US011283151B2

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

(10) **Patent No.: US 11,283,151 B2**
(45) **Date of Patent: Mar. 22, 2022**

(54) **ANTENNA SYSTEM FOR TRANSMITTING AND RECEIVING MM-WAVE SIGNAL**

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

(72) Inventors: **Ji Hoon Kim**, Suwon-si (KR); **Ji Yong Kim**, Suwon-si (KR); **Jong In Lee**, Suwon-si (KR); **Yeon Jeong Kim**, Suwon-si (KR); **Yong Jun An**, Suwon-si (KR); **Hyo Seok Na**, 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 267 days.

(21) Appl. No.: **16/202,596**

(22) Filed: **Nov. 28, 2018**

(65) **Prior Publication Data**

US 2019/0165449 A1 May 30, 2019

(30) **Foreign Application Priority Data**

Nov. 28, 2017 (KR) 10-2017-0159884

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

(52) **U.S. Cl.**
CPC ***H01Q 1/2283*** (2013.01); ***H01L 23/66*** (2013.01); ***H01P 5/187*** (2013.01); ***H01Q 1/24*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC .. H01Q 1/2283; H01Q 9/0407; H01Q 9/0414; H01Q 21/0093; H01Q 1/24;
(Continued)

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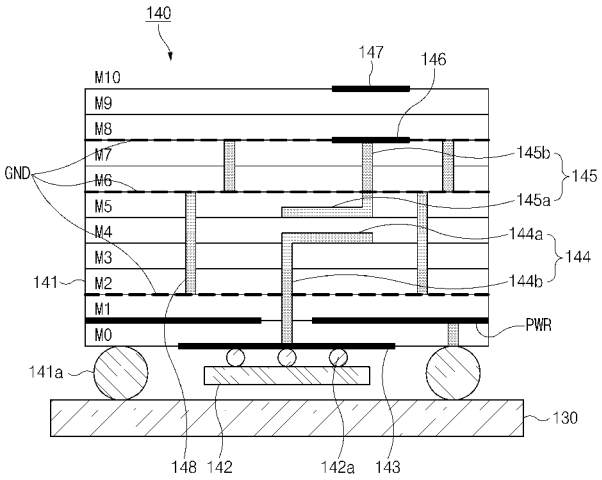
Primary Examiner — Dieu Hien T Duong
(74) *Attorney, Agent, or Firm* — Nixon & Vanderhye P.C.

(57) **ABSTRACT**

Disclosed in an electronic device, which includes a housing that includes a first plate and a second plate facing a direction opposite the first plate, a conductive plate that is disposed in a first plane between the first plate and the second plate, and is parallel to the second plate, a wireless communication circuit that is disposed within the housing and is configured to transmit and/or receive a signal having a frequency ranging from 20 GHz to 100 GHz, a first electrical path having a first end electrically connected with the wireless communication circuit and a second end floated, the first electrical path including a first portion between the first end and the second end, a second electrical path having a third end electrically connected with the conductive plate and a fourth end floated, the second electrical path including a second portion between the third end and the fourth end.

20 Claims, 18 Drawing Sheets



US011283153B2

(12) **United States Patent**
Bonnet

(10) **Patent No.: US 11,283,153 B2**
(45) **Date of Patent: Mar. 22, 2022**

(54) **ANTENNA FOR MOBILE COMMUNICATION DEVICE**

(71) Applicant: **STMICROELECTRONICS (TOURS) SAS**, Tours (FR)

(72) Inventor: **Benoit Bonnet**, Tours (FR)

(73) Assignee: **STMICROELECTRONICS (TOURS) SAS**, Tours (FR)

(*) 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.: **16/530,493**

(22) Filed: **Aug. 2, 2019**

(65) **Prior Publication Data**

US 2019/0356039 A1 Nov. 21, 2019

Related U.S. Application Data

(63) Continuation of application No. 15/691,285, filed on Aug. 30, 2017, now Pat. No. 10,403,963.

(30) **Foreign Application Priority Data**

Jan. 19, 2017 (FR) 1750418
Jan. 19, 2017 (FR) 1750419

(51) **Int. Cl.**

H01Q 9/00	(2006.01)
H01Q 1/24	(2006.01)
H01Q 9/04	(2006.01)
H01Q 5/30	(2015.01)
H01Q 5/328	(2015.01)
H01Q 9/42	(2006.01)
H01Q 1/48	(2006.01)

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

CPC ***H01Q 1/242*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 5/30*** (2015.01); ***H01Q 5/328*** (2015.01); ***H01Q 9/0421*** (2013.01); ***H01Q 9/42*** (2013.01); *H01Q 1/48* (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/242; H01Q 5/328; H01Q 1/243; H01Q 9/42; H01Q 9/0421; H01Q 5/30; H01Q 1/48; H01Q 1/36; H01Q 1/50

See application file for complete search history.

(56) **References Cited**

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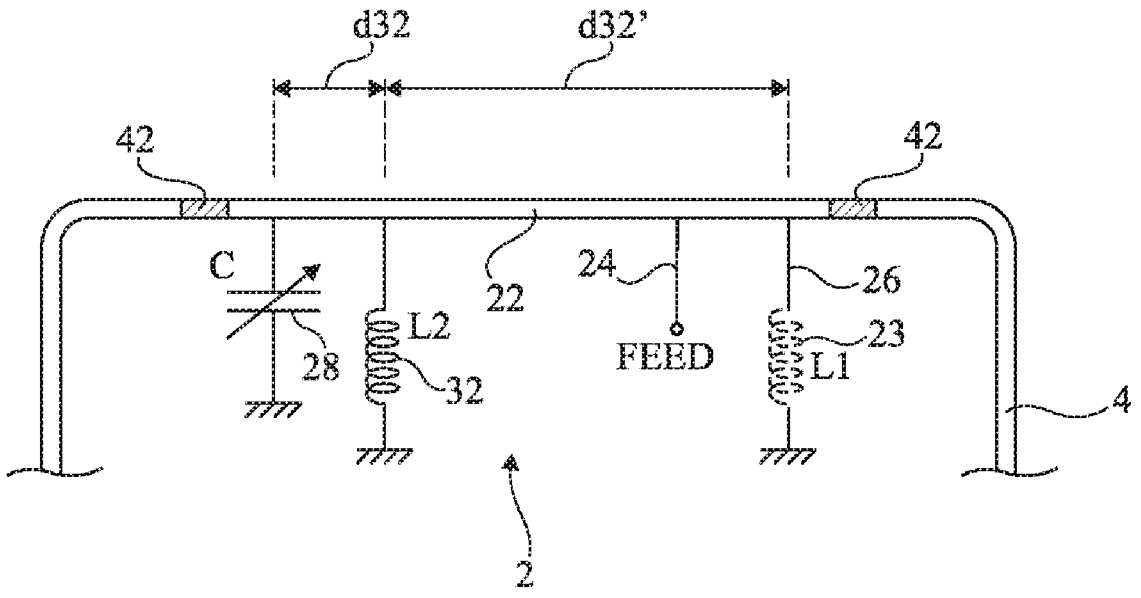
(Continued)

Primary Examiner — Dieu Hien T Duong
(74) *Attorney, Agent, or Firm* — Slater Matsil, LLP

(57) **ABSTRACT**

The invention relates to an antenna comprising: an elongate conducting band; an antenna socket; a connection to earth; at least one first capacitive element of adjustable capacitance; and at least one first inductive element in series with the first capacitive element.

20 Claims, 2 Drawing Sheets



US011283154B2

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

(10) **Patent No.: US 11,283,154 B2**
(45) **Date of Patent: Mar. 22, 2022**

(54) **COMMUNICATIONS TERMINAL**

(71) Applicant: **Huawei Device Co., Ltd.**, Guangdong (CN)

(72) Inventors: **Dingliang Wen**, London (GB); **Yang Hao**, London (GB); **Hanyang Wang**, Reading (GB); **Hai Zhou**, Reading (GB); **Shuhui Sun**, Shenzhen (CN)

(73) Assignee: **Huawei Device 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 523 days.

(21) Appl. No.: **16/304,970**

(22) PCT Filed: **May 28, 2016**

(86) PCT No.: **PCT/CN2016/083776**
§ 371 (c)(1),
(2) Date: **Nov. 27, 2018**

(87) PCT Pub. No.: **WO2017/205998**
PCT Pub. Date: **Dec. 7, 2017**

(65) **Prior Publication Data**

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(51) **Int. Cl.**
H01Q 1/24 (2006.01)
G04G 21/04 (2013.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***G04G 21/04*** (2013.01); ***G04R 60/06*** (2013.01); ***H01Q 1/273*** (2013.01); ***H01Q 1/36*** (2013.01); ***H01Q 13/103*** (2013.01)

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

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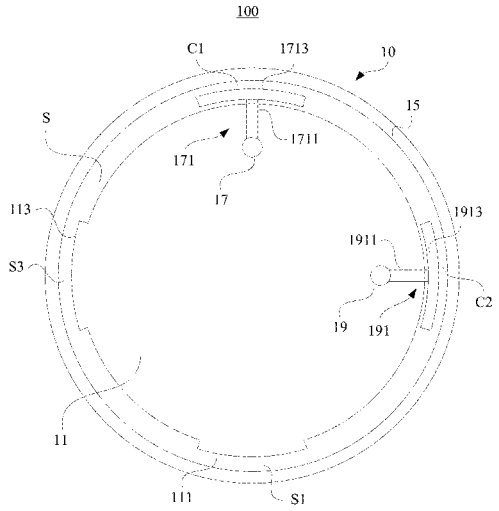
Primary Examiner — Trinh V Dinh
(74) *Attorney, Agent, or Firm* — Conley Rose, P.C.

(57) **ABSTRACT**

A communications terminal includes an antenna Which includes a circuit hoard, a radiator, two feeds, and two coupling structures. The radiator is disposed around an outer edge of the circuit board, and a ring-shape slot is formed between the outer edge of the circuit board and the radiator. A first feed is electrically coupled to a first coupling structure, the first coupling structure is coupled to the radiator along one direction, and a current in a first polarization direction is formed on the circuit board by using the radiator and the ring-shape slot. A second feed is electrically coupled to a second coupling structure, the second coupling structure is coupled to the radiator along another direction, and a current in a second polarization direction is formed on the circuit board by using the radiator and the ring-shape slot. A specific included angle is formed between the above two directions.

20 Claims, 10 Drawing Sheets



US011283156B2

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

(10) **Patent No.: US 11,283,156 B2**
(45) **Date of Patent: Mar. 22, 2022**

(54) **ANTENNA AND ELECTRONIC DEVICE INCLUDING CONDUCTIVE MEMBER ADJACENT TO THE ANTENNA**

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

(72) Inventors: **Seunggil Jeon**, Gyeonggi-do (KR); **Namwoo Kim**, Gyeonggi-do (KR); **Seongbeom Hong**, Gyeonggi-do (KR); **Kyunghoon Moon**, Gyeonggi-do (KR); **Yunbum 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 0 days.

(21) Appl. No.: **16/788,925**

(22) Filed: **Feb. 12, 2020**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Feb. 12, 2019 (KR) 10-2019-0015885

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

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

(58) **Field of Classification Search**
CPC H01Q 1/24; H01Q 1/243; H01Q 5/307; H01Q 9/0407; H01Q 1/2283; H01Q 1/2291; H01Q 1/38; H01Q 21/29; H01Q 21/293
See application file for complete search history.

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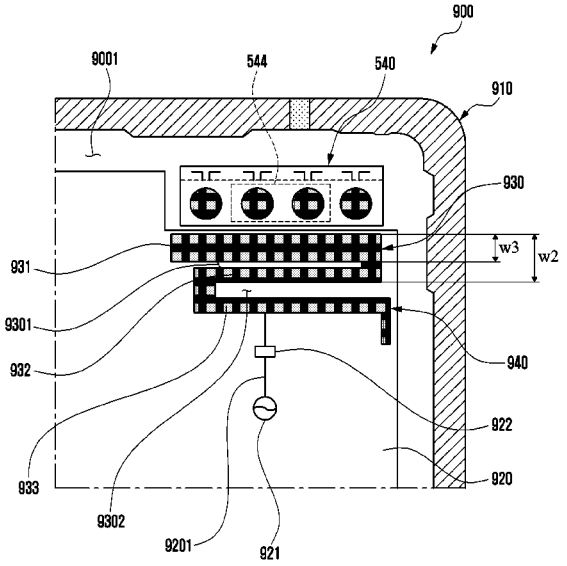
Primary Examiner — Thai Pham
(74) *Attorney, Agent, or Firm* — The Farrell Law Firm, P.C.

(57) **ABSTRACT**

Disclosed is an electronic device including a housing including a first plate facing a first direction, a second plate facing a second direction opposite to the first direction, and a lateral member surrounding a space between the first plate and the second plate, a first antenna structure disposed to be substantially parallel with the second plate in the space, and including a substrate disposed in the space, and at least one antenna element disposed on the substrate to face at least the second plate, a conductive member disposed in the space and spaced apart from the at least one antenna element by a predetermined interval when the second plate is viewed from above.

10 Claims, 13 Drawing Sheets



US011283158B2

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

(10) **Patent No.: US 11,283,158 B2**
(45) **Date of Patent: Mar. 22, 2022**

(54) **MOBILE DEVICE AND ANTENNA MODULE THEREOF**

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

(72) Inventors: **Chung-Hsuan Chen**, Hsinchu (TW); **Chen-Ming Li**, 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 40 days.

(21) Appl. No.: **17/013,949**

(22) Filed: **Sep. 8, 2020**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

May 21, 2020 (TW) 109116968

(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H01Q 1/38	(2006.01)
H01Q 1/48	(2006.01)
H01Q 21/28	(2006.01)
H01Q 9/04	(2006.01)

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

CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 9/0421*** (2013.01); ***H01Q 21/28*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 21/28; H01Q 1/38; H01Q 1/48; H01Q 1/243; H01Q 9/0421

See application file for complete search history.

(56) **References Cited**

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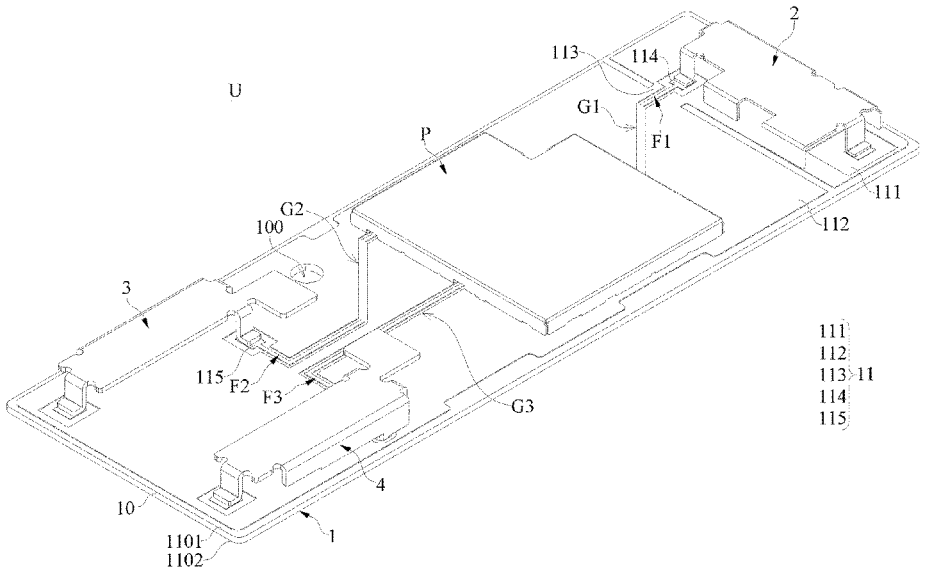
Primary Examiner — Graham P Smith
Assistant Examiner — Jae K Kim
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

A mobile device and an antenna module thereof are provided. The antenna module includes a substrate, a first antenna and a second antenna. The first antenna and the second antenna are disposed on the substrate. The substrate includes a substrate body, a first ground layer and a second ground layer. The first ground layer includes a first slot, the second ground layer includes a second slot, and a vertical projection of the first slot onto substrate body at least partially overlaps with a vertical projection of the second slot onto substrate body. The first slot and the second slot are located between the first antenna and the second antenna, and the first antenna is located closer to the first slot and the second slot than the second antenna.

