



US011848477B2

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

(10) **Patent No.:** **US 11,848,477 B2**
(45) **Date of Patent:** **Dec. 19, 2023**

(54) **ELECTRONIC APPARATUS FOR TRANSMITTING SIGNALS THROUGH PLURALITY OF ANTENNAS, AND STRUCTURE THEREFOR**

(52) **U.S. Cl.**
CPC **H01Q 1/523** (2013.01); **H01Q 1/243** (2013.01); **H04B 7/0413** (2013.01); **H04W 88/06** (2013.01)

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

(58) **Field of Classification Search**
CPC H01Q 1/523; H01Q 1/243; H01Q 9/42; H01Q 1/521; H01Q 21/28; H04B 7/0413; (Continued)

(72) Inventors: **Dongju Lee**, Suwon-si (KR); **Bongsup Son**, Suwon-si (KR); **Kyongsun Lee**, Suwon-si (KR); **Wonjin Choi**, Suwon-si (KR); **Jiwoo Lee**, 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 288 days.

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(21) Appl. No.: **17/260,119**

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(22) PCT Filed: **May 15, 2019**

International Search Report for PCT/KR2019/005819 dated Aug. 27, 2019, 5 pages.

(86) PCT No.: **PCT/KR2019/005819**

(Continued)

§ 371 (c)(1),
(2) Date: **Jan. 13, 2021**

Primary Examiner — Hai V Tran
Assistant Examiner — Bamidele A Jegede

(87) PCT Pub. No.: **WO2020/027410**

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

PCT Pub. Date: **Feb. 6, 2020**

(65) **Prior Publication Data**

(57) **ABSTRACT**

US 2021/0288401 A1 Sep. 16, 2021

An electronic device may include a housing including a first conductive portion, a second conductive portion electrically isolated from the first conductive portion, and a third conductive portion electrically isolated from the first conductive portion and the second conductive portion, a first wireless communication circuit disposed in the space and to transmit or receive a first signal and a second signal, which have a frequency in a first frequency range, through Multiple Input Multiple Output (MIMO) using the first conductive portion

(30) **Foreign Application Priority Data**

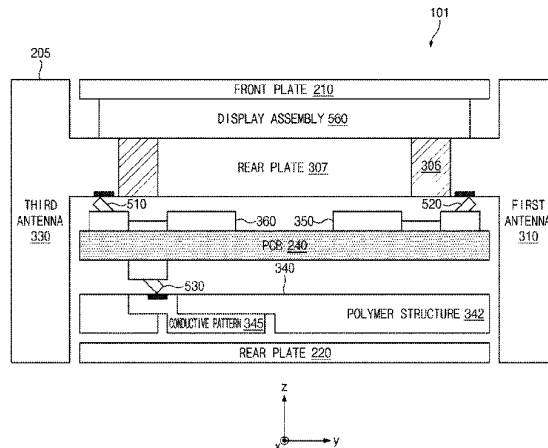
Aug. 3, 2018 (KR) 10-2018-0090637

(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H01Q 1/52 (2006.01)

(Continued)

(Continued)





US011848485B2

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

(10) **Patent No.:** **US 11,848,485 B2**
(45) **Date of Patent:** **Dec. 19, 2023**

(54) **ANTENNA MODULE**
(71) Applicant: **PEGATRON CORPORATION**, Taipei (TW)
(72) Inventors: **Chin-Ting Huang**, Taipei (TW); **Sony Chayadi**, Taipei (TW); **Hsi-Kai Hung**, Taipei (TW); **Chun-Kai Wang**, Taipei (TW)
(73) Assignee: **PEGATRON CORPORATION**, Taipei (TW)
(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 135 days.

(56) **References Cited**
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(21) Appl. No.: **17/125,538**

Primary Examiner — Ricardo I Magallanes

(22) Filed: **Dec. 17, 2020**

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

(65) **Prior Publication Data**
US 2021/0257718 A1 Aug. 19, 2021

(57) **ABSTRACT**

(30) **Foreign Application Priority Data**
Feb. 15, 2020 (TW) 109104837

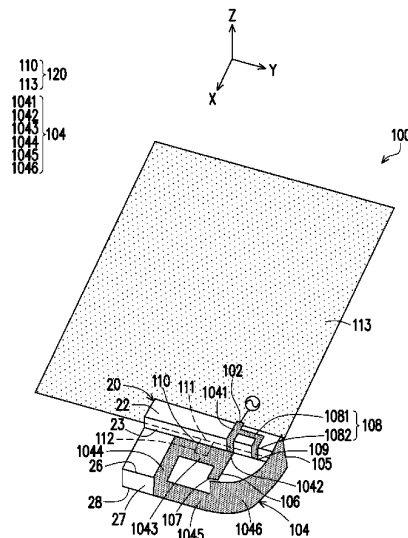
An antenna module includes a feeding end, a first radiator, a second radiator, a third radiator, and a ground structure. The first radiator excites a first frequency and a second frequency. The second radiator extends from the first radiator and excites a third frequency with a part of the first radiator. The third radiator extends from the first radiator and excites a fourth frequency with a part of the first radiator. The ground structure includes a main ground surface and an extending portion extending from the main ground surface. The main ground surface is located below the feeding end, and the extending portion extends from the main ground surface to a bottom of the first radiator and is apart from the first radiator. An extending direction of a portion of the first radiator above the extending portion is orthogonal to an extending direction of the extending portion.

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/357 (2015.01)
H01Q 1/48 (2006.01)
H01Q 9/16 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/245** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/357** (2015.01); **H01Q 9/16** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/38; H01Q 5/371; H01Q 5/357; H01Q 1/2283; H01Q 1/36; H01Q 5/28; H01Q 9/42; H01Q 1/245
See application file for complete search history.

9 Claims, 4 Drawing Sheets





US011862838B2

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

(10) **Patent No.:** **US 11,862,838 B2**
(45) **Date of Patent:** **Jan. 2, 2024**

(54) **ELECTRONIC DEVICES HAVING WIDEBAND ANTENNAS**

(56) **References Cited**

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

U.S. PATENT DOCUMENTS

(72) Inventors: **Lijun Zhang**, San Jose, CA (US);
Jiangfeng Wu, San Jose, CA (US);
Mattia Pascolini, San Francisco, CA (US);
Siwen Yong, San Francisco, CA (US);
Yi Jiang, Cupertino, CA (US)

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

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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 0 days.

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(21) Appl. No.: **16/851,812**

Primary Examiner — Ab Salam Alkassim, Jr.

