



US012687894B2

(12) **United States Patent**
Hsieh

(10) **Patent No.:** **US 12,687,894 B2**
(45) **Date of Patent:** **Jul. 21, 2026**

(54) **ELECTRONIC DEVICE**

(71) Applicant: **Getac Technology Corporation**, New Taipei City (TW)

(72) Inventor: **Cheng Yu Hsieh**, Taipei City (TW)

(73) Assignee: **Getac Technology Corporation**, New Taipei City (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 97 days.

(21) Appl. No.: **18/939,749**

(22) Filed: **Nov. 7, 2024**

(65) **Prior Publication Data**
US 2025/0224775 A1 Jul. 10, 2025

(30) **Foreign Application Priority Data**
Jan. 8, 2024 (CN) 202410023088.2

(51) **Int. Cl.**
G06F 1/16 (2006.01)
H01Q 1/22 (2006.01)

(52) **U.S. Cl.**
CPC **G06F 1/1658** (2013.01); **G06F 1/1681** (2013.01); **H01Q 1/2266** (2013.01)

(58) **Field of Classification Search**
CPC G06F 1/1658; G06F 1/1681; H01Q 1/2266
See application file for complete search history.

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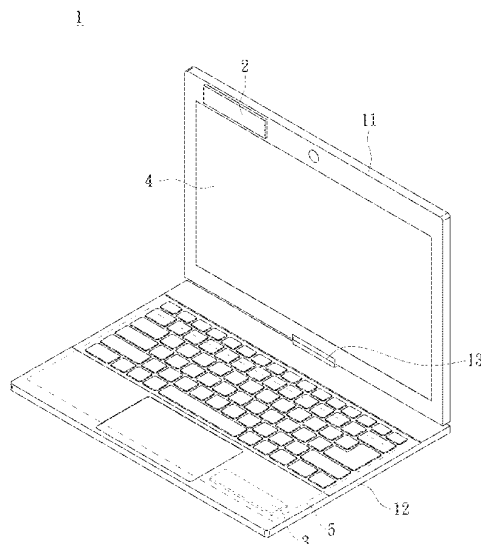
Primary Examiner — Michael Pervan

(74) Attorney, Agent, or Firm — Cooper Legal Group, LLC

(57) **ABSTRACT**

An electronic device includes a first housing for disposing a display screen, and a second housing for disposing a system circuit board, wherein a first side of the second housing is directly connected to a first side of the first housing through a rotating pivot; wherein an antenna circuit board is disposed on a second side of the first housing relative to the rotating pivot, the antenna circuit board has a radiating portion and a first grounding portion, and the radiating portion includes an antenna segment; wherein a second side of the second housing relative to the rotating pivot has a conductor layer, and the conductor layer has a coupling portion and a second grounding portion; when the electronic device is in the tablet mode, the conductor layer overlaps the antenna circuit board. In this way, the impedance mismatch and frequency offset of the antenna in tablet mode are improved.

10 Claims, 6 Drawing Sheets





US012689113B2

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

(10) **Patent No.:** **US 12,689,113 B2**
(45) **Date of Patent:** **Jul. 21, 2026**

(54) **TERMINAL ANTENNA SYSTEM AND ELECTRONIC DEVICE**

(71) Applicant: **HONOR DEVICE CO., LTD.**,
Shenzhen (CN)

(72) Inventors: **Shaobo Li**, Shenzhen (CN); **Yiwu Hu**,
Shenzhen (CN)

(73) Assignee: **HONOR DEVICE CO., LTD.**,
Shenzhen (CN)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 334 days.

(21) Appl. No.: **18/266,959**

(22) PCT Filed: **Sep. 7, 2022**

(86) PCT No.: **PCT/CN2022/117659**

§ 371 (c)(1),

(2) Date: **Jun. 13, 2023**

(87) PCT Pub. No.: **WO2023/082812**

PCT Pub. Date: **May 19, 2023**

(65) **Prior Publication Data**

US 2023/0420827 A1 Dec. 28, 2023

(30) **Foreign Application Priority Data**

Nov. 12, 2021 (CN) 202111340312.3

(51) **Int. Cl.**
H01Q 5/20 (2015.01)
H01Q 1/24 (2006.01)

(Continued)

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

(58) **Field of Classification Search**

CPC H01Q 1/48; H01Q 1/243; H01Q 5/20;
H01Q 5/371; H01Q 5/378; H01Q 9/42;
(Continued)

(56) **References Cited**

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Primary Examiner — Dimary S Lopez Cruz

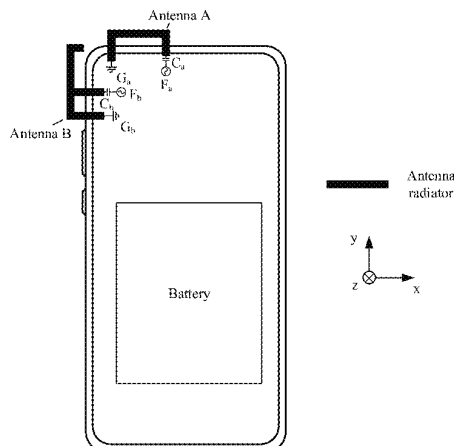
Assistant Examiner — Marin Stoytchev Stoytchev

(74) *Attorney, Agent, or Firm* — WOMBLE BOND
DICKINSON (US) LLP

(57) **ABSTRACT**

Embodiments of this application relate to the field of antenna technologies, and disclose a terminal antenna system and an electronic device, to effectively reduce mutual impact between adjacent antennas. A specific solution is as follows: The terminal antenna system includes: a first radiator and a second radiator, where a first end of the first radiator is coupled to a first end of the second radiator through a gap. A first feed point is provided at a second end, away from the second radiator, of the first radiator, and a first ground point is further provided on the first radiator. A second feed point is provided at a second end of the second radiator, and the second end of the second radiator is an end away from the first radiator.

19 Claims, 12 Drawing Sheets





US012689125B2

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

(10) **Patent No.:** **US 12,689,125 B2**
(45) **Date of Patent:** **Jul. 21, 2026**

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

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

(72) Inventors: **Yafei Zhang**, Beijing (CN); **Dongdong Zhang**, Beijing (CN); **Mengwen Jia**, Beijing (CN); **Xudong Zhang**, Beijing (CN)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 83 days.

(21) Appl. No.: **18/665,648**

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

(65) **Prior Publication Data**
US 2024/0322434 A1 Sep. 26, 2024

Related U.S. Application Data
(63) Continuation of application No. PCT/CN2023/083282, filed on Mar. 23, 2023.

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

(52) **U.S. Cl.**
CPC **H01Q 9/0414** (2013.01); **H01Q 1/22** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/0414; H01Q 1/22; H01Q 9/045; H01Q 1/2283; H01Q 1/243
See application file for complete search history.

(56) **References Cited**

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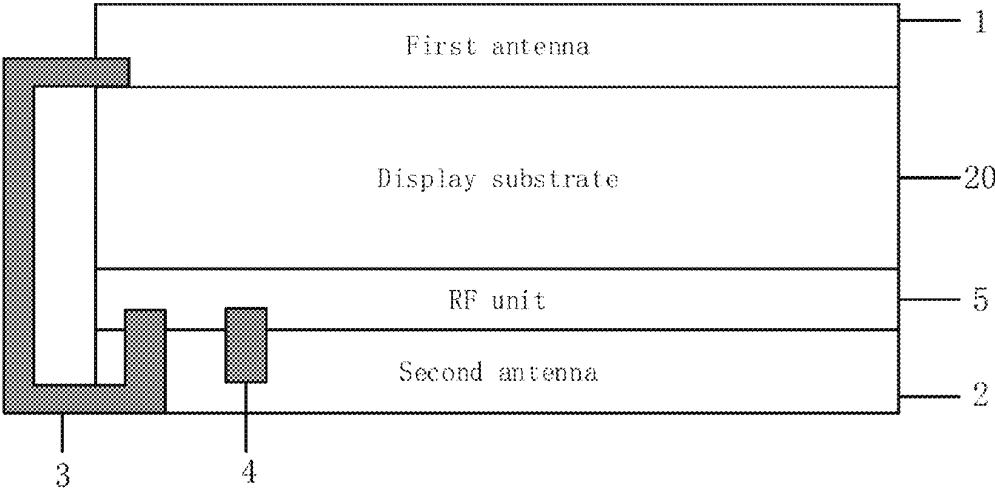
Office Action dated Nov. 13, 2025, issued in counterpart CN Application No. 202380008430.5, with English translation. (16 pages).