20 Claims, 15 Drawing Sheets



US011283174B2

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

(10) **Patent No.: US 11,283,174 B2**
(45) **Date of Patent: Mar. 22, 2022**

(54) **ANTENNA**

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

(72) Inventors: **Sangik Cho**, Suwon-si (KR); **Ju Ho Kim**, Suwon-si (KR)

(73) Assignee: **SAMSUNG ELECTRO-MECHANICS CO., LTD.**

(*) 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.: **16/905,324**

(22) Filed: **Jun. 18, 2020**

(65) **Prior Publication Data**

US 2021/0320416 A1 Oct. 14, 2021

(30) **Foreign Application Priority Data**

Apr. 14, 2020 (KR) 10-2020-0045140

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 1/12 (2006.01)
H01Q 21/06 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 9/0407*** (2013.01); ***H01Q 1/12*** (2013.01); ***H01Q 21/065*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/04; H01Q 9/0407; H01Q 9/0414; H01Q 9/045; H01Q 9/0457; H01Q 9/0485; H01Q 5/10; H01Q 5/378; H01Q 5/385; H01Q 1/12; H01Q 1/422; H01Q 21/06; H01Q 21/061; H01Q 21/065
See application file for complete search history.

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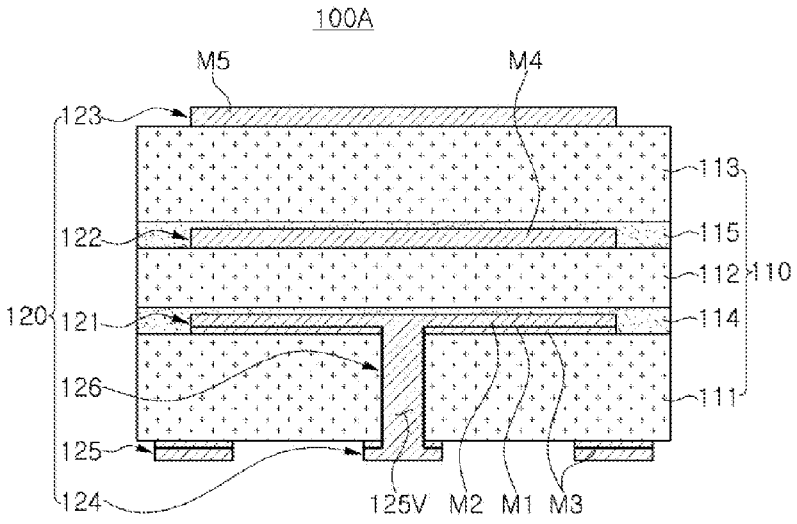
Primary Examiner — Jason Crawford
(74) *Attorney, Agent, or Firm* — Morgan, Lewis & Bockius LLP

(57) **ABSTRACT**

An antenna includes a first dielectric layer having a first surface and a second surface opposing the first surface; a second dielectric layer having a third surface, and a fourth surface opposing the third surface; a third dielectric layer having a fifth surface and a sixth surface opposing the fifth surface; a first adhesive layer disposed between the second surface and the third surface; a second adhesive layer disposed between the fourth surface and the fifth surface; a patch pattern disposed on the second surface and embedded in the first adhesive layer; a first coupling pattern disposed on the fourth surface and embedded in the second adhesive layer, and a second coupling pattern disposed on the sixth surface. The patch pattern, the first coupling pattern, and the second coupling pattern at least partially overlap one another on a plane.

19 Claims, 8 Drawing Sheets



US011283175B2

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

(10) **Patent No.: US 11,283,175 B2**
(45) **Date of Patent: Mar. 22, 2022**

(54) **ANTENNA APPARATUS**

(71) Applicants: **SAMSUNG ELECTRO-MECHANICS CO., LTD.**, Suwon-si (KR); **Research & Business Foundation Sungkyunkwan University**, Suwon-si (KR)

(72) Inventors: **Myeong Woo Han**, Suwon-si (KR); **Nam Ki Kim**, Suwon-si (KR); **Young Sik Hur**, Suwon-si (KR); **Yong Serk Kim**, Suwon-si (KR); **Keum Cheol Hwang**, Suwon-si (KR); **Nam Heung Kim**, Suwon-si (KR); **Jeong Ki Ryoo**, Suwon-si (KR)

(73) Assignees: **Samsung Electro-Mechanics Co., Ltd.**, Suwon-si (KR); **Research & Business Foundation Sungkyunkwan University**, 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 28 days.

(21) Appl. No.: **16/822,143**

(22) Filed: **Mar. 18, 2020**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Nov. 20, 2019 (KR) 10-2019-0149282

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

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

(58) **Field of Classification Search**
CPC H01Q 1/38; H01Q 1/48; H01Q 9/045; H01Q 15/006; H01Q 15/0026; H01Q 21/065
See application file for complete search history.

(56) **References Cited**

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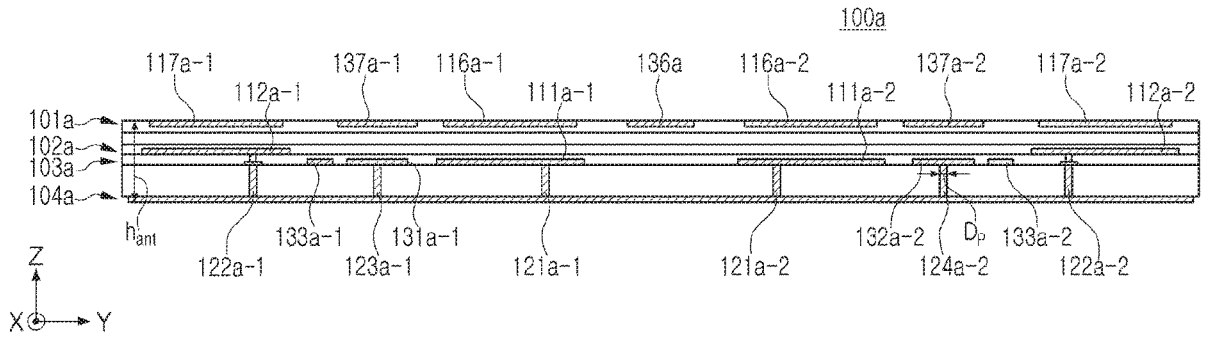
KR 10-2019-0089955 A 7/2019
WO WO 2018/119153 A1 6/2018

Primary Examiner — Tung X Le
(74) *Attorney, Agent, or Firm* — NSIP Law

(57) **ABSTRACT**

An antenna apparatus includes a ground plane; first and second patch antenna patterns disposed above and spaced apart from a first surface of the ground plane and from each other; a second feed via to provide a second feed path of the second patch antenna pattern, and disposed adjacent to an edge of the second patch antenna pattern; a first feed via to provide a first feed path of the first patch antenna pattern, and disposed adjacent to an edge of the first patch antenna pattern that is opposite to the second patch antenna pattern; a first coupling pattern disposed between the first patch antenna pattern and the second patch antenna pattern along the first direction; a ground via; and a second coupling pattern disposed between the second patch antenna pattern and the first coupling pattern along the first direction.

24 Claims, 15 Drawing Sheets



US011283180B2

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

(10) **Patent No.: US 11,283,180 B2**
(45) **Date of Patent: Mar. 22, 2022**

(54) **ELECTRONIC DEVICE HAVING 5G ANTENNA**

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

(72) Inventors: **Dongjin Kim**, Seoul (KR); **Cheolwan Park**, Seoul (KR); **Youngbae Kwon**, Seoul (KR); **Byungwoon Jung**, Seoul (KR); **Jihun Ha**, 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 19 days.

(21) Appl. No.: **16/918,630**

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

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Mar. 9, 2020 (WO) PCT/KR2020/003262

(51) **Int. Cl.**

H01Q 13/10	(2006.01)
H01Q 1/24	(2006.01)
H01Q 3/36	(2006.01)
H01Q 21/28	(2006.01)
H01Q 3/26	(2006.01)

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

CPC ***H01Q 13/106*** (2013.01); ***H01Q 1/245*** (2013.01); ***H01Q 3/2617*** (2013.01); ***H01Q 3/36*** (2013.01); ***H01Q 21/28*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/245; H01Q 3/2617; H01Q 3/36; H01Q 13/106; H01Q 21/28

See application file for complete search history.

(56) **References Cited**

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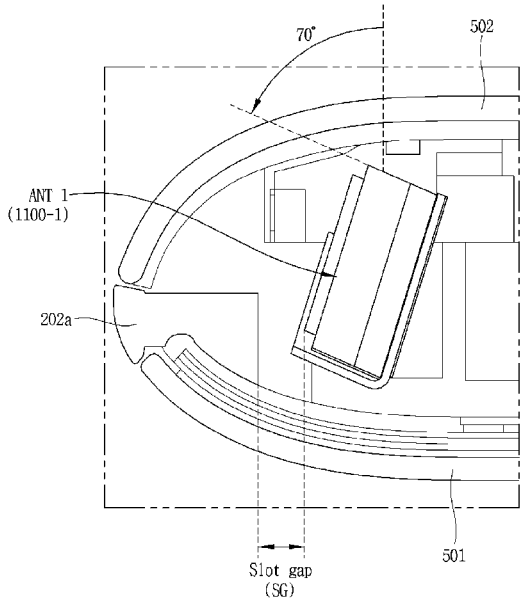
Primary Examiner — Hoang V Nguyen

(74) *Attorney, Agent, or Firm* — Lee, Hong, Degerman, Kang & Waimey PC

(57) **ABSTRACT**

An electronic device having a fifth-generation (5G) antenna according to an embodiment is provided. The electronic device includes a cover glass through which electromagnetic waves are transmitted, a metal frame having a metal rim formed on side surfaces of the electronic device, an antenna module configured to transmit or receive beamformed signals through a plurality of antenna elements, and a frame mold made of a dielectric and disposed between the metal frame and the antenna module, wherein a frame slot is formed in a lower portion of the metal frame so that the signals transmitted or received in the antenna module is radiated through the frame slot.

15 Claims, 38 Drawing Sheets



US011283181B2

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

(10) **Patent No.: US 11,283,181 B2**
(45) **Date of Patent: Mar. 22, 2022**

(54) **ANTENNA MODULE**

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

(72) Inventors: **Chien-Yi Wu**, Taipei (TW); **Chao-Hsu Wu**, Taipei (TW); **Ching-Hsiang Ko**, Taipei (TW); **Cheng-Hsiung Wu**, Taipei (TW); **Shih-Keng Huang**, Taipei (TW); **Yi-Ru Yang**, Taipei (TW); **Sheng-Chin Hsu**, Taipei (TW)

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

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

(21) Appl. No.: **17/035,435**

(22) Filed: **Sep. 28, 2020**

(65) **Prior Publication Data**

US 2021/0159602 A1 May 27, 2021

(30) **Foreign Application Priority Data**

Nov. 25, 2019 (TW) 108142812

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 13/10 (2006.01)
H01Q 13/16 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 13/16*** (2013.01); ***H01Q 13/103*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 13/103; H01Q 13/10; H01Q 13/16; H01Q 5/36; H01Q 5/364; H01Q 1/24; H01Q 1/38; H01Q 5/10
See application file for complete search history.

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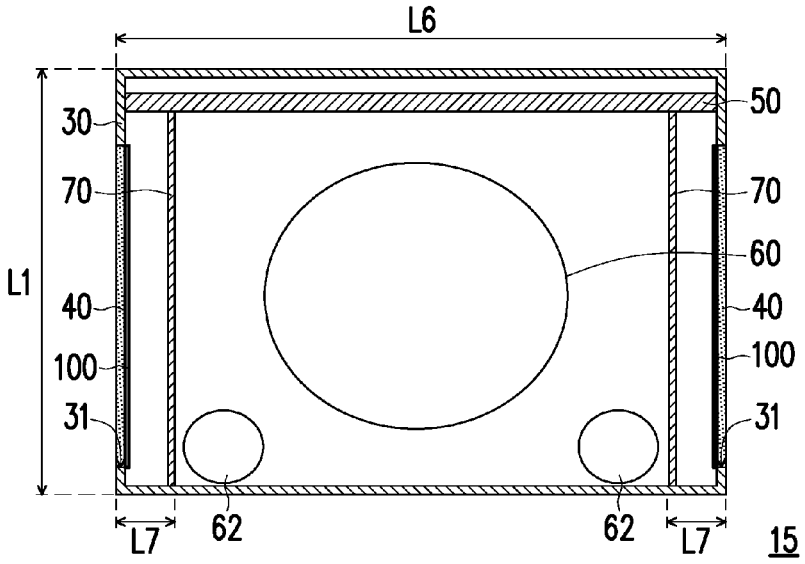
Primary Examiner — Tho G Phan
(74) *Attorney, Agent, or Firm* — J.C. Patents

(57) **ABSTRACT**

An antenna module includes a metal frame and an antenna structure. The metal frame includes an opening and a first edge and a second edge located at two opposite sides of the opening. The antenna structure is disposed at the opening and includes a first radiator, a second radiator, a first conductor, and a second conductor. The first radiator includes first and second sections. The first section is near the first edge and includes a feeding end, and the second section extends from the first section to the second edge. The second radiator is located between the first section and the first edge and includes a ground end. A first slit is formed between the second radiator and the first section. The first conductor is connected between the second radiator and the metal frame. The second conductor is connected between the second radiator and the metal frame.

10 Claims, 9 Drawing Sheets



US011283191B2

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

(10) **Patent No.: US 11,283,191 B2**
(45) **Date of Patent: Mar. 22, 2022**

(54) **ANTENNA ARRAY AND ANTENNA MODULE**

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

(72) Inventors: **Kengo Onaka**, Kyoto (JP); **Tadashi Sugahara**, Kyoto (JP); **Yoshiki Yamada**, Kyoto (JP); **Hirotsugu Mori**, 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 5 days.

(21) Appl. No.: **16/912,803**

(22) Filed: **Jun. 26, 2020**

(65) **Prior Publication Data**

US 2020/0328531 A1 Oct. 15, 2020

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2018/039630, filed on Oct. 25, 2018.

(30) **Foreign Application Priority Data**

Dec. 28, 2017 (JP) JP2017-252770

(51) **Int. Cl.**
H01Q 21/06 (2006.01)
H01Q 1/48 (2006.01)
H01Q 1/52 (2006.01)

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

(58) **Field of Classification Search**
CPC H01Q 1/38–1/52; H01Q 21/065
See application file for complete search history.

(56) **References Cited**

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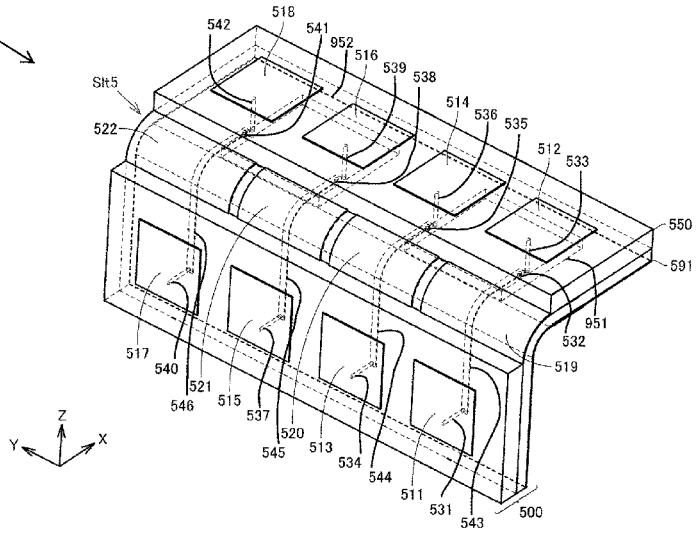
(Continued)

Primary Examiner — Hasan Islam
(74) *Attorney, Agent, or Firm* — Pearne & Gordon LLP

(57) **ABSTRACT**

In an antenna array of the present disclosure, in a plan view from a direction that is normal to an isolation element, the isolation element is formed between a first antenna element and a second antenna element. A first distance between the first antenna element and a first ground electrode is different from a second distance between the isolation element and the first ground electrode. A third distance between the second antenna element and the first ground electrode is different from the second distance. In a plan view from a direction that is normal to the first antenna element, the isolation element is spaced apart from the first antenna element. In a plan view from a direction that is normal to the second antenna element, the isolation element is spaced apart from the second antenna element.