Assistant Examiner — Bamidele A Jegede

(22) Filed: **Apr. 17, 2020**

(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.;
Tianyi He

(65) **Prior Publication Data**

US 2021/0328346 A1 Oct. 21, 2021

(57) **ABSTRACT**

(51) **Int. Cl.**
H01Q 5/10 (2015.01)
H01Q 5/328 (2015.01)
H01Q 7/00 (2006.01)

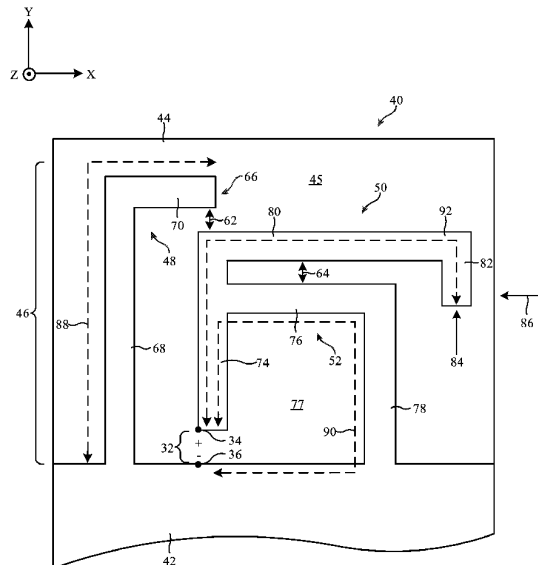
An electronic device may include a curved cover layer and an antenna. The antenna may include a ground and a resonating element on a curved surface of a substrate. The curved surface may have a curvature that matches that of the cover layer. The resonating element may include first, second, and third arms fed by a feed. The first arm and a portion of the ground may form a loop antenna resonating element. The second arm and the first arm may form an inverted-F antenna resonating element, where a portion of the first arm forms a return path to the antenna ground for the inverted-F antenna resonating element. A gap between the first and second arms may form a distributed capacitance. The third arm may form an L-shaped antenna resonating element. The antenna may have a wide bandwidth from below 2.4 GHz to greater than 9.0 GHz.

(52) **U.S. Cl.**
CPC **H01Q 5/10** (2015.01); **H01Q 5/328** (2015.01); **H01Q 7/00** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/10; H01Q 7/00; H01Q 5/328;
H01Q 1/50; H01Q 1/48; H01Q 3/34;
H01Q 21/0075; H01Q 21/065; H01Q 3/40; H01Q 1/38; H01Q 3/30; H01Q 21/0006; H01Q 21/061; H01P 3/081; H01P 3/088

See application file for complete search history.

20 Claims, 6 Drawing Sheets





US011862866B2

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

(10) **Patent No.:** **US 11,862,866 B2**
(45) **Date of Patent:** **Jan. 2, 2024**

- (54) **ANTENNA MODULE AND ELECTRONIC DEVICE**
- (71) Applicant: **PEGATRON CORPORATION**, Taipei (TW)
- (72) Inventors: **Cheng-Hsiung Wu**, Taipei (TW); **Chien-Yi Wu**, Taipei (TW); **Chao-Hsu Wu**, Taipei (TW); **Hau Yuen Tan**, Taipei (TW); **Ching-Hsiang Ko**, Taipei (TW); **Shih-Keng Huang**, Taipei (TW); **Chia-Hung Chen**, Taipei (TW)
- (73) Assignee: **PEGATRON CORPORATION**, Taipei (TW)

- (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 137 days.

Primary Examiner — Ab Salam Alkassim, Jr.
Assistant Examiner — Leah Rosenberg
(74) *Attorney, Agent, or Firm* — J.C. PATENTS

(21) Appl. No.: **17/676,723**

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

(65) **Prior Publication Data**
US 2022/0328961 A1 Oct. 13, 2022

(30) **Foreign Application Priority Data**
Apr. 13, 2021 (TW) 110113154

(51) **Int. Cl.**
H01Q 5/364 (2015.01)
H01Q 1/24 (2006.01)
H01Q 9/04 (2006.01)

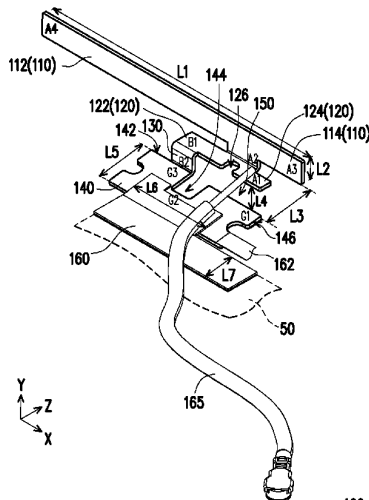
(52) **U.S. Cl.**
CPC **H01Q 5/364** (2015.01); **H01Q 1/243** (2013.01); **H01Q 9/0421** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/2258; H01Q 1/2266; H01Q 1/243; H01Q 1/48; H01Q 5/364; H01Q 9/0421
See application file for complete search history.

(57) **ABSTRACT**

An antenna module includes a first, a second, a third radiators, and a ground radiator. The first radiator includes a first section and a second section. The second radiator is connected to the first radiator, and includes a third section and a fourth section connected to each other. The fourth section includes a feed end. The third radiator is connected to the third section of the second radiator. The ground radiator is connected to the third radiator. The first, the second, the third, and the ground radiator are sequentially connected in a bent manner to form a stepped shape. The first section of the first radiator and the fourth section of the second radiator jointly resonate at a low frequency band, and the second section of the first radiator, the second radiator, the third radiator, and the ground radiator jointly resonate at a high frequency band.

17 Claims, 10 Drawing Sheets





US011862873B2

(12) **United States Patent**
Hamabe

(10) **Patent No.:** **US 11,862,873 B2**
(45) **Date of Patent:** **Jan. 2, 2024**

(54) **ANTENNA DEVICE**

(56) **References Cited**

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

U.S. PATENT DOCUMENTS

(72) Inventor: **Taichi Hamabe**, Osaka (JP)

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343/795

(73) Assignee: **PANASONIC INTELLECTUAL PROPERTY MANAGEMENT CO., LTD.**, Osaka (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 92 days.

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(21) Appl. No.: **17/557,369**

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JP 2006-135672 5/2006

(22) Filed: **Dec. 21, 2021**

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(65) **Prior Publication Data**
US 2022/0209412 A1 Jun. 30, 2022

Notice of Reasons for Refusal dated Dec. 20, 2022, in corresponding Japanese Patent Application No. 2020-219304, with English translation.

(30) **Foreign Application Priority Data**
Dec. 28, 2020 (JP) 2020-219304

Primary Examiner — Jason Crawford

(74) *Attorney, Agent, or Firm* — Wenderoth, Lind & Ponack, L.L.P.

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 13/10 (2006.01)
H01Q 21/06 (2006.01)