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

(57) **ABSTRACT**

An is applied in the display device and includes a first antenna, a first transmission structure, a second antenna, a second transmission structure, and a radio frequency unit; the first antenna is electrically connected to the radio frequency unit at least through the first transmission structure, and the second antenna is electrically connected to the radio frequency unit through the second transmission structure; when the antenna module is applied in a display device, the first antenna is located on the display surface side of the display device, and the second antenna is located on a side of the display device away from the display surface side.

19 Claims, 14 Drawing Sheets





US012689126B2

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

(10) **Patent No.:** **US 12,689,126 B2**
(45) **Date of Patent:** **Jul. 21, 2026**

(54) **ELECTRONIC DEVICE HAVING ANTENNA WITH VENT STRUCTURES**

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

(72) Inventors: **Yiren Wang**, Cupertino, CA (US); **Yuan Tao**, Santa Clara, CA (US); **Hao Xu**, Cupertino, CA (US); **Yuancheng Xu**, San Jose, CA (US); **Enrique Ayala Vazquez**, Watsonville, CA (US); **Nikolaj P Kammersgaard**, Copenhagen (DK); **Eric W Bates**, San Jose, CA (US); **Peter A Dvorak**, Menlo Park, CA (US); **Victor C Lee**, Santa Clara, CA (US); **Han Wang**, Campbell, 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 309 days.

(21) Appl. No.: **18/458,811**

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

(65) **Prior Publication Data**
US 2024/0079785 A1 Mar. 7, 2024

Related U.S. Application Data

(60) Provisional application No. 63/404,100, filed on Sep. 6, 2022.

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

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

(58) **Field of Classification Search**

CPC H01Q 9/0421; H01Q 1/243; H01Q 9/42; H01Q 1/36; H01Q 1/02; H01Q 1/22; H01Q 1/241; H01Q 1/48; H01Q 1/50; H01Q 13/10; H01Q 23/00; H01R 12/78; H05K 7/20127

See application file for complete search history.

(56) **References Cited**

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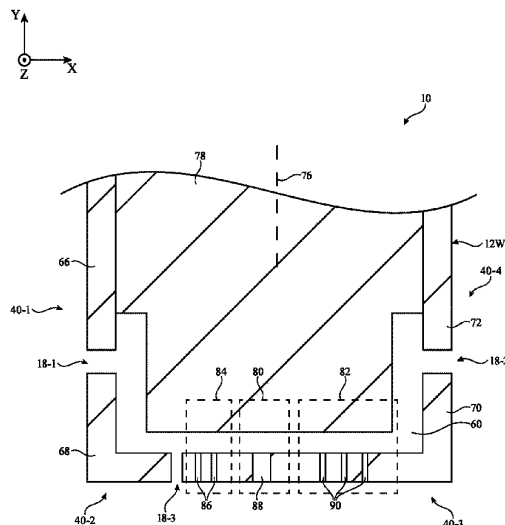
Primary Examiner — Amr A Awad

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

(57) **ABSTRACT**

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

20 Claims, 10 Drawing Sheets





US012695175B2

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

(10) **Patent No.:** **US 12,695,175 B2**
(45) **Date of Patent:** **Jul. 28, 2026**

(54) **PORTABLE TERMINAL SUPPORTING
SHORT-RANGE COMMUNICATION FROM
TOP AND BACK**

(71) Applicant: **AMOTECH CO., LTD.**, Incheon (KR)

(72) Inventors: **Jinwon Noh**, Incheon (KR); **Jooseung
Maeng**, Incheon (KR)

(73) Assignee: **AMOTECH CO., LTD.**, Incheon (KR)

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

(21) Appl. No.: **18/875,125**

(22) PCT Filed: **Jun. 13, 2023**

(86) PCT No.: **PCT/KR2023/008090**

§ 371 (c)(1),

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

(87) PCT Pub. No.: **WO2023/243980**

PCT Pub. Date: **Dec. 21, 2023**

(65) **Prior Publication Data**

US 2025/0364715 A1 Nov. 27, 2025

(30) **Foreign Application Priority Data**

Jun. 15, 2022 (KR) 10-2022-0072502

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

H01Q 7/00 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 7/00**
(2013.01)

(58) **Field of Classification Search**

CPC . H01Q 1/243; H01Q 7/00; H04B 5/26; H04B
5/43

See application file for complete search history.

(56) **References Cited**

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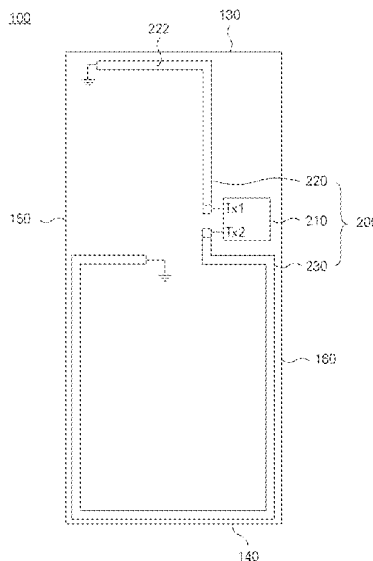
Primary Examiner — Daniel Munoz

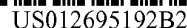
(74) *Attorney, Agent, or Firm* — Maschoff Brennan

(57) **ABSTRACT**

The present disclosure presents a portable terminal which has antennas connected to first and second transmission ends of an NFC chipset, respectively, to enable short-range communication from the top and the back of the portable terminal. The presented portable terminal comprises: the NFC chipset having the first transmission end and the second transmission end; a first antenna connected to the first transmission end and having a region disposed parallel to the top of the portable terminal; and a second antenna connected to the second transmission end and having a loop disposed parallel to the back of the portable terminal.

12 Claims, 13 Drawing Sheets





(10) **Patent No.:** US 12,695,192 B2
(45) **Date of Patent:** Jul. 28, 2026

(58) **Field of Classification Search**

CPC H01Q 7/00; H01Q 1/22; H01Q 1/243;
H01Q 1/38; H01Q 1/48; H01Q 5/30–35;
H01Q 13/10

See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Hasan Islam

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

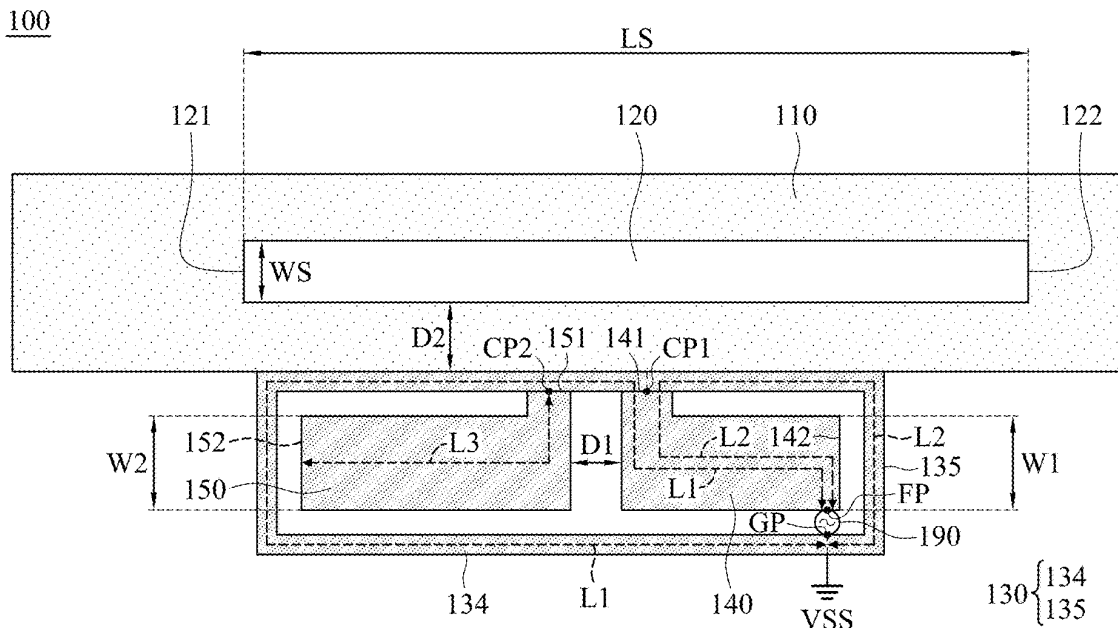
(57) **ABSTRACT**

A communication device includes a metal mechanism element, a loop radiation element, a first radiation element, and a second radiation element. The metal mechanism element has a slot. The loop radiation element is coupled to the metal mechanism element. The first radiation element has a feeding point. The first radiation element is coupled to a first connection point on the loop radiation element. The second radiation element is coupled to a second connection point on the loop radiation element. Both the first radiation element and the second radiation element are disposed inside the loop radiation element. An antenna structure is formed by the metal mechanism element, the loop radiation element, the first radiation element, and the second radiation element.

