US011011829B2

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

(10) **Patent No.: US 11,011,829 B2**
(45) **Date of Patent: May 18, 2021**

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

(71) Applicant: **E Ink Holdings Inc.**, Hsinchu (TW)

(72) Inventors: **Yu-Ming Lee**, Hsinchu (TW); **Chuen-Jen Liu**, Hsinchu (TW)

(73) Assignee: **E Ink Holdings Inc.**, Hsinchu (TW)

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

(21) Appl. No.: **16/596,772**

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

(65) **Prior Publication Data**

US 2020/0044322 A1 Feb. 6, 2020

Related U.S. Application Data

(63) Continuation of application No. 15/904,448, filed on Feb. 26, 2018, now Pat. No. 10,490,885.

(30) **Foreign Application Priority Data**

Aug. 17, 2017 (CN) 201710705390.6

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

(52) **U.S. Cl.**
CPC ***H01Q 1/248*** (2013.01); ***H01Q 5/30*** (2015.01); ***H01Q 5/364*** (2015.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/248; H01Q 1/22; H01Q 1/36; H01Q 1/38; H01Q 5/20; H01Q 5/28;
(Continued)

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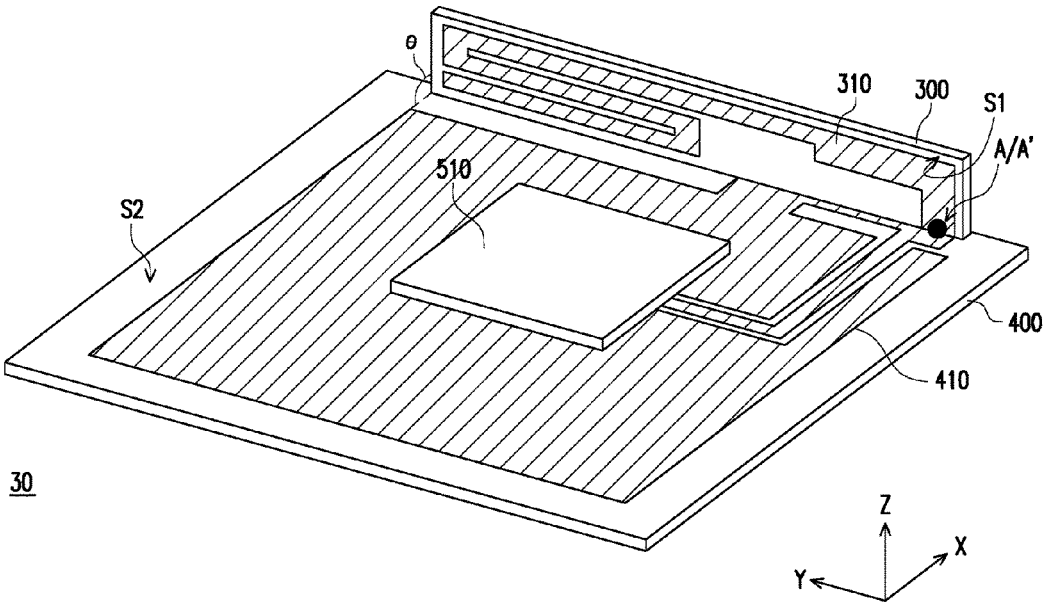
"Office Action of China Counterpart Application," dated Feb. 6, 2020, p. 1-p. 9.

Primary Examiner — Hoang V Nguyen
(74) *Attorney, Agent, or Firm* — JCIPRNET

(57) **ABSTRACT**

An antenna device including an antenna radiator and a feed line layer is provided. The antenna radiator is disposed on a first surface of a detachable substrate. The antenna radiator receives a microwave signal of at least one frequency band. The feed line layer is disposed on a second surface of a control circuit board. The feed line layer includes a signal feed line. The signal feed line is coupled to the antenna radiator through a connection point. The connection point is located on one side of the control circuit board. The detachable substrate and the control circuit board are arranged to have an angle between the first surface and the second surface. In addition, an electronic apparatus is also provided.

12 Claims, 4 Drawing Sheets



US011011831B2

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

(10) **Patent No.: US 11,011,831 B2**
(45) **Date of Patent: May 18, 2021**

(54) **DIRECTIONAL ANTENNA**

(71) Applicant: **YAMAHA HATSUDOKI KABUSHIKI KAISHA**, Iwata (JP)

(72) Inventors: **Yasushi Hashimoto**, Iwata (JP); **Yoshihiko Kuwahara**, Hamamatsu (JP)

(73) Assignee: **YAMAHA HATSUDOKI KABUSHIKI KAISHA**, Iwata (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.: **16/256,135**

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

(65) **Prior Publication Data**

US 2019/0229409 A1 Jul. 25, 2019

(30) **Foreign Application Priority Data**

Jan. 24, 2018 (JP) JP2018-009364

(51) **Int. Cl.**
H01Q 1/32 (2006.01)
H01Q 9/04 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 1/32*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 9/0407*** (2013.01);
(Continued)

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

(56) **References Cited**

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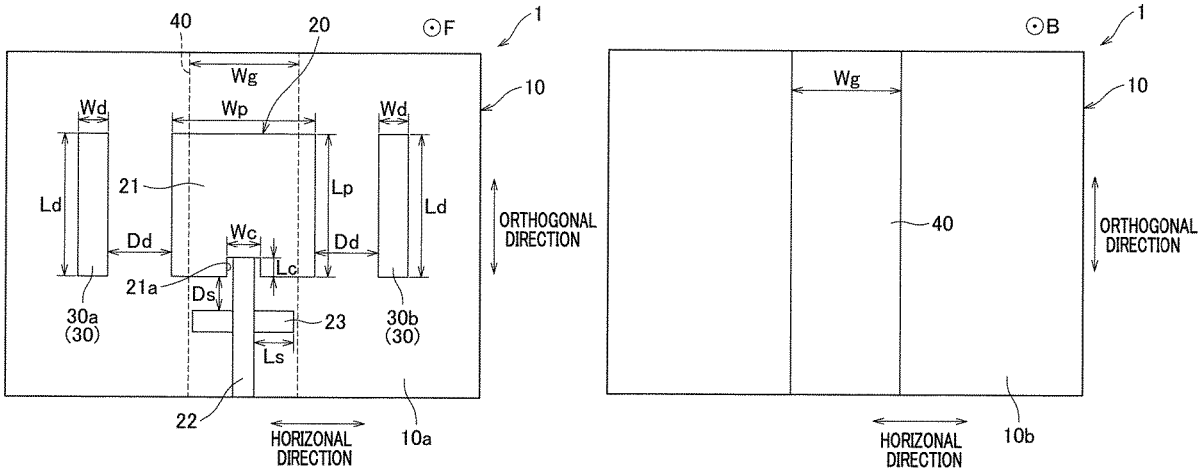
Primary Examiner — Seokjin Kim
(74) *Attorney, Agent, or Firm* — Rabin & Berdo, P.C.

(57) **ABSTRACT**

A directional antenna includes a substrate, a power-supply radiating element, paired non-power-supply radiating elements, and a metal plate. The power-supply radiating element is formed on the front surface of the substrate to be along the vertical direction. The power-supply radiating element receives electric power from the power-supplying portion. The paired non-power-supply radiating elements are provided along the vertical direction and oppose each other across the power-supply radiating element in a horizontal direction which is a direction along the front surface of the substrate on the horizontal plane, when viewed in a front-rear direction. A part of the metal plate is provided behind a part of the power-supply radiating element. The metal plate is not provided behind the paired non-power-supply radiating elements. The 3 dB beam width of the directional antenna on the horizontal plane is equal to or greater than 180 degrees including the range forward of the directional antenna.

8 Claims, 3 Drawing Sheets



US011011833B2

(12) **United States Patent**
Huang

(10) **Patent No.: US 11,011,833 B2**
(45) **Date of Patent: May 18, 2021**

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

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

(72) Inventor: **Chun-Lin Huang**, Hsinchu (TW)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 25 days.

(21) Appl. No.: **16/543,811**

(22) Filed: **Aug. 19, 2019**

(65) **Prior Publication Data**

US 2020/0067182 A1 Feb. 27, 2020

(30) **Foreign Application Priority Data**

Aug. 24, 2018 (TW) 107129656

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

(52) **U.S. Cl.**
CPC ***H01Q 1/36*** (2013.01); ***H01Q 1/22*** (2013.01); ***H01Q 5/10*** (2015.01)

(58) **Field of Classification Search**
CPC .. H01Q 1/36; H01Q 5/10; H01Q 1/22; H01Q 5/48; H01Q 25/001; H01Q 1/38; H01Q 11/10; H01Q 11/105
See application file for complete search history.

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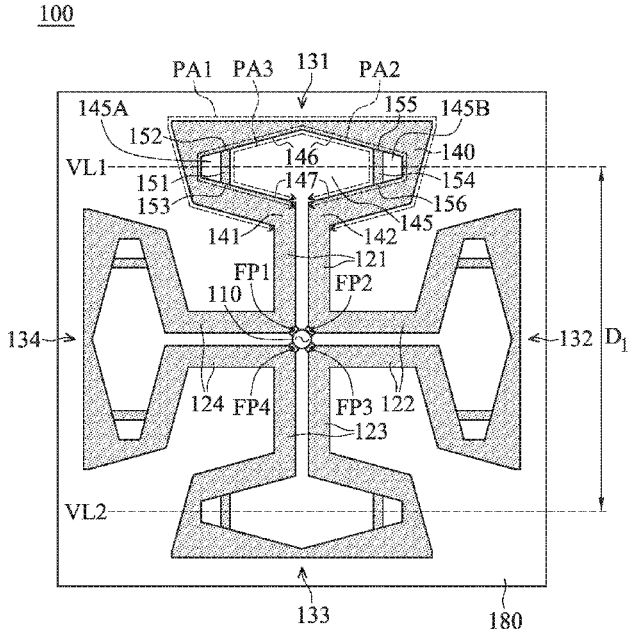
* cited by examiner

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

(57) **ABSTRACT**

An antenna structure includes a signal source, four transmission lines, and four radiation elements. The radiation elements are coupled through the transmission lines to the signal source, respectively. Each of the radiation elements includes a loop structure, a first connection element, and a second connection element. The loop structure has a first inner edge and a second inner edge which are opposite to each other. A looped region is formed between the first inner edge and the second inner edge. The looped region has first and second sides. The first connection element extends across the first side of the looped region. The first connection element is coupled between the first inner edge and the second inner edge. The second connection element extends across the second side of the looped region. The second connection element is coupled between the first inner edge and the second inner edge.

20 Claims, 11 Drawing Sheets



US011011837B2

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

(10) **Patent No.: US 11,011,837 B2**
(45) **Date of Patent: May 18, 2021**

(54) **COMMUNICATIONS TERMINAL**

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

(72) Inventors: **Pengfei Wu**, Shanghai (CN); **Dong Yu**, Shanghai (CN); **Chien-Ming Lee**, Shanghai (CN)

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

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

(21) Appl. No.: **16/461,561**

(22) PCT Filed: **Nov. 17, 2016**

(86) PCT No.: **PCT/CN2016/106269**
§ 371 (c)(1),
(2) Date: **May 16, 2019**

(87) PCT Pub. No.: **WO2018/090295**
PCT Pub. Date: **May 24, 2018**

(65) **Prior Publication Data**

US 2020/0058992 A1 Feb. 20, 2020

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/52 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 1/523*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 21/0025*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/44; H01Q 1/48; H01Q 1/52; H01Q 5/30–392; H01Q 1/24–48; H01Q 1/523
See application file for complete search history.

(56) **References Cited**

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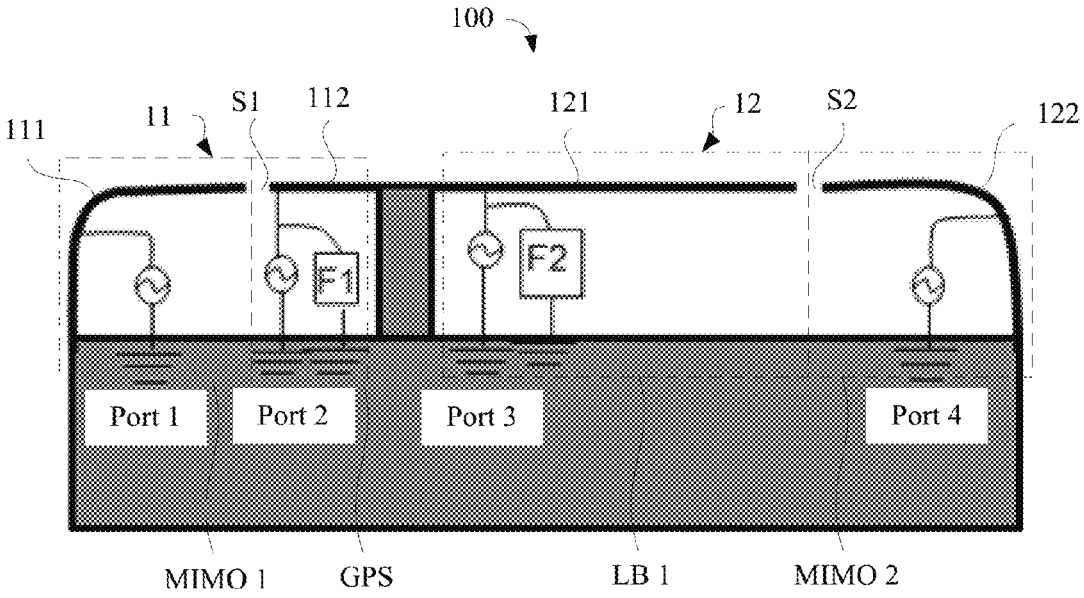
Primary Examiner — Hasan Z Islam
(74) *Attorney, Agent, or Firm* — Slater Matsil, LLP

(57) **ABSTRACT**

A communications terminal includes a multiple-input multiple-output antenna system. The multiple-input multiple-output antenna system includes a first antenna module, a second antenna module, and a first ground structure. The first antenna module includes a first radiator configured to form a first MIMO antenna and a second radiator configured to form a GPS antenna, and a first slit is provided between the first radiator and the second radiator. The second antenna module includes a third radiator configured to form a low frequency antenna and a fourth radiator configured to form a second MIMO antenna. The second radiator is connected to the third radiator. One end of the first ground structure is connected to the second radiator or the third radiator, and another end is connected to a ground plane of the communications terminal.

17 Claims, 17 Drawing Sheets



US011011850B2

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

(10) **Patent No.: US 11,011,850 B2**
(45) **Date of Patent: May 18, 2021**

(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 242 days.

(21) Appl. No.: **16/173,574**

(22) Filed: **Oct. 29, 2018**

(65) **Prior Publication Data**

US 2019/0207319 A1 Jul. 4, 2019

(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**
CPC H01Q 1/243
See application file for complete search history.

(56) **References Cited**

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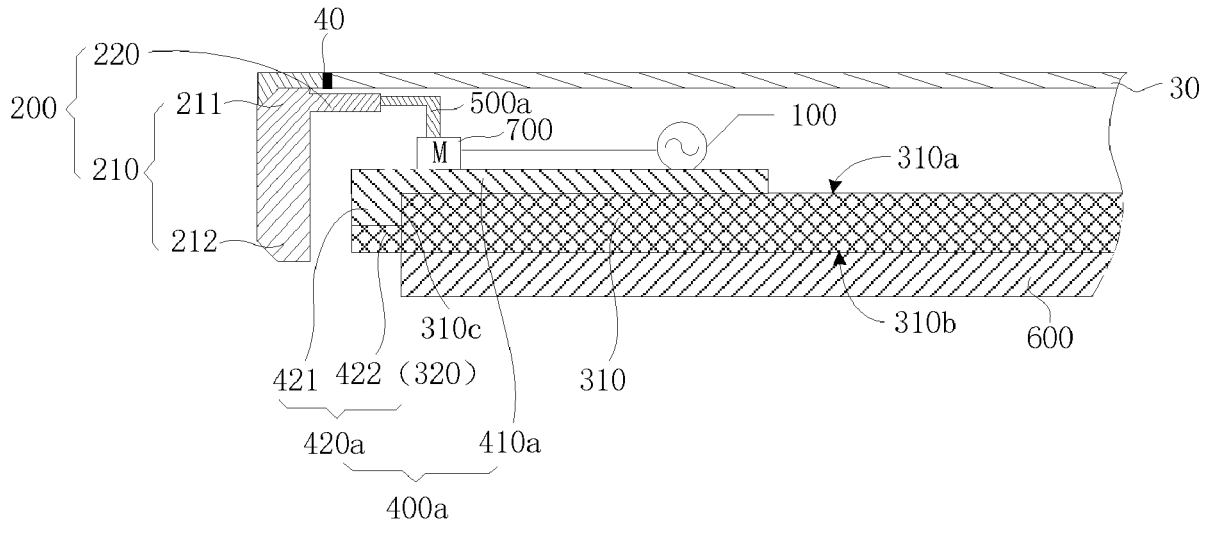
Primary Examiner — Ab Salam Alkassim, Jr.

(57) **ABSTRACT**

An antenna apparatus and an electronic device are provided. The antenna apparatus includes an antenna radiator, a support member, and a first extension portion. The antenna radiator includes a radiator body and a power feeding portion. The radiator body includes a first end and a second end. The power feeding portion is disposed at the first end and configured to receive an excitation signal. The support member includes a first surface, a second surface opposite to the second surface, and a side surface disposed between the first surface and the second surface and adjacent to the radiator body. The first extension portion is located adjacent to the second end and electrically connected to the support member through the side surface. The first extension portion, the side surface, and the antenna radiator cooperatively define a gap region constituting at least part of a clearance area of the antenna radiator.