(57) **ABSTRACT**

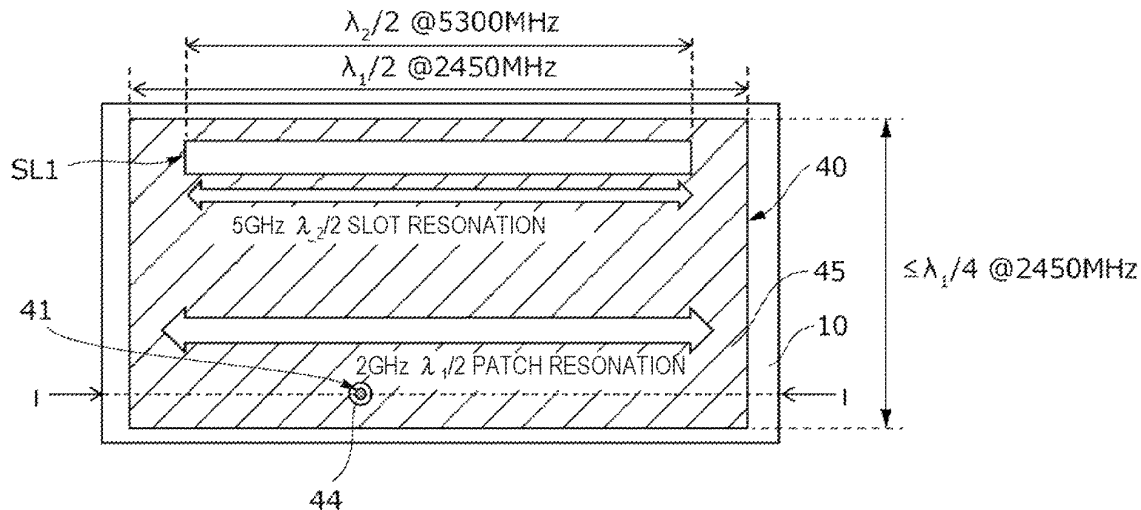
An antenna device includes a first conductor corresponding to communication in a first frequency band, a ground conductor that faces the first conductor, and a second conductor that is disposed between the first conductor and the ground conductor, faces the first conductor and the ground conductor, and has a power supply point. The second conductor is disposed so as to face one end side of the first conductor in an upper-lower direction of the first conductor. The first conductor has a slot disposed at a position facing the other end side opposite to the second conductor, the slot corresponding to communication in a second frequency band that is different from the first frequency band.

(52) **U.S. Cl.**
CPC **H01Q 9/0407** (2013.01); **H01Q 13/10** (2013.01); **H01Q 21/064** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/04; H01Q 9/0407; H01Q 9/0414; H01Q 9/0445; H01Q 9/045; H01Q 13/08; H01Q 13/085; H01Q 13/10; H01Q 1/36; H01Q 1/38

See application file for complete search history.

4 Claims, 10 Drawing Sheets





US011870145B2

(12) **United States Patent**
Tanbo

(10) **Patent No.:** **US 11,870,145 B2**
(45) **Date of Patent:** **Jan. 9, 2024**

- (54) **ANTENNA MODULE AND COMMUNICATION DEVICE INCORPORATING THE SAME**
- (71) Applicant: **Murata Manufacturing Co., Ltd.**, Kyoto (JP)
- (72) Inventor: **Yasuo Tanbo**, Kyoto (JP)
- (73) Assignee: **MURATA MANUFACTURING CO., LTD.**, Kyoto (JP)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 267 days.

- (21) Appl. No.: **17/369,370**
- (22) Filed: **Jul. 7, 2021**

(65) **Prior Publication Data**
US 2021/0336349 A1 Oct. 28, 2021

Related U.S. Application Data
(63) Continuation of application No. PCT/JP2020/002728, filed on Jan. 27, 2020.

(30) **Foreign Application Priority Data**
Feb. 1, 2019 (JP) 2019-016980

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

(52) **U.S. Cl.**
 CPC **H01Q 13/10** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/307** (2015.01)

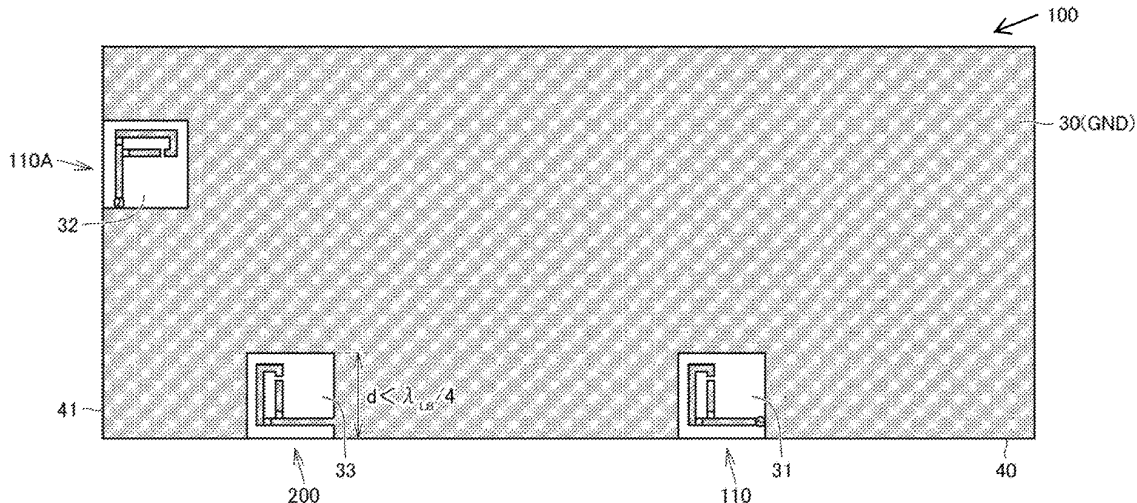
(58) **Field of Classification Search**
 CPC H01Q 13/10; H01Q 1/48; H01Q 5/307; H01Q 5/321; H01Q 1/523; H01Q 5/371; H01Q 21/28
 See application file for complete search history.

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Primary Examiner — Daniel D Chang
(74) *Attorney, Agent, or Firm* — Pearne & Gordon LLP

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

20 Claims, 16 Drawing Sheets





US011870151B2

(12) **United States Patent**
Lin

(10) **Patent No.:** **US 11,870,151 B2**
(45) **Date of Patent:** **Jan. 9, 2024**

(54) **ANTENNA ARRAY**
(71) Applicant: **Wistron Corp.**, New Taipei (TW)
(72) Inventor: **Po-Tsang Lin**, New Taipei (TW)
(73) Assignee: **WISTRON CORP.**, New Taipei (TW)
(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 32 days.

(21) Appl. No.: **17/561,791**

(22) Filed: **Dec. 24, 2021**

(65) **Prior Publication Data**
US 2023/0147065 A1 May 11, 2023

(30) **Foreign Application Priority Data**
Nov. 10, 2021 (TW) 110141789

(51) **Int. Cl.**
H01Q 21/28 (2006.01)
H01Q 21/06 (2006.01)
H01Q 21/30 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 21/28** (2013.01); **H01Q 21/065** (2013.01); **H01Q 21/30** (2013.01)