21 Claims, 5 Drawing Sheets

(51) **Int. Cl.**
H01Q 1/22 (2006.01)
H01Q 7/00 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 7/00** (2013.01); **H01Q 1/2291**
(2013.01)





US012700671B2

(12) **United States Patent**
Yong

(10) **Patent No.:** **US 12,700,671 B2**
(45) **Date of Patent:** **Aug. 4, 2026**

(54) **ANTENNA ASSEMBLY, DUAL-FREQUENCY WIDEBAND ANTENNA, AND ELECTRONIC DEVICE**

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

(72) Inventor: **Zhengdong Yong**, 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 24 days.

(21) Appl. No.: **18/817,088**

(22) Filed: **Aug. 27, 2024**

(65) **Prior Publication Data**
US 2024/0429603 A1 Dec. 26, 2024

Related U.S. Application Data
(63) Continuation of application No. PCT/CN2022/140156, filed on Dec. 19, 2022.

(30) **Foreign Application Priority Data**
Mar. 10, 2022 (CN) 202210234322.7

(51) **Int. Cl.**
H01Q 5/25 (2015.01)
H01Q 1/48 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 5/25** (2015.01); **H01Q 1/48** (2013.01); **H01Q 5/50** (2015.01); **H01Q 9/0414** (2013.01); **H01Q 9/26** (2013.01); **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**
CPC .. H01Q 5/25; H01Q 1/48; H01Q 5/50; H01Q 9/0414; H01Q 9/26; H01Q 9/42;
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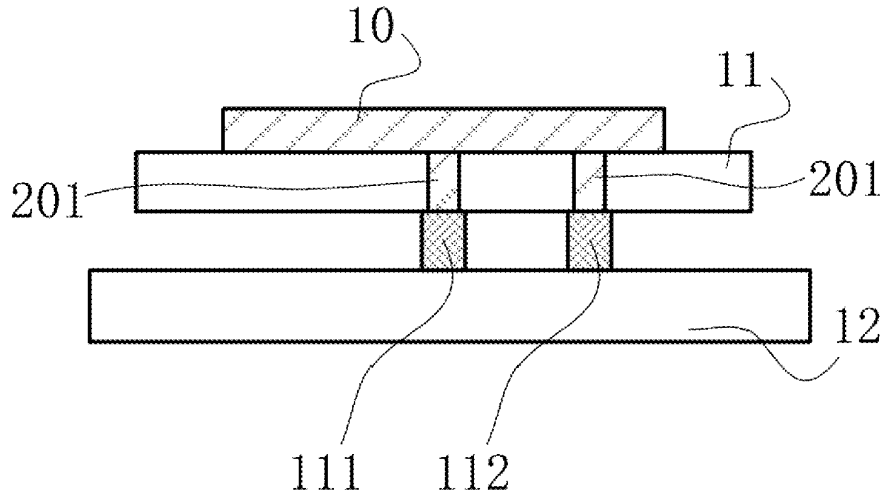
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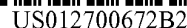
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Primary Examiner — Seung H Lee
(74) *Attorney, Agent, or Firm* — Ladas & Parry, LLP

(57) **ABSTRACT**
An antenna assembly, a dual-frequency wideband antenna, and an electronic device are provided. The antenna assembly includes an antenna radiator, a grounding point, and a feeding point. The grounding point is arranged on a middle portion of the antenna radiator. The feeding point is arranged on the antenna radiator and spaced from the grounding point. The feeding point is fed by a feeding source, such that the antenna radiator supports a first frequency band and a second frequency band. The first frequency band is different from the second frequency band.

16 Claims, 11 Drawing Sheets





(10) **Patent No.:** US 12,700,672 B2
(45) **Date of Patent:** Aug. 4, 2026

(58) **Field of Classification Search**

CPC H01Q 5/378; H01Q 1/38; H01Q 13/08;
H01Q 5/385

(56) **References Cited**

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(2) Date: **Jun. 27, 2024**

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Jun. 20, 2024, International Preliminary Report on Patentability
issued in International Patent Application No. PCT/JP2022/048366.

US 2025/0105515 A1 Mar. 27, 2025

Primary Examiner — Dameon E Levi

Assistant Examiner — Jordan E. DeWitt

(74) *Attorney, Agent, or Firm* — Oliff PLC

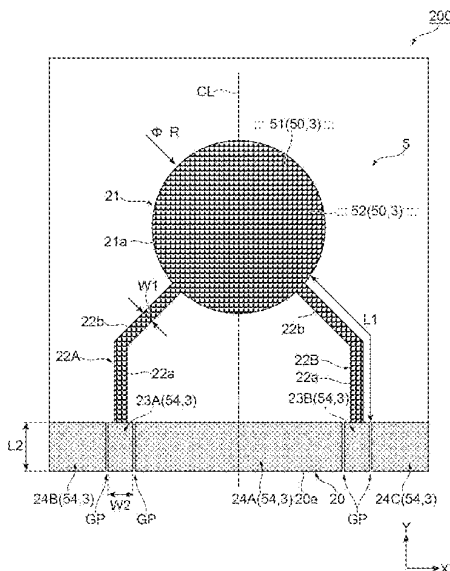
Dec. 28, 2021 (JP) 2021-214184

(57) **ABSTRACT**

An antenna includes a radiation conductor having a circular shape, a feed line configured to feed power to the radiation conductor, and a terminal connected to the feed line, in which impedance of the feed line is greater than impedance of a feed point of the terminal, and a line length of the feed line is longer than a radius of the radiation conductor.

(52) **U.S. Cl.**
CPC *H01Q 5/378* (2015.01); *H01Q 1/38*
(2013.01); *H01Q 13/08* (2013.01)

13 Claims, 14 Drawing Sheets





US012700674B2

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

(10) **Patent No.:** **US 12,700,674 B2**
(45) **Date of Patent:** **Aug. 4, 2026**

(54) **ANTENNA ASSEMBLY AND ANTENNA ARRAY**

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

(72) Inventors: **Chien-Yi Wu**, Taipei City (TW);
Tse-Hsuan Wang, Taipei City (TW);
Chih-Fu Chang, Taipei City (TW);
Hsin-Feng Hsieh, Taipei City (TW);
Wu-Hua Chen, Taipei City (TW);
Chih-Wei Liao, Taipei City (TW);
Chao-Hsu Wu, Taipei City (TW)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 47 days.

(21) Appl. No.: **18/679,295**

(22) Filed: **May 30, 2024**

(65) **Prior Publication Data**
US 2025/0087888 A1 Mar. 13, 2025

(30) **Foreign Application Priority Data**
Sep. 7, 2023 (TW) 112134122

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 1/48 (2006.01)
H01Q 21/06 (2006.01)
H01Q 21/24 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 9/0414** (2013.01); **H01Q 1/48** (2013.01); **H01Q 21/065** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/22; H01Q 1/2283; H01Q 1/38;
H01Q 1/48; H01Q 9/04; H01Q 9/0407;
H01Q 9/0414; H01Q 9/045; H01Q
9/0457; H01Q 9/042; H01Q 13/10; H01Q
13/106; H01Q 21/065; H01Q 21/24
See application file for complete search history.

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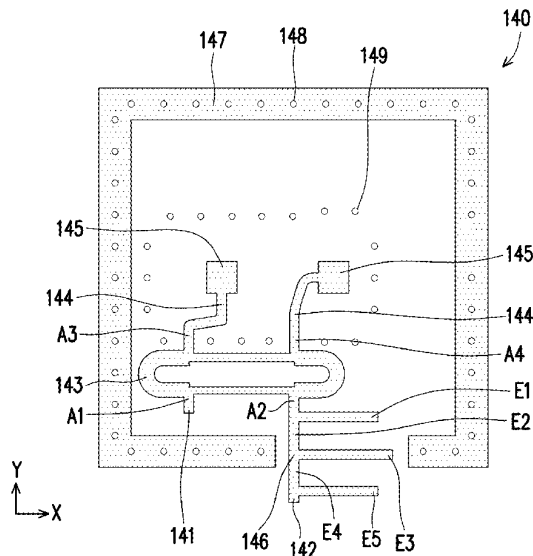
Primary Examiner — Thai Pham

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

(57) **ABSTRACT**

An antenna assembly includes a patch antenna, a metal layer, and a feed-in signal layer. The metal layer is disposed on a side of the patch antenna and includes a first slot and a second slot. The feed-in signal layer is disposed on a side of the metal layer opposite the second antenna and includes a transmitting port, a receiving port, a hybrid coupler, and two microstrips. The transmitting port and the receiving port are connected to the hybrid coupler, and the two microstrips are extended in the direction away from the hybrid coupler. Projections of two ends of the two microstrips onto the metal layer are overlapped with the first slot and the second slot. An antenna array is also mentioned.