15 Claims, 14 Drawing Sheets



US011283193B2

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

(10) **Patent No.: US 11,283,193 B2**
(45) **Date of Patent: Mar. 22, 2022**

(54) **SUBSTRATE INTEGRATED WAVEGUIDE ANTENNA**

(71) Applicant: **SONY MOBILE COMMUNICATIONS INC.**, Tokyo (JP)

(72) Inventors: **Zhinong Ying**, Lund (SE); **Kun Zhao**, Stockholm (SE)

(73) Assignee: **Sony Group Corporation**, Tokyo (JP)

(*) 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.: **16/960,806**

(22) PCT Filed: **Mar. 8, 2018**

(86) PCT No.: **PCT/IB2018/051518**
§ 371 (c)(1),
(2) Date: **Jul. 8, 2020**

(87) PCT Pub. No.: **WO2019/171148**
PCT Pub. Date: **Sep. 12, 2019**

(65) **Prior Publication Data**

US 2020/0403324 A1 Dec. 24, 2020

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

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

(58) **Field of Classification Search**
CPC H01Q 21/24; H01Q 1/2283; H01Q 9/0407
See application file for complete search history.

(56) **References Cited**

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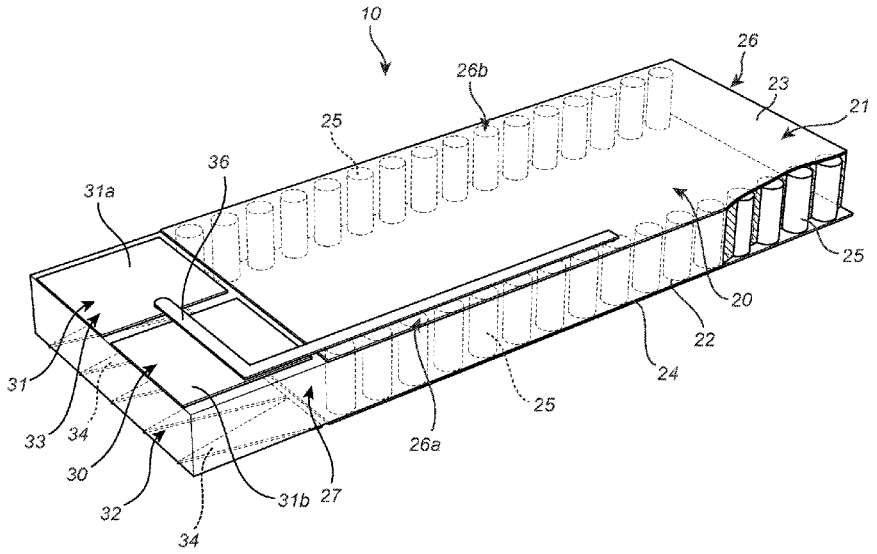
(Continued)

Primary Examiner — Peguy Jean Pierre
(74) *Attorney, Agent, or Firm* — Tucker Ellis LLP

(57) **ABSTRACT**

A SIW-antenna includes a SIW-structure extending along a horizontal plane for guiding electromagnetic waves along a longitudinal direction from a first feed to a radiation aperture, and a parallel plate resonator arranged at the radiation aperture and having a first flat portion extending in a first plane parallel with the horizontal plane and a second flat portion extending in a second plane parallel with the horizontal plane. The first and second planes are separate from each other. The first flat portion has an additional antenna structure connected to a second feed. The second flat portion has a plurality of flat tabs extending in the longitudinal direction. The SIW-structure is configured to radiate electromagnetic waves polarized in a first direction. The additional antenna structure is configured to radiate electromagnetic waves polarized in a second direction orthogonal to the first direction.

19 Claims, 3 Drawing Sheets



US011283195B2

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

(10) **Patent No.: US 11,283,195 B2**
(45) **Date of Patent: Mar. 22, 2022**

(54) **FAST ROLLOFF ANTENNA ARRAY FACE WITH HETEROGENEOUS ANTENNA ARRANGEMENT**

(71) Applicant: **JOHN MEZZALINGUA ASSOCIATES, LLC**, Liverpool, NY (US)

(72) Inventors: **Taehee Jang**, Fayetteville, NY (US); **Niranjan Sundararajan**, Liverpool, NY (US); **Jordan Ragos**, Syracuse, NY (US)

(73) Assignee: **JOHN MEZZALINGUA ASSOCIATES, LLC**, Liverpool, NY (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.: **16/962,892**

(22) PCT Filed: **Jan. 24, 2019**

(86) PCT No.: **PCT/US2019/014899**
§ 371 (c)(1),
(2) Date: **Jul. 17, 2020**

(87) PCT Pub. No.: **WO2019/147769**
PCT Pub. Date: **Aug. 1, 2019**

(65) **Prior Publication Data**

US 2021/0050675 A1 Feb. 18, 2021

Related U.S. Application Data

(60) Provisional application No. 62/621,314, filed on Jan. 24, 2018.

(51) **Int. Cl.**
H01Q 21/26 (2006.01)
H01Q 5/42 (2015.01)
H01Q 1/24 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 21/26*** (2013.01); ***H01Q 1/246*** (2013.01); ***H01Q 5/42*** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 21/26; H01Q 5/42; H01Q 1/246
See application file for complete search history.

(56) **References Cited**

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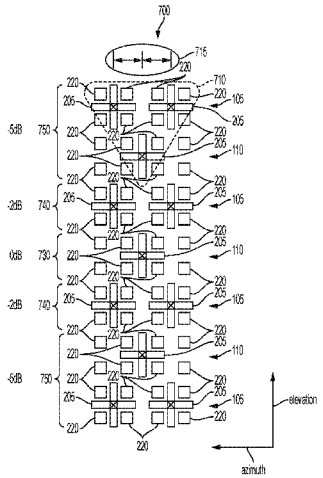
Primary Examiner — Lam T Mai
(74) *Attorney, Agent, or Firm* — Meunier Carlin & Curfman LLC

(57) **ABSTRACT**

A multiband antenna has a plurality of first, unit cells and second unit cells. Each first unit cell has two high band radiator clusters and two low band radiators disposed approximately in the center of each of the high band radiator clusters. Each second unit cell has two high band radiator clusters and one low band radiator that is disposed between the two high band radiator clusters. The first unit cell is designed for a superior low band gain pattern, and the second unit cell is designed for a superior high band gain pattern. By selectively arranging the first and second unit cells in a specific heterogeneous pattern, the characteristics of the two unit cells may advantageously and constructively

(Continued)



US011284538B2

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

(10) **Patent No.: US 11,284,538 B2**
(45) **Date of Patent: Mar. 22, 2022**

(54) **ELECTRONIC DEVICE INCLUDING COMPOSITE HEAT DISSIPATION MEMBER AND METHOD OF MANUFACTURING THE SAME**

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

(72) Inventors: **Ohhyuck Kwon**, Suwon-si (KR); **Min Park**, Suwon-si (KR); **Jaeyoung Huh**, Suwon-si (KR); **Daesuk Kang**, Suwon-si (KR); **Ji Eom**, Suwon-si (KR); **Ewidon Jeong**, Suwon-si (KR); **Sungchul Park**, 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.: **16/988,980**

(22) Filed: **Aug. 10, 2020**

(65) **Prior Publication Data**

US 2021/0059076 A1 Feb. 25, 2021

(30) **Foreign Application Priority Data**

Aug. 19, 2019 (KR) 10-2019-0100901

(51) **Int. Cl.**
H05K 7/20 (2006.01)
G06F 1/20 (2006.01)
H01Q 1/02 (2006.01)

(52) **U.S. Cl.**
CPC ***H05K 7/20445*** (2013.01); ***G06F 1/203*** (2013.01); ***H01Q 1/02*** (2013.01)

(58) **Field of Classification Search**
CPC H05K 7/20445; H05K 7/2039; H05K 1/0203; H05K 7/205; H05K 2201/10098; H05K 7/20; G06F 1/203; H01Q 1/02; H01L 2924/1421; B29L 2031/3456
See application file for complete search history.

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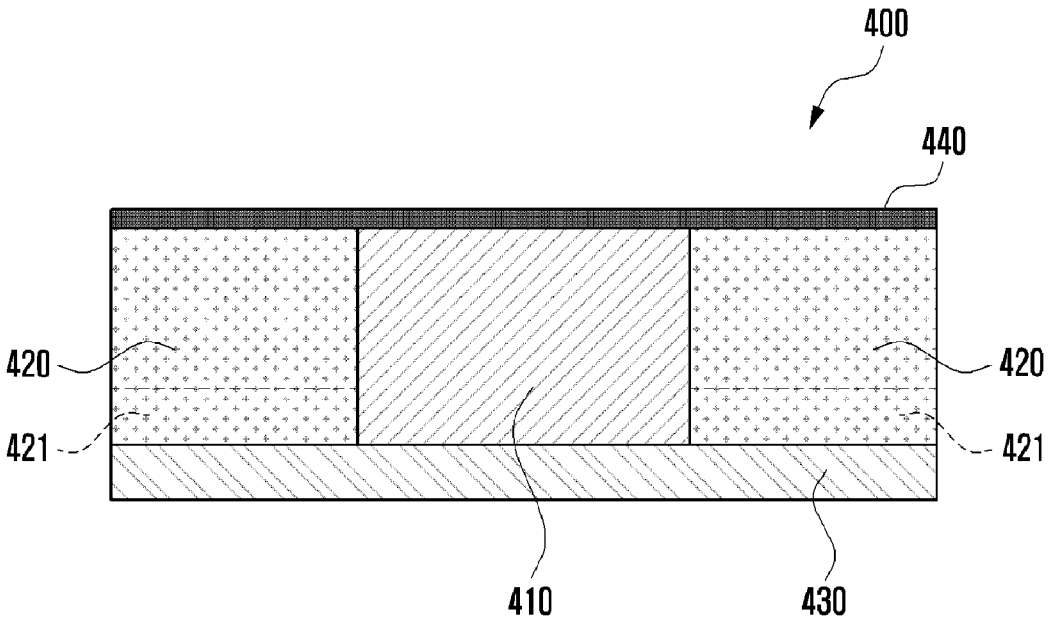
Primary Examiner — Michael A Matey

(57) **ABSTRACT**

A composite heat dissipation member and an electronic device comprising the composite heat dissipation member. The composite head dissipation member may include a first heat dissipation sheet disposed to be overlapped with an antenna module, and a second heat dissipation sheet disposed adjacent to the first heat dissipation sheet without an overlap with the first heat dissipation sheet, thermally connected to the first heat dissipation sheet, and having a higher thermal conductivity than the first heat dissipation sheet.

18 Claims, 12 Drawing Sheets



US011289790B2

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

(10) **Patent No.: US 11,289,790 B2**
(45) **Date of Patent: Mar. 29, 2022**

(54) **ELECTRONIC DEVICE INCLUDING ANTENNA MODULE HAVING HEAT TRANSFER MEMBER EXTENDING THEREFROM**

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

(72) Inventors: **Jungmin Park**, Suwon-si (KR); **Chonghwa Seo**, Suwon-si (KR); **Dongil Son**, Suwon-si (KR); **Jongwon Lee**, Suwon-si (KR); **Sangwon Ha**, 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 6 days.

(21) Appl. No.: **17/025,096**

(22) Filed: **Sep. 18, 2020**

(65) **Prior Publication Data**

US 2021/0091450 A1 Mar. 25, 2021

(30) **Foreign Application Priority Data**

Sep. 19, 2019 (KR) 10-2019-0115535

(51) **Int. Cl.**
H01Q 1/02 (2006.01)
H01Q 21/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 1/02*** (2013.01); ***H01Q 1/2283*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 21/00*** (2013.01);
(Continued)

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

(56) **References Cited**

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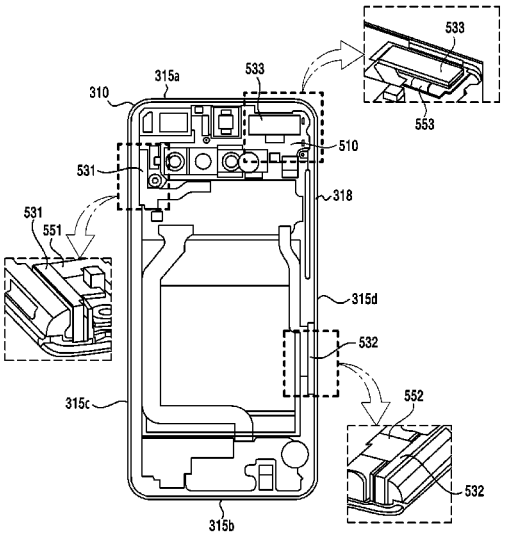
Primary Examiner — David E Lotter
(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

(57) **ABSTRACT**

An electronic device is provided. The electronic device includes a housing, an antenna module disposed along an inner wall of the housing, and a heat dissipation member disposed inside the housing. The antenna module may include a first circuit board including a plurality of layers, wherein the plurality of layers include a plurality of conductive layers and a plurality of non-conductive layers, and the conductive layer and the non-conductive layer are alternately stacked, at least one integrated circuit mounted on the first circuit board, an antenna array disposed on any one of the plurality of layers and electrically coupled with the at least one integrated circuit, and a heat transfer member including a conductive member extending from any one conductive layer among the plurality of conductive layers and a non-conductive member surrounding, at least in part, the conductive member.

20 Claims, 16 Drawing Sheets



US011289797B2

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

(10) **Patent No.: US 11,289,797 B2**
(45) **Date of Patent: Mar. 29, 2022**

(54) **ELECTRONIC DEVICE**

(71) Applicant: **Lenovo (Beijing) Co., Ltd.**, Beijing (CN)

(72) Inventors: **Wei Wang**, Beijing (CN); **Jian Ren**, Beijing (CN); **Zhiyuan Duan**, Beijing (CN); **Shuangjie Wu**, Beijing (CN)

(73) Assignee: **LENOVO (BEIJING) 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 77 days.

(21) Appl. No.: **16/581,731**

(22) Filed: **Sep. 24, 2019**

(65) **Prior Publication Data**

US 2020/0106165 A1 Apr. 2, 2020

(30) **Foreign Application Priority Data**

Sep. 30, 2018 (CN) 201811162945.8

(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H01Q 21/06	(2006.01)
H01Q 5/50	(2015.01)
H01Q 13/10	(2006.01)

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

CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/24*** (2013.01); ***H01Q 5/50*** (2015.01); ***H01Q 13/10*** (2013.01); ***H01Q 21/06*** (2013.01); ***H01Q 21/064*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 13/10; H01Q 5/50; H01Q 21/064; H01Q 1/24; H01Q 21/06; H01Q 5/40; H01Q 1/2258; H01Q 1/242; H01Q 1/44

USPC 343/770

See application file for complete search history.

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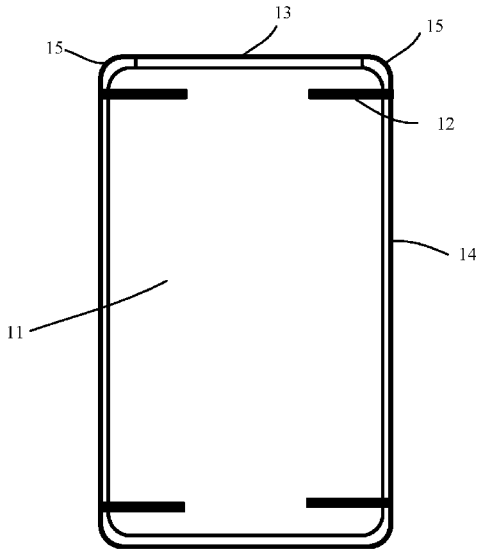
Primary Examiner — Hai V Tran

(74) *Attorney, Agent, or Firm* — Anova Law Group, PLLC

(57) **ABSTRACT**

The present disclosure provides an electronic device including: a metal housing having four antenna slots, which correspond to four antennas that enable the electronic device to support a fifth generation mobile communication network. The present disclosure can realize antennas that enable an electronic device having a metal back housing to support a fifth generation mobile communication network.