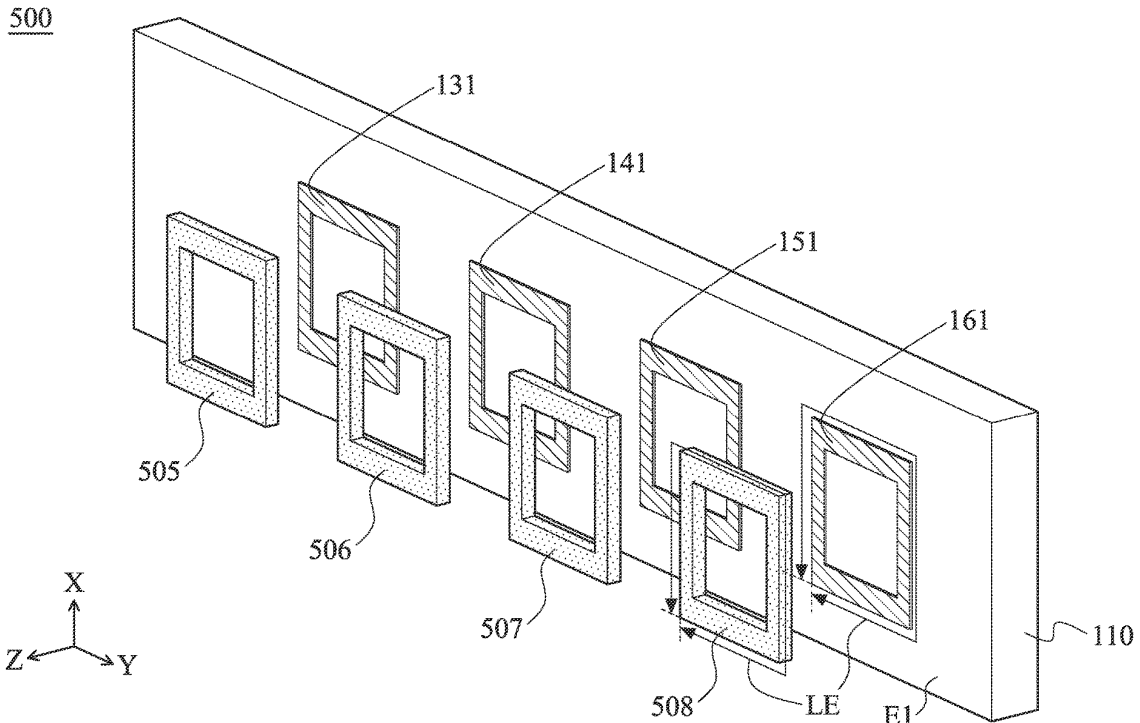
(58) **Field of Classification Search**
CPC H01Q 21/30; H01Q 21/065; H01Q 21/28
See application file for complete search history.

(56) **References Cited**
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340/10.1
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Primary Examiner — Graham P Smith
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**
An antenna array includes a first antenna unit, a second antenna unit, a third antenna unit, a fourth antenna unit, a first auxiliary metal element, a second auxiliary metal element, a third auxiliary metal element, and a fourth auxiliary metal element. The first auxiliary metal element is adjacent to the first antenna unit. The second auxiliary metal element is adjacent to the second antenna unit. The third auxiliary metal element is adjacent to the third antenna unit. The fourth auxiliary metal element is adjacent to the fourth antenna unit. The first auxiliary metal element, the second auxiliary metal element, the third auxiliary metal element, and the fourth auxiliary metal element are configured to increase the radiation gain of the antenna array.

20 Claims, 9 Drawing Sheets





US011870153B2

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

(10) **Patent No.:** **US 11,870,153 B2**
(45) **Date of Patent:** **Jan. 9, 2024**

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

(56) **References Cited**

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

U.S. PATENT DOCUMENTS

(72) Inventors: **Cheng-Wei Chiang**, Hsinchu (TW);
Cheng-Rui Zhang, Hsinchu (TW);
Ching-Wen Chen, Hsinchu (TW)

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

(Continued)

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

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Primary Examiner — Dimary S Lopez Cruz

Assistant Examiner — Jordan E. DeWitt

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

(21) Appl. No.: **17/810,689**

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

(65) **Prior Publication Data**

US 2023/0178887 A1 Jun. 8, 2023

(30) **Foreign Application Priority Data**

Dec. 7, 2021 (TW) 110145605

(51) **Int. Cl.**
H01Q 3/24 (2006.01)
H01Q 5/328 (2015.01)

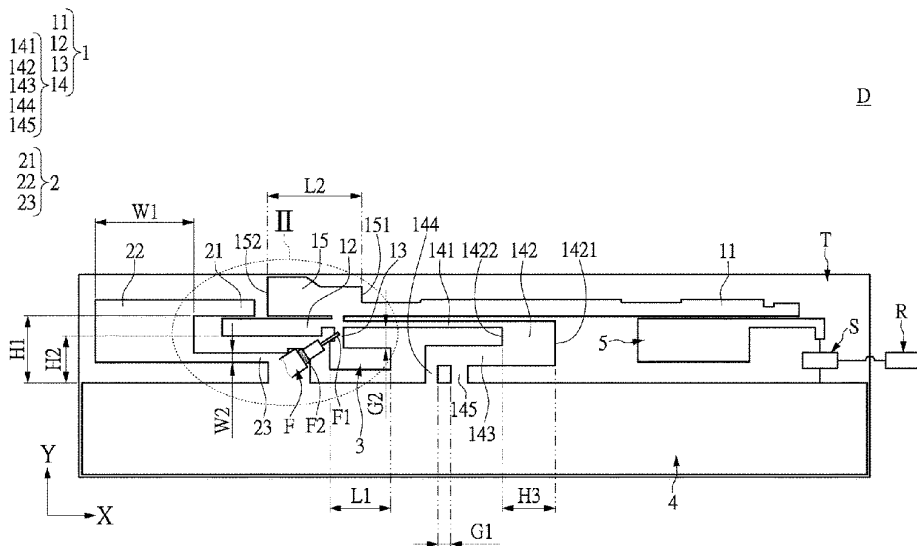
(52) **U.S. Cl.**
CPC **H01Q 3/247** (2013.01); **H01Q 5/328** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 3/247; H01Q 5/328; H01Q 5/357;
H01Q 5/364; H01Q 5/378; H01Q 1/243
See application file for complete search history.

(57) **ABSTRACT**

An electronic device and an antenna structure thereof are provided. The antenna structure includes a first, a second and a third radiating element and a grounding element. The first radiating element includes a first and a second radiating portion, a feeding portion and a grounding portion. The grounding portion includes a first, a second, a third, a fourth and a fifth section. The first section is connected between the first radiating portion and the feeding portion. The grounding element is connected with the fourth section and the fifth section. The second radiating element is connected with the grounding element. The second radiating element includes a third radiating portion, and the third and the second radiating portion are coupled with each other. The third radiating element is connected with the feeding portion, and the third radiating element and the first section are coupled with each other.

17 Claims, 6 Drawing Sheets





US011870164B2

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

(10) **Patent No.:** **US 11,870,164 B2**
(45) **Date of Patent:** **Jan. 9, 2024**

(54) **ANTENNA MODULE AND COMMUNICATION DEVICE EQUIPPED WITH THE SAME**

(58) **Field of Classification Search**
CPC H01Q 9/0421; H01Q 5/378; H01Q 1/50
See application file for complete search history.

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

(56) **References Cited**

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(72) Inventors: **Keisei Takayama**, Kyoto (JP); **Kaoru Sudo**, Kyoto (JP)

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(73) Assignee: **MURATA MANUFACTURING CO., LTD.**, Kyoto (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 400 days.

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Written Opinion for International Application No. PCT/JP2020/000720, dated Mar. 24, 2020.

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

(65) **Prior Publication Data**

US 2021/0328350 A1 Oct. 21, 2021

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2020/000720, filed on Jan. 10, 2020.

