US010930998B2

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

(10) **Patent No.: US 10,930,998 B2**
(45) **Date of Patent: Feb. 23, 2021**

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

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

(72) Inventors: **Yongli Chen**, Shenzhen (CN); **Zhongyue Wang**, Shenzhen (CN); **Yue Liang**, Shenzhen (CN)

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

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

(21) Appl. No.: **16/699,155**

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

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Dec. 24, 2018 (CN) 201811581112.5

(51) **Int. Cl.**

H04B 1/40	(2015.01)
H04M 1/02	(2006.01)
H01Q 1/24	(2006.01)
H01Q 5/314	(2015.01)
H04W 88/06	(2009.01)

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

CPC ***H01Q 1/243*** (2013.01); ***H01Q 5/314*** (2015.01); *H04W 88/06* (2013.01)

(58) **Field of Classification Search**

CPC H04B 7/024; H04B 7/0413; H04B 7/0452; H04B 1/40; H04B 1/03; H04B 1/08; H04M 1/02; H04M 1/03; H01Q 1/243; H01Q 5/314; H04W 88/06

See application file for complete search history.

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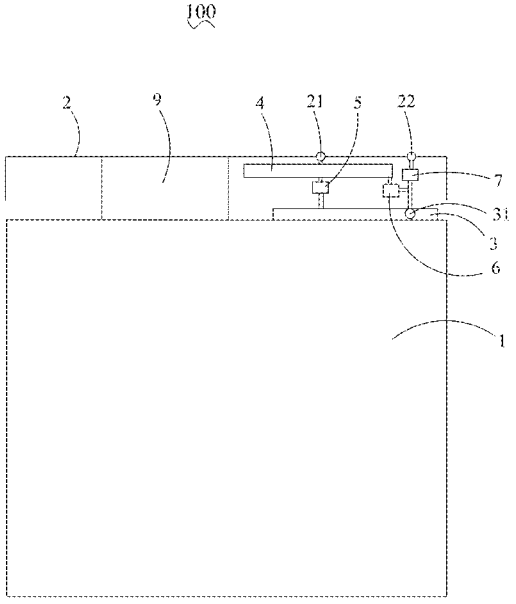
Primary Examiner — Andrew Wendell

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

(57) **ABSTRACT**

An antenna system is provided. The antenna system has a system grounding unit, a metal frame and a main board. The metal frame is spaced apart from the system grounding unit to form a clearance zone. The metal frame is a first radiator. The antenna system further has a second radiator, a switch, a capacitor and a main matching circuit. The second radiator is located in the clearance zone. The main board has a feeding point. The metal frame has a first connecting part and a second connecting part. An end of the capacitor is connected to the second radiator, and another end of the capacitor is connected to the main matching circuit. The second radiator is connected to the main board via the switch.

7 Claims, 3 Drawing Sheets



US010930999B2

(12) **United States Patent**
Shen

(10) **Patent No.: US 10,930,999 B2**
(45) **Date of Patent: Feb. 23, 2021**

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

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

(72) Inventor: **Yachuan Shen**, Shenzhen (CN)

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

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

(21) Appl. No.: **16/702,501**

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

(65) **Prior Publication Data**

US 2020/0212540 A1 Jul. 2, 2020

(30) **Foreign Application Priority Data**

Dec. 27, 2018 (CN) 201822223712.6

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/328 (2015.01)
H01Q 1/38 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 5/328*** (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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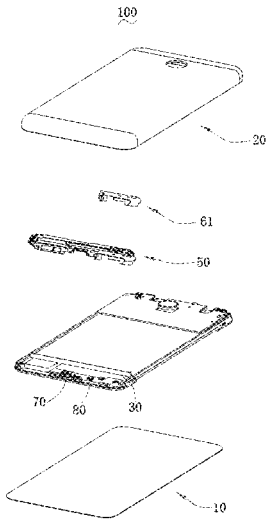
Primary Examiner — Hsinchun Liao
(74) *Attorney, Agent, or Firm* — W&G Law Group LLP

(57) **ABSTRACT**

The present invention provides an antenna module and a mobile terminal. The mobile terminal comprises a back cover, a main board, a plastic back shell, and a USB interface, the antenna module comprises a radiator structured on a surface of the plastic back shell facing the back cover and a feeding point and a grounding point disposed on the main board, the antenna module further comprises a matching network, a first tuning switch, a second tuning switch and a third tuning switch, the surface of the plastic back shell facing the back cover includes a first structuring region for structuring the radiator and a second region other than the first structuring region, the radiator completely covers the first structuring region, and the orthographic projections of the radiator and the USB interface on the main board do not overlap each other.

9 Claims, 6 Drawing Sheets



US010931001B2

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

(10) **Patent No.: US 10,931,001 B2**
(45) **Date of Patent: Feb. 23, 2021**

(54) **ELECTRONIC APPARATUS AND SMARTPHONE**

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

(72) Inventors: **Ning Zhao**, Dongguan (CN); **Tianping Liang**, Dongguan (CN); **Yantao Li**, Dongguan (CN)

(73) Assignee: **GUANGDONG OPPO MOBILE TELECOMMUNICATIONS CORP., 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.: **16/387,067**

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

(65) **Prior Publication Data**

US 2019/0334226 A1 Oct. 31, 2019

(30) **Foreign Application Priority Data**

Apr. 28, 2018 (CN) 2018 1 0402824

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/307 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 1/244*** (2013.01); ***H01Q 5/307*** (2015.01); ***H04B 7/0404*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/10; H01Q 1/22; H01Q 1/243; H01Q 1/244; H01Q 5/307; H01Q 21/28;
(Continued)

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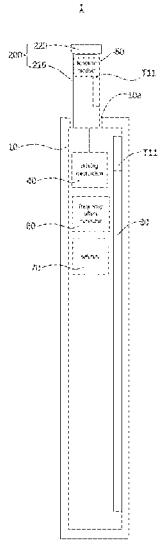
Primary Examiner — Seokjin Kim
(74) *Attorney, Agent, or Firm* — Ladas & Parry, LLP

(57) **ABSTRACT**

The present disclosure provides an electronic apparatus including a main body, a sliding seat, a middle frame and four first antenna radiators. The main body may have a receiving space defined therein. An opening may be formed in the main body to communicate with the receiving space such that the receiving space can be communicated outside via the opening. The sliding seat may be received in the receiving space and movably connected to the main body such that the sliding seat can have a capability of being moved out from or retracted into the receiving space via the opening. The middle frame may be received in the receiving space. Four first antenna radiators may be disposed on the middle frame and the sliding seat respectively. The four first antenna radiators may have a capability of operating at a first frequency band.

19 Claims, 7 Drawing Sheets



US010931006B2

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

(10) **Patent No.: US 10,931,006 B2**
(45) **Date of Patent: Feb. 23, 2021**

(54) **CHIP ANTENNA**

(71) Applicants: **KABUSHIKI KAISHA TOSHIBA**, Tokyo (JP); **TOSHIBA ELECTRONIC DEVICES & STORAGE CORPORATION**, Tokyo (JP)

(72) Inventors: **Jia Liu**, Yokohama Kanagawa (JP); **Hiroshi Ota**, Misato Saitama (JP)

(73) Assignees: **KABUSHIKI KAISHA TOSHIBA**, Tokyo (JP); **TOSHIBA ELECTRONIC DEVICES & STORAGE 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 21 days.