14 Claims, 6 Drawing Sheets



US011289809B2

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

(10) **Patent No.: US 11,289,809 B2**
(45) **Date of Patent: Mar. 29, 2022**

(54) **DUAL-BAND DIRECTIONAL ANTENNA, WIRELESS DEVICE, AND WIRELESS COMMUNICATION SYSTEM**

(71) Applicant: **THE ANTENNA COMPANY INTERNATIONAL N.V.**, Willemstad (CW)

(72) Inventors: **Bedilu Befekadu Adela**, Eindhoven (NL); **Daniel Alexandru Cringus**, Veldhoven (NL); **Diego Caratelli**, Eersel (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 49 days.

(21) Appl. No.: **16/831,002**

(22) Filed: **Mar. 26, 2020**

(65) **Prior Publication Data**

US 2020/0313295 A1 Oct. 1, 2020

(30) **Foreign Application Priority Data**

Mar. 27, 2019 (NL) 2022823

(51) **Int. Cl.**
H01Q 5/30 (2015.01)
H01Q 21/24 (2006.01)
H01Q 1/24 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 5/30*** (2015.01); ***H01Q 1/246*** (2013.01); ***H01Q 21/24*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/30; H01Q 1/246; H01Q 21/0043; H01Q 21/064; H01Q 21/24; H01Q 13/08; H01Q 13/085; H01Q 13/10; H01Q 19/13
See application file for complete search history.

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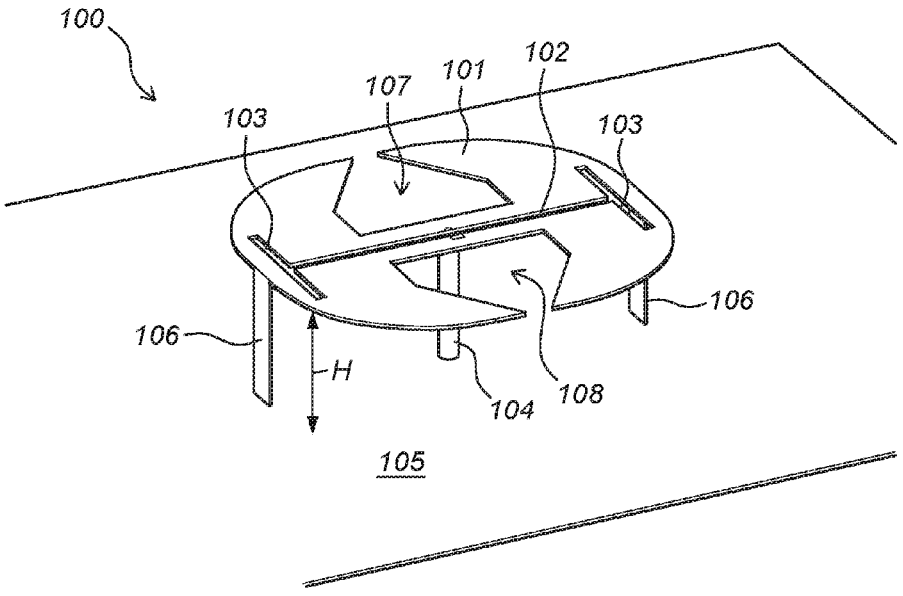
Primary Examiner — Jason Crawford
(74) *Attorney, Agent, or Firm* — Nath, Goldberg & Meyer; Joshua B. Goldberg

(57) **ABSTRACT**

A dual-band directional antenna for customer-premise equipment (CPE) applications is provided. The dual-band directional antenna includes at least one conductive radiating element, a probing structure connected to the radiating element, a conductive ground plane, and at least one mounting element for mounting the at least one radiating element on the ground plane at a distance therefrom. The antenna is configured to operate in two different frequency bands. The radiating element partially encloses at least one first cut-out portion and partially encloses at least one second cut-out portion, where the at least one first cut-out portion and the at least one second cut-out portion are positioned at opposite sides of a first slot of the radiating element.

19 Claims, 15 Drawing Sheets



US011289810B2

(12) **United States Patent**
Lyu

(10) **Patent No.: US 11,289,810 B2**
(45) **Date of Patent: Mar. 29, 2022**

(54) **MULTI-BAND ANTENNA**

(71) Applicants: **Inventec (Pudong) Technology Corporation**, Shanghai (CN); **INVENTEC CORPORATION**, Taipei (TW)

(72) Inventor: **Chao-An Lyu**, Taipei (TW)

(73) Assignees: **Inventec (Pudong) Technology Corporation**, Shanghai (CN); **INVENTEC 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 224 days.

(21) Appl. No.: **16/711,454**

(22) Filed: **Dec. 12, 2019**

(65) **Prior Publication Data**

US 2021/0151885 A1 May 20, 2021

(30) **Foreign Application Priority Data**

Nov. 15, 2019 (CN) 201911120474.9

(51) **Int. Cl.**

H01Q 5/307	(2015.01)
H01Q 1/48	(2006.01)
H01Q 9/42	(2006.01)
H01Q 5/10	(2015.01)
H01Q 9/04	(2006.01)
H01Q 5/385	(2015.01)

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

CPC ***H01Q 5/307*** (2015.01); ***H01Q 1/48*** (2013.01); ***H01Q 5/10*** (2015.01); ***H01Q 9/42*** (2013.01); *H01Q 5/385* (2015.01); *H01Q 9/0457* (2013.01)

(58) **Field of Classification Search**

CPC H01Q 5/371; H01Q 5/378; H01Q 9/0457; H01Q 5/40; H01Q 5/385; H01Q 5/328

See application file for complete search history.

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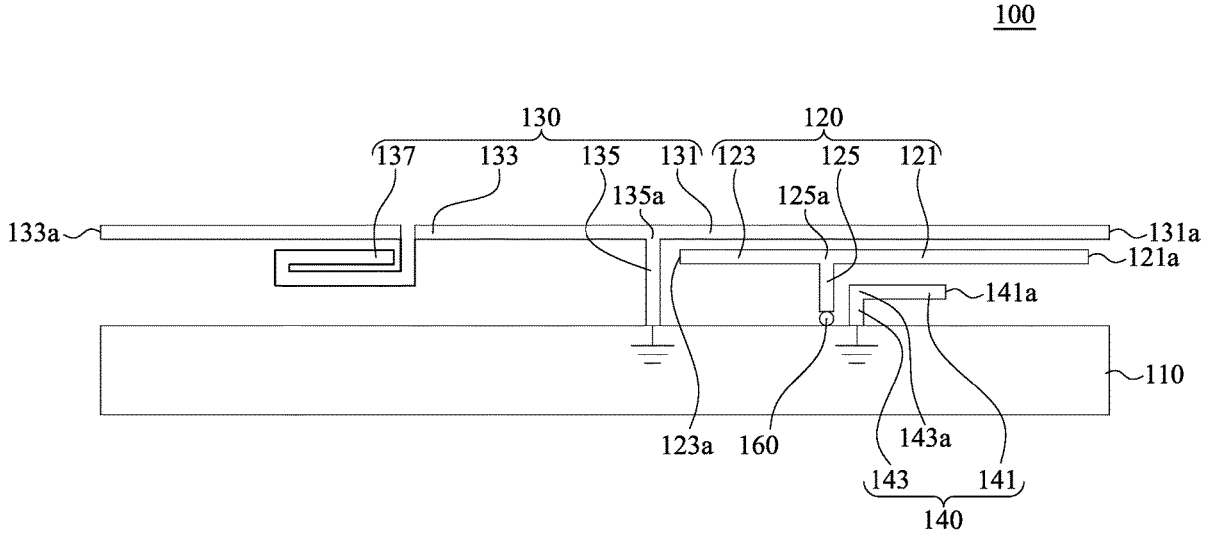
Primary Examiner — Ricardo I Magallanes

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

(57) **ABSTRACT**

A multi-band antenna includes a grounding conductor, a first radiator, and a second radiator. The grounding conductor has a grounding function. The first radiator has a first radiating portion, a second radiating portion, and a feeding portion configured to connect to a signal source. The second radiator includes a third radiating portion, a fourth radiating portion, and a first grounding portion. A length of the third radiating portion or a length of the fourth radiating portion is longer than lengths of first radiating portion and the second radiating portion combined, and the third radiating portion or the fourth radiating portion is radiationally coupled with the first radiating portion and the second radiating portion.

7 Claims, 2 Drawing Sheets



US011289811B2

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

(10) **Patent No.: US 11,289,811 B2**
(45) **Date of Patent: Mar. 29, 2022**

(54) **CLOSED-LOOP ANTENNA WITH MULTIPLE GROUNDING POINTS**

(71) Applicant: **MediaTek Inc**, Hsinchu (TW)

(72) Inventors: **Tsung-Ju Wu**, Hsinchu (TW); **Ting-Wei Kang**, Hsinchu (TW); **Chung-Yu Hung**, Hsinchu (TW)

(73) Assignee: **MediaTek Inc.**

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 277 days.

(21) Appl. No.: **16/110,506**

(22) Filed: **Aug. 23, 2018**

(65) **Prior Publication Data**

US 2019/0067815 A1 Feb. 28, 2019

Related U.S. Application Data

(60) Provisional application No. 62/549,480, filed on Aug. 24, 2017.

(51) **Int. Cl.**

H01Q 5/35	(2015.01)
H01Q 1/48	(2006.01)
H01Q 1/50	(2006.01)
H01Q 5/50	(2015.01)
H01Q 7/00	(2006.01)
H01Q 13/10	(2006.01)
H01Q 5/328	(2015.01)

(Continued)

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

CPC ***H01Q 5/35*** (2015.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 1/50*** (2013.01);

(Continued)

(58) **Field of Classification Search**

CPC H01Q 5/35; H01Q 13/103; H01Q 5/328; H01Q 1/243; H01Q 5/371; H01Q 7/00;

(Continued)

(56) **References Cited**

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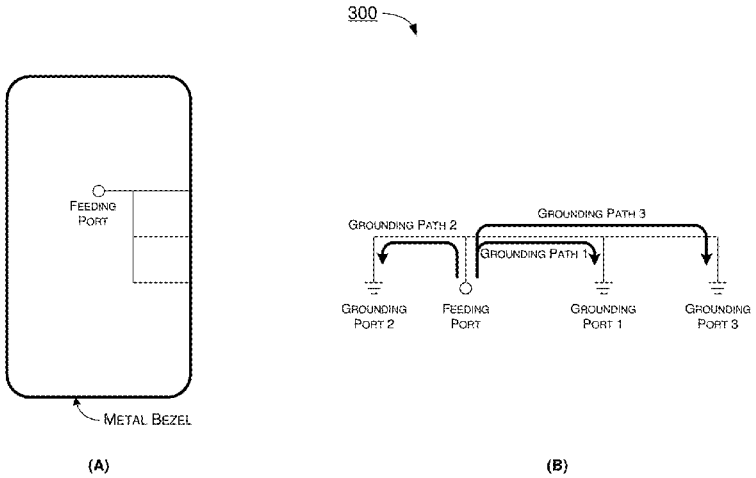
Primary Examiner — Dimary S Lopez Cruz
Assistant Examiner — Michael M Bouizza
(74) *Attorney, Agent, or Firm* — Han IP PLLC; Andy M. Han

(57) **ABSTRACT**

Various examples and schemes pertaining to a closed-loop antenna with multiple grounding points are described. An apparatus includes an electromagnetic (EM) wave interface device capable of radiating and sensing EM waves. The EM wave interface device includes a feeding port, a first grounding port coupled to an electric ground, and a second grounding port coupled to the electric ground. A first electrically-conductive path connected between the feeding port and the first grounding port forms a closed-loop antenna. A second electrically-conductive path connected between the feeding port and the second grounding port forms a non-radiative closed-loop path. A length of the first electrically-conductive path is greater than a length of the second electrically-conductive path.

20 Claims, 18 Drawing Sheets



US011289812B2

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

(10) **Patent No.: US 11,289,812 B2**
(45) **Date of Patent: Mar. 29, 2022**

(54) **SINGLE ANTENNA SYSTEM**

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

(72) Inventors: **Che-Chi Wan**, Taipei (TW); **Saou-Wen Su**, Taipei (TW); **Cheng-Tse Lee**, Taipei (TW)

(73) Assignee: **ASUSTEK COMPUTER INC.**, Taipei (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.: **17/075,790**

(22) Filed: **Oct. 21, 2020**

(65) **Prior Publication Data**

US 2021/0126365 A1 Apr. 29, 2021

(30) **Foreign Application Priority Data**

Oct. 29, 2019 (TW) 108139136

(51) **Int. Cl.**

H01Q 1/38	(2006.01)
H01Q 5/35	(2015.01)
H01Q 1/22	(2006.01)
H01Q 9/04	(2006.01)

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

CPC ***H01Q 5/35*** (2015.01); ***H01Q 1/2283*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 9/0407*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 5/35; H01Q 1/2283; H01Q 1/38; H01Q 9/0407

USPC 343/702

See application file for complete search history.

(56) **References Cited**

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2021/0167491	A1 *	6/2021	Chang	H01Q 5/371

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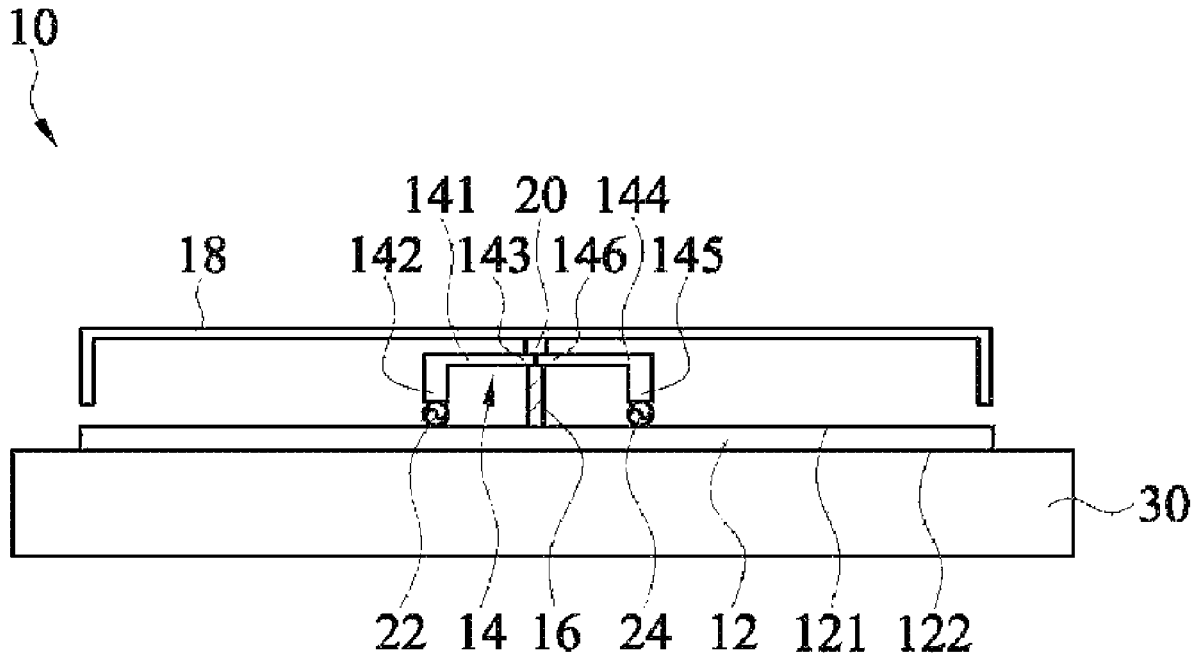
Primary Examiner — Peguy Jean Pierre

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

(57) **ABSTRACT**

The disclosure provides a single antenna system comprising a ground element, a feeding metal part, at least one shorting metal part, a radiating metal part, a decoupling circuit, a first feed source, and a second feed source. The single antenna system with an integrated decoupled circuit not only effectively achieves size reduction, but achieve high antenna isolation. Moreover, the single antenna system is applied for narrow-bezel notebooks and small-size antenna systems in future.