17 Claims, 4 Drawing Sheets



US011011855B2

(12) **United States Patent**
Huang

(10) **Patent No.: US 11,011,855 B2**
(45) **Date of Patent: May 18, 2021**

(54) **ANTENNA SYSTEM**

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

(72) Inventor: **Chun-Lin Huang**, Hsinchu (TW)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 64 days.

(21) Appl. No.: **16/700,041**

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

(65) **Prior Publication Data**

US 2021/0021054 A1 Jan. 21, 2021

(30) **Foreign Application Priority Data**

Jul. 16, 2019 (TW) 108125019

(51) **Int. Cl.**

H01Q 21/26	(2006.01)
H01Q 9/16	(2006.01)
H01Q 1/38	(2006.01)
H01Q 25/00	(2006.01)
H01Q 1/48	(2006.01)
H01Q 1/24	(2006.01)
H01Q 5/307	(2015.01)
H01Q 9/28	(2006.01)

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

CPC ***H01Q 21/26*** (2013.01); ***H01Q 9/16*** (2013.01); *H01Q 1/243* (2013.01); *H01Q 1/38* (2013.01); *H01Q 1/48* (2013.01); *H01Q 5/307* (2015.01); *H01Q 9/28* (2013.01); *H01Q 25/001* (2013.01)

(58) **Field of Classification Search**

CPC H01Q 21/26; H01Q 1/38; H01Q 1/48; H01Q 1/243; H01Q 5/307; H01Q 9/28; H01Q 25/001

USPC ..... 343/797, 795, 793, 810, 803, 700 MS

See application file for complete search history.

(56) **References Cited**

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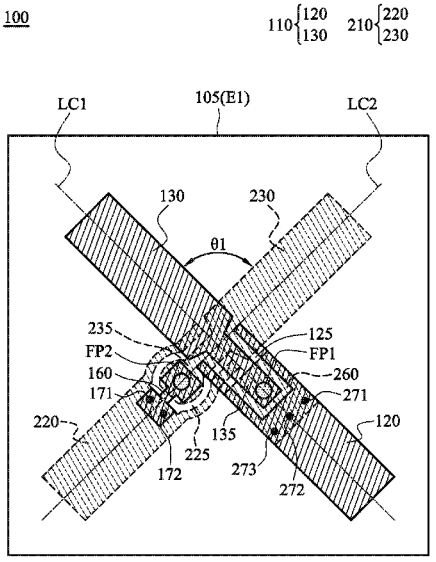
Primary Examiner — Joseph J Lauture

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

(57) **ABSTRACT**

An antenna system includes a dielectric substrate, a first dipole antenna element, a second dipole antenna element, a first additional metal element, a second additional metal element, first conductive via elements, and second conductive via elements. The first dipole antenna element and the first additional metal element are disposed on a first surface of the dielectric substrate. The first dipole antenna element includes a first radiation element and a second radiation element. The second dipole antenna element and the second additional metal element are disposed on a second surface of the dielectric substrate. The second dipole antenna element includes a third radiation element and a fourth radiation element. The first additional metal element is coupled through the first conductive via elements to the third radiation element. The second additional metal element is coupled through the second conductive via elements to the first radiation element.

20 Claims, 7 Drawing Sheets



US011013149B2

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

(10) **Patent No.: US 11,013,149 B2**
(45) **Date of Patent: May 18, 2021**

(54) **ELECTRONIC DEVICE INCLUDING HEAT DISSIPATION STRUCTURE**

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

(72) Inventors: **Yonghwa Kim**, Suwon-si (KR); **Dongil Son**, Suwon-si (KR); **Chihwei Lee**, 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.: **16/810,144**

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

(65) **Prior Publication Data**

US 2020/0367386 A1 Nov. 19, 2020

(30) **Foreign Application Priority Data**

May 15, 2019 (KR) 10-2019-0056849

(51) **Int. Cl.**

H05K 7/20 (2006.01)
H05K 5/00 (2006.01)
H01Q 1/00 (2006.01)
H04M 1/02 (2006.01)

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

CPC ***H05K 7/20436*** (2013.01); ***H01Q 1/002*** (2013.01); ***H05K 5/0004*** (2013.01); ***H05K 5/0017*** (2013.01); ***H05K 7/2099*** (2013.01); ***H05K 7/20336*** (2013.01); ***H05K 7/20963*** (2013.01); *H04M 1/0202* (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

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International Search Report dated Jun. 11, 2020, issued in International Application No. PCT/KR2020/003002.

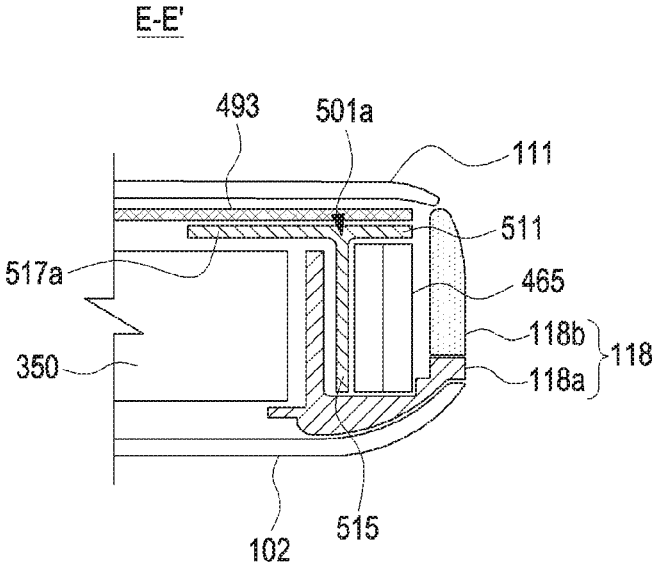
Primary Examiner — Courtney L Smith

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

(57) **ABSTRACT**

An electronic device is provided. The electronic device includes a housing including a front plate, a rear plate facing away from the front plate, and a side structure surrounding a space between the front plate and the rear plate, a heat dissipation member accommodated inside the housing, at least one antenna module disposed adjacent to the side structure or at least partially accommodated in the side structure, the at least one antenna module being disposed to be inclined or perpendicular relative to the front plate or the rear plate, and a fixing member coupled to and at least partially surrounding the antenna module. The fixing member may include a first heat transfer portion at least partially surrounding a rear face of the antenna module, and a second heat transfer portion disposed in contact with the heat dissipation member.

19 Claims, 15 Drawing Sheets



US011018412B2

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

(10) **Patent No.: US 11,018,412 B2**
(45) **Date of Patent: May 25, 2021**

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

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

(72) Inventors: **Jihoon Kim**, Gyeonggi-do (KR); **Junghwan Son**, Gyeonggi-do (KR); **Chaejun 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.: **16/804,805**

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

(65) **Prior Publication Data**

US 2020/0321686 A1 Oct. 8, 2020

(30) **Foreign Application Priority Data**

Feb. 28, 2019 (KR) 10-2019-0023866

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

(52) **U.S. Cl.**
CPC ***H01Q 1/24*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 5/30*** (2015.01); *H01Q 1/273* (2013.01)

(58) **Field of Classification Search**
CPC .. H01Q 1/24; H01Q 5/30; H01Q 1/38; H01Q 1/273
(Continued)

(56) **References Cited**

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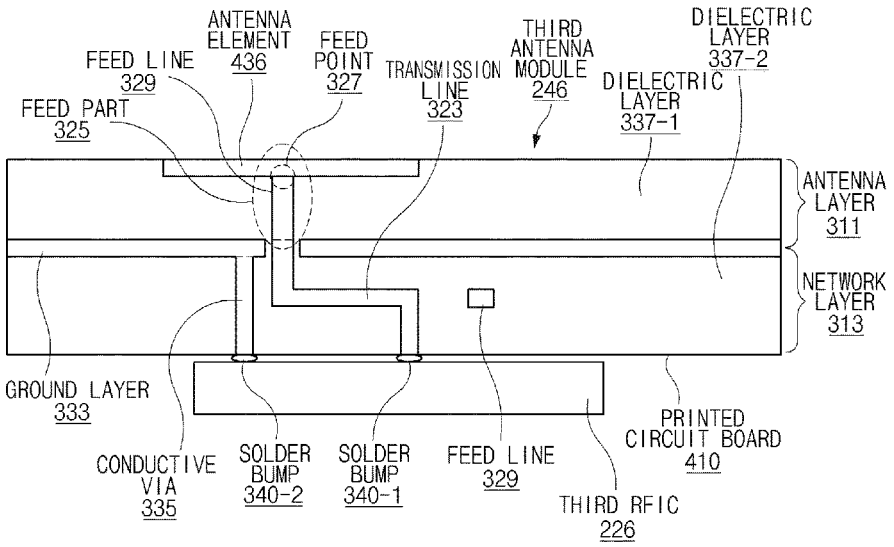
(Continued)

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

(57) **ABSTRACT**

An electronic device including a housing; a display; a wireless communication circuit comprising a first port, a second port, a third port, and a fourth port, wherein the wireless communication circuit is configured to transmit a first signal having a first frequency via the first port; receive a second signal having the first frequency via the second port; transmit a third signal having a second frequency different from the first frequency via the third port; and receive a fourth signal having the second frequency via the fourth port; and an antenna structure disposed inside the housing, wherein the antenna structure comprises: a conductive pattern; a first node, a second node, and a third node electrically connected to the conductive pattern; a first electrical path; a second electrical path; a third electrical path; a fourth electrical path; a fifth electrical path; a sixth electrical path; and a seventh electrical path.

20 Claims, 13 Drawing Sheets



US011018420B2

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

(10) **Patent No.: US 11,018,420 B2**
(45) **Date of Patent: May 25, 2021**

(54) **DISPLAY DEVICE AND COMMUNICATION SYSTEM**

(71) Applicant: **SHARP KABUSHIKI KAISHA**, Sakai (JP)

(72) Inventors: **Takenori Maruyama**, Sakai (JP); **Kazutoshi Kida**, Sakai (JP); **Shinji Yamagishi**, Sakai (JP); **Jean Mugiraneza**, Sakai (JP); **Takuma Yamamoto**, Sakai (JP); **Yukio Mizuno**, Sakai (JP); **Yasuhiro Sugita**, Sakai (JP); **Hiroshi Fukushima**, Sakai (JP); **Hidetsugu Kawamori**, Sakai (JP)

(73) Assignee: **SHARP KABUSHIKI KAISHA**, Sakai (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.: **16/584,543**

(22) Filed: **Sep. 26, 2019**

(65) **Prior Publication Data**

US 2020/0119438 A1 Apr. 16, 2020

Related U.S. Application Data

(60) Provisional application No. 62/743,668, filed on Oct. 10, 2018.

(51) **Int. Cl.**
H01Q 1/44 (2006.01)
H01Q 1/36 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 1/44*** (2013.01); ***G02F 1/13338*** (2013.01); ***G06F 3/0446*** (2019.05); ***H01Q 1/22*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC G02F 1/13338; G02F 2001/133331; G06F 1/1601; G06F 3/0443; G06F 3/0446;
(Continued)

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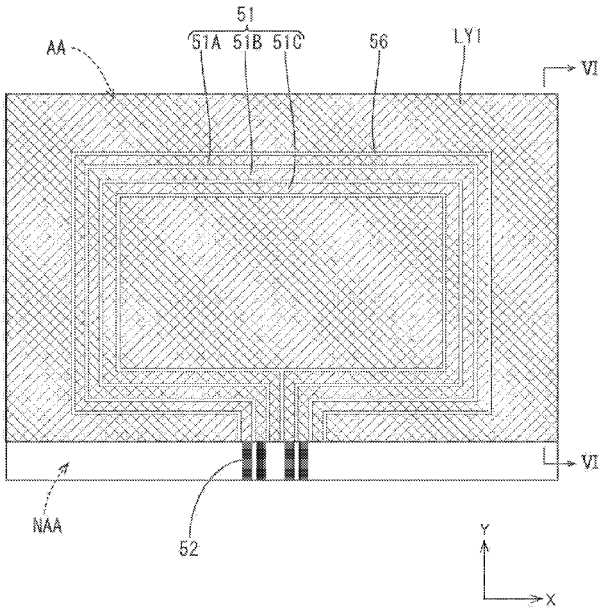
Primary Examiner — Kwin Xie
(74) *Attorney, Agent, or Firm* — ScienBiziP, P.C.

(57) **ABSTRACT**

A display device includes a display panel displaying an image, a transparent antenna substrate arranged on one surface of the display panel and having transparency, a first conductive film having a mesh shape and arranged on a surface of the transparent antenna substrate opposite to the display panel, and a second conductive film having a mesh shape and arranged on a surface of the transparent antenna substrate facing the display panel. The first conductive film includes an antenna body portion having a thin film pattern and insulated from a surrounding portion by a slit, and the antenna body portion constitutes a transparent antenna performing wireless communication with an external communication device.

13 Claims, 13 Drawing Sheets



US011018426B2

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

(10) **Patent No.: US 11,018,426 B2**
(45) **Date of Patent: May 25, 2021**

(54) **ANTENNA STRUCTURE**

(71) Applicant: **Wistron Corp.**, New Taipei (TW)

(72) Inventors: **Nien-Chao Chuang**, New Taipei (TW); **Pei-Cheng Hu**, New Taipei (TW); **Feng-Yi Lin**, New Taipei (TW)

(73) Assignee: **WISTRON CORP.**, New Taipei (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 56 days.

(21) Appl. No.: **16/380,117**

(22) Filed: **Apr. 10, 2019**

(65) **Prior Publication Data**

US 2020/0259260 A1 Aug. 13, 2020

(30) **Foreign Application Priority Data**

Feb. 13, 2019 (TW) 108104687

(51) **Int. Cl.**

H01Q 5/30	(2015.01)
H01Q 1/36	(2006.01)
H01Q 9/04	(2006.01)
H01Q 1/24	(2006.01)

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

CPC ***H01Q 5/30*** (2015.01); ***H01Q 1/241*** (2013.01); ***H01Q 1/36*** (2013.01); ***H01Q 9/04*** (2013.01)

(58) **Field of Classification Search**

CPC .. H01Q 5/30; H01Q 5/40; H01Q 1/24; H01Q 1/241; H01Q 1/243; H01Q 1/36; H01Q 9/00; H01Q 9/04; H01Q 9/12

See application file for complete search history.

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(Continued)

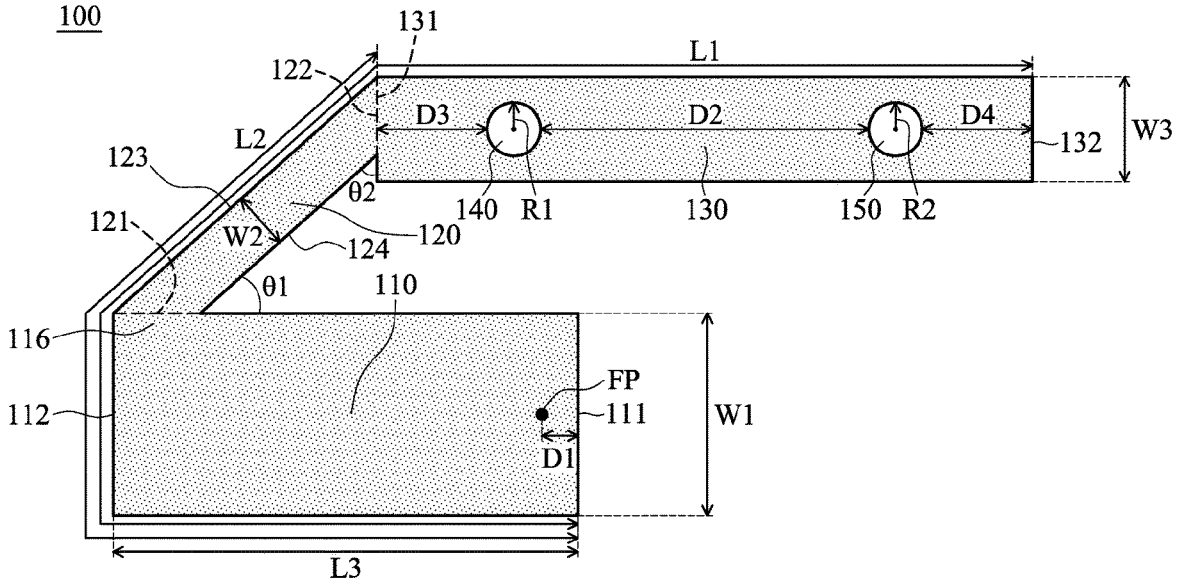
Primary Examiner — Thai Pham

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

(57) **ABSTRACT**

An antenna structure includes a first radiation element, a second radiation element, and a third radiation element. The first radiation element has a feeding point. The third radiation element is coupled through the second radiation element to the first radiation element. The third radiation element has a first opening and a second opening which are separate from each other. The antenna structure covers a first frequency band, a second frequency band, and a third frequency band.