(21) Appl. No.: **16/289,333**

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

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Jun. 7, 2018 (JP) JP2018-109874

(51) **Int. Cl.**

H01L 35/00	(2006.01)
H01Q 1/36	(2006.01)
H01Q 3/44	(2006.01)
H01Q 1/38	(2006.01)
H01Q 9/04	(2006.01)
H01Q 1/52	(2006.01)
H01Q 1/24	(2006.01)

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

CPC ***H01Q 1/38*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/526*** (2013.01); ***H01Q 9/0407*** (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

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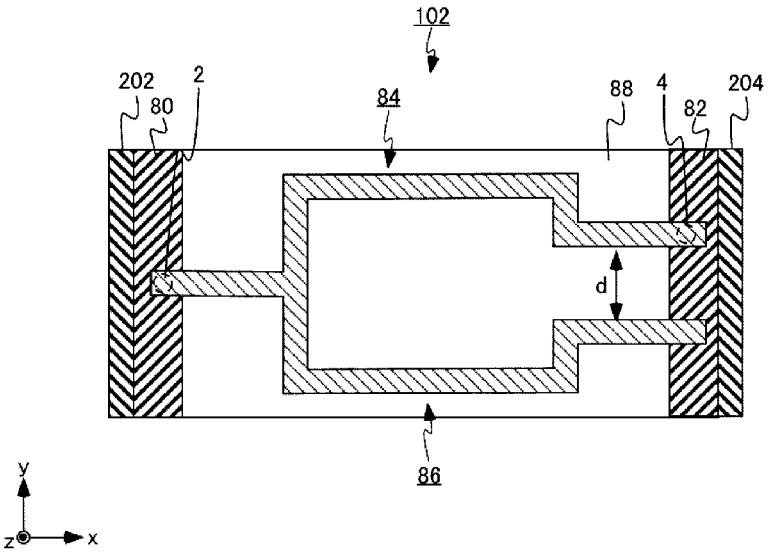
Primary Examiner — Anh Q Tran

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

(57) **ABSTRACT**

According to one embodiment, a chip antenna comprises a first electrode, a second electrode spaced from the first electrode, a first antenna conductor connected to the first electrode and the second electrode, and a second antenna conductor connected to at least one of the first electrode and the second electrode. An insulator surrounds the first electrode, the second electrode, the first antenna conductor, and the second antenna conductor.

13 Claims, 8 Drawing Sheets



US010931008B2

(12) **United States Patent**
Qiu

(10) **Patent No.: US 10,931,008 B2**
(45) **Date of Patent: Feb. 23, 2021**

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

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

(72) Inventor: **Xiaojun Qiu**, 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 91 days.

(21) Appl. No.: **16/524,074**

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

(65) **Prior Publication Data**

US 2020/0058993 A1 Feb. 20, 2020

(30) **Foreign Application Priority Data**

Aug. 20, 2018 (CN) 201810946067.2

(51) **Int. Cl.**

H01Q 5/30	(2015.01)
H01Q 5/20	(2015.01)
H01Q 1/52	(2006.01)
H01Q 1/24	(2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/523*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 5/20*** (2015.01); ***H01Q 5/30*** (2015.01)

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

(56) **References Cited**

U.S. PATENT DOCUMENTS

2018/0034148 A1* 2/2018 Nam H01Q 1/243

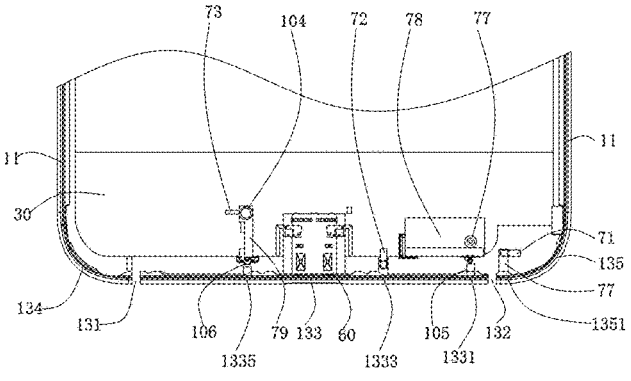
* cited by examiner

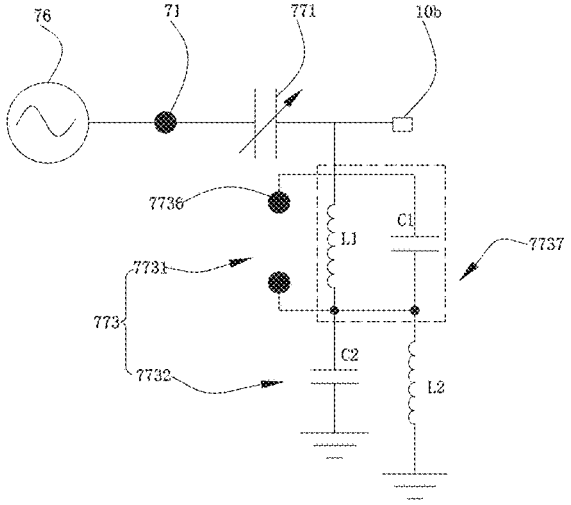
Primary Examiner — Henry Luong
(74) *Attorney, Agent, or Firm* — W&G Law Group LLP

(57) **ABSTRACT**

An antenna module including a first antenna and a second antenna close to the first antenna. The second antenna includes an isolation circuit and a second tuning switch controlling an access state of the isolation circuit. The second tuning switch includes two modes. When the second tuning switch is in a first mode, the isolation circuit accesses to a feeding network of the second antenna. When the second tuning switch is in a second mode, the isolation circuit does not access to the feeding network of the second antenna. Isolation of the first antenna and the second antenna in a preset band in the first mode is superior to that in the second mode.

10 Claims, 11 Drawing Sheets





US010931017B2

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

(10) **Patent No.: US 10,931,017 B2**
(45) **Date of Patent: Feb. 23, 2021**

(54) **ANTENNA**

(71) Applicant: **AGC Inc.**, Chiyoda-ku (JP)

(72) Inventors: **Ryuta Sonoda**, Chiyoda-ku (JP); **Toshiki Sayama**, Chiyoda-ku (JP); **Koji Ikawa**, Chiyoda-ku (JP)

(73) Assignee: **AGC Inc.**, Chiyoda-ku (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.: **16/157,539**

(22) Filed: **Oct. 11, 2018**

(65) **Prior Publication Data**

US 2019/0044239 A1 Feb. 7, 2019

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2017/015201, filed on Apr. 13, 2017.

(30) **Foreign Application Priority Data**

Apr. 15, 2016 (JP) JP2016-081706

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 1/38 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 9/0485*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/38*** (2013.01); ***H01Q 1/48*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 9/0485; H01Q 1/48; H01Q 1/38; H01Q 9/0414; H01Q 7/00; H01Q 1/243; H01Q 19/26; H01Q 9/30
See application file for complete search history.

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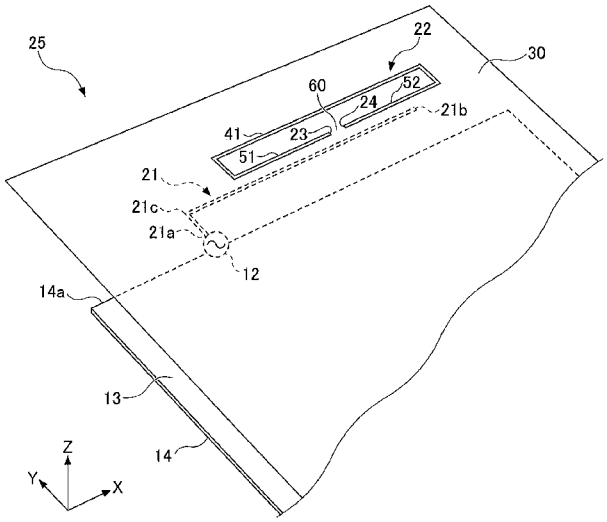
Primary Examiner — Hai V Tran
Assistant Examiner — Michael M Bouizza
(74) *Attorney, Agent, or Firm* — Oblon, McClelland, Maier & Neustadt, L.L.P.

