



US012531331B2

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

(10) **Patent No.:** **US 12,531,331 B2**
(45) **Date of Patent:** **Jan. 20, 2026**

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

(58) **Field of Classification Search**
CPC H01Q 1/38; H01Q 1/22
See application file for complete search history.

(71) Applicant: **Huawei Technologies Co., Ltd.**,
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(56) **References Cited**

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

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(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 53 days.

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(21) Appl. No.: **18/717,866**

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

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(2) Date: **Jun. 7, 2024**

(87) PCT Pub. No.: **WO2023/103945**

PCT Pub. Date: **Jun. 15, 2023**

(65) **Prior Publication Data**

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Primary Examiner — Henry Luong

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

(30) **Foreign Application Priority Data**

Dec. 9, 2021 (CN) 202111495734.8

(51) **Int. Cl.**

H01Q 1/22 (2006.01)

H01Q 1/38 (2006.01)

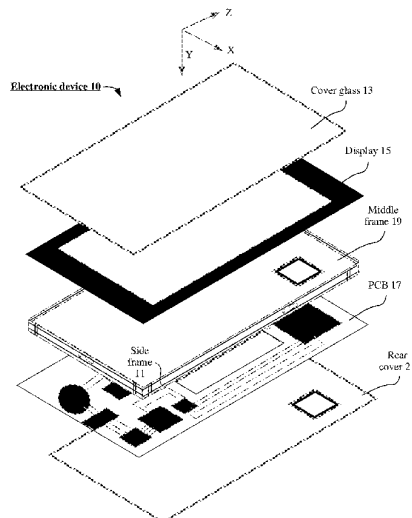
(52) **U.S. Cl.**

CPC **H01Q 1/38** (2013.01); **H01Q 1/22**
(2013.01)

(57) **ABSTRACT**

An antenna structure includes a metal cavity and a first radiator. A first slot and a second slot are provided on a first metal layer of the metal cavity, and a first end of the second slot is connected to the first slot. A first feed point is disposed in the first slot, and a second feed point is disposed in the second slot.

20 Claims, 17 Drawing Sheets





US012531349B2

(12) **United States Patent**
Yang

(10) **Patent No.:** **US 12,531,349 B2**
(45) **Date of Patent:** **Jan. 20, 2026**

(54) **ANTENNA AND ELECTRONIC DEVICE**

(56) **References Cited**

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

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(72) Inventor: **Shuo Yang**, Beijing (CN)

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

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 102 days.

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(21) Appl. No.: **18/701,241**

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

Primary Examiner — Seung H Lee

(86) PCT No.: **PCT/CN2023/086960**

(74) *Attorney, Agent, or Firm* — HOUTTEMAN LAW LLC

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(2) Date: **Apr. 14, 2024**

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(65) **Prior Publication Data**

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(51) **Int. Cl.**
H01Q 21/06 (2006.01)
H01Q 1/38 (2006.01)

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

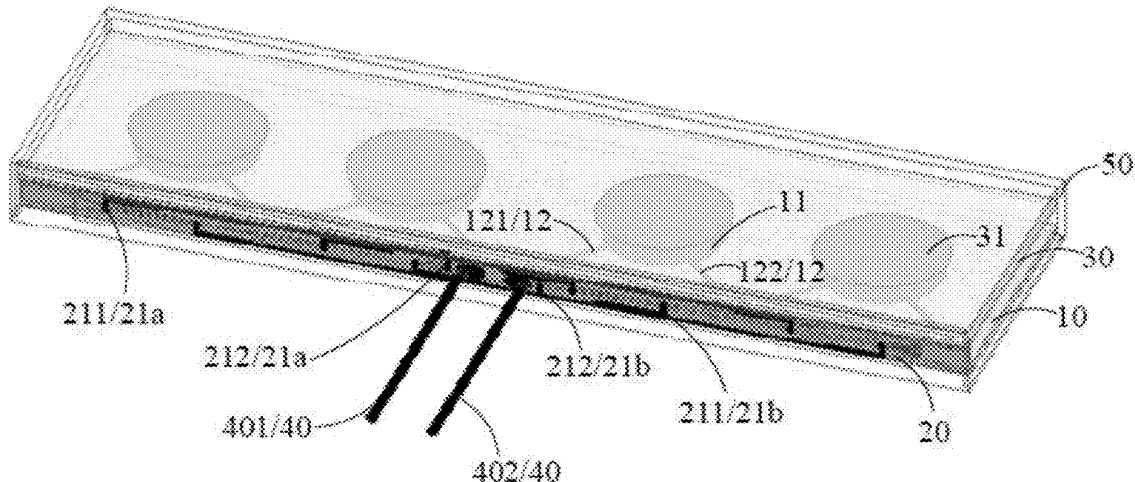
(58) **Field of Classification Search**
CPC H01Q 21/061; H01Q 1/38; H01Q 1/42; H01Q 21/08

See application file for complete search history.

(57) **ABSTRACT**

An antenna includes: a first substrate and a second substrate. The first substrate includes: a first dielectric substrate, a first reference electrode layer, a first radiation part, and a feeder group. The first dielectric substrate includes a main substrate and a side substrate, the feeder group includes at least one feeder, in each of which, each feeder is electrically connected to one first radiation part, and different feeders are electrically connected to different first radiation parts. The second substrate includes: a second dielectric substrate, a second reference electrode layer, and a feed structure. The feed structure corresponds to the feeder group, and for corresponding feed structure and feeder group, each first feed port in the feed structure is electrically connected to one feeder in the feeder group through a first connection via which runs through at least the side substrate, the second reference electrode layer, and the second dielectric substrate.

20 Claims, 9 Drawing Sheets





US012531350B2

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

(10) **Patent No.:** **US 12,531,350 B2**
(45) **Date of Patent:** **Jan. 20, 2026**

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

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

(72) Inventors: **Jongmin Lee**, Suwon-si (KR);
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Jungmin Park, Suwon-si (KR);
Bumhee Lee, Suwon-si (KR); **Seokmin Lee**, Suwon-si (KR); **Seungho Choi**, Suwon-si (KR)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 145 days.

(21) Appl. No.: **18/078,356**

(22) Filed: **Dec. 9, 2022**

(65) **Prior Publication Data**

US 2023/0187844 A1 Jun. 15, 2023

Related U.S. Application Data

(63) Continuation of application No. PCT/KR2022/018715, filed on Nov. 24, 2022.

(30) **Foreign Application Priority Data**

Dec. 14, 2021 (KR) 10-2021-0178919
Jan. 13, 2022 (KR) 10-2022-0005354

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

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

(58) **Field of Classification Search**

CPC H01Q 21/065; H01Q 25/001; H01Q 1/24; H01Q 9/04; H01Q 9/0414; H01Q 21/24; H01Q 21/08; H01Q 1/246; H04B 7/0413
See application file for complete search history.

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Primary Examiner — Hai V Tran

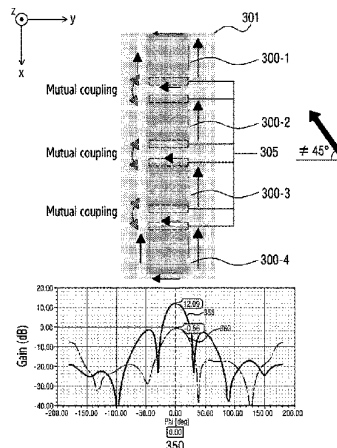
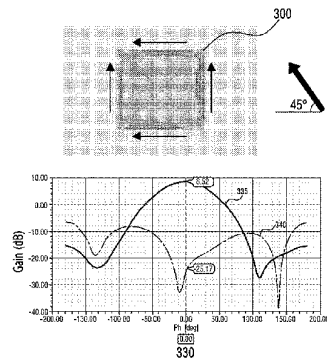
Assistant Examiner — Austin M Back

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

(57) **ABSTRACT**

The present disclosure relates to a 5th generation (5G) or pre-5G communication system for supporting a higher data transmission rate after a 4th generation (4G) communication system such as long-term evolution (LTE). An antenna in a wireless communication system may include: a plurality of antenna elements including a first antenna element and a second antenna element, the first antenna element and the second antenna element may include patch antennas, the first antenna element and the second antenna element may

(Continued)





US012537285B2

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

(10) **Patent No.:** **US 12,537,285 B2**
(45) **Date of Patent:** **Jan. 27, 2026**

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

(71) Applicant: **Panasonic Intellectual Property Management Co., Ltd.**, Osaka (JP)

(72) Inventors: **Hironori Kikuchi**, Miyagi (JP); **Kenji Nishikawa**, Hyogo (JP); **Kazuya Tani**, Osaka (JP)

(73) Assignee: **Panasonic Intellectual Property Management Co., Ltd.**, Osaka (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 164 days.

(21) Appl. No.: **18/541,128**

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

(65) **Prior Publication Data**
US 2024/0145899 A1 May 2, 2024

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(63) Continuation of application No. PCT/JP2022/019799, filed on May 10, 2022.

(30) **Foreign Application Priority Data**
Jun. 29, 2021 (JP) 2021-107998

(51) **Int. Cl.**
H01Q 1/22 (2006.01)
H01Q 1/42 (2006.01)
H01Q 21/08 (2006.01)
(52) **U.S. Cl.**
CPC **H01Q 1/22** (2013.01); **H01Q 1/42** (2013.01); **H01Q 21/08** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/22; H01Q 1/42; H01Q 21/08; H01Q 1/02; H01Q 1/246; H01Q 1/24
See application file for complete search history.

(56) **References Cited**

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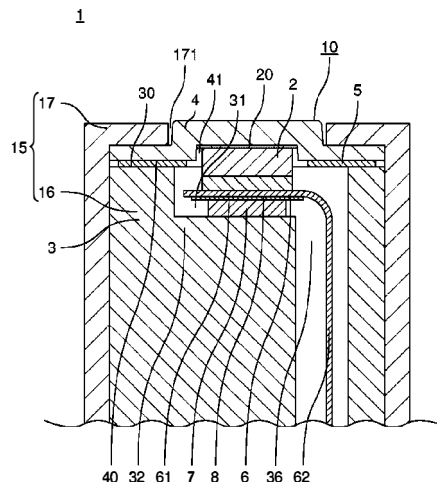
Primary Examiner — Seung H Lee

(74) *Attorney, Agent, or Firm* — Renner, Otto, Boisselle & Sklar, LLP

(57) **ABSTRACT**

An antenna device including: an antenna module for performing communication at a predetermined communication frequency; a base having conductivity, the base including a first surface and a first recess, the first recess accommodating the antenna module and being disposed on the first surface; a radome that is a dielectric, the radome including a second surface facing the first surface of the base and a second recess which faces the first recess and is disposed on the second surface; and a waterproof structure for waterproofing the antenna module, the waterproof structure being disposed between the first surface and the second surface. The antenna module includes one or a plurality of antenna elements, and an antenna surface on which the one or plurality of antenna elements are disposed. The antenna module is accommodated in the first recess to cause the antenna surface to project from the first surface into the second recess.

23 Claims, 16 Drawing Sheets





US012537300B2

(12) **United States Patent**
Tsai

(10) **Patent No.:** **US 12,537,300 B2**
(45) **Date of Patent:** **Jan. 27, 2026**

(54) **ANTENNA STRUCTURE**

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

(72) Inventor: **Tsung-Jung Tsai**, Hsinchu (TW)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 378 days.

(21) Appl. No.: **18/313,443**

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

(65) **Prior Publication Data**
US 2023/0402751 A1 Dec. 14, 2023

(30) **Foreign Application Priority Data**
Jun. 9, 2022 (TW) 111121363

(51) **Int. Cl.**
H01Q 5/307 (2015.01)
H01Q 1/22 (2006.01)
H01Q 1/48 (2006.01)
H01Q 9/04 (2006.01)
H01Q 13/10 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 5/307** (2015.01); **H01Q 1/2266** (2013.01); **H01Q 1/48** (2013.01); **H01Q 9/0421** (2013.01); **H01Q 13/106** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 13/18; H01Q 9/0421; H01Q 13/106; H01Q 1/48; H01Q 1/226; H01Q 5/307
See application file for complete search history.

