US011757171B2

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

(10) **Patent No.: US 11,757,171 B2**
(45) **Date of Patent: Sep. 12, 2023**

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

(71) Applicant: **The Antenna Company International N.V.**, Willemstad (CW)

(72) Inventors: **Diego Caratelli**, Eersel (NL); **Avraam Loutridis**, Eindhoven (NL); **János Sófalvi**, Eindhoven (NL)

(73) Assignee: **THE ANTENNA COMPANY INTERNATIONAL N.V.**, Willemstad (CW)

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 284 days.

(21) Appl. No.: **16/825,082**

(22) Filed: **Mar. 20, 2020**

(65) **Prior Publication Data**

US 2020/0303807 A1 Sep. 24, 2020

(30) **Foreign Application Priority Data**

Mar. 22, 2019 (GR) ..... 20190100143
Mar. 22, 2019 (NL) ..... 2022792

(51) **Int. Cl.**

| | |
|---|---|
| ***H01Q 1/22*** | (2006.01) |
| ***H01Q 1/48*** | (2006.01) |
| ***H01Q 5/371*** | (2015.01) |
| ***H01Q 5/378*** | (2015.01) |
| ***H01Q 5/48*** | (2015.01) |
| ***H01Q 5/50*** | (2015.01) |
| ***H04B 7/0413*** | (2017.01) |

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

CPC ..... ***H01Q 1/2291*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 5/371*** (2015.01); ***H01Q 5/378*** (2015.01); ***H01Q 5/48*** (2015.01); ***H01Q 5/50*** (2015.01); ***H04B 7/0413*** (2013.01)

(58) **Field of Classification Search**

CPC ..... H01Q 1/2291; H01Q 1/48; H01Q 5/371; H01Q 5/378; H01Q 5/48; H01Q 5/50; H01Q 5/42; H01Q 21/28; H04B 7/0413

See application file for complete search history.

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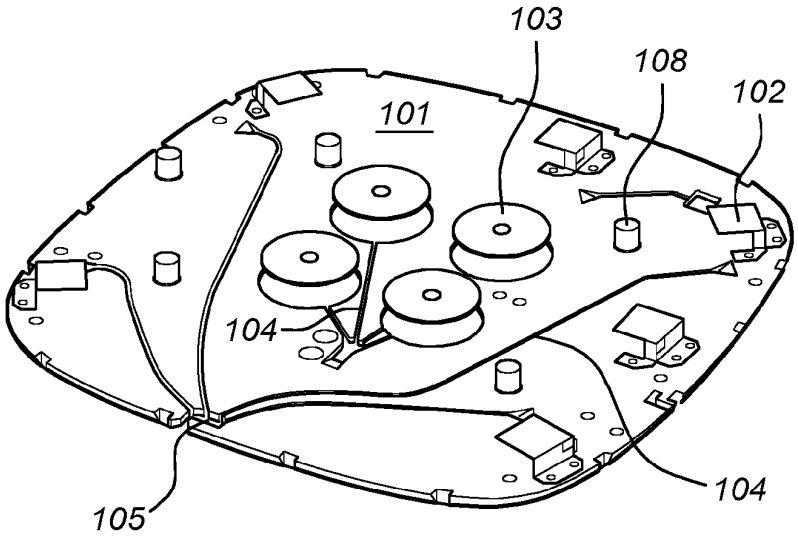
*Primary Examiner* — Hai V Tran
*Assistant Examiner* — Michael M Bouizza
(74) *Attorney, Agent, or Firm* — Nath, Goldberg & Meyer; Joshua B. Goldberg

(57) **ABSTRACT**

The invention relates to a MIMO antenna system for IEEE 802.11 WiFi communication. The invention also relates to a wireless device, such as a wireless access point (AP), a router, a gateway, and/or a bridge, comprising at least one antenna system according to the invention. The invention further relates to a wireless communication system, comprising a plurality of antenna systems according to the invention, and, preferably, a plurality of wireless devices according to the invention.

**20 Claims, 30 Drawing Sheets**



US011757178B2

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

(10) **Patent No.: US 11,757,178 B2**
(45) **Date of Patent: Sep. 12, 2023**

(54) **ANTENNA OF A TERMINAL DEVICE**

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

(72) Inventors: **Yijin Wang**, Dongguan (CN); **Huan-chu Huang**, Dongguan (CN); **Xianjing Jian**, 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 356 days.

(21) Appl. No.: **17/200,164**

(22) Filed: **Mar. 12, 2021**

(65) **Prior Publication Data**

US 2021/0218136 A1 Jul. 15, 2021

**Related U.S. Application Data**

(63) Continuation of application No. PCT/CN2019/101509, filed on Aug. 20, 2019.

(30) **Foreign Application Priority Data**

Sep. 14, 2018 (CN) ..... 201811076745.0

(51) **Int. Cl.**
***H01Q 1/24*** (2006.01)
***H01Q 1/44*** (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ..... ***H01Q 1/44*** (2013.01); ***H01Q 1/36*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 1/50*** (2013.01); ***H01Q 21/0006*** (2013.01)

(58) **Field of Classification Search**
CPC .... H01Q 13/10; H01Q 21/0006; H01Q 1/243; H01Q 1/38–52; H01Q 1/2266
See application file for complete search history.