10 Claims, 6 Drawing Sheets



US011289820B2

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

(10) **Patent No.: US 11,289,820 B2**
(45) **Date of Patent: Mar. 29, 2022**

(54) **HIGH-ISOLATION ANTENNA SYSTEM**

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

(72) Inventors: **Artem Yurievich Nikishov**, Kolomna (RU); **Gennadiy Aleksandrovich Evtyushkin**, Moscow (RU); **Elena Aleksandrovna Shepeleva**, Kostroma (RU); **Anton Sergeevich Lukyanov**, Moscow (RU); **Byung Kwan Kim**, Suwon-si (KR); **Jong-Sok Kim**, Hwaseong-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 168 days.

(21) Appl. No.: **16/703,647**

(22) Filed: **Dec. 4, 2019**

(65) **Prior Publication Data**

US 2020/0185834 A1 Jun. 11, 2020

(30) **Foreign Application Priority Data**

Dec. 10, 2018 (RU) RU2018143560
Sep. 10, 2019 (KR) 10-2019-0111979

(51) **Int. Cl.**
H01Q 19/17 (2006.01)
H01Q 1/52 (2006.01)
H01Q 21/24 (2006.01)
H01Q 21/28 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 19/17*** (2013.01); ***H01Q 1/521*** (2013.01); ***H01Q 21/24*** (2013.01); ***H01Q 21/28*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 19/17; H01Q 1/521; H01Q 21/24; H01Q 21/28
See application file for complete search history.

(56) **References Cited**

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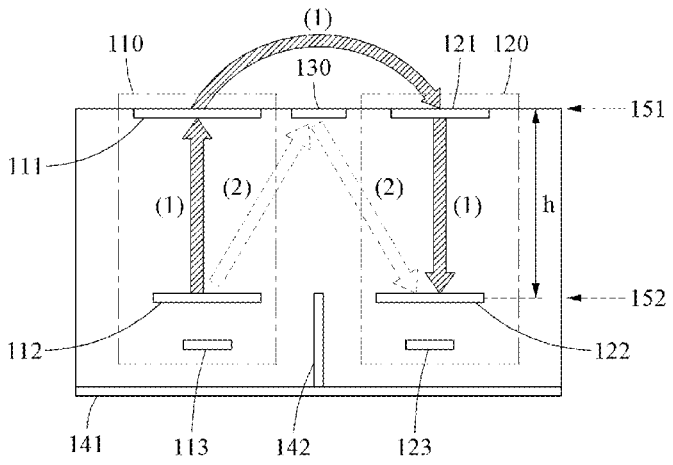
Primary Examiner — Graham P Smith
(74) *Attorney, Agent, or Firm* — NSIP Law

(57) **ABSTRACT**

An antenna system includes a first antenna including first radiating components and first planar re-radiating components, a second antenna including second radiating components and second planar re-radiating components, and reflective components positioned between the first planar re-radiating components and the second planar re-radiating components.

22 Claims, 17 Drawing Sheets



US011289822B2

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

(10) **Patent No.: US 11,289,822 B2**
(45) **Date of Patent: Mar. 29, 2022**

(54) **ANTENNA DEVICE**

(71) Applicant: **Mitsubishi Electric Corporation**, Tokyo (JP)

(72) Inventors: **Jun Goto**, Tokyo (JP); **Takashi Maruyama**, Tokyo (JP); **Toru Fukasawa**, Tokyo (JP)

(73) Assignee: **MITSUBISHI ELECTRIC CORPORATION**, Tokyo (JP)

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

(21) Appl. No.: **16/933,295**

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

(65) **Prior Publication Data**

US 2020/0350694 A1 Nov. 5, 2020

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2018/002325, filed on Jan. 25, 2018.

(51) **Int. Cl.**

H01Q 21/06	(2006.01)
H01Q 21/00	(2006.01)
H01Q 1/00	(2006.01)
H01Q 9/04	(2006.01)

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

CPC ***H01Q 21/0075*** (2013.01); ***H01Q 1/002*** (2013.01); ***H01Q 9/0407*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 21/065; H01Q 1/38; H01Q 21/0075

See application file for complete search history.

(56) **References Cited**

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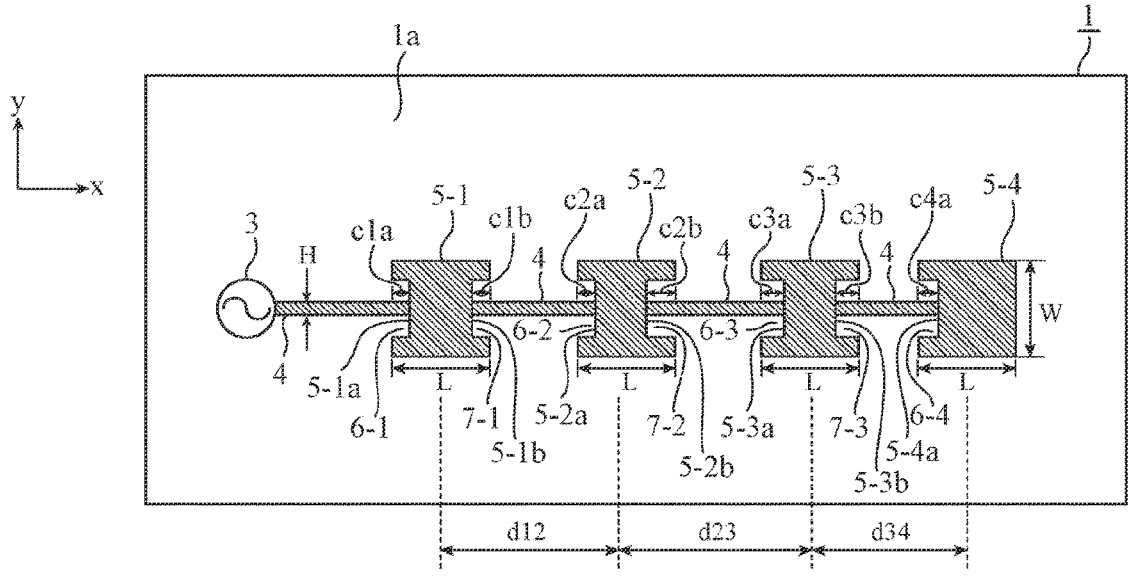
Primary Examiner — Hasan Islam

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

(57) **ABSTRACT**

In radiation elements, recessed portions for adjusting the power of an electromagnetic wave that passes through the radiation elements are formed as power adjustment portions at coupling portions, respectively, which are on the opposite side of a feeding unit out of sets of two coupling portions to a feed line.

5 Claims, 6 Drawing Sheets



US011289823B2

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

(10) **Patent No.: US 11,289,823 B2**
(45) **Date of Patent: Mar. 29, 2022**

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

(71) Applicant: **AAC Technologies Pte. Ltd.**, Singapore (SG)

(72) Inventors: **Si Chen**, Shenzhen (CN); **Jing Wu**, Shenzhen (CN)

(73) Assignee: **AAC Technologies Pte. Ltd.**, Singapore (SG)

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

(21) Appl. No.: **16/995,836**

(22) Filed: **Aug. 18, 2020**

(65) **Prior Publication Data**

US 2020/0412014 A1 Dec. 31, 2020

Related U.S. Application Data

(63) Continuation of application No. PCT/CN2019/093994, filed on Jun. 29, 2019.

(51) **Int. Cl.**
H01Q 21/06 (2006.01)
H01Q 1/48 (2006.01)
H01Q 21/00 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 21/061*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 21/0006*** (2013.01); *H01Q 21/0075* (2013.01); *H01Q 21/0081* (2013.01); *H01Q 21/065* (2013.01)

(58) **Field of Classification Search**
CPC .. H01Q 21/061; H01Q 19/005; H01Q 21/065; H01Q 21/0075; H01Q 21/0081
See application file for complete search history.

(56) **References Cited**

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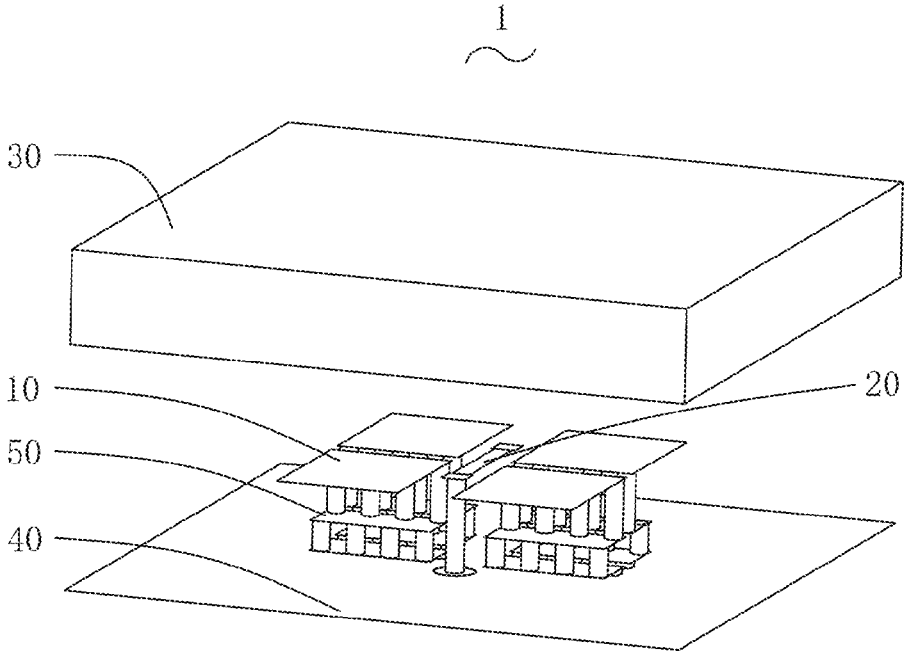
Primary Examiner — Ricardo I Magallanes
(74) *Attorney, Agent, or Firm* — W&G Law Group

(57) **ABSTRACT**

The invention relates to an antenna and an electronic device. The antenna has a radiation part, a grounding sheet arranged separated from the radiation part and a number of ground connection parts. The radiation part has four radiators forming a first gap and a second gap. Each radiator is electrically connected to the grounding sheet through a ground connection part. The ground connection part includes at least an attaching sheet and a number of metal through holes. Each side of opposite two sides of each attaching sheet is electrically connected to at least one of the metal through holes. The electronic device includes the antenna. According to the technical scheme, the antenna has the advantage of low profile.

12 Claims, 5 Drawing Sheets



US011296394B2

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

(10) **Patent No.: US 11,296,394 B2**
(45) **Date of Patent: Apr. 5, 2022**

(54) **FLEXIBLE ANTENNA BELTS**

(71) Applicant: **HEWLETT-PACKARD DEVELOPMENT COMPANY, L.P.**, Spring, TX (US)

(72) Inventors: **Kuan-Ting Wu**, Taipei (TW); **Wei-Chung Chen**, Taipei (TW); **Shih Huang Wu**, Spring, TX (US)

(73) Assignee: **Hewlett-Packard Development Company, L.P.**, Spring, TX (US)

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

(21) Appl. No.: **16/760,998**

(22) PCT Filed: **Dec. 8, 2017**

(86) PCT No.: **PCT/US2017/065330**
§ 371 (c)(1),
(2) Date: **May 1, 2020**

(87) PCT Pub. No.: **WO2019/112608**
PCT Pub. Date: **Jun. 13, 2019**

(65) **Prior Publication Data**

US 2020/0313274 A1 Oct. 1, 2020

(51) **Int. Cl.**

H01Q 1/08	(2006.01)
H01Q 1/42	(2006.01)
H01Q 1/22	(2006.01)
G06F 1/16	(2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/085*** (2013.01); ***G06F 1/1652*** (2013.01); ***H01Q 1/42*** (2013.01); *H01Q 1/2266* (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/085; H01Q 1/12; H01Q 1/125; H01Q 1/1264; H01Q 1/20; H01Q 1/22; H01Q 1/2258; H01Q 1/2266; H01Q 1/42; G06F 1/1652
See application file for complete search history.

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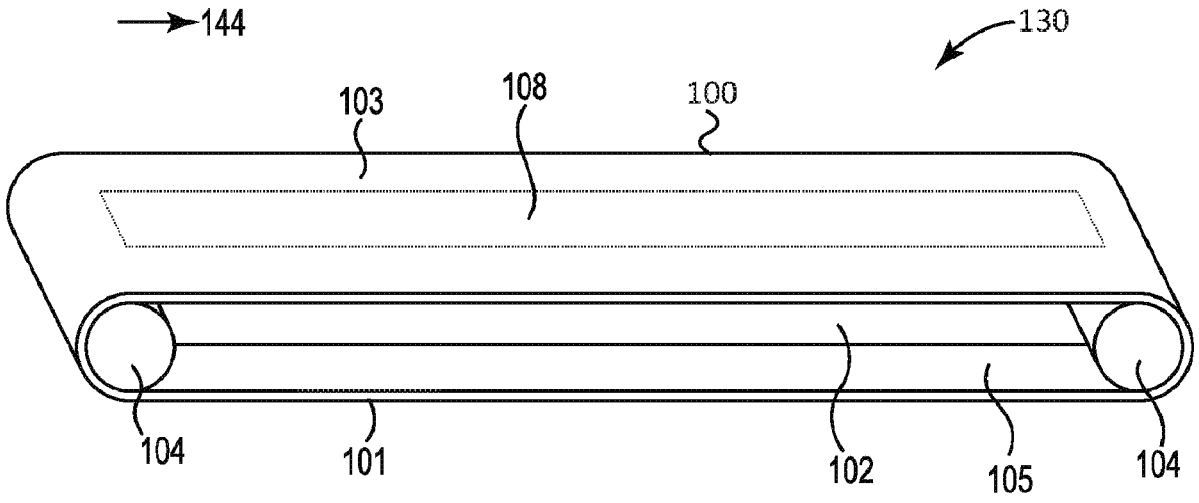
Primary Examiner — Jason Crawford
(74) *Attorney, Agent, or Firm* — Brooks, Cameron & Huebsch PLLC

(57) **ABSTRACT**

Examples described herein relate to flexible antenna belts. For instance, a system may comprise a flexible antenna belt, where the flexible antenna belt is to transition between a closed position and an open position, and a flexible display coupled to the flexible antenna belt.

15 Claims, 8 Drawing Sheets



US011296400B2

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

(10) **Patent No.: US 11,296,400 B2**
(45) **Date of Patent: Apr. 5, 2022**

(54) **ANTENNA DEVICE**

(71) Applicant: **FUJITSU LIMITED**, Kawasaki (JP)

(72) Inventors: **Takashi Yamagajo**, Yokosuka (JP); **Yohei Koga**, Kawasaki (JP); **Manabu Yoshikawa**, Yokohama (JP); **Tabito Tonooka**, Kawasaki (JP); **Hirotake Sumi**, Kawasaki (JP)

(73) Assignee: **FUJITSU LIMITED**, Kawasaki (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 217 days.

(21) Appl. No.: **16/374,255**

(22) Filed: **Apr. 3, 2019**

(65) **Prior Publication Data**

US 2019/0341675 A1 Nov. 7, 2019

(30) **Foreign Application Priority Data**

May 7, 2018 (JP) JP2018-089427

(51) **Int. Cl.**

H01Q 1/48	(2006.01)
H01Q 7/00	(2006.01)
H01Q 5/10	(2015.01)
H01Q 9/42	(2006.01)
H01Q 1/24	(2006.01)
H01Q 1/38	(2006.01)
H01Q 13/08	(2006.01)

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

CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 5/10*** (2015.01); ***H01Q 7/00*** (2013.01); ***H01Q 9/42*** (2013.01); ***H01Q 13/08*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 9/42; H01Q 1/48; H01Q 1/243; H01Q 9/265; H01Q 1/521

See application file for complete search history.