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Primary Examiner — Dameon E Levi

Assistant Examiner — David Andrew Kubera

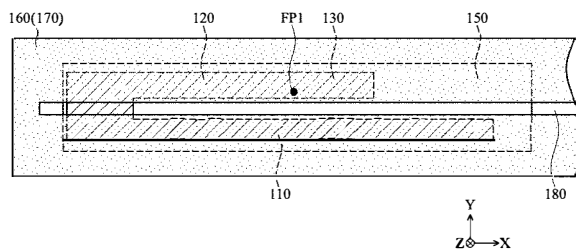
(74) Attorney, Agent, or Firm — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

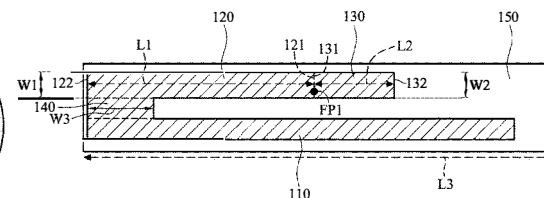
An antenna structure includes a ground element, a first radiation element, a second radiation element, a nonconductive support element, and a metal cavity. The first radiation element has a feeding point. The first radiation element is coupled to the ground element. The second radiation element is coupled to the feeding point. The second radiation element and the first radiation element substantially extend in opposite directions. The ground element, the first radiation element, and the second radiation element are disposed on the nonconductive support element. The metal cavity includes a coupling metal plate with a slot. The ground element, the first radiation element, the second radiation element, and the nonconductive support element are disposed inside the metal cavity. The first radiation element and the second radiation element are adjacent to the coupling metal plate. The feeding point is covered by the coupling metal plate.

19 Claims, 10 Drawing Sheets

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US012537302B2

(12) **United States Patent**
Wu

(10) **Patent No.:** **US 12,537,302 B2**
(45) **Date of Patent:** **Jan. 27, 2026**

(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 283 days.

(21) Appl. No.: **18/343,489**

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

(65) **Prior Publication Data**
US 2023/0344128 A1 Oct. 26, 2023

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(30) **Foreign Application Priority Data**

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

(52) **U.S. Cl.**
CPC **H01Q 5/335** (2015.01); **H01Q 1/243** (2013.01); **H01Q 5/10** (2015.01); **H01Q 5/20** (2015.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 5/335; H01Q 1/243; H01Q 5/35; H01Q 5/378; H01Q 9/42; H01Q 5/10;
(Continued)

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Primary Examiner — Dameon E Levi

Assistant Examiner — Yonchan J Kim

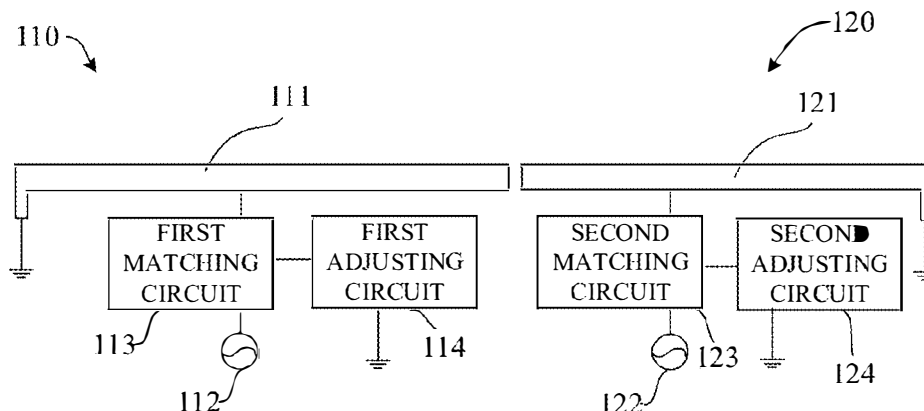
(74) *Attorney, Agent, or Firm* — Hodgson Russ LLP

(57) **ABSTRACT**

An antenna assembly includes a first antenna and a second antenna. The first antenna includes a first radiator, a first signal-source, a first matching circuit, and a first adjusting circuit. The first signal-source is electrically connected to the first matching circuit to the first radiator, and the first adjusting circuit is configured to adjust a resonant frequency-point of the first antenna to make the first antenna support an electromagnetic wave signal in a first frequency band. The second antenna includes a second radiator, a second signal-source, a second matching circuit, and a second adjusting circuit. The second signal-source is electrically connected to the second matching circuit to the second radiator, the second adjustment circuit is configured to adjust a resonant frequency-point of the second antenna to make the second antenna support an electromagnetic wave signal in a second frequency band and a third frequency band.

20 Claims, 16 Drawing Sheets

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US012542346B2

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

(10) **Patent No.:** **US 12,542,346 B2**
(45) **Date of Patent:** **Feb. 3, 2026**

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

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

(72) Inventors: **Yu-Sheng Fan**, Hsinchu (TW);
Chia-Hao Chang, Hsinchu (TW);
Hong-Jun Jian, Hsinchu (TW)

(73) Assignee: **WISTRON NEWEB CORPORATION**, Hsinchu (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 103 days.

(21) Appl. No.: **18/731,439**

(22) Filed: **Jun. 3, 2024**

(65) **Prior Publication Data**
US 2025/0112356 A1 Apr. 3, 2025

(30) **Foreign Application Priority Data**
Sep. 28, 2023 (TW) 112137339

(51) **Int. Cl.**
H01Q 1/36 (2006.01)
H01Q 1/22 (2006.01)
H01Q 5/371 (2015.01)
H01Q 13/10 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/2266** (2013.01); **H01Q 5/371** (2015.01); **H01Q 13/10** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/2266; H01Q 5/371; H01Q 13/10;
H01Q 13/106; H01Q 1/243
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Dimary S Lopez Cruz

Assistant Examiner — Bamidele A Immanuel

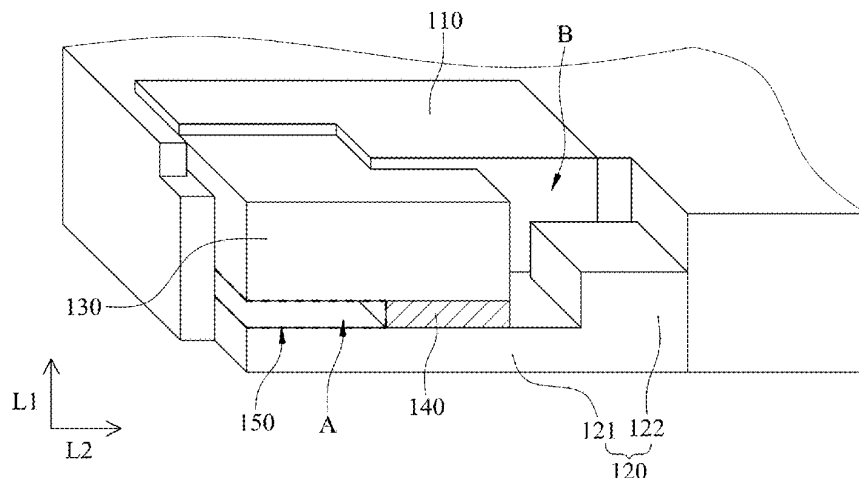
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

An antenna structure disposed in a case includes a blocking part, a cooling module, an antenna module, and a ground component. The cooling module is disposed on a side of the blocking part. The antenna module is disposed on the side of the blocking part and has an interval space between the antenna module and the cooling module along a first direction. The ground component is disposed in the interval space, and is electrically connected to the antenna module and the cooling module. The ground component, the antenna module and the cooling module jointly define a slot in the interval space. The antenna module has a resonant frequency, and the antenna module couples and excites the slot to generate another resonant frequency. Thus, the antenna structure of the present disclosure can provide multiple frequency bands and great radiation characteristics in an environment with multiple metals.

17 Claims, 5 Drawing Sheets

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US012542349B2

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

(10) **Patent No.:** **US 12,542,349 B2**
(45) **Date of Patent:** **Feb. 3, 2026**

(54) **ANTENNA**

(71) Applicant: **City University of Hong Kong,**
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(72) Inventors: **Kwok Wa Leung,** Kowloon (HK);
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(73) Assignee: **City University of Hong Kong,**
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(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 157 days.

(21) Appl. No.: **18/305,469**

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

(65) **Prior Publication Data**
US 2023/0387587 A1 Nov. 30, 2023

Related U.S. Application Data

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26, 2022.

(51) **Int. Cl.**
H01Q 1/52 (2006.01)
H01Q 1/48 (2006.01)
H01Q 9/30 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/521** (2013.01); **H01Q 1/48**
(2013.01); **H01Q 9/30** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/521; H01Q 1/48; H01Q 9/30;
H01Q 9/32; H01Q 21/28; H01Q 1/40
See application file for complete search history.

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Primary Examiner — Minh Tran

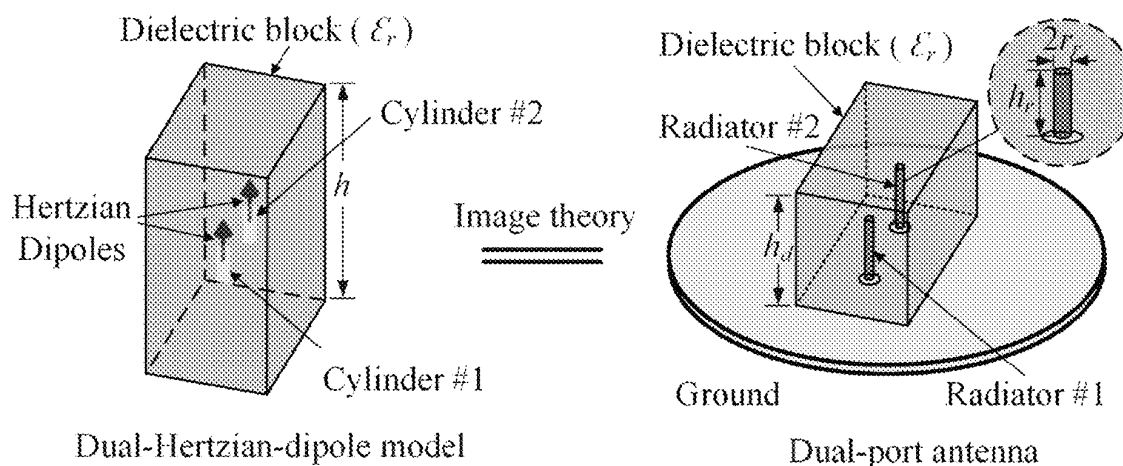
(74) *Attorney, Agent, or Firm* — Renner, Kenner, Greive,
Bobak, Taylor & Weber

(57)

ABSTRACT

An antenna includes a plurality of antenna elements each
respectively operable as a radiator of electromagnetic
waves, and a decoupler arrangement operably coupled with
the plurality of antenna elements. The decoupler arrange-
ment is configured to prevent, reduce, or substantially elimi-
nate mutual coupling of at least two of the plurality of
antenna elements when at least one of the plurality of
antenna elements is operated as radiator.

21 Claims, 25 Drawing Sheets





US012542350B2

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

(10) **Patent No.:** **US 12,542,350 B2**
(45) **Date of Patent:** **Feb. 3, 2026**

(54) **ANTENNA STRUCTURE FOR INCREASING ISOLATION**

(71) Applicant: **ARCADYAN TECHNOLOGY CORPORATION**, Hsinchu (TW)

(72) Inventors: **Kuo-Chang Lo**, Hsinchu (TW);
Chih-Yung Huang, Hsinchu (TW)

(73) Assignee: **ARCADYAN TECHNOLOGY CORPORATION**, Hsinchu (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 2 days.

(21) Appl. No.: **18/664,571**

(22) Filed: **May 15, 2024**

(65) **Prior Publication Data**
US 2024/0387989 A1 Nov. 21, 2024

(30) **Foreign Application Priority Data**
May 16, 2023 (TW) 112118201

(51) **Int. Cl.**
H01Q 1/52 (2006.01)
H01Q 1/48 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/521** (2013.01); **H01Q 1/48** (2013.01); **H01Q 1/52** (2013.01); **H01Q 1/523** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/521; H01Q 1/52; H01Q 1/523; H01Q 1/48

See application file for complete search history.