(56) **References Cited**

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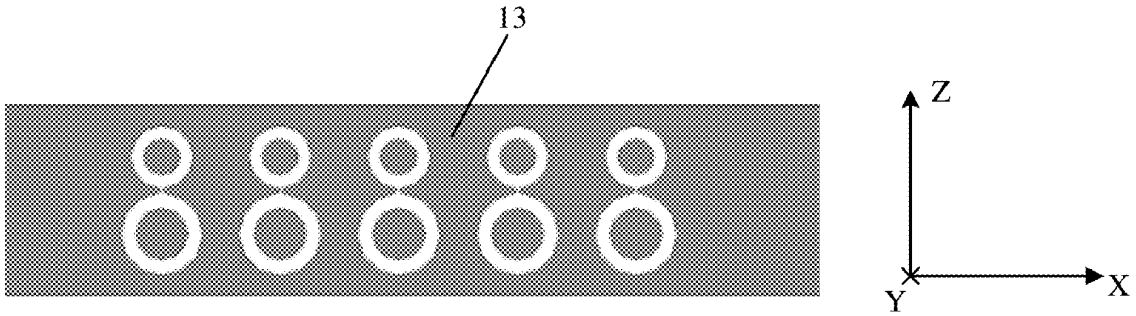
*Primary Examiner* — Hasan Islam
(74) *Attorney, Agent, or Firm* — Harness, Dickey & Pierce, P.L.C.

(57) **ABSTRACT**

An antenna of a terminal device, the antenna includes a metal frame, a side of the metal frame is provided with at least two slot units, each slot unit includes a first slot ring and a second slot ring, the first slot ring and the second slot ring communicate through a third slot, an outer edge circumference of the first slot ring is different from that of the second slot ring. Portions of the metal frame on both sides of the third slot are provided with an antenna feed point and a ground feed point, respectively. The metal frame is electrically connected with a ground plate in the terminal device.

**14 Claims, 4 Drawing Sheets**



US011757179B2

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

(10) **Patent No.: US 11,757,179 B2**
(45) **Date of Patent: Sep. 12, 2023**

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

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

(72) Inventors: **Cheolhong Son**, Gyeonggi-do (KR); **Kyungjae Lee**, Gyeonggi-do (KR); **Sangha Lee**, Gyeonggi-do (KR); **Soonho Hwang**, Gyeonggi-do (KR); **Sungjun Lee**, Gyeonggi-do (KR); **Hyunjeong Lee**, Gyeonggi-do (KR)

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

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 357 days.

(21) Appl. No.: **17/090,459**

(22) Filed: **Nov. 5, 2020**

(65) **Prior Publication Data**

US 2021/0135351 A1 May 6, 2021

(30) **Foreign Application Priority Data**

Nov. 5, 2019 (KR) ..... 10-2019-0140186

(51) **Int. Cl.**

| | |
|---|---|
| ***H01Q 1/24*** | (2006.01) |
| ***H01Q 1/48*** | (2006.01) |
| ***H01Q 5/328*** | (2015.01) |
| ***H01Q 5/40*** | (2015.01) |
| *H05K 1/18* | (2006.01) |

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

CPC ..... ***H01Q 1/48*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 5/328*** (2015.01); ***H01Q 5/40*** (2015.01);

(Continued)

(58) **Field of Classification Search**

CPC ..... H01Q 1/243; H01Q 1/48–50; H01Q 5/30–40; H01Q 5/307–328

See application file for complete search history.

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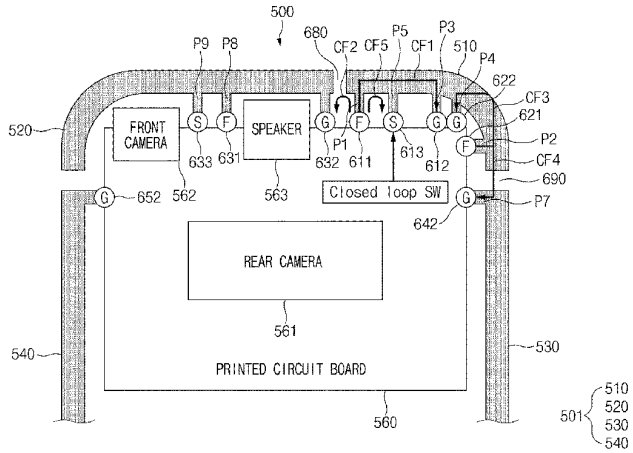
*Primary Examiner* — Hasan Islam
(74) *Attorney, Agent, or Firm* — The Farrell Law Firm, P.C.

(57) **ABSTRACT**

An electronic device includes a housing including a front plate, a rear plate facing away from the front plate, and a side member surrounding a space between the front plate and the rear plate and connecting one side of the front plate to one side of the rear plate, an antenna structure including at least part of the conductive portion, and a printed circuit board disposed in the space and including at least one processor. At least part of the side member is a conductive portion. The conductive portion includes a first conductive pattern, a second conductive pattern disposed at least partially coupled to the first conductive pattern, and a third conductive pattern disposed at least partially coupled to the first conductive pattern and spaced apart from the second conductive pattern. The antenna structure includes a first feeding part electrically connected to a first location of the first conductive pattern, a second feeding part electrically connected to a second location of the first conductive pattern, wherein the second location is closer to the third conductive pattern than the first location, a first ground part electrically connected to a third location between the first location and the second

(Continued)



US011769939B2

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

(10) **Patent No.: US 11,769,939 B2**
(45) **Date of Patent: Sep. 26, 2023**

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

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

(72) Inventors: **Hsuan-Jui Chang**, Hsinchu (TW); **Hsieh-Chih Lin**, Hsinchu (TW); **Guan-Ren Su**, Hsinchu (TW); **Wei-Shan Chang**, Hsinchu (TW); **Yi-Feng Wu**, Hsinchu (TW); **Shang-Sian You**, 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 0 days.

(21) Appl. No.: **17/835,239**

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

(65) **Prior Publication Data**

US 2023/0216173 A1 Jul. 6, 2023

(51) **Int. Cl.**

| | |
|---|---|
| ***H01Q 1/24*** | (2006.01) |
| ***H01Q 1/22*** | (2006.01) |
| ***H01Q 13/10*** | (2006.01) |
| ***H01Q 9/42*** | (2006.01) |
| ***H01Q 3/22*** | (2006.01) |
| ***H01Q 5/35*** | (2015.01) |

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

CPC ..... ***H01Q 1/2258*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 3/22*** (2013.01); ***H01Q 5/35*** (2015.01); ***H01Q 9/42*** (2013.01); ***H01Q 13/10*** (2013.01)

(58) **Field of Classification Search**

CPC ..... H01Q 13/10; H01Q 9/42; H01Q 3/22; H01Q 1/243; H01Q 5/35; H01Q 1/2258

See application file for complete search history.