11 Claims, 20 Drawing Sheets





US012700675B2

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

(10) **Patent No.:** **US 12,700,675 B2**
(45) **Date of Patent:** **Aug. 4, 2026**

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

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

(72) Inventors: **Naida Zhu**, Shenzhen (CN); **Pengfei Wu**, Shanghai (CN); **Yu Yao**, Shanghai (CN); **Youquan Wu**, 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 0 days.

(21) Appl. No.: **18/881,187**

(22) PCT Filed: **Jun. 30, 2023**

(86) PCT No.: **PCT/CN2023/104915**

§ 371 (c)(1),

(2) Date: **Jan. 3, 2025**

(87) PCT Pub. No.: **WO2024/007996**

PCT Pub. Date: **Jan. 11, 2024**

(65) **Prior Publication Data**

US 2026/0011923 A1 Jan. 8, 2026

(30) **Foreign Application Priority Data**

Jul. 7, 2022 (CN) 202210802163.6

(51) **Int. Cl.**

H01Q 9/04 (2006.01)

H01Q 5/307 (2015.01)

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

CPC **H01Q 9/0421** (2013.01); **H01Q 5/307**

(2015.01); **H01Q 9/0414** (2013.01)

(58) **Field of Classification Search**

CPC **H01Q 9/0421**; **H01Q 5/307**; **H01Q 9/0414**;

H01Q 5/385; **H01Q 1/38**; **H01Q 19/005**

See application file for complete search history.

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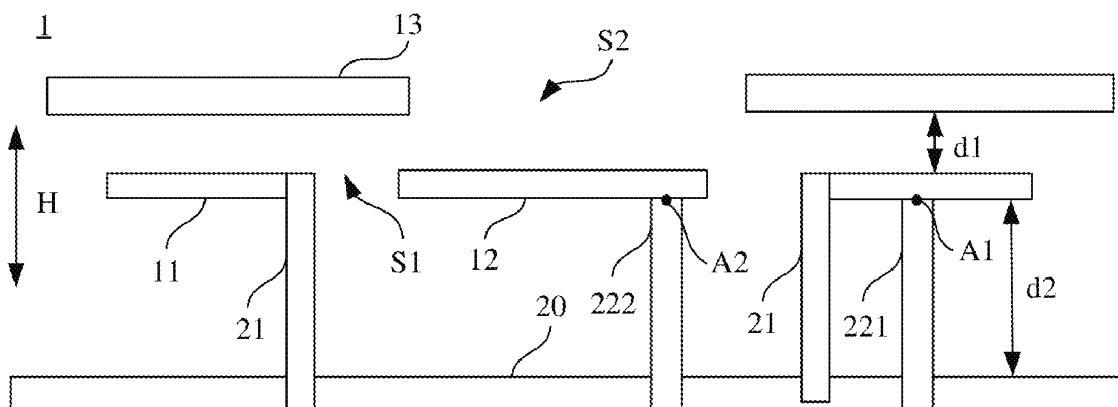
Primary Examiner — Dieu Hien T Duong

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

(57) **ABSTRACT**

Antenna elements and electronic devices are provided, including an antenna element includes a first radiator, a second radiator, and a radiator array. The first radiator is connected to a ground plane through a grounding component, the second radiator is spaced from the ground plane and disposed opposite to the ground plane, and the second radiator and the first radiator are spaced apart. The radiator array is spaced from the first radiator and disposed opposite to the first radiator, and is located on a side that is of the first radiator and that is further from the ground plane. The radiator array includes at least two sub-radiators, and the at least two sub-radiators are spaced from each other in an extension direction of a plane on which the radiator array is located. The first radiator includes a first hollow region, and the radiator array includes a second hollow region.

20 Claims, 12 Drawing Sheets





US012700678B2

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

(10) **Patent No.:** **US 12,700,678 B2**
(45) **Date of Patent:** **Aug. 4, 2026**

(54) **ELECTRONIC DEVICE INCLUDING ANTENNA**

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

(72) Inventors: **Jiho Kim**, Suwon-si (KR); **Sumin Yun**,
Suwon-si (KR); **Hyeonuk Kang**,
Suwon-si (KR); **Kyungmoon Seol**,
Suwon-si (KR); **Seongyong An**,
Suwon-si (KR); **Kyihyun Jang**,
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 0 days.

(21) Appl. No.: **18/323,738**

(22) PCT Filed: **Nov. 29, 2021**

(86) PCT No.: **PCT/KR2021/017770**

§ 371 (c)(1),

(2) Date: **Oct. 14, 2025**

(87) PCT Pub. No.: **WO2022/114896**

PCT Pub. Date: **Jun. 2, 2022**

(65) **Prior Publication Data**

US 2024/0113441 A1 Apr. 4, 2024

(30) **Foreign Application Priority Data**

Nov. 30, 2020 (KR) 10-2020-0165013

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

(52) **U.S. Cl.**
CPC **H01Q 13/10** (2013.01); **H01Q 1/243**
(2013.01)

(58) **Field of Classification Search**

CPC H01Q 13/10; H01Q 1/243; H01Q 1/24;
H01Q 1/38; H01Q 13/18
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Dameon E Levi

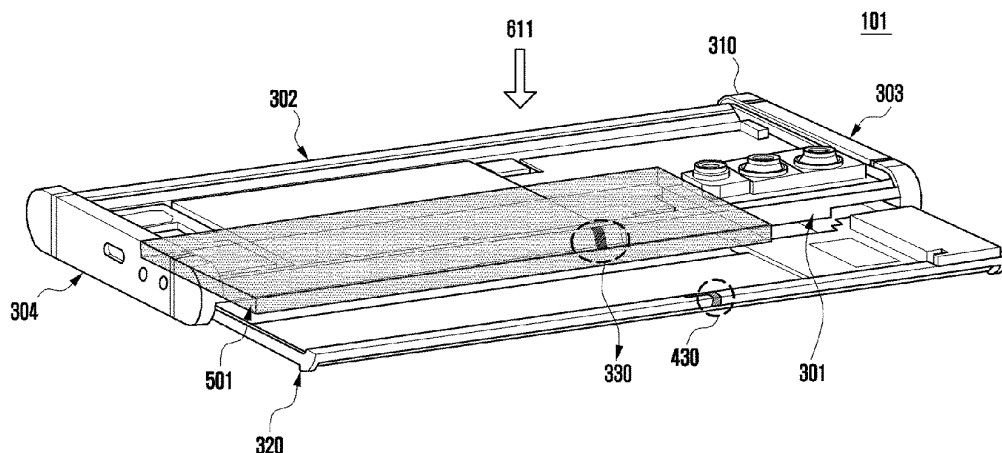
Assistant Examiner — Jordan E. DeWitt

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

(57) **ABSTRACT**

An electronic device including an antenna is provided. The electronic device includes a housing and a sliding plate, wherein: the housing comprises an antenna circuit unit arranged on a side surface corresponding to the sliding operation direction of the sliding plate, and a contact unit for electrically connecting the housing and the sliding plate, wherein the antenna circuit unit further includes, as a radiator, at least one frame arranged on the side surface, wherein the housing and the plate form a space, and wherein the space, the contact unit, and the antenna circuit unit can form a cavity antenna.

16 Claims, 15 Drawing Sheets





US012700680B2

(12) **United States Patent**
Sato

(10) **Patent No.:** **US 12,700,680 B2**
(45) **Date of Patent:** **Aug. 4, 2026**

(54) **ANTENNA MODULE AND
COMMUNICATION APPARATUS
INCLUDING THE SAME**

(56) **References Cited**

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

11,335,991 B2 * 5/2022 Kim H01Q 1/2283
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(72) Inventor: **Yosuke Sato**, Nagaokakyo (JP)

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

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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 193 days.