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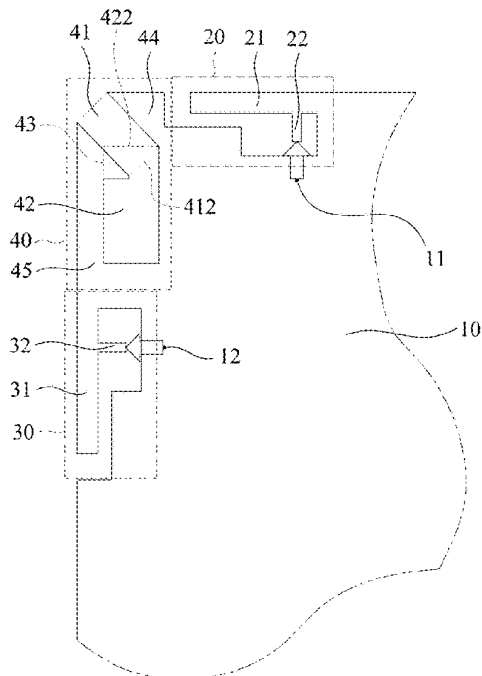
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Primary Examiner — Hai V Tran

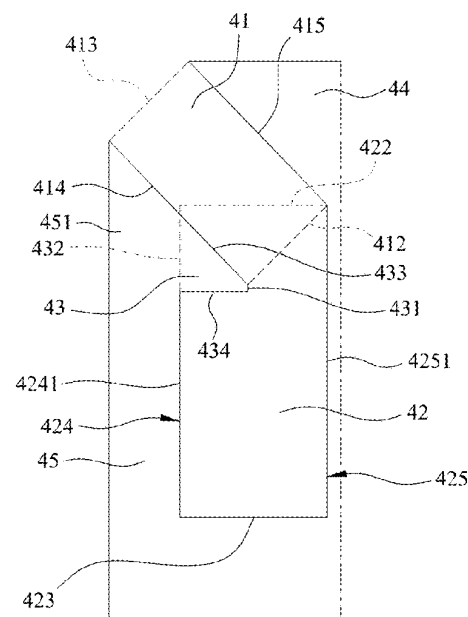
(57) **ABSTRACT**

An antenna structure includes a ground surface, a first antenna, a second antenna, and a printed-type guiding structure located between the first antenna and the second antenna. The first antenna, the second antenna, and the printed-type guiding structure are electrically connected to the ground surface. The printed-type guiding structure includes a first hollow portion, a second hollow portion, and a protruding portion. The angle between the axes of the two hollow portions is 30°-50°. The protruding portion is disposed between the external of the first side of the first hollow portion and the interior of the first side of the second hollow portion. The second hollow portion has a short arm on the first side and a long arm on the second side. The total length of the short arm and the long arm is 0.2-0.3 times the operating frequency wavelength.

10 Claims, 7 Drawing Sheets



40





US012542353B2

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

(10) **Patent No.:** **US 12,542,353 B2**
(45) **Date of Patent:** **Feb. 3, 2026**

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

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

(72) Inventors: **Shih-Chiang Wei**, Hsinchu (TW);
Yung-Chieh Yu, Hsinchu (TW);
Hsieh-Chih Lin, Hsinchu (TW)

(73) Assignee: **WISTRON NEWEB CORPORATION**, Hsinchu (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 192 days.

(21) Appl. No.: **18/519,213**

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

(65) **Prior Publication Data**
US 2024/0266733 A1 Aug. 8, 2024

(30) **Foreign Application Priority Data**
Feb. 2, 2023 (TW) 112103560

(51) **Int. Cl.**
H01Q 5/378 (2015.01)
H01Q 5/328 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 5/378** (2015.01); **H01Q 5/328** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 5/328; H01Q 5/378; H01Q 9/42
See application file for complete search history.

(56) **References Cited**

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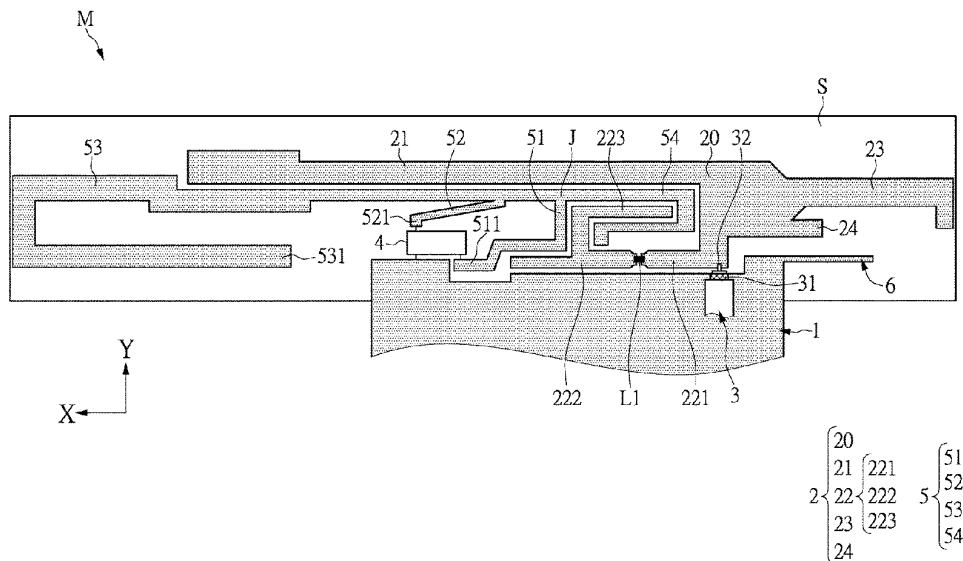
Primary Examiner — Thien M Le

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

(57) **ABSTRACT**

An electronic device and an antenna structure are provided. The antenna structure includes a grounding element, a feeding radiation element, a feeding element, a switching circuit, and a first parasitic radiation element. The feeding radiation element includes a feeding portion, a first radiating portion, and a second radiating portion. The feeding portion is connected between the first radiating portion and the second radiating portion. The feeding element includes a grounding end and a feeding end. The grounding end is connected to the grounding element. The feeding end is connected to the feeding portion or the second radiating portion. The switching circuit is electrically connected to the grounding element. The first parasitic radiation element includes a first grounding branch and a second grounding branch. The first grounding branch and the second grounding branch are electrically connected to the switching circuit.

18 Claims, 7 Drawing Sheets





US012542359B2

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

(10) **Patent No.:** **US 12,542,359 B2**
(45) **Date of Patent:** **Feb. 3, 2026**

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

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

(72) Inventors: **Doo Hyun Yang**, Suwon-si (KR); **Doo
Seok Choi**, Suwon-si (KR); **Sang Hyun
Baek**, Suwon-si (KR); **Young Ki Lee**,
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 175 days.

(21) Appl. No.: **18/351,200**

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

(65) **Prior Publication Data**
US 2024/0021996 A1 Jan. 18, 2024

(30) **Foreign Application Priority Data**
Jul. 18, 2022 (KR) 10-2022-0088030

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

(52) **U.S. Cl.**
CPC **H01Q 9/0414** (2013.01); **H01Q 1/2283**
(2013.01); **H01Q 9/045** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/0414; H01Q 1/2283; H01Q 9/045;
H01Q 21/06; H01Q 9/0457
See application file for complete search history.

(56) **References Cited**

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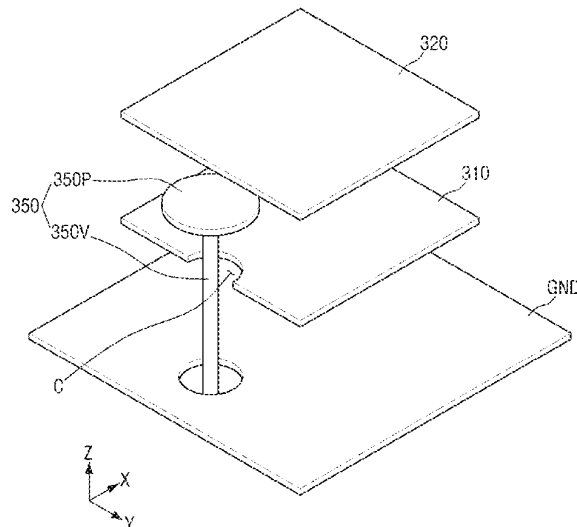
Primary Examiner — Renan Luque

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

(57) **ABSTRACT**

Provided is an antenna module including a first antenna
patch for radiating electromagnetic energy of a first fre-
quency band, a second antenna patch for radiating electro-
magnetic energy of a second frequency band different from
the first frequency band, and both the first antenna patch and
the second antenna patch spaced apart from a ground
structure in a first direction, and a feed structure spaced apart
from each of the first antenna patch and the second antenna
patch, the feed structure being between the first antenna
patch and the second antenna patch, the feed structure being
connected to the ground structure, and the feed structure
being configured to provide an RF signal to the first antenna
patch and second antenna patch, and the feed structure
including a horizontal feed line extending in a second
direction intersecting the first direction, and a vertical feed
line extending in the first direction.

20 Claims, 14 Drawing Sheets





US012542360B2

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

(10) **Patent No.:** **US 12,542,360 B2**
(45) **Date of Patent:** **Feb. 3, 2026**

(54) **LAMINATED PATCH ANTENNA, ANTENNA ARRAY, AND ANTENNA PACKAGE**

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

(72) Inventors: **Taeksun Kwon**, Suwon-si (KR);
Chanju Park, Suwon-si (KR); **Jungi Jeong**,
Suwon-si (KR); **Jungwoo Seo**, Suwon-si (KR);
Seungyoon Lee, Suwon-si (KR); **Dongjin Jung**,
Suwon-si (KR)

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

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 59 days.

(21) Appl. No.: **18/563,132**

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

(86) PCT No.: **PCT/KR2022/005592**

§ 371 (c)(1),

(2) Date: **Nov. 21, 2023**

(87) PCT Pub. No.: **WO2022/250294**

PCT Pub. Date: **Dec. 1, 2022**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

May 25, 2021 (KR) 10-2021-0066697

Aug. 26, 2021 (KR) 10-2021-0113399

(51) **Int. Cl.**

H01Q 9/04 (2006.01)

H01Q 21/00 (2006.01)

H01Q 21/06 (2006.01)

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

CPC **H01Q 9/0414** (2013.01); **H01Q 21/0006**
(2013.01); **H01Q 21/065** (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

(56)

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Primary Examiner — Crystal L Hammond

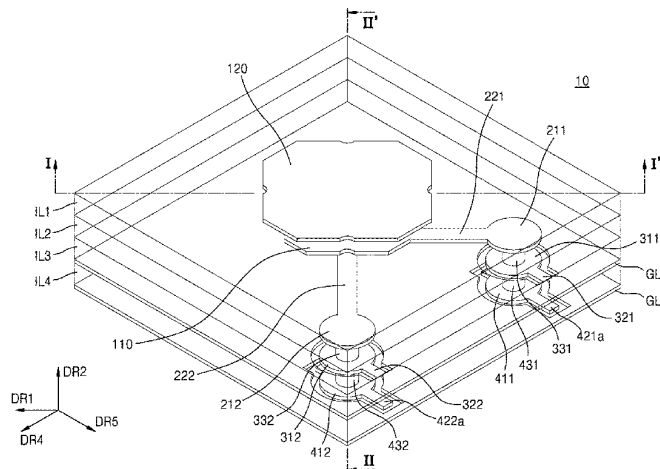
(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

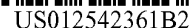
(57)

ABSTRACT

A stacked patch antenna includes an upper ground plate including a first upper hole, a first feed pad provided on the upper ground plate, a first feed line extending from the first feed pad along a first direction, a lower antenna patch provided on the first feed pad, an upper antenna patch provided on the lower antenna patch, a first upper pad provided in the first upper hole, and a first upper stub protruding from a side surface of the first upper pad.

15 Claims, 24 Drawing Sheets





(10) **Patent No.:** US 12,542,361 B2
(45) **Date of Patent:** Feb. 3, 2026

(52) U.S. Cl.

CPC *H01Q 9/0414* (2013.01); *H01Q 1/50*
(2013.01); *H01Q 9/0457* (2013.01); *H01Q*
9/30 (2013.01); *H01Q 21/30* (2013.01)

(58) **Field of Classification Search**

None
See application file for complete search history.