(57) **ABSTRACT**

An antenna includes a ground plane; a first resonator connected to a feeding point with reference to the ground plane; and a second resonator that is fed power by the first resonator according to an electromagnetic field coupling with no contact. The second resonator includes a first conductor part, and a second conductor part capacitively-coupled to the first conductor part through a gap. A dielectric loss tangent of a substrate part, on which the second resonator is formed, is greater than zero and less than or equal to 0.01.

20 Claims, 15 Drawing Sheets



US010931034B2

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

(10) **Patent No.: US 10,931,034 B2**
(45) **Date of Patent: Feb. 23, 2021**

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

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

(72) Inventors: **Yufei Zhu**, Shenzhen (CN); **Mingjun Hang**, Shenzhen (CN); **Dawei Shi**, Shenzhen (CN); **Kai Dong**, 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 32 days.

(21) Appl. No.: **16/524,054**

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

(65) **Prior Publication Data**

US 2020/0044364 A1 Feb. 6, 2020

(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**

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

(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

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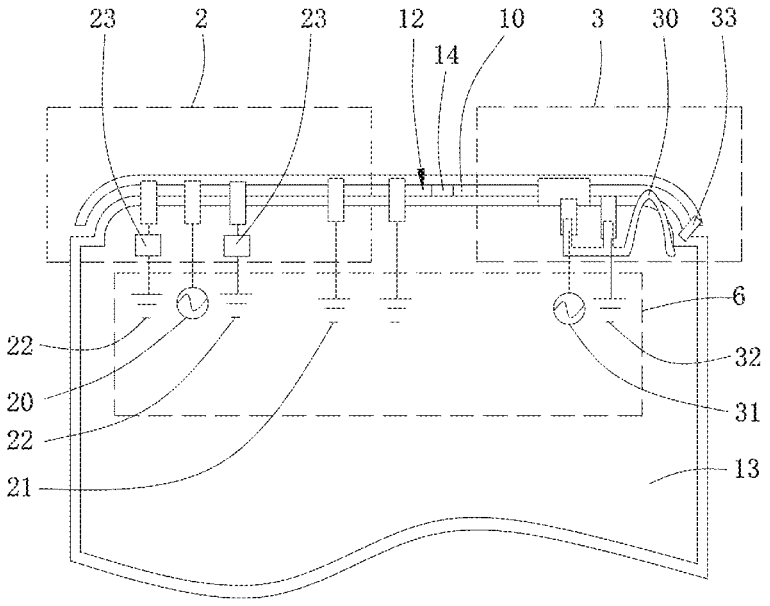
Primary Examiner — Crystal L Hammond

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

(57) **ABSTRACT**

A mobile communication device is provided. The mobile communication device includes: a metal housing, a diversity antenna unit, an integrated antenna unit, a first main antenna unit, a second main antenna unit, and a main board. Compared with the related art, with the antenna system provided by the present disclosure, the diversity antenna unit, the integrated antenna unit, the first main antenna unit, and the second main antenna unit constitute 4×4 MIMO of an LTE Band3 and an LTE Band7, so that performance of the medium frequency and high frequency is improved; and the integrated antenna unit and the second main antenna unit constitute 2×2 MIMO of the Wi-Fi5G, so that performance of the Wi-Fi5G is improved.

9 Claims, 10 Drawing Sheets



US010938088B2

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

(10) **Patent No.: US 10,938,088 B2**
(45) **Date of Patent: Mar. 2, 2021**

(54) **BASE COVERS ALIGNED FOR SLOT ANTENNAS ON CONVERTIBLE COMPUTING DEVICES**

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

(72) Inventors: **Kuan-Jung Hung**, Taipei (TW); **Shih Huang Wu**, Houston, TX (US)

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

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

(21) Appl. No.: **16/481,495**

(22) PCT Filed: **Jul. 7, 2017**

(86) PCT No.: **PCT/US2017/041235**
§ 371 (c)(1),
(2) Date: **Jul. 29, 2019**

(87) PCT Pub. No.: **WO2019/009924**
PCT Pub. Date: **Jan. 10, 2019**

(65) **Prior Publication Data**

US 2020/0127365 A1 Apr. 23, 2020

(51) **Int. Cl.**
H01Q 1/22 (2006.01)
G06F 1/16 (2006.01)
H01Q 13/10 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/2266*** (2013.01); ***G06F 1/1618*** (2013.01); ***H01Q 13/106*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/2266; H01Q 1/2291; H01Q 13/10; H01Q 13/106; G06F 1/1618; G06F 1/1698; G06F 1/1616; G06F 1/162; G06F 1/1643; G06F 1/1679; G06F 1/1681; H04M 1/026; H04M 1/0202; H04M 1/0206; H04M 1/0214; H04M 1/0225; H04M 1/0227; H04M 1/0231; H04M 1/0233
See application file for complete search history.

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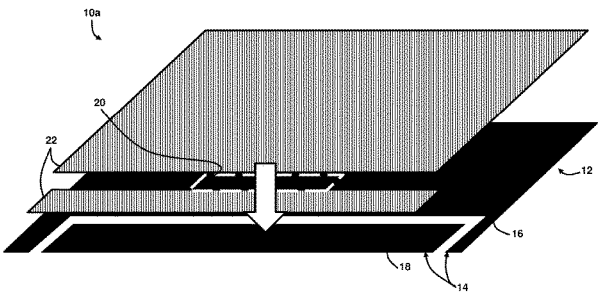
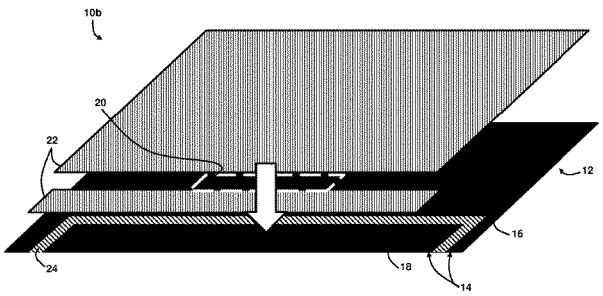
Primary Examiner — Haissa Philogene
(74) *Attorney, Agent, or Firm* — Rahman LLC

(57) **ABSTRACT**

An example base cover for a lower housing of a convertible computing device includes a first metallic structure positioned in the lower housing, and a second metallic structure electrically isolated from the first metallic structure. The second metallic structure is positioned in the lower housing and directly below an antenna slot defined in an upper housing of the convertible computing device when the upper housing is positioned over and parallel to the lower housing.

15 Claims, 10 Drawing Sheets





US010938092B2

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

(10) **Patent No.: US 10,938,092 B2**
(45) **Date of Patent: Mar. 2, 2021**

(54) **ANTENNA ASSEMBLY**

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

(72) Inventors: **Nanbo Jin**, San Jose, CA (US); **Devon A. Monaco**, San Jose, CA (US); **Donald J. Parr**, Mountain View, CA (US); **Erica J. Tong**, Pacifica, CA (US); **Han Wang**, 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 31 days.

(21) Appl. No.: **16/297,395**

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

(65) **Prior Publication Data**

US 2020/0083592 A1 Mar. 12, 2020

Related U.S. Application Data

(60) Provisional application No. 62/730,485, filed on Sep. 12, 2018.

(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H05K 1/02	(2006.01)
H05K 1/03	(2006.01)
H05K 1/18	(2006.01)
H01Q 1/22	(2006.01)

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

CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/2283*** (2013.01); ***H05K 1/0219*** (2013.01); ***H05K 1/0298*** (2013.01); ***H05K 1/0393*** (2013.01); ***H05K 1/189*** (2013.01); *H05K 2201/0715* (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/38; H01Q 1/40; H01Q 1/243; H01Q 1/2283; H01Q 13/10

USPC 343/702, 841

See application file for complete search history.

