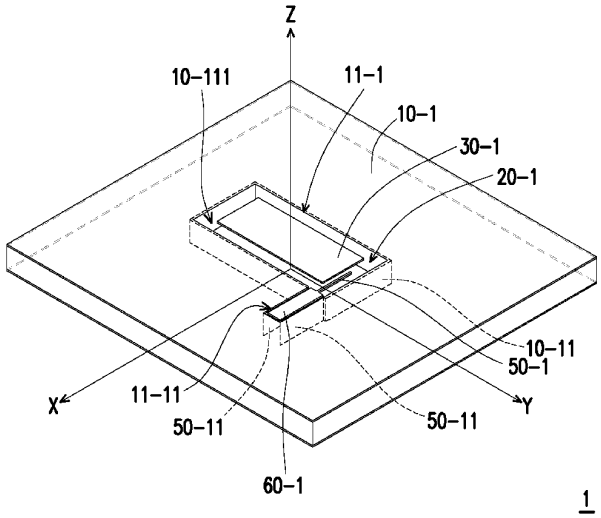
Primary Examiner — Daniel Munoz
(74) *Attorney, Agent, or Firm* — JCIPRNET

(57) **ABSTRACT**

An antenna apparatus is provided. The antenna apparatus includes a cavity element, a radiating element, and a feeding element. The cavity element includes an opening. The radiating element is located within the opening and disposed at a conductive layer. An outline of the radiating element and the opening form a surrounding slot. An imagining rectangle has four sides respectively abutted against an external outline of the surrounding slot. The feeding element is disposed at the same conductive layer. The feeding element includes a first section and a second section. A coupling distance is provided between the first section and the radiating element. A tail end of the first section is an open circuit. A shift distance is provided between the second section and a central line of the imagining rectangle.

19 Claims, 19 Drawing Sheets



US012424770B2

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

(10) **Patent No.: US 12,424,770 B2**
(45) **Date of Patent: Sep. 23, 2025**

(54) **MULTIBAND ANTENNA ARRAY**

(71) Applicant: **MEDIATEK INC.**, Hsinchu (TW)

(72) Inventors: **Li-Yu Chen**, Hsinchu (TW); **Yeh-Chun Kao**, Hsinchu (TW); **Chih-Wei Lee**, Hsinchu (TW)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 223 days.

(21) Appl. No.: **18/331,398**

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

(65) **Prior Publication Data**

US 2024/0014572 A1 Jan. 11, 2024

Related U.S. Application Data

(60) Provisional application No. 63/367,822, filed on Jul. 7, 2022.

(51) **Int. Cl.**
H01Q 5/10 (2015.01)
H01Q 21/08 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 21/08*** (2013.01); ***H01Q 5/10*** (2015.01)

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

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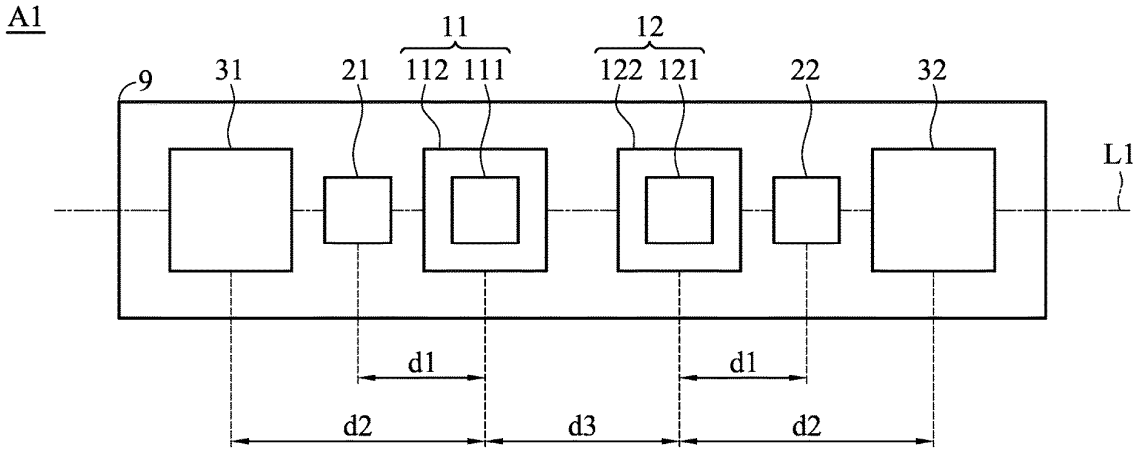
Primary Examiner — Daniel Munoz
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

A multiband antenna array is provided. The multiband antenna array includes a first multi-band antenna unit, a first high band antenna member, and a first low band antenna member. The first multi-band antenna unit includes a first high band antenna element and a first low band antenna element. A first distance is formed between the center of the first multi-band antenna unit and the center of the first high band antenna member. The first distance is 0.3~0.8 times the wavelength of a high band signal. A second distance is formed between the center of the first multi-band antenna unit and the center of the first low band antenna member. The second distance is 0.3~0.8 times the wavelength of a low band signal.

9 Claims, 6 Drawing Sheets



US012425095B2

(12) **United States Patent**
Farmahini Farahani et al.

(10) **Patent No.: US 12,425,095 B2**
(45) **Date of Patent: Sep. 23, 2025**

(54) **PASSIVE MIMO DEVICE**

(71) Applicant: **QUALCOMM Incorporated**, San Diego, CA (US)

(72) Inventors: **Mohsen Farmahini Farahani**, Encinitas, CA (US); **Lida Akhoondzadehasl**, Sunnyvale, CA (US); **Allen Minh-Triet Tran**, Rancho Santa Fe, CA (US)

(73) Assignee: **QUALCOMM Incorporated**, San Diego, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 469 days.

(21) Appl. No.: **17/934,886**

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

(65) **Prior Publication Data**

US 2024/0106520 A1 Mar. 28, 2024

(51) **Int. Cl.**
H04B 7/145 (2006.01)
H01Q 1/50 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H04B 7/145*** (2013.01); ***H01Q 1/50*** (2013.01); ***H01Q 3/40*** (2013.01); ***H01Q 19/06*** (2013.01); ***H01Q 21/061*** (2013.01)

(58) **Field of Classification Search**
CPC H04B 7/145; H04B 7/04013; H04B 7/15528; H04B 7/0874; H04B 7/0691;
(Continued)

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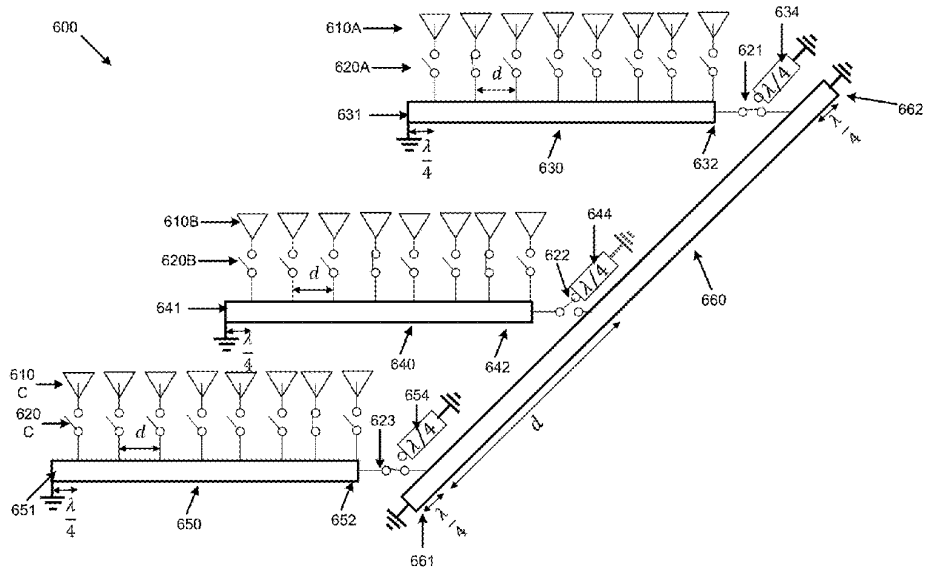
Primary Examiner — Lana N Le
(74) *Attorney, Agent, or Firm* — Polsinelli/Qualcomm Incorporated

(57) **ABSTRACT**

Aspects of the disclosure related to devices, wireless communication apparatuses, methods, and other aspects of passive multiple input multiple output. In some aspects, an apparatus is provided that includes a first radio frequency (RF) transmission line having a first terminated with a quarter wavelength grounded transmission line, and a first array of antennas including a plurality of antenna elements. The apparatus also includes a switch array including a corresponding switch for each antenna element of the plurality of antenna elements of the first array of antennas, to selectively connect each antenna element to the first RF transmission line, and path lengths selectable by the switches at half wavelength distances for passive transmission. The apparatus also includes or more lens elements configured to modify wireless inputs signals to the first array of antennas and to modify wireless output signals from the first array of antennas.

20 Claims, 15 Drawing Sheets



US012431619B2

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

(10) **Patent No.: US 12,431,619 B2**
(45) **Date of Patent: Sep. 30, 2025**

(54) **ANTENNA AND ELECTRONIC DEVICE**

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

(72) Inventors: **Jing Wang**, Beijing (CN); **Yi Ding**, Beijing (CN); **Haocheng Jia**, Beijing (CN); **Zhifeng Zhang**, Beijing (CN); **Chuncheng Che**, Beijing (CN); **Hao Guo**, Beijing (CN); **Yan Lu**, Beijing (CN); **Weisi Zhou**, Beijing (CN); **Wenxue Ma**, Beijing (CN)

(73) Assignees: **BEIJING BOE SENSOR TECHNOLOGY 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 0 days.