(56) **References Cited**

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| TW | I742159 B | 10/2021 |

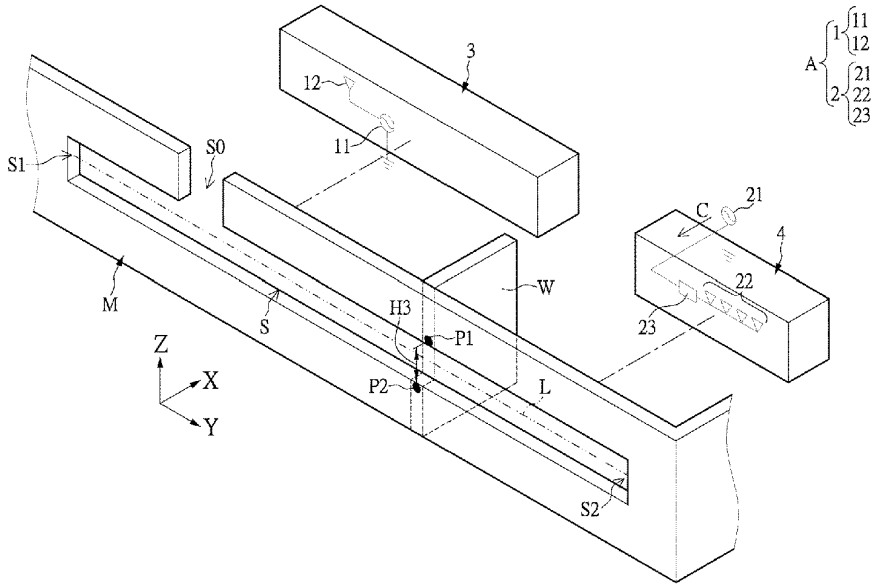
*Primary Examiner* — Graham P Smith

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

(57) **ABSTRACT**

An electronic device and an antenna structure are provided. The electronic device includes a metal housing, a partition wall, a first antenna module, and a second antenna module. The metal housing has a T-shaped slot. The slot includes an opening end, a first closed end, and a second closed end. The partition wall is connected with the metal housing. The first antenna module has a first feeding element and a radiating element. The second antenna module has a second feeding element and an antenna array. The first antenna module and the second antenna module are respectively disposed on two sides of the partition wall, and the first antenna module is closer to the opening end than the second antenna module.

**15 Claims, 9 Drawing Sheets**



US011769940B2

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

(10) **Patent No.: US 11,769,940 B2**
(45) **Date of Patent: Sep. 26, 2023**

(54) **ELECTRONIC DEVICE HOUSING WITH INTEGRATED ANTENNA**

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

(72) Inventors: **Nicholas A. Renda**, San Francisco, CA (US); **Carlo Catalano**, Cupertino, CA (US); **Chen Wang**, Cupertino, CA (US); **David R. Cramer**, Cupertino, CA (US); **Kellen M. Atom**, Cupertino, CA (US); **Lindsay D. Corbet**, Cupertino, CA (US); **Melody L. Kuna**, Palo Alto, CA (US); **Robert J. Durand**, Cupertino, CA (US); **Stephanie L. Ternullo**, Cupertino, CA (US); **Sunita Venkatesh**, Cupertino, CA (US); **Suvrat Lele**, Cupertino, CA (US); **Wang Chung Alston Cheung**, Cupertino, CA (US)

(73) Assignee: **APPLE INC.**, Cupertino, CA (US)

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 62 days.

(21) Appl. No.: **17/544,837**

(22) Filed: **Dec. 7, 2021**

(65) **Prior Publication Data**

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**Related U.S. Application Data**

(60) Provisional application No. 63/242,252, filed on Sep. 9, 2021.

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

(52) **U.S. Cl.**
CPC ..... ***H01Q 1/243*** (2013.01); ***H01Q 1/42*** (2013.01); ***H01Q 13/10*** (2013.01)

(58) **Field of Classification Search**
CPC ..... H01Q 1/24; H01Q 1/243; H01Q 1/244; H01Q 1/42; H01Q 13/10; H01Q 1/2266;
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(56) **References Cited**

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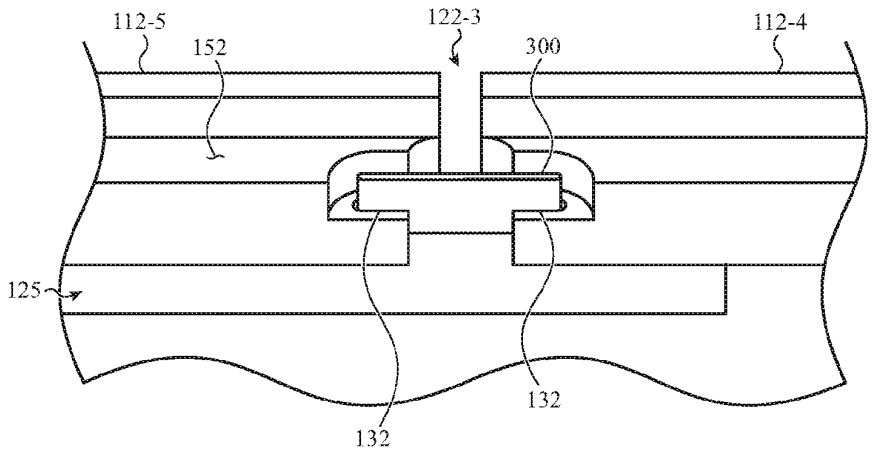
*Primary Examiner* — Thai Pham
(74) *Attorney, Agent, or Firm* — Brownstein Hyatt Farber Schreck, LLP

(57) **ABSTRACT**

An electronic device includes a display, and a housing at least partially surrounding the display and comprising a first housing member defining a first portion of an exterior surface of the electronic device and a second housing member defining a second portion of the exterior surface of the electronic device and configured to function as an antenna. The electronic device also includes a joining structure positioned between the first housing member and the second housing member including a reinforcement plate and a molded element at least partially encapsulating the reinforcement plate and engaged with the first housing member and the second housing member, thereby retaining the first housing member to the second housing member.