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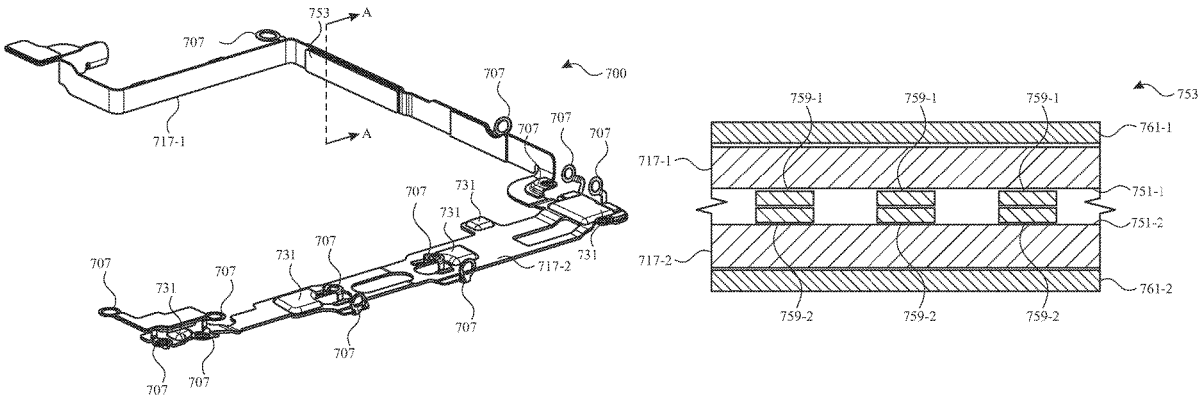
Primary Examiner — Tung X Le

(74) *Attorney, Agent, or Firm* — Morgan, Lewis & Bockius LLP

(57) **ABSTRACT**

A disclosed antenna assembly includes a first flexible circuit having a first signal line, at least one first shielding layer, and a first attachment region. The first attachment region includes a first signal pad and first shielding pads disposed around the first signal pad. The antenna assembly further includes a second flexible circuit having a second signal line, at least one second shielding layer, and a second attachment region. The second attachment region includes a second signal pad and second shielding pads disposed around the second signal pad. The first attachment region is attached to the second attachment region.

20 Claims, 13 Drawing Sheets



US010938097B2

(12) **United States Patent**
Hovmoller

(10) **Patent No.: US 10,938,097 B2**
(45) **Date of Patent: Mar. 2, 2021**

(54) **PCB ANTENNA**

(71) Applicant: **Axis AB**, Lund (SE)

(72) Inventor: **Henrik Hovmoller**, Holbaek (DK)

(73) Assignee: **Axis AB**, Lund (SE)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 68 days.

(21) Appl. No.: **15/629,415**

(22) Filed: **Jun. 21, 2017**

(65) **Prior Publication Data**

US 2017/0365919 A1 Dec. 21, 2017

(30) **Foreign Application Priority Data**

Jun. 21, 2016 (EP) 16175439

(51) **Int. Cl.**

H01Q 1/22	(2006.01)
H01Q 1/38	(2006.01)
H01Q 1/48	(2006.01)
H01Q 5/371	(2015.01)
H01Q 5/30	(2015.01)
H01Q 5/40	(2015.01)
H01Q 9/42	(2006.01)
H01Q 13/10	(2006.01)

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

CPC ***H01Q 1/38*** (2013.01); ***H01Q 1/22*** (2013.01); ***H01Q 1/2291*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 5/30*** (2015.01); ***H01Q 5/371*** (2015.01); ***H01Q 5/40*** (2015.01); ***H01Q 9/42*** (2013.01); ***H01Q 13/10*** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/22–1/48; H01Q 5/364–5/371; H01Q 5/30–5/40

USPC 343/702, 846

See application file for complete search history.

(56) **References Cited**

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(Continued)

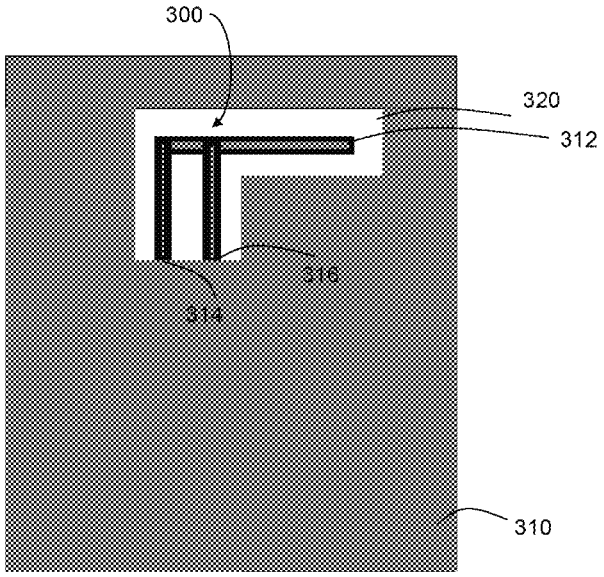
Primary Examiner — Hasan Z Islam

(74) *Attorney, Agent, or Firm* — Oblon, McClelland, Maier & Neustadt, L.L.P.

(57) **ABSTRACT**

An antenna (**200**) comprises an antenna body (**212**). The antenna body is integrally formed as a part of a PCB (**210**) and the antenna body is enclosed by metal. The antenna body may be enclosed by printed or plated metal on both top and bottom surfaces of the PCB and by edge plated metal along the circumference of the antenna body.

6 Claims, 4 Drawing Sheets



US010938100B2

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

(10) **Patent No.: US 10,938,100 B2**
(45) **Date of Patent: Mar. 2, 2021**

(54) **DUAL-FEED LOOP ANTENNA STRUCTURE AND ELECTRONIC DEVICE**

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

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

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 10 days.

(21) Appl. No.: **16/557,743**

(22) Filed: **Aug. 30, 2019**

(65) **Prior Publication Data**

US 2020/0083603 A1 Mar. 12, 2020

(30) **Foreign Application Priority Data**

Sep. 10, 2018 (TW) 107131659

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

(52) **U.S. Cl.**
CPC ***H01Q 1/521*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 5/335*** (2015.01); ***H01Q 5/35*** (2015.01); ***H01Q 7/00*** (2013.01); ***H01Q 9/045*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/521; H01Q 1/48; H01Q 1/523; H01Q 1/526; H01Q 1/38; H01Q 1/50; H01Q 1/22; H01Q 5/335; H01Q 5/35; H01Q 5/371; H01Q 5/10; H01Q 5/20; H01Q 5/40; H01Q 7/00; H01Q 9/045; H01Q 9/06
See application file for complete search history.