Primary Examiner — Graham P Smith
(74) *Attorney, Agent, or Firm* — Pearne & Gordon LLP

(30) **Foreign Application Priority Data**

Jan. 10, 2019 (JP) 2019-002322

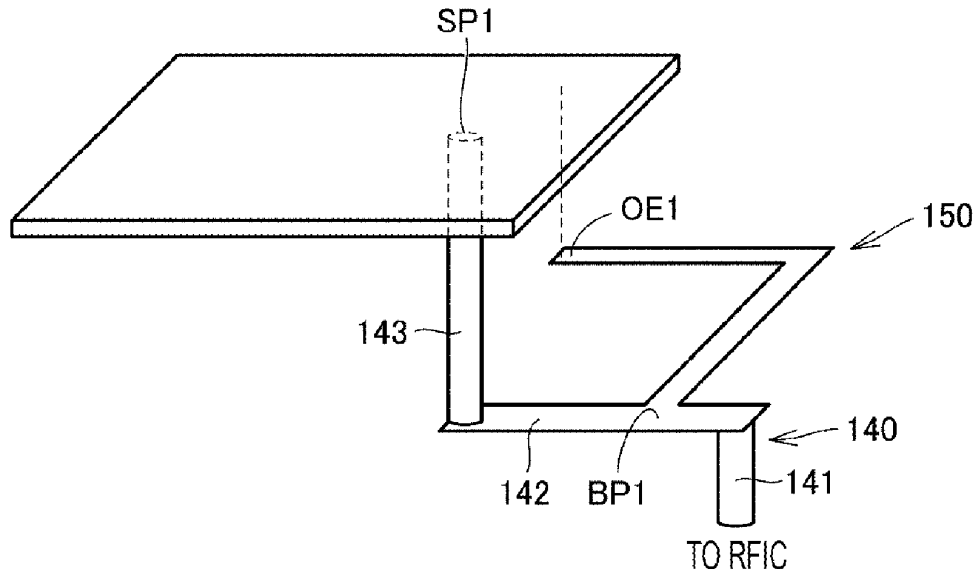
(57) **ABSTRACT**

An antenna module includes a dielectric substrate having a multilayer structure, a ground electrode disposed in the dielectric substrate, a plate-like fed element facing the ground electrode and disposed at a layer different from a layer including the ground electrode, a feed line for transferring a radio-frequency signal to a feed point of the fed element, and a stub. The stub branches off from the feed line at a branch point of the feed line and has an open end. The stub is disposed between the fed element and the ground electrode. When the dielectric substrate is viewed in plan view, the open end coincides with the fed element.

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 5/378 (2015.01)
H01Q 1/50 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 9/0421** (2013.01); **H01Q 1/50** (2013.01); **H01Q 5/378** (2015.01)

14 Claims, 14 Drawing Sheets





US011870413B2

(12) **United States Patent**
Li

(10) **Patent No.:** **US 11,870,413 B2**
(45) **Date of Patent:** **Jan. 9, 2024**

- (54) **ANTENNA STRUCTURE AND COMMUNICATIONS TERMINAL**
- (71) Applicant: **VIVO MOBILE COMMUNICATION CO., LTD.**, Guangdong (CN)
- (72) Inventor: **Rihui Li**, Dongguan (CN)
- (73) Assignee: **VIVO MOBILE COMMUNICATION CO., LTD.**, Dongguan (CN)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 393 days.

- (21) Appl. No.: **17/343,985**
- (22) Filed: **Jun. 10, 2021**
- (65) **Prior Publication Data**
US 2021/0305962 A1 Sep. 30, 2021

Related U.S. Application Data

- (63) Continuation of application No. PCT/CN2019/117446, filed on Nov. 12, 2019.

Foreign Application Priority Data

Dec. 12, 2018 (CN) 201811519716.7

- (51) **Int. Cl.**
H01Q 5/371 (2015.01)
H03H 7/38 (2006.01)
(Continued)
- (52) **U.S. Cl.**
CPC **H03H 7/38** (2013.01); **H01Q 1/2291** (2013.01); **H01Q 9/045** (2013.01)
- (58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 21/28; H01Q 5/328; H01Q 1/521; H01Q 5/378; H01Q 5/335;
(Continued)

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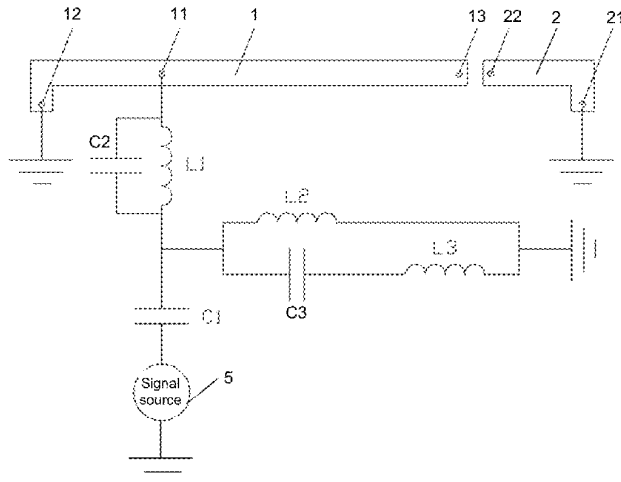
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(Continued)

Primary Examiner — Linh V Nguyen
(74) *Attorney, Agent, or Firm* — Harness, Dickey & Pierce, P.L.C.

- (57) **ABSTRACT**
An antenna structure includes a first antenna radiator, a second antenna radiator, a first impedance matching circuit, a second impedance matching circuit, and a signal source, wherein the first antenna radiator is coupled to the second antenna radiator by means of a slot; the end of the first antenna radiator away from the slot is grounded, and the first antenna radiator is provided with a feed point, the end of the second antenna radiator away from the slot is grounded; a first end of the first impedance matching circuit is connected to the feed point, and a second end of the first impedance matching circuit is connected to a first end of the signal source; a first end of the second impedance matching circuit is connected to a third end of the first impedance matching circuit, and a second end of the second impedance matching circuit is grounded.

20 Claims, 5 Drawing Sheets





US011876279B2

(12) **United States Patent
Harper**

(10) **Patent No.: US 11,876,279 B2**
(45) **Date of Patent: Jan. 16, 2024**

- (54) **HYBRID CAVITY MODE ANTENNA**
- (71) Applicant: **Microsoft Technology Licensing, LLC**,
Redmond, WA (US)
- (72) Inventor: **Marc Harper**, Snohomish, WA (US)
- (73) Assignee: **Microsoft Technology Licensing, LLC**,
Redmond, WA (US)
- (*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 558 days.

- (56) **References Cited**
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1992 (Year: 1992).*

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Primary Examiner — Graham P Smith
Assistant Examiner — Amal Patel

(74) *Attorney, Agent, or Firm* — Holzer Patel Drennan

(57) **ABSTRACT**

A communication device includes a metal chassis, a printed circuit board positioned within the metal chassis, and a hybrid cavity mode antenna. The hybrid cavity mode antenna includes a conductive wall defining at least a portion of a cavity, wherein the cavity is further defined by one or more surfaces of the metal chassis and the printed circuit board, and an electrically-fed antenna configured to radiate a first radiofrequency signal in a first frequency range. The electrically-fed antenna is electrically driven from the printed circuit board of the communication device. The electrically-fed antenna is positioned within the cavity to drive the cavity to radiate a second radiofrequency signal in a second frequency range.