(56)

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Primary Examiner — Crystal L Hammond

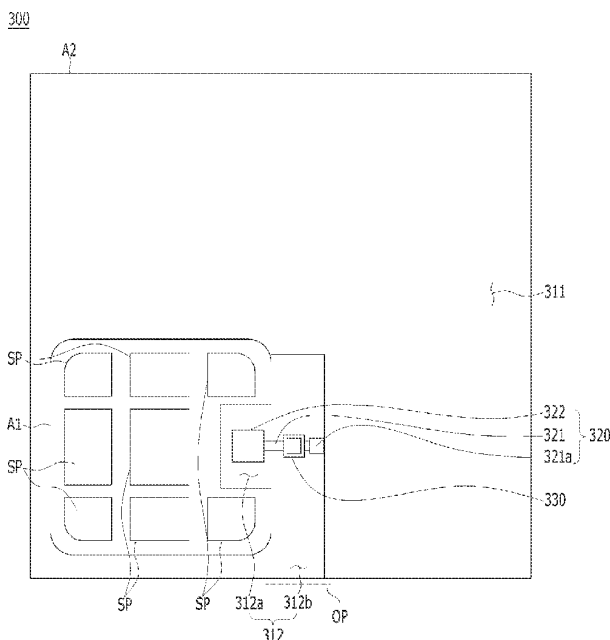
(74) *Attorney, Agent, or Firm* — Maschoff Brennan

(57) **ABSTRACT**

Presented is a multi-band antenna module in which antennas having different polarization characteristics are coupled to prevent deterioration in isolation caused by interference between the antennas. The presented multi-band antenna module comprises: a patch antenna for transmitting/receiving a signal of a first frequency band; and a circuit board which has the patch antenna mounted on the top surface thereof, and which has a conductor pattern for transmitting/receiving a signal of a second frequency band while feeding the patch antenna.

17 Claims, 23 Drawing Sheets

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 1/50 (2006.01)
H01Q 9/30 (2006.01)
H01Q 21/30 (2006.01)





US012542363B2

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

(10) **Patent No.:** **US 12,542,363 B2**
(45) **Date of Patent:** **Feb. 3, 2026**

(54) **MINIATURIZED ANTENNA**

(71) Applicant: **ROGERS CORPORATION**, Chandler,
AZ (US)

(72) Inventors: **Shailesh Pandey**, Woburn, MA (US);
Yajie Chen, Brighton, MA (US); **Lance**
Young, Shrewsbury, MA (US); **Kristi**
Pance, Auburndale, MA (US); **Lori**
Brock, Ipswich, MA (US)

(73) Assignee: **ROGERS CORPORATION**, Chandler,
AZ (US)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 216 days.

(21) Appl. No.: **18/234,307**

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

(65) **Prior Publication Data**

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Related U.S. Application Data

(60) Provisional application No. 63/398,375, filed on Aug.
16, 2022.

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

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

(58) **Field of Classification Search**
CPC H01Q 9/0421; H01Q 1/22; H01Q 9/0407;
H01Q 1/38

See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Dameon E Levi

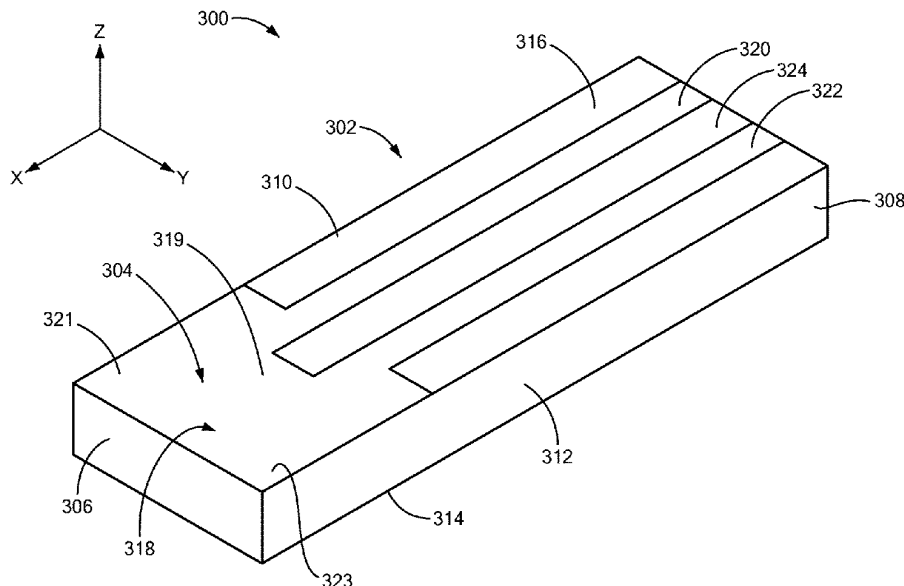
Assistant Examiner — Michael M Bouizza

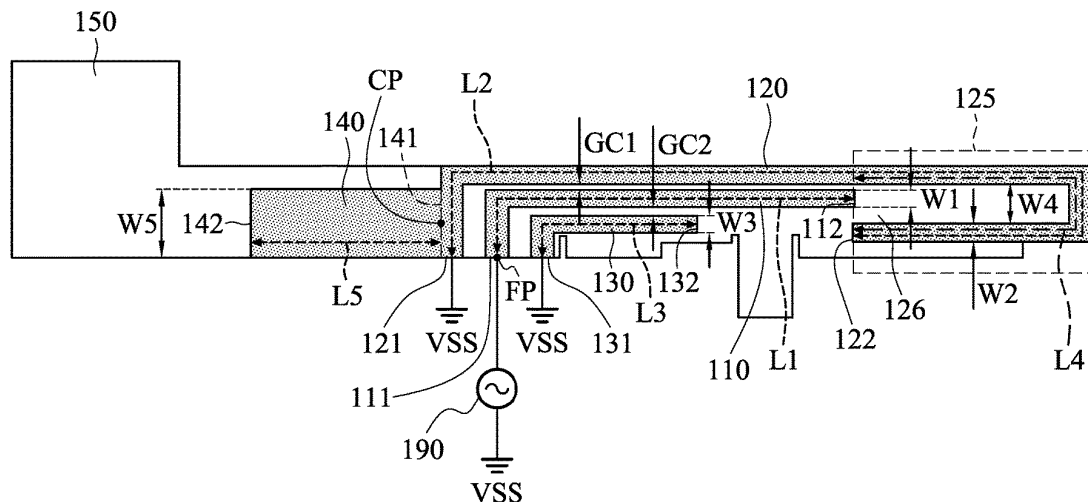
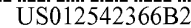
(74) *Attorney, Agent, or Firm* — CANTOR COLBURN
LLP

(57) **ABSTRACT**

An antenna includes a substrate and an electromagnetic, EM, radiator. The substrate includes a magnetodielectric material. The EM radiator includes an electrically conductive material disposed on an upper surface of the substrate. The EM radiator further includes a root, and a pair of forks that are contiguous with and extend from the root along a first axis. The pair of forks are separated from one another by a slot in the electrically conductive material of the EM radiator to define a fork-shaped EM radiator. The root includes a bridge portion extending between the pair of forks in a direction of a second axis perpendicular to the first axis to electrically connect together the pair of forks.

17 Claims, 22 Drawing Sheets







US012542373B2

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

(10) **Patent No.:** **US 12,542,373 B2**
(45) **Date of Patent:** **Feb. 3, 2026**

(54) **TWO-DIMENSIONAL MICROSTRIP PATCH ANTENNAS AND ARRAYS WITH RADIATION PATTERN DECOUPLING**

(71) Applicant: **City University of Hong Kong,**
Kowloon (HK)

(72) Inventors: **Kwok Wa Leung,** Kowloon Tong
(HK); **Guangyao Liu,** Kowloon Tong
(HK); **Nan Yang,** Guangzhou (CN);
Kwai Man Luk, Kowloon Tong (HK)

(73) Assignee: **City University of Hong Kong,**
Kowloon (HK)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 75 days.

(21) Appl. No.: **18/648,999**

(22) Filed: **Apr. 29, 2024**

(65) **Prior Publication Data**
US 2025/0337174 A1 Oct. 30, 2025

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

(52) **U.S. Cl.**
CPC **H01Q 21/065** (2013.01); **H01Q 9/0414**
(2013.01); **H01Q 9/0485** (2013.01); **H01Q**
9/065 (2013.01)

(58) **Field of Classification Search**
CPC .. H01Q 9/0407; H01Q 9/0414; H01Q 9/0428;
H01Q 9/0457; H01Q 9/0485; H01Q
9/523; H01Q 21/065
See application file for complete search history.

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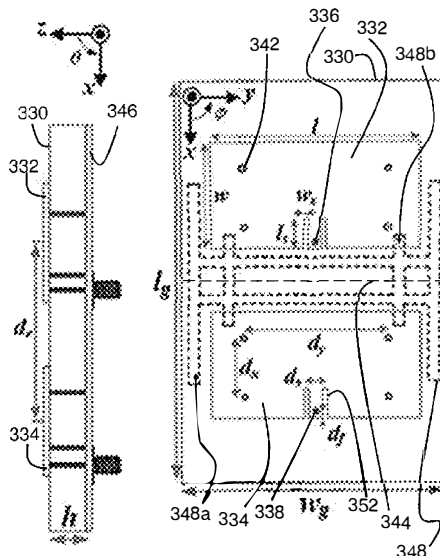
Primary Examiner — Tung X Le

(74) *Attorney, Agent, or Firm* — Renner, Kenner, Greive,
Bobak, Taylor & Weber

(57) **ABSTRACT**

A microstrip antenna which includes a substrate, a ground on
a second side of the substrate, a first patch on a first side of
the substrate, and a second patch on the first side of the
substrate. The first patch is connected to a first port. The
second patch is separated from the first patch and connected
to a second port. Each of the first and second patches is
further formed with a plurality of shorting vias connected to
the ground. The radiation patterns of each element also
feature the RPD characteristic, which is promising for
large-scale MIMO or array antennas.

19 Claims, 31 Drawing Sheets





US01254883B2

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

(10) **Patent No.:** **US 12,548,883 B2**
(45) **Date of Patent:** **Feb. 10, 2026**

(54) **ELECTRONIC DEVICE CO-CONSTRUCTED WITH HINGE ANTENNA AND HINGE ANTENNA THEREOF**

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

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(72) Inventors: **Shih-Hsun Chang**, Taipei (TW);
Min-Yang Li, Taipei (TW)

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

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 228 days.

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TW 201840060 A 11/2018

(21) Appl. No.: **18/467,924**

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

(65) **Prior Publication Data**

US 2024/0213655 A1 Jun. 27, 2024

Primary Examiner — Thien M Le

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

(30) **Foreign Application Priority Data**

Dec. 21, 2022 (TW) 111149311

(57) **ABSTRACT**

(51) **Int. Cl.**
H01Q 1/22 (2006.01)
H01Q 1/44 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/2266** (2013.01); **H01Q 1/44** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/084; H01Q 1/2266; H01Q 1/44
See application file for complete search history.

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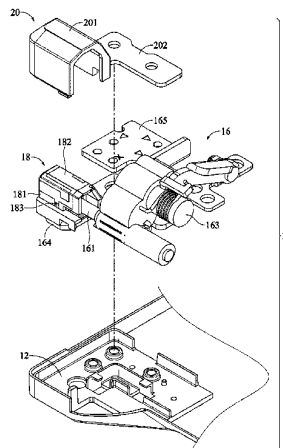
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2006/0105819 A1* 5/2006 Liao B60R 11/0241
455/569.1

An electronic device co-constructed with a hinge antenna and the hinge antenna thereof are provided. The electronic device includes a first casing, a second casing, a hinge assembly, and a hinge antenna. The hinge assembly is connected to the first casing and the second casing, so that the first casing and the second casing are opened and closed through rotation of the hinge assembly. The hinge assembly includes a horizontal fixed shaft. The hinge antenna is mounted on the horizontal fixed shaft and fixed on the hinge assembly. Therefore, the hinge antenna is mounted on the hinge assembly on the premise of maintaining the original appearance design, to improve the space utilization of the antenna.

10 Claims, 5 Drawing Sheets





US012548885B2

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

(10) **Patent No.:** **US 12,548,885 B2**
(45) **Date of Patent:** **Feb. 10, 2026**

(54) **Wi-Fi AND BLUETOOTH COMBINED
ANTENNA APPARATUS AND
CONFIGURATION METHOD THEREFOR,
AND TERMINAL DEVICE**

(71) Applicant: **HONOR DEVICE CO., LTD.,**
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(73) Assignee: **HONOR DEVICE CO., LTD.,**
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(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
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(21) Appl. No.: **18/279,301**

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

(86) PCT No.: **PCT/CN2022/114297**
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(2) Date: **Aug. 29, 2023**

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(65) **Prior Publication Data**
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(30) **Foreign Application Priority Data**
Sep. 17, 2021 (CN) 202111091425.4

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

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/36**
(2013.01); **H01Q 1/48** (2013.01); **H01Q 21/28**
(2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/36; H01Q 1/48;
H01Q 21/28
See application file for complete search history.