19 Claims, 3 Drawing Sheets



US011018430B2

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

(10) **Patent No.: US 11,018,430 B2**
(45) **Date of Patent: *May 25, 2021**

(54) **SELF-GROUNDED SURFACE MOUNTABLE BOWTIE ANTENNA ARRANGEMENT, AN ANTENNA PETAL AND A FABRICATION METHOD**

(71) Applicant: **GAPWAVES AB**, Göteborg (SE)

(72) Inventors: **Per-Simon Kildal**, Pixbo (SE); **Sadegh Mansouri Moghaddam**, Gothenburg (SE); **Andrés Alayon Glazunov**, Upplands Väsby (SE)

(73) Assignee: **GAPWAVES AB**, Gothenburg (SE)

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

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **15/776,959**

(22) PCT Filed: **Mar. 14, 2016**

(86) PCT No.: **PCT/SE2016/050207**
§ 371 (c)(1),
(2) Date: **May 17, 2018**

(87) PCT Pub. No.: **WO2017/086855**
PCT Pub. Date: **May 26, 2017**

(65) **Prior Publication Data**

US 2018/0358706 A1 Dec. 13, 2018

(30) **Foreign Application Priority Data**

Nov. 17, 2015 (WO) PCT/SE2015/051231
Dec. 8, 2015 (WO) PCT/SE2015/051315

(51) **Int. Cl.**
H01Q 9/28 (2006.01)
H01Q 1/48 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 9/26*** (2013.01); ***H01Q 1/246*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 9/28*** (2013.01);
(Continued)

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

(56) **References Cited**

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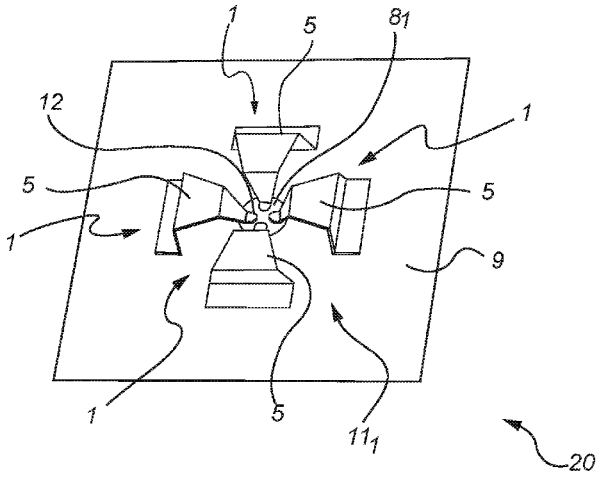
Primary Examiner — Trinh V Dinh
(74) *Attorney, Agent, or Firm* — Buchanan Ingersoll & Rooney P.C.

(57) **ABSTRACT**

A self-grounded bowtie antenna arrangement including an antenna structure including a number of antenna petals including arm sections tapering towards a respective end tip portion and being made of an electrically, conducting material, the end tip portions being arranged to approach a base portion on a first side thereof and to be connected to feeding ports, a specific port being provided for each antenna petal. The base portion includes a conducting ground plane or a Printed Circuit Board, and each antenna petal is made in one
(Continued)



US011018433B2

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

(10) **Patent No.: US 11,018,433 B2**
(45) **Date of Patent: May 25, 2021**

(54) **TRIPLE WIDEBAND HYBRID LTE SLOT ANTENNA**

(71) Applicant: **SMART ANTENNA TECHNOLOGIES LTD**, Birmingham (GB)

(72) Inventors: **Sampson Hu**, Birmingham (GB); **Jinsong Song**, Birmingham (GB); **Qing Liu**, Birmingham (GB); **Liang Wan**, Birmingham (GB)

(73) Assignee: **Smart Antenna Technologies Ltd.**, Birmingham (GB)

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

(21) Appl. No.: **16/487,058**

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

(86) PCT No.: **PCT/GB2018/050434**
§ 371 (c)(1),
(2) Date: **Aug. 19, 2019**

(87) PCT Pub. No.: **WO2018/150202**
PCT Pub. Date: **Aug. 23, 2018**

(65) **Prior Publication Data**

US 2020/0161769 A1 May 21, 2020

(30) **Foreign Application Priority Data**

Feb. 20, 2017 (GB) 1702748
Jul. 24, 2017 (GB) 1711909

(51) **Int. Cl.**
H01Q 13/10 (2006.01)
H01Q 1/38 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 13/10*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 9/0407*** (2013.01); ***H01Q 9/42*** (2013.01); *H01Q 1/241* (2013.01)

(58) **Field of Classification Search**
CPC H01Q 13/10; H01Q 1/38; H01Q 1/48; H01Q 9/0407; H01Q 9/42; H01Q 1/241;
(Continued)

(56) **References Cited**

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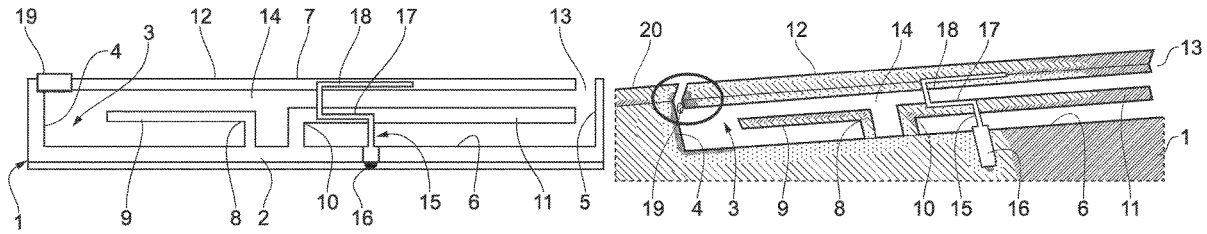
(Continued)

Primary Examiner — Khai M Nguyen
(74) *Attorney, Agent, or Firm* — Shumaker & Sieffert, P.A.

(57) **ABSTRACT**

There is disclosed an antenna arrangement for a portable electronic device. The antenna arrangement comprises a conductive ground plane having an edge and a substantially rectangular recess formed in the edge of the ground plane. The recess has a base, an open edge opposed to the base, and at least a first side extending from the base. A first conductor element extends across the open edge of the recess, a first end of the first conductor element being connected to the
(Continued)



US011018706B2

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

(10) **Patent No.: US 11,018,706 B2**
(45) **Date of Patent: *May 25, 2021**

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

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

(72) Inventors: **Gunhee Son**, Gumi-si (KR); **Hyeongwoo Kim**, Busan (KR); **Soon-Sang Park**, Daegu (KR); **Seunghyun Yeo**, Daegu (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.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **16/817,493**

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

(65) **Prior Publication Data**

US 2020/0212947 A1 Jul. 2, 2020

Related U.S. Application Data

(63) Continuation of application No. 16/284,966, filed on Feb. 25, 2019, now Pat. No. 10,594,344, which is a (Continued)

(30) **Foreign Application Priority Data**

Jul. 28, 2015 (KR) 10-2015-0106687

(51) **Int. Cl.**
H04B 1/04 (2006.01)
H01Q 1/24 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H04B 1/0483*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 5/328*** (2015.01); ***H01Q 5/371*** (2015.01);
(Continued)

(58) **Field of Classification Search**
CPC combination set(s) only.
See application file for complete search history.

(56) **References Cited**

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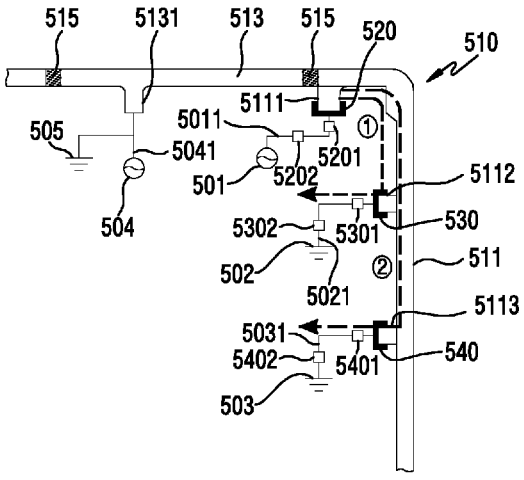
(Continued)

Primary Examiner — Junpeng Chen

(57) **ABSTRACT**

Various embodiments provide an antenna device that includes: a metal member configured to have a length that contributes to at least a part of an electronic device; a printed circuit board (PCB) configured to be feed-connected to a preset position of the metal member in order to apply the metal member as an antenna radiator; and at least one electronic component electrically connected to a position different from the feeding position of the metal member and grounded to the PCB, and provide an electronic device that includes the same. Accordingly, the antenna device is grounded to the PCB in a desired position of the metal member by using the basically provided electronic component so that it is possible to exclude a separate electrical connection member, thereby reducing the cost, increasing

(Continued)



US011024945B2

(12) **United States Patent**
Wu

(10) **Patent No.: US 11,024,945 B2**
(45) **Date of Patent: Jun. 1, 2021**

(54) **ANTENNA SYSTEM AND MOBILE TERMINAL**

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

(72) Inventor: **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 106 days.

(21) Appl. No.: **16/233,423**

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

(65) **Prior Publication Data**

US 2019/0229429 A1 Jul. 25, 2019

(30) **Foreign Application Priority Data**

Jan. 25, 2018 (CN) 201810071729.6

(51) **Int. Cl.**

H01Q 13/10	(2006.01)
H01Q 5/35	(2015.01)
H01Q 21/28	(2006.01)
H01Q 1/24	(2006.01)

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

CPC ***H01Q 1/243*** (2013.01); ***H01Q 5/35*** (2015.01); ***H01Q 13/106*** (2013.01); ***H01Q 21/28*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/521; H01Q 5/35; H01Q 13/10; H01Q 13/106; H01Q 13/16; H01Q 21/28

See application file for complete search history.

(56) **References Cited**

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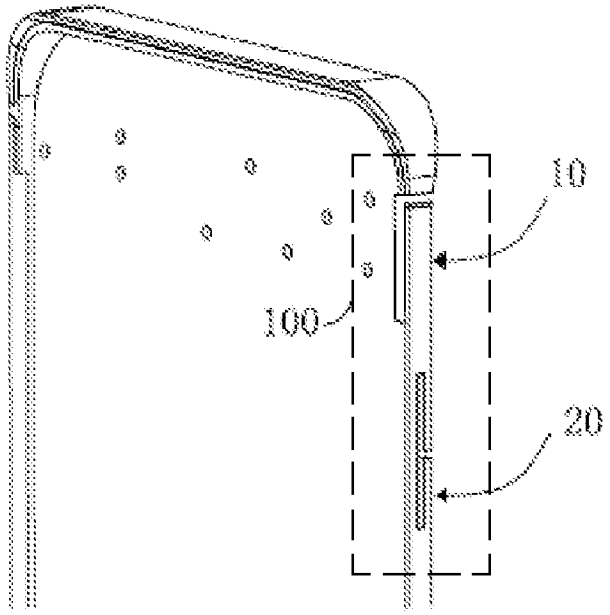
Primary Examiner — Robert Karacsony

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

(57) **ABSTRACT**

Embodiments of the present disclosure relate to the field of communications technologies, and disclose an antenna system and a mobile terminal. The antenna system is applied to the mobile terminal. The mobile terminal includes a metal frame and a metal middle frame accommodated in the metal frame and connected to the metal frame, and the antenna system includes at least one antenna group formed on the metal middle frame and the metal frame, and each antenna group includes a first antenna and a second antenna away from each other, where the first antenna and the second antenna are spaced away from each other along a circumferential direction of the metal frame. In the present disclosure, at least one antenna group is added to the terminal based on the original structure, ensuring that the terminal can satisfy a multi-band working requirement and a data transmission requirement.

11 Claims, 9 Drawing Sheets



US011024946B2

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

(10) **Patent No.: US 11,024,946 B2**
(45) **Date of Patent: Jun. 1, 2021**

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

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

(72) Inventors: **Yohei Koga**, Kawasaki (JP); **Takashi Yamagajo**, Yokosuka (JP); **Manabu Kai**, Yokohama (JP); **Tabito Tonooka**, 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 0 days.

(21) Appl. No.: **16/286,419**

(22) Filed: **Feb. 26, 2019**

(65) **Prior Publication Data**

US 2019/0190124 A1 Jun. 20, 2019

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2018/012696, filed on Mar. 28, 2018.

(30) **Foreign Application Priority Data**

Jun. 15, 2017 (JP) JP2017-118088

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/10 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 5/10*** (2015.01); ***H01Q 5/371*** (2015.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/48; H01Q 9/42; H01Q 5/371; H01Q 5/378; H01Q 7/00; H01Q 9/04; H01Q 5/10
See application file for complete search history.

(56) **References Cited**

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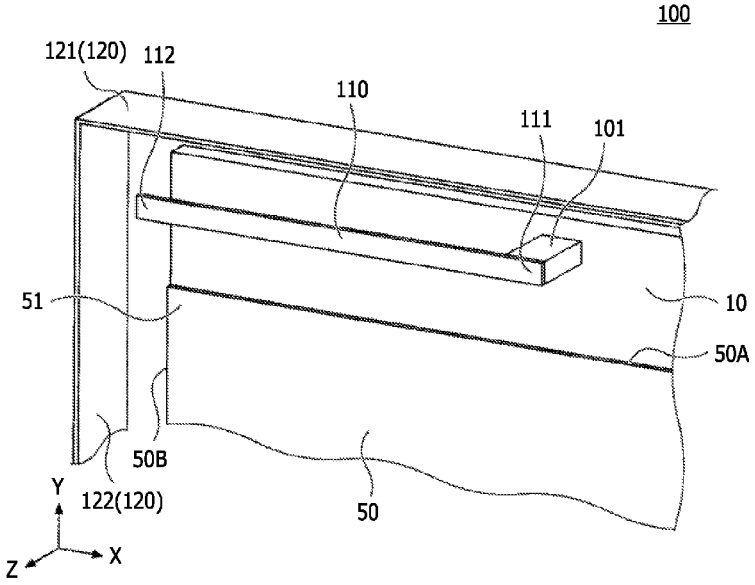
Primary Examiner — Dieu Hien T Duong
(74) *Attorney, Agent, or Firm* — Arent Fox LLP

(57) **ABSTRACT**

An antenna device includes: a ground plane which has an edge side; a metal member arranged along the edge side of the ground plane; a first connection line which couples the metal member and the ground plane; a second connection line which couples the metal member and the ground plane; and a power feeding element which has a power feeding point, extends along the metal member from the power feeding point between the first connection line and the second connection line, and is electromagnetic-field-coupled to the metal member.

14 Claims, 24 Drawing Sheets



US011024948B2

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

(10) **Patent No.: US 11,024,948 B2**
(45) **Date of Patent: Jun. 1, 2021**

(54) **USER DEVICE HAVING HALF SLOT ANTENNA**

(71) Applicant: **MOTOROLA MOBILITY LLC**, Chicago, IL (US)

(72) Inventors: **Prem K. Ganeshan**, Arlington Heights, IL (US); **Md Rashidul Islam**, Lombard, IL (US); **Umesh D. Navsariwala**, Bartlett, IL (US)

(73) Assignee: **Motorola Mobility LLC**, Chicago, IL (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 203 days.

(21) Appl. No.: **15/843,571**

(22) Filed: **Dec. 15, 2017**

(65) **Prior Publication Data**

US 2019/0190126 A1 Jun. 20, 2019

(51) **Int. Cl.**

H01Q 13/10	(2006.01)
H01Q 1/24	(2006.01)
H01Q 21/06	(2006.01)
H04M 1/02	(2006.01)
H01Q 21/28	(2006.01)
H01Q 5/307	(2015.01)

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

CPC ***H01Q 1/245*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 13/10*** (2013.01); ***H01Q 21/064*** (2013.01); ***H01Q 21/28*** (2013.01); ***H04M 1/026*** (2013.01); *H01Q 5/307* (2015.01); *H04M 1/0202* (2013.01); *H04M 1/0283* (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/245; H01Q 21/28; H01Q 13/10; H01Q 1/243; H01Q 21/064; H01Q 5/307; H04M 1/026; H04M 1/0202; H04M 1/0283

See application file for complete search history.

(56) **References Cited**

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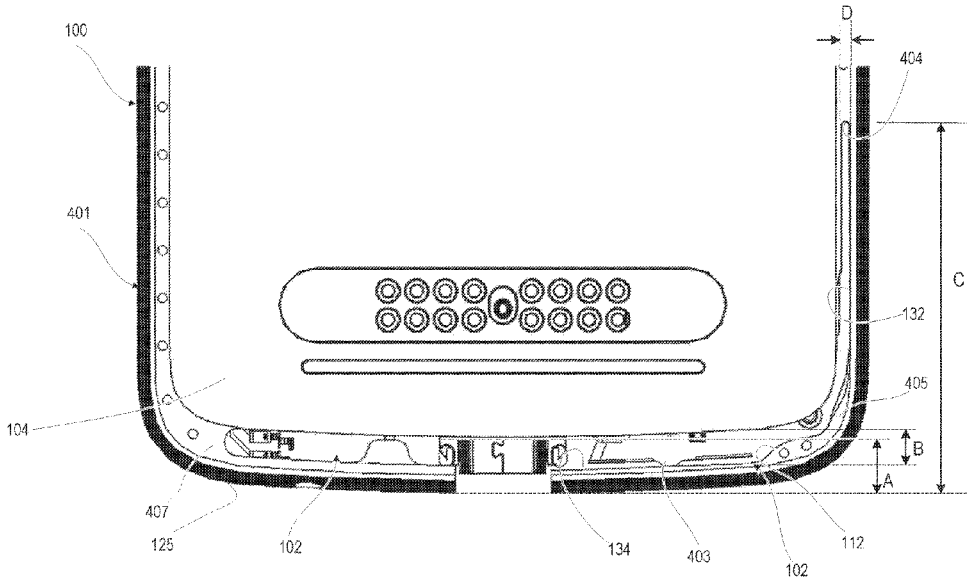
Primary Examiner — Trinh V Dinh

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

(57) **ABSTRACT**

A user device includes an enclosure having an interior mounting surface for receiving one or more functional components. An antenna assembly has an electrical interface connectable to at least one of the one or more functional components. The antenna assembly includes a first half slot antenna angularly formed along both inner perimeter sides of a first corner of the enclosure.