24 Claims, 6 Drawing Sheets

- (21) Appl. No.: **16/887,209**
- (22) Filed: **May 29, 2020**
- (65) **Prior Publication Data**
US 2021/0265735 A1 Aug. 26, 2021

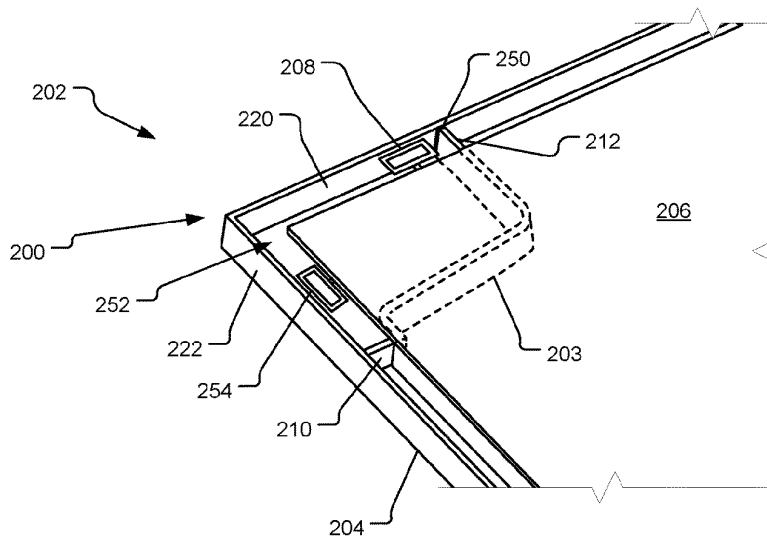
Related U.S. Application Data

- (60) Provisional application No. 62/981,129, filed on Feb. 25, 2020.

- (51) **Int. Cl.**
H01Q 13/18 (2006.01)
H01Q 9/40 (2006.01)
H01Q 7/00 (2006.01)
H05K 1/02 (2006.01)

- (52) **U.S. Cl.**
CPC **H01Q 13/18** (2013.01); **H01Q 7/00**
(2013.01); **H01Q 9/40** (2013.01); **H05K**
1/0243 (2013.01)

- (58) **Field of Classification Search**
CPC H01Q 7/00; H01Q 9/40; H01Q 13/18;
H05K 1/0243
See application file for complete search history.





US011876285B2

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

(10) **Patent No.:** **US 11,876,285 B2**
(45) **Date of Patent:** **Jan. 16, 2024**

(54) **ANTENNA APPARATUS AND TERMINAL**

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

(72) Inventors: **Le Chang**, Shenzhen (CN); **Kunpeng Wei**, 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 374 days.

(21) Appl. No.: **17/418,515**

(22) PCT Filed: **Dec. 27, 2018**

(86) PCT No.: **PCT/CN2018/124495**

§ 371 (c)(1),
(2) Date: **Jun. 25, 2021**

(87) PCT Pub. No.: **WO2020/133111**

PCT Pub. Date: **Jul. 2, 2020**

(65) **Prior Publication Data**

US 2022/0123456 A1 Apr. 21, 2022

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/40 (2015.01)
H01Q 13/10 (2006.01)
H01Q 21/24 (2006.01)
H01Q 21/28 (2006.01)
H01Q 1/38 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 5/40** (2015.01); **H01Q 13/10** (2013.01); **H01Q 21/24** (2013.01); **H01Q 21/28** (2013.01); **H01Q 1/38** (2013.01)

(58) **Field of Classification Search**

CPC **H01Q 1/243**; **H01Q 13/10**; **H01Q 1/38**;
H01Q 21/28; **H01Q 5/40**; **H01Q 21/24**;
H01Q 9/40

See application file for complete search history.

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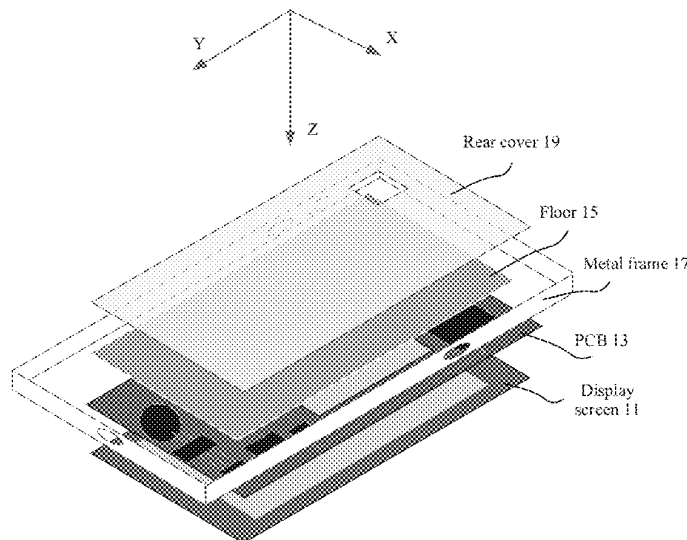
Primary Examiner — Joseph J Lauture

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

(57) **ABSTRACT**

A terminal comprises a printed circuit board (PCB), a PCB floor, and a rear cover. The metal frame is disposed at edges of the PCB floor. The PCB floor is disposed between the PCB and the rear cover, and the PCB floor is used to ground electronic components. The antenna apparatus may include a split antenna formed by a split provided on the metal frame, and a slot antenna formed by a slot connecting to the split. The slot may be connected to the split at a middle position on one side of the slot, and the slot may be provided on the metal frame of the terminal or on a PCB floor of the terminal.

20 Claims, 16 Drawing Sheets





US011876299B2

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

(10) **Patent No.:** **US 11,876,299 B2**
(45) **Date of Patent:** **Jan. 16, 2024**

(54) **5G BROADBAND DUAL-POLARIZED BASE STATION ANTENNA OF MULTIMODE RESONANCE STRUCTURE**

(58) **Field of Classification Search**
CPC H01Q 25/001; H01Q 1/246; H01Q 21/26; H01Q 25/00; H01Q 1/24
USPC 343/702
See application file for complete search history.

(71) Applicant: **Anhui University**, Hefei (CN)

(56) **References Cited**

(72) Inventors: **Lixia Yang**, Hefei (CN); **Dawei Ding**, Hefei (CN); **Aidi Ren**, Hefei (CN); **Zhixiang Huang**, Hefei (CN); **Guanghui Xu**, Hefei (CN); **Qian Chen**, Hefei (CN); **Xianliang Wu**, Hefei (CN)

U.S. PATENT DOCUMENTS

(73) Assignee: **ANHUI UNIVERSITY**, Hefei (CN)

2015/0295313 A1* 10/2015 Zimmerman H01Q 5/50 343/810

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 80 days.

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Primary Examiner — Hai V Tran

(21) Appl. No.: **17/695,471**

(74) *Attorney, Agent, or Firm* — Kirk A. Wilson; Joseph T. Guy; Patent Filing Specialist Inc.

(22) Filed: **Mar. 15, 2022**

(57) **ABSTRACT**

(65) **Prior Publication Data**

US 2023/0006368 A1 Jan. 5, 2023

The present disclosure provides a 5th generation (5G) broadband dual-polarized base station antenna of a multimode resonance structure, including: a first resonance structure, a main radiating unit, a feed balun set, and a metal reflecting plate, where the feed balun set is disposed on the metal reflecting plate, the main radiating unit is disposed on a first feed balun and a second feed balun, and the first resonance structure is disposed on the main radiating unit; the main radiating unit includes a second resonance structure and a third resonance structure, the first resonance structure is configured to control a resonance point at a high frequency, and the third resonance structure is configured to control a resonance point at a low frequency; and the feed balun set is configured to provide a balance current for the main radiating unit and the first resonance structure.