(56) **References Cited**
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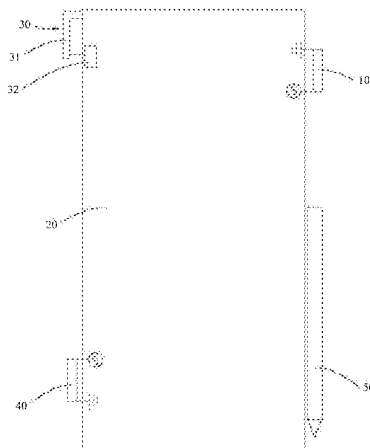
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Primary Examiner — Graham P Smith
(74) *Attorney, Agent, or Firm* — WOMBLE BOND
DICKINSON (US) LLP

(57) **ABSTRACT**
A Wi-Fi and Bluetooth combined antenna apparatus and a
configuration method therefor, and a terminal device. The
Wi-Fi and Bluetooth combined antenna apparatus includes a
Wi-Fi antenna, a ground plate, a perturbation unit, and a
Bluetooth antenna. The Wi-Fi antenna generates a ground
plate current on the ground plate; the perturbation unit is
configured to generate a reverse current after being excited
(Continued)





US012548898B2

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

(10) **Patent No.:** **US 12,548,898 B2**
(45) **Date of Patent:** **Feb. 10, 2026**

(54) **ANTENNA AND ELECTRONIC DEVICE**

(56) **References Cited**

(71) Applicant: **BOE Technology Group Co., Ltd.**,
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(72) Inventors: **Jianxing Liu**, Beijing (CN); **Shiyu Zhang**, Beijing (CN); **Zhuofan Jiao**,
Beijing (CN); **Mengxia Yu**, Beijing
(CN); **Jianyun Zhao**, Beijing (CN)

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(Continued)

(73) Assignee: **BOE Technology Group Co., Ltd.**,
Beijing (CN)

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(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 121 days.

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(21) Appl. No.: **18/637,292**

PCT/CN2023/085561 international search report dated Dec. 27,
2023.

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

Primary Examiner — Tho G Phan

(65) **Prior Publication Data**

US 2024/0347908 A1 Oct. 17, 2024

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

Related U.S. Application Data

(63) Continuation of application No.
PCT/CN2023/085561, filed on Mar. 31, 2023.

(57) **ABSTRACT**

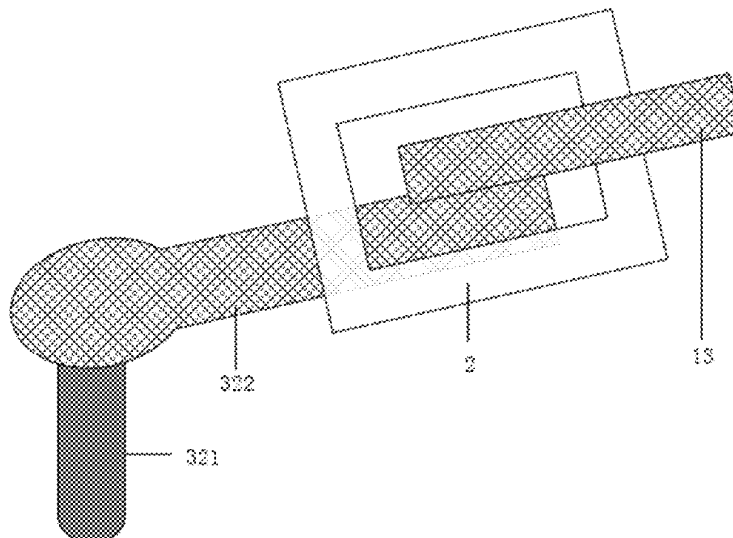
(51) **Int. Cl.**
H01Q 3/36 (2006.01)
H01P 1/18 (2006.01)
(Continued)

Provided is an antenna. The antenna includes: at least one phase-shifting structure, a first reference electrode layer, and a feed substrate; wherein each of the at least one phase-shifting structure includes a first dielectric substrate, a second dielectric substrate, a first electrode layer, a second electrode layer, and a tunable dielectric layer; a first via is defined in the first reference electrode layer; the feed substrate includes a first dielectric layer and a feed structure, and a second via is defined in the first dielectric layer; and the antenna further includes a conductive member, wherein the feed structure includes a main circuit and at least one branch circuit, one of the at least one branch circuit is electrically connected to the conductive member, the conductive member is electrically connected to the first electrode layer through the first via, the second via, and a third via.

(52) **U.S. Cl.**
CPC **H01Q 3/34** (2013.01); **H01Q 1/422**
(2013.01)

(58) **Field of Classification Search**
CPC .. H01Q 1/24; H01Q 1/38; H01Q 1/42; H01Q
1/422; H01Q 3/34; H01Q 3/26;
(Continued)

20 Claims, 19 Drawing Sheets





US012548906B2

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

(10) **Patent No.:** **US 12,548,906 B2**
(45) **Date of Patent:** **Feb. 10, 2026**

(54) **PATCH ANTENNA AND DUAL-BAND
INTERLEAVED ARRAY WITH PASSIVE
ELEMENT**

(71) Applicant: **QUALCOMM Incorporated**, San
Diego, CA (US)
(72) Inventors: **Assaf Aviv**, Carlsbad, CA (US); **Jeongil
Jay Kim**, San Diego, 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 189 days.

(21) Appl. No.: **18/340,770**

(22) Filed: **Jun. 23, 2023**

(65) **Prior Publication Data**
US 2024/0429610 A1 Dec. 26, 2024

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 5/40 (2015.01)
H01Q 21/08 (2006.01)
(52) **U.S. Cl.**
CPC **H01Q 9/0407** (2013.01); **H01Q 5/40**
(2015.01); **H01Q 21/08** (2013.01)

(58) **Field of Classification Search**
CPC .. H01Q 9/0407; H01Q 9/0414; H01Q 9/0464;
H01Q 5/30; H01Q 5/378; H01Q 5/385;
H01Q 5/392; H01Q 5/40; H01Q 5/42;
H01Q 21/06; H01Q 21/065; H01Q 21/08;
H01Q 21/10; H01Q 21/12; H01Q 21/24
See application file for complete search history.

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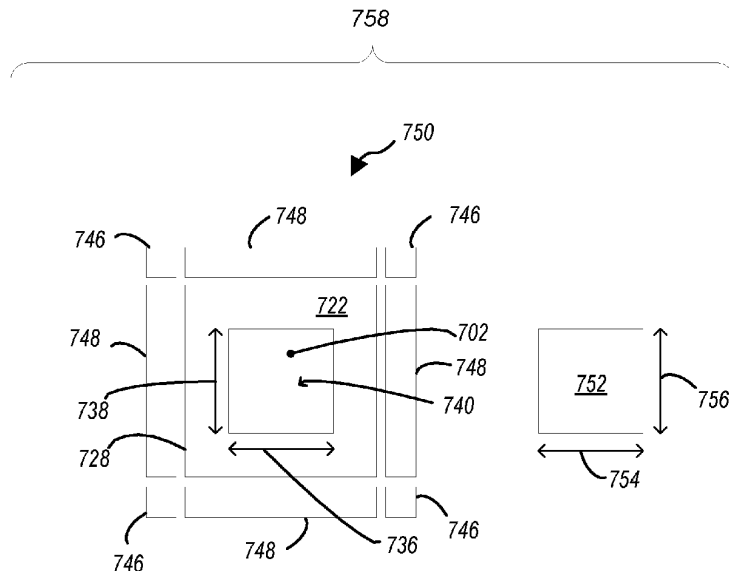
Primary Examiner — Jason M Crawford

(74) Attorney, Agent, or Firm — Smith Tempel Blaha
LLC/Qualcomm Incorporated

(57) **ABSTRACT**

A patch antenna array includes a plurality of high-band
patch antennas configured to radiate at frequencies in a
relatively higher frequency band; and a plurality of low-
band patch antennas configured to radiate at frequencies in
a relatively lower frequency band, the low-band patch
antennas interleaved with the high-band patch antennas.
Each low-band patch antenna includes: an active element;
and a passive element comprising a metal ring with an outer
edge and an inner edge, the inner edge defining an inner
opening. A corresponding patch antenna includes an active
rectangular patch element; and a passive element disposed
above the active element with a metal ring defining an inner
opening, wherein the passive element is disposed above the
active element. The passive, metal ring elements can opti-
mize the dual-band performance by controlling interference.
Very narrow substrates can be enabled.

20 Claims, 13 Drawing Sheets





US012548910B2

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

(10) **Patent No.:** **US 12,548,910 B2**
(45) **Date of Patent:** **Feb. 10, 2026**

(54) **ANTENNA AND METHOD OF MAKING ANTENNA PART**

(71) Applicant: **City University of Hong Kong,**
Kowloon (HK)

(72) Inventors: **Kwok Wa Leung,** Kowloon (HK);
Chen Yang, Kowloon (HK)

(73) Assignee: **City University of Hong Kong,**
Kowloon (HK)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 363 days.

(21) Appl. No.: **18/193,141**

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

(65) **Prior Publication Data**
US 2024/0332806 A1 Oct. 3, 2024

(51) **Int. Cl.**
H01Q 1/52 (2006.01)
H01Q 9/04 (2006.01)
H01Q 15/24 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 9/0485** (2013.01); **H01Q 15/24**
(2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/0485; H01Q 15/24; H01Q 1/523;
H01Q 1/24; H01Q 1/521; H01Q 21/28
See application file for complete search history.

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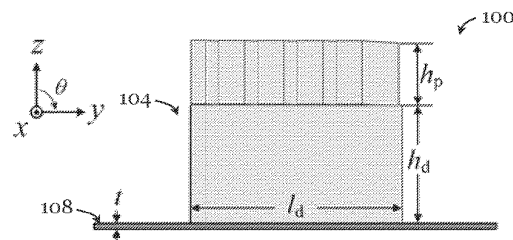
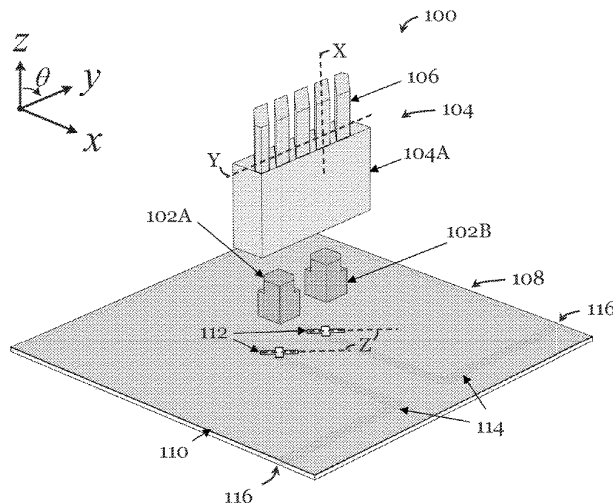
Primary Examiner — Awat M Salih

(74) *Attorney, Agent, or Firm* — Renner, Kenner, Greive, Bobak, Taylor & Weber

(57) **ABSTRACT**

An antenna includes a plurality of antenna elements each respectively operable as a radiator of electromagnetic waves and a decoupler arrangement configured to prevent or reduce mutual coupling of the plurality of antenna elements when one or more of the plurality of antenna elements are operated as radiator.

24 Claims, 20 Drawing Sheets





US012548911B2

(12) **United States Patent**
Cheng

(10) **Patent No.:** **US 12,548,911 B2**
(45) **Date of Patent:** **Feb. 10, 2026**

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

(71) Applicant: **CyberTAN Technology Inc.**, Hsinchu (TW)

(72) Inventor: **Shih-Hung Cheng**, Hsinchu (TW)

(73) Assignee: **CyberTAN Technology 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 43 days.