20 Claims, 9 Drawing Sheets



US011024956B2

(12) **United States Patent**
Hamabe

(10) **Patent No.: US 11,024,956 B2**
(45) **Date of Patent: Jun. 1, 2021**

(54) **ANTENNA DEVICE**

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

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

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

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

(21) Appl. No.: **16/812,759**

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

(65) **Prior Publication Data**

US 2020/0212558 A1 Jul. 2, 2020

Related U.S. Application Data

(60) Division of application No. 15/918,327, filed on Mar. 12, 2018, now abandoned, which is a continuation of application No. PCT/JP2016/004234, filed on Sep. 16, 2016.

(30) **Foreign Application Priority Data**

Sep. 25, 2015 (JP) 2015-188479

(51) **Int. Cl.**

H01Q 1/48	(2006.01)
H01Q 1/38	(2006.01)
H01Q 1/22	(2006.01)
H01Q 9/04	(2006.01)

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

CPC ***H01Q 1/48*** (2013.01); ***H01Q 1/2291*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 9/0421*** (2013.01); ***H01Q 9/0457*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/48; H01Q 1/38; H01Q 1/2291; H01Q 9/0421; H01Q 9/0457

See application file for complete search history.

(56) **References Cited**

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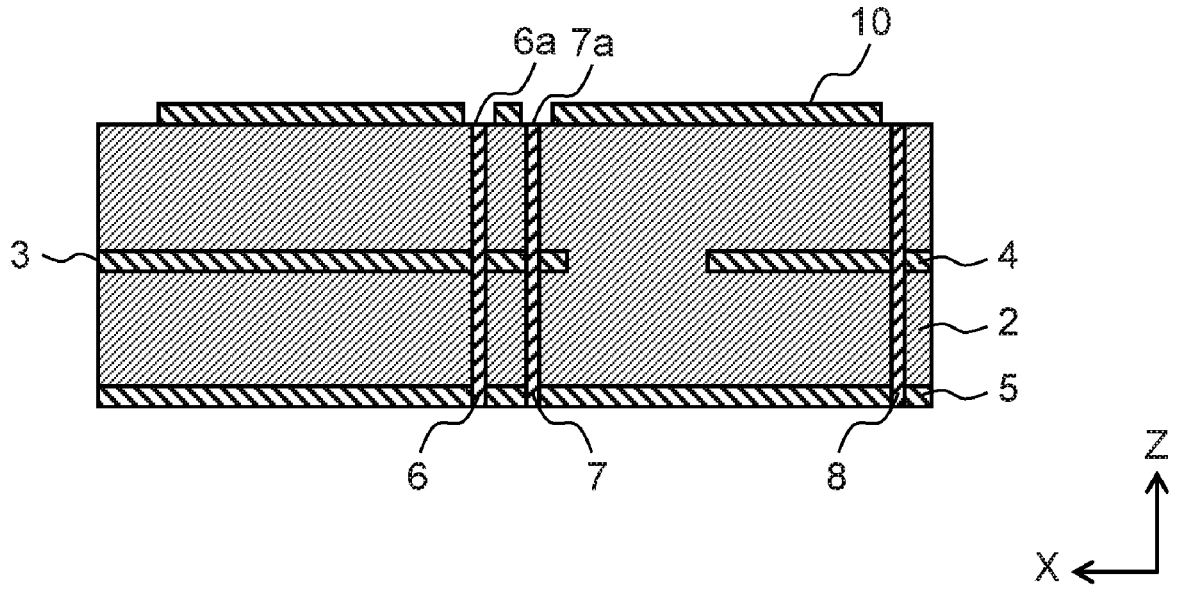
Primary Examiner — Hoang V Nguyen

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

(57) **ABSTRACT**

Antenna device includes substrate, antenna formed on front side of substrate, first ground formed on front side of substrate, and second ground formed on back side of the substrate. Second ground is larger in area than antenna and larger in area than first ground. First ground is insulated from antenna and is connected with second ground through an end of substrate. Consequently, overall antenna device can come down in size while maintaining a capability of antenna.

10 Claims, 5 Drawing Sheets



US011024964B2

(12) **United States Patent**
Zhu

(10) **Patent No.: US 11,024,964 B2**
(45) **Date of Patent: Jun. 1, 2021**

(54) **ANTENNA SYSTEM AND MOBILE TERMINAL**

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

(72) Inventor: **Yufei Zhu**, 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 49 days.

(21) Appl. No.: **16/524,217**

(22) Filed: **Jul. 29, 2019**

(65) **Prior Publication Data**

US 2020/0044340 A1 Feb. 6, 2020

(30) **Foreign Application Priority Data**

Aug. 3, 2018 (CN) 201810875750.1

(51) **Int. Cl.**
H01Q 5/328 (2015.01)
H01Q 1/24 (2006.01)
H01Q 1/48 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 5/328*** (2015.01); ***H01Q 1/241*** (2013.01); ***H01Q 1/48*** (2013.01)

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

(56) **References Cited**

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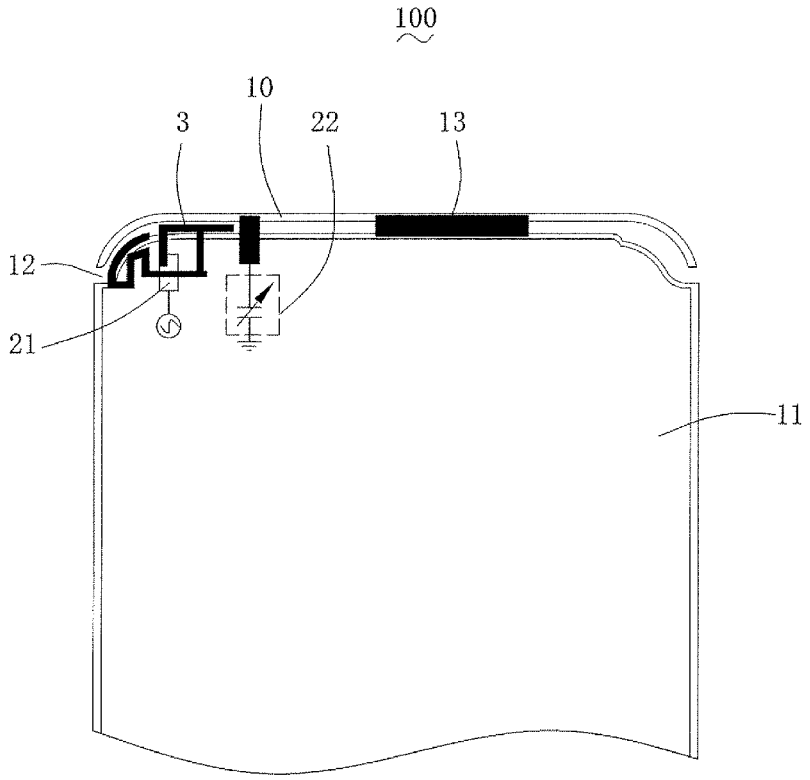
Primary Examiner — Jany Richardson
(74) *Attorney, Agent, or Firm* — W&G Law Group LLP

(57) **ABSTRACT**

The present disclosure provides an antenna system, including: a metal housing including a radiation frame and a grounded back shell; a circuit board located in the metal housing and including a radio frequency feeding source and a tunable capacitor; and an antenna unit connected to the radio frequency feeding source and configured to be coupled to the radiation frame. A fracture is formed between each of two ends of the radiation frame and the grounded back shell. The tunable capacitor is connected to the radiation frame so as to change an electrical length of the antenna system by switching to different capacitances. Compared with the related art, the antenna system provided by present disclosure, by providing the tunable capacitor as a tuner of the antenna system, not only can achieve that the radiation frequency of the antenna system covers 790-960 MHz and 1710-2690 MHz, but also has good radiation performance.

8 Claims, 10 Drawing Sheets



US011024965B2

(12) **United States Patent**
Komura

(10) **Patent No.: US 11,024,965 B2**
(45) **Date of Patent: Jun. 1, 2021**

(54) **DUAL BAND ANTENNA DEVICE**

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

(72) Inventor: **Ryo Komura**, 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 0 days.

(21) Appl. No.: **16/654,191**

(22) Filed: **Oct. 16, 2019**

(65) **Prior Publication Data**

US 2020/0044342 A1 Feb. 6, 2020

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2018/018891, filed on May 16, 2018.

(30) **Foreign Application Priority Data**

Jun. 27, 2017 (JP) JP2017-124781

(51) **Int. Cl.**
H01Q 5/314 (2015.01)
H01Q 5/335 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 5/335*** (2015.01); ***H01Q 1/50*** (2013.01); ***H01Q 5/10*** (2015.01); ***H01Q 7/00*** (2013.01); ***H01Q 9/40*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/335; H01Q 5/10; H01Q 1/50; H01Q 7/00; H01Q 9/40; H01Q 1/243
See application file for complete search history.

(56) **References Cited**

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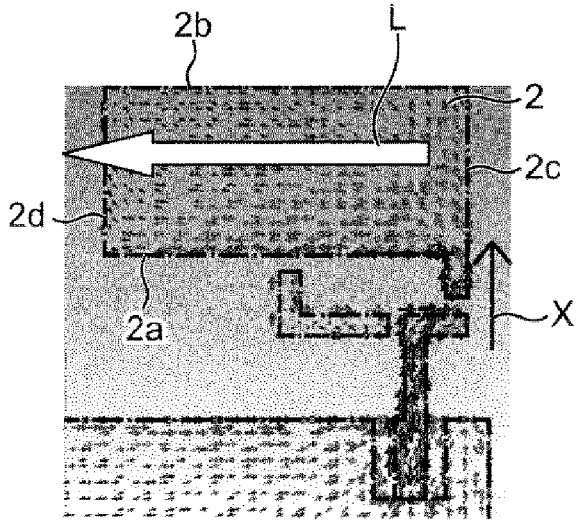
Written Opinion for PCT/JP2018/018891 dated Jul. 31, 2018.

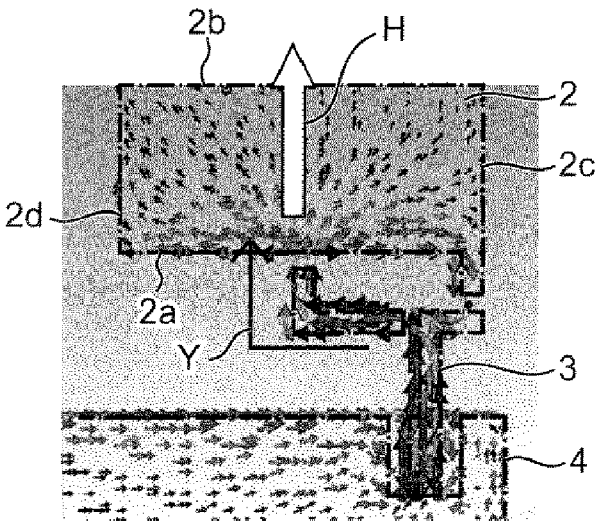
Primary Examiner — Dimary S Lopez Cruz
Assistant Examiner — Bamidele A Jegede
(74) *Attorney, Agent, or Firm* — Pearne & Gordon LLP

(57) **ABSTRACT**

The dual-band antenna device includes: a feeding electrode that branches into a first branch feeding electrode that serves as a low-frequency signal path and a second branch feeding electrode that serves as a high-frequency signal path; and a radiation electrode having a rectangular shape with a longitudinal direction and having a low-frequency feeding point to which the first branch feeding electrode is electrically connected and a high-frequency feeding point to which the second branch feeding electrode is electrically connected. In the radiation electrode, the low-frequency feeding point or the high-frequency feeding point is formed close to an end portion of the rectangular shape in the longitudinal direction, and the high-frequency feeding point or the low-frequency feeding point is formed at a center portion of a side of the rectangular shape that extends in the longitudinal direction.

20 Claims, 10 Drawing Sheets





US011024970B2

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

(10) **Patent No.: US 11,024,970 B2**
(45) **Date of Patent: Jun. 1, 2021**

(54) **CIRCULARLY POLARIZED ANTENNA FOR RADIO FREQUENCY ENERGY HARVESTING**

(71) Applicant: **AGENCY FOR SCIENCE, TECHNOLOGY AND RESEARCH**, Singapore (SG)

(72) Inventors: **Nasimuddin Nasimuddin**, Singapore (SG); **Muhammad Faeyz Karim**, Singapore (SG); **Karthik Thothathri Chandrasekaran**, Singapore (SG)

(73) Assignee: **AGENCY FOR SCIENCE, TECHNOLOGY AND RESEARCH**, 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.: **16/637,230**

(22) PCT Filed: **Aug. 6, 2018**

(86) PCT No.: **PCT/SG2018/050399**
§ 371 (c)(1),
(2) Date: **Feb. 6, 2020**

(87) PCT Pub. No.: **WO2019/032047**
PCT Pub. Date: **Feb. 14, 2019**

(65) **Prior Publication Data**

US 2020/0168996 A1 May 28, 2020

(30) **Foreign Application Priority Data**

Aug. 7, 2017 (SG) 10201706417P

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 5/307 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 9/0428*** (2013.01); ***H01Q 5/307*** (2015.01); ***H01Q 5/50*** (2015.01); ***H01Q 9/0414*** (2013.01); ***H02J 50/27*** (2016.02)

(58) **Field of Classification Search**
CPC H01Q 9/0428; H01Q 5/307; H01Q 5/50; H01Q 9/0414; H01Q 9/0464; H01Q 9/0492; H02J 50/27; H02J 50/005; H02J 50/001
See application file for complete search history.

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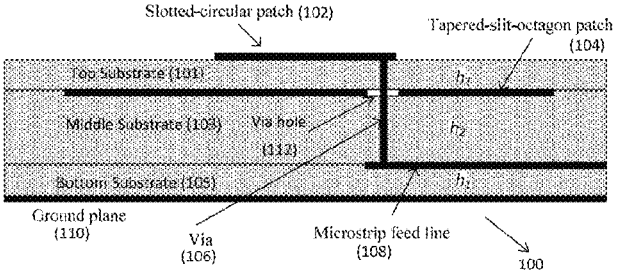
(Continued)

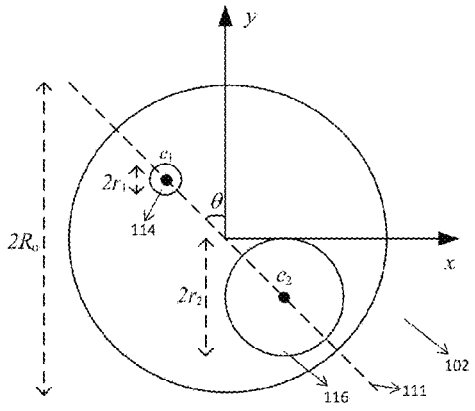
Primary Examiner — Vibol Tan
(74) *Attorney, Agent, or Firm* — George S. Blasiak; Heslin Rothenberg Farley & Mesiti PC

(57) **ABSTRACT**

A circularly polarized (CP) antenna for Radio Frequency energy harvesting comprising: a top substrate; a bottom substrate disposed on a ground plane; a middle substrate disposed between the top substrate and the bottom substrate; a slotted patch comprising more than one slots, the slotted patch being disposed on the top substrate; a slitted patch comprising a plurality of slits, the slitted patch being disposed between the top substrate and the middle substrate; a microstrip feed line disposed between the middle substrate
(Continued)



Cross-sectional view of the proposed dual-band CP antenna



Top view of Slotted-circular patch

US011024976B2

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

(10) **Patent No.: US 11,024,976 B2**
(45) **Date of Patent: Jun. 1, 2021**

(54) **MOBILE TERMINAL**

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

(72) Inventors: **Wei Zhao**, Shenzhen (CN); **Zhimin Zhu**, Shenzhen (CN); **Zhengdong Yong**, Shenzhen (CN); **Xiaoyue Xia**, Shenzhen (CN); **Chao Wang**, 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 58 days.

(21) Appl. No.: **16/702,475**

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

(65) **Prior Publication Data**

US 2020/0212583 A1 Jul. 2, 2020

(30) **Foreign Application Priority Data**

Dec. 28, 2018 (CN) 201811627448.0

(51) **Int. Cl.**

H01Q 13/08	(2006.01)
H01Q 1/24	(2006.01)
H01Q 13/20	(2006.01)
H01Q 9/04	(2006.01)
H01Q 1/42	(2006.01)
H04M 1/02	(2006.01)

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

CPC ***H01Q 13/085*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/422*** (2013.01); ***H01Q 9/0421*** (2013.01); ***H01Q 13/206*** (2013.01); ***H04M 1/0266*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 13/08; H01Q 13/085; H01Q 13/206; H01Q 9/0421; H01Q 1/24; H01Q 1/243; H01Q 1/422

See application file for complete search history.