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(21) Appl. No.: **18/796,323**

International Search Report and Written Opinion mailed on Feb. 14,
2023, received for PCT Application PCT/JP2022/046654, filed on
Dec. 19, 2022, 11 pages including English Translation.

(22) Filed: **Aug. 7, 2024**

(65) **Prior Publication Data**

US 2024/0396232 A1 Nov. 28, 2024

Primary Examiner — Ab Salam Alkassim, Jr.

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

Related U.S. Application Data

(63) Continuation of application No.
PCT/JP2022/046654, filed on Dec. 19, 2022.

(30) **Foreign Application Priority Data**

Feb. 16, 2022 (JP) 2022-022340

(57) **ABSTRACT**

An antenna module that includes dielectric substrates, radiating elements that are of a plate shape and disposed in or on the dielectric substrates, ground electrodes, and a peripheral electrode. The ground electrode is disposed in or on the dielectric substrate to face the radiating element. The ground electrode is disposed in or on the dielectric substrate to face the radiating element and is electrically connected to the ground electrode. The peripheral electrode is disposed in a layer, in the dielectric substrate, between the ground electrode and the radiating element and is electrically connected to the ground electrode. A direction normal to the radiating element is a first direction from the ground electrode toward the radiating element. A direction normal to the radiating element is a second direction different from the first direction. The peripheral electrode extends from the ground electrode in the first direction.

(51) **Int. Cl.**
H01Q 21/06 (2006.01)
H01Q 1/22 (2006.01)

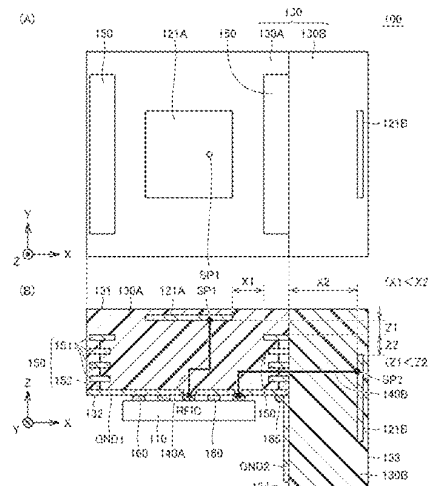
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 21/065** (2013.01); **H01Q 1/2283**
(2013.01); **H01Q 1/523** (2013.01); **H01Q**
9/0407 (2013.01); **H01Q 21/24** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/2283; H01Q 1/523; H01Q
9/0407-0492; H01Q 21/065; H01Q
21/24; H01Q 1/521

See application file for complete search history.

20 Claims, 9 Drawing Sheets





US012706372B2

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

(10) **Patent No.:** **US 12,706,372 B2**
(45) **Date of Patent:** **Aug. 11, 2026**

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

(56)

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

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(72) Inventors: **Junwoo Kim**, Suwon-si (KR);
Himchan Yun, Suwon-si (KR);
Cheolhong Son, Suwon-si (KR);
Sangha Lee, Suwon-si (KR); **Soonho Hwang**, Suwon-si (KR)

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(73) Assignee: **SAMSUNG ELECTRONICS CO., LTD.**, Gyeonggi-Do (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 353 days.

The extended European search report for EP 22756473.9 mailed on Jun. 28, 2024.

(Continued)

(21) Appl. No.: **18/451,840**

(22) Filed: **Aug. 18, 2023**

Primary Examiner — Zhitong Chen

(65) **Prior Publication Data**

US 2023/0395970 A1 Dec. 7, 2023

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

Related U.S. Application Data

(63) Continuation of application No. PCT/KR2022/002248, filed on Feb. 16, 2022.

(57)

ABSTRACT

(30) **Foreign Application Priority Data**

Feb. 18, 2021 (KR) 10-2021-0022056

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

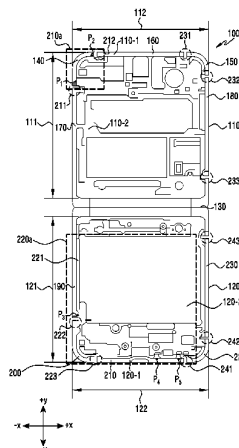
(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H04M 1/026** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/2291; H01Q 9/42;
H01Q 1/24; H01Q 1/46; H04M 1/026;
H04M 1/0214; H04M 1/0249; G09F
9/301

An electronic apparatus includes: a first housing; a second housing rotatably connected to the first housing; an opening formed along a third edge of the second housing; a switch located on a path that connects the opening and a ground region; and a wireless communication circuit. The first housing includes a first edge extending in a first direction and a second edge extending in a second direction. The second housing includes the third edge corresponding to the first edge and a fourth edge corresponding to the second edge when the first and second housings face each other. Parts of the first and second edge are made of a conductive material. When the first housing and the second housing face each other, the wireless communication circuit feeds power to the conductive material and controls the switch to electrically short-circuit the third edge and the ground region.

See application file for complete search history.

18 Claims, 34 Drawing Sheets





US012706386B2

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

(10) **Patent No.:** **US 12,706,386 B2**
(45) **Date of Patent:** **Aug. 11, 2026**

(54) **PATCH ANTENNA, OMNIDIRECTIONAL ANTENNA ARRAY AND COPLANAR RADIATING ANTENNA ARRAY INCLUDING THE SAME**

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

(72) Inventors: **Bingyang Liu**, Beijing (CN); **Jia Fang**, Beijing (CN); **Yiqun Hu**, Beijing (CN); **Ying Ding**, Beijing (CN)

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

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

(21) Appl. No.: **18/996,700**

(22) PCT Filed: **May 14, 2024**

(86) PCT No.: **PCT/CN2024/093079**
§ 371 (c)(1),
(2) Date: **Jan. 17, 2025**

(87) PCT Pub. No.: **WO2024/260153**
PCT Pub. Date: **Dec. 26, 2024**

(65) **Prior Publication Data**
US 2026/0039020 A1 Feb. 5, 2026

(30) **Foreign Application Priority Data**
Jun. 21, 2023 (CN) 202310745904.6

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 21/06 (2006.01)
H01Q 21/20 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 9/0414** (2013.01); **H01Q 9/045** (2013.01); **H01Q 21/065** (2013.01); **H01Q 21/205** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/0414; H01Q 9/045; H01Q 1/38; H01Q 1/50; H01Q 21/065
See application file for complete search history.

(56) **References Cited**

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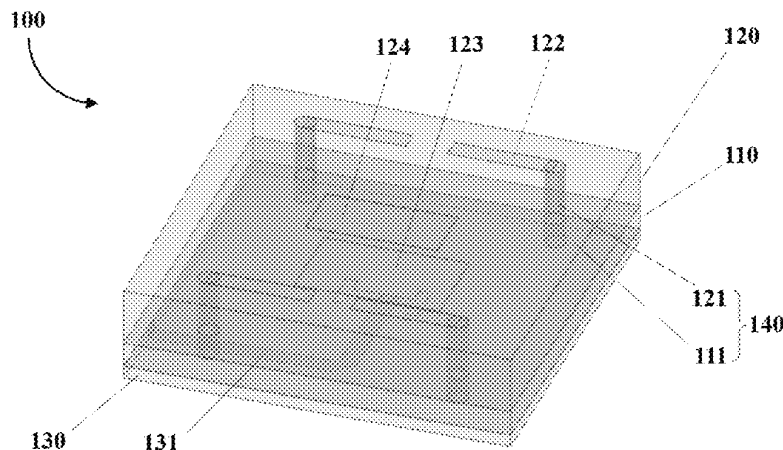
Primary Examiner — Daniel Munoz

(74) *Attorney, Agent, or Firm* — Myers Bigel, P.A.

(57) **ABSTRACT**

The present disclosure provides a patch antenna including stacked first and second insulating medium substrates, and a radiating patch is provided on the second insulating medium substrate. The patch antenna further includes a plurality of strip-shaped metal structures, each passing through the first and second insulating medium substrates, a first end thereof being electrically connected with the metal layer and a second end thereof being attached to a metal sheet. At least two strip-shaped metal structures are located at a first side of the radiating patch, and at least two strip-shaped metal structures are located at an opposite second side. Metal sheets attached to two strip-shaped metal structures that are farthest apart from each other and located at a same side are

(Continued)





US012706387B2

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

(10) **Patent No.:** **US 12,706,387 B2**
(45) **Date of Patent:** **Aug. 11, 2026**

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

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

(72) Inventors: **Sho Suzuki**, Nagaokakyo (JP); **Kengo
Onaka**, Nagaokakyo (JP)

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

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 110 days.