(21) Appl. No.: **18/027,994**

(22) PCT Filed: **Mar. 29, 2022**

(86) PCT No.: **PCT/CN2022/083623**
§ 371 (c)(1),
(2) Date: **Mar. 23, 2023**

(87) PCT Pub. No.: **WO2023/184138**
PCT Pub. Date: **Oct. 15, 2023**

(65) **Prior Publication Data**

US 2024/0322425 A1 Sep. 26, 2024

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01P 1/18 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 3/36*** (2013.01); ***H01P 1/18*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 21/0006*** (2013.01); ***H01Q 21/065*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/24; H01Q 1/38; H01Q 21/00; H01Q 21/0006; H01Q 21/06;
(Continued)

(56) **References Cited**

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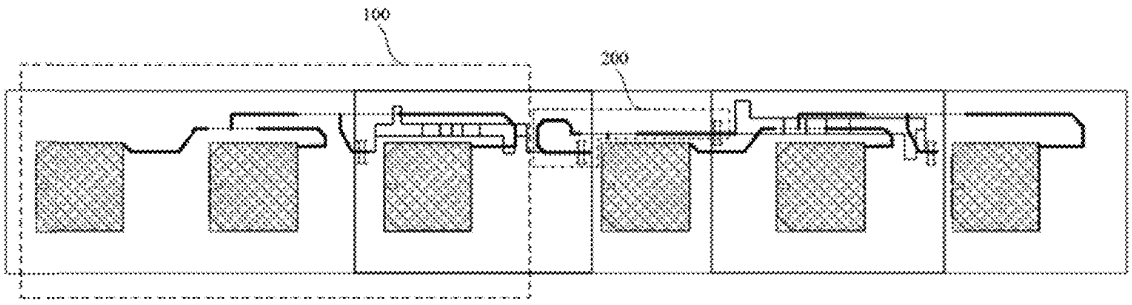
Primary Examiner — Tho G Phan
(74) *Attorney, Agent, or Firm* — Nath, Goldberg & Meyer; Joshua B. Goldberg

(57) **ABSTRACT**

An antenna and an electronic device are provided, and belong to the field of communication technology. The antenna includes: a first dielectric substrate, at least one sub-array and at least one first feed structure. Each sub-array includes at least one first radiation portion, at least one phase shifter, at least one second feed structure and a reference electrode layer. Each transmission component includes a first transmission structure and a second transmission structure; the at least one first radiation portion and the at least one second feed structure are on a side of the first dielectric substrate away from the at least one transmission component. The reference electrode layer is on the first dielectric substrate. Each first feed structure includes a first feed port
(Continued)



US012431621B2

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

(10) **Patent No.: US 12,431,621 B2**
(45) **Date of Patent: Sep. 30, 2025**

(54) **COMPACT DUAL BAND ANTENNA**

(71) Applicant: **Honeywell International Inc.**, Charlotte, NC (US)

(72) Inventors: **Zhong Liu**, Doylestown, PA (US); **Amit B. Kulkarni**, Duluth, GA (US); **Justin Jose**, Muvattupuzha (IN)

(73) Assignee: **HONEYWELL INTERNATIONAL INC.**, Charlotte, NC (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 105 days.

(21) Appl. No.: **18/160,065**

(22) Filed: **Jan. 26, 2023**

(65) **Prior Publication Data**

US 2024/0258693 A1 Aug. 1, 2024

(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 9/0407*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/30; H01Q 5/307; H01Q 5/378; H01Q 5/392; H01Q 9/04; H01Q 9/0407; H01Q 9/0414; H01Q 9/42; H01Q 1/2291; H01Q 1/243
See application file for complete search history.

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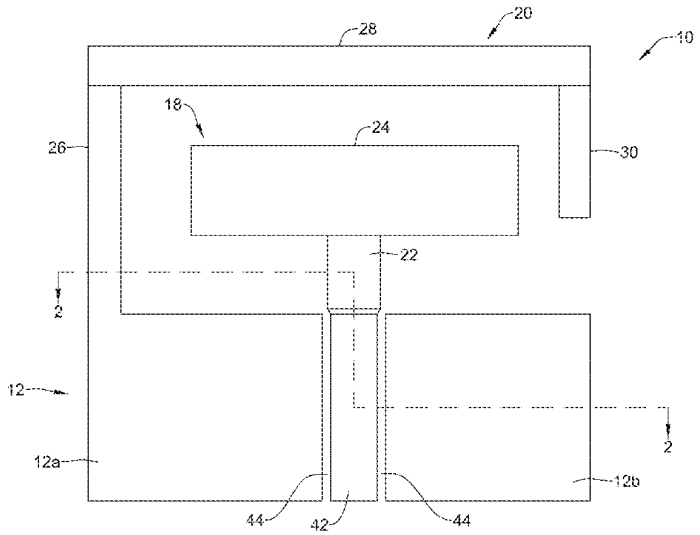
Primary Examiner — Jason M Crawford
(74) *Attorney, Agent, or Firm* — Seager, Tufte & Wickhem, LLP

(57) **ABSTRACT**

An antenna system formed by one or more layers of a Printed Circuit Board (PCB). The antenna system includes a first antenna element configured to resonate in a first frequency band centered at about 5.4 GHz and a second antenna element configured to resonate in a second frequency band centered at about 2.4 GHz. The first antenna element and the second antenna element fit within a rectangular area of less than about 100 square millimeters on the PCB. The first antenna element has a bandwidth of at least 2 GHz and the second antenna element has a bandwidth of at least 100 MHz, wherein the bandwidth is defined as having less than a −10 dB return loss within the band. The first antenna element and the second antenna element may be formed on a common conductive layer of a PCB.

20 Claims, 7 Drawing Sheets



US012431622B2

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

(10) **Patent No.: US 12,431,622 B2**
(45) **Date of Patent: Sep. 30, 2025**

(54) **MOBILE DEVICE SUPPORTING WIDEBAND OPERATION**

(71) Applicant: **Acer Incorporated**, New Taipei (TW)

(72) Inventors: **Kun-Sheng Chang**, New Taipei (TW); **Ching-Chi Lin**, New Taipei (TW)

(73) Assignee: **ACER INCORPORATED**, New Taipei (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 165 days.

(21) Appl. No.: **18/459,214**

(22) Filed: **Aug. 31, 2023**

(65) **Prior Publication Data**

US 2025/0015496 A1 Jan. 9, 2025

(30) **Foreign Application Priority Data**

Jul. 5, 2023 (TW) 112125046

(51) **Int. Cl.**
H01Q 5/307 (2015.01)
H01Q 1/22 (2006.01)
H01Q 1/48 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 5/307*** (2015.01); ***H01Q 1/22*** (2013.01); ***H01Q 1/48*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/307; H01Q 1/22; H01Q 1/48
See application file for complete search history.

(56) **References Cited**

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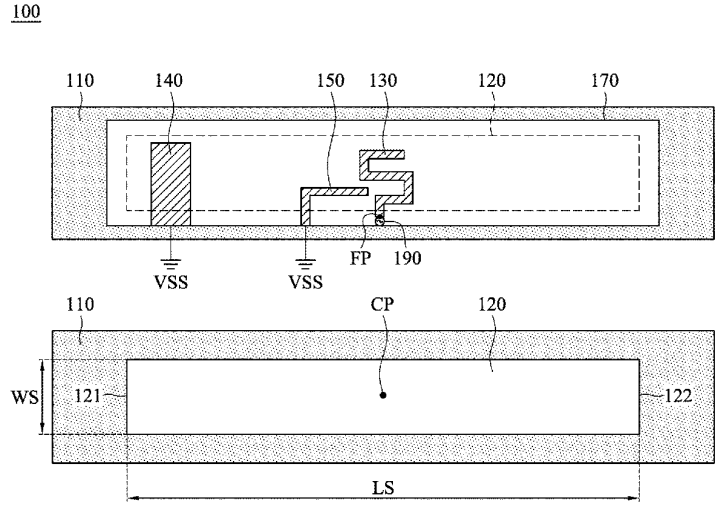
Primary Examiner — Henry Luong
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

A mobile device supporting wideband operations includes a metal mechanism element, a first radiation element, a second radiation element, a third radiation element, and a dielectric substrate. A slot is formed in the metal mechanism element. The first radiation element has a feeding point. The second radiation element is coupled to a ground voltage. The third radiation element is coupled to the ground voltage. The third radiation element is disposed between the first radiation element and the second radiation element. The dielectric substrate is adjacent to the slot of the metal mechanism element. The first radiation element, the second radiation element, and the third radiation element are disposed on the dielectric substrate. An antenna structure is formed by the slot of the metal mechanism element, the first radiation element, the second radiation element, and the third radiation element.

14 Claims, 7 Drawing Sheets



US012431626B2

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

(10) **Patent No.: US 12,431,626 B2**
(45) **Date of Patent: Sep. 30, 2025**

(54) **PLANAR INVERTED F ANTENNA PAIR AND ELECTRONIC DEVICE**

(71) Applicants: **Honor Device Co., Ltd.**, Shenzhen (CN); **Tsinghua University**, Beijing (CN)

(72) Inventors: **Weiquan Zhang**, Beijing (CN); **Zhijun Zhang**, Shenzhen (CN)

(73) Assignees: **Honor Device Co., Ltd.**, Shenzhen (CN); **Tsinghua University**, Beijing (CN)

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

(21) Appl. No.: **18/289,886**

(22) PCT Filed: **May 8, 2023**

(86) PCT No.: **PCT/CN2023/092721**
§ 371 (c)(1),
(2) Date: **Nov. 7, 2023**

(87) PCT Pub. No.: **WO2024/012026**
PCT Pub. Date: **Jan. 18, 2024**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Jul. 13, 2022 (CN) 202210821490.6

(51) **Int. Cl.**
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H01Q 1/48 (2006.01)
H01Q 5/15 (2015.01)

(52) **U.S. Cl.**
CPC ***H01Q 9/0421*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 5/15*** (2015.01)

(58) **Field of Classification Search**
CPC .. H01Q 1/36; H01Q 1/48; H01Q 1/50; H01Q 1/521; H01Q 1/523; H01Q 5/15;
(Continued)

(56) **References Cited**

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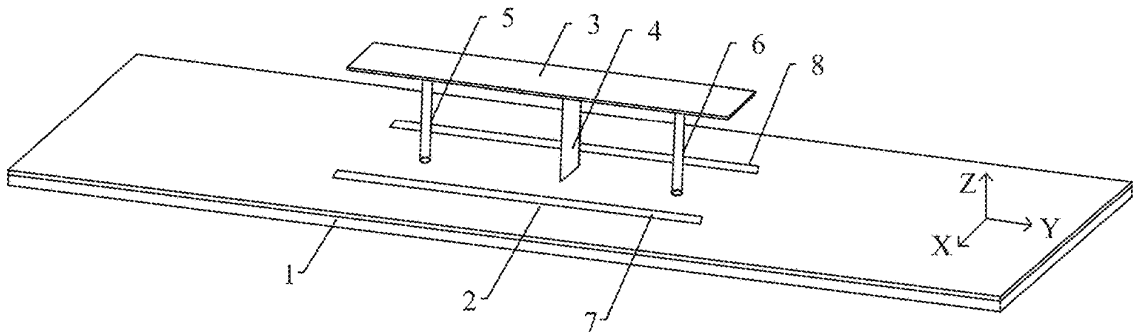
Primary Examiner — Hoang V Nguyen
(74) *Attorney, Agent, or Firm* — Leydig, Voit & Mayer, Ltd.