(56) **References Cited**

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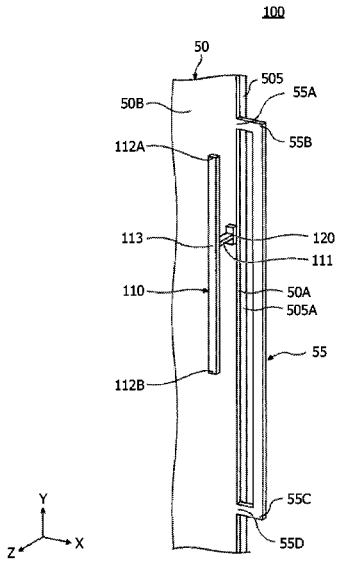
Primary Examiner — Ricardo I Magallanes

(74) *Attorney, Agent, or Firm* — ArentFox Schiff LLP

(57) **ABSTRACT**

An antenna device includes a ground plane that includes an edge and a surface, a protruding metallic member that includes a first connecting part and a second connecting part coupled to the ground plane, protrudes from the edge, and constructs a first loop including the edge, and a T-shaped antenna element that extends from a feeding point to a first end and a second end along the edge, the feeding point being disposed in the vicinity of the surface between the first connecting part and the second connecting part of the first loop, wherein a length of the first loop corresponds to an electric length of one wavelength in a first frequency, and corresponds to an electric length of two wavelengths in a second frequency that is a second order harmonic of the first frequency.

3 Claims, 34 Drawing Sheets



US011296401B2

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

(10) **Patent No.: US 11,296,401 B2**
(45) **Date of Patent: Apr. 5, 2022**

(54) **FILM ANTENNA AND DISPLAY DEVICE INCLUDING THE SAME**

(71) Applicants: **DONGWOO FINE-CHEM CO., LTD.**, Jeollabuk-do (KR); **KREEMO INC.**, Seoul (KR)

(72) Inventors: **Jong Min Kim**, Gyeonggi-do (KR); **Yun Seok Oh**, Gyeonggi-do (KR); **Yoon Ho Huh**, Seoul (KR); **Won Bin Hong**, Seoul (KR)

(73) Assignees: **DONGWOO FINE-CHEM CO., LTD.**, Jeollabuk-Do (KR); **KREEMO 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.: **16/860,836**

(22) Filed: **Apr. 28, 2020**

(65) **Prior Publication Data**

US 2020/0259245 A1 Aug. 13, 2020

Related U.S. Application Data

(63) Continuation of application No. PCT/KR2018/013341, filed on Nov. 6, 2018.

(30) **Foreign Application Priority Data**

Nov. 6, 2017 (KR) 10-2017-0146872

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

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 1/44*** (2013.01); ***H01Q 9/0407*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/38; H01Q 1/44; H01Q 9/0407; H01Q 21/08; H01Q 21/24; H01Q 21/28
See application file for complete search history.

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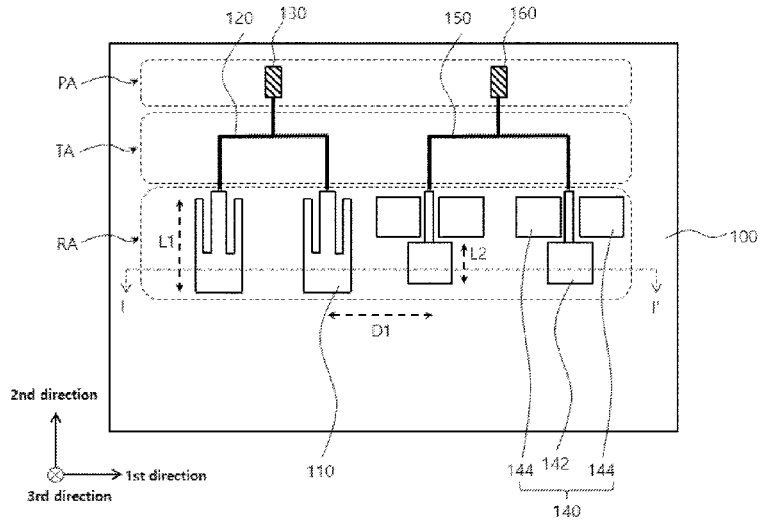
Primary Examiner — Seung H Lee
(74) *Attorney, Agent, or Firm* — The PL Law Group, PLLC

(57) **ABSTRACT**

A film antenna according to an embodiment of the present invention includes a dielectric layer, and a vertical radiation pattern and a horizontal radiation pattern on an upper surface of the dielectric layer. The vertical radiation pattern and the horizontal radiation pattern are arranged together on the same plane. Multi-axis radiation properties may be implemented in the same film by the vertical radiation pattern and the horizontal radiation pattern.

17 Claims, 7 Drawing Sheets



US011296412B1

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

(10) **Patent No.: US 11,296,412 B1**
(45) **Date of Patent: Apr. 5, 2022**

(54) **5G BROADBAND ANTENNA**

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

(72) Inventors: **Ziming He**, Irvine, CA (US); **Alven Jan Delos Santos Eusantos**, San Diego, CA (US)

(73) Assignee: **Airgain, Inc.**, San Diego, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 217 days.

(21) Appl. No.: **16/379,767**

(22) Filed: **Apr. 9, 2019**

Related U.S. Application Data

(63) Continuation-in-part of application No. 16/258,611, filed on Jan. 27, 2019, now Pat. No. 10,868,354.

(60) Provisional application No. 62/793,871, filed on Jan. 17, 2019.

(51) **Int. Cl.**

H01Q 5/28	(2015.01)
H01Q 21/00	(2006.01)
H01Q 5/50	(2015.01)
H01Q 5/371	(2015.01)

(52) **U.S. Cl.**
CPC ***H01Q 5/28*** (2015.01); ***H01Q 5/371*** (2015.01); ***H01Q 5/50*** (2015.01); ***H01Q 21/0043*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/371; H01Q 5/15; H01Q 5/30; H01Q 5/357; H01Q 5/364
See application file for complete search history.

(56) **References Cited**

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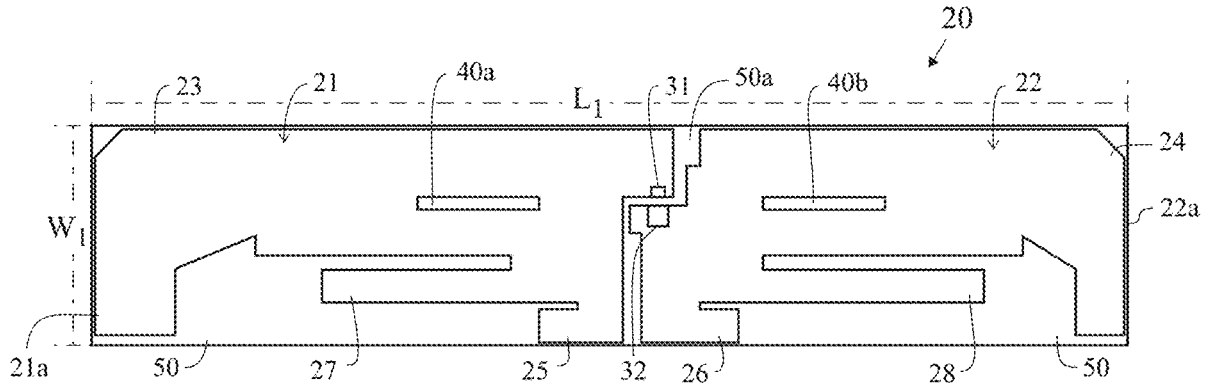
Primary Examiner — Dameon E Levi
Assistant Examiner — Jennifer F Hu
(74) *Attorney, Agent, or Firm* — Clause Eight; Michael Catania

(57) **ABSTRACT**

A 5G broadband antenna is disclosed herein. The 5G broadband antenna comprises a first antenna element and a second antenna element. Each of the first antenna element and the second antenna element has a main branch with a slot therein. The antenna apparatus covers a first frequency band of 617-960 MegaHertz, a second frequency band of 1.4-1.6 GigaHertz (GHZ), a third frequency band of 1.71-2.7 GHz, a fourth frequency band of 3.3 to 4.2 GHz, and a fifth frequency band of 4.3 to 6.0 GHz.

11 Claims, 13 Drawing Sheets



US011296413B2

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

(10) **Patent No.: US 11,296,413 B2**
(45) **Date of Patent: Apr. 5, 2022**

(54) **ANTENNA STRUCTURE**

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

(72) Inventors: **Chih-Feng Tai**, Hsinchu (TW); **Tzu-Chi Lu**, 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 95 days.

(21) Appl. No.: **17/020,999**

(22) Filed: **Sep. 15, 2020**

(65) **Prior Publication Data**

US 2021/0313692 A1 Oct. 7, 2021

(30) **Foreign Application Priority Data**

Apr. 1, 2020 (TW) 109111381

(51) **Int. Cl.**
H01Q 5/371 (2015.01)
H01Q 9/04 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 5/371*** (2015.01); ***H01Q 9/0407*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/30; H01Q 5/307; H01Q 5/321; H01Q 5/371; H01Q 5/378; H01Q 5/385; H01Q 5/392; H01Q 5/50; H01Q 1/241–243; H01Q 9/04; H01Q 9/0407
See application file for complete search history.

(56) **References Cited**

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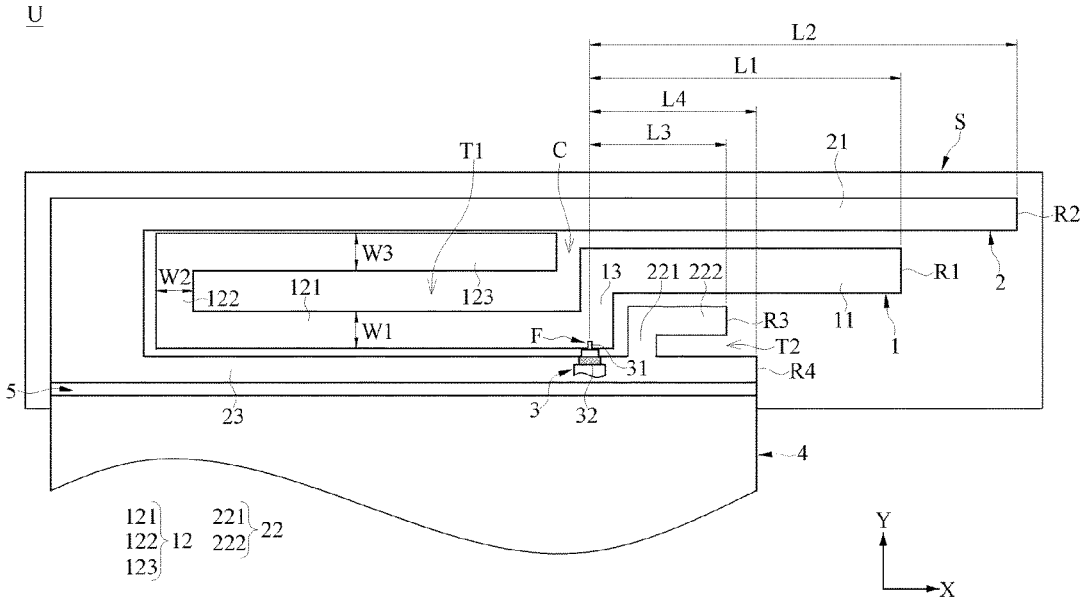
Primary Examiner — Jason Crawford
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

An antenna structure is provided. The antenna structure includes a first radiation element, a second radiation element, and a feeding element. The first radiation element includes a first radiation portion, a second radiation portion, and a feeding portion. The second radiation element includes a third radiation portion, a fourth radiation portion, and a grounding portion. The third radiation portion and the first radiation portion are separate from each other and coupled to each other, the third radiation portion and the second radiation portion are separate from each other and coupled to each other, and the fourth radiation portion and the first radiation portion are separate from each other and coupled to each other. The feeding element is electrically connected with the feeding portion and the grounding portion. A junction between the feeding element and the feeding portion is defined as a feeding point.

15 Claims, 9 Drawing Sheets



US011296415B2

(12) **United States Patent**
Fabrega Sanchez et al.

(10) **Patent No.: US 11,296,415 B2**
(45) **Date of Patent: Apr. 5, 2022**

(54) **MULTI-LAYER PATCH ANTENNA**

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

(72) Inventors: **Jorge Fabrega Sanchez**, San Diego, CA (US); **Alireza Mohammadian**, San Diego, CA (US); **Mohammad Ali Tassoudji**, San Diego, CA (US); **Assaf Haviv**, Petch-Tikwa (IL)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 552 days.

(21) Appl. No.: **16/147,232**

(22) Filed: **Sep. 28, 2018**

(65) **Prior Publication Data**

US 2020/0106183 A1 Apr. 2, 2020

(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H01Q 9/04	(2006.01)
H01Q 5/378	(2015.01)
H01Q 21/06	(2006.01)
H04B 1/04	(2006.01)

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

CPC ***H01Q 9/0414*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 5/378*** (2015.01); ***H01Q 9/0464*** (2013.01); ***H01Q 21/065*** (2013.01); ***H04B 1/0458*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/38; H01Q 9/0407; H01Q 19/005; H01Q 9/0414; H01Q 5/385

See application file for complete search history.

(56) **References Cited**

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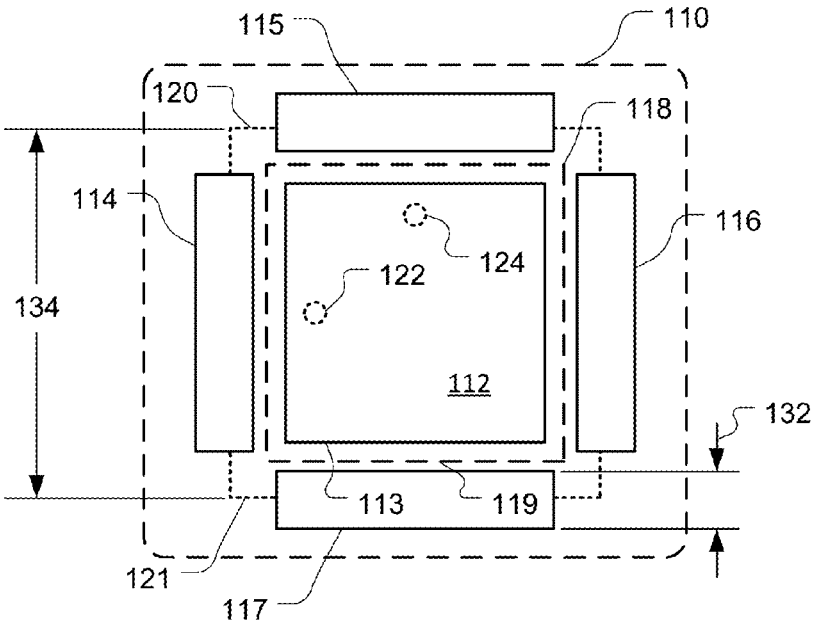
Primary Examiner — Graham P Smith

(74) *Attorney, Agent, or Firm* — Qualcomm Incorporated

(57) **ABSTRACT**

An antenna system includes: a patch radiator being electrically conductive and configured to radiate energy in a first frequency band and a second frequency band, different from the first frequency band; a parasitic patch radiator overlapping with the patch radiator, the parasitic patch radiator being electrically conductive and being configured to radiate energy in the first frequency band; and at least one parasitic element including a conductor sized and disposed relative to the parasitic patch radiator such that a combination of the parasitic patch radiator and the at least one parasitic element will radiate energy in the second frequency band.