**20 Claims, 15 Drawing Sheets**



US011769945B2

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

(10) **Patent No.: US 11,769,945 B2**
(45) **Date of Patent: Sep. 26, 2023**

(54) **ELECTRONIC DEVICE**

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

(72) Inventors: **Kuo-Heng Cheng**, Taipei (TW); **Chia-Chun Kao**, Taipei (TW)

(73) Assignee: **GETAC TECHNOLOGY CORPORATION**, 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 54 days.

(21) Appl. No.: **17/507,286**

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

(65) **Prior Publication Data**

US 2022/0131265 A1 Apr. 28, 2022

(30) **Foreign Application Priority Data**

Oct. 23, 2020 (CN) ..... 202011146695.6

(51) **Int. Cl.**
***H01Q 3/36*** (2006.01)
***H01Q 1/24*** (2006.01)
***H01Q 1/22*** (2006.01)

(52) **U.S. Cl.**
CPC ..... ***H01Q 3/36*** (2013.01); ***H01Q 1/2266*** (2013.01); ***H01Q 1/24*** (2013.01)

(58) **Field of Classification Search**
CPC ..... H01Q 3/36; H01Q 1/24; H01Q 1/2266
USPC ..... 343/893
See application file for complete search history.

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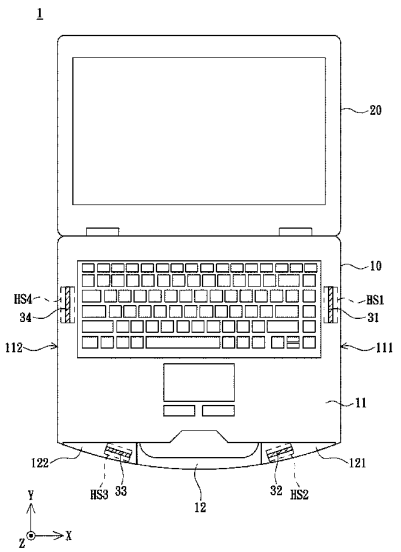
*Primary Examiner* — Hai V Tran
(74) *Attorney, Agent, or Firm* — Locke Lord LLP; Tim Tingkang Xia, Esq.

(57) **ABSTRACT**

An electronic device provided includes a host device and a display device. The host device includes a base shell and a handle, wherein the base shell has a first accommodating space and a fourth accommodating space. The handle has a second accommodating space and a third accommodating space. The electronic device further includes a first array antenna, a second array antenna, and a third array antenna. The first array antenna, the second array antenna, and the third array antenna are respectively arranged in three of the first accommodating space, the second accommodating space, the third accommodating space, and the fourth accommodating space, wherein the first array antenna, the second array antenna, and the third array antenna respectively have a first beam, a second beam, and a third beam facing a first axis. Accordingly, the electronic device provides stable connection quality and a higher transmission rate.

**8 Claims, 7 Drawing Sheets**



US011769946B2

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

(10) **Patent No.: US 11,769,946 B2**
(45) **Date of Patent: Sep. 26, 2023**

(54) **ELECTRONIC DEVICE COMPRISING ANTENNA**

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

(72) Inventors: **Jae Hyung Kim**, Yongin-si (KR); **Kyung Bae Ko**, Hwaseong-si (KR); **Tae Gyu Kim**, Hwaseong-si (KR); **Je Sun Moon**, Suwon-si (KR); **Jin Kyu Bang**, Suwon-si (KR); **Sang Hoon Lee**, Seoul (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 1191 days.

(21) Appl. No.: **16/344,172**

(22) PCT Filed: **Nov. 2, 2017**

(86) PCT No.: **PCT/KR2017/012363**
§ 371 (c)(1),
(2) Date: **Apr. 23, 2019**

(87) PCT Pub. No.: **WO2018/084615**
PCT Pub. Date: **May 11, 2018**

(65) **Prior Publication Data**

US 2019/0288392 A1 Sep. 19, 2019

(30) **Foreign Application Priority Data**

Nov. 7, 2016 (KR) ..... 10-2016-0147315

(51) **Int. Cl.**
***H01Q 5/30*** (2015.01)
***H05K 7/14*** (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ..... ***H01Q 5/30*** (2015.01); ***H01Q 1/24*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 5/364*** (2015.01);
(Continued)

(58) **Field of Classification Search**
CPC ..... H01Q 5/30; H01Q 1/38; H05K 5/0086; H05K 5/0226; H05K 7/1427; H05K 7/14; H05K 5/00; H05K 5/02; H04B 1/3827
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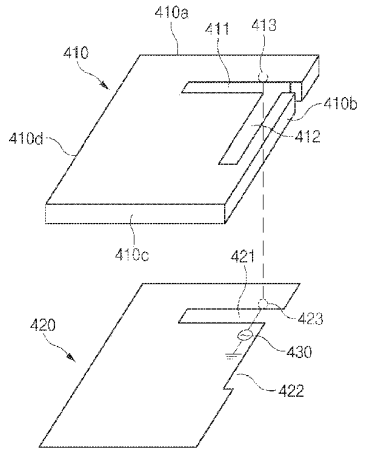
*Primary Examiner* — Hai V Tran
(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