(57) **ABSTRACT**

This application discloses a planar inverted F antenna pair and an electronic device, and relates to the field of antenna technologies. The planar inverted F antenna pair includes a dielectric substrate, a ground metal plane, and a radiation unit, where the ground metal plane is arranged on a side of the dielectric substrate, two ends of the radiation unit are respectively connected to a first feed portion and a second feed portion, the radiation unit is connected to the ground metal plane through a ground metal sheet, the ground metal sheet is located between the first feed portion and the second feed portion, distances from the first feed portion and the second feed portion to the ground metal sheet are not equal,
(Continued)



US012431635B2

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

(10) **Patent No.: US 12,431,635 B2**
(45) **Date of Patent: Sep. 30, 2025**

(54) **ELECTRONIC DEVICE INCLUDING ANTENNA**

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

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

(73) Assignee: **SAMSUNG ELECTRONICS CO., LTD.**, Suwon-si (KR)

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

(21) Appl. No.: **18/118,422**

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

(65) **Prior Publication Data**

US 2023/0216213 A1 Jul. 6, 2023

Related U.S. Application Data

(63) Continuation of application No. PCT/KR2022/014532, filed on Sep. 28, 2022.

(30) **Foreign Application Priority Data**

Oct. 12, 2021 (KR) 10-2021-0135114

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

(52) **U.S. Cl.**
CPC ***H01Q 21/065*** (2013.01); ***H01Q 1/2283*** (2013.01); ***H01Q 1/521*** (2013.01); ***H01Q 5/321*** (2015.01); ***H01Q 9/0414*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/2283; H01Q 1/243; H01Q 1/521; H01Q 3/36; H01Q 5/321; H01Q 9/0407; H01Q 9/0414; H01Q 21/065
See application file for complete search history.

(56) **References Cited**

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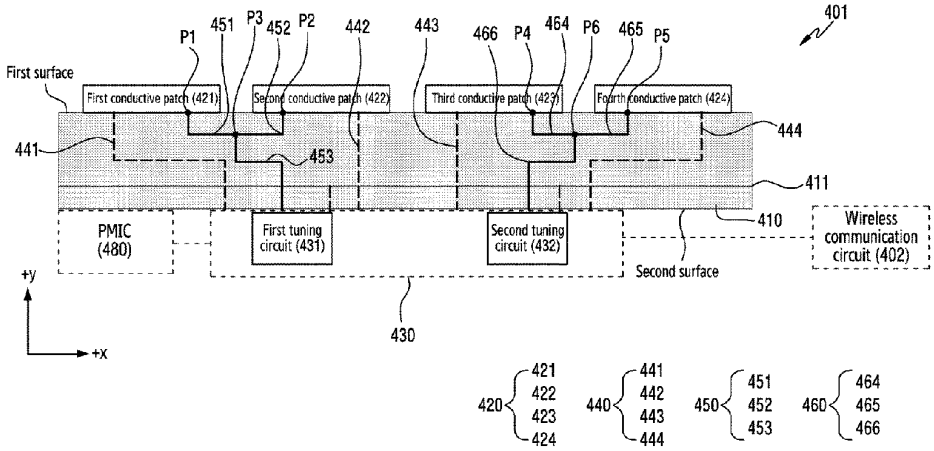
Primary Examiner — Daniel Munoz
(74) *Attorney, Agent, or Firm* — Nixon & Vanderhye, P.C.

(57) **ABSTRACT**

An example electronic device may include an antenna module including a printed circuit board, a plurality of conductive patches including a first conductive patch and a second conductive patch, an RFIC which is disposed on the second surface of the printed circuit board and includes a first tuning circuit, and a first conductive structure which includes a first portion extending from the first conductive patch, a second portion extending from the second conductive patch and connected to the first portion at a point positioned at one end of the first portion, and a first common portion connected to the first tuning circuit and connecting the first conductive patch and the second conductive patch to the first tuning circuit, a ground, and a wireless communication circuit, and the wireless communication circuit may
(Continued)



US012432289B2

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

(10) **Patent No.: US 12,432,289 B2**
(45) **Date of Patent: Sep. 30, 2025**

(54) **ELECTRONIC DEVICE INCLUDING ANTENNA AND METHOD THEREOF**

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

(72) Inventors: **Wonhyung Heo**, Suwon-si (KR); **Taeho Kim**, Suwon-si (KR); **Dongil Son**, Suwon-si (KR); **Choongsun Shim**, Suwon-si (KR); **Sanghyun Han**, 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 495 days.

(21) Appl. No.: **18/077,609**

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

(65) **Prior Publication Data**

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Related U.S. Application Data

(63) Continuation of application No. PCT/KR2022/016498, filed on Oct. 26, 2022.

(30) **Foreign Application Priority Data**

Oct. 26, 2021 (KR) 10-2021-0143913

(51) **Int. Cl.**
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H01Q 1/24 (2006.01)
H03H 7/38 (2006.01)

(52) **U.S. Cl.**
CPC ***H04M 1/0245*** (2013.01); ***H01Q 1/243*** (2013.01); ***H03H 7/38*** (2013.01); ***H04M 1/0216*** (2013.01); ***H04M 1/0237*** (2013.01)

(58) **Field of Classification Search**
CPC H04M 1/0245; H04M 1/0216; H04M 1/0237; H04M 1/0241; H04M 1/0243;
(Continued)

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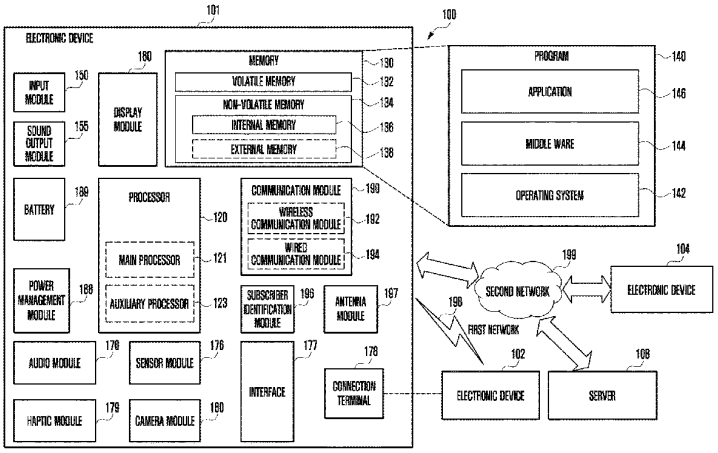
Primary Examiner — Dhaval V Patel
(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

(57) **ABSTRACT**

An electronic device is provided. The electronic device includes a housing structure including a first housing and a second housing connected to first housing, the second housing being connected to the first housing so as to be slidable while being at least partially inserted into or withdrawn from the first housing, a sensor module including at least one sensor, an antenna, an antenna tuner electrically connected to the antenna and configured to match impedance of the antenna, and a processor operatively connected to the sensor module, the antenna, and the antenna tuner, wherein the processor is configured to determine withdrawal information about a withdrawn degree of the second housing by using the sensor module, select an index corresponding to the withdrawal information from among multiple indices in which impedance values of the antenna according to multiple different pieces of withdrawal information are sampled, and control, based on a tuning code corresponding to the selected
(Continued)



US012438254B2

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

(10) **Patent No.: US 12,438,254 B2**
(45) **Date of Patent: Oct. 7, 2025**

(54) **ELECTRONIC DEVICE**

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

(72) Inventors: **Pengfei Wu**, Shanghai (CN); **Hanyang Wang**, Reading (GB); **Meng Hou**, Shanghai (CN); **Chien-Ming Lee**, Shenzhen (CN)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 82 days.

(21) Appl. No.: **18/259,190**

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

(86) PCT No.: **PCT/CN2021/136349**
§ 371 (c)(1),
(2) Date: **Jun. 23, 2023**

(87) PCT Pub. No.: **WO2022/135148**
PCT Pub. Date: **Jun. 30, 2022**

(65) **Prior Publication Data**

US 2024/0304982 A1 Sep. 12, 2024

(30) **Foreign Application Priority Data**

Dec. 25, 2020 (CN) 202011564230.2

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

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 1/50*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/24; H01Q 1/242; H01Q 1/243; H01Q 1/36; H01Q 1/38; H01Q 1/48;
(Continued)

(56) **References Cited**

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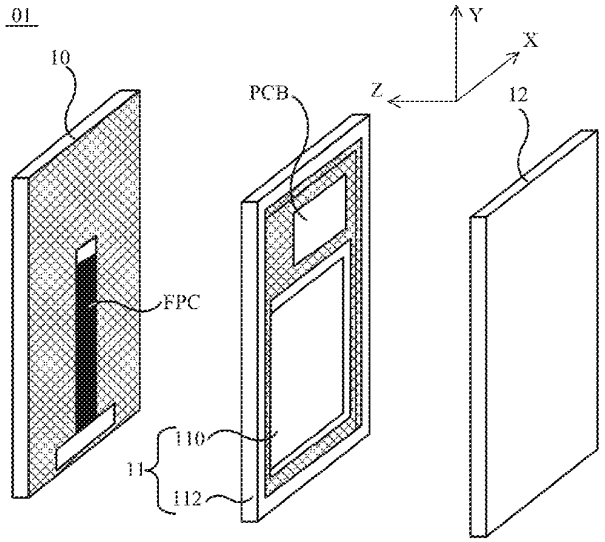
Primary Examiner — Hoang V Nguyen
(74) *Attorney, Agent, or Firm* — Conley Rose, P.C.

(57) **ABSTRACT**

An electronic device includes a conductive frame and a first antenna unit. The conductive frame is disposed around a periphery of the electronic device. The first antenna unit includes a first conductive layer and a second conductive layer spaced apart in a thickness direction of the electronic device; a conductive connection portion is configured to connect the first conductive layer and the second conductive layer; and a first conductive frame, is a part of the conductive frame. The conductive connection portion, the first conductive frame, the first conductive layer, and the second conductive layer enclose a first cavity, and the first conductive layer and the first conductive frame are spaced apart to form a first slot of the first cavity.

20 Claims, 22 Drawing Sheets



US012438257B2

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

(10) **Patent No.: US 12,438,257 B2**
(45) **Date of Patent: Oct. 7, 2025**

(54) **ELECTRONIC DEVICE**

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

(72) Inventors: **Dawei Zhou**, Shenzhen (CN); **Hanyang Wang**, Reading (GB); **Xiaotao Cai**, Shenzhen (CN); **Wenlong Hu**, Shenzhen (CN)

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

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

(21) Appl. No.: **18/255,014**

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

(86) PCT No.: **PCT/CN2021/134207**
§ 371 (c)(1),
(2) Date: **May 30, 2023**

(87) PCT Pub. No.: **WO2022/111716**
PCT Pub. Date: **Jun. 2, 2022**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Nov. 30, 2020 (CN) 202011378857.9

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/38 (2006.01)
H01Q 1/42 (2006.01)
H01Q 21/30 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/244*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 1/422*** (2013.01); ***H01Q 21/30*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/24; H01Q 1/243; H01Q 1/244; H01Q 1/422; H01Q 9/40; H01Q 9/42; H01Q 21/30
See application file for complete search history.