30 Claims, 9 Drawing Sheets



US011296416B2

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

(10) **Patent No.: US 11,296,416 B2**
(45) **Date of Patent: Apr. 5, 2022**

(54) **METAMATERIAL STRUCTURE ANTENNA AND METAMATERIAL STRUCTURE ARRAY**

(71) Applicants: **Samsung Electronics Co., Ltd.**, Gyeonggi-do (KR); **Hongik University Industry-Academia Cooperation Foundation**, Seoul (KR)

(72) Inventors: **Jae-Seok Park**, Gyeonggi-do (KR); **Jeong-Hae Lee**, Seoul (KR); **Jae-Hyun Park**, Gyeonggi-do (KR); **Kwi-Seob Um**, Seoul (KR); **Young-Ho Ryu**, Gyeonggi-do (KR); **Chang-Hyun Lee**, Incheon (KR); **Sang-Wook Kwon**, Gyeonggi-do (KR); **Sung-Bum Park**, Gyeonggi-do (KR); **Jae-Gon Lee**, Gyeonggi-do (KR); **Sang-Wook Chi**, Incheon (KR)

(73) Assignees: **Samsung Electronics Co., Ltd**; **Hongik University Industry-Academica Cooperation Foundation**

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 265 days.

(21) Appl. No.: **16/608,621**

(22) PCT Filed: **Apr. 19, 2018**

(86) PCT No.: **PCT/KR2018/004537**
§ 371 (c)(1),
(2) Date: **Oct. 25, 2019**

(87) PCT Pub. No.: **WO2018/199549**
PCT Pub. Date: **Nov. 1, 2018**

(65) **Prior Publication Data**

US 2020/0052405 A1 Feb. 13, 2020

(30) **Foreign Application Priority Data**

Apr. 25, 2017 (KR) 10-2017-0052988

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 1/48 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 9/0428*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/245*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 3/36*** (2013.01); ***H01Q 15/148*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/0428; H01Q 19/005; H01Q 15/0086; H01Q 15/148; G02F 2202/30
See application file for complete search history.

(56) **References Cited**

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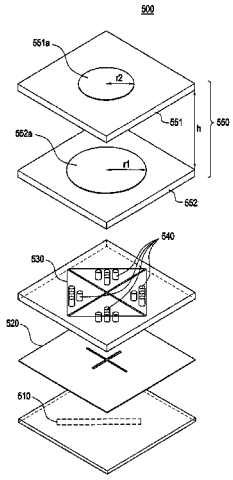
PCT/ISA/237 Written Opinion issued on PCT/KR2018/004537, pp. 5.

Primary Examiner — Ricardo I Magallanes
(74) *Attorney, Agent, or Firm* — The Farrell Law Firm, P.C.

(57) **ABSTRACT**

In various embodiments, a metamaterial structure antenna may comprise: a feed line for feeding a signal; a ground plane comprising a cross-shaped aperture forming circular polarization on the basis of a magnetic field induced by the
(Continued)



US011296418B2

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

(10) **Patent No.: US 11,296,418 B2**
(45) **Date of Patent: Apr. 5, 2022**

(54) **LOW-PROFILE DUAL-POLARIZATION FILTERING MAGNETO-ELECTRIC DIPOLE ANTENNA**

(71) Applicant: **SOUTH CHINA UNIVERSITY OF TECHNOLOGY**, Guangdong (CN)

(72) Inventors: **Xiuyin Zhang**, Guangzhou (CN); **Shengjie Yang**, Guangzhou (CN); **Zhijie Zhang**, Guangzhou (CN); **Yongmei Pan**, Guangzhou (CN); **Yunfei Cao**, Guangzhou (CN); **Yao Zhang**, Guangzhou (CN)

(73) Assignee: **SOUTH CHINA UNIVERSITY OF TECHNOLOGY**, Guangdong (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 46 days.

(21) Appl. No.: **17/046,315**

(22) PCT Filed: **Oct. 25, 2019**

(86) PCT No.: **PCT/CN2019/113146**
§ 371 (c)(1),
(2) Date: **Oct. 9, 2020**

(87) PCT Pub. No.: **WO2020/177341**
PCT Pub. Date: **Sep. 10, 2020**

(65) **Prior Publication Data**

US 2021/0151890 A1 May 20, 2021

(30) **Foreign Application Priority Data**

Mar. 1, 2019 (CN) 201910153863.5

(51) **Int. Cl.**
H01Q 9/16 (2006.01)
H01Q 1/38 (2006.01)
H01Q 1/50 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 9/16*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 1/50*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/16; H01Q 1/38; H01Q 1/50
(Continued)

(56) **References Cited**

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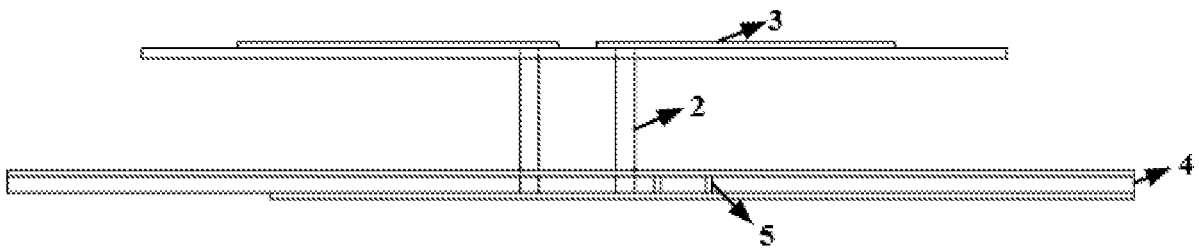
Primary Examiner — Andrea Lindgren Baltzell
(74) *Attorney, Agent, or Firm* — JMB Davis Ben-David

(57) **ABSTRACT**

The invention discloses a dual-polarized filtering magneto-electric dipole antenna, which comprises an upper dielectric substrate and a lower dielectric substrate. The upper surface of the upper dielectric substrate is printed with a radiator structure, and the lower dielectric substrate is printed with a slot coupling feed network; the radiator structure comprises four parasitic patches loaded with symmetrical slots. The parasitic patches are loaded with short-circuit probes, and the slot coupling feed network comprises two orthogonal sets of Y-shaped feeders and cross-shaped slots, and the cross-shaped slots are printed on a metal floor. The new parasitic slot structures on the radiator structure increases the bandwidth while introducing a high roll-off band edge filtering effect, and combined with the slot coupling feed network with filtering function to achieve good band-pass filtering characteristics and hardly introduce additional insertion loss.

5 Claims, 4 Drawing Sheets



US011296422B2

(12) **United States Patent**
Van Wonterghem et al.

(10) **Patent No.: US 11,296,422 B2**
(45) **Date of Patent: Apr. 5, 2022**

(54) **MILLIMETER-WAVE ASSEMBLY**

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

(72) Inventors: **Jari Kristian Van Wonterghem**, Kista (SE); **Alexander Khripkov**, Helsinki (FI); **Dong Liu**, Helsinki (FI); **Janne Ilvonen**, Helsinki (FI); **Jian Ou**, Kista (SE); **Ruiyuan Tian**, Helsinki (FI); **Changnian Xu**, Shenzhen (CN); **Wei Huang**, Shenzhen (CN); **Zlatoljub Milosavljevic**, Helsinki (FI)

(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.: **17/237,845**

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

(65) **Prior Publication Data**

US 2021/0249783 A1 Aug. 12, 2021

Related U.S. Application Data

(63) Continuation of application No. PCT/EP2019/055249, filed on Mar. 4, 2019.

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

(52) **U.S. Cl.**
CPC ***H01Q 21/0025*** (2013.01); ***H01Q 1/24*** (2013.01); ***H01Q 21/00*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 21/0025; H01Q 1/24; H01Q 21/28; H01Q 21/00; H01Q 1/243
USPC 343/893
See application file for complete search history.

(56) **References Cited**

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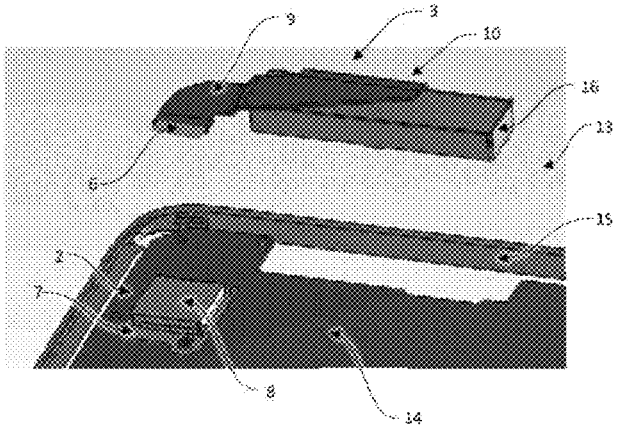
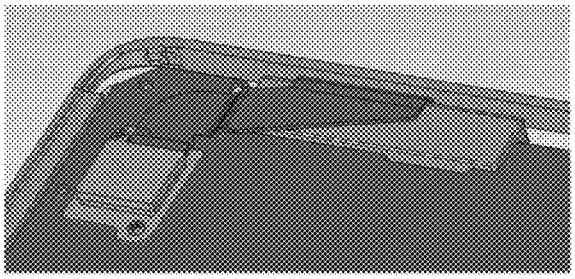
Primary Examiner — Hai V Tran
(74) *Attorney, Agent, or Firm* — Conley Rose, P.C.

(57) **ABSTRACT**

A millimeter-wave (mmWave) assembly (**1**) comprising a first mmWave module (**2**), a second mmWave module (**3**), and a connector (**4**) configured to releasably interconnect the first mmWave module (**2**) and the second mmWave module (**3**). The connector (**4**) comprises a first connector element (**5**) associated with the first mmWave module (**2**). The first mmWave module (**2**) comprises a first substrate (**7**) and an mmWave radio frequency integrated circuit (RFIC) (**8**), and the second mmWave module (**3**) comprises a second substrate (**9**) and an mmWave antenna array (**10**). The connector (**4**) is configured to transmit at least one signal between the mmWave RFIC (**8**) and the mmWave antenna array (**10**) when the first mmWave module (**2**) and the second mmWave module (**3**) are interconnected.

20 Claims, 4 Drawing Sheets





US011303022B2

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

(10) **Patent No.: US 11,303,022 B2**
(45) **Date of Patent: Apr. 12, 2022**

(54) **ELECTRONIC DEVICES HAVING ENCLOSURE-COUPLED MULTI-BAND ANTENNA STRUCTURES**

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(72) Inventors: **Bilgehan Avser**, Mountain View, CA (US); **Xu Han**, Santa Clara, CA (US); **Salih Yarga**, Sunnyvale, CA (US); **Jingni Zhong**, Campbell, CA (US); **Hao Xu**, Cupertino, CA (US); **Mattia Pascolini**, San Francisco, CA (US)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 19 days.

(21) Appl. No.: **16/553,045**

(22) Filed: **Aug. 27, 2019**

(65) **Prior Publication Data**

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(51) **Int. Cl.**

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H01Q 1/48	(2006.01)
H01Q 23/00	(2006.01)
H04B 1/38	(2015.01)

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

CPC ***H01Q 5/25*** (2015.01); ***H01Q 1/48*** (2013.01); ***H01Q 23/00*** (2013.01); ***H04B 1/38*** (2013.01)

(58) **Field of Classification Search**

CPC . H01Q 5/25; H01Q 1/48; H01Q 23/00; H04B 1/38

USPC 455/77, 73; 343/770, 702, 745, 848, 750, 343/729

See application file for complete search history.

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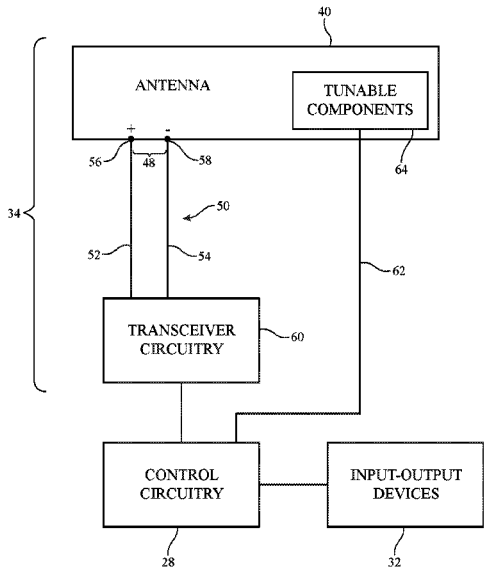
Primary Examiner — Ernest G Tacsik
Assistant Examiner — Max Mathew
(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.; Michael H. Lyons; Tianyi He

(57) **ABSTRACT**

An electronic device may be provided with a housing and an antenna having a resonating element. The resonating element may have first and second arms extending from opposing sides of a feed. The first arm and a portion of the housing may radiate in a cellular ultra-high band. The first arm may have a fundamental mode that radiates in a first ultra-wideband (UWB) communications band at 6.5 GHz. The second arm may have a fundamental mode that radiates in a 5.0 GHz wireless local area network band. The first and second arms may have a harmonic mode that radiates in a second UWB communications band at 8.0 GHz. The antenna may convey radio-frequency signals in each of these communications bands without the need for adjusting components in the antenna to switch between the UWB communications bands.

20 Claims, 9 Drawing Sheets



US011303024B2

(12) **United States Patent**
Teng

(10) **Patent No.: US 11,303,024 B2**
(45) **Date of Patent: Apr. 12, 2022**

(54) **ANTENNA STRUCTURE**

(71) Applicants: **Inventec (Pudong) Technology Corporation**, Shanghai (CN); **INVENTEC CORPORATION**, Taipei (TW)

(72) Inventor: **Pei-Ling Teng**, Taipei (TW)

(73) Assignees: **Inventec (Pudong) Technology Corporation**, Shanghai (CN); **INVENTEC 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 0 days.

(21) Appl. No.: **17/013,678**

(22) Filed: **Sep. 7, 2020**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**

H01Q 1/36	(2006.01)
H01Q 5/15	(2015.01)
H01Q 5/30	(2015.01)
H01Q 5/371	(2015.01)
H01Q 9/04	(2006.01)

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

CPC ***H01Q 5/371*** (2015.01); ***H01Q 9/0421*** (2013.01); ***H01Q 9/0442*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 5/371; H01Q 9/0421; H01Q 9/0442

See application file for complete search history.

(56) **References Cited**

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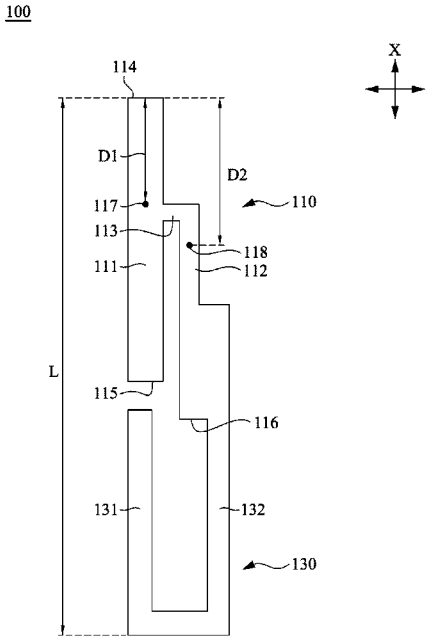
Primary Examiner — Hai V Tran
Assistant Examiner — Michael M Bouizza
(74) *Attorney, Agent, or Firm* — CKC & Partners Co., LLC

(57) **ABSTRACT**

An antenna structure includes a h-shaped radiator and a first radiator. The h-shaped radiator has a first segment, a second segment opposite to the first segment, a first end and a second end which are located at the first segment, a third end located at the second segment, a short-circuit point at the first segment, and a feeding point at the second segment, in which the first segment is longer than the second segment. The first radiator is connected to the second segment.

13 Claims, 9 Drawing Sheets



US011303025B2

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

(10) **Patent No.: US 11,303,025 B2**
(45) **Date of Patent: Apr. 12, 2022**

(54) **5G DUAL-POLARIZED ANTENNA MODULE AND TERMINAL DEVICE**

(71) Applicant: **SHENZHEN SUNWAY COMMUNICATION CO., LTD.**, Guangdong (CN)

(72) Inventors: **Yue Zhao**, Shenzhen (CN); **Anping Zhao**, Shenzhen (CN)

(73) Assignee: **SHENZHEN SUNWAY COMMUNICATION 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 128 days.