(21) Appl. No.: **18/744,757**

(22) Filed: **Jun. 17, 2024**

(65) **Prior Publication Data**

US 2025/0385431 A1 Dec. 18, 2025

(51) **Int. Cl.**
H01Q 9/22 (2006.01)
H01Q 5/50 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 9/22** (2013.01); **H01Q 5/50** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 9/22; H01Q 5/50
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Dameon E Levi

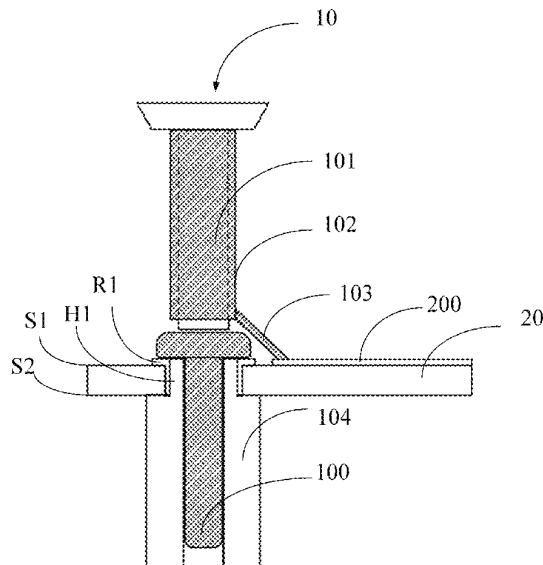
Assistant Examiner — Jordan E. DeWitt

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

(57) **ABSTRACT**

A antenna structure is arranged on a circuit board, a first surface of the circuit board includes an RF circuit, and the antenna structure includes: a metal screw, fixed on the first surface through a metal hole; the metal hole forms a metal ring; a plastic column, set above the metal screw; a metal tube, embedded with the plastic column, wherein there is a first predetermined distance between the metal tube and the metal screw; a metal shrapnel, extending from a bottom of the metal tube, wherein the metal screw is electrically connected to the RF circuit or the metal tube is electrically connected to the RF circuit to enable the metal screw and the metal tube to transmit or receive signals. The present disclosure also provides an electronic device, and the metal screw also uses to fix the circuit board to the housing of the electronic device.

17 Claims, 5 Drawing Sheets





US012548913B2

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

(10) **Patent No.:** **US 12,548,913 B2**
(45) **Date of Patent:** **Feb. 10, 2026**

(54) **INVERTED L ANTENNA AND ANTENNA
DEVICE**

(71) Applicant: **KABUSHIKI KAISHA TOKAI RIKAI
DENKI SEISAKUSHO**, Aichi (JP)

(72) Inventors: **Koji Inafune**, Aichi (JP); **Kenichi
Koga**, Aichi (JP); **Tatsuya Koike**, Aichi
(JP); **Satoshi Mori**, Aichi (JP)

(73) Assignee: **KABUSHIKI KAISHA TOKAI RIKAI
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(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
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(21) Appl. No.: **18/397,010**

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

(65) **Prior Publication Data**
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(30) **Foreign Application Priority Data**
Jan. 30, 2023 (JP) 2023-011973

(51) **Int. Cl.**
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H01Q 1/38 (2006.01)
H01Q 9/42 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 9/42** (2013.01); **H01Q 1/38**
(2013.01)

(58) **Field of Classification Search**

CPC H01Q 9/42; H01Q 1/38; H01Q 1/243;
H01Q 9/0421; H01Q 1/36; H01Q 1/12
See application file for complete search history.

(56) **References Cited**

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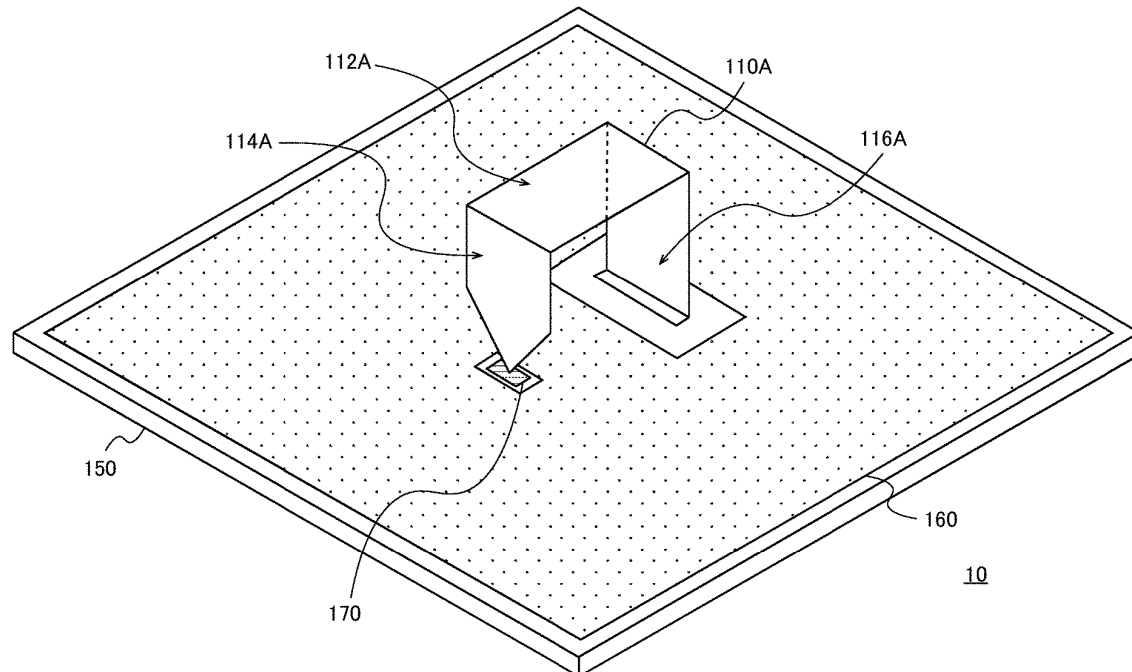
Primary Examiner — David E Lotter

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

(57) **ABSTRACT**

There is provided an inverted L antenna arranged on a
substrate, the inverted L antenna comprising: a parallel part
arranged in substantially parallel to the substrate; a power
feeding point contact part extended from the parallel part
substantially perpendicularly to the parallel part; and a leg
part formed separately from the power feeding point contact
part, and extended from the parallel part substantially per-
pendicularly to the parallel part, wherein a contact portion of
the leg part and the substrate is electrically insulated.

10 Claims, 15 Drawing Sheets





US012548916B2

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

(10) **Patent No.:** **US 12,548,916 B2**
(45) **Date of Patent:** **Feb. 10, 2026**

(54) **FEED STRUCTURE OF ANTENNA,
ANTENNA, AND COMMUNICATION
SYSTEM**

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

(72) Inventors: **Junfeng Lu**, Xi'an (CN); **Li Jin**, Xi'an
(CN); **Liwan Zhang**, Xi'an (CN);
Shuangfei Wang, 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 286 days.

(21) Appl. No.: **18/339,863**

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

(65) **Prior Publication Data**

US 2023/0352848 A1 Nov. 2, 2023

Related U.S. Application Data

(63) Continuation of application No.
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(51) **Int. Cl.**
H01Q 21/00 (2006.01)
H01Q 1/36 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 21/0006** (2013.01); **H01Q 1/36**
(2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/24; H01Q 1/241; H01Q 1/243;
H01Q 1/36; H01Q 11/04; H01Q 21/00;
H01Q 21/0006; H01Q 21/08

See application file for complete search history.

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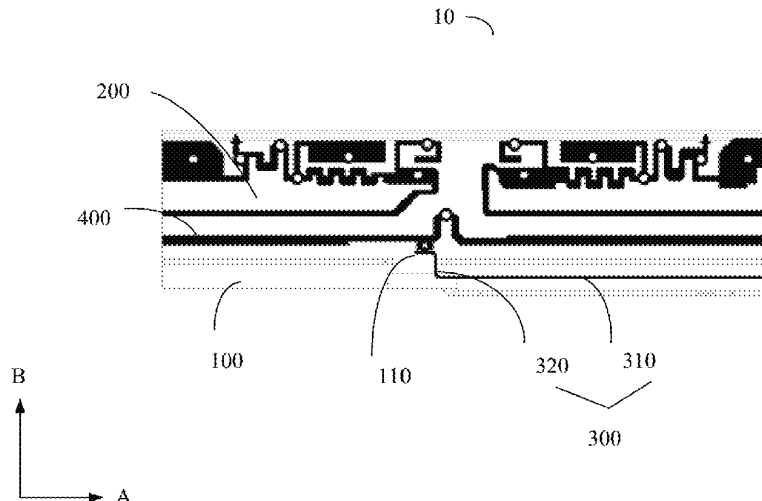
Primary Examiner — Thai Pham

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

(57) **ABSTRACT**

The present disclosure relates to feed structures of antennas,
antennas, and communication devices. One example feed
structure includes a first cavity with a first signal cable and
a second cavity with a second signal cable. The first signal
cable includes a first main part and a first elastic bending part
located at one end of the first main part. The first main part
extends along a first direction. An extension direction of the
first elastic bending part intersects with the first direction,
and the first elastic bending part can be deformed towards
the extension direction of the first main part. A first hole is
provided between the first cavity and the second cavity. The
first cavity and the second cavity are connected through the
first hole.

20 Claims, 12 Drawing Sheets





US012549149B1

(12) **United States Patent**
Dueweke

(10) **Patent No.:** **US 12,549,149 B1**
(45) **Date of Patent:** **Feb. 10, 2026**

(54) **TUNABLE FILTERS AND ANTENNAS, AND METHODS OF MAKING AND USING THE SAME**

(71) Applicant: **Michael J. Dueweke**, Campbell, CA (US)

(72) Inventor: **Michael J. Dueweke**, Campbell, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 536 days.

(21) Appl. No.: **18/069,389**

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

Related U.S. Application Data

(60) Provisional application No. 63/296,103, filed on Jan. 3, 2022.

(51) **Int. Cl.**
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H01Q 7/00 (2006.01)
H01Q 9/04 (2006.01)
H03H 7/01 (2006.01)

(52) **U.S. Cl.**
CPC **H03H 7/0153** (2013.01); **H01P 1/203** (2013.01); **H01Q 7/005** (2013.01); **H01Q 9/0442** (2013.01); **H03H 7/0115** (2013.01)

(58) Field of Classification Search

CPC .. H01P 1/203; H01P 1/20354; H01P 1/20363; H01P 1/20372; H01P 1/20381; H01Q 9/047; H01Q 9/04; H01Q 9/065; H01Q 13/206; H01Q 1/38

See application file for complete search history.

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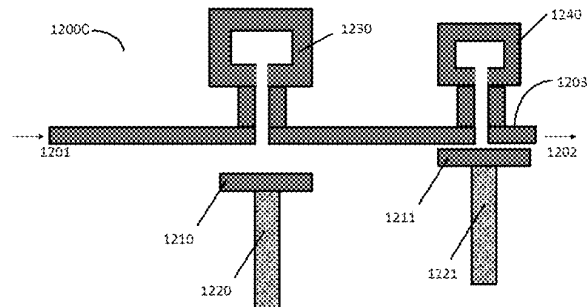
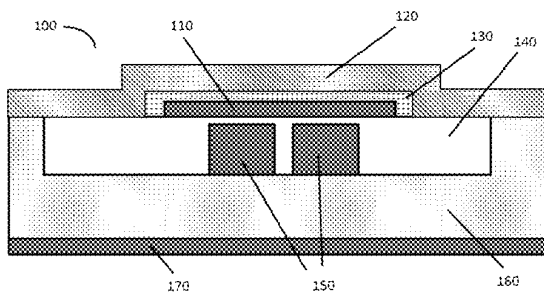
Primary Examiner — Stephen E. Jones

(74) *Attorney, Agent, or Firm* — Central California IP Group, P.C.; Andrew D. Fortney

(57) ABSTRACT

Tunable electromagnetic filters and antennas are described. The tunable electromagnetic filters and tunable antennas comprise a transmission line or antenna feed line, an isolated conductor or semiconductor material, and a support structure supporting a mechanical or electromagnetic actuator. The mechanical or electromagnetic actuator moves the isolated conductor or semiconductor material, and tunes the resonance frequency of an electromagnetic resonator.

20 Claims, 29 Drawing Sheets





US012555892B2

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

(10) **Patent No.:** **US 12,555,892 B2**
(45) **Date of Patent:** **Feb. 17, 2026**

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

(56) **References Cited**

(71) Applicants: **Chih-Heng Lin**, Taipei (TW); **Li-Chun Lee**, Taipei (TW); **Shih-Chia Liu**, Taipei (TW); **Jui-Hung Lai**, Taipei (TW); **Hung-Yu Yeh**, Taipei (TW)

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					343/702

(72) Inventors: **Chih-Heng Lin**, Taipei (TW); **Li-Chun Lee**, Taipei (TW); **Shih-Chia Liu**, Taipei (TW); **Jui-Hung Lai**, Taipei (TW); **Hung-Yu Yeh**, Taipei (TW)

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(73) Assignee: **COMPAL ELECTRONICS, INC.**, Taipei (TW)

TW	201611408	3/2016
TW	M593666	4/2020

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 209 days.