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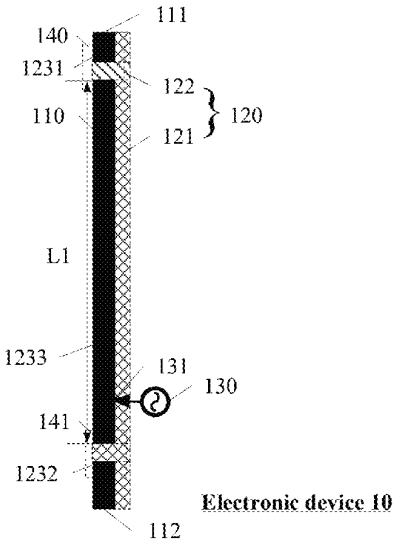
Primary Examiner — Thai Pham
(74) *Attorney, Agent, or Firm* — Conley Rose, P.C.

(57) **ABSTRACT**

An electronic device includes an antenna structure. The electronic device includes a bezel and a dielectric layer. The bezel has a first position and a second position, and a bezel between the first position and the second position is configured as an antenna radiator. A first dielectric is disposed on at least a part of an inner surface of the bezel besides the bezel between the first position and the second position. A second dielectric is disposed on at least a part of a surface of the antenna radiator. The first dielectric is different from the second dielectric.

20 Claims, 25 Drawing Sheets



US012438273B2

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

(10) **Patent No.: US 12,438,273 B2**
(45) **Date of Patent: Oct. 7, 2025**

(54) **ANTENNA AND COMMUNICATION DEVICE**

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

(72) Inventors: **Li Jin**, Xi'an (CN); **Junfeng Lu**, Xi'an (CN); **Qiqiang Gao**, Xi'an (CN); **Xinming Liu**, Xi'an (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 204 days.

(21) Appl. No.: **18/337,921**

(22) Filed: **Jun. 20, 2023**

(65) **Prior Publication Data**

US 2023/0335905 A1 Oct. 19, 2023

Related U.S. Application Data

(63) Continuation of application No. PCT/CN2020/137913, filed on Dec. 21, 2020.

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

(52) **U.S. Cl.**
CPC ***H01Q 5/50*** (2015.01)

(58) **Field of Classification Search**
CPC .. H01Q 5/50; H01Q 3/36; H01Q 3/30; H01Q 3/32; H01Q 1/246; H01Q 1/50
See application file for complete search history.

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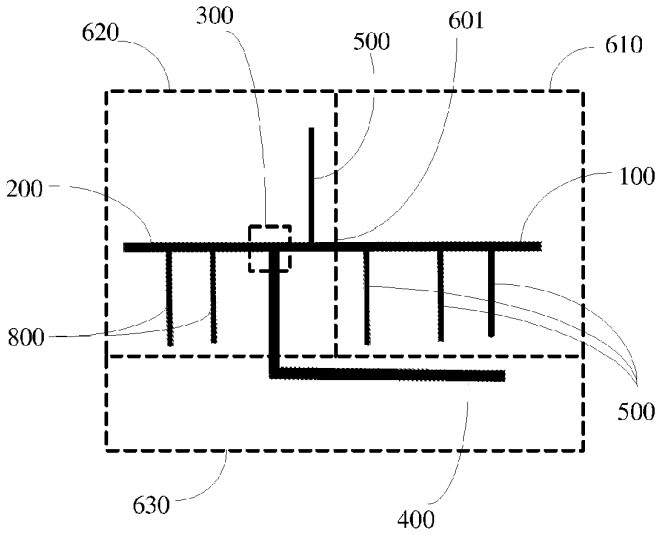
(Continued)

Primary Examiner — Seokjin Kim
(74) *Attorney, Agent, or Firm* — HAUPTMAN HAM, LLP

(57) **ABSTRACT**

An antenna includes a first signal cable, a second signal cable, a combiner, a combined transmission line, a plurality of first filters and a plurality of cavities. The first signal cable is configured to transmit a first signal. Output ends of the first signal cable and the second signal cable are connected to an input end of the combined transmission line through the combiner. The plurality of first filters are each electrically connected to the first signal cable and are respectively located in at least two different cavities of the plurality of cavities. The plurality of first filters are configured to filter a second signal thereby generating the first signal.

18 Claims, 6 Drawing Sheets



US012438276B2

(12) **United States Patent**
Sakr

(10) **Patent No.: US 12,438,276 B2**
(45) **Date of Patent: Oct. 7, 2025**

(54) **CIRCULARLY-POLARIZED ANTENNAS WITH WIDE SCANNING RANGES**

(71) Applicant: **Analog Devices International Unlimited Company**, Limerick (IE)

(72) Inventor: **Ahmed A. Sakr**, New Cairo (EG)

(73) Assignee: **Analog Devices International Unlimited Company**, Limerick (IE)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 157 days.

(21) Appl. No.: **18/259,729**

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

(86) PCT No.: **PCT/EP2022/051384**
§ 371 (c)(1),
(2) Date: **Jun. 28, 2023**

(87) PCT Pub. No.: **WO2022/161873**
PCT Pub. Date: **Aug. 4, 2022**

(65) **Prior Publication Data**

US 2024/0055765 A1 Feb. 15, 2024

Related U.S. Application Data

(60) Provisional application No. 63/142,212, filed on Jan. 27, 2021.

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

(52) **U.S. Cl.**
CPC ***H01Q 9/0435*** (2013.01); ***H01Q 9/045*** (2013.01); ***H01Q 21/065*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/281; H01Q 5/378; H01Q 9/045; H01Q 9/0407; H01Q 9/0414;
(Continued)

(56) **References Cited**

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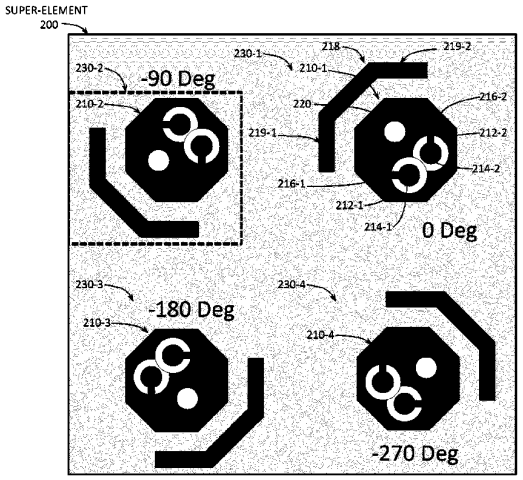
(Continued)

Primary Examiner — Tung X Le
(74) *Attorney, Agent, or Firm* — Knobbe, Martens, Olson & Bear, LLP

(57) **ABSTRACT**

New antenna designs for realizing circularly-polarized antennas with a wide scanning range are disclosed. The designs are based on arranging four sequentially fed antenna patches to be considered as a single antenna element, referred to as a "super-element," in the overall phased array. An example super-element includes relatively short transmission lines to provide excitations for the vertically and horizontally polarized fields, with the transmission lines for the vertically and horizontally polarized fields being perpendicular to one other. A parasitic transmission line may be placed around a part of each antenna patch of the super-element to serve as a coupler to further enforce the field vector direction for keeping the circular polarization. With such designs, an axial ratio below 3.6 dB for scanning angles of at least 75 degrees at 39.5 GHz may be achieved.

20 Claims, 8 Drawing Sheets



US012438282B2

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

(10) **Patent No.: US 12,438,282 B2**
(45) **Date of Patent: Oct. 7, 2025**

(54) **ANTENNA DEVICE, RADAR SENSOR DEVICE AND METHOD FOR PRODUCING AN ANTENNA DEVICE**

(71) Applicant: **Robert Bosch GmbH**, Stuttgart (DE)

(72) Inventors: **Christian Hollaender**, Waldbronn (DE); **Juergen Hildebrandt**, Weilheim (DE); **Klaus Baur**, Mietingen (DE); **Michael Schoor**, Stuttgart (DE); **Minh Nhat Pham**, Leinfelden-Echterdingen (DE)

(73) Assignee: **ROBERT BOSCH GMBH**, Stuttgart (DE)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 295 days.

(21) Appl. No.: **18/064,539**

(22) Filed: **Dec. 12, 2022**

(65) **Prior Publication Data**

US 2023/0291115 A1 Sep. 14, 2023

(30) **Foreign Application Priority Data**

Feb. 10, 2022 (DE) 10 2022 201 374.3

(51) **Int. Cl.**
H01Q 13/10 (2006.01)
H01Q 9/04 (2006.01)
H01Q 21/28 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 13/106*** (2013.01); ***H01Q 9/0407*** (2013.01); ***H01Q 21/28*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/0485; H01Q 1/02; H01Q 1/2283
See application file for complete search history.