(56) **References Cited**

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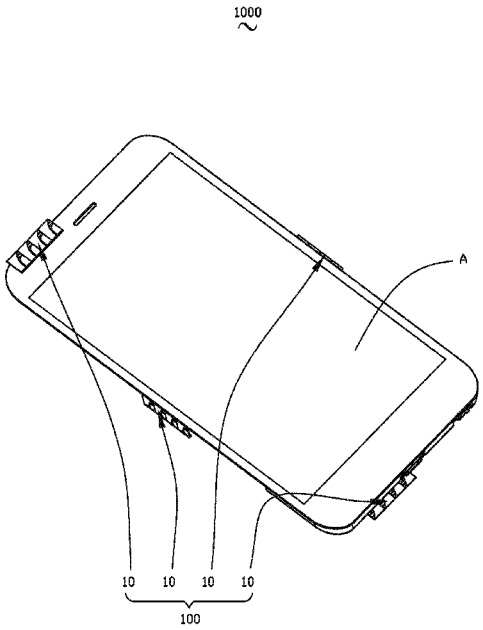
Primary Examiner — Hoang V Nguyen
(74) *Attorney, Agent, or Firm* — W&G Law Group LLP

(57) **ABSTRACT**

The present invention provides a mobile terminal, which includes a Vivaldi antenna system arranged in the mobile terminal, wherein the Vivaldi antenna system includes two pairs of Vivaldi antenna arrays, opening directions of one pair of the Vivaldi antenna arrays are along a length direction of the mobile terminal, opening directions of the other pair of the Vivaldi antenna arrays are along a thickness direction of the mobile terminal, and each pair of the Vivaldi antenna arrays includes two Vivaldi antenna arrays with opposite opening directions, and the Vivaldi antenna arrays operate in a frequency band of 5G millimeter waves. Compared with the related art, the mobile terminal provided by the present disclosure has wide and uniform beam bandwidths in a non-scanning direction, thus achieving excellent spatial coverage efficiency.

8 Claims, 12 Drawing Sheets



US011024980B2

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

(10) **Patent No.: US 11,024,980 B2**
(45) **Date of Patent: Jun. 1, 2021**

(54) **DUAL-POLARIZED ANTENNA**

(71) Applicant: **Telefonaktiebolaget LM Ericsson (publ)**, Stockholm (SE)

(72) Inventors: **Andreas Vollmer**, Rosenheim (DE); **Manfred Stolle**, Bad Aibling (DE)

(73) Assignee: **Telefonaktiebolaget LM Ericsson (publ)**, Stockholm (SE)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 108 days.

(21) Appl. No.: **15/756,416**

(22) PCT Filed: **Aug. 31, 2016**

(86) PCT No.: **PCT/EP2016/001472**
§ 371 (c)(1),
(2) Date: **Jul. 23, 2018**

(87) PCT Pub. No.: **WO2017/036599**
PCT Pub. Date: **Mar. 9, 2017**

(65) **Prior Publication Data**

US 2018/0337462 A1 Nov. 22, 2018

(30) **Foreign Application Priority Data**

Sep. 1, 2015 (DE) 10 2015 011 426

(51) **Int. Cl.**
H01Q 21/26 (2006.01)
H01Q 9/16 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 21/26*** (2013.01); ***H01Q 1/246*** (2013.01); ***H01Q 9/16*** (2013.01); ***H01Q 13/10*** (2013.01); *H01Q 1/364* (2013.01)

(58) **Field of Classification Search**
CPC H01Q 21/26; H01Q 1/246; H01Q 9/16; H01Q 13/10; H01Q 1/364; H01Q 9/26; H01Q 11/10; H01Q 21/30
(Continued)

(56) **References Cited**

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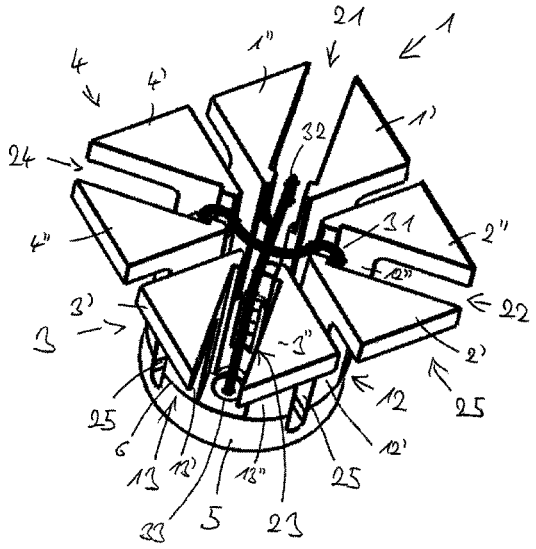
Primary Examiner — Hai V Tran
(74) *Attorney, Agent, or Firm* — Withrow & Terranova, PLLC

(57) **ABSTRACT**

The invention relates to a dual-polarized antenna having four dipole elements which are each provided on an associated support element, wherein a slot extends in the volume of each dipole element and is prolonged from the dipole element into the associated support element.

19 Claims, 18 Drawing Sheets



US011024982B2

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

(10) **Patent No.: US 11,024,982 B2**
(45) **Date of Patent: Jun. 1, 2021**

(54) **ANTENNA APPARATUS**

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

(72) Inventors: **Nam Ki Kim**, Suwon-si (KR); **Jae Min Keum**, Suwon-si (KR); **Won Cheol Lee**, Suwon-si (KR); **Dae Ki Lim**, Suwon-si (KR); **Eun Young Jung**, Suwon-si (KR); **Jeong Ki Ryoo**, 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 0 days.

(21) Appl. No.: **16/655,887**

(22) Filed: **Oct. 17, 2019**

(65) **Prior Publication Data**

US 2020/0303839 A1 Sep. 24, 2020

(30) **Foreign Application Priority Data**

Mar. 21, 2019 (KR) 10-2019-0032468
Jun. 11, 2019 (KR) 10-2019-0068925

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

(52) **U.S. Cl.**
CPC ***H01Q 25/00*** (2013.01); ***H01Q 1/2283*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 5/357*** (2015.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 5/48; H01Q 5/357; H01Q 9/44; H01Q 9/16; H01Q 9/065; H01Q 13/085;
(Continued)

(56) **References Cited**

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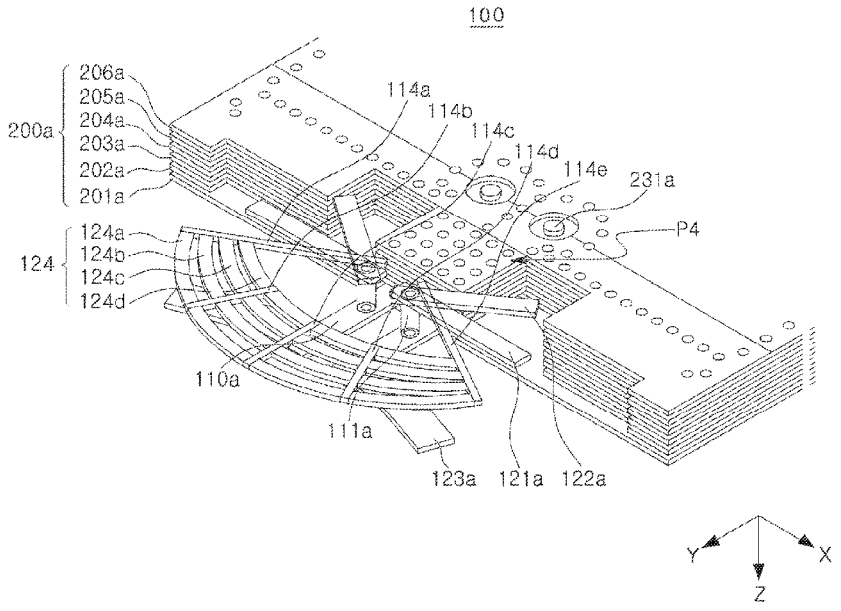
Primary Examiner — Ab Salam Alkassim, Jr.
(74) *Attorney, Agent, or Firm* — NSIP Law

(57) **ABSTRACT**

An antenna apparatus may include: a feed line; a ground plane disposed around a portion of the feed line; a feed via electrically connected to the feed line; a first end-fire antenna pattern disposed in front of the ground plane to be spaced apart from the ground plane, and electrically connected to the feed via; a second end-fire antenna pattern electrically connected to the feed line and disposed farther forward than the first end-fire antenna pattern; and a third end-fire antenna pattern electrically connected to the feed via, and disposed in front of the first end-fire antenna pattern in such a manner that a portion of the third end-fire antenna pattern overlaps the second end-fire antenna pattern.

12 Claims, 23 Drawing Sheets



US011025285B2

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

(10) **Patent No.: US 11,025,285 B2**
(45) **Date of Patent: Jun. 1, 2021**

(54) **ELECTRONIC DEVICE WITH MILLIMETER WAVE ANTENNAS**

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

(72) Inventors: **Yuehui Ouyang**, Sunnyvale, CA (US); **Yi Jiang**, Cupertino, CA (US); **Matthew A. Mow**, Los Altos, CA (US); **Basim Noori**, Scotts Valley, CA (US); **Mattia Pascolini**, San Francisco, CA (US); **Ruben Caballero**, San Jose, 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 0 days.

(21) Appl. No.: **16/854,771**

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

(65) **Prior Publication Data**

US 2020/0295789 A1 Sep. 17, 2020

Related U.S. Application Data

(63) Continuation of application No. 16/138,881, filed on Sep. 21, 2018, now Pat. No. 10,680,663, which is a (Continued)

(51) **Int. Cl.**
H04B 1/04 (2006.01)
H01Q 1/22 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H04B 1/04*** (2013.01); ***H01Q 1/2266*** (2013.01); ***H01Q 1/243*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC .. H01Q 1/2266; H01Q 1/243; H01Q 21/0025; H01Q 21/062; H01Q 21/065;
(Continued)

(56) **References Cited**

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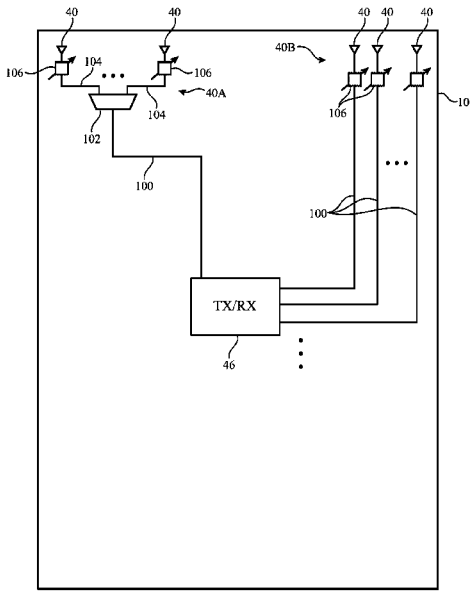
Primary Examiner — Hai V Nguyen
(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.; G. Victor Treyz; Michael H. Lyons

(57) **ABSTRACT**

An electronic device may be provided with wireless circuitry. The wireless circuitry may include one or more antennas. The antennas may include phased antenna arrays each of which includes multiple antenna elements. Phased antenna arrays may be mounted along edges of a housing for the electronic device, behind a dielectric window such as a dielectric logo window in the housing, in alignment with dielectric housing portions at corners of the housing, or elsewhere in the electronic device. A phased antenna array may include arrays of patch antenna elements on dielectric layers separated by a ground layer. A baseband processor may distribute wireless signals to the phased antenna arrays at intermediate frequencies over intermediate frequency signal paths. Transceiver circuits at the phased antenna arrays may include upconverters and downconverters coupled to the intermediate frequency signal paths.

20 Claims, 13 Drawing Sheets



US011025307B2

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

(10) **Patent No.: US 11,025,307 B2**
(45) **Date of Patent: Jun. 1, 2021**

(54) **ELECTRONIC DEVICE FOR SENSING LOCATION AND CONTACT OF EXTERNAL OBJECT**

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

(72) Inventors: **Hoyeon Kim**, Gyeonggi-do (KR); **Jeongsik Kim**, Gyeonggi-do (KR); **Sungjun Kim**, Gyeonggi-do (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 33 days.

(21) Appl. No.: **16/678,083**

(22) Filed: **Nov. 8, 2019**

(65) **Prior Publication Data**

US 2020/0186203 A1 Jun. 11, 2020

(30) **Foreign Application Priority Data**

Dec. 10, 2018 (KR) 10-2018-0158295

(51) **Int. Cl.**
H04B 7/024 (2017.01)
H04L 5/00 (2006.01)
H04J 11/00 (2006.01)

(52) **U.S. Cl.**
CPC ***H04B 7/024*** (2013.01); ***H04J 11/0053*** (2013.01); ***H04L 5/0035*** (2013.01)

(58) **Field of Classification Search**
CPC H04B 7/0814; H04B 7/0608; H04B 7/024; H04J 11/0053; H04J 11/00; H04L 5/0035
See application file for complete search history.

(56) **References Cited**

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WO 2018/034518 A1 2/2018

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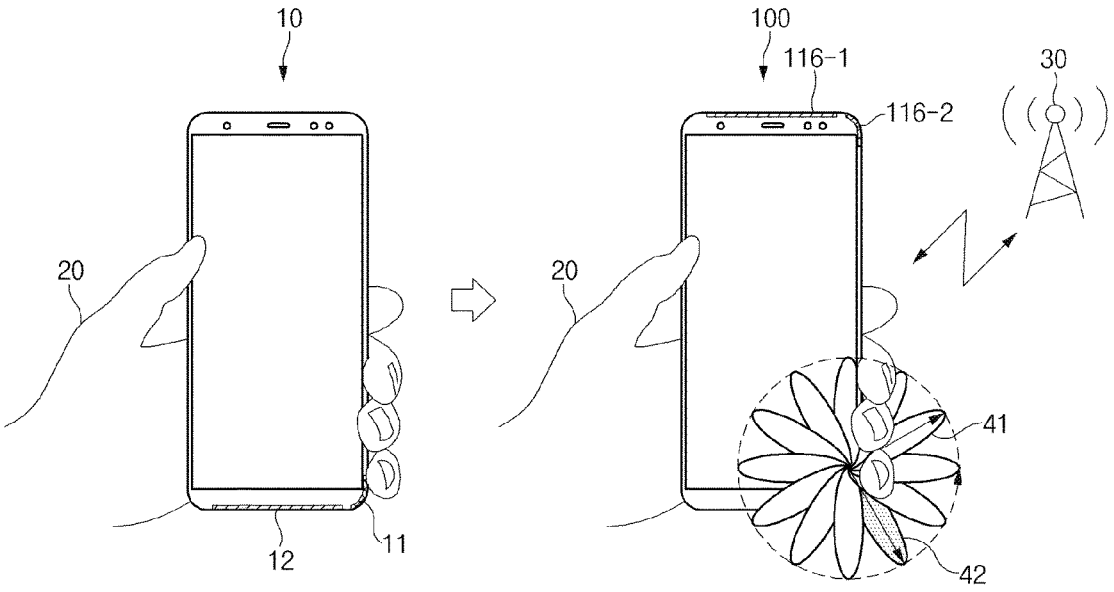
Primary Examiner — Syed Ali
(74) *Attorney, Agent, or Firm* — Cha & Reiter, LLC.

(57) **ABSTRACT**

An electronic device includes a housing, a first antenna included in a first region of the housing, a second antenna included in a second region of the housing, an antenna structure that is disposed within the housing, a coupler that obtains an impedance of each of the antennas and the antenna structure, a memory that stores a table in which the impedances of each of the antennas and the antenna structure are matched to a location or a contact of an external object, and a processor, and the processor obtains the impedances of each of the antennas and the antenna structure from the coupler when the external object approaches the electronic device, obtains the location or the contact of the external object based on the obtained impedances and the table, and transceives a signal through the antenna structure in a direction where the external object is absent.

12 Claims, 20 Drawing Sheets



US011025761B1

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

(10) **Patent No.: US 11,025,761 B1**
(45) **Date of Patent: Jun. 1, 2021**

(54) **MOBILE TERMINAL**

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

(72) Inventors: **Hongjo Shim**, Seoul (KR); **Sunwon Yoo**, Seoul (KR); **Jungwhan Kim**, Seoul (KR); **Hyunwoo Kim**, Seoul (KR)

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

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

(21) Appl. No.: **16/821,902**

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

(30) **Foreign Application Priority Data**

Jan. 2, 2020 (WO) PCT/KR2020/000065

(51) **Int. Cl.**
H04M 1/02 (2006.01)
H01Q 1/24 (2006.01)
H04M 1/72412 (2021.01)

(52) **U.S. Cl.**
CPC ***H04M 1/0266*** (2013.01); ***H01Q 1/243*** (2013.01); ***H04M 1/72412*** (2021.01); *H04M 2250/12* (2013.01)

(58) **Field of Classification Search**
CPC G06F 3/016; G06F 1/169; G06F 2203/04105; G06F 1/1626; G06F 3/017; G06F 3/04144
See application file for complete search history.

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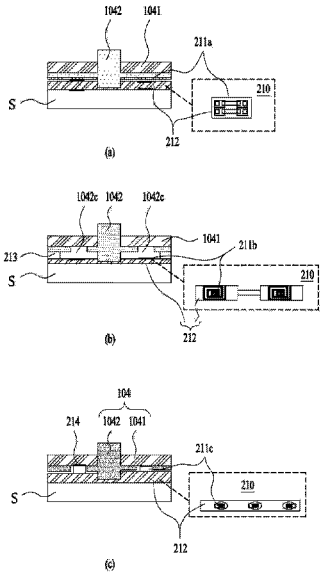
Primary Examiner — Dung Hong
(74) *Attorney, Agent, or Firm* — Lee, Hong, Degerman, Kang & Waimey

(57) **ABSTRACT**

Disclosed herein is a mobile terminal capable of indicating the position of a force sensor arranged inside a side case using the shape of a non-conductive mold disposed between conductive members to sense pressure. For the mobile terminal, a user input unit and an antenna may be arranged to overlap each other, and a bump and a recess may be formed using a non-conductive mold that is easy to process. Accordingly, uniformity of appearance may be maintained without forming a bump and a recess on the conductive member.