(21) Appl. No.: **16/769,428**

(22) PCT Filed: **Apr. 7, 2020**

(86) PCT No.: **PCT/CN2020/083464**
§ 371 (c)(1),
(2) Date: **Jun. 3, 2020**

(87) PCT Pub. No.: **WO2021/139014**
PCT Pub. Date: **Jul. 15, 2021**

(65) **Prior Publication Data**

US 2022/0006192 A1 Jan. 6, 2022

(30) **Foreign Application Priority Data**

Jan. 10, 2020 (CN) 202010024407.3

(51) **Int. Cl.**
H01Q 5/378 (2015.01)
H01Q 1/24 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 5/378*** (2015.01); ***H01Q 1/242*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 1/48*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 19/13; H01Q 21/28; H01Q 1/243
See application file for complete search history.

(56) **References Cited**

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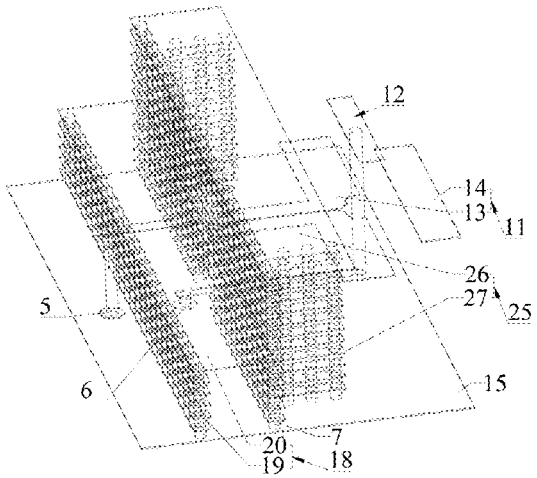
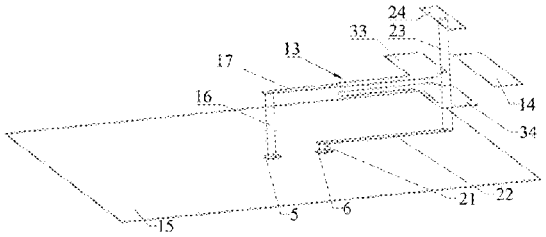
Primary Examiner — Ricardo I Magallanes
(74) *Attorney, Agent, or Firm* — Oliff PLC

(57) **ABSTRACT**

A 5G dual-polarized antenna module and a terminal device are disclosed. The 5G dual-polarized antenna module comprises a substrate, a first metal ground and at least one antenna unit group are disposed in the substrate, the first metal ground partitions the substrate into a first region and a second region, the antenna unit group includes a first antenna unit and a second antenna unit which are located in the first region, and the first antenna unit comprises a dipole element and a parasitic element matched with the dipole element; the second antenna unit comprises a T-shaped probe, which is partially located between the dipole element and the parasitic element; and a first ground layer conductive with the first metal ground is disposed on the bottom surface
(Continued)





US011303035B2

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

(10) **Patent No.: US 11,303,035 B2**
(45) **Date of Patent: Apr. 12, 2022**

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

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

(72) Inventors: **Qing Wu**, Guangdong (CN); **Haijun Tang**, Guangdong (CN); **Huanhong Liu**, Guangdong (CN); **Guolin Liu**, Guangdong (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 0 days.

(21) Appl. No.: **17/230,794**

(22) Filed: **Apr. 14, 2021**

(65) **Prior Publication Data**

US 2021/0273341 A1 Sep. 2, 2021

Related U.S. Application Data

(63) Continuation of application No. 16/173,574, filed on Oct. 29, 2018, now Pat. No. 11,011,850.

(30) **Foreign Application Priority Data**

Dec. 29, 2017 (CN) 201711499678.9
Dec. 29, 2017 (CN) 201721928944.0

(51) **Int. Cl.**
H01Q 13/18 (2006.01)
H01Q 1/24 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 13/18*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/44*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 5/357*** (2015.01)

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

(56) **References Cited**

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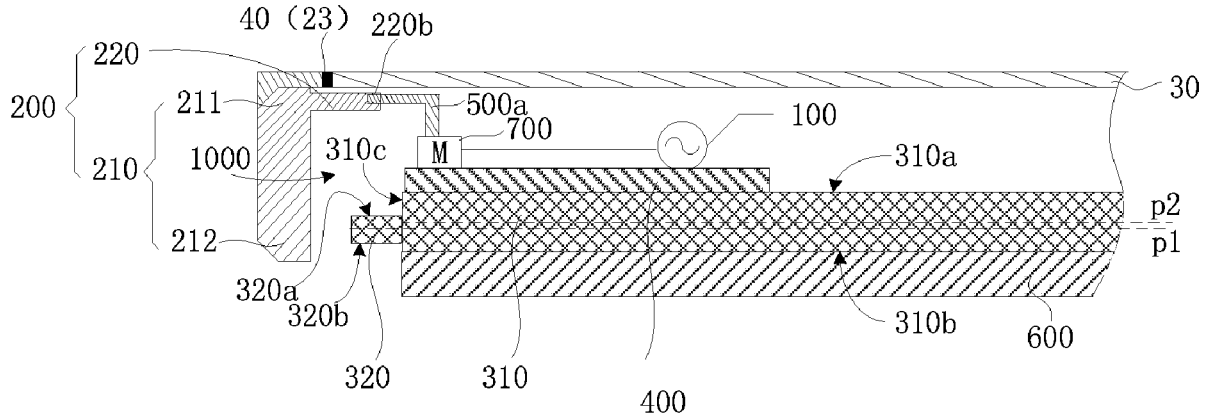
Primary Examiner — Ab Salam Alkassim, Jr.
(74) *Attorney, Agent, or Firm* — Young Basile Hanlon & MacFarlane, P.C.

(57) **ABSTRACT**

An antenna apparatus and an electronic device are provided. The antenna apparatus includes an excitation source, a conductive member, an antenna radiator comprising a radiator body and a power feeding portion, a first extension portion and a support member, the radiator body comprises a first end and a second end opposite to the first end, and the power feeding portion is disposed at the first end; the first extension portion disposed adjacent to the second end of the antenna radiator, the support member disposed at an end of the first extension portion away from the second end of the antenna radiator, an excitation signal generated by the excitation source transmitted to the support member through the conductive member, the power feeding portion, the first end, the radiator body, the second end, and the first extension portion in sequence.

16 Claims, 4 Drawing Sheets



US011303038B2

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

(10) **Patent No.: US 11,303,038 B2**
(45) **Date of Patent: Apr. 12, 2022**

(54) **ANTENNA APPARATUS**

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

(72) Inventors: **Won Cheol Lee**, Suwon-si (KR); **Jeong Ki Ryoo**, Suwon-si (KR); **Nam Ki Kim**, Suwon-si (KR); **Myeong Woo Han**, Suwon-si (KR); **Sang Hyun Kim**, Suwon-si (KR)

(73) Assignee: **Samsung Electro-Mechanics 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 65 days.

(21) Appl. No.: **16/738,375**

(22) Filed: **Jan. 9, 2020**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Aug. 8, 2019 (KR) 10-2019-0096690

(51) **Int. Cl.**

H01Q 1/38	(2006.01)
H01Q 21/06	(2006.01)
H01Q 9/04	(2006.01)
H01Q 5/42	(2015.01)
H01Q 21/24	(2006.01)

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

CPC ***H01Q 21/061*** (2013.01); ***H01Q 5/42*** (2015.01); ***H01Q 9/045*** (2013.01); ***H01Q 21/24*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 21/061; H01Q 9/045; H01Q 5/42; H01Q 21/24

See application file for complete search history.

(56) **References Cited**

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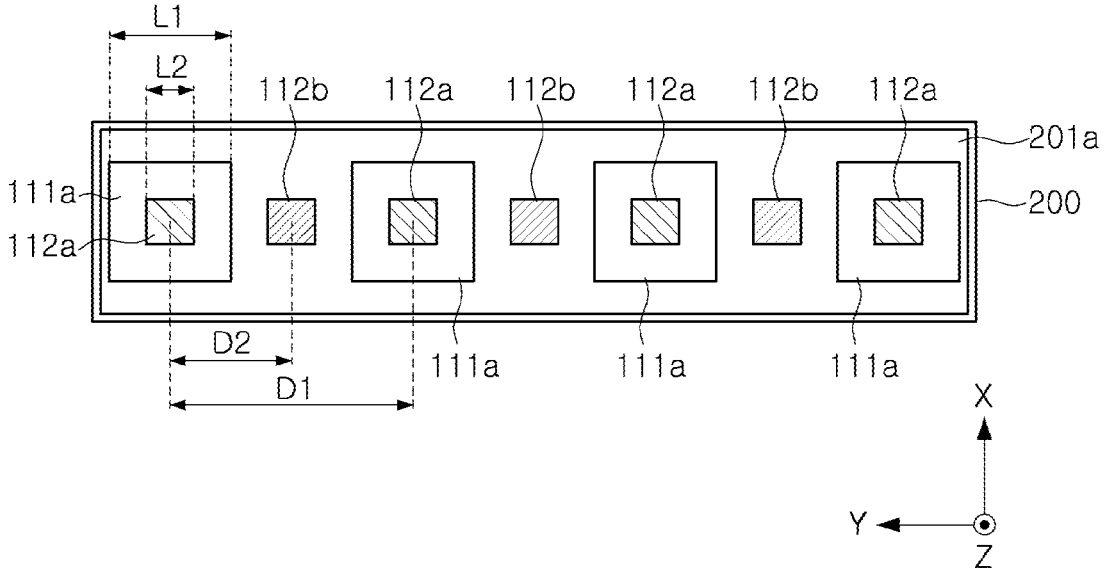
Primary Examiner — Dieu Hien T Duong
(74) *Attorney, Agent, or Firm* — NSIP Law

(57) **ABSTRACT**

An antenna apparatus includes a ground plane, a plurality of first patch antenna patterns arranged on a level higher than the ground plane and each configured to transmit and/or receive a first radio frequency signal of a first frequency, a plurality of second patch antenna patterns arranged on a level higher than the ground plane and each having a size smaller than a size of each of the first patch antenna patterns, wherein the plurality of second patch antenna patterns include at least one feed patch antenna pattern configured to transmit and/or receive a second radio frequency signal of a second frequency different from the first frequency, and at least one dummy patch antenna pattern which is not fed any of the first and second radio frequency signals.

21 Claims, 27 Drawing Sheets



US011303042B2

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

(10) **Patent No.: US 11,303,042 B2**
(45) **Date of Patent: Apr. 12, 2022**

(54) **COMMUNICATION DEVICE**

(71) Applicant: **HTC Corporation**, Taoyuan (TW)

(72) Inventors: **Cheng-Hung Lin**, Taoyuan (TW); **Szu-Po Wang**, Taoyuan (TW); **Chun-Chieh Wang**, Taoyuan (TW); **Yu-Yu Chen**, Taoyuan (TW); **Shih-Hua Wu**, Taoyuan (TW); **Dun-Yuan Cheng**, Taoyuan (TW)

(73) Assignee: **HTC CORPORATION**, Taoyuan (TW)

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

(21) Appl. No.: **16/860,833**

(22) Filed: **Apr. 28, 2020**

(65) **Prior Publication Data**

US 2020/0373680 A1 Nov. 26, 2020

Related U.S. Application Data

(60) Provisional application No. 62/851,674, filed on May 23, 2019.

(51) **Int. Cl.**

H01Q 21/24	(2006.01)
H01Q 3/26	(2006.01)
H01Q 21/28	(2006.01)
H04B 7/06	(2006.01)
H04B 7/10	(2017.01)

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

CPC ***H01Q 21/245*** (2013.01); ***H01Q 3/26*** (2013.01); ***H01Q 21/28*** (2013.01); ***H04B 7/063*** (2013.01); ***H04B 7/10*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 21/245; H01Q 3/26; H01Q 21/28

See application file for complete search history.

(56) **References Cited**

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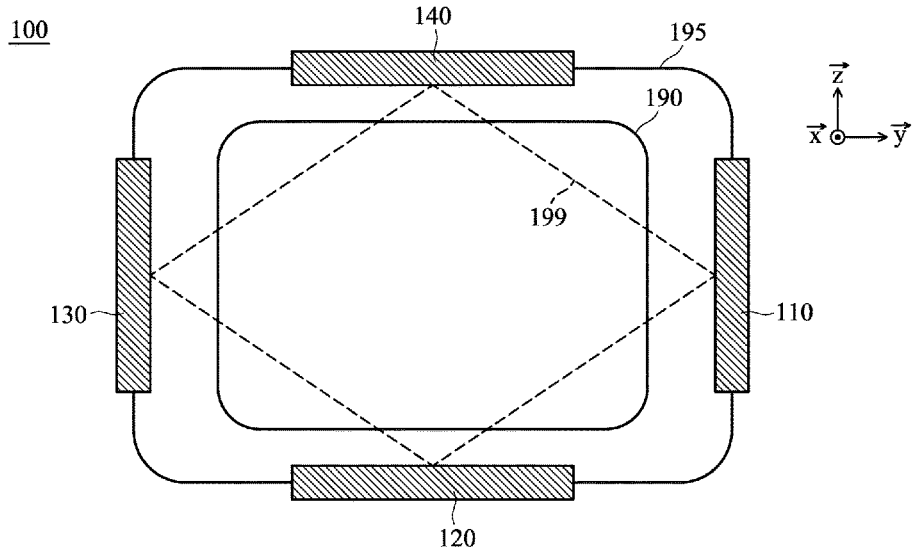
Primary Examiner — Graham P Smith

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

(57) **ABSTRACT**

A communication device includes a display device, a first antenna element, a second antenna element, a third antenna element, and a fourth antenna element. The display device is surrounded by the first antenna element, the second antenna element, the third antenna element, and the fourth antenna element. Any adjacent two of the first antenna element, the second antenna element, the third antenna element, and the fourth antenna element have different polarization directions.

19 Claims, 6 Drawing Sheets



US011303163B2

(12) **United States Patent**
Jang

(10) **Patent No.: US 11,303,163 B2**
(45) **Date of Patent: Apr. 12, 2022**

(54) **WIRELESS POWER RECEIVING MODULE AND PORTABLE ELECTRONIC DEVICE COMPRISING SAME**

(71) Applicant: **AMOSENSE CO., LTD.**, Cheonan-si (KR)

(72) Inventor: **Kil Jae Jang**, Seongnam-si (KR)

(73) Assignee: **AMOSENSE CO., LTD.**, Cheonan-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.: **16/980,050**

(22) PCT Filed: **Mar. 13, 2019**

(86) PCT No.: **PCT/KR2019/002883**
§ 371 (c)(1),
(2) Date: **Sep. 11, 2020**

(87) PCT Pub. No.: **WO2019/177357**
PCT Pub. Date: **Sep. 19, 2019**

(65) **Prior Publication Data**

US 2021/0021161 A1 Jan. 21, 2021

(30) **Foreign Application Priority Data**

Mar. 14, 2018 (KR) 10-2018-0029827
Aug. 10, 2018 (KR) 10-2018-0093780

(51) **Int. Cl.**

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H02J 50/10	(2016.01)
H01F 27/255	(2006.01)
H01F 27/28	(2006.01)
H02J 7/02	(2016.01)
H04M 1/02	(2006.01)

(52) **U.S. Cl.**
CPC ***H02J 50/70*** (2016.02); ***H01F 27/255*** (2013.01); ***H01F 27/2804*** (2013.01); ***H01F 27/2885*** (2013.01); ***H02J 7/02*** (2013.01); ***H02J 50/10*** (2016.02); ***H04M 1/0202*** (2013.01)

(58) **Field of Classification Search**
CPC H02J 50/70; H02J 50/10; H01F 27/255; H01F 27/2804; H01F 27/2885
USPC 307/104
See application file for complete search history.

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Primary Examiner — Alfonso Perez Borroto
(74) *Attorney, Agent, or Firm* — Rothwell, Figg, Ernst & Manbeck, P.C.

(57) **ABSTRACT**

A wireless power receiving module is provided. A wireless power receiving module according to one embodiment of the present invention comprises: a wireless power receiving antenna in which a conductive member having a rectangular cross section is formed in a loop shape; and a shielding sheet disposed on one surface of the antenna for shielding a magnetic field, wherein one surface of the antenna is directly attached to the shielding sheet.

17 Claims, 12 Drawing Sheets