(56) **References Cited**

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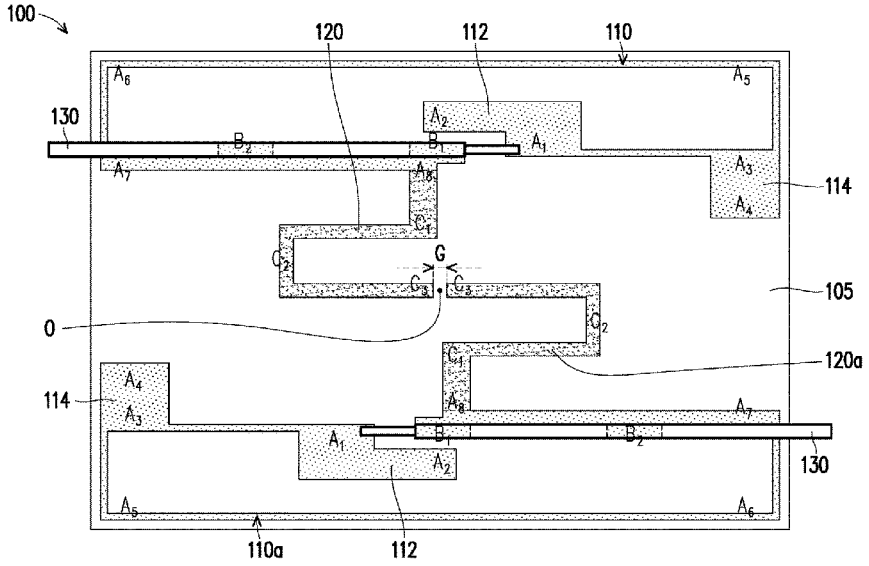
Primary Examiner — Raymond R Chai
(74) *Attorney, Agent, or Firm* — J.C. Patents

(57) **ABSTRACT**

A dual-feed loop antenna structure adapted to be disposed on a substrate includes two loop antennas and two open-loop grounding radiators. Each of the loop antennas is used for resonating at a first frequency band and a second frequency band and includes a feed-in end and a ground segment. The two open-loop grounding radiators are located between the two loop antennas. Each of the open-loop grounding radiators extends from the ground segment of the corresponding loop antenna. A coupling gap is formed between the two open-loop grounding radiators. One of the loop antennas and the open-loop grounding radiator connected thereto completely overlap the other loop antenna and the other open-loop grounding radiator connected thereto after being mirrored and reversed. An electronic device is further provided.

15 Claims, 10 Drawing Sheets



US010938101B2

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

(10) **Patent No.: US 10,938,101 B2**
(45) **Date of Patent: Mar. 2, 2021**

(54) **ELECTRONIC DEVICE**

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

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

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

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

(21) Appl. No.: **16/595,141**

(22) Filed: **Oct. 7, 2019**

(65) **Prior Publication Data**

US 2020/0144712 A1 May 7, 2020

(30) **Foreign Application Priority Data**

Nov. 2, 2018 (TW) 107139068

(51) **Int. Cl.**

H01Q 1/52	(2006.01)
H01Q 1/22	(2006.01)
H01Q 5/30	(2015.01)
H01Q 1/24	(2006.01)
H04M 1/03	(2006.01)

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

CPC ***H01Q 1/521*** (2013.01); ***H01Q 1/2291*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/526*** (2013.01); ***H01Q 5/30*** (2015.01); ***H04M 1/03*** (2013.01)

(58) **Field of Classification Search**

CPC .. H01Q 1/52; H01Q 5/30; H01Q 1/22; H01Q 1/24

USPC 343/841

See application file for complete search history.

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TW	201806245	2/2018

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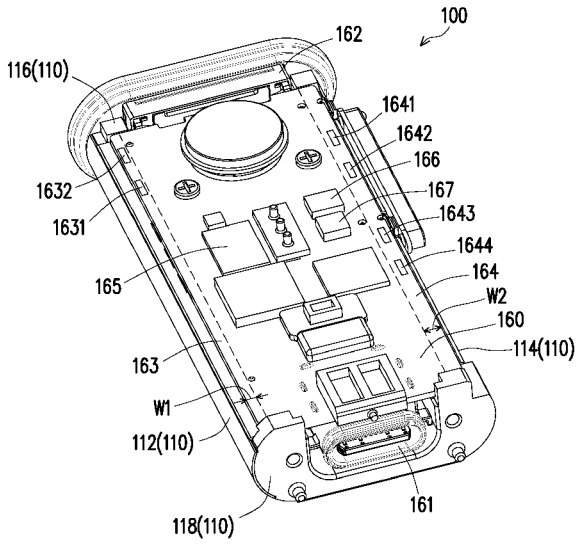
Primary Examiner — Andrea Lindgren Baltzell
(74) *Attorney, Agent, or Firm* — J.C. Patents

(57) **ABSTRACT**

The disclosure provides an electronic device including a carrier, a first antenna, a second antenna, a third antenna, and a shielding structure. The carrier includes a first side and a second side opposite to each other, and a third side and a fourth side opposite to each other. The first antenna is disposed at the first side of the carrier. The second antenna and the third antenna are disposed at the second side of the carrier. The first, second, and third antennas are used for transmitting and receiving wireless signals at first, second, and third frequency bands, respectively. The shielding structure is disposed between the first antenna and the second antenna, and between the first antenna and the third antenna, so that the shielding structure shields interference signals between the first antenna and the second antenna, and interference signals between the first antenna and the third antenna.

13 Claims, 8 Drawing Sheets



US010938106B2

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

(10) **Patent No.: US 10,938,106 B2**
(45) **Date of Patent: Mar. 2, 2021**

(54) **ELECTRONIC APPARATUS**

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

(72) Inventors: **Yasuharu Matsuoka**, Osaka (JP); **Kazuya Nakano**, Osaka (JP); **Kenji Nishikawa**, Hyogo (JP); **Keita Endo**, Osaka (JP); **Shintarou Tanaka**, Osaka (JP); **Ryo Yonezawa**, Kyoto (JP); **Kazuki Zusho**, 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.: **16/799,507**

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

(65) **Prior Publication Data**

US 2020/0194891 A1 Jun. 18, 2020

Related U.S. Application Data

(60) Division of application No. 15/820,228, filed on Nov. 21, 2017, which is a continuation of application No. PCT/JP2016/004512, filed on Oct. 7, 2016.

(30) **Foreign Application Priority Data**

Oct. 30, 2015 (JP) JP2015-214879

(51) **Int. Cl.**
H01Q 1/22 (2006.01)
H01Q 5/35 (2015.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 5/35*** (2015.01); ***H01Q 1/2266*** (2013.01); ***H01Q 1/2291*** (2013.01); ***H01Q 1/24*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/2266; H01Q 1/2291; H01Q 1/243; H01Q 5/35–5/378
See application file for complete search history.

(56) **References Cited**

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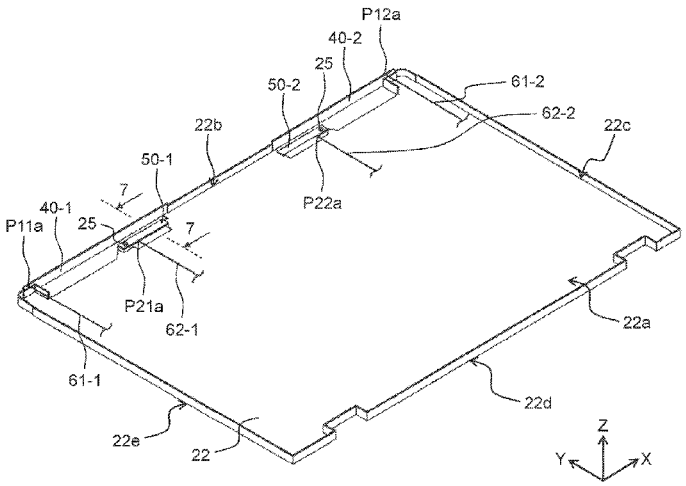
Primary Examiner — Hasan Z Islam
(74) *Attorney, Agent, or Firm* — Renner, Otto, Boisselle & Sklar, LLP

(57) **ABSTRACT**

An electronic apparatus includes: a first antenna board having a plate shape and extending with a first length; a second antenna board having a plate shape and extending with a second length; and a rectangular parallelepiped upper casing for accommodating the first antenna board and the second antenna board. The first antenna board and the second antenna board are arranged such that a longitudinal direction of the first antenna board and a longitudinal direction of the second antenna board are parallel to one side of one main surface of the rectangular parallelepiped upper casing. The first antenna board and the second antenna board are arranged parallel to each other.