14 Claims, 12 Drawing Sheets



US011031671B2

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

(10) **Patent No.: US 11,031,671 B2**
(45) **Date of Patent: Jun. 8, 2021**

(54) **AOG ANTENNA SYSTEM AND MOBILE TERMINAL**

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

(72) Inventors: **Xiaoyue Xia**, Shenzhen (CN); **Zhengdong Yong**, Shenzhen (CN); **Zhimin Zhu**, Shenzhen (CN); **Chao Wang**, 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 3 days.

(21) Appl. No.: **16/524,092**

(22) Filed: **Jul. 28, 2019**

(65) **Prior Publication Data**

US 2020/0052368 A1 Feb. 13, 2020

(30) **Foreign Application Priority Data**

Aug. 12, 2018 (CN) 201810911473.5

(51) **Int. Cl.**

H01Q 1/12	(2006.01)
H01Q 21/28	(2006.01)
H01Q 1/24	(2006.01)
H01Q 9/04	(2006.01)
H01Q 21/08	(2006.01)

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

CPC ***H01Q 1/1271*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 9/0407*** (2013.01); ***H01Q 21/08*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/38; H01Q 1/243; H01Q 9/0407; H01Q 9/0457; H01Q 23/00; H01Q 21/0006; H01Q 1/1271; H01Q 21/28; H04M 1/0202; H02M 1/026

See application file for complete search history.

(56) **References Cited**

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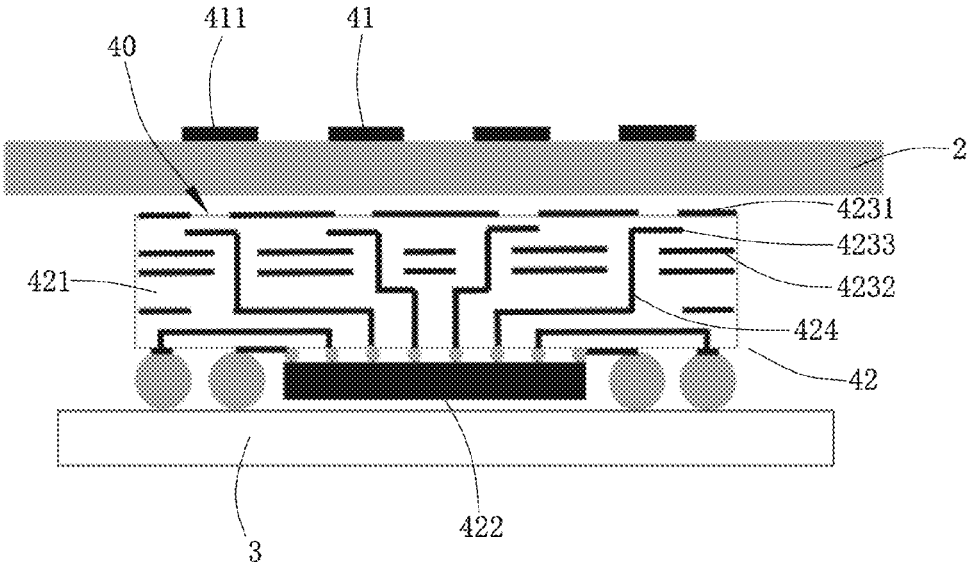
Primary Examiner — Haissa Philogene
(74) *Attorney, Agent, or Firm* — W&G Law Group LLP

(57) **ABSTRACT**

The present disclosure provides an AOG antenna system and a mobile terminal. The AOG antenna system includes a 3D glass back cover and a main board arranged opposite to and spaced apart from the 3D glass back cover. The AOG antenna system includes: a metal antenna attached to a surface of the 3D glass back cover; and a packaged feeding module provided between the 3D glass back cover and the main board and electrically connected to the main board. The packaged feeding module corresponds to a position of the metal antenna and feeds the metal antenna with power by coupling.

7 Claims, 7 Drawing Sheets



US011031674B1

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

(10) **Patent No.: US 11,031,674 B1**
(45) **Date of Patent: Jun. 8, 2021**

(54) **SYSTEM AND METHOD FOR ANTENNA PATTERN POSITIONING OF INTEGRATED ANTENNA VENT**

(71) Applicant: **Dell Products, LP**, Round Rock, TX (US)

(72) Inventors: **Suresh K. Ramasamy**, Cedar Park, TX (US); **Sumana Pallampati**, Austin, TX (US); **Changsoo Kim**, Cedar Park, TX (US)

(73) Assignee: **Dell Products, LP**, Round Rock, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 25 days.

(21) Appl. No.: **16/704,998**

(22) Filed: **Dec. 5, 2019**

(51) **Int. Cl.**
H01Q 1/22 (2006.01)
H01Q 1/48 (2006.01)
G06F 1/16 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/2266*** (2013.01); ***G06F 1/1683*** (2013.01); ***H01Q 1/48*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/2266; H01Q 1/48; H01Q 1/24; G06F 1/1683
See application file for complete search history.

(56) **References Cited**

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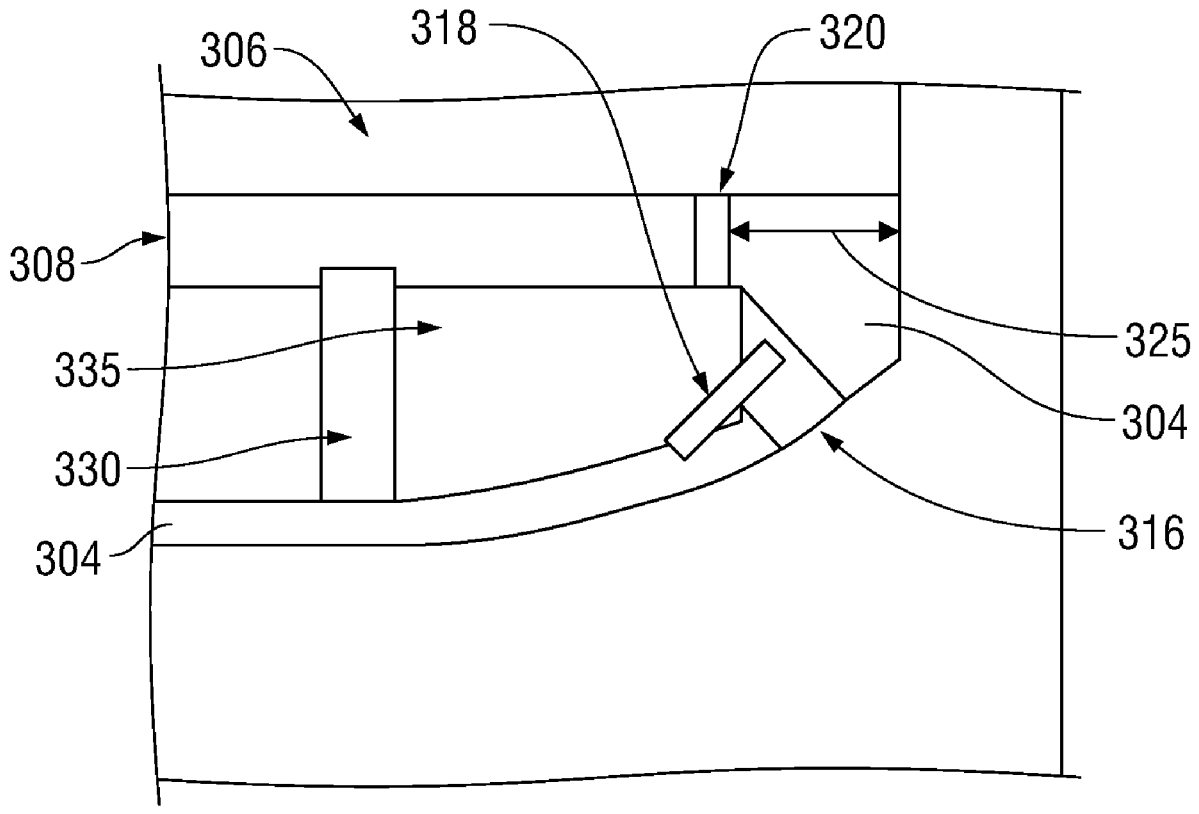
* cited by examiner

Primary Examiner — Daniel D Chang
(74) *Attorney, Agent, or Firm* — Prol Intellectual Property Law, PLLC; H. Kenneth Prol

(57) **ABSTRACT**

An information handling system to wirelessly transmit and receive data at an antenna may include a base housing metal chassis containing components of the information handling system, the base housing metal chassis including a C-cover and D-cover housing the components; and an antenna cavity formed within the C-Cover and D-cover including: a first aperture formed through a portion of the D-cover; a second aperture formed through a portion of the C-cover; and a grounding wall formed within the antenna cavity to operatively couple currents associated with the antenna such that the currents travel from the first aperture to the send aperture causing emitted electromagnetic radiation to be emitted towards the second aperture.

20 Claims, 7 Drawing Sheets



US011031676B2

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

(10) **Patent No.: US 11,031,676 B2**
(45) **Date of Patent: Jun. 8, 2021**

(54) **MILLIMETER WAVE ARRAY ANTENNA ARCHITECTURE**

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

(72) Inventors: **Xiaoyue Xia**, Shenzhen (CN); **Chao Wang**, 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 29 days.

(21) Appl. No.: **16/524,087**

(22) Filed: **Jul. 28, 2019**

(65) **Prior Publication Data**

US 2020/0044314 A1 Feb. 6, 2020

(30) **Foreign Application Priority Data**

Aug. 3, 2018 (CN) 201821255632.2

(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H01Q 1/38	(2006.01)
H01Q 21/29	(2006.01)
H01Q 21/06	(2006.01)
H01Q 9/04	(2006.01)

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

CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 9/04*** (2013.01); ***H01Q 21/065*** (2013.01); ***H01Q 21/29*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/38; H01Q 21/29; H01Q 21/065; H01Q 9/04; H01Q 21/28; H01Q 21/08

USPC 343/702

See application file for complete search history.

(56) **References Cited**

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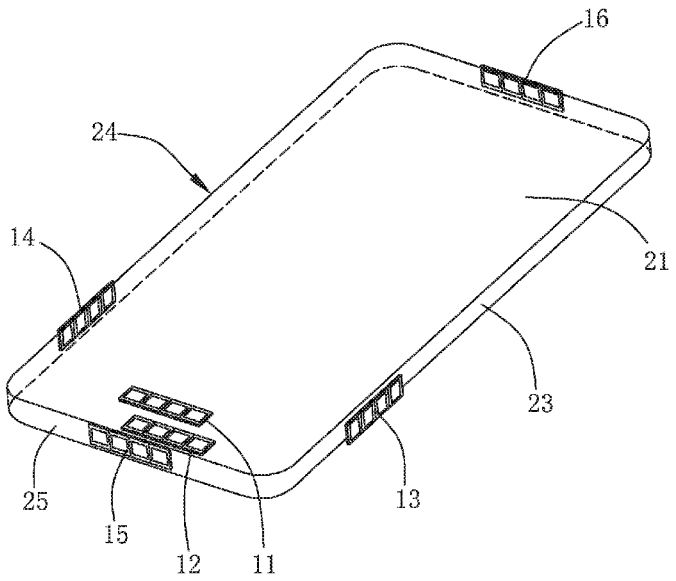
Primary Examiner — Don P Le

(74) *Attorney, Agent, or Firm* — W&G Law Group LLP

(57) **ABSTRACT**

The present disclosure provides a millimeter wave array antenna architecture including six antenna arrays and an installation body for installing the six antenna arrays, the installation body being of a cuboid or a cube and the six antenna arrays being respectively disposed on six installation faces of the installation body. In the millimeter wave array antenna architecture in the present disclosure, due to the six antenna arrays' non-dead-spot full-space scanning on the installation faces of the installation body, areas with weak wave beam coverage on the installation body are reduced to the least, which is advantageous for ensuring an antenna coverage efficiency, thereby improving stability of the mobile communication system and a user's experience.

12 Claims, 4 Drawing Sheets



US011031687B2

(12) **United States Patent**
Uchimura

(10) **Patent No.: US 11,031,687 B2**
(45) **Date of Patent: Jun. 8, 2021**

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

(71) Applicant: **KYOCERA Corporation**, Kyoto (JP)

(72) Inventor: **Hiroshi Uchimura**, Kagoshima (JP)

(73) Assignee: **KYOCERA CORPORATION**, Kyoto (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.: **16/795,574**

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

(65) **Prior Publication Data**

US 2020/0235470 A1 Jul. 23, 2020

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2019/032876, filed on Aug. 22, 2019.

(30) **Foreign Application Priority Data**

Aug. 27, 2018 (JP) JP2018-158793

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

(52) **U.S. Cl.**
CPC ***H01Q 1/528*** (2013.01); ***H01Q 1/24*** (2013.01); ***H01Q 5/307*** (2015.01); ***H01Q 9/0421*** (2013.01); ***H01Q 9/0457*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/528; H01Q 9/045; H01Q 9/0457; H01Q 9/0421; H01Q 9/0428;
(Continued)

(56) **References Cited**

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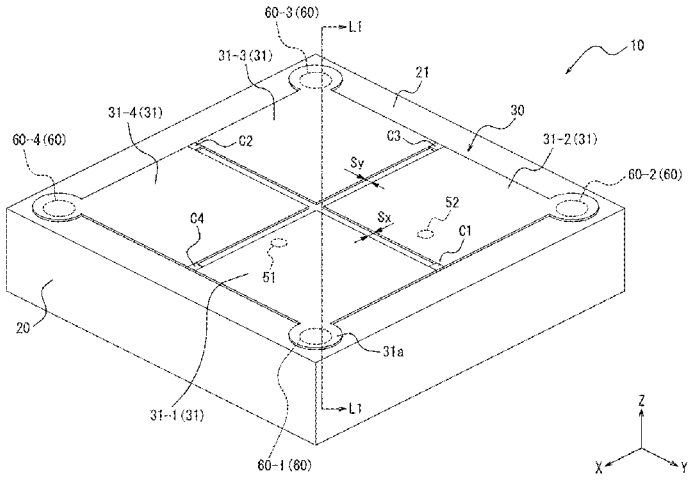
Primary Examiner — Dameon E Levi
Assistant Examiner — Jennifer F Hu
(74) *Attorney, Agent, or Firm* — Hauptman Ham, LLP

(57) **ABSTRACT**

A resonant structure includes a conducting portion extending along a first plane and including first conductors, a ground conductor located away from the conducting portion and extending along the first plane, and a first predetermined number of connecting conductors extending from the ground conductor towards the conducting portion. At least two first conductors are connected to different connecting conductors. A first connecting pair of two of the connecting conductors is aligned along a first direction in the first plane and a second connecting pair of two of the connecting conductors is aligned along a second direction, in the first plane, intersecting the first direction. The resonant structure resonates at a first frequency along a first current path including the ground conductor, conducting portion, and first connecting pair and at a second frequency along a second current path including the ground conductor, conducting portion, and second connecting pair.

13 Claims, 77 Drawing Sheets



US011031694B2

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

(10) **Patent No.: US 11,031,694 B2**
(45) **Date of Patent: Jun. 8, 2021**

(54) **ANTENNA**

(71) Applicant: **Yazaki Corporation**, Tokyo (JP)

(72) Inventors: **Eita Itou**, Susono (JP); **Kunihiko Yamada**, Susono (JP); **Yoshikazu Nagashima**, Susono (JP); **Kenji Matsushita**, Yokosuka (JP); **Tatsuo Toba**, Yokosuka (JP)

(73) Assignee: **YAZAKI 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 22 days.

(21) Appl. No.: **16/777,238**

(22) Filed: **Jan. 30, 2020**

(65) **Prior Publication Data**

US 2020/0168994 A1 May 28, 2020

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2018/018107, filed on May 10, 2018.

(30) **Foreign Application Priority Data**

Aug. 2, 2017 (JP) JP2017-149871

(51) **Int. Cl.**
H01Q 21/00 (2006.01)
H01Q 7/00 (2006.01)
H01Q 21/24 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 7/00*** (2013.01); ***H01Q 21/24*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 21/24; H01Q 1/3208; H01Q 7/00
USPC 343/867
See application file for complete search history.