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“Office Action of Taiwan Counterpart Application”, issued on Aug. 7, 2024, pp. 1-8.

(21) Appl. No.: **18/473,267**

* cited by examiner

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

(65) **Prior Publication Data**

US 2024/0113414 A1 Apr. 4, 2024

Primary Examiner — Dameon E Levi

Assistant Examiner — Michael M Bouizza

Related U.S. Application Data

(74) Attorney, Agent, or Firm — JCIPRNET

(60) Provisional application No. 63/411,625, filed on Sep. 29, 2022.

(57) **ABSTRACT**

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

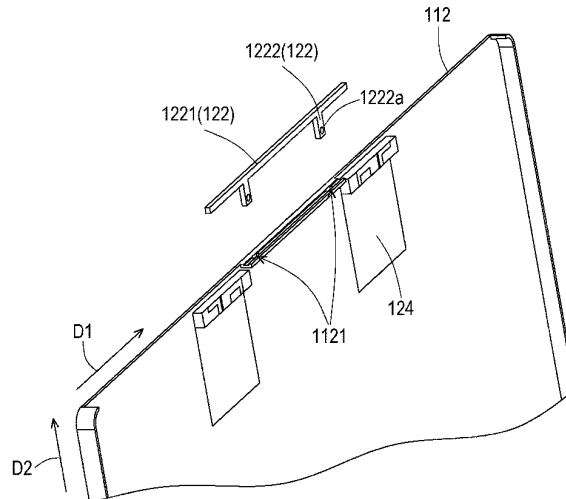
Disclosed is an electronic device including a device body and an antenna module. The antenna module includes a conductive element and at least one antenna element. The conductive element includes a main body portion and at least one assembly portion connected with each other. The at least one assembly portion is assembled on the device body. The at least one antenna element is disposed on the device body and coupled with the conductive element to excite a first resonance mode. The at least one assembly portion overlaps the at least one antenna element in the length direction of the main body portion.

(52) **U.S. Cl.**
CPC **H01Q 1/2291** (2013.01); **H01Q 9/0414** (2013.01); **H01Q 9/0421** (2013.01)

(58) **Field of Classification Search**
CPC .. H01Q 1/2291; H01Q 9/0414; H01Q 9/0421;
H01Q 5/342; H01Q 7/00; H01Q 21/28;
H01Q 1/2266; H01Q 1/243; H01Q 5/378;
H01Q 9/42

See application file for complete search history.

9 Claims, 14 Drawing Sheets





US012555893B2

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

(10) **Patent No.:** **US 12,555,893 B2**
(45) **Date of Patent:** **Feb. 17, 2026**

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

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

(72) Inventors: **Youngjung Kim**, Suwon-si (KR);
Jonghyuck Lee, Suwon-si (KR);
Youngjun Kim, Suwon-si (KR);
Jongsuk Kim, Suwon-si (KR);
Kyungbin Kim, Suwon-si (KR);
Kwangseo Kim, Suwon-si (KR);
Donghwan Kim, 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 221 days.

(21) Appl. No.: **18/244,039**

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

(65) **Prior Publication Data**
US 2023/0420826 A1 Dec. 28, 2023

Related U.S. Application Data

(63) Continuation of application No.
PCT/KR2022/002127, filed on Feb. 14, 2022.

(30) **Foreign Application Priority Data**

Mar. 9, 2021 (KR) 10-2021-0030897

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 1/24 (2006.01)
H01Q 21/08 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 9/0407**
(2013.01); **H01Q 21/08** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 9/0407; H01Q 21/08
See application file for complete search history.

(56) **References Cited**

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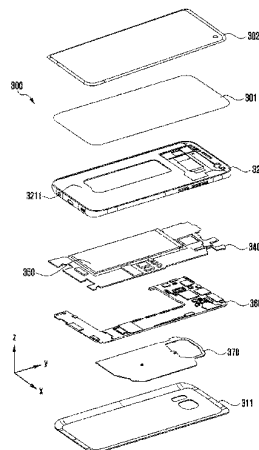
Primary Examiner — Jimmy T Vu

(74) *Attorney, Agent, or Firm* — CANTOR COLBURN
LLP

(57) **ABSTRACT**

An electronic device according to various embodiments may comprise: a housing; an antenna structure comprising a substrate, which comprises a first substrate surface facing a first direction and a second substrate surface facing a second direction opposite from the first substrate surface, and at least one antenna element disposed on the substrate so as to form a beam pattern in the first direction; a first support part disposed so as to at least partially correspond to the second substrate surface; a conductive bracket comprising at least one conductive extension part disposed higher than the second substrate surface with respect to the first support part; and a wireless communication circuit configured to transmit and/or receive a wireless signal in a designated frequency band by means of the at least one antenna element.

20 Claims, 19 Drawing Sheets





US012555900B2

(12) **United States Patent**
Tachibana

(10) **Patent No.:** **US 12,555,900 B2**
(45) **Date of Patent:** **Feb. 17, 2026**

(54) **FILTER DEVICE, ANTENNA APPARATUS,
AND ANTENNA MODULE**

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

(72) Inventor: **Shinya Tachibana**, Nagaokakyo (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 106 days.

(21) Appl. No.: **18/596,816**

(22) Filed: **Mar. 6, 2024**

(65) **Prior Publication Data**

US 2024/0213665 A1 Jun. 27, 2024

Related U.S. Application Data

(63) Continuation of application No.
PCT/JP2022/041921, filed on Nov. 10, 2022.

(30) **Foreign Application Priority Data**

Nov. 22, 2021 (JP) 2021-189150

(51) **Int. Cl.**
H01Q 1/50 (2006.01)
H03H 7/01 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/50** (2013.01); **H03H 7/0115**
(2013.01); **H03H 7/175** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/22; H01Q 1/50; H01Q 1/243;
H01Q 1/378; H01Q 1/521; H01Q 5/335;
H01Q 5/342; H03H 5/02; H03H 7/09;
H03H 7/175; H03H 7/0115
See application file for complete search history.

(56) **References Cited**

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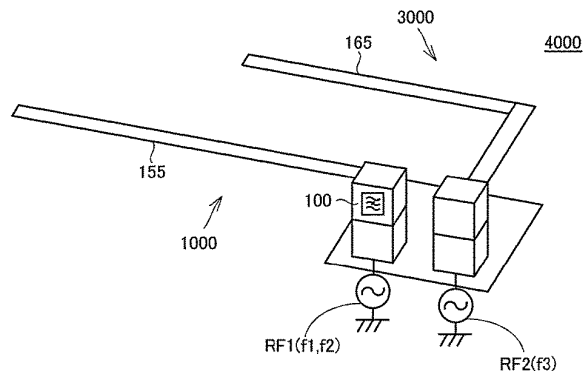
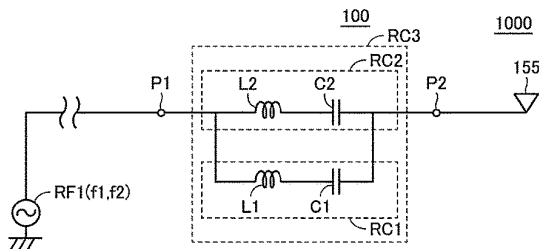
Primary Examiner — Tung X Le

(74) *Attorney, Agent, or Firm* — Keating & Bennett, LLP

(57) **ABSTRACT**

A filter device includes a first LC series resonator to resonate in series at a first series resonant frequency with a first inductor and a first capacitor, and a second LC series resonator to resonate in series at a second series resonant frequency with a second inductor and a second capacitor. The first and second LC series resonators are connected in parallel and resonate in parallel at a parallel resonant frequency. The second series resonant frequency is lower than the first series resonant frequency. The parallel resonant frequency is between the first and second series resonant frequencies.

20 Claims, 18 Drawing Sheets





US012555909B2

(12) **United States Patent**
Ohshige

(10) **Patent No.:** **US 12,555,909 B2**
(45) **Date of Patent:** **Feb. 17, 2026**

(54) **ANTENNA APPARATUS**

(56)

References Cited

(71) Applicant: **CANON KABUSHIKI KAISHA,**
Tokyo (JP)

U.S. PATENT DOCUMENTS

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343/702

(72) Inventor: **Reiya Ohshige,** Kanagawa (JP)

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(73) Assignee: **Canon Kabushiki Kaisha,** Tokyo (JP)

CN 111786134 B * 2/2022 H01Q 1/242
JP 2005167827 A 6/2005

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 66 days.

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(21) Appl. No.: **18/746,794**

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(22) Filed: **Jun. 18, 2024**

Primary Examiner — Renan Luque

(65) **Prior Publication Data**

(74) *Attorney, Agent, or Firm* — Canon U.S.A., Inc. IP
Division

US 2024/0421485 A1 Dec. 19, 2024

(30) **Foreign Application Priority Data**

(57) **ABSTRACT**

Jun. 19, 2023 (JP) 2023-100271
Nov. 13, 2023 (JP) 2023-193058

An antenna apparatus that operates at first and second
operating frequencies may include: a first conductor includ-
ing an aperture portion including approximately parallel first
and second sides; and a feeding line separated from the
aperture portion. When viewed from a stacking direction,
the feeding line includes: a first portion including a portion
from a first intersection of the first side and the feeding line
to an open end of the feeding line, a second portion
connecting a second intersection of the second side and the
feeding line and a feeding unit, and a third portion connect-
ing the first intersection and the second intersection to
obliquely straddle the aperture portion, and a distance from
the second intersection to one end of the second side and a
distance from the second intersection to the other end of the
second side are different.

(51) **Int. Cl.**

H01Q 5/50 (2015.01)

H01Q 13/10 (2006.01)

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

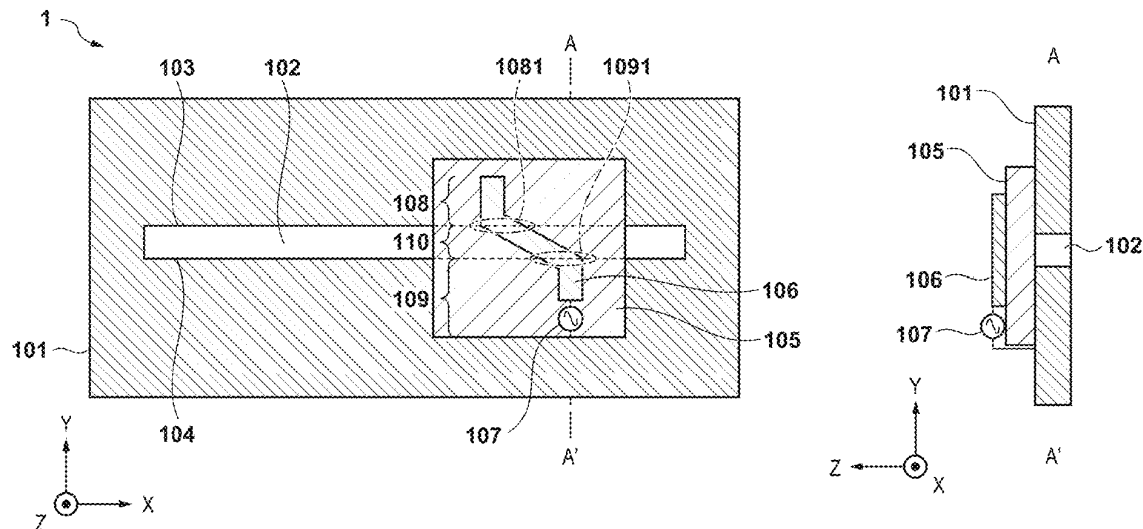
CPC **H01Q 5/50** (2015.01); **H01Q 13/10**
(2013.01)

(58) **Field of Classification Search**

CPC H01Q 5/50; H01Q 13/10; H01Q 9/0457;
H01Q 9/0407; H01Q 1/50; H01Q 1/48;
H01Q 1/38; H01Q 1/22

See application file for complete search history.

16 Claims, 9 Drawing Sheets





US012555911B2

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

(10) **Patent No.:** **US 12,555,911 B2**
(45) **Date of Patent:** **Feb. 17, 2026**

(54) **ELECTRONIC DEVICE WITH ANTENNA
FOR RADIATING THROUGH REAR WALL**

(56)

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

(72) Inventors: **Seyed Mohammad Amjadi**, Santa Clara, CA (US); **Yiren Wang**, Cupertino, CA (US); **Hao Xu**, Cupertino, CA (US); **Sidharath Jain**, Redwood City, CA (US); **Cosan Caglayan**, San Mateo, CA (US); **Carlo Di Nallo**, Belmont, CA (US); **Mattia Pascolini**, San Francisco, CA (US)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 51 days.