12 Claims, 17 Drawing Sheets



US010939552B2

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

(10) **Patent No.: US 10,939,552 B2**
(45) **Date of Patent: Mar. 2, 2021**

(54) **ELECTRONIC DEVICE INCLUDING INTERPOSER**

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

(72) Inventors: **Jungsik Park**, Suwon-si (KR); **Soyoung Lee**, Gwacheon-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.: **16/887,585**

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

(65) **Prior Publication Data**

US 2020/0296833 A1 Sep. 17, 2020

Related U.S. Application Data

(63) Continuation of application No. 16/121,085, filed on Sep. 4, 2018, now Pat. No. 10,674,607.

(30) **Foreign Application Priority Data**

Sep. 12, 2017 (KR) 10-2017-0116517

(51) **Int. Cl.**
H05K 1/11 (2006.01)
H05K 1/14 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H05K 1/144*** (2013.01); ***G06F 1/1626*** (2013.01); ***G06F 1/1635*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H05K 1/144; H05K 1/116; H05K 2201/10378; H05K 1/0216;
(Continued)

(56) **References Cited**

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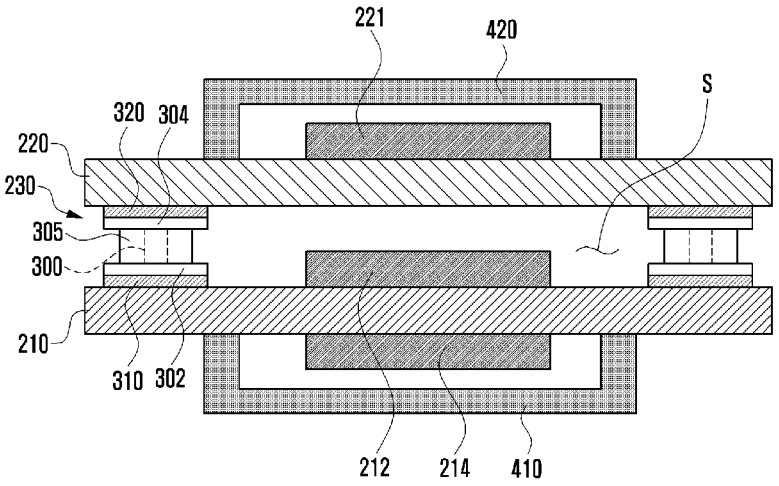
Primary Examiner — Yuriy Semenenko
(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

(57) **ABSTRACT**

An electronic device including an interposer is provided. The electronic device includes a first circuit board having a first connection terminal formed thereon, an application processor (AP) connected to the first connection terminal and deployed on the first circuit board, an interposer having a via formed therein and having a first surface attached to the first circuit board, the interposer at least partly surrounding at least a partial region of the first circuit board and a first end portion of the via being electrically connected to the first connection terminal, a second circuit board having a second connection terminal formed thereon and attached to a second surface of the interposer in an opposite direction to the first surface, the second connection terminal being electrically connected to a second end portion of the via and the second circuit board forming an inner space together with the first circuit board and the interposer, a communication processor (CP) connected to the second connection terminal and deployed on the second circuit board, and an antenna electrically connected to the CP.

10 Claims, 27 Drawing Sheets



US010944151B2

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

(10) **Patent No.: US 10,944,151 B2**
(45) **Date of Patent: Mar. 9, 2021**

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

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

(72) Inventors: **Wen-Chang Hsu**, New Taipei (TW); **Shu-Wei Jhang**, New Taipei (TW); **Jia-Hung Hsiao**, New Taipei (TW); **Tun-Yuan Tsou**, New Taipei (TW); **Tze-Hsuan Chang**, New Taipei (TW); **Yen-Jung Tseng**, New Taipei (TW); **Yi-Ting Chen**, New Taipei (TW); **Jung-Sheng Chih**, 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 299 days.

(21) Appl. No.: **15/881,864**

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

(65) **Prior Publication Data**

US 2018/0248250 A1 Aug. 30, 2018

Related U.S. Application Data

(60) Provisional application No. 62/462,941, filed on Feb. 24, 2017.

(30) **Foreign Application Priority Data**

Oct. 31, 2017 (CN) 201711049796.X

(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H04M 1/02	(2006.01)
H01Q 13/10	(2006.01)
H01Q 5/35	(2015.01)
H01Q 5/378	(2015.01)

(Continued)

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

CPC ***H01Q 1/243*** (2013.01); ***H01Q 5/35*** (2015.01); ***H01Q 5/371*** (2015.01); ***H01Q 5/378*** (2015.01);

(Continued)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 21/28; H01Q 9/42; H01Q 9/30; H01Q 5/371; H01Q 5/378;

(Continued)

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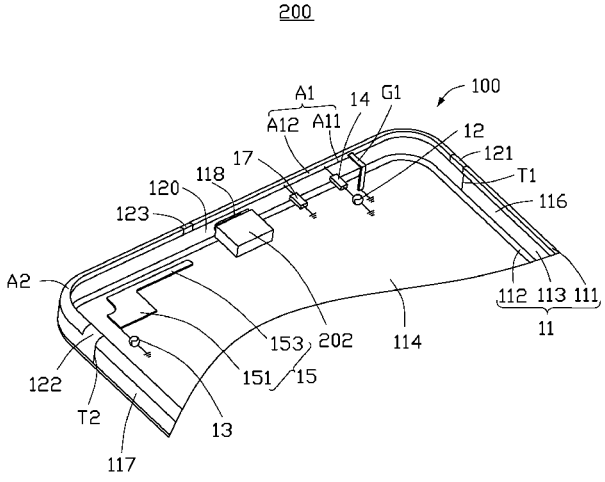
Primary Examiner — Dimary S Lopez Cruz
Assistant Examiner — Bamidele A Jegede
(74) *Attorney, Agent, or Firm* — ScienBiziP, P.C.

(57) **ABSTRACT**

An antenna structure includes a housing, a first feed source, a ground portion, a radiator, and a second feed source. The housing includes a front frame, a backboard, and a side frame. The side frame defines a slot. The front frame defines a first gap, a second gap, and a groove. A radiating portion and a coupling portion are divided from the housing by the slot, the first gap, the second gap, and the groove. The first feed source is electrically connected to the radiating portion. One end of the ground portion is electrically connected to the radiating portion and another end of the ground portion is grounded. The radiator is coupled with and apart from the coupling portion. The second feed source is electrically connected to the radiator and a current from the second feed source is coupled to the coupling portion through the radiator.

18 Claims, 8 Drawing Sheets



US010944152B2

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

(10) **Patent No.: US 10,944,152 B2**
(45) **Date of Patent: Mar. 9, 2021**

(54) **ANTENNA STRUCTURE**

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

(72) Inventors: **Jia-Hung Hsiao**, New Taipei (TW); **Shu-Wei Jhang**, New Taipei (TW); **Wen-Yuan Chen**, New Taipei (TW); **Chang-Hsin Ou**, New Taipei (TW); **Ming-Yu Chou**, New Taipei (TW); **Chia-Ming Liang**, New Taipei (TW); **Kuo-Lun Huang**, 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 31 days.