(30) **Foreign Application Priority Data**

Jul. 2, 2021 (CN) 202110751601.6

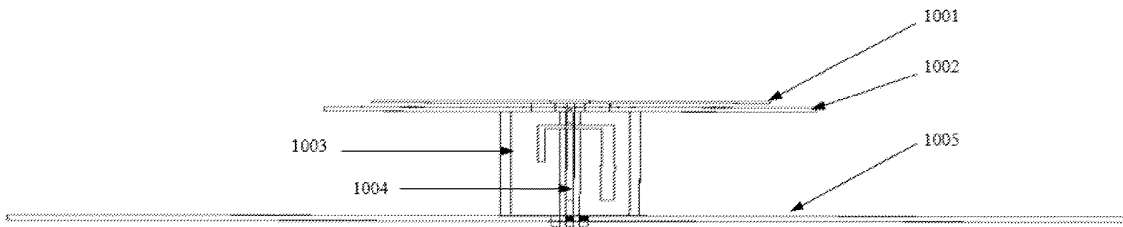
(51) **Int. Cl.**

H01Q 25/00 (2006.01)
H01Q 21/26 (2006.01)
H01Q 1/24 (2006.01)

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

CPC **H01Q 25/001** (2013.01); **H01Q 1/24** (2013.01); **H01Q 1/246** (2013.01); **H01Q 21/26** (2013.01); **H01Q 25/00** (2013.01)

5 Claims, 8 Drawing Sheets





US011876304B2

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

(10) **Patent No.:** **US 11,876,304 B2**
(45) **Date of Patent:** **Jan. 16, 2024**

(54) **MULTIBAND PATCH ANTENNA**
(71) Applicant: **Intel Corporation**, Santa Clara, CA (US)
(72) Inventors: **Maruti Tamrakar**, Chennai (IN); **Jayprakash Thakur**, Bangalore (IN)
(73) Assignee: **Intel Corporation**, Santa Clara, CA (US)
(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.
(21) Appl. No.: **17/448,722**
(22) Filed: **Sep. 24, 2021**

(65) **Prior Publication Data**
US 2022/0200149 A1 Jun. 23, 2022
(30) **Foreign Application Priority Data**
Dec. 17, 2020 (EP) 20214956

(51) **Int. Cl.**
H01Q 5/40 (2015.01)
H01Q 9/04 (2006.01)
H01Q 5/392 (2015.01)
H01Q 21/06 (2006.01)
H01Q 5/378 (2015.01)
(52) **U.S. Cl.**
CPC **H01Q 5/40** (2015.01); **H01Q 5/378** (2015.01); **H01Q 5/392** (2015.01); **H01Q 9/0414** (2013.01); **H01Q 9/0435** (2013.01); **H01Q 9/0457** (2013.01); **H01Q 21/065** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/40; H01Q 9/0407; H01Q 9/0435; H01Q 9/0464; H01Q 19/005
See application file for complete search history.

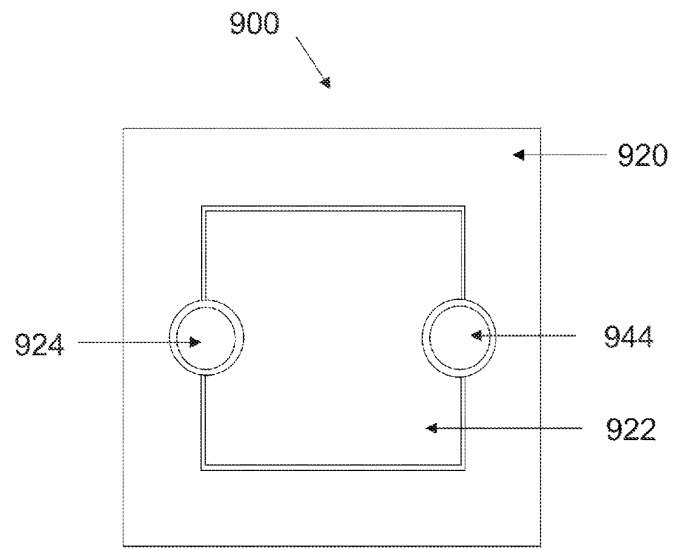
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Primary Examiner — Ab Salam Alkassim, Jr.
(74) *Attorney, Agent, or Firm* — SPL Patentanwälte PartG mbB; Kieran O'Leary

(57) **ABSTRACT**
Examples relate to concepts for patch antennas and particular to a method for forming a multiband patch antenna. A multiband patch antenna may comprise a ground layer and an excitation layer, comprising a first excitation patch, a second excitation patch and a feeding patch, wherein the patch is arranged to excite the first excitation patch and the second excitation simultaneously.

15 Claims, 28 Drawing Sheets





US011876306B2

(12) **United States Patent
Harper**

(10) **Patent No.:** US 11,876,306 B2
(45) **Date of Patent:** Jan. 16, 2024

- (54) **CHASSIS ANTENNA**
- (71) Applicant: **Microsoft Technology Licensing, LLC**,
Redmond, WA (US)
- (72) Inventor: **Marc Harper**, Snohomish, WA (US)
- (73) Assignee: **Microsoft Technology Licensing, LLC**,
Redmond, WA (US)

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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 95 days.

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(21) Appl. No.: **17/354,615**

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

(65) **Prior Publication Data**

US 2022/0407229 A1 Dec. 22, 2022

- (51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/378 (2015.01)
H01Q 7/00 (2006.01)

- (52) **U.S. Cl.**
 CPC **H01Q 7/005** (2013.01); **H01Q 1/241**
 (2013.01)

- (58) **Field of Classification Search**
 CPC H01Q 1/24; H01Q 1/241; H01Q 1/243;
 H01Q 7/00; H01Q 7/005; H01Q 1/22;
 H01Q 1/2266; H01Q 5/328; H01Q 5/378;
 H01Q 5/40; H01Q 9/40; H01Q 9/42
 See application file for complete search history.

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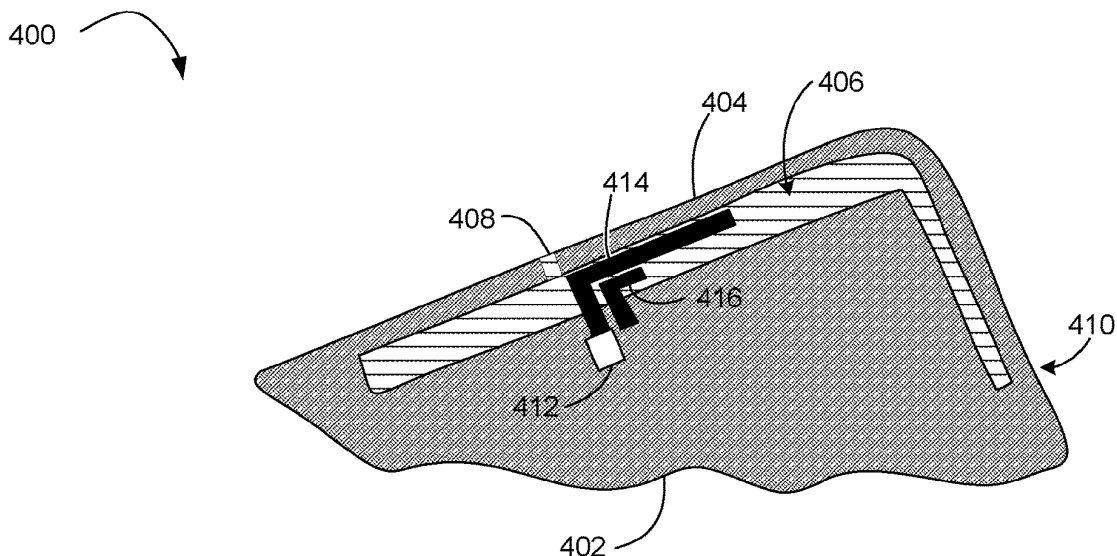
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Primary Examiner — Thai Pham
 (74) *Attorney, Agent, or Firm* — Alleman Hall Creasman & Tuttle LLP