(56) **References Cited**

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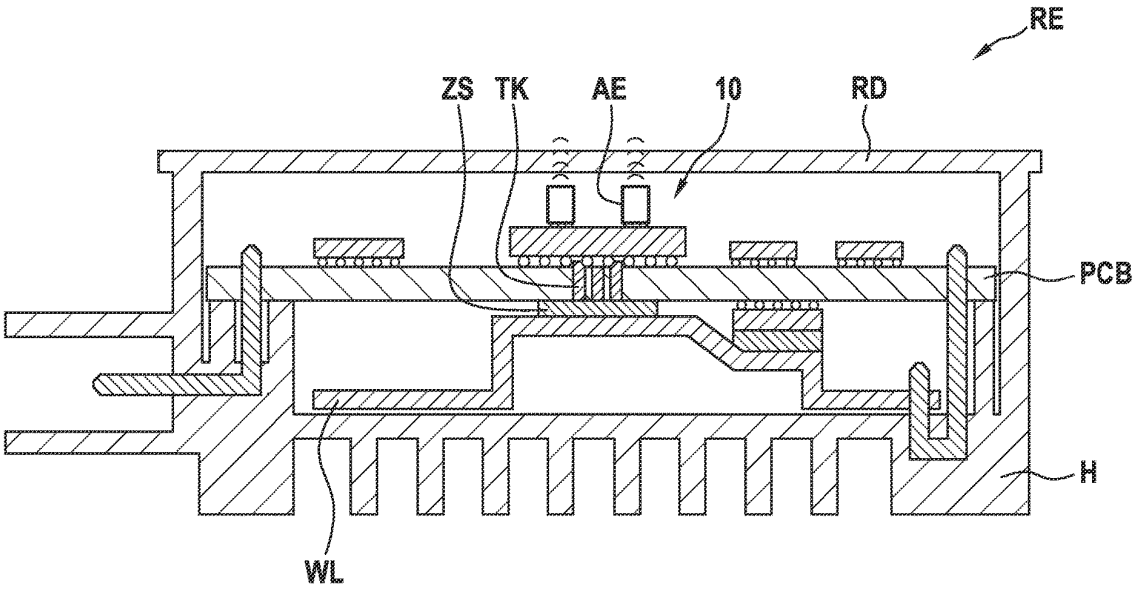
Primary Examiner — Dameon E Levi
Assistant Examiner — Aladdin Abdulbaki
(74) *Attorney, Agent, or Firm* — NORTON ROSE FULBRIGHT US LLP

(57) **ABSTRACT**

An antenna device. The antenna device includes a carrier element having at least one first strip conductor and having a second strip conductor; at least one fastening structure, which is formed in or on the carrier element; at least one antenna element, which is arranged or fastened on or in the fastening structure and is connected to the strip conductor; a transmitter device, which is arranged on the carrier element and is connected to the second strip conductor, and is designed to transmit a transmitter signal to the at least one antenna element and/or to receive a transmitter signal from the at least one antenna element.

18 Claims, 5 Drawing Sheets



US012438288B2

(12) **United States Patent**
Wu

(10) **Patent No.: US 12,438,288 B2**
(45) **Date of Patent: Oct. 7, 2025**

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

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

(72) Inventor: **Xiaopu Wu**, Guangdong (CN)

(73) Assignee: **GUANGDONG OPPO MOBILE TELECOMMUNICATIONS CORP., LTD.**, Guangdong (CN)

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

(21) Appl. No.: **18/215,802**

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

(65) **Prior Publication Data**

US 2023/0344151 A1 Oct. 26, 2023

Related U.S. Application Data

(63) Continuation of application No. PCT/CN2021/131176, filed on Nov. 17, 2021.

(30) **Foreign Application Priority Data**

Dec. 29, 2020 (CN) 202011613294.7

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

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

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 5/328; H01Q 21/30; H04B 1/0064; H01R 2201/02; H03J 2200/11
See application file for complete search history.

(56) **References Cited**

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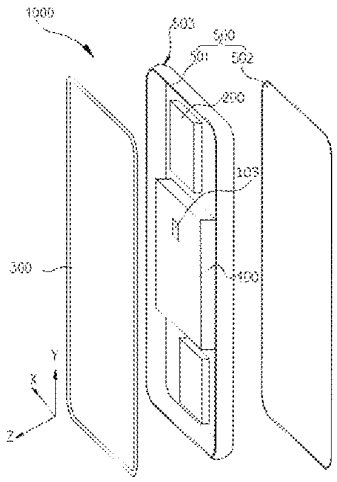
Primary Examiner — Monica C King
(74) *Attorney, Agent, or Firm* — Hodgson Russ LLP

(57) **ABSTRACT**

An antenna assembly and an electronic device are provided in the disclosure. The antenna assembly includes a first antenna element, a second antenna element, and a third antenna element. The first antenna element includes a first radiator. The second antenna element includes a second radiator. A first gap is defined between one end of the second radiator and one end of the first radiator, and at least part of the second radiator is configured to be coupled to the first radiator through the first gap. The third antenna element includes a third radiator. A second gap is defined between the third radiator and the other end of the second radiator, and at least part of the third radiator is configured to be coupled to the second radiator through the second gap.

20 Claims, 16 Drawing Sheets



US012443253B2

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

(10) **Patent No.: US 12,443,253 B2**
(45) **Date of Patent: Oct. 14, 2025**

(54) **ELECTRONIC APPARATUS**

(71) Applicant: **LENOVO (SINGAPORE) PTE. LTD.**, Singapore (SG)

(72) Inventors: **Ryota Watanabe**, Yokohama (JP); **Qianyi Lu**, Yokohama (JP); **Jun Iwasaki**, Yokohama (JP); **Masaaki Bandoh**, Yokohama (JP)

(73) Assignee: **LENOVO (SINGAPORE) PTE. LTD.**, Singapore (SG)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 288 days.

(21) Appl. No.: **18/457,514**

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

(65) **Prior Publication Data**

US 2024/0160258 A1 May 16, 2024

(30) **Foreign Application Priority Data**

Nov. 16, 2022 (JP) 2022-183510

(51) **Int. Cl.**

G06F 1/20	(2006.01)
G06F 1/16	(2006.01)
H05K 7/20	(2006.01)
H05K 9/00	(2006.01)

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

CPC ***G06F 1/203*** (2013.01); ***G06F 1/1656*** (2013.01); ***G06F 1/1698*** (2013.01); ***H05K 7/20154*** (2013.01); ***H05K 7/20336*** (2013.01); ***H05K 7/2049*** (2013.01); ***H05K 9/0022*** (2013.01)

(58) **Field of Classification Search**

CPC G06F 1/203; G06F 1/1656; G06F 1/1698; H05K 7/20154; H05K 7/20336; H05K 7/2049; H05K 9/0022

See application file for complete search history.

(56) **References Cited**

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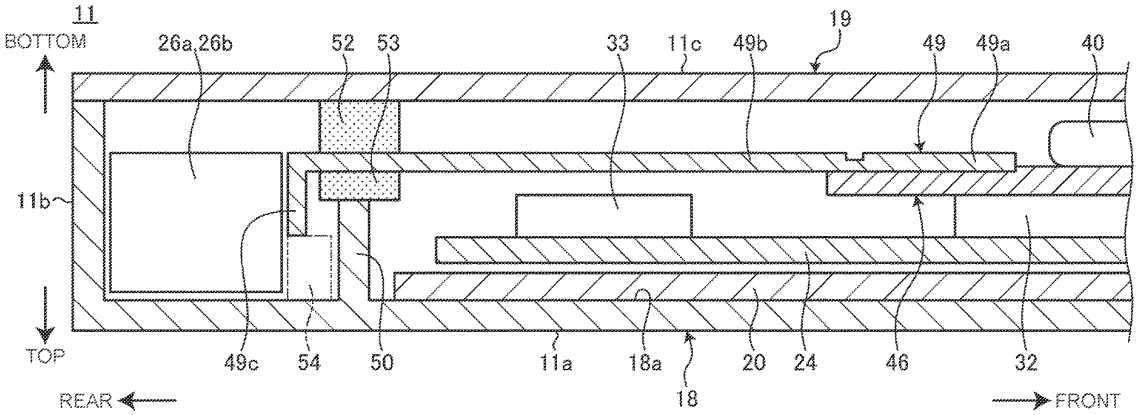
Primary Examiner — Mukundbhai G Patel
(74) *Attorney, Agent, or Firm* — SHIMOKAJI IP

(57) **ABSTRACT**

An electronic apparatus includes a chassis, a heat generating body provided in the chassis, an antenna configured to be provided in the chassis and be capable of receiving radio waves, an electronic part arranged to be aligned with the antenna within the chassis, and a cooling module configured to have a plate-shaped metal part and cool the heat generating body within the chassis. The metal part includes a shield wall interposed between the antenna and the electronic part.

6 Claims, 7 Drawing Sheets



US012444817B2

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

(10) **Patent No.: US 12,444,817 B2**
(45) **Date of Patent: *Oct. 14, 2025**

(54) **FEEDING STRUCTURE, MICROWAVE RADIO FREQUENCY DEVICE AND ANTENNA**

(71) Applicants: **Beijing BOE Sensor Technology Co., Ltd.**, Beijing (CN); **BOE TECHNOLOGY GROUP CO., LTD.**, Beijing (CN)

(72) Inventors: **Haocheng Jia**, Beijing (CN); **Tienlun Ting**, Beijing (CN); **Ying Wang**, Beijing (CN); **Jie Wu**, Beijing (CN); **Liang Li**, Beijing (CN); **Cuiwei Tang**, Beijing (CN); **Qiangqiang Li**, Beijing (CN)

(73) Assignees: **Beijing BOE Sensor Technology 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 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **18/443,214**

(22) Filed: **Feb. 15, 2024**

(65) **Prior Publication Data**

US 2024/0186668 A1 Jun. 6, 2024

Related U.S. Application Data

(63) Continuation of application No. 17/280,873, filed as application No. PCT/CN2020/108821 on Aug. 13, 2020, now Pat. No. 11,949,142.

(30) **Foreign Application Priority Data**

Aug. 14, 2019 (CN) 201910750841.7

(51) **Int. Cl.**
H01P 1/18 (2006.01)
H01P 1/20 (2006.01)
H01P 5/12 (2006.01)

(52) **U.S. Cl.**
CPC ***H01P 1/18*** (2013.01); ***H01P 1/20*** (2013.01); ***H01P 5/12*** (2013.01)

(58) **Field of Classification Search**
CPC H01P 1/18; H01P 1/20; H01P 1/184; H01P 5/12; H01P 5/10; H01Q 1/50; H01Q 3/36
See application file for complete search history.

(56) **References Cited**

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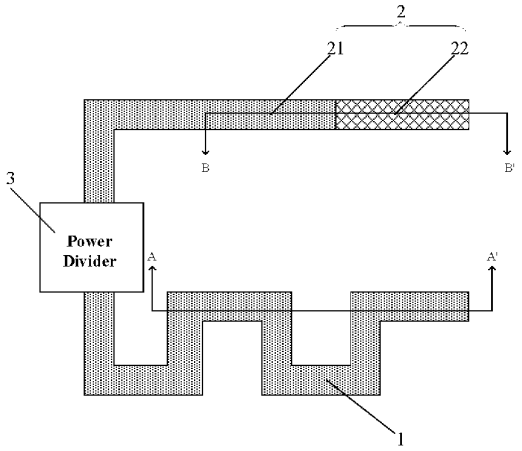
Primary Examiner — Seokjin Kim
(74) *Attorney, Agent, or Firm* — HOUTTEMAN LAW LLC

(57) **ABSTRACT**

A radio frequency device includes a feeding structure and a phase shifting structure. The feeding structure includes opposite first and second substrates, and a dielectric layer between the first and second substrates. The first substrate

(Continued)



US012444830B2

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

(10) **Patent No.: US 12,444,830 B2**
(45) **Date of Patent: Oct. 14, 2025**

(54) **ELECTRONIC DEVICE INCLUDING ANTENNA**

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

(72) Inventors: **Woosup Lee**, Suwon-si (KR); **Jungsik Park**, Suwon-si (KR); **Jungoh Sung**, Suwon-si (KR); **Muyeol Lee**, Suwon-si (KR); **Sehwan Choi**, Suwon-si (KR); **Sukgi 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 190 days.