(56) **References Cited**

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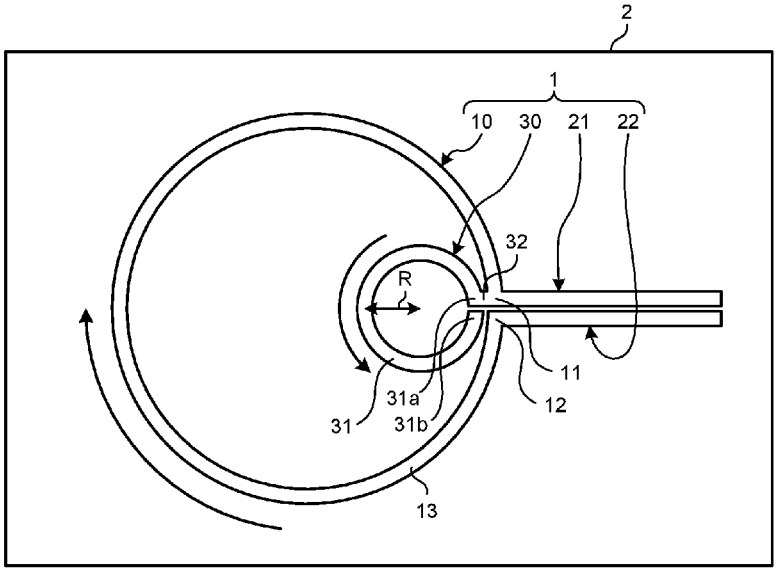
JP 2008-135932 A 6/2008

Primary Examiner — Jean B Jeanglaude
(74) *Attorney, Agent, or Firm* — Sughrue Mion, PLLC

(57) **ABSTRACT**

In an antenna, the outer conductor is formed of a first linear conductor, the first linear conductor having a length corresponding to one wavelength of a right-handed circularly polarized wave and circularly extended from a first feed point to a second feed point. The inner conductor is disposed inside the outer conductor and formed of a second linear conductor, the second linear conductor being different from the first linear conductor and having a length determined based on one wavelength of a left-handed circularly polarized wave. The inner conductor has a starting point of the second linear conductor connected to the first feed point and has an end point of the second linear conductor kept free from connection at a location inside the outer conductor, and causes current to flow in a direction opposite to the current flow in the outer conductor.

8 Claims, 21 Drawing Sheets



US011031695B2

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

(10) **Patent No.: US 11,031,695 B2**
(45) **Date of Patent: Jun. 8, 2021**

(54) **LOOP ANTENNA**

(71) Applicant: **MERRY ELECTRONICS (SHENZHEN) CO., LTD.**, Guangdong (CN)

(72) Inventors: **Hsien-Chang Lin**, Taichung (TW); **Heng-Yi Liao**, Taichung (TW); **Shuo-Man Yuan**, Taichung (TW); **Tsu-Jung Wang**, Taichung (TW)

(73) Assignee: **MERRY ELECTRONICS (SHENZHEN) 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.: **16/827,707**

(22) Filed: **Mar. 24, 2020**

(65) **Prior Publication Data**

US 2021/0104820 A1 Apr. 8, 2021

(30) **Foreign Application Priority Data**

Oct. 7, 2019 (TW) 108136281

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 1/48 (2006.01)
H01Q 7/00 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 7/00*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 1/48*** (2013.01)

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

(56) **References Cited**

U.S. PATENT DOCUMENTS

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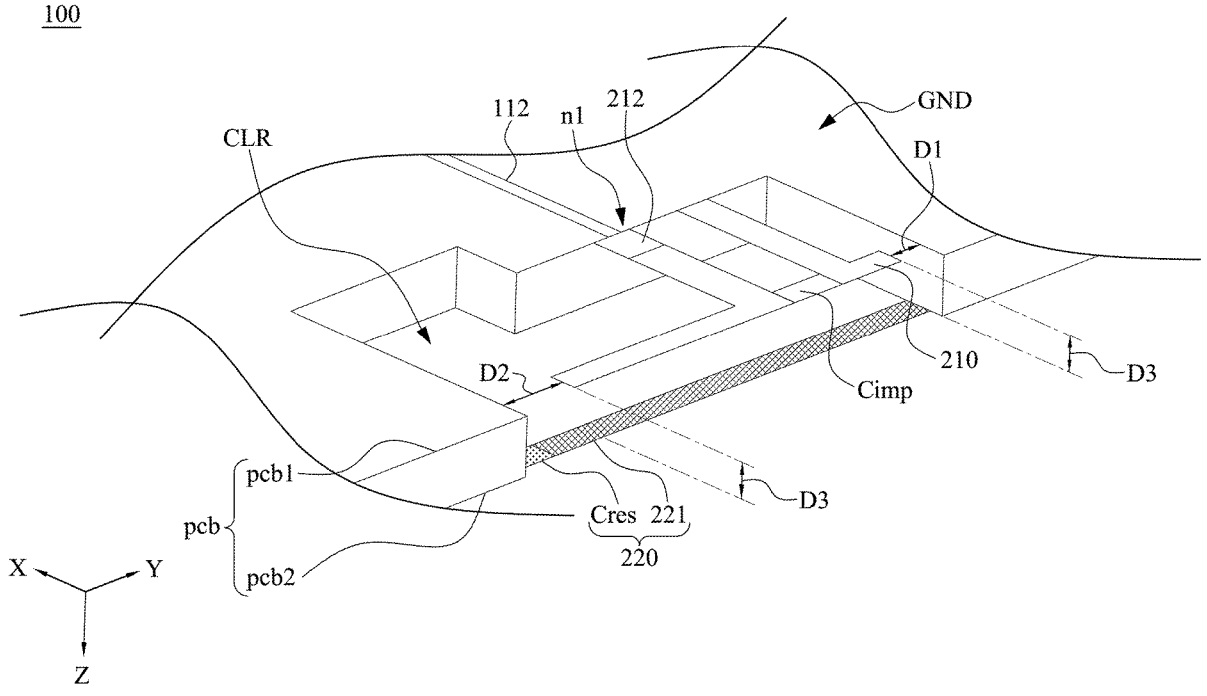
Primary Examiner — Anh Q Tran
(74) *Attorney, Agent, or Firm* — CKC & Partners Co., LLC

(57) **ABSTRACT**

A loop antenna includes a printed circuit board (PCB), a first antenna structure and a second antenna structure. The PCB includes a first surface and a second surface relative to the first surface, and the PCB includes a clear region and a ground region, wherein the clear region is adjacent to the ground region. The first antenna structure is disposed in the clear region at the first surface. The first antenna structure includes a feed structure and a first ground end. The feed structure is coupled to a power feed end which is disposed in the ground region. The first ground end is coupled to the ground region. The second antenna structure is disposed relative to the first antenna structure at the second surface. The second antenna structure includes a second ground end. The second ground end is coupled to the ground region.

11 Claims, 5 Drawing Sheets



US011031696B2

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

(10) **Patent No.: US 11,031,696 B2**
(45) **Date of Patent: Jun. 8, 2021**

(54) **ANTENNA-IN-PACKAGE SYSTEM AND MOBILE TERMINAL**

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

(72) Inventors: **Xiaoyue Xia**, Shenzhen (CN); **Chao Wang**, 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 54 days.

(21) Appl. No.: **16/705,225**

(22) Filed: **Dec. 6, 2019**

(65) **Prior Publication Data**

US 2020/0212577 A1 Jul. 2, 2020

(30) **Foreign Application Priority Data**

Dec. 29, 2018 (CN) 201811640857.4

(51) **Int. Cl.**

H01Q 9/04	(2006.01)
H01Q 23/00	(2006.01)
H01Q 21/06	(2006.01)
H01Q 1/24	(2006.01)

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

CPC ***H01Q 9/0414*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 21/065*** (2013.01); ***H01Q 23/00*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 9/0414; H01Q 1/243; H01Q 21/065; H01Q 23/00

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

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* cited by examiner

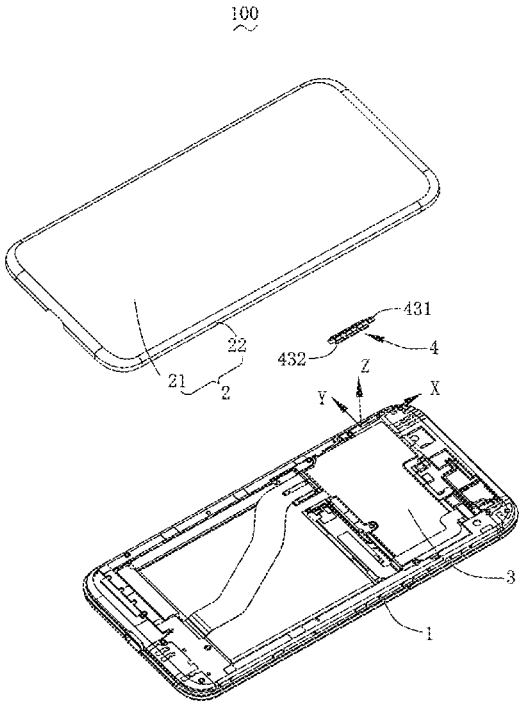
Primary Examiner — Graham P Smith

(74) *Attorney, Agent, or Firm* — W&G Law Group LLP

(57) **ABSTRACT**

An antenna-in-package system and a mobile terminal are provided. The mobile terminal includes a screen, a back covering, connected to, and fitting with the screen to form a receiving space, and a main board interposed between the screen and the back cover. The antenna-in-package system includes a substrate provided between the screen and the back cover, a metal antenna provided on a side of the substrate facing away from the main board. The metal antenna includes a first antenna and a second antenna that are stacked, and the first antenna is provided on a side of the second antenna facing away from the main board. A beam of the first antenna covers a space of Y>0, and a beam of the second antenna covers a space of Z>0.

18 Claims, 7 Drawing Sheets



US011031701B2

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

(10) **Patent No.: US 11,031,701 B2**
(45) **Date of Patent: Jun. 8, 2021**

(54) **ELECTRONIC DEVICE**

(71) Applicant: **BEIJING XIAOMI MOBILE SOFTWARE CO., LTD.**, Beijing (CN)

(72) Inventors: **Peng Li**, Beijing (CN); **Xuwang Cui**, Beijing (CN)

(73) Assignee: **BEIJING XIAOMI MOBILE SOFTWARE 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 0 days.

(21) Appl. No.: **16/737,072**

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

(65) **Prior Publication Data**

US 2021/0075121 A1 Mar. 11, 2021

(30) **Foreign Application Priority Data**

Sep. 5, 2019 (CN) 201910838737.3

(51) **Int. Cl.**

H01Q 21/00	(2006.01)
H04M 1/02	(2006.01)
H04B 1/38	(2015.01)
H01Q 1/24	(2006.01)
H01Q 21/06	(2006.01)

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

CPC ***H01Q 21/06*** (2013.01); ***H01Q 1/243*** (2013.01); ***H04M 1/0268*** (2013.01)

(58) **Field of Classification Search**

CPC H04B 1/006; H04B 1/40; H04B 1/406; H04B 1/3833; H04M 1/0202; H04M 1/1214; H04M 1/0216; H04M 1/0222; H04M 1/0268; H04W 88/02; H01Q 1/242; H01Q 1/243; H01Q 3/01; H01Q 9/42; H01Q 21/06; H01Q 21/28; H01Q 21/29; H01Q 21/30; H01Q 25/00; H01Q 5/30; H01Q 5/307

See application file for complete search history.

(56) **References Cited**

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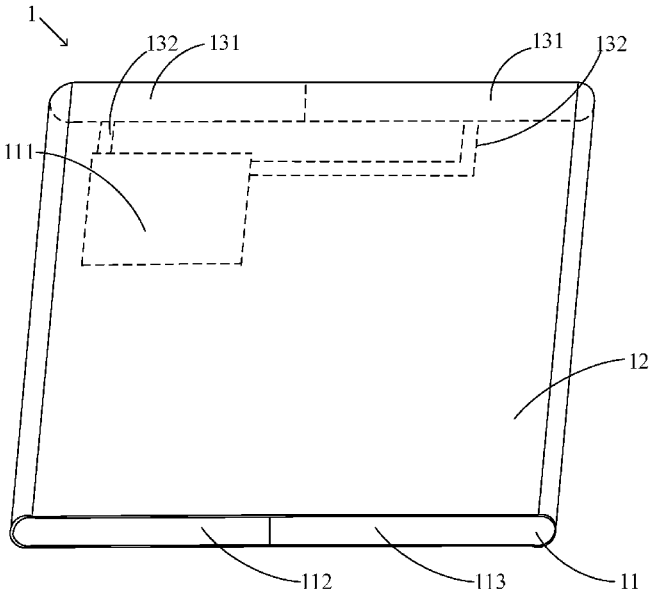
(Continued)

Primary Examiner — Quochien B Vuong
(74) *Attorney, Agent, or Firm* — Oblon, McClelland, Maier & Neustadt, L.L.P.

(57) **ABSTRACT**

The disclosure relates to an electronic device, including a device body; a flexible screen assembled on the device body; and an antenna component assembled on the device body. A bent display status of the flexible screen matches with a contracted status of the device body, and an unfolded display status of the flexible screen matches with an extended status of the device body, so that the electronic device can be used in contraction and extension statuses. Furthermore, the main board of the device body can control at least one radiating element of the antenna component to form a first antenna scheme when the device body is in the extended status, and form a second antenna scheme when the device body is in the contracted status.

12 Claims, 6 Drawing Sheets



US011031703B2

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

(10) **Patent No.: US 11,031,703 B2**
(45) **Date of Patent: Jun. 8, 2021**

(54) **ANTENNA UNIT AND ANTENNA SYSTEM**

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

(72) Inventors: **Jianchuan Liu**, Shenzhen (CN); **Yuehua Yue**, Shenzhen (CN); **Hongjuan Han**, 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 36 days.

(21) Appl. No.: **16/524,061**

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

(65) **Prior Publication Data**

US 2020/0052417 A1 Feb. 13, 2020

(30) **Foreign Application Priority Data**

Aug. 12, 2018 (CN) 201810912482.6

(51) **Int. Cl.**

H01Q 5/328	(2015.01)
H01Q 21/28	(2006.01)
H01Q 5/50	(2015.01)
H01Q 1/24	(2006.01)
H01Q 9/04	(2006.01)

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

CPC ***H01Q 21/28*** (2013.01); ***H01Q 1/241*** (2013.01); ***H01Q 5/328*** (2015.01); ***H01Q 5/50*** (2015.01); ***H01Q 9/0407*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 21/28; H01Q 5/328; H01Q 5/50; H01Q 1/241; H01Q 9/0407; H01Q 21/30; H01Q 21/24; H01Q 25/001; H01Q 13/08; H01Q 1/38

See application file for complete search history.

(56) **References Cited**

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2006/0170596	A1 *	8/2006	Habib	H01Q 9/26 343/700 MS
2019/0319367	A1 *	10/2019	Edwards	H01Q 1/243

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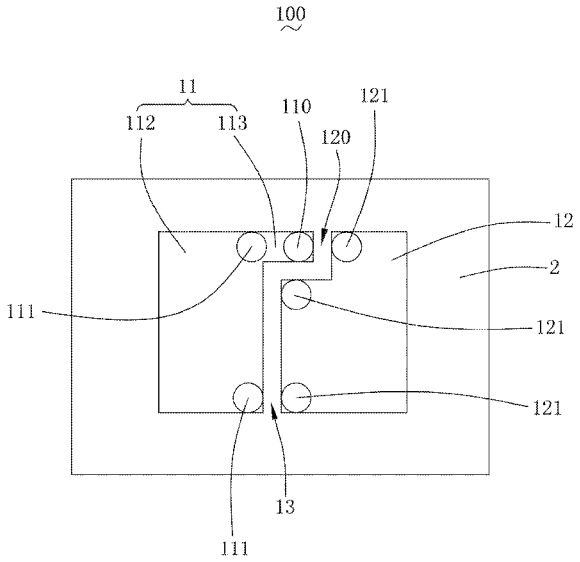
Primary Examiner — Henry Luong
(74) *Attorney, Agent, or Firm* — W&G Law Group LLP

(57) **ABSTRACT**

An antenna unit, including a radiator, a dielectric layer and an antenna ground plane which are sequentially stacked. The radiator includes a first antenna unit and a second antenna unit that are opposite to, spaced apart from and structurally complementary to each other. The first antenna unit is provided with a feeding point connected to an external power source and two first grounding points connected to the antenna ground plane. The second antenna unit is provided with three second grounding points connected to the antenna ground plane. Compared with the related art, the antenna unit provided by the present disclosure works in the 37-42.5 GHz band, has a good antenna performance, wide working band, simple structure, and low profile, and is easy to implement.

6 Claims, 7 Drawing Sheets



US011031965B2

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

(10) **Patent No.: US 11,031,965 B2**
(45) **Date of Patent: *Jun. 8, 2021**

(54) **SMALL ANTENNA APPARATUS AND METHOD FOR CONTROLLING THE SAME**

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

(72) Inventors: **Jungsik Park**, Bucheon-si (KR); **Sooung Chun**, Suwon-si (KR)

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

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

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **16/884,487**

(22) Filed: **May 27, 2020**

(65) **Prior Publication Data**

US 2020/0287581 A1 Sep. 10, 2020

Related U.S. Application Data

(63) Continuation of application No. 16/155,248, filed on Oct. 9, 2018, now Pat. No. 10,680,671, which is a (Continued)

(30) **Foreign Application Priority Data**

Jan. 13, 2012 (KR) 10-2012-0004448

(51) **Int. Cl.**
H04B 1/18 (2006.01)
H01Q 1/24 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H04B 1/18*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 9/145*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H04B 1/18; H04B 1/0458; H01Q 1/243; H01Q 1/48; H01Q 9/145; H01Q 9/16; H01Q 9/42; H04W 88/02
See application file for complete search history.