(57) **ABSTRACT**

An electronic device according to an embodiment may comprise: a housing including a first slit having a length corresponding to a first frequency and a second slit extending from one point of the first slit in a different direction from the first slit and having a length corresponding to a second frequency, and configured to resonate at the first frequency and the second frequency by the first slit and the second slit; a printed circuit board disposed in the housing
(Continued)



US011769948B2

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

(10) **Patent No.: US 11,769,948 B2**
(45) **Date of Patent: Sep. 26, 2023**

(54) **DUAL-BAND DUAL-POLARIZED ANTENNA FOR 5G APPLICATIONS**

(71) Applicant: **THE REGENTS OF THE UNIVERSITY OF MICHIGAN**, Ann Arbor, MI (US)

(72) Inventors: **Kamal Sarabandi**, Ann Arbor, MI (US); **Menglou Rao**, Ann Arbor, MI (US)

(73) Assignee: **THE REGENTS OF THE UNIVERSITY OF MICHIGAN**, Ann Arbor, MI (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.

(21) Appl. No.: **17/320,784**

(22) Filed: **May 14, 2021**

(65) **Prior Publication Data**

US 2021/0359413 A1 Nov. 18, 2021

**Related U.S. Application Data**

(60) Provisional application No. 63/026,000, filed on May 16, 2020.

(51) **Int. Cl.**
***H01Q 21/06*** (2006.01)
***H01Q 5/385*** (2015.01)
***H01Q 9/04*** (2006.01)

(52) **U.S. Cl.**
CPC ..... ***H01Q 5/385*** (2015.01); ***H01Q 9/0414*** (2013.01); ***H01Q 21/062*** (2013.01); ***H01Q 21/065*** (2013.01)

(58) **Field of Classification Search**
CPC .... H01Q 5/385; H01Q 9/0414; H01Q 21/062; H01Q 21/065
See application file for complete search history.

(56) **References Cited**

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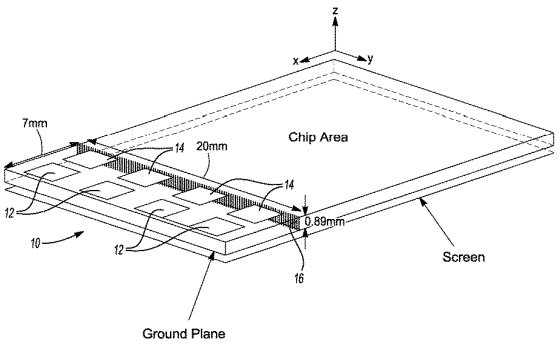
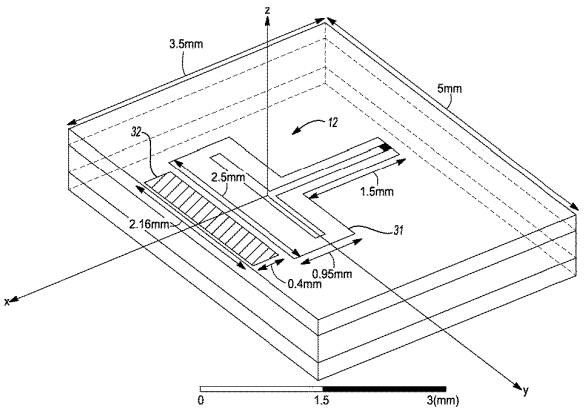
*Primary Examiner* — Dieu Hien T Duong
(74) *Attorney, Agent, or Firm* — Harness, Dickey & Pierce, P.L.C.

(57) **ABSTRACT**

A dual-polarized antenna is presented for 5G mobile communications. The antenna includes two discrete elements—a folded dipole and a folded monopole, which generate two orthogonal polarizations. Parasitic elements are used to realize higher-band operation. In one example, the antenna covers both the 28 GHz band and the 39 GHz band. The entire structure is designed on an ultra-thin four-layer laminate and is intended to be incorporated along the edges of smartphones to enable 5G operation.

**18 Claims, 28 Drawing Sheets**



US011769952B2

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

(10) **Patent No.: US 11,769,952 B2**
(45) **Date of Patent: Sep. 26, 2023**

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

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

(72) Inventors: **Huan-Chu Huang**, Guangdong (CN); **Rongjie Ma**, Guangdong (CN); **Xianjing Jian**, Guangdong (CN)

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

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

(21) Appl. No.: **17/531,627**

(22) Filed: **Nov. 19, 2021**

(65) **Prior Publication Data**

US 2022/0085512 A1 Mar. 17, 2022

**Related U.S. Application Data**

(63) Continuation of application No. PCT/CN2020/090507, filed on May 15, 2020.

(30) **Foreign Application Priority Data**

May 22, 2019 (CN) ..... 201910430968.0

(51) **Int. Cl.**
***H01Q 9/06*** (2006.01)
***H01Q 19/18*** (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ..... ***H01Q 9/065*** (2013.01); ***H01Q 1/523*** (2013.01); ***H01Q 5/45*** (2015.01); ***H01Q 5/48*** (2015.01); ***H01Q 19/18*** (2013.01)

(58) **Field of Classification Search**
CPC ..... H01Q 9/065; H01Q 19/18; H01Q 1/523; H01Q 5/45; H01Q 5/48; H01Q 21/24;
(Continued)

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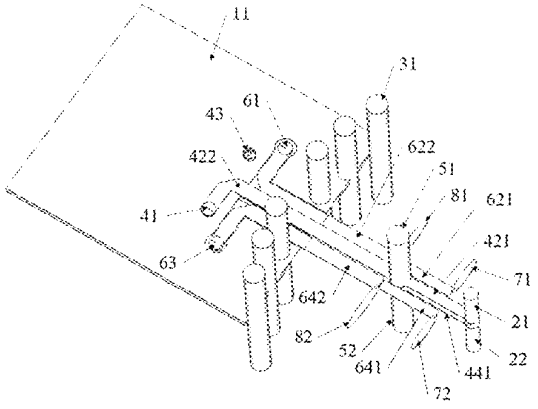
(Continued)