(21) Appl. No.: **18/630,878**

(22) Filed: **Apr. 9, 2024**

(65) **Prior Publication Data**

US 2025/0316903 A1 Oct. 9, 2025

(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H01Q 1/22 (2006.01)
H01Q 1/48 (2006.01)
H01Q 9/04 (2006.01)

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

CPC **H01Q 9/0414** (2013.01); **H01Q 1/22** (2013.01); **H01Q 1/48** (2013.01); **H01Q 9/0421** (2013.01)

(58) **Field of Classification Search**

CPC .. **H01Q 1/22**; **H01Q 1/48**; **H01Q 1/24**; **H01Q 9/04**; **H01Q 9/0414**; **H01Q 9/0421**
See application file for complete search history.

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Primary Examiner — Tho G Phan

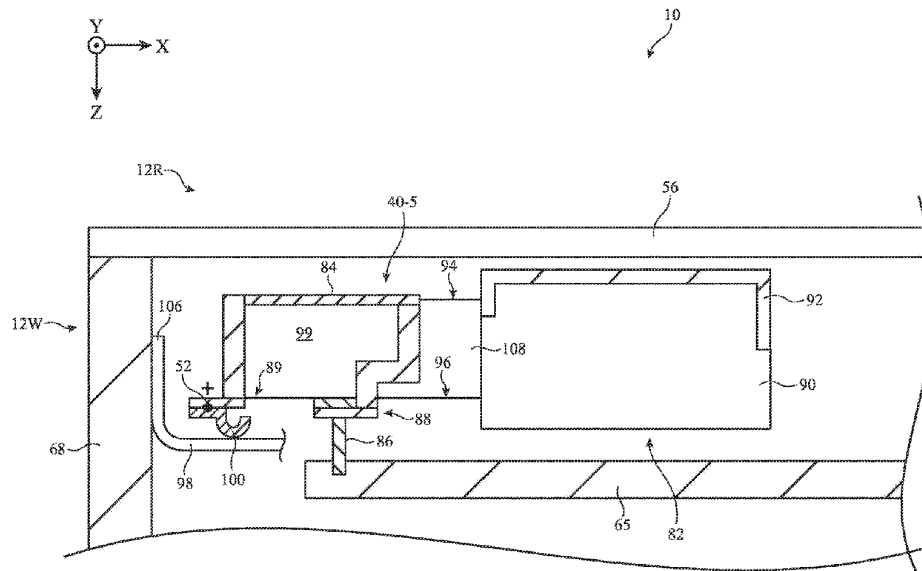
(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.;
Michael H. Lyons

(57)

ABSTRACT

An electronic device may be provided with peripheral conductive housing structures, a rear wall, a first antenna, and a second antenna. The first antenna may have a resonating element formed from the peripheral conductive housing structures. The second antenna may have a folded antenna element overlapping the first antenna. The folded element may be disposed on at least three sides of a substrate. The folded element may follow a meandering path along at least two of the sides. A first end of the folded element may be coupled to a positive feed terminal. A second end of the folded element may be shorted to a conductive chassis. The folded element may exhibit minimum peak current magnitude at a surface of the substrate facing the rear wall, minimizing electromagnetic coupling between the first and second antennas and optimizing a radiation pattern of the second antenna through the rear wall.

20 Claims, 10 Drawing Sheets





(10) **Patent No.:** US 12,555,914 B2
(45) **Date of Patent:** Feb. 17, 2026

(58) **Field of Classification Search**

CPC .. H01Q 9/42; H01Q 1/48; H01Q 5/50; H01Q 9/0457; H01Q 5/371
See application file for complete search history.

(56) **References Cited**

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

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Primary Examiner — Dameon E Levi
Assistant Examiner — Jordan E. DeWitt

(74) *Attorney, Agent, or Firm* — J.C. PATENTS

(21) Appl. No.: 18/770,374

(22) Filed: **Jul. 11, 2024**

(65) **Prior Publication Data**

US 2025/0149797 A1 May 8, 2025

(30) **Foreign Application Priority Data**

Nov. 3, 2023 (TW) 112142411

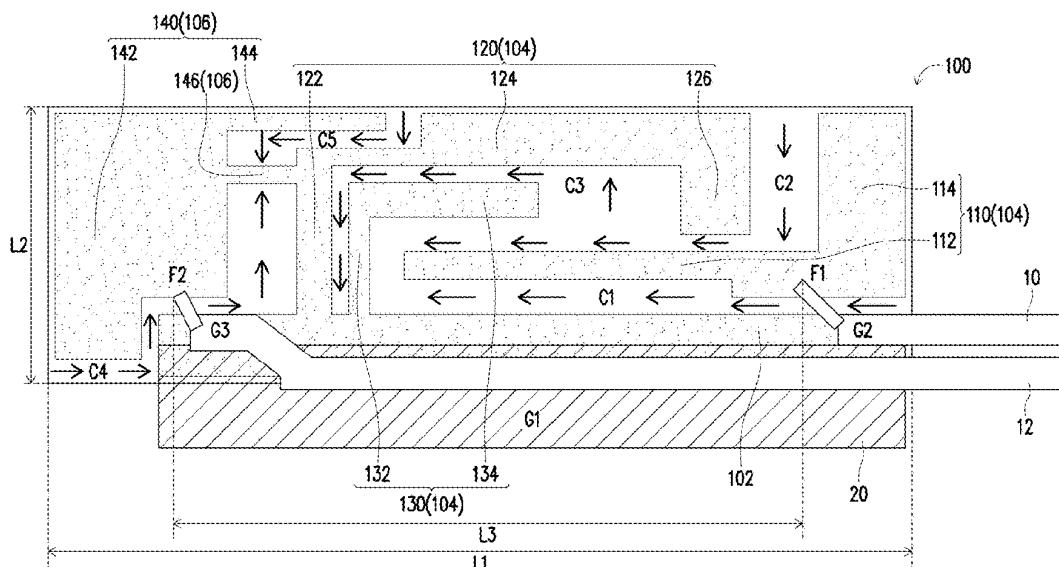
(51) **Int. Cl.**
H01Q 9/42 (2006.01)
H01Q 1/48 (2006.01)
H01Q 5/50 (2015.01)
H01Q 9/04 (2006.01)

(52) **U.S. Cl.**
CPC *H01Q 9/42* (2013.01); *H01Q 1/48*
(2013.01); *H01Q 5/50* (2015.01); *H01Q*
9/0457 (2013.01)

(57) **ABSTRACT**

An antenna module includes a ground radiator, a first antenna, and a second antenna. The first antenna comprises a first radiator, a second radiator, and a third radiator. The first radiator and the second radiator resonate at a low frequency band and a first high frequency band, and a part of the first radiator and the third radiator resonate at a second high frequency band. The second antenna includes a fourth radiator, the second radiator, and a connecting section. The connecting section is connected between the fourth radiator and the second radiator. A part of the fourth radiator, the connecting section, and the second radiator resonate at the low frequency band and the second high frequency band, and the fourth radiator, the connecting section, and a part of the second radiator resonate at the first high frequency band.

11 Claims, 8 Drawing Sheets





US012555925B2

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

(10) **Patent No.:** **US 12,555,925 B2**
(45) **Date of Patent:** **Feb. 17, 2026**

(54) **FEED STRIPLINE, PHASE SHIFTER, ARRAY ANTENNA, AND BASE STATION**

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

(72) Inventors: **Xiaodong Wei**, Xi'an (CN); **Qiqiang Gao**, Xi'an (CN); **Xinming Liu**, Xi'an (CN); **Jiejun Zhou**, 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 253 days.

(21) Appl. No.: **18/343,114**

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

(65) **Prior Publication Data**
US 2023/0344146 A1 Oct. 26, 2023

Related U.S. Application Data

(63) Continuation of application No.
PCT/CN2020/141100, filed on Dec. 29, 2020.

(51) **Int. Cl.**
H01Q 21/00 (2006.01)
H01Q 1/24 (2006.01)
H01Q 3/32 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 21/0075** (2013.01); **H01Q 1/246**
(2013.01); **H01Q 3/32** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 21/0075; H01Q 1/246; H01Q 3/32
See application file for complete search history.

(56) **References Cited**

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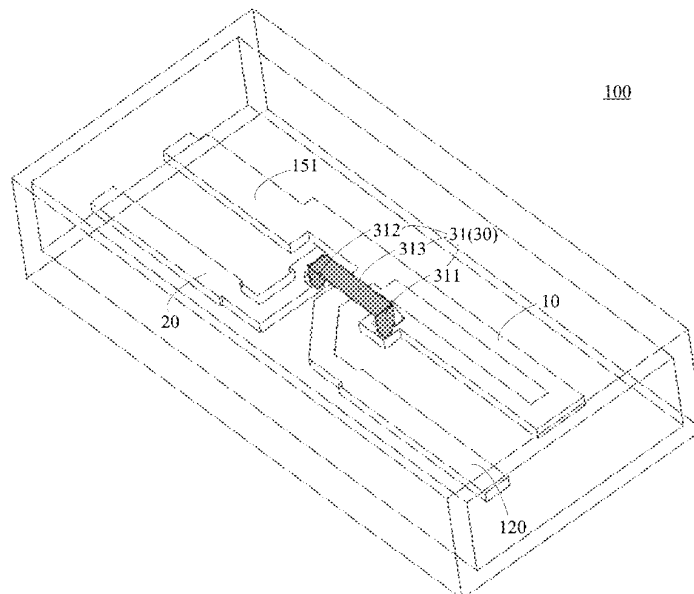
Primary Examiner — Hai V Tran

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

(57) **ABSTRACT**

In accordance with an embodiment, a feed stripline includes: a signal input line; a first power branch line; and a second power branch line. A first end of the signal input line is configured to be conductively coupled to an external signal source, a second end of the signal input line is electrically connected to each of the first power branch line and the second power branch line, the first power branch line includes a jump structure, the first power branch line spans from a first side of the second power branch line to a second other side of the second power branch line via the jump structure, and the jump structure and the second power branch line are spaced apart from each other.

20 Claims, 20 Drawing Sheets





US012556037B2

(12) **United States Patent**
Kim

(10) **Patent No.:** **US 12,556,037 B2**
(45) **Date of Patent:** **Feb. 17, 2026**

(54) **ANTENNA STRUCTURE SUPPORTING
WIRELESS CHARGING AND ELECTRONIC
DEVICE HAVING THE SAME**

(58) **Field of Classification Search**
USPC 320/106, 107, 108, 109, 110
See application file for complete search history.

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

(56) **References Cited**

U.S. PATENT DOCUMENTS

(72) Inventor: **Dohyeon Kim**, Suwon-si (KR)

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

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(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 843 days.

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(21) Appl. No.: **17/745,238**

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(22) Filed: **May 16, 2022**

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005540.

(65) **Prior Publication Data**

US 2023/0022349 A1 Jan. 26, 2023

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Related U.S. Application Data

(63) Continuation of application No.
PCT/KR2022/005540, filed on Apr. 18, 2022.

Primary Examiner — Brian Ngo

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

(30) **Foreign Application Priority Data**

Jul. 26, 2021 (KR) 10-2021-0097657
Nov. 19, 2021 (KR) 10-2021-0160617

(57) **ABSTRACT**

Provided is an antenna structure configured to wirelessly
charge, the antenna structure including an insulating sub-
strate, a coil formed on a first surface of the insulating
substrate in a winding structure, the coil being wound a
certain number of times in a clockwise and/or a counter-
clockwise direction around an axis normal to the insulating
substrate, a coating layer including a first magnetic material,
the coating layer being disposed adjacent to and surrounding
the coil in a winding structure corresponding to the winding
structure of the coil, and a shielding sheet including a second
magnetic material and facing the second surface of the
insulating substrate.

(51) **Int. Cl.**
H02J 50/10 (2016.01)
H01F 27/28 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC **H02J 50/10** (2016.02); **H01F 27/2804**
(2013.01); **H01F 27/288** (2013.01); **H05K**
1/0277 (2013.01); **H05K 1/165** (2013.01)

18 Claims, 10 Drawing Sheets