(56) **References Cited**

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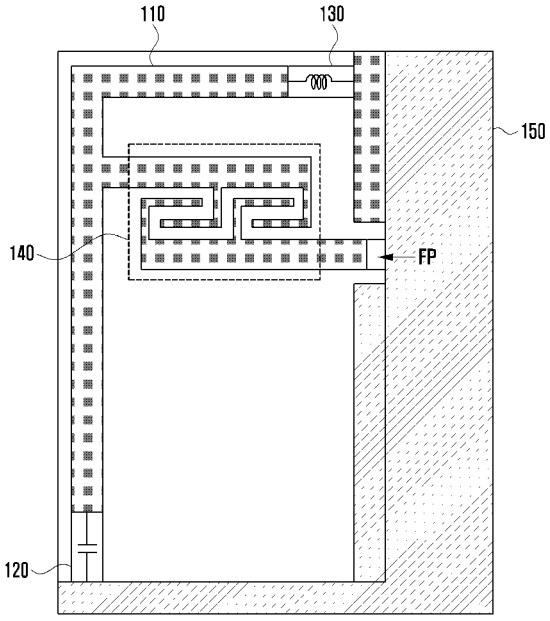
(Continued)

Primary Examiner — Nguyen T Vo
(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

(57) **ABSTRACT**

An antenna apparatus for a mobile terminal is provided. The antenna apparatus includes an antenna pattern, a first electric circuit and a second electric circuit respectively connected between both ends of the antenna pattern and a system ground, and a third electric circuit disposed between the antenna pattern and a feeding line, wherein the first electric circuit and the second electric circuit extend electrical wavelengths of the antenna pattern and the third electric circuit increases input impedance matching.

17 Claims, 13 Drawing Sheets



US011031971B2

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

(10) **Patent No.: US 11,031,971 B2**
(45) **Date of Patent: *Jun. 8, 2021**

(54) **ADAPTIVE ANTENNA AND RADIO**

(71) Applicant: **Microsoft Technology Licensing, LLC**, Redmond, WA (US)

(72) Inventors: **Nahal Niakan**, Issaquah, WA (US); **Sean Russell Mercer**, Issaquah, WA (US)

(73) Assignee: **Microsoft Technology Licensing, LLC**, Redmond, WA (US)

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

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **16/887,151**

(22) Filed: **May 29, 2020**

(65) **Prior Publication Data**

US 2020/0336167 A1 Oct. 22, 2020

Related U.S. Application Data

(63) Continuation of application No. 16/003,574, filed on Jun. 8, 2018, now Pat. No. 10,707,914.

(51) **Int. Cl.**
H04B 1/50 (2006.01)
H04B 17/318 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H04B 1/50*** (2013.01); ***H04B 1/1081*** (2013.01); ***H04B 17/318*** (2015.01); ***H04B 17/336*** (2015.01); ***H04W 72/082*** (2013.01)

(58) **Field of Classification Search**
CPC H04B 1/50; H04B 17/318; H04B 17/336; H04B 1/1081; H04B 17/20; H04W 72/082; H04W 16/14
See application file for complete search history.

(56) **References Cited**

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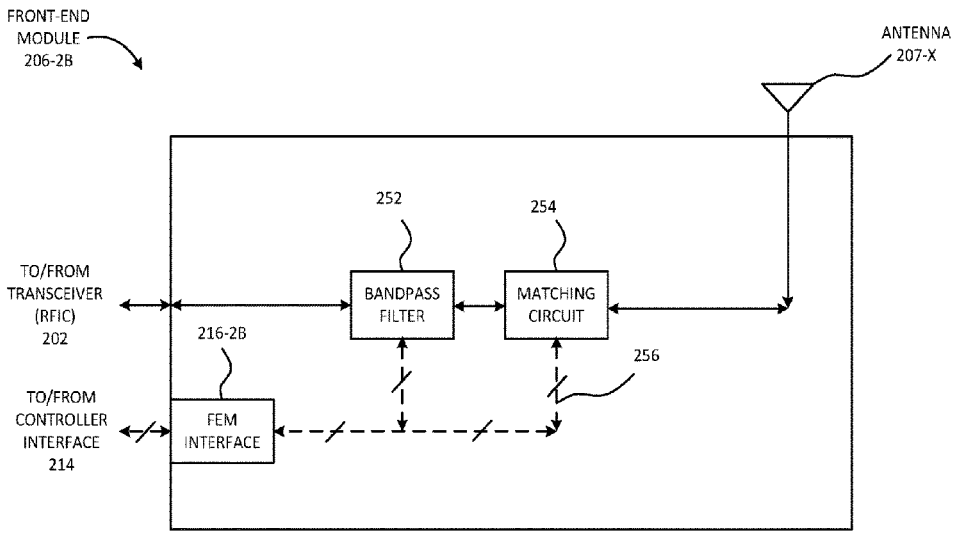
Primary Examiner — Nizar N Sivji
(74) *Attorney, Agent, or Firm* — Holzer Patel Drennan

(57) **ABSTRACT**

A method and system for selecting a sub-band in a television white space frequency band may include configuring an antenna matching circuit based on the selected sub-band and configuring a bandpass filter based on the selected sub-band. The method may include receiving a first signal through a radio-frequency path including the antenna matching circuit and not including the bandpass filter, measuring a parameter of received first signal, and determining whether the selected sub-band is usable based on the measured parameter of the received first signal. The method may include receiving a second signal through radio-frequency path including the antenna matching circuit and the bandpass filter, measuring a parameter of the received second signal, and determining whether the selected sub-band is usable based on the measured parameter of the received second signal.

20 Claims, 64 Drawing Sheets



US011031987B2

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

(10) **Patent No.: US 11,031,987 B2**
(45) **Date of Patent: Jun. 8, 2021**

(54) **QUASI-LINEAR ANTENNA PLACEMENT IN MILLIMETER WAVE SYSTEMS**

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

(72) Inventors: **Vasanthan Raghavan**, West Windsor Township, NJ (US); **Jung Ho Ryu**, Fort Lee, NJ (US); **Junyi Li**, Chester, NJ (US)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 84 days.

(21) Appl. No.: **16/583,709**

(22) Filed: **Sep. 26, 2019**

(65) **Prior Publication Data**

US 2020/0106508 A1 Apr. 2, 2020

Related U.S. Application Data

(60) Provisional application No. 62/738,939, filed on Sep. 28, 2018.

(51) **Int. Cl.**

H04W 4/00	(2018.01)
H04B 7/06	(2006.01)
H01P 1/18	(2006.01)
H01Q 21/06	(2006.01)

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

CPC ***H04B 7/0695*** (2013.01); ***H01P 1/18*** (2013.01); ***H01Q 21/065*** (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

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Partial International Search Report—PCT/US2019/053503—ISA/EPO—dated Dec. 2, 2019.

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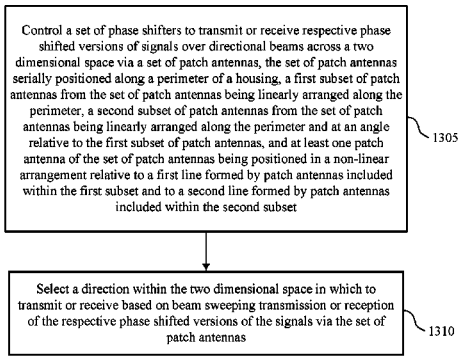
Primary Examiner — Phuongchau Ba Nguyen

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

(57) **ABSTRACT**

Methods, systems, and devices for wireless communications are described. A user equipment (UE) may include a set of patch antennas in a quasi-linear arrangement along a top linear edge and one or more side linear edges of the UE in addition to a curved part between the two linear edges. For example, a first subset of the patch antennas may be linearly arranged on a first edge along the UE (e.g., the top of the UE), a second subset of the patch antennas may be linearly arranged along a second edge of the UE that is at an angle relative to the first edge (e.g., a side of the UE), and at least one patch antenna may be non-linearly arranged (e.g., quasi-linearly) on a curved line formed between the first subset of the patch antennas and the second subset of the patch antennas.

29 Claims, 16 Drawing Sheets



US011038254B2

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

(10) **Patent No.: US 11,038,254 B2**
(45) **Date of Patent: Jun. 15, 2021**

(54) **MOBILE DEVICE**

(71) Applicant: **Acer Incorporated**, New Taipei (TW)

(72) Inventors: **Kun-Sheng Chang**, New Taipei (TW); **Ching-Chi Lin**, New Taipei (TW)

(73) Assignee: **ACER INCORPORATED**, 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 0 days.

(21) Appl. No.: **16/577,061**

(22) Filed: **Sep. 20, 2019**

(65) **Prior Publication Data**

US 2021/0044000 A1 Feb. 11, 2021

(30) **Foreign Application Priority Data**

Aug. 6, 2019 (TW) 108127855

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/30 (2015.01)
H01Q 1/38 (2006.01)

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

(58) **Field of Classification Search**
CPC .. H01Q 1/24; H01Q 5/30; H01Q 1/38; H01Q 5/385; H01Q 5/35
USPC 343/702
See application file for complete search history.

(56) **References Cited**

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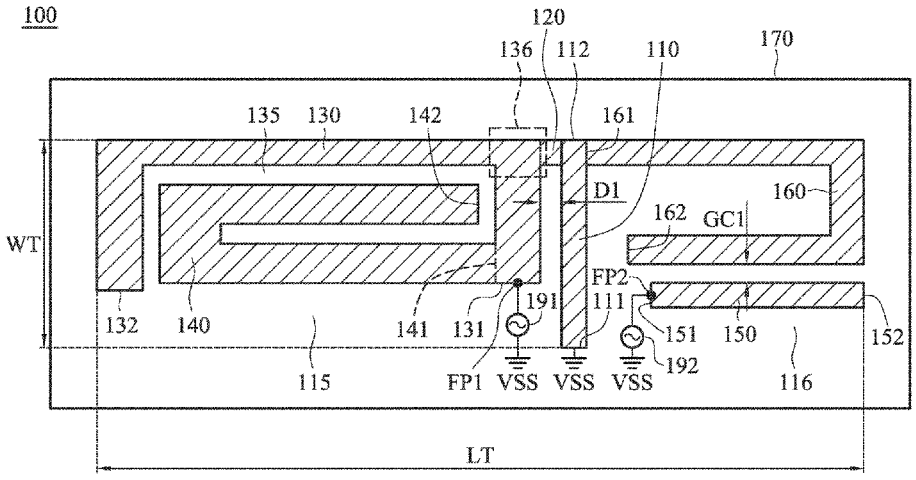
Primary Examiner — Dimary S Lopez Cruz
Assistant Examiner — Yonchan J Kim
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

A mobile device includes a common ground element, a connection element, a first radiation element, a second radiation element, a third radiation element, a fourth radiation element, and a dielectric substrate. The first radiation element has a first feeding point. The first radiation element is coupled through the connection element to the common ground element. The second radiation element is coupled to the first feeding point. The second radiation element is at least partially surrounded by the first radiation element. The third radiation element has a second feeding point. The fourth radiation element is adjacent to the third radiation element. The fourth radiation element is coupled to the common ground element. An antenna structure disposed on the dielectric substrate is formed by the common ground element, the connection element, the first radiation element,

(Continued)



US011038255B2

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

(10) **Patent No.: US 11,038,255 B2**
(45) **Date of Patent: *Jun. 15, 2021**

(54) **MOBILE TERMINAL**

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

(72) Inventors: **Dongjin Kim**, Seoul (KR); **Yunmo Kang**, Seoul (KR); **Youngbae Kwon**, Seoul (KR); **Yeomin Youn**, 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 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **16/870,237**

(22) Filed: **May 8, 2020**

(65) **Prior Publication Data**

US 2020/0274228 A1 Aug. 27, 2020

Related U.S. Application Data

(63) Continuation of application No. 16/530,760, filed on Aug. 2, 2019, now Pat. No. 10,693,214, which is a (Continued)

(30) **Foreign Application Priority Data**

May 3, 2018 (KR) 10-2018-0051313

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

(52) **U.S. Cl.**
CPC ***H01Q 1/242*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 9/42*** (2013.01); ***H01Q 13/10*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/242; H01Q 21/28; H01Q 1/243; H01Q 9/42; H01Q 13/10; H01Q 21/30;
(Continued)

(56) **References Cited**

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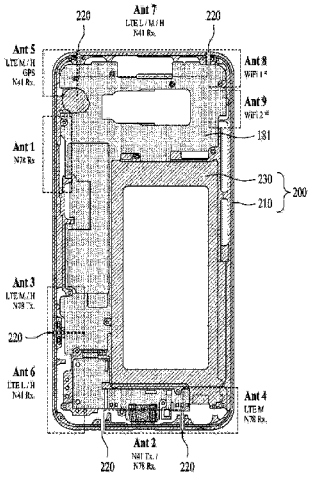
(Continued)

Primary Examiner — Ayodeji O Ayotunde
(74) *Attorney, Agent, or Firm* — Lee, Hong, Degerman, Kang & Waimey

(57) **ABSTRACT**

A mobile terminal is provided including a display unit; a middle frame including a supporting unit that supports a rear surface of the display unit with a side portion around the supporting portion; a main board at a rear surface of the middle frame including a ground; a first wireless communication unit in the main board to transceive a first signal; a second wireless communication unit in the main board to transceive a second signal; and a rear case covering a rear surface of the main board, where the side portion includes a plurality of conductive members with ends divided into slits and the plurality of the conductive members includes a common antenna electrically connectable with the first and second wireless communication units to receive the first and second signals such that the mobile terminal receives dif-
(Continued)



US011038256B2

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

(10) **Patent No.: US 11,038,256 B2**
(45) **Date of Patent: Jun. 15, 2021**

(54) **ANTENNA STRUCTURE AND WIRELESS COMMUNICATION DEVICE USING SAME**

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

(72) Inventors: **Cheng-Han Lee**, New Taipei (TW); **Yi-Wen Hsu**, New Taipei (TW); **Wei-Xuan Ye**, 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 980 days.

(21) Appl. No.: **15/647,280**

(22) Filed: **Jul. 12, 2017**

(65) **Prior Publication Data**

US 2018/0026344 A1 Jan. 25, 2018

Related U.S. Application Data

(60) Provisional application No. 62/364,303, filed on Jul. 19, 2016.

(30) **Foreign Application Priority Data**

Jun. 29, 2017 (CN) 201710518319.7

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

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/2291*** (2013.01); ***H01Q 1/521*** (2013.01); ***H01Q 1/528*** (2013.01); ***H01Q 5/371*** (2015.01); ***H01Q 5/50*** (2015.01); ***H01Q 9/145*** (2013.01); ***H01Q 9/42*** (2013.01); ***H01Q 21/28*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243–245; H01Q 5/321; H01Q 5/371; H01Q 1/52
See application file for complete search history.

(56) **References Cited**

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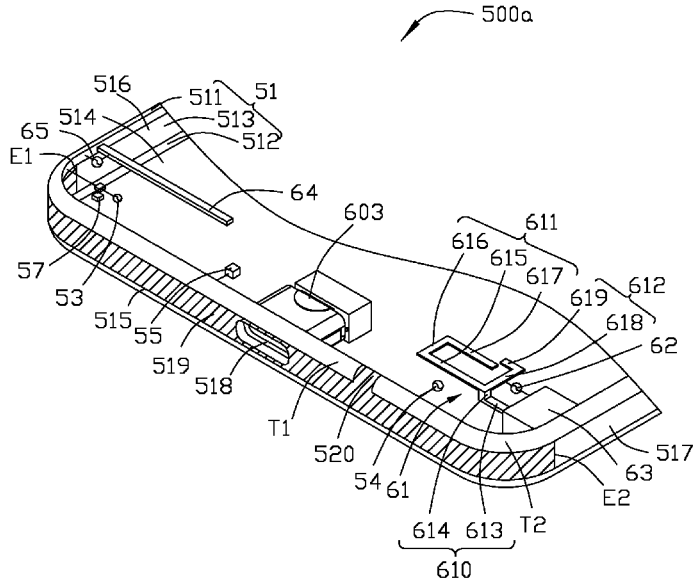
Primary Examiner — Graham P Smith
Assistant Examiner — Amal Patel
(74) *Attorney, Agent, or Firm* — ScienBiziP, P.C.

(57) **ABSTRACT**

An antenna structure includes a metal housing, a first radiator, and an isolating portion. The metal housing includes a front frame, a backboard, and a side frame. The side frame is positioned between the front frame and the backboard. The side frame defines a slot and the front frame defines a gap. The gap communicates with the slot and extends across the front frame. The metal housing is divided into at least a long portion and a short portion by the slot and the gap. The first radiator is positioned adjacent to the short portion. The isolating portion is connected to the first radiator to improve isolation between the short portion and the first radiator.

30 Claims, 83 Drawing Sheets



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(54) **COMMUNICATION DEVICE**

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H01Q 5/328	(2015.01)
H01Q 9/04	(2006.01)
H01Q 1/48	(2006.01)

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

CPC ***H01Q 5/328*** (2015.01); ***H01Q 1/48*** (2013.01); ***H01Q 9/045*** (2013.01); ***H01Q 9/0421*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 5/328; H01Q 1/48; H01Q 9/045; H01Q 9/0421; H01Q 1/243

See application file for complete search history.

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(57) **ABSTRACT**

A communication device includes a ground metal element and an antenna element. The antenna element includes a first metal element, a second metal element, a third metal element, a first capacitive element, a second capacitive element, an inductive element, and a signal feeding source. A first connection point of the first metal element is coupled through the first capacitive element to the third metal element. A second connection point of the first metal element is coupled through the second capacitive element to the ground metal element. A third connection point of the second metal element is coupled through the inductive element to the third metal element. A shorting end of the third metal element is coupled to the ground metal element. The signal feeding source is coupled between the first metal element and the third metal element or the ground metal element.

10 Claims, 6 Drawing Sheets