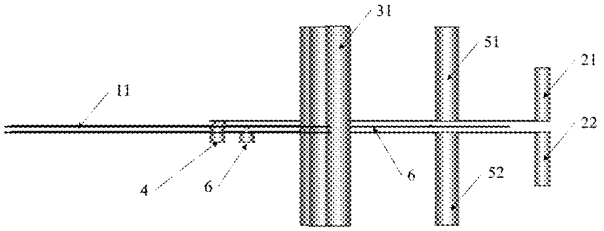
*Primary Examiner* — Vibol Tan
(74) *Attorney, Agent, or Firm* — IP & T GROUP LLP

(57) **ABSTRACT**

An antenna element includes a substrate, a first vertically polarized dipole antenna, a second vertically polarized dipole antenna, a reflector and a first feeding structure. The substrate has a ground plate. The first vertically polarized dipole antenna includes a first antenna branch and a second antenna branch that are disposed in the substrate at an interval. The second vertically polarized dipole antenna includes a third antenna branch and a fourth antenna branch that are disposed in the substrate at an interval. The reflector includes several reflection pillars that are arranged in the substrate at intervals along a parabola. The first feeding structure electrically connects each of the first antenna branch, the second antenna branch, the third antenna branch, and the fourth antenna branch to the ground plate.

**20 Claims, 14 Drawing Sheets**



US011784393B2

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

(10) **Patent No.: US 11,784,393 B2**
(45) **Date of Patent: Oct. 10, 2023**

(54) **ANTENNA MODULE**

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

(72) Inventors: **Chin-Ting Huang**, Taipei (TW); **Hsi-Kai Hung**, Taipei (TW); **Sony Chayadi**, 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 71 days.

(21) Appl. No.: **17/519,381**

(22) Filed: **Nov. 4, 2021**

(65) **Prior Publication Data**

US 2022/0149528 A1 May 12, 2022

(30) **Foreign Application Priority Data**

Nov. 6, 2020 (TW) ..... 109138931

(51) **Int. Cl.**

| | |
|---|---|
| ***H01Q 1/24*** | (2006.01) |
| ***H01Q 21/28*** | (2006.01) |
| ***H01Q 13/10*** | (2006.01) |
| ***H01Q 9/28*** | (2006.01) |
| ***H01Q 9/30*** | (2006.01) |
| ***H01Q 13/18*** | (2006.01) |

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

CPC ..... ***H01Q 1/24*** (2013.01); ***H01Q 9/28*** (2013.01); ***H01Q 9/30*** (2013.01); ***H01Q 13/10*** (2013.01); ***H01Q 13/18*** (2013.01); ***H01Q 21/28*** (2013.01)

(58) **Field of Classification Search**

CPC .. H01Q 1/2258; H01Q 1/2266; H01Q 1/2291; H01Q 1/24; H01Q 1/241; H01Q 1/242; H01Q 1/243; H01Q 1/36; H01Q 1/44; H01Q 1/48; H01Q 5/20; H01Q 5/25; H01Q 5/30; H01Q 5/307; H01Q 5/342; H01Q 5/35; H01Q 5/357; H01Q 9/0421; H01Q 9/16; H01Q 9/26; H01Q 9/265; H01Q 9/28; H01Q 9/30; H01Q 9/38; H01Q 9/40; H01Q 9/42; H01Q 13/10; H01Q 13/103; H01Q 13/12; H01Q 13/14; H01Q 13/18; H01Q 21/28

See application file for complete search history.

(56) **References Cited**

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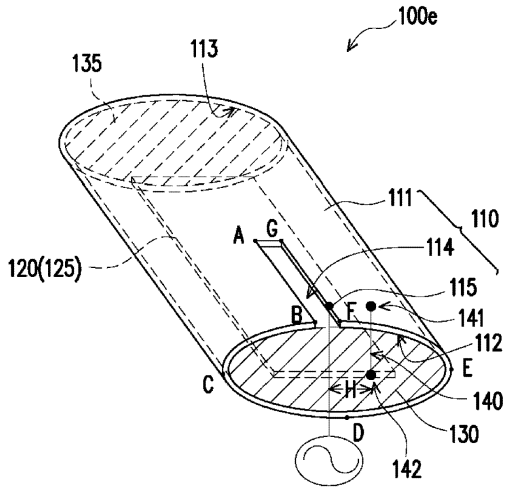
*Primary Examiner* — Robert Karacsony
(74) *Attorney, Agent, or Firm* — J.C. PATENTS

(57) **ABSTRACT**

An antenna module includes a hollow cylindrical conductor structure. The hollow cylindrical conductor structure includes a cylinder wall, at least one first slot, and a first feed point. The at least one first slot and the first feed point are located on the cylinder wall. The cylinder wall includes a first end edge and a second end edge opposite to each other. The at least one first slot extends from an internal position of the cylinder wall to the first end edge, and forms a first closed path together with the first end edge. The first feed point is located beside the at least one first slot. The antenna module is adapted to excite a first frequency band through the first closed path.

**9 Claims, 7 Drawing Sheets**



US011784411B2

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

(10) **Patent No.: US 11,784,411 B2**
(45) **Date of Patent: Oct. 10, 2023**

(54) **WIRELESS COMMUNICATION APPARATUS AND PRINTED DUAL BAND ANTENNA THEREOF**

(71) Applicant: **REALTEK SEMICONDUCTOR CORPORATION**, Hsinchu (TW)

(72) Inventors: **Ching-Wei Ling**, Hsinchu (TW); **Chih-Pao Lin**, Hsinchu (TW)

(73) Assignee: **REALTEK SEMICONDUCTOR 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 20 days.