(21) Appl. No.: **18/743,184**

(22) Filed: **Jun. 14, 2024**

(65) **Prior Publication Data**
US 2024/0332810 A1 Oct. 3, 2024

Related U.S. Application Data

(63) Continuation of application No.
PCT/JP2022/046172, filed on Dec. 15, 2022.

(30) **Foreign Application Priority Data**

Dec. 21, 2021 (JP) 2021-207284

(51) **Int. Cl.**
H01Q 13/08 (2006.01)
H01Q 5/35 (2015.01)
H01Q 21/06 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 13/08** (2013.01); **H01Q 5/35**
(2015.01); **H01Q 21/06** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 13/08; H01Q 5/35; H01Q 21/06;
H01Q 5/40; H01Q 9/0407; H01Q 1/243;
H01Q 9/42; H01Q 21/28
See application file for complete search history.

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Dec. 15, 2022, 8 pages including English Translation.

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Primary Examiner — Jason M Crawford

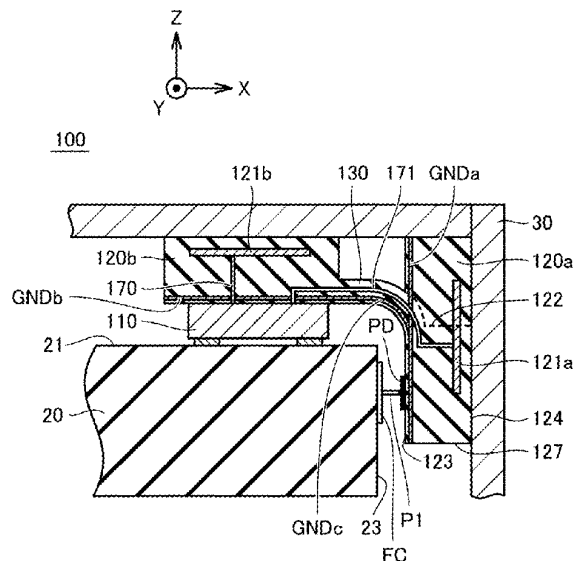
Assistant Examiner — Jose A. Miranda Gonzalez

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

(57) **ABSTRACT**

An antenna module that includes a bent portion and a first
flat portion. The first flat portion has a connection surface
connected to the bent portion, a back surface intersecting the
connection surface, a power feed pad connected to a flexible
cable, a first ground electrode, and a radiating element. The
first ground electrode is connected to a second ground
electrode of the bent portion on the connection surface and
is connected to the power feed pad.

21 Claims, 15 Drawing Sheets





US012706391B2

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

(10) **Patent No.:** **US 12,706,391 B2**
(45) **Date of Patent:** **Aug. 11, 2026**

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

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

(72) Inventors: **Seungmin Woo**, Seoul (KR); **Yusuhk
Suh**, Seoul (KR); **Dongik Lee**, Seoul
(KR)

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

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

(21) Appl. No.: **19/141,723**

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

(86) PCT No.: **PCT/KR2022/021094**

§ 371 (c)(1),

(2) Date: **Jun. 20, 2025**

(87) PCT Pub. No.: **WO2024/135890**

PCT Pub. Date: **Jun. 27, 2024**

(65) **Prior Publication Data**

US 2026/0121300 A1 Apr. 30, 2026

(51) **Int. Cl.**
H01Q 15/24 (2006.01)
H01Q 1/22 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 15/24** (2013.01); **H01Q 1/22**
(2013.01); **H01Q 1/526** (2013.01); **H01Q**
9/0414 (2013.01); **H01Q 21/06** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 15/24; H01Q 1/22; H01Q 1/526;
H01Q 9/0414; H01Q 21/06
See application file for complete search history.

(56) **References Cited**

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tional Search Report dated Sep. 18, 2023, 4 pages.

Primary Examiner — Regis J Betsch

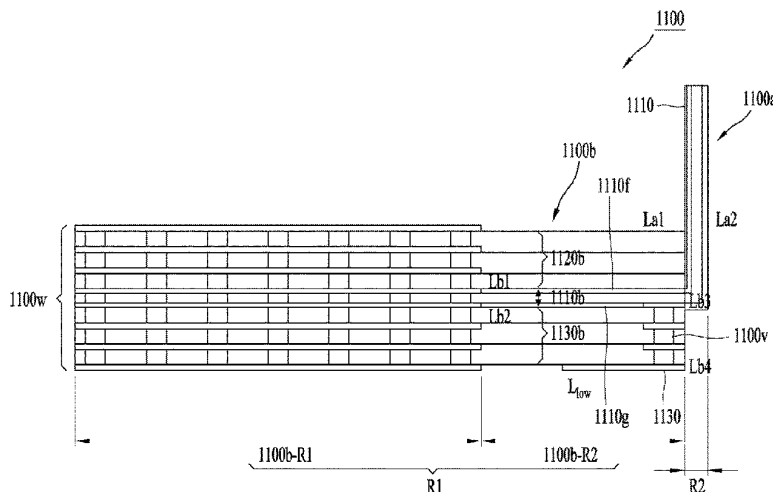
Assistant Examiner — Jose A. Miranda Gonzalez

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

(57) **ABSTRACT**

This antenna module may comprise a multi-layer substrate
composed of a plurality of dielectrics, and conductive pat-
terns. The multi-layer substrate includes: a first layer made
of a flexible first material; second layers, which are formed
on one side surface of the first layer and are composed of a
plurality of layers made of a stiff second material; and third
layers, which are formed on the other side surface of the first
layer and are composed of a plurality of layers made of the
stiff second material. The conductive patterns includes: a
first conductive pattern formed on the one side surface in
first and second regions of the one side surface of the first
layer; a second conductive pattern formed on a lower third
layer; and a third conductive pattern formed on a lower
fourth layer. The second and third conductive patterns can be
connected through via holes.

20 Claims, 30 Drawing Sheets





US012706630B2

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

(10) **Patent No.:** **US 12,706,630 B2**
(45) **Date of Patent:** **Aug. 11, 2026**

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

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

(72) Inventors: **Jaehyung Kim**, Suwon-si (KR);
Cheolhong Son, Suwon-si (KR);
Seunghwan Kim, Suwon-si (KR);
Jaebong Chun, 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 114 days.

(21) Appl. No.: **18/657,181**

(22) Filed: **May 7, 2024**

(65) **Prior Publication Data**
US 2024/0333331 A1 Oct. 3, 2024

Related U.S. Application Data
(63) Continuation of application No.
PCT/KR2024/003717, filed on Mar. 25, 2024.

(30) **Foreign Application Priority Data**
Mar. 27, 2023 (KR) 10-2023-0039693
Apr. 19, 2023 (KR) 10-2023-0051219

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/50 (2015.01)
H04B 1/40 (2015.01)

(52) **U.S. Cl.**
CPC **H04B 1/40** (2013.01); **H01Q 5/50**
(2015.01); **H01Q 1/241** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/24; H01Q 1/241; H01Q 1/243;
H01Q 1/38; H01Q 1/42; H01Q 5/50;
(Continued)

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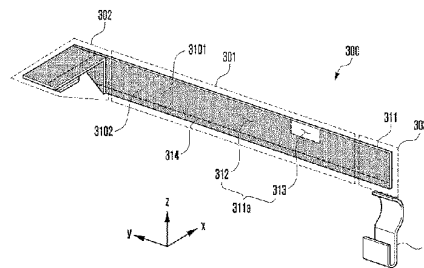
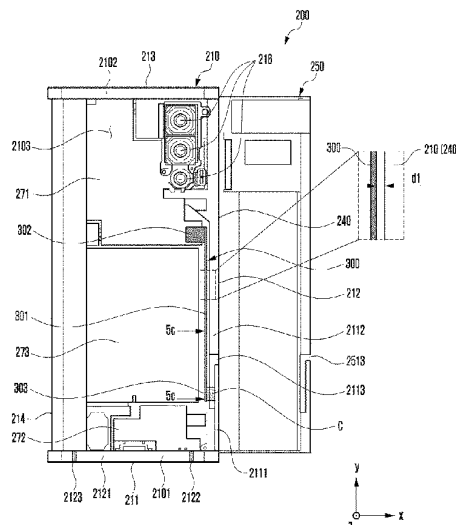
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Primary Examiner — Thai Pham
(74) *Attorney, Agent, or Firm* — Nixon & Vanderhye P.C.