(21) Appl. No.: **16/545,223**

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

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Aug. 31, 2018 (CN) 201811010843.4

(51) **Int. Cl.**

H01Q 1/24	(2006.01)
H01Q 1/12	(2006.01)
H01Q 5/371	(2015.01)
H01Q 21/28	(2006.01)
H01Q 5/335	(2015.01)
H01Q 21/00	(2006.01)

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

CPC ***H01Q 1/243*** (2013.01); ***H01Q 1/1207*** (2013.01); ***H01Q 5/335*** (2015.01); ***H01Q 5/371*** (2015.01); ***H01Q 21/0006*** (2013.01); ***H01Q 21/28*** (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

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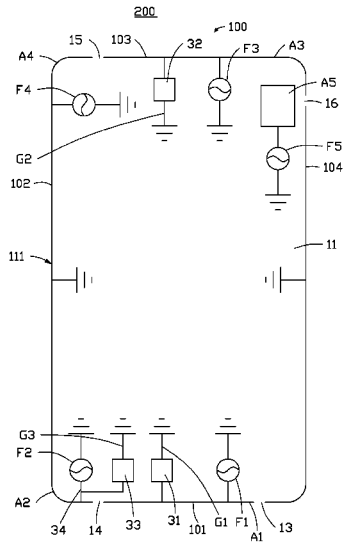
Primary Examiner — Jany Richardson

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

(57) **ABSTRACT**

An antenna structure includes a metal frame. The metal frame includes a first gap, a second gap, a third gap, and a fourth gap to separate a first antenna, a second antenna, a third antenna, and a fourth antenna from the metal frame. The metal frame includes a fifth antenna. The first antenna, the second antenna, the third antenna, and the fourth antenna cooperatively form a first multiple-input multiple-output (MIMO) antenna to provide a 4×4 multiple-input multiple-output function in a second frequency band. The first antenna, the second antenna, the third antenna, and the fifth antenna cooperatively form a second MIMO antenna to provide a 4×4 multiple-input multiple-output function in a third frequency band. The first antenna and the third antenna cooperatively form a third MIMO antenna to provide a 2×2 multiple-input multiple-output function in a first frequency band.

18 Claims, 15 Drawing Sheets



US010944153B1

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

(10) **Patent No.: US 10,944,153 B1**
(45) **Date of Patent: Mar. 9, 2021**

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

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

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

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

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

(21) Appl. No.: **16/556,026**

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

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 5/25 (2015.01)
H01Q 5/30 (2015.01)

(52) **U.S. Cl.**
CPC ***H01Q 1/243*** (2013.01); ***H01Q 5/25*** (2015.01); ***H01Q 5/30*** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 1/12; H01Q 1/21; H01Q 1/241; H01Q 1/242; H01Q 1/243; H01Q 5/20; H01Q 5/25; H01Q 5/30
See application file for complete search history.

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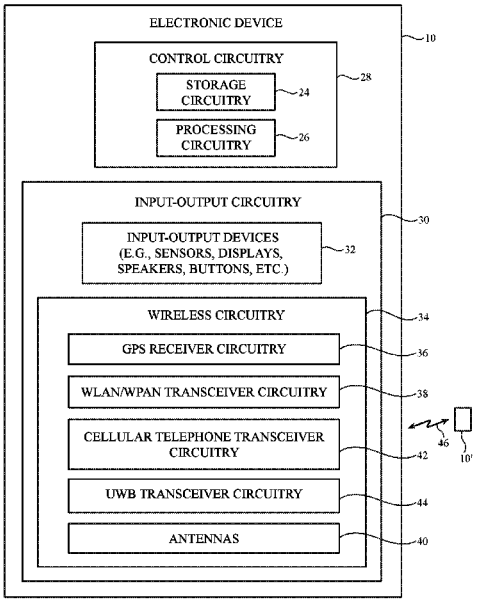
Primary Examiner — Jason Crawford
(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.; Michael H. Lyons; Tianyi He

(57) **ABSTRACT**

An electronic device may be provided with an antenna having a resonating element. The resonating element may have first and second arms extending from opposing sides of a feed. The first arm may have a fundamental mode that radiates in a first communications band such as a 5.0 GHz wireless local area network band. The second arm may have a fundamental mode that radiates in a second communications band such as one or more cellular ultra-high bands. The second resonating element arm may have a harmonic mode that radiates in first and second ultra-wideband (UWB) communications bands. The antenna may include a tunable component that is adjustable between first and second states. The second arm may radiate in the first UWB communications band while the tunable component is in the first state and in the second UWB communications band while the tunable component is in the second state.

20 Claims, 12 Drawing Sheets



US010944176B2

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

(10) **Patent No.: US 10,944,176 B2**
(45) **Date of Patent: Mar. 9, 2021**

(54) **LOW PROFILE WIDEBAND ANTENNA**

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

(72) Inventors: **Yugang Ma**, Singapore (SG); **Pankaj Sharma**, Singapore (SG); **Ser Wah Oh**, 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 225 days.

(21) Appl. No.: **16/089,352**

(22) PCT Filed: **Mar. 28, 2017**

(86) PCT No.: **PCT/SG2017/050165**
§ 371 (c)(1),
(2) Date: **Sep. 27, 2018**

(87) PCT Pub. No.: **WO2017/171642**
PCT Pub. Date: **Oct. 5, 2017**

(65) **Prior Publication Data**

US 2020/0313302 A1 Oct. 1, 2020

(30) **Foreign Application Priority Data**

Mar. 29, 2016 (SG) 10201602454V

(51) **Int. Cl.**
H01Q 9/40 (2006.01)
H01Q 1/48 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H01Q 9/40*** (2013.01); ***H01Q 1/48*** (2013.01); ***H01Q 9/42*** (2013.01); ***H01Q 13/16*** (2013.01)

(58) **Field of Classification Search**
CPC .. H01Q 9/40; H01Q 9/42; H01Q 1/48; H01Q 13/16
See application file for complete search history.

(56) **References Cited**

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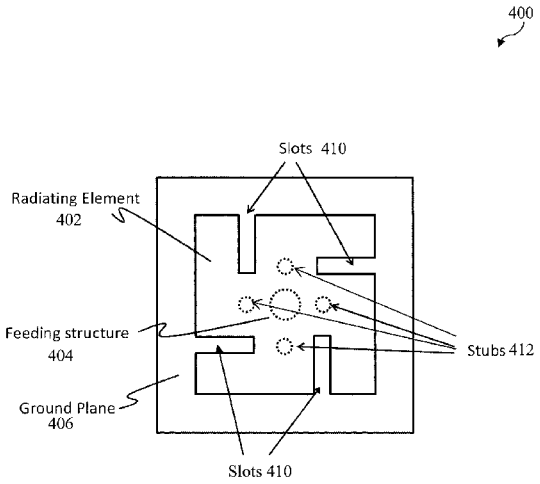
Primary Examiner — Hoang V Nguyen
(74) *Attorney, Agent, or Firm* — Womble Bond Dickinson (US) LLP

(57) **ABSTRACT**

A low-profile wideband monopole antenna is provided. The antenna may include a radiating element configured in a bent monopole arrangement to provide a vertical polarization such that an omni-directional radiating characteristic is achieved. The radiating element may include a plurality of slots formed at or edged from each side of the radiating element to increase the effective current path length of the radiating element. The antenna may include a feed and a feeding structure extending from the radiating element to the feed. The antenna may further include a ground plane. The radiating element may be arranged substantially parallel to the ground plane. The surface area of the radiating element may be smaller than the ground plane.

14 Claims, 10 Drawing Sheets



US010950950B2

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

(10) **Patent No.: US 10,950,950 B2**
(45) **Date of Patent: *Mar. 16, 2021**

(54) **ANTENNA**

(71) Applicant: **TDK CORPORATION**, Tokyo (JP)

(72) Inventors: **Tatsuya Fukunaga**, Tokyo (JP); **Yuichi Kimura**, Saitama (JP)

(73) Assignee: **TDK CORPORATION**, Tokyo (JP)

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

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **16/550,799**

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

(65) **Prior Publication Data**

US 2020/0076087 A1 Mar. 5, 2020

(30) **Foreign Application Priority Data**

Aug. 30, 2018 (JP) 2018-161918

(51) **Int. Cl.**
H01Q 13/10 (2006.01)
H01Q 21/30 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 13/106*** (2013.01); ***H01Q 21/30*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 13/10; H01Q 13/106; H01Q 21/30; H01Q 9/0414; H01Q 9/0464; H01Q 5/392
See application file for complete search history.