(21) Appl. No.: **17/524,910**

(22) Filed: **Nov. 12, 2021**

(65) **Prior Publication Data**

US 2022/0158348 A1 May 19, 2022

(30) **Foreign Application Priority Data**

Nov. 18, 2020 (TW) ..... 109140207

(51) **Int. Cl.**
***H01Q 1/38*** (2006.01)
***H01Q 5/378*** (2015.01)
***H01Q 9/04*** (2006.01)

(52) **U.S. Cl.**
CPC ..... ***H01Q 5/378*** (2015.01); ***H01Q 1/38*** (2013.01); ***H01Q 9/0421*** (2013.01)

(58) **Field of Classification Search**
CPC ..... H01Q 5/378; H01Q 1/38; H01Q 9/0421; H01Q 9/42
See application file for complete search history.

(56) **References Cited**

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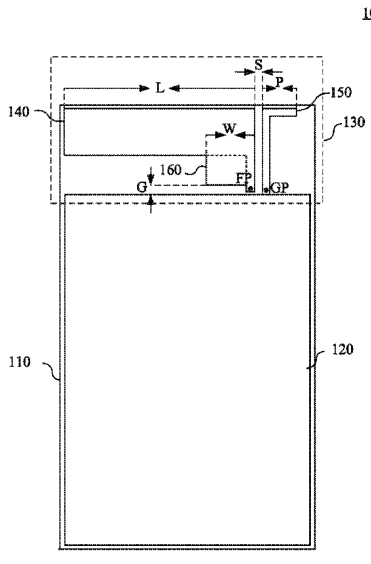
*Primary Examiner* — Hai V Tran
*Assistant Examiner* — Michael M Bouizza
(74) *Attorney, Agent, or Firm* — WPAT, P.C

(57) **ABSTRACT**

The present invention discloses a printed dual band antenna that includes a primary radiation portion and a parasitic radiation portion. The primary radiation portion is configured to perform signal transmitting and receiving based on a first resonant frequency and a second resonant frequency. The parasitic radiation portion is disposed on a neighboring side of the primary radiation portion, distanced from the primary radiation portion by a distance and electrically isolated from the primary radiation portion. The parasitic radiation portion couples to and resonates with the primary radiation portion to perform signal transmitting and receiving based on the second resonant frequency. The parasitic radiation portion is a grounded monopole parasitic antenna.

**9 Claims, 7 Drawing Sheets**



US011791540B2

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

(10) **Patent No.: US 11,791,540 B2**
(45) **Date of Patent: Oct. 17, 2023**

(54) **SIGNAL FEEDING ASSEMBLY, ANTENNA MODULE AND ELECTRONIC EQUIPMENT**

(71) Applicant: **Chiun Mai Communication Systems, Inc.**, New Taipei (TW)

(72) Inventors: **Cho-Kang Hsu**, New Taipei (TW); **Min-Hui Ho**, New Taipei (TW); **Yen-Hui Lin**, New Taipei (TW); **Wei-Cheng Su**, New Taipei (TW)

(73) Assignee: **Chiun Mai Communication Systems, Inc.**, 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 349 days.

(21) Appl. No.: **17/374,020**

(22) Filed: **Jul. 13, 2021**

(65) **Prior Publication Data**

US 2022/0021117 A1 Jan. 20, 2022

**Related U.S. Application Data**

(60) Provisional application No. 63/052,611, filed on Jul. 16, 2020.

(51) **Int. Cl.**

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|---|---|
| ***H01Q 5/371*** | (2015.01) |
| ***H01Q 3/24*** | (2006.01) |
| ***H01Q 25/04*** | (2006.01) |
| ***H01Q 1/24*** | (2006.01) |
| ***H01Q 23/00*** | (2006.01) |

(Continued)

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

CPC ..... ***H01Q 1/243*** (2013.01); ***H01Q 3/24*** (2013.01); ***H01Q 5/371*** (2015.01); ***H01Q 9/0407*** (2013.01); ***H01Q 13/085*** (2013.01); ***H01Q 23/00*** (2013.01); ***H01Q 25/04*** (2013.01)

(58) **Field of Classification Search**

CPC ..... H01Q 1/243; H01Q 13/085; H01Q 23/00; H01Q 25/04; H01Q 3/24; H01Q 5/371; H01Q 5/40; H01Q 9/0407

USPC ..... 455/82

See application file for complete search history.

(56) **References Cited**

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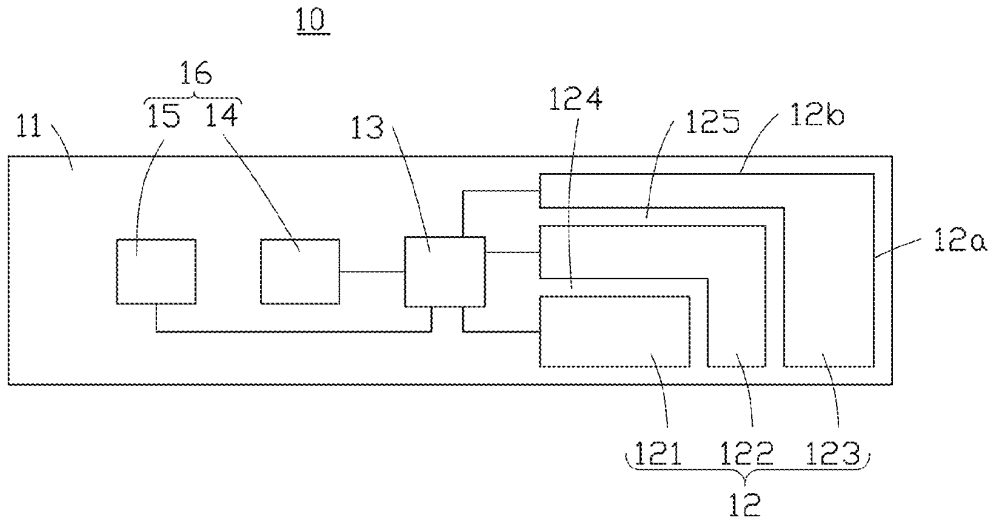
*Primary Examiner* — Tan H Trinh

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

(57) **ABSTRACT**

A signal feeding assembly to a radiating element which is not formed from a metal frame or casing includes a substrate, a signal coupling unit, a switching unit, and a transmission unit. The switching unit includes at least two switching output ends. The transmission unit can transmit and receive a baseband signal and an RF signal. The signal coupling unit is spaced from a radiation element and can generate a plurality of radiation modes. The signal coupling unit includes at least two coupling pieces. Each coupling piece is electrically connected to a switching output end. The switching unit controls switching of the coupling pieces through the switching output ends and can switch a plurality of radiation modes. The application also provides an antenna module and an electronic device.