(57) **ABSTRACT**
According to various embodiments, an electronic device
may include: a housing comprising a conductive portion and
non-conductive portion forming a portion of an exterior side
surface, a circuit board disposed in the housing, a commu-
nication circuit disposed on the circuit board, and a connec-
tion circuit board electrically connecting the communication
circuit to the conductive portion, wherein the connection
circuit board may comprise a first layer including a conduc-
tive area and a non-conductive area, the non-conductive area
being located within a proximity of the non-conductive
portion, and the communication circuit may be configured to
transmit or receive signals via the conductive portion.

18 Claims, 30 Drawing Sheets





US012712254B2

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

(10) **Patent No.:** **US 12,712,254 B2**
(45) **Date of Patent:** **Aug. 18, 2026**

(54) **ANTENNA MODULE AND PORTABLE
ELECTRIC DEVICE USING THE SAME**

(71) Applicant: **QuantumZ Inc.**, Kaohsiung City (TW)

(72) Inventors: **Kun Yen Tu**, Kaohsiung City (TW);
Po-Ting Chen, Kaohsiung City (TW);
Sin-Siang Wang, Kaohsiung City
(TW); **Wei Ting Lee**, Kaohsiung City
(TW)

(73) Assignee: **QuantumZ Inc.**, Kaohsiung City (TW)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 117 days.

(21) Appl. No.: **18/749,581**

(22) Filed: **Jun. 20, 2024**

(65) **Prior Publication Data**

US 2025/0023223 A1 Jan. 16, 2025

Related U.S. Application Data

(60) Provisional application No. 63/513,357, filed on Jul.
13, 2023.

(51) **Int. Cl.**

H01Q 1/22 (2006.01)
H01Q 1/38 (2006.01)
H05K 1/02 (2006.01)
H05K 1/03 (2006.01)
H01Q 15/14 (2006.01)

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

CPC **H01Q 1/22** (2013.01); **H01Q 1/38**
(2013.01); **H05K 1/028** (2013.01); **H05K**
1/032 (2013.01); **H01Q 15/14** (2013.01);
H05K 2201/0141 (2013.01); **H05K**
2201/10098 (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/22; H01Q 1/38; H01Q 15/14;
H01Q 21/28; H01Q 1/243; H01Q 23/00;
H05K 1/028; H05K 1/032; H05K
2201/0141; H05K 2201/10098

See application file for complete search history.

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Primary Examiner — Seung H Lee

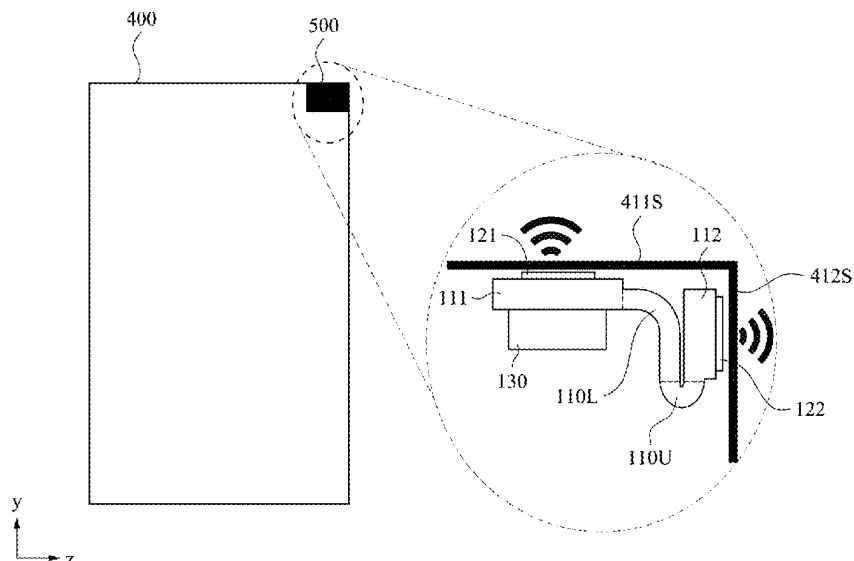
(74) *Attorney, Agent, or Firm* — CKC & Partners Co.,
LLC

(57)

ABSTRACT

An antenna module and a portable electric device are provided. The antenna module includes a flexible substrate, a first antenna circuit and a second antenna circuit. Each of an L-shaped bent portion and a U-shaped bent portion of the flexible substrate has a first end and a second end opposite to each other. The first end of the L-shaped bent portion is connected to a first main body of the flexible substrate. The first end of the U-shaped bent portion is connected to the second end of the L-shaped bent portion. The second end of the U-shaped bent portion is connected to a second main body of the flexible substrate. The first antenna circuit and the second antenna circuit are respectively disposed on the first main body and the second main portion. The portable electric device includes a casing and the antenna module disposed at a corner.

15 Claims, 6 Drawing Sheets





US012712257B2

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

(10) **Patent No.:** **US 12,712,257 B2**
(45) **Date of Patent:** **Aug. 18, 2026**

(54) **ANTENNA MODULE INCLUDING
STRUCTURE FOR EXTENDING GROUND
AND ELECTRONIC DEVICE INCLUDING
SAME**

(58) **Field of Classification Search**
CPC H01Q 1/2283; H01Q 1/2291; H01Q 1/243;
H01Q 1/38; H01Q 1/521; H01Q 1/526;
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(71) Applicant: **Samsung Electronics Co., Ltd.**,
Suwon-si (KR)

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(72) Inventors: **Sinhyung Jeon**, Suwon-si (KR); **Sanggi
Oh**, Suwon-si (KR); **Jeongnam Cheon**,
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 26 days.

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(21) Appl. No.: **18/908,429**

(22) Filed: **Oct. 7, 2024**

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(65) **Prior Publication Data**
US 2025/0030149 A1 Jan. 23, 2025

International Search Report for PCT /KR2023/003853 mailed Jul. 4,
2023, 5 pages.

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Related U.S. Application Data

(63) Continuation of application No.
PCT/KR2023/003853, filed on Mar. 23, 2023.

Primary Examiner — Ab Salam Alkassim, Jr.

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

(30) **Foreign Application Priority Data**

Apr. 22, 2022 (KR) 10-2022-0049938
May 25, 2022 (KR) 10-2022-0064328

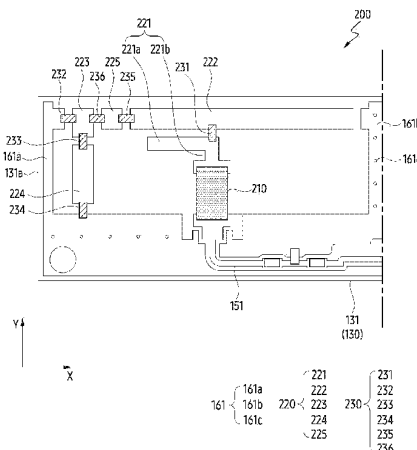
(57) **ABSTRACT**

An electronic device according to an embodiment includes:
a printed circuit board; a first antenna module including at
least one antenna; a second antenna module including at
least one antenna; a Bluetooth module comprising circuitry;
and at least one processor, comprising processing circuitry,
wherein the first antenna module includes: a chip antenna; a
feeding line; at least one first ground area; a set of first
conductive patterns; and a first lumped element comprising
a conductive material, set including a first lumped element,
a second lumped element, a third lumped element, and a
fourth lumped element. A third conductive pattern, fourth
conductive pattern, and the at least one first ground area

(Continued)

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

(52) **U.S. Cl.**
CPC **H01Q 1/2283** (2013.01); **H01Q 1/2291**
(2013.01); **H01Q 1/243** (2013.01);
(Continued)





US012712270B2

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

(10) **Patent No.:** **US 12,712,270 B2**
(45) **Date of Patent:** **Aug. 18, 2026**

(54) **MULTIPLE PIFA/IFA TYPE ANTENNAS
OPERATING AT THE SAME FREQUENCY
INCLUDING SHORT PINS TO MINIMIZE
ANTENNA SEPARATION**

(71) Applicant: **Plume Design, Inc.**, Palo Alto, CA
(US)

(72) Inventors: **Miroslav Samardzija**, Mountain View,
CA (US); **Cosan Caglayan**, San Mateo,
CA (US); **Isaac Wang**, Taoyuan City
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CA (US)

(73) Assignee: **PLUME DESIGN, INC.**, Palo Alto,
CA (US)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 101 days.