(21) Appl. No.: **18/080,177**

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

(65) **Prior Publication Data**

US 2023/0110427 A1 Apr. 13, 2023

Related U.S. Application Data

(63) Continuation of application No. PCT/KR2021/004700, filed on Apr. 14, 2021.

(30) **Foreign Application Priority Data**

Jun. 18, 2020 (KR) 10-2020-0074519

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

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/02*** (2013.01); ***H01Q 1/526*** (2013.01); ***H01Q 7/06*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC .. H05K 1/02; H05K 1/14; H05K 7/20; H05K 2201/066
See application file for complete search history.

(56) **References Cited**

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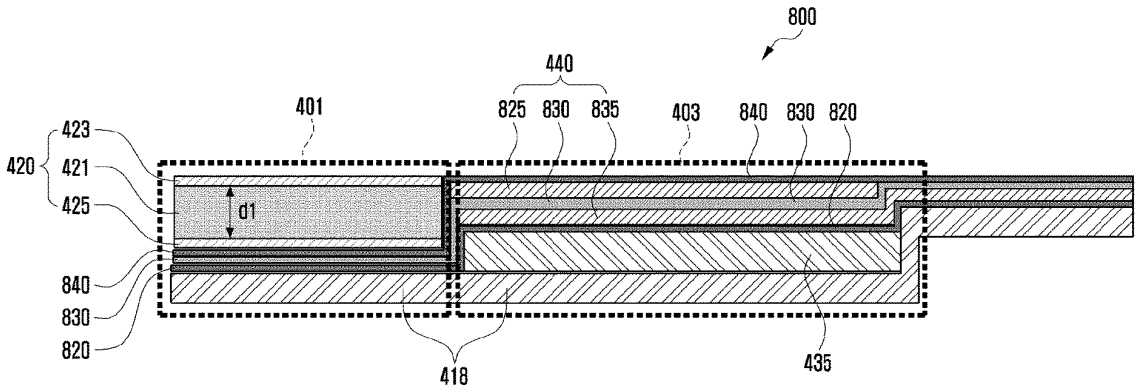
Primary Examiner — Dimary S Lopez Cruz
Assistant Examiner — Austin M Back
(74) *Attorney, Agent, or Firm* — Nixon & Vanderhye P.C.

(57) **ABSTRACT**

An electronic device including an antenna according to various embodiments comprises: a printed circuit board disposed in a first area of the electronic device; a battery disposed in a second area of the electronic device; a heat dissipation member including a thermally conductive material disposed on the upper part of the printed circuit board and the battery; a first antenna disposed in the first area on the heat dissipation member; and a second antenna disposed in the second area on the heat dissipation member, wherein the frequency bands and the dielectric constants of the first antenna and the second antenna may be configured differently.

13 Claims, 15 Drawing Sheets



US012444835B2

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

(10) **Patent No.: US 12,444,835 B2**
(45) **Date of Patent: Oct. 14, 2025**

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

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

(72) Inventors: **Pengfei Wu**, Shanghai (CN); **Jiahui Chu**, Shanghai (CN); **Hanyang Wang**, Reading (GB); **Meng Hou**, Shanghai (CN); **Chien-Ming Lee**, Shenzhen (CN)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 171 days.

(21) Appl. No.: **18/256,238**

(22) PCT Filed: **Dec. 2, 2021**

(86) PCT No.: **PCT/CN2021/135167**
§ 371 (c)(1),
(2) Date: **Jun. 7, 2023**

(87) PCT Pub. No.: **WO2022/121776**
PCT Pub. Date: **Jun. 16, 2022**

(65) **Prior Publication Data**

US 2024/0021982 A1 Jan. 18, 2024

(30) **Foreign Application Priority Data**

Dec. 8, 2020 (CN) 202011423001.9

(51) **Int. Cl.**
H01Q 1/22 (2006.01)
H01Q 1/24 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 1/52*** (2013.01); ***H01Q 1/22*** (2013.01); ***H01Q 1/36*** (2013.01); ***H01Q 9/0421*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/22; H01Q 1/24; H01Q 1/243; H01Q 1/36; H01Q 1/44; H01Q 1/52;
(Continued)

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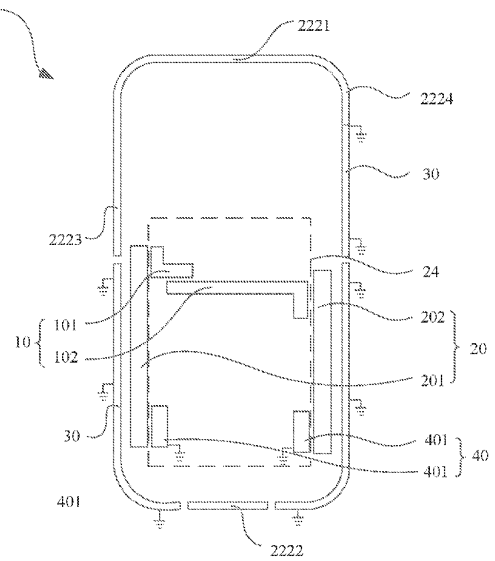
Primary Examiner — Tho G Phan
(74) *Attorney, Agent, or Firm* — Conley Rose, P.C.

(57) **ABSTRACT**

An antenna apparatus for an electronic device having a middle frame, a cover, and a battery located between the middle frame and the cover. The antenna apparatus includes at least one group of coupling feeding elements and at least one group of radiation elements. A first radiator and a second radiator in each group of radiation elements are arranged on an inner surface of a cover. The first radiator and the second radiator are respectively located on two sides of a coupling feeding element, and the coupling feeding element is separately coupled to feed the first radiator and the second radiator.

20 Claims, 44 Drawing Sheets



US012444840B2

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

(10) **Patent No.: US 12,444,840 B2**
(45) **Date of Patent: Oct. 14, 2025**

(54) **ANTENNA AND MOBILE TERMINAL**

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

(72) Inventors: **Liang Xue**, Shanghai (CN); **Hanyang Wang**, Reading (GB); **Chuanbo Shi**, Shanghai (CN); **Yiwen Gong**, Shanghai (CN); **Jikang Wang**, Shanghai (CN); **Xiaowei Zhang**, Shenzhen (CN); **Dong Yu**, Shanghai (CN)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 65 days.

(21) Appl. No.: **18/003,656**

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

(86) PCT No.: **PCT/CN2021/103880**
§ 371 (c)(1),
(2) Date: **Dec. 28, 2022**

(87) PCT Pub. No.: **WO2022/002172**
PCT Pub. Date: **Jan. 6, 2022**

(65) **Prior Publication Data**

US 2023/0291102 A1 Sep. 14, 2023

(30) **Foreign Application Priority Data**

Jun. 30, 2020 (CN) 202010615049.3

(51) **Int. Cl.**
H01Q 5/385 (2015.01)
H01Q 1/24 (2006.01)
H01Q 1/48 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 5/385*** (2015.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/48*** (2013.01)

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

(56) **References Cited**

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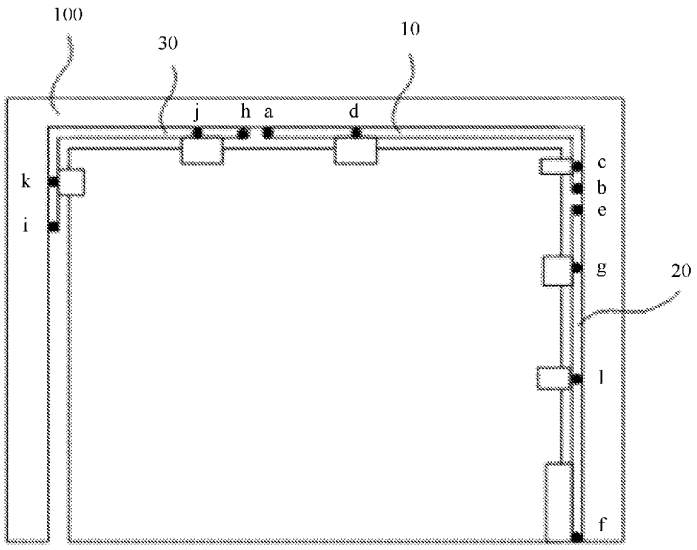
Primary Examiner — Dameon E Levi
Assistant Examiner — Anh N Ho
(74) *Attorney, Agent, or Firm* — Leydig, Voit & Mayer, Ltd.

(57) **ABSTRACT**

An antenna is provided, which includes: a main stub, a first parasitic stub, and a second parasitic stub. The first parasitic stub and the second parasitic stub are respectively arranged on two sides of the main stub. The first parasitic stub and the second parasitic stub are configured to excite resonances to improve main resonance efficiency or expand bandwidth. A frequency of the resonance excited by the first parasitic stub is greater than a frequency of a resonance excited by the main stub. A frequency of the resonance excited by the second parasitic stub is less than the frequency of the resonance excited by the main stub.

14 Claims, 23 Drawing Sheets



US012444842B2

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

(10) **Patent No.: US 12,444,842 B2**
(45) **Date of Patent: Oct. 14, 2025**

(54) **ELECTRONIC DEVICE COMPRISING ANTENNA**

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

(72) Inventors: **Himchan Yun**, Suwon-si (KR); **Museok Bang**, Suwon-si (KR); **Dongyeon Kim**, Suwon-si (KR); **Haeyeon Kim**, Suwon-si (KR); **Nakchung Choi**, Suwon-si (KR); **Soonho 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 201 days.

(21) Appl. No.: **18/099,740**

(22) Filed: **Jan. 20, 2023**

(65) **Prior Publication Data**

US 2023/0163469 A1 May 25, 2023

Related U.S. Application Data

(63) Continuation of application No. PCT/KR2021/009490, filed on Jul. 22, 2021.