(57) **ABSTRACT**

Examples are disclosed that relate to an antenna formed in a chassis of a device. One example provides a wireless device comprising a chassis and a chassis antenna formed at least in part by a dielectric gap between a body of the chassis and the chassis antenna, where a first end of the chassis antenna is defined by a cut-out in the chassis and where a second end of the chassis antenna being conductively connected to a body of the chassis. The wireless device further comprises a modem, and a coupled feed connected to the modem and capacitively coupled to the chassis antenna.

17 Claims, 7 Drawing Sheets





US011876307B2

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

(10) **Patent No.:** **US 11,876,307 B2**
(45) **Date of Patent:** **Jan. 16, 2024**

(54) **ANTENNA STRUCTURE**
(71) Applicant: **Wistron NeWeb Corporation**, Hsinchu (TW)
(72) Inventors: **Chih-Feng Tai**, Hsinchu (TW); **Yang-Shun Liu**, 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 157 days.

(21) Appl. No.: **17/488,524**
(22) Filed: **Sep. 29, 2021**
(65) **Prior Publication Data**
US 2022/0336956 A1 Oct. 20, 2022
(30) **Foreign Application Priority Data**
Apr. 19, 2021 (TW) 110113982

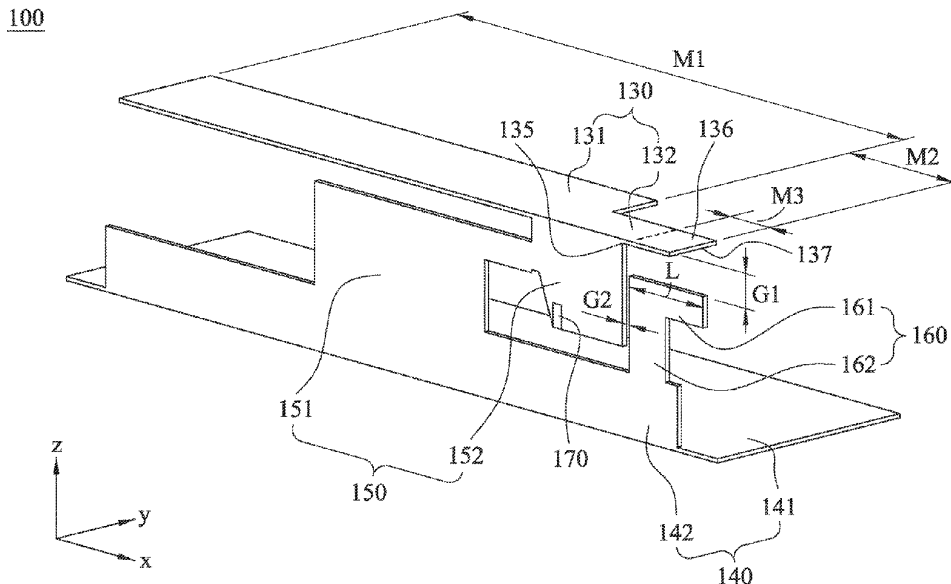
(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 1/48 (2006.01)
H01Q 1/22 (2006.01)
(52) **U.S. Cl.**
CPC **H01Q 9/0407** (2013.01); **H01Q 1/48** (2013.01); **H01Q 1/2291** (2013.01)
(58) **Field of Classification Search**
CPC H01Q 1/2291; H01Q 1/48; H01Q 5/378; H01Q 5/392; H01Q 9/42; H01Q 9/0407-0492
See application file for complete search history.

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Primary Examiner — Ricardo I Magallanes
Assistant Examiner — Aladdin Abdalbaki
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**
An antenna structure includes a radiating portion, a grounding portion, a connecting portion and a collaboration portion. The connecting portion is electrically connected between the radiating portion and the grounding portion. The connecting portion is provided for a feeding port to be disposed thereon for feeding a signal to the antenna structure. The collaboration portion is electrically connected to the grounding portion. The collaboration portion is coupling to the radiating portion and the connecting portion. The collaboration portion and the radiating portion are separated from each other. The collaboration portion and the connecting portion are separated from each other.

10 Claims, 8 Drawing Sheets





US011876309B2

(12) **United States Patent**
Uchida

(10) **Patent No.:** **US 11,876,309 B2**
(45) **Date of Patent:** **Jan. 16, 2024**

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

(71) Applicant: **NEC Platforms, Ltd.**, Kawasaki (JP)

(72) Inventor: **Jun Uchida**, Kanagawa (JP)

(73) Assignee: **NEC Platforms, Ltd.**, Kanagawa (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 263 days.

(21) Appl. No.: **17/289,303**

(22) PCT Filed: **Sep. 12, 2019**

(86) PCT No.: **PCT/JP2019/035941**

§ 371 (c)(1),
(2) Date: **Apr. 28, 2021**

(87) PCT Pub. No.: **WO2020/100402**

PCT Pub. Date: **May 22, 2020**

(65) **Prior Publication Data**

US 2021/0408689 A1 Dec. 30, 2021

(30) **Foreign Application Priority Data**

Nov. 12, 2018 (JP) 2018-212048

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

(52) **U.S. Cl.**
CPC **H01Q 9/26** (2013.01)

(58) **Field of Classification Search**
CPC .. H01Q 1/36; H01Q 9/16; H01Q 9/26; H01Q 9/28; H01Q 9/44; H01Q 19/22; H01Q 19/24

See application file for complete search history.

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Primary Examiner — Jason Crawford

(57) **ABSTRACT**

Three elements of a first (1/4) wavelength element and a second (1/4) wavelength element which have a length of (1/4) wavelength at an arbitrary frequency designated in advance and a half-wavelength element which has a length of a three-wavelength at the arbitrary frequency are arranged in a three-orthogonal state where those are orthogonal to each other, one end portion of the first (1/4) wavelength element is joined to one end portion of the second (1/4) wavelength element, another end portion of the second (1/4) wavelength element is joined to one end portion of the half-wavelength element, a feeding point for antenna power feeding is arranged in a position in which the one end portion of the first (1/4) wavelength element is joined to the one end portion of the second (1/4) wavelength element, and an antenna is formed as a one-wavelength twisted Z-shaped three-orthogonal dipole antenna.

3 Claims, 36 Drawing Sheets

ONE-WAVELENGTH TWISTED Z-SHAPED THREE-ORTHOGONAL DIPOLE ANTENNA