(21) Appl. No.: **17/977,441**

(22) Filed: **Oct. 31, 2022**

(65) **Prior Publication Data**

US 2024/0145922 A1 May 2, 2024

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H04B 7/0413 (2017.01)

(52) **U.S. Cl.**
CPC **H01Q 9/0414** (2013.01); **H04B 7/0413**
(2013.01)

(58) **Field of Classification Search**
CPC ... H01Q 9/0414; H04B 7/0413; H05K 1/0222
See application file for complete search history.

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Primary Examiner — Dimary S Lopez Cruz

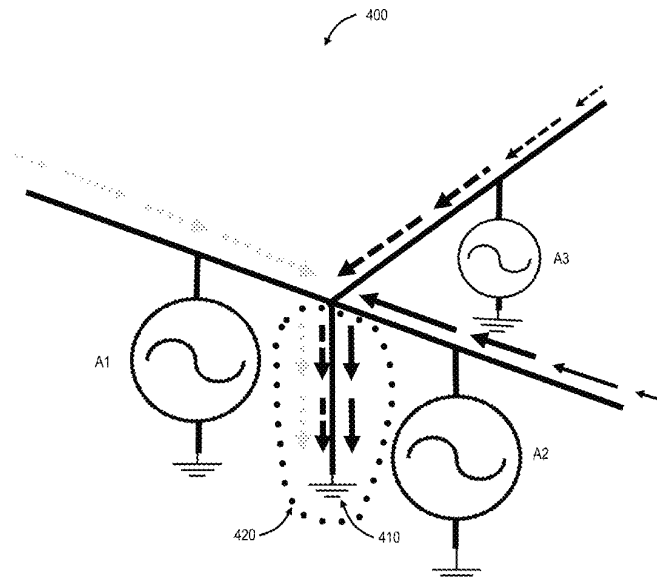
Assistant Examiner — Austin M Back

(74) *Attorney, Agent, or Firm* — Nicholas Martin;
Greenberg Traurig, LLP

(57) **ABSTRACT**

An antenna system includes a plurality of PIFA/IFA type
wherein each of the plurality of antennas have either a same
short pin or different short pins located together to minimize
antenna separation between the plurality of antennas. The
antennas share the same short pin with the width between at
least two antennas of the plurality of antennas designed to
minimize coupling when the at least two antennas operate at
a same frequency. The short pin width is at least $\lambda/8$ where
 λ is based on a lowest frequency of operation of the antenna
system, the lowest frequency of operation is about 2.4 GHz.
The common short pin also includes a minimum distance to
the associated antenna feed. Where the different short pins
are located together the antenna includes a first short pin as
a cylinder and a second short pin located within the cylinder
without contact therebetween.

18 Claims, 18 Drawing Sheets





US012712272B1

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

(10) **Patent No.:** **US 12,712,272 B1**
(45) **Date of Patent:** ***Aug. 18, 2026**

(54) **NOISE-IMMUNE MINIATURIZED ANTENNA**

(71) Applicant: **Amazon Technologies, Inc.**, Seattle, WA (US)

(72) Inventors: **Mohana Vamshi Komandla**, Sunnyvale, CA (US); **Syed Abdullah Nauroze**, Ottawa (CA); **Peruvemba Ranganath Sai Ananthanarayanan**, Fremont, CA (US); **Hariharan Muthukrishnan**, Milpitas, CA (US)

H01Q 1/44; H01Q 1/002; H01Q 1/243;
H01Q 13/106; H01Q 21/28; H01Q 1/24;
H01Q 13/10; H01Q 5/10; H01Q 5/30;
H01Q 5/378; H01Q 7/00; H01Q 1/3233;
H01Q 1/36; H01Q 1/48; H01Q 13/16;
H01Q 13/18; H01Q 13/22; H01Q 21/005;
H01Q 21/20; H01Q 5/335; H01Q 5/42;
H01Q 9/0421

See application file for complete search history.

(73) Assignee: **Amazon Technologies, Inc.**, Seattle, WA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 38 days.

This patent is subject to a terminal disclaimer.

(56)

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Primary Examiner — Monica C King

(74) *Attorney, Agent, or Firm* — K&L Gates LLP

(21) Appl. No.: **18/828,227**

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

Related U.S. Application Data

(63) Continuation of application No. 18/081,566, filed on Dec. 14, 2022, now Pat. No. 12,119,567.

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 5/335 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 9/0421** (2013.01); **H01Q 5/335** (2015.01)

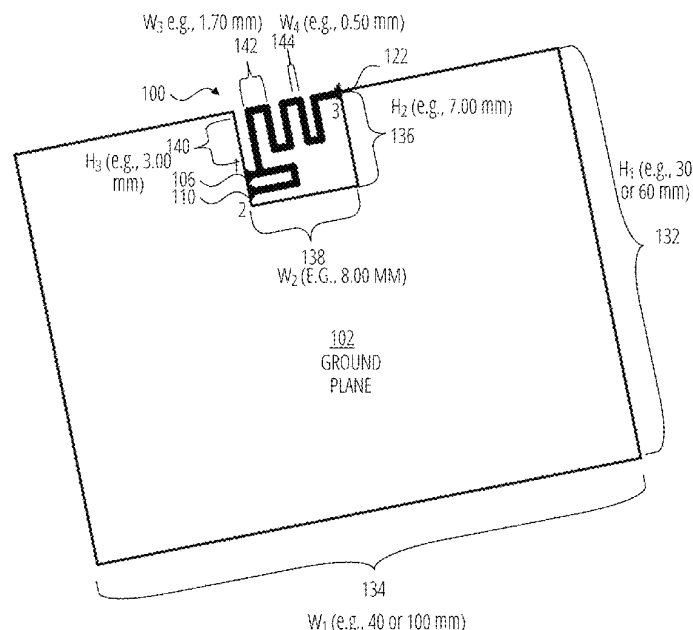
(58) **Field of Classification Search**
CPC H01Q 9/42; H01Q 1/02; H01Q 1/2291;

(57)

ABSTRACT

Technologies directed to a noise-immune miniaturized antenna (NIMA) structure in a main logic board (MLB) and diverting surface currents from the MLB to a metal structure to reduce noise coupling from a chipset on the MLB to the NIMA structure are described. The NIMA structure is located at a side of the MLB and includes a first tuning component coupled to a distal end of a radiating arm of the NIMA structure and a second tuning component coupled to a distal end of a shorting arm of the NIMA structure. The NIMA structure radiates in a first frequency range and a second frequency range. A conductive fastener couples the MLB to a metal structure to divert surface currents from the MLB to the metal structure.

20 Claims, 29 Drawing Sheets





US012712280B2

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

(10) **Patent No.:** **US 12,712,280 B2**
(45) **Date of Patent:** **Aug. 18, 2026**

(54) **PLANAR ANTENNA**

(71) Applicant: **ALPHA NETWORKS INC.**, Hsinchu (TW)

(72) Inventors: **Chih-Yen Lin**, Hsinchu (TW); **Jia-Yan Lin**, Hsinchu (TW)

(73) Assignee: **ALPHA NETWORKS INC.**, Hsinchu (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 39 days.

(21) Appl. No.: **18/928,914**

(22) Filed: **Oct. 28, 2024**

(65) **Prior Publication Data**

US 2025/0385435 A1 Dec. 18, 2025

(30) **Foreign Application Priority Data**

Jun. 17, 2024 (TW) 113122332

(51) **Int. Cl.**
H01Q 13/10 (2006.01)
H01Q 1/48 (2006.01)
H01Q 5/30 (2015.01)
H01Q 9/04 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 13/106** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/30** (2015.01); **H01Q 9/0407** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 13/106; H01Q 1/48; H01Q 5/30; H01Q 9/0407
See application file for complete search history.

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Primary Examiner — Dieu Hien T Duong

(74) *Attorney, Agent, or Firm* — Birch, Stewart, Kolasch & Birch, LLP

(57) **ABSTRACT**

A planar antenna is defined with a first axis having a first direction and a second direction opposite to the first direction and a second axis having a third direction and a fourth direction opposite to the third direction and includes a substrate having a surface on which a first radiation element, a first ground element, a second radiation element, and a second ground element are disposed. An end of a first main section of the first radiation element is for being fed with a signal. The first ground element is on a side of the first radiation element in the second direction. The second radiation element is on a side of the first main section in the third direction. The second ground element is on a side of a second main section of the first ground element in the third direction.

9 Claims, 19 Drawing Sheets