(30) **Foreign Application Priority Data**

Jul. 22, 2020 (KR) 10-2020-0091136

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

(52) **U.S. Cl.**
CPC ***H01Q 9/0407*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 9/0442*** (2013.01); ***H01Q 9/045*** (2013.01); ***H01Q 15/24*** (2013.01); ***H01Q 21/24*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/0407; H01Q 1/243; H01Q 15/24; H01Q 1/273; H01Q 5/321; H01Q 5/364;
(Continued)

(56) **References Cited**

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(Continued)

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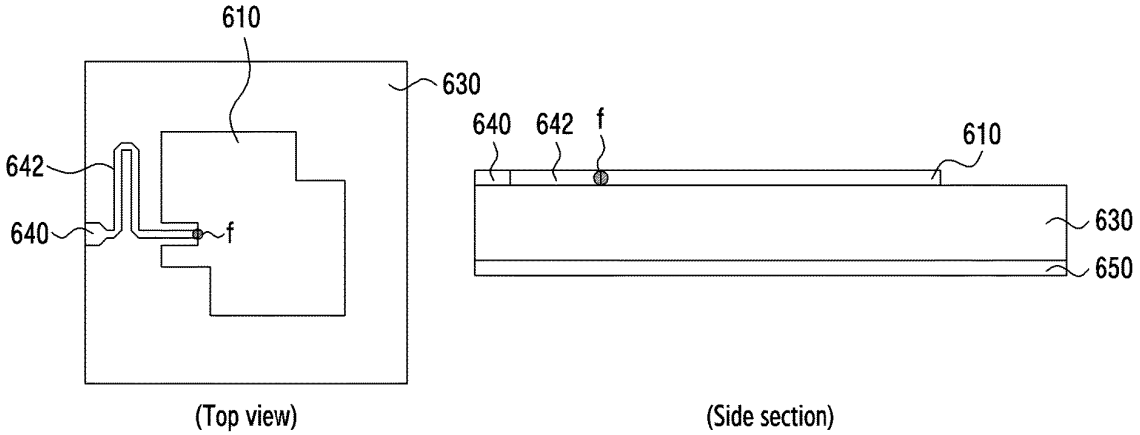
(Continued)

Primary Examiner — Dameon E Levi
Assistant Examiner — Yonchan J Kim
(74) *Attorney, Agent, or Firm* — Sughrue Mion, PLLC

(57) **ABSTRACT**

An electronic device includes at least one processor, a first antenna comprises a first conductive patch disposed on a first layer, a first transmission line disposed on the first layer and electrically connected to one point of the first conductive patch, a ground disposed on a second layer and a dielectric disposed on a third layer between the first layer and the second layer, the first conductive patch has a shape of a rectangle in which a first corner portion of the rectangle and a second corner portion of the rectangle are removed, and the at least one processor transmits and/or receives at least one of a first RF signal having a first polarization characteristic and a second RF signal having a second polarization characteristic.

15 Claims, 32 Drawing Sheets



US012444844B2

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

(10) **Patent No.: US 12,444,844 B2**
(45) **Date of Patent: Oct. 14, 2025**

(54) **ANTENNA MOUNTING SYSTEM**

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

(72) Inventors: **Yuuji Kakuya**, Nisshin (JP); **Kenichirou Sanji**, Kariya (JP); **Tomokazu Miyashita**, Kariya (JP); **Masakazu Ikeda**, Nisshin (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 393 days.

(21) Appl. No.: **18/079,323**

(22) Filed: **Dec. 12, 2022**

(65) **Prior Publication Data**

US 2023/0114784 A1 Apr. 13, 2023

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2021/024123, filed on Jun. 25, 2021.

(30) **Foreign Application Priority Data**

Jul. 6, 2020 (JP) 2020-116682

(51) **Int. Cl.**

H01Q 9/04	(2006.01)
H01Q 1/12	(2006.01)
H01Q 1/48	(2006.01)
H01Q 3/36	(2006.01)

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

CPC ***H01Q 9/0421*** (2013.01); ***H01Q 1/12*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 3/36*** (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

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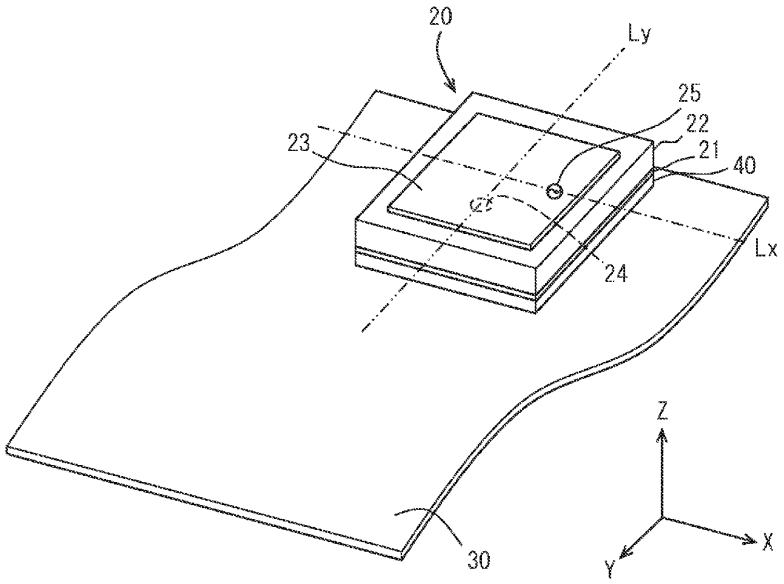
Primary Examiner — Whitney Moore

(74) *Attorney, Agent, or Firm* — Harness, Dickey & Pierce, P.L.C.

(57) **ABSTRACT**

An antenna mounting system includes an antenna device and a conductive base plate. The antenna device includes a ground plate, an opposing conductive plate, and a short-circuit pin. The short-circuit pin is positioned to cause a radio wave radiated from the antenna device in a direction perpendicular to the ground plate such that radio wave: has a polarization component that oscillates in a direction parallel to a main plane of polarization of a radio wave radiated from the conductive base plate in the direction perpendicular to the ground plate; and is shifted in phase from the radio wave radiated from the conductive base plate by a phase difference within a range from 90 degrees to 270 degrees.

3 Claims, 6 Drawing Sheets



US012444845B2

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

(10) **Patent No.: US 12,444,845 B2**
(45) **Date of Patent: Oct. 14, 2025**

(54) **ANTENNA AND RADAR**

(71) Applicant: **SHENZHEN YINWANG INTELLIGENT TECHNOLOGIES CO., LTD.**, Shenzhen (CN)

(72) Inventors: **Zhe Cheng**, Xi'an (CN); **Rui Yang**, Dongguan (CN)

(73) Assignee: **Shenzhen Yinwang Intelligent 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 156 days.

(21) Appl. No.: **17/894,399**

(22) Filed: **Aug. 24, 2022**

(65) **Prior Publication Data**

US 2022/0416431 A1 Dec. 29, 2022

Related U.S. Application Data

(63) Continuation of application No. PCT/CN2021/077339, filed on Feb. 23, 2021.

(30) **Foreign Application Priority Data**

Feb. 25, 2020 (CN) 202010115641.7

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 1/32 (2006.01)
H01Q 21/08 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 9/045*** (2013.01); ***H01Q 1/3233*** (2013.01); ***H01Q 21/08*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/3233; H01Q 9/045; H01Q 21/065; H01Q 21/08
See application file for complete search history.

(56) **References Cited**

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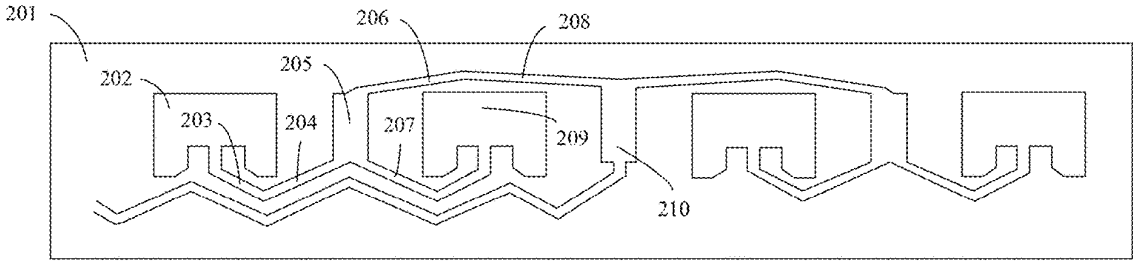
Primary Examiner — Dameon E Levi
Assistant Examiner — Leah Rosenberg
(74) *Attorney, Agent, or Firm* — Fish & Richardson P.C.

(57) **ABSTRACT**

Embodiments of this application disclose an antenna. The antenna may be applied to the field of automatic driving and the field of vehicle-to-everything, and the antenna includes a first radiating element and a first feed line. A first end of the first feed line is connected to the first radiating element. The first radiating element and the first feed line are arranged on a same surface of a dielectric substrate. The first feed line includes a first feed line segment, and an acute angle between the first feed line segment and a current direction of the first radiating element is greater than or equal to 20 degrees, and is less than or equal to 70 degrees. A feeding manner of the antenna is parallel feeding.

19 Claims, 7 Drawing Sheets



US012444849B2

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

(10) **Patent No.: US 12,444,849 B2**
(45) **Date of Patent: Oct. 14, 2025**

(54) **ANTENNA MODULE**

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

(72) Inventors: **Chien-Yi Wu**, Taipei (TW); **Shao-Chi Wang**, Taipei (TW); **Hau Yuen Tan**, Taipei (TW); **Hung-Te Liao**, Taipei (TW); **Chao-Hsu Wu**, Taipei (TW); **Chih-Hung Cho**, Taipei (TW); **Tse-Hsuan Wang**, Taipei (TW); **I-Shu Lee**, Taipei (TW); **Jr-Wei Hsu**, Taipei (TW)

(73) Assignee: **PEGATRON CORPORATION**, Taipei (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 57 days.

(21) Appl. No.: **18/652,976**

(22) Filed: **May 2, 2024**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Sep. 15, 2023 (TW) 112135280

(51) **Int. Cl.**
H01Q 5/30 (2015.01)
H01Q 1/48 (2006.01)
H01Q 5/10 (2015.01)
H01Q 13/16 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 13/16*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 5/10*** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 1/22; H01Q 1/243; H01Q 1/38; H01Q 1/48; H01Q 1/52; H01Q 5/30–40; H01Q 9/42; H01Q 13/10; H01Q 13/16
See application file for complete search history.