(56) **References Cited**

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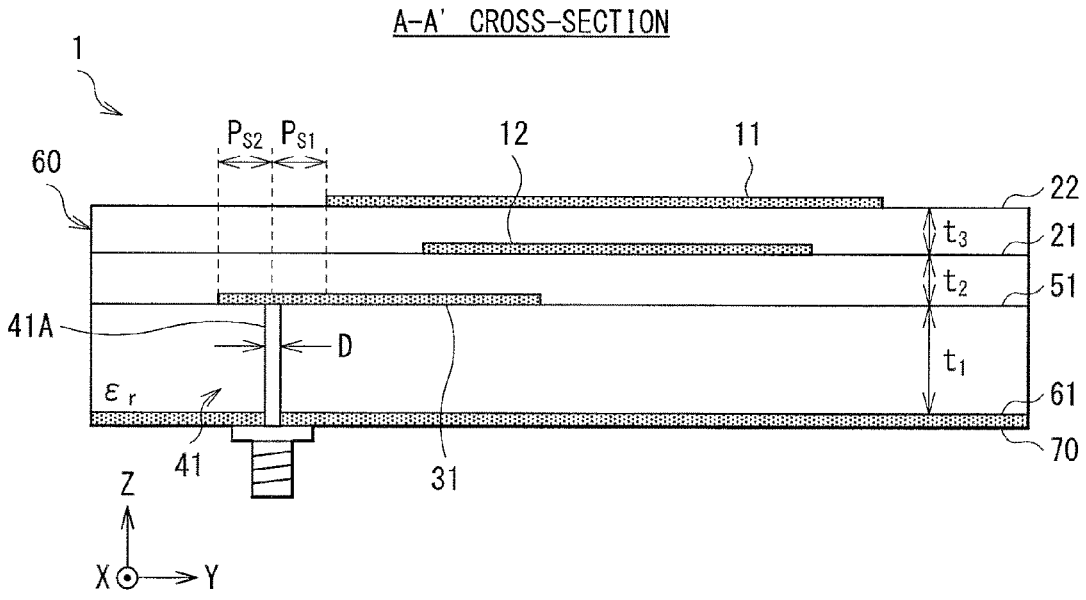
Primary Examiner — Thai Pham
(74) *Attorney, Agent, or Firm* — Oliff PLC

(57) **ABSTRACT**

An antenna includes a dielectric, first and second antenna electrodes each having an annular shape, and a probe electrode. The dielectric has first to third planes parallel to each other in a stacking direction. The first and second antenna electrodes are respectively disposed on the first and second planes. The second antenna electrode is different in size from the first antenna electrode and disposed inward from the outer periphery of the first antenna electrode. The probe electrode is disposed on the third plane and overlaps the first and second antenna electrodes in plan view along the stacking direction. The first and second antenna electrodes are electrically powered via the probe electrode. The probe electrode is remote from the first antenna electrode by a first distance and remote from the second antenna electrode by a second distance different from the first distance along the stacking direction.

10 Claims, 12 Drawing Sheets



US010950953B2

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

(10) **Patent No.: US 10,950,953 B2**
(45) **Date of Patent: Mar. 16, 2021**

(54) **ANTENNA UNIT, MIMO ANTENNA AND HANDHELD DEVICE**

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

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

(73) Assignee: **SHENZHEN SUNWAY COMMUNICATION CO., LTD.**, Shenzhen (CN)

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

(21) Appl. No.: **16/474,818**

(22) PCT Filed: **Jan. 14, 2019**

(86) PCT No.: **PCT/CN2019/071574**
§ 371 (c)(1),
(2) Date: **Jun. 28, 2019**

(87) PCT Pub. No.: **WO2019/137522**
PCT Pub. Date: **Jul. 18, 2019**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Jan. 15, 2018 (CN) 201810035964.8

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 21/08 (2006.01)
H01Q 1/48 (2006.01)

(52) **U.S. Cl.**
CPC ***H01Q 21/08*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 1/48*** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/48; H01Q 1/38; H01Q 1/22–24; H01Q 21/06–08
See application file for complete search history.

(56) **References Cited**

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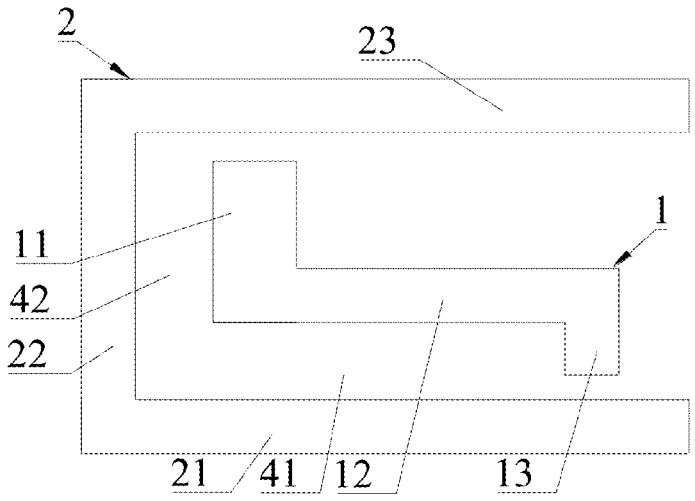
Primary Examiner — Hasan Z Islam
(74) *Attorney, Agent, or Firm* — Oliff PLC

(57) **ABSTRACT**

An antenna unit, a MIMO antenna and a handheld device. The antenna unit includes a feeder and a radiator, wherein the radiator is in a 90°-rotated U shape and includes a first horizontal part, a first vertical part and a second horizontal part, two ends of the first vertical part are respectively connected to the first horizontal part and the second horizontal part; the feeder is located in the U shape and includes a second vertical part, a third horizontal part and a third vertical part, two ends of the third horizontal part are respectively connected to the second vertical part and the third vertical part, and the second vertical part and the third vertical part are located on different sides of the third horizontal part. The MIMO antenna has an ultra wideband.

14 Claims, 4 Drawing Sheets



US010951260B2

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

(10) **Patent No.: US 10,951,260 B2**
(45) **Date of Patent: Mar. 16, 2021**

(54) **MOBILE TERMINAL**

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

(72) Inventors: **Kangjae Jung**, Seoul (KR); **Dongjin Kim**, Seoul (KR); **Yunmo Kang**, Seoul (KR); **Sungjoon Hong**, Seoul (KR); **Kyoungsun Hwang**, Seoul (KR); **Sungjung Rho**, 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.

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(22) PCT Filed: **Jan. 26, 2017**

(86) PCT No.: **PCT/KR2017/000952**
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(2) Date: **Jul. 25, 2019**

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(65) **Prior Publication Data**

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(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H04B 1/525 (2015.01)
H04M 1/02 (2006.01)

(52) **U.S. Cl.**
CPC ***H04B 1/525*** (2013.01); ***H01Q 1/243*** (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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Primary Examiner — Anh Q Tran
(74) *Attorney, Agent, or Firm* — Birch, Stewart, Kolasch & Birch, LLP

(57) **ABSTRACT**

A mobile terminal comprises: a body having an electronic equipment part therein; a middle frame mounted in the body; a main substrate mounted in the body; a side case which is located around a lateral surface of the body and includes a plurality of antenna radiators and a plurality of slits among the plurality of antenna radiators; a ground line connected to the antenna radiators; and a power feeding line for applying power to the antenna radiators, wherein the slits include first and second slits, which are located at a first lateral surface of the mobile terminal, and third and fourth slits, which are located at second and third lateral surfaces adjacent to the first lateral surface of the mobile terminal, thereby improving antenna performance by minimizing interference among the antenna radiators for transmitting and receiving each frequency signal.

12 Claims, 12 Drawing Sheets