**20 Claims, 11 Drawing Sheets**



US011791551B2

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

(10) **Patent No.: US 11,791,551 B2**
(45) **Date of Patent: Oct. 17, 2023**

(54) **ANTENNA SYSTEM AND WIRELESS DEVICE**

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

(72) Inventors: **Shuguang Xiao**, Nanjing (CN); **Jie Zhao**, Nanjing (CN); **Xiao Zhou**, Shanghai (CN); **Xin Luo**, Chengdu (CN); **Yi Chen**, Chengdu (CN)

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

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

(21) Appl. No.: **17/318,646**

(22) Filed: **May 12, 2021**

(65) **Prior Publication Data**

US 2021/0359407 A1 Nov. 18, 2021

(30) **Foreign Application Priority Data**

May 13, 2020 (CN) ..... 202010403893.X

(51) **Int. Cl.**
***H01Q 1/52*** (2006.01)
***H01Q 5/48*** (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC ..... ***H01Q 1/525*** (2013.01); ***H01Q 5/48*** (2015.01); ***H01Q 7/00*** (2013.01); ***H01Q 9/0485*** (2013.01); ***H04B 1/525*** (2013.01)

(58) **Field of Classification Search**
CPC ..... H01Q 1/525; H01Q 5/48; H01Q 7/00; H01Q 9/0485; H01Q 21/28; H01Q 25/001;
(Continued)

(56) **References Cited**

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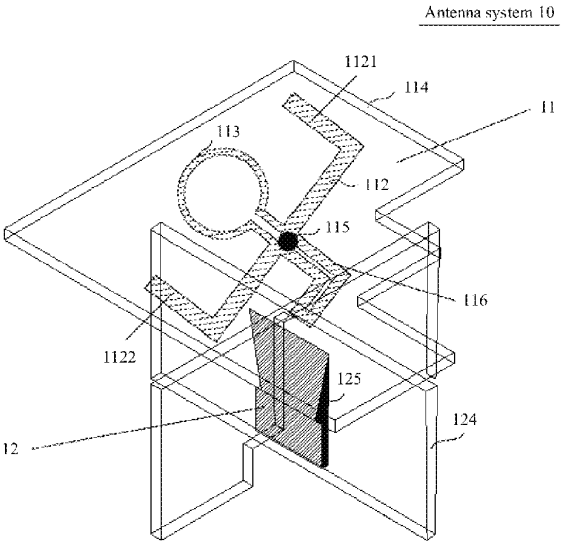
*Primary Examiner* — Hai V Tran
*Assistant Examiner* — Michael M Bouizza
(74) *Attorney, Agent, or Firm* — WOMBLE BOND DICKINSON (US) LLP

(57) **ABSTRACT**

This application provides an antenna system and a wireless device, and pertains to the field of communications technologies. In this application, a decoupling resonator is connected to a first antenna, and a resonance frequency of the decoupling resonator is within an operating frequency band of a second antenna, so that the decoupling resonator can resonate within the operating frequency band of the second antenna. The decoupling resonator reduces coupling between the first antenna and the second antenna, and isolation between the first antenna and the second antenna is improved.

**20 Claims, 19 Drawing Sheets**



US011791569B2

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

(10) **Patent No.: US 11,791,569 B2**
(45) **Date of Patent: Oct. 17, 2023**

(54) **ANTENNA AND TERMINAL**

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

(72) Inventors: **Jie Liu**, Wuhan (CN); **Jinjin Shao**, Wuhan (CN); **Liang Ma**, Wuhan (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 430 days.

(21) Appl. No.: **17/209,676**

(22) Filed: **Mar. 23, 2021**

(65) **Prior Publication Data**

US 2021/0210872 A1 Jul. 8, 2021

**Related U.S. Application Data**

(63) Continuation of application No. PCT/CN2018/109201, filed on Sep. 30, 2018.

(51) **Int. Cl.**
***H01Q 1/24*** (2006.01)
***H01Q 21/28*** (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ..... ***H01Q 21/28*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 9/065*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC ..... H01Q 21/28; H01Q 1/38; H01Q 9/065; H01Q 21/0006; H01Q 1/3275; H01Q 1/36; H01Q 1/48
See application file for complete search history.

(56) **References Cited**

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*Primary Examiner* — Joseph J Lauture
(74) *Attorney, Agent, or Firm* — SLATER MATSIL, LLP

(57) **ABSTRACT**

An antenna includes a first antenna having a first feeding portion and at least one stub, and a second antenna having a second feeding portion and at least one stub. The first feeding portion is disposed on a first side of a first diagonal line of the rectangular region. The at least one stub of the first antenna extends from the first feeding portion in a first direction. A first angle is between the first direction and a long-edge direction of the rectangular region. The second feeding portion is disposed on a second side of the first diagonal line of the rectangular region. The at least one stub of the second antenna extends from the second feeding portion in a second direction. A second angle is between the second direction and the long-edge direction of the rectangular region and is different from the first angle.

**20 Claims, 9 Drawing Sheets**