(56) **References Cited**

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TW	I765621	5/2022

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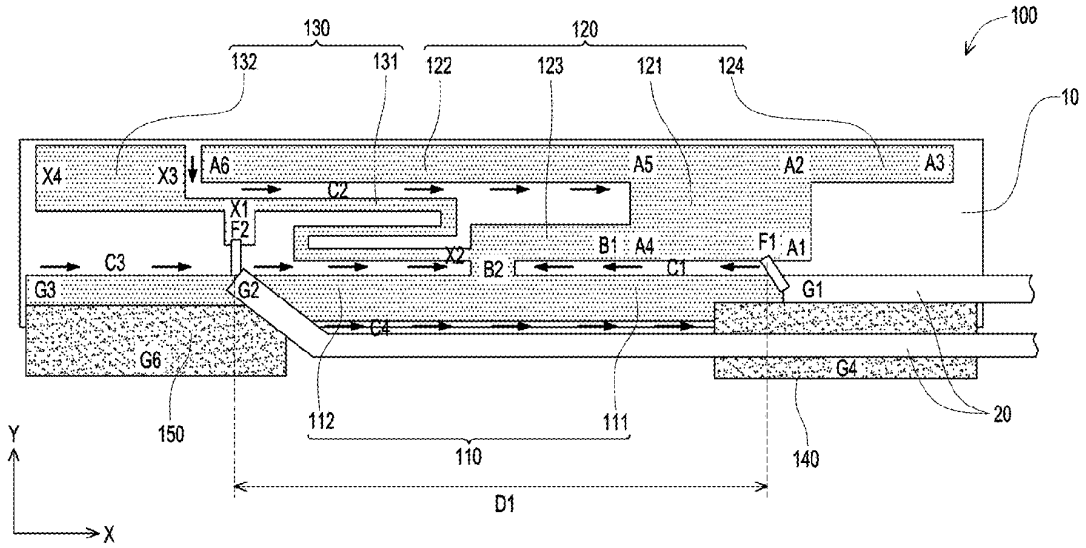
Primary Examiner — Hasan Islam
(74) *Attorney, Agent, or Firm* — J.C. PATENTS

(57) **ABSTRACT**

An antenna module includes a ground radiator, a first antenna, and a second antenna. The first antenna includes a first feeding end, a first segment, a second segment, a third segment, and a fourth segment. A first area of the first antenna and a second area including a part of the first antenna and a part of the ground radiator resonate at a first frequency band. A third area of the first antenna and the second area resonate at a second frequency band. An area including a part of the second antenna, the third segment, the first segment, and the second segment resonates at the first frequency band. An area of the second antenna and an area including the part of the second antenna, a part of the third segment, and another part of the ground radiator resonate at the second frequency band.

10 Claims, 10 Drawing Sheets



US012444857B2

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

(10) **Patent No.: US 12,444,857 B2**
(45) **Date of Patent: Oct. 14, 2025**

(54) **ANTENNA DEVICE AND ANTENNA UNIT**

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

(72) Inventors: **Ryo Komura**, Kyoto (JP); **Masahiro Izawa**, Kyoto (JP)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 195 days.

(21) Appl. No.: **18/448,506**

(22) Filed: **Aug. 11, 2023**

(65) **Prior Publication Data**

US 2023/0387603 A1 Nov. 30, 2023

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2022/004870, filed on Feb. 8, 2022.

(30) **Foreign Application Priority Data**

Mar. 5, 2021 (JP) 2021-035559

(51) **Int. Cl.**
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H01Q 1/08 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 19/02*** (2013.01); ***H01Q 1/085*** (2013.01); ***H01Q 1/2291*** (2013.01); ***H01Q 1/48*** (2013.01)

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

(56) **References Cited**

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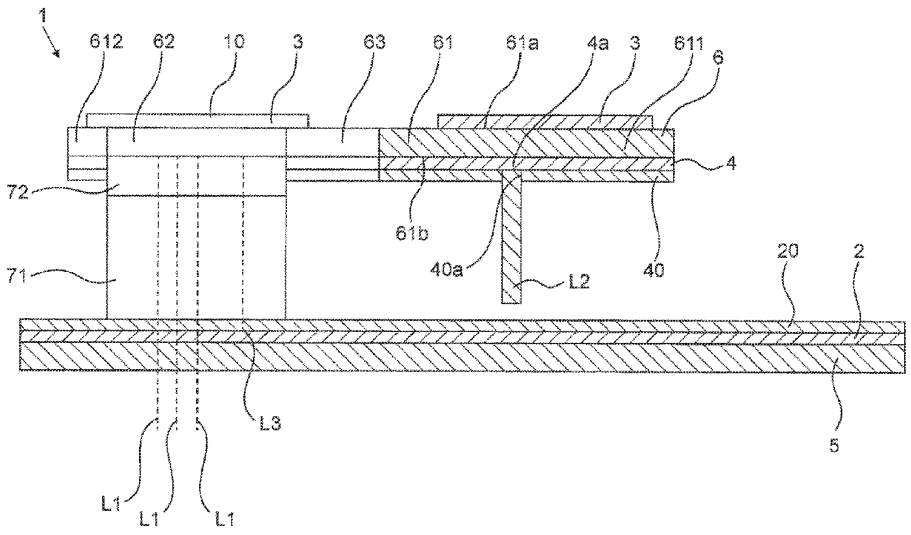
Primary Examiner — Dameon E Levi
Assistant Examiner — Anh N Ho
(74) *Attorney, Agent, or Firm* — McDonald Hopkins LLC

(57) **ABSTRACT**

An antenna device includes: a ground electrode plate; one or more first radiating electrode plates which face the ground electrode plate; a second radiating electrode plate which lies between the ground electrode plate and the one or more first radiating electrode plates; one or more first feeder lines which are connected to the one or more first radiating electrode plates; a second feeder line which is not connected to the one or more first feeder lines but is connected to the second radiating electrode plate; and a ground line which does not connect the one or more first radiating electrode plates to the ground electrode plate but connects the second radiating electrode plate to the ground electrode plate. The one or more first radiating electrode plates lie inside the second radiating electrode plate as viewed from a thickness direction of the ground electrode plate.

13 Claims, 13 Drawing Sheets



US012444858B2

(12) **United States Patent**
Franson

(10) **Patent No.: US 12,444,858 B2**
(45) **Date of Patent: Oct. 14, 2025**

(54) **ANTENNA APPARATUS EMPLOYING COPLANAR WAVEGUIDE INTERCONNECT BETWEEN RF COMPONENTS**

(71) Applicant: **VIASAT, INC.**, Carlsbad, CA (US)

(72) Inventor: **Steven J. Franson**, Scottsdale, AZ (US)

(73) Assignee: **VIASAT, INC.**, Carlsbad, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 181 days.

(21) Appl. No.: **18/548,631**

(22) PCT Filed: **Mar. 4, 2021**

(86) PCT No.: **PCT/US2021/020975**
§ 371 (c)(1),
(2) Date: **Sep. 1, 2023**

(87) PCT Pub. No.: **WO2022/186835**
PCT Pub. Date: **Sep. 9, 2022**

(65) **Prior Publication Data**

US 2024/0154320 A1 May 9, 2024

(51) **Int. Cl.**
H01Q 21/00 (2006.01)
H01Q 1/22 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 21/0025*** (2013.01); ***H01Q 1/2283*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 21/0075*** (2013.01); ***H01Q 21/061*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 21/0025; H01Q 1/2283; H01Q 1/38; H01Q 21/0075; H01Q 21/061; H01Q 23/00; H01P 5/028; H01P 1/047
See application file for complete search history.

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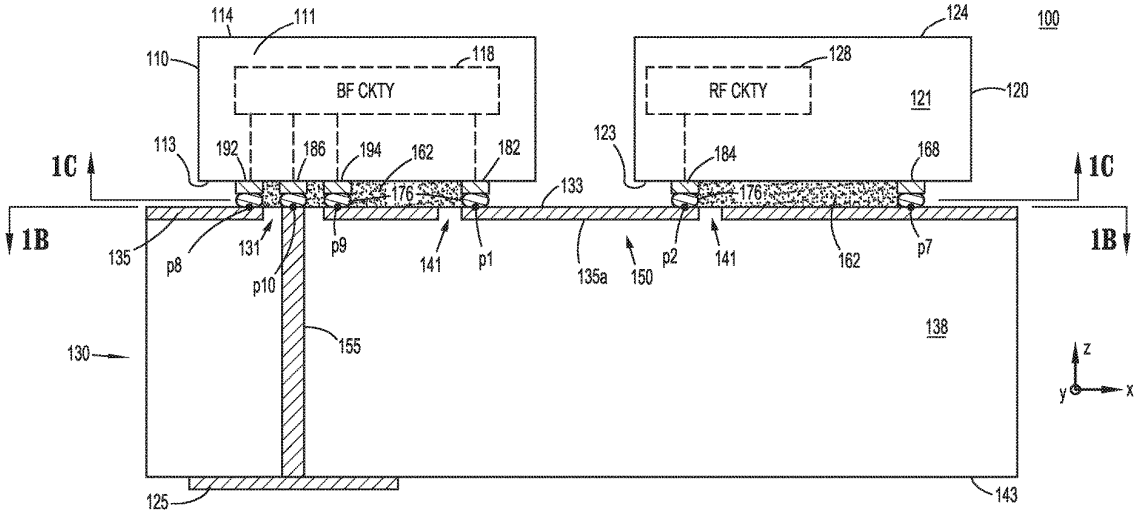
Primary Examiner — Seung H Lee
(74) *Attorney, Agent, or Firm* — F. CHAU & ASSOCIATES, LLC

(57) **ABSTRACT**

An antenna apparatus includes an antenna substrate having a first surface and an opposite second surface, with an antenna ground plane at the second surface. An antenna element is at the first surface of the antenna substrate. A first RF component is attached to the second surface of the antenna substrate and includes RF circuitry to adjust a signal communicated with the antenna element. A second RF component is attached to the second surface of the antenna substrate. A coplanar waveguide (CPW) interconnect couples the first RF component to the second RF component and includes a central conductor and first and second ground conductors on opposite sides of the central conductor. The central conductor has a profile within an opening in the antenna ground plane.

31 Claims, 13 Drawing Sheets



US012445549B2

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

(10) **Patent No.: US 12,445,549 B2**
(45) **Date of Patent: Oct. 14, 2025**

(54) **ANTENNA STRUCTURE FOR IMPROVING RADIATION PERFORMANCE AND ELECTRONIC DEVICE INCLUDING SAME**

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

(72) Inventors: **Nakchung Choi**, Gyeonggi-do (KR); **Himchan Yun**, Gyeonggi-do (KR); **Jaebong Chun**, Gyeonggi-do (KR); **Soonho Hwang**, Gyeonggi-do (KR)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 300 days.

(21) Appl. No.: **18/197,480**

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

(65) **Prior Publication Data**

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(57) **ABSTRACT**

Disclosed is a foldable electronic device including an antenna structure having an adjustable electric length by way of a switch circuit, thereby reducing antenna performance degradation in the foldable electronic device.

20 Claims, 18 Drawing